

SOIL

A THREATENED RESOURCE?

Soil Erosion and Its Control



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INTRODUCTION

Man's survival on the North American continent has always depended on the natural resources at his disposal. The United States now is an industrialized nation but our development and economy are strongly tied to agricultural production and natural resources.

Agriculture is North Dakota's number one industry. It generates over \$2.2 billion in cash receipts from crops and livestock marketings. This does not include the additional billions of dollars generated by agricultural businesses.

Our environment and economy are significantly affected by soil and water quality. Their importance has far-reaching effects in our society. As we look back in history and marvel at our accomplishments we must ask ourselves "but at what price?" and "what about the future?"

Current concerns regarding deteriorating water quality, soil erosion and long-term agricultural production have led to new areas of research and protective legislation but more importantly these concerns have stimulated an awakening of public interest in these important issues.

The Soil Conservation Service (SCS) in its 1982 National Resources Inventory reports that 5.4 billion tons of soil erode in the United States on non-federal rural land every year. In North Dakota approximately 60 percent of soil erosion is caused by wind, while water causes the remaining 40 percent.

Land Resource Area

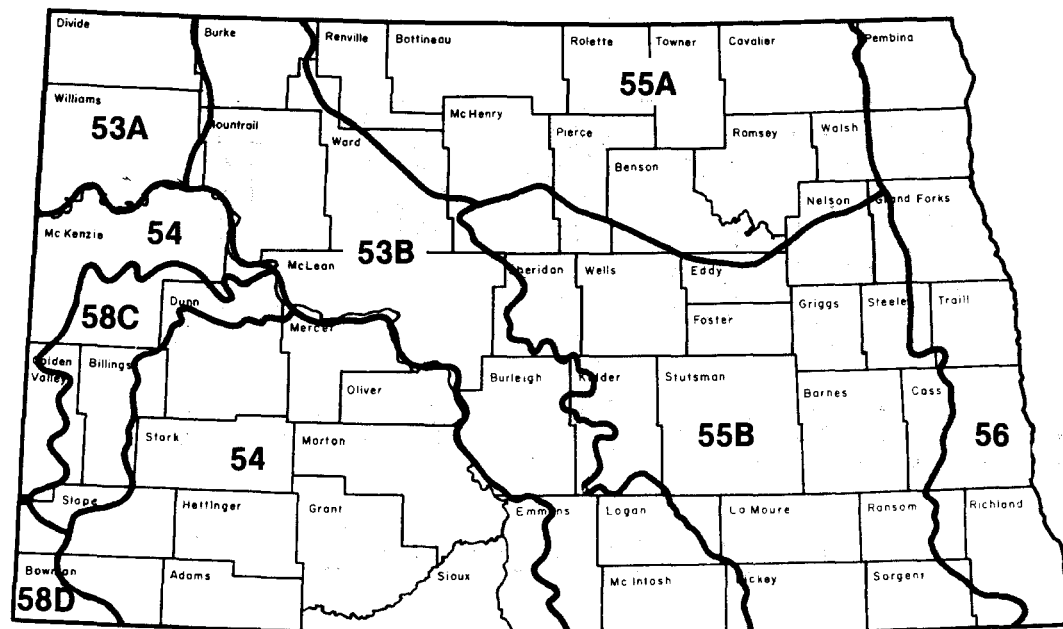
North Dakota is divided by SCS into eight major land resource areas, based on soil patterns, climate, water resources and land uses, as indicated in Figure 1. The average soil erosion on North Dakota's cropland acres is 5.4 tons per acre. Figure 2 shows wind erosion is responsible for 3.3 tons per acre and water erosion for 2.1 tons per acre. Rangeland and pastureland average less than one ton per acre of soil loss.

1985 FARM BILL

When soil erosion is viewed on a national level we find a major proportion occurs on relatively few acres. The conservation provisions of the 1985 Farm Bill are specifically directed at controlling



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|--|---|
| 56 Red River Valley of the North | 53B Central Dark Brown Glaciated Plains |
| 55A Northern Black Glaciated Plains | 54 Rolling Soft Shale Plain |
| 55B Central Black Glaciated Plains | 58C Northern Rolling High Plains, Northeastern Part |
| 53A Northern Dark Brown Glaciated Plains | 58D Northern Rolling High Plains, Eastern Part |

Figure 1. Eight land resource areas of North Dakota.

soil erosion on these highly erodible acres. It also focuses on reducing the loss of wetlands from the landscape. This is the first farm legislation that ties a producer's conservation practices to eligibility for government program support. The 1985 Farm Bill has four major conservation programs as diagrammed in Figure 3.

The Conservation Reserve Program (CRP) was created to take highly erodible land out of annual crop production and return it to a permanent cover of grass or trees. Additions to this program allow wetlands, scour eroded land, vegetative filterstrips and tree plantings to be bid into CRP. When acres are accepted into CRP the farmer receives an annual government payment during the ten year contract period. This land cannot be harvested or grazed during this time. The goal of CRP is to retire up to 45 million cropland acres in the United States.

The swampbuster provision was designed to reduce the conversion of wetlands to annual crop production. Producers who drain wetlands after December 1985 may not be eligible for United States Department of Agriculture (USDA) farm program benefits.

The sodbuster provision was implemented to prevent the conversion of highly erodible land from permanent cover, such as grass, pasture or trees, to annual crop production. This provision specifically applies to any field that was not planted to

an annual crop or designated as set-aside or diverted acres for at least one year between December 1980 and December 1985. A producer intending to convert any highly erodible permanent cover field into annual crop production must develop and apply a locally approved conservation plan to remain eligible for USDA farm program benefits.

The conservation compliance provision applies to any highly erodible field that was planted at least one year between December 1980 and December 1985. Producers must develop a locally approved conservation plan on these highly erodible fields by **December 31, 1989**, and have it fully implemented by **January 1, 1995**, to remain eligible for USDA farm program benefits.

Highly Erodible Definitions

A highly erodible soil is any soil that has the *potential* to erode at eight times the rate at which that soil can maintain its naturally occurring productivity. "T" is the soil's erosion tolerance level.

A highly erodible field, under *conservation compliance*, contains at least *one-third* highly erodible soils or the highly erodible area is 50 acres or larger in size. This differs from CRP fields which must be *two-thirds* highly erodible.

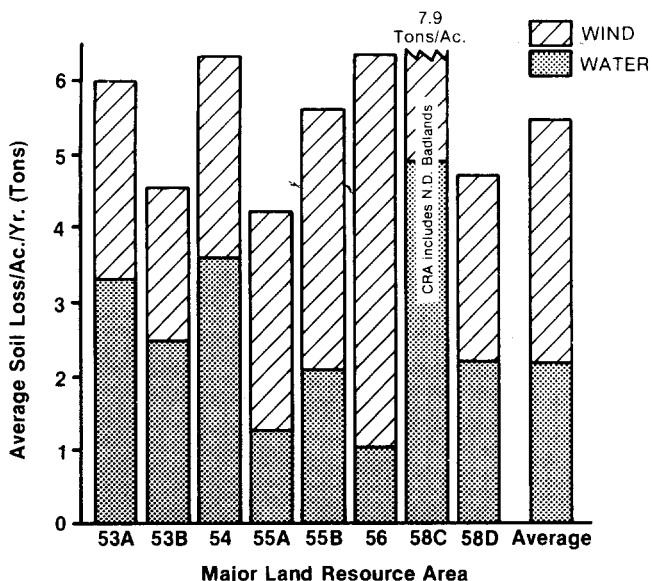


Figure 2. Average North Dakota cropland soil loss in tons/acre/year by wind and water erosion for each land resource area.

Highly erodible land (HEL) is a designation given to a highly erodible field.

The SCS is responsible for making highly erodible soil and highly erodible field determinations.

SOIL EROSION

Soil erosion is movement of soil, by the action of wind or water, from one location to another. It is a naturally occurring phenomenon that has changed geologic raw materials into the soil essential for agricultural production. Although wind and water erosion are vital to soil formation, excessive erosion on cultivated fields leads to loss of valuable topsoil and reduced agricultural production, or in cases of severe erosion, complete loss of all production potential.

The Erosion Process

The wind and water erosion process is divided into three important parts:

- 1) **Soil detachment** is the breaking loose of individual soil particles from the soil mass.
- 2) **Soil transport** is the movement of soil particles.
- 3) **Soil deposition** is the placement of soil particles in a new location.

It is important to note that erosion does not occur if the soil particles do not become detached from the soil mass. Let's now look at how wind erosion and water erosion occur.

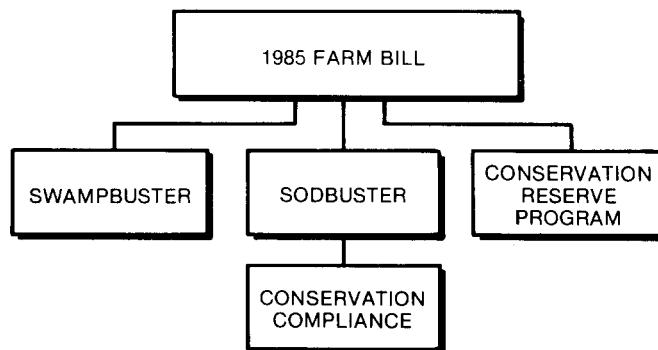


Figure 3. Diagram of the 1985 Farm Bill Conservation provisions.

WIND EROSION

Types of Wind Erosion

Saltation begins when detached particles are transported by the wind. The first particles to detach are intermediate in size because they are large enough to be exposed to the force of the wind and yet small enough to be moved by it. Saltation is surface soil movement caused by the slamming of wind and gravity moving particles into other surface particles, both large and small. Saltation accounts for about 80 percent of all wind erosion.

Suspension is the most visible form of wind erosion. The smallest particles, because of their light weight, become airborne and may be carried great distances.

Surface creep is the rolling action of large soil particles. These particles, because of their weight, are not lifted by the wind but rather moved along the surface by both the action of wind and saltation (Figure 4).

Soil avalanche refers to increase in size and intensity of soil erosion caused by saltation. Wind erosion often begins at one location and avalanches or expands in size across a field in a funnel-shaped pattern.

Factors Affecting Wind Erosion

Soil Surface Condition and Wind Speed

Wind erosion starts under these conditions:

- 1) The soil surface is loose, dry, smooth, lacking in cover, and of an area large enough for air transport to occur.
- 2) Wind speed is great enough to begin moving the soil. Wind speeds of 12 miles per hour,

one foot above the ground, can start soil detachment and particle movement.

While soil surface conditions and wind speed are major factors, there are others.

Susceptibility of the Soil

Soils vary in their susceptibility to wind erosion because of naturally occurring soil property differences. Soil texture may be the most important

guide to determining a soil's tendency to blow. The course- and fine-textured soils are most susceptible and equally difficult to manage. Left bare and unprotected over winter, these soils can suffer extensive wind erosion. The more susceptible soil textures are shown in Figure 5.

Soil texture is the percent by weight of sand, silt and clay particles in a soil. A comparison of soil particle size is shown in Figure 6.

Usually it is impractical to change chemical and physical properties of soil, so wind erosion must be reduced by wise use of soil management techniques.

Current Climatic Conditions

Climatic conditions like hot dry winds and low humidity cannot be controlled. But conservation practices and management techniques can be used that consider climatic conditions in the Northern Great Plains.

Topography and Field Size

The field size and lay of the land affect wind erosion. Erosion is usually greater in fields that are large or contain knolls than it is in narrow flat fields. Reducing field width, planting shelterbelts and other management practices must be used to reduce wind erosion.

Surface Roughness

Field roughness affects soil erosion in two ways. First, the miniature hills and valleys formed by tillage reduce the force of the wind at the surface and trap moving soil. Second, soil clods serve as protection to individual soil particles more susceptible to wind erosion.

Vegetative Cover

A vegetative cover of growing plants or plant residue is effective wind erosion control if there is a high percentage of groundcover or, in the case of shelterbelts, if there is adequate height.

Individual Management

Basically, the prevention of wind erosion depends on understanding how erosion occurs and implementing proper conservation management practices. Any protective practice selected should reduce the force of the wind at the soil surface and trap moving soil. Conservation options include strip cropping, windbreak and stable area plantings, crop selection, high residue tillage management, as well as other practices.

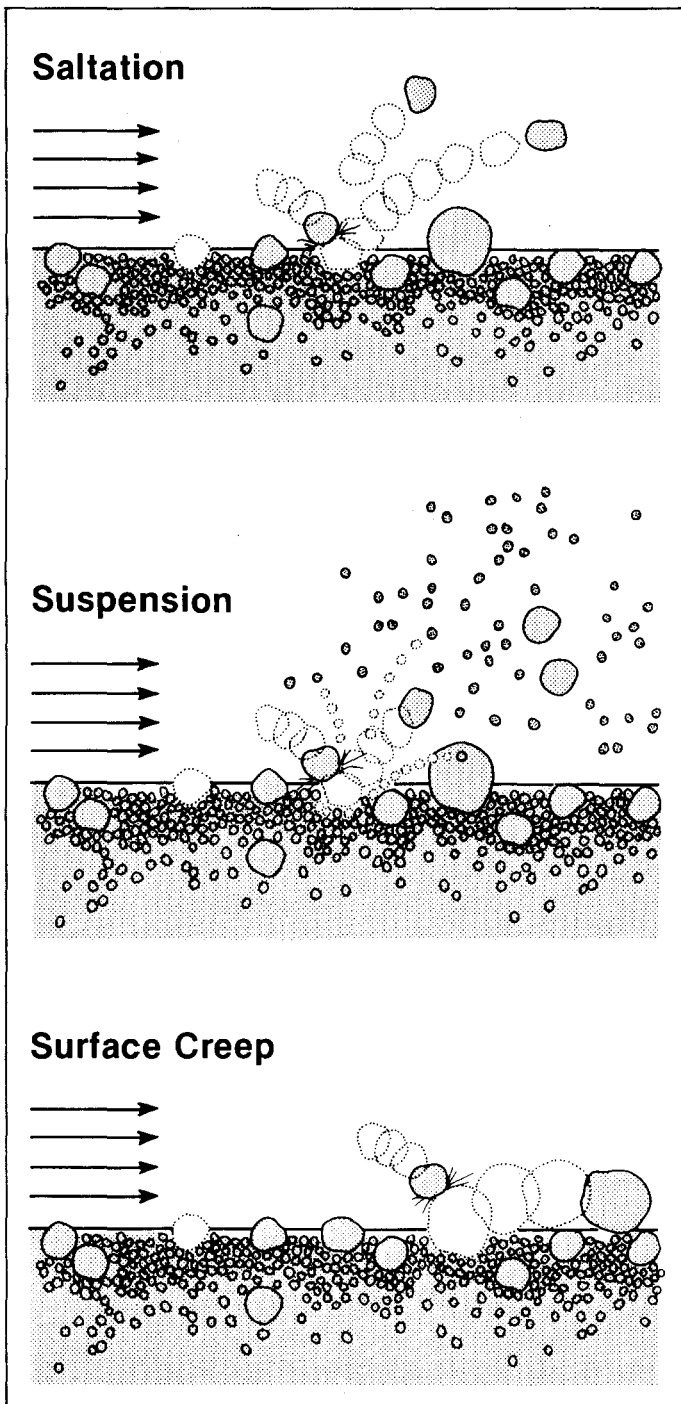


Figure 4. Types of wind erosion.

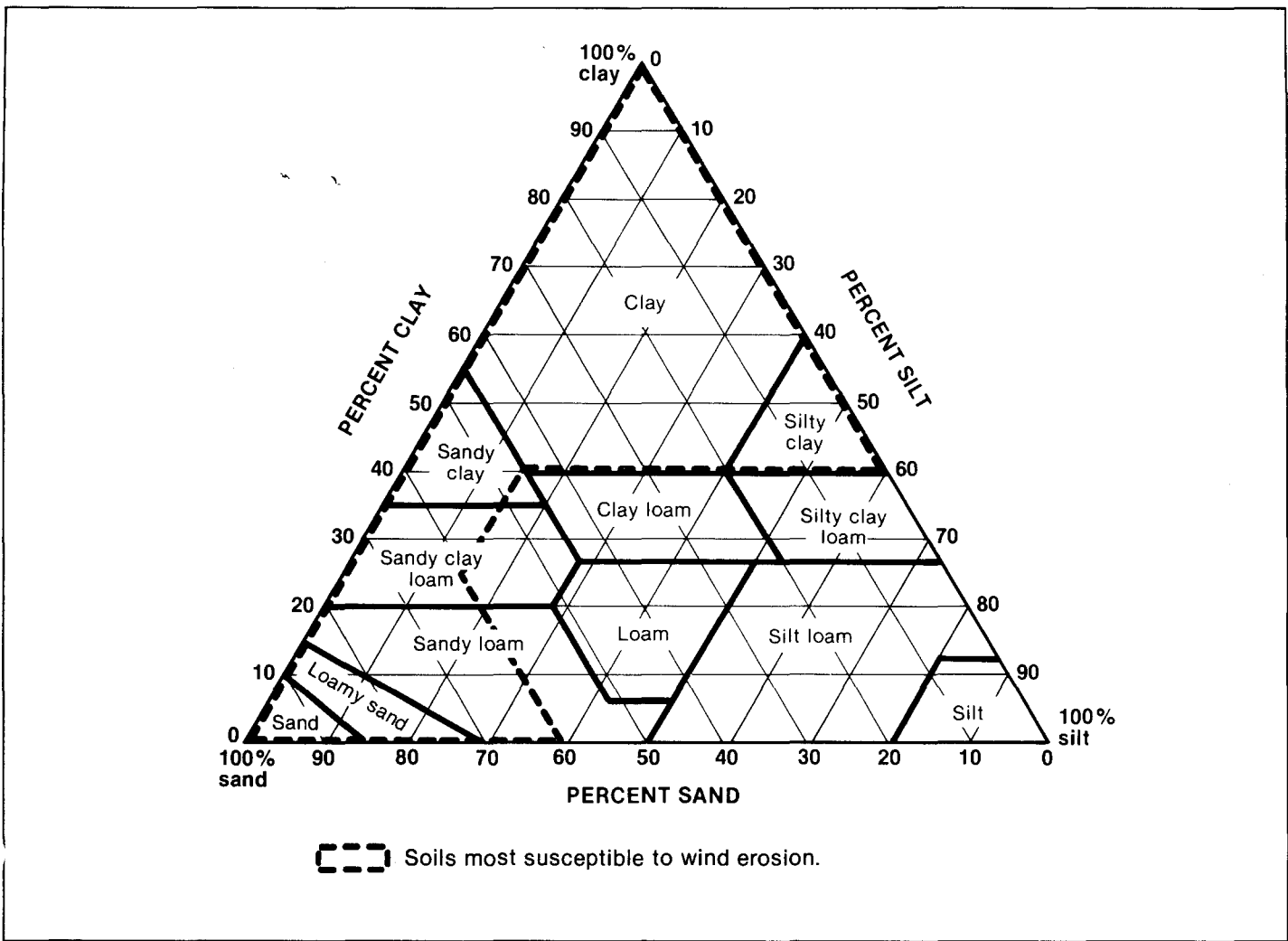


Figure 5. Soil textural classes based on soil particle size.

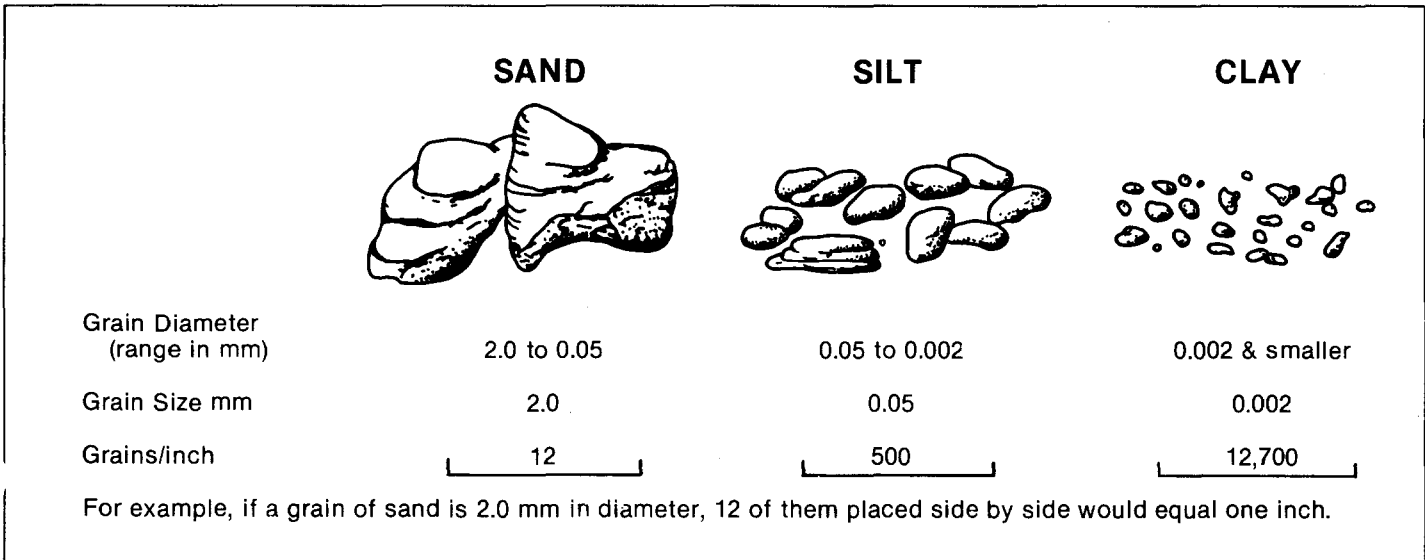


Figure 6. Comparison of individual soil particles.

WATER EROSION

The water erosion process starts with detachment of soil particles from the soil mass and transportation of these particles to a new location. This process begins as the first raindrops hit bare soil. Raindrops hit the soil surface with an explosive force (Figure 7a). In a high intensity rainstorm soil particles can be lifted as high as three feet into the air and moved five feet from the area of contact. The soil found attached to the side of a house or barn after a rain gives evidence of the erosive power of raindrops.

The transportation of soil particles by water first requires particle detachment from the soil mass. Slow-moving water, by itself, is not very erosive. But as slopes increase in steepness or length the volume and velocity of runoff also increases, causing more erosion (Figure 7b). Larger volumes of high velocity water can carry greater amounts of soil that in turn scour away at the edges and bottom of a stream bed.

Massive soil loss caused by water erosion can occur when a uniform shallow runoff combines with the force of falling raindrops (Figure 7c). Although this type of erosion may not leave the dramatic visible signs of high velocity stream erosion, it can move enormous amounts of soil down-slope. Over relatively short periods of time hilltops become less productive as valuable topsoil is floated downhill.

Stages of Water Erosion

Water erosion is divided into six progressive stages.

Splash erosion is caused by raindrops detaching soil particles and is usually associated with other types of erosion.

Rill erosion forms the tiny streams or rills caused by the gathering of water, especially in downhill rows left by tillage equipment. They are usually seasonal, a few inches deep, and filled in by normal tillage.

Interrill erosion is commonly called sheet erosion and occurs when areas of loose soil are floated downhill in a large shallow sheet of water.

Ephemeral gully erosion forms small field gullies, usually less than one foot deep but up to several feet wide. They reappear yearly, are passable to farm equipment and are usually filled by tillage operations.

Gully erosion is the development of a true permanent gully that is usually not passable to farm equipment and cannot be filled by normal tillage. This erosion progresses upstream as falling water undercuts the head of the gully.

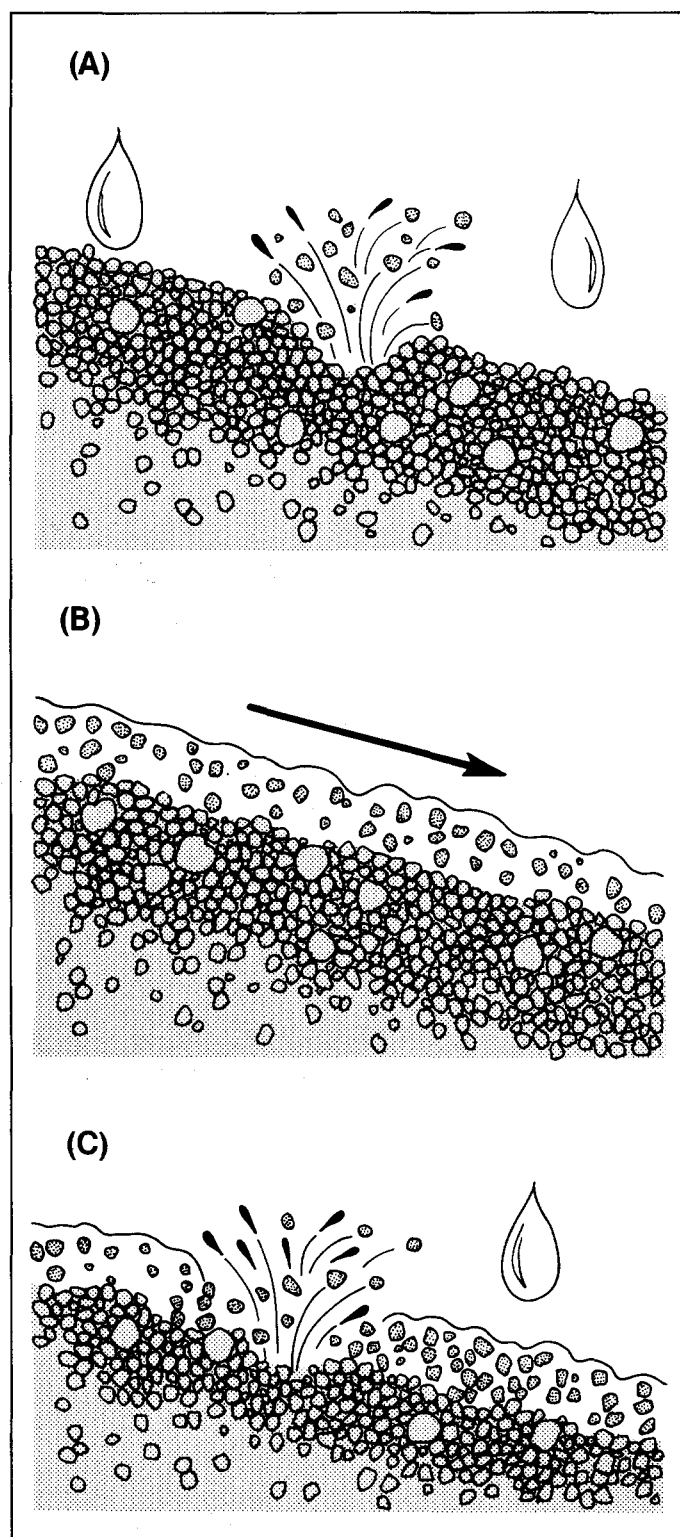


Figure 7. The water erosion process. (A) Raindrops on bare soil. (B) Water flow over bare soil. (C) Soil erosion caused by combined water flow and raindrop action.

Streambank erosion occurs when moving water within a river or stream erodes the sides of the channel, eventually causing collapse of the upper bank.

Factors Affecting Water Erosion

The following factors affect the occurrence and severity of water erosion problems.

Climatic Conditions

Rain, snow and freezing temperatures are major climatic factors that affect soil erosion in the Northern Great Plains and the Pacific Northwest. The intensity and duration of rains may be the two most important factors affecting water erosion. Snow melt or rain on frozen ground can be especially erosive on sloping land.

Soil Erodibility

Certain soils because of their naturally occurring properties are more susceptible to water erosion. It is almost impossible to change the chemical and physical properties of soil, so wise soil management techniques must be used to reduce water erosion.

Topography

The topography or slope of land affects the volume and velocity of water runoff. Altering slope, in many situations, is not economical. But producers should seriously consider contour strip cropping, terracing or other management options that affect the rate of water runoff on sloping ground.

Soil Cover

Soil cover refers to vegetative growth or plant residues protecting the soil surface. This plant material protects the soil surface from the erosive impact of raindrops and slows downslope water movement.

Individual Management

Once a producer understands how water erosion occurs, management practices can be put into place that reduce valuable soil loss. Producers should consider implementing residue management, tillage operation changes, use of grassed waterways, use of contour strip-cropping, terraces and soil saving operations. Fortunately, tillage and residue management practices that control wind erosion are also effective for controlling water erosion.

CONSERVATION PRACTICES FOR WIND AND WATER EROSION

Only when a producer understands how wind and water erosion occur, and how erosion affects each field, can he implement practices that will reduce soil loss. Wind and water erosion require specialized control practices, but sometimes these overlap.

Vegetative Cover

Maintaining a vegetative cover is the best control for wind and water erosion. For annual crop producers vegetative cover may be either growing plants or plant residue left on the soil surface.

Options for providing **growing plant** vegetative cover include:

- 1) crop rotations that include better soil-protecting annuals or perennials,
- 2) cover crops for wind protection and snow trapping,
- 3) closer planting of row crops to provide more ground cover,
- 4) special vegetative plantings in highly erodible areas.

A producer with severe soil erosion problems should consider permanent vegetative cover such as pasture, rangeland, trees, wildlife plantings or CRP.

Plant residue management requires producers to evaluate their tillage operations. Research indicates that maintaining 30 percent crop residue on the soil surface reduces soil loss by 60 percent (Figure 8).

Residue Management

Residue amounts on the soil surface can be increased with the following management program changes:

- 1) delay the time of tillage,
- 2) reduce the number of tillage trips,
- 3) change the type of tillage operation (Table 1).

Residue materials such as straw, manure or other mulches can also be hauled to specific sites to control soil detachment and reduce wind and water erosion.

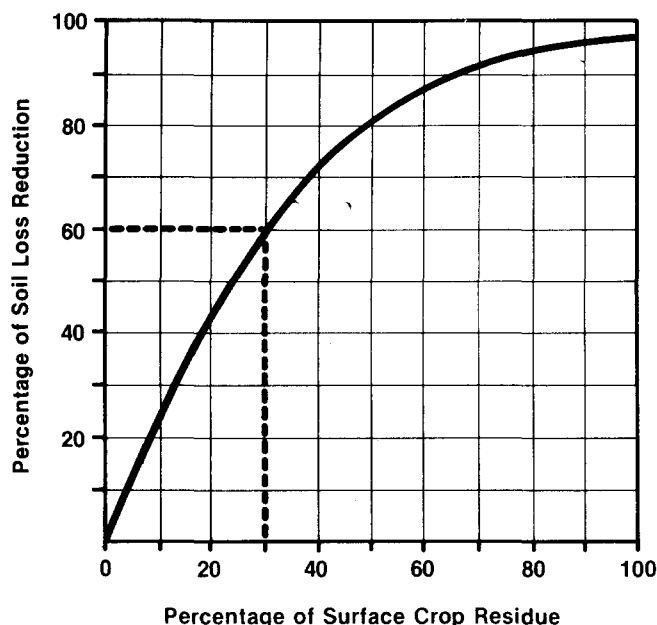


Figure 8. Percentage reduction in soil loss as a percentage of surface crop residue. For example a 30 percent surface cover of crop residue reduces soil loss by 60 percent as compared to the same field with no crop residue.

Table 1. Percentage of residue left after various tillage operations.

Tillage Operation	Percent Residue Left After the Operation
Spraying (for chemical fallow)	100
Undercutters, Sweeps (24" or wider)	90
Cultivator (14" - 22" low crown shovels)	85
Cultivator (8" - 12" shovels) Rodweeder with shovels	80
Cultivator with chisels or spikes	75
One-way disk (18" - 22" disks)	60
Tandem disk, Off-set disk	50
One-way disk (24" - 26" disks)	50
Moldboard plow	10
Overwintering (no tillage)	70-80

EXAMPLE: A field with 65% residue cover.
 FIRST TRIP: cultivator with spikes - 75%, (.65 x .75) = 45% residue cover remaining.
 SECOND TRIP: 12" shovel cultivator - 80%, (.45 x .80) = 36% residue cover remaining. Residue amounts would continue to be reduced by each additional tillage operation.

CONTROL PRACTICES SPECIFIC FOR WIND EROSION

Wind Barriers and Stable Areas

Reduce unsheltered field distance by establishing wind barriers or stable areas to reduce the erosive force of the wind. Field protection width is usually equal to ten times the height of the wind barrier as indicated in Figure 9. Barriers can be trees, shrubs, field crops, snow fences, plastic screens or other natural or man-made materials. Stable areas are usually vegetated plantings less than three feet tall. They reduce erosion by holding the soil they cover in place and preventing the spread of avalanching, as illustrated in Figure 10. Strip cropping is an example of stable area planting.

Soil Ridging

Soil surface ridging is most effective in controlling wind erosion if two conditions are met:

- 1) Ridges are at a 90 degree angle to the prevailing wind.
- 2) Equipment is designed and operated to leave ridges with a 1 to 4 ratio between ridge height and ridge width (Figure 11).

CONTROL PRACTICES SPECIFIC FOR WATER EROSION

The first defense against water erosion is a vegetative cover to reduce raindrop impact and decrease soil detachment. The following conservation practices are designed to reduce water erosion by controlling the volume and velocity of moving water.

Grass waterways are man-made or natural waterways planted into permanent vegetation to carry away concentrated water flow. They do not prevent erosion on nearby slopes.

Contour strip cropping is the planting of row crops, small grains or sod formers in an alternating pattern across the slope of the land.

Terraces are channels or embankments that alter one long slope into a series of short slopes. The erosive force of moving water is reduced by shortening the slope. The terrace channel slope also reduces water velocity for safe discharge to a waterway or other protected discharge site.

Diversions are large terrace-like structures built at the bottom of a permanently vegetated slope to direct runoff water from cropland located near the base of the slope.

Sediment and water control basins are small dam-like structures built in waterways to slow heavy runoffs.

Grade stabilization structures are special man-made structures designed to prevent gully erosion when water is rapidly moved to a lower level.

CONSERVATION TILLAGE PRACTICES

The Conservation Technology Information Center (CTIC) in its 1988 national survey of conservation tillage practices shows that of North Dakota's 17,201,366 reported acres, over 20 percent is in some type of conservation tillage (Table 2).

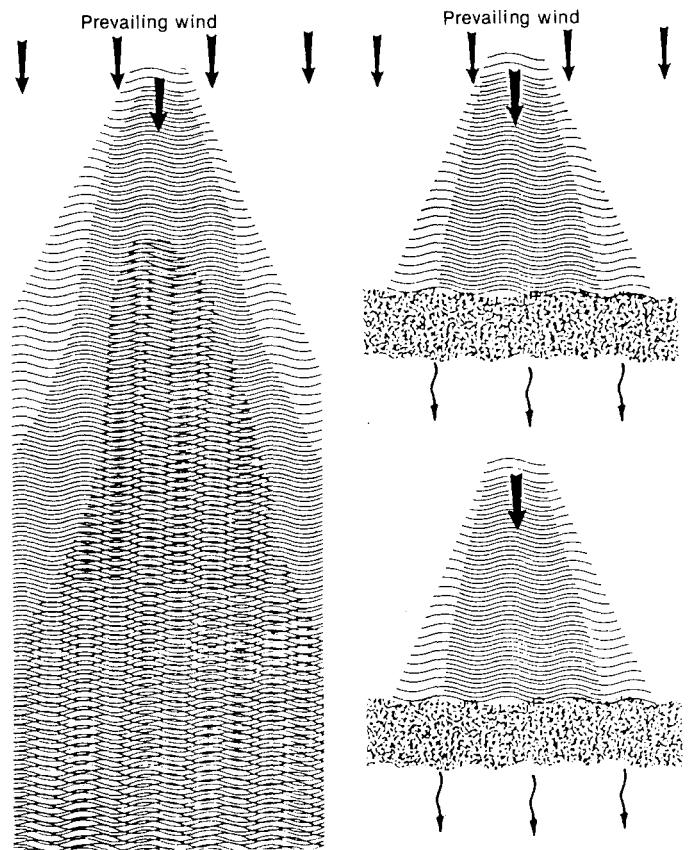


Figure 10. Soil avalanching in unprotected field and field with barriers or stable areas.

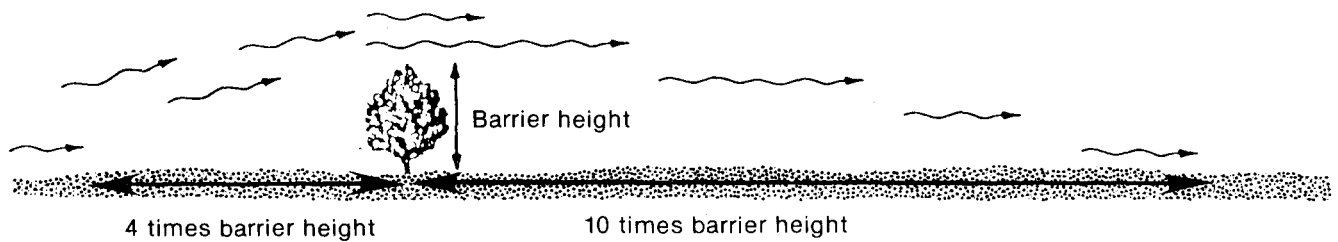


Figure 9. Barriers protect soil for a distance of 4 times the barrier height on the leeward side and 10 times the barrier height on the windward side of the barrier.

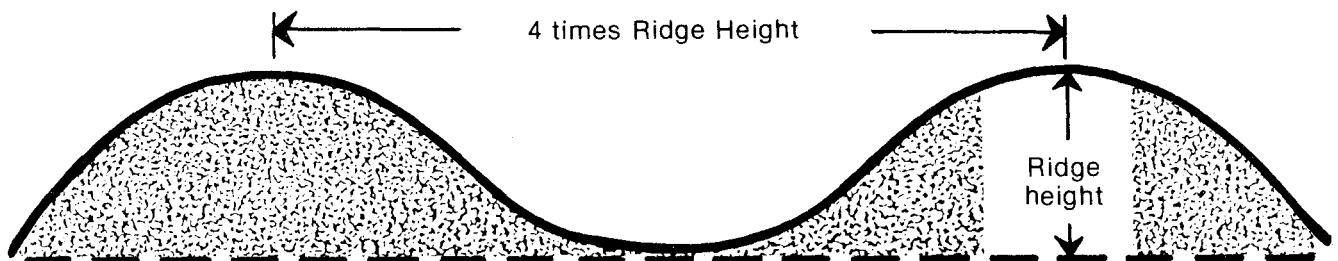


Figure 11. Soil surface ridging with 1 to 4 ratio between ridge height and ridge width.

Table 2. Percentage of conservation tillage by type in North Dakota, 1988.

Type	Percent
no-till	2.00
ridge-till	.13
strip-till	.02
mulch-till	10.61
reduced-till	7.43
Total	20.19

While conservation tillage comes in many forms, all forms fit one of the following commonly accepted definitions:

No-till is direct planting in undisturbed residue from the previous crop.

Ridge-till is direct planting on undisturbed ridges that have 1 to 2 inches of the top removed at planting. The ridges are rebuilt by cultivation and are 4 to 6 inches high.

Strip-till is planting in a previously undisturbed field in tilled rows that leaves about one-third of the surface disturbed. Tillage is performed by roto-tilling or in-row cultivation.

Mulch-till is planting into a previously disturbed soil surface. Tillage equipment includes chisels, field cultivators, sweeps and disks.

Reduced-till is any other planting and tillage operation that leaves at least a 30 percent soil cover and does not fit into one of the preceding conservation definitions.

SOIL LOSS AND ECONOMICS

Only limited economic information on soil erosion has been available to the producer because economic factors vary between counties, farms, fields and crops. For a producer with an eroding field it is difficult to place an economic value on soil loss.

Reasons include:

- Difficulty in determining the amount of soil lost. Eroded soil may be partially hidden and soon covered by plant growth or it may have been completely washed away. The old saying "out of sight, out of mind" may apply.
- The field still produces a crop. Annual soil loss in small amounts does not dramatically impact yearly crop production. Long-term crop production loss, caused by soil erosion, has been offset by technologies such as fertilizer, herbicides and new grain varieties.
- The visible signs of soil erosion seem insignificant compared to the total amount of soil in the field.
- Some producers may consider soil loss as normal.
- No exact dollar value has been placed on a ton of soil.

When a producer has difficulty placing an economic value on soil loss it is hard implementing conservation practices that have a specific dollar investment. The individual producer must view soil conservation not as a short-term expense but as long-term investment. Shelterbelts, as an example, have a substantial beginning investment but over a 40- or 50-year life, have a low yearly cost and may provide an economic advantage in crop production.

North Dakota soil management research with wheat indicates that eroded hilltops yield less bushels with lower protein and produce less crop residue than adjacent non-eroded areas with equal inputs. Hilltop areas under conventional tillage often produce a cycle of less production, less residue and more erosion. Historical research shows that these eroded areas have expanded in size over time.

Producers must select and learn to manage conservation practices that provide the best soil protection while maintaining long-term farm productivity.

SUMMARY

Soil and water are vital natural resources. Without them economic development, political stability and our very existence are at risk. Concern about the care we've given these resources has led to new initiatives and legislation. Agricultural producers and others in the agricultural community **must** know how these actions affect them.

Soil erosion prevention requires a producer to first understand how wind and water erosion occur. Next, determinations must be made of how erosion affects each field. Only then can proper conservation practices be applied. Soil conservation technical assistance can be obtained by contacting your local SCS office.

Soil loss can be greatly reduced if a protective cover of growing plants or plant residue is left on the soil surface. Producers can provide this cover by using proper crop rotations, planting cover crops, developing special area plantings, delaying tillage, reducing the number of tillage trips or changing the type of tillage operations.

Soil conservation has played an important role in history yet soil erosion can be found all across the country. Although there are many reasons why erosion is still a problem, public concern and legislative action have given soil conservation renewed importance. It is the responsibility of those dependent on the soil to make sure that this important resource is available not only for this generation, but for generations to come.

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