Lightning Fires in North Dakota Grasslands and in Pine-Savanna Lands of South Dakota and Montana

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Abstract

Lightning strike fires which occurred between 1940 and 1981 were studied in mixed-grass prairie grasslands and in pine-savanna lands in the Northern Great Plains region. A majority (73%) of ignitions occurred during July and August, while a lesser number was recorded in April, May, June, and September. The April-September period is also the average time of the freeze-free period and approximates the average distribution period for thunderstorm activity in this region. The area burned by each of 293 lightning fires (most of which were suppressed) ranged from 0.004-1158.3 ha ($\bar{X}$ = 10.8 ha). The frequency of lightning fires in mixed-grass prairie grasslands averaged 6.0/yr per 10,000 km² in eastern North Dakota, 22.4/yr per 10,000 km² in southcentral North Dakota, 24.7/yr per 10,000 km² in western North Dakota, and 91.7/yr per 10,000 km² in pine-savanna lands in northwestern South Dakota and southeastern Montana. The ecological role of lightning-set fires is discussed relative to the development of resource research and management plans and to the interpretation of historical records of natural fire occurrence in the Northern Great Plains region.

Climate and fires are strongly supported in recent reviews as primary agents affecting the origin and development of native grasslands in North America (Vogl 1974, Wright and Bailey 1980). Lightning has for many years been recognized as an important cause of forest fires (Komarek 1966, 1968; Stokes and Dieterich 1980) but there is less agreement about its importance as a natural cause of grassland fires.

Rowe (1969) and Vogl (1974) summarized historical perspectives of the arguments relative to the purported unimportance or absence of lightning fires in North American grasslands. However, authentic instances of lightning-caused fires have been reported in grasslands or steppes in Alberta (Nelson and England 1971), Saskatchewan (Raby 1966, Rowe 1969, Coupland 1973), Kansas (Brock 1925, Malin 1956), Nebraska (Kirsch and Kruse 1973, Wolfe 1973, Westover 1977, Bragg 1978), and Washington (Uresk et al. 1976).

Komarck (1966) reported lightning-caused fires for South Dakota and Nebraska, all of which were associated with forest or forest-savanna vegetative types. Thus, lightning-caused fires are a natural phenomenon in the Central and Northern Great Plains grasslands but there is a paucity of information about their seasonality, frequency, and extent.

The present paper summarizes and characterizes the events of 294 known occurrences of lightning-caused fires in grasslands in North Dakota and in pine-savanna lands of nearby South Dakota and Montana.

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The author would like to thank H.A. Kantrud, A.D. Kruse, G.K. Clambey, R. Komarek, D.H. Johnson, H.D. Wickware, and D.P. Aicher for manuscript review, and K.A. Smith, C.T. Odell, and R. Riddle for assisting with data collection.

Manuscript received August 20, 1982.

Study Areas

Lightning fire records were obtained for 4 areas within the Northern Great Plains (Fig. 1). These were the Sheyenne National Grasslands of Custer National Forest (1970–81), the brush hills

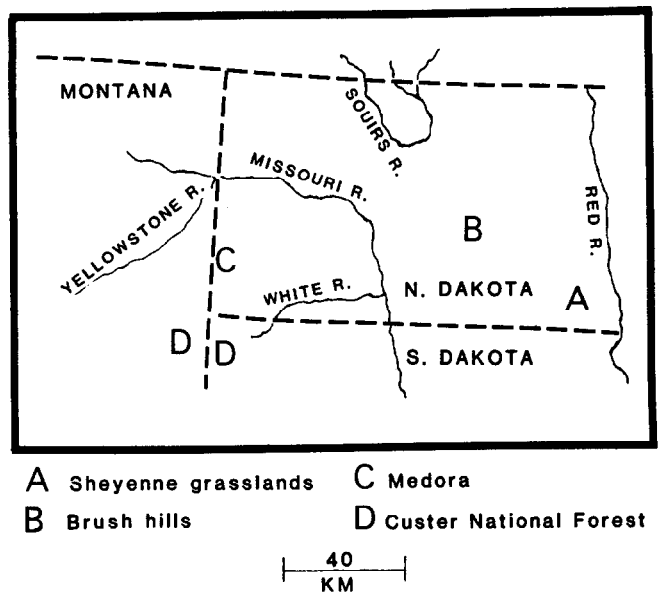

Fig. 1. *Location of study area.*

grassland area on the Missouri Coteau (1959–81), Theodore Roosevelt National Park (1949–81), and the Sioux Ranger District of Custer National Forest (1940–81). Thirteen lightning fires that occurred along the boundary of Theodore Roosevelt National Park were also included as part of the data for that study area.

The Sheyenne National Grasslands of the Custer National Forest in North Dakota are on a geologic formation known as the Sheyenne Delta, a formation at the mouth of the Sheyenne River as it discharged into glacial Lake Agassiz. The grasslands are composed of 4 major habitat associations: choppy sandhills, savanna, dry mixed-grass prairie, and moist mixed-grass prairie. These habitat associations support a variety of plant species representative of tall grass prairie, mixed-grass prairie, and oak-savanna lands. Barker (1974) listed the characteristic species for 9 native plant communities within these habitat associations and described their distribution by soil-moisture relationships.

The brush hills mixed-grass prairie area is privately owned rangeland on the Missouri Coteau in Stutsman County, N. Dak. Major plant species of this area were listed by Küchler (1964). The area is steep to rolling with considerable variation in topographic relief.

The grasslands of Theodore Roosevelt National Park are mostly in the badlands of western North Dakota, an area of extremely

rugged topography. These grasslands are typical mixed-grass prairie and were described by Hanson and Whitman (1938) and Dix (1960).

The pine-savanna lands of the Sioux Ranger District of the Custer National Forest are in northwestern South Dakota and southeastern Montana. These savannas have a grass understory composed of mixed-grass prairie species (Hanson and Whitman 1938, Dix 1960) interspersed with scattered stands of ponderosa pine *(Pinus ponderosa).*

Methods

Records of lightning-caused fires were obtained from published reports, files of public agencies, and from personal observations. Size classes of lightning fires conform to the U.S. Forest Service codes.

Nearly all of the data were from federally owned or managed lands. Presumably, these records are the most consistent because of agency mandates relative to fire records and fire suppression. Personal observations were also included. Because of the doubtful circumstances and generalities in many newspaper accounts, no effort was made to retrieve records from this source. Records from local fire departments were used to substantiate personal observations.

Results and Discussion

Records of 294 lightning-caused fires were obtained in the 4-study areas. The size of 1 lightning fire was undetermined for the brush hills study area. Lightning ignited fires in grasslands and pine-savanna lands during all months from April to September (Fig. 2). Seventy-three percent of lightning ignitions (Fig. 2) and

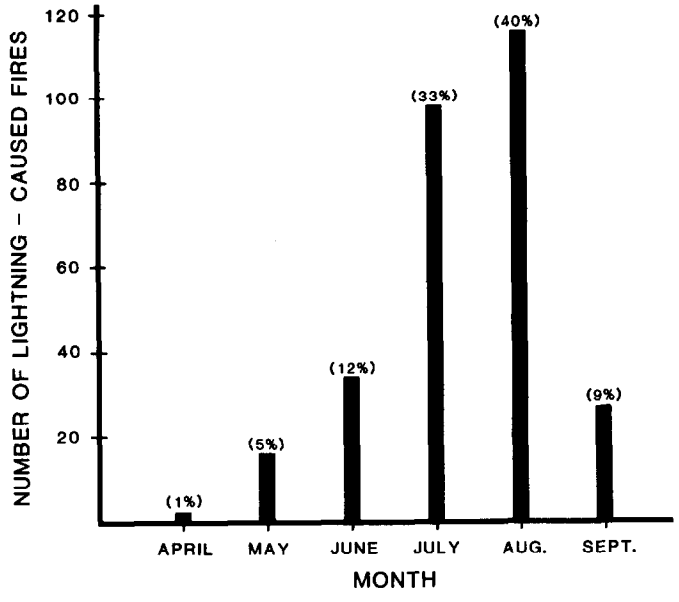

Fig. 2. *Monthly distribution of 293 lightning-caused fires in the Northern Great Plains.*

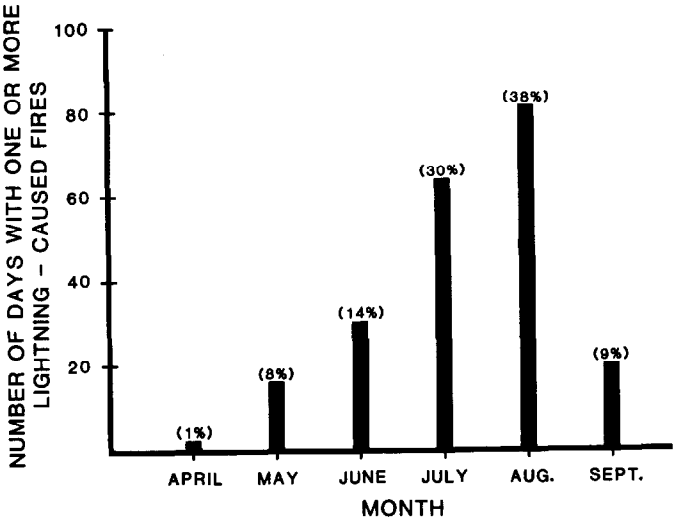

Fig. 3. *Monthly distribution of 213 days with one or more lightning-caused fires in the Northern Great Plains.*

68% of the days with fires (Fig. 3) occurred during July and August with lesser numbers in April, May, June, and September. Multiple ignitions (more than 1 fire in 1 area on a single calendar day) occurred in all months from June–September. Eighty-six percent of the days (n = 44) with multiple ignitions occurred from July 1–August 31.

The area burned by each of 293 grassland lightning fires ranged from 0.004–1158.3 ha ($\bar{X}$ = 10.8 ha). Eighty-eight percent of these fires burned an area of 3.64 ha or less (Fig. 4). Mean monthly sizes of these fires are shown in Table 1. The largest mean area burned occurred in July, followed by May, August, June, September, and April. Fires of 40.5 ha or larger occurred in all months from May–August. Only 2 fires burned more than 405 ha; both occurred in July.

Frequency of lightning fires averaged 6.0/yr per 10,000 km² in eastern North Dakota grasslands, 22.4/yr per 10,000 km² in south-central North Dakota grasslands, 24.7/yr per 10,000 km² in western North Dakota grasslands, and 91.7/yr per 10,000 km² in pine-savanna lands in northwestern South Dakota and southeastern Montana (Table 2). Fires caused by lightning strikes were about 4 times more frequent in pine-savanna lands than in grasslands with few trees. Although the period of record is relatively short (n = 12 years) for eastern North Dakota, fires caused by lightning strikes seemingly occurred more frequently west of the Missouri River in North Dakota than east of the river.

The mean size of 4 lightning fires where no suppression was applied was less than 8.1 ha (Table 3). This sample may not reflect the expected mean size of unsuppressed fires for northern grasslands but it represents all the information currently available.

These data demonstrate that lightning is a common cause of fires in northern mixed-grass prairie grasslands. Fire records from 42 years (1940–81) show that lightning strikes caused periodic grassland fires in all months during April–September. This period coin-

Table 1. Sizes of 293 lightning-caused fires in North Dakota grasslands and in nearby pine-savanna lands in South Dakota and Montana by months.

Variables	April	May	June	July	August	September	Total
Number of fires	2	16	34	98	116	27	293
Total hectares burned[a]	1.22	252.51	109.41	1884.38	905.18	32.21	3184.91
Mean fire size (hectares)[a]	0.61	15.78	3.22	19.23	7.80	1.19	10.87

[a]These figures are minimal because nearly all fires were subject to suppression.

Table 2. Frequency of lightning-set fires in North Dakota grasslands and in pine-savanna lands in nearby South Dakota and Montana.

Variables	Sheyenne National Grasslands in southeastern ND	Privately-owned grasslands in south-central ND	Theodore Roosevelt National Park in western ND	Sioux Ranger District in northwestern SD & southeastern MT
Area (ha)	28,423	3,888	28,350	66,015
Vegetative type	Tall grass prairie	Mixed-grass prairie	Mixed-grass prairie	Mixed-grass prairie/ponderosa pine
Period of record	1970–81 (12 years)	1959–81 (23 years)	1949–81 (33 years)	1940–81 (42 years)
Number of lightning-set fires	2	2	36	254
Fire frequency (no/yr)	0.17	0.09	1.09	6.05
Fire frequency (no/yr/10,000 km²)	5.985	22.377	38.477	91.717

cides with the freeze-free period at these latitudes and approximates the average distribution period for thunderstorm activity in this region (Jensen 1972).

Table 3. Size of lightning fires in North Dakota grasslands when suppression was not applied.

Year	Month	Size (ha)	Means of extinguishment
1971 or 1972[a]	July or Aug.	6.1–8.1	Unknown
1973[a]	Aug. or Sept.	≃8.1	Unknown
1978[a]	July	≃8.1	Rain
1981[b]	May 2	≃4.05	Natural burn out

[a]Records from Karen Smith, Manager, Lostwood NWR, ND.
[b]Observations by the author.

The incidence of grassland fires from lightning strikes in this study was greatest during July and August (73%), with lesser numbers in April, May, June, and September. This is understandable because (1) the fine fuels of grasslands are usually dry during this period, (2) July is the peak month for thunderstorms although they occur nearly as often in June and August (Jensen 1972), and (3) the highest average temperatures occur during July and August (Jensen 1972).

Other reports also support the premise that the probability of lightning-caused fires in grasslands is greatest but not exclusive to the summer and late-summer season in the Northern Great Plains. A 1792 quote from the journal of Peter Fidler (Nelson and England 1971) stated of the Canadian grasslands, "...lightning in the spring and fall frequently lights the grass." Rowe (1969) noted the occurrence of over 40 ignitions of grassland by lightning on 21 different dates in southwestern Saskatchewan and the nearby United States; all ignitions occurred during July, August, and September.

A very conservative perspective of the extent of lightning-set fires was demonstrated by the data in the present study because some degree of suppression was applied to nearly all of the fires on record. Nevertheless, if the assumption is made that equal initial suppressive efforts were applied to all of the fires, then the pattern of fire sizes should be somewhat reflective of their natural potential. Consequently, relative fire sizes were greatest during July, the month with the highest mean temperature and peak numbers of thunderstorms. Furthermore, even with suppressive actions, 2 lightning-set fires in grasslands exceeded 405 ha, both in July. A limited number (n = 4) of lightning fires free of suppressive actions averaged slightly less than 8.1 ha.

Lightning fires in the past century have been largely affected by cultural obstacles and practices—mainly roads, cultivated fields, heavy grazing, and new suppression techniques. Even with numerous obstacles, lightning has caused fires of considerable extent. Rowe (1969) listed 2 large grassland fires (3, 110 and 4,666 ha) for southwestern Saskatchewan, and Wolfe (1973) reported a May lightning fire in Nebraska that originated on a prairie and burned over 7,290 ha of rangeland and forest. This fire skipped across the valley and Middle Loup River, a railroad right-of-way, and a highway right-of-way (Komarek 1966). These examples demonstrate that extensive grassland fires of lightning origin can occur even during recent times despite advanced suppressive techniques and cultural obstacles, if fuel and weather conditions are dry and winds are high. Large fires like these occur infrequently. Records indicate that the size of lightning fires in northern grasslands is frequently limited because of rain shortly after the frontal passage of a thunderstorm system.

Except for fire frequency, the temporal patterns of lightning-set fires were very nearly identical between the mixed-grass prairie grasslands in Theodore Roosevelt National Park and the ponderosa pine-savanna lands of the Sioux Ranger District. Fires caused by lightning strikes were slightly more than 4 times as frequent in the pine-savanna lands than in grasslands with few trees or shrubs. Lightning-set fires occurred as frequently as once in 12 years on 3,888 ha of privately owned pastureland in southcentral North Dakota, once in 6 years on 28,423 ha of grazed Forest Service

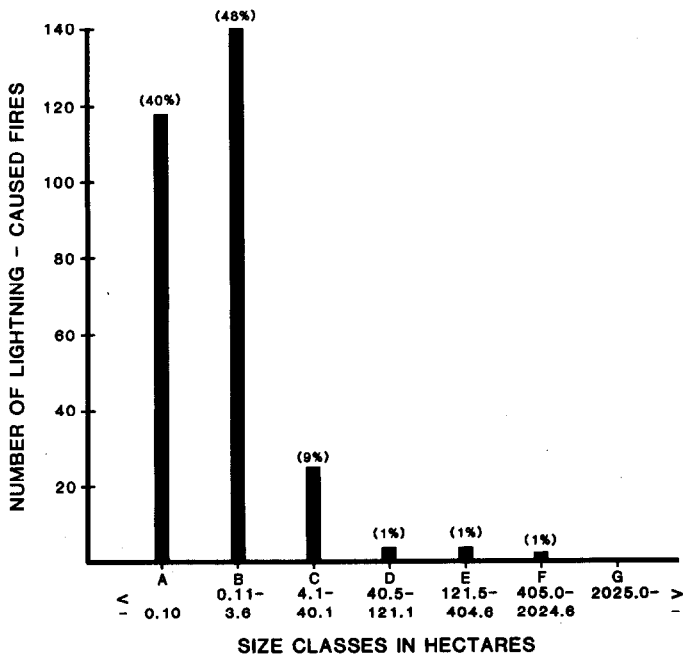

Fig. 4. *Distribution of 293 lightning-caused fires in the Northern Great Plains by size classes.*

grasslands in eastern North Dakota, and once per year on 28,350 ha of mixed grasslands on National Park Service lands in western North Dakota. In earlier studies in mixed grasslands in western North Dakota, Quinnild and Cosby (1958) gave evidence that fire had not occurred for 16–17 years, and the study areas of Dix (1960) were believed free from fire for at least 20 years. In pine-savanna lands in northwestern South Dakota and in southeastern Montana, lightning-set fires occurred on an average of 6 times per year or once a month during the season for lightning fires (April–September) on 66,015 ha of Forest Service lands. These data suggest that lightning-set fires occur at a higher frequency in the western part than in the eastern part of the region. The western parts of North Dakota and South Dakota and eastern parts of Montana are also more xeric than the eastern parts of the Dakotas.

Most fires in the pine-savanna lands were caused by lightning-to-tree strikes (D. Aicher, pers. comm.), whereas most fires in Theodore Roosevelt National Park and the Sheyenne National Grasslands areas of North Dakota were lightning-to-grass strikes (H. Wickware and R. Riddle, pers. comm.). Fires in the park were initiated most frequently on or near the tops of grassy buttes.

The ecological ramifications of fires in northern grasslands are multiple. However, if we accept the concept that for the past few hundred years northern grasslands have occupied their present ranges and that weather conditions have been fairly arid during this period (Will 1946, Dix 1964, McAndrews et al. 1967, Shay 1967, Wells 1970), then some ecological deductions can be made relative to past and present occurrences of lightning fires in grasslands of the Northern Great Plains regions of the United States and Canada:

(1) Nearly all fires during the fall-winter period (October–March) reported in journals and letters from the Northern Great Plains region since ca. 1750 were probably caused by sources other than lightning strikes, most likely man. This is an important interpretation factor relative to the cause and historical occurrence of natural fires in northern grasslands.

(2) A greater percentage and size of lightning-set fires during summer and early fall would tend to favor grasslands over woodlands (except on areas of rougher and more dissected topography), mid to short graminoid vegetation over taller species, and cool-season species of graminoids over warm-season species. The natural vegetation type was probably very similar to that described by Hanson and Whitman (1938) and Küchler (1964).

(3) The frequency and extent of lightning fires have been confounded by the cultural features of recent years. They were also confounded in the historic past by the patterns of grazing animals that unevenly reduced the fuel loads. However, the frequency and extent of historic lightning fires would probably be higher and greater than in the post-bison era because of continuum of fuel, regardless of height or density.

(4) Although historic journals dating back to ca. 1750 give many descriptions of accidental and intentional use of fire by American Indians, there are no records of fire suppression efforts by these peoples except to save occupied camp sites. Thus, lightning and cultural fires of pre-settlement times probably proceeded without event until interrupted by precipitation, cool atmospheric temperatures, natural barriers of streams and wetlands, interruptions in fuels caused by grazing of wild herbivores, or by significant changes in topographic relief.

Many studies substantiate that the native flora and fauna of northern grasslands and savannas are strongly adapted to an ecosystem with fire acting frequently as a functional entity in the evolutionary processes. These data suggest that the occurrence of lightning ignition was sufficient to produce ecological adaptions to lightning-set fires if they ocurred similarly during historic time. Even though the data identify general patterns of lightning-set fires, resource managers should keep in mind that different management objectives may also require different prescribed fire frequencies even on the same area.

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