Spatial and Temporal Effects of Burning on Plant Community Characteristics and Composition in a Fescue Prairie

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Abstract

Conserving structural and compositional diversity in Fescue Prairie requires reintroducing natural disturbances according to their historic regime. Fire is an important natural process that may be a source of spatial heterogeneity in Fescue Prairies. The effects of burning in all months of the year except January and February were evaluated in a Fescue Prairie in central Saskatchewan for 6 years following burning on 2 sites that had not been previously burned and 2 sites that had been burned 5 years earlier. Except for burning in March, burning reduced cover of litter ($P<0.01$) and *Festuca hallii* (Vasey) Piper ($P=0.01$) while increasing bare soil ($P<0.01$) for 1 to 5 years. Cover of *Elymus lanceolatus* (Scribn. & J.G. Sm.) Gould ($P<0.01$), graminoids ($P=0.02$), and species evenness ($P=0.01$) increased with burning frequency. Burning in late-summer reduced cover of graminoids ($P=0.03$), plants other than the dominant grasses ($P=0.03$), and total plant cover ($P=0.02$). Burning increased the spatial variance (s^2) in litter cover ($P<0.01$) and bare soil ($P<0.01$) for 1 to 3 years. Aside from burning in early spring, burning reduced s^2 in total standing crop ($P=0.02$) and *F. hallii* ($P=0.01$). Variability in the cover of *E. lanceolatus* ($P<0.01$) and graminoids ($P=0.04$) increased with burning frequency. Canonical correspondence analysis (CCA) indicated that pre-burn history had a dominant effect on plant community composition, explaining 13% of the variation ($P<0.01$). The cumulative effects of repeated burning, annual variability in weather, and exposure to temperature extremes may have caused a shift in the composition of the plant community. The first 4 ordination axes explained 22% of the variation in plant community composition after burning, indicating that many other environmental or site variables controlled community composition. A range of burning dates and frequencies should be reintroduced or maintained in Fescue Prairie to create a mosaic of plant communities in various stages of recovery after burning. A mosaic will increase the structural and compositional diversity in remnant Fescue Prairies.

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Dedication

I dedicate this work to my family, especially Mom and Dad, Marilyn and Peter Gross, for their love and support throughout my life.

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1.0 Introduction

Fescue Prairie is one of the most threatened ecosystems in the Canadian Prairies (World Wildlife Fund, 1988) primarily because this grassland has been ploughed for annual crop production (Romo, 2003). Less than 5% of the Fescue Prairie remains in Saskatchewan (Grilz and Romo, 1995) while about 15% of *Festuca*-dominated plant communities are extant in Alberta (Alberta Prairie Conservation Forum, 2001). Since the time of European settlement, widespread destruction of Fescue Prairie has created a landscape with small, isolated patches of remnant native vegetation embedded in a dissimilar matrix of cultivated fields, grazed pastures, roads, and human settlements, while reducing biological diversity (Archibold and Wilson, 1980; Romo, 2003). This isolation prevents the occurrence and spread of fires and it has permanently altered the natural fire regime in remnant Fescue Prairie (Bradley and Wallace, 1996). Fire suppression has altered the structure, function, and composition of Fescue Prairie remnants from their natural, pre-settlement state leading to further reductions in native plant and animal biodiversity (Hobbs and Huenneke, 1992).

Conserving Fescue Prairie requires reintroducing natural disturbances according to their historic spatial and temporal regime (Romo, 2003). Fire was an important natural disturbance in the Fescue Prairie, influencing its structural, compositional, and functional diversity (Romo, 2003). Fires created complex spatial patterns of burned and unburned areas on the landscape, leaving patches of vegetation in various stages of recovery (Turner *et al*., 1999). Historically, fire had the potential to occur in the Northern Great Plains throughout the year (Higgins, 1986; Romo, 2003). Estimated fire return intervals ranged from 5 to 10 years (Wright and Bailey, 1982).

Fire suppression in Fescue Prairie has been incredibly successful, excluding fires in some areas for more than 80 years (Bailey, 1978; Grilz and Romo, 1994). Excluding fire from Fescue Prairie remnants removes the heterogeneity imposed by the disturbance. In the absence of fire, the composition and structure of Fescue Prairie can become more homogeneous because of dominance by *Festuca* (Moss and Campbell, 1947; Coupland and Brayshaw, 1953; Coupland, 1961), litter accumulation, and encroachment by woody species (Pylypec, 1986; Bailey and Wroe, 1978; Pylypec and Romo, 2003). Exceeding the natural range of variability for fire return intervals in Fescue Prairie may permanently change the composition, structure, function, and disturbance regimes (Westoby *et al.*, 1989; Friedel, 1991; Laycock, 1991; Suding, 2004).

Current fire prescriptions for Fescue Prairie typically involve burning in the spring or fall, depending on the desired effects on the plant community (Bailey, 1978; Bailey and Anderson, 1978; Wright and Bailey, 1982). Burning only in the spring or fall does not allow the full expression of the historic fire regime. By varying the timing and frequency of burning within the natural range of variability, a heterogeneous assemblage of patches is created that allows the historic diversity of plant communities to coexist in the landscape (Stewart *et al.*, 2000). Restoring the historic disturbance regime, under which a diverse range of plant species has evolved, enhances biodiversity (Hobbs and Huenneke, 1992).

Fire suppression has simplified the structure, composition, and function of the prairie, and reduced biodiversity of native organisms (Bradley and Wallace, 1996). Reintroducing fire into remnant Fescue Prairies requires understanding of the spatial and temporal effects of burning at different times of the year on sites with different burning histories on plant community characteristics and plant community composition. This research was motivated by the need for more information to develop guidelines for using fire in conserving biodiversity in remnant Fescue Prairies.

The objective of this study was to determine the spatial and temporal effects of burning at different times of the year on plant community characteristics and plant community composition in sites with 2 different burning histories in a remnant Fescue Prairie. Results of this study will be used to make recommendations for reintroducing fire as a natural process to enhance biodiversity in Fescue Prairie.

The following hypotheses were tested:

(1) Plant community characteristics differ the first 6 years after burning in different months on sites not previously burned and sites burned 5 years earlier.

(2) The spatial variance in plant community characteristics differs the first 6 years after burning in different months on sites not previously burned and sites burned 5 years earlier.

(3) Environmental variables explain plant community composition the first 6 years after burning at different times of the year in sites not previously burned and sites burned 5 years earlier.

2.0 Literature Review

2.1 Ecology of Fescue Prairie

The largest and most continuous stands of Fescue Prairie in the Northern Great Plains have been described in Saskatchewan (Coupland and Brayshaw, 1953; Coupland, 1961; Baines, 1973; Pylypec, 1986; Coupland, 1992; Thorpe, 1999), Alberta (Moss, 1944; Moss and Campbell, 1947; Looman, 1969; Stringer, 1973; Rowe and Coupland, 1983), Interior British Columbia (Tisdale, 1947; McLean and Marchand, 1968; Looman, 1969), and Montana (Stickney, 1960; Ross and Hunter, 1976; Mueggler and Stewart, 1980). Fescue Prairie originally formed an arc around the northern edge of the Mixed Prairie in the transition from grassland to forest (Moss and Campbell, 1947; Coupland and Brayshaw, 1953). It is the grassland component of the Aspen Parkland from central Saskatchewan west into Alberta and south in the foothills of the Rocky Mountains in southern Alberta and northern Montana (Moss, 1944; Moss and Campbell, 1947; Romo, 2003). Areas of *Festuca*-dominated plant communities have also been described in Manitoba (Blood, 1966; Looman, 1969), North Dakota (Cosby, 1965), and Washington (Hodgkinson and Young, 1973).

Landscapes occupied by Fescue Prairie were once covered by extensive ice sheets, which have since retreated, leaving a thick mantle of glacial drift (Coupland and Brayshaw, 1953; Christensen, 1979; Acton *et al.*, 1998). Various morainic, glacio-fluvial and lacustrine deposits represent the surface materials, with unsorted glacial till being the most common (Coupland and Brayshaw, 1953; Acton *et al.*, 1998). Soils are predominantly black in colour and classified as Black or Dark Brown Chernozems (Coupland and Brayshaw, 1953; Looman, 1969; Acton *et al.*, 1998). Topography of the Fescue Prairie varies from level to rolling (Coupland and Brayshaw, 1953; Acton *et al.*, 1998).

The climate of Fescue Prairie is characterized as semi-arid to humid continental (Acton *et al.*, 1998) with an average annual temperature less than 4°C (Coupland and Brayshaw, 1953). Precipitation is limited, averaging 350 mm, and most precipitation is received during the growing season from May to July (Romo, 2003). Northerly aspects and higher elevations have greater effective precipitation, favouring *Festuca*-dominated plant communities within the drier Mixed Prairie (Coupland and Brayshaw, 1953; Coupland, 1961; Romo, 2003).

Fescue Prairie is not dominated by a single *Festuca* species (Pavlick and Looman, 1984; Hill *et al*., 1997; Romo, 2003). *Festuca hallii* (Vasey) Piper, a weakly rhizomatous, perennial bunchgrass, dominates the Northern Great Plains from the Aspen Parkland to wetter portions of the Mixed Prairie (Hill *et al*., 1997; Romo, 2003). *Festuca campestris* Rydb. prevails in the Rocky Mountain foothills and Cypress Hills (Hill *et al*., 1997).

Fescue Prairie is associated with many species of the Mixed Prairie, Palouse Prairie, Aspen Parkland, and Boreal Forest (Moss, 1944; Moss and Campbell, 1947; Coupland and Brayshaw, 1953; Coupland, 1961). On drier sites, graminoids common to the Mixed Prairie are prevalent, including *Hesperostipa* spp., *Elymus* spp., *Pascopyrum smithii* (Rydb.) A. Löve, *Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths, *Koeleria macrantha* (Ledeb.) J.A. Schultes, *Helictotrichon hookeri* (Scribn.) Henr., *Muhlenbergia richardsonis* (Trin.) Rydb., and *Carex* spp. (Coupland, 1961). *Elymus lanceolatus* (Scribn. & J.G. Sm.) Gould and *Hesperostipa curtiseta* (A.S. Hitchc.) Barkworth are perennial grasses that become locally abundant with *F. hallii* at the transition between Northern Mixed Prairie and Fescue Prairie (Redmann *et al*., 1993). Species common to the Palouse Prairie of the Northwest United States extend into the Fescue Prairie of southern Alberta, including *F. idahoensis* Elmer, *Achnatherum nelsonii* ssp. *dorei* (Barkworth & Maze) Barkworth, *Pseudoroegneria spicata* ssp. *spicata* (Pursh) A. Löve, *Geranium viscosissimum* Fisch. & C.A. Mey. ex C.A. Mey., *Lithospermum ruderale* Dougl. ex Lehm., and *Balsamorhiza sagittata* (Pursh) Nutt. (Moss and Campbell, 1947).

Through most of its northern range, Fescue Prairie exists in dynamic equilibrium with Aspen Parkland, occurring in a shifting mosaic-ecotone of forest and grassland. *Populus tremuloides* Michx. forms dense groves in moist areas that can invade adjacent

Fescue Prairie (Moss and Campbell, 1944; Coupland and Brayshaw, 1953; Anderson and Bailey, 1980). Trees including *Picea glauca* (Moench) Voss, *Pinus contorta* var. *latifolia* Engelm. ex S. Wats., and *Pseudotsuga menziesii* (Mirbel) Franco are associated with Fescue Prairie at higher altitudes (Moss and Campbell, 1947).

About 200 vascular plant species grow in Fescue Prairie, most of which are forbs (Moss and Campbell, 1947; Coupland and Brayshaw, 1953; Anderson and Bailey, 1980; Antos *et al.*, 1983; Pylypec, 1986; Bork *et al.*, 2002). Forbs common to Fescue Prairie include *Artemisia* spp., *Solidago* spp., *Potentilla* spp., *Achillea millefolium* L., *Galium boreale* L., *Geum triflorum* Pursh, and *Symphyotrichum* spp. (Coupland and Brayshaw, 1953; Pylypec, 1986). Prominent shrubs include *Symphoricarpos occidentalis* Hook., *Rosa arkansana* Porter, and *Elaeagnus commutata* Bernh. ex Rydb. (Coupland and Brayshaw, 1953). Fescue Prairie is also habitat for numerous insect, avian, and mammalian species (Acton *et al.*, 1998).

Ninety-five million hectares or 75% of the prairie in Canada has been cultivated, including 68% of Alberta's prairie, 80% in Saskatchewan, and 78% of Manitoba (Bradley and Wallace, 1996). Less than 5% and 15% of Fescue Prairie remains in Saskatchewan and Alberta, respectively, and it is therefore one of the most threatened ecosystems on the Canadian prairies (World Wildlife Fund, 1988; Grilz and Romo, 1994; 1995; Alberta Prairie Conservation Forum, 2001). Furthermore, about 109,600 oil and gas well sites have been cleared along with associated access roads and pipelines in Alberta (Kerr *et al*., 1993). Saskatchewan has more road surface than any other province in Canada, about 250,000 km (Tourism Saskatchewan, 1994), and the most extensive road system per capita in the world (Barry *et al*., 2000). Introduction of invasive species (Grilz and Romo, 1995), woody plant encroachment (Bailey and Wroe, 1978), and alteration of burning (Gerling *et al.*, 1995; Romo, 2003) and grazing regimes (Grilz *et al.*, 1994; Acton *et al.*, 1998) threaten what little Fescue Prairie remains with extinction (Looman, 1969; Thorpe and Godwin, 1999). Conserving remnants of Fescue Prairie is therefore critical to the persistence of biological diversity in the Northern Great Plains (Dyson, 1996; PCAP Partnership, 2003).

2.2 Natural variability and Fescue Prairie

Conserving Fescue Prairie requires reintroducing the historic variability of the natural disturbance regime (Romo, 2003). The natural disturbance regime is the spatial and temporal dynamics of all disturbances in a given region over time (Turner *et al.*, 2001). Natural or historic variability is the “variability of ecological conditions within a given time period and geographical area” (Landres *et al.*, 1999, p. 1180). Re-establishing past ecological conditions, including disturbances, under which a variety of species have adapted, provides conservationists with an approach to managing protected areas for biodiversity (Landres *et al.*, 1999).

Fire is an important natural disturbance in Fescue Prairie (Romo, 2003). A disturbance is any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment (White and Pickett, 1985). Historically fire was common in Fescue Prairie due to the accumulation of flammable fuels and frequent occurrence of climatic conditions favourable to fuel ignition (Redmann, 1991; Pylypec and Romo, 2003; Romo, 2003).

Historical records suggest that before European settlement, fire occurred frequently over large areas of the Northern Great Plains (Nelson and England, 1971; Wright and Bailey, 1982; Axelrod, 1985; Higgins, 1986) creating complex spatial patterns of burned and unburned vegetation (Turner *et al*., 1999). Estimated fire return intervals ranged from 5 to 10 years (Wright and Bailey, 1982). Fire had the potential to occur in Fescue Prairie in all months of the year (Romo, 2003). Across the Northern Great Plains, 85% of lightning set fires occurred in June, July, and August. Indian-set fires occurred in nearly all months with a majority in late summer and autumn, often corresponding to plains bison (*Bison bison bison* L.) migrations (Higgins, 1986). Fires were frequent in spring and fall during dry conditions, but they could also occur during the winter in many areas, favoured by warm, dry Chinook winds (Nelson and England, 1971).

From the time of European settlement, about 150 years ago, Fescue Prairie has undergone dramatic modification, from natural grassland to a highly disturbed, mostly cultivated landscape (Looman, 1969; Romo, 2003). Cultivated fields, overgrazed pastures, and roads function as barriers to the spread of wildfire (Romo, 2003). Fire is also suppressed out of fear of damage to life and property (Driver, 1987). Fire suppression in Fescue Prairie has excluded fire in some areas for more than 80 years (Bailey, 1978; Grilz and Romo, 1994). Consequently, the spatial and temporal variability of fire in Fescue Prairie has been drastically altered relative to its natural, pre-European settlement state (Romo, 2003).

Land managers and conservationists have recognized the need to reintroduce fire in Fescue Prairie (Bailey, 1978; Romo, 2003). Fire prescriptions for Fescue Prairie involve burning in either the spring or fall, depending on the objectives of the land manager (Bailey, 1978; Bailey and Anderson, 1978; Wright and Bailey, 1982). Burning is used to control tree and shrub encroachment into prairie (Bailey and Wroe, 1974; Steuter *et al*., 1990), reduce unwanted vegetation, provide food and cover for livestock and wildlife (Bailey, 1978), and restore viability of rare or endangered species (Lesica, 1999; Kaye *et al*., 2001). Burning only in the spring or fall does not allow the full expression of the natural fire regime and thereby limits the biodiversity adapted to the historic range of variability (Baker, 1992; Romo, 2003).

Fire suppression has altered the fire regime from the historic range of variability, simplifying the structure, composition, and function of the prairie, while reducing native biodiversity (Axelrod, 1985; Bradley and Wallace, 1996). Reintroducing fire as a natural process in Fescue Prairie can be achieved by burning at different times of the year and altering fire return intervals (Romo, 2003). Re-establishing the spatial and temporal variability of fire within its historic regime will create a mosaic of burned and unburned patches of vegetation, allowing a diverse range of species to coexist, and encouraging the persistence of Fescue Prairie (Stewart *et al*., 2000; Romo, 2003).

2.3 Heterogeneity and biodiversity in Fescue Prairie

Fire is a source of spatial and temporal heterogeneity in Fescue Prairie and it affects structural, functional, and compositional diversity (Romo, 2003). Heterogeneity is spatial or temporal variation in a measured parameter (Wiens, 2000; Fuhlendorf and

Engle, 2001) and is a precursor to biodiversity (Fuhlendorf and Engle, 2001). Biodiversity is "the variety of life and its processes, including the variety of organisms, the genetic differences between them, the communities, ecosystems, and landscapes in which they occur, plus the interactions of these components" (West, 1993, p. 3). Landscapes that are spatially heterogeneous should provide more potential niches for plants and animals than homogeneous landscapes thereby increasing biodiversity (Simpson, 1949; MacArthur and Wilson, 1967; Burnett *et al*., 1998). Positive correlations between habitat heterogeneity and animal species diversity have been reported in grasslands (Tews *et al*., 2004), including insects (Dennis *et al*., 1999; Bestelmeyer and Wiens, 2001), birds (Roth, 1976; Madden *et al*., 1999; 2000; Fletcher and Koford, 2002), and mammals (Ceballos *et al*., 1999).

Fescue Prairie remnants have inherent spatial heterogeneity due to variability in abiotic factors including the physical and chemical properties of soils, topography, and microclimate (Burnett *et al*., 1998; Stewart *et al.*, 2000). Organisms respond to environmental heterogeneity and further contribute to heterogeneity through processes including dispersal, germination, growth, and senescence (Urban *et al.*, 1987; Stewart *et al.*, 2000). Superimposed over this biogeophysical variability is the heterogeneity provided by disturbances (Stewart *et al.*, 2000; Wiens, 2000). Fire creates complex spatial patterns in vegetation in Fescue Prairie (Redmann *et al.*, 1993). Variability in the timing, frequency, severity, and spatial distribution of fire further contributes to the heterogeneity created by burning (Romo, 2003). Varying the timing, frequency, and spatial distribution of burning creates a mosaic of stands in various stages of recovery, increasing the spatial heterogeneity of the landscape (Romo, 2003).

Reintroducing fire to conserve Fescue Prairie manipulates succession, or temporal heterogeneity in the plant community (Denslow, 1985; Miles, 1987). Burning removes aboveground plant material and opens the canopy so plants can establish vegetatively or from seed (Keeley and Fotheringham, 2000). Other species may also establish in the newly created gaps, changing the composition or relative abundances of species (Connell and Slayter, 1977) and increasing the temporal heterogeneity of the plant community (Denslow, 1985).

Excluding fire from Fescue Prairie remnants removes the heterogeneity imposed by burning, leading to a more homogeneous landscape. In the absence of burning, compositional and structural heterogeneity of plant communites is reduced in Fescue Prairie because litter accumulates and trees and shrubs increase (Bailey and Anderson, 1978; Bailey and Wroe, 1978; Pylypec, 1986; Pylypec and Romo, 2003). Litter accumulation increases soil water (Redmann *et al.*, 1993), which in turn favours succession to *P. tremuloides*-dominated plant communities (Gerling *et al.*, 1995).

Several techniques are available for measuring and quantifying spatial and temporal heterogeneity (Roth, 1976; Armesto *et al.*, 1991; Wiens, 2000). Spatial variance (s^2) is the variation among sample points in a given area (Wiens, 2000). Uniform distribution of a measured parameter in space has a variance or $s^2=0$. Heterogeneity is indicated when $s^2>0$ because heterogeneity increases with s^2 (Wiens, 2000). Spatial variance does not identify spatial pattern; rather, it indicates that not all samples have the same value for a measured parameter (Armesto *et al.*, 1991; Wiens, 2000). Temporal heterogeneity is determined through repeated sampling of the same space over time (Kolasa and Rollo, 1991; Collins, 1992).

Detecting and measuring heterogeneity depends on the scale of observation (Wiens, 2000). What is heterogeneous at one scale appears uniform at another scale. For example, the effects of burning at the landscape-scale are typically heterogeneous, creating patches of burned and unburned vegetation representing a mosaic of successional stages (Watt, 1947; Turner *et al.*, 1999). Within burns, however, the effects of burning may be quite uniform (Turner *et al.*, 1999). The scale-dependent nature of heterogeneity necessitates that the scale of observations be specified (Wiens, 2000).

2.4 Effects of burning in Fescue Prairie

Reintroducing the historic variability of fire into remnant Fescue Prairie requires understanding the spatial and temporal effects of burning on individual plants, plant communities, and the microenvironment. Burning influences plants and plant communities by the direct effects of burning and by the indirect effects of modifying the microenvironment (Romo *et al.*, 1993). The effects of burning in Fescue Prairie have been investigated in Saskatchewan (Toynbee, 1987; Redmann, 1991; Redmann *et al.*, 1993; Romo *et al.*, 1993; Grilz and Romo, 1994; 1995; Archibold *et al.*, 1998; Archibold *et al.*, 2003; Pylypec and Romo, 2003), Alberta (Bailey and Wroe, 1974; Bailey and Anderson, 1978; Anderson and Bailey, 1980; Bailey and Anderson, 1980; Bailey *et al.*, 1990; Horton, 1991; Gerling *et al.*, 1995; Bork *et al.*, 2002; Bogen *et al.*, 2003), and Montana (Antos *et al.*, 1983; Jourdonnais and Bedunah, 1990; Lesica and Martin, 2003). Few studies have quantified the effects of burning on spatial and temporal heterogeneity in plant community characteristics (Roth, 1976; Madden *et al.*, 1999; 2000) and composition in grasslands (Collins, 1989; Collins, 1992; Glenn *et al.*, 1992). Apparently, no information exists on the effects of burning on spatial and temporal heterogeneity in plant community characteristics and composition in Fescue Prairie.

The effects of burning Fescue Prairie at different times of the year have been studied in Saskatchewan (Toynbee, 1987; Redmann *et al.*, 1993; Romo *et al.*, 1993; Grilz and Romo 1994; 1995; Archibold *et al.*, 2003), Alberta (Bailey and Anderson, 1978; Gerling *et al.*, 1995), and Montana (Jourdonnais and Bedunah, 1990; Lesica and Martin, 2003). Fire effects on plants depend on the timing of burning (Old, 1969; Towne and Owensby, 1984; Brown and Whelan, 1999). Plants are more susceptible to fire injury when they are rapidly growing compared to periods of dormancy or early growth (Anderson *et al.*, 1970). Temporal variability in carbohydrate reserves may make plants more or less vulnerable to the effects of burning at different times of the year (White, 1973; Dahl and Hyder, 1977; Caldwell, 1984; Busso *et al.*, 1990; Kowalenko and Romo, 1998a). The amount of residual photosynthetic material or the availability of active meristems determined by burning intensity, however, is more important to regrowth than the limited amounts of carbon stored in plants (Briske and Richards, 1995).

Burning at different times of the year alters plant community composition in Fescue Prairie by altering the cover of dominant grasses, graminoids, and forbs (Bailey and Anderson, 1978). Cover of *Festuca hallii* decreases after burning in May or October (Bailey and Anderson, 1978). Burning in October reduces cover of *Hesperostipa curtiseta*, but cover of this perennial grass is unaffected by burning in May (Bailey and Anderson, 1978). Apparently, no information exists on the response of *Elymus lanceolatus* to the effects of burning at different times of the year. Burning in October reduces the canopy cover of graminoids more than burning in April, while perennial forbs increase (Bailey and Anderson, 1978) or decrease after burning (Redmann *et al.*, 1993). Leach and Givnish (1996) hypothesized that nitrogen-fixing plants, such as legumes, would decline in the absence of fire in Tallgrass Prairie remnants. Burning in May or October increases the cover of legumes relative to unburned areas in the Aspen Parkland of Alberta (Bailey and Anderson, 1978). Various legume species increase (Niering and Dreyer, 1989; Dudley and Lajtha, 1993; Nagel *et al*., 1994), decrease (Hadley, 1970) or remain unchanged (Curtis and Partch, 1948; Kucera and Koelling, 1964) after burning in other grasslands of the Northern Great Plains.

Whereas individual plant species and species groups are affected by burning, the plant community as a whole appears more resilient to the effects of a single burn. Burning at different times of the year has little impact on species richness in Fescue Prairie (Anderson and Bailey, 1978; Grilz and Romo, 1995). The response of the Shannon-Weiner diversity index (H') to burning at different times of the year in Fescue Prairie is not known. Diversity (H') increases (Johnson and Knapp, 1995), decreases (Towne and Kemp, 2003), or is unaffected (Wilson and Shay, 1990; Brockway *et al.*, 2002) following burning in the Northern Great Plains. Total plant cover increases slightly after a May burn, but cover decreases after burning in October in the Aspen Parkland of Alberta (Bailey and Anderson, 1978). Burning in spring or fall has no effect on total plant cover in the Fescue Prairie of western Montana (Jourdonnais and Bedunah, 1990).

Changes in plants and plant communities after burning are attributed in part to the effects of burning on microenvironmental conditions, especially water regimes (Romo, 2003). Burning removes above ground plant biomass and reduces vegetation structure, subsequently reducing snow cover in winter, especially after burning in October (Archibold *et al.*, 2003). Snow cover is an important source of soil water recharge in Fescue Prairie (de Jong and MacDonald, 1975). Soil water is greater after burning in April compared to burning in October, but less than unburned areas in the Fescue Prairie of Saskatchewan (Grilz and Romo, 1994). Burning in April or October reduces litter cover and increases bare soil (Jourdonnais and Bedunah, 1990). Litter accumulation is associated with greater soil water in Fescue Prairie (Redmann *et al.*, 1993) because litter increases infiltration of water into the soil and decreases evaporation of water from the soil surface (Wright and Bailey, 1982; Willms *et al.*, 1986).

Reduced soil water following burning increases plant water stress and reduces productivity in the Northern Great Plains (Redmann, 1978). However, burning in May or October has no effect on annual herbage production in the Fescue Prairie of central Alberta (Bailey and Anderson, 1978). The variability of responses of plant productivity to burning is partially attributed to variation in environmental conditions before, during, and after burning (Daubenmire, 1968; Bailey and Anderson, 1978; Redmann *et al.*, 1993).

Environmental factors associated with the timing of burning alter the character and effect of burning on plants, plant communities, and the microenvironment (Daubenmire, 1968). Greater fuel loads increase fire temperatures and the intensity and severity of burning in the Fescue Prairie of Saskatchewan (Archibold *et al.*, 1998). Increased fuel water reduces the rate of combustion and spread of grassland fires (Daubenmire, 1968; Wright and Bailey, 1982), increasing spatial patchiness in the plant community (Watt, 1956). Consumption of fine fuels by fire is determined primarily by relative humidity, which is influenced by air temperature, further contributing to the spatial variability of burning (Britton and Wright, 1971). Wind speed often overrides the effects of other environmental factors, increasing the temperature and velocity of the fire (Daubenmire, 1968; Wright and Bailey, 1982).

The effects of frequency of burning, or the number of fires in the same area over a given time period, on Fescue Prairie have been investigated in Alberta (Anderson and Bailey, 1980). Annual burning in early spring alters plant community composition of the Aspen Parkland to one more representative of the drier Mixed Prairie (Anderson and Bailey 1980). Cover of dominant plant species decreases while species richness increases under burning (Anderson and Bailey, 1980). Cover of *F. hallii* and *H. curtiseta* decrease, while frequency of *Pascopyrum* (*Agropyron*) *smithii* increases. Annual spring burning increases the number of forb species, cover of herbaceous species and legumes while cover of woody species, litter, and total standing crop decline (Anderson and Bailey, 1980). Three consecutive years of annual spring burning reduces the cover of the dominant plant species and increases bare soil in the Mixed Prairie of southwestern Manitoba (Shay *et al*., 2001).

Spatial variability in plant community characteristics, which reflect structural heterogeneity, generally decreases with increasing fire frequency (Madden *et al*., 1999; 2000). Increased fire frequency reduces patchiness in grasses and forbs and increases litter patchiness in the Mixed Prairie of northwestern North Dakota (Madden *et al*., 1999; 2000). Annual burning in mid-April reduces heterogeneity in plant community composition compared to unburned vegetation in the Tallgrass Prairie of Oklahoma (Collins, 1989). Heterogeneity in composition is negatively correlated with frequency of burning in the Tallgrass Prairie of Kansas (Collins, 1992).

Recovery of microenvironmental conditions, plants, and plant communities after burning Fescue Prairie has been studied in Saskatchewan (Redmann *et al.*, 1993; Archibold *et al.*, 2003; Pylypec and Romo, 2003), Alberta (Bailey and Anderson, 1978), and Montana (Antos *et al.*, 1983; Jourdonnais and Bedunah, 1990). Microenvironmental factors including surface albedo, soil temperature, soil water, and plant water demand recover within one growing season after a single burn in May, June, or October in Saskatchewan (Archibold *et al.*, 2003). Cover of litter decreases and bare soil increases for at least 3 years following burning in Montana (Jourdonnais and Bedunah, 1990) while litter mass may require up to 11 years to return to pre-burns amounts in Saskatchewan (Pylypec and Romo, 2003). Recovery of total standing crop ranges from 3 to 8 years after a single early spring burn (Redmann *et al.*, 1993; Pylypec and Romo, 2003). In the Aspen Parkland of Alberta, total plant cover and cover of *F. hallii* are reduced while species richness and cover of *H. curtiseta* are unaffected for 3 years following burning (Bailey and Anderson, 1978). Overall, few studies have monitored changes in plant community characteristics and composition beyond the growing season following burning, limiting the ability to identify trends after burning.

Fluctuations in weather contribute to temporal heterogeneity in plant community characteristics and plant community composition in the Northern Great Plains (Coupland, 1958). Precipitation is positively correlated with plant productivity in Fescue Prairie (Bork *et al.*, 2002; Pylypec and Romo, 2003). Annual variation in temperature and precipitation affects plant productivity (Smoliak, 1986), plant cover, and community composition in the Mixed Prairie of Alberta (Clarke *et al.*, 1943). Year-to-year variation in weather after burning is the principle agent determining plant community composition in the Tallgrass Prairie of Kansas (Gibson and Hulbert, 1987). Few studies have investigated the relative importance of meteorological variables on temporal changes in grasslands (Smoliak, 1986; Aguando-Santacruz and Garcia-Moya, 1998; Kammer, 2002). The relative contribution of precipitation, growing degree-days, and cold stress-days to changes in plant community composition after burning in Fescue Prairie is not known.

3.0 Materials and Methods

3.1 Site description and experimental design

The study was conducted at Kernen Prairie, a 130-ha native prairie 1 km NE of Saskatoon, SK (52^{o} 10' N, 106^{o} 33' W, elevation 510 m). Fine-textured glacio-lacustrine parent material underlies the prairie, deposited by Glacial Lake Saskatoon approximately 12,000 years ago upon the retreat of the Wisconsinan Glaciation (Christiansen, 1979). Soils are classified as Orthic Dark Brown Chernozems (Acton and Ellis, 1978). Bradwell sandy loams predominate in a north-south ridge across Kernen Prairie, while finer-textured Sutherland soils are prevalent in slightly lower slope positions (Baines, 1973; Souster, 1979).

The climate of the region is classified as Boreal (arid, with a cold season) (Walter and Lieth, 1960-1967). The 30-year mean annual temperature is 2.4°C, ranging from a January mean minimum of – 16.4°C to an average July maximum of 18.5°C (Table 3-1). Mean annual precipitation is 336.4 mm, one-half of which falls from April to July (Redmann *et al.*, 1993; Table 3-1). In 1996, annual precipitation was 133% of the 30-year mean, while only one-half of the average annual precipitation was received in 2001. Over the duration of the study, average annual growing degree-days and cold stress-days were 2,599 and 1,726, respectively (Table 3-2). Annual growing degree-days ranged from 2,242 in 2004 to 2,879 in 2003. Annual cold stress-days varied from 1,270 in 1999 to 2,572 in 1996.

Kernen Prairie is a mosaic of plant communities representing Mixed Prairie (Coupland, 1950), Fescue Prairie (Coupland and Brayshaw, 1953) and Boreal Forest Associations (Swan and Dix, 1966) with distribution primarily controlled by

Table 3-1. Mean monthly temperatures, annual temperatures, monthly precipiaiton and annual precipitation in 1995-2004, and the 30-year mean monthly temperatures,annual temperatures and precipitation at Saskatoon, Saskatchewan. Data are from Environment Canada [http://www.climate.weatheroffice.ec.gc.ca/advanceSearch/searchHistoricData Stations_e.html]. Last updated: 31 January 2005.

Months	Years										30-Year Mean
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	
Mean temperature (°C)											
January	-14.6	-24.6	-21.1	-18.4	-17.3	-17.3	-9.0	-14.6	-16.6	-19.5	-16.4
February	-12.9	-13.9	-11.3	-5.6	-9.9	-11.2	-17.6	-8.6	-16.1	-10.4	-12.9
March	-6.0	-11.4	-9.7	-7.3	-4.5	-1.9	-3.1	-13.6	-8.9	-4.2	-6.1
April	0.7	3.1	2.2	7.2	6.5	4.4	4.6	-0.5	5.3	5.1	4.4
May	10.3	8.4	10.2	13.0	10.7	10.5	12.4	8.9	12.1	8.5	11.4
June	17.4	15.9	16.5	14.5	14.6	14.3	15.5	17.3	16.0	13.1	16.0
July	16.9	17.6	18.3	18.7	16.4	18.7	19.7	20.1	18.9	17.3	18.5
August	15.5	18.1	17.8	20.0	17.8	16.8	19.8	16.6	20.9	14.6	17.3
September	11.5	10.2	13.5	13.2	10.3	11.7	13.9	11.4	11.5	10.7	11.5
October	4.6	2.5	4.0	4.8	4.5	4.5	2.4	-0.9	6.5	3.1	4.3
November	-10.0	-12.6	-4.0	-4.2	-1.3	-6.2	-1.3	-4.3	-9.8	-1.9	-6.0
December	-16.6	-19.4	-5.7	-13.1	-7.5	-19.4	-13.4	-8.8	-8.8	-26.0	-13.6
Average	1.4	-0.5	2.6	3.6	3.4	2.1	3.7	2.0	2.6	0.9	2.4
Total precipitation (mm)											
January	11.8	14.0	15.6	12.5	27.5	19.6	2.1	2.3	9.0	23.1	13.7
February	12.9	12.4	5.1	4.2	5.9	12.6	2.9	6.7	9.9	12.2	9.4
March	30.0	12.8	19.3	9.2	8.5	21.9	2.0	8.0	8.7	27.0	13.7
April	34.0	30.1	35.8	7.3	14.7	41.2	5.5	14.8	46.2	11.8	23.3
May	14.9	58.7	25.6	8.6	114.8	16.4	21.6	1.5	16.0	27.0	48.2
June	32.6	100.8	53.1	75.4	58.9	49.8	38.3	52.2	19.0	79.7	56.5
July	81.4	114.1	24.6	31.1	80.4	82.8	52.2	69.5	48.5	75.0	57.4
August	84.6	18.4	49.6	37.2	43.4	42.0	6.0	75.2	30.0	73.5	40.1
September	0.6	40.3	55.4	27.1	19.7	27.0	7.6	48.9	25.5	21.0	31.5
October	34.7	5.5	21.1	49.9	8.5	0.4	6.5	11.1	13.0	31.5	17.1
November	16.0	22.7	2.6	6.5	5.0	10.1	6.5	2.4	4.5	2.0	11.7
December	22.0	16.6	5.1	11.0	14.1	20.8	8.5	6.7	3.5	26.0	13.7
Total	375.5	446.4	312.9	280.0	401.4	344.6	159.7	299.3	233.8	409.8	336.4

Table 3-2. Monthly and annual growing degree-days[1] and cold stress-days[1] in 1995-2004 at Saskatoon, Saskatchewan. Data are from Environment Canada [http://www.climate.weatheroffice.ec.gc.ca/advanceSearch/searchHistoricData Stations_e.html]. Last updated: 31 January 2005.

Months	Years									
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Growing degree-days[1]										
January	0	0	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0	0	0
March	33	0	0	22	22	44	0	0	33	0
April	65	121	110	215	196	156	161	72	197	155
May	319	259	314	401	330	323	385	280	375	265
June	521	475	495	435	437	428	465	519	478	394
July	523	546	566	579	506	578	609	621	586	535
August	481	559	552	620	552	521	614	515	648	453
September	346	306	405	397	310	350	416	343	343	322
October	166	109	138	160	143	150	96	55	217	118
November	0	0	17	8	40	10	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0
Sum	2,455	2,376	2,598	2,836	2,535	2,560	2,745	2,403	2,879	2,242
Cold stress-days[1]										
January	454	762	652	570	538	537	277	455	515	606
February	363	402	277	157	277	324	493	243	451	288
March	177	357	320	248	158	106	117	422	308	161
April	0	25	55	0	0	0	1	74	0	0
May	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0	0
September	0	0	0	0	0	0	0	0	0	0
October	23	42	0	0	0	0	35	76	16	29
November	301	382	137	138	60	194	87	144	292	79
December	516	602	177	407	236	600	414	273	271	377
Sum	1,835	2,572	1,617	1,519	1,270	1,760	1,425	1,686	1,853	1,540

[1]Growing degree-days and cold stress-days calculated with a base temperature of 0°C.

microtopography and water availability (Baines, 1973). A mesic grassland community type, dominated by *Festuca hallii*, occurs on clay-textured soils in lower topographic positions while a *Hesperostipa-Elymus* (*Stipa-Agropyron*) community occurs in more xeric sites with slightly elevated topography (Baines, 1973).

Portions of Kernen Prairie were grazed or hayed periodically until 1967 (Pylypec, 1986). In 1992 and 1993, areas about 10-ha in size were burned in early spring with headfires (Wright and Bailey, 1982; Figure 3-1). Experimental plots were established 5 years later in 1997 and 1998 in the areas burned in 1992 and 1993, respectively. Plots were set up in 2 nearby areas of unburned vegetation. Unburned areas of Kernen Prairie have not been burned for at least 80 years (Grilz and Romo, 1995). Sites for experimental plots were selected based on the degree of homogeneity in grassland vegetation, the lack of non-native plant species and the scarcity of shrubs.

Fifty-two, 35 by 35 m experimental plots were sampled within Kernen Prairie (Figure 3-1). North and Middle blocks were each composed of 12 plots and located primarily on Bradwell sandy loam soil while the East and West blocks, located on Sutherland clay soil, each contained 14 plots (Souster, 1979). East and Middle blocks were located in areas not previously burned and North and West blocks were in areas burned 5 years earlier. Each plot within a block was randomly assigned to a date of burning (Figure 3-1; Table 3-3). Plots were burned in headfires (Wright and Bailey, 1982) in all months of the year except January and February in 2 consecutive years (Table 3-3). An unburned control plot was included in all 4 blocks (Figure 3-1).

Burns were conducted between 10:00 and 21:00 hours in the North and Middle plots from November 1997 to August 1998 and in the East and West plots from September 1998 to September 1999 (Figure 3-1; Table 3-3). At the time of burning, fuel loads ranged from 577 g m^{-2} to 820 g m^{-2} in plots not previously burned (Table 3-3). When burned 5 years earlier, fuel loads varied from 301 g m^{-2} to 609 g m^{-2}. Fuel water averaged 42%, varying from 15% in 26 April 1999 to 84% in 20 July 1999. Temperature and relative humidity ranged from –4^{o}C to 32^{o}C and 17% to 70%, respectively. Wind speed varied from 5 km h^{-1} to 25 km h^{-1} at the time of burning.

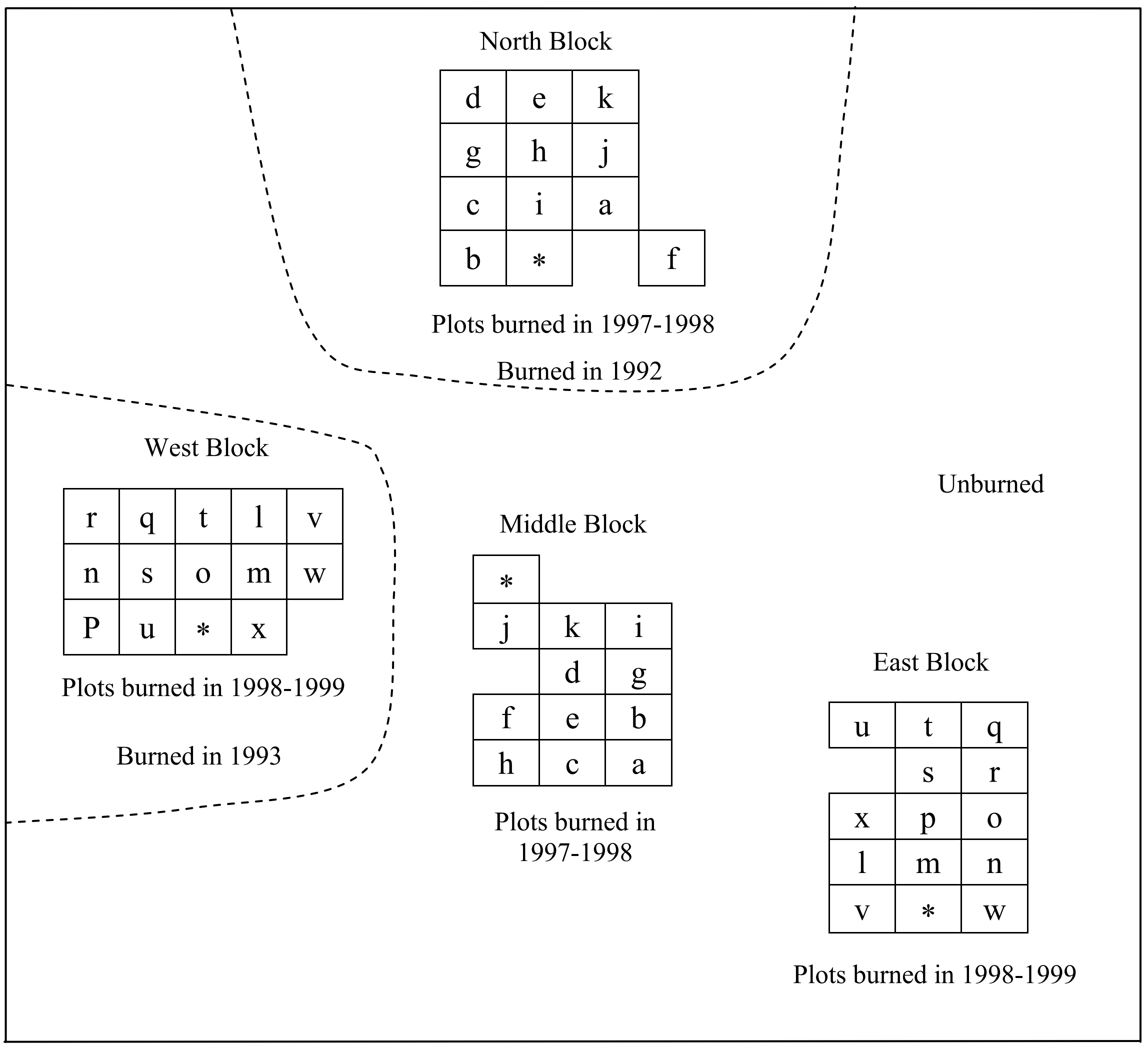

Figure 3-1. Layout of experimental plots burned at different times of the year in sites not previously burned and sites burned 5 years earlier at Kernen Prairie, near Saskatoon, Saskatchewan. The dashed-line indicates the location of burns in 1992 and 1993. Lowercase letters represent dates of burning as given in Table 3-3. An asterisk (*) represents an unburned control plot. This schematic is not drawn to scale.

Table 3-3. Dates of burning, fuel loads, fuel water, and environmental conditions at the time of burning at Kernen Prairie, near Saskatoon, Saskatchewan. Dates of burning are coded to correspond to Figure 3-1.

Code	Date of burning	Fuel load ($g\ m^{-2}$)	Fuel water (% dry weight)	Temperature (^oC)	Relative humidity (%)	Wind speed ($km\ h^{-1}$)	Time of day
Not previously burned							
a	15 Nov. 1997	710	52	0	45	20-25	15:00
b	17 Dec. 1997	663	19	5	58	27	15:00
c	25 Mar. 1998	705	--[1]	8	67	16	15:00
d	16 Apr. 1998	593	20	12	21	7	14:00
e	1 May 1998	455	17	15	17	11	19:00
f	13 May 1998	600	22	12	24	4	17:00
g	25 May 1998	670	28	28	22	17	20:00
h	5 Jun. 1998	612	35	13	40	8	14:00
i	27 Jun. 1998	791	37	19	48	15	17:00
j	14 Jul. 1998	820	53	19	33	11-22	14:00
k	25 Aug. 1998	803	29	19	50	13	10:00
l	11 Sep. 1998	620	30	25	22	9	14:00
m	20 Oct. 1998	555	60	14	58	10	15:00
n	7 Nov. 1998	649	27	-4	61	10	13:00
o	29 Mar. 1999	677	45	8	23	6-15	14:00
p	26 Apr. 1999	588	38	12	60	12-18	18:30
q	17 May 1999	549	48	10	70	11	13:00
r	27 May 1999	635	38	23	21	13	20:00
s	7 Jun. 1999	501	57	18	39	20	15:00
t	20 Jun. 1999	581	57	24	46	6	14:00
u	6 Jul. 1999	567	61	18	56	15	19:00
v	20 Jul. 1999	577	62	26	63	17	13:00
w	30 Aug. 1999	697	31	29	52	7	14:00
x	27 Sep. 1999	713	23	12	41	6	16:00
Burned 5 years earlier							
a	15 Nov. 1997	430	63	0	45	20-25	17:00
b	17 Dec. 1997	208	25	5	58	27	15:00
c	25 Mar. 1998	345	71	7	69	21	14:00
d	16 Apr. 1998	301	16	12	20	11	14:00
e	1 May 1998	277	26	15	17	11	19:00
f	13 May 1998	344	31	12	27	12	15:00
g	25 May 1998	395	43	28	22	17	19:00
h	5 Jun. 1998	305	45	13	40	8	14:00
i	27 Jun. 1998	344	42	19	48	15	17:00
j	14 Jul. 1998	568	57	19	33	11-22	14:00
k	25 Aug. 1998	464	44	19	50	13	10:00
l	14 Sep. 1998	544	28	18	18	3	18:00
m	20 Oct. 1998	361	53	14	55	16	16:00
n	7 Nov. 1998	355	27	-4	61	10	12:00
o	29 Mar. 1999	235	43	8	23	6-15	14:00
p	26 Apr. 1999	328	15	17	41	20	10:00
q	17 May 1999	460	48	13	61	7-15	15:00
r	27 May 1999	609	31	23	27	7	21:00
s	7 Jun. 1999	336	75	19	36	9	16:00
t	20 Jun. 1999	608	53	27	36	5	15:00
u	6 Jul. 1999	349	83	16	69	9	20:00
v	20 Jul. 1999	420	84	27	57	13	15:00
w	30 Aug. 1999	363	31	32	36	6	16:00
x	27 Sep. 1999	336	29	12	46	10	15:00

[1]Missing data.

3.2 Data collection

Sampling of plots was completed by Judy Haraldson and Dr. Jim Romo from 1997-2002, while the author completed sampling in 2003-2004. In total, observations were repeated for 6 years in each plot. Canopy cover of all plant species, litter cover, and cover of bare soil were determined in each plot in October the first year after burning and then from late-June to late-July the next 5 growing seasons after burning. Five, 20 by 50 cm quadrats were randomly located on 4, 30 m transects in each plot for a total of 20 quadrats (2.0 m^2) per plot. Canopy cover of each species, litter cover, and bare ground were estimated in each quadrat using the Daubenmire (1959) cover classes: class 1= 0 to 5% cover, class 2=5 to 25% cover, class 3= 25 to 50% cover, class 4= 50 to 75% cover, class 5=75 to 95% cover, and class 6= 95 to 100% cover. Daubenmire cover class values were converted to the midpoint values (2.5, 15, 37.5, 62.5, 85, and 97.5, respectively) for analysis. The average canopy cover of all plant species and cover of litter and bare soil collected among 20 quadrats per plot during the course of the study are given in Appendix A.

Soil water in the 0-15 cm layer was determined gravimetrically in late-July to early August. Soil water was not collected the first year after burning. Three soil cores were taken from random locations in each plot using a 2-cm diameter soil corer. Soil cores were weighed, oven-dried at 80^oC for 48 hours, and reweighed.

With the exception of the first year after burning, total standing crop (litter plus current year standing crop and standing dead) was harvested at the end of each growing season in late August to early-September. Five, 50 by 50 cm quadrats were randomly located in each plot; plants were clipped at ground level and oven-dried at 80^oC for 48 hours. Respectively, average soil water and total standing crop among 3 and 5 samplesper plot over 5 years of observation are given in Appendix B.

Meterological variables including daily, monthly, and annual precipitation and mean temperature for Saskatoon, Saskatchewan during 1995 to 2004 were obtained from Environment Canada (2005). Cumulative precipitation, cumulative growing degree-days, and cumulative cold stress-days were calculated over the 12 and 24 months before and after burning and 12 and 24 months before sampling. Cumulative growing degree-days were determined to be the cumulative °C above 0°C after 5 consecutive days of above 0°C temperatures in spring. Growing degree-days were not counted after 5 consecutive days of below 0°C temperatures in the autumn. Cumulative cold stress-days were calculated as cumulative °C below 0°C and tabulated after 5 consecutive days of below 0°C temperatures in autumn. Cold stress-days ceased being tabulated after 5 consecutive days with temperatures above 0°C in the spring.

3.3 Data analysis

3.3.1 Univariate analysis of plant community characteristics

Plant community characteristics measured in this study included litter cover, cover of bare soil, soil water, total standing crop, canopy cover of the dominant grasses including *E. lanceolatus*, *F. hallii*, and *H. curtiseta*, canopy cover of plant species excluding the dominant grasses, canopy cover of annual and perennial forbs, canopy and the Shannon-Weiner diversity index. Litter was determined as the percentage of fallen, detached, and standing dead plant material from previous years (Pylypec and Romo, 2003). Species evenness describes how abundance is distributed among species, approaching 1 when all species have equal abundance and declining toward 0 when few species dominate (McCune and Grace, 2002). The Shannon-Weiner diversity index combines richness (number of species per unit area) and evenness into a single value (McCune and Grace, 2002).

Variance (s^2) was used as an estimate of the spatial heterogeneity of plant community characteristics within each plot (Wiens, 2000). Therefore, $s^2=0$ when plant community characteristics are uniformly distributed in space. Heterogeneity in a plant community characteristic is indicated when $s^2>0$ with heterogeneity and s^2 increasing together (Wiens, 2000). The s^2 in litter cover, bare soil, selected plant species, and plant groups was calculated among the 20, 20 by 50 cm quadrats per plot. The s^2 in soil water and total standing crop was based on the 3 and 5 randomly located samples within each plot, respectively.

From the 52 experimental plots sampled in each year of the study (Figure 3-1), 14 dates of burning and 4 control plots were selected to represent months of burning and unburned controls. Months of burning were November (15 November 1997 and 7 November 1998), March (25 March 1998 and 29 March 1999), April (16 April 1998 and 26 April 1999), May (25 May 1998 and 27 May 1999), June (27 June 1998 and 20 June 1999), July (14 July 1998 and 20 July 1999), and August (25 August 1998 and 30 August 1999) (Table 3-4).

Plant community characteristics and the s^2 in plant community characteristics were analyzed using analysis of variance (ANOVA). Analysis of variance was based on a 3-factor split-split-plot in a randomized complete block design with 2 replicates (Peterson, 1985). Pre-burn history was the whole plot factor. The 7 months of burning and unburned controls were treated as subplots. The number of years after burning was the sub-sub-plot factor. The split-split-plot ANOVA was appropriate to analyze multiple factors and multiple levels within factors (Gomez and Gomez, 1976) and accommodated experimental units with large spatial requirements (Mead *et al*., 1993). Analysis of variance tables for all dependent variables are given in Appendix C.

Where appropriate, pre-burn histories were compared, months of burning were compared to unburned controls, and years after burning were compared to the response in the first year after burning using the Fisher-protected Least Significant Difference (LSD; Bowley, 1999). Analysis of variance and LSD were performed using the PROC GLM procedure in SAS V8 (SAS Institute, Cary, NC). In all cases statistical significance was assumed at $P \leq 0.05$.

3.3.2 Multivariate analysis of plant community composition

Several types of multivariate analyses are available to analyze the correlation between plant community composition and "environmental" or explanantory data (Gauch, 1982; ter Braak, 1987; McCune and Grace, 2002; ter Braak and Smilauer, 2002). These analyses are interpreted with an ordination diagram, a scatterplot in which sites or species are represented by points and distances between points indicate dissimilarity (McCune and Grace, 2002). Selection of an appropriate method of analysis depends on the specific research question and nature of the community and environmental data (McCune and Grace, 2002).

Research questions focused primarily on explaining total plant community variation with secondary interest on environmental factors controlling that variation are advised to use an indirect gradient analysis, such as correspondence analysis (CA) or principle components analysis (PCA) (ter Braak, 1986). Researchers interested only in plant community variation explained by a set of measured environmental variables use a direct gradient analysis technique, including canonical correspondence analysis (CCA) and redundancy analysis (RDA; McCune and Grace, 2002). Direct gradient analysis has the advantage of testing the significance of environmental variables in relation to plant community composition data (ter Braak, 1986).

Species respond either in a linear or unimodal fashion along an environmental gradient (ter Braak, 1987) and dictate the model of analysis, scaling, and interpretation of ordination diagrams (McCune and Grace, 2002). Species' responses less than 2 to 3 standard deviations along a gradient indicate a linear response, and linear methods of multivariate analyses including PCA and RDA are recommended (ter Braak, 1987). Standard deviations greater than 3 or 4 suggest a unimodal species response where CA and CCA are appropriate (ter Braak, 1987). Community data with many zero values (common in plant community analysis) are best analyzed with a unimodal technique (ter Braak and Smilauer, 2002).

Analysis of ordination diagrams requires understanding of several scaling and interpretation techniques. Selection of appropriate scaling and interpretation methods is determined primarily by species responses along environmental gradients. For linear species responses, biplot (called centered with unit variance by McCune and Grace [2002]) scaling is recommended while unimodal species responses are best scaled using Hill's technique (ter Braak and Smilauer, 2002). With biplot scaling, ordination diagrams may be interpreted in precise mathematically terms, based on the positions of species or sample points (McCune and Grace, 2002). Diagrams using Hill's scaling, known as joint plots, can only be interpreted in a relative way (ter Braak, 1987; McCune and Grace, 2002). Ordination diagrams are most often interpreted in a relative fashion, and this is possible using biplots or joint plots (McCune and Grace, 2002).

In this study, CCA was used to determine if plant community composition in the 52 plots sampled the first 6 years after burning at different times of the year in sites with different burning histories could be explained by a set of measured variables. Species responses along environmental gradients were calculated using detrended canonical correspondence analysis (DCCA; ter Braak and Smilauer, 2002). Variation in the plant community unrelated to the set of chosen environmental variables used in CCA was evaluated with CA (Leeson *et al.*, 2000). Multivariate analyses were performed using CANOCO for Windows version 4.52 (ter Braak and Smilauer, 2003).

Canonical correspondence analysis (CCA) was used to determine the relationship between measured variables and plant community composition the first year after burning. Canonical correspondence analysis (CCA) compared a matrix of plant community data based on canopy cover (%) of individual species with variables of the "environmental" or explanatory matrix (McCune and Grace, 2002). There were 52 plots sampled the first year after burning. Four plots sampled the first year after burning were removed from the analysis because plants had not regrown since being burned and it was not possible to accurately identify plants. The plant species matrix consisted of the canopy cover (%) of 46 species that occurred in at least 5% of plots.

The environmental matrix was composed of variables including date of burning (converted to Julian days), fuel load, fuel water, temperature, relative humidity, wind speed, and time of day (Table 3-3), cumulative precipitation, cumulative growing degree-days, and cumulative cold-stress-days over the 12 and 24 months before burning and 12 months after burning (Table 3-1 and 3-2), and months since burning in the first year after burning (Appendix D). Pre-burn history was considered a nominal variable and separated into dummy variables for plots not previously burned and plots burned 5 years earlier.

Variables of the environmental matrix were evaluated using forward selection, a step-wise selection procedure in CANOCO that utilizes a Monte Carlo permutation test to assess the significance of each variable as it is included in the regression model. Samples are randomly shuffled to detect patterns between plant community composition and variables of the environmental matrix (ter Braak and Smilauer, 2002). The Monte Carlo test was used with 9999 permutations under a reduced model. A reduced model better maintains the Type I error in small data sets and yields the exact Monte Carlo significance level in the absence of covariables (ter Braak and Smilauer, 2002). Variables were considered to contribute significantly to the model at $P \leq 0.01$ (Qian *et al.*, 2003). Non-significant variables were excluded from further analyses.

Canonical correspondence analysis (CCA) was then used to determine if measued environmental variables and plant community composition were correlated over all 6 years after burning. Forty-eight plots were sampled in the first year after burning and 52 plots were sampled in each of the next 5 years after burning for a total of 308 plots. The plant species matrix was composed of the canopy cover (%) of 53 species that occurred in at least 5% of plots.

Variables in the environmental matrix were calculated from sampling dates the first 6 years after burning and included years since burning, cover of litter and bare soil, soil water, and cumulative precipitation, cumulative growing degree-days, and cumulative cold stress-days over the 12 and 24 months before sampling. Pre-burn history was treated as a nominal variable. Variables were evaluated for significance using the same procedure as the first CCA.

Additional analyses were conducted using CCA to determine the influence of other environmental variables that affected plant community composition at Kernen Prairie. Exploratory analyses of ordination diagrams involved segregated diagrams based on block, number of years after burning, and dates of burning to identify other sources of variation affecting plant community composition. Canonical correspondence analyses (CCAs) were undertaken on within year (second year after burning) and within site (North block) data using the same criteria for removal of rare species. The environmental matrix of the second year plant community composition data was composed of the same variables as the initial CCA of the year 1 data described above. The variables of the environmental matrix used to explain plant community composition of the North plots were the same ones used to explain composition of the plant community at Kernen Prairie over all 6 years after burning. Additional analyses and ordination diagrams are provided in Appendix E.

Finally, plant community composition in burn plots was compared to controls in each year after burning using a similarity index (Armesto *et al.*, 1991) to determine the number of years required for plant community composition to become similar (≥ 80%) to unburned controls. Similarity in plant community composition was determined using the Bray-Curtis ordination (Bray and Curtis, 1957) procedure of PC-ORD V 4.10 for Windows (McCune and Mefford, 1999).

4.0 Results

4.1 Overview of the plant communities at Kernen Prairie

In control plots not previously burned, canopy cover of the vegetation classes was greatest in years 1 or 2, and least in the fourth year of observation (Table 4-1). *Festuca hallii* was the dominant plant with at least 2.5-times the cover of all other species. Other dominant plants included grasses, forbs, and shrubs. *Symphoricarpos occidentalis*, *Hesperostipa curtiseta*, *Rosa arkansana*, *Symphyotrichum ericoides* (L.) Nesom, and *Artemisia ludoviciana* Nutt. each contributed ≥5% cover in at least 1 growing season during the 6 years of observation. Species richness in 4 m^2 ranged from 38 in year 2 to 28 species in the fifth year. Total standing crop averaged 501 g m^{-2}, varying from 549 g m^{-2} in the second year to 355 g m^{-2} in year 5.

In control plots burned 5 years earlier, canopy cover of all plants, graminoids, and forbs followed a trend similar to plant communities not previously burned (Table 4-1). Shrub cover was greatest in the second and third year and declined to a minimum in year 5. In control plots burned 5 years earlier, the sward was dominated by graminoids, with forbs and shrubs no longer major components of the plant community. *Carex obtusata* Lilj. had the greatest average cover over 6 years of observation, although cover of *F. hallii* exceeded *C. obtusata* cover by more than 2-fold in the third year. Other plants with ≥5% cover in at least 1 year included *C. pensylvanica* Lam., *H. curtiseta*, *Elymus lanceolatus*, *S. occidentalis*, and *E. trachycaulus* (Link) Gould ex Shinners. Species richness in 4 m^2 averaged 28 species and varied little over the course of the study. Total standing crop ranged from 443 g m^{-2} in year 2 to 361 g m^{-2} in the sixth year.

Table 4-1. Canopy cover (%) of vegetation classes and dominant plant species[1], species richness in 4 m^2, and total standing crop (g m^{-2}) in control plots not previously burned and control plots burned 5 years earlier the first 6 years after burning at Kernen Prairie, near Saskatoon, Saskatchewan.

Category	Time since burning (Years)					
	1	2	3	4	5	6
------Not previously burned------						
Canopy cover:						
All plants	80	80	78	36	37	58
Graminiods	55	42	49	21	22	37
Forbs	14	24	20	8	10	11
Shrubs	11	14	9	7	5	9
Festuca hallii	42	25	31	12	10	27
Symphoricarpos occidentalis	8	8	6	4	4	7
Hesperostipa curtiseta	3	9	7	4	4	6
Rosa arkansana	3	6	2	3	1	2
Symphyotrichum ericoides	5	4	2	1	2	2
Artemisia ludoviciana	1	2	5	1	1	1
[2]Species richness in 4 m^2	33	38	36	31	28	35
Total standing crop (g m^{-2})	--[3]	549	527	615	355	457
------Burned 5 years earlier------						
Canopy cover:						
All plants	96	87	55	39	44	73
Graminiods	86	68	40	33	38	63
Forbs	9	13	10	4	4	5
Shrubs	2	6	6	2	3	4
Carex obtusata	28	14	6	8	10	18
Festuca hallii	22	16	13	6	3	4
Carex pensylvanica	11	10	7	7	8	12
Hesperostipa curtiseta	11	10	7	6	5	11
Elymus lanceolatus	1	8	2	1	5	12
Symphoricarpos occidentalis	2	4	5	2	1	3
Elymus trachycaulus	7	2	2	2	2	<1
Species richness in 4 m^2	29	26	29	28	28	29
Total standing crop (g m^{-2})	--[3]	398	443	410	409	361

[1]Dominant plant species have at least 5% canopy cover in at least 1 year of observation.
[2]Species richness is number of species in 20, 20 by 50 cm quadrats (2 m^2) in each replicate for a total of 4 m^2
[3]Missing data.

4.2 Interpretation of analysis of variance (ANOVA)

Plant community characteristics and the variance of plant community characteristics were analysed with a split-split plot ANOVA. Results of the ANOVA are presented from significant effects of the highest order interactions to simplest interactions to main effects. When interactions were significant, main effects were no longer considered because it is only appropriate to discuss interacting effects (Petersen, 1985). The significant main effects were presented only when that factor did not interact signficantly with another factor. No 3-way interactions of pre-burn history by month of burning by years since burning were significant (Appendix C).

4.3 Effects of burning on plant community characteristics

4.3.1 Plant community characteristics responding to a month of burning by years since burning interaction

Cover of litter and bare soil responded to a month of burning by years since burning interaction ($P<0.01$ and $P<0.01$, respectively; Figures 4-1 and 4-2). With the exception of burning in March, burning reduced litter cover and increased cover of bare soil compared to control in the first year after burning. Burning in August had the greatest impact on cover of litter and bare soil, reducing litter cover by 73% and causing a 20-fold increase in bare soil compared to control the first year after burning. Litter cover was reduced for 2 years following burning in April and 3 years after burning in November, May, June, or July (Figure 4-1). Bare soil was greater than the control for 2 years after burning in November, April, or May and 3 growing seasons following burning in June or July (Figure 4-2). Burning in August also had the greatest long-term impact, reducing litter cover for 5 years while cover of bare soil was greater than the control for 4 years following burning.

Month of burning	Time since burning (Years)					
	1	2	3	4	5	6
Nov.	b[1]	b	b	a	a	a
Mar.	a	a	a	a	a	a
Apr.	b	b	a	a	a	a
May	b	b	b	a	a	a
Jun.	b	b	b	a	a	a
Jul.	b	b	b	a	a	a
Aug.	b	b	b	b	b	a

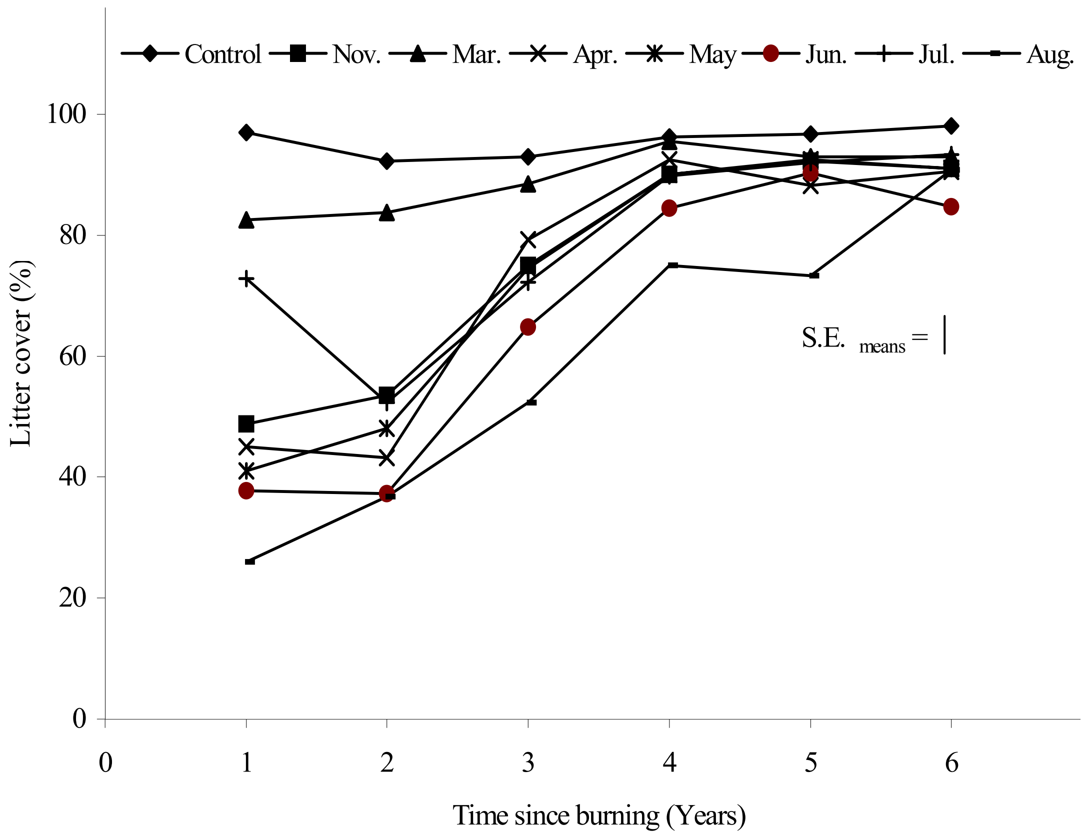

Figure 4-1. Changes in litter cover (%) the first 6 years after burning in different months at Kernen Prairie, near Saskatoon, Saskatchewan. S.E. $_{means}$ is the standard error determined from the interaction of month of burning by years since burning.

[1]An ‘a’ within years indicates the mean was similar (P≤0.05) to the control while ‘b’ indicates the mean was different (P≤0.05) from the control based on LSD.

Month of burning	Time since burning (Years) 1	2	3	4	5	6
Nov.	b[1]	b	a	a	a	a
Mar.	a	a	a	a	a	a
Apr.	b	b	a	a	a	a
May	b	b	a	a	a	a
Jun.	b	b	b	a	a	a
Jul.	b	b	b	a	a	a
Aug.	b	b	b	b	a	a

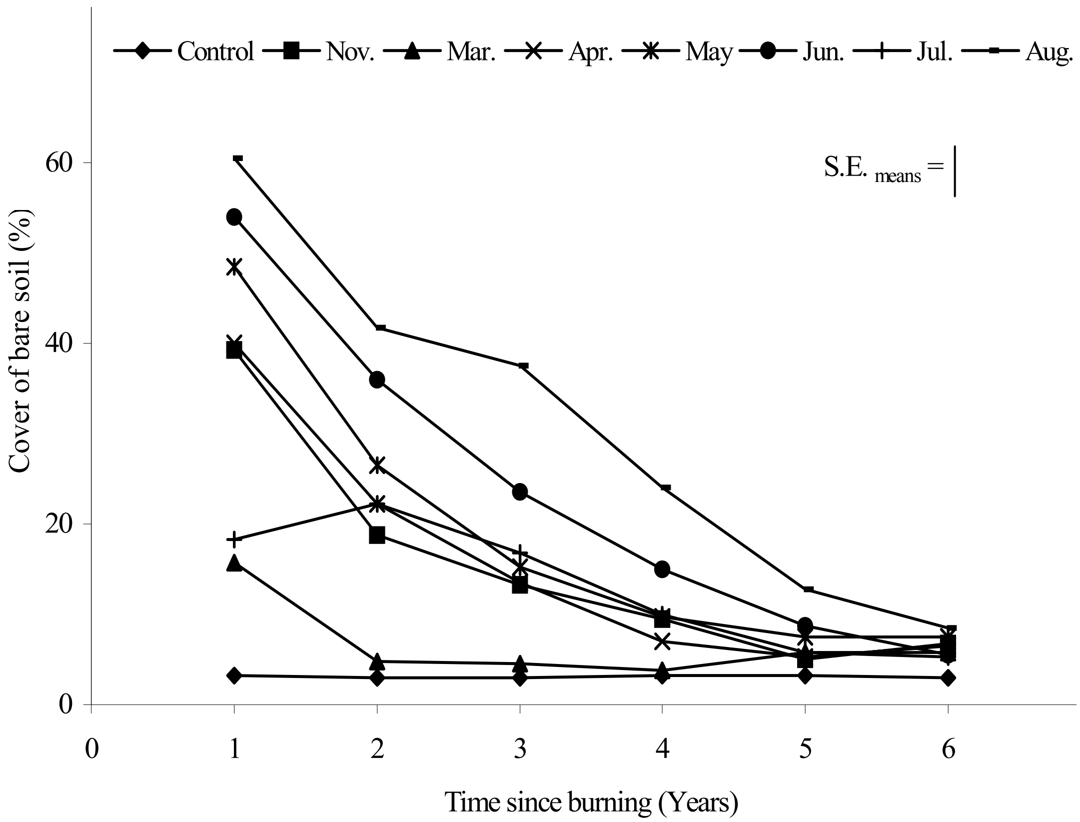

Figure 4-2. Changes in cover (%) of bare soil the first 6 years after burning in different months at Kernen Prairie, near Saskatoon, Saskatchewan. S.E. $_{means}$ is the standard error determined from the interaction of month of burning by years since burning.

[1]An 'a' within years indicates the mean was similar (P≤0.05) to the control while 'b' indicates the mean was different (P≤0.05) from the control based on LSD.

Canopy cover of *Festuca hallii* responded to a month of burning by years since burning interaction (P=0.01; Figure 4-3). With the exception of burning in March, cover decreased in the first year after burning, ranging from 56% less than control after burning in April to 84% less than control after burning in August. Cover was reduced for 1 growing season after burning in November, April, May, June, or July and 3 years after burning in August. Compared to control cover was reduced in the sixth year after burning in November, April, or June. Burning in March increased cover by 1.4-times greater than control in year 2. *Festuca hallii* cover varied considerably in the unburned control over the 6 years with cover reaching a minimum of 6% in year 5, 81% less than the first year.

Burning affected the cover of all other plant species excluding the dominant grasses *E. lanceolatus*, *F. hallii*, and *H. curtiseta* as evidenced by a month of burning by time since burning interaction (P=0.03; Figure 4-4). Burning in July or August initially reduced cover of other plant species, causing a 38% and 86% reduction compared to control in year 1, respectively. Cover of other plant species recovered quickly and was not different from control by the second year after burning. Cover of other plant species also varied in the unburned control the first 6 years after burning, reaching a minimum in year 4, 54% less than the first year after burning.

Month of burning	Time since burning (Years) 1	2	3	4	5	6
Nov.	b[1]	a	a	a	a	b
Mar.	a	b	a	a	a	a
Apr.	b	a	a	a	a	b
May	b	a	a	a	a	a
Jun.	b	a	a	a	a	b
Jul.	b	a	a	a	a	a
Aug.	b	b	b	a	a	a

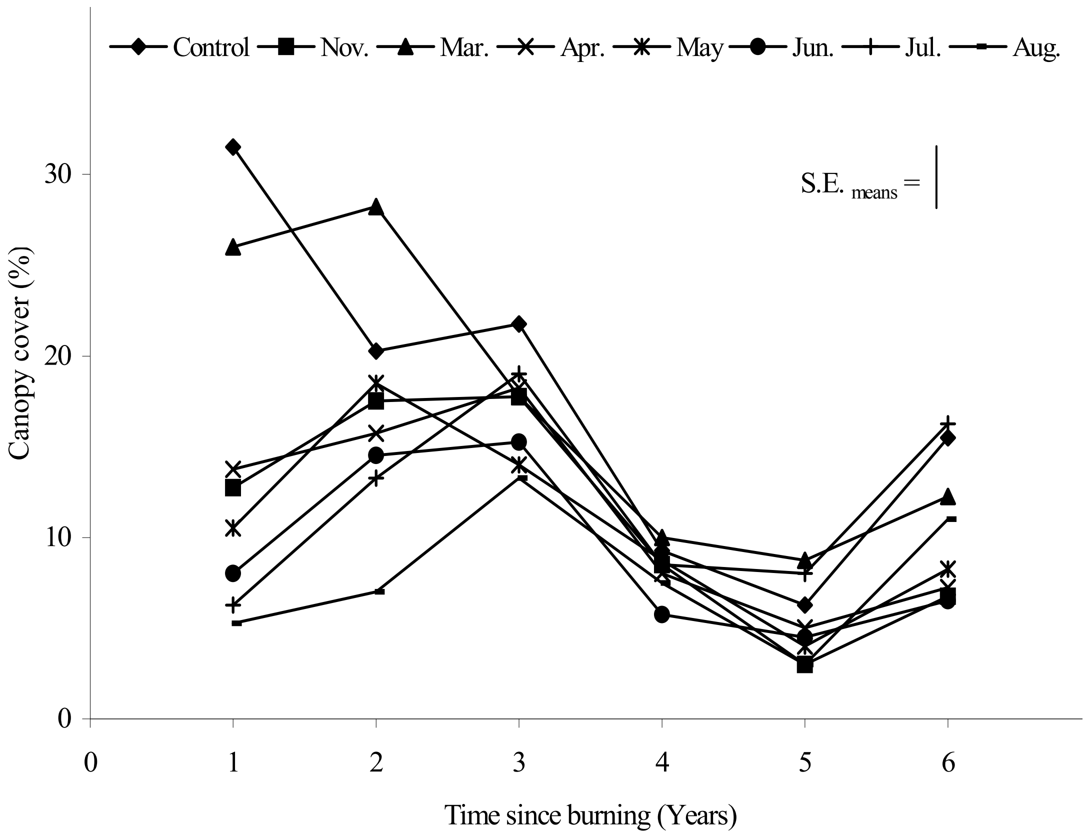

Figure 4-3. Changes in the canopy cover (%) of *Festuca hallii* the first 6 years after burning in different months at Kernen Prairie, near Saskatoon, Saskatchewan. S.E. $_{means}$ is the standard error determined from the interaction of month of burning by years since burning.

[1]An 'a' within years indicates the mean was similar (P≤0.05) to the control while 'b' indicates the mean was different (P≤0.05) from the control based on LSD.

Month of burning	Time since burning (Years) 1	2	3	4	5	6
Nov.	a[1]	a	a	a	a	a
Mar.	a	a	a	a	a	a
Apr.	a	a	a	a	a	a
May	a	a	a	a	a	a
Jun.	a	a	a	a	a	a
Jul.	b	a	a	a	a	a
Aug.	b	a	a	a	a	a

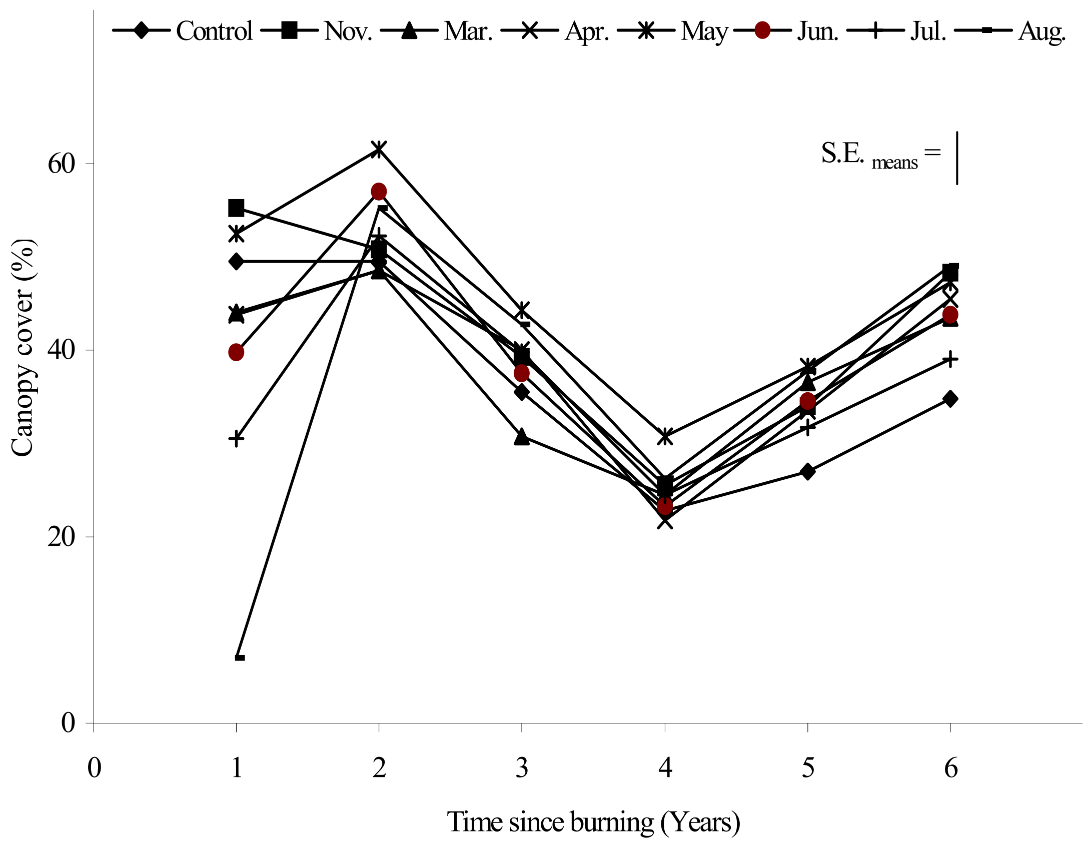

Figure 4-4. Changes in the canopy cover (%) of other plants species excluding *Elymus lanceolatus*, *Festuca hallii*, and *Hesperostipa curtiseta* the first 6 years after burning in different months at Kernen Prairie, near Saskatoon, Saskatchewan. S.E. $_{means}$ is the standard error determined from the interaction of month of burning by years since burning.

[1]An ‘a’ within years indicates the mean was similar (P≤0.05) to the control while ‘b’ indicates the mean was different (P≤0.05) from the control based on LSD.

4.3.2 Plant community characteristics responding to a month of burning by pre-burn history interaction

Soil water and total standing crop responded to a month of burning by pre-burn history interaction (P=0.02 and P=0.04, respectively). Soil water was greater when not previously burned compared to burning 5 years earlier (Figure 4-5). In plant communities not previously burned, burning in different months of the year reduced soil water, ranging from 14% less than control after burning in March or July to 29% less than control after burning in November. When burned 5 years earlier, soil water in March or April burns was not significantly different from control, but soil water was reduced by burning in all other months, ranging from 13% less than control after burning in May to 20% less than control after burning in July.

Regardless of pre-burn history, burning reduced total standing crop (Figure 4-6). Burning in March reduced total standing crop the least, declining 25% compared to the control when not previously burned and 36% when burned 5 years earlier. Except for controls and March or July burns, total standing crop was not different in plant communities not previously burned compared to those burned burned 5 years earlier.

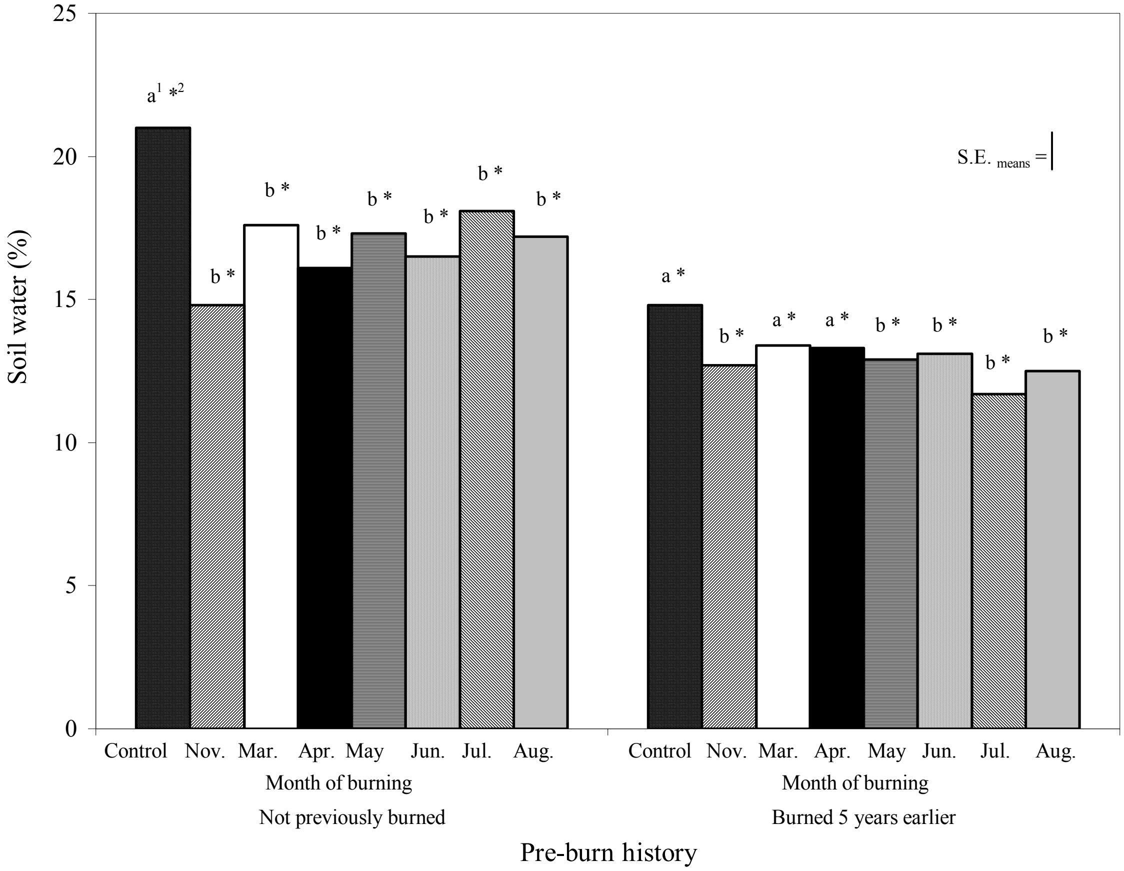

Figure 4-5. Effect of different months of burning on soil water (%) in plots not previously burned and plots burned 5 years earlier at Kernen Prairie, near Saskatoon, Saskatchewan. S.E. $_{means}$ is the standard error determined from the interaction of month of burning by pre-burn history.

[1]Means with different lowercase letters above bars indicate differences ($P \leq 0.05$) between control and months of burning within each pre-burn history based on LSD.

[2]Means with an asterisk (*) above bars indicate differences ($P \leq 0.05$) within the same months of burning between pre-burn histories based on LSD.

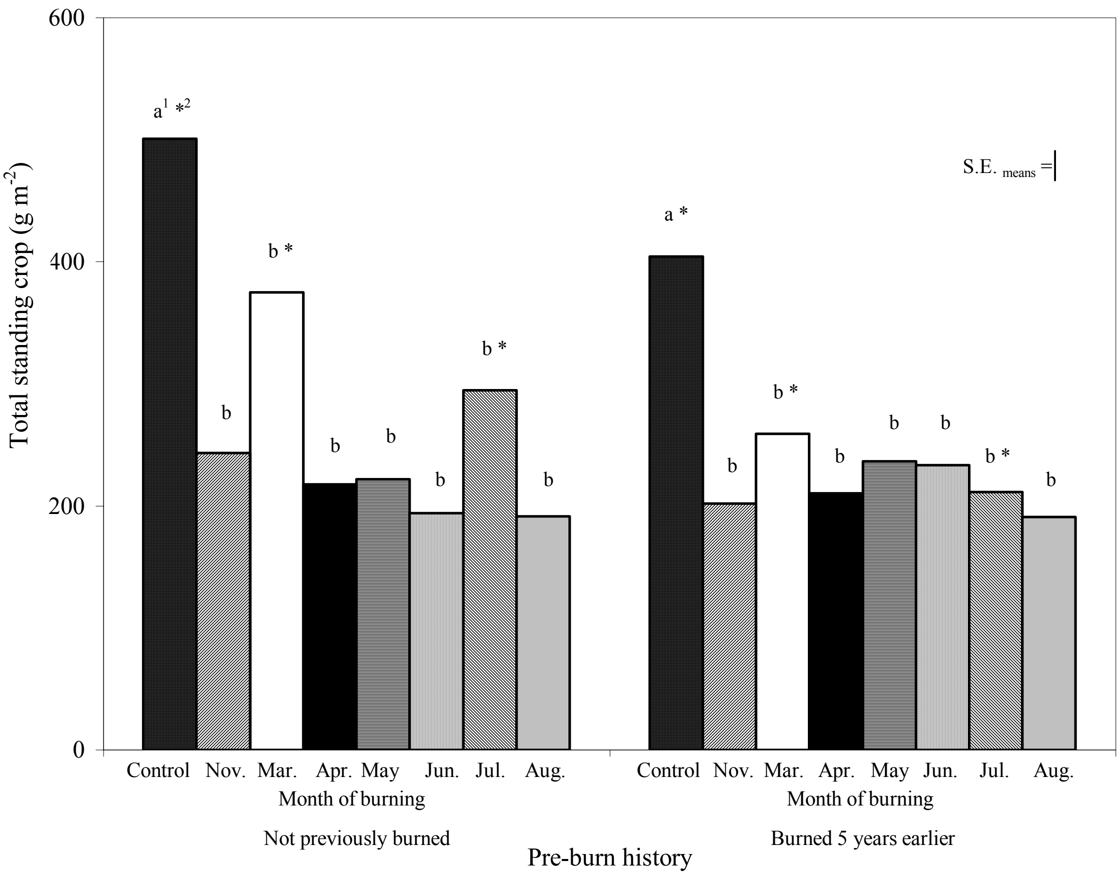

Figure 4-6. Effect of different months of burning on total standing crop (g m^{-2}) in plots not previously burned and plots burned 5 years earlier at Kernen Prairie, near Saskatoon, Saskatchewan. S.E. $_{means}$ is the standard error determined from the interaction of month of burning by pre-burn history.

[1]Means with different lowercase letters above bars indicate differences ($P \leq 0.05$) between control and months of burning within each pre-burn history based on LSD.

[2]Means with an asterisk (*) above bars indicate differences ($P \leq 0.05$) within the same months of burning between pre-burn histories based on LSD.

4.3.3 Plant community characteristics responding to a pre-burn history by years since burning interaction

Canopy cover of *Elymus lanceolatus* responded to a pre-burn history by years since burning interaction (P<0.01; Figure 4-7). Canopy cover of *E. lanceolatus* increased in the second, fifth, and sixth years after burning in plant communities burned 5 years earlier compared to plant communities not previously burned.

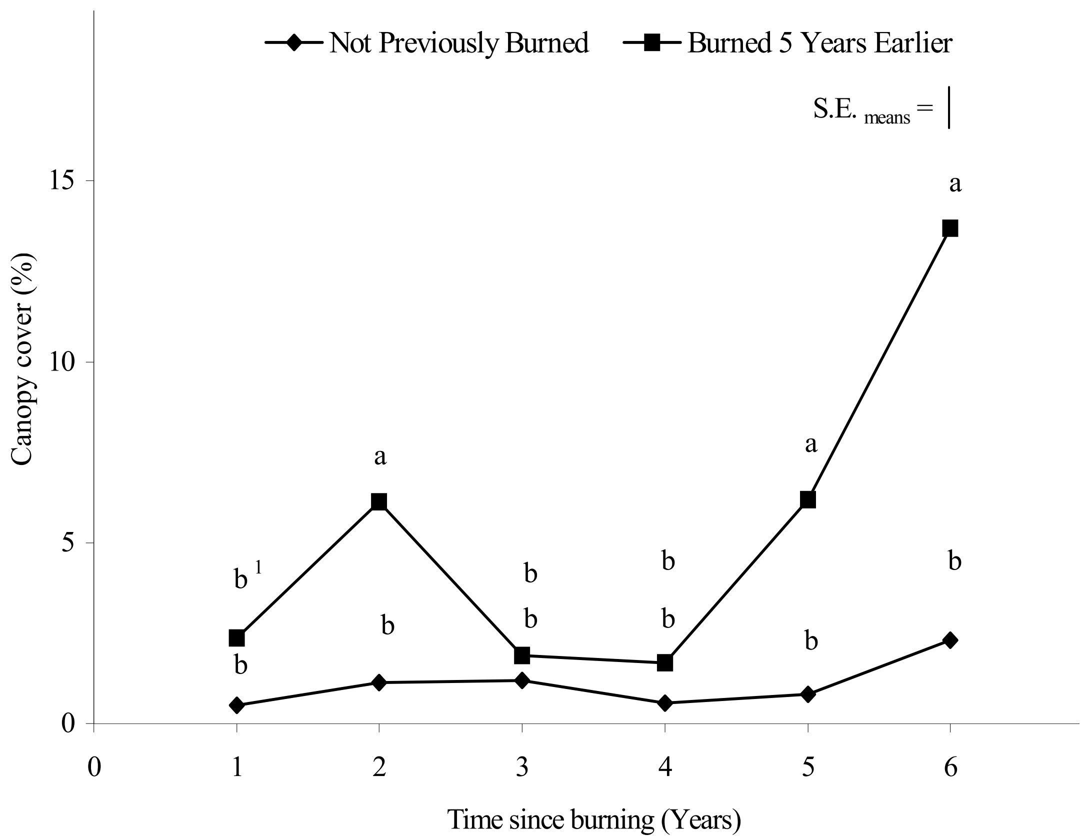

Figure 4-7. Changes in the canopy cover (%) of *Elymus lanceolatus* the first 6 years after burning in plots not previously burned and plots burned 5 years at Kernen Prairie, near Saskatoon, Saskatchewan. S.E. $_{means}$ is the standard error determined from the interaction of pre-burn history by years since burning.
[1]Means with similar letters between pre-burn histories within the same year are not significantly different (P≤0.05) based on LSD.

Canopy cover of graminoids responded to a pre-burn history by years since burning interaction (P=0.02; Figure 4-8). In plant communities burned 5 years earlier canopy cover of graminoids increased in years 1, 2, 5, and 6 relative to plant communities not previously burned. Cover of graminoids in plant communities burned 5 years earlier reached a maximum in year 6, 1.6-times greater than in plant communities not previously burned.

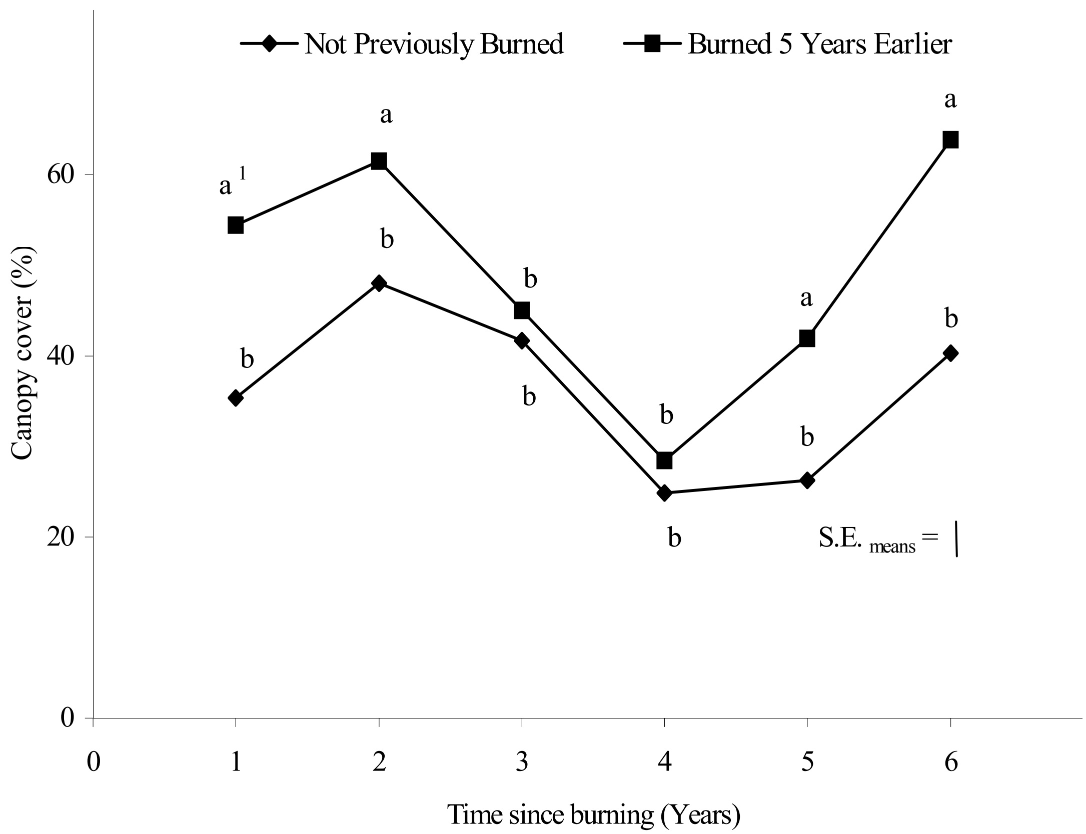

Figure 4-8. Changes in the canopy cover (%) of graminoids the first 6 years after burning in plots not previously burned and plots burned 5 years at Kernen Prairie, near Saskatoon, Saskatchewan. S.E. $_{means}$ is the standard error determined from the interaction of pre-burn history by years since burning.
[1]Means with similar letters between pre-burn histories within the same year are not different (P≤0.05) based on LSD.

4.3.4 Plant community characteristics responding to month of burning

Graminoid cover responded to month of burning (P=0.03; Table 4-2). Burning in August reduced the canopy cover of graminoids by 30 relative to the control. Total plant cover declined after burning in July or August (P=0.02; Table 4-2), reflecting the reduction in the cover of *F. hallii* and other plants excluding *E. lanceolatus*, *F. hallii*, and *H. curtiseta*. Burning in July and August reduced total plant cover 13% and 20%, respectively, compared to control.

Table 4-2. Effect of month of burning on the canopy cover (%) of graminoids and total plant cover (%) at Kernen Prairie, near Saskatoon, Saskatchewan.

Time of burning (Month)								S.E. $_{means}$
Control	November	March	April	May	June	July	August	
Canopy cover of graminoids (%)								
46a[1]	46a	46a	45a	44a	40a	40a	32b	3.1
Total plant cover (%)								
64a	61a	64a	59a	65a	57a	56b	51b	3.6

[1]Means within a row with the same letter are not different (P≤0.05) based on LSD.

4.3.5 Plant community characteristics responding to pre-burn history

Species evenness responded to pre-burn history (P=0.01). In plant communities not previously burned, species evenness averaged 0.69 (S.E. ± 0.010) while burning 5 years earlier increased species evenness to 0.72 (S.E. ± 0.010), indicating cover of dominant plants declined in response to repeated burning.

4.3.6 Plant community characteristics responding to years since burning

The majority of plant community characteristics responded to years since burning (Table 4-3). Soil water also responded to years after burning, declining in years 3 and 4 relative to the second year after burning (P<0.01). Canopy cover of *Hesperostipa curtiseta*, perennial forbs, annual forbs, and legumes responded only to years since burning. *Hesperostipa curtiseta* cover increased in the second, third, and sixth years after burning, reaching a maximum in year 2 with a 2-fold increase in cover compared to the first year after burning (P<0.01). Perennial forb cover increased 59% in the second year after burning compared to year 1 (P<0.01). Cover of perennial forbs declined in years 3, 4, and 5. Canopy cover of annual forbs increased in year 2, 6-times greater than the first year after burning, and declined thereafter (P<0.01). Legume cover increased in years 2, 3, 5, and 6 relative to the first year after burning, reaching a maximum the second year after burning, 6.5-times greater than in year 1 (P<0.01). Total plant cover also responded to years since burning, increasing in year 2, declining in years 4 and 5, and was similar to total plant cover the first year after burning in year 6 (P<0.01). Species evenness increased in the second, fourth, and fifth years after burning, a 9% increase over year 1 (P=0.02) while the Shannon-Weiner diversity index was highest the second and third years after burning, relative to year 1 (P<0.01).

Table 4-3. Soil water (%) and canopy cover (%) of *Hesperostipa curtiseta*, perennial forbs, annual forbs, and legumes, total plant cover (%), species evenness (S), and the Shannon-Weiner diversity index (H') the first 6 years after burning at Kernen Prairie, near Saskatoon, Saskatchewan.

Time since burning (Years)						S.E. $_{means}$
1	2	3	4	5	6	
Soil water (%)						
--[1]	17a[2]	12b	13b	16a	17a	0.8
Canopy cover of Hesperostipa curtiseta (%)						
4b[1]	8a	6a	4b	3b	6a	0.5
Canopy cover of perennial forbs (%)						
9.7b[1]	15.4a	11.8b	6.2c	6.2c	8.7b	0.93
Canopy cover of annual forbs (%)						
0.3c	1.8a	1.2b	0.0c	0.3c	0.7c	0.20
Canopy cover of legumes (%)						
0.4d	2.6a	1.4b	0.5d	0.9c	1.0c	0.18
Total plant cover (%)						
60b	81a	63b	38c	46c	68b	3.2
Species evenness (S)						
0.67b	0.73a	0.71b	0.73a	0.73a	0.68b	0.016
Shannon-Weiner diversity index (H')						
2.0c	2.4a	2.2a	2.2b	2.2b	2.1c	0.06

[1]Means within a row with the same letter are not different (P≤0.05) based on LSD.

4.4 Effects of burning on the variance in plant community characteristics

4.4.1 Variance in plant community characteristics responding to a month of burning by years since burning interaction

The variance (s^2) in cover, which is used to represent spatial heterogeneity or patchiness, of litter and bare soil responded to a month of burning by years since burning interaction ($P<0.01$ and $P<0.01$, respectively; Figures 4-9 and 4-10). Except for burning in August, burning increased the s^2 of litter cover in year 1, ranging from a 26-fold increase after burning in March to a 82-fold increase after burning in May relative to control (Figure 4-9). The variability in litter cover was greater than the control for 1 growing season after burning in November, March, April, June, or July and 3 years after burning in May. Variation in litter cover exceeded the control in the fifth year after August burning and in the sixth year after burning in November or June.

Burning increased the s^2 in cover of bare soil the first year after burning (Figure 4-10), ranging from 46-times greater than control after burning in March to 165-times greater after burning in May. Variation in the cover of bare soil was not different from control the second year after burning in November, March, or April and the third year after burning in May, June, July, or August. Within months of burning, variability of bare soil cover fluctuated among years, becoming greater than control in the fourth year after June or August burning.

Month of burning	Time since burning (Years) 1	2	3	4	5	6
Nov.	b[1]	a	a	a	a	b
Mar.	b	a	a	a	a	a
Apr.	b	a	a	a	a	a
May	b	b	b	a	a	a
Jun.	b	a	a	a	a	b
Jul.	b	a	a	a	a	a
Aug.	a	a	a	a	b	a

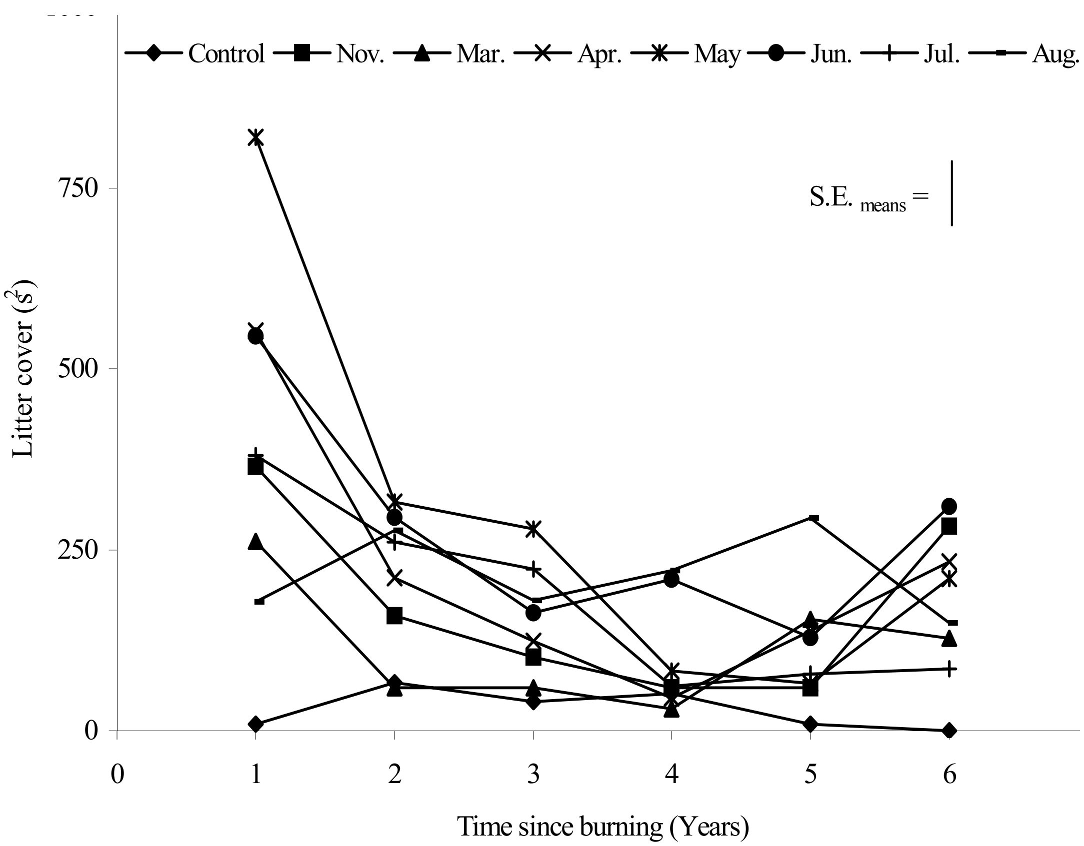

Figure 4-9. Changes in the variance (s^2) of litter cover the first 6 years after burning in different months of the year at Kernen Prairie, near Saskatoon, Saskatchewan. S.E. $_{means}$ is the standard error determined from the interaction of month of burning by years since burning.
[1]An 'a' within years indicates the mean was similar (P≤0.05) to the control while 'b' indicates the mean was different (P≤0.05) from the control based on LSD.

Month of burning	Time since burning (Years) 1	2	3	4	5	6
Nov.	b[1]	a	a	a	a	a
Mar.	b	a	a	a	a	a
Apr.	b	a	a	a	a	a
May	b	b	a	a	a	a
Jun.	b	b	a	b	a	a
Jul.	b	b	a	a	a	a
Aug.	b	b	a	b	a	a

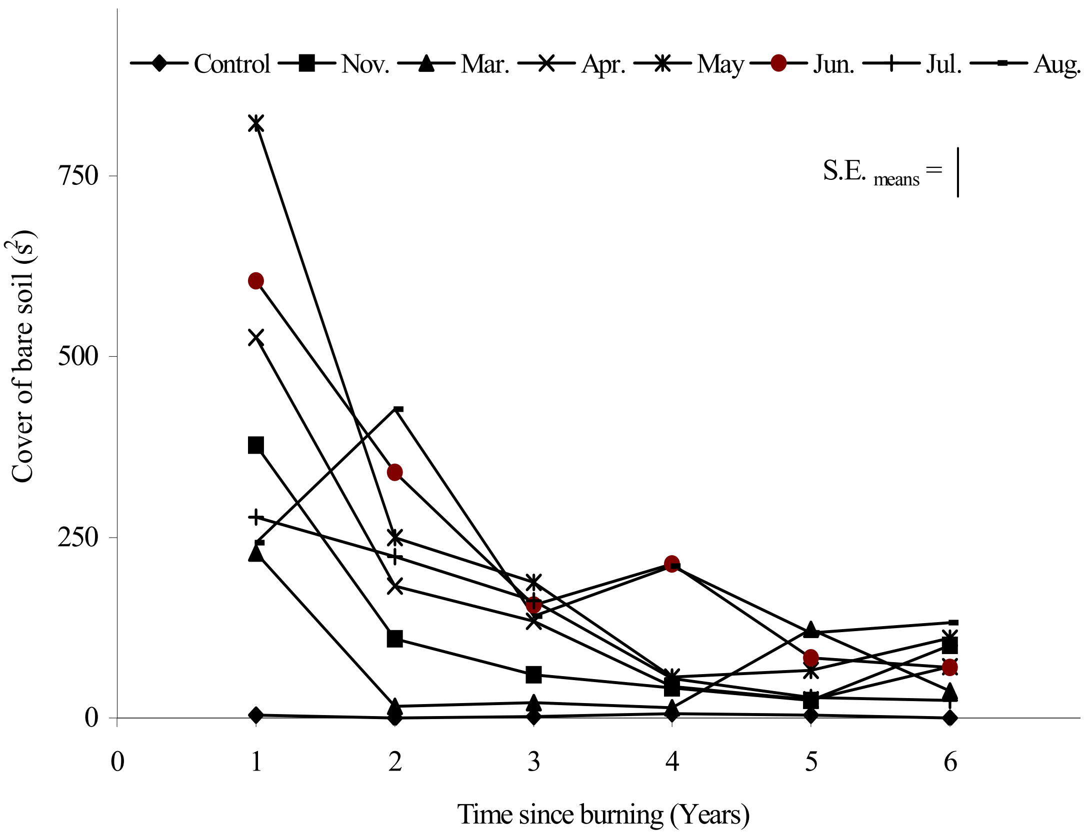

Figure 4-10. Changes in the variance (s^2) in cover of bare soil the first 6 years after burning in different months of the year at Kernen Prairie, near Saskatoon, Saskatchewan. S.E. $_{means}$ is the standard error determined from the interaction of month of burning by years since burning.

[1]An 'a' within years indicates the mean was similar (P≤0.05) to the control while 'b' indicates the mean was different (P≤0.05) from the control based on LSD.

4.4.2 Variance in plant community characteristics responding to a month of burning by pre-burn history interaction

The s^2 in cover of perennial forbs responded to a month of burning by pre-burn history interaction (P=0.01; Figure 4-11). In plant communities not previously burned, burning in March, July, or August reduced s^2 in the cover of perennial forbs. A single burn in July reduced variability of cover by 60% compared to control. When burned 5 years earlier, burning in April caused a nearly 2-fold increase in the variation of cover compared to control.

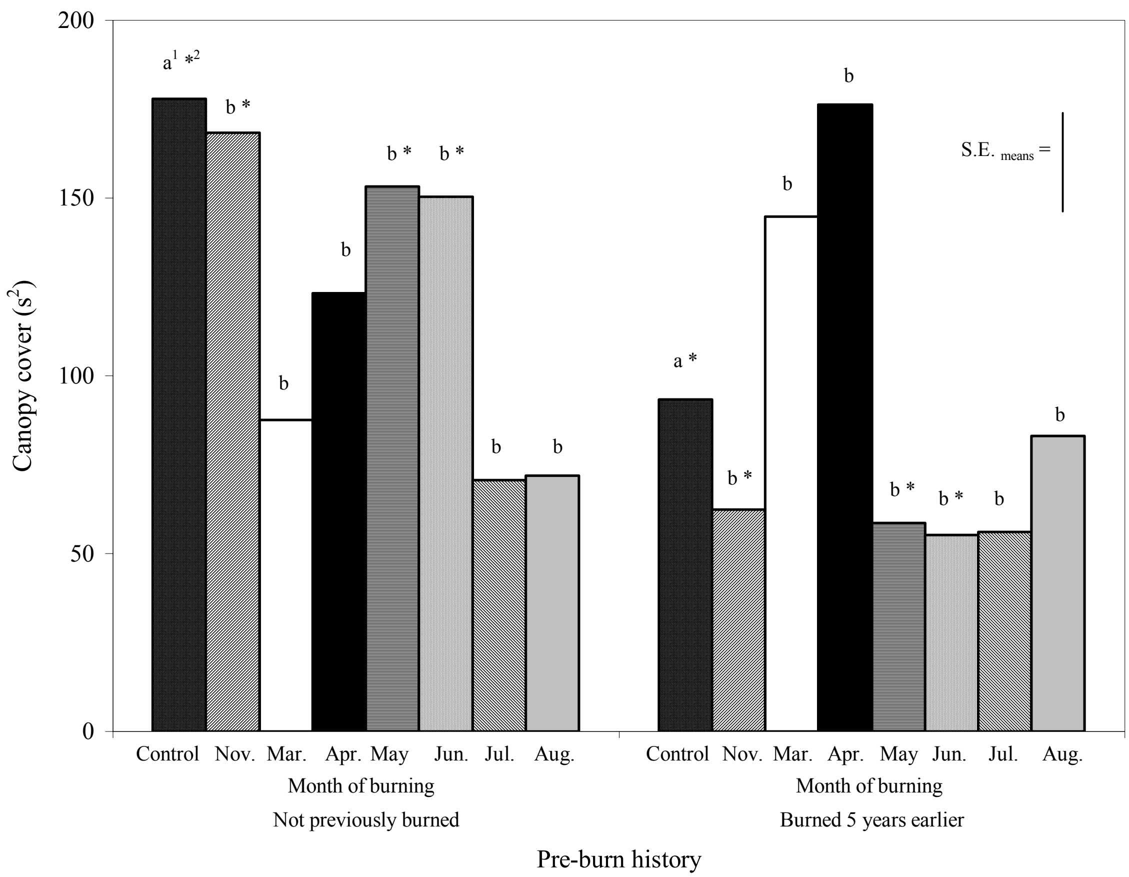

Figure 4-11. Effect of different months of burning on variance (s^2) in cover of perennial forbs in plots not previously burned and plots burned 5 years earlier at Kernen Prairie, near Saskatoon, Saskatchewan. S.E. $_{means}$ is the standard error determined from the interaction of month of burning by pre-burn history.
[1]Means with different lowercase letters above bars indicate differences (P≤0.05) between control and months of burning within each pre-burn history based on LSD.
[2]Means an asterisk (*) above bars indicate differences (P≤0.05) within the same months of burning between pre-burn histories based on LSD.

4.4.3 Variance in plant community characteristics responding to pre-burn history by year since burning interaction

Frequency and yearssince burning affected the s^2 in cover of *Elymus lanceolatus* as evidenced by a pre-burn history by years since burning interaction (P<0.01; Figure 4-12). In plant communities burned 5 years earlier, the variability of *E. lanceolatus* cover increased by 23- and 21-times in years 2 and 6, respectively, relative to plant communities not previously burned.

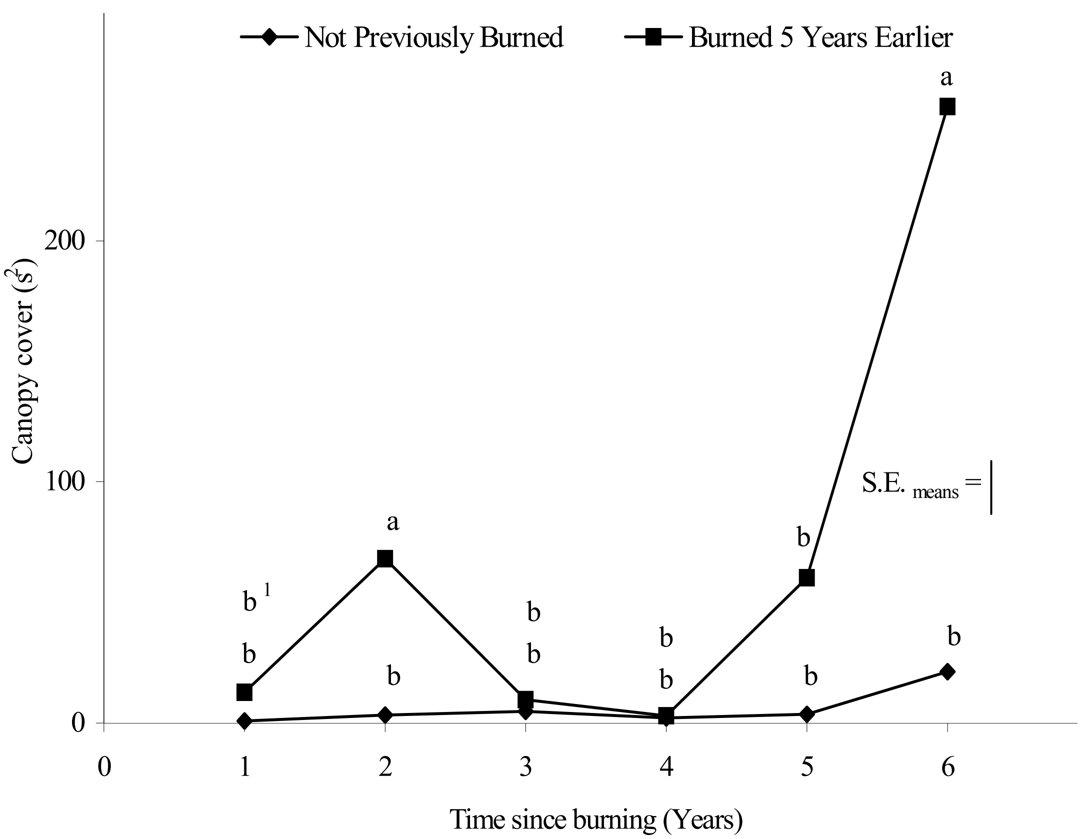

Figure 4-12. Changes in the variance (s^2) in cover of *Elymus lanceolatus* the first 6 years after burning in plots not previously burned and plots burned 5 years at Kernen Prairie, near Saskatoon, Saskatchewan. S.E. $_{means}$ is the standard error determined from the interaction of pre-burn history by years since burning. [1]Means with similar letters between pre-burn histories within the same year are not significantly different (P≤0.05) based on LSD.

4.4.4 Variance in plant community characteristics responding to month of burning

Aside from burning in March, burning reduced the s^2 of total standing crop (P=0.02). Burning in all months except March or April significantly (P=0.01) reduced the s^2 in cover of *Festuca hallii*, ranging from 43% less than control after November burning to 60% after burning in August (Table 4-4).

Table 4-4. Effect of month of burning on the variance (s^2) in total standing crop and canopy cover of *Festuca hallii* at Kernen Prairie, near Saskatoon, Saskatchewan.

Time of burning (Month)								S.E. $_{means}$
Control	November	March	April	May	June	July	August	
---Total standing crop (s^2)---								
8,624a[1]	3,226b	6,073a	3,052b	4,014b	3,848b	5,381b	3,857b	1,029.0
---Canopy cover of *Festuca hallii* (s^2)---								
251a	144b	266a	162a	126b	105b	140b	100b	29.0

[1]Means within rows with the same letter are not different (P≤0.05) based on LSD.

4.4.5 Variance in plant community characteristics responding to pre-burn history

The s^2 in cover of graminoids responded to pre-burn history (P=0.04). In plant communities not previously burned, variability in graminoid cover averaged 194 (S.E. ± 16.9) while burning 5 years earlier increased patchiness in cover to 281 (S.E. ± 16.9).

4.4.6 Variance in plant community characteristics responding to years since burning

Most of the variance in plant community characteristics responded to years since burning (Table 4-5). The s^2 in cover of *F. hallii*, graminoids, and perennial forbs also responded to years after burning. Variation in *F. hallii* cover declined in the fourth and fifth years after burning but increased in year 2 and 6, relativeto year 1 (P<0.01). Variability of perennial forb cover declined after year 3 (P<0.01). Variation in cover of graminoids declined in the third, fourth, and fifth years after burning, reaching a minimum in year 4 (P<0.01). The s^2 in cover of *Hesperostipa curtiseta,* all other plant species excluding *E. lanceolatus*, *F. hallii*, and *H. curtiseta*, annual forbs, and legumes, and s^2 in total plant cover, species evenness, and the Shannon-Weiner diversity index responded only to years after burning. Variation in *H. curtiseta* cover increased in the second and sixth years after burning compared to year 1 following burning (P<0.01). In year 6, variability in cover was 2.2-times greater than the first year after burning. Variation in cover of all other plant species declined in the third, fourth, and fifth years after burning, reaching a minimum in year 4 ($P<0.01$). The variability in annual forb cover decreased in the third and fourth years after burning ($P = 0.02$). In year 4, variation in annual forb cover was 97% less than the first year after burning. Variability in the cover of legumes increased in year 2, about 11-times greater than the first year after burning ($P<0.01$). Variation in total plant cover declined in the third, fourth, and fifth years after burning, decreasing the most in year 4, with 66% less than the first year after burning ($P<0.01$). Variability of species evenness declined in year 2 and increased the sixth year after burning compared to year 1 ($P<0.01$). The variance for the Shannon-Weiner diversity index (H') was reduced in the third year after burning and increased in year 6 compared to the first year after burning ($P=0.02$). Variability in soil water was unaffected by month of burning, frequency of burning, or years since burning ($P>0.05$), averaging 5.9 (SE $\pm$ 1.87) across all treatments.

Table 4-5. Variance (s^2) in canopy cover of *Festuca hallii*, *Hesperostipa curtiseta,* other plant species excluding *Elymus lanceolatus*, *Festuca hallii*, and *Hesperostipa curtiseta*, graminoids, perennial and annual forbs, and legumes the first 6 years after burning at Kernen Prairie, near Saskatoon, Saskatchewan.

Time since burning (Years)						
1	2	3	4	5	6	S.E. $_{means}$
			Canopy cover of *Fesuca hallii* (s^2)			
210a[1]	212a	236a	67b	58b	185a	25.1
			Canopy cover of *Hesperostipa curtiseta* (s^2)			
47b	88a	51b	24b	45b	104a	12.6
			Canopy cover of other plant species (s^2)			
419a	488a	357b	141b	260b	454a	40.3
			Canopy cover of graminoids (s^2)			
318a	291a	194b	91b	178b	354a	29.2
			Canopy cover of perennial forbs (s^2)			
152a	167a	136a	44b	62b	90b	20.3
			Canopy cover of annual forbs (s^2)			
4.3a	5.2a	1.3a	0.1b	0.5b	1.3a	1.24
			Canopy cover of legumes (s^2)			
0.8b	9.0a	2.5b	1.4b	1.2b	1.4b	1.17
			Total plant cover (s^2)			
423a	419a	330b	141b	228b	343a	32.5
			Species evenness (s^2)			
0.012b	0.010c	0.015b	0.011b	0.011b	0.019a	0.0012
			Shannon-Weiner diversity (s^2)			
0.09b	0.10b	0.12a	0.11b	0.09b	0.12a	0.008

[1]Means within each row with the same letter are not different (P≤0.05) based on LSD.

4.5 Effects of burning on plant community composition

Detrended canonical correspondence analysis (DCCA) indicated a linear species response along environmental gradients in the first 4 ordination axes (2.394, 1.378, 1.030, and 0.916) in the first year after burning. Plant communities were selected for this study based on homogeneity in composition, such that the full spectrum of species' responses along environmental gradients was unlikely to be observed. Biplot scaling was used as the appropriate scaling technique in canonical correspondence analysis (CCA) (ter Braak and Smilauer, 2002). Pre-burn history was the only measured variable in the environmental matrix significantly correlated with plant community composition the first year after burning (P<0.01). All other variables were eliminated from further analyses.

Over all 6 years after burning, DCCA again indicated a linear response of species along environmental gradients in the first 4 ordination axes (1.790, 1.220, 0.847, and 0.615), such that biplot scaling was used in CCA (ter Braak and Smilauer, 2002). Pre-burn history, years after burning, cumulative precipitation and cumulative cold stress-days 12 and 24 months before sampling, cumulative growing degree-days 12 months before sampling, soil water, and litter cover affected plant community composition the first 6 years after burning ($P \leq 0.01$) (Table 4-6). Cover of bare soil and cumulative growing degree-days 24 months before sampling were not significantly correlated with plant community composition and were excluded from further analyses.

Table 4-6. Environmental variables used in CCA to explain plant community composition (based on canopy cover [%]) the first 6 years after burning at Kernen Prairie, near Saskatoon, Saskatchewan. λ_A is the additional variance the variable contributes to the model at the time of its inclusion. P and F-values were generated by Monte Carlo permutation tests at 9999 permutations under a reduced model. Environmental variables were included in CCA at $P \leq 0.01$ using forward selection in CANOCO.

Variable[1]	λ_A	P	F
NOT PREV	0.15	<0.01	32.66
BURNED 5	0.15	<0.01	32.66
CSD24BS	0.06	<0.01	11.97
GDD12BS	0.03	<0.01	8.09
YEAR	0.03	<0.01	6.84
CSD12BS	0.03	<0.01	7.90
SOILH2O	0.04	<0.01	8.71
PPT24BS	0.03	<0.01	6.70
PPT12BS	0.02	<0.01	5.71
LITTER	0.02	<0.01	4.55
BARE	<0.01	0.06	1.56
GDD24BS	0.01	0.08	1.46

[1]NOT PREV=not previously burned, BURNED 5=burned 5 years earlier, CSD24BS=cumulative cold stress-days over the 24 months before sampling, GDD12BS=cumulative growing degree-days over the 12 months before sampling, YEAR=years after burning, CSD12BS=cumulative cold stress-days over the 12 months before sampling, SOILH2O=soil water, PPT24BS=cumulative precipitation over the 24 months before sampling, PPT12BS=cumulative precipitation over the 12 months before sampling, LITTER=litter cover, BARE=cover of bare soil, GDD24BS=cumulative growing degree-days over the 24 months before sampling.

The first 4 ordination axes explained 22% of the variation in plant community composition the first 6 years after burning (Table 4-7). Most of the variation was explained by the first axis (13%), which also had the highest eigenvalue. Axes 2, 3, and 4 combined explained<10% of the variation in plant community composition after burning.

Table 4-7. Summary of the first 4 ordination axes of CCA using selected variables to explain plant community composition (based on canopy cover [%]) the first 6 years after burning at Kernen Prairie, near Saskatoon, Saskatchewan.

Summary Statistics	Axis			
	1	2	3	4
Eigenvalue	0.204	0.089	0.033	0.027
Variance in plant community composition				
% variance explained	13.0	5.6	2.1	1.7
Cumulative % explained	13.0	18.6	20.7	22.4

Variation in plant community composition unrelated to measured variables used in CCA was evaluated with correspondence analysis (CA) (Leeson *et al.*, 2000). Eigenvalues for the first 4 ordination axes in CCA (Table 4-7) were less than those generated by CA (0.345, 0.151, 0.088, and 0.082), indicating other environmental or site variables influenced plant community composition at Kernen Prairie the first 6 years after burning (Leeson *et al.*, 2000), but were not measured and therefore they are not included in the CCA.

Pre-burn history was highly correlated with the first axis (Table 4-8) and had a strong influence on plant community composition relative to the other measured variables (Figure 4-13). Plant community composition in areas not previously burned were correlated with cumulative precipitation over the 12 and 24 months before sampling and soil water, indicating that water availability was an important factor controlling species composition (Figure 4-13). Plant communities burned 5 years earlier were associated with cumulative cold stress-days over the 12 and 24 months before sampling, cumulative growing degree-days over the 12 months before sampling, litter cover, and years since burning.

Table 4-8. Intraset correlations between the first 4 ordination axes of a CCA and selected environmental variables used to explain plant community composition (based on canopy cover [%]) the first 6 years after burning at Kernen Prairie, near Saskatoon, Saskatchewan.

Variable[1]	Axis			
	1	2	3	4
NOT PREV	0.842	-0.124	0.317	0.151
BURNED 5	-0.842	0.124	-0.317	-0.151
CSD24BS	-0.410	0.259	0.390	0.571
GDD12BS	-0.130	-0.442	0.077	0.518
YEAR	-0.351	0.334	0.675	-0.180
CSD12BS	-0.234	0.465	0.194	-0.141
SOILH2O	0.203	0.159	0.713	-0.451
PPT24BS	0.316	-0.167	-0.045	-0.152
PPT12BS	0.126	0.046	0.008	-0.302
LITTER	-0.170	0.193	0.246	-0.094

[1]NOT PREV=not previously burned, BURNED 5=burned 5 years earlier, CSD24BS=cumulative cold stress-days over the 24 months before sampling, GDD12BS=cumulative growing degree-days over the 12 months before sampling, YEAR=years after burning, CSD12BS=cumulative cold stress-days over the 12 months before sampling, SOILH2O=soil water, PPT24BS=cumulative precipitation over the 24 months before sampling, PPT12BS=cumulative precipitation over the 12 months before sampling, LITTER=litter cover.

Additional analyses conducted using CCA to determine the influence of other environmental variables that affected plant community composition at Kernen Prairie are given in Appendix E. Exploratory analyses of ordination diagrams identified block as an important factor influencing species composition. However, canonical correspondence analysis within North plots indicated that marginally less variation in plant community composition was explained using this alternative method. The first 4 ordination axes of the CCA within year 2 explained the most variation in plant community composition of all other analyses, suggesting that the number of years after burning was an important factor influencing plant community composition at Kernen Prairie.

In plant communities not previously burned, plant community composition was similar to the unburned controls in years 2 and 3 after burning in 20 October 1998, in year 4 after burning in 17 December 1997, and in the third and sixth years after burning in 20 July 1999 (Table 4-9). Composition of plant communities burned 5 years earlier was similar to unburned controls in the third year after burning in 20 June 1999, in the fourth year after burning in 25 May 1998 and 27 June 1998, and in year 6 after burning in 27 May 1999.

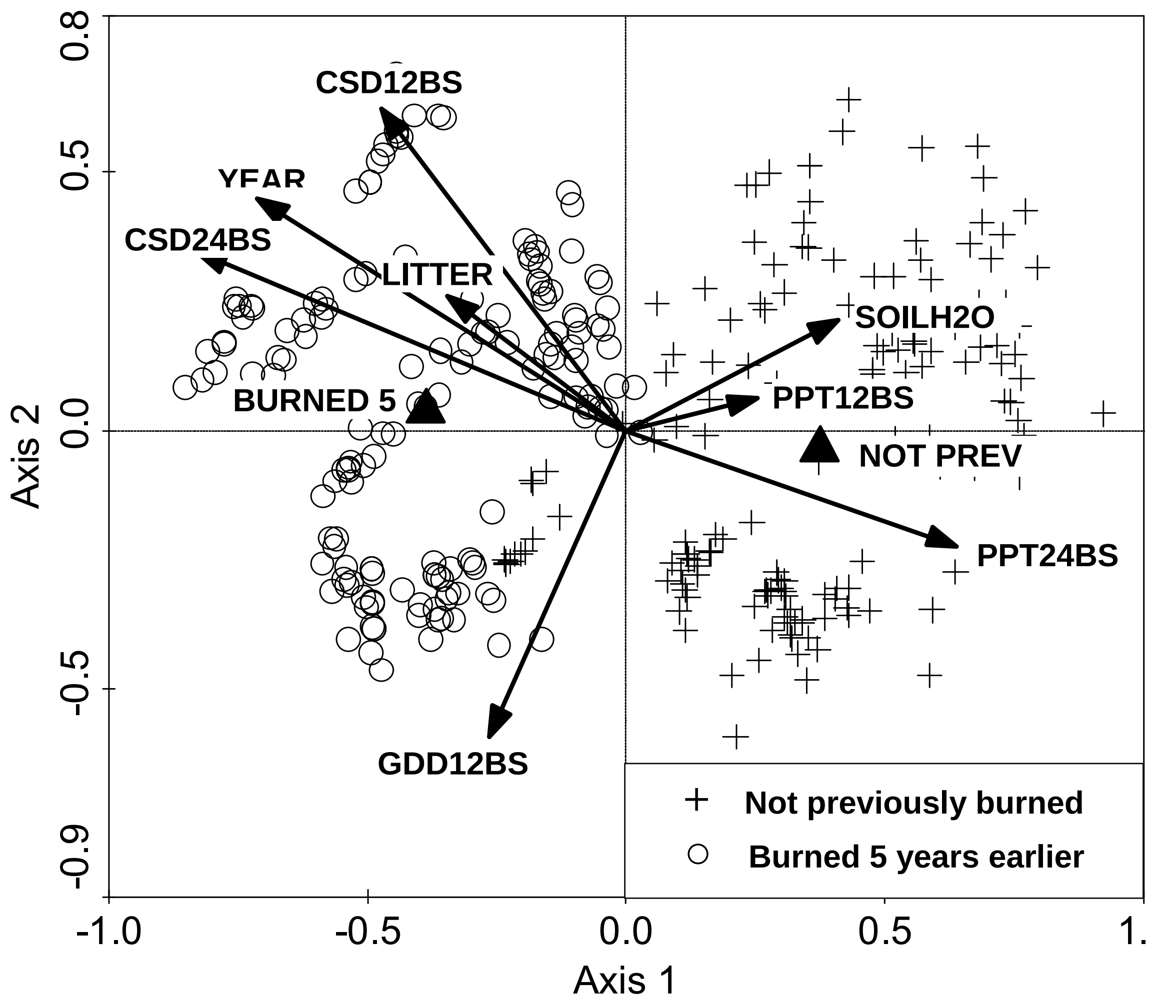

Figure 4-13. Canonical correspondence analysis (CCA) of axis 1 (horizontal) against axis 2 (vertical) illustrating dissimilarity in plant community composition in plots with different burning histories when constrained by selected variables at Kernen Prairie, near Saskatoon, Saskatchewan. Points represent burn plots that are linear combinations of variables. Nominal variables are represented by large upright triangles. Arrows represent continuous variables.

NOT PREV=not previously burned, BURNED 5=burned 5 years earlier, CSD24BS=cumulative cold stress-days over the 24 months before sampling, GDD12BS=cumulative growing degree-days over the 12 months before sampling, YEAR=years after burning, CSD12BS=cumulative cold stress-days over the 12 months before sampling, SOILH2O=soil water, PPT24BS=cumulative precipitation over the 24 months before sampling, PPT12BS=cumulative precipitation over the 12 months before sampling, LITTER=litter cover.

Table 4-9. Similarity (%) of plant community composition (based on canopy cover [%]) to controls after burning in different dates in plots not previously burned and plots burned 5 years earlier the first 6 years after burning at Kernen Prairie, near Saskatoon, Saskatchewan. Similarity is assumed at ≥ 80%.

Date of burning	Time since burning (Years)					
	1	2	3	4	5	6
Not previously burned						
15 Nov. 1997	49	60	64	70	63	54
17 Dec. 1997	56	62	70	**84**	56	62
25 Mar. 1998	76	58	73	68	56	62
16 Apr. 1998	60	59	65	65	45	55
1 May 1998	53	52	64	65	50	39
13 May 1998	36	57	60	70	45	35
25 May 1998	46	58	61	69	39	44
5 Jun. 1998	40	60	65	68	50	38
27 Jun. 1998	44	70	70	70	57	58
14 Jul. 1998	33	52	62	59	50	61
25 Aug. 1998	28	59	68	68	59	57
11 Sep. 1998	62	72	56	74	68	50
20 Oct. 1998	75	**81**	**80**	67	68	59
7 Nov. 1998	58	63	57	57	58	43
29 Mar. 1999	79	72	64	73	67	63
26 Apr. 1999	44	34	31	38	39	27
17 May 1999	71	71	78	77	70	65
27 May 1999	64	70	65	69	63	62
7 Jun. 1999	63	60	56	64	59	36
20 Jun. 1999	52	71	64	65	59	57
6 Jul. 1999	44	40	53	66	35	35
20 Jul. 1999	44	67	**81**	71	69	**83**
30 Aug. 1999	--[1]	56	58	69	58	72
27 Sep. 1999	--[1]	29	38	45	54	31
Burned 5 years earlier						
15 Nov. 1997	39	70	73	77	65	70
17 Dec. 1997	59	68	59	72	61	59
25 Mar. 1998	70	78	74	72	68	67
16 Apr. 1998	42	60	56	71	60	72
1 May 1998	49	58	72	77	71	65
13 May 1998	42	64	70	73	67	61
25 May 1998	39	72	76	**80**	66	73
5 Jun. 1998	47	71	62	69	48	64
27 Jun. 1998	41	71	72	**82**	68	67
14 Jul. 1998	31	62	74	71	70	62
25 Aug. 1998	45	55	64	75	60	62
14 Sep. 1998	66	64	78	66	71	62
20 Oct. 1999	70	70	73	59	65	77
7 Nov. 1998	70	62	55	76	72	71
29 Mar. 1999	74	79	58	63	74	61
26 Apr. 1999	59	70	76	63	63	76
17 May 1999	49	47	40	43	58	60
27 May 1999	63	58	69	73	77	**80**
7 Jun. 1999	66	66	75	61	77	69
20 Jun. 1999	56	67	**86**	73	72	74
6 Jul. 1999	60	65	76	61	76	65
20 Jul. 1999	52	68	79	70	77	71
30 Aug. 1999	--[1]	58	65	48	55	49
27 Sep. 1999	--[1]	62	67	45	57	54

[1]Missing data.

5.0 Discussion

Numerous, complex interactions affect the responses of plant communities to burning in grasslands (Hulbert, 1988). Heat generated during burning directly affects plants through the combustion of above ground plant biomass (Daubenmire, 1968; Wright and Bailey, 1982). Burning indirectly affects plants and plant communities by modifying microenvironmental conditions including temperature and water regimes (Romo *et al.*, 1993). Temporal variability in temperature and precipitation also modifies the response of plants and plant communities to burning (Coupland, 1958). The results of this thesis provide a unique data set of vegetation responses following multiple dates of burning on sites with different burning histories that were monitored over 6 years after burning. Variation in the timing and frequency of burning affected the spatial and temporal responses of plant community characteristics and plant community composition, reflecting the historic range of variability imposed by fire in Fescue Prairie.

In the case of litter and bare soil, the interaction of month of burning and years since burning illustrated the variability of responses to fire and duration of fire effects in Fescue Prairie. In the present study cover of litter and bare soil were unaffected the first 6 years after burning in March. Water and ice on the soil surface at the time of burning in March prevented complete combustion of the fuel, leaving a layer of unburned litter (J.T. Romo, personal communication). On the other hand, August burning increased bare soil and reduced the cover of litter for 4 and 5 years after burning, respectively. The increased longevity of burning effects on bare soil and litter is attributed in part to the timing of burning. Other burns occurred before or during the growing season, providing an opportunity for plants to partially regrow lost tissues before the onset of winter. The exposure of recently burned plants to increased evaporation in autumn and lower temperatures in winter was likely detrimental to plant growth (Kowalenko and Romo, 1998b; Archibold *et al.*, 2003) leading to reduced litter cover (Facelli and Pickett, 1991) and, consequently, an increase in bare ground. Thus, the variability in environmental conditions before, during, and after burning can have long-lasting effects in Fescue Prairie (Daubenmire, 1968; Redmann *et al.*, 1993). Aside from burning in March, litter cover was reduced and bare soil increased for 2 to 5 years, depending on the month of burning. Similar responses were observed in the Fescue Prairie of western Montana, where burning in April or October reduced litter cover and increased bare soil for at least 3 years (Jourdonnais and Bedunah, 1990).

Variance in plant community characteristics within burns was used as an indicator of small-scale spatial heterogeneity or patchiness (Roth, 1976; Madden *et al*., 1999, 2000) with the intent of monitoring changes in patchiness between months of burning in sites with different burning histories. In the present study, except for burning in August, consumption of litter by burning was likely uneven, increasing the spatial variance of litter and bare soil for at least 1 year. Similar observations were made in an earlier study at Kernen Prairie, in which fire created a spatially variable mosaic of burned and unburned patches of litter (Redmann *et al*., 1993). In the present study, the major increases in the patchiness of litter and bare soil were relatively short-lived. Patchiness after burning remained greater than the unburned control, albeit not always significantly, further reinforcing the notion of a long-term effect of burning on litter in Fescue Prairie (Redmann *et al*., 1993). Up to 11 years may be required for the mass of litter to recover to pre-burn amounts in Fescue Prairie (Pylypec and Romo, 2003) likely contributing to the increase in patchiness observed over the 6 years after burning in the present study.

Environmental conditions at the time of burning may have contributed to the observed variability in patchiness of litter. For instance, patchiness in litter cover was not different from the unburned control the first 4 years after burning in August, likely due to decreased fuel water and relative humidity at the time of burning, favouring the uniform destruction of the litter layer. Conversely, increased fuel water and higher relative humidity lead to a patchy burn in May, increasing the spatial variability of litter for 3 years following burning. Increased fuel water reduces the combustion and spread of grassland fires (Daubenmire, 1968). Britton and Wright (1971) concluded that the ability of fire to consume fine fuels such as litter was determined primarily by relative humidity.

Burning in different months reduced soil water, and soil water was less in plant communities burned 5 years earlier than in those not previously burned. Soils on burned Northern Mixed Prairie and Fescue Prairie are drier because of less snow capture, reduced infiltration, and increased evaporation (de Jong and MacDonald, 1975; Archibold *et al*., 2003). However, in plant communities burned 5 years earlier, soil water in March and April burns were not significantly different from unburned controls. In an earlier study at Kernen Prairie, soil water was greater after burning in April compared to burning in October, but it was less than unburned areas (Grilz and Romo, 1994). Litter is associated with increased water infiltration in Fescue Prairie (Redmann *et al*., 1993) and patchy distribution of litter may contribute to spatial variability in soil water (Facelli and Pickett, 1991), but this was not evident in the present study. Precipitation (James *et al.*, 2003) and microtopography (Baines, 1973) likely had major influences on soil water and overrode the effects of burning.

Burning in different months reduced total standing crop, whereas plots not previously burned had greater total standing crop only in unburned controls or March or July burns than in plant communities burned 5 years earlier. Burning in spring or fall also reduced above ground plant biomass in earlier studies of *Festuca*-dominated plant communities at Kernen Prairie (Pylypec and Romo, 2003). Reduced soil water after burning increases plant water stress and reduces productivity in the Northern Mixed Prairie (Redmann, 1978). In the present study, increased fire frequency was expected to reduce total standing crop because it is slowest to reover after buring (see Pylypec and Romo, 2003). However, total standing crop was not different in plant communities not previously burned or theose burned 5 years earlier in November, April, May, June, or August burns. Increased fuel accumulation at the time of burning in plant communities not previously burned may have contributed to greater fire temperatures (Archibold *et al*., 1998) and thereby greater reductions in total standing crop. Together the greater fuel loads and greater temperatures may have masked the effects of burning when plant communities were burned 5 years earlier.

Total standing crop did not vary between years. The productivity of plant communities does not necessarily change because high productivity of some species in a particular year may be compensated by low productivity of others (Chapin and Shaver, 1985; Jonasson, 1992). Furthermore, litter, standing dead, and current year standing crop were combined in this study and measured as total standing crop (Pylypec and Romo 2003), perhaps muting year-to-year changes in productivition.

Environmental conditions at the time of burning also influence the characteristics and effects of burning on plants (Daubenmire, 1968). The wet or frozen litter layer and mineral soil when burned in March probably dissipated heat and protected growing points and root crowns of *Festuca* from lethal temperatures, as previously shown (Bailey and Anderson, 1980; Antos *et al.*, 1983). The patchiness of *F. hallii* cover and total standing crop was also unaffected by March burning, perhaps reflecting the increase or maintenance of *F. hallii* cover after burning in March. Early spring burning was also least detrimental to *Festuca* production compared to other months of burning in the Aspen Parkland of central Alberta (Gerling *et al.*, 1995). Bogen *et al.* (2002) hypothesized that *F. campestris* growth can be enhanced under moderate temperatures, indicating a low intensity burn could stimulate tiller growth and increase plant cover.

Retention of litter after burning in March may have benefited *F. hallii* because of increased soil nutrients. Soil microorganisms buried under the insulating cover of litter and snow can remain active during winter, producing nutrients that are available to plants the following growing season (Sturm *et al*., 2005). Nitrogen mineralization and nitrogen availability are enhanced after burning in some grasslands (Sharrow and Wright, 1977; Hobbs and Schimel, 1984). However, in an earlier study at Kernen Prairie, losses of nitrogen after burning *Festuca*-dominated plant communities were 3- to 6-times greater than inputs of nitrogen (Redmann, 1991). Ash may also have a fertilizing effect on plant growth, but only in some years (Sharrow and Wright, 1977).

Aside from burning in March, burning reduced cover of *F. hallii* for 1 to 3 years, indicating that fire may have injured plant tissues. Injured plants thus required more time to recover following burning. Combustion of above ground plant biomass by burning reduces photosynthetic material and carbohydrate reserves required by plants for metabolism, growth, and reproduction (Wright and Bailey, 1982; Busso *et al*., 1990). Reduced cover of *Festuca hallii* after burning was also reported in the Aspen Parkland of Alberta, where cover of the grass decreased after burning in May or October and remained reduced relative to unburned areas for 3 years (Bailey and Anderson, 1978).

Year-to-year changes in plant cover were especially evident for *F. hallii*. Productivity of *F. idahoensis* varied from year-to-year in a montane grassland in Montana, likely because of yearly differences in weather (Mueggler, 1975). Precipitation in the years leading up to the present study exceeded the long-term average, during which time *F. hallii* likely responded by increasing in cover. Coupland (1961) observed an increase in the *F. hallii* cover with above average precipitation from 1950 to 1957 in the Fescue Prairie of Saskatchewan. Precipitation was below average during the present study, especially in 2001, and this reduced precipiation may have caused a decline in the cover of *F. hallii*. *Festuca campestris* is also sensitive to changing moisture conditions, as evidenced by a 50% reduction in productivity during a 2-year drought in the Fescue Prairie of west-central Montana (Jourdonnais and Bedunah, 1990).

Burning in late summer reduced cover of *F. hallii*, graminoids, other plant species excluding the dominant grasses, and total plant cover. In the Aspen Parkland of Alberta, autumn burning reduced canopy cover of graminoids more than spring burning, while total plant cover increased slightly after a May burn, but it decreased after burning in October (Bailey and Anderson, 1978). Burning at the end of the growing season may be detrimental to plants because burning can alter microenvironmental conditions. Burning increases bare soil and black ash, reducing the reflectivity of solar radiation at the soil surface whileincreasing temperatures and evaporation (Archibold *et al.*, 2003). In an earlier study at Kernen Prairie, burning in October reduced snow cover and soil water in the following year (Archibold *et al.*, 2003). Plant, litter, and snow cover insulate plants in winter (Kowalenko and Romo, 1998b). In the absence of litter or snow cover, plants may be exposed to colder temperatures, which in turn increases their susceptibility to freezing damage and reduces growth (Kowalenko and Romo, 1998b).

Competition among plants for soil water in the drier, post-fire conditions may influence the responses of individual plants and alter plant community composition (Defosse and Robberecht, 1996). *Elymus lanceolatus* is relatively more resistant to water stress and it has a deeper root system than *F. hallii* and *Hesperostipa curtiseta* (Coupland and Johnson, 1965). *Elymus lanceolatus*, therefore, may have a competitive advantage and be able to access more soil water during periods of decreased soil water availability. Thus, plant responses after burning may be related more to microenvironmental conditions following burning and the capacity of plants to compete for soil water than to the direct effects of burning on plants (Defosse and Robberecht, 1996).

While *F. hallii* and *E. lanceolatus* responded to burning, *H. curtiseta* was unaffected, likely responding to year-to-year variability in precipitation. Cover of *H. curtiseta* decreased after burning in October, but its cover was unaffected by burning in

May (Bailey and Anderson, 1978). *Festuca hallii* evolved under the influence of periodic fire (Wright and Bailey, 1982); however, the tufted growth-habit with perenniating buds above the soil surface increases the susceptibility of *Festuca* to injury from burning (Pavlick and Looman, 1984; Bogen *et al*., 2002). Growing points of rhizomatous plants, such as *E. lanceolatus*, usually escape lethal temperatures because they are located below the soil surface (Allen and Partridge, 1988; Steuter and McPherson, 1995). Annual spring burning increased the frequency of the rhizomatous *Pascopyrum smithii* in *Festuca*-dominated plant communities in Alberta (Anderson and Bailey, 1980). *Elymus* and *Hesperostipa* are also more resistant to burning than *Festuca* because less flammable litter accumulates at the base of the plants (Wright and Bailey, 1982; Erichsen-Arychuk *et al*., 2002). Accumulation of litter near plants may increase fire temperatures and duration of those temperatures, causing greater damage to plants and increased modification to the microenvironment (Bogen *et al*., 2002).

In the present study, cover of annual and perennial forbs and the patchiness in annual forb cover responded only to the number of years after burning or the response could have corresponded with yearlyprecipitation. Similar responses were observed in a mixed mesquite/acacia savanna in Texas where forbs were unaffected by season or frequency of burning; however, their abundance varied among years, suggesting that annual weather patterns were the driving variable for forbs in that community (Owens *et al*., 2002). Forbs increase (Bailey and Anderson, 1978) or decrease (Redmann *et al*., 1993) following burning in Fescue Prairie. An increase in soil temperature and enhanced nutrient supply may drive the increase in perennial forbs after burning in the Aspen Parkland of Alberta (Bailey and Anderson, 1978). Below average precipitation was credited for reduced abundance of forbs following burning in October in the Fescue Prairie of Saskatchewan (Redmann *et al*., 1993).

Variation in the timing and frequency of burning produced a variety of responses in the patchiness of perennial forbs. Spatial distribution of forbs varied depending on the timing of burning in the Mixed Prairie of South Dakota (Biondini *et al*., 1989). Forbs were randomly distributed in unburned grassland or after burning in spring or summer while forbs were clustered after autumn burning (Biondini *et al*., 1989). Biondini *et al*. (1989) hypothesized that fall burns were more in tune with the evolutionary history of the

Mixed Prairie, favouring the growth of perennial forbs that were established in small-scale disturbances that occurred in the past. In the present study, the increase in the patchiness of perennial forbs may indicate that April burning in plots burned 5 years earlier created intense, small-scale disturbances in a complex mosaic that increased the spatial heterogeneity of perennial forbs within the predominantly grass matrix (Phillips, 1936; Laycock, 1958; Platt, 1975).

Burning reduces nitrogen in Fescue Prairie (Redmann, 1991). Plants that fix nitrogen should have an advantage in a post-fire, nitrogen-stressed environment (Lauenroth and Dodd, 1979; Leach and Givnish, 1996). However, this was not evident in the present study as legumes responded only to the number of years after burning. Burning more frequently than every three years may be required to cause a nitrogen deficit in Fescue Prairie (Redmann, 1991) and thereby invoke a positive response of legumes to burning.

In the present study, the Shannon-Weiner diversity index (H') was unaffected by timing or frequency of burning, responding only to years after burning. Diversity was also unaffected after burning in the Mixed Prairie of southern Manitoba (Wilson and Shay, 1990) and the Shortgrass Prairie of New Mexico (Brockway *et al*., 2002). The effects of burning may have been insufficient to cause an increase in diversity because it is only part of the natural disturbance regime. Fescue Prairie evolved under intermittent grazing by nomadic bison herds (Moss and Campbell, 1947). The interaction of fire and grazing presumably created a shifting mosaic of patches of vegetation in various stages of recovery, increasing spatial and temporal heterogeneity in the Tallgrass Prairie of Kansas (Knapp *et al*., 1999). Thus, the interaction of fire and grazing, within the natural range of variability, may be required to enhance the Shannon-Weiner diversity index in Fescue Prairie.

Neither date of burning nor variables associated with timing of fire including fuel load, fuel water, relative humidity, temperature, wind speed, or time of day were correlated with plant community composition. The lack of responses of the plant community to characteristics of the burns indicates that burning at different times of the year creates unique plant communities and that other factors have greater roles in determining plant community composition. No 2 fires are the same, including burns in the same season in different years, because of differences in conditions before and after burning, fuel quality, fuel water, arrangement of fuels, phenological status of plants, and weather (Towne and Owensby, 1984; Howe, 1995; Engle and Bidwell, 2001). Thus, a variety of plant community responses to the timing of burning are possible and rules-of-thumb that generalize responses may be misleading (Blankespoor and Larson, 1994; Engle and Bidwell, 2001).

Year-to-year variation in weather, represented by the number of years after burning, was an important factor controlling plant community composition. Time since burning was also the primary agent determining plant community composition in the Tallgrass Prairie of Kansas (Gibson and Hulbert, 1987). Similarity of plant community composition to control within years was infrequent and did not exceed 2 consecutive growing seasons. The effects of variability in weather often exceed the effects of other disturbances (White and Loftin, 2000). Biondini *et al*. (1998) concluded that disturbances play a secondary role in the plant community, with annual fluctuations in weather, especially drought, controlling major trends in plant community composition in the Northern Mixed Prairie. Thus, fire alone was not an exceptional event, but rather it falls within the normal year-to-year variation (Biondini *et al*., 1989).

In the present study, the majority of plant community characteristics appeared to correspond to annual changes in precipitation. The effect of year-to-year variability in rainfall also equalled the effects of burning at different times of the year in the Mixed Prairie of South Dakota (Biondini *et al*., 1989). Semiarid regions, such as the Fescue Prairie, are characterized by highly variable weather with water as the limiting factor. It is, therefore, not surprising that plant community characteristics at Kernen Prairie corresponded to precipitation patterns.

Fire frequency had a persistent affect on plant community characteristics and was the dominant variable affecting plant community composition. Species evenness, *E. lanceolatus*, and graminoids increased in plant communities burned 5 years earlier. Annual burning in spring increased cover of herbaceous species and reduced the cover of the dominant grasses and shrubs in the Aspen Parkland of Alberta (Anderson and Bailey, 1980). Increased fire frequency may have altered microenvironmental conditions and thus the plant community composition. The composition of plant communities not previously burned was influenced by cumulative precipitation and soil water. *Festuca*-dominated plant communities at Kernen Prairie are associated with mesic conditions (Baines, 1973; Pylypec, 1986). Before the onset of the present study, areas of Kernen Prairie had not been burned for at least 80 years (Grilz and Romo, 1995). Thus, a single burn event in at least the last 80 years may have been insufficient to significantly alter plant community composition. The microenvironmental effects of a single burn in Fescue Prairie at different times of the year disappear quickly and, therefore, the impact of burning on plants and plant communities is short-term (Archibold *et al.*, 2003).

Litter moderates the temperature regime within the plant microclimate (Hopkins, 1954; Whitman, 1974). In the present study, repeated removal of plant material and litter from 2 burning events may have exposed plants to lower temperatures in winter, as indicated by the association of cumulative cold stress-days with plant communities burned 5 years earlier. Plants experience more cold stress because of reduced cover, less insulation, and less snow trapping (Kowalenko and Romo, 1998b) and small changes in temperature may be important when the plant was near its temperature limit (Carlsson and Callaghan, 1991). Spatial and temporal variability of insulating snow cover alters plant community composition in alpine (Billings and Bliss, 1959; Johnson and Billings, 1962; Thilenius, 1975; Sonesson and Callaghan, 1991) and arctic environments (Felix *et al*. 1992; Timoney *et al*., 1992).

Cold temperatures rarely kill plants in winter (Billings, 1974; Thilenius, 1975; Kowalenko and Romo, 1998b), but exposure to freezing temperatures can reduce plant growth (Kowalenko and Romo, 1998b). Cold hardiness of *E. lanceolatus* increased while tiller growth decreased after a single defoliation the in the Mixed Prairie of Saskatchewan (Kowalenko and Romo, 1998b). Kowalenko and Romo (1998b) suggested that while plants can tolerate a single defoliation event before the onset of cold temperatures, the effects of repeated defoliation might decrease cold hardiness in plants and increase mortality in winter. This same reasoning may be applicable to herbage removal by buring. Few studies have investigated the effects of cold temperatures on plant community composition in the Northern Great Plains, indicating the opportunity for further research in this area.

Repeated burning may have exacerbated the effects of drought on plants, including higher temperatures experienced during the growing season. Soil temperatures were increased for 2 growing seasons after burning, with the greatest increases in soil temperature after burning in summer in the Fescue Prairie of Saskatchewan (Archibold *et al.*, 2003). Increased temperatures and evaporation after burning may reduce soil water and increase plant water stress (Wright and Bailey, 1982; Redmann, 1978). Maximum summer temperature was correlated with plant community composition in *Bouteloua*-dominated plant communities in Mexico (Aguado-Santacruz and Garcia-Moya, 1998).

The cumulative effects of repeated burning, annual variability in weather, and exposure to temperature extremes may have caused a shift in plant community composition as documented elsewhere (Anderson and Bailey, 1980). By varying the frequency of burning, plant communities with different structure and composition are created, increasing overall heterogeneity in the landscape (Collins, 1989; 1992).

Just 22% of the overall variation in plant community composition at Kernen Prairie was accounted by the measured environmental variables used in CCA. Additional sources of variation include soil type, year, and random events that were not controlled for in the study. Experimental plots were located in areas of either Bradwell or Sutherland soils. However, these plots were also burned in different years, creating confusion over which factor was affecting plant community composition. Furthermore, the use of annual and biannual cumulative precipitation, cold stress-days, and growing degree-days may have been too broad-scale, missing important short-term variability in weather, such as a late-spring frost or extreme high temperatures, that may have affected plant community composition. However, alternative analyses indicated that only slightly more or less variance was accounted for by altering the spatial or temporal scale of the analysis. The percentages of variance in plant community composition explained by ordination axes are typically low in studies involving CCA (ter Braak and Smilauer, 2002). Nonetheless, CCA indicated important correlations between environmental variables and plant community composition at Kernen Prairie.

Recent research has indicated that accelerated climate change may increase spatial and temporal heterogeneity in precipitation (Akinremi *et al.*, 2001), increase average annual temperatures, and decrease effective precipitation in the Northern Great Plains

(James *et al.*, 2001). These changes are predicted to cause dramatic shifts in plant community composition (James *et al*., 2001). The present study suggests that year-to-year variability in temperature and precipitation, with the additional effects of repeated burning, alters plant community composition in Fescue Prairie within a relatively short time period.

6.0 Summary and Implications for Conservation

The effects of burning in all months of the year except January and February were evaluated in a Fescue Prairie in central Saskatchewan for 6 years following burning on sites with different burning histories. The following hypotheses were tested: (1) plant community characteristics differ the first 6 years after burning in different months on sites not previously burned and sites burned 5 years earlier, (2) the spatial variance in plant community characteristics differs the first 6 years after burning in different months on sites not previously burned and sites burned 5 years earlier, and (3) environmental variables explain plant community composition the first 6 years after burning at different times of the year in sites not previously burned and sites burned 5 years earlier.

No 3-way interactions between pre-burn history, month of burning, and years since burning were evident in the present study for plant community characteristics. Therefore, the hypothesis that plant community characteristics differ the first 6 years after burning in different months on sites not previously burned and sites burned 5 years earlier is rejected. However, several plant community characteristics responded to 2-way interactions and main effects. Except for burning in March, burning in different months reduced cover of litter and *Festuca hallii* and increased bare soil for 1 to 5 years. Soil water and total standing crop decreased or were unaffected depending on timing and frequency of burning. Canopy cover of *Elymus lanceolatus,* canopy cover of graminoids, and species evenness increased with burning frequency. Burning in August reduced cover of graminoids by 30%. July or August burning reduced canopy cover of plants other than the dominant grasses and total plant cover.

No 3-way interactions between pre-burn history, month of burning, and years since burning were evident in the present study for the spatial variance of plant community characteristics. The hypothesis that the spatial variance of plant community characteristics differ the first 6 years after burning in different months on sites not previously burned and sites burned 5 years earlier is rejected. However, several of the variances in plant community characteristics responded to 2-way interactions and main effects. Burning in different months increased variance (s^2) in litter cover and bare soil for 1 to 3 years. Aside from burning in March, burning reduced s^2 in total standing crop, ranging from 38% to 65% less than control. Other than burning in March or April, burning reduced the variability in *F. hallii* cover, varying from 43% to 60% less than control. In plants communities burned 5 years earlier, variability of *E. lanceolatus* and graminoid cover increased compared to plant communities not previously burned. The variation in perennial forb cover increased, decreased, or was unaffected depending on timing and frequency of burning.

Pre-burn history had a dominant effect on plant community composition, explaining 13% of the variation. Soil water and cumulative precipitation during the 12 and 24 months before sampling influenced the composition of plant communities not previously burned while composition of plant communities burned 5 years earlier was correlated with litter cover, cumulative cold stress-days 12 and 24 months before sampling, cumulative growing degree-days in the 12 months before sampling, and the number of years after burning. The number of years after burning was an important factor controlling plant community characteristics and plant community composition. The cumulative effects of repeated burning, annual variability in weather, and exposure to temperature extremes may have caused a shift in plant species composition. The hypothesis that measured variables in the environmental matrix explain plant community composition the first 6 years after burning at different times of the year in sites not previously burned and sites burned 5 years earlier is accepted. The first 4 ordination axes explained 22% of the variation in plant community composition after burning, indicating that many other environmental or site variables control plant community composition at Kernen Prairie.

The following recommendations for reintroducing fire as a natural process in Fescue Prairie that are based on the present study include:

(1) Burning should be done at all times of the year within the historic range of variability in Fescue Prairies before European settlement.
(2) Burning frequencies should be varied to create plant communities with different structure and composition and increase overall biodiversity of Fescue Prairies.

(3) The impacts of weather, especially year-to-year changes in precipitation, must be considered because of its influence on the effects of burning on plants and plant communities in Fescue Prairies.

For fire to be reintroduced as a natural process in Fescue Prairie, it must occur within the natural range of variability (Romo, 2003). Variation in the timing, frequency, and location of burning will create a mosaic of patches within the plant community, in different stages of recovery (Watt, 1947), allowing a greater expression of biological diversity than current fire prescriptions (Pylypec and Romo, 2003; Romo, 2003). Altering the spatial extent of burning and the types of fire used are additional techniques available to conservationists and land managers using burning to enhance biodiversity in Fescue Prairie (Martin and Sapsis, 1991; Romo, 2003).

Reintroducing fire alone may be insufficient to restore the historic range of biodiversity in Fescue Prairie, as it is only part of the natural disturbance regime. The interaction of fire and grazing, with additional small-scale disturbances, creates a shifting mosaic of patches in different stages of succession, providing spatial and temporal heterogeneity in the landscape (Collins and Barber, 1985; Steuter *et al*., 1990; Crockett and Engle, 1999; Knapp *et al*., 1999; Fuhlendorf and Engle, 2001; 2004), essential for the persistence of biodiversity in remnant Fescue Prairies.

Literature Cited

Acton, D.F. and J.G. Ellis. 1978. The soils of the Saskatoon map area. Saskatchewan Inst. Pedology. Pub. S4. Univ. Saskatchewan, Saskatoon, SK.

Acton, D.F., G.A. Padbury, and C.T. Stushnoff. 1998. The ecoregions of Saskatchewan. Plains Res. Center. Univ. Regina, Regina, SK.

Aguado-Santacruz, G.A. and E. Garcia-Moya. 1998. Environmental factors and community dynamics at the southern most part of the North American Graminetum. I. On the contribution of climatic factors to temporal variation in species composition. Plant Ecol. 135:13-29.

Akinremi, O.O., S.M. McGinn, and H.W. Cutforth. 2001. Seasonal and spatial patterns of rainfall trends on the Canadian Prairies. J. Climate 14:2177-2182.

Alberta Prairie Conservation Forum. 2001. http://www.albertapcf.ab.ca/. 25 April, 2005.

Allen, R.B. and T.R. Partridge. 1988. Effects of spring and autumn fires on the composition of *Chionochloa rigida* tussock grassland, New Zealand. Vegetatio 76:37-44.

Anderson, H.G. and A.W. Bailey. 1980. Effects of annual burning on grassland in the Aspen Parkland of east-central Alberta. Can. J. Bot. 58:985-996.

Anderson, K.L., E.F. Smith, and C.E. Owensby. 1970. Burning bluestem range. J. Range Manage. 23:81-92.

Antos, J.A., B. McCune, and C. Bara. 1983. The effect of fire on an ungrazed western Montana grassland. Amer. Midl. Natur. 110:354-364.

Archibold, O.W., L.J. Nelson, E.A. Ripley, and L. Delanoy. 1998. Fire temperatures in plant communities of the Northern Mixed Prairie. Can. Field-Natur. 112:234-240.

Archibold, O.W., E.A. Ripley, and L. Delanoy. 2003. Effects of season of burning on the microenvironment of Fescue Prairie in central Saskatchewan. Can. Field-Natur. 117:257-266.

Archibold, O. W. and M.R. Wilson. 1980. The natural vegetation of Saskatchewan prior to agricultural settlement. Can. J. Bot. 58:2031-2042.

Armesto, J.J., S.T.A. Pickett, and M.J. McDonnell. 1991. Spatial heterogeneity during succession: A cyclic model of invasion and exclusion, p. 256-269. *In*: J. Kolasa. and S.T.A. Pickett (eds.), Ecological heterogeneity. Springer-Verlag, New York, NY.

Axelrod, D.I. 1985. Rise of the grassland biome, central North America. Bot. Rev. 51:163-201.

Bailey, A.W. 1978. Use of fire to manage grasslands of the Great Plains: Northern Great Plains and adjacent forests. Proc. 1st Int. Rangeland Congr. 1:691-693.

Bailey, A.W. and H.G. Anderson. 1978. Prescribed burning of a *Festuca-Stipa* grassland. J. Range Manage. 31:446-449.

Bailey, A.W. and H.G. Anderson. 1980. Fire temperatures in grass, shrub, and aspen forest communities of central Alberta. J. Range Manage. 33:37-40.

Bailey, A.W, B.D. Irving, and R.D. Fitzgerald. 1990. Regeneration of woody species following burning and grazing in Aspen Parkland. J. Range Manage. 43:212-215.

Bailey, A.W. and R.A. Wroe. 1974. Aspen invasion in a portion of the Alberta Parklands. J. Range Manage. 27:263-266.

Baines, G.B.K. 1973. Plant distributions on a Saskatchewan prairie. Vegetatio 28:99-123.

Barry, B., V. Gooliaff, and R. Reid. 1999. Development of transportation, p. 261. *In*: K. Fung, B. Barry and M. Wilson (eds.), Atlas of Saskatchewan, 2nd Ed. Univ. Saskatchewan, Saskatoon, SK.

Bestelmeyer, B.T. and J.A. Wiens. 2001. Ant biodiversity in semiarid landscape mosaics: The consequences of grazing vs. natural heterogeneity. Ecol. Appl. 11:1123-1140.

Billings, W.D. 1974. Adaptations and origins of alpine plants. Arctic Alpine Res. 6:129-142.

Billings, W.D. and L.C. Bliss. 1959. An alpine snowbank environment and its effects on vegetation, plant development and productivity. Ecology 40:388-397.

Biondini, M.E., B.D. Patton, and P.E. Nyren. 1998. Grazing intensity and ecosystem processes in a Northern Mixed-Grass Prairie. Ecol. Appl. 8:469-479.

Biondini, M.E., A.A. Steuter, and C.E. Grygiel. 1989. Seasonal fire effects on the diversity patterns, spatial distribution, and community structure of forbs in the Northern Mixed Prairie, USA. Vegetatio 85:21-31.

Blankespoor, G.W. and E.A. Larson. 1994. Response of smooth brome (*Bromus inermis* Leyss.) to burning under varying soil moisture conditions. Amer. Midl. Natur. 131:266-272.

Blood, D.A. 1966. The *Festuca scabrella* association of Riding Mountain National Park, Manitoba. Can. Field-Natur. 80:24-32.

Bogen, A.D., E.W. Bork, and W.D. Willms. 2002. Rough fescue (*Festuca campestris* Rydb.) response to heat injury. Can. J. Plant Sci. 82:721-729.

Bogen, A.D., E.W. Bork, and W.D. Willms. 2003. Defoliation impacts on *Festuca campestris* (Rydb.) plants exposed to wildfire. J. Range Manage. 56:375-381.

Bork, E.W., B.W. Adams, and W.D. Willms. 2002. Resilience of foothills rough fescue, *Festuca campestris*, rangeland to wildfire. Can. Field-Natur. 116:51-59.

Bowley, S.R. 1999. A hitchhiker's guide to statistics in plant biology. Any Old Subject Books. Guelph, ON.

Bradley, C. and C. Wallis. 1996. Prairie ecosystem management: An Alberta perspective, p. 25-44. *In*: W.D. Willms and J.F. Dormaar (eds.), Proc. 4th Prairie Conserv. Endangered Species Workshop. Prov. Museum Alberta Natur. History Occasional Paper 23. Edmonton, AB.

Bray, J.R. and J.T. Curtis. 1957. An ordination of the upland forest communities in southern Wisconsin. Ecol. Monogr. 27:325-349.

Briske, D.D. and J.H. Richards. 1995. Plant responses to defoliation: A physiological, morphological, and demographic evaluation, p. 635-710. *In*: D.J. Bedunah and R.E. Sosebee (eds.), Wildland plants: Physiological ecology and developmental morphology. Soc. Range Manage, Denver, CO.

Britton, C.M. and H.A. Wright. 1971. Correlation of weather and fuel variables to mesquite damage by fire. J. Range Manage. 24:136-141.

Brockway, D.G., R.G. Gatewood, and R.B. Paris. 2002. Restoring fire as an ecological process in Shortgrass Prairie ecosystems. J. Environ. Manage. 65:135-152.

Brown, C.L. and R.J. Whelan. 1999. Seasonal occurrence of fire and availability of germinable seeds in *Hakea sericea* and *Petrophile sessilis*. J. Ecol. 87:932-941.

Burnett, M.R., P.V. August, J.H. Brown, Jr., and K.T. Killingbeck. 1998. The influence of geomorphological heterogeneity on biodiversity. I. A patch-scale perspective. Conserv. Biol. 12:363-370.

Busso, C.A., J.H. Richards, and N.J. Chatterton. 1990. Nonstructural carbohydrates and spring regrowth of two cool season grasses: Interaction of drought and clipping. J. Range Manage. 43:336-343.

Caldwell, M.M. 1984. Plant requirements for prudent grazing, p. 117-152. *In*: Developing strategies for rangeland management. Report Prepared by the Committee on Developing Rangeland Manage. Nat. Res. Counc./Nat. Acad. Sci. Westview Press, Boulder, CO.

Carlsson, B.A. and T.V. Callaghan. 1991. Positive plant interactions in tundra vegetation and the importance of shelter. J. Ecol. 79:973-983.

Ceballos, G., J. Pacheco, and R. List. 1999. Influence of prairie dogs (*Cynomys ludovicianus*) on habitat heterogeneity and mammalian diversity in Mexico. J. Arid Environ. 41:161–172.

Chapin, III, F.S. and G.R. Shaver. 1985. Individualistic growth response of tundra plant species to environmental manipulations in the field. Ecology 66:564-576.

Christiansen, E.A. 1979. The Wisconsinan deglaciation of southern Saskatchewan and adjacent areas. Can. J. Earth Sci. 16:913-938.

Collins, S.L. 1989. Experimental analysis of patch dynamics and community heterogeneiety in Tallgrass Prairie. Vegetatio 85:57-66.

Collins, S.L. 1992. Fire frequency and community heterogeneity in Tallgrass Prairie vegetation. Ecology 73:2001-2006.

Collins, S.L. and S.C. Barber. 1985. Effects of disturbance on diversity in Mixed-Grass Prairie. Vegetatio 64:87-94.

Connell, J.H. and Slayter, R.O. 1977. Mechanisms of succession in natural communities and their roles in community stability and organization. Amer. Natur. 111:1119-1144.

Cosby, H.E. 1965. Fescue grassland in North Dakota. J. Range Manage. 18:284-285.

Coupland, R.T. 1950. Ecology of Mixed Prairie in Canada. Ecol. Monogr. 20:271-315.

Coupland, R.T. 1958. The effects of fluctuations in weather upon the grasslands of the Great Plains. Bot. Rev. 24:273-317.

Coupland, R.T. 1961. A reconsideration of grassland classification in the Northern Great Plains of North America. J. Ecol. 49:135-167.

Coupland, R.T. 1992. Fescue Prairie, p. 291-295. *In*: R.T. Coupland (ed.), Natural grasslands: Ecosystems of the world 8A. Elsiever, New York, NY.

Coupland, R.T. and T.C. Brayshaw. 1953. The fescue grassland in Saskatchewan. Ecology 34:386-405.

Coupland, R.T. and R.E. Johnson. 1965. Rooting characteristics of native grassland species in Saskatchewan. J. Ecol. 53:475-507.

Crockett, J.S. and D.M. Engle. 1999. Combustion characteristics of bison (*Bison bison*) fecal pats ignited by grassland fires. Amer. Midl. Natur. 141:12-18.

Curtis, J.T. and M.L. Partch. 1948. Effect of fire on the competition between blue grass and certain prairie plants. Amer. Midl. Natur. 39:437-443.

Dahl, B.E. and D.N. Hyder. 1977. Developmental morphology and management implications, p. 257-290. *In*: Range Sci. Ser. 4: Range Plant Physiol. Soc. Range Manage, Denver, CO.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Sci. 33:43-66.

Daubenmire, R. 1968. Ecology of fire in grasslands. Adv. Ecol. Res. 5:209-266.

DeFosseé, G. E. and R. Robberecht. 1996. Effects of competition on the post-fire recovery of 2 bunchgrass species. J. Range Manage. 49:137-142.

DeJong, E. and K.B. MacDonald. 1975. The soil moisture regime under a native grassland. Geoderma 14:207-221.

Dennis, P., M.R. Young, and I.J. Gordon. 1998. Distribution and abundance of small insects and arachnids in relation to structural heterogeneity of grazed, indigenous grasslands. Ecol. Entomol. 23:253–264.

Denslow, J.S. 1985. Disturbance-mediated coexistence of species, p. 307-321. *In*: S.T.A. Pickett and P.S. White (eds.), The ecology of natural disturbance and patch dynamics. Acad. Press, San Diego, CA.

Driver, E.A. 1987. Fire on grasslands - friend or foe? Blue Jay 45:217-225.

Dudley, J.L. and K. Lajtha. 1993. Effects of prescribed burning on nutrient availability and primary production in sandplain grasslands. Amer. Midl. Natur. 130:286-298.

Dyson, I.W. 1996. Canada's prairie conservation action plan, p. 175-186. *In*: F.B. Samson and F.L. Knopf (eds.), Prairie conservation: Preserving North America's most endangered ecosystem. Island Press, Covela, CA.

Engle, D.M. and T.G. Bidwell. 2001. Viewpoint: The response of central North American prairies to seasonal fire. J. Range Manage. 54:2-10.

Erichsen-Arychuk, C., E.W. Bork, and A.W. Bailey. 2002. Northern dry mixed prairie responses to summer wildfire and drought. J. Range Manage. 55:164-170.

Facelli, J.M. and S.T.A. Pickett. 1991. Plant litter: Its dynamics and effects on plant community structure. Bot. Rev. 57:1-32.

Fletcher, R.J. and R.R. Koford. 2002. Habitat and landscape associations of breeding birds in native and restored grasslands. J. Wildl. Manage. 66:1011-1022.

Friedel, H.M. 1991. Range condition assessment and the concept of thresholds: A viewpoint. J. Range Manage. 44:422-426.

Fuhlendorf, S.D. and D.M. Engel. 2001. Restoring heterogeneity on rangelands: Ecological management based on evolutionary grazing patterns. BioScience 51:625-632.

Fuhlendorf, S.D. and D.M. Engel. 2004. Application of the fire–grazing interaction to restore a shifting mosaic on Tallgrass Prairie. J. Appl. Ecol. 41:604-614.

Gauch, H.G. 1982. Multivariate analysis in community ecology. Cambridge Univ. Press, New York, NY.

Gerling, H.S., A.W. Bailey, and W.D. Willms. 1995. The effects of burning on *Festuca hallii* in the Parklands of central Alberta. Can. J. Bot. 73:937-942.

Gibson, D.J. and L.C. Hulbert. 1987. Effects of fire, topography, and year-to-year climatic variation on species composition in Tallgrass Prairie. Vegetatio 72:175-183.

Glenn, S.M., S.L. Collins, and D.J. Gibson. 1992. Disturbances in Tallgrass Prairie: Local and regional effects on community heterogeneity. Landscape Ecol. 7:243-251.

Gomez, K.A. and A.A. Gomez. 1976. Statistical procedures of agricultural research, with emphasis on rice. Inter. Rice Res. Inst., Los Banos, PH.

Grilz, P.L. and J.T. Romo. 1994. Water relations and growth of *Bromus inermis* Leyss (smooth brome) following spring or autumn burning in a Fescue Prairie. Amer. Midl. Natur. 132:340-348.

Grilz, P.L. and J.T. Romo. 1995. Management considerations for controlling smooth brome in Fescue Prairie. Natur. Areas J. 15:148-156.

Hadley, E.B. 1970. Net productivity and burning responses of native eastern North Dakota prairie communities. Amer. Midl. Natur. 84:121-135.

Higgins, K.F. 1986. Interpretation and compendium of historical fire accounts in the Northern Great Plains. U.S. Fish Wildl. Serv. Resource Pub. 161. Washington, DC.

Hill, M.J., R.J. Aspinall, and W.D. Willms. 1997. Knowledge based and inductive modelling of rough fescue (*Festuca altaica, F. campestris,* and *F. hallii*) distribution in Alberta, Canada. Ecol. Modeling 103:135-150.

Hobbs, N.T. and D.S. Schimel. 1984. Fire effects on nitrogen mineralization and fixation in mountain shrub and grassland communities. J. Range Manage. 37:402-405.

Hobbs, R.J. and L.F. Huenneke. 1992. Disturbance, diversity and invasion: Implications for conservation. Conserv. Biol. 6:324-337.

Hodgkinson, H.S. and A.E. Young. 1973. Rough fescue (*Festuca scabrella* Torr.) in Washington. J. Range Manage. 26:25-26.

Hopkins, H.H. 1954. Effects of mulch upon certain factors of the grassland environment. J. Range Manage. 7:255-258.

Horton, P.R. 1991. Some effects of defoliation on plains rough fescue (*Festuca hallii* [Vasey] Piper) in central Alberta. Ph.D Thesis, Univ. Alberta, Edmonton, AB.

Howe, H.F. 1995. Succession and fire season in experimental prairie plantings. Ecology 76:1917-1925.

Hulbert, L.C. 1988. Causes of fire effects in Tallgrass Prairie. Ecology 69:46-58.

James, P., K. Murphy, E. Espie, D. Gauthier, and R. Anderson. 2001. Predicting the impact of climate change on fragmented prairie biodiversity: A pilot landscape model. Final Rep. Climate Change Action Fund. Univ. Regina, Regina, SK.

James, S.E., M. Partel, S.D. Wilson, and D.A. Peltzer. 2003. Temporal heterogeneity of soil moisture in grassland and forest. J. Ecol. 91:234-239.

Johnson, P.L. and W.D. Billings. 1962. The alpine vegetation of the Beartooth Plateau in relation to cryopedogenic processes and patterns. Ecol. Monogr. 32:105-135.

Johnson, S.R. and A.K. Knapp. 1995. The influence of fire on *Spartina pectinata* wetland communities in a northeastern Tallgrass Prairie. Can. J. Bot. 73:84-90.

Jonasson, S. 1992. Plant responses to fertilization and species removal in tundra related to community structure and clonality. Oikos 63:420-429.

Jourdonnais, C.S. and D.J. Bedunah. 1990. Prescribed fire and cattle grazing on an elk winter range in Montana. Wildl. Soc. Bull. 18:232-240.

Kammer, P.M. 2002. Developmental responses of subdominant grassland species to current weather conditions and their relevance for annual vegetation changes. Folia-Geobotanica 37:185-204.

Kaye, T.N., K.L. Pendergrass, K. Finley, and J.B. Kaufman. 2001. The effect of fire on the population viability of an endangered prairie plant. Ecol. Appl. 11:1366-1380.

Keeley, J.E. and C.J. Fotheringham. 2000. Role of fire in regeneration from seed, p. 311-330. *In*: M. Fenner (ed.), Seeds: The ecology of regeneration in plant communities, 2nd Ed. CABI Publ., New York, NY.

Kerr, D.S., L.J. Morrison, and K.E. Wilkinson. 1993. Reclamation of native grasslands in Alberta: A review of the literature. Alberta Land Conserv. Reclamation Counc. Rep. No. RRTAC 93-1. Edmonton, AB.

Knapp, A.K., J.M. Blair, J.M. Briggs, S.L. Collins, D.C. Hartnett, L.C. Johnson, and E.G. Towne. 1999. Keystone role of bison in North American Tallgrass Prairie. BioScience 49:39-50.

Kolasa, J. and C.D. Rollo. 1991. Introduction: The heterogeneity of heterogeneity: A glossary, p. 1-23. *In*: J. Kolasa. and S.T.A. Pickett (eds.), Ecological heterogeneity. Springer-Verlag, New York, NY.

Kowalenko, B.L. and J.T. Romo. 1998a. Defoliation and cold hardiness of northern wheatgrass. J. Range Manage. 51:63-68.

Kowalenko, B.L. and J.T. Romo. 1998b. Regrowth and rest requirements of northern wheatgrass following defoliation. J. Range Manage. 51:73-78.

Kucera, C.L. and M. Koelling. 1964. The influence of fire on composition of a central Missouri prairie. Amer. Midl. Natur. 72:142-147.

Lauenroth, W.K. and J.L. Dodd. 1979. Response of native grassland legumes to water and nitrogen treatments. J. Range Manage. 32:292-294.

Lawton, J.H. 1983. Plant architecture and the diversity of phytophagous insects. Ann. Rev. Entomol. 28:23–39.

Laycock, W.A. 1958. The initial pattern of revegetation of pocket gopher mounds. Ecology 39:346-351.

Laycock, W.A. 1991. Stable states and thresholds of range condition on North American rangelands: A viewpoint. J. Range Manage. 44:427-433.

Leach, M.K. and T.J. Givnish. 1996. Ecological determinants of species loss in remnant prairies. Science 273:1555-1558.

Leeson, J.Y., J.W. Sheard, and A.G. Thomas. 2000. Weed communities associated with arable Saskatchewan management systems. Can. J. Plant Sci. 80:177-185.

Lesica, P. 1999. Effects of fire on the demography of the endangered geophytic herb, *Silene spaldingii* (Caryophyllaceae). Amer. J. Bot. 86:996-1002.

Lesica, P. and B. Martin. 2003. Effects of prescribed fire and season of burn on recruitment of the invasive exotic plant *Potentilla recta*, in a semiarid grassland. Restor. Ecol. 11:516-523.

Looman, J. 1969. The fescue grasslands of western Canada. Vegetatio 19:128-145.

MacArthur, R.H. and E.O. Wilson. 1967. The theory of island biogeography. Princeton Univ. Press, Princeton, MA.

Madden, E.M., A.J. Hansen, and R.K. Murphy. 1999. Influence of prescribed fire history on habitat and abundance of passerine birds in Northern Mixed-Grass Prairie. Can. Field-Natur. 113:627-640.

Madden, E.M., R.K. Murphy, A.J. Hansen, and L. Murray. 2000. Models for guiding management of prairie bird habitat in northwestern North Dakota. Amer. Midl. Natur. 144:377-392.

Martin, R.E. and D. B. Sapsis. 1991. Fires as agents of biodiversity: Pyrodiversity promotes biodiversity, p. 150-157. *In*: H.M. Kerner (ed.), Proc. Symposium Biodiversity Northwestern Calif. Univ. Calif, Berkeley, CA.

McLean, A. and L. Marchand. 1968. Grassland ranges in the southern interior of British Columbia. Can. Dept. Agr. Pub. 1319. Ottawa, ON.

McCune, B. and J.B. Grace. 2002. Analysis of ecological communities. MJM Software, Gleneden Beach, OR.

McCune, B. and M.J. Mefford. 1999. Multivariate analysis of ecological data, version 4.10. MJM Software, Gleneden Beach, OR.

McDaniel. K.C., Hart, R.C., and D.B. Carroll. 1997. Broom snakeweed control with fire on New Mexico blue grama rangeland. J. Range Manage. 50:652-659.

Mead, R., R.N. Cowan, and M. Hasted. 1993. Statistical methods in agriculture and experimental biology, 2^{nd} Ed. Chapman and Hall, London, UK.

Miles, J. 1987. Vegetation succession: Past and present perceptions, p. 1-29. *In*: A.J. Gray, M.J. Crawley, and P.J. Edwards (eds.), Colonization, succession, and stability. Blackwell, Oxford, UK.

Moss, E.H. 1944. The prairie and associated vegetation of southwestern Alberta. Can. J. Res. 22:11-31.

Moss, E.H., and J.A. Campbell. 1947. The fescue grasslands of Alberta. Can. J. Res. 25:209-227.

Mueggler, W.F. 1975. Rate and pattern of vigor recovery in Idaho fescue and bluebunch wheatgrass. J. Range Manage. 28:198-204.

Mueggler, W.F. and W.L. Stewart. 1980. Grassland and shrubland habitat types of western Montana. USDA For. Serv. Gen. Tech. Rep. INT-99. Ogden, UT.

Nagel, H.G., R.A. Nicholson, and A.A. Steuter. 1994. Management effects on Willa Cather Prairie after 17 years. Prairie Natur. 26:241-249.

Nelson, J.G. and R.E. England. 1971. Some comments on the causes and effects of fire in the northern grasslands area of Canada and the nearby United States, ca. 1750-1900. Can. Geogr. 15:295-306.

Niering, W.A. and G.D. Dreyer. 1989. Effects of prescribed burning on *Andropogon scoparius* in postagriculture grasslands in Connecticut. Amer. Midl. Natur. 122:88-102.

Old, S.M. 1969. Microclimate, fire, and plant production in an Illinois prairie. Ecol. Monogr. 39:355-384.

Owens, M.K., J.W. Mackley, and C.J. Carol. 2002. Vegetation dynamics following seasonal fires in mixed mesquite/acacia savannas. J. Range Manage. 55:509-516.

Pavlick, L.E. and J. Looman. 1984. Taxonomy and nomenclature for rough fescue, *Festuca altaica*, *F. campestris* (*F. scabrella* var. *major*), and *F. hallii*, in Canada and adjacent parts of the United States. Can. J. Bot. 62:1739-1749.

Petersen, R.G. 1985. Design and analysis of experiments. Marcel Dekker, Inc. New York, NY.

PCAP Partnership. 2003. Saskatchewan prairie conservation action plan 2003-2008. Can. Plains Res. Cen., Univ. Regina, Regina, SK.

Phillips, P. 1936. The distribution of rodents in overgrazed and normal grasslands of central Oklahoma. Ecology 17:673-679.

Platt, W.J. 1975. The colonization and formation of equilibrium plant species associations of badger disturbances in Tallgrass prairie. Ecol. Monogr. 45:285-305.

Pylypec. B. 1986. The Kernen prairie: A relic fescue grassland near Saskatoon, Saskatchewan. Blue Jay 44:222-231.

Pylypec, B. and J.T. Romo. 2003. Long-term effects of burning *Festuca* and *Stipa-Agropyron* grasslands. J. Range Manage. 56:640-645.

Qian, H., K. Klinka, R.H. Økland, P. Krestov, and G.J. Kayahara. 2003. Understorey vegetation in boreal *Picea mariana* and *Populus tremuloides* stands in British Columbia. J. Veg. Sci. 14:173-184.

Redmann, R.E. 1978. Plant and soil water potentials following fire in a northern mixed grassland. J. Range Manage. 31:443-445.

Redmann, R.E. 1991. Nitrogen losses to the atmosphere from grassland fires in Saskatchewan, Canada. Int. J. Wildland Fire 1:239-244.

Redmann, R.E., J.T Romo, B. Pylypec, and E.A. Driver. 1993. Impacts of burning on primary productivity of *Festuca* and *Stipa-Agropyron* grasslands in central Saskatchewan. Amer. Midl. Natur. 130:262-273.

Romo, J.T. 2003. Reintroducing fire for conservation of Fescue Prairie Association remnants in the northern Great Plains. Can. Field-Natur. 117:89-99.

Romo, J.T., P.L. Grilz, R.E. Redmann, and E.A. Driver. 1993. Standing crop, biomass allocation patterns & soil-plant water relations in *Symphoricarpos occidentalis* Hook. following autumn or spring burning. Amer. Midl. Natur. 130:106-115.

Ross, R.L. and H.E. Hunter. 1976. Climax vegetation of Montana based on soils and climate. USDA Soil Conserv. Serv. Bozeman, MT.

Roth, R.R. 1976. Spatial heterogeneity and bird species diversity. Ecology 57:773-782.

Sharrow, S.H. and H.A. Wright. 1977. Effects of fire, ash, and litter on soil nitrate, temperature, moisture, and tobosagrass production in the Rolling Plains. J. Range Manage. 30:266-270.

Shay, J., D. Kunec, and B. Dyck. 2001. Short-term effects of fire frequency on vegetation composition and biomass in Mixed Prairie in southwestern Manitoba. Plant Ecol. 155:157-167.

Simpson, E.H. 1949. Measurement of diversity. Nature 163:688.

Smoliak, S. 1986. Influence of climatic conditions on production of *Stipa-Bouteloua* prairie over a 50-year period. J. Range Manage. 39:100-103.

Souster, W.E. 1979. Soils of the Kernen Crop Research Farm. Inst. Pedology Pub. M51. Univ. Saskatchewan, Saskatoon, SK.

Steuter, A.A., C.E. Grygiel, and M.E. Biondini. 1990. A synthesis approach to research and management planning: The conceptual development and implementation. Natur. Areas J. 10:61-68.

Steuter, A.A. and G.R. McPherson. 1995. Fire as a physical stress, p. 550-579. *In*: D.J. Bedunah and R.E. Sosebee (eds.), Wildland plants: Physiological ecology and developmental morphology. Soc. Range Manage. Denver, CO.

Stewart, A.J.A., E.A. John, and M.J. Hutchings. 2000. The world is heterogeneous: Ecological consequences of living in a patchy environment, p. 1-8. *In*: M.J. Hutchings, E.A. John, and A.J.A Stewart (eds.), The ecological consequences of environmental heterogeneity. Blackwell Science, Oxford, UK.

Stickney, P.F. 1960. Range of rough fescue (*Festuca scabrella* Torr.) in Montana. Proc. Mont. Acad. Sci. 2:12-17.

Stringer, P.W. 1973. An ecological study of grasslands in Banff, Jasper, and Waterton Lakes National Parks. Can. J. Bot. 51:383-411.

Sturm, M., J. Schimel, G. Michaelson, J.M. Welker, S.F. Oberbauer, G.E. Liston, J. Fahnestock, and V.E. Romanovsky. 2005. Winter biological processes could help convert arctic tundra to shrubland. BioScience 55:17-26.

Suding, K.N., K.L. Gross, and G.R. Houseman. 2004. Alternative states and positive feedbacks in restoration ecology. Trends Ecol. Evol. 19:46-53.

Swan, J.M.A. and R.L. Dix. 1966. The phytosociological structure of upland forest at Candle Lake, Saskatchewan. J. Ecol. 54:13-40.

ter Braak, C.J.F. 1986. Canonical correspondence analysis: A new eigenvector technique for multivariate direct gradient analysis. Ecology 67:1167-1179.

ter Braak, C.J.F. 1987. Ordination, p. 91-173. *In*: R.H.G. Jongman, C.J.F. ter Braak, and O.F.R.van Tongeren (eds.), Data analysis in community and landscape ecology. Pudoc, Wageingen, NL.

ter Braak, C.J.F. and P. Smilauer. 2002. CANOCO reference manual and CanoDraw for Windows user's guide: Software for Canonical Community Ordination (version 4.5). Microcomputer Power, Ithica, New York, NY.

Tews, J., U. Brose, V. Grimm, K. Tielborger, M. C. Wichman1, M. Schwager and F. Jeltsch. 2004. Animal species diversity driven by habitat heterogeneity/diversity: The importance of keystone structures. J Biogeogr. 31:79-92.

Tisdale, E.W. 1947. The grasslands of the Southern Interior of British Columbia. Ecology 28:346-382.

Thilenius, J.F. 1975. Apline range management in the western United States-Principles, practices, and problems: The status of our knowledge. USDA Forest Serv. Res. Paper RM-157. Fort Collins, CO.

Thorpe, J. 1999. Natural vegetation, p. 133-137. *In*: K. Fung, B. Barry and M Wilson (eds.), Atlas of Saskatchewan, 2nd Ed., Univ. Saskatchewan, Saskatoon, SK.

Thorpe, J. and B. Godwin. 1999. Threats to biodiversity in Saskatchewan. Plant Ecol. Sec. Environ. Branch SRC Pub. No. 11158-1C99, Saskatoon, SK.

Tourism Saskatchewan. 1994. The great Saskatchewan vacation book. Saskatchewan Economic Development, Regina, SK.

Towne, E.G. and K.E. Kemp. 2003. Vegetation dynamics from annually burning Tallgrass Prairie in different seasons. J. Range Manage. 56:185-192.

Towne, G. and C. Owensby. 1984. Long-term effects of annual burning at different dates in ungrazed Kansas Tallgrass Prairie. J. Range Manage. 37:392-397.

Toynbee, K. 1987. Prolific flowering year for plains rough fescue at the Kernen Prairie. Blue Jay 45:142-143.

Turner, M.G., V.H. Dale, and E.H. Everham III. 1999. Fires, hurricanes, and volcanoes: Comparing large disturbances. BioScience 47:758-768.

Turner, M.G., R.H. Gardner, and R.V. O'Neill. 2001. Landscape ecology in theory and practice: Pattern and process. Springer-Verlag Publ., New York, NY.

Urban, D.L., R.V. O'Neill, and H.H. Shugart Jr. 1987. Landscape ecology: A hierarchical perspective can help scientists understand spatial patterns. BioScience 37:119-127.

Walter, H. and H. Lieth. 1960-1967. Klimadiagramm-Weltatlas. VEG Gustav Fischer-Verlag, Jena, DE.

Watt, A.S. 1947. Pattern and process in the plant community. J. Ecol. 35:1-22.

Watt, A.S. 1956. Contributions to the ecology of bracken (*Pteridium aquilinum*). VII. Bracken and litter. 1. The origin of rings. New Phytol. 55:369-388.

West, N.E. 1993. Biodiversity in rangelands. J. Range Manage. 46:2-13.

Westoby, M., B. Walker, and I. Noy-Meir. 1989. Opportunistic management for rangelands not at equilibrium. J. Range Manage. 42:266-274.

White, C.S. and S.R. Loftin. 2000. Responses of 2 semiarid grasslands to cool-season prescribed fire. J. Range Manage. 53:52-61.

White, L.M. 1973. Carbohydrate reserves in grasses: A review. J. Range Manage. 26:13-18.

White, P.S. and S.T.A Pickett. 1985. Natural disturbance and patch dynamics: An introduction, p. 3-13. *In*: S.T.A. Pickett and P.S. White (eds.), The ecology of natural disturbance and patch dynamics. Academic Press, San Diego, CA.

Whitman, W.C. 1974. Influence of grazing on the microclimate of Mixed Grass Prairie, p. 207-218. *In*: K.W. Krietlow and R.H. Hart (coordinators), Plant morphogenesis as the basis for scientific management of range resources. USDA Misc. Pub. 1271. Fort Collins, CO.

Wiens, J.A. 2000. Ecological heterogeneity: An ontogeny of concepts and approaches, p. 9-32. *In*: M.J. Hutchings, E.A. John, and A.J.A Stewart (eds.), The ecological consequences of environmental heterogeneity. Blackwell Sci., Oxford, UK.

Willms, W.D., S. Smoliak, and A.W. Bailey. 1986. Herbage production following litter removal on Alberta native grasslands. J. Range Manage. 39:536-540.

World Wildlife Fund. 1988. Prairie conservation action plan: 1989 – 1994. World Wildl. Fund Canada, Toronto, ON.

Wright, H.A. and A.W. Bailey. 1982. Fire ecology: United States and southern Canada. Wiley-InterScience Publ., New York, NY.

Appendix A

Table 1. Cover (%) of bare soil and litter and canopy cover (%) of grasses, sedges, forbs, and shrubs sampled in 1998 after burning in 1997-1998 at different times of the year in plots not previously burned and plots burned 5 years earlier at Kernen Prairie, near Saskatoon, SK. Nomenclature is from Integrated Taxonomic Information System [http://www.itis.usda.gov/index.html]. Last updated: 23 November 2004.

	Bare soil	Litter	**Grasses**	*Agrostis scabra*	*Bouteloua gracilis*	*Calamagrostis montanensis*	*Calamagrostis stricta spp. inexpansa*	*Calamagrostis stricta spp. stricta*	*Elymus lanceolatus*	*Elymus trachycaulus spp. subsecundus*	*Elymus trachycaulus spp. trachycaulus*	*Festuca hallii*	*Helictotrichon hookeri*	*Hesperostipa comata*	*Hesperostipa curtiseta*	*Koeleria macrantha*	*Muhlenbergia richardsonis*	*Nassella viridula*	*Pascopyrum smithii*	*Poa compressa*	*Poa cusickii*	*Poa palustris*	*Poa pratensis*
----------Not previously burned----------																							
Control	3	97	x	0	0	0	0	<1	<1	<1	0	47	5	0	4	2	0	0	0	<1	0	0	<1
15 Nov. 1997	44	36	x	0	0	0	0	7	2	1	0	19	<1	0	1	<1	0	0	0	0	<1	0	0
17 Dec. 1997	53	26	x	0	<1	0	0	2	<1	<1	0	21	5	0	4	<1	0	0	0	0	0	0	<1
27 Mar. 1998	3	95	x	0	0	0	0	<1	1	1	0	37	<1	0	4	1	0	0	0	<1	0	0	<1
16 Apr. 1998	44	31	x	<1	<1	0	0	0	1	1	0	26	2	0	2	1	0	0	0	0	0	0	0
1 May 1998	61	22	x	0	0	<1	0	3	2	4	0	20	<1	0	3	2	0	0	0	0	0	0	<1
13 May 1998	71	15	x	0	0	0	0	0	<1	4	0	10	0	0	6	1	0	0	0	0	0	0	0
25 May 1998	49	32	x	0	0	<1	0	0	<1	2	0	12	3	0	2	1	0	0	0	0	0	0	<1
5 Jun. 1998	75	18	x	0	0	0	0	0	4	5	0	11	0	0	7	1	0	0	0	4	0	0	0
27 Jun. 1998	80	15	x	0	0	0	0	0	<1	2	0	12	<1	0	3	0	<1	<1	0	0	0	0	<1
14 Jun. 1998	11	85	x	0	<1	0	0	0	<1	1	0	8	<1	0	1	1	0	0	0	0	0	0	0
25 Aug. 1998	50	32	x	0	<1	0	0	0	2	<1	0	2	2	0	1	1	0	0	0	0	0	0	<1
----------Burned 5 years earlier----------																							
Control	3	97	x	0	0	0	0	0	1	<1	0	30	3	0	14	3	0	0	0	0	0	0	<1
15 Nov. 1997	29	43	x	0	<1	0	0	0	2	2	0	9	<1	0	2	4	0	0	0	0	0	0	1
17 Dec. 1997	34	29	x	0	0	0	0	0	3	<1	0	22	2	0	1	<1	0	0	0	0	0	0	<1
27 Mar. 1998	11	85	x	0	0	0	0	0	2	2	0	22	3	0	6	2	<1	2	0	0	0	0	<1
16 Apr. 1998	25	41	x	0	<1	<1	0	0	6	1	0	10	1	0	2	1	0	0	0	7	<1	0	0
1 May 1998	28	26	x	0	<1	0	0	0	4	5	0	11	0	0	<1	<1	0	0	0	0	0	0	<1
13 May 1998	45	28	x	0	<1	0	0	0	2	5	0	10	2	0	1	<1	0	0	0	0	0	0	0
25 May 1998	32	45	x	0	<1	0	0	0	2	3	0	6	<1	0	5	1	0	0	0	<1	0	0	0
5 Jun. 1998	54	23	x	0	<1	0	0	0	2	2	0	11	4	0	2	2	0	0	0	1	0	0	<1
27 Jun. 1998	30	48	x	0	<1	0	0	0	1	2	0	7	<1	0	0	3	0	0	0	<1	0	0	0
14 Jun. 1998	21	51	x	0	0	0	0	0	3	0	0	8	1	0	2	<1	0	0	0	0	0	0	0
25 Aug. 1998	22	66	x	0	0	0	0	0	8	<1	0	19	1	0	<1	<1	0	0	0	0	<1	0	0

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	Setaria viridis	**Sedges**	*Carex duriuscula*	*Carex filifolia*	*Carex obtusata*	*Carex pensylvanica*	*Carex praegracilis*	*Carex praticola*	**Forbs**	*Achillea millefolium*	*Agoseris glauca*	*Amaranthus sp.*	*Androsace septentrionalis*	*Antennaria neglecta*	*Antennaria parvifolia*	*Arabis divaricarpa*	*Arabis hirsuta*	*Arabis holboellii*	*Artemisia frigida*	*Artemisia ludoviciana*	*Astragalus adsurgens*	*Astragalus flexuosus*	*Astragalus pectinatus*
---Not previously burned---																							
Control	0	x	<1	0	2	4	0	0	x	<1	0	0	0	0	0	0	0	0	2	2	0	0	0
15 Nov. 1997	0	x	<1	0	7	19	0	0	x	<1	0	0	0	0	0	0	0	0	3	0	0	0	0
17 Dec. 1997	0	x	<1	0	6	17	0	0	x	<1	0	0	0	0	0	0	0	0	<1	14	0	0	0
27 Mar. 1998	0	x	<1	0	5	10	0	0	x	<1	0	0	0	0	0	0	0	0	<1	2	0	0	0
16 Apr. 1998	0	x	0	0	3	14	0	0	x	<1	0	0	0	0	0	0	0	0	<1	<1	<1	0	0
1 May 1998	0	x	<1	0	4	12	0	0	x	0	0	0	0	0	0	0	0	0	1	<1	<1	0	0
13 May 1998	0	x	0	0	4	22	0	0	x	<1	0	0	0	0	0	0	0	0	0	<1	<1	0	0
25 May 1998	0	x	<1	0	3	14	0	0	x	<1	0	0	0	0	0	0	0	0	2	2	0	0	0
5 Jun. 1998	0	x	0	0	2	14	0	0	x	0	0	0	0	0	0	0	0	0	<1	3	3	0	0
27 Jun. 1998	0	x	2	0	2	11	0	0	x	<1	0	0	0	0	0	0	0	0	0	<1	0	0	0
14 Jun. 1998	0	x	0	0	2	2	0	0	x	0	0	0	0	0	0	0	0	0	0	0	<1	0	0
25 Aug. 1998	0	x	<1	0	2	2	0	0	x	<1	0	0	0	0	0	0	0	0	0	<1	0	0	0
---Burned 5 years earlier---																							
Control	0	x	<1	0	30	7	0	0	x	0	0	0	0	0	0	0	0	0	<1	5	0	0	0
15 Nov. 1997	0	x	4	0	5	24	0	0	x	<1	0	0	0	0	0	0	0	0	<1	1	0	0	0
17 Dec. 1997	0	x	0	0	8	17	0	0	x	<1	0	0	0	0	0	0	0	0	0	2	0	0	0
27 Mar. 1998	0	x	3	<1	16	12	0	0	x	0	0	0	0	0	<1	0	0	0	3	3	0	0	0
16 Apr. 1998	0	x	0	0	7	26	0	0	x	<1	0	0	0	0	0	0	0	0	<1	3	0	0	0
1 May 1998	0	x	2	0	14	14	0	0	x	0	0	0	0	0	0	0	0	0	<1	0	0	0	0
13 May 1998	0	x	<1	0	6	20	0	0	x	<1	0	0	0	0	0	0	0	0	<1	<1	0	0	0
25 May 1998	0	x	<1	0	5	20	0	0	x	<1	0	0	0	0	<1	0	0	0	<1	3	0	0	0
5 Jun. 1998	0	x	1	0	4	14	0	0	x	<1	0	0	0	0	0	0	0	0	1	2	0	0	0
27 Jun. 1998	0	x	12	0	12	12	0	0	x	<1	0	0	0	0	0	0	0	0	0	<1	0	0	0
14 Jun. 1998	0	x	6	0	2	3	0	0	x	<1	0	0	0	0	0	0	0	0	<1	<1	0	0	0
25 Aug. 1998	0	x	<1	0	6	20	0	0	x	<1	0	0	0	0	<1	0	0	0	2	3	0	0	0

Table continued on next page

Table continued

	Axyris amaranthoides	*Campanula rotundifolia*	*Cerastium arvense*	*Chenopodium album*	*Cirsium arvense*	*Cirsium flodmanii*	*Comandra umbellata*	*Conyza canadensis var. canadensis*	*Crepis tectorum*	*Descurainia sophia*	*Erigeron caespitosus*	*Erigeron lonchophyllus*	*Erysimum inconspicuum*	*Fragaria virginiana*	*Gaillardia aristata*	*Galium boreale*	*Gentianella amarella*	*Geum triflorum*	*Helianthus pauciflorus ssp. subrhomboideus*	*Heterotheca villosa*	*Heuchera richardsonii*	*Lactuca tatarica var. pulchella*	*Lesquerella arenosa*
---Not previously burned---																							
Control	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 Nov. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
17 Dec. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	<1	0	0	0
16 Apr. 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	0
1 May 1998	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
13 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
25 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
5 Jun. 1998	0	0	0	3	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	0
14 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 Aug. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	0
---Burned 5 years earlier---																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 Nov. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 Dec. 1997	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
16 Apr. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 May 1998	0	<1	0	0	0	0	<1	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0
25 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Jun. 1998	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
14 Jun. 1998	0	0	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0
25 Aug. 1998	0	0	0	0	0	0	<1	0	0	0	3	0	0	0	0	<1	0	0	0	<1	0	0	0

Table continued on next page

Table continued

	Lomatium foeniculaceum	*Lygodesma juncea*	*Melilotus alba*	*Monarda bradburiana*	*Monolepis nuttalliana*	*Oligoneuron rigidum var. rigidum*	*Orthocarpus luteus*	*Oxytropis campestris*	*Oxytropis sericea*	*Pediomelum argophyllum*	*Pediomelum esculentum*	*Penstemon gracilis*	*Penstemon procerus*	*Phlox hoodii*	*Polygonum convolvulus*	*Potentilla arguta*	*Potentilla concinna*	*Potentilla gracilis*	*Potentilla pensylvanica*	*Pulsatilla patens ssp. multifida*	*Ratibida columnifera*	*Salsola kali*	*Selaginella densa*
---Not previously burned---																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
15 Nov. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1
17 Dec. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	2
16 Apr. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0
1 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
13 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1
5 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1
14 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
25 Aug. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	<1
---Burned 5 years earlier---																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 Nov. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
17 Dec. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
16 Apr. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
13 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0
25 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	2
5 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
27 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 Aug. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	<1	0	0	<1	0	0	<1	0	0	5

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Table continued

	Silene drummondii var. drummondii	*Sisyrinchium montanum*	*Solidago canadensis*	*Solidago missouriensis*	*Solidago simplex var. spathulata*	*Solidago sp.*	*Sonchus arvensis*	*Stellaria longipes*	*Symphyotrichum ericoides*	*Symphyotrichum laeve*	*Taraxacum officinale*	*Thalictrum venulosum*	*Thlaspi arvense*	*Tragopogon dubius*	*Vicia americana*	*Viola adunca*	*Zigadenus sp.*	*Zizia aptera*	**Shrubs**	*Elaeagnus commutata*	*Rosa arkansana*	*Spiraea alba*	*Symphoricarpos occidentalis*
-----Not previously burned-----																							
Control	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	x	0	<1	0	0
15 Nov. 1997	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	<1	0	0
17 Dec. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	0	0	0
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	x	0	<1	0	0
16 Apr. 1998	0	0	0	0	1	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	<1	0	<1
1 May 1998	0	0	0	0	4	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	2
13 May 1998	0	0	0	0	<1	0	0	0	4	0	0	0	0	0	0	0	0	0	x	0	<1	0	6
25 May 1998	0	0	0	<1	2	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	9
5 Jun. 1998	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
27 Jun. 1998	0	0	0	1	<1	0	0	0	2	0	0	0	0	0	0	0	0	0	x	0	0	0	0
14 Jun. 1998	0	0	0	<1	<1	0	0	0	0	0	0	0	0	0	<1	0	0	0	x	0	<1	0	1
25 Aug. 1998	0	0	0	0	<1	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	<1
-----Burned 5 years earlier-----																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	x	0	<1	0	4
15 Nov. 1997	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	0	0	0
17 Dec. 1997	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	2	0	2
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	<1	0	1
16 Apr. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	1	0	1
1 May 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	<1	0	1
13 May 1998	0	0	0	1	<1	0	0	0	2	0	0	0	0	0	<1	0	0	0	x	0	<1	0	3
25 May 1998	0	0	0	1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	0
5 Jun. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	<1	0	0
27 Jun. 1998	0	0	0	0	0	0	0	0	8	0	0	0	0	0	<1	0	0	0	x	0	<1	0	0
14 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	x	0	0	0	0
25 Aug. 1998	0	0	0	0	0	<1	0	0	3	0	0	0	0	0	0	0	0	0	x	0	<1	0	<1

Table 2. Cover (%) of bare soil and litter and canopy cover (%) of grasses, sedges, forbs, and shrubs sampled in 1999 after burning in 1997-1998 at different times of the year in plots not previously burned and plots burned 5 years earlier at Kernen Prairie, near Saskatoon, SK. Nomenclature is from Integrated Taxonomic Information System [http://www.itis.usda.gov/index.html]. Last updated: 23 November 2004.

	Bare soil	Litter	**Grasses**	*Agrostis scabra*	*Bouteloua gracilis*	*Calamagrostis montanensis*	*Calamagrostis stricta spp. inexpansa*	*Calamagrostis stricta spp. stricta*	*Elymus lanceolatus*	*Elymus trachycaulus spp. subsecundus*	*Elymus trachycaulus spp. trachycaulus*	*Festuca hallii*	*Helictotrichon hookeri*	*Hesperostipa comata*	*Hesperostipa curtiseta*	*Koeleria macrantha*	*Muhlenbergia richardsonis*	*Nassella viridula*	*Pascopyrum smithii*	*Poa compressa*	*Poa cusickii*	*Poa palustris*	*Poa pratensis*
---Not previously burned---																							
Control	3	98	x	<1	0	0	0	0	1	0	<1	20	7	0	14	0	0	0	<1	0	0	0	0
15 Nov. 1997	28	49	x	0	0	6	0	0	2	<1	0	27	2	0	8	0	0	0	0	0	0	0	0
17 Dec. 1997	37	39	x	<1	0	1	0	0	1	<1	0	26	3	0	5	0	0	0	0	0	0	0	0
27 Mar. 1998	3	94	x	0	0	<1	0	0	2	<1	0	49	<1	0	13	0	0	0	0	<1	0	0	0
16 Apr. 1998	37	41	x	0	0	<1	0	0	1	<1	0	28	4	0	6	<1	0	0	1	0	0	0	0
1 May 1998	24	54	x	0	0	2	0	0	7	0	0	29	4	0	5	0	0	<1	0	0	0	0	0
13 May 1998	25	52	x	0	0	<1	0	0	2	<1	0	18	0	0	16	0	0	0	4	0	0	0	0
25 May 1998	42	35	x	0	0	<1	0	0	2	<1	0	30	3	0	7	0	0	0	0	0	0	0	0
5 Jun. 1998	26	50	x	<1	0	<1	0	0	4	2	0	26	0	0	12	0	0	0	10	2	0	0	0
27 Jun. 1998	42	35	x	<1	0	<1	0	0	1	<1	0	18	4	0	11	<1	<1	0	0	0	0	0	0
14 Jun. 1998	9	78	x	0	0	<1	0	0	2	3	0	21	1	0	8	0	0	0	4	0	0	0	0
25 Aug. 1998	32	58	x	0	<1	2	0	0	2	<1	0	12	4	0	9	<1	0	0	<1	0	0	0	0
---Burned 5 years earlier---																							
Control	3	98	x	0	0	0	0	0	12	0	0	21	7	0	9	1	0	0	<1	0	0	0	0
15 Nov. 1997	21	34	x	0	0	<1	0	0	6	1	0	15	<1	0	8	1	0	0	<1	0	0	0	0
17 Dec. 1997	12	65	x	0	0	<1	0	0	4	1	0	22	<1	0	5	<1	0	0	<1	0	0	0	0
27 Mar. 1998	4	83	x	0	0	3	0	0	7	0	0	15	5	0	12	3	0	5	<1	0	0	0	0
16 Apr. 1998	13	15	x	0	0	<1	0	0	4	<1	0	18	1	0	3	1	0	0	3	0	0	0	<1
1 May 1998	9	27	x	0	0	2	0	0	3	<1	0	9	<1	0	9	2	0	0	2	0	0	0	3
13 May 1998	30	44	x	0	0	<1	0	0	6	0	0	11	<1	0	10	<1	0	0	2	0	0	0	0
25 May 1998	18	49	x	0	0	<1	0	0	7	2	0	22	4	0	7	2	0	<1	0	0	0	0	0
5 Jun. 1998	40	35	x	0	0	<1	0	0	7	<1	0	16	6	0	7	3	0	0	0	0	0	0	0
27 Jun. 1998	36	33	x	0	0	0	0	0	5	3	0	12	3	0	9	<1	0	0	<1	0	0	0	<1
14 Jun. 1998	16	43	x	0	0	<1	<1	0	5	<1	<1	5	2	0	6	1	0	0	<1	0	0	0	0
25 Aug. 1998	18	37	x	0	0	<1	0	0	4	<1	<1	6	1	0	<1	<1	0	<1	2	0	0	3	3

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Table continued

	Setaria viridis	**Sedges**	*Carex duriuscula*	*Carex filifolia*	*Carex obtusata*	*Carex pensylvanica*	*Carex praegracilis*	*Carex praticola*	**Forbs**	*Achillea millefolium*	*Agoseris glauca*	*Amaranthus sp.*	*Androsace septentrionalis*	*Antennaria neglecta*	*Antennaria parvifolia*	*Arabis divaricarpa*	*Arabis hirsuta*	*Arabis holboellii*	*Artemisia frigida*	*Artemisia ludoviciana*	*Astragalus adsurgens*	*Astragalus flexuosus*	*Astragalus pectinatus*
Not previously burned																							
Control	0	x	0	<1	2	2	0	0	x	1	0	0	<1	0	0	0	0	0	0	4	<1	0	0
15 Nov. 1997	0	x	<1	0	6	9	0	0	x	<1	0	0	2	0	0	0	0	0	<1	1	<1	0	0
17 Dec. 1997	0	x	0	0	4	11	0	0	x	1	0	0	2	0	0	0	0	0	<1	10	<1	0	0
27 Mar. 1998	0	x	0	0	4	5	0	0	x	<1	0	0	1	0	0	0	0	0	2	<1	<1	0	0
16 Apr. 1998	0	x	<1	0	4	14	0	0	x	<1	0	0	2	0	0	0	0	0	<1	<1	<1	0	0
1 May 1998	0	x	0	0	9	15	0	0	x	<1	0	0	2	0	0	0	0	0	3	<1	<1	0	0
13 May 1998	0	x	<1	0	8	26	0	0	x	<1	0	0	1	0	0	0	0	0	3	2	1	0	0
25 May 1998	0	x	0	0	4	23	0	0	x	0	0	0	2	0	0	0	0	0	0	2	<1	0	0
5 Jun. 1998	0	x	0	0	3	12	0	0	x	0	0	0	2	0	0	0	0	0	<1	3	<1	0	0
27 Jun. 1998	0	x	0	<1	9	15	0	0	x	3	<1	0	2	0	<1	0	0	0	0	5	<1	0	0
14 Jun. 1998	0	x	0	0	3	5	0	0	x	0	0	0	4	0	0	0	<1	0	1	0	0	0	0
25 Aug. 1998	0	x	<1	0	3	16	0	0	x	0	0	0	1	0	<1	0	0	0	<1	1	<1	0	0
Burned 5 years earlier																							
Control	0	x	0	0	19	9	0	0	x	0	0	0	<1	0	0	0	0	0	<1	5	0	0	0
15 Nov. 1997	0	x	0	<1	19	17	0	0	x	<1	0	0	4	0	0	<1	0	0	<1	2	3	0	0
17 Dec. 1997	0	x	0	0	8	16	0	0	x	1	0	0	2	0	0	0	0	0	0	2	<1	0	0
27 Mar. 1998	0	x	4	0	18	9	0	0	x	0	0	0	2	0	<1	0	0	0	3	1	<1	0	0
16 Apr. 1998	0	x	0	<1	8	10	0	0	x	<1	0	0	2	0	0	<1	0	0	<1	2	<1	0	0
1 May 1998	0	x	0	0	7	14	0	0	x	<1	0	0	2	0	<1	0	0	0	3	3	<1	0	0
13 May 1998	0	x	0	<1	12	15	0	0	x	0	0	0	2	0	0	0	0	0	<1	1	1	0	0
25 May 1998	0	x	0	<1	13	27	0	0	x	0	<1	0	3	0	<1	0	0	0	<1	<1	<1	0	0
5 Jun. 1998	0	x	0	0	12	14	0	0	x	2	<1	0	2	0	<1	0	0	0	3	4	1	0	0
27 Jun. 1998	0	x	0	0	19	22	0	0	x	<1	0	0	3	0	<1	0	0	0	1	4	<1	0	0
14 Jun. 1998	0	x	0	0	25	13	0	0	x	<1	0	0	2	0	0	0	0	0	<1	1	2	0	0
25 Aug. 1998	0	x	0	0	17	15	0	0	x	<1	<1	0	<1	0	<1	0	0	0	<1	7	<1	0	0

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Table continued

	Axyris amaranthoides	*Campanula rotundifolia*	*Cerastium arvense*	*Chenopodium album*	*Cirsium arvense*	*Cirsium flodmanii*	*Comandra umbellata*	*Conyza canadensis var. canadensis*	*Crepis tectorum*	*Descurainia sophia*	*Erigeron caespitosus*	*Erigeron lonchophyllus*	*Erysimum inconspicuum*	*Fragaria virginiana*	*Gaillardia aristata*	*Galium boreale*	*Gentianella amarella*	*Geum triflorum*	*Helianthus pauciflorus ssp. subrhomboideus*	*Heterotheca villosa*	*Heuchera richardsonii*	*Lactuca tatarica var. pulchella*	*Lesquerella arenosa*
Not previously burned																							
Control	0	<1	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
15 Nov. 1997	0	0	<1	<1	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
17 Dec. 1997	0	<1	0	0	0	0	0	0	0	0	0	1	0	0	0	<1	0	0	0	0	0	0	<1
27 Mar. 1998	0	0	<1	0	<1	0	0	<1	0	0	0	0	<1	0	0	<1	0	0	0	0	0	0	0
16 Apr. 1998	0	0	0	0	0	0	5	0	0	0	0	<1	<1	0	0	<1	0	0	0	0	0	0	0
1 May 1998	0	<1	<1	0	0	0	2	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
13 May 1998	0	<1	<1	<1	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
25 May 1998	0	0	<1	<1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
5 Jun. 1998	0	0	0	<1	<1	0	0	0	0	0	0	0	<1	0	0	<1	0	0	0	0	0	0	0
27 Jun. 1998	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
14 Jun. 1998	0	0	<1	<1	0	0	<1	<1	<1	<1	0	0	2	0	0	<1	0	0	0	0	0	0	0
25 Aug. 1998	0	<1	0	<1	0	0	<1	0	<1	0	0	0	<1	0	0	2	0	0	0	0	0	0	0
Burned 5 years earlier																							
Control	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
15 Nov. 1997	0	<1	<1	0	0	0	2	0	0	<1	0	0	0	0	0	<1	0	0	0	0	0	0	0
17 Dec. 1997	0	<1	<1	0	0	0	4	0	0	0	0	0	0	0	0	<1	0	0	<1	0	<1	0	<1
27 Mar. 1998	0	0	<1	<1	0	0	0	0	0	<1	<1	0	0	0	0	<1	0	0	0	0	0	0	0
16 Apr. 1998	0	<1	<1	<1	0	0	7	0	0	<1	2	0	0	0	0	2	0	0	0	0	<1	0	0
1 May 1998	0	1	<1	<1	0	0	<1	0	0	<1	<1	0	0	0	0	<1	0	0	0	0	0	0	0
13 May 1998	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1
25 May 1998	0	<1	<1	<1	0	0	<1	0	0	<1	<1	0	0	0	0	<1	0	0	0	0	0	0	0
5 Jun. 1998	0	1	<1	<1	0	0	<1	0	0	<1	<1	0	0	0	0	1	0	0	0	0	0	0	0
27 Jun. 1998	0	0	<1	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	<1
14 Jun. 1998	0	<1	<1	<1	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	0	0	0	<1
25 Aug. 1998	<1	<1	0	0	<1	0	0	0	0	1	0	0	0	0	0	<1	0	0	0	0	0	0	0

Table continued on next page

Table continued

	Lomatium foeniculaceum	*Lygodesma juncea*	*Melilotus alba*	*Monarda bradburiana*	*Monolepis nuttalliana*	*Oligoneuron rigidum var. rigidum*	*Orthocarpus luteus*	*Oxytropis campestris*	*Oxytropis sericea*	*Pediomelum argophyllum*	*Pediomelum esculentum*	*Penstemon gracilis*	*Penstemon procerus*	*Phlox hoodii*	*Polygonum convolvulus*	*Potentilla arguta*	*Potentilla concinna*	*Potentilla gracilis*	*Potentilla pensylvanica*	*Pulsatilla patens ssp. multifida*	*Ratibida columnifera*	*Salsola kali*	*Selaginella densa*
---Not previously burned---																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	<1
15 Nov. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	<1	0	2	0	0	0
17 Dec. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	<1
16 Apr. 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
1 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
13 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
25 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	<1	0	0	0
5 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
27 Jun. 1998	0	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	0	0	0	0	3	0	0	0
14 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 Aug. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	3	0	0	0
---Burned 5 years earlier---																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
15 Nov. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1
17 Dec. 1997	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	<1
16 Apr. 1998	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	<1	0	0	<1
1 May 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	<1
13 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	4	0	0	<1
25 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	<1
5 Jun. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0
27 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
25 Aug. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0

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Table continued

	Silene drummondii var. drummondii	*Sisyrinchium montanum*	*Solidago canadensis*	*Solidago missouriensis*	*Solidago simplex var. spathulata*	*Solidago sp.*	*Sonchus arvensis*	*Stellaria longipes*	*Symphyotrichum ericoides*	*Symphyotrichum laeve*	*Taraxacum officinale*	*Thalictrum venulosum*	*Thlaspi arvense*	*Tragopogon dubius*	*Vicia americana*	*Viola adunca*	*Zigadenus sp.*	*Zizia aptera*	**Shrubs**	*Elaeagnus commutata*	*Rosa arkansana*	*Spiraea alba*	*Symphoricarpos occidentalis*
---Not previously burned---																							
Control	0	0	0	<1	0	0	0	0	1	0	<1	0	0	0	2	0	0	0	x	0	<1	0	2
15 Nov. 1997	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	<1	0	0
17 Dec. 1997	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	x	0	0	0	0
27 Mar. 1998	0	0	0	<1	0	0	0	0	<1	0	<1	0	0	<1	1	0	<1	<1	x	0	<1	0	0
16 Apr. 1998	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	x	0	<1	0	8
1 May 1998	0	0	0	5	0	0	0	0	0	0	0	0	0	0	2	0	<1	0	x	0	<1	0	11
13 May 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	3	0	<1	0	x	0	1	0	17
25 May 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	3	0	0	0	x	0	0	0	12
5 Jun. 1998	0	0	0	2	0	0	0	0	<1	0	<1	0	0	0	1	0	0	0	x	0	2	0	0
27 Jun. 1998	0	<1	0	<1	0	0	0	0	4	0	<1	0	0	0	2	0	0	0	x	0	<1	0	<1
14 Jun. 1998	0	0	<1	1	0	0	0	0	0	0	<1	0	0	0	1	0	0	0	x	0	7	0	21
25 Aug. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	2	0	8
---Burned 5 years earlier---																							
Control	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	3	0	0	0	x	0	2	0	9
15 Nov. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	x	0	<1	0	4
17 Dec. 1997	0	0	0	<1	0	0	0	0	0	0	<1	0	0	0	3	0	0	0	x	0	5	0	10
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	x	0	3	0	10
16 Apr. 1998	0	0	0	0	0	<1	0	0	1	0	<1	0	0	0	2	0	0	0	x	0	1	0	4
1 May 1998	0	0	0	<1	0	0	0	0	0	0	<1	0	0	0	5	0	0	0	x	0	2	0	4
13 May 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	4	0	0	0	x	0	0	0	1
25 May 1998	0	0	0	<1	0	0	0	0	2	0	0	0	0	0	3	0	0	0	x	0	4	0	6
5 Jun. 1998	0	0	<1	2	0	0	0	0	3	0	0	0	0	0	2	0	0	0	x	0	3	0	0
27 Jun. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	<1	0	4
14 Jun. 1998	0	0	0	0	0	0	0	0	2	0	<1	0	0	0	2	0	0	0	x	0	6	0	<1
25 Aug. 1998	0	0	0	4	0	0	0	0	2	0	0	0	0	0	4	0	0	0	x	0	<1	0	0

Table 3. Cover (%) of bare soil and litter and canopy cover (%) of grasses, sedges, forbs, and shrubs sampled in 2000 after burning in 1997-1998 at different times of the year in plots not previously burned and plots burned 5 years earlier at Kernen Prairie, near Saskatoon, SK. Nomenclature is from Integrated Taxonomic Information System [http://www.itis.usda.gov/index.html]. Last updated: 23 November 2004.

	Bare soil	Litter	**Grasses**	*Agrostis scabra*	*Bouteloua gracilis*	*Calamagrostis montanensis*	*Calamagrostis stricta spp. inexpansa*	*Calamagrostis stricta spp. stricta*	*Elymus lanceolatus*	*Elymus trachycaulus spp. subsecundus*	*Elymus trachycaulus spp. trachycaulus*	*Festuca hallii*	*Helictotrichon hookeri*	*Hesperostipa comata*	*Hesperostipa curtiseta*	*Koeleria macrantha*	*Muhlenbergia richardsonis*	*Nassella viridula*	*Pascopyrum smithii*	*Poa compressa*	*Poa cusickii*	*Poa palustris*	*Poa pratensis*
Not previously burned																							
Control	3	89	x	<1	0	0	0	0	3	0	0	30	5	0	13	<1	<1	0	0	0	0	0	0
15 Nov. 1997	12	68	x	0	0	3	0	0	1	0	0	37	<1	0	7	0	0	0	0	0	0	0	0
17 Dec. 1997	19	60	x	0	0	2	0	0	<1	0	0	27	3	0	16	0	0	0	0	0	0	0	0
27 Mar. 1998	4	85	x	0	<1	<1	0	0	1	<1	0	30	<1	0	12	0	0	0	0	0	0	0	0
16 Apr. 1998	11	69	x	0	0	<1	0	0	1	<1	<1	25	2	0	5	0	<1	0	0	0	0	0	0
1 May 1998	10	71	x	0	0	2	0	0	4	0	0	24	0	0	9	0	0	2	<1	0	0	0	0
13 May 1998	17	61	x	0	0	<1	0	0	1	<1	0	26	0	0	9	0	0	0	3	0	0	0	0
25 May 1998	17	62	x	0	0	<1	0	0	<1	<1	0	12	3	0	11	<1	0	0	0	0	0	0	0
5 Jun. 1998	13	63	x	0	0	0	0	0	4	<1	0	24	0	0	7	0	0	0	6	0	0	0	0
27 Jun. 1998	22	55	x	0	0	0	0	0	2	0	0	23	1	0	11	0	<1	0	<1	0	0	0	0
14 Jun. 1998	11	69	x	0	0	0	0	0	4	<1	0	23	<1	0	11	0	0	0	1	0	0	0	0
25 Aug. 1998	14	62	x	0	0	1	0	0	3	0	2	19	6	0	10	<1	<1	0	0	0	0	0	0
Burned 5 years earlier																							
Control	3	88	x	0	0	<1	0	0	4	<1	0	18	2	0	10	<1	0	0	0	0	0	0	0
15 Nov. 1997	29	48	x	0	0	<1	0	0	3	<1	<1	19	2	0	8	2	0	0	0	0	0	0	0
17 Dec. 1997	13	67	x	0	0	<1	0	0	2	<1	0	38	3	0	4	2	0	0	0	0	0	0	0
27 Mar. 1998	6	78	x	0	0	<1	0	0	5	0	0	17	5	0	12	2	0	0	0	0	0	0	0
16 Apr. 1998	27	66	x	0	0	<1	0	0	2	0	0	34	2	0	2	0	0	0	<1	0	0	0	0
1 May 1998	11	69	x	<1	0	1	0	0	3	<1	0	29	<1	0	6	<1	0	0	<1	2	0	0	0
13 May 1998	24	55	x	<1	0	<1	0	0	4	0	0	24	<1	0	9	<1	0	0	<1	0	0	0	0
25 May 1998	10	73	x	<1	0	0	0	0	4	1	0	23	1	0	8	0	0	0	0	0	0	0	0
5 Jun. 1998	18	60	x	0	0	<1	0	0	3	<1	<1	20	1	0	<1	1	0	7	0	0	0	0	0
27 Jun. 1998	21	57	x	0	0	<1	0	0	5	<1	0	19	4	0	6	<1	0	0	<1	<1	0	0	0
14 Jun. 1998	21	57	x	0	0	1	0	0	4	<1	0	18	2	0	4	0	0	0	<1	0	0	0	0
25 Aug. 1998	11	70	x	<1	0	0	0	0	2	<1	3	25	<1	0	2	<1	0	0	0	0	0	0	0

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Table continued

	Setaria viridis	**Sedges**	*Carex duriuscula*	*Carex filifolia*	*Carex obtusata*	*Carex pensylvanica*	*Carex praegracilis*	*Carex praticola*	**Forbs**	*Achillea millefolium*	*Agoseris glauca*	*Amaranthus sp.*	*Androsace septentrionalis*	*Antennaria neglecta*	*Antennaria parvifolia*	*Arabis divaricarpa*	*Arabis hirsuta*	*Arabis holboellii*	*Artemisia frigida*	*Artemisia ludoviciana*	*Astragalus adsurgens*	*Astragalus flexuosus*	*Astragalus pectinatus*
Not previously burned																							
Control	0	x	0	0	4	4	0	0	x	<1	0	0	0	0	0	0	0	0	<1	9	<1	<1	0
15 Nov. 1997	0	x	<1	0	4	12	0	0	x	2	0	0	2	0	0	0	0	0	3	<1	<1	<1	0
17 Dec. 1997	0	x	<1	0	3	9	0	0	x	<1	0	0	2	0	0	0	0	0	8	0	<1	<1	0
27 Mar. 1998	0	x	0	0	7	11	0	0	x	<1	0	0	<1	0	0	0	0	0	3	3	2	<1	0
16 Apr. 1998	0	x	<1	0	9	10	0	0	x	<1	<1	0	3	0	0	0	0	0	<1	1	<1	0	0
1 May 1998	0	x	<1	0	4	14	0	0	x	0	0	0	2	0	0	0	0	0	<1	2	<1	0	0
13 May 1998	0	x	<1	0	7	20	0	0	x	0	0	0	1	0	0	0	0	0	0	2	<1	0	0
25 May 1998	0	x	<1	0	3	13	0	0	x	<1	<1	0	2	0	0	0	0	0	<1	3	<1	<1	0
5 Jun. 1998	0	x	<1	0	3	17	0	0	x	0	<1	0	2	0	0	0	0	0	<1	6	<1	2	0
27 Jun. 1998	0	x	<1	0	4	9	0	0	x	<1	0	0	2	<1	0	0	0	0	0	2	<1	<1	0
14 Jun. 1998	0	x	0	0	5	5	0	0	x	0	<1	0	3	0	0	0	<1	<1	1	<1	0	<1	0
25 Aug. 1998	0	x	0	<1	4	12	0	0	x	1	0	0	1	0	0	0	0	0	<1	1	<1	0	0
Burned 5 years earlier																							
Control	0	x	<1	0	10	5	0	0	x	<1	0	0	<1	0	0	0	0	0	4	4	<1	0	0
15 Nov. 1997	0	x	<1	0	9	14	0	0	x	1	0	0	3	0	0	0	<1	0	1	2	1	<1	0
17 Dec. 1997	0	x	<1	0	3	6	0	0	x	<1	<1	0	2	0	0	0	0	0	<1	2	<1	0	0
27 Mar. 1998	0	x	3	<1	4	8	0	0	x	<1	0	0	2	0	0	0	0	0	5	1	1	0	0
16 Apr. 1998	0	x	1	0	7	8	0	0	x	<1	<1	0	2	0	0	0	0	0	<1	1	<1	0	0
1 May 1998	0	x	<1	<1	10	13	0	0	x	<1	0	0	2	0	0	0	0	0	4	2	0	0	0
13 May 1998	0	x	<1	0	10	17	0	0	x	<1	0	0	2	0	0	0	0	0	<1	<1	<1	0	0
25 May 1998	0	x	<1	0	14	14	0	0	x	<1	<1	0	2	0	0	0	0	0	<1	2	1	0	0
5 Jun. 1998	0	x	<1	0	7	13	0	0	x	<1	<1	0	2	0	0	0	0	0	2	3	<1	<1	0
27 Jun. 1998	0	x	<1	<1	12	14	0	0	x	<1	0	0	2	0	0	0	0	0	0	4	<1	0	0
14 Jun. 1998	0	x	<1	0	19	8	0	0	x	<1	0	0	2	0	0	0	0	0	<1	<1	<1	0	0
25 Aug. 1998	0	x	<1	<1	16	15	0	0	x	<1	<1	0	<1	0	0	0	0	0	3	5	<1	0	0

Table continued on next page

Table continued

	Axyris amaranthoides	*Campanula rotundifolia*	*Cerastium arvense*	*Chenopodium album*	*Cirsium arvense*	*Cirsium flodmanii*	*Comandra umbellata*	*Conyza canadensis var. canadensis*	*Crepis tectorum*	*Descurainia sophia*	*Erigeron caespitosus*	*Erigeron lonchophyllus*	*Erysimum inconspicuum*	*Fragaria virginiana*	*Gaillardia aristata*	*Galium boreale*	*Gentianella amarella*	*Geum triflorum*	*Helianthus pauciflorus ssp. subrhomboideus*	*Heterotheca villosa*	*Heuchera richardsonii*	*Lactuca tatarica var. pulchella*	*Lesquerella arenosa*
----Not previously burned----																							
Control	0	0	<1	0	0	0	3	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	<1
15 Nov. 1997	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	<1
17 Dec. 1997	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
27 Mar. 1998	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	<1
16 Apr. 1998	0	0	<1	0	0	0	6	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
1 May 1998	0	0	<1	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 May 1998	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1
25 May 1998	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	<1
5 Jun. 1998	0	0	0	<1	1	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	<1
27 Jun. 1998	0	<1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1
14 Jun. 1998	0	<1	<1	0	0	0	5	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	2
25 Aug. 1998	0	1	<1	0	0	0	2	0	0	<1	0	0	0	0	0	2	<1	0	0	0	0	0	<1
----Burned 5 years earlier----																							
Control	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
15 Nov. 1997	0	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	<1
17 Dec. 1997	0	<1	<1	0	0	0	3	0	0	0	0	0	0	0	0	1	0	0	<1	0	0	0	<1
27 Mar. 1998	0	<1	<1	<1	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
16 Apr. 1998	0	1	<1	0	<1	0	5	0	0	0	3	0	0	0	0	2	0	0	0	0	0	0	<1
1 May 1998	0	<1	<1	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	<1
13 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	<1
25 May 1998	0	<1	<1	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	<1
5 Jun. 1998	0	<1	<1	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	<1
27 Jun. 1998	0	<1	<1	0	0	0	<1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	<1
14 Jun. 1998	0	<1	<1	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	<1	0	<1
25 Aug. 1998	0	<1	1	0	0	0	<1	0	0	0	<1	0	0	0	0	2	0	0	0	0	0	0	0

Table continued on next page

Table continued

	Lomatium foeniculaceum	*Lygodesma juncea*	*Melilotus alba*	*Monarda bradburiana*	*Monolepis nuttalliana*	*Oligoneuron rigidum var. rigidum*	*Orthocarpus luteus*	*Oxytropis campestris*	*Oxytropis sericea*	*Pediomelum argophyllum*	*Pediomelum esculentum*	*Penstemon gracilis*	*Penstemon procerus*	*Phlox hoodii*	*Polygonum convolvulus*	*Potentilla arguta*	*Potentilla concinna*	*Potentilla gracilis*	*Potentilla pensylvanica*	*Pulsatilla patens ssp. multifida*	*Ratibida columnifera*	*Salsola kali*	*Selaginella densa*
----Not previously burned----																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1
15 Nov. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
17 Dec. 1997	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	<1
16 Apr. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	4	0	0	0
1 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
13 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
25 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
5 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Jun. 1998	0	0	0	0	0	0	0	0	<1	0	0	<1	0	0	0	0	0	0	0	2	0	0	0
14 Jun. 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
25 Aug. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	1	0	0	0	0	0	5	0	0	<1
----Burned 5 years earlier----																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
15 Nov. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
17 Dec. 1997	0	0	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	0	0	0	<1	0	0	<1
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	<1
16 Apr. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
1 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
25 May 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	2	0	0	0
5 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0
27 Jun. 1998	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 Jun. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
25 Aug. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0

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Table continued

	Silene drummondii var. drummondii	*Sisyrinchium montanum*	*Solidago canadensis*	*Solidago missouriensis*	*Solidago simplex var. spathulata*	*Solidago sp.*	*Sonchus arvensis*	*Stellaria longipes*	*Symphyotrichum ericoides*	*Symphyotrichum laeve*	*Taraxacum officinale*	*Thalictrum venulosum*	*Thlaspi arvense*	*Tragopogon dubius*	*Vicia americana*	*Viola adunca*	*Zigadenus sp.*	*Zizia aptera*	**Shrubs**	*Elaeagnus commutata*	*Rosa arkansana*	*Spiraea alba*	*Symphoricarpos occidentalis*
--Not previously burned--																							
Control	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	<1	0	2
15 Nov. 1997	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	x	0	<1	0	0
17 Dec. 1997	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	<1	0	0
27 Mar. 1998	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	x	0	5	0	0
16 Apr. 1998	0	0	0	<1	0	0	0	0	2	0	0	0	0	0	<1	0	0	0	x	0	<1	0	5
1 May 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	1	0	5
13 May 1998	0	0	0	4	0	0	0	0	3	0	0	0	0	0	2	0	0	0	x	0	<1	0	9
25 May 1998	0	0	0	1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	0	0	14
5 Jun. 1998	0	0	0	1	0	0	0	0	<1	0	0	0	0	0	1	0	0	0	x	0	3	0	0
27 Jun. 1998	0	0	0	2	0	0	0	0	3	0	0	0	0	0	2	0	0	0	x	0	<1	0	<1
14 Jun. 1998	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	x	0	2	0	24
25 Aug. 1998	0	0	0	1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	4	0	2
--Burned 5 years earlier--																							
Control	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	2	0	9
15 Nov. 1997	0	0	0	0	0	0	0	0	3	0	0	0	0	0	2	0	0	0	x	0	0	0	2
17 Dec. 1997	0	0	0	0	0	0	0	0	2	0	0	0	0	0	<1	0	0	0	x	0	5	0	3
27 Mar. 1998	0	0	0	0	0	0	0	0	<1	0	<1	0	0	0	1	0	0	0	x	0	5	0	2
16 Apr. 1998	0	0	0	<1	0	0	0	0	1	0	<1	0	0	0	<1	0	0	0	x	0	<1	0	2
1 May 1998	0	0	0	<1	0	0	0	0	1	0	<1	0	0	0	3	0	0	0	x	0	1	0	5
13 May 1998	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	x	0	<1	0	0
25 May 1998	0	0	0	<1	0	0	0	0	<1	0	<1	0	0	0	2	0	0	0	x	0	<1	0	10
5 Jun. 1998	0	0	0	<1	0	0	0	0	7	0	0	0	0	0	3	0	0	0	x	0	2	0	0
27 Jun. 1998	0	0	0	2	0	0	0	0	1	0	<1	0	0	0	2	0	0	0	x	0	<1	0	2
14 Jun. 1998	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	x	0	2	0	4
25 Aug. 1998	0	0	0	<1	0	0	0	0	<1	0	<1	0	0	0	2	0	0	0	x	0	1	0	0

Table 4. Cover (%) of bare soil and litter and canopy cover (%) of grasses, sedges, forbs, and shrubs sampled in 2001 after burning in 1997-1998 at different times of the year in plots not previously burned and plots burned 5 years earlier at Kernen Prairie, near Saskatoon, SK. Nomenclature is from Integrated Taxonomic Information System [http://www.itis.usda.gov/index.html]. Last updated: 23 November 2004.

	Bare soil	Litter	**Grasses**	*Agrostis scabra*	*Bouteloua gracilis*	*Calamagrostis montanensis*	*Calamagrostis stricta spp. inexpansa*	*Calamagrostis stricta spp. stricta*	*Elymus lanceolatus*	*Elymus trachycaulus spp. subsecundus*	*Elymus trachycaulus spp. trachycaulus*	*Festuca hallii*	*Helictotrichon hookeri*	*Hesperostipa comata*	*Hesperostipa curtiseta*	*Koeleria macrantha*	*Muhlenbergia richardsonis*	*Nassella viridula*	*Pascopyrum smithii*	*Poa compressa*	*Poa cusickii*	*Poa palustris*	*Poa pratensis*
--------Not previously burned--------																							
Control	3	98	x	0	0	0	0	0	<1	<1	<1	15	<1	0	7	0	0	0	<1	0	0	0	0
15 Nov. 1997	7	91	x	<1	0	<1	0	0	<1	0	<1	23	<1	0	2	0	0	0	0	<1	0	0	0
17 Dec. 1997	10	87	x	0	0	<1	0	0	0	0	<1	15	<1	0	6	0	0	0	0	0	0	0	0
27 Mar. 1998	3	98	x	0	0	<1	0	0	<1	<1	2	23	1	0	5	<1	0	0	<1	0	0	0	0
16 Apr. 1998	8	91	x	0	0	0	0	0	<1	0	<1	15	2	0	2	<1	0	0	0	0	0	0	0
1 May 1998	4	95	x	0	0	0	0	0	<1	0	<1	11	0	0	4	<1	0	<1	0	0	0	0	0
13 May 1998	5	94	x	0	0	0	0	0	<1	0	1	15	<1	0	5	0	0	0	1	0	0	0	0
25 May 1998	8	91	x	0	0	0	0	0	0	<1	<1	16	2	0	5	0	0	<1	0	0	0	0	0
5 Jun. 1998	6	94	x	0	0	0	0	0	<1	0	<1	17	0	0	3	0	0	0	2	0	0	0	0
27 Jun. 1998	6	93	x	0	0	0	0	0	<1	0	<1	9	2	0	9	<1	0	0	0	0	0	0	0
14 Jun. 1998	4	96	x	0	0	<1	0	0	<1	0	<1	10	<1	0	8	0	0	0	<1	0	0	0	0
25 Aug. 1998	6	94	x	0	0	0	0	0	<1	0	<1	12	2	0	7	0	0	0	<1	<1	0	0	0
--------Burned 5 years earlier--------																							
Control	3	96	x	0	0	0	0	0	<1	0	2	11	<1	0	8	<1	0	0	<1	0	0	0	0
15 Nov. 1997	16	83	x	0	0	<1	0	0	<1	0	2	8	<1	0	9	2	0	0	<1	<1	0	0	0
17 Dec. 1997	7	93	x	0	0	<1	0	0	<1	<1	<1	12	1	0	3	<1	0	0	0	0	0	0	0
27 Mar. 1998	5	93	x	0	0	<1	0	0	2	0	<1	7	<1	0	10	2	0	0	0	0	0	0	0
16 Apr. 1998	7	92	x	0	<1	0	0	0	<1	<1	1	14	1	0	2	<1	0	0	0	0	0	0	0
1 May 1998	7	88	x	0	<1	1	0	0	<1	<1	2	8	<1	0	6	<1	0	<1	<1	<1	0	0	0
13 May 1998	16	83	x	0	0	<1	0	0	<1	<1	1	5	<1	0	8	<1	0	<1	<1	0	0	0	0
25 May 1998	6	93	x	0	0	0	0	0	1	1	<1	9	<1	0	7	1	<1	0	0	0	0	0	0
5 Jun. 1998	17	83	x	0	0	<1	0	0	<1	<1	1	9	<1	0	4	<1	0	<1	0	0	0	0	0
27 Jun. 1998	9	91	x	0	0	0	0	0	<1	<1	2	9	1	0	7	1	0	<1	0	0	0	0	0
14 Jun. 1998	14	85	x	0	0	<1	0	0	<1	0	1	9	<1	0	4	<1	0	0	0	0	0	0	0
25 Aug. 1998	6	90	x	<1	0	<1	0	0	<1	<1	2	8	0	0	5	<1	0	0	0	<1	0	0	0

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Table continued

	Setaria viridis	**Sedges**	*Carex duriuscula*	*Carex filifolia*	*Carex obtusata*	*Carex pensylvanica*	*Carex praegracilis*	*Carex praticola*	**Forbs**	*Achillea millefolium*	*Agoseris glauca*	*Amaranthus sp.*	*Androsace septentrionalis*	*Antennaria neglecta*	*Antennaria parvifolia*	*Arabis divaricarpa*	*Arabis hirsuta*	*Arabis holboellii*	*Artemisia frigida*	*Artemisia ludoviciana*	*Astragalus adsurgens*	*Astragalus flexuosus*	*Astragalus pectinatus*
----Not previously burned----																							
Control	0	x	0	0	2	2	0	0	x	<1	0	0	0	0	0	0	0	0	2	1	<1	<1	0
15 Nov. 1997	0	x	0	0	3	6	0	0	x	<1	0	0	0	0	0	0	0	0	2	<1	<1	0	0
17 Dec. 1997	0	x	0	0	3	4	0	0	x	<1	0	0	0	0	0	0	0	0	4	2	<1	0	0
27 Mar. 1998	0	x	0	0	3	9	0	0	x	0	<1	0	0	0	0	0	0	0	<1	<1	<1	<1	0
16 Apr. 1998	0	x	<1	0	3	7	0	0	x	<1	0	0	0	0	0	0	0	0	<1	<1	0	0	0
1 May 1998	0	x	<1	0	3	9	0	0	x	<1	0	0	0	0	0	0	0	0	2	<1	<1	0	0
13 May 1998	0	x	0	0	4	9	0	0	x	0	0	0	0	0	0	0	0	0	<1	<1	<1	0	0
25 May 1998	0	x	<1	0	2	7	0	0	x	<1	0	0	0	0	0	0	0	0	<1	1	0	0	0
5 Jun. 1998	0	x	0	<1	4	9	0	0	x	0	0	0	0	0	0	0	0	0	<1	3	<1	0	0
27 Jun. 1998	0	x	<1	0	2	6	0	0	x	<1	0	0	0	0	0	0	0	0	0	<1	<1	0	0
14 Jun. 1998	0	x	0	0	4	4	0	0	x	0	0	0	0	0	0	0	0	0	<1	<1	0	<1	0
25 Aug. 1998	0	x	0	0	4	7	0	0	x	<1	0	0	0	0	0	0	0	0	<1	<1	<1	0	0
----Burned 5 years earlier----																							
Control	0	x	0	0	6	5	0	0	x	0	0	0	0	0	0	0	0	0	2	1	<1	0	0
15 Nov. 1997	0	x	0	<1	6	10	0	0	x	<1	0	0	0	0	0	0	0	0	1	1	0	0	0
17 Dec. 1997	0	x	<1	0	3	6	0	0	x	<1	0	0	0	0	0	0	0	0	1	<1	0	0	0
27 Mar. 1998	0	x	1	<1	7	3	0	0	x	<1	0	0	0	<1	0	0	0	0	2	<1	<1	0	0
16 Apr. 1998	0	x	0	<1	5	7	0	0	x	<1	0	0	0	0	0	0	0	0	1	<1	<1	<1	0
1 May 1998	0	x	<1	<1	6	5	0	0	x	<1	0	0	0	0	0	0	0	0	4	2	0	0	0
13 May 1998	0	x	<1	<1	3	5	0	0	x	0	0	0	0	0	0	0	<1	0	1	<1	0	0	0
25 May 1998	0	x	0	0	6	8	0	0	x	<1	<1	0	0	0	0	0	0	0	<1	2	0	0	0
5 Jun. 1998	0	x	<1	<1	5	3	0	0	x	<1	0	0	0	0	0	0	0	0	<1	1	0	0	0
27 Jun. 1998	0	x	<1	0	4	5	0	0	x	<1	0	0	0	<1	0	0	0	0	<1	2	0	0	0
14 Jun. 1998	0	x	<1	0	6	8	0	0	x	<1	0	0	0	0	0	0	0	0	<1	<1	<1	0	0
25 Aug. 1998	0	x	0	<1	7	8	0	0	x	0	0	0	0	0	0	0	0	0	2	4	0	0	0

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	Axyris amaranthoides	*Campanula rotundifolia*	*Cerastium arvense*	*Chenopodium album*	*Cirsium arvense*	*Cirsium flodmanii*	*Comandra umbellata*	*Conyza canadensis var. canadensis*	*Crepis tectorum*	*Descurainia sophia*	*Erigeron caespitosus*	*Erigeron lonchophyllus*	*Erysimum inconspicuum*	*Fragaria virginiana*	*Gaillardia aristata*	*Galium boreale*	*Gentianella amarella*	*Geum triflorum*	*Helianthus pauciflorus ssp. subrhomboideus*	*Heterotheca villosa*	*Heuchera richardsonii*	*Lactuca tatarica var. pulchella*	*Lesquerella arenosa*
Not previously burned																							
Control	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
15 Nov. 1997	0	0	<1	0	0	0	<1	0	0	0	0	0	<1	0	0	<1	0	0	0	0	0	0	0
17 Dec. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
16 Apr. 1998	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
1 May 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	0
13 May 1998	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 May 1998	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0
5 Jun. 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
27 Jun. 1998	0	0	0	0	0	0	<1	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0
14 Jun. 1998	0	0	0	0	0	0	1	0	0	0	0	0	<1	0	0	<1	0	0	0	0	0	0	0
25 Aug. 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
Burned 5 years earlier																							
Control	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 Nov. 1997	0	0	<1	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0
17 Dec. 1997	0	0	<1	0	<1	0	<1	0	0	0	0	0	<1	0	0	<1	0	0	0	0	0	0	0
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0
16 Apr. 1998	0	<1	<1	0	0	0	2	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	0	<1
1 May 1998	0	<1	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0
13 May 1998	0	0	<1	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	<1
25 May 1998	0	<1	<1	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 Jun. 1998	0	<1	<1	0	0	0	<1	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0
27 Jun. 1998	0	0	<1	0	0	0	<1	0	0	0	<1	0	<1	0	0	<1	0	0	0	0	0	0	0
14 Jun. 1998	0	<1	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0
25 Aug. 1998	0	<1	<1	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0

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Table continued

	Lomatium foeniculaceum	*Lygodesma juncea*	*Melilotus alba*	*Monarda bradburiana*	*Monolepis nuttalliana*	*Oligoneuron rigidum var. rigidum*	*Orthocarpus luteus*	*Oxytropis campestris*	*Oxytropis sericea*	*Pediomelum argophyllum*	*Pediomelum esculentum*	*Penstemon gracilis*	*Penstemon procerus*	*Phlox hoodii*	*Polygonum convolvulus*	*Potentilla arguta*	*Potentilla concinna*	*Potentilla gracilis*	*Potentilla pensylvanica*	*Pulsatilla patens ssp. multifida*	*Ratibida columnifera*	*Salsola kali*	*Selaginella densa*
-----Not previously burned-----																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
15 Nov. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	1
17 Dec. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	<1
16 Apr. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	5	0	0	0
1 May 1998	0	<1	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0
13 May 1998	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
25 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	<1
5 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1
27 Jun. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	2	0	0	0
14 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
25 Aug. 1998	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	1	0	0	0
-----Burned 5 years earlier-----																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
15 Nov. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0
17 Dec. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	<1
27 Mar. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	<1
16 Apr. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
1 May 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0	0	0
13 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	<1	0	<1	0	0	<1
25 May 1998	<1	0	0	0	0	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
5 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
27 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1
14 Jun. 1998	<1	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 Aug. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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Table continued

	Silene drummondii var. drummondii	*Sisyrinchium montanum*	*Solidago canadensis*	*Solidago missouriensis*	*Solidago simplex var. spathulata*	*Solidago sp.*	*Sonchus arvensis*	*Stellaria longipes*	*Symphyotrichum ericoides*	*Symphyotrichum laeve*	*Taraxacum officinale*	*Thalictrum venulosum*	*Thlaspi arvense*	*Tragopogon dubius*	*Vicia americana*	*Viola adunca*	*Zigadenus sp.*	*Zizia aptera*	**Shrubs**	*Elaeagnus commutata*	*Rosa arkansana*	*Spiraea alba*	*Symphoricarpos occidentalis*
Not previously burned																							
Control	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	0
15 Nov. 1997	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
17 Dec. 1997	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	0
27 Mar. 1998	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	x	0	2	0	0
16 Apr. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	<1	0	2
1 May 1998	0	0	0	1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	1	0	5
13 May 1998	0	0	0	2	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	4
25 May 1998	0	0	0	2	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	0	0	6
5 Jun. 1998	0	0	0	2	0	0	<1	0	<1	0	0	0	0	0	0	0	0	0	x	0	1	0	0
27 Jun. 1998	0	0	0	<1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	x	0	0	0	0
14 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	x	0	3	0	16
25 Aug. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	1	0	8
Burned 5 years earlier																							
Control	0	0	0	<1	<1	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	<1	0	4
15 Nov. 1997	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	0	0	<1
17 Dec. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	2	0	1
27 Mar. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	2	0	<1
16 Apr. 1998	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	x	0	<1	0	<1
1 May 1998	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	x	0	<1	0	2
13 May 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	0
25 May 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	<1	0	3
5 Jun. 1998	0	0	0	<1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	x	0	1	0	0
27 Jun. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	0	0	3
14 Jun. 1998	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	x	0	1	0	0
25 Aug. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	<1	0	0

Table 5. Cover (%) of bare soil and litter and canopy cover (%) of grasses, sedges, forbs, and shrubs sampled in 2002 after burning in 1997-1998 at different times of the year in plots not previously burned and plots burned 5 years earlier at Kernen Prairie, near Saskatoon, SK. Nomenclature is from Integrated Taxonomic Information System [http://www.itis.usda.gov/index.html]. Last updated: 23 November 2004.

	Bare soil	Litter	**Grasses**	*Agrostis scabra*	*Bouteloua gracilis*	*Calamagrostis montanensis*	*Calamagrostis stricta spp. inexpansa*	*Calamagrostis stricta spp. stricta*	*Elymus lanceolatus*	*Elymus trachycaulus spp. subsecundus*	*Elymus trachycaulus spp. trachycaulus*	*Festuca hallii*	*Helictotrichon hookeri*	*Hesperostipa comata*	*Hesperostipa curtiseta*	*Koeleria macrantha*	*Muhlenbergia richardsonis*	*Nassella viridula*	*Pascopyrum smithii*	*Poa compressa*	*Poa cusickii*	*Poa palustris*	*Poa pratensis*
Not previously burned																							
Control	3	96	x	0	0	<1	0	0	<1	<1	2	5	<1	0	5	0	0	0	0	0	0	0	0
15 Nov. 1997	4	94	x	0	0	3	0	0	<1	0	2	4	<1	0	2	0	0	0	0	0	0	0	0
17 Dec. 1997	8	91	x	0	0	<1	0	0	<1	<1	1	6	<1	0	2	0	0	0	0	0	0	0	0
27 Mar. 1998	3	98	x	0	0	<1	0	0	<1	0	2	10	<1	0	3	0	0	0	0	0	0	0	0
16 Apr. 1998	8	93	x	0	0	0	0	0	<1	<1	<1	4	<1	0	2	<1	0	0	0	0	0	0	0
1 May 1998	5	93	x	0	0	0	0	0	<1	0	<1	6	0	<1	<1	0	0	2	<1	0	0	0	0
13 May 1998	4	95	x	0	0	<1	0	0	<1	0	<1	5	0	0	<1	0	0	0	2	0	0	0	0
25 May 1998	9	91	x	0	0	<1	0	0	<1	0	<1	2	<1	0	1	<1	0	<1	0	0	0	0	0
5 Jun. 1998	4	96	x	0	0	<1	0	0	<1	<1	1	6	0	0	0	0	0	0	2	0	0	0	0
27 Jun. 1998	10	90	x	0	0	<1	0	0	<1	<1	<1	3	0	0	3	<1	<1	0	0	0	0	0	0
14 Jun. 1998	6	94	x	0	0	<1	0	0	<1	0	1	6	<1	0	4	0	0	0	<1	0	0	0	0
25 Aug. 1998	7	92	x	0	0	<1	0	0	<1	<1	2	2	<1	0	5	0	<1	0	<1	0	0	0	0
Burned 5 years earlier																							
Control	3	97	x	0	<1	0	0	0	<1	<1	<1	3	<1	0	3	0	0	0	<1	<1	0	0	0
15 Nov. 1997	8	91	x	0	0	<1	0	0	2	0	2	3	<1	0	2	<1	0	0	<1	0	0	0	0
17 Dec. 1997	8	93	x	0	0	<1	0	0	2	<1	1	5	<1	0	2	<1	0	0	0	0	0	0	0
27 Mar. 1998	10	90	x	0	0	2	0	0	1	0	1	1	<1	0	5	<1	0	0	0	0	0	0	0
16 Apr. 1998	5	94	x	0	0	<1	0	0	2	0	<1	7	0	0	1	<1	0	0	0	0	0	0	0
1 May 1998	7	93	x	0	0	<1	0	0	1	0	1	3	0	0	2	0	0	0	<1	0	0	0	0
13 May 1998	8	93	x	0	0	<1	0	0	2	0	2	1	<1	0	2	<1	0	0	<1	0	0	0	0
25 May 1998	5	95	x	0	0	<1	0	0	2	<1	2	2	0	0	3	<1	0	0	<1	0	0	0	0
5 Jun. 1998	7	93	x	0	0	<1	0	0	1	0	2	2	0	0	2	<1	0	0	0	0	0	0	0
27 Jun. 1998	4	96	x	0	0	0	0	0	1	<1	<1	6	0	0	3	<1	0	0	<1	0	<1	0	0
14 Jun. 1998	6	94	x	0	0	<1	0	0	2	0	0	2	0	0	1	<1	0	0	<1	0	0	<1	0
25 Aug. 1998	4	96	x	0	0	<1	0	0	2	<1	2	1	0	0	<1	0	0	0	0	<1	0	0	0

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Table continued

	Setaria viridis	**Sedges**	*Carex duriuscula*	*Carex filifolia*	*Carex obtusata*	*Carex pensylvanica*	*Carex praegracilis*	*Carex praticola*	**Forbs**	*Achillea millefolium*	*Agoseris glauca*	*Amaranthus sp.*	*Androsace septentrionalis*	*Antennaria neglecta*	*Antennaria parvifolia*	*Arabis divaricarpa*	*Arabis hirsuta*	*Arabis holboellii*	*Artemisia frigida*	*Artemisia ludoviciana*	*Astragalus adsurgens*	*Astragalus flexuosus*	*Astragalus pectinatus*
Not previously burned																							
Control	0	x	0	0	2	2	0	0	x	<1	0	0	0	0	0	0	0	0	2	2	<1	0	0
15 Nov. 1997	0	x	<1	0	3	7	0	0	x	0	0	0	0	0	0	0	0	0	2	3	<1	0	0
17 Dec. 1997	0	x	0	<1	4	8	0	0	x	<1	0	0	0	0	0	0	0	0	<1	7	0	0	0
27 Mar. 1998	0	x	0	0	5	11	0	0	x	0	0	0	0	0	0	0	0	0	2	<1	<1	<1	0
16 Apr. 1998	0	x	<1	0	7	7	0	0	x	0	0	0	0	0	0	0	0	0	<1	<1	<1	0	0
1 May 1998	0	x	0	0	4	11	0	0	x	0	0	0	0	0	0	0	0	0	3	<1	0	0	0
13 May 1998	0	x	<1	<1	3	15	0	0	x	0	0	0	0	0	0	0	0	0	2	<1	0	0	0
25 May 1998	0	x	<1	0	6	13	0	0	x	0	0	0	0	0	0	0	0	0	<1	1	0	0	0
5 Jun. 1998	0	x	0	0	4	13	0	0	x	0	0	0	0	0	0	0	0	0	0	3	0	<1	0
27 Jun. 1998	0	x	1	0	2	9	0	0	x	<1	0	0	0	0	0	0	0	0	0	1	0	0	0
14 Jun. 1998	0	x	0	0	3	7	0	0	x	0	0	0	0	0	0	0	0	0	<1	<1	0	<1	0
25 Aug. 1998	0	x	<1	0	3	10	0	0	x	<1	0	0	0	<1	0	0	0	0	0	0	0	<1	0
Burned 5 years earlier																							
Control	0	x	<1	0	9	3	0	0	x	<1	0	0	0	0	0	0	0	0	<1	<1	<1	0	0
15 Nov. 1997	0	x	<1	0	6	7	0	0	x	<1	0	0	0	0	0	0	0	0	2	<1	0	<1	0
17 Dec. 1997	0	x	<1	0	3	6	0	0	x	0	0	0	0	0	0	0	0	0	<1	<1	0	0	0
27 Mar. 1998	0	x	<1	<1	5	5	0	0	x	0	0	0	0	0	0	0	0	0	2	<1	0	0	0
16 Apr. 1998	0	x	<1	0	8	8	0	0	x	0	0	0	0	0	0	0	0	0	4	<1	<1	0	0
1 May 1998	0	x	<1	0	6	9	0	0	x	<1	0	0	0	<1	0	0	0	0	<1	2	0	0	0
13 May 1998	0	x	<1	<1	12	8	0	0	x	0	0	0	0	<1	0	0	0	0	<1	1	<1	0	0
25 May 1998	0	x	0	<1	6	13	0	0	x	<1	<1	0	0	0	0	0	0	0	0	2	<1	0	0
5 Jun. 1998	0	x	<1	0	5	17	0	0	x	<1	<1	0	0	<1	0	0	0	0	<1	2	0	0	0
27 Jun. 1998	0	x	0	<1	7	11	0	0	x	<1	0	0	0	0	0	0	0	0	<1	1	0	0	0
14 Jun. 1998	0	x	<1	0	9	7	0	0	x	<1	<1	0	0	0	0	0	0	0	<1	1	0	0	0
25 Aug. 1998	0	x	<1	0	15	9	0	0	x	<1	0	0	0	0	0	0	0	0	<1	3	0	0	0

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Table continued

	Axyris amaranthoides	*Campanula rotundifolia*	*Cerastium arvense*	*Chenopodium album*	*Cirsium arvense*	*Cirsium flodmanii*	*Comandra umbellata*	*Conyza canadensis var. canadensis*	*Crepis tectorum*	*Descurainia sophia*	*Erigeron caespitosus*	*Erigeron lonchophyllus*	*Erysimum inconspicuum*	*Fragaria virginiana*	*Gaillardia aristata*	*Galium boreale*	*Gentianella amarella*	*Geum triflorum*	*Helianthus pauciflorus ssp. subrhomboideus*	*Heterotheca villosa*	*Heuchera richardsonii*	*Lactuca tatarica var. pulchella*	*Lesquerella arenosa*
Not previously burned																							
Control	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
15 Nov. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	<1
17 Dec. 1997	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	<1	0	0
16 Apr. 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	<1
1 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 May 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1
5 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1	0	0	0	0
27 Jun. 1998	0	<1	<1	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	0	0	0	<1	0	0
14 Jun. 1998	0	0	0	0	0	0	<1	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0
25 Aug. 1998	0	<1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0
Burned 5 years earlier																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
15 Nov. 1997	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0
17 Dec. 1997	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 Apr. 1998	0	<1	<1	0	0	0	<1	0	0	0	<1	0	0	0	0	<1	0	0	0	0	<1	0	<1
1 May 1998	0	0	0	0	0	0	<1	0	0	0	<1	0	0	0	0	<1	0	0	0	0	<1	0	0
13 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0
25 May 1998	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 Jun. 1998	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
27 Jun. 1998	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	<1	0	0	0	0	0	0	0
14 Jun. 1998	0	<1	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1	0	0	0	0	0	0	0
25 Aug. 1998	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0

Table continued on next page

Table continued

	Lomatium foeniculaceum	*Lygodesma juncea*	*Melilotus alba*	*Monarda bradburiana*	*Monolepis nuttalliana*	*Oligoneuron rigidum var. rigidum*	*Orthocarpus luteus*	*Oxytropis campestris*	*Oxytropis sericea*	*Pediomelum argophyllum*	*Pediomelum esculentum*	*Penstemon gracilis*	*Penstemon procerus*	*Phlox hoodii*	*Polygonum convolvulus*	*Potentilla arguta*	*Potentilla concinna*	*Potentilla gracilis*	*Potentilla pensylvanica*	*Pulsatilla patens ssp. multifida*	*Ratibida columnifera*	*Salsola kali*	*Selaginella densa*
---Not previously burned---																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0
15 Nov. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
17 Dec. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1
27 Mar. 1998	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1
16 Apr. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
1 May 1998	0	<1	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0
13 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
25 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0
5 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
27 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	<1	0	0	0
14 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
25 Aug. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
---Burned 5 years earlier---																							
Control	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1
15 Nov. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 Dec. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0
16 Apr. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
1 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 May 1998	0	<1	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	<1	0	<1	0	0	<1
25 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0
27 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
14 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 Aug. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1

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Table continued

	Silene drummondii var. drummondii	*Sisyrinchium montanum*	*Solidago canadensis*	*Solidago missouriensis*	*Solidago simplex var. spathulata*	*Solidago sp.*	*Sonchus arvensis*	*Stellaria longipes*	*Symphyotrichum ericoides*	*Symphyotrichum laeve*	*Taraxacum officinale*	*Thalictrum venulosum*	*Thlaspi arvense*	*Tragopogon dubius*	*Vicia americana*	*Viola adunca*	*Zigadenus sp.*	*Zizia aptera*	**Shrubs**	*Elaeagnus commutata*	*Rosa arkansana*	*Spiraea alba*	*Symphoricarpos occidentalis*
---Not previously burned---																							
Control	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	x	0	<1	0	0
15 Nov. 1997	0	0	<1	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0	x	0	1	0	0
17 Dec. 1997	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	x	0	<1	0	0
27 Mar. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	2	0	0
16 Apr. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	<1	<1	0	0	0	x	0	0	0	4
1 May 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	<1	1	0	0	0	x	0	2	0	3
13 May 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	1	0	0	0	x	0	<1	0	6
25 May 1998	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	x	0	<1	0	4
5 Jun. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	1	0	0	0	x	0	<1	0	0
27 Jun. 1998	0	0	0	<1	0	0	0	0	2	0	0	0	0	0	1	0	0	0	x	0	<1	0	<1
14 Jun. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	<1	<1	0	0	0	x	0	3	0	13
25 Aug. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	1	0	0	0	x	0	1	0	2
---Burned 5 years earlier---																							
Control	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	2	0	3
15 Nov. 1997	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	<1	0	<1
17 Dec. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	x	0	1	0	1
27 Mar. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0	x	0	3	0	3
16 Apr. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	<1
1 May 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	1	0	3
13 May 1998	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	x	0	0	0	1
25 May 1998	0	0	0	<1	0	0	0	0	<1	0	<1	0	0	0	2	0	0	0	x	0	1	0	4
5 Jun. 1998	0	0	0	<1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	x	0	<1	0	0
27 Jun. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	0	0	1
14 Jun. 1998	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	x	0	<1	0	<1
25 Aug. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	<1	0	0

Table 6. Cover (%) of bare soil and litter and canopy cover (%) of grasses, sedges, forbs, and shrubs sampled in 2003 after burning in 1997-1998 at different times of the year in plots not previously burned and plots burned 5 years earlier at Kernen Prairie, near Saskatoon, SK. Nomenclature is from Integrated Taxonomic Information System [http://www.itis.usda.gov/index.html]. Last updated: 23 November 2004.

	Bare soil	Litter	**Grasses**	*Agrostis scabra*	*Bouteloua gracilis*	*Calamagrostis montanensis*	*Calamagrostis stricta spp. inexpansa*	*Calamagrostis stricta spp. stricta*	*Elymus lanceolatus*	*Elymus trachycaulus spp. subsecundus*	*Elymus trachycaulus spp. trachycaulus*	*Festuca hallii*	*Helictotrichon hookeri*	*Hesperostipa comata*	*Hesperostipa curtiseta*	*Koeleria macrantha*	*Muhlenbergia richardsonis*	*Nassella viridula*	*Pascopyrum smithii*	*Poa compressa*	*Poa cusickii*	*Poa palustris*	*Poa pratensis*
Not previously burned																							
Control	3	98	x	0	0	0	0	0	2	0	0	18	0	0	10	0	0	0	0	0	0	0	0
15 Nov. 1997	4	96	x	0	0	<1	0	0	6	0	<1	12	0	0	4	0	0	0	0	0	0	0	0
17 Dec. 1997	4	96	x	0	0	0	0	0	1	<1	0	21	<1	0	6	0	0	0	0	0	0	0	<1
27 Mar. 1998	3	96	x	0	0	0	0	0	5	2	2	16	0	0	6	<1	0	0	<1	0	0	0	0
16 Apr. 1998	7	93	x	0	0	0	0	0	1	<1	0	17	<1	0	4	<1	0	0	0	0	0	0	0
1 May 1998	6	94	x	0	0	<1	0	0	3	0	<1	9	<1	0	6	<1	0	3	0	0	0	0	3
13 May 1998	5	95	x	0	0	0	0	0	2	<1	<1	11	0	0	3	0	0	0	<1	0	0	0	0
25 May 1998	6	94	x	0	<1	0	0	0	2	<1	0	11	<1	0	5	<1	0	0	0	0	0	0	0
5 Jun. 1998	3	94	x	0	0	0	0	0	10	<1	0	12	0	0	<1	0	0	0	3	0	0	0	0
27 Jun. 1998	4	96	x	0	0	0	0	0	2	0	<1	11	<1	0	11	<1	2	0	0	0	0	0	<1
14 Jun. 1998	3	97	x	0	0	0	0	0	2	<1	0	17	<1	0	8	0	0	0	<1	0	0	0	<1
25 Aug. 1998	5	95	x	0	0	0	0	0	3	0	0	12	<1	0	9	<1	<1	0	<1	0	0	0	<1
Burned 5 years earlier																							
Control	3	98	x	0	0	0	0	0	7	2	0	7	<1	0	13	0	0	0	0	2	0	0	2
15 Nov. 1997	3	95	x	0	<1	0	0	0	9	<1	0	10	0	0	7	<1	0	0	0	0	0	0	<1
17 Dec. 1997	5	92	x	0	0	<1	0	0	7	<1	<1	18	<1	0	2	<1	0	0	0	0	0	0	0
27 Mar. 1998	6	89	x	0	0	0	0	0	8	<1	1	11	<1	0	10	2	0	<1	<1	0	0	0	0
16 Apr. 1998	9	81	x	0	0	<1	0	0	7	0	<1	10	<1	0	6	<1	0	0	0	0	0	0	0
1 May 1998	4	88	x	0	0	<1	0	0	6	<1	0	4	0	0	2	<1	0	0	<1	0	0	0	<1
13 May 1998	9	88	x	0	0	<1	0	0	8	<1	0	3	0	0	5	<1	0	0	3	0	0	0	0
25 May 1998	6	94	x	0	0	<1	0	0	7	2	0	8	<1	0	1	<1	0	0	0	0	0	0	<1
5 Jun. 1998	12	87	x	0	0	0	0	0	13	0	<1	4	0	0	7	<1	0	<1	0	0	0	0	0
27 Jun. 1998	3	96	x	0	0	0	0	0	10	1	0	9	<1	0	4	0	0	0	2	0	0	0	<1
14 Jun. 1998	8	86	x	0	0	<1	0	0	15	3	<1	12	0	0	2	<1	0	0	0	0	0	0	<1
25 Aug. 1998	4	92	x	0	0	0	0	0	8	<1	0	4	0	0	1	0	0	0	0	0	0	0	<1

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Table continued

	Setaria viridis	**Sedges**	*Carex duriuscula*	*Carex filifolia*	*Carex obtusata*	*Carex pensylvanica*	*Carex praegracilis*	*Carex praticola*	**Forbs**	*Achillea millefolium*	*Agoseris glauca*	*Amaranthus sp.*	*Androsace septentrionalis*	*Antennaria neglecta*	*Antennaria parvifolia*	*Arabis divaricarpa*	*Arabis hirsuta*	*Arabis holboellii*	*Artemisia frigida*	*Artemisia ludoviciana*	*Astragalus adsurgens*	*Astragalus flexuosus*	*Astragalus pectinatus*
Not previously burned																							
Control	0	x	0	0	2	1	0	0	x	<1	<1	0	<1	0	0	0	0	0	2	<1	0	0	0
15 Nov. 1997	0	x	0	0	8	13	0	0	x	0	0	0	<1	0	<1	0	0	0	2	<1	0	0	0
17 Dec. 1997	0	x	0	0	5	21	0	0	x	<1	0	0	<1	0	0	<1	0	0	3	2	0	<1	0
27 Mar. 1998	0	x	0	0	9	9	0	0	x	<1	0	0	<1	0	0	0	0	0	7	<1	<1	<1	0
16 Apr. 1998	0	x	0	0	8	24	0	0	x	0	0	0	<1	0	0	<1	0	0	<1	<1	0	0	0
1 May 1998	0	x	0	0	18	28	0	0	x	0	0	0	<1	0	0	0	0	0	<1	<1	0	0	0
13 May 1998	0	x	0	0	21	36	0	0	x	<1	0	0	<1	0	0	0	0	0	<1	<1	0	0	0
25 May 1998	0	x	0	0	13	27	0	0	x	0	0	0	<1	0	0	0	0	0	0	<1	0	0	0
5 Jun. 1998	0	x	<1	0	11	26	0	0	x	0	0	0	<1	0	0	0	0	0	<1	2	<1	<1	0
27 Jun. 1998	0	x	0	0	10	17	0	0	x	<1	<1	0	<1	0	0	<1	0	0	0	2	0	0	0
14 Jun. 1998	0	x	0	0	8	13	0	0	x	0	0	0	0	0	0	0	0	0	<1	<1	0	0	0
25 Aug. 1998	0	x	0	0	4	24	0	0	x	0	0	0	<1	0	0	0	0	0	<1	<1	0	0	0
Burned 5 years earlier																							
Control	0	x	0	0	14	9	0	0	x	<1	0	0	0	0	0	0	0	0	1	1	0	0	0
15 Nov. 1997	0	x	0	0	13	15	0	0	x	<1	0	0	<1	0	0	0	0	<1	4	1	0	0	0
17 Dec. 1997	0	x	0	0	7	18	0	0	x	0	0	0	<1	0	0	0	0	0	1	1	0	0	0
27 Mar. 1998	0	x	3	0	6	9	0	0	x	0	0	0	<1	0	0	0	0	0	4	<1	0	0	0
16 Apr. 1998	0	x	0	0	14	12	0	0	x	0	0	0	1	0	0	0	0	0	4	2	0	0	0
1 May 1998	0	x	0	0	19	15	0	0	x	0	0	0	<1	0	0	0	0	0	4	2	0	0	0
13 May 1998	0	x	1	0	12	19	0	0	x	0	0	0	<1	0	0	0	0	0	3	1	0	0	0
25 May 1998	0	x	0	0	14	18	0	0	x	0	0	0	<1	0	0	0	0	0	<1	<1	<1	0	0
5 Jun. 1998	0	x	0	0	12	15	0	0	x	<1	0	0	<1	0	<1	0	0	0	3	1	0	0	0
27 Jun. 1998	0	x	0	0	13	24	0	0	x	<1	0	0	<1	0	0	0	0	0	3	2	0	0	0
14 Jun. 1998	0	x	0	0	21	12	0	0	x	<1	0	0	<1	0	0	0	0	0	<1	1	<1	0	0
25 Aug. 1998	0	x	0	0	26	12	0	0	x	<1	0	0	<1	0	0	0	0	0	5	2	<1	0	0

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Table continued

	Axyris amaranthoides	*Campanula rotundifolia*	*Cerastium arvense*	*Chenopodium album*	*Cirsium arvense*	*Cirsium flodmanii*	*Comandra umbellata*	*Conyza canadensis var. canadensis*	*Crepis tectorum*	*Descurainia sophia*	*Erigeron caespitosus*	*Erigeron lonchophyllus*	*Erysimum inconspicuum*	*Fragaria virginiana*	*Gaillardia aristata*	*Galium boreale*	*Gentianella amarella*	*Geum triflorum*	*Helianthus pauciflorus ssp. subrhomboideus*	*Heterotheca villosa*	*Heuchera richardsonii*	*Lactuca tatarica var. pulchella*	*Lesquerella arenosa*
---Not previously burned---																							
Control	0	0	0	0	<1	0	<1	0	0	0	0	0	0	0	<1	1	0	0	0	0	<1	<1	0
15 Nov. 1997	0	0	<1	0	0	0	<1	0	0	0	0	0	<1	0	0	<1	0	0	0	0	0	0	0
17 Dec. 1997	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1	0	0	0	0	0	0	0
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
16 Apr. 1998	0	0	0	0	0	0	2	0	0	0	0	0	<1	0	0	<1	0	0	0	0	0	0	0
1 May 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
13 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
25 May 1998	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	<1	0	0	0	0	0	0	0
5 Jun. 1998	0	0	<1	<1	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
27 Jun. 1998	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	0	0	0	<1	0	0
14 Jun. 1998	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
25 Aug. 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	0
---Burned 5 years earlier---																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0
15 Nov. 1997	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0
17 Dec. 1997	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	<1	0	0	<1	0	<1	0	0
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 Apr. 1998	0	0	<1	0	0	0	<1	0	0	0	<1	<1	<1	0	0	<1	0	0	0	0	<1	0	0
1 May 1998	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0
13 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 May 1998	0	0	<1	0	0	0	<1	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0
5 Jun. 1998	0	0	0	0	0	0	<1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
27 Jun. 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
14 Jun. 1998	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0
25 Aug. 1998	0	0	<1	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0

Table continued on next page

Table continued

	Lomatium foeniculaceum	*Lygodesma juncea*	*Melilotus alba*	*Monarda bradburiana*	*Monolepis nuttalliana*	*Oligoneuron rigidum var. rigidum*	*Orthocarpus luteus*	*Oxytropis campestris*	*Oxytropis sericea*	*Pediomelum argophyllum*	*Pediomelum esculentum*	*Penstemon gracilis*	*Penstemon procerus*	*Phlox hoodii*	*Polygonum convolvulus*	*Potentilla arguta*	*Potentilla concinna*	*Potentilla gracilis*	*Potentilla pensylvanica*	*Pulsatilla patens ssp. multifida*	*Ratibida columnifera*	*Salsola kali*	*Selaginella densa*
---Not previously burned---																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	<1
15 Nov. 1997	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
17 Dec. 1997	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0
16 Apr. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
1 May 1998	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
13 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
25 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
5 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
27 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	<1	0	0	0	1	0	0	0
14 Jun. 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
25 Aug. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	<1	<1	0	0	0
---Burned 5 years earlier---																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 Nov. 1997	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
17 Dec. 1997	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	0	0
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
16 Apr. 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
1 May 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	<1	0	0	<1	0	0	0
13 May 1998	0	<1	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
25 May 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
5 Jun. 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
27 Jun. 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0
14 Jun. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1
25 Aug. 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	<1	0	0	<1	0	0	0

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Table continued

	Silene drummondii var. drummondii	*Sisyrinchium montanum*	*Solidago canadensis*	*Solidago missouriensis*	*Solidago simplex var. spathulata*	*Solidago sp.*	*Sonchus arvensis*	*Stellaria longipes*	*Symphyotrichum ericoides*	*Symphyotrichum laeve*	*Taraxacum officinale*	*Thalictrum venulosum*	*Thlaspi arvense*	*Tragopogon dubius*	*Vicia americana*	*Viola adunca*	*Zigadenus sp.*	*Zizia aptera*	**Shrubs**	*Elaeagnus commutata*	*Rosa arkansana*	*Spiraea alba*	*Symphoricarpos occidentalis*
---Not previously burned---																							
Control	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	1	0	<1
15 Nov. 1997	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	0
17 Dec. 1997	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	<1	0	0
27 Mar. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	<1	<1	0	0	0	x	0	<1	0	0
16 Apr. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	1	0	2
1 May 1998	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	x	0	<1	0	1
13 May 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	0	0	5
25 May 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	<1	0	6
5 Jun. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	<1	2	0	0	0	x	0	<1	0	0
27 Jun. 1998	0	0	0	<1	0	0	0	0	2	0	0	0	0	0	1	0	0	0	x	0	<1	0	0
14 Jun. 1998	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	x	0	3	0	11
25 Aug. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	<1	1	0	0	0	x	0	1	0	4
---Burned 5 years earlier---																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	1	0	0	0	x	0	<1	0	7
15 Nov. 1997	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	0
17 Dec. 1997	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	3
27 Mar. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	x	0	2	0	2
16 Apr. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	2
1 May 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	<1	0	<1
13 May 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
25 May 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	2	0	4
5 Jun. 1998	0	0	0	0	0	0	0	0	1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	0
27 Jun. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	2
14 Jun. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	0
25 Aug. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	0

Table 7. Cover (%) of bare soil and litter and canopy cover (%) of grasses, sedges, forbs, and shrubs sampled in 1999 after burning in 1998-1999 at different times of the year in plots not previously burned and plots burned 5 years earlier at Kernen Prairie, near Saskatoon, SK. Nomenclature is from Integrated Taxonomic Information System [http://www.itis.usda.gov/index.html]. Last updated: 23 November 2004.

	Bare soil	Litter	**Grasses**	*Agrostis scabra*	*Bouteloua gracilis*	*Calamagrostis montanensis*	*Calamagrostis stricta spp. inexpansa*	*Calamagrostis stricta spp. stricta*	*Elymus lanceolatus*	*Elymus trachycaulus spp. subsecundus*	*Elymus trachycaulus spp. trachycaulus*	*Festuca hallii*	*Helictotrichon hookeri*	*Hesperostipa comata*	*Hesperostipa curtiseta*	*Koeleria macrantha*	*Muhlenbergia richardsonis*	*Nassella viridula*	*Pascopyrum smithii*	*Poa compressa*	*Poa cusickii*	*Poa palustris*	*Poa pratensis*
---Not previously burned---																							
Control	3	98	x	0	0	0	0	0	<1	1	0	36	<1	0	2	<1	0	0	0	0	0	0	0
11 Sep. 1998	70	21	x	<1	0	0	0	0	<1	2	0	10	0	0	<1	<1	<1	0	0	0	0	0	0
20 Oct. 1998	14	77	x	0	0	0	0	0	0	<1	<1	27	0	0	<1	0	0	0	0	0	0	0	0
7 Nov. 1998	28	72	x	0	0	0	0	0	<1	<1	4	17	<1	0	1	<1	0	3	<1	0	0	0	0
29 Mar. 1999	15	85	x	0	0	0	0	0	<1	<1	<1	31	0	0	1	0	0	0	0	0	0	0	0
25 Apr. 1999	44	56	x	0	0	1	0	0	0	0	10	14	<1	0	7	0	0	0	<1	<1	0	0	0
17 May 1999	27	73	x	0	0	0	0	0	0	0	<1	20	<1	0	2	0	<1	0	0	0	0	0	0
27 May 1999	53	47	x	0	0	<1	0	0	<1	<1	0	14	<1	0	5	<1	<1	3	0	0	0	0	0
7 Jun. 1999	35	65	x	0	0	0	0	0	<1	2	0	12	0	0	7	0	0	0	0	0	0	0	0
20 Jun. 1999	39	55	x	0	0	<1	0	0	<1	<1	0	5	0	0	3	<1	<1	0	0	<1	0	0	0
6 Jul. 1999	41	57	x	0	0	0	0	0	2	0	1	5	<1	0	1	<1	<1	<1	0	0	0	0	0
20 Jul. 1999	6	91	x	0	0	0	0	0	<1	0	0	6	1	0	3	<1	0	0	0	0	0	0	0
30 Aug. 1999	85	3	x	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Sep. 1999	85	3	x	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
---Burned 5 years earlier---																							
Control	4	96	x	<1	<1	<1	0	0	<1	0	15	13	0	0	9	<1	0	0	<1	<1	0	0	<1
14 Sep. 1998	58	43	x	0	0	2	0	0	2	4	9	13	<1	0	8	0	0	0	3	0	0	0	0
20 Oct. 1998	44	56	x	0	0	1	0	0	<1	<1	7	8	0	0	9	2	0	0	<1	0	0	0	0
7 Nov. 1998	56	44	x	<1	0	<1	0	0	2	0	6	6	<1	0	9	1	0	0	<1	0	0	0	0
29 Mar. 1999	34	65	x	0	0	<1	0	<1	1	0	2	14	0	0	11	2	0	<1	<1	0	0	0	0
25 Apr. 1999	47	52	x	0	0	4	0	<1	5	<1	8	5	<1	0	4	2	0	<1	4	0	0	0	<1
17 May 1999	37	61	x	<1	0	<1	0	0	<1	2	4	5	<1	0	12	0	0	0	<1	1	0	0	0
27 May 1999	60	40	x	0	0	3	0	0	2	0	10	10	2	0	4	0	0	4	<1	0	0	0	0
7 Jun. 1999	59	41	x	0	0	<1	0	<1	<1	2	12	3	0	0	7	3	0	2	1	2	0	0	0
20 Jun. 1999	67	33	x	0	0	<1	0	0	<1	1	8	8	0	0	5	0	0	<1	<1	0	0	0	0
6 Jul. 1999	43	58	x	0	<1	0	0	0	<1	0	4	4	<1	0	7	1	0	0	1	3	0	0	0
20 Jul. 1999	35	64	x	0	0	<1	0	0	2	0	7	3	6	0	6	<1	0	<1	<1	0	0	0	0
30 Aug. 1999	85	3	x	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Sep. 1999	85	3	x	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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Table continued

	Setaria viridis	**Sedges**	*Carex duriuscula*	*Carex filifolia*	*Carex obtusata*	*Carex pensylvanica*	*Carex praegracilis*	*Carex praticola*	**Forbs**	*Achillea millefolium*	*Agoseris glauca*	*Amaranthus sp.*	*Androsace septentrionalis*	*Antennaria neglecta*	*Antennaria parvifolia*	*Arabis divaricarpa*	*Arabis hirsuta*	*Arabis holboellii*	*Artemisia frigida*	*Artemisia ludoviciana*	*Astragalus adsurgens*	*Astragalus flexuosus*	*Astragalus pectinatus*
---Not previously burned---																							
Control	0	x	0	<1	2	2	0	0	x	<1	0	0	0	0	0	0	0	0	<1	0	<1	0	0
11 Sep. 1998	0	x	<1	<1	3	3	<1	0	x	<1	0	0	0	0	0	0	0	0	0	1	1	0	0
20 Oct. 1998	0	x	0	<1	2	5	0	0	x	<1	0	0	0	0	0	0	0	0	<1	1	<1	0	0
7 Nov. 1998	0	x	0	<1	6	5	0	0	x	<1	0	0	0	0	0	0	0	0	4	3	<1	0	0
29 Mar. 1999	0	x	0	<1	3	2	0	0	x	<1	0	0	0	0	0	0	0	0	1	<1	<1	0	0
25 Apr. 1999	0	x	1	<1	6	3	0	0	x	<1	0	0	0	0	0	0	0	0	4	0	<1	0	0
17 May 1999	0	x	<1	<1	4	3	<1	0	x	<1	0	0	0	0	0	0	0	0	1	2	3	0	0
27 May 1999	0	x	0	<1	2	4	0	0	x	<1	0	0	0	0	0	0	0	0	<1	0	<1	0	0
7 Jun. 1999	0	x	0	<1	4	4	0	0	x	<1	0	0	0	0	0	0	0	0	0	3	1	0	0
20 Jun. 1999	<1	x	0	0	3	3	<1	0	x	0	0	0	0	0	0	0	0	0	0	<1	<1	0	0
6 Jul. 1999	0	x	0	<1	5	4	<1	0	x	<1	0	0	0	0	0	0	0	0	<1	<1	<1	0	0
20 Jul. 1999	0	x	0	0	2	2	0	0	x	<1	<1	0	0	0	0	0	0	0	<1	<1	0	0	0
30 Aug. 1999	0	x	0	0	0	0	0	0	x	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Sep. 1999	0	x	0	0	0	0	0	0	x	0	0	0	0	0	0	0	0	0	0	0	0	0	0
---Burned 5 years earlier---																							
Control	0	x	<1	<1	27	15	0	0	x	<1	0	0	<1	0	0	0	0	0	4	0	0	0	0
14 Sep. 1998	0	x	<1	0	11	10	0	0	x	<1	0	0	<1	0	0	0	0	0	<1	0	<1	0	0
20 Oct. 1998	0	x	<1	0	15	8	0	0	x	1	0	0	0	0	0	0	0	0	7	0	0	0	0
7 Nov. 1998	0	x	8	<1	18	22	0	0	x	1	0	0	<1	0	0	0	0	0	5	<1	0	0	0
29 Mar. 1999	0	x	<1	<1	18	12	0	0	x	<1	0	0	<1	0	0	0	0	0	3	1	<1	0	0
25 Apr. 1999	0	x	2	<1	15	11	0	0	x	<1	0	0	<1	0	0	0	0	0	6	0	0	0	0
17 May 1999	0	x	0	<1	14	11	0	0	x	<1	<1	0	0	0	0	0	0	0	1	8	<1	0	0
27 May 1999	0	x	1	0	9	15	0	0	x	<1	0	0	<1	0	0	0	0	0	<1	0	<1	0	0
7 Jun. 1999	0	x	<1	0	14	18	0	0	x	3	0	0	0	0	0	0	0	0	<1	1	<1	0	0
20 Jun. 1999	0	x	<1	0	9	10	<1	0	x	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
6 Jul. 1999	0	x	0	0	13	25	0	0	x	<1	0	0	<1	0	0	0	0	0	1	<1	0	0	0
20 Jul. 1999	0	x	<1	0	12	9	0	0	x	0	<1	0	0	0	0	0	0	0	<1	0	0	0	0
30 Aug. 1999	0	x	0	0	0	0	0	0	x	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Sep. 1999	0	x	0	0	0	0	0	0	x	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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Table continued

	Axyris amaranthoides	*Campanula rotundifolia*	*Cerastium arvense*	*Chenopodium album*	*Cirsium arvense*	*Cirsium flodmanii*	*Comandra umbellata*	*Conyza canadensis var. canadensis*	*Crepis tectorum*	*Descurainia sophia*	*Erigeron caespitosus*	*Erigeron lonchophyllus*	*Erysimum inconspicuum*	*Fragaria virginiana*	*Gaillardia aristata*	*Galium boreale*	*Gentianella amarella*	*Geum triflorum*	*Helianthus pauciflorus ssp. subrhomboideus*	*Heterotheca villosa*	*Heuchera richardsonii*	*Lactuca tatarica var. pulchella*	*Lesquerella arenosa*
Not previously burned																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	2	0	2	0	0	<1	0	0
11 Sep. 1998	<1	0	0	<1	0	0	0	<1	0	0	0	0	<1	0	0	5	0	14	0	0	0	0	0
20 Oct. 1998	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	11	<1	0	0	0	0
7 Nov. 1998	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	6	0	2	0	0	0	0	0
29 Mar. 1999	0	0	<1	<1	0	0	0	0	0	0	0	0	0	0	0	5	0	<1	0	0	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1	0	<1	0	0	0	0	0
17 May 1999	0	0	<1	0	0	0	0	0	0	0	0	<1	0	0	0	3	0	<1	0	<1	0	0	0
27 May 1999	0	0	0	<1	0	0	<1	0	0	0	0	0	<1	0	0	8	0	0	0	0	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	3	0	0	0	0	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	3	0	7	<1	<1	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	2	0	0	0	0	0	0	0
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1	0	0	0	0	0	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Burned 5 years earlier																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
14 Sep. 1998	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	<1	0	0	0	0	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
7 Nov. 1998	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29 Mar. 1999	0	0	<1	<1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0
17 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	<1	0	1	2	0	0	0	0
27 May 1999	0	0	0	1	<1	0	0	<1	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	2	0	0	0	0	0	<1	0
20 Jul. 1999	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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Table continued

	Lomatium foeniculaceum	*Lygodesma juncea*	*Melilotus alba*	*Monarda bradburiana*	*Monolepis nuttalliana*	*Oligoneuron rigidum var. rigidum*	*Orthocarpus luteus*	*Oxytropis campestris*	*Oxytropis sericea*	*Pediomelum argophyllum*	*Pediomelum esculentum*	*Penstemon gracilis*	*Penstemon procerus*	*Phlox hoodii*	*Polygonum convolvulus*	*Potentilla arguta*	*Potentilla concinna*	*Potentilla gracilis*	*Potentilla pensylvanica*	*Pulsatilla patens ssp. multifida*	*Ratibida columnifera*	*Salsola kali*	*Selaginella densa*
----Not previously burned----																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	<1	0	0
11 Sep. 1998	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	<1	<1	<1	0	0	0
20 Oct. 1998	0	0	0	0	0	1	0	0	0	0	0	0	0	<1	0	3	0	0	0	<1	0	0	<1
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	<1	0	0	<1
29 Mar. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	<1	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	<1
17 May 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	<1	0	0	0	0	<1	4	0	0	0
27 May 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0
20 Jun. 1999	0	0	0	0	0	<1	0	0	0	0	2	0	0	0	0	<1	0	0	0	<1	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	<1
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
----Burned 5 years earlier----																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1
14 Sep. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	<1
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	<1
29 Mar. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
17 May 1999	0	0	0	0	0	1	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0
27 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	<1
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	2
30 Aug. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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Table continued

	Silene drummondii var. drummondii	*Sisyrinchium montanum*	*Solidago canadensis*	*Solidago missouriensis*	*Solidago simplex var. spathulata*	*Solidago sp.*	*Sonchus arvensis*	*Stellaria longipes*	*Symphyotrichum ericoides*	*Symphyotrichum laeve*	*Taraxacum officinale*	*Thalictrum venulosum*	*Thlaspi arvense*	*Tragopogon dubius*	*Vicia americana*	*Viola adunca*	*Zigadenus sp.*	*Zizia aptera*	**Shrubs**	*Elaeagnus commutata*	*Rosa arkansana*	*Spiraea alba*	*Symphoricarpos occidentalis*
--------Not previously burned--------																							
Control	0	0	0	<1	0	0	0	0	8	4	0	0	0	0	<1	<1	0	0	x	<1	5	0	17
11 Sep. 1998	0	0	0	<1	0	0	0	0	9	8	0	0	0	0	0	<1	0	0	x	0	8	0	23
20 Oct. 1998	0	0	0	0	0	0	0	0	3	4	0	0	0	0	0	<1	0	0	x	0	4	0	14
7 Nov. 1998	0	0	0	0	0	0	0	0	14	0	0	0	0	0	<1	<1	0	0	x	0	5	0	8
29 Mar. 1999	0	0	0	0	0	0	0	0	6	0	0	0	0	0	<1	<1	0	<1	x	0	6	0	28
25 Apr. 1999	0	0	0	0	<1	0	0	0	9	0	0	0	0	0	0	0	0	0	x	0	0	0	<1
17 May 1999	0	0	0	1	1	0	0	0	12	3	0	0	0	0	<1	<1	0	0	x	0	2	0	15
27 May 1999	0	0	0	0	0	0	<1	0	16	4	0	0	0	0	<1	0	0	0	x	0	14	0	16
7 Jun. 1999	0	0	0	0	0	0	0	0	11	<1	0	0	<1	0	<1	<1	0	0	x	0	11	0	19
20 Jun. 1999	0	0	0	0	0	0	0	0	6	12	0	0	0	0	1	<1	0	<1	x	0	16	0	8
6 Jul. 1999	0	0	0	0	<1	0	0	0	12	<1	0	0	0	0	<1	0	0	0	x	<1	0	0	6
20 Jul. 1999	0	0	0	0	0	0	0	0	7	<1	0	0	0	0	0	0	0	0	x	0	1	0	3
30 Aug. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	0	0	0
--------Burned 5 years earlier--------																							
Control	0	0	0	<1	0	0	0	0	7	0	0	0	0	0	0	0	0	0	x	0	<1	0	0
14 Sep. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	2	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
29 Mar. 1999	0	0	0	0	0	0	0	0	1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	0	0	0
17 May 1999	0	0	0	0	0	0	0	0	3	<1	0	0	0	0	<1	0	0	0	x	0	8	0	26
27 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	x	0	0	0	2
7 Jun. 1999	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	x	0	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	x	0	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	2	0	0
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	0	0	0

Table 8. Cover (%) of bare soil and litter and canopy cover (%) of grasses, sedges, forbs, and shrubs sampled in 2000 after burning in 1998-1999 at different times of the year in plots not previously burned and plots burned 5 years earlier at Kernen Prairie, near Saskatoon, SK. Nomenclature is from Integrated Taxonomic Information System [http://www.itis.usda.gov/index.html]. Last updated: 23 November 2004.

	Bare soil	Litter	**Grasses**	*Agrostis scabra*	*Bouteloua gracilis*	*Calamagrostis montanensis*	*Calamagrostis stricta spp. inexpansa*	*Calamagrostis stricta spp. stricta*	*Elymus lanceolatus*	*Elymus trachycaulus spp. subsecundus*	*Elymus trachycaulus spp. trachycaulus*	*Festuca hallii*	*Helictotrichon hookeri*	*Hesperostipa comata*	*Hesperostipa curtiseta*	*Koeleria macrantha*	*Muhlenbergia richardsonis*	*Nassella viridula*	*Pascopyrum smithii*	*Poa compressa*	*Poa cusickii*	*Poa palustris*	*Poa pratensis*
-----Not previously burned-----																							
Control	3	88	x	0	0	0	0	0	<1	<1	<1	30	<1	0	3	0	0	0	0	0	0	0	0
11 Sep. 1998	31	37	x	0	0	0	0	0	<1	2	0	15	0	0	4	<1	0	<1	<1	0	0	0	0
20 Oct. 1998	12	69	x	0	<1	0	0	0	<1	<1	<1	23	0	0	8	<1	<1	2	0	0	0	0	0
7 Nov. 1998	11	69	x	0	0	0	0	0	<1	<1	<1	26	<1	0	10	<1	0	3	<1	0	0	0	0
29 Mar. 1999	3	84	x	0	0	0	0	0	<1	1	0	34	0	0	2	0	<1	<1	0	0	0	0	0
25 Apr. 1999	17	62	x	0	0	<1	0	0	3	0	8	9	2	0	12	<1	0	3	<1	<1	0	0	0
17 May 1999	14	61	x	0	<1	0	0	0	1	2	0	20	0	0	6	0	<1	<1	<1	0	0	0	0
27 May 1999	25	51	x	0	0	0	0	0	<1	1	<1	19	0	0	8	0	0	<1	0	<1	0	0	0
7 Jun. 1999	31	45	x	0	0	0	0	0	<1	2	<1	13	0	0	10	0	0	0	<1	0	0	0	0
20 Jun. 1999	33	38	x	0	0	0	0	0	<1	2	0	14	0	0	7	<1	0	0	0	<1	0	0	0
6 Jul. 1999	29	49	x	0	0	<1	0	0	5	<1	1	12	2	0	13	1	0	<1	<1	0	0	0	0
20 Jul. 1999	31	45	x	0	<1	0	0	0	<1	<1	<1	20	0	0	4	0	<1	<1	0	<1	0	0	0
30 Aug. 1999	65	23	x	0	0	0	0	0	<1	<1	0	7	0	0	<1	0	<1	0	0	0	0	0	0
27 Sep. 1999	52	34	x	0	0	<1	0	0	9	1	0	7	<1	0	5	<1	0	2	2	0	0	0	0
-----Burned 5 years earlier-----																							
Control	3	85	x	0	0	<1	0	0	3	2	4	10	<1	0	12	1	0	3	1	2	0	0	0
14 Sep. 1998	22	57	x	0	0	2	0	0	5	1	5	6	3	0	7	0	0	0	2	0	0	0	0
20 Oct. 1998	11	70	x	0	0	2	0	0	3	1	2	2	<1	0	15	1	0	0	2	0	0	0	0
7 Nov. 1998	15	62	x	<1	0	3	0	0	6	<1	1	2	<1	0	8	3	0	0	2	<1	0	0	0
29 Mar. 1999	9	74	x	0	0	2	0	0	3	<1	2	15	<1	0	16	1	0	0	<1	0	0	0	0
25 Apr. 1999	22	55	x	0	0	3	0	0	8	<1	4	8	<1	0	5	2	0	<1	3	0	0	0	0
17 May 1999	15	62	x	0	0	<1	0	0	<1	2	0	10	<1	0	7	<1	2	0	<1	0	0	0	0
27 May 1999	21	57	x	0	0	3	0	0	9	0	6	3	0	0	5	0	0	3	2	0	0	0	0
7 Jun. 1999	23	55	x	0	0	<1	0	0	3	3	3	3	<1	0	8	2	0	<1	2	<1	0	0	0
20 Jun. 1999	33	43	x	0	0	2	0	0	2	4	0	14	0	0	7	<1	0	<1	2	0	0	0	0
6 Jul. 1999	28	48	x	0	<1	1	0	0	2	2	<1	11	<1	0	8	<1	0	0	2	<1	0	0	0
20 Jul. 1999	33	43	x	0	<1	2	0	0	10	0	<1	7	3	0	9	1	0	0	4	0	0	0	0
30 Aug. 1999	52	29	x	0	0	<1	0	0	7	2	<1	3	0	0	2	<1	0	<1	4	0	0	0	0
27 Sep. 1999	42	34	x	0	0	<1	0	0	9	0	<1	1	0	0	7	1	<1	0	1	<1	0	0	0

Table continued on next page

Table continued

	Setaria viridis	**Sedges**	*Carex duriuscula*	*Carex filifolia*	*Carex obtusata*	*Carex pensylvanica*	*Carex praegracilis*	*Carex praticola*	**Forbs**	*Achillea millefolium*	*Agoseris glauca*	*Amaranthus sp.*	*Androsace septentrionalis*	*Antennaria neglecta*	*Antennaria parvifolia*	*Arabis divaricarpa*	*Arabis hirsuta*	*Arabis holboellii*	*Artemisia frigida*	*Artemisia ludoviciana*	*Astragalus adsurgens*	*Astragalus flexuosus*	*Astragalus pectinatus*
---Not previously burned---																							
Control	0	x	0	0	3	0	0	0	x	<1	0	0	0	0	0	0	0	0	2	0	0	<1	<1
11 Sep. 1998	0	x	<1	0	2	8	0	0	x	<1	0	0	<1	0	0	0	0	0	0	<1	<1	0	0
20 Oct. 1998	0	x	0	0	3	7	0	0	x	<1	0	0	<1	0	<1	0	0	0	<1	<1	0	<1	0
7 Nov. 1998	0	x	<1	<1	4	7	0	0	x	1	0	0	<1	0	0	0	0	0	2	5	<1	<1	0
29 Mar. 1999	0	x	<1	0	1	3	0	0	x	<1	<1	0	<1	0	0	0	<1	0	<1	1	<1	<1	0
25 Apr. 1999	0	x	<1	<1	6	8	0	0	x	2	0	0	1	0	0	<1	<1	0	5	0	0	0	0
17 May 1999	0	x	0	0	4	8	0	0	x	<1	0	0	<1	0	0	0	<1	0	<1	2	0	1	0
27 May 1999	0	x	<1	0	2	4	0	0	x	<1	0	0	<1	0	0	0	0	0	0	2	<1	2	0
7 Jun. 1999	0	x	<1	0	4	9	0	0	x	<1	0	0	1	0	0	0	<1	0	<1	3	<1	2	0
20 Jun. 1999	0	x	0	0	3	6	0	0	x	<1	0	0	<1	0	0	0	0	0	0	3	0	<1	0
6 Jul. 1999	0	x	4	<1	3	11	0	0	x	<1	0	0	<1	0	0	0	0	0	<1	0	<1	<1	0
20 Jul. 1999	0	x	<1	0	3	6	0	0	x	<1	0	0	<1	0	0	0	0	0	3	2	0	<1	0
30 Aug. 1999	0	x	0	0	<1	2	0	0	x	0	0	0	<1	0	0	0	0	0	0	5	<1	0	0
27 Sep. 1999	0	x	2	0	2	10	0	0	x	0	0	0	0	0	0	0	0	0	<1	<1	<1	<1	<1
---Burned 5 years earlier---																							
Control	0	x	0	0	9	12	0	0	x	2	0	0	<1	0	0	0	0	0	2	<1	0	<1	0
14 Sep. 1998	0	x	<1	0	4	22	0	0	x	1	0	0	<1	0	<1	0	<1	0	<1	2	0	1	0
20 Oct. 1998	0	x	0	0	15	14	0	0	x	<1	0	0	<1	0	<1	0	0	0	3	3	0	<1	0
7 Nov. 1998	0	x	<1	0	11	24	0	0	x	<1	0	0	<1	0	0	0	0	0	2	0	0	1	0
29 Mar. 1999	0	x	<1	0	7	18	0	0	x	2	0	0	<1	0	0	0	0	0	2	<1	0	<1	0
25 Apr. 1999	0	x	<1	2	6	11	0	0	x	<1	0	0	<1	0	0	0	0	0	6	0	<1	<1	0
17 May 1999	0	x	<1	0	2	10	0	0	x	<1	0	0	<1	0	0	0	0	0	<1	8	0	2	0
27 May 1999	0	x	0	3	1	14	0	4	x	0	0	0	<1	0	0	0	0	0	0	0	<1	<1	0
7 Jun. 1999	0	x	<1	0	3	22	0	0	x	7	0	0	0	0	0	0	0	0	5	0	0	0	0
20 Jun. 1999	0	x	0	0	3	11	0	0	x	<1	0	0	<1	0	0	0	0	0	0	2	0	<1	0
6 Jul. 1999	0	x	0	0	3	26	0	0	x	3	<1	0	<1	0	0	0	0	0	<1	3	0	<1	0
20 Jul. 1999	0	x	2	0	6	12	0	0	x	<1	0	0	<1	0	0	0	0	0	<1	0	0	0	0
30 Aug. 1999	0	x	<1	0	8	18	0	0	x	0	0	0	0	0	0	0	0	0	0	3	0	<1	0
27 Sep. 1999	0	x	<1	0	9	19	0	0	x	<1	0	0	0	0	0	0	0	0	<1	0	0	<1	0

Table continued on next page

Table continued

	Axyris amaranthoides	*Campanula rotundifolia*	*Cerastium arvense*	*Chenopodium album*	*Cirsium arvense*	*Cirsium flodmanii*	*Comandra umbellata*	*Conyza canadensis var. canadensis*	*Crepis tectorum*	*Descurainia sophia*	*Erigeron caespitosus*	*Erigeron lonchophyllus*	*Erysimum inconspicuum*	*Fragaria virginiana*	*Gaillardia aristata*	*Galium boreale*	*Gentianella amarella*	*Geum triflorum*	*Helianthus pauciflorus ssp. subrhomboideus*	*Heterotheca villosa*	*Heuchera richardsonii*	*Lactuca tatarica var. pulchella*	*Lesquerella arenosa*
---Not previously burned---																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	5	0	8	0	0	<1	0	0
11 Sep. 1998	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	5	0	15	0	0	<1	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1	2	0	10	0	0	0	0	0
7 Nov. 1998	0	0	<1	0	0	0	0	0	0	0	0	0	<1	0	<1	5	0	0	0	0	0	0	<1
29 Mar. 1999	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	<1
17 May 1999	0	0	<1	0	0	0	0	0	0	0	<1	0	<1	0	<1	5	0	4	0	0	<1	0	0
27 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	11	0	<1	0	0	<1	0	<1
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	6	0	<1	<1	0	0	0	0
20 Jun. 1999	0	<1	0	<1	0	0	0	0	0	0	0	0	0	0	<1	4	0	6	0	0	<1	0	<1
6 Jul. 1999	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	3	0	0	0	0	0	0	0
20 Jul. 1999	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	<1	2	0	<1	0	0	0	0	<1
30 Aug. 1999	0	0	<1	<1	0	0	0	0	0	0	0	0	0	0	<1	11	0	0	0	0	0	0	<1
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	2	0	0	0	0	0
---Burned 5 years earlier---																							
Control	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0
14 Sep. 1998	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
7 Nov. 1998	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29 Mar. 1999	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1	0	0	0	0	0	0	0
17 May 1999	0	<1	0	0	0	0	0	0	0	0	0	0	0	2	0	3	0	<1	6	0	0	0	0
27 May 1999	0	0	0	0	2	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
20 Jun. 1999	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	<1
6 Jul. 1999	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
30 Aug. 1999	0	0	<1	<1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	<1

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Table continued

	Lomatium foeniculaceum	*Lygodesma juncea*	*Melilotus alba*	*Monarda bradburiana*	*Monolepis nuttalliana*	*Oligoneuron rigidum var. rigidum*	*Orthocarpus luteus*	*Oxytropis campestris*	*Oxytropis sericea*	*Pediomelum argophyllum*	*Pediomelum esculentum*	*Penstemon gracilis*	*Penstemon procerus*	*Phlox hoodii*	*Polygonum convolvulus*	*Potentilla arguta*	*Potentilla concinna*	*Potentilla gracilis*	*Potentilla pensylvanica*	*Pulsatilla patens ssp. multifida*	*Ratibida columnifera*	*Salsola kali*	*Selaginella densa*
----Not previously burned----																							
Control	0	0	0	<1	0	0	0	0	0	0	0	0	0	<1	0	2	0	0	0	1	0	0	0
11 Sep. 1998	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	<1	<1	<1	0	1	0	0	0
20 Oct. 1998	0	0	0	0	0	<1	0	0	0	0	0	0	0	<1	0	2	0	0	0	2	0	0	0
7 Nov. 1998	0	0	<1	0	0	<1	0	0	0	0	0	0	0	<1	0	0	0	<1	<1	3	0	0	<1
29 Mar. 1999	0	0	<1	0	0	2	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	<1
17 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	2	0	0	0	1	0	0	0
27 May 1999	0	0	<1	0	0	2	0	0	0	0	0	0	0	0	0	<1	0	0	0	2	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0
20 Jun. 1999	0	0	0	0	0	3	0	0	0	0	<1	0	0	0	0	2	0	0	0	2	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	<1
20 Jul. 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
----Burned 5 years earlier----																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
14 Sep. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
29 Mar. 1999	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
17 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
27 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0
20 Jul. 1999	0	<1	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	<1	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0

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Table continued

	Silene drummondii var. drummondii	*Sisyrinchium montanum*	*Solidago canadensis*	*Solidago missouriensis*	*Solidago simplex var. spathulata*	*Solidago sp.*	*Sonchus arvensis*	*Stellaria longipes*	*Symphyotrichum ericoides*	*Symphyotrichum laeve*	*Taraxacum officinale*	*Thalictrum venulosum*	*Thlaspi arvense*	*Tragopogon dubius*	*Vicia americana*	*Viola adunca*	*Zigadenus sp.*	*Zizia aptera*	**Shrubs**	*Elaeagnus commutata*	*Rosa arkansana*	*Spiraea alba*	*Symphoricarpos occidentalis*
--------Not previously burned--------																							
Control	0	0	0	<1	0	0	0	<1	7	5	0	0	0	0	<1	<1	0	0	x	0	12	0	14
11 Sep. 1998	0	0	0	<1	0	0	0	0	4	6	0	0	0	0	<1	<1	0	0	x	0	8	0	15
20 Oct. 1998	0	0	0	0	0	0	0	0	5	6	0	0	0	0	<1	<1	0	0	x	0	9	0	15
7 Nov. 1998	0	0	0	0	0	0	0	0	10	0	0	0	0	0	<1	<1	0	0	x	0	3	0	8
29 Mar. 1999	0	0	0	<1	0	0	0	0	5	2	0	0	0	0	<1	<1	0	0	x	0	6	0	23
25 Apr. 1999	0	0	0	0	0	0	0	0	3	0	0	0	0	0	2	0	0	0	x	0	0	0	6
17 May 1999	0	0	0	<1	0	0	0	<1	11	6	0	0	0	0	<1	<1	0	0	x	0	6	0	9
27 May 1999	0	0	0	<1	0	0	0	0	9	5	0	0	0	0	1	<1	0	0	x	0	10	0	22
7 Jun. 1999	0	0	0	0	0	0	0	0	9	0	0	0	0	0	<1	0	0	0	x	0	7	0	20
20 Jun. 1999	0	0	0	<1	0	0	0	<1	9	12	0	<1	0	0	<1	<1	0	0	x	0	11	0	11
6 Jul. 1999	0	0	0	<1	0	0	0	0	12	0	0	0	0	0	1	0	0	0	x	0	<1	0	6
20 Jul. 1999	0	0	0	<1	0	0	<1	0	7	2	0	0	0	0	<1	<1	0	0	x	0	4	0	20
30 Aug. 1999	0	0	0	2	0	0	0	0	5	2	0	0	0	0	1	0	0	0	x	0	10	0	19
27 Sep. 1999	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	0	0	2
--------Burned 5 years earlier--------																							
Control	0	0	0	0	0	0	0	0	4	0	0	0	0	0	1	0	0	0	x	0	1	0	0
14 Sep. 1998	0	0	0	3	0	0	0	0	0	0	0	0	0	0	2	0	0	0	x	0	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	x	0	<1	0	0
7 Nov. 1998	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
29 Mar. 1999	0	0	0	<1	0	0	0	0	2	0	0	0	0	0	2	0	0	0	x	0	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	0	0	0
17 May 1999	0	0	0	1	0	0	0	<1	2	4	0	0	0	0	<1	0	0	0	x	0	9	<1	21
27 May 1999	0	0	0	0	0	0	0	<1	3	0	0	0	0	0	1	0	0	0	x	0	0	0	2
7 Jun. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0	x	0	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	3	0	0	0	0	0	2	0	0	0	x	0	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	3	0	0	0	0	0	1	0	0	0	x	0	3	0	3
20 Jul. 1999	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	<1	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	2	0	0	0	0	0	4	0	0	0	x	0	<1	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	0	0	0

Table 9. Cover (%) of bare soil and litter and canopy cover (%) of grasses, sedges, forbs, and shrubs sampled in 2001 after burning in 1998-1999 at different times of the year in plots not previously burned and plots burned 5 years earlier at Kernen Prairie, near Saskatoon, SK. Nomenclature is from Integrated Taxonomic Information System [http://www.itis.usda.gov/index.html]. Last updated: 23 November 2004.

	Bare soil	Litter	**Grasses**	*Agrostis scabra*	*Bouteloua gracilis*	*Calamagrostis montanensis*	*Calamagrostis stricta spp. inexpansa*	*Calamagrostis stricta spp. stricta*	*Elymus lanceolatus*	*Elymus trachycaulus spp. subsecundus*	*Elymus trachycaulus spp. trachycaulus*	*Festuca hallii*	*Helictotrichon hookeri*	*Hesperostipa comata*	*Hesperostipa curtiseta*	*Koeleria macrantha*	*Muhlenbergia richardsonis*	*Nassella viridula*	*Pascopyrum smithii*	*Poa compressa*	*Poa cusickii*	*Poa palustris*	*Poa pratensis*
---Not previously burned---																							
Control	3	97	x	0	0	0	0	0	0	<1	<1	32	0	0	1	0	<1	0	0	<1	0	0	0
11 Sep. 1998	24	73	x	<1	<1	0	0	0	<1	<1	<1	9	0	0	2	<1	<1	<1	0	0	0	0	0
20 Oct. 1998	7	92	x	0	0	0	0	0	<1	<1	<1	22	<1	0	1	0	0	0	0	0	0	0	0
7 Nov. 1998	9	88	x	0	0	0	0	0	<1	<1	1	13	<1	0	4	<1	0	<1	<1	0	0	0	0
29 Mar. 1999	3	96	x	0	0	0	0	0	<1	<1	0	16	0	0	3	<1	0	<1	<1	0	0	0	0
25 Apr. 1999	12	87	x	0	0	5	0	0	<1	0	7	6	2	0	3	<1	0	2	<1	0	0	0	0
17 May 1999	8	89	x	0	<1	0	0	0	<1	<1	<1	23	0	0	3	<1	<1	0	<1	0	0	0	0
27 May 1999	25	73	x	0	0	0	0	0	<1	<1	<1	15	0	0	5	0	0	0	<1	<1	0	0	0
7 Jun. 1999	24	76	x	0	<1	0	0	0	<1	4	<1	12	<1	0	3	<1	0	0	0	0	0	0	0
20 Jun. 1999	39	59	x	0	0	0	0	0	<1	<1	<1	11	<1	0	3	<1	<1	0	<1	<1	0	0	0
6 Jul. 1999	23	77	x	0	0	0	0	0	<1	<1	2	11	0	0	7	1	<1	0	<1	0	0	0	0
20 Jul. 1999	24	75	x	0	0	0	0	0	<1	1	0	27	<1	0	<1	0	0	0	0	<1	0	0	0
30 Aug. 1999	77	24	x	0	0	0	0	0	<1	<1	0	8	0	0	1	0	0	0	0	0	0	0	0
27 Sep. 1999	48	52	x	0	0	0	0	0	<1	<1	2	9	<1	0	3	1	0	0	1	0	0	0	0
---Burned 5 years earlier---																							
Control	3	98	x	0	0	0	0	0	<1	0	3	7	0	0	4	<1	0	<1	<1	0	0	0	0
14 Sep. 1998	14	85	x	0	0	<1	0	0	<1	<1	5	5	<1	0	4	<1	0	0	2	0	0	0	0
20 Oct. 1998	5	95	x	0	0	<1	0	0	0	<1	2	7	0	0	6	1	0	0	1	0	0	0	0
7 Nov. 1998	3	96	x	0	0	<1	0	0	0	0	4	2	<1	0	3	<1	0	0	2	0	0	0	0
29 Mar. 1999	5	95	x	0	0	<1	0	0	0	0	2	8	<1	0	6	0	0	0	<1	0	0	0	0
25 Apr. 1999	4	95	x	0	0	<1	0	0	0	0	5	8	0	0	2	<1	0	<1	2	0	0	0	0
17 May 1999	4	94	x	0	0	0	0	0	<1	1	<1	3	<1	0	5	<1	0	0	0	<1	0	0	0
27 May 1999	9	90	x	0	0	<1	0	0	<1	<1	9	6	0	0	3	0	0	0	1	0	0	0	0
7 Jun. 1999	11	88	x	0	<1	0	0	0	0	0	3	3	<1	0	4	<1	0	0	1	<1	0	0	0
20 Jun. 1999	12	88	x	0	0	<1	0	0	<1	<1	3	8	0	0	4	<1	0	<1	<1	0	0	0	0
6 Jul. 1999	17	82	x	0	0	0	0	0	0	<1	3	4	<1	0	5	<1	0	0	2	0	0	0	0
20 Jul. 1999	11	88	x	0	0	<1	0	0	<1	0	4	8	2	0	6	0	0	0	1	0	0	0	0
30 Aug. 1999	48	53	x	0	0	<1	0	0	0	0	3	1	0	0	3	<1	0	0	2	0	0	0	0
27 Sep. 1999	41	59	x	0	0	0	0	0	0	0	2	5	0	0	1	<1	0	0	1	0	0	0	0

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Table continued

	Setaria viridis	**Sedges**	*Carex duriuscula*	*Carex filifolia*	*Carex obtusata*	*Carex pensylvanica*	*Carex praegracilis*	*Carex praticola*	**Forbs**	*Achillea millefolium*	*Agoseris glauca*	*Amaranthus sp.*	*Androsace septentrionalis*	*Antennaria neglecta*	*Antennaria parvifolia*	*Arabis divaricarpa*	*Arabis hirsuta*	*Arabis holboellii*	*Artemisia frigida*	*Artemisia ludoviciana*	*Astragalus adsurgens*	*Astragalus flexuosus*	*Astragalus pectinatus*
---Not previously burned---																							
Control	0	x	0	0	2	2	0	0	x	<1	0	0	0	0	0	0	0	0	3	<1	0	<1	0
11 Sep. 1998	0	x	<1	0	<1	3	0	0	x	<1	0	0	0	0	0	0	0	0	0	<1	0	<1	0
20 Oct. 1998	0	x	0	<1	2	4	0	0	x	<1	0	0	<1	0	0	0	0	0	<1	0	0	<1	0
7 Nov. 1998	0	x	0	0	4	2	0	0	x	<1	0	0	0	0	0	0	0	0	6	1	<1	<1	0
29 Mar. 1999	0	x	<1	0	1	1	0	0	x	<1	0	0	0	0	0	0	0	0	<1	<1	<1	0	0
25 Apr. 1999	0	x	0	<1	5	4	0	0	x	<1	0	0	0	0	0	0	0	0	5	0	0	0	0
17 May 1999	0	x	<1	0	4	4	0	0	x	<1	0	0	0	0	0	0	0	0	2	2	<1	<1	0
27 May 1999	0	x	<1	0	3	2	0	0	x	0	0	0	<1	0	0	0	0	0	<1	<1	<1	<1	0
7 Jun. 1999	0	x	<1	<1	3	4	0	0	x	<1	0	0	<1	0	0	0	0	0	<1	<1	0	0	0
20 Jun. 1999	0	x	<1	0	3	5	0	0	x	<1	0	0	<1	0	0	0	0	0	0	<1	0	0	0
6 Jul. 1999	0	x	1	<1	3	4	0	0	x	<1	0	0	0	0	0	0	0	0	<1	<1	0	<1	0
20 Jul. 1999	0	x	0	0	2	3	0	0	x	<1	0	0	<1	0	0	0	<1	0	2	<1	0	<1	0
30 Aug. 1999	0	x	0	0	1	<1	0	0	x	0	0	0	0	0	0	0	0	0	0	<1	<1	<1	0
27 Sep. 1999	0	x	0	0	2	6	0	0	x	0	0	0	0	0	0	0	0	0	<1	<1	0	0	0
---Burned 5 years earlier---																							
Control	0	x	0	0	3	10	0	0	x	2	0	0	0	0	0	0	0	0	<1	<1	<1	<1	0
14 Sep. 1998	0	x	<1	<1	2	11	0	0	x	<1	0	0	0	0	0	0	0	0	1	1	<1	0	0
20 Oct. 1998	0	x	<1	0	6	8	0	0	x	0	0	0	0	0	0	0	0	0	2	<1	0	0	0
7 Nov. 1998	0	x	<1	0	10	22	0	0	x	<1	0	0	0	0	0	0	0	0	3	0	0	0	0
29 Mar. 1999	0	x	0	0	0	0	0	0	x	<1	0	0	0	0	0	0	0	0	<1	<1	0	<1	0
25 Apr. 1999	0	x	<1	<1	4	10	0	0	x	<1	0	0	0	0	0	0	0	0	3	0	0	0	0
17 May 1999	0	x	<1	0	5	2	0	0	x	<1	0	0	0	0	0	0	0	0	<1	3	<1	<1	0
27 May 1999	0	x	0	0	2	12	0	0	x	<1	0	0	0	0	0	0	0	0	0	3	0	0	0
7 Jun. 1999	0	x	<1	0	1	11	0	0	x	1	0	0	0	0	<1	0	0	0	1	0	0	0	0
20 Jun. 1999	0	x	0	0	3	11	0	0	x	<1	0	0	<1	0	0	0	0	0	0	<1	0	<1	0
6 Jul. 1999	0	x	0	0	3	14	0	0	x	2	0	0	0	0	0	0	0	0	<1	<1	0	0	0
20 Jul. 1999	0	x	<1	0	3	12	0	0	x	0	0	0	<1	0	0	0	0	0	<1	0	0	0	0
30 Aug. 1999	0	x	2	0	1	12	0	0	x	<1	0	0	0	0	0	0	0	0	0	1	0	0	0
27 Sep. 1999	0	x	0	<1	3	17	0	0	x	<1	0	0	0	0	0	0	0	0	1	0	0	0	0

Table continued on next page

Table continued

	Axyris amaranthoides	*Campanula rotundifolia*	*Cerastium arvense*	*Chenopodium album*	*Cirsium arvense*	*Cirsium flodmanii*	*Comandra umbellata*	*Conyza canadensis var. canadensis*	*Crepis tectorum*	*Descurainia sophia*	*Erigeron caespitosus*	*Erigeron lonchophyllus*	*Erysimum inconspicuum*	*Fragaria virginiana*	*Gaillardia aristata*	*Galium boreale*	*Gentianella amarella*	*Geum triflorum*	*Helianthus pauciflorus ssp. subrhomboideus*	*Heterotheca villosa*	*Heuchera richardsonii*	*Lactuca tatarica var. pulchella*	*Lesquerella arenosa*
Not previously burned																							
Control	0	0	<1	0	0	0	0	0	0	0	<1	0	0	0	0	2	0	2	0	0	<1	0	0
11 Sep. 1998	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	2	0	9	0	0	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	3	0	3	0	0	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
29 Mar. 1999	0	<1	0	0	0	0	<1	0	0	0	<1	0	0	0	3	0	0	0	0	0	0	0	<1
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1	0	0	0	0	0	0	0
17 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3	0	0	0	0	0
27 May 1999	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
20 Jun. 1999	0	0	<1	0	0	0	0	0	0	0	0	0	<1	0	0	2	0	4	<1	0	0	0	0
6 Jul. 1999	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	0	2	0	0	0	0	0	0	<1
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	<1	0	<1	0	0	1	0	0	0	0	0	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	2	0	0	0	0	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1	0	<1	0	0	0	0	0
Burned 5 years earlier																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0
14 Sep. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
7 Nov. 1998	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29 Mar. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 May 1999	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
27 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
6 Jul. 1999	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1	0	0	0	0	<1	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0

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Table continued

	Lomatium foeniculaceum	*Lygodesma juncea*	*Melilotus alba*	*Monarda bradburiana*	*Monolepis nuttalliana*	*Oligoneuron rigidum var. rigidum*	*Orthocarpus luteus*	*Oxytropis campestris*	*Oxytropis sericea*	*Pediomelum argophyllum*	*Pediomelum esculentum*	*Penstemon gracilis*	*Penstemon procerus*	*Phlox hoodii*	*Polygonum convolvulus*	*Potentilla arguta*	*Potentilla concinna*	*Potentilla gracilis*	*Potentilla pensylvanica*	*Pulsatilla patens ssp. multifida*	*Ratibida columnifera*	*Salsola kali*	*Selaginella densa*
Not previously burned																							
Control	0	0	0	0	0	2	0	0	0	<1	0	0	0	<1	0	0	0	0	0	<1	0	0	0
11 Sep. 1998	0	0	0	0	0	0	0	0	0	0	0	<1	0	<1	0	<1	0	0	0	1	0	0	0
20 Oct. 1998	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	<1	0	0	0	1	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0
29 Mar. 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	1	0	0	0	<1	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	3	0	0	<1
17 May 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
27 May 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	3	0	0	0
20 Jun. 1999	0	0	0	0	0	2	0	0	0	0	0	<1	0	<1	0	0	0	0	0	2	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	<1
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
30 Aug. 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	<1	0	0	0	1	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
Burned 5 years earlier																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
14 Sep. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
29 Mar. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
17 May 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0
27 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1
30 Aug. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0

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Table continued

	Silene drummondii var. drummondii	*Sisyrinchium montanum*	*Solidago canadensis*	*Solidago missouriensis*	*Solidago simplex var. spathulata*	*Solidago sp.*	*Sonchus arvensis*	*Stellaria longipes*	*Symphyotrichum ericoides*	*Symphyotrichum laeve*	*Taraxacum officinale*	*Thalictrum venulosum*	*Thlaspi arvense*	*Tragopogon dubius*	*Vicia americana*	*Viola adunca*	*Zigadenus sp.*	*Zizia aptera*	**Shrubs**	*Elaeagnus commutata*	*Rosa arkansana*	*Spiraea alba*	*Symphoricarpos occidentalis*
---Not previously burned---																							
Control	0	0	0	<1	0	0	0	0	3	2	0	<1	0	0	<1	0	0	0	x	0	4	0	10
11 Sep. 1998	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	<1	0	0	x	0	4	0	10
20 Oct. 1998	0	0	0	0	0	0	0	0	3	1	0	0	0	0	<1	0	0	0	x	0	4	0	11
7 Nov. 1998	0	0	0	<1	0	0	0	0	2	0	0	0	0	0	<1	0	0	0	x	0	2	0	5
29 Mar. 1999	0	0	<1	0	0	0	0	0	2	<1	0	0	0	0	<1	<1	0	<1	x	0	3	0	16
25 Apr. 1999	0	0	0	0	0	0	0	0	2	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
17 May 1999	0	0	0	<1	0	0	0	0	4	<1	0	0	0	0	<1	0	0	0	x	0	6	0	10
27 May 1999	0	0	0	<1	0	0	0	0	2	2	0	0	0	0	<1	0	0	0	x	0	8	0	18
7 Jun. 1999	0	0	0	0	0	0	0	0	5	<1	0	0	0	0	0	<1	0	0	x	0	9	0	14
20 Jun. 1999	0	0	0	<1	0	0	0	0	3	5	0	0	0	0	1	0	0	<1	x	0	10	0	10
6 Jul. 1999	0	0	0	0	0	0	0	0	3	0	0	0	0	0	<1	0	0	0	x	0	<1	0	9
20 Jul. 1999	0	0	0	<1	0	0	0	0	3	1	0	0	0	0	<1	0	0	0	x	0	2	0	15
30 Aug. 1999	0	0	0	<1	0	0	0	0	4	2	0	0	0	0	<1	0	0	0	x	0	5	0	21
27 Sep. 1999	0	0	0	0	0	0	0	0	1	0	0	0	0	0	<1	0	0	0	x	0	0	0	<1
---Burned 5 years earlier---																							
Control	0	0	0	<1	0	0	0	0	1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	0
14 Sep. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0	x	0	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
29 Mar. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
25 Apr. 1999	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
17 May 1999	0	<1	0	0	0	0	0	0	2	2	0	0	0	0	<1	0	0	0	x	0	4	0	15
27 May 1999	0	0	0	0	0	0	0	0	1	0	0	0	0	0	<1	0	0	0	x	0	0	0	2
7 Jun. 1999	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	0	0	0
6 Jul. 1999	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	x	<1	2	0	<1
20 Jul. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	2	0	0	0	0	0	<1	0	0	0	x	0	<1	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0

Table 10. Cover (%) of bare soil and litter and canopy cover (%) of grasses, sedges, forbs, and shrubs sampled in 2002 after burning in 1998-1999 at different times of the year in plots not previously burned and plots burned 5 years earlier at Kernen Prairie, near Saskatoon, SK. Nomenclature is from Integrated Taxonomic Information System [http://www.itis.usda.gov/index.html]. Last updated: 23 November 2004.

	Bare soil	Litter	**Grasses**	*Agrostis scabra*	*Bouteloua gracilis*	*Calamagrostis montanensis*	*Calamagrostis stricta spp. inexpansa*	*Calamagrostis stricta spp. stricta*	*Elymus lanceolatus*	*Elymus trachycaulus spp. subsecundus*	*Elymus trachycaulus spp. trachycaulus*	*Festuca hallii*	*Helictotrichon hookeri*	*Hesperostipa comata*	*Hesperostipa curtiseta*	*Koeleria macrantha*	*Muhlenbergia richardsonis*	*Nassella viridula*	*Pascopyrum smithii*	*Poa compressa*	*Poa cusickii*	*Poa palustris*	*Poa pratensis*
----Not previously burned----																							
Control	4	94	x	0	0	0	0	0	<1	<1	0	9	0	0	<1	0	0	0	0	<1	0	0	0
11 Sep. 1998	26	74	x	0	0	0	0	0	<1	<1	<1	7	0	0	<1	<1	<1	0	<1	<1	0	0	0
20 Oct. 1998	3	98	x	0	0	0	0	0	<1	<1	<1	6	0	0	2	<1	<1	0	0	0	0	0	0
7 Nov. 1998	11	90	x	0	<1	0	0	0	<1	1	1	2	0	0	2	<1	0	<1	<1	0	0	0	0
29 Mar. 1999	3	97	x	0	0	0	0	0	<1	<1	<1	9	0	0	<1	0	<1	<1	0	<1	0	0	0
25 Apr. 1999	9	91	x	0	<1	0	0	0	2	<1	1	2	<1	0	4	<1	0	<1	<1	0	0	0	0
17 May 1999	4	96	x	0	<1	0	0	0	1	0	<1	10	0	0	3	<1	<1	0	<1	0	0	0	0
27 May 1999	21	80	x	0	0	0	0	0	<1	1	<1	9	0	0	2	<1	0	<1	<1	<1	0	0	0
7 Jun. 1999	18	82	x	0	0	0	0	0	0	<1	0	3	<1	0	3	0	0	<1	<1	0	0	0	0
20 Jun. 1999	23	76	x	0	0	0	0	0	<1	<1	<1	3	0	0	1	<1	1	0	<1	<1	0	0	0
6 Jul. 1999	19	81	x	0	0	0	0	0	<1	0	<1	7	0	0	4	0	0	0	0	<1	0	0	0
20 Jul. 1999	13	87	x	0	0	0	0	0	1	0	<1	13	0	0	2	<1	0	0	<1	1	0	0	0
30 Aug. 1999	54	46	x	0	0	0	0	0	<1	0	0	9	0	0	2	<1	0	0	0	0	0	0	0
27 Sep. 1999	34	64	x	0	0	0	0	0	5	0	<1	5	0	0	2	<1	0	<1	<1	<1	0	0	0
----Burned 5 years earlier----																							
Control	3	97	x	0	0	0	0	0	1	<1	2	2	<1	0	4	0	0	2	1	1	0	0	0
14 Sep. 1998	9	91	x	0	0	<1	0	0	5	<1	1	2	0	0	<1	<1	0	0	2	0	0	0	0
20 Oct. 1998	6	94	x	<1	0	<1	0	0	1	<1	<1	1	0	0	3	<1	0	0	1	0	0	0	0
7 Nov. 1998	4	96	x	0	0	<1	0	0	2	0	2	<1	0	0	2	<1	0	0	2	0	0	0	0
29 Mar. 1999	4	94	x	0	0	<1	0	0	1	0	1	1	0	0	1	<1	0	0	<1	0	0	0	0
25 Apr. 1999	4	96	x	0	0	<1	0	0	2	0	1	1	0	0	1	<1	0	0	2	0	0	0	0
17 May 1999	6	91	x	0	0	0	0	0	<1	<1	<1	2	0	0	<1	<1	1	0	<1	0	0	0	0
27 May 1999	4	96	x	0	0	0	0	0	2	0	2	1	0	0	1	0	0	0	2	<1	0	0	0
7 Jun. 1999	10	90	x	0	<1	<1	0	0	2	0	2	<1	0	0	2	<1	0	<1	<1	0	0	0	0
20 Jun. 1999	22	78	x	0	0	0	0	0	4	<1	3	2	0	0	1	0	0	<1	2	0	0	0	0
6 Jul. 1999	16	84	x	0	0	<1	0	0	2	0	2	<1	0	0	2	0	0	0	2	0	0	0	0
20 Jul. 1999	9	91	x	0	<1	<1	0	0	3	0	3	2	0	0	3	<1	0	0	1	0	0	0	0
30 Aug. 1999	30	70	x	0	0	0	0	0	3	0	<1	<1	0	0	<1	<1	0	0	2	0	0	0	0
27 Sep. 1999	35	66	x	0	<1	0	0	0	2	0	<1	<1	0	0	1	<1	0	0	1	0	0	0	0

Table continued on next page

Table continued

	Setaria viridis	**Sedges**	*Carex duriuscula*	*Carex filifolia*	*Carex obtusata*	*Carex pensylvanica*	*Carex praegracilis*	*Carex praticola*	**Forbs**	*Achillea millefolium*	*Agoseris glauca*	*Amaranthus sp.*	*Androsace septentrionalis*	*Antennaria neglecta*	*Antennaria parvifolia*	*Arabis divaricarpa*	*Arabis hirsuta*	*Arabis holboellii*	*Artemisia frigida*	*Artemisia ludoviciana*	*Astragalus adsurgens*	*Astragalus flexuosus*	*Astragalus pectinatus*
---Not previously burned---																							
Control	0	x	<1	0	1	2	0	0	x	<1	0	0	0	0	0	0	0	0	2	<1	0	0	0
11 Sep. 1998	0	x	0	0	3	3	0	0	x	0	0	0	0	0	<1	0	0	0	0	0	0	<1	0
20 Oct. 1998	0	x	<1	0	2	4	0	0	x	0	0	0	0	0	0	0	0	0	<1	<1	0	0	0
7 Nov. 1998	0	x	<1	0	4	5	0	0	x	<1	0	0	0	0	0	0	0	0	6	<1	0	0	0
29 Mar. 1999	0	x	<1	0	3	3	0	0	x	0	<1	0	0	0	0	0	0	0	<1	<1	<1	0	0
25 Apr. 1999	0	x	<1	<1	4	4	0	0	x	<1	0	0	0	0	0	0	0	0	5	0	0	0	0
17 May 1999	0	x	0	0	2	2	0	0	x	<1	0	0	0	0	<1	0	0	0	2	<1	0	0	0
27 May 1999	0	x	<1	0	4	4	0	0	x	<1	0	0	0	0	0	0	0	0	<1	0	<1	0	0
7 Jun. 1999	0	x	<1	0	3	6	0	0	x	<1	0	0	0	0	0	0	0	0	2	2	0	0	0
20 Jun. 1999	0	x	0	0	<1	6	0	0	x	<1	0	0	0	0	0	0	0	0	<1	<1	0	0	0
6 Jul. 1999	0	x	0	0	2	8	0	0	x	<1	0	0	0	0	0	0	0	0	<1	<1	0	0	0
20 Jul. 1999	0	x	<1	0	4	3	0	0	x	<1	0	0	0	0	0	0	0	0	1	<1	0	0	0
30 Aug. 1999	0	x	0	0	1	1	0	0	x	0	0	0	0	0	0	0	0	0	0	3	<1	0	0
27 Sep. 1999	0	x	<1	0	<1	3	0	0	x	0	0	0	0	0	0	0	0	0	<1	<1	0	0	0
---Burned 5 years earlier---																							
Control	0	x	<1	0	9	9	0	0	x	<1	0	0	0	0	0	0	0	0	<1	0	0	<1	0
14 Sep. 1998	0	x	<1	<1	7	8	0	0	x	0	0	0	0	0	0	0	0	0	<1	1	0	0	0
20 Oct. 1998	0	x	<1	<1	5	5	0	0	x	0	0	0	0	0	0	0	0	0	3	<1	0	0	0
7 Nov. 1998	0	x	<1	<1	9	7	0	<1	x	<1	0	0	0	0	0	0	0	0	1	0	0	<1	0
29 Mar. 1999	0	x	<1	<1	4	8	0	0	x	<1	0	0	0	0	0	0	0	0	4	<1	0	<1	0
25 Apr. 1999	0	x	2	<1	4	7	0	0	x	<1	0	0	0	0	0	0	0	0	<1	0	<1	0	<1
17 May 1999	0	x	<1	<1	8	5	0	0	x	<1	0	0	0	0	0	0	0	0	2	3	0	0	0
27 May 1999	0	x	<1	<1	12	7	0	<1	x	0	0	0	0	0	0	0	0	0	<1	0	0	0	0
7 Jun. 1999	0	x	<1	<1	3	6	0	0	x	<1	0	0	0	0	<1	0	0	0	<1	0	0	0	0
20 Jun. 1999	0	x	<1	0	7	6	0	0	x	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
6 Jul. 1999	0	x	0	<1	5	6	0	0	x	0	0	<1	0	0	0	0	0	0	<1	2	0	0	0
20 Jul. 1999	0	x	<1	<1	7	6	0	0	x	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 Aug. 1999	0	x	<1	0	2	6	0	0	x	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
27 Sep. 1999	0	x	1	0	1	4	0	0	x	0	0	0	0	0	0	0	0	0	<1	<1	0	0	0

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Table continued

	Axyris amaranthoides	*Campanula rotundifolia*	*Cerastium arvense*	*Chenopodium album*	*Cirsium arvense*	*Cirsium flodmanii*	*Comandra umbellata*	*Conyza canadensis var. canadensis*	*Crepis tectorum*	*Descurainia sophia*	*Erigeron caespitosus*	*Erigeron lonchophyllus*	*Erysimum inconspicuum*	*Fragaria virginiana*	*Gaillardia aristata*	*Galium boreale*	*Gentianella amarella*	*Geum triflorum*	*Helianthus pauciflorus ssp. subrhomboideus*	*Heterotheca villosa*	*Heuchera richardsonii*	*Lactuca tatarica var. pulchella*	*Lesquerella arenosa*
----Not previously burned----																							
Control	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	1	0	<1	0	0	<1	0	<1
11 Sep. 1998	0	0	0	<1	0	0	0	0	0	0	0	<1	<1	0	0	1	0	3	0	0	<1	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	1	0	1	0	0	0	0	0
7 Nov. 1998	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
29 Mar. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	2	0	0	0	0	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	0
17 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
27 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	2	0	0	0	0	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	<1	0	2	<1	0	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
20 Jul. 1999	0	0	0	<1	0	0	0	0	0	0	0	<1	0	0	0	<1	0	<1	0	0	0	0	0
30 Aug. 1999	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
----Burned 5 years earlier----																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
14 Sep. 1998	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29 Mar. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 May 1999	0	0	0	<1	0	0	0	0	0	0	0	0	0	<1	0	<1	0	2	<1	0	0	0	0
27 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 Jun. 1999	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1
20 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1	0	0	0	0	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Sep. 1999	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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Table continued

	Lomatium foeniculaceum	*Lygodesma juncea*	*Melilotus alba*	*Monarda bradburiana*	*Monolepis nuttalliana*	*Oligoneuron rigidum var. rigidum*	*Orthocarpus luteus*	*Oxytropis campestris*	*Oxytropis sericea*	*Pediomelum argophyllum*	*Pediomelum esculentum*	*Penstemon gracilis*	*Penstemon procerus*	*Phlox hoodii*	*Polygonum convolvulus*	*Potentilla arguta*	*Potentilla concinna*	*Potentilla gracilis*	*Potentilla pensylvanica*	*Pulsatilla patens ssp. multifida*	*Ratibida columnifera*	*Salsola kali*	*Selaginella densa*
----Not previously burned----																							
Control	0	0	0	0	0	<1	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
11 Sep. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	2	0	0	0
20 Oct. 1998	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	<1	0	0	0	<1	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	3	0	0	0
29 Mar. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	3	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	<1
17 May 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	<1	0	<1	0	0	<1	1	0	0	0
27 May 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
7 Jun. 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	<1	0	0	0	0	0	3	0	0	<1
20 Jun. 1999	0	0	0	0	0	<1	0	0	0	0	<1	0	0	<1	0	0	0	0	0	2	0	0	<1
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0
30 Aug. 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
----Burned 5 years earlier----																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
14 Sep. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
29 Mar. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	<1
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
17 May 1999	0	0	0	0	0	<1	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0
27 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
20 Jul. 1999	0	<1	0	0	0	0	0	0	0	0	<1	0	0	<1	0	0	0	0	0	<1	0	<1	0
30 Aug. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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Table continued

	Silene drummondii var. drummondii	*Sisyrinchium montanum*	*Solidago canadensis*	*Solidago missouriensis*	*Solidago simplex var. spathulata*	*Solidago sp.*	*Sonchus arvensis*	*Stellaria longipes*	*Symphyotrichum ericoides*	*Symphyotrichum laeve*	*Taraxacum officinale*	*Thalictrum venulosum*	*Thlaspi arvense*	*Tragopogon dubius*	*Vicia americana*	*Viola adunca*	*Zigadenus sp.*	*Zizia aptera*	**Shrubs**	*Elaeagnus commutata*	*Rosa arkansana*	*Spiraea alba*	*Symphoricarpos occidentalis*
----Not previously burned----																							
Control	0	0	0	0	0	0	0	0	2	1	0	0	0	0	<1	0	0	0	x	0	5	0	9
11 Sep. 1998	0	0	0	<1	0	0	0	0	1	<1	0	0	0	0	<1	0	0	0	x	0	4	0	9
20 Oct. 1998	0	0	0	<1	0	0	0	0	2	<1	0	0	0	0	<1	0	0	0	x	0	2	0	6
7 Nov. 1998	0	0	0	<1	0	0	0	0	3	0	0	0	0	0	1	0	0	0	x	0	2	0	7
29 Mar. 1999	0	0	0	<1	0	0	0	0	2	0	0	0	0	0	<1	0	0	0	x	0	<1	0	12
25 Apr. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	2
17 May 1999	0	0	0	<1	0	0	0	0	3	0	0	0	0	0	<1	0	0	0	x	0	3	0	7
27 May 1999	0	0	0	<1	0	0	0	0	3	<1	0	0	0	0	<1	0	0	0	x	0	6	0	19
7 Jun. 1999	0	0	0	<1	0	0	0	0	3	<1	0	0	0	0	<1	0	0	0	x	0	3	0	8
20 Jun. 1999	0	0	0	<1	0	0	0	0	2	<1	0	0	0	0	<1	0	0	0	x	0	6	0	6
6 Jul. 1999	0	0	0	<1	0	0	0	0	2	0	0	0	0	0	<1	0	0	0	x	0	0	0	10
20 Jul. 1999	0	0	0	0	0	0	0	0	3	<1	0	0	0	0	<1	<1	0	0	x	0	<1	0	8
30 Aug. 1999	0	0	0	0	0	0	0	0	3	<1	0	0	0	0	<1	0	0	0	x	0	6	0	21
27 Sep. 1999	0	0	0	0	0	0	0	0	1	0	0	0	0	0	<1	0	0	0	x	0	0	0	2
----Burned 5 years earlier----																							
Control	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0	x	0	0	0	0
14 Sep. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
29 Mar. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
17 May 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0	x	0	2	<1	20
27 May 1999	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	x	0	0	0	<1
7 Jun. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	x	0	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	<1
20 Jul. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	x	0	<1	0	0
27 Sep. 1999	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	0	0	0

Table 11. Cover (%) of bare soil and litter and canopy cover (%) of grasses, sedges, forbs, and shrubs sampled in 2003 after burning in 1998-1999 at different times of the year in plots not previously burned and plots burned 5 years earlier at Kernen Prairie, near Saskatoon, SK. Nomenclature is from Integrated Taxonomic Information System [http://www.itis.usda.gov/index.html]. Last updated: 23 November 2004.

	Bare soil	Litter	**Grasses**	*Agrostis scabra*	*Bouteloua gracilis*	*Calamagrostis montanensis*	*Calamagrostis stricta spp. inexpansa*	*Calamagrostis stricta spp. stricta*	*Elymus lanceolatus*	*Elymus trachycaulus spp. subsecundus*	*Elymus trachycaulus spp. trachycaulus*	*Festuca hallii*	*Helictotrichon hookeri*	*Hesperostipa comata*	*Hesperostipa curtiseta*	*Koeleria macrantha*	*Muhlenbergia richardsonis*	*Nassella viridula*	*Pascopyrum smithii*	*Poa compressa*	*Poa cusickii*	*Poa palustris*	*Poa pratensis*
Not previously burned																							
Control	3	98	x	0	0	0	0	0	<1	<1	0	14	<1	0	2	0	0	0	0	0	0	0	3
11 Sep. 1998	10	68	x	0	<1	0	0	0	<1	<1	<1	13	0	0	4	<1	<1	<1	<1	0	<1	0	0
20 Oct. 1998	3	94	x	0	0	0	0	0	<1	<1	0	9	<1	0	5	0	0	1	0	0	<1	0	0
7 Nov. 1998	3	91	x	0	0	0	0	0	2	<1	0	4	0	0	3	0	0	<1	<1	0	0	0	<1
29 Mar. 1999	3	92	x	0	0	0	0	0	<1	1	<1	17	0	0	<1	<1	0	0	0	0	0	0	0
25 Apr. 1999	4	72	x	0	0	0	0	0	5	0	<1	8	<1	<1	11	<1	0	2	<1	0	0	0	0
17 May 1999	5	95	x	0	0	0	0	0	<1	<1	0	21	0	0	7	<1	<1	0	0	0	0	0	0
27 May 1999	10	90	x	0	0	0	0	0	0	<1	0	8	0	0	3	0	<1	<1	0	0	0	0	0
7 Jun. 1999	10	90	x	0	0	0	0	0	<1	1	<1	5	0	0	6	<1	2	<1	0	0	0	0	0
20 Jun. 1999	12	84	x	0	0	<1	0	0	<1	<1	<1	5	0	0	3	<1	<1	0	0	0	0	0	0
6 Jul. 1999	8	86	x	0	<1	0	0	0	8	<1	4	5	0	0	13	<1	0	0	0	0	0	0	0
20 Jul. 1999	7	84	x	0	0	0	0	0	<1	<1	<1	23	0	0	2	<1	0	0	0	0	0	0	<1
30 Aug. 1999	22	41	x	0	0	0	0	0	1	<1	0	8	0	0	2	0	0	0	0	0	0	0	0
27 Sep. 1999	18	76	x	0	0	0	0	0	4	<1	4	9	0	0	5	0	0	<1	<1	0	0	0	<1
Burned 5 years earlier																							
Control	4	96	x	0	0	0	0	0	10	1	3	3	0	0	7	<1	0	5	<1	<1	0	0	<1
14 Sep. 1998	9	90	x	0	0	<1	0	0	10	0	8	1	0	0	<1	<1	0	0	5	0	0	0	0
20 Oct. 1998	4	93	x	0	0	<1	0	0	3	<1	6	<1	0	0	8	1	0	0	4	0	0	0	0
7 Nov. 1998	5	93	x	0	0	<1	0	0	12	0	3	<1	0	0	3	<1	0	0	<1	0	<1	0	0
29 Mar. 1999	7	92	x	0	0	0	0	0	8	<1	4	7	0	0	4	1	0	0	<1	0	0	0	0
25 Apr. 1999	4	94	x	0	0	<1	0	0	19	<1	0	<1	0	0	2	<1	0	<1	2	0	0	0	0
17 May 1999	5	95	x	0	0	0	0	0	6	1	<1	3	0	0	2	0	<1	0	<1	0	0	0	0
27 May 1999	6	94	x	0	0	0	0	0	11	0	2	4	0	0	10	<1	0	0	<1	0	0	0	0
7 Jun. 1999	12	84	x	0	0	0	0	0	10	1	5	0	0	0	3	2	0	0	2	<1	0	0	1
20 Jun. 1999	9	91	x	0	0	1	0	0	9	<1	9	4	0	0	4	2	0	<1	1	0	0	0	0
6 Jul. 1999	11	86	x	0	0	0	0	0	9	<1	7	1	0	0	4	<1	0	<1	3	0	0	0	<1
20 Jul. 1999	4	96	x	0	0	<1	0	0	13	0	7	<1	0	0	7	<1	0	<1	4	0	0	0	0
30 Aug. 1999	18	64	x	0	0	<1	0	0	4	0	7	1	0	0	4	0	0	0	9	0	0	0	0
27 Sep. 1999	17	66	x	0	0	0	0	0	7	0	8	1	0	0	2	1	0	0	5	0	0	0	0

Table continued on next page

Table continued

	Setaria viridis	**Sedges**	*Carex duriuscula*	*Carex filifolia*	*Carex obtusata*	*Carex pensylvanica*	*Carex praegracilis*	*Carex praticola*	**Forbs**	*Achillea millefolium*	*Agoseris glauca*	*Amaranthus sp.*	*Androsace septentrionalis*	*Antennaria neglecta*	*Antennaria parvifolia*	*Arabis divaricarpa*	*Arabis hirsuta*	*Arabis holboellii*	*Artemisia frigida*	*Artemisia ludoviciana*	*Astragalus adsurgens*	*Astragalus flexuosus*	*Astragalus pectinatus*
---Not previously burned---																							
Control	0	x	0	0	3	3	0	0	x	<1	0	0	<1	0	0	0	0	0	<1	1	0	0	0
11 Sep. 1998	0	x	0	0	8	13	0	0	x	<1	0	0	1	0	0	0	0	0	<1	<1	0	0	0
20 Oct. 1998	0	x	0	0	6	8	0	0	x	<1	0	0	<1	0	0	0	<1	<1	1	<1	0	0	0
7 Nov. 1998	0	x	<1	0	10	11	0	0	x	<1	0	0	<1	0	0	0	0	0	1	<1	0	0	0
29 Mar. 1999	0	x	0	0	5	3	0	0	x	<1	0	0	<1	0	0	0	0	0	2	<1	0	0	0
25 Apr. 1999	0	x	<1	0	6	11	0	0	x	<1	0	0	2	0	0	0	0	0	4	<1	0	0	0
17 May 1999	0	x	0	0	6	5	0	0	x	<1	0	0	<1	0	0	0	0	0	<1	<1	<1	0	0
27 May 1999	0	x	<1	0	5	4	0	0	x	0	0	0	<1	0	0	0	0	0	0	<1	<1	0	0
7 Jun. 1999	0	x	<1	0	4	11	0	0	x	<1	0	0	<1	0	0	0	0	0	2	1	0	0	0
20 Jun. 1999	0	x	<1	0	7	9	0	0	x	<1	0	0	0	0	0	0	0	0	0	<1	<1	0	0
6 Jul. 1999	0	x	3	0	13	7	0	0	x	0	0	0	<1	0	0	0	0	0	5	<1	0	0	0
20 Jul. 1999	0	x	0	0	7	5	0	0	x	0	0	0	1	0	0	0	0	<1	4	<1	0	0	0
30 Aug. 1999	0	x	0	0	2	4	0	0	x	<1	0	0	1	0	0	0	0	0	<1	<1	0	<1	0
27 Sep. 1999	0	x	4	0	3	10	0	0	x	0	0	0	<1	0	0	0	0	0	<1	0	0	0	0
---Burned 5 years earlier---																							
Control	0	x	<1	0	12	13	0	0	x	<1	0	0	0	0	0	0	0	0	2	<1	0	0	0
14 Sep. 1998	0	x	0	0	15	18	0	0	x	0	0	0	<1	0	0	0	0	0	2	<1	0	0	0
20 Oct. 1998	0	x	0	0	10	11	0	0	x	0	0	0	<1	0	0	0	0	0	10	0	0	0	0
7 Nov. 1998	0	x	5	0	14	18	0	0	x	0	0	0	<1	0	0	0	0	0	3	0	0	0	0
29 Mar. 1999	0	x	<1	0	12	20	0	0	x	<1	0	0	1	0	0	0	0	0	6	<1	<1	0	0
25 Apr. 1999	0	x	10	0	14	12	0	0	x	0	0	0	<1	0	0	0	0	0	8	0	0	0	0
17 May 1999	0	x	<1	0	14	11	0	0	x	<1	0	0	0	0	0	0	0	0	<1	4	<1	0	0
27 May 1999	0	x	3	0	15	19	0	0	x	<1	0	0	0	0	0	0	0	0	1	0	0	0	0
7 Jun. 1999	0	x	1	0	13	16	0	0	x	0	0	0	<1	0	0	0	0	0	2	0	0	0	0
20 Jun. 1999	0	x	0	0	16	20	0	0	x	<1	0	0	0	0	0	0	0	0	0	2	0	0	0
6 Jul. 1999	0	x	<1	0	10	18	0	0	x	0	0	0	<1	0	0	0	0	0	2	<1	0	0	0
20 Jul. 1999	0	x	<1	0	12	11	0	0	x	0	0	0	0	0	0	0	0	0	<1	0	0	0	0
30 Aug. 1999	0	x	7	0	5	13	0	0	x	0	0	0	<1	0	0	0	0	0	<1	<1	0	0	0
27 Sep. 1999	0	x	<1	0	5	20	0	0	x	0	0	0	<1	0	0	0	0	0	0	<1	0	0	0

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Table continued

	Axyris amaranthoides	*Campanula rotundifolia*	*Cerastium arvense*	*Chenopodium album*	*Cirsium arvense*	*Cirsium flodmanii*	*Comandra umbellata*	*Conyza canadensis var. canadensis*	*Crepis tectorum*	*Descurainia sophia*	*Erigeron caespitosus*	*Erigeron lonchophyllus*	*Erysimum inconspicuum*	*Fragaria virginiana*	*Gaillardia aristata*	*Galium boreale*	*Gentianella amarella*	*Geum triflorum*	*Helianthus pauciflorus ssp. subrhomboideus*	*Heterotheca villosa*	*Heuchera richardsonii*	*Lactuca tatarica var. pulchella*	*Lesquerella arenosa*
Not previously burned																							
Control	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	<1	0	0	<1	0	0
11 Sep. 1998	0	<1	0	<1	0	0	0	0	0	0	0	0	<1	0	0	1	0	1	0	0	<1	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	2	0	4	0	0	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	<1	1	0	<1	0	0	<1	0	0
29 Mar. 1999	0	<1	<1	0	0	0	0	0	0	0	0	<1	<1	0	0	2	0	0	0	0	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1	0	<1	0	0	0	0	0
17 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	<1	0	0
27 May 1999	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	2	0	<1	0	0	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	1	0	<1	0	0	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	3	<1	0	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1	0	<1	0	0	<1	0	0
30 Aug. 1999	0	0	0	<1	0	0	0	0	0	0	0	<1	<1	0	0	2	0	0	0	0	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Burned 5 years earlier																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0
14 Sep. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29 Mar. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1	0	2	1	0	0	0	0
27 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 Jun. 1999	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
6 Jul. 1999	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0

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Table continued

	Lomatium foeniculaceum	*Lygodesma juncea*	*Melilotus alba*	*Monarda bradburiana*	*Monolepis nuttalliana*	*Oligoneuron rigidum var. rigidum*	*Orthocarpus luteus*	*Oxytropis campestris*	*Oxytropis sericea*	*Pediomelum argophyllum*	*Pediomelum esculentum*	*Penstemon gracilis*	*Penstemon procerus*	*Phlox hoodii*	*Polygonum convolvulus*	*Potentilla arguta*	*Potentilla concinna*	*Potentilla gracilis*	*Potentilla pensylvanica*	*Pulsatilla patens ssp. multifida*	*Ratibida columnifera*	*Salsola kali*	*Selaginella densa*
Not previously burned																							
Control	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
11 Sep. 1998	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
20 Oct. 1998	0	0	0	0	0	<1	0	0	0	0	0	0	0	<1	0	<1	0	0	0	1	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	3	0	0	0
29 Mar. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1	0	0	<1	0	0	<1
17 May 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
27 May 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
7 Jun. 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
20 Jun. 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1	0	0	<1	0	0	0
30 Aug. 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
Burned 5 years earlier																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
14 Sep. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29 Mar. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
17 May 1999	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
27 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	<1
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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Table continued

	Silene drummondii var. drummondii	*Sisyrinchium montanum*	*Solidago canadensis*	*Solidago missouriensis*	*Solidago simplex var. spathulata*	*Solidago sp.*	*Sonchus arvensis*	*Stellaria longipes*	*Symphyotrichum ericoides*	*Symphyotrichum laeve*	*Taraxacum officinale*	*Thalictrum venulosum*	*Thlaspi arvense*	*Tragopogon dubius*	*Vicia americana*	*Viola adunca*	*Zigadenus sp.*	*Zizia aptera*	**Shrubs**	*Elaeagnus commutata*	*Rosa arkansana*	*Spiraea alba*	*Symphoricarpos occidentalis*
---Not previously burned---																							
Control	0	0	0	0	0	0	0	0	2	1	0	0	0	0	<1	0	0	0	x	0	2	0	7
11 Sep. 1998	0	0	0	<1	0	0	0	0	2	<1	0	0	0	0	<1	0	0	0	x	0	3	0	12
20 Oct. 1998	0	0	0	0	0	0	0	0	2	<1	0	0	0	0	<1	0	0	0	x	0	2	0	9
7 Nov. 1998	0	0	0	<1	0	0	0	0	3	0	0	0	0	0	1	0	0	0	x	0	1	0	9
29 Mar. 1999	0	0	0	<1	0	0	0	0	2	<1	0	0	0	0	<1	0	0	0	x	0	2	0	26
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	x	0	0	0	<1
17 May 1999	0	0	0	<1	<1	0	0	0	3	0	0	0	0	0	<1	0	0	0	x	0	6	0	5
27 May 1999	0	0	0	<1	0	0	0	0	2	<1	0	0	0	0	0	0	0	0	x	0	4	0	22
7 Jun. 1999	0	0	0	<1	0	0	0	0	3	0	0	0	0	0	<1	0	0	0	x	0	4	0	10
20 Jun. 1999	0	0	0	<1	0	0	0	0	2	<1	0	0	0	0	<1	0	0	0	x	0	5	0	6
6 Jul. 1999	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	x	0	0	0	2
20 Jul. 1999	<1	0	0	0	0	0	0	0	2	<1	0	0	0	0	<1	0	0	0	x	0	1	0	11
30 Aug. 1999	0	0	0	0	0	0	0	0	4	<1	0	0	0	0	<1	0	0	0	x	0	5	0	29
27 Sep. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	<1	0	5
---Burned 5 years earlier---																							
Control	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	<1	0	0
14 Sep. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	0	0	0
29 Mar. 1999	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	0	0	0
17 May 1999	0	0	0	0	0	0	0	0	1	<1	0	0	0	0	0	0	0	0	x	0	9	0	17
27 May 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	0	0	4
7 Jun. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	x	0	0	0	0
6 Jul. 1999	0	0	0	0	0	0	<1	0	<1	0	0	0	0	0	0	0	0	0	x	0	1	0	<1
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	0	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0

Table 12. Cover (%) of bare soil and litter and canopy cover (%) of grasses, sedges, forbs, and shrubs sampled in 2004 after burning in 1998-1999 at different times of the year in plots not previously burned and plots burned 5 years earlier at Kernen Prairie, near Saskatoon, SK. Nomenclature is from Integrated Taxonomic Information System [http://www.itis.usda.gov/index.html]. Last updated: 23 November 2004.

	Bare soil	Litter	**Grasses**	*Agrostis scabra*	*Bouteloua gracilis*	*Calamagrostis montanensis*	*Calamagrostis stricta spp. inexpansa*	*Calamagrostis stricta spp. stricta*	*Elymus lanceolatus*	*Elymus trachycaulus spp. subsecundus*	*Elymus trachycaulus spp. trachycaulus*	*Festuca hallii*	*Helictotrichon hookeri*	*Hesperostipa comata*	*Hesperostipa curtiseta*	*Koeleria macrantha*	*Muhlenbergia richardsonis*	*Nassella viridula*	*Pascopyrum smithii*	*Poa compressa*	*Poa cusickii*	*Poa palustris*	*Poa pratensis*
Not previously burned																							
Control	3	98	x	<1	0	0	0	0	<1	<1	0	36	0	0	2	0	0	0	0	<1	0	0	<1
11 Sep. 1998	6	94	x	0	<1	0	0	0	<1	<1	2	4	0	0	2	<1	0	<1	0	0	0	0	2
20 Oct. 1998	4	96	x	<1	<1	0	0	0	1	1	<1	13	0	0	5	0	<1	<1	0	0	0	0	0
7 Nov. 1998	16	81	x	0	<1	0	0	0	1	<1	<1	3	0	0	3	<1	0	1	<1	<1	0	0	<1
29 Mar. 1999	3	98	x	<1	0	0	0	0	<1	<1	<1	16	0	0	3	0	<1	0	0	0	0	0	0
25 Apr. 1999	7	90	x	0	0	0	0	4	10	0	<1	2	0	0	14	<1	0	5	<1	<1	0	0	0
17 May 1999	4	87	x	0	0	0	0	0	<1	<1	0	15	0	0	4	<1	<1	<1	0	0	0	0	0
27 May 1999	14	80	x	<1	0	0	0	0	<1	<1	0	10	0	0	2	0	<1	<1	0	<1	0	0	0
7 Jun. 1999	6	77	x	0	0	0	0	0	<1	<1	0	2	0	0	14	<1	<1	0	0	<1	0	0	0
20 Jun. 1999	6	55	x	0	0	0	0	0	<1	1	<1	4	0	0	<1	<1	1	0	0	<1	0	0	0
6 Jul. 1999	3	79	x	0	0	0	0	0	8	<1	<1	5	0	0	5	0	<1	<1	0	<1	0	0	2
20 Jul. 1999	6	94	x	0	0	0	0	0	<1	<1	0	34	0	0	5	0	0	3	<1	<1	0	0	2
30 Aug. 1999	16	84	x	<1	0	0	0	0	<1	<1	<1	22	0	0	1	0	0	0	0	0	0	0	0
27 Sep. 1999	13	84	x	0	0	0	0	0	12	2	3	5	0	0	9	<1	0	<1	<1	2	0	0	0
Burned 5 years earlier																							
Control	3	98	x	<1	0	0	0	0	18	1	<1	<1	0	0	10	<1	0	5	1	0	0	0	0
14 Sep. 1998	3	97	x	0	0	1	0	0	11	0	1	7	0	0	7	<1	0	0	2	0	0	0	0
20 Oct. 1998	3	97	x	0	0	0	0	0	7	0	<1	1	0	0	16	<1	0	<1	2	0	0	0	0
7 Nov. 1998	4	92	x	0	0	0	0	0	15	0	<1	2	0	0	2	1	0	0	4	0	0	0	0
29 Mar. 1999	11	89	x	0	0	0	0	0	11	0	0	6	0	0	4	7	0	0	<1	0	0	0	0
25 Apr. 1999	3	98	x	0	0	0	0	0	19	0	<1	<1	0	0	10	1	0	0	1	0	0	0	0
17 May 1999	3	97	x	0	<1	0	0	0	4	1	3	1	0	0	2	<1	<1	0	0	0	0	0	0
27 May 1999	4	96	x	0	0	0	0	0	28	0	<1	4	0	0	10	0	0	0	<1	0	0	0	0
7 Jun. 1999	3	97	x	0	0	0	0	0	25	0	7	0	0	0	7	2	0	0	2	11	0	0	0
20 Jun. 1999	9	92	x	0	0	<1	0	0	18	0	<1	2	0	0	13	0	0	0	6	<1	0	0	0
6 Jul. 1999	7	93	x	0	0	0	0	0	12	0	2	<1	0	0	3	<1	0	0	5	2	0	0	0
20 Jul. 1999	4	96	x	0	0	0	0	0	30	<1	<1	2	0	0	13	<1	0	0	1	0	0	0	0
30 Aug. 1999	9	92	x	0	0	0	0	0	9	0	5	6	0	0	4	0	0	<1	10	0	0	0	0
27 Sep. 1999	11	89	x	0	<1	0	0	0	15	0	<1	2	0	0	10	<1	0	0	6	0	0	0	0

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Table continued

	Setaria viridis	**Sedges**	*Carex duriuscula*	*Carex filifolia*	*Carex obtusata*	*Carex pensylvanica*	*Carex praegracilis*	*Carex praticola*	**Forbs**	*Achillea millefolium*	*Agoseris glauca*	*Amaranthus sp.*	*Androsace septentrionalis*	*Antennaria neglecta*	*Antennaria parvifolia*	*Arabis divaricarpa*	*Arabis hirsuta*	*Arabis holboellii*	*Artemisia frigida*	*Artemisia ludoviciana*	*Astragalus adsurgens*	*Astragalus flexuosus*	*Astragalus pectinatus*
------Not previously burned------																							
Control	0	x	0	0	2	2	0	0	x	<1	0	0	1	0	0	0	0	0	2	<1	0	<1	0
11 Sep. 1998	0	x	<1	0	5	6	0	0	x	0	0	0	<1	<1	0	0	0	0	<1	<1	<1	<1	0
20 Oct. 1998	0	x	2	0	3	4	0	0	x	0	0	0	<1	0	0	0	0	<1	5	0	0	0	0
7 Nov. 1998	0	x	2	0	3	6	0	0	x	0	0	0	<1	0	0	0	0	0	21	<1	0	0	0
29 Mar. 1999	0	x	0	0	3	5	0	0	x	<1	0	0	<1	0	0	0	0	0	1	<1	<1	0	0
25 Apr. 1999	0	x	0	0	8	2	0	0	x	<1	0	0	1	0	0	0	0	0	15	0	0	0	0
17 May 1999	0	x	<1	0	2	3	0	0	x	<1	0	0	<1	0	0	0	<1	0	3	1	0	0	0
27 May 1999	0	x	<1	0	2	2	0	0	x	0	0	0	<1	0	0	0	0	0	<1	<1	<1	0	0
7 Jun. 1999	0	x	<1	0	3	4	0	0	x	<1	0	0	<1	0	0	0	0	0	2	<1	<1	0	0
20 Jun. 1999	0	x	<1	0	2	4	0	0	x	<1	0	0	<1	0	0	0	0	0	2	1	0	0	0
6 Jul. 1999	0	x	6	0	5	4	0	0	x	0	0	0	<1	0	0	0	0	0	6	<1	0	0	0
20 Jul. 1999	0	x	<1	0	6	5	0	0	x	<1	0	0	<1	0	0	<1	<1	<1	2	<1	0	0	0
30 Aug. 1999	0	x	0	0	2	1	0	0	x	0	0	0	1	0	0	0	0	0	<1	<1	0	<1	0
27 Sep. 1999	0	x	9	<1	<1	8	0	0	x	0	0	0	1	0	0	0	0	0	5	0	<1	0	0
------Burned 5 years earlier------																							
Control	0	x	0	0	21	16	0	0	x	<1	0	0	<1	0	0	0	0	0	2	<1	0	<1	0
14 Sep. 1998	0	x	1	0	10	28	0	0	x	<1	0	0	<1	0	0	0	0	0	<1	<1	0	0	0
20 Oct. 1998	0	x	3	0	20	17	0	0	x	<1	0	0	<1	0	0	0	0	0	2	<1	0	0	0
7 Nov. 1998	0	x	10	0	22	25	0	0	x	0	0	0	1	<1	0	0	0	0	3	0	0	0	0
29 Mar. 1999	0	x	4	0	11	18	0	0	x	<1	0	0	<1	0	0	0	0	0	11	<1	0	<1	0
25 Apr. 1999	0	x	5	0	14	25	0	0	x	<1	0	0	<1	0	0	0	0	0	6	0	0	0	0
17 May 1999	0	x	<1	0	27	16	<1	0	x	<1	0	0	<1	0	0	0	0	0	4	2	0	<1	0
27 May 1999	0	x	<1	0	24	13	0	0	x	<1	0	0	<1	0	0	0	0	0	1	<1	0	0	0
7 Jun. 1999	0	x	<1	0	14	21	0	0	x	0	0	0	<1	0	0	0	0	0	1	<1	0	0	0
20 Jun. 1999	0	x	<1	0	9	20	0	0	x	0	0	0	<1	0	0	0	0	0	2	1	0	0	0
6 Jul. 1999	0	x	<1	0	13	30	0	0	x	0	0	0	<1	0	0	0	0	0	4	<1	0	0	0
20 Jul. 1999	0	x	2	0	15	7	0	0	x	0	0	0	<1	0	0	0	0	0	3	0	0	0	0
30 Aug. 1999	0	x	9	0	5	24	0	0	x	0	0	0	<1	0	0	0	0	0	0	<1	0	0	0
27 Sep. 1999	0	x	19	0	4	12	0	0	x	0	0	0	<1	0	0	0	0	0	18	<1	0	0	0

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Table continued

	Axyris amaranthoides	*Campanula rotundifolia*	*Cerastium arvense*	*Chenopodium album*	*Cirsium arvense*	*Cirsium flodmanii*	*Comandra umbellata*	*Conyza canadensis var. canadensis*	*Crepis tectorum*	*Descurainia sophia*	*Erigeron caespitosus*	*Erigeron lonchophyllus*	*Erysimum inconspicuum*	*Fragaria virginiana*	*Gaillardia aristata*	*Galium boreale*	*Gentianella amarella*	*Geum triflorum*	*Helianthus pauciflorus ssp. subrhomboideus*	*Heterotheca villosa*	*Heuchera richardsonii*	*Lactuca tatarica var. pulchella*	*Lesquerella arenosa*
Not previously burned																							
Control	0	0	<1	0	0	0	0	0	0	0	0	0	<1	0	0	2	0	<1	0	0	<1	0	0
11 Sep. 1998	0	<1	0	<1	0	0	0	0	0	0	0	<1	<1	0	0	1	0	5	0	0	0	0	0
20 Oct. 1998	0	0	0	0	<1	0	0	0	0	0	0	0	<1	0	0	2	0	4	<1	0	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	1	0	<1	0	0	0	0	0
29 Mar. 1999	0	0	0	<1	0	0	<1	0	0	0	<1	0	0	0	0	2	0	0	0	0	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	0
17 May 1999	0	0	<1	<1	0	0	0	0	0	0	0	0	0	0	0	1	0	<1	0	0	0	0	0
27 May 1999	0	0	0	<1	0	0	<1	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	2	0	<1	0	0	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	1	0	3	<1	0	<1	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	<1	0	0	0	0	0	0	0
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	<1	0	0	<1	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	<1	2	0	<1	0	0	0	0	0
27 Sep. 1999	0	0	0	<1	0	0	0	0	0	0	0	0	<1	0	0	<1	0	0	0	0	0	0	0
Burned 5 years earlier																							
Control	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0
14 Sep. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0
7 Nov. 1998	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29 Mar. 1999	0	0	0	<1	0	0	0	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	0	0
25 Apr. 1999	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 May 1999	0	0	0	<1	0	0	0	0	0	0	0	0	0	<1	0	<1	0	<1	2	0	0	0	0
27 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 Jun. 1999	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
6 Jul. 1999	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0
20 Jul. 1999	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 Aug. 1999	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Sep. 1999	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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Table continued

	Lomatium foeniculaceum	*Lygodesma juncea*	*Melilotus alba*	*Monarda bradburiana*	*Monolepis nuttalliana*	*Oligoneuron rigidum var. rigidum*	*Orthocarpus luteus*	*Oxytropis campestris*	*Oxytropis sericea*	*Pediomelum argophyllum*	*Pediomelum esculentum*	*Penstemon gracilis*	*Penstemon procerus*	*Phlox hoodii*	*Polygonum convolvulus*	*Potentilla arguta*	*Potentilla concinna*	*Potentilla gracilis*	*Potentilla pensylvanica*	*Pulsatilla patens ssp. multifida*	*Ratibida columnifera*	*Salsola kali*	*Selaginella densa*
Not previously burned																							
Control	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	<1	0	0	0	1	0	0	0
11 Sep. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
20 Oct. 1998	0	0	0	0	0	3	0	0	0	0	0	0	0	<1	0	<1	0	0	0	2	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	3	0	0	0
29 Mar. 1999	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	0	0	0	0	<1	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	<1
17 May 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
27 May 1999	0	0	0	0	0	<1	0	<1	0	0	0	0	0	0	0	<1	0	0	0	<1	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0
20 Jun. 1999	0	0	0	0	0	<1	0	0	0	0	0	<1	0	<1	0	0	0	0	0	<1	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0
30 Aug. 1999	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0
Burned 5 years earlier																							
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
14 Sep. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
29 Mar. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0
17 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
27 May 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
20 Jul. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0

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Table continued

	Silene drummondii var. drummondii	*Sisyrinchium montanum*	*Solidago canadensis*	*Solidago missouriensis*	*Solidago simplex var. spathulata*	*Solidago sp.*	*Sonchus arvensis*	*Stellaria longipes*	*Symphyotrichum ericoides*	*Symphyotrichum laeve*	*Taraxacum officinale*	*Thalictrum venulosum*	*Thlaspi arvense*	*Tragopogon dubius*	*Vicia americana*	*Viola adunca*	*Zigadenus sp.*	*Zizia aptera*	**Shrubs**	*Elaeagnus commutata*	*Rosa arkansana*	*Spiraea alba*	*Symphoricarpos occidentalis*
----Not previously burned----																							
Control	0	0	0	<1	0	0	0	0	4	2	0	0	0	0	<1	0	0	0	x	0	4	0	13
11 Sep. 1998	0	0	0	<1	0	0	0	0	7	<1	0	0	0	0	<1	0	0	0	x	0	6	0	18
20 Oct. 1998	0	0	0	0	0	0	0	0	2	1	0	0	0	0	<1	0	0	0	x	0	14	0	16
7 Nov. 1998	0	0	0	<1	0	0	0	0	5	0	0	0	0	0	1	0	0	0	x	0	5	0	7
29 Mar. 1999	0	0	0	0	0	0	0	0	3	<1	0	0	0	0	<1	0	0	0	x	0	6	0	32
25 Apr. 1999	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	x	0	0	0	6
17 May 1999	0	0	0	<1	0	0	0	0	4	<1	0	0	0	0	<1	0	0	0	x	0	5	0	4
27 May 1999	0	0	0	<1	0	0	0	0	3	4	0	0	0	0	<1	0	0	0	x	0	6	0	24
7 Jun. 1999	0	0	0	<1	0	0	0	0	10	<1	0	0	0	0	<1	0	0	0	x	0	6	0	0
20 Jun. 1999	0	0	0	<1	0	0	0	0	3	2	0	<1	0	0	1	0	0	<1	x	0	5	0	11
6 Jul. 1999	0	0	0	<1	0	0	0	0	2	0	0	0	0	0	<1	0	0	0	x	0	0	0	4
20 Jul. 1999	<1	0	0	<1	0	0	0	0	4	1	0	0	0	0	1	0	0	0	x	0	3	0	12
30 Aug. 1999	<1	0	0	<1	0	0	0	0	5	<1	0	0	0	0	<1	0	0	0	x	0	10	0	25
27 Sep. 1999	0	0	0	0	0	0	0	0	4	0	0	0	0	0	<1	0	0	0	x	0	0	0	4
----Burned 5 years earlier----																							
Control	0	0	0	0	0	0	0	0	1	0	0	0	0	0	<1	0	0	0	x	0	1	0	0
14 Sep. 1998	0	0	0	<1	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	0	0	0
20 Oct. 1998	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	0	0	0
7 Nov. 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	x	0	0	0	0
29 Mar. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	0	0	0
25 Apr. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	x	0	0	0	0
17 May 1999	0	0	0	0	0	0	0	0	<1	<1	0	0	0	0	1	0	0	0	x	0	8	0	15
27 May 1999	0	0	0	0	0	0	0	0	2	0	0	0	0	0	<1	0	0	0	x	0	0	0	4
7 Jun. 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
20 Jun. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0	x	0	0	0	0
6 Jul. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	1	0	0	0	x	0	1	0	<1
20 Jul. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0
30 Aug. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	2	0	0	0	x	0	0	0	0
27 Sep. 1999	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	<1	0	0	0	x	0	0	0	0

Appendix B

Table 1. Soil water (%) in 1999-2003 after burning in 1997-1998 at different times of the year in plots not previously burned and plots burned 5 years earlier at Kernen, Prairie, near Saskatoon, SK.

Date of burning	Year of sampling				
	1999	2000	2001	2002	2003
---Not previously burned---					
Control	23	16	11	26	13
15 Nov. 1997	17	12	8	17	13
17 Dec. 1997	18	12	9	17	12
25 Mar. 1998	20	12	9	22	12
16 Apr. 1998	17	12	8	17	12
1 May 1998	18	12	9	18	12
13 May 1998	15	12	8	18	12
25 May 1998	20	11	9	17	14
5 Jun. 1998	17	12	7	17	12
27 Jun. 1998	19	12	8	16	13
14 Jul. 1998	25	12	10	19	12
25 Aug. 1998	18	12	9	16	16
---Burned 5 years earlier---					
Control	20	13	11	19	12
15 Nov. 1997	16	11	9	16	13
17 Dec. 1997	18	11	9	21	12
25 Mar. 1998	18	11	9	19	12
16 Apr. 1998	23	12	9	16	14
1 May 1998	17	12	9	16	12
13 May 1998	17	11	9	16	12
25 May 1998	16	11	9	17	11
5 Jun. 1998	19	11	9	18	13
27 Jun. 1998	17	10	9	18	13
14 Jul. 1998	17	10	9	15	13
25 Aug. 1998	17	10	9	14	14

Table 2. Soil water (%) in 2000-2004 after burning in 1998-1999 at different times of the year in plots not previously burned and plots burned 5 years earlier at Kernen, Prairie, near Saskatoon, SK.

Date of burning	Year of sampling				
	2000	2001	2002	2003	2004
---Not previously burned---					
Control	24	17	26	22	31
11 Sep. 1998	18	14	21	18	25
20 Oct. 1998	19	16	17	20	27
7 Nov. 1998	17	14	7	16	27
29 Mar. 1999	18	16	22	18	27
26 Apr. 1999	16	13	28	15	23
17 May 1999	19	16	22	19	27
27 May 1999	19	16	23	18	28
7 Jun. 1999	19	22	17	18	24
20 Jun. 1999	19	15	19	20	25
6 Jul. 1999	14	11	3	14	20
20 Jul. 1999	20	15	21	20	26
30 Aug. 1999	21	17	20	18	29
27 Sep. 1999	14	11	18	14	19
---Burned 5 years earlier---					
Control	14	9	16	15	17
14 Sep. 1998	11	10	13	13	18
20 Oct. 1999	12	8	18	12	21
7 Nov. 1998	11	8	14	11	19
29 Mar. 1999	12	9	17	11	16
26 Apr. 1999	12	9	13	12	15
17 May 1999	15	10	5	16	25
27 May 1999	13	10	13	12	16
7 Jun. 1999	14	9	19	13	15
20 Jun. 1999	13	8	14	11	18
6 Jul. 1999	11	10	12	13	21
20 Jul. 1999	10	8	12	10	13
30 Aug. 1999	12	9	12	12	17
27 Sep. 1999	13	9	16	13	18

Table 3. Total standing crop (g m^{-2}) in 1999-2003 after burning in 1997-1998 at different times of the year in plots not previously burned and plots burned 5 years earlier at Kernen, Prairie, near Saskatoon, SK.

Date of burning	Year of sampling 1999	2000	2001	2002	2003
Not previously burned					
Control	527	528	469	441	504
15 Nov. 1997	227	293	216	298	260
17 Dec. 1997	255	242	219	202	219
25 Mar. 1998	363	470	370	396	329
16 Apr. 1998	251	277	181	189	254
1 May 1998	272	270	229	178	224
13 May 1998	299	300	227	267	241
25 May 1998	247	227	221	208	164
5 Jun. 1998	191	314	270	260	285
27 Jun. 1998	211	212	188	199	167
14 Jul. 1998	245	315	346	315	289
25 Aug. 1998	149	198	234	177	205
Burned 5 years earlier					
Control	401	475	555	494	391
15 Nov. 1997	224	231	172	274	182
17 Dec. 1997	291	230	235	234	167
25 Mar. 1998	427	311	252	239	190
16 Apr. 1998	261	236	137	207	182
1 May 1998	228	251	226	231	262
13 May 1998	167	243	150	222	175
25 May 1998	209	238	218	243	220
5 Jun. 1998	241	231	152	263	174
27 Jun. 1998	176	202	245	238	218
14 Jul. 1998	152	192	190	257	183
25 Aug. 1998	203	272	246	225	321

Table 4. Total standing crop (g m^{-2}) 2000-2004 after burning in 1998-1999 at different times of the year in plots not previously burned and plots burned 5 years earlier at Kernen, Prairie, near Saskatoon, SK.

Date of burning	Year of sampling				
	2000	2001	2002	2003	2004
--Not previously burned--					
Control	572	526	762	268	410
11 Sep. 1998	204	221	186	165	197
20 Oct. 1998	311	278	415	264	265
7 Nov. 1998	255	224	245	111	302
29 Mar. 1999	441	374	315	292	399
26 Apr. 1999	223	178	172	204	250
17 May 1999	362	333	206	266	406
27 May 1999	284	157	179	214	319
7 Jun. 1999	224	243	214	183	279
20 Jun. 1999	221	148	174	172	267
6 Jul. 1999	205	160	162	196	261
20 Jul. 1999	224	268	382	219	342
30 Aug. 1999	121	133	258	180	260
27 Sep. 1999	86	91	94	165	384
--Burned 5 years earlier--					
Control	395	411	266	325	330
14 Sep. 1998	228	214	210	199	327
20 Oct. 1999	236	238	217	230	234
7 Nov. 1998	210	102	139	175	308
29 Mar. 1999	235	208	122	303	303
26 Apr. 1999	214	188	186	155	335
17 May 1999	326	318	275	226	332
27 May 1999	265	180	254	212	324
7 Jun. 1999	218	167	155	183	269
20 Jun. 1999	196	203	200	197	393
6 Jul. 1999	169	178	141	176	260
20 Jul. 1999	216	189	266	197	271
30 Aug. 1999	68	62	98	151	262
27 Sep. 1999	61	72	88	194	235

Appendix C

Table 1. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for variance (s^2) in litter cover.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	140076	140076	0.85	0.526
Pre-burn history (P)	1	1740	1740	0.01	0.935
Error 1 (R x P)	1	165205	165205	5.82	0.018
Month of burning (M)	7	1235680	176526	5.35	0.004
P x M	7	275346	39335	1.19	0.368
Error 2 (R x P[M])	14	462310	33022	1.16	0.320
Year since burning (Y)	5	1807838	361568	12.73	< 0.001
P x Y	5	210975	42195	1.49	0.204
M x Y	35	1675966	47885	1.69	0.028
P x M x Y	35	499639	14275	0.50	0.987
Error 3	80	2271605	28395		

Table 2. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for litter cover.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	13	13	0.03	0.898
Pre-burn history (P)	1	17	17	0.04	0.882
Error 1 (R x P)	1	478	478	3.93	0.051
Month of burning (M)	7	23162	3309	6.26	0.002
P x M	7	2097	300	0.57	0.771
Error 2 (R x P[M])	14	7397	528	4.34	< 0.01
Year since burning (Y)	5	44707	8941	73.48	< 0.001
P x Y	5	898	180	1.48	0.207
M x Y	35	13943	398	3.27	< 0.001
P x M x Y	35	1606	46	0.38	0.999
Error 3	80	97	35	121.69	

Table 3. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for variance (s^2) in cover of bare soil.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	60954	60954	239.62	0.041
Pre-burn history (P)	1	6041	6041	23.75	0.129
Error 1 (R x P)	1	254	254	0.01	0.907
Month of burning (M)	7	1241740	177391	10.43	< 0.001
P x M	7	281941	40277	2.37	0.080
Error 2 (R x P[M])	14	238047	17003	0.91	0.550
Year since burning (Y)	5	2531373	506275	27.15	< 0.001
P x Y	5	27218	5444	0.29	0.916
M x Y	35	1675238	47864	2.57	< 0.001
P x M x Y	35	343008	9800	0.53	0.982
Error 3	80	1491843	18648		

Table 4. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for cover of bare soil.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	1271	1271	97.61	0.064
Pre-burn history (P)	1	192	192	14.75	0.162
Error 1 (R x P)	1	13	13	0.15	0.702
Month of burning (M)	7	13248	1893	4.84	0.006
P x M	7	1369	196	0.50	0.819
Error 2 (R x P[M])	14	5471	391	4.42	< 0.001
Year since burning (Y)	5	19517	3903	44.10	< 0.001
P x Y	5	129	26	0.29	0.916
M x Y	35	8349	239	2.70	< 0.001
P x M x Y	35	937	27	0.30	1.000
Error 3	80	7081	89		

Table 5. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for variance (s^2) in cover of *Festuca hallii*.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	276109	276109	5.86	0.249
Pre-burn history (P)	1	28984	28984	0.62	0.577
Error 1 (R x P)	1	47094	47094	2.33	0.131
Month of burning (M)	7	668399	95486	4.30	0.010
P x M	7	194725	27818	1.25	0.340
Error 2 (R x P[M])	14	310833	22202	1.10	0.372
Year since burning (Y)	5	981400	196280	9.71	< 0.001
P x Y	5	99206	19841	0.98	0.434
M x Y	35	824053	23544	1.16	0.284
P x M x Y	35	401723	11478	0.57	0.968
Error 3	80	1616941	20212		

Table 6. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for cover of *Festuca hallii*.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	1323	1323	7.50	0.223
Pre-burn history (P)	1	2745	2745	15.57	0.158
Error 1 (R x P)	1	176	176	5.71	0.019
Month of burning (M)	7	2041	292	3.96	0.014
P x M	7	1024	146	1.99	0.130
Error 2 (R x P[M])	14	1031	74	2.38	0.008
Year since burning (Y)	5	3711	742	24.02	< 0.001
P x Y	5	257	51	1.66	0.153
M x Y	35	2376	68	2.20	0.002
P x M x Y	35	1199	34	1.11	0.345
Error 3	80	2472	31		

Table 7. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for variance (s^2) in cover of *Elymus lanceolatus*.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	55863	55863	0.93	0.512
Pre-burn history (P)	1	186190	186190	3.10	0.329
Error 1 (R x P)	1	60102	60102	7.77	0.007
Month of burning (M)	7	34729	4961	1.28	0.329
P x M	7	38704	5529	1.42	0.272
Error 2 (R x P[M])	14	54425	3888	0.50	0.925
Year since burning (Y)	5	425331	85066	11.00	< 0.001
P x Y	5	314138	62828	8.13	< 0.001
M x Y	35	111948	3199	0.41	0.998
P x M x Y	35	146190	4177	0.54	0.978
Error 3	80	618580	7732		

Table 8. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for cover of *Elymus lanceolatus*.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	39	39	0.35	0.660
Pre-burn history (P)	1	863	863	7.67	0.221
Error 1 (R x P)	1	113	113	9.74	< 0.01
Month of burning (M)	7	73	10	1.05	0.444
P x M	7	63	9	0.91	0.526
Error 2 (R x P[M])	14	139	10	0.86	0.602
Year since burning (Y)	5	1072	214	18.56	< 0.001
P x Y	5	646	129	11.17	< 0.001
M x Y	35	169	5	0.42	0.997
P x M x Y	35	186	5	0.46	0.994
Error 3	80	924	12		

Table 9. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for variance (s^2) in cover of *Hesperostipa curtiseta*.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	1976	1976	0.04	0.876
Pre-burn history (P)	1	11781	11781	0.23	0.713
Error 1 (R x P)	1	50376	50376	9.96	< 0.01
Month of burning (M)	7	70014	10002	0.84	0.573
P x M	7	65965	9424	0.79	0.607
Error 2 (R x P[M])	14	166757	11911	2.35	0.009
Year since burning (Y)	5	142997	28599	5.65	< 0.001
P x Y	5	42872	8574	1.69	0.146
M x Y	35	127187	3634	0.72	0.861
P x M x Y	35	95719	2735	0.54	0.978
Error 3	80	404817	5060		

Table 10. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for cover of *Hesperostipa curtiseta*.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	85	85	0.73	0.550
Pre-burn history (P)	1	15	15	0.13	0.780
Error 1 (R x P)	1	117	117	13.23	0.001
Month of burning (M)	7	234	33	1.11	0.409
P x M	7	211	30	1.00	0.470
Error 2 (R x P[M])	14	421	30	3.39	< 0.001
Year since burning (Y)	5	435	87	9.82	< 0.001
P x Y	5	62	12	1.39	0.235
M x Y	35	249	7	0.80	0.760
P x M x Y	35	110	3	0.36	1.000
Error 3	80	709	9		

Table 11. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for variance (s^2) in cover of all other plant species excluding *Festuca hallii*, *Hesperostipa curtiseta*, and *Elymus lanceolatus*.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	115788	115788	0.55	0.595
Pre-burn history (P)	1	27961	27961	0.13	0.778
Error 1 (R x P)	1	212069	212069	4.09	0.047
Month of burning (M)	7	427572	61082	1.71	0.186
P x M	7	297428	42490	1.19	0.370
Error 2 (R x P[M])	14	500512	35751	0.69	0.779
Year since burning (Y)	5	2757726	551545	10.63	< 0.001
P x Y	5	241704	48341	0.93	0.465
M x Y	35	1768930	50541	0.97	0.521
P x M x Y	35	1076676	30762	0.59	0.956
Error 3	80	4150716	51884		

Table 12. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for cover of all other plant species excluding *Festuca hallii*, *Hesperostipa curtiseta*, and *Elymus lanceolatus*.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	1155	1155	0.55	0.593
Pre-burn history (P)	1	101	101	0.05	0.862
Error 1 (R x P)	1	2087	2087	16.84	< 0.001
Month of burning (M)	7	1856	265	1.34	0.303
P x M	7	1133	162	0.82	0.588
Error 2 (R x P[M])	14	2770	198	1.60	0.098
Year since burning (Y)	5	14107	2821	22.76	< 0.001
P x Y	5	1030	206	1.66	0.153
M x Y	35	7256	207	1.67	0.030
P x M x Y	35	2696	77	0.62	0.941
Error 3	80	9917	124		

Table 13. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for variance (s^2) in cover of graminoids.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	30628	30628	24.00	0.128
Pre-burn history (P)	1	362008	362008	283.67	0.038
Error 1 (R x P)	1	1276	1276	0.05	0.830
Month of burning (M)	7	338676	48382	2.00	0.128
P x M	7	41600	5943	0.25	0.966
Error 2 (R x P[M])	14	339292	24235	0.89	0.576
Year since burning (Y)	5	1597421	319484	11.69	< 0.001
P x Y	5	102088	20418	0.75	0.591
M x Y	35	843603	24103	0.88	0.654
P x M x Y	35	222479	6357	0.23	1.000
Error 3	80	2187197	27340		

Table 14. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for cover of graminoids.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	2611	2611	0.93	0.512
Pre-burn history (P)	1	8295	8295	2.96	0.335
Error 1 (R x P)	1	2806	2806	15.02	< 0.001
Month of burning (M)	7	3828	547	3.20	0.030
P x M	7	886	127	0.74	0.643
Error 2 (R x P[M])	14	2392	171	0.91	0.547
Year since burning (Y)	5	18221	3644	19.50	< 0.001
P x Y	5	2716	543	2.91	0.018
M x Y	35	9432	269	1.44	0.091
P x M x Y	35	1674	48	0.26	1.000
Error 3	80	14949	187		

Table 15. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for variance (s^2) in cover of perennial forbs.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	141756	141756	1.29	0.460
Pre-burn history (P)	1	55999	55999	0.51	0.606
Error 1 (R x P)	1	110065	110065	8.33	0.005
Month of burning (M)	7	133748	19107	2.72	0.053
P x M	7	200777	28682	4.08	0.012
Error 2 (R x P[M])	14	98416	7030	0.53	0.907
Year since burning (Y)	5	407175	81435	6.16	< 0.001
P x Y	5	27345	5469	0.41	0.838
M x Y	35	324582	9274	0.70	0.878
P x M x Y	35	380692	10877	0.82	0.736
Error 3	80	1057562	13220		

Table 16. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for cover of perennial forbs.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	261	261	0.21	0.726
Pre-burn history (P)	1	1376	1376	1.11	0.484
Error 1 (R x P)	1	1240	1240	44.37	< 0.001
Month of burning (M)	7	403	58	1.51	0.242
P x M	7	551	79	2.07	0.117
Error 2 (R x P[M])	14	533	38	1.36	0.191
Year since burning (Y)	5	2020	404	14.45	< 0.001
P x Y	5	153	31	1.10	0.369
M x Y	35	668	19	0.68	0.895
P x M x Y	35	549	16	0.56	0.970
Error 3	80	2236	28		

Table 17. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for variance (s^2) in cover of annual forbs.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	64	64	1.49	0.437
Pre-burn history (P)	1	47	47	1.09	0.486
Error 1 (R x P)	1	43	43	0.87	0.353
Month of burning (M)	7	297	42	0.83	0.583
P x M	7	369	53	1.03	0.456
Error 2 (R x P[M])	14	719	51	1.04	0.426
Year since burning (Y)	5	710	142	2.87	0.020
P x Y	5	523	105	2.11	0.072
M x Y	35	1805	52	1.04	0.428
P x M x Y	35	1925	55	1.11	0.342
Error 3	80	3958	49		

Table 18. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for cover of annual forbs.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	10.55	10.55	4.59	0.278
Pre-burn history (P)	1	0.01	0.01	0.00	0.970
Error 1 (R x P)	1	2.30	2.30	1.83	0.180
Month of burning (M)	7	13.91	1.99	2.13	0.109
P x M	7	6.54	0.93	1.00	0.471
Error 2 (R x P[M])	14	13.07	0.93	0.74	0.726
Year since burning (Y)	5	68.34	13.67	10.87	< 0.001
P x Y	5	4.46	0.89	0.71	0.618
M x Y	35	21.37	0.61	0.49	0.990
P x M x Y	35	11.74	0.34	0.27	1.000
Error 3	80	100.58	1.26		

Table 19. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for variance (s^2) in cover of legumes.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	80	80	2.97	0.335
Pre-burn history (P)	1	11	11	0.41	0.638
Error 1 (R x P)	1	27	27	0.61	0.436
Month of burning (M)	7	405	58	1.36	0.297
P x M	7	235	34	0.79	0.609
Error 2 (R x P[M])	14	597	43	0.97	0.494
Year since burning (Y)	5	1577	315	7.16	< 0.001
P x Y	5	178	36	0.81	0.547
M x Y	35	2174	62	1.41	0.105
P x M x Y	35	1136	32	0.74	0.842
Error 3	80	3525	44		

Table 20. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for cover of legumes.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	7.13	7.13	54.76	0.086
Pre-burn history (P)	1	1.88	1.88	14.44	0.164
Error 1 (R x P)	1	0.13	0.13	0.13	0.717
Month of burning (M)	7	8.16	1.17	1.04	0.446
P x M	7	3.74	0.53	0.48	0.835
Error 2 (R x P[M])	14	15.66	1.12	1.14	0.339
Year since burning (Y)	5	100.05	20.01	20.37	< 0.001
P x Y	5	8.84	1.77	1.80	0.122
M x Y	35	17.74	0.51	0.52	0.984
P x M x Y	35	15.29	0.44	0.44	0.996
Error 3	80	78.58	0.98		

Table 21. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for variance (s^2) in species evenness.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	0.0001	0.0001	1.36	0.451
Pre-burn history (P)	1	0.0001	0.0001	1.00	0.500
Error 1 (R x P)	1	0.0001	0.0001	1.55	0.218
Month of burning (M)	7	0.0004	0.0001	0.35	0.915
P x M	7	0.0004	0.0001	0.35	0.918
Error 2 (R x P[M])	14	0.0025	0.0002	3.74	< 0.001
Year since burning (Y)	5	0.0018	0.0004	7.38	< 0.001
P x Y	5	0.0003	0.0001	1.21	0.312
M x Y	35	0.0010	0.0000	0.59	0.956
P x M x Y	35	0.0014	0.0000	0.82	0.743
Error 3	80	0.0039	0.0000		

Table 22. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for species evenness.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	0.0001	0.0001	6.25	0.242
Pre-burn history (P)	1	0.0481	0.0481	5776.00	0.008
Error 1 (R x P)	1	0.0000	0.0000	0.00	0.975
Month of burning (M)	7	0.1089	0.0156	0.94	0.508
P x M	7	0.0883	0.0126	0.76	0.627
Error 2 (R x P[M])	14	0.2319	0.0166	1.91	0.038
Year since burning (Y)	5	0.1200	0.0240	2.76	0.024
P x Y	5	0.0182	0.0036	0.42	0.834
M x Y	35	0.4255	0.0122	1.40	0.109
P x M x Y	35	0.0830	0.0024	0.27	1.000
Error 3	80	0.6945	0.0087		

Table 23. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for variance (s^2) in the Shannon-Weiner diversity index.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	0.0036	0.0036	7.17	0.228
Pre-burn history (P)	1	0.0047	0.0047	9.39	0.201
Error 1 (R x P)	1	0.0005	0.0005	0.26	0.611
Month of burning (M)	7	0.0256	0.0037	0.79	0.608
P x M	7	0.0183	0.0026	0.56	0.773
Error 2 (R x P[M])	14	0.0647	0.0046	2.41	0.007
Year since burning (Y)	5	0.0266	0.0053	2.78	0.023
P x Y	5	0.0066	0.0013	0.69	0.634
M x Y	35	0.0362	0.0010	0.54	0.978
P x M x Y	35	0.0404	0.0012	0.60	0.952
Error 3	80	0.1532	0.0019		

Table 24. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for the Shannon-Weiner diversity index.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	0.07	0.07	0.09	0.816
Pre-burn history (P)	1	0.02	0.02	0.03	0.890
Error 1 (R x P)	1	0.82	0.82	9.44	0.003
Month of burning (M)	7	1.31	0.19	0.74	0.644
P x M	7	1.25	0.18	0.70	0.669
Error 2 (R x P[M])	14	3.54	0.25	2.92	0.013
Year since burning (Y)	5	2.54	0.51	5.87	< 0.001
P x Y	5	0.38	0.08	0.88	0.499
M x Y	35	3.22	0.09	1.06	0.401
P x M x Y	35	0.63	0.02	0.21	1.000
Error 3	80	6.93	0.09		

Table 25. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for variance (s^2) in total plant cover.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	17309	17309	0.06	0.850
Pre-burn history (P)	1	10107	10107	0.03	0.885
Error 1 (R x P)	1	300913	300913	8.90	0.004
Month of burning (M)	7	563674	80525	2.42	0.075
P x M	7	141477	20211	0.61	0.740
Error 2 (R x P[M])	14	465277	33234	0.98	0.479
Year since burning (Y)	5	1963507	392701	11.61	< 0.001
P x Y	5	22769	4554	0.13	0.984
M x Y	35	1298010	37086	1.10	0.360
P x M x Y	35	709476	20271	0.60	0.953
Error 3	80	2705686	33821		

Table 26. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for total plant cover.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	37	37	0.02	0.901
Pre-burn history (P)	1	85	85	0.06	0.851
Error 1 (R x P)	1	1508	1508	4.73	0.033
Month of burning (M)	7	3753	536	3.38	0.025
P x M	7	619	88	0.56	0.779
Error 2 (R x P[M])	14	2224	159	0.50	0.928
Year since burning (Y)	5	37830	7566	23.72	< 0.001
P x Y	5	2833	567	1.78	0.127
M x Y	35	13252	379	1.19	0.261
P x M x Y	35	2878	82	0.26	1.000
Error 3	80	25519	319		

Table 27. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for variance (s^2) in soil water.

Replicate (R)	DF	Sum of squares	Mean Square	F	P
Pre-burn history (P)	1	57	57	0.22	0.721
Error 1 (R x P)	1	610	610	2.37	0.367
Month of burning (M)	1	258	258	0.44	0.510
P x M	7	4542	649	1.10	0.417
Error 2 (R x P[M])	7	2296	328	0.55	0.781
Year since burning (Y)	14	8293	592	1.01	0.457
P x Y	4	2213	553	0.94	0.446
M x Y	4	1953	488	0.83	0.511
P x M x Y	28	13156	470	0.80	0.740
Error 3	28	17986	642	1.09	0.375
Error	64	37622	588		

Table 28. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for soil water.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	210	210	0.51	0.606
Pre-burn history (P)	1	737	737	1.77	0.410
Error 1 (R x P)	1	415	415	19.43	< 0.001
Month of burning (M)	7	210	30	9.66	< 0.001
P x M	7	86	12	3.98	0.013
Error 2 (R x P[M])	14	43	3	0.15	1.000
Year since burning (Y)	4	814	204	9.53	< 0.001
P x Y	4	19	5	0.22	0.928
M x Y	28	98	3	0.16	1.000
P x M x Y	28	101	4	0.17	1.000
Error 3	64	1367	21		

Table 29. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for variance (s^2) in total standing crop.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	36289298	36289298	2.14	0.382
Pre-burn history (P)	1	252971276	252971276	14.93	0.161
Error 1 (R x P)	1	16948785	16948785	0.80	0.374
Month of burning (M)	7	490163264	70023323	3.83	0.016
P x M	7	347752319	49678903	2.72	0.053
Error 2 (R x P[M])	14	256085531	18291824	0.86	0.600
Year since burning (Y)	4	78264746	19566186	0.92	0.456
P x Y	4	15424836	3856209	0.18	0.947
M x Y	28	589866102	21066647	0.99	0.490
P x M x Y	28	408036588	14572735	0.69	0.862
Error 3	64	1355439535	21178743		

Table 30. Analysis of variance based on a 3-factor split-split-plot in a randomized complete block design for total standing crop.

Source	DF	Sum of squares	Mean Square	F	P
Replicate (R)	1	14726	14726	2.64	0.351
Pre-burn history (P)	1	53181	53181	9.53	0.199
Error 1 (R x P)	1	5581	5581	1.30	0.258
Month of burning (M)	7	1034094	147728	28.20	< 0.001
P x M	7	112720	16103	3.07	0.035
Error 2 (R x P[M])	14	73340	5239	1.22	0.281
Year since burning (Y)	4	30568	7642	1.78	0.143
P x Y	4	25865	6466	1.51	0.210
M x Y	28	147245	5259	1.23	0.246
P x M x Y	28	49046	1752	0.41	0.995
Error 3	64	274082	4283		

Appendix D

Time since burning in different dates in plots not previously burned and plots burned 5 years earlier the first 6 years after burning at Kernen Prairie, near Saskatoon, Saskatchewan.

Date of burning	Time since burning in each year of sampling (Months)					
	1	2	3	4	5	6
Not previously burned						
15 Nov. 1997	10.7	19.7	31.7	44.0	56.4	67.9
17 Dec. 1997	9.7	18.7	30.6	43.0	55.4	66.8
25 Mar. 1998	6.4	15.6	27.4	39.7	52.1	63.6
16 Apr. 1998	6.2	14.8	26.9	39.1	51.5	62.8
1 May 1998	5.3	14.3	26.3	38.6	51.0	62.3
13 May 1998	4.9	14.0	25.8	38.1	50.6	61.9
25 May 1998	4.9	13.4	25.6	37.8	50.1	61.5
5 Jun. 1998	4.1	13.3	25.1	37.4	49.8	61.3
27 Jun. 1998	3.9	12.3	24.4	36.7	49.1	60.4
14 Jul. 1998	3.4	11.9	23.9	36.2	48.6	59.8
25 Aug. 1998	1.9	10.5	22.5	34.8	47.1	58.5
11 Sep. 1998	11.9	22.4	33.7	49.2	57.6	70.5
20 Oct. 1998	10.7	21.0	32.5	44.6	56.3	69.2
7 Nov. 1998	10.1	20.4	31.6	43.9	55.7	68.6
29 Mar. 1999	5.4	15.7	27.0	39.2	51.0	63.9
26 Apr. 1999	4.5	14.8	26.2	38.4	50.1	63.0
17 May 1999	3.8	14.1	25.5	37.6	50.3	62.2
27 May 1999	3.5	13.8	25.1	37.3	50.1	61.9
7 Jun. 1999	3.1	13.4	24.8	36.9	49.7	61.5
20 Jun. 1999	2.6	13.1	24.4	36.5	49.2	61.1
6 Jul. 1999	2.0	12.4	23.9	36.0	48.7	60.6
20 Jul. 1999	1.5	12.0	23.5	35.6	47.4	60.2
30 Aug. 1999	--[1]	10.6	21.9	34.1	46.0	58.8
27 Sep. 1999	--[1]	9.7	21.2	33.3	46.0	57.9
Burned 5 years earlier						
15 Nov. 1997	10.7	20.5	31.6	44.6	56.1	68.2
17 Dec. 1997	9.7	18.6	30.6	43.3	55.0	67.2
25 Mar. 1998	6.4	15.3	27.3	40.0	51.7	63.8
16 Apr. 1998	5.5	14.4	26.6	39.4	51.0	63.0
1 May 1998	5.1	13.9	26.1	39.0	50.5	62.5
13 May 1998	4.8	13.6	25.7	38.7	50.1	62.3
25 May 1998	4.3	13.2	25.3	38.1	49.8	61.7
5 Jun. 1998	3.9	12.9	25.0	37.8	49.5	61.4
27 Jun. 1998	3.2	12.2	24.2	37.2	48.7	60.8
14 Jul. 1998	2.8	11.5	23.7	36.7	48.0	60.1
25 Aug. 1998	1.2	10.1	22.3	35.2	46.6	58.6
14 Sep. 1998	12.3	22.5	33.8	45.9	58.4	70.6
20 Oct. 1998	11.1	21.2	32.6	44.7	57.2	69.4
7 Nov. 1998	10.5	20.7	31.9	44.1	56.5	68.7
29 Mar. 1999	5.8	16.0	27.5	39.6	51.9	64.1
26 Apr. 1999	4.6	15.2	26.3	38.5	50.9	63.1
17 May 1999	4.3	14.4	25.8	37.8	50.2	62.4
27 May 1999	3.9	14.1	25.3	37.5	49.8	62.1
7 Jun. 1999	3.5	13.7	25.2	37.1	49.5	61.7
20 Jun. 1999	3.1	13.3	24.7	36.7	49.2	61.4
6 Jul. 1999	2.3	12.8	24.1	36.1	48.6	60.8
20 Jul. 1999	2.1	12.2	23.6	35.7	48.2	60.4
30 Aug. 1999	--[1]	10.9	22.3	34.4	46.8	59.1
27 Sep. 1999	--[1]	10.0	21.4	33.6	45.9	58.2

[1]Missing data.

Appendix E

Table 1. Summary of the first 4 ordination axes of CCA using selected variables to explain plant community composition (based on canopy cover [%]) the second year after burning at Kernen Prairie, near Saskatoon, Saskatchewan.

	Axis				
	1	2	3	4	∑
Eigenvalue	0.267	0.089	0.059	0.039	
Species/environmental correlation	0.916	0.865	0.850	0.764	
Cumulative % variance of					
Species data explained	21.1	28.1	32.8	35.9	
Species/environmental relation explained	53.2	70.9	82.7	90.5	
Eigenvalues					1.267
Canonical eigenvalues					0.502

Table 2. Summary of the first 4 ordination axes of CCA using selected variables to explain plant community composition (based on canopy cover [%]) in the North plots the first 6 years after burning.

	Axis				
	1	2	3	4	∑
Eigenvalue	0.084	0.057	0.042	0.028	
Species/environmental correlation	0.848	0.815	0.861	0.773	
Cumulative % variance of					
Species data explained	8.6	14.5	18.8	21.7	
Species/environmental relation explained	34.3	57.6	74.7	85.9	
Eigenvalues					0.974
Canonical eigenvalues					0.246

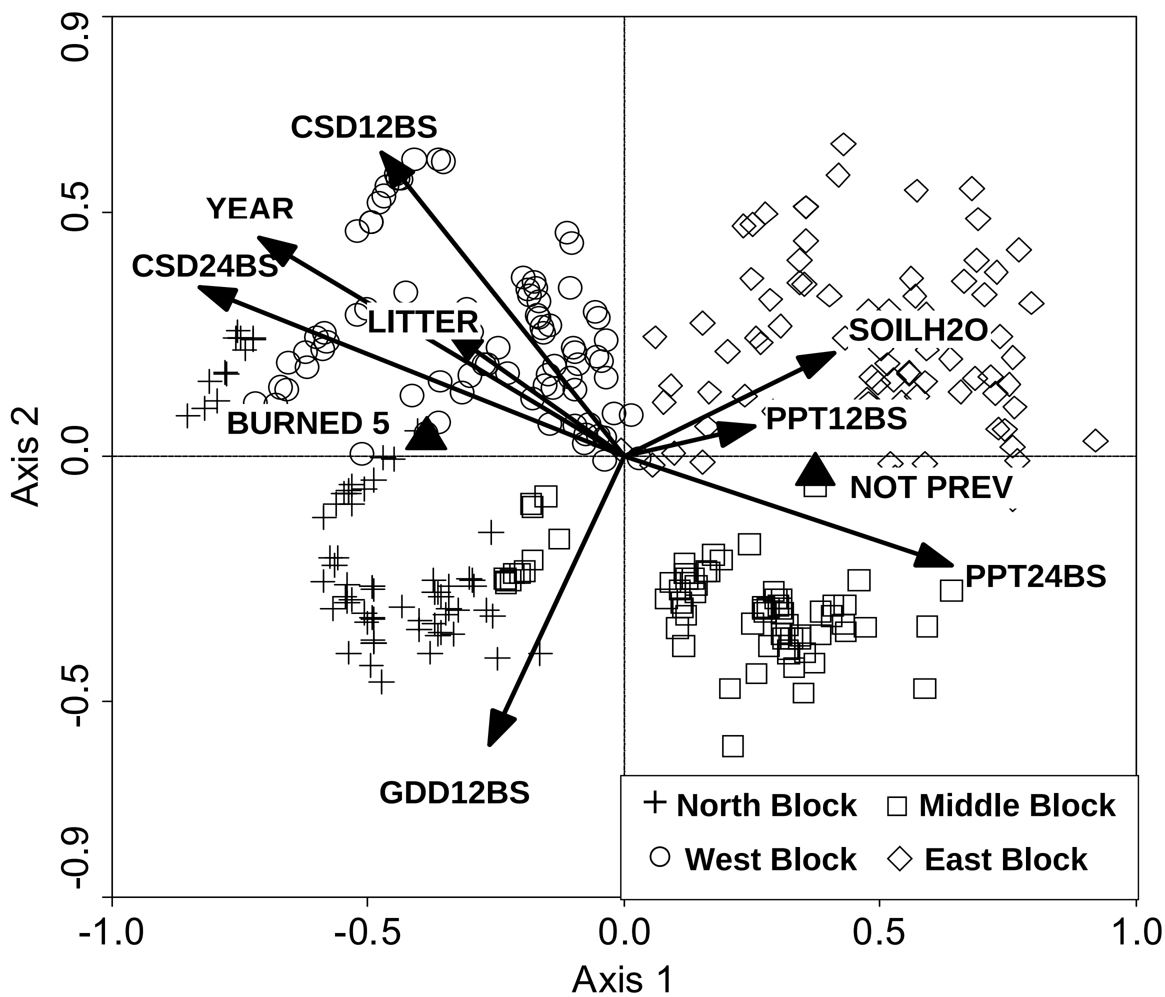

Figure 1. Canonical correspondence analysis (CCA) of axis 1 (horizontal) against axis 2 (vertical) illustrating dissimilarity in plant community composition in the North, West, Middle, and East blocks after burning when constrained by selected variables at Kernen Prairie, near Saskatoon, Saskatchewan. Points represent burn plots that are linear combinations of variables. Nominal variables are represented by large upright triangles. Arrows represent continuous variables.

NOT PREV=not previously burned, BURNED 5=burned 5 years earlier, CSD24BS=cumulative cold stress-days over the 24 months before sampling, GDD12BS=cumulative growing degree-days over the 12 months before sampling, YEAR=years after burning, CSD12BS=cumulative cold stress-days over the 12 months before sampling, SOILH2O=soil water, PPT24BS=cumulative precipitation over the 24 months before sampling, PPT12BS=cumulative precipitation over the 12 months before sampling, LITTER=litter cover.

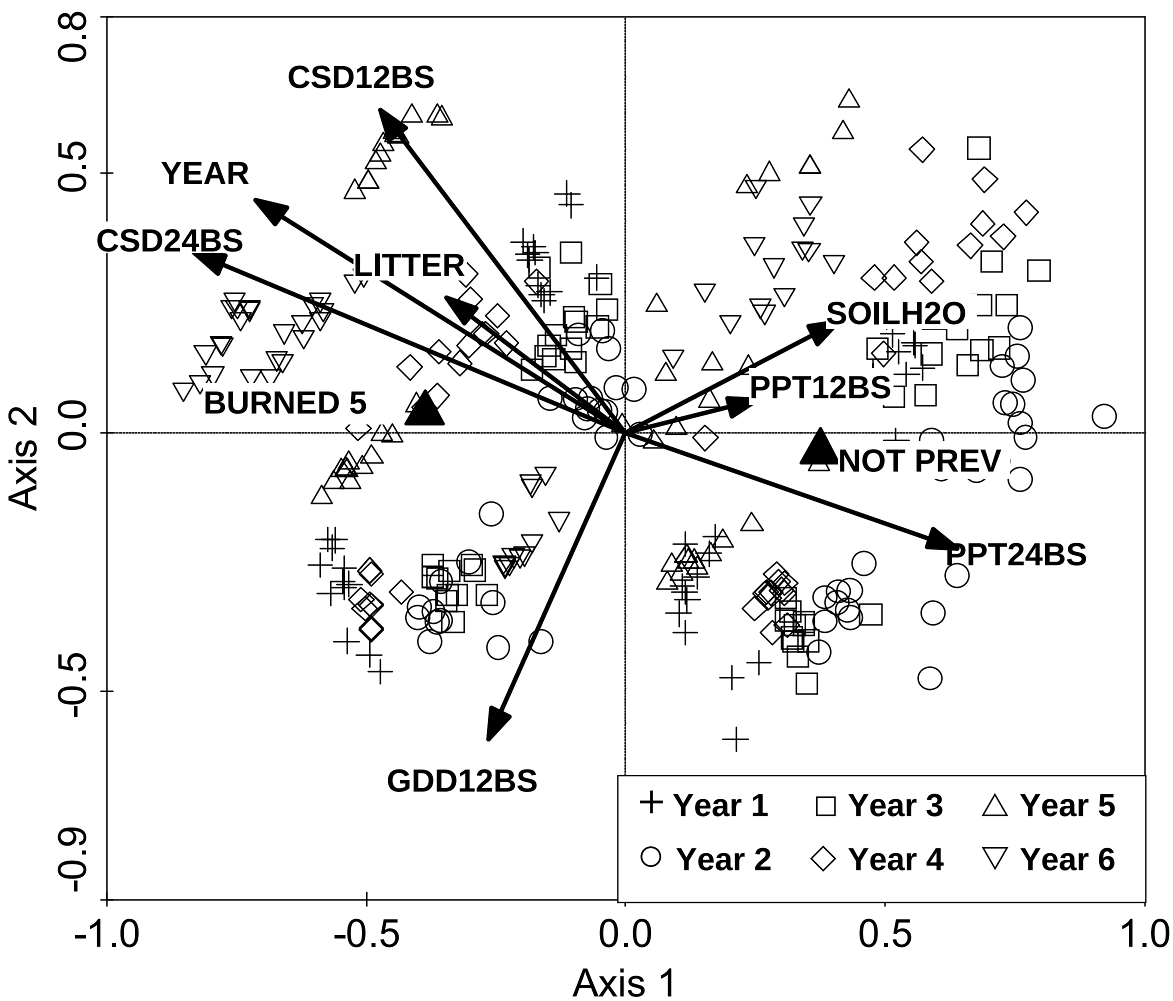

Figure 2. Canonical correspondence analysis (CCA) of axis 1 (horizontal) against axis 2 (vertical) illustrating dissimilarity in plant community composition in plots the first 6 years after burning when constrained by selected variables at Kernen Prairie, near Saskatoon, Saskatchewan. Points represent burn plots that are linear combinations of variables. Nominal variables are represented by large upright triangles. Arrows represent continuous variables. NOT PREV=not previously burned, BURNED 5=burned 5 years earlier, CSD24BS=cumulative cold stress-days over the 24 months before sampling, GDD12BS=cumulative growing degree-days over the 12 months before sampling, YEAR=years after burning, CSD12BS=cumulative cold stress-days over the 12 months before sampling, SOILH2O=soil water, PPT24BS=cumulative precipitation over the 24 months before sampling, PPT12BS=cumulative precipitation over the 12 months before sampling, LITTER=litter cover.

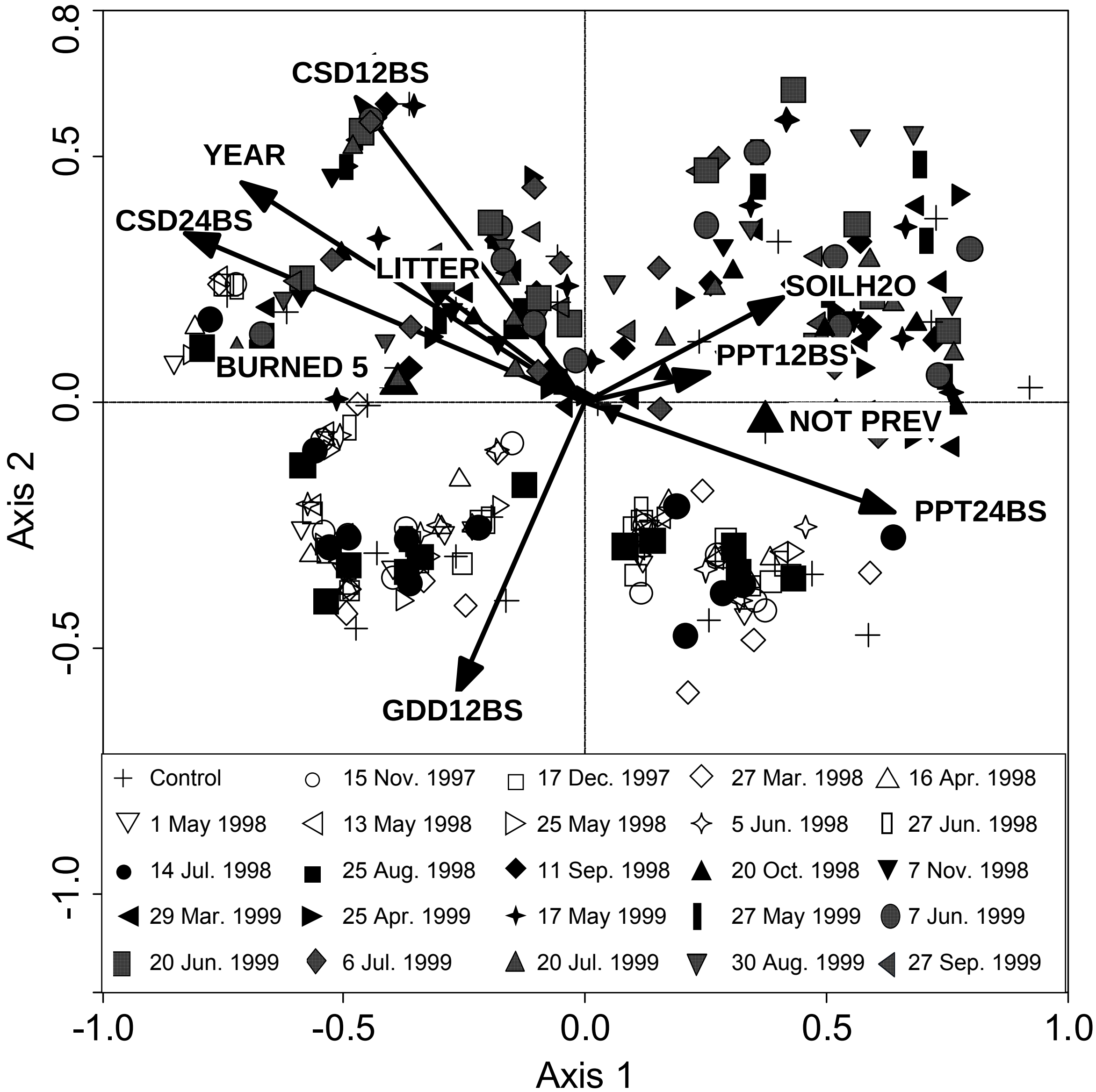

Figure 3. Canonical correspondence analysis (CCA) of axis 1 (horizontal) against axis 2 (vertical) illustrating dissimilarity in plant community composition in plots burned at different times of the year when constrained by selected variables at Kernen Prairie, near Saskatoon, Saskatchewan. Points represent burn plots that are linear combinations of variables. Nominal variables are represented by large upright triangles. Arrows represent continuous variables.

NOT PREV=not previously burned, BURNED 5=burned 5 years earlier, CSD24BS=cumulative cold stress-days over the 24 months before sampling, GDD12BS=cumulative growing degree-days over the 12 months before sampling, YEAR=years after burning, CSD12BS=cumulative cold stress-days over the 12 months before sampling, SOILH2O=soil water, PPT24BS=cumulative precipitation over the 24 months before sampling, PPT12BS=cumulative precipitation over the 12 months before sampling, LITTER=litter cover.