A Study of Wind Erosion in Central Wisconsin

BY

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Introduction

Recently wind erosion has become a problem of considerable consequence on the approximate 2.2 million acres of Plainfield, Oshtemo, Sparta, and Gotham light- and dark-colored sandy soils in central Wisconsin. Wind erosion also occurs on some of the approximate 3.1 million acres of Hixton, Norden, and Gale sandy loams and thin silts and on the Houghton peat and muck areas located in the depressions within the sandy areas. Corn, potatoes, beans, vegetable crops, and mint are grown on the soils affected by wind erosion. The reason for increased wind erosion is believed to be due to the recent development of irrigated agriculture which has caused large tracts of land to be cleared and intensive cultivation of row crops.

Field and laboratory investigations designed to gain specific information on the various factors influencing erodibility of cultivated lands in the central sand area of Wisconsin were carried out in 1969.

Personnel from the Soil Science and Horticulture Departments of the University of Wisconsin and the Agricultural Research Service participated in the investigation. The study comprised (a) analysis of climatic data, (b) erodibility tests using a portable wind tunnel from the Wind Erosion Laboratory at Manhattan, Kansas, (c) analysis of soil and residue factors related to erodibility, and (d) applications of the wind erosion equation. This report summarizes the results of investigation.

General Description of Area

The land in central Wisconsin lies at an altitude ranging from approximately 652 feet above sea level at La Crosse to 858 feet above sea level at Madison. The average precipitation is about 30 inches. The average annual windspeed is about 10 m.p.h. and the prevailing direction is northwest from December through April and generally south from May to November. High velocity winds can occur most any month of the year but longtime records indicate fastest miles in the 50 to 60 m.p.h. range in April, May, and June at La Crosse and fastest miles in the 70 to 77 m.p.h. range in March, April, and May at Madison.

The soils belong, for the most part, to the gray-brown Podzolic Great Soil Group; however, four soil series (Keowns, Nekoosa, Newton, Vesper) within the control sand region are poorly drained acidic sands or silt loams which belong to the Humic-Gley Great Soil Group. The terrain is generally level with some undulation. Drainage ranges from excessively drained on some of the light-colored sands like the Boone series to well drained on the Gale silt loams to poorly drained on all the Humic-Gley Group soils. The light-colored sandy soils (Plainfield, Oshtemo) have low moisture-holding capacity, are drouthy, and are subject to wind erosion. They do have an abundance of ground water which allows substantial irrigation farming of an intensive nature, causing the land to be in a highly erodible condition during certain times of the year. The primary crops of hay, oats, and corn utilize 93 percent of the land farmed. Mint and vegetable crops, including snap beans, potatoes, beets, and tomatoes, are also produced in the area.

Procedure

Analysis of Climatic Data

Wind and precipitation data from Madison and La Crosse, the closest locations to the study area with complete records, were examined and plotted.

The monthly climatic factors for 30 counties in central Wisconsin were tabulated from previously prepared climatic factor maps (8, 4).

Prevailing wind erosion directions and preponderance and magnitude of wind erosion forces for Madison and La Crosse, Wisconsin, were determined and graphed from previously prepared reports (8).

Selection of Sites

Portable wind tunnel tests were run on 10 sites. Six of the sites were on the Hancock Experimental Station, Hancock, Wisconsin, one was on a muck soil north of Hancock, one was located on the sandy soils northeast of Hancock, and two were on the sandy soils on the west side of the State near Midoro, northeast of La Crosse. Sites on all the sands were selected to represent different methods of preparing land for corn planting. The muck soil site was used to evaluate the erodibility of muck soil prepared for potato planting.

Soil samples were also taken in late 1968 from the above four sites and from two sites near Spring Green, Wisconsin, and sent to the Wind Erosion Laboratory at Manhattan, Kansas, for determination of basic wind erodibility index, I', values.

The soils used in this study are described as follows:

Capability unit	Soil type	Description
IVs-3	Plainfield loamy sand	Excessively drained, droughty, light-colored sandy soils formed from level to rolling sandy glacial drift. Abundance of ground water allows irrigation. Subject to wind erosion. Windbreaks needed on cultivated fields.
IIIw-9	Houghton mucky peat (68 percent O.M.)	Fibrous peat. Occur in depressions. Some of these soils used for crop production (potatoes, mint, vegetables, etc.), pasture, and sod farming. Also, prime wildlife habitats.
IIIs-4	Richford loamy sand	Excessively drained light-colored sandy soils with slight textural B horizons. Associated with Plainfield and Wyocena.
IVs-3	Plainfield loamy fine sand	Same general characteristics as Plainfield loamy sand except slightly darker color and contains 3 to 5 percent more silt.
IVs-3	Boone-Hixton loamy sand	Well drained sandy loams formed from Cambrian sandstone, siltstone, and shale.

Portable Wind Tunnel Tests

Triplicate wind tunnel tests were made on each site and a total of 30 separate tests were conducted during the period May 19-23, 1969. The tests were run with wind applied parallel to the row on those sites where corn had been planted. Wind velocity through the center of the tunnel was approximately 38 m.p.h. On all the fields except one (Site 2), the wind was applied until erosion ceased. Four minutes was required for the surface to stabilize. Site 2 did not stabilize in 4 minutes so weight of soil removal at the end of three successive time periods (3, 6, and 9 minutes) was determined and the total amount of erosion was then estimated from extrapolation of the trend line of soil loss with time.

When wind velocity in the center of the tunnel duct is held constant, the wind force applied to the test surfaces varies with roughness. Soil loss before a surface becomes stabilized varies with surface drag to the 2.5 power (5). This power function of soil loss with surface drag was used to adjust all losses to a common wind force level of 3,000 pounds per acre which is equal to the drag exerted by a wind of about 85 m.p.h. measured at the 50-foot elevation blowing over a relatively smooth field with a roughness Z_0 of 0.005 foot.

An aerodynamic roughness of test surfaces expressed in terms of "ridge roughness equivalent" was determined from pressure relationships measured in the tunnel (11). This measurement expresses natural field roughness in terms of the effect of ridges composed of fine gravel 2 to 6.4 mm. in diameter and having a height-spacing ratio of 1:4. Its value depends on many factors such as height, length, density, quality of vegetative cover, and the size and shape of clods, ripples, and ridges.

Semiportable Wind Tunnel Tests

In addition to its use on field tests, the portable wind tunnel was used at the Manhattan, Kansas, headquarters to determine the basic wind erodibility, I', for representative soils from six sites in central Wisconsin. The relative wind tunnel erodibility index $I_w = 10\ X_2/X_1$, in which X_1 is the quantity eroded when the soil contains 60 percent by weight of clods greater than 0.84 mm. and X_2 is the quantity eroded under the same set of conditions from soil containing any other proportion of clods greater than 0.84 mm., was determined by placing the soils in 5-foot-long by 0.5-foot-wide trays and exposing them to a drag velocity of 61 cm. per second in the wind tunnel. The relative field erodibility or soil erodibility, I', used in the wind erosion equation was then computed from the relationship

$$I' = 1/3\ 140 I_w^{0.287} - \frac{1}{(0.01525)(1.065)^{I_w}}$$

Detailed theory and background for determination of erodibility, I', is given in a previous publication (3).

Soil and Residue Sampling

Soil and residue samples were obtained for each wind tunnel test during the wind tunnel runs. General procedures were as follows:

(a) Crop residue weight.--Crop residues on the soil surface were collected from a 1-square-meter quadrant, bagged, washed, ovendried, and weighed.

(b) Nonerodible soil fraction.--Random subsamples of the surface inch were collected with a flat shovel at each wind tunnel run site and placed in a 20- by 20- by 3-inch metal soil tray. Approximately 15 pounds of soil was collected on each tray. The trays of soil were transported to Manhattan where the soil was ovendried and passed through an automatic rotary sieve used regularly in this work to determine the percent of dry aggregates greater than 0.84 mm. in diameter and the mechanical stability of the clods (1).

Composite soil samples of about 150 pounds were taken under air-dry conditions to a depth of 1 inch from each of the six sites used to determine erodibility index, I'. The samples were placed in large wooden trays to prevent pulverization and were transported to Manhattan. Each sample was split into three parts. Two parts were used to provide material for running replicated wind tunnel tests and the third part was used to determine size distribution of dry aggregates or clods with the automatic rotary sieve.

Results

Precipitation and Wind Movement

Figures 1 and 2 show average and 1968-69 rainfall and wind movement for Madison and La Crosse, Wisconsin, the closest weather stations with complete data. These figures indicate two critical periods for potential wind erosion in Wisconsin. One is in October and November when precipitation is low and wind movement relatively high and the other is in March, April, and May when precipitation is fairly good but wind

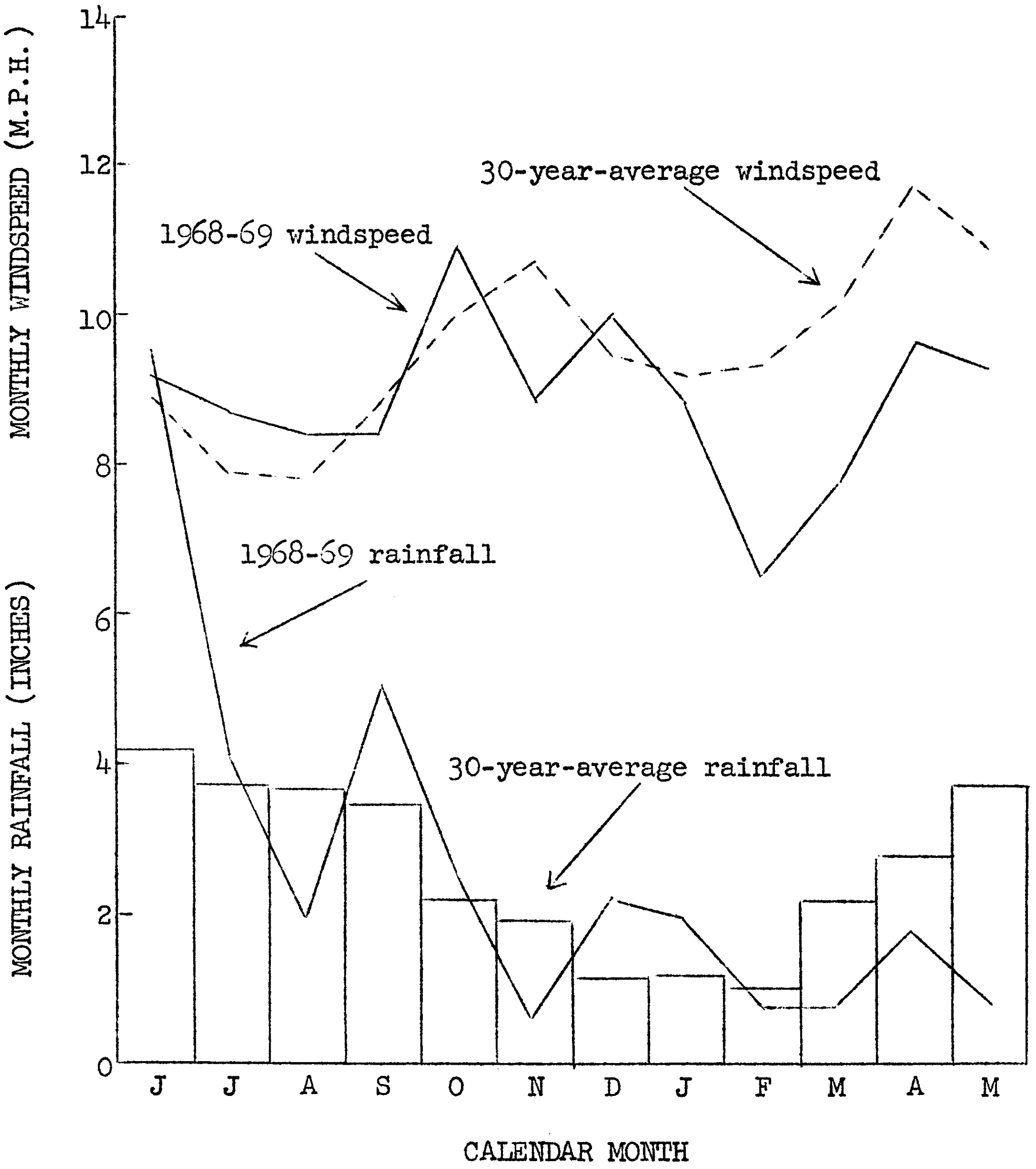


Figure 1.--Average and 1968-69 rainfall and windspeed by calendar months at La Crosse, Wisconsin. Average rainfall and windspeed is based on period 1931-60.

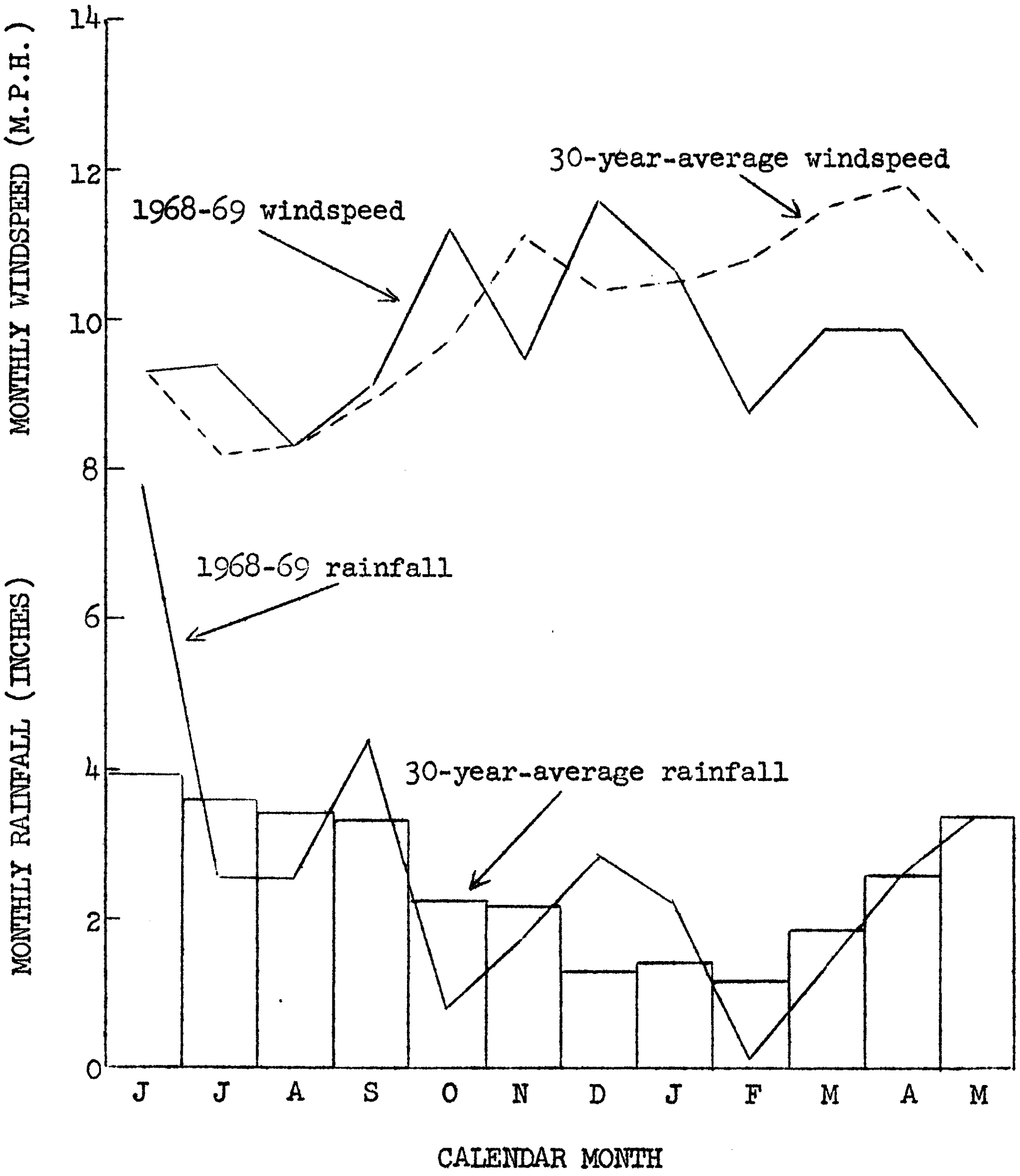


Figure 2.--Average and 1968-69 rainfall and windspeed by calendar months at Madison, Wisconsin. Average rainfall and windspeed is based on period 1931-60.

movement is considerably higher than during other parts of the year. This is also shown by fastest mile data, figure 3. While it is apparent that there is more high velocity wind movement at Madison than at La Crosse, both locations indicate potential for high velocity winds in March, April, and May, and Madison shows this potential for October. Since field preparation and planting is underway during April and May, fields are bare and in a highly erodible condition and this would appear to be the most critical period for wind erosion in Wisconsin.

Wind movement during the summer and fall of 1968 was about equal to the 30-year-average but was considerably below average during the spring of 1969 at both La Crosse and Madison. This was probably due to large-scale climatic effects resulting in less wind over the general region. However if this is not the cause, then figures 1 and 2 do not lend much validity to the popular opinion that removal of woodlands has resulted in higher wind velocities in recent years.

Monthly Climatic Factors

Table 1 shows monthly climatic factors for 30 counties in central Wisconsin. This factor, which interprets the influence of both wind velocity and surface soil water on wind erosion, indicates that April, May, and November have the highest wind erosion hazard; therefore, maximum values (12 to 18) should be used in the wind erosion equation when designing practices for wind erosion control in Wisconsin.

The climatic factors for Wisconsin are very low compared to the Great Plains and other more arid regions. This means that on the average the area has a relatively low potential wind erosion hazard which would

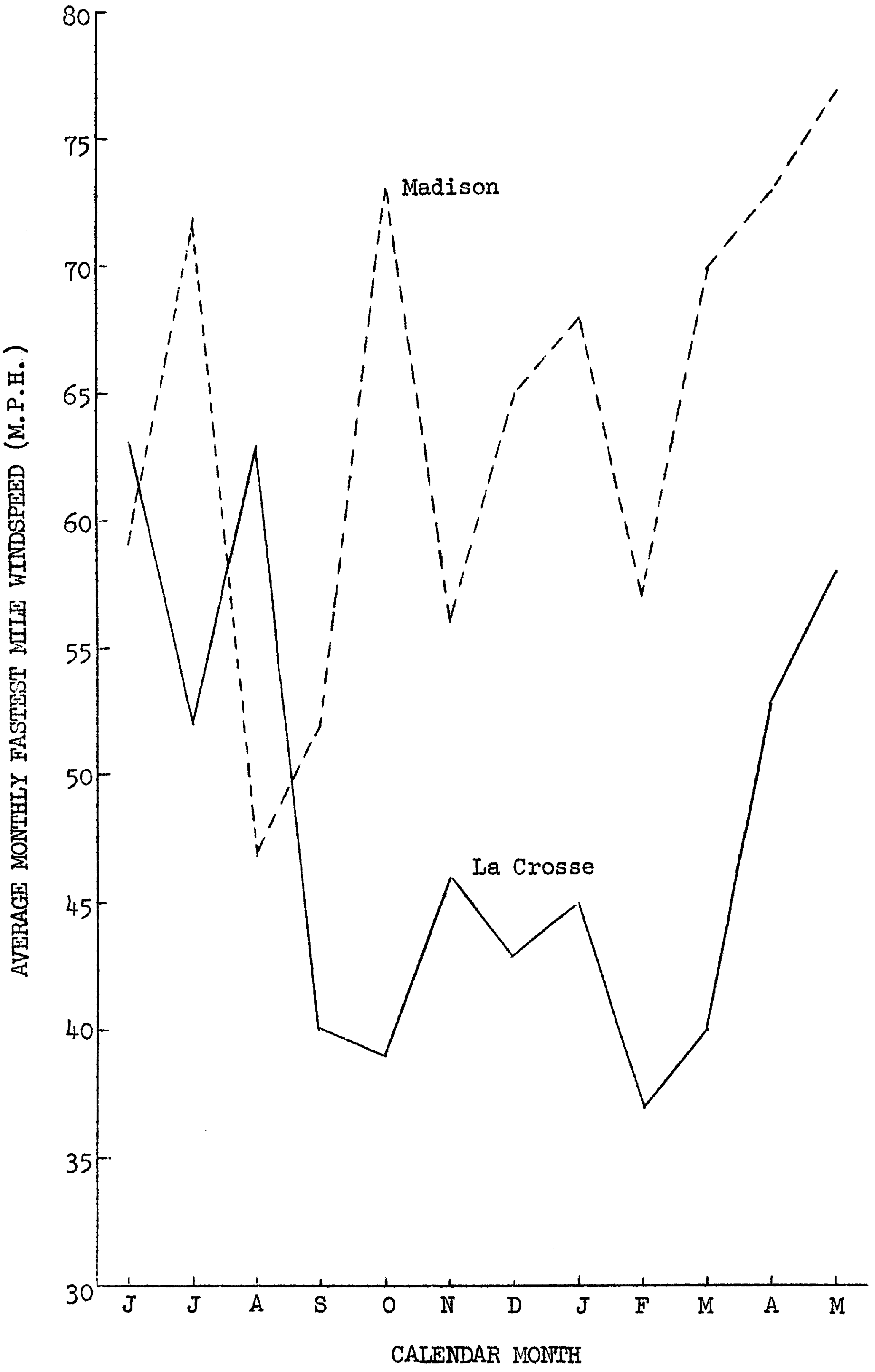


Figure 3.--Fastest mile windspeed by calendar months at La Crosse and Madison, Wisconsin. Averages are based on period 1931-60.

Table 1.--Monthly climatic factors C' for 30 counties in central Wisconsin.

County	Monthly value of C'											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Adams	8	8	10	14	10	7	5	5	5	10	13	10
Barron	7	6	9	16	9	7	5	5	5	10	13	10
Buffalo	8	10	9	15	12	9	5	5	6	10	13	10
Chippewa	7	5	9	15	9	6	5	5	5	10	13	10
Clark	7	5	8	14	9	6	5	5	5	10	12	10
Columbia	10	10	16	18	10	8	5	4	6	10	15	10
Dunn	8	9	9	16	12	8	5	5	6	10	13	10
Eau Claire	7	5	9	15	10	8	5	5	5	10	13	10
Green Lake	10	10	15	17	10	8	5	4	6	10	15	10
Jackson	7	7	9	14	12	8	5	5	5	10	13	10
Juneau	7	8	10	14	10	7	5	5	5	10	13	10
La Crosse	7	8	10	14	12	6	5	5	5	10	14	10
Marathon	7	6	8	12	9	6	5	3	5	10	12	10
Marquette	9	9	14	17	10	7	5	4	5	10	14	10
Menominee	7	7	8	12	8	6	5	3	5	10	11	10
Monroe	7	8	10	14	10	6	5	5	5	10	14	10
Pepin	8	10	9	15	12	10	5	5	6	10	13	10
Pierce	10	10	10	17	12	10	5	6	8	10	14	10
Polk	7	9	10	16	10	9	5	5	6	10	14	10
Portage	7	7	9	13	10	7	5	4	5	10	12	10
Richland	8	10	13	16	12	7	5	5	5	10	14	10
Rusk	6	5	8	15	7	5	5	4	5	10	12	10
St. Croix	9	10	10	17	12	10	5	6	8	10	14	10

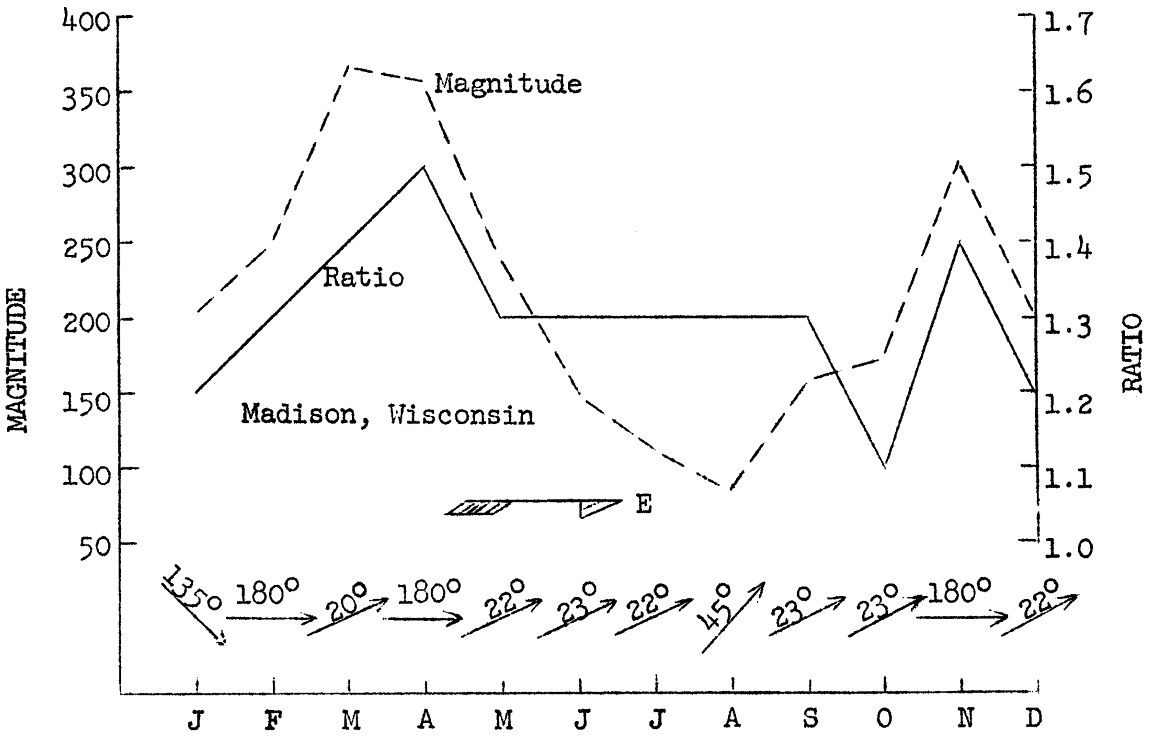
Table 1.--Continued

County	Monthly value of C'											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Sauk	9	10	14	17	10	7	5	5	5	10	14	10
Shawano	8	8	9	12	10	7	5	3	5	10	11	10
Trempealeau	7	7	9	14	12	8	5	5	6	10	13	10
Vernon	7	9	10	14	12	8	5	5	5	10	14	10
Waupaca	8	8	10	12	10	7	5	4	5	10	12	10
Waushara	8	9	12	13	10	7	5	4	5	10	13	10
Wood	7	7	9	13	10	7	5	4	5	10	12	10

be expected where precipitation is fairly uniformly distributed throughout the year and averages about 30 inches annually. However, as was indicated by figure 3 and the previous discussion, the area does have short periods of high velocity wind which often attains speeds equal to those reached in the Great Plains. These winds applied to the extremely sandy soils which dry quickly on the surface and are bare and pulverized from intensive cultivation can cause serious wind erosion.

Prevailing Wind Erosion Direction

Figure 4 shows direction, magnitude, and preponderance of wind erosion forces at La Crosse and Madison, Wisconsin. The magnitude of wind erosion forces which indicates the relative capacity of the wind to cause soil blowing also shows that March, April, and May, and October and November are the two critical periods for wind erosion in Wisconsin. There is little difference in the magnitude of wind erosion forces between La Crosse and Madison except during May where La Crosse shows



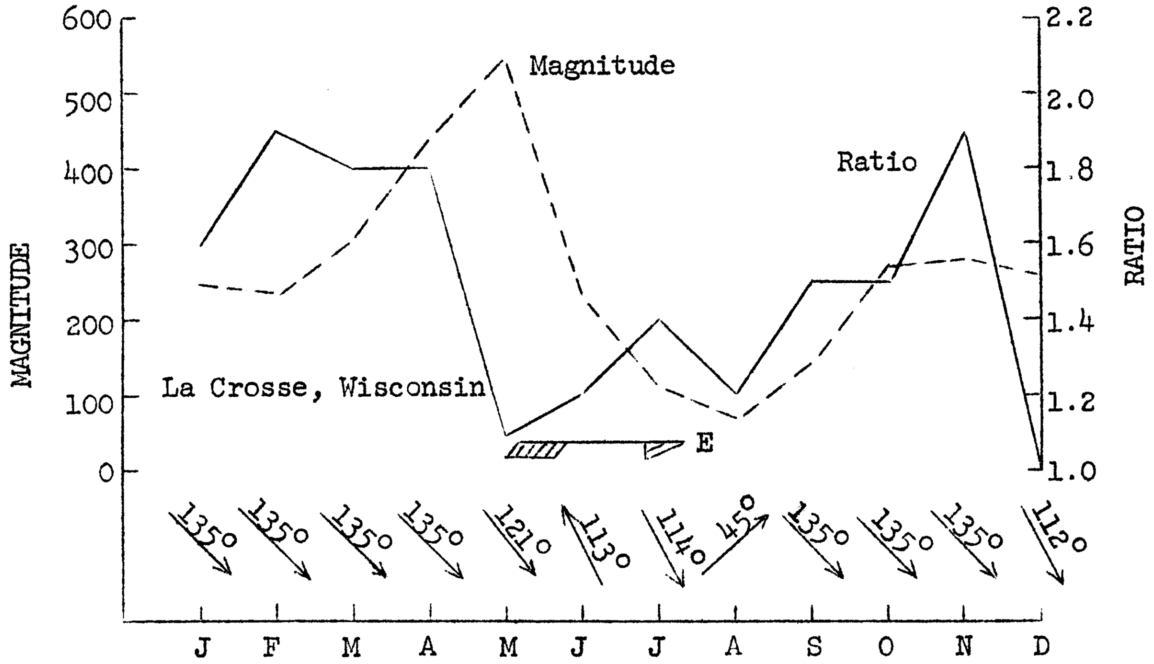


Figure 4.--Direction, magnitude, and preponderance (ratio) of wind erosion forces at two locations in Wisconsin. Arrows indicate predominant direction of winds. The magnitude of wind erosion forces indicates the relative capacity of the wind to cause soil blowing. Preponderance is a measure of the prevalence in the wind erosion direction and the larger the ratio the greater the prevalence.

a value more than two times greater than Madison. This occurs despite the fact that fastest mile wind (figure 3) is greater for Madison (77 m.p.h.) than for La Crosse (58 m.p.h.). The magnitude of wind erosion forces is computed by summing the product of mean windspeed cubed and a duration factor for all directions. Apparently at La Crosse the somewhat lower velocity winds during May have a longer duration and therefore the magnitude is greater for La Crosse than for Madison.

The direction arrows indicate significant differences in prevailing wind erosion directions between La Crosse and Madison. At Madison, winds during the critical periods--March, April, and May, and October and November--are from a west to west-southwest direction and the ratios for parallel to perpendicular winds are in the 1.4 to 1.5 range, indicating that shelterbelts or other kinds of barriers would be most effective if oriented at right angles to direction arrows or in a north-south direction. At La Crosse, winds during the two critical periods are from a northwest direction and the ratios for parallel to perpendicular winds are about 1.8, slightly higher than ratios at Madison, indicating more importance in orienting barriers at right angles to direction arrows or in a southwest-northeast direction. If this angled orientation could not be considered and the barriers must follow the usual north-south or east-west field and property boundaries, then, although there is really no advantage for a north-south orientation over an east-west orientation, the north-south orientation probably should be selected, especially at locations to the east and south of the La Crosse area.

Wind Erodibility, I'

Figure 5 and table 2 show the results of the semiportable tunnel tests to determine wind erodibility, I', for representative central

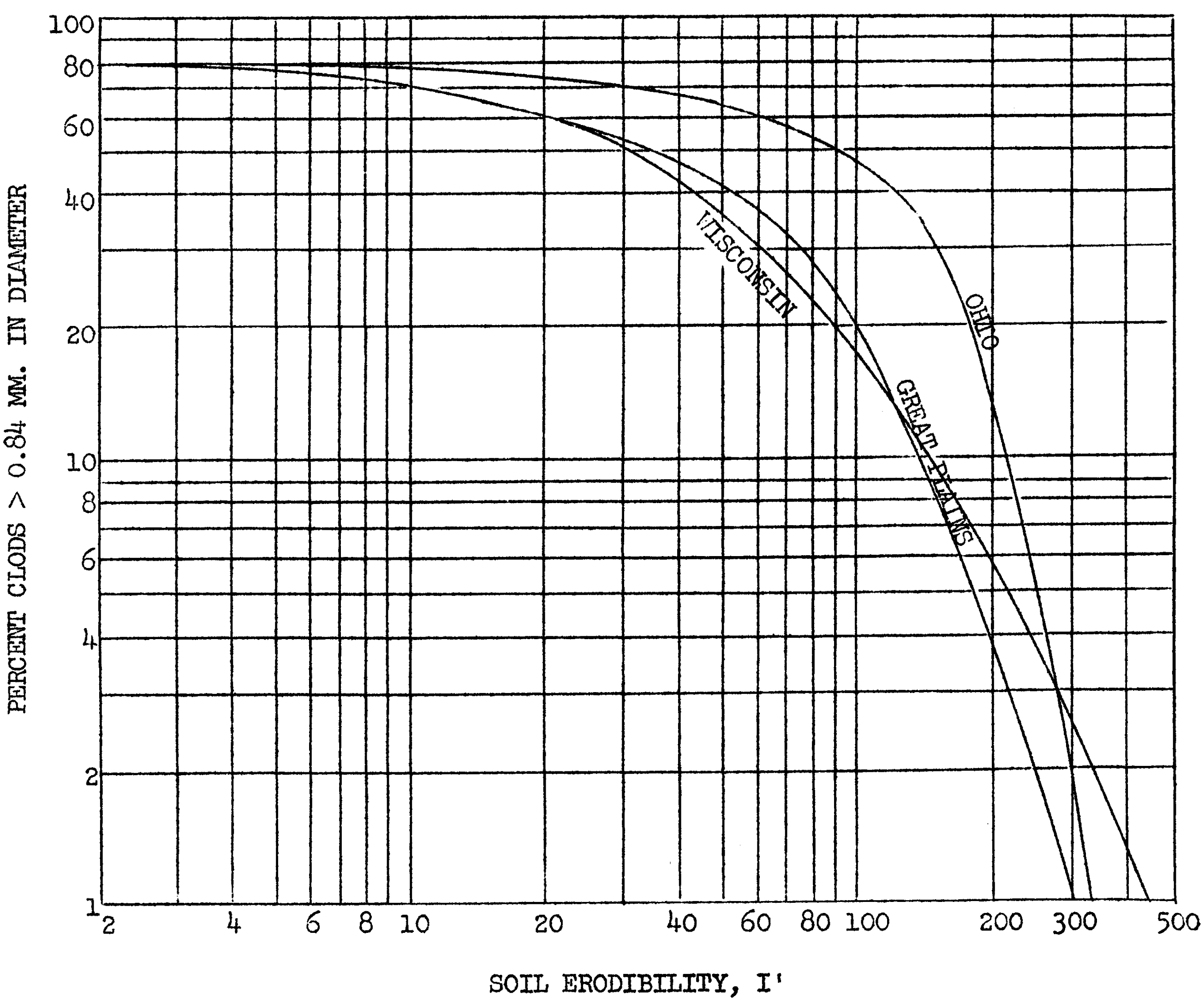


Figure 5.--Comparison of soil erodibility, I', for Ohio, Wisconsin, and Great Plains soils.

Wisconsin soils. Figure 5 indicates that the erosive potential of the Wisconsin soils is more similar to the Great Plains soils than to the Ohio soils. However, the Wisconsin loamy sands with cloddiness in the range from 15 to 60 percent greater than 0.84 mm. are slightly less erosive than the Great Plains, and the Wisconsin sands with cloddiness in the range from 1 to 15 percent are more erosive than the Great Plains. Because of these differences it is recommended that table 2 of this report be used, especially for the sands, rather than tables 1 or 3 of the wind erosion equation publications (8, 10) when applying the equation to Wisconsin conditions. The importance of this can be seen if field length and residue conditions are assumed and the equation is applied to the Radcliffe and Hooter sites that were sampled.

Table 2.--Soil erodibility, I', for Wisconsin soils with different percentages of nonerodible fractions as determined by standard dry sieving.

Percentage of dry soil fractions > 0.84 mm. Units > Tens ↓	0	1	2	3	4	5	6	7	8	9
	Tons/A.									
0	---	455	338	285	250	225	208	185	170	160
10	150	142	132	125	119	112	106	102	97	93
20	88	86	82	79	75	72	69	66	64	62
30	60	58	56	54	52	51	48	46	44	43
40	40	39	38	37	36	35	34	33	32	31
50	30	29	28	27	26	24	23	22	21	20
60	20	19	18	17	16	15	14	13	12	12
70	11	11	10	9	8	7	6	5	4	3
80	2	---	---	---	---	---	---	---	---	---

Radcliffe.--Table 2 of this report indicates an I' value of 58 for the 31.2 percent fractions greater than 0.84 mm. in diameter in this soil but tables 1 or 3 of the wind erosion equation publications (8, 10) indicate an I' value of 72 for this same cloddiness condition. If we assumed a field with an L' equal to 1/4 mile, a K' equal to 1.0, and 700 pounds per acre of residue, and calculated E with the wind erosion equation using a C' of 15 for March for Wisconsin, we would get 1.5 tons per acre with an I' value of 58 and 2.6 tons per acre with an I' value of 72. Use of I' values from the Great Plains table would therefore cause us to overestimate potential soil loss by about 73 percent. Conversely, if we used the equation to determine the amount of residue or width of strip needed to reduce soil loss to a tolerable amount of 1.0 ton per acre, we would calculate 100 pounds per acre too much on the residue needed and 300 feet short on the tolerable width of strip if we used the Great Plains I' table.

Hooter.--Table 2 of this report indicates I' values of 306 for the 2.5 percent fractions greater than 0.84 mm. in diameter in this soil but tables 1 or 3 of the wind erosion publications (8, 10) indicate an I' value of 235 for this cloddiness condition. Again, if we assume the same field size, roughness, residue, and climatic condition as for Radcliffe and calculate soil loss with the wind erosion equation, we get 23 tons per acre with an I' value of 306 and 16 tons per acre with an I' value of 235, so using Great Plains I' values underestimates soil loss by about 30 percent. If we used the equation to determine amount of residue to reduce soil loss to a tolerable amount of 1.0 ton per acre, we would find 1,800 pounds per acre required if an I' value of 306 were used and 1,600 pounds per acre required if a value of 235 were used; thus, we calculate 200 pounds per acre below requirements if we use the Great Plains table. On such highly erodible soil, it is unlikely that erosion-resistant strips could ever be used to reduce erosion to 1.0 ton per acre; however, if we establish the tolerable limit at 5.0 tons per acre, use of the Great Plains table values in the equation would result in strip widths that were 22 feet too wide to control the erosion at a tolerable level of 5.0 tons per acre.

In conclusion, these tests indicate that the potential erosiveness of Wisconsin soils is less than the Great Plains soils where cloddiness is in the 5 to 60 percent greater than 0.84 mm. range, and greater than Great Plains soils where the cloddiness is in the 1 to 15 percent range. It therefore is recommended that I' values given in this report (table 2) be used when applying the wind erosion equation to Wisconsin conditions.

Wind Tunnel Soil Losses

Photographs of conditions of each of the 10 sites on which 30 wind tunnel tests were conducted are shown on Appendix pages 41 to 50. A summary of information relative to location, cropping, soil characteristics, and amount of soil eroded in the portable tunnel is given for each site. Complete information for each of the 30 tunnel tests is given in Appendix Table 1, page 51.

Conditions for wind tunnel testing were not ideal in Wisconsin during the week of May 19-23, 1969. Substantial precipitation on May 17 had thoroughly wet the fields. Some drying occurred during the 18th and early 19th and a thin crust had formed by late afternoon on the 19th when tests began; therefore, the soils were not in a highly erodible condition. Nine tests were completed on May 19. Additional rain during the night of the 19th again wet the fields and testing was delayed until May 22 and 23. Average soil losses from the 10 sites tested are summarized in figure 6 and range from 0.04 to 83.8 tons per acre, with one individual replicate on Plainfield loamy sand on plowed, crusted cornland going as high as 108.5 tons per acre.

It is evident from figure 6 that clean tillage for corn, i.e., plowing, disking, and planting, is a poor practice for the Plainfield loamy sands in Wisconsin. The 83.8-ton-per-acre loss from the plowed, disked cornfield on the Hancock Station under the crusted, moist conditions at the time of testing indicates that this kind of soil preparation leaves the land in a condition highly susceptible to wind erosion. Conversely, it is evident that any practice which leaves some residue, i.e., old cornstalks, disked winter-killed oats or standing chemically killed wheat and rye, greatly reduces the wind erosion hazard on the Plainfield loamy sands. The tests on the plowed, disked cornfield where the crust was broken by raking, and the tests on the freshly plowed and disked field adjacent to the Station Headquarters show the importance of clods, even fragile clods, in reducing wind erosion. Soil loss from the raked plots was still high at 20 tons per acre but was only about one-fourth of the loss from the same field with a crust and some loose sand grains on the surface. Soil loss from the freshly plowed and disked field was practically zero.

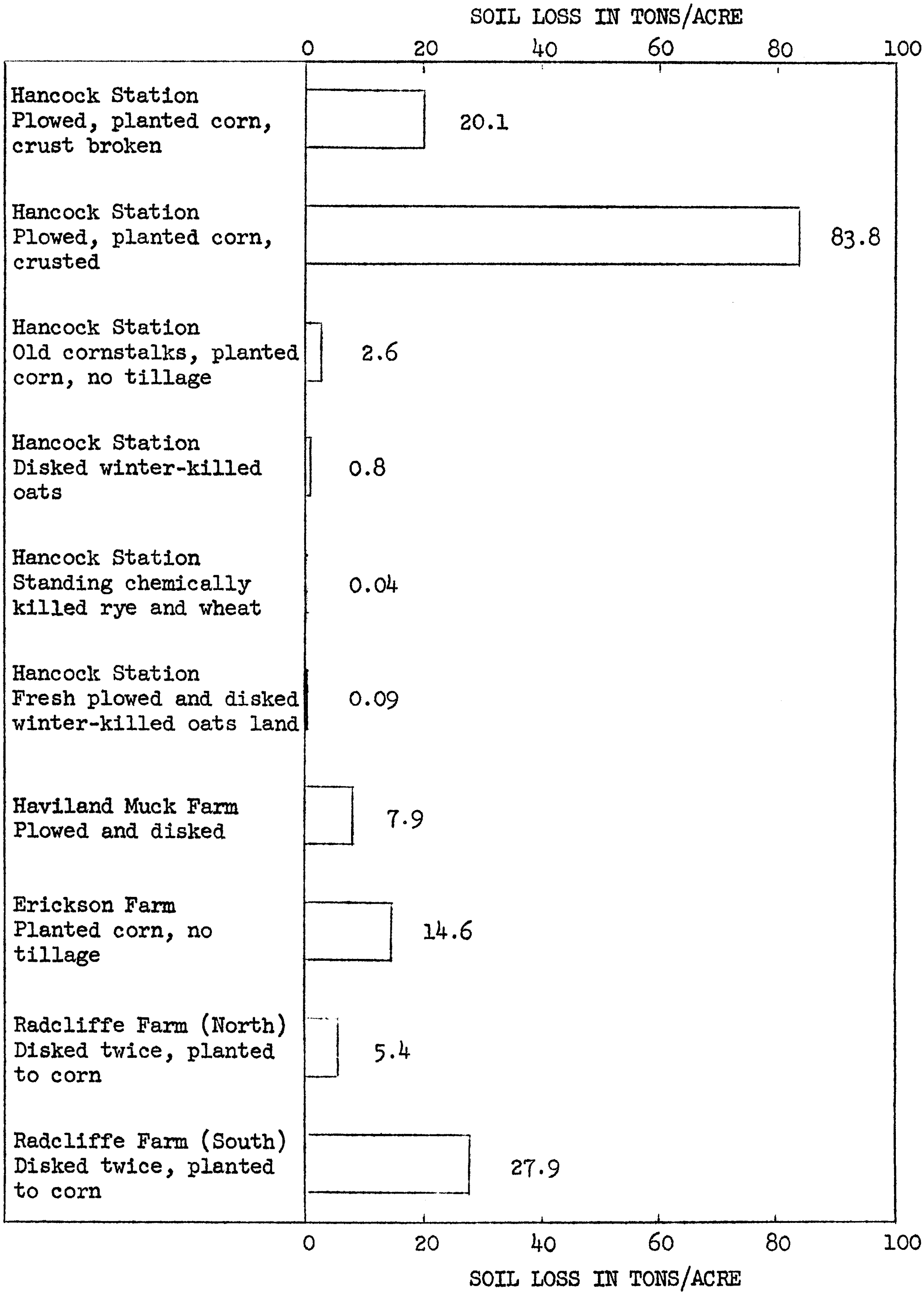


Figure 6.--Average soil loss as measured with portable tunnel on 10 sites in central Wisconsin on May 19-23, 1969.

The Houghton mucky peat soil on the Haviland farm was in a fairly rough, cloddy condition with moist soil immediately under a thin, dry, top layer; however, tunnel soil loss was quite high, exceeding a tolerable rate for vegetable growing. Land preparation which either maintains more residue on the surface or leaves the soil surface in an extremely smooth, compacted condition so wind stress cannot act against the lightweight soil grains seems to be indicated for these muck soils.

An average soil loss of 14.6 tons per acre on the Richford loamy sand on the Erickson farm shows this soil to be highly susceptible to wind erosion and indicates that there was insufficient residue to prevent erosion. Prior cropping history of this land is not known but it would seem that nothing was gained in the way of wind erosion control by planting with no tillage.

The Radcliffe system of two diskings and planting apparently reduces the wind erosion hazard but tunnel soil losses of 5.4 and 27.9 tons per acre under the rainy weather-soil crusted conditions of these tests indicates that disking does not leave sufficient cornstalk residue on the surface to provide adequate protection, especially on the Boone-Hixton loamy sands. Residue on this field measured 1,329 pounds per acre but according to the wind erosion equation using a climatic factor of 18, which is about a maximum for Wisconsin conditions, approximately 2,240 pounds per acre of flattened cornstalks would be required to hold erosion to 5 tons per acre on a field with a length of 40 rods along the prevailing wind erosion direction.

Wind Tunnel Soil Losses in Relation to Surface Variables

Data from the 30 wind tunnel tests were used to examine relationships between the dependent variable, soil loss, and the independent variables, residue, surface roughness, and soil cloddiness. The data were analyzed with complete logarithmic transformation to derive the following curvilinear power function:

$$E = \frac{248.5}{A^{0.94}\,(RK)^{0.32}}$$

where E = wind tunnel soil loss in tons per acre

A = percent surface clods greater than 0.84 mm. in diameter

RK = residue on surface in pounds per acre times surface roughness in equivalent inches.

R^2 for this relationship was only 0.14.

An equation of this type has been used quite successfully to express relationships between dependent and independent variables from previous wind tunnel tests at other locations, e.g., this type of equation accounted for about 85 percent of the variability in the data from the Ohio wind tunnel tests (9) and for better than 90 percent of the variability in the data from tests on potato land in the Nebraska Panhandle (6). Since the equation accounts for only about 14 percent of the variability, it is apparent that some other variable or variables must be overshadowing the effect of soil cloddiness, roughness, and residue. It seems probable that soil moisture is the variable that exerted strongest influence on the erodibility of the Wisconsin soils. Chepil (2) found that erodibility of soil by wind is a function of the cohesive force of absorbed water films surrounding the soil particles and that the rate of erosion was inversely proportional to the approximate square of the equivalent moisture of the soil. He found little difference in rates of erosion when soil moisture was less than about 1/3 of the 15 atmosphere percentage but at higher water content, erodibility decreased until it reached zero at about the 15 atmosphere percentage. Unfortunately soil moisture measurements were not made in connection with these tests but the rainy weather conditions and observations of the extremely wet condition of the soils immediately beneath a thin, dry surface layer leave little doubt that soil losses were strongly influenced by soil water.

Comparison of Measured Soil Losses with Losses Calculated from the Wind Erosion Equation

Table 3 presents a summary of average data from the three replications of the wind tunnel tests on each of the 10 locations. The last two columns are shown to give some rough idea of how soil losses obtained with the wind tunnel compare with those one might calculate with the wind erosion equation, $E = f(I', K', C', L', V)$.

Good data for making these comparisons are not available and there is a very definite need for measurements of natural wind erosion in central Wisconsin. The wind tunnel determines the erodibility of a particular field for the particular wind velocity or shear stress applied at the particular field condition tested. This erodibility is expressed in tons per acre. The wind erosion equation also determines the erodibility of the field for the particular field conditions but it expresses

Table 3.--Comparison of average measured soil losses with losses estimated from the wind erosion equation.

Location	Surface condition	Soil type	Residue	Soil fractions > 0.84 mm. in diameter	Roughness K'	Soil loss: Wind tunnel Measured	Soil loss: Wind tunnel Adjusted1/	Soil loss: Calculated from equation2/
			Lbs./A.	Percent	Inches	Tons/A.	Tons/A./Yr.	Tons/A./Yr.
Hancock Station	Plowed, planted to corn, raked	Plainfield loamy sand	0	9.2	1.3	20.1	17.0	35.0
Hancock Station	Plowed, planted to corn, crusted	Plainfield loamy sand	0	9.7	1.3	83.8	22.0	34.0
Hancock Station	Cornstalk field, planted, no tillage	Plainfield loamy sand	1,668	10.2	2.0	2.6	7.5	27.0
Hancock Station	Disked winter-killed oats	Plainfield loamy sand	522	18.2	1.7	0.8	2.7	13.0
Hancock Station	Chemically killed rye and wheat	Plainfield loamy sand	837	13.3	3.5	0.04	0	3.5
Hancock Station	Plowed and disked winter-killed oats	Plainfield loamy sand	0	31.1	1.1	0.09	0	6.0
Haviland muck farm	Plowed, disked for potatoes	Houghton mucky peat	0	63.9	2.0	7.9	12.2	2.0
Erickson farm	Planted to corn, no tillage	Richford loamy sand	0	30.5	1.4	14.6	14.5	11.0
Radcliffe farm	Disked twice, planted to corn	Plainfield loamy fine sand	795	30.1	1.7	5.4	10.5	9.0
Radcliffe farm	Disked twice, planted to corn	Boone-Hixton loamy sand	1,329	14.5	1.9	27.9	18.5	19.5

1/ Adjusted to 40-rod field length based on natural erosion measured in Ohio (9).
2/ Based on field length of 40 rods and climatic factor, C', = 18.

the erodibility in terms of tons per acre per year. In other words, the equation expresses an annual loss that could be expected from a field located in the particular climatic area with the cloddiness, residue, and roughness conditions measured. Interpretation of wind tunnel data in terms of annual soil loss requires some information on natural erosion. Annual losses expressed by the wind erosion equation are based on a comparison of natural losses from a large number of fields in the Great Plains during 1954-56 with wind tunnel losses from these same fields. The climatic factor for the Great Plains is about 100. The climatic factor for Wisconsin is about 18. Therefore, it is not reasonable to adjust Wisconsin wind tunnel losses to annual losses on a basis of Great Plains data. Since no natural erosion losses are available from Wisconsin, the measured wind tunnel losses were adjusted to annual losses based on relationships obtained in Ohio (9) where soils and climatic conditions are similar to Wisconsin and where some measurements of natural erosion have been made and can be used to adjust wind tunnel soil losses to an annual basis.

A climatic factor, C', of 18 percent, average values of K' as determined by the tunnel, and measured values of residue and soil cloddiness were used in calculating soil losses with the wind erosion equation. I' values corresponding to the measured soil fractions were taken from table 2 of this report. Field length, L', was taken to be 40 rods.

A comparison of the last two columns of table 3 indicates close agreement is obtained between the two methods of determining soil loss on three sites, reasonable agreement on three sites, and rather poor agreement on four sites. Generally, agreement is best on sites having moderate to high wind tunnel erodibility and poorest on sites with low tunnel erodibility where the equation tends to overestimate erodibility. The equation seriously underestimated erodibility of the muck soil.

Because of the lack of natural erosion data from Wisconsin, these can only be considered as very rough and highly speculative comparisons. However, since there is some indication of agreement and since the wind erosion equation, with the exception of the muck soils, does not seem to underestimate the situation, it is believed it could serve as a useful tool in making recommendations for residue requirements and in designing other control practices in central Wisconsin.

Applications of the Wind Erosion Equation to Wisconsin Conditions

Ready reference tables 4, 5, and 6 were prepared from the wind erosion equation and give information on the amounts of growing cover crops of small grains, flattened cornstalks, and bean residue required to hold wind erosion on Wisconsin sands to tolerances of 1, 2, 3, 4, and 5 tons per acre. As indicated in the footnotes of the tables, these amounts are based on a climatic factor, C', of 18, which is about a maximum for Wisconsin, a roughness, K', of 1.0, which means a relatively smooth surface, and an average soil cloddiness of 14 to 15 percent.

Detailed examples of applications of the wind erosion equation will not be given in this report; however, charts and tables needed to solve the equation, examples of field applications to determine potential erodibility of a given field, vegetative cover required to hold erosion to a tolerable level, and width of strips needed to control erosion are given in "A Wind Erosion Equation" (10), in "Wind Erosion Forces in the

Table 4.--Ready reference from wind erosion equation for determining amount[1] of cover crop of growing small grain (rye, wheat, oats) needed to hold wind erosion on Wisconsin sands to tolerable.

Field length, L'	Residue required to hold wind erosion to: 1 ton/A.	2 tons/A.	3 tons/A.	4 tons/A.	5 tons/A.
Rods	Lbs./A.	Lbs./A.	Lbs./A.	Lbs./A.	Lbs./A.
3	330	170	70	0	0
10	550	460	375	300	230
20	600	520	460	400	340
40	660	570	510	465	420
60	685	590	540	500	455
80	710	610	555	515	470
120	725	620	565	520	480
160	740	640	575	530	490

1/ Based on C' = 18, K' = 1.0 (smooth surface), and average cloddiness of Wisconsin sands of 14 to 15 percent > 0.84 mm. in diameter, so I' = 120.

Table 5.--Ready reference from wind erosion equation for determining amount[1/] of flattened cornstalks needed to hold wind erosion on Wisconsin sands to tolerable.

Field length, L'	Residue required to hold wind erosion to:				
	1 ton/A.	2 tons/A.	3 tons/A.	4 tons/A.	5 tons/A.
Rods	Lbs./A.	Lbs./A.	Lbs./A.	Lbs./A.	Lbs./A.
3	1,800	700	200	0	0
10	3,000	2,400	2,000	1,600	1,400
20	3,650	3,000	2,600	2,275	2,000
40	3,850	3,250	2,850	2,500	2,240
60	4,050	3,500	3,050	2,720	2,400
80	4,200	3,650	3,250	2,850	2,550
120	4,275	3,800	3,375	3,000	2,700
160	4,350	3,900	3,475	3,100	2,850

1/ Based on C' = 18, K' = 1.0 (smooth surface), and average cloddiness of Wisconsin sands of 14 to 15 percent > 0.84 mm. in diameter, so I' = 120.

Table 6.--Ready reference from wind erosion equation for determining amount[1] of soybean or other bean residue needed to hold wind erosion on Wisconsin sands to tolerable.

Field length, L'	Residue required to hold wind erosion to:				
	1 ton/A.	2 tons/A.	3 tons/A.	4 tons/A.	5 tons/A.
Rods	Lbs./A.	Lbs./A.	Lbs./A.	Lbs./A.	Lbs./A.
3		2,000	500	0	0
10				3,400	2,600
20					
40	Amounts required would exceed bean residue that could be produced.				
60					
80					
120					
160					

1/ Based on C' = 18, K' = 1.0 (smooth surface), and average cloddiness of Wisconsin sands of 14 to 15 percent > 0.84 mm. in diameter.

United States and Their Use in Predicting Soil Loss" (8), and in "Principles and Methods of Wind Erosion Control in Iowa" (7). When applying the wind erosion equation to Wisconsin conditions, the information given in these publications should be supplemented with C' and I' data from tables 1 and 2 of this report.

Summary

Field and laboratory investigations designed to gain specific information on the various factors influencing erodibility of cultivated lands in the central sand area of Wisconsin were carried out in 1969. The study included: (a) analysis of climatic data, (b) erodibility tests using a portable wind tunnel, (c) analysis of soil and residue factors related to erodibility, and (d) applications of the wind erosion equation.

Wind velocity-precipitation data indicate two critical periods for potential wind erosion in central Wisconsin. One is in October and November when precipitation is low and wind movement relatively high and the other is in March through May when precipitation is fairly good but wind movement is considerably higher than during other times of the year. Field preparation and planting is underway during April and May and fields are bare and in a highly erodible condition, thus making this the most critical period for wind erosion.

Monthly climatic factors are low in comparison to the Great Plains, with maximums of only 12 to 18 percent in April, May, and November. However, short periods of high velocity wind, which often attains speeds equal to those reached in the Great Plains, applied to the extremely sandy soils which dry quickly on the surface and are bare and pulverized from intensive cultivation can cause serious wind erosion.

Magnitude of wind erosion force analysis confirms March through May and October-November as the two most critical periods for wind erosion in central Wisconsin. There is little difference in magnitude of wind erosion forces between La Crosse and Madison except during May when La Crosse shows a value more than two times greater than Madison. Direction data and ratios of parallel to perpendicular winds indicate that barriers would be most effective if oriented in a north-south direction in the Madison area and in a southwest-northeast direction in the La Crosse area. Preponderance ratios indicate that it is more important that these orientations be followed at La Crosse than at Madison.

Central Wisconsin soils have erosive potential similar to the Great Plains with the exception of loamy sands with cloddiness in the range from 15 to 60 percent greater than 0.84 mm. which are slightly less erosive and the sands with cloddiness in the range from 1 to 15 percent which are more erosive than the Plains. Use of table 2 of this report, which gives I' values in relation to fractions greater than 0.84 mm. in diameter, is recommended when applying the wind erosion equation to central Wisconsin conditions.

Portable wind tunnel tests indicate that plowing is a poor practice for preparing land for corn on the sands of central Wisconsin. Planting directly in previous year cornstalks with no prior tillage, as was done at the Hancock Station, effectively controlled erosion. Tandem disking, as on the Radcliffe farm, reduced wind erosion but did not leave sufficient cornstalk residue to provide adequate protection, especially on the Boone-Hixton loamy sands. Disked or chemically killed cover crops of oats, rye, and wheat effectively controlled erosion on the Plainfield loamy sands. Erosion was practically zero on plowed, winter-killed oats, but since there was no residue, it is believed the control was temporary due to the moist, cloddy soil and that this field would become susceptible to erosion after rains disintegrated clods. The significant amount of erosion (7.9 tons per acre) which occurred on the Haviland muck farm under the moist soil conditions at the time of the tunnel tests indicates that the land preparation of plowing and disking does not provide adequate protection from wind erosion, especially if vegetables are involved.

A multiple regression equation expressing wind tunnel soil loss as a function of the independent variables, residue times roughness and soil cloddiness, was developed. This equation, $E = 248.5/A^{0.94}(RK)^{0.74}$, was very poor and accounted for only 14 percent of the variability in the data. Since an equation of this type has been used successfully in previous wind tunnel work, apparently soil moisture, which was not measured, strongly influenced the erodibility of the Wisconsin soils at the time of these tests.

Natural erosion data is not available from Wisconsin for making comparisons between soil losses measured by the wind tunnel and those calculated with the wind erosion equation; however, comparison based on natural erosion measurements in Ohio where soils and climate are similar indicate close agreement between the two methods on three sites, reasonable agreement on three sites, and poor agreement on four sites. The equation seriously underestimates erodibility of the muck soils. More data are needed; however, it is believed the wind erosion equation can serve as a useful tool in making wind erosion control recommendations for the central Wisconsin sands. It should not be used on the mucks. Ready reference tables were prepared from the wind erosion equation and give information on amounts of growing cover crops of small grains, flattened cornstalks, and bean residue required to hold wind erosion on Wisconsin sands to tolerances of 1, 2, 3, 4, and 5 tons per acre.

Recommendations

These recommendations include suggestions for both additional research and practical methods of controlling the wind erosion problem in central Wisconsin. They are based partly on results of this study and partly on experience gained from studies of wind erosion in other parts of the country.

1.--For wind erosion control on the Wisconsin sands, more residue is needed on the land surface than is maintained by present land preparation methods. The plow-disk-packer clean tillage method of field preparation for corn should be discouraged. Farmers should be encouraged to use a no-tillage-plant, subsurface sweep, and perhaps combinations of single disking or single sweep operations with applications of herbicides.

2.--In connection with the above recommendation, experiment stations should conduct research to determine if disease and phytotoxic effects result from increasing amounts of surface residue under Wisconsin climatic conditions. Experience elsewhere indicates this is not likely but the possibility should be investigated.

3.--Experimental trials should be carried out with subsurface sweeps which are wider than 10 to 12 inches. Experience in the Plains indicates that 24- and 30-inch and even wider (up to 5-foot) sweeps conserve more residue, provide better weed control, and are easier to use because of fewer shanks which reduce the clogging problem.

4.--If experience and research show that clean tillage field preparation for corn is best under Wisconsin conditions, then perhaps the Midwest and Southwest method of listing or bedding, i.e., planting row crops in furrows, should be evaluated. Listing leaves an extremely rough surface and considerable wind erosion control is obtained from the 10-inch-high ridges formed.

5.--Wind erosion control practices in the central Wisconsin sands should be designed to provide adequate protection for the period March-May. The hazard is highest during this time because of above-average windspeeds and a high degree of erosion susceptibility due to bare, pulverized soils resulting from land preparation.

6.--The wind erosion equation can be used with judgment and common sense to design wind erosion control practices on the sands in central Wisconsin. Answers regarding minimum residue requirements for controlling erosion determined by solving the equation appear to be in good agreement with the portable tunnel tests and with experience on similar soils in other areas. The equation seriously underestimates erosion potential on muck soils and should not be used on these soils.

7.--Stripcrops, windbreaks, and crop rows will be most effective if oriented in a north-south direction in the central and in a southwest-northeast direction in the west-central area of Wisconsin.

8.--To hold wind erosion on Wisconsin sands to a tolerable 5 tons per acre, width of cultivated land between buffer strips of rye or wheat should not exceed 80 feet if clean tillage is practiced or 100 feet if a form of stubble mulching is practiced and 500 pounds per acre of flattened cornstalks are on the land surface. If a tolerance of 3 tons per acre is the goal, then widths between buffers would be reduced to 50 and 70 feet, respectively, for the clean and 500-pound-per-acre residue situation.

9.--Research has shown that the best tree windbreaks will prevent soil movement under conditions of 40 m.p.h. winds measured at the 50-foot elevation for distances equal to only 15 to 18 times their height. Thus, maximum spacings for windbreaks with a height potential of 30 feet is only about 32.5 rods. In irrigated areas, especially where mobile overhead systems are used, this spacing is not practical. It therefore appears that tall-growing tree windbreaks should be planted at about 80-rod intervals and other wind erosion control practices such as strip-crops, buffers, or stubble mulching should be used to supplement protection provided by the windbreaks.

10.--Barriers of two or three rows of tall-growing annual crops such as corn or sorghums or perennial grasses should be evaluated as a means of wind erosion control for Wisconsin. Spacing should be determined from assessment of cloddiness, roughness, and erosion tolerance conditions but probably should be in the 50- to 75-foot range.

11.--Perhaps soil ridges or earthen banks as a method of controlling wind erosion should be investigated for use on the irrigated Wisconsin sands. Research in England reports that 2-foot-high earthen banks provided protection from wind erosion for a distance of 60 feet.

12.--Some research effort should be expended to obtain better measurements of the natural wind erosion that occurs with different farming practices on the sands of central Wisconsin. Bagnold or Schmidt saltation and surface creep catchers should be placed in a number of fields in the spring to measure sand movement. Records of number of days with blowing sand should also be tabulated.

13.--The portable tunnel tests in Wisconsin under the wet soil conditions pointed out the need for more research to evaluate the effect of soil moisture on the rate of soil movement by wind. This research probably could be best conducted under the controlled conditions provided by the large laboratory wind tunnel.

14.--More research needs to be done on wind erosion of muck soils. Measurements of natural erosion should be made. Further portable wind tunnel tests to evaluate a range of conditions could provide useful information. Additional studies in the laboratory wind tunnel to determine thresholds for movement and erosion rates in relation to soil particle density and diameter should be conducted. Control practices such as applications of spray-on adhesives, smooth rolling to minimize the ability of wind force to attack soil grains, and residue-covered surfaces should be evaluated.

15.--Cover crops of rye, wheat, or oats should continue to be used for winter protection of fields which would otherwise be bare and vulnerable to wind erosion. Chemically killing these crops with direct no-tillage planting of the next crop appears to provide excellent protection from wind erosion.

16.--Spray-on adhesives should be evaluated for use on the central Wisconsin sands, especially where high-economic-return vegetable crops are grown. Recent research indicates that 60 gallons per acre of resin-in-water emulsion (Coherex) diluted with 240 gallons of water and sprayed with a fine-spray high-atomization nozzle or 60 gallons of Coherex per acre diluted with 1,140 gallons of water and sprayed with a full-jet coarse-spray industrial nozzle will provide effective, temporary (3 to 4 week) wind erosion control on sands at a materials cost of about $12 per acre. Anionic asphalt emulsion and oil/latex polymer emulsions are also effective but at higher costs.

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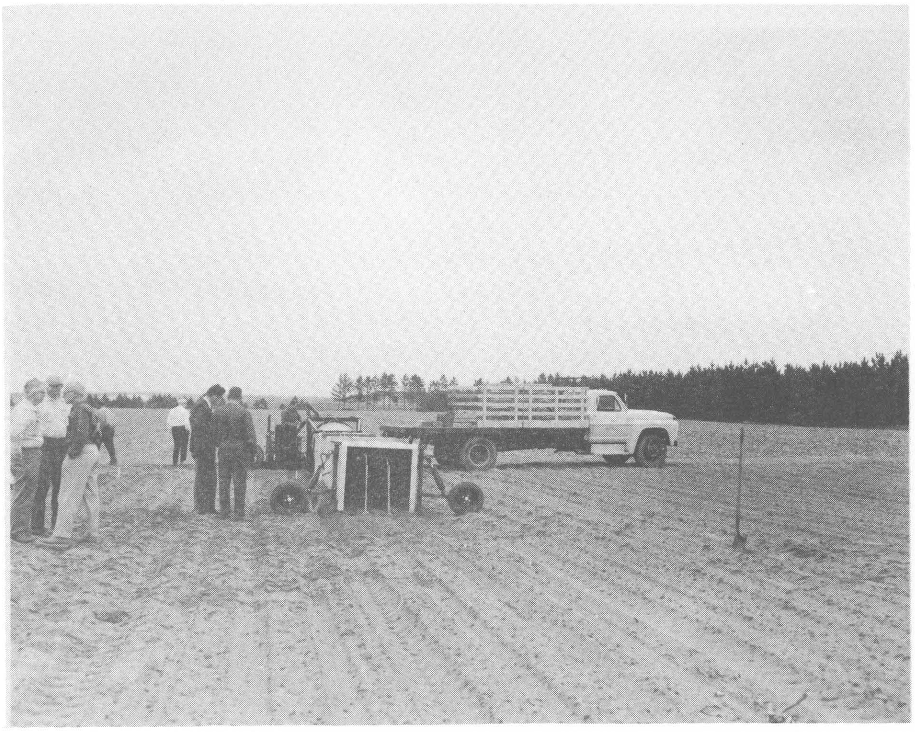
Appendix



Tests 1-3

Hancock Station (Sec. 16, T19N, R8E, Plainfield T.) Waushara County, Wisconsin

Capability Unit: IVs-3 Soil Type: Plainfield loamy sand

May 19, 1969. Field plowed, planted to corn with surface planter, and hand raked to break surface crust. A very thin layer of dry, loose, erodible sand on surface. Tractor wheel tracks quite evident. A few fragile clods from raking. No residue. Test site stabilized in 5 minutes. Topography flat. Soil slightly moist from raking and very moist immediately under surface layer. Atmospheric conditions: damp, precipitation eminent. Field rated as only moderately erodible at time of test.

Surface Conditions:

Residue, R	0 lbs./acre
Ridge roughness, K'	1.3 inches
Soil fractions greater than 0.84 mm.	9.2 percent
Mechanical stability of clods	23.9 percent
Soil eroded in tunnel parallel to row	20.1 tons/acre

Tests 4-6

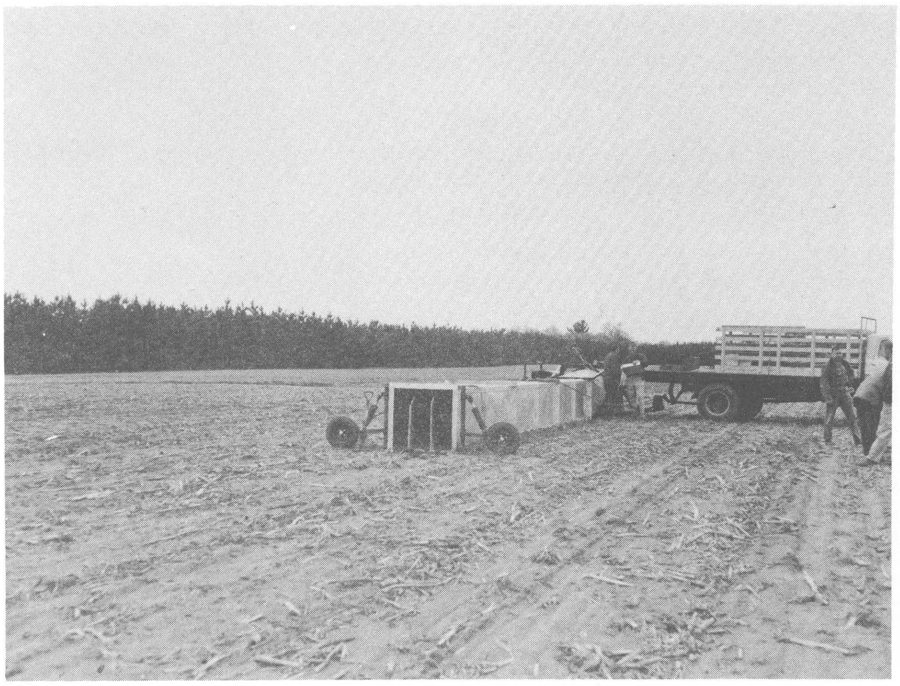
Hancock Station (Sec. 16, T19N, R8E, Plainfield T.) Waushara County, Wisconsin

Capability Unit: IVs-3 Soil Type: Plainfield loamy sand

May 19, 1969. Field plowed, planted to corn with surface planter, and crusted. Some loose, erodible sand on surface. Tractor wheel tracks evident. Very few clods. No residue. Test site did not stabilize in 9 minutes--average estimated time to stabilize from projection of rate data was 14 minutes. Topography flat. Soil moist immediately under surface crust. Atmospheric conditions: damp, precipitation eminent. Field rated only moderately erodible at time of test.

Surface Conditions:

Residue, R	0 lbs./acre
Ridge roughness, K'	1.3 inches
Soil fractions greater than 0.84 mm.	9.7 percent
Mechanical stability of clods	28.6 percent
Soil eroded in tunnel parallel to row	83.8 tons/acre



Tests 7-9

Hancock Station (Sec. 16, T19N, R8E, Plainfield T.) Waushara County, Wisconsin

Capability Unit: IVs-3 Soil Type: Plainfield loamy sand

May 19, 1969. Old cornstalk field planted to corn with surface planter without prior tillage. Field surface crusted with only few grains of loose sand on surface. Sufficient cornstalk residue to provide moderate protection from wind. Test site stabilized in 4 minutes. Topography flat. Soil moist immediately under crust. Atmospheric conditions: damp, a few raindrops fell before completion of tests. Field rated slightly susceptible to wind erosion at time of test.

Surface Conditions:

Residue, R	1,668 lbs./acre
Ridge roughness, K'	2.0 inches
Soil fractions greater than 0.84 mm.	10.2 percent
Mechanical stability of clods	24.5 percent
Soil eroded in tunnel parallel to row	2.6 tons/acre

Tests 10-12

Hancock Station (Sec. 15, T19N, R8E, Plainfield T.) Waushara County, Wisconsin

Capability Unit: IVs-3 Soil Type: Plainfield loamy sand

May 22, 1969. Single disked winter-killed oats. Some crusting and compaction due to tractor wheels. Sufficient oat residue to provide good protection from wind. Test site stabilized in 5 minutes. Topography flat. Soil moist immediately under a very thin crust. Atmospheric conditions: sunny but damp from early morning dew and rain 2 days prior to tests. Field rated not susceptible to wind erosion at time of tests.

Surface Conditions:

Residue, R	522 lbs./acre
Ridge roughness, K'	1.7 inches
Soil fractions greater than 0.84 mm.	18.2 percent
Mechanical stability of clods	31.1 percent
Soil eroded in tunnel parallel to row	0.8 ton/acre

Tests 13-15

Hancock Station (Sec. 15, T19N, R8E, Plainfield T.) Waushara County, Wisconsin

Capability Unit: IVs-3 Soil Type: Plainfield loamy sand

May 22, 1969. Standing, chemically killed rye and wheat. More than adequate residue to provide protection from wind. Test site stabilized in 4 minutes. Topography flat. Soil moist immediately under a very thin crust. Atmospheric conditions: sunny but damp from early morning dew and rain 2 days prior to tests. Field rated not susceptible to wind erosion at time of tests.

Surface Conditions:

Residue, R	837 lbs./acre
Ridge roughness, K'	3.5 inches
Soil fractions greater than 0.84 mm.	13.3 percent
Mechanical stability of clods	28.2 percent
Soil eroded in tunnel parallel to row	0.04 ton/acre

Tests 16-18

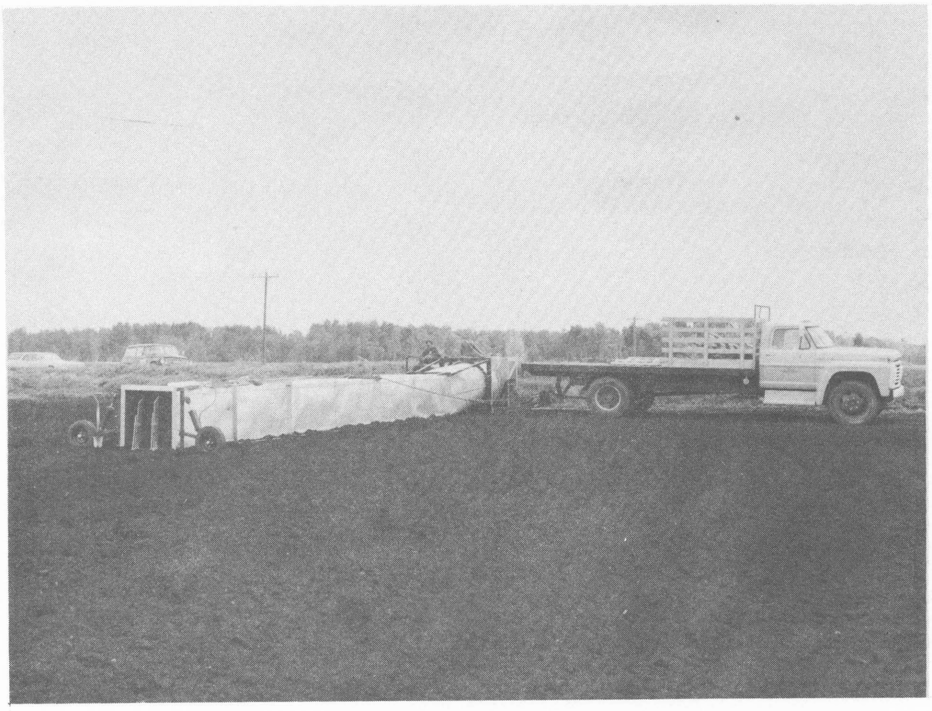
Hancock Station (Sec. 15, T19N, R8E, Plainfield T.) Waushara County, Wisconsin

Capability Unit: IVs-3 Soil Type: Plainfield loamy sand

May 22, 1969. Winter-killed oats plowed down and disked. Sufficient fragile soil clods to prevent wind erosion at time of tests. Test site stabilized in 4 minutes. Topography flat. Soil moist immediately under surface. Atmospheric conditions: sunny but damp from early morning dew and rain 2 days prior to tests. Field rated slightly susceptible to wind erosion at time of tests.

Surface Conditions:

Residue, R	0 lbs./acre
Ridge roughness, K'	1.1 inches
Soil fractions greater than 0.84 mm.	31.1 percent
Mechanical stability of clods	33.6 percent
Soil eroded in tunnel parallel to row	0.09 ton/acre



Tests 19-21

Haviland Muck Farm (Sec. 26, T22N, R8E, Buena Vista T.) Portage County, Wisconsin

Capability Unit: IIIw-9 Soil Type: Houghton mucky peat

May 22, 1969. Field plowed and disked and ready for potato planting. Soil surface rough from tillage. A considerable number of medium size clods. Surface soil extremely fluffy and loose but moist immediately under surface. Topography flat. Atmospheric conditions: warm and dry. Field rated moderately susceptible to wind erosion at time of tests.

Surface Conditions:

Residue, R	0 lbs./acre
Ridge roughness, K'	2.0 inches
Soil fractions greater than 0.84 mm.	63.9 percent
Mechanical stability of clods	83.7 percent
Soil eroded in tunnel parallel to row	7.9 tons/acre

Tests 22-24

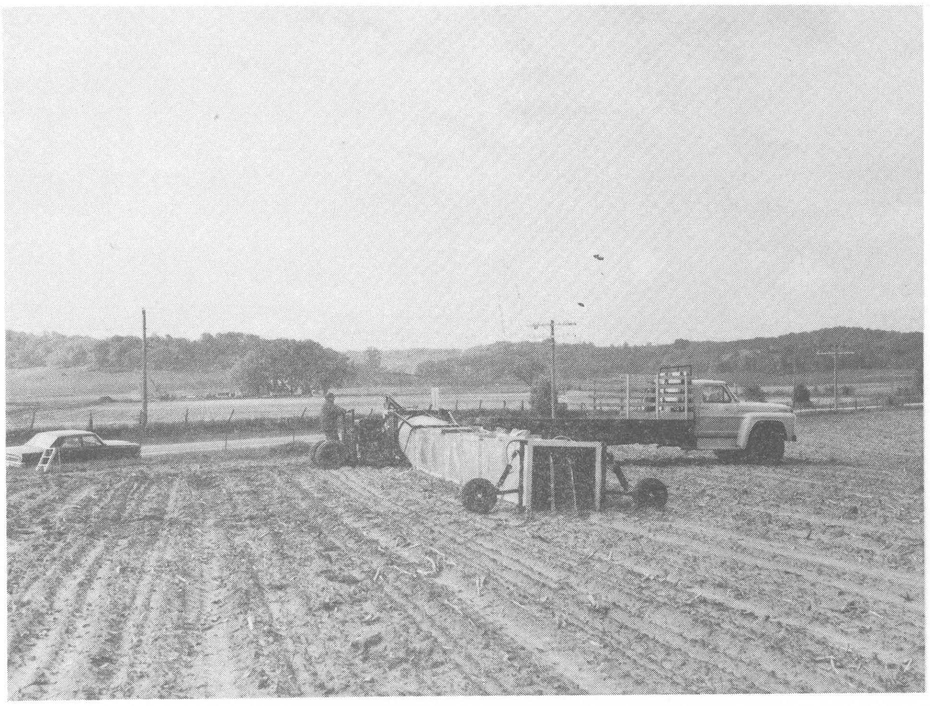
Erickson Farm (Sec. 4, T19N, R9E, Deerfield T.) Waushara County, Wisconsin

Capability Unit: IIIs-4 Soil Type: Richford loamy sand

May 22, 1969. Field planted to corn with surface planter without tillage. Crusted on surface, especially in tractor-wheel tracks. Some loose sand on surface but sufficient fragile clods to provide some protection from wind. Topography undulating. Tests conducted on top of knoll. Field susceptible to wind erosion at time of tests. Atmospheric conditions: warm and dry.

Surface Conditions:

Residue, R	0 lbs./acre
Ridge roughness, K'	1.4 inches
Soil fractions greater than 0.84 mm.	30.5 percent
Mechanical stability of clods	38.8 percent
Soil eroded in tunnel parallel to row	14.6 tons/acre



Tests 25-27

Radcliffe Farm (North) (Sec. 11, T18N, R6W, Farmington T.) La Crosse County, Wisconsin

Capability Unit: IVs-3 Soil Type: Plainfield loamy fine sand

May 23, 1969. Field disked twice and planted to corn with surface planter. Some corn up. Surface crusted but there were a few loose sand grains on surface. Sufficient residue to provide some protection from wind. Soil moist immediately under surface. Atmospheric conditions: dry and warm. Topography undulating. Field rated slightly susceptible to wind erosion at time of test.

Surface Conditions:

Residue, R	795 lbs./acre
Ridge roughness, K'	1.7 inches
Soil fractions greater than 0.84 mm.	30.1 percent
Mechanical stability of clods	45.6 percent
Soil eroded in tunnel parallel to row	5.4 tons/acre

Tests 28-30

Radcliffe Farm (South) (Sec. 11, T18N, R6W, Farmington T.) La Crosse County, Wisconsin

Capability Unit: IVs-3 Soil Type: Boone-Hixton loamy sand

May 23, 1969. Field disked twice and planted to corn with surface planter. Corn up. Surface crusted but appeared looser than north Radcliffe field and there were some loose sand grains on surface. Adequate corn residue for some protection from wind erosion. Not many clods but a number of sandstone rocks. Topography undulating. Atmospheric conditions: dry and warm. Field rated susceptible to wind erosion at time of tests.

Surface Conditions:

Residue, R	1,329 lbs./acre
Ridge roughness, K'	1.9 inches
Soil fractions greater than 0.84 mm.	14.5 percent
Mechanical stability of clods	52.6 percent
Soil eroded in tunnel parallel to row	27.9 tons/acre

Appendix Table 1.--Conditions of soil structure, surface roughness, crop residue, and wind tunnel erodibility of 30 field sites tested with portable tunnel in central Wisconsin, May 19-23, 1969.

Site no.	Location and treatment or crop	Soil type	Soil fractions > 0.84 mm.	Mechanical stability	Ridge roughness	Crop residue	Tunnel soil loss
			Percent	Percent	Inches	Lbs./A.	Tons/A.
1	Hancock Station, Waushara County,	Plainfield	6.4	37.6	1.3	0	6.8
2	plowed, planted to corn, and	loamy sand	11.0	15.8	1.5	0	10.6
3	raked.		10.3	18.5	1.0	0	42.9
4	Hancock Station, Waushara County,	Plainfield	12.2	30.4	1.2	0	108.5
5	plowed, planted to corn, crusted.	loamy sand	9.6	31.1	1.6	0	52.2
6			7.2	24.2	1.2	0	90.8
7	Hancock Station, Waushara County,	Plainfield	8.0	22.7	1.7	1,727	6.0
8	old cornstalk field planted to	loamy sand	10.8	26.7	2.0	1,736	0.6
9	corn without prior tillage.		11.9	24.3	2.2	1,540	1.3
10	Hancock Station, Waushara County,	Plainfield	17.3	37.6	1.7	650	1.1
11	disked winter-killed oats.	loamy sand	16.3	28.3	2.0	525	0.2
12			21.0	27.5	1.5	392	1.0
13	Hancock Station, Waushara County,	Plainfield	13.6	27.8	3.3	899	0.1
14	standing chemically killed rye	loamy sand	12.9	24.1	4.2	819	0.01
15	and wheat.		13.3	32.6	3.0	792	0.02
16	Hancock Station, Waushara County,	Plainfield	28.3	35.0	1.0	0	0.06
17	winter-killed oats plowed and	loamy sand	30.7	30.1	1.2	0	0.13
18	disked.		34.3	35.6	1.2	0	0.07
19	Haviland muck farm, Portage	Houghton	58.9	81.5	1.6	0	7.5
20	County, plowed and disked for	mucky peat	68.2	85.9	1.8	0	6.5
21	potato planting.		64.5	83.8	2.5	0	9.6
22	Erickson farm, Waushara County,	Richford	33.5	40.5	1.1	0	7.6
23	planted to corn without tillage.	loamy sand	25.7	34.5	1.7	0	14.6
24			32.4	41.4	1.3	0	20.7
25	Radcliffe farm, La Crosse	Plainfield	23.5	39.0	2.0	560	4.1
26	County, disked twice and	loamy fine	28.7	45.6	1.5	1,095	11.2
27	planted to corn.	sand	38.2	52.3	1.7	730	1.0
28	Radcliffe farm, La Crosse	Boone-Hixton	11.0	36.4	2.2	1,210	16.5
29	County, disked twice and	loamy sand	21.1	50.3	1.8	1,824	27.2
30	planted to corn.		11.3	71.3	1.7	952	40.2