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Research Article

Patterns of Anthropogenic Fire within the Midwestern Tallgrass Prairie 1673–1905: Evidence from Written Accounts

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ABSTRACT

We conducted literature searches of records from Illinois, Indiana, Iowa, Minnesota, Missouri, North Dakota, Ohio, and Wisconsin to create a source bibliography of wildland fire descriptions occurring between 1673 and 1905. A total of 795 landscape fire records were identified within or near the eastern tallgrass prairie–forest transition region, including 32 attributed to Native Americans, 194 to Europeans from spontaneous records in the nineteenth century, and 569 to Europeans from a systematic dataset collected during the late nineteenth and early twentieth centuries in Minnesota. From these historical accounts, we find overwhelming evidence that a two- to three-week period during October and November, known then as "Indian summer," was the primary wildland fire season. Our records indicate that Native Americans used fire primarily for hunting, whereas Euro-American fires were set to reduce fire hazards near their habitations, to eliminate crop residues, and to facilitate plowing, or they were escapes due to mere carelessness. Only five lightning-caused fires were identified. Individual fires frequently burned thousands of hectares, creating dense smoke, damaging trees, personal property, and occasionally burning inhabitants fatally. South and southwest were the most frequent wind directions during wildfires. Drought years, including 1796, 1819, 1856, and 1871, were characterized by extensive fires, which ultimately resulted in legislation to protect property owners and public welfare. Fire events for the study period are certainly underestimated by this dataset because only large, spectacular, threatening fires were recorded, especially during European settlement. In addition, our estimate of Native American fire frequency and prevalence is less than their historical/expected frequency, due to their widespread population collapse and changed hunting methods following contact and dispossession by Europeans.

Index terms: Europeans; fire frequency; fire legislation; fire season; grassland; Indian summer; Native Americans; wildfire

INTRODUCTION

The central North American grassland of pre-European settlement stretched northward from Texas and Oklahoma to Manitoba, central Canada, and west from Ohio to Wyoming and Montana. Regional variation in precipitation, bedrock, soils, topography, and climate, plus the effects of immense grazing/browsing herbivore populations and human-caused wildfire ignitions, resulted in a mosaic of plant communities and vegetation types throughout it (Küchler 1964; Williams 2002; Anderson 2006, 2012). One prominent feature of this region's grasslands was the gradual increase in plant height from west to east, a phenomenon corresponding to increasing precipitation, and giving the easternmost portion its characteristically tall vegetation height and grass structure. The Midwestern Tallgrass Prairie (MTP), the prairie/forest transition (Anderson 1970), and the prairie peninsula (Transeau 1935), included the states of Illinois, Iowa, Indiana, Minnesota, Missouri, North Dakota, Ohio, and Wisconsin (Figure 1). Most of this region averaged more than sufficient precipitation to support continuous forest cover (75–100 cm per year). However, prairie occupied 8,661,417 ha (58%) of Illinois, 11,257,137 ha (79.5%) of Iowa, 7,317,000 ha (32.5%) of Minnesota, and 390,000 ha (3.4%) of Ohio ca. 1820 (Anderson 1970; Marschner 1974; Risser et al. 1981; Sears 1926; Whittaker 1975; Smith 1998).

While grasslands have a long and dynamic history in North America dating back millions of years to the Miocene, fire is considered to be the primary reason for their modern origin and persistence in the MTP region (Gleason 1913; Sauer 1950; Anderson 2006, 2012). French explorers, while traveling through the Illinois Territory in 1673, noted a widespread use of landscape fire by Native Americans (Hennepin 1880; Parkman 1891). Nineteenth century observers recognized the influence of fire on grasslands, causing them to describe how "prairies have been continued (here) by the combustion of vegetables" (Wells 1819; McClain and Elzinga 1994). Other observers described the role of fire in restricting timber to stream margins in Illinois (Beckwith 1880a; Ernst 1903; Gleason 1913).

Although wildland fire clearly has a long history in the MTP, documenting patterns in its occurrence has been problematic compared to other regions because few physical remnants, such as tree scar data, remain on the landscape. Thus, the development of date-specific fire chronologies that include data on wind direction, areal extent, and ignition sources must rely upon written accounts that vary considerably in detail and are time consuming and difficult to locate (Russell 1983, 1997). This issue is further complicated because Native American populations were greatly diminished prior to and during European settlement due to epidemics, warfare, European intrusion, and westward expulsion from their territories (Cronon 1983; Sultz-

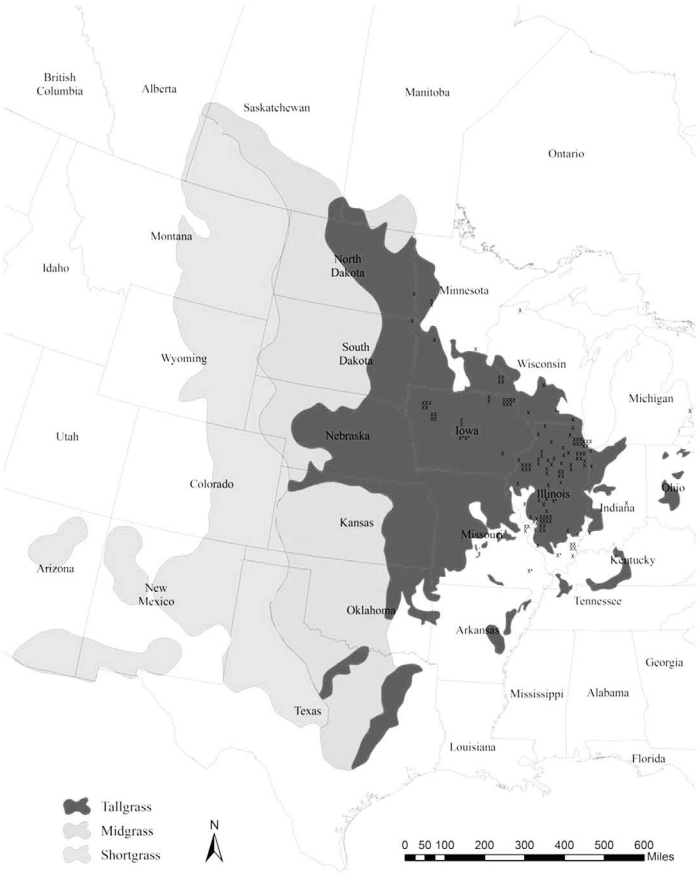

Figure 1.—The North American grasslands with historical wildland fire locations reported herein marked with an x.

man 1997; Richter 2001; Jones 2004; Morgan 2010; Morrissey 2015). Moreover, the freedom of movement of Native Americans was greatly restricted before much was written about their use of wildland fire (Denevan 1992; Russell 1997). The absence of fire data for Native Americans in the MTP contrasts sharply with the western plains where indigenous cultures used landscape fire into the late 1800s, permitting extensive documentation and study of fire by ethno-historians (cf. Moore 1972; Higgins 1984, 1986; Stewart 2002; Williams 2002). These data provide valuable insights on the occurrence and purpose of human ignition patterns in the plains, but they contain little information on the eastern tallgrass prairies. This lack of data has resulted in controversial speculation and assertions regarding historical fires across the MTP. An absence of information has important implications for modern habitat managers interested in native flora/fauna conservation and restoration. For example, assumptions about historical fire regimes often underlie modern management concerns regarding fire seasonality (Knapp et. al. 2009), frequency, effects on wildlife (Swengel 2001), invasive species, rare species, and plant species composition and diversity (Dibble et. al. 2008; Howe 2011). Thus, the purpose of this study is to document historical evidence on the frequency, cause, location, size, season of occurrence, and effects of reported wildland fires within the MTP for the period of 1673 to 1905, to document legislation aimed at reducing their occurrence, and to inform ecological managers of the historical fire regimes.

METHODS

Early Europeans often recorded events observed during journeys throughout the eastern United States. The resultant body of literature, books, letters, reports, and travel manuscripts contains accounts of native inhabitants and their customs, unusual weather, plant and animal life, and events that stirred the emotions. Some scenes were vividly captured in the form of paintings and illustrations by well-known artists (Catlin 1845), but especially by the writings of European settlers and travelers. One oft-noted and frequently described event was the uncontrolled prairie fire when driven by strong winds. These conflagrations obviously presented great dangers to crops, livestock, buildings, and human lives, causing them to be terrifying experiences for immigrants.

We searched for wildland fire narratives in literature pertaining to Illinois, Indiana, Iowa, Minnesota, Missouri, North Dakota, Ohio, and Wisconsin to create a source bibliography of accounts of fire occurrence. We documented fires from 1673, which was the earliest record found, to 1905, which was near the end date for landscape fires within the MTP. We separated descriptions into three categories: Native American fires, nineteenth century European settlement fires, and late nineteenth and early twentieth century European fires from a systematic fire documentation program in Minnesota from 1896 to 1905. This latter category represents this area's intensive agriculturalization/industrialization period, and its data are based on documentation by state fire wardens and their work in suppressing fires within their respective townships (Andrews 1896-1905, described below). Methodologies, areas of blackened ground, and firsthand observations were recorded for Native American- and European-set fires in our study. We recorded the location, date of occurrence, size, wind direction and velocity, weather conditions, source of ignition, and other pertinent data as available. We omitted fire reports lacking location and date information. We also recorded only one fire record per narrative, unless an actual number was specified. These data were used as a basis to document seasonality, causes, and decadal ignition trends from pre- to early-European settlement time periods. We converted all measurements given in sources to metric equivalents.

Efforts were also made to identify data illustrating changing fire use in the MTP due to obvious land use and settlement trends such as agriculture intensification and transportation (roads, railroads, etc.). For example, although once feared and avoided, fire eventually became a tool used to burn off fallow grounds and crop residues by Europeans (Pettis 1903). In our search, we found an important series of annual fire reports dating from the late nineteenth and early twentieth centuries, which offered keen insight into how Euro-American settlers were altering fire regimes and fire use to protect crops, settlements, and other infrastructure across the state of Minnesota. We use this 10-year period of annual fire reports published by the Chief Fire Warden of Minnesota to report on the causes of wildfire, season of occurrence, and their areal extent in a more systematic

Table 1.—Wildfires attributed to Native Americans, 1673 to 1836, in the Midwestern Tallgrass Prairie.

Date	Location	Notes (quoted from text)	Purpose	Tribe	Reference
Fall 1673	Upper Mississippi River	Hunt buffalo with fire	Bison hunt	Illinois	Shea 1852
Fall 1673	Kankakee River, IL	Prairie scorched, horizon glowed	Bison hunt	Miami	Parkman 1891
Dec 1679	Illinois Territory	Plains burnt, Miami's set fire to grass	Bison hunt	Miami	Anderson 1901
Dec 1679	Kankakee River, IL	Set fire around bison herd	Bison hunt	Miami	Hennepin 1880
Mar 1680	Illinois Territory	LaSalle set fire to grass	Hide tracks	de LaSalle	Anderson 1901
1720	Illinois Territory	Set fire around bison	Bison hunt	Illinois	Blair 1911
1720	Northern Illinois	Surround bison with fire	Bison hunt	Illinois	Charlevoix 1761
Fall 1750	Missouri	Savages fire prairies at end of autumn		Osage	Houck 1908
Oct 1757	Sandusky River, OH	Ring fire, prairie burned	Deer hunt	Ottawa	Washburn 1977
1758	Upper Mississippi River	Hunters form square, set fire to grass	Bison hunt	Illinois	L. du Pratz 1758
Fall 1766	Wisconsin	Natives form circle, set fire to grass	Bison hunt	Santee Sioux	Carver 1807
Early 1800s	General	Indians set woods and prairies on fire	Deer hunt		Stoddard 1812
Fall 1804	White Co., IL	Wagon and contents burned	Harassment	Kickapoo	USGS 1804
Fall 1812	Central Illinois	Indians fire the prairies	Hunt	Illinois	Ernst 1903
Fall 1812	Northern Illinois	Fire used against American soldiers	Warfare	Kickapoo	Blane 1824
Fall 1819	Sangamon Co., IL	Wind west, grass dry as powder	Harassment	Kickapoo	Selby 1912
Fall 1820	Upper Mississippi River	Set fire to grass around bison	Bison hunt		Schoolcraft 1953
1820s	Mississippi River Valley	Indians form circle, set grass on fire		Potawatomie	Flint 1826
Oct 1820	Logan Co., IL	Prairies burned by Indian hunting party	Hunt	Kickapoo	Johnson 1886
Oct 1821	Okaw River, IL	Immense burning, clouds of smoke	Deer hunt	Potawatomie	Williams 1881
13 Nov 1821	Bond Co., IL	Thousands of hectares of prairie on fire	Deer hunt	Kickapoo	Newhall 1821
Fall 1826	Logan Co., IL	Prairies burned by Indians	Deer hunt	Kickapoo	Stringer 1911
Fall 1826	Tazewell Co., IL	Wind a strong gale	Deer hunt	Kickapoo	Chapman 1878
Fall 1828	Tazewell Co., IL		Warfare	Kickapoo	Chapman 1878
Fall 1832	Turkey River, IA	Prairies burned to drive out white hunters	Warfare		Murray 1839
Fall 1832	LaSalle Co., IL	Much prairie burned by Indians	Deer hunt	Potawatomie	Angle 1972
27 Aug 1833	DeKalb Co., IL	Prairies burning, mostly smoke		Potawatomie	Benton 1957
Sep 1833	Marinette Co., WI	Columns of smoke in all directions			Latrobe 1835
Jan 1834	LaSalle Co., IL	Prairie burnt far as eye can reach			Hoffman 1835
Sep 1835	Kenosha Co., WI	Southwest wind, roaring terror	Hunt	Menominee	Lothrop 1856
29 Nov 1835	Columbia Co., WI	Wind W to NW, Prairies on fire	Hunt	Winnebago	Foot 1836
9 Sept 1836	Southwestern IL	Describes use of ring fires by Indians	Deer hunt	Illinois	Reynolds 1887

fashion. We present findings for that particular region and time period as representative of fire use changes and frequencies that probably took place earlier in states farther east, given the pattern of European population movement and increase from east to west.

RESULTS AND DISCUSSION

Our results show that landscape fires in the MTP were first described by French explorers during the late seventeenth century following contact with indigenous tribes. However, despite increasing travel by settlers/explorers through the region after that, wildland fire descriptions of this type were rare throughout the eighteenth and early part of the nineteenth century, when only 32 such descriptions could be attributed to fires set by Native Americans (Table 1). There is little doubt that there were fewer fires during this time due to the decrease in Native American population numbers there, as well as due to changes to their hunting practices. This contrasts with 194 fires from the early years of European settlement (1794–1887, Table 2), and 569 in Minnesota during the period 1895 to 1905 (Figures 2 and 3). We documented a pattern where, from 1820 onward, fire frequency appeared to be driven by increasing European settlement across the region, peaking between 1830 and 1850, then decreasing after railroad expansion and prairie fragmentation by around 1870. European fire use or ignitions were dominated by burning stubble, crop residue, and locomotives from the 1850s through the early 1900s (Figure 3). Efforts by individual states to control rural burning were well established by 1910 across most of the central North American grasslands (see Wildfire Legislation). Along with increased landscape fragmentation and rapid population growth, this meant uncontrolled wildfires mostly ended by the early 1900s. The changing patterns in fire regimes following European exploration and then settlement that we have documented parallel what appears to be a repeating pattern across North America regions as they received waves of Euro-American settlers (Guyette et al. 2002).

Ignition Sources

Considerable debate has occurred among scientists and resource managers across North America and within the MTP specifically regarding the frequency of lightning-caused fires (Russell 1997; Parker and Ruffner 2004). Based on our data, this ignition source was relatively rare in the central North American grasslands (see also Moore 1972). In the MTP, our review found that Native American ignitions greatly outnumbered lightning ignitions, and they should therefore be considered primary for the origin and maintenance of these grasslands (Abrams and Nowacki 2008). Only three lightning-caused ignitions were noted out of 194 fires from 1794 to 1887 (Table 2), and just two out of 569 fires for Minnesota from 1895 to 1904 (Andrews

Table 2.—Wildfires attributed to Euro-Americans, 1794 to 1887, in the Midwestern Tallgrass Prairie. Abbreviations: N = North, E = East, S = South, W = West, NW = Northwest, SW = Southwest, SE = Southeast, V. = very, Str. = Strong, G = Gale, PWFL = Powerful, Pr. = Prairie.

Date	Location	Notes (quoted from text, excepting km distance)	# of Fires	Weather	Wind	Reference
8 Jan 1794	St. Clair Co., IL	Fired commons, Pr. Du Pont	1			St. Clair Co. Court 1794
6 Mar 1804	White Co., IL	Woods burnt	1			USGS Field Notes 1805
24 Nov 1804	Red River, MN	Prairies on fire, bison killed	1			Wilcox 1907
25 Nov 1804	Red River, ND	Plains burnt, dead, dying buffalo	1			Wilcox 1907
Dec 1804	White Co., IL	Woods burned	1			USGS Field Notes 1804
Mar 1805	White Co., IL	Woods burned	1			USGS Field Notes 1804
30 Oct 1806	White Co., IL	Woods destroyed by fire	1			USGS Field Notes 1806
Fall 1816	Bond Co., IL	Grass all burned	1			Perrin 1882
Oct 1818	Edwards Co., IL	1000 hectares of prairie in flames	6	Drought	S, strong	Fordham 1906
2 Jan 1819	Jersey Co., IL	Shrubs almost all burned	1			USGS Field Notes 1819
Oct 1819	Edwards Co., IL	Prairie and forest consumed	1	Drought	S, furious	Flower 1882
30 Oct 1819	Gallatin Co., IL	Woods full of fire; no sun for days	3			Woods 1822
30 Oct 1819	Edwards Co., IL	Woods on fire	1	Dry		Woods 1822
Nov 1819	Gibson Co., IN	Rode all day, thick smoke and fire	2	Drought		Faux 1823
Fall 1819	Morgan Co., IL	Prairie on fire	1			Heinl 1925
Fall 1819	Southern IL	Manifest injury to forests	1	Drought		James 1823
Fall 1819	Edwards Co., IL	Thousands of hectares on fire	1	Dry		Flower 1882
3 Nov 1821	Bond Co., IL	Seven thousand hectares on fire	2			Newhall 1821
8 Nov 1821	Bond Co., IL	Fires have resumed	1			Newhall 1821
10 Feb 1822	Edwards Co., IL	Pioneers set fire to prairie	1			Monaghan 1946
Nov 1822	Edwards Co., IL	Prairie black	1			Tillson 1919
15 Jan 1823	Edwards Co., IL	Set fire to prairie, burned poorly	1			Monaghan 1946
Spring 1823	Clinton Co., IL	Prairies on fire in distance	3		W, violent	Blane 1824
Spring 1823	Clinton Co., IL	Flames nearly two km wide	4	Dry	W, violent	Blane 1824
25 Dec 1824	Edwards Co., IL	Slow moving fire	1			Monaghan 1946
Fall 1825	St. Louis Co., MO	Thousands of hectares burning	1			Flint 1826
Fall 1826	McLean Co., IL	Most terrible fire, country black	1			Duis 1874
Fall 1829	Schuyler Co., IL	Fires flashed across the prairies	1			Larkin 1830
Fall 1830	McLean Co., IL	Burned fences, wheat, and hay	1		S	Duis 1874
Fall 1830	Tazewell Co., IL	Burned fence, wheat and hay	1		S	Chapman 1878
Fall 1830	Madison Co., IL	Prairies burnt	1	Dry		Ferrall 1832
Fall 1830	McLean Co., IL	Burned rails, wheat, hay	1		S	Duis 1874
Oct 1830	Pocahontas Co., IA	Flames high as tree tops	1		NW, great	Pollock 1832
Fall 1831	Knox Co., IL	Burned wagon, killed horse	1			Chapman 1878
Fall 1831	Knox Co., IL	Fire destroyed grain	1			Chapman 1878
Fall 1832	Edgar Co., IL	Hundreds of ha woods burned	1			Parker 1836
Fall 1832	Pocahontas Co., IA	Flames high as trees	1		NW, strong	Pollock 1832
22 Mar 1833	Randolph Co., IL	Woods along river on fire	1			Thwaites 1906
Fall 1833	Putnam Co., IL	Traveled 22 km over burnt prairie	2			Hoffman 1835
Fall 1833	Southeast MO	Forest on fire, dense smoke	1			Featherstonhaugh 1844
Fall 1835	Iroquois Co., IL	Fire killed wild animals	1	Windy	W, stiff gale	Iroquois Co. Hist. Soc. 1985
Fall 1835	Kankakee Co., IL	Deep holes burnt in marshes	1	Dry	W	Bartlett 1904
Oct. 1835	McLean Co., IL	Burned rail fences	1			Duis 1874
15 Oct 1835	Bureau Co., IL	20 km of prairie on fire at night	5	Dry	W, fierce	Brunson 1900
15 Oct 1835	Logan Co., IL	Fire consumed hay stack	1		W	Stringer 1911
Spring 1836	McHenry Co., IL	Terrific fire	1	Dry	S, strong	Coon 1837
Nov 1836	Stark Co., IL	10 km wide fire burned 100 km	1		SW, strong	Matson 1872
Nov 1836	Carroll Co., IL	Man started fire	1			Bateman et al. 1913
Fall 1836	Knox Co., IL	Burned Henry, Knox Co.	1		N, furious	Chapman 1878
Fall 1836	Whiteside Co., IL	Lost fingers, powder for backfire	1			Bent 1877
Fall 1836	Traverse Co., MN	Fire 75 km wide, went 300 km	2		E, terrific	Anonymous 1837
Fall 1836	Tazewell Co., IL	Thousands of ha prairie on fire	1			Farnham 1846
Fall 1837	Cook Co., IL	Prairie takes fire every dry day	1	Mild, dry		Burley 1837
20 Nov 1837	St. Louis Co., MO	Prairie on fire	1			Mitchell 1837
20 Nov 1837	Kankakee Co., IL	Burned to Chicago by 4:00 PM	1		S, strong	Paddock et al. 1883
Fall 1838	McLean Co., IL	Burned fences	1			Duis 1874
Fall 1838	Knox Co., IL	Fire front 3.5 km wide	1		N, furious	Chapman 1878
Fall 1839	Stephenson Co., IL	Smoke in prairie to south	1		S, strong	Fulwider 1910
Fall 1839	Whiteside Co., IL	Extensive fire swept over country	1			Bent 1877
Fall 1840	McLean Co., IL	Jumped plowed ground	1			Duis 1874
Fall 1840	Kankakee Co., IL	Fire set to drive game	1			Paddock et al. 1883
Fall 1840	Bond Co., IL	Fire passed the previous day	1			Oliver 1843
2 Apr 1841	Winnebago Co., IL	Burned field, facilitate plowing	1		Strong	Sackett 1842

Table 2.—Continued.

Date	Location	Notes (quoted from text, excepting km distance)	# of Fires	Weather	Wind	Reference
Fall 1841	Winnebago Co., IL	Fire burning in thicket	1			Sackett 1842
Fall 1842	Ogle Co., IL	Fires Miss. River to Rock River	1		W	Bateman et. al. 1909
Fall 1843	Ogle Co., IL	Fires Miss. River to Rock River	1		W	Bateman et. al. 1909
Fall 1843	Wayne Co., IL	Fire killed hogs, wild animals	1		NW, violent	Anonymous 1884b
Fall 1843	DuPage Co., IL	Prairies on fire	1			Lee 1915
21 Oct 1843	Coles Co., IL	Prairies on fire all around	1			Hendrick and Hendrick 1981
Dec 1843	DuPage Co., IL	Prairie on fire, many kilometers	1			Lee 1915
Dec 1843	DuPage Co., IL	Fires in all directions	1	Cold	Hurricane	Lee 1915
11 Dec 1843	Kane Co., IL	John Johnson fired prairie	1			Kane Co. Circuit Court 1846
Fall 1844	Kankakee Co., IL	Fire burned slough and field	1			Burroughs 1923
Fall 1844	DuPage Co., IL	Prairies on fire again	1	Mild		Lee 1915
Fall 1844	Tazewell Co., IL	Sea of fire, many kilometers	3		W	Farnham 1846
15 Nov 1845	Shelby Co., IL	John McCarty fired prairie	1			Shelby Co. Circuit Court 1845
22 Nov 1845	Knox Co., IL	N. Case indicted, fired prairie	1			Chapman 1878
22 Nov 1845	Knox Co., IL	J. Matlock indicted, fired prairie	1			Chapman 1878
21 Dec 1845	Knox Co., IL	M. Herbert indicted, fired prairie	1			Chapman 1878
21 Dec 1845	Knox Co., IL	D. Ogden indicted, fired prairie	1			Chapman 1878
Spring 1847	Kendall Co., IL	Fire set by neighbor	1		S	Bateman and Selby 1914
Sep 1847	Washington Co., IA	Houses, barns, and grain burned	1			Anonymous 1847
Fall 1847	Saline Co., MO	Church burned, large prairie fire	1			Missouri Hist. Soc. 1881
Fall 1849	Grant Co., WI	Prairie on fire, Indian Summer	1			Curtiss 1852
Fall 1849	Newton Co., IN	Fire burned 25 to 30 km	1		W	Hamilton and Darroch 1916
Fall 1850	Shelby Co., IL	Burge Vermilion fired prairie	1			Shelby Co. Circuit Court 1851
7 Oct 1850	Cook Co., IL	Lake plain prairie on fire	4			Cunynghame 1851
Summer 1852	Cook Co., IL	Blackened patches in prairie	1	Dry		Ellet 1853
Dec 1852	Mercer Co., IL	Tremendous fires all directions	3	Very warm	Very windy	Marsh 1978
Jan 1853	Woodford Co., IL	Blackened prairies, Minonk	1			Wilson 1853
Fall 1853	Story Co., IA	Prairie fires burned log home	1			Payne 1911
27 Oct 1853	Macoupin Co., IL	Skies illuminated night for week	1	Dry, warm		Anonymous 1853
Mar 1854	Carver Co., MN	Prairie fires raging all month	2			Nichols 1939
30 Mar 1854	Marshall Co., IL	Man, horses severely burned	1	Very dry	W, fierce	Ellsworth 1880
Fall 1854	Poweshiek Co., IA	Fires moving like a race horse	2		S	Flickinger 1904
14 Dec 1854	Walworth Co., WI	Prairie all black	1			Nelson 1955
14 Dec 1854	Dane Co., WI	Fire in distance	1			Nelson 1955
1 Mar 1855	Winneshiek Co., IA	Fires spreading	5		Violent	Nelson 1955
6 Mar 1855	Winneshiek Co., IA	Prairie fires rage everywhere	3	Dry, warm	Strong	Nelson 1955
15 Mar 1855	Winneshiek Co., IA	Smoke in day, huge fire at night	1	Very warm	Strong	Nelson 1955
17 Mar 1855	Winneshiek Co., IA	Fires nearly every night	1			Nelson 1955
28 Mar 1855	Winneshiek Co., IA	Set fire to field	1			Nelson 1955
Oct 1855	Winona Co., WI	Prairie fire burned 407 ha	1			Marshall 1989
2 Nov 1855	Winneshiek Co., IA	Fire all around	1		Very strong	Nelson 1955
11 Nov 1855	Winneshiek Co., IA	Fire burning woods	1			Nelson 1955
1 Sep 1856	Ford Co., IL	Burned county; peat fires months	1	Very dry	S, strong	Anonymous 1884a
2 Oct 1856	Mitchell Co., IA	Burned grain and hay	1		W, gale	Union Publishing Co. 1884
5 Oct 1856	Christian Co., IL	Four burned to death, much smoke	1			Anonymous 1856
Fall 1857	Floyd Co., IA	Hills covered with fire	1			Anonymous 1882
Fall 1857	Story Co., IA	Prairie fires burnt grass frost	1			Payne 1911
20 Dec 1857	Delaware Co., IA	Two or three fires at distance	2			Fairchild 1960
Feb 1858	Hamilton Co., IA	Prairies blackened	1			Aldrich 1895
3 Mar 1859	Madison Co., IA	Fires raging each night, light sky	1			Anonymous 1906
15 Oct 1859	Kankakee Co., IL	Fire set by deer hunters	1	Very dry	SW, v. str.	Beckwith 1880b
1 Nov 1859	Delaware Co., IA	Flames higher than ocean waves	1		S	Kenyon and Kenyon 1960
Fall 1859	Pocahontas Co., IA	Burned peat in wetlands	1	Very dry		Flickinger 1904
23 Sep 1860	Story Co., IA	Girl burned to death	1		E	Tjernagel 1953
23 Sep 1860	Iroquois Co., IL	Fire set by deer hunter	1	Dry	SW, v. str.	Beckwith 1880b
23 Sep 1860	Livingston Co., IL	Lightning caused fires	3		W, strong	Woods 1861
Oct 1860	Story Co., IA	Five burned to death	1		Strong	Tjernagel 1953
Oct 1860	Kossuth Co., IA	Followed prairie fire at night	1			Anonymous 1917
Oct 1861	Champaign Co., IL	Fire like devouring army	1	Dry	W	Cunningham 1905
5 Nov 1861	Webster Co., IA	Fires all directions, two weeks	1			Anonymous 1906
Fall 1862	Champaign Co., IL	Fire like devouring army	1	Dry	W	Cunningham 1905
6 Jul 1863	Cass Co., MN	Fires burning on all sides	1	Very dry, warm		Clandening 1927
7 Jul 1863	Cass Co., MN	Prairie and brushwood on fire	1			Clandening 1927
10 Jul 1863	Otter Tail Co., MN	Prairie burnt, can scarcely see	1			Clandening 1927

Table 2.—Continued.

Date	Location	Notes (quoted from text, excepting km distance)	# of Fires	Weather	Wind	Reference
8 Oct 1864	Pocahontas Co., IA	Several counties burned	1	Dry & warm	NW, pwfl	Flickinger 1904
7 Oct 1866	Pocahontas Co., IA	Fire burned north days, then SE	1	Tinder dry	S, NW str.	Flickinger 1904
Fall 1866	IA	Fire swept around us	1	Frost killed grass	W, strong	White 1871
Fall 1868	Hardin Co., IA	Fire burned stable, man killed	1			Moir 1911
1 Oct 1870	Pocahontas Co., IA	Woman and child burned to death	1		NW, v. str.	Flickinger 1904
25 Oct 1870	Becker Co., MN	Burned hundreds of hectares	1			Wilcox 1907
Fall 1870	Swift Co., MN	Fire burning on prairie all day	1	Grass dry	W, strong	Gjerset 1928
Oct 1870	Lake Co., IN	Huge blazes, lake counties	1	Very dry		Ball 1873
Fall 1870	Cherokee Co., IA	House burned, 8 homeless	1			McCulla 1914
Fall 1871	Pocahontas Co., IA	Destroyed hay	1		S	Flickinger 1904
3 Oct 1871	Clay Co., IA	Fire swept across county	1			Anonymous 1917
4 Oct 1871	Cherokee Co., IA	Burned hay and railroad bridges	1	Dry	S, fearful g.	McCulla 1914
8 Oct 1871	Cook Co., IL	Clouds of fire	1	Drought	SW, g. for.	Lapham 1873
8 Oct 1871	St. Louis Co., MO	Ran through burning prairie	1			Catlin 1845
8 Oct 1871	Pocahontas Co., IA	Ocean of fire, most destructive	1	Very dry	SE	Flickinger 1904
Oct 1871	Cherokee Co., IA	Houses lost, 17 homeless	1			McCulla 1914
Oct 1871	Becker Co., MN	Peat burned wetlands till January	1	Remarkably dry	SW, strong	Wilcox 1907
Fall 1873	Mitchell Co., IA	Young girl burned to death	1	Dry	W, strong	Mitchell Co. Hist. Soc. 1973
7 Oct 1873	Pocahontas Co., IA	Prairie fires raging for two days	1			Flickinger 1904
5 Jun 1875	Becker Co., MN	Prairies burned, kill grasshoppers	1			Wilcox 1907
Fall 1875	Pocahontas Co., IA	Orchards, buildings destroyed	1		S	Flickinger 1904
12 Nov 1875	Sac Co., IA	Horizon lighted by burning grass	1			Hart 1914
16 Oct 1876	Floyd Co., IA	Fire burned house and hay	1			Anonymous 1882
10 Oct 1878	Griggs Co., ND	Fire jumped Sheyenne River	1		W, strong	Wilcox 1907
Fall 1879	Griggs Co., ND	Burned county; antelope crippled	1			Wilcox 1907
Fall 1879	Cherokee Co., IA	Fire burned hundreds of ha	1	Dry	N, Strong	McCulla 1914
Fall 1880	Cherokee Co., IA	Caused great fear	1		W	McCulla 1914
8 Apr 1887	Sac Co., IA	Locomotive started fire	1		SW, strong	Hart 1914
30 Oct 1887	Emmet Co., IA	Crops, buildings burned	1			Anonymous 1917
Totals	156 Locations		194	39 records	61 records	

reports 1896-1905). The three lightning-caused fires during the European settlement era of 1794–1887 occurred in Livingston County, Illinois, in September of 1860, and were notably observed by the party of the Prince of Wales while on a hunting trip to the United States (Table 2).

In this episode, rain followed the lightning, but the precipitation was insufficient to extinguish the flames. The fires continued to burn, eventually becoming one and sweeping across a considerable expanse of prairie (Woods 1861; Table 2).

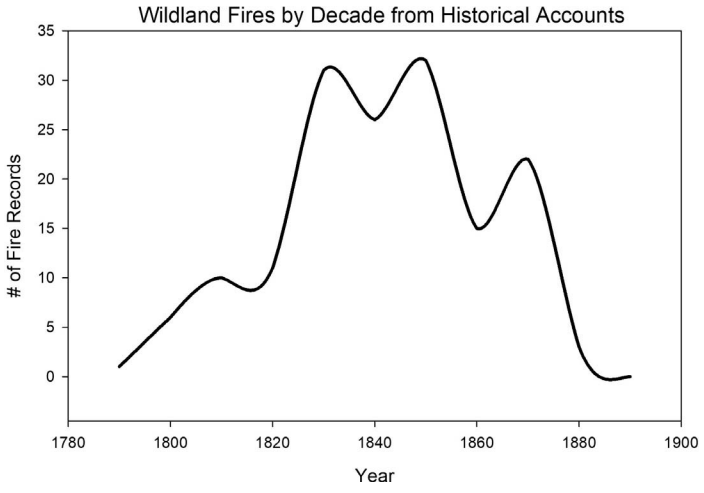

Figure 2.—Wildland fires by decade within the Midwestern Tallgrass Prairie Region from written accounts (summarized from Table 2).

There were other mentions of lightning-caused fires, like those in southwestern Illinois by Oliver (1843), but details were not provided. Residents near Bloomington in McLean County, Illinois, associated small circular areas in summer prairie to lightning (Short 1845). Later, Ellet (1853) described blackened patches of prairie vegetation near Chicago during July in 1852 that were considered to be lightning-caused. June and July are

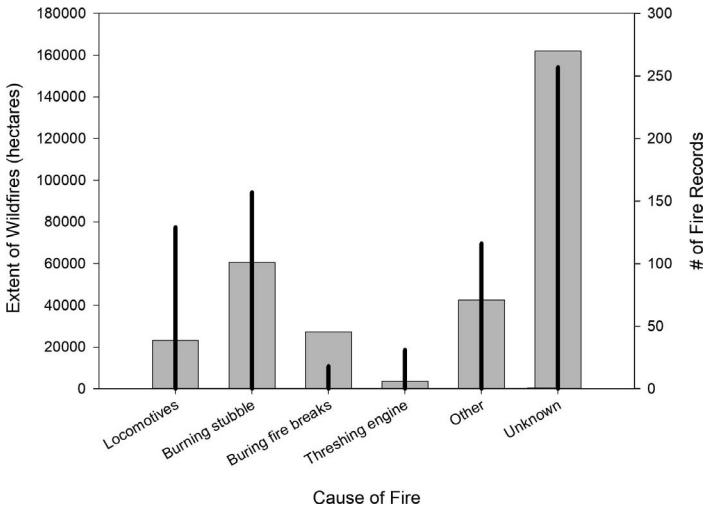

Figure 3.—Number of wildfire reports (dark line, right axis) and sizes in hectares (bars, left axis) by cause reported by state fire wardens in Minnesota from 1895 to 1904 (data source: Andrews 1896-1905).

characterized by frequent lightning strikes, especially in the northern and central parts of the central North American grasslands (Higgins 1984). Prairie vegetation is usually too moist to burn during summer months when lightning strikes are most frequent. Periodic drought years, such as 1819, 1856, or 1871, could have potentially desiccated vegetation enough to enable lightning ignition and then fire persistence (Clandening 1927; Table 2). The Grand Prairie Natural Division of east-central Illinois, plus much of the prairie regions of Iowa and Minnesota, remained relatively unpopulated until the arrival of railroads in the 1850s (Pooley 1968). Therefore, observations and descriptions of lightning-caused fires on the open, flat prairies would likely be rare within large portions of the MTP due to sparse populations and the obvious absence of observers during these years. However, even when they ignited, such fires seemed rarely to become the landscape-level conflagrations that were especially common during the fall and primarily associated with human ignition.

One common fire-starting method of Native Americans, as described by Hennepin (1972), involved the use of a cedar (eastern red cedar, *Juniperus virginiana* L.) plank or fire-board containing numerous small, circular holes that did not completely penetrate the wood. A stick of a harder wood was inserted into a hole and twirled quickly by hand or a small bow until a fine, hot powder was produced (Schoolcraft 1851). This powder was placed on dry grass and gently blown upon, causing flames to develop almost immediately (Pease and Werner 1934). Once started the fire could have been placed on tinder such as grass or punky wood. Other authors suggest Native Americans commonly used iron pyrites and flint to ignite fuels (Hough 1926; Stirling 1955; Williams 2002).

The methods of ignition for fires attributed to Europeans often involved the use of steel, flint rock, and tinder. Tinder included wood shavings, dry grass, birch bark, rotten wood, or even wool. The flint was struck forcefully with the steel to produce a spark. Repeated efforts caused the tinder to smolder or burst into a small flame. The fire maker blew on the tinder, increasing the flame. More tinder was added, and a small fire was soon produced. Many pioneers kept a tinder box at home that included abundant tinder along with pieces of tackcloth, flint, and steel. The introduction of matches made the tinder box obsolete.

Ignition sources changed during the latter part of the nineteenth and early twentieth centuries as commerce, including railroads, increased and agricultural technology advanced. The Minnesota data suggest that burning of stubble, crop residue, and prairie to facilitate plowing became the dominant sources of ignitions (Figure 3). Another prominent source was wood- and coal-burning locomotives (Pettis 1903; Kinney 1917). Residents along the North Missouri Railroad "suffered greatly from prairie and grass fires," causing them to be "afraid to leave home" during dry seasons (Switzler 1882). In Iowa a locomotive of the Northwestern Line "set the prairie on fire west of Sac City," and a "large amount of hay was burnt" (Hart 1914). A prairie fire, started by a locomotive near the town of Goose Prairie in Clay County, Minnesota, on 12 October 1895, burned nearly 394 ha (Andrews 1896). The vegetation was as "dry as powder" on 26 October 1895 when a southbound Baltimore and Ohio locomotive started four major fires while traveling the 135 km between Flora and Shawneetown in southeastern Illinois, destroying hay, fences, and several orchards (Anonymous 1895). Another locomotive started a fire in Onstad Township, Minnesota, on 28 September 1898, burning 750 ha of prairie, several homes, a schoolhouse, grain, hay, and numerous fences. The schoolhouse was destroyed when especially strong south winds blew embers a distance of approximately 35 m onto the dry, wooden shingles of the building (Andrews 1899).

Purpose

The purpose of Native American fires seemed to include deer and bison hunting, harassment of Europeans, and vegetation management. Seventeen fires set by Native Americans were for hunting deer or bison (Morrissey 2015; Table 1). Hunting may have taken them great distances from home as stated by Deuel (1958) for the Illinois Territory: "When these savages go hunting, they commonly go out in great numbers, and oftentimes a great many days journey from home." This travel may have facilitated fire ignition over large expanses. We found evidence for Native American use of a hunting method known as a ring fire, circle fire, or "surround" when pursuing deer (*Odocoileus virginianus* Zimm.) or bison (*Bison bison* L.) (Reynolds 1887; Anderson 1901; Hodge 1907-1910; Deuel 1958; Sultzman 1997). The process began in the MTP with the selection of a "fire chief" by the tribal council (McClain and Elzinga 1994; Stewart 2002). This person organized the tribe into three or four groups that went onto the prairie before sunrise to surround the bison. This hunting methodology involved a large number of people from the village. Fire was started on all sides once conditions were suitable. Severe penalties were imposed upon anyone who scared the bison, including destruction of personal property and banishment (Blair 1911).

Data from Native American fires indicate recognition and use of local weather conditions during hunts. One such event describes a party that waited until the sun had dried the grass before setting fire to it during a bison hunt (Blair 1911). Dry grass would ensure faster burning and hotter fires compared to those involving wet grass. Damp grass would also produce much more smoke. In a hunt on the Sandusky Plains of Ohio, Ottawa hunters waited until rain was about to fall before setting fire to the grass, hoping the precipitation would put out the fire so unburned prairie would remain and additional circle hunts for deer could be conducted at later dates. Rain did not develop, and the entire prairie burned, ending their circle hunts for the season (Washburn 1977).

Although hunting was a primary use of fire, it was also used to harass Europeans. Government surveyors in White County, Illinois, in 1804 returned to camp to learn that their wagon and other items had been burned (USGS Field Notes 1804). There was hostility toward surveyors, called "land lookers," because they were using tools, surveying compasses and chains, that took land away from Native Americans (Ferris 1856). Woods and prairies were burned over a period of several days near the Turkey River in eastern Iowa in an effort by Native Americans to drive white hunters off the land (Murray 1839). A prairie fire in the fall of 1819 in Sangamon County, Illinois, is suspected to be harassment. This fire, driven by a strong west wind, came

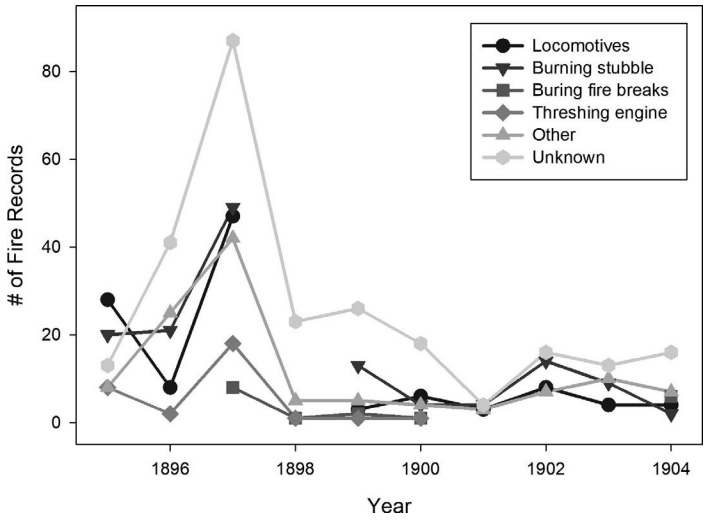

Figure 4.—Causes of grassland fires reported by state fire wardens in Minnesota from 1895 to 1904 (Andrews 1896-1905).

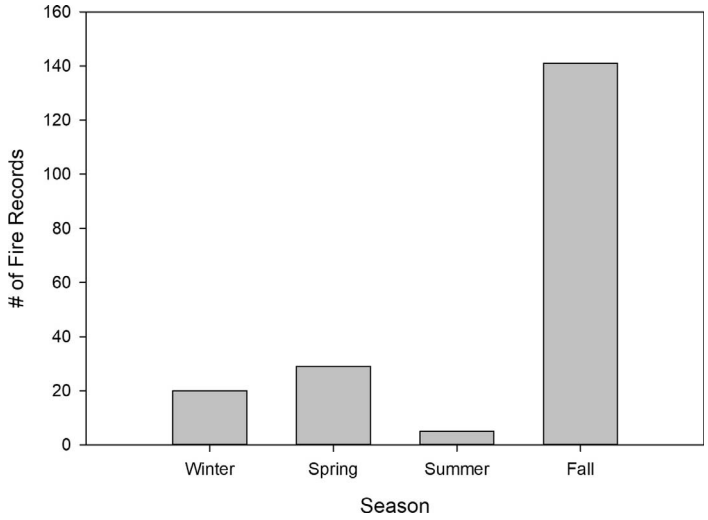

Figure 5.—Seasonality of wildland fires during 1794–1887 within the Midwestern Tallgrass Prairie Region (summarized from Table 2).

roaring at a home site, causing the family to work feverishly to save their cabin from the flames. Their cabin was the only one present in the vicinity, making it unlikely for a fire to have originated from other settlers (Selby 1912). Other authors suggest Native Americans used fires to extend hunting seasons, to keep vegetation low near dwellings, for protection from humans and rattlesnakes, the creation of desirable wildlife habitat, and to promote the growth of certain plants (Ruffner 1999; Stewart 2002; Williams 2002; Abrams and Nowacki 2008).

We were unable to determine the exact purpose of most fires attributed to Europeans (36%; Table 2), but in the earlier study period most were likely accidental and attributable to campfires, brush and woods clearing, or locomotives especially in later years, as suggested by the Minnesota data and other authors (Pettis 1903; Kinney 1917; Hough 1926). Similar proportions of fire were caused by burning pastures and field stubble (19–22%), locomotives (12–18%), and burning firebreaks (2–21%; Figure 4). Moore (1972) reported carelessness as a major cause of fires by European settlers during the 1800s in the northeast and central regions of the western plains. Our results provide evidence that the causes of ignitions differed by season and time period across the MTP, while Moore (1972) found that campfires were a primary reason for European fires in the Central Plains.

Even though fires frequently escaped, there was often a purpose to the initial ignition. For example, it was common practice in Illinois during early European settlement to use fire to eliminate prairie thatch to make the breaking of prairie sod easier (Sackett 1842). Fire was also used to burn strips around crops and buildings to reduce danger from uncontrolled prairie fires (Mitchell 1837; Short 1845; Baldwin 1877). It was also an aid used to eliminate thatch to prepare ground for planting of cool-season grasses, like Kentucky bluegrass (*Poa pratensis* L.) or smooth brome (*Bromus inermis* Leyss.), which could provide forage, but also serve as fuelbreaks (Mitchell 1837; Gerhard 1857). Fuelbreaks were often constructed using plows, rakes, and backfires to protect buildings and property. Roads also served as fuelbreaks, although that was ancillary to their primary purpose. Other agriculture related tasks, such as burning field stubble or protecting threshing machines, were often mentioned as subsequent causes of wildfires (Figure 3).

Farmers were known to burn prairies in May to kill nesting prairie chickens (*Tympanuchus cupido* L.) because they were eating corn that was left standing in the fields during winter months (Kennicott 1855; Maue 1928; Schorger 1943). Fire was also used in June of 1870 to kill young grasshoppers that were devastating crops in Becker County, Minnesota (Wilcox 1907). In more wooded areas, such as glades and savannas, fire was used to remove underbrush and encourage grasses and forbs for pasturing and grazing animals (Pettis 1903; Russell 1997; Nelson et al. 2008; Considine et al. 2013). No evidence was found in the literature indicating use of circle fires or other hunting methodology during the European settlement period (1794–1887; Table 2). While hunters were often blamed for the origin of fires (Hough 1926), little documentation was found to support this statement. However, rural people clearly organized action groups (Table 2) to protect capital, including crops and outbuildings, so we must assume a strong level of organization for fire containment on the part of the Euro-American settlers during the period 1794–1887 (see Wildfire Legislation below).

Seasons of Occurrence and Indian Summer

Our historical data reflect a strong seasonal relationship across Native and Euro-American periods (Figures 5 and 6). Grasslands worldwide are generally characterized by a season during which the vegetation becomes dry and flammable (Sauer 1950). In the MTP, this time period begins following the first killing frosts of October or early November when gentle breezes, warm temperatures, and clear skies prevail (Curtiss 1852). A mass of Pacific air often dominates the weather during this time producing low humidity and westerly winds (Bryson and Lahey 1958; Huschke 1959). Regularly occurring weather patterns of this nature are known as singularities (Wahl 1952, 1954; Peck 1975). This fairly regular weather pattern was noted as "Indian summer" in eastern states as early as 1788 (often "Second Summer" in modern usage), but this term increased in

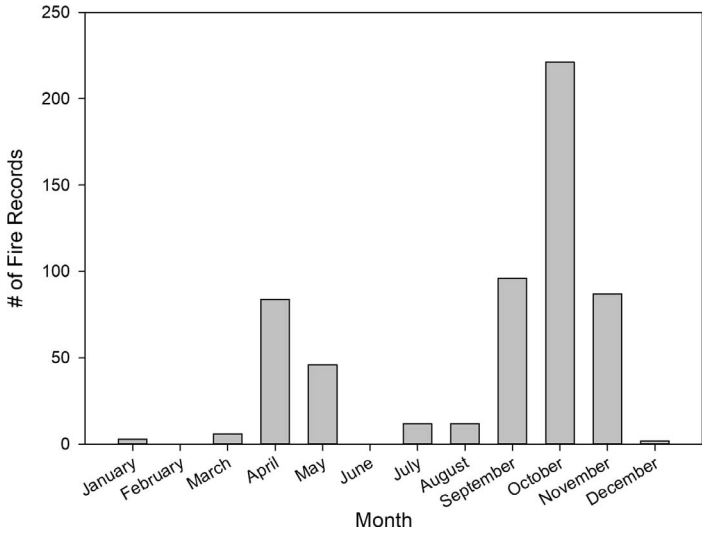

Figure 6.—Seasonality of Euro-American grassland fires reported by state fire wardens in Minnesota from 1895 to 1904 (data source: Andrews 1896-1905).

vernacular use by Europeans in the Midwest during the nineteenth century (Volney 1804; Drake 1815; Foot 1836; Huschke 1959; McClain and Elzinga 1994; Oliver 2005). Lapham (1873), writing about the great fires of 1871, related the tinder dry condition of October to this annual weather pattern, which was manifest in that year by drought conditions and strong southwest winds. Grasses in the time of Indian summer, according to some pioneers, "presented a combustible material surpassed only by kerosene and gunpowder" (Perrin 1882).

The fall fire season was often characterized by a smoky atmosphere sometimes dense enough to obscure the sun and moon for days or weeks (Faux 1823; Foot 1836; Anonymous 1856; Flower 1882; McMurray et. al. 2007). Andrew Ellicott, while on a journey down the Ohio River from Pittsburgh in October of 1796, encountered 15 days of smoke dense enough to prevent him from seeing the length of the boat, or to the opposite bank (Ellicott 1814). Major Steven Long experienced dense smoke on 15 of the days between 22 September and 8 November 1819 due to burning prairies while stationed at Council Bluffs, Iowa (Thwaites 1904). Welby, in Maryland in November of 1819, described "what in England would be thought a fog,–here they say it is smoke arising from burning barrens and prairies which are yearly at this time set on fire; indeed we have lately passed close enough to woodland on fire to see the flames and to hear the crackling of the timber" (Thwaites 1905). The sun appeared as a giant orange ball on days when the smoke was less dense (Faux 1823; Mitchell 1837; Oliver 1843; Gerhard 1857). Days of this nature were described by John James Audubon, while on the Ohio River at Henderson, Kentucky, on 20 November 1820: "The Indian summer, this extraordinary phenomenon of North America, is now in all of its splendor, the blood rising sun and the constant smoky atmosphere" (Audubon 1999).

In Bond and Montgomery counties, Illinois, "dense smoke arising from the (prairie) fires of Indian summer often enveloped the country in the shades of evening" (Perrin 1882). Smoke created by fires in Edgar County, Illinois, caused people to become lost in the forests in daytime because "it being so dark, owing to the thick smoke, they could not see their way" (Perrin et al. 1879). Lapham (1873), while writing about the great fires of 1871, stated: "A smoky atmosphere in autumn (in the Midwest) has been the common experience every year, and this smokiness has its origin in prairies fires." Grandma Jane Patton of Piatt County, Illinois, also wrote about smoke from the fires of 1871: "Mr. Patton and I went to Indiana, and came home the first week of October, I think the driest time I ever saw, and fires filled the air so full of smoke that you could not see very far" (Gardner 1908). Pioneers attributed the dense smoke to the burning of prairies by Native Americans, causing them to apply the term "Indian summer" to this season (Wells 1819; Flint 1826; Bell 1830; Foot 1836; Dunlap 1855; Caird 1859; Blanchard 1882).

We found records of 23 fire events attributable to Native Americans during the fall months (September through November). The earliest known ignition was recorded in 1673 in the Illinois Territory and the latest in the fall of 1836 in southwestern Illinois (Table 1). No record of a spring fire (March through May) was identified, but a single summer fire, described as more smoke than flame, was observed by Benton (1957) in Lee County, Illinois, during August of 1833 (Table 1). Fire history studies from the Great Plains demonstrate the use of fire every month except January by Native Americans, with a peak during October and November in the northeast and central regions (Moore (1972). Higgins (1986) found spring and fall to be peak burning seasons for Native Americans in the high plains of the West. Ignitions were still being described by travelers on the western plains for years following the Civil War, enabling the construction of more detailed fire histories for indigenous people compared to the eastern part of the central North American grasslands.

Our data include 140 fires for September through November that were attributed to Europeans. Blackened ground was noted 16 times, documenting fires at earlier dates, including six that were fall fires based upon the date of observation (Table 2). Two of these fires were extensive, burning hundreds of hectares of prairie and forest, including whole counties. This compares with 14 fires started during spring months (Mar–May) during the European settlement period (Table 2 and Figure 6). Baldwin (1877) described use of July fires on unburned prairie as a method of providing fresh grass for grazing, and as a way to eliminate prairie sod. Other prairies burned in the spring because wet weather during the previous fall prevented ignitions (Blane 1824). Increased landscape fragmentation from encroaching railroads and surveyed farm and road boundaries may have prevented fire from spreading into some prairies, making them a potential source of landscape fires during dry spring months.

Spring burning of field stubble and native grassland became increasingly common during European settlement as grasslands were converted to agriculture (Andrews 1896-1905). A total of 157 Minnesota wildland fires were due to burning stubble to facilitate plowing (Figure 4). Containment was always a problem during these times because the implements used—"wet sacks, brooms, branches, and rakes"—were not efficient for fire

containment. The most effective firebreak then in use was plowed ground, but strong winds could easily blow embers across these lines into flammable fuel, which was recorded in the Minnesota reports.

Weather

Weather data for fires attributed to Native Americans were generally not available. Only five descriptions contained information on wind conditions (Table 1). It is assumed that dry conditions prevailed during many of these burns, thus allowing Native Americans to complete their hunts as reported in the data. Escaped ring fires would continue to burn once the hunt commenced, spreading throughout the territory and burning through all areas having fuel dry enough to sustain fire, as reported in Ohio (Washburn 1977).

Weather conditions during the European Settlement era were described as "dry" (21 fires), "tinder dry," "remarkably dry," or "very dry" (9 fires), and "drought" conditions (11 fires). The weather was "warm" or "very warm" (8 fires), "mild" or "very mild" (2 fires), and "cold" (1 fire; Tables 1 and 2). Prevailing wind directions were from the west (22 fires) and south (16 fires; Figure 7). Three fires were driven by a north wind, and two by east winds. Wind velocity was described as "strong" or "very strong" (30 fires), "gale" force, "stiff gale," "great velocity," or "violent" (17 fires), "terrific fury," "fierce," or "furious" (8 fires), and "very windy," "powerful," or "hurricane force" (4 fires; Table 2). The intensity of the southwest winds during the great fires of 8 October 1871 was described as "powerful enough to force a strong person to the ground" (Lapham 1873).

Frequency and Trends over Time

The earliest known wildfire descriptions for the MTP were written by Jesuit priests and French explorers in the later part of the seventeenth century. Few descriptions were identified for the next 125 y despite the continuous presence of French settlements and hunting parties that routinely searched the landscape for bison, deer, and other fur-bearing animals. The 32 fire events identified for Native Americans are insufficient to establish frequency. However, sources suggest fire hunting was an annual event prior to the introduction of horses (Shea 1852). J.A. Oakwood (1886), a resident of Vermilion County, Illinois, described how Native Americans (the nearby Miami Tribe), "previous to 1834, annually set fire to the tall prairie grass, and burned off the whole face of the country, timber and prairie." Tribes in Ohio used the plains lying between the Portage and Maumee rivers in the northwestern part of the state "every fall for the ring hunt" (Finley 1859). Fire hunting was continued by some tribes following the arrival of Europeans, but the introduction of firearms, beginning early in the seventeenth century, reduced the need for this use of fire. Schoolcraft (1953) remarked how "these practices (fire hunting) are less common now than formerly, the introduction of firearms among most of the tribes, putting it in the power of almost every individual to kill sufficient for the support of his family."

Precipitous Native American population declines following contact with Europeans also likely contributed to a reduced use of landscape fire (Thornton 1987; Denevan 1992). Indigenous tribes along the Mississippi River lost scores of individuals to smallpox and other diseases in the 1700s (Le Page du Pratz 1758). Epidemics of smallpox, measles, and other diseases swept the country, sometimes eliminating entire villages (Charlevoix 1761; Thornton 1987; Jones 2004; Morgan 2010). The Illinois Confederacy, formerly a powerful group of at least 11 tribes and more than 10,000 members in 1673, was reduced to only 500 individuals in 1800 (Temple 1958; Sultzman 1997; Morrissey 2015). Henry Brackenridge, while writing about Native Americans in Missouri and neighboring states, described their populations as less than 10% of what they were 30 y earlier (Brackenridge 1814).

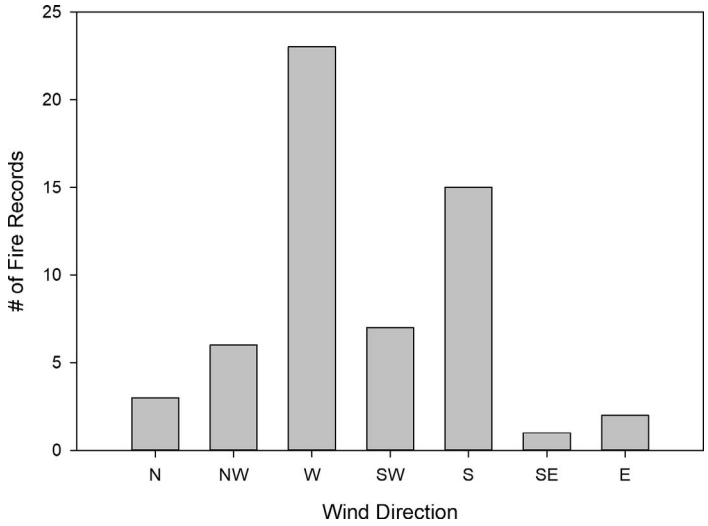

Figure 7.—Wind directions for early European settlement ignitions, 1794–1887 (summarized from Tables 1 and 2).

The number of European recorded ignitions increased rapidly after the year 1820, coinciding with the arrival of waves of immigrants (Table 2; Figure 2). Fire records were identified for nearly every year from 1816 until 1904 when they began to diminish due to landscape fragmentation associated with agriculture resulting in the disappearance of large expanses of grassland. This pattern generally corresponds with fire frequency trends documented by tree fire scar data in the Midwest (Guyette et al. 2002; McClain et al. 2010). The years with the greatest number of identified ignitions in the European settlement era were 1819 (11), 1843 and 1855 (7 and 14), 1836 (8), and 1835 and 1871 (9 and 8). Fires were widespread in 1819, being reported from Illinois, Iowa, Indiana, and Maryland. The increase in the number of ignitions may be related to the strong emphasis on agriculture and industry by the European population. These ignitions, as well as those from Minnesota from the years 1895–1905, appear to represent "waves of fire" associated with increasing agricultural intensification here and elsewhere in the MTP (Andrews 1896-1905; Stambaugh et. al. 2018; Figures 2 and 4).

Areal Extent

The unbroken landscape of the Midwest, with its flat to gently rolling topography, presented few barriers capable of stopping wildfires driven by strong winds. A fire in Ohio in 1756 burned a prairie estimated to be over 25,000 ha in size (Washburn 1977).

The narrative of Andrew Ellicott, on his journey down the Ohio River from Pittsburgh, Pennsylvania, in 1796, includes almost daily comments on wildland fires for the period 29 October to 16 November 1796 (Ellicott 1814). William Faux (1823), while traveling through southwestern Indiana and southeastern Illinois on 1 November 1819, described prairie and forest fires with sky-reddening blazes, dense smoke, and blackened ground on a journey covering approximately 75 km. In November of 1819, John Woods (1822) traveled north through burning timber for three days on a journey from Shawneetown on the Ohio River to Albion in Edwards County, Illinois, a distance of approximately 90 km. Flint (1826) described thousands of hectares of prairie on fire in the fall of 1825 near St. Louis, Missouri, and Foot (1836) described burning prairies for approximately 60 km in all directions at Fort Winnebago, Wisconsin. Robert Campbell traveled across burnt prairie for several days between 13 and 23 November 1832 along the Red River Valley of North Dakota, a linear distance estimated to exceed 150 km (Sutherland 1926).

A large fire started at 10:00 AM in the fall of 1836 in prairie near the Spoon River in Stark County, Illinois. This fire burned north, driven by a strong south wind, for 160 km, reaching the Rock River where Rockford now stands by 4:00 PM, and blackening thousands of hectares of prairie (Matson 1872). An Illinois fire, in September of 1856, burned through Ford and Iroquois counties before stopping at the Kankakee River, consuming thousands of hectares of grassland (Anonymous 1884a). Prairie fires in Minnesota, likely in the fall of 1856, "licked the country clean for hundreds" of kilometers (Anonymous 1857). Thousands of hectares of burning prairie were described by Brunson (1900), Newhall (1821), Blane (1824), Marsh (1978), Fordham (1906), and Cunynghame (1851) (Table 2). The fires of 1871 were unprecedented in their extent, property damage, and loss of human lives within the midwestern tallgrass prairie. This year included the Chicago and Great Peshtigo, Wisconsin, fires, the latter being the deadliest fire in the history of the United States, which is estimated to have burned 500,000 ha of land, killed an estimated 1500 people, and left thousands more missing, injured, and homeless (Lapham 1873; Pernin 1971).

Fire Effects on Vegetation

One of the earlier descriptions of the effects of fire upon woody vegetation within the MTP was written by James Smith in 1756 in Ohio while a captive of Native Americans. He described the rapid growth of tree sprouts in unburned prairie and their destruction once fire returned (Washburn 1977). Similar observations were made in Illinois by Jones (1838): "The yearly burning consumes all the new trees and shrubs." Fires in Missouri and Illinois, owing to the severe drought of 1819, burned longer and deeper into the forests, causing great injury to trees (James 1823). Faux (1823), also writing about the fires of 1819, described the sound of falling trees near Princeton, Indiana, as "like the discharge of ordnance." Hall (1831), also writing about Illinois, stated: "All of the young timber is destroyed by fires." Hundreds of hectares of forest were destroyed by fire in eastern Illinois (Parker 1836). "The timber is destroyed on the high ground (in southwestern Illinois) where fire can run" (Flagg 1838). These drought-year fires also had profound effects on wetlands, often changing them dramatically. Fires in the fall of 1835, September of 1856, and October of 1871 in Kankakee and Ford counties, Illinois, and Becker County, Minnesota, burned peat in marshes, creating deep holes and making ponds and lakes out of former shallow wetlands. These fires continued to burn long after the arrival of the winter snows, melting snow and producing volumes of steam for months until accumulating moisture finally extinguished them (Anonymous 1884a; Bartlett 1904; Wilcox 1907).

Fire Effects on People

Uncontrolled prairie fires, driven by strong winds, were menaces greatly feared by pioneers. Personal property, including crops, livestock, "snake" or Virginia rail fences, barns and outbuildings, was frequently destroyed. A petition presented to the Illinois Territorial legislature in 1807 by a group of Gallatin County farmers complained of livestock injury and mortality due to prairie fires (Anonymous 1815). Personal injury was rare, but a seven-year-old girl burned to death in Story County, Iowa, on 1 November 1859 after becoming lost in prairie during a fire (Tjernagel 1953). A family of five, also in Story County, Iowa, perished on the open prairie, after encountering a roaring headfire driven by a strong wind (Tjernagel 1953). A young couple and their horse perished in a prairie fire in Kankakee County, Illinois, prior to 1849 (Burroughs 1923). Prairie fires were "unusually disastrous in Iowa" in October of 1872, "destroying a number of houses and a large amount of grain, fences, and other property, and burning two children to death" (Anonymous 1872). In September of 1885 the Dakotas were "fearfully ravaged by prairie fires. Hundreds of farmers [were] burned out, losing houses and crops" (Anonymous 1885). Insurance companies advertised in newspapers, urging farmers to "prepare in time for the fires of fall" (Anonymous 1861). These advertisements often listed damages caused by prairie fires in several states as evidence of the need for insurance.

Early Wildfire Legislation

From the earliest stages, protection from wildfires was highly desired by Europeans in the MTP. In 1785 the French Village of Cahokia in St. Clair County, Illinois, passed an act to control fires: "It shall be prohibited for all hunters and other persons who may be going or coming to set fire to the meadow which may result [in] the burning of the fences and the feed of the cattle." Those that set fires were responsible for the damages, a fine of 150 livres (value of one livre equal to a pound of silver), and confinement "in irons for eight days" (McDermott 1949). Louis Giroux was indicted at Prairie du Pont (now Dupo, Illinois) in 1794 for setting fire to the commons, causing the loss of fence rails (St. Clair County Circuit Court Case 1794).

The Northwest Territory (comprising Illinois, Indiana, Michigan, Northeastern Minnesota, Ohio, and Wisconsin) legislature passed a law in December of 1799 restricting wildland fire use (Pease 1925). The rapid conversion of the landscape to agriculture, and the increasing number of settlers, buildings, crops, and livestock, made wildland fires increasingly less desirable. Citizens continued to complain, thus promoting more restrictive legislation and penalties. The Illinois and Indiana Territorial Government made the act of burning prairies a

misdemeanor in 1807, and persons found guilty were subject to a fine of not less than $5 nor more than $100 (Philbrink 1945). Additional legislation was enacted in Illinois in 1845, making the negligent, careless, intentional, or willful burning of prairies or woods illegal, except for the necessary preservation of personal property once two days' notice was given to neighbors. An open burning period was generally allowed across many MTP states from the first day of March until the last day of November (Brayman 1845; Kinney 1917).

These laws were rarely enforced, resulting in few convictions. A Kane County, Illinois, lawsuit involving Peter Johnson was an exception. His son, John Johnson, set fire to prairie on family property on 15 November 1845, but the fire passed onto a neighbor's land, destroying his house and crops (500 bushels of wheat, 500 bushels of oats, and 15 tons of hay) and 6500 fence rails having a presumed value of $1480 (Kane County, Illinois Circuit Court 1846). Damages were awarded to the plaintiff, but the case was contested, causing it to make its way to the Supreme Court of Illinois, which affirmed the circuit court's ruling, awarding damages to the plaintiff, Newman Barber (Illinois Supreme Court 1849). The Johnson's property was subsequently sold at a sheriff's auction, probably to pay the judgement of the court.

Prairie burning continued, as did damages from fires, but identifying the guilty person(s) was difficult. Some individuals, including John McCarthy and Burge Vermilion, were indicted, jailed, and placed on $100 bond in Shelby County, Illinois, in 1845 and 1851 for the crime of "firing the prairies" (Shelby County, Illinois, Circuit Court 1845, 1851). Likewise, Matthew Herbert, David Ogden, Nelson Case, and John Matlock were indicted in December of 1845 for "firing prairies" in Knox County, Illinois, and subsequently fined $5 each (Chapman 1878). Indictments likely resulted more often when the firing of prairies caused some sort of property damage.

All states enacted wildland fire legislation by the late 1800s following the Chicago and Peshtigo fires of 1871, and the Hinkley, Minnesota, fire of 1894. These laws, depending upon the state, imposed fines ranging from $1 to $1000, jail sentences of up to one year, or both, and resulted in fewer fire starts per decade by the early 1900s (Fernow 1896; Pettis 1903). These acts were considered necessary for the protection of people and property, plus the successful management of forest resources. The end result, in most cases, was greater emphasis on fire suppression. Some states, such as Minnesota, implemented a system of fire wardens, one per township, who were responsible for responding to, containing, and extinguishing wildland fires. Annual reports for this state were compiled by a chief fire warden whose job was to oversee the fire suppression program (cf. Andrews 1896-1905). Elsewhere, localized burning, mostly within forested regions like southern Illinois, continued well into the 1900s, causing State Forester R.B. Miller to regard fire as the most destructive element threatening the forests in this part of the state (Miller 1920).

We found evidence that many early fire laws allowed for "necessary burning" with permits and trained crewmen and fire wardens to provide oversight. Legislation required railroad companies to treat potential fuels within their rights-of-way with either burning or cutting brush and plow lines (Kinney 1917). Until later laws, such as the Weeks Act (1911), required state Forestry Commissions to develop fire control methods, there was no way to extinguish fires driven by a strong wind; they were allowed to burn without regard for the potential for property damage to landowners living far from the fire's origin (Kinney 1917; Bramwell 2012). In general, most fire laws written after 1885 included stiffer penalties for violating burn bans or negligent escapes (Kinney 1917). Obviously, greater attention to rogue fires became a hallmark of the US Forest Service and most conservation agencies after the disastrous conflagrations of 1894, 1897, and 1910.

Effects of Fire Absence

The grasslands of the MTP were essential to the livelihood and survival of Native Americans. Fire was an effective tool in seasonal deer and bison hunts, events that were repeated annually. In contrast, Europeans greatly feared fast-moving fires, causing the application of the terms "trains of desolation" and "messengers of death." Stopping these threats became a major goal, but it was one that ultimately meant eliminating the MTP, a landscape which once occupied more than 20 million hectares of central North America. The end came quickly through a combination of plowing, fire suppression, overgrazing, and drainage. The loss of grasslands in Minnesota was accelerated by an annual $20,000 legislative appropriation designated for tree planting in prairies, a practice of 25 y duration by 1896 (Andrews 1896). Today Illinois, Indiana, and Wisconsin have lost 99.9% of their prairies while Minnesota and Missouri have lost 99.6% and 99.5%, respectively (Bogue 1963; Smith 1998, 2001).

Prairie wildfires ended in the MTP by the late 1800s due to landscape fragmentation (Guyette et al 2002). Boies (1868) described how "very speedily, the prairie fires went out when the prairies were being crossed here and there by highways, hedges, and dwelling houses." A rapid growth of trees was noticed on prairie and barren sites early in the nineteenth century following an apparent reduced use of fire by Native Americans (Bourne 1819; Ferris 1856; Dorney 1981). This rapid tree growth was likely initiated by well-developed root systems of trees, known as grubs, which were repeatedly top-killed by fires. Grubs were evident to a Cook County, Illinois, man when he tried to plow his prairie. He found it to be "full of roots of trees which had been prevented from growing by previous annual prairie fires" (Andreas 1884). Edwin James, while writing about forests near St. Louis in 1820, described a "dense growth of oaks and elms since the yearly ravages of fires have been prevented" (Thwaites 1905). Flagg (1838), visiting the same site 16 y later, described "a young forest that was a treeless, shrubless waste" 30 y earlier. A St. Clair County, Illinois, forest, about the year 1855, contained trees large enough to provide timber for a small building, but was reported as prairie 35 y previously (Peck 1975).

The absence of fire resulted in profound changes in forest communities throughout the MTP. Baber's Woods in Edgar County, Illinois, now regarded as an upland forest, was an open savanna community at the time of Euro-settlement characterized by large, open-grown, widely spaced white oaks. Its overstory currently contains an oak cohort whose ages correspond to the cessation of wildland fires in the 1800s (Ebinger and McClain

1991; Parker and Ruffner 2004; Lhotka et al. 2016). A post oak woodland in Hamilton County, Illinois, contains an oak cohort having ages corresponding to a 33 y fire-free interval beginning in 1852 (McClain et. al. 2010). Oak cohorts whose growth coincides with pioneer settlement are also known from Iowa, Indiana, and Wisconsin (Thomson and Hertel 1981; Duvick and Blasing 1983; Apfelbaum and Haney 1991).

Further Observations and Conclusions

We consider the number of fires attributed to Native Americans to be small considering the size of our study area, the length of our study, and the number ignitions reported by similar studies in the western plains (Moore 1972). Diseases, population loss, forced migration, firearms, warfare, the introduction of horses, and widespread cultural destabilization associated with European contact likely contributed to a reduced number of fire hunting events attributed to indigenous people during the late seventeenth, eighteenth, and early nineteenth centuries (Denevan 1992; Sultzman 1997). Localized or occasional use of landscape fire certainly continued, as evidenced by the Potawatomie near the Kaskaskia (Okaw) River in Illinois, the Miami Tribe in eastern Illinois prior to their removal in 1834, and the annual ring fires on the plains between the Portage and Maumee rivers of Ohio (Finley 1859; Williams 1881; Oakwood 1886). However, early nineteenth-century observations by Bourne (1819), James (Thwaites 1905), and Flagg (1838) regarding the rapid woody invasion and conversion of prairie to woodland suggest use of landscape fire by native people within the MTP during that time was functionally nonexistent over a majority of the region (Morgan 2010).

We also believe ignitions are underrepresented for the early Euro-American settlement and agricultural intensification period (Table 2, Figures 3 and 4). Narratives from 1832 to 1894 contain language that suggests only highly threatening fires, events that would create great panic, were recorded. Descriptions of 44 fires describe wind velocities as "strong, furious, violent, hurricane," or "gale force." Others report fires as "terrific, raging, awful," or "threatening" (Tables 1 and 2). Documents were located that mentioned very damaging wildfire events, like those for Gallatin County, Illinois, for the early 1800s, but no information on their size, location, and date of occurrence could be identified (Anonymous 1815). McCulla (1914) refers to numerous undescribed fires in Iowa, a statement supported by Hart (1914): "There is not a county in all western or central Iowa but what can furnish facts for a chapter of prairie fires which would chill one's blood at the terrible recital of havoc from 1855 to 1876." Years of terror were recorded for the Dakotas in the 1880s and 1890s when powerful winds drove prairie fires, causing great losses and the application of terms like "fearful, destructive beyond precedent, tremendous, immense, raging, great, total, and furious" to these events (Anonymous 1879, 1885, 1887, 1888, 1889, 1890, 1891). No data, including the number of fires, their locations, or their areal extents, were identified for these ignitions. In contrast to powerful wind-driven fires, slow-moving or nonthreatening fires were rarely mentioned in the literature. The author of the history of Becker County, Minnesota, regarded slow-moving fires as a "tame affair," and residents rarely paid much attention to them (Wilcox 1907).

The 569 grassland fires identified in Minnesota for the 1896–1905 agricultural intensification period represent uncontained ignitions, fires that required the intervention of wardens and their crews. The use of fire to clear thatch from fields to facilitate plowing was widespread, and inadequate preparations were often the cause of an escaped fire. Wardens were required to prepare a report, citing the cause, extent, and damages caused by escaped fires. In contrast, no records exist for ignitions that were contained without incident (Andrews 1896-1905). This 10 y record of a high number of unreported annual grassland fires no doubt characterized other states of the MTP as well.

It is currently a common practice within the MTP to utilize prescribed fire during late winter or early spring prior to the growing season. A primary objective for the selection of this time of year is the preservation of wildlife habitat during winter months. These late winter burns remove thatch, but they have been insufficient to retard woody invasion at numerous sites, resulting in a major management problem for grassland remnants in Illinois (Robertson et. al. 1996). Woody invasion continues on sites that have a prescribed burn history spanning nearly 50 y (McClain and Ebinger 2012). More than 60% of the area of several grasslands in Illinois has been lost since the 1930s (McClain 1983; Robertson et. al. 1996). Costly, time-consuming tree and shrub removal programs have been implemented to mitigate the woody invasion, but much grassland appears to have been permanently converted to forest (Robertson et. al. 1996). Observations of late-winter burn sites suggest these events also benefit cool-season plant species such as Kentucky bluegrass and smooth brome, allowing them to achieve greater dominance within the plant communities. Nearly 50 y of late-winter prescribed burning may also benefit big bluestem (*Andropogon gerardii* Vitman.) and Indian grass (*Sorghastrum nutans* (L.) Nash.). The increase in dominance of these grasses may be contributing to a loss of rare plant species at some sites (McClain and Ebinger 2012; McClain et. al. 2014).

The late-winter prescribed burns of today are conducted during weather conditions that are vastly different from the Indian summer burns of the seventeenth, eighteenth, and nineteenth centuries (Table 2). Fire management has become progressively more complicated with time due to the effects of invasive exotic species, the presence of roads, developments, and communities, strict burning regulations, and a changing climate. These issues make the timing of prescribed burns especially critical when managing to maintain biodiversity and to maintain grasslands. We suggest an assessment of the timing and seasonality of prescribed burns to allow greater flexibility in the application of fire to address current management problems.

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