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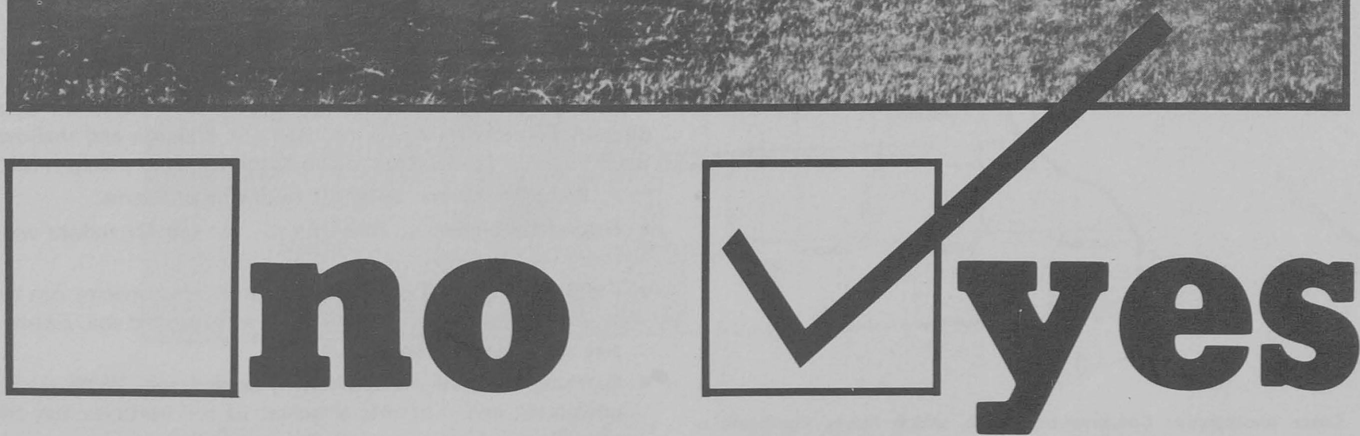
UNIVERSITY OF MINNESOTA

Extension Folder 496—1979

Wind Erosion: Its Control in Minnesota



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Wind Erosion: Its Control in Minnesota

Wind erosion can be controlled. Farmers have a responsibility to themselves, their neighbors, and the general public to limit wind erosion to an acceptable level. The first step in accomplishing this goal is to understand the causes of wind erosion and the control methods described in this folder.

Impact of Wind Erosion

Soil erosion by wind can be a severe problem in Minnesota, especially on sandy soils and in portions of the Red River Valley. Although wind erosion in the central and southern Great Plains states is more frequent and potentially more severe than in Minnesota, sizeable portions of northwestern and central Minnesota have the potential for average annual amounts of soil erosion by wind in excess of 1 ton per acre. Smaller areas in southwestern and west-central Minnesota have a potential for moderate amounts of soil erosion by wind (see accompanying map).

Severe wind erosion has occurred. During the winter and early spring of 1977-78, part of west-central Minnesota experienced severe wind erosion problems intensified by fall primary tillage methods. The soil was left bare and unprotected over winter, with few large clods. Similar problems occurred in 1973 in the Red River Valley. Part of the Anoka Sand Plain in Sherburne County suffered severe wind erosion in the 1930s and '40s and is now the Sand Dunes State Forest.

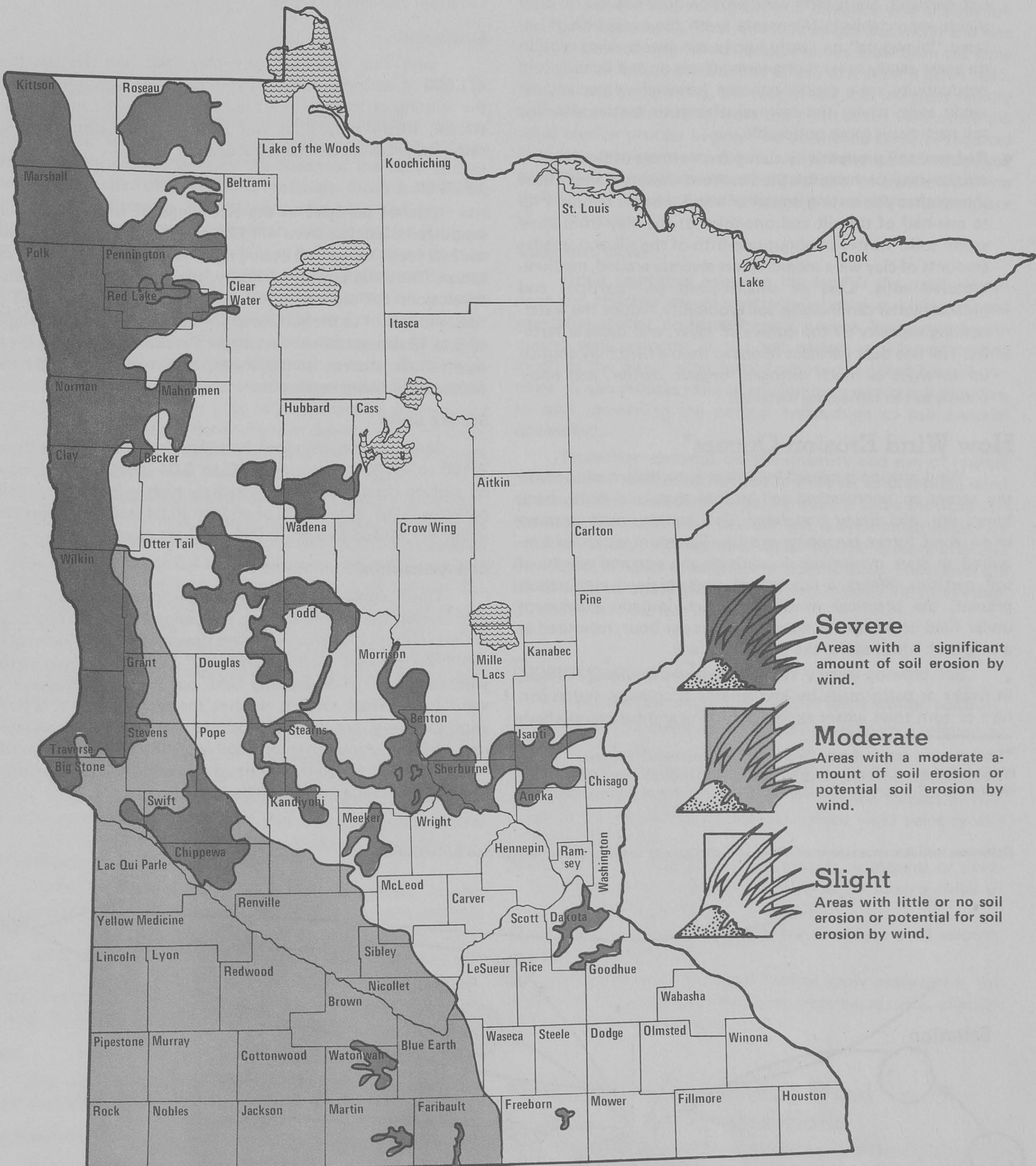
Wind erosion usually is more noticeable and objectionable to the average citizen than water erosion. Small amounts of soil in drifted snow are highly visible. Wind-blown dust in houses is very objectionable. Severe soil blowing may temporarily reduce visibility on highways.

The costs of wind erosion are shared by all Minnesotans. The taxpayer pays for removing eroded soil from roadside ditches. Farmers may have to clean out drainage and shallow field ditches. In some cases, blowing soil damages young crops.

Wind erosion can cause the following problems:

- **Hazardous highways.** Airborne soil can greatly reduce visibility on a highway.
- **Filling of road and drainage ditches.** Ditch capacity can be severely reduced by deposition of wind-eroded soil. Expensive clean-out may be required.
- **Carrying away of materials with eroded soil.** Weed seeds, chemicals, and nutrients attached to soil particles may be moved and redeposited with the eroded soil.
- **Unfavorable working conditions.** Working in blowing soil can be unpleasant and even harmful.

Cover photograph: Conservation tillage, which leaves significant amounts of crop residue on the surface, is the most easily adopted control method for most of Minnesota's cropland. The fall plowed field on the left eroded, while the chisel plowed soybean stubble on the right did not erode.


Kittson
Roseau
Lake of the Woods
Koochiching
Marshall
Beltrami
St. Louis
Polk
Pennington
Red Lake
Clear Water
Itasca
Cook
Lake
Norman
Mahnomen
Hubbard
Cass
Clay
Becker
Aitkin
Wadena
Crow Wing
Carlton
Otter Tail
Wilkin
Todd
Pine
Morrison
Mille Lacs
Kanabec
Grant
Douglas
Benton
Stevens
Pope
Stearns
Isanti
Traverse
Big Stone
Sherburne
Chisago
Swift
Kandiyohi
Anoka
Meeker
Wright
Chippewa
Hennepin
Ramsey
Washington
Lac Qui Parle
McLeod
Carver
Renville
Yellow Medicine
Scott
Dakota
Sibley
Lincoln
Lyon
Redwood
LeSueur
Rice
Goodhue
Nicollet
Brown
Wabasha
Waseca
Steele
Dodge
Olmsted
Winona
Pipestone
Murray
Cottonwood
Watonwan
Blue Earth
Rock
Nobles
Jackson
Martin
Faribault
Freeborn
Mower
Fillmore
Houston
Severe
Areas with a significant amount of soil erosion by wind.
Moderate
Areas with a moderate amount of soil erosion or potential soil erosion by wind.
Slight
Areas with little or no soil erosion or potential for soil erosion by wind.

- **Reduced crop yields.** In some cases crop yields may be reduced by physical damage to young plants from wind-blown soil particles. Short-term wind erosion does not reduce crop yields appreciably in Minnesota (with the exception of isolated "blowouts" on sandy knolls and severe wind erosion on some sandy soils). Long-term effects on soil fertility and productivity are a greater concern, however— especially for sandy soils, where the removal of organic matter and fine soil particles is more noticeable.
- **Reduced soil productivity.** Long-term effects of severe wind erosion may be harmful. Studies from western Canada have shown that the sorting action of wind erosion removed up to one-half of the silt and one-third of the clay from some sandy soils. Losses of about one-fifth of the silt and smaller amounts of clay were measured on severely eroded, medium-textured soils. Loss of smaller-sized soil particles and organic matter can increase soil erodibility, reduce the water-holding capacity of the cultivated layer, and deplete fertility. The fine dust particles removed from a field may contain up to twice as much nitrogen, organic matter, and phosphorus as the remaining material.

How Wind Erosion Occurs*

Wind erosion is caused by a strong, turbulent wind blowing across an unprotected soil surface that is smooth, bare, loose, dry, and finely granulated. Soil particles start to move when wind forces overcome gravity. Minimum windspeed required to start movement depends on the size and weight of soil particles. Where a mixture of single-grained materials is present, the practical windspeed which initiates movement under field conditions is about 13 miles per hour, measured at a height of 1 foot above the ground surface.

Soil blowing usually starts on exposed knolls or hilltops, in tracks or paths made by implements or animals, and in corners or turn rows where excessive turning and cultivation have pulverized the surface soil. After soil particles start to move, the wind carries them in three types of movement—suspension, saltation, and surface creep.

*This section taken from "How to Control Wind Erosion." N. P. Woodruff, Leon Lyles, F. H. Siddeway, and D. W. Fryear. Agriculture Information Bulletin Number 354, USDA, Agricultural Research Service.

Suspension

Very fine sand, silt, and clay-sized particles less than 4/1,000 of an inch (0.004 inch) in diameter (about one-eighth the spacing of the gap in a spark plug) are lifted into the airstream, where they float and are carried in suspension for many miles before being redeposited.

Saltation

Coarser particles in the size range of fine and medium sand-sized particles, from 4/1,000 to 2/100 of an inch (0.004 to 0.02 inch) move in a bouncing or jumping action called saltation. They rise almost vertically, rotating at several hundred revolutions per second, travel 10 to 15 times their height of rise, and return to the surface at forward and downward angles of 6 to 12 degrees. When they strike the soil surface, they break down clods, destroy stable crusts, and wear down vegetative residues and living vegetation.

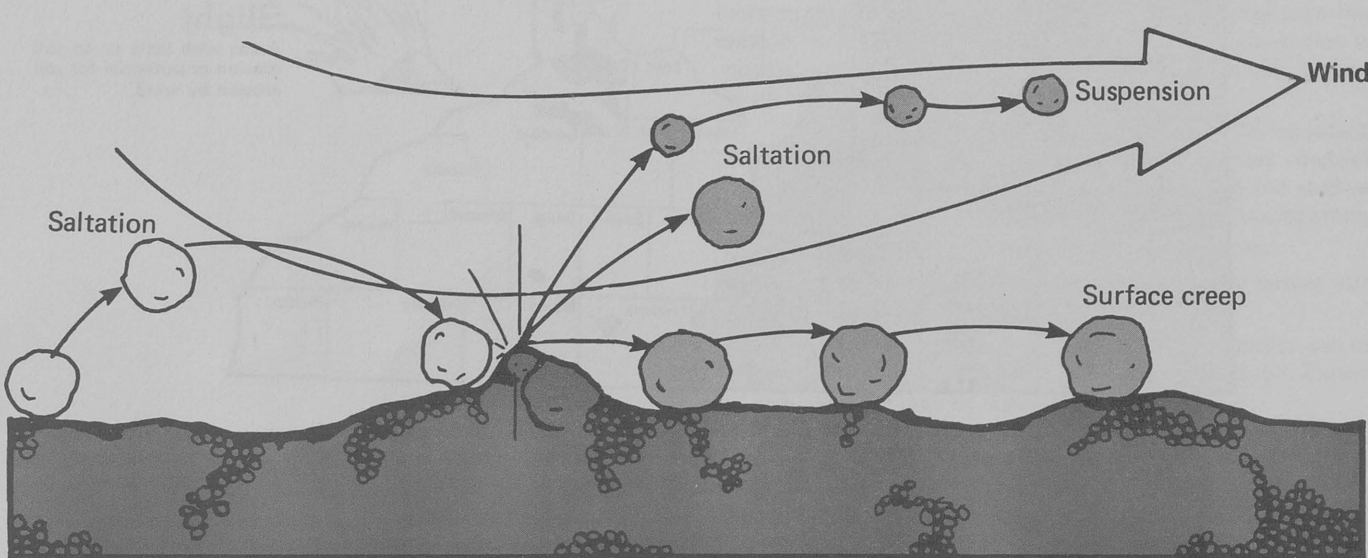
Surface Creep

Most of the dislodged particles in the size range from 2/100 to 4/100 of an inch (0.02 to 0.04 inch), roll and move by surface creep. Winds of extremely high velocity may move particles larger than 4/100 of an inch (0.04 inch), but particles about 4/1,000 of an inch (0.004 inch) are most erodible.

Soil Avalanching

Once blowing begins, the soil particles jumping in saltation severely abrade the surface. Increasing numbers of particles are set in motion as erosion moves downwind. Such increase in soil flow is called "soil avalanching." Soil flow is zero at the windward edge of an eroding field, but the rate increases leeward (downwind) until it reaches the maximum that a given wind can carry. The distance downwind at which the maximum rate of flow occurs varies with soil erodibility. The more erodible the soil, the greater the rate of avalanching and the shorter the distance to maximum soil movement.

Saltation initiates movement of other soil particles in suspension, saltation, and surface creep.



Factors Affecting Wind Erosion*

Major factors that affect the amount of erosion from a given field are soil cloddiness, surface roughness, windspeed, soil moisture, field size, and vegetative cover. A discussion of each follows.

Soil Cloddiness

The cloddiness of a given soil largely indicates whether the wind will erode it. Soil clods prevent wind erosion because they are large enough to resist the forces of the wind and because they shelter other erodible materials. Clods form during tillage. Their firmness and stability vary with soil type and depend on soil moisture, compaction, organic matter, clay content, lime content, and microbial activity. Clods are broken down by weathering, tillage, implement and animal traffic, and abrasion by wind-driven soil particles. Weathering includes freezing and thawing, wetting and drying, and raindrop impact.

Sandy loams, loamy sands, and sands are most susceptible to erosion and breakdown and are least likely to form stable clods. These soils have low silt, clay, and organic-matter content. They form clods only when cultivated while moist and firm. Such clods are readily broken down by rainfall or by freezing and thawing. The cloddiest and *least erodible soils* are the loams, silt loams, clay loams, and silty clay loams.

Several criteria commonly are used to specify the cloddiness required to control erosion on field soils. Examples of these are that 50 percent of the soil surface ought to be covered with clods greater than 0.4 inch in diameter, that 50 percent of the surface clods ought to be greater than 0.04 inch in diameter, and that two-thirds of the surface soil by weight ought to be of "nonerodible" size (greater than 0.03 inch in diameter). These criteria are approximate, but soils that meet any one of them usually will resist all but the very strongest winds.

Surface Roughness

In addition to clods and soil aggregates, ridges and depressions formed by tillage alter windspeed by absorbing and deflecting part of the wind energy away from erodible soil. Effective ridges must be nearly perpendicular to the direction of prevailing winds. Rough surfaces also trap saltating particles. This reduces abrasion and the normal build-up of eroding materials downwind.

While the general effect of surface roughness reduces wind erosion, it also increases wind turbulence and exposes smaller areas on ridges to greater wind forces. Too much roughness, then, may substantially reduce the benefits. Optimum roughness for wind erosion depends on the distance between ridges. For example, optimum roughness is approximately 2 to 5 inches for ridges spaced 8 to 20 inches apart.

Wind

The rate of erosion caused by a 30-mile-per-hour wind is more than three times that of a 20-mile-per-hour wind.

Soil Moisture

Wind erosion decreases as soil moisture increases. For example, air-dry soil erodes about one-and-one-third times more than soil with moisture at the approximate wilting point for plants.

*This section taken from "How to Control Wind Erosion." N. P. Woodruff, Leon Lyles, F. H. Siddeway, and D. W. Fryear. Agriculture Information Bulletin Number 354, USDA, Agricultural Research Service.

Field Size

Erosive winds vary greatly in direction and seldom follow field boundaries. Thus, the field length and width and also the consistency with which erosive winds blow from the same direction all affect the amount of soil lost from a given field. Due to soil avalanching, the rate of soil loss increases rapidly with distance downwind from the point in the field where the wind erosion process begins. The downwind distance required to reach a maximum rate depends on soil and surface roughness conditions. Barriers on the windward side of the field provide shelter from the wind and reduce the area of the field subject to wind erosion.

Vegetative Cover

Good vegetative cover on the land is the most permanent and effective way to control wind erosion. Living or dead vegetative matter protects the soil surface from wind by reducing wind velocity at the soil surface and by preventing much of the direct wind force from reaching erodible soil particles. It also reduces rates of erosion by trapping soil particles, in turn preventing the normal avalanching of soil material downwind.

Protection depends on the quantity and size of residue and how the residue is oriented in relation to prevailing wind direction. The finer the residue, the more it slows the wind and the more it reduces wind erosion. Size is determined largely by kind of residue; for example, wheat stubble is more effective than equal weights of sorghum or corn stubble. The higher the residue stands above ground, the more it slows the wind velocity and lowers the rate of erosion.

Principles of Control

There are four major principles of wind erosion control:

1) *Establish and maintain vegetation or vegetative residues* to protect the soil.
2) *Reduce field widths* across the prevailing wind direction by establishing wind barriers, such as field windbreaks or trap strips at designated intervals to reduce wind velocity and soil avalanching.
3) *Produce, or bring to the soil surface, aggregates or clods* large enough to resist the wind force by using a chisel or other tillage implement.
4) *Roughen or ridge the land surface* to reduce wind velocity and trap drifting soil.

While these principles of control apply everywhere, the usefulness of each varies with local cropping systems, climate, soil, and land-use conditions.

Methods for Controlling Wind Erosion on Cultivated Soils

Wind erosion can be controlled by several different practices or combinations of practices, some permanent and some temporary. Permanent or continuing practices include conservation tillage, cover crops, strip-cropping, crop rotations, shelterbelts, buffer strips, grass seeding, and tree planting. Temporary methods include placement of artificial barriers, hauled-in mulches, emergency tillage to roughen and bring clods to the surface, and spray-on adhesives.

Conservation Tillage

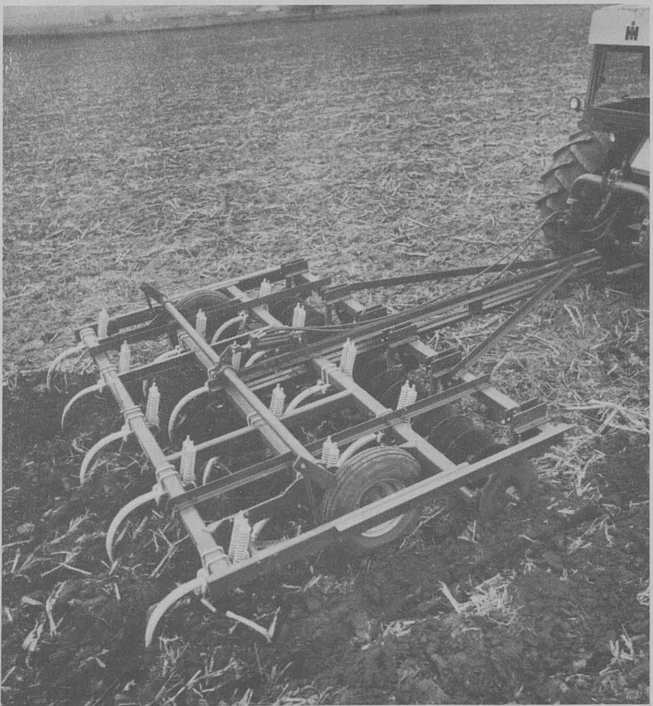
Conservation tillage, which leaves significant amounts of crop residue on the surface, is the most easily adopted control method for most of Minnesota's cropland. The surface residue decreases wind velocity at ground level and traps dislodged soil particles. Conservation tillage may be used with other wind erosion practices to provide increased protection.

As an example, the relative amount of Hubbard loamy coarse sand expected to erode with different tillage systems is given in table 1. Note that chisel plowing reduces the potential soil loss to only a trace. The 2,000 pounds of cornstalk residue remaining after two passes with a tandem disk reduced soil loss to less than 2 tons per acre per year. Excessive tillage, however, buries most of the surface residue, which destroys the ability of conservation tillage to control wind erosion. Two passes with the tandem disk after chiseling reduced surface residue to only 1,000 pounds per acre and increased soil loss to 7.5 tons per acre.

Table 1. Predicted soil loss by wind erosion followed a 160 bushel/acre irrigated corn crop (Sherburne County Hubbard loamy coarse sand.

Fall tillage	Pounds of surface residue remaining after tillage	Soil loss (tons/acre)	Erosion control suitability
Moldboard plow	0	13.4	Inadequate
Tandem disk			
2 passes	2,000	1.7	†
1 pass	4,000	0	Adequate
Chisel			
2 passes	2,800	Trace	Adequate
1 pass	4,800	Trace	Adequate
Chisel plus 2 passes with tandem disk	1,000	7.5	Inadequate

†Soil adequately protected, but protection not adequate for some crops.



The chisel plow, recommended to reduce potential soil loss.

A surface mulch can effectively control erosion only if sufficient mulch is retained on the surface; thus, conservation tillage is better adapted to some situations and some crops than others. For example, little residue remains after potato harvest, which is often too late to permit planting a cover crop. Soybeans and sunflowers also produce relatively small amounts of crop residue. A surface mulch may interfere with customary methods of herbicide application or incorporation and may increase the potential for damage by certain insects. A change in weed and insect control measures may be necessary to provide adequate protection against these pests.

Cover Crops

Winter cover crops such as rye or oats may be used in certain situations. These crops may be used after silage corn, if the crop is removed early enough for the cover crop to reach sufficient height to provide adequate winter protection.

Strip-Cropping

Alternate strips of row crops and close growing crops control wind erosion by halting the saltation process before the avalanching of eroded soil particles can reach serious levels. As with wind barriers, the strips should be as nearly at right angles to the prevailing wind direction as possible, because neither barrier nor strips protect against soil erosion from winds parallel to the direction of the strips. The main drawback of wind strip-cropping is that alternate strips of small grain, hay, or other close growing crop must be grown tall enough to be effective during the time when wind erosion may be a problem. Unplowed cornstalk strips 8 rows wide for each 40 plowed rows is a modification of wind strips which is useful over winter and also may increase snow catch.

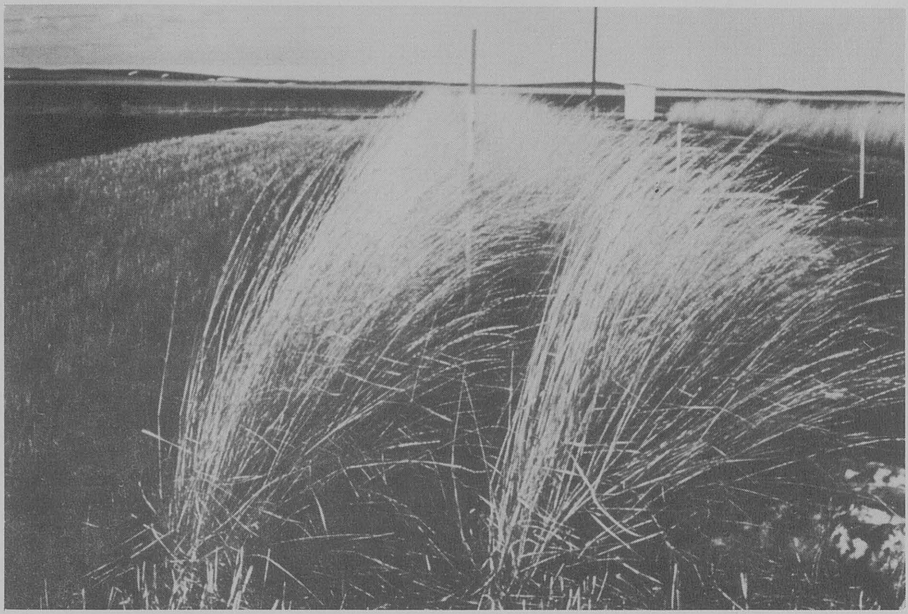
Wind Barriers

Wind barriers are placed parallel to the field boundary which is most nearly perpendicular to the prevailing wind direction in April. Prevailing wind directions vary with location in Minnesota, and farmers are advised to check with their local Soil Conservation Service district conservationist for recommendations on windbreak direction, spacing, tree type, and maintenance requirements.

The most common wind barrier is the single-row tree windbreak. As a general rule, a windbreak protects for a distance downwind of approximately 10 to 12 (or more) times the height of the windbreak, depending on soil conditions and supporting practices. Windbreaks may be combined with other conservation practices to provide increased effectiveness. Beneficial effects on the microclimate around the crop, as well as increased snow catch, may increase crop yields in certain cases.

Problems encountered with windbreaks include removal of 5 percent or more of the cropland from production, tree maintenance and replacement, restriction on diagonal and cross-tillage, competition of trees with adjacent crop for water and sunlight, weed control in windbreaks, and large snowbanks which form behind a dense barrier and may delay spring work on fine-textured soils.

Other types of barriers may be more suitable in certain circumstances. Rows of shrubs can be used in some cases to protect against wind erosion with center pivot irrigation systems. Single or double rows of grass also can provide protection, but the rows must be spaced much closer together than tree windbreaks.



Double rows of grass provide protection by forming a wind barrier.

In western Minnesota studies conducted by USDA's Soil and Water Conservation Laboratory, double-row-spaced corn windbreaks increased soybean yields by protecting the crop from hot, dry winds and by providing a more favorable microclimate for plant growth. Barriers have increased yields of sugarbeets, dry beans, and small grain in studies in nearby states.

Mulches

Straw, manure, native hay, or corncobs may be placed on highly erodible areas. These mulches have limited value in controlling wind erosion. Their principal use in farming is to treat highly erosive knolls and blowouts, particularly in sandy soils.

Use 1 to 2 tons of straw or hay, 4 to 5 tons of corncobs, or 15 to 20 tons of wet manure per acre to effectively control erosion on vulnerable spots and prevent its spreading to other parts of the field. Materials may be spread by hand or with a manure spreader. They should be anchored with a disk packer or ordinary disk operated at a very small angle, so the disks do not bury residue.

Emergency Tillage

If vegetative cover is unavailable, emergency tillage will be necessary. It should be used only after such methods as stubble mulching, cover crops, strip-cropping, crop rotations, regular tillage, and windbreaks and other barriers have failed. Use emergency tillage to create a rough, cloddy soil surface to resist the force of the wind. It is only a temporary measure because clods readily disintegrate. Use emergency tillage before soil blowing starts, rather than after. Soil erodes more rapidly under abrasion by moving soil particles and requires drastic control measures to prevent further erosion. If soil blowing has started, begin emergency tillage on the windward edge of the field. Chisel the entire field, rather than at intervals across the field.

Sandy soils are the most difficult to hold with emergency tillage. Few clods are obtained, regardless of the depth tilled or tool used. Fine- and medium-textured soils respond more readily to emergency tillage than sand.

Effective implements for use in emergency tillage to create a rough, cloddy surface include heavy duty chisel plows with spear points, duckfoot and widespread shovel cultivators, one-way disks with two or three disks removed at intervals to give a lister effect, the "sand fighter," and pitting machines. The choice of implement and the method used depends on the seriousness of possible erosion, soil texture, and the cropping system.

Wind Erosion Equation

This equation is used by the USDA, Soil Conservation Service, in designing control practices and advising farmers on conservation programs:

$$E = f(I,K,C,L,V)$$

Average annual soil loss in tons per acre by wind erosion (E) from a given field is determined by these five factors:

I — is the soil erodibility index indicated by soil aggregates greater than 0.03 inches in diameter and percentage of land slope.

K — is soil surface roughness.

C — is the climatic factor indicated by wind velocity and surface soil moisture.

L — is the unsheltered distance across a field along the prevailing wind erosion direction.

V — is vegetative cover.

The equation is a highly useful management tool in (1) determining potential wind erosion on any field under existing conditions, and (2) determining conditions of surface roughness, soil cloddiness, vegetative cover, sheltering, or width and orientation of field necessary to reduce wind erosion to a tolerable amount.

For additional general information on wind erosion control, contact your county extension director. For specific advice on control measures, contact your local soil and water conservation district and Soil Conservation Service district conservationist.

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