

Frequency of Suitable Prescribed Burning Weather in East-Central Minnesota

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ABSTRACT

Prescribed burning in the Lake States occurs primarily in April and May, and in August through October. Analysis of St. Cloud, Minnesota, weather records for these months revealed that conditions suitable for three severity levels of prescribed burning occurred most frequently in east-central Minnesota from mid-April to mid-May and mid-September to mid-October. Wind direction on most suitable days is from the southwest, south, or southeast.

INTRODUCTION

Fire management is a young science that revolves around the use of carefully controlled fire to accomplish specific goals. Some of these goals are:

Hazard reduction is the epitome of fighting fire with fire. Dangerous or nuisance accumulations of fuel such as logging slash or grass can be disposed of safely by burning under controlled conditions. Left unburned, this material might ignite at a time of high fire danger, resulting in significant damage and high suppression costs.

Site preparation for forest regeneration can be accomplished by burning in some cases. The burning reduces debris and litter and releases nutrients that have been held in the wood and litter. Competition from undesirable plants may be temporarily eliminated or reduced.

Natural area management implies that the area be subjected to the natural forces that shaped the charac-

ter of the vegetation. Fire is one of these agents and is often used in the management of natural areas.

Wildlife habitat management also uses fire to stimulate shrub sprouting, favor aspen regeneration on cut-over sites, maintain forest openings against the encroachment of woody plants, stimulate the growth of grasses, and clear marshes of tangled rough. Fire, by setting existing vegetation stages back to an earlier successional stage, creates a larger diversity of local habitats and thus benefits wildlife.

The capricious nature of suitable prescribed burning weather, however, complicates the process of prescribed burn scheduling. This requires that burning programs be flexible and easily mobilized. Although exact predictions cannot be made, it is possible to identify the times of the year when suitable burning weather most frequently occurs. The selection of actual burning dates must then be

based on the weather, fuel moisture, vegetative state, and crew and equipment availability for the specific day(s) being considered.

A 10-year historical weather record was analyzed in an attempt to clearly identify the date of suitable prescribed burning weather targets. Although 10 years is a relatively short period for weather analysis, it seems to provide a sufficient basis for estimating the relative frequency of suitable burning weather.

One objective of this analysis was to determine the times of the year having the highest frequency of suitable prescribed burning weather as defined by three severity levels of prescribed burning prescriptions.

A second objective was to determine the wind directions most often associated with suitable prescribed burning weather as defined by the medium-severity-level prescribed burning prescription.

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METHODS

Donoghue (1974) reports that the large majority of prescribed burns in Michigan, Wisconsin, and Minnesota occur in the periods April through May and August through October. Therefore, 10 years of daily weather observations were obtained from the St. Cloud, Minnesota, airport for the periods April 1 through June 2 and August 15 through October 30.

The weather variables considered were the daily 3 p.m. Central Standard Time (CST) observations of temperature (degrees Fahrenheit), relative humidity (percent), wind-speed (miles per hour at 20 feet above ground level), and wind direction. In addition, the number of days since at least 0.01 inches of precipitation occurred was determined.

The selected time of weather observation was 3 p.m. CST because this is within the time of the day generally considered to be the most severe in terms of fire weather. The years of record include portions of 1955, 1956, 1957, 1969, and 1978 as well as all of 1970 through 1977. (See Figure 1.) Since consistent observations were not available for 10 complete years, observations collected in four different years (1955, 1957, 1969, and 1978) were combined to provide the ninth and tenth sets of consistent observations for the analysis.

The prescriptions used to define suitable burning weather are found in Table 1. The low-severity prescription might be used in a grass or marsh situation for rough reduction or growth stimulation. The medium-severity prescription might be useful in hardwood regeneration stimulation, slash reduction, and site preparation. The practical utility of the high-severity prescription is limited, but it may be used to regenerate non-

Suitable spring prescribed burning weather

Tables 2, 3, and 4 show the tabulation (by year, week, and prescription severity level) of suitable prescribed burning days that occurred in the 10-year record of weather from April 1

Figure 1—Weather record used in this research.

Year	Spring		Fall	
	Apr. 1—June 2	Aug. 15—Aug. 31	Sept. 1—Sept. 30	Oct. 1—Oct. 30
1955			X	
1956		X	X	X
1957	X	X		
1969				X
1970	X	X	X	X
1971	X	X	X	X
1972	X	X	X	X
1973	X	X	X	X
1974	X	X	X	X
1975	X	X	X	X
1976	X	X	X	X
1977	X	X	X	X
1978	X			

Table 1—Prescription severity levels used in this research

Weather variable	Prescription severity level		
	Low	Medium	High
Temperature (°F)	50—80	60+	70—80
Relative humidity (%)	25—50	20—35	20—30
Windspeed (m.p.h.)	5—15	5—15	10—15
Days since at least 0.01 inches of precipitation	3+	4+	5+

commercial hardwood timber for improved wildlife habitat.

The 10 years of weather data for April 1 through June 2 and August 15 through October 30 periods were broken down into one-week segments. A simple FORTRAN sorting routine was then used to pick out each suitable burning day and identify it by prescription severity level and week and year of occurrence. A four-week-long burning target for each of the three prescription severity levels was identified in the April 1 through June 2 period and the August 15 through October 30 period. These burning target periods were defined as being the period of four consecutive weeks having the highest frequency of suitable prescribed burning days within

the general period considered. A chi-square test was used to determine whether the frequency of suitable days in the target period was significantly higher than chance would allow.

The data were then divided into four 31-day-long periods and one 15-day-long period: April 1 through May 1, May 2 through June 1, August 15 through September 14, September 15 through October 15, and October 16 through October 30. Within each of these periods, a chi-square test was used to determine whether burning day suitability (as defined by the medium-severity-level prescription) and wind direction on suitable burning days were related (dependent) or not related (independent).

RESULTS—DISCUSSION

through June 2. Note that just as some weeks have a higher frequency of suitable prescribed burning days, individual years vary widely in their frequency of suitable burning weather.

Table 5 summarizes Tables 2, 3, and 4 and delineates the four-week-

long target burning periods. Under the low-severity-level prescription, the target burning date is identified as April 15 through May 12. This period contained 40 days (59% of the total identified suitable burning days) of suitable burning weather. A chi-square test shows that the preponder-

Table 2—Suitable spring prescribed burning days by week and year for a low-severity-level prescription.

Week	Year										Total
	1957	1970	1971	1972	1973	1974	1975	1976	1977	1978	
4/1—4/7	—	—	2	—	—	—	—	2	—	—	4
4/8—4/14	—	1	2	—	—	1	—	1	2	—	7
4/15—4/21	1	—	—	—	1	5	—	3	—	1	11
4/22—4/28	1	2	2	1	1	—	—	2	—	1	10
4/29—5/5	1	1	—	1	1	—	—	1	—	1	6
5/6—5/12	—	3	1	3	—	2	2	—	1	1	13
5/13—5/19	—	—	—	—	—	—	1	—	—	4	5
5/20—5/26	1	—	1	—	—	1	—	—	—	2	5
5/27—6/2	1	—	—	1	2	—	2	1	—	—	7
Total	5	7	8	6	5	9	5	10	3	10	68

Table 3—Suitable spring prescribed burning days by week and year for a medium-severity-level prescription.

Week	Year										Total
	1957	1970	1971	1972	1973	1974	1975	1976	1977	1978	
4/1—4/7	—	—	1	—	—	—	—	1	—	—	2
4/8—4/14	—	—	—	—	—	—	—	2	1	—	3
4/15—4/21	—	—	—	—	—	1	—	—	—	—	1
4/22—4/28	—	1	—	1	—	—	—	1	3	—	6
4/29—5/5	1	—	—	—	—	—	—	—	—	1	2
5/6—5/12	1	2	1	2	—	—	1	—	3	1	11
5/13—5/19	—	—	—	1	—	—	2	1	1	1	6
5/20—5/26	—	—	—	—	—	1	—	3	—	—	4
5/27—6/2	1	—	—	—	1	—	1	—	—	—	3
Total	3	3	2	4	1	2	4	8	8	3	38

Table 4—Suitable spring prescribed burning days by week and year for a high-severity-level prescription.

Week	Year										Total
	1957	1970	1971	1972	1973	1974	1975	1976	1977	1978	
4/1—4/7	—	—	—	—	—	—	—	—	—	—	0
4/8—4/14	—	—	—	—	—	—	—	—	—	—	0
4/15—4/21	—	—	—	—	—	—	—	—	—	—	0
4/22—4/28	—	—	—	—	—	—	—	—	2	—	2
4/29—5/5	—	—	—	—	—	—	—	—	—	—	0
5/6—5/12	—	—	—	—	—	—	—	—	1	—	1
5/13—5/19	—	—	—	—	—	—	1	—	—	—	1
5/20—5/26	—	—	—	—	—	—	—	1	—	—	1
5/27—6/2	—	—	—	—	—	—	—	—	—	—	0
Total	0	0	0	0	0	0	1	1	3	0	5

ance of suitable prescribed burning days in this four-week period is greater than random chance would allow ($0.01 < p < 0.025$).

With the medium-severity-level prescription, 25 days (66% of the total of identified suitable burning days) occurred in the four-week period from April 22 through May 19. Again, a chi-square test shows that the clumping of suitable burning days in this four-week-long period is significant ($0.005 < p < 0.01$).

Under the high-severity-level prescription, four days (80% of the identified suitable burning days in 10 years) fell in the target period from

April 22 through May 19. The aggregation of suitable burning days in this period and for this prescription is not statistically significant ($0.1 < p < 0.25$). However, the intuitive trend is apparent.

Note that the target period for the low-severity-level prescription occurs a week earlier than the target for both the medium- and high-severity-level prescriptions. This is probably due to the lower temperature allowance of the low-severity prescription.

It is interesting to note that as prescriptions increase in severity, the number of suitable days per year decreases, but the percent of these days

that fall within the target period increases. In addition to an adequate frequency of suitable burning days, these target periods seem to be a good compromise between early spring, when soils and fuels are damp, and late spring, when green vegetation is more severely harmed by fire and when green fuels lower the flammability of the fuel complex.

It should be remembered that these four-week periods are only targets. Burning days can obviously occur outside of the target periods. Burning programs should be flexible enough to mobilize quickly and take advantage of good burning weather when it occurs. For example, when an early spring occurs, burns should be scheduled earlier than normal.

Suitable fall prescribed burning weather

Tables 6, 7, and 8 show the tabulation (by year, week, and prescription severity level) of suitable prescribed burning days that occurred in the 10-year record of weather from August 15 through October 30.

Table 9, the summary table, outlines the target periods. The four-week period with the highest frequency of suitable low-severity-level burning days is September 26 through October 23. Sixty-eight days (47%) of 144 suitable burning days occurred in this period. The concentration of suitable burning days in this period is significant ($p < 0.005$).

Both the medium- and high-severity-level prescriptions are satisfied most frequently (24 days and three days, respectively) in the four-week-long period from September 12 through October 9. This period contains 47% of the suitable burning days as defined by the medium-severity-level prescription. However, it is not a significant association ($0.1 < p < 0.25$). Fifty percent of the high-severity-level suitable burning days fall in this same period, but again the association is not significant ($0.25 < p < 0.5$).

The fall target period for burning with the low-severity-level prescription occurs two weeks later than the target period for either of the other two prescriptions. Again, this probably results from the lower

Table 5—Number of suitable spring prescribed burning days by week and prescription severity level. Four-week target periods are delineated by shaded areas.

Week	Prescription severity level		
	Low ¹	Medium ²	High ³
Apr. 1—7	4	2	0
Apr. 8—14	7	3	0
Apr. 15—21	11	1	0
April 22—28	10	6	2
Apr. 29—May 5	6	2	0
May 6—12	13	11	1
May 13—19	5	6	1
May 20—26	5	4	1
May 27—June 2	7	3	0
Total	68	38	5
Percent of total burning days in target period	59	66	80

¹The four-week target period for this prescription has significantly more suitable prescribed burning days than random chance would allow (0.01 < p < 0.025).

²The four-week target period for this prescription has significantly more suitable prescribed burning days than random chance would allow (0.005 < p < 0.01).

³The four-week target period for this prescription does not have significantly more suitable prescribed burning days than random chance would allow (0.1 < p < 0.25).

Table 6—Suitable fall prescribed burning days by week and year for a low-severity-level prescription.

Week	Year(s)										Total
	1955 ¹ 1957 1969	1956	1970	1971	1972	1973	1974	1975	1976	1977	
8/15—8/21	1	2	2	1	—	—	1	1	1	3	12
8/22—8/28	—	1	—	—	—	—	3	1	1	3	9
8/29—9/4	4	2	—	—	—	—	4	2	—	—	12
9/5—9/11	4	1	—	—	1	1	1	—	—	—	8
9/12—9/18	1	—	1	4	3	—	2	1	2	2	16
9/19—9/25	—	1	—	3	1	—	3	2	2	—	12
9/26—10/2	1	2	2	—	1	—	3	5	2	—	16
10/3—10/9	1	1	1	2	1	2	2	2	—	1	13
10/10—10/16	—	1	1	—	1	3	4	3	2	1	16
10/17—10/23	—	5	3	—	—	4	2	5	—	4	23
10/24—10/30	—	1	—	—	—	1	1	—	2	2	7
Total	12	17	10	10	8	11	26	22	12	16	144

¹This column represents data from Aug. 15-31, 1957; Sept. 1-30, 1955; and Oct. 1-30, 1969.

Table 7—Suitable fall prescribed burning days by week and year for a medium-severity-level prescription.

Week	Year(s)										Total
	1955 ¹ 1957 1969	1956	1970	1971	1972	1973	1974	1975	1976	1977	
8/15—8/21	—	—	2	—	—	—	—	—	1	—	3
8/22—8/28	—	—	4	1	—	—	1	—	3	1	10
8/29—9/4	—	—	—	—	—	—	1	—	1	—	2
9/5—9/11	1	—	—	—	—	—	—	—	1	—	2
9/12—9/18	1	—	—	—	1	—	2	—	1	—	5
9/19—9/25	—	—	—	2	—	—	1	—	2	—	5
9/26—10/2	—	1	2	—	—	—	1	2	2	—	8
10/3—10/9	—	2	1	—	—	2	—	1	—	—	6
10/10—10/16	—	—	—	—	—	—	2	—	1	—	3
10/17—10/23	—	1	—	—	—	1	—	—	—	2	4
10/24—10/30	—	—	—	—	—	—	1	—	—	2	3
Total	2	4	9	3	1	3	9	3	12	5	51

¹This column represents data from Aug. 15-31, 1957; Sept. 1-30, 1955; and Oct. 1-30, 1969.

temperature allowance of the low-severity-level prescription.

As was noted previously, suitable burning days can occur outside of the target periods. Program flexibility should be maintained to capitalize on these occurrences. However, fire effects can vary with seasonal phenology and physiological changes in vegetation, so the probability of obtaining desired fire effects as well as suitable weather must be considered when planning prescribed burns.

Wind direction on suitable burning days

In using the chi-square procedure to test the independence of the occurrence of suitable prescribed burning weather (as defined by the medium-severity-level prescription) and wind direction, only two of the individual wind periods show a statistically significant lack of independence between wind direction and the suitability of a day for prescribed burning. The periods of May 2 through June 1 and September 15 through October 15 show that south and southwest winds are the most common winds on suitable burning days (0.01 < p < 0.025 and 0.025 < p < 0.05, respectively).

The pooled spring periods show a significant (p < 0.005) association between suitable burning days and southeast, south, and southwest winds. The combined fall periods do not show a significant association (0.1 < p < 0.25) between wind direction and suitable days. However, southeast, south, and southwest are strongly implicated as being the most frequent wind directions on suitable burning days.

The combination of the spring and fall periods show a significant association (p < 0.005) of wind direction and burning day suitability. As before, southeast, south, and southwest winds are seen to be the most frequent winds on suitable burning days.

Table 10 shows the percent of suitable prescribed burning days having wind from each direction.

In a 10-year study of weather data from International Falls, Duluth, and Minneapolis, Minnesota, Sando

Table 8—Suitable fall prescribed burning days by week and year for a high-severity-level prescription.

Week	Year(s)										Total
	1955 ¹										
	1957	1956	1970	1971	1972	1973	1974	1975	1976	1977	
8/15—8/21	—	—	1	—	—	—	—	—	—	—	1
8/22—8/28	—	—	—	—	—	—	—	—	1	—	1
8/29—9/4	—	—	—	—	—	—	—	—	—	—	0
9/5—9/11	1	—	—	—	—	—	—	—	—	—	1
9/12—9/18	—	—	—	—	—	—	—	—	—	—	0
9/19—9/25	—	—	—	—	—	—	—	—	—	—	0
9/26—10/2	—	—	—	—	—	—	—	—	1	—	1
10/3—10/9	—	1	1	—	—	—	—	—	—	—	2
10/10—10/16	—	—	—	—	—	—	—	—	—	—	0
10/17—10/23	—	—	—	—	—	—	—	—	—	—	0
10/24—10/30	—	—	—	—	—	—	—	—	—	—	0
Total	1	1	2	0	0	0	0	0	2	0	6

¹This column represents data from Aug. 15-31, 1957; Sept. 1-30, 1955; and Oct. 1-30, 1969.

Table 9—Number of suitable fall prescribed burning days by week and prescription severity level. Four-week target periods are delineated by shaded area.

Week	Prescription severity level		
	Low ¹	Medium ²	High ³
Aug. 15-21	12	3	1
Aug. 22-28	9	10	1
Aug. 29-Sept. 4	12	2	0
Sept. 5-11	8	2	1
Sept. 12-18	16	5	0
Sept. 19-25	12	5	0
Sept. 26-Oct. 2	16	8	1
Oct. 3-9	13	6	2
Oct. 10-16	16	3	0
Oct. 17-23	23	4	0
Oct. 24-30	7	3	0
Total	144	51	6
Percent of total burning days in target period	47	47	50

¹The four-week target period for this prescription has significantly more suitable prescribed burning days than random chance would allow ($p < 0.005$).

²The four-week target period for this prescription does not have significantly more suitable prescribed burning days than random chance would allow ($0.1 < p < 0.25$).

³The four-week target period for this prescription does not have significantly more suitable prescribed burning days than random chance would allow ($0.25 < p < 0.5$).

Table 10—Percent of suitable days¹ having wind from the indicated direction²

Period	Wind direction							
	N	NE	E	SE	S	SW	W	NW
April 1—May 1	7.7	7.7	7.7	30.7	15.4	7.7	7.7	15.4
May 2—June 1 ³	8.0	0.0	12.0	16.0	28.0	24.0	0.0	12.0
Apr. 1—June 1 ³	7.9	2.6	10.5	21.0	23.7	18.4	2.6	13.3
Aug. 15—Sept. 14	5.6	5.6	5.6	22.2	16.6	16.6	5.6	22.2
Sept. 15—Oct. 15 ³	4.0	0.0	4.0	8.0	44.0	16.0	16.0	8.0
Oct. 16—Oct. 30	25.0	0.0	0.0	0.0	37.5	25.0	12.5	0.0
Aug. 15—Oct. 30	7.8	2.0	3.9	11.8	33.3	17.6	11.8	11.8
Apr. 1—June 1 and Aug. 15—Oct. 30 ³	7.9	2.2	6.7	15.7	29.2	18.0	7.9	12.4

¹A suitable day is defined as having a temperature of greater than or equal to 60°F, relative humidity between 20 and 35%, windspeed of 5 to 15 m.p.h., and four or more days since 0.01 inch of precipitation.

²Suitability and wind direction based on 3 p.m. CST weather.

³These periods display a significant ($p < 0.05$) lack of independence between burning day suitability and wind direction.

(1969) found that northwest winds were the most common winds observed on days suitable for burning. However, his graphic displays, particularly those for Minneapolis, show that winds from the southern quadrant are also quite common on suitable burning days and sometimes exceed the frequency of northwest winds. The disparity between Sando's conclusions and the results of this study may be due to the broader definition of suitable prescribed burning day used by Sando. By using more restricted specifications, this study determined that southeast, south, and southwest winds are most common on suitable burning days in the St. Cloud area.

Another factor that may contribute to the discrepancy is that this study does not consider wind persistence as a factor in defining burning day suitability. In this regard, Sando (1969) found that northwest winds are the most persistent. Additionally, he determined that winds with speeds in excess of 8 m.p.h. were quite persistent, regardless of their direction.

Winds from the southern quadrant would be associated with good burning weather since they often occur on the "backside" of a high-pressure system. This often means that the area has been subjected to conditions of dry, subsiding air, clear skies, and several days without rain. The presence of these winds also suggests that a front may be approaching and that wind direction could shift. Keeping abreast of the current weather situation is critical in prescribed burn planning.

Knowledge of the most common wind directions on suitable prescribed burning days provides a basis for planning the orientation of burn area, firebreak location and orientation, firing sequence, and smoke management.

SUMMARY

The times of the year most likely to produce generally good burning weather are from the middle of April through the middle of May and the middle of September through the middle of October. However, suitable

burning weather is certainly not limited to these times. Prescribed burning programs should be flexible enough to take advantage of suitable weather when it occurs. Other factors such as fuel moisture, soil moisture,

and vegetative state must be considered in addition to suitable weather when planning prescribed burns. In general, southeast, south, and southwest winds are the most common on suitable prescribed burning days.

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