Soil Erosion and the Iowa Soil 2000 Program

In the spring of 1980, the Iowa General Assembly enacted comprehensive legislation that specifies long-term objectives concerning erosion of topsoil. This legislation established what is referred to as the "Iowa Soil 2000 Program." The primary objective of this program is reduction of excessive erosion from all land within the state by the year 2000. To achieve this goal in an orderly and timely manner, the Iowa General Assembly developed legislation that includes educational, financial, and technical assistance.

The program evolved from a series of hearings conducted by a legislative interim study committee in 1979 at several locations across Iowa. The purpose of the legislative study committee was to review and strengthen the existing Iowa soil conservation program.

This publication describes alternatives that landowners and operators can use to meet goals of the Iowa Soil 2000 Program.

Soil erosion is a natural process. Most forms of agriculture practiced on sloping landscapes increase the erosion potential, which is commonly called accelerated or excessive erosion.

Soil properties found in a soil profile are a result of the parent material the soil was formed in and the weathering environment present during soil development. Thus, provided a stable environment and sufficient time, soils have the ability to renew their properties. When a soil is experiencing accelerated erosion, however, removal of renewed soil properties occurs faster than renewal rates. In Iowa, it takes approximately 30 years or more to develop 1 inch of topsoil under ideal conditions where erosion is very low. This would be the equal to about 165 tons per acre. Therefore, tolerable soil losses range from 2 to 5 tons per acre per year for different soils.

Societal Concerns

Erosion reduces the natural productivity of Iowa's soils while also polluting the water resources. More Iowans are becoming aware of this as the soil erosion problem has become a major public issue. As a result, many Iowans are voicing their concern about soil erosion. Unfortunately, just being concerned about soil erosion is not enough. Excessive soil erosion can be controlled. Farmers and other land users must continue to effectively use soil and water conservation practices and develop a soil stewardship ethic.

It is easy to blame the farmer for Iowa's soil erosion problems, but this group of land users is among the strongest advocates of soil conservation. Excessive soil erosion occurs for a number of reasons beyond the immediate control of the farmer.

Iowa's farmers are under increasing pressure to produce more grain for export while also meeting demands on their land from nonagricultural uses. The farmer is often put in the difficult position of having to produce more from existing land resources to offset the rapidly increasing prices of farm inputs such as fuel, chemicals, and machinery. In addition, record land prices and soaring interest rates often restrict the ability of the farmer to invest in conservation.

Overall, one can conclude that there are a number of social and economic factors that are causing excessive erosion to occur while also limiting the farmer's ability to act on stewardship beliefs.

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Erosion Process

Soil erosion is the detachment and movement of the mineral particles and organic material of the soil through the action of water or wind.

Soil erosion by water generally begins when raindrops and their splash strike bare or incompletely vegetated soil on sloping land. Unless the soil surface is protected by vegetation, a surface mulch, or some other type of covering, raindrops and splash detach soil particles. Some of these particles move downslope in the runoff that occurs when rainfall exceeds the capacity of the soil to absorb it. When runoff concentrates in small, natural depressions or in marks left by farm implements, networks of small channels or rills begin to form. Once rilling begins, it increases rapidly as small channels are widened and deepened. Continued rill erosion can result in large channels that cut through the topsoil and into the subsoil. Not all of the soil eroded by water leaves the field to enter surface water courses. Some of it is deposited at the bases of slopes, in depressional areas, or in areas with greater vegetative cover.

Soil erosion by wind occurs when the force of wind blowing over unprotected soil is great enough to detach soil particles. These detached particles are blown against other soil particles, to further accelerate the erosion process. Soil particles too large to be carried by wind are skidded along the ground surface by the impact of other bouncing particles. These particles move with the wind until stopped by a fence, road, ditch, strip of vegetation, or other obstruction. Fine soil particles are lifted into the air and carried by the wind to cause air pollution. These are deposited elsewhere, often far from the source, as the winds subside.

Soil erosion occurs in two steps: **detachment** of soil particles by raindrop impact, splash, flowing water, or blowing wind and **transport** of detached particles by splash, flowing water, or blowing wind. Soil erosion is a physical process requiring energy, and its control is based on the dissipation and reduction of energy involved in detachment and transport. Detachment energy can be dissipated by protecting the soil surface with vegetation or a mulch or plant residue. In addition, soil and crop management practices that increase or maintain soil organic matter levels can be effective by maintaining or increasing the ability of soil to resist erosion forces.

Transport energy for water erosion can be controlled by reducing the amount and velocity of runoff. Transport energy for wind erosion can be controlled by reducing wind velocity near the surface and manipulating the soil to bring up clods large enough that will resist movement by wind.

Consequences of Erosion

Soil erosion and soil productivity are intricately related and cannot be easily separated. Erosion of any soil usually results in a net decrease of the long-term inherent productivity of the soil.

Soil erosion affects long-term productivity by reducing tilth and the soil's water holding capacity. In particular, long-term productivity is decreased by removal of plant nutrients and organic matter from the soil surface horizon, by removing the fine silt and clay sized-particles that related to a soil's ability to hold plant available water and provide nutrients to plant roots, and by decreasing water infiltration into the soil, which increases water runoff.

In Iowa, the effect of soil erosion on long-term productivity can be measured by changes in three properties of the soil profile. These are: (1) topsoil thickness; (2) rooting depth, which relates to the plant available water capacity of a soil; and (3) depth to maximum clay content in the soil profile. A decrease in topsoil thickness usually results in the maximum clay content being closer to the surface in eroded soils.

The productivity of some soils is not as sensitive to erosion as other soils. The productivity of those soils with deep rooting potential, formed in permeable parent materials with favorable subsoil characteristics, will not be adversely affected by successive minor increments of erosion. In western Iowa, for example, many upland soils have these characteristics. Crop yields may be somewhat lower on these eroded soils but with above average management, yields from eroded and uneroded sites will be similar.

The productivity of soils with limited rooting depth potential and slowly permeable subsoils will be adversely affected by excessive erosion over a long term. In southern Iowa, for example, many upland soils have these characteristics. Crop yields on these soils will be significantly lower when erosion has occurred. A high level of management will not compensate for lost yield potential.

The productivity of fragile soils, those soils shallow to bedrock or coarse sands and gravels, also will be adversely affected by excessive erosion. In northeastern Iowa, for example, many upland soils are classified as fragile. Crop yields on these soils will be very low when excessive erosion has occurred due to the lack of rooting depth. Management cannot compensate for the lack of soil material.

A portion of the soil eroded from fields and much of the sediment derived from the stream bank erosion is carried downstream and can cause site problems. Sediment deposition can cause: (1) deposition of low quality sediments on flood plains that can result in loss of agricultural productivity; (2) reduction in storage of water reservoirs; (3) clogged ditches and culverts; (4) added cost of water treatment to control turbidity in public water supplies; (5) degradation of channels used for drainage of agricultural lands and roads; (6) destruction of aquatic habitat; and (7) loss of recreation and aesthetic value as a result of muddy water flowing in streams.

Sediment increases the turbidity of water, which can destroy fish populations. Sediment is also a carrier of chemical pollutants. Soil particles can absorb plant nutrients, pesticides, and toxic metals that may, in turn, cause water pollution problems. Many pollutants are attached to sediment particles because of the high absorptive capacity of the sediments. As much as 90 percent of the total loss of nitrogen and phosphorus from agricultural watersheds is associated with the sediment carried by runoff water.

Soil erosion affects pesticide transport in a watershed. Many pesticides enter waterways attached to soil particles.

Erosion Potential

An erosion sensitivity map of Iowa is shown in figure 1. This map groups the erosion of Iowa cropland into four major soil erosion potential categories: least, slight, moderate, and severe. This classification allows a statewide comparison of potential erosion, but should not be used to determine the erosion potential of a specific tract of land.

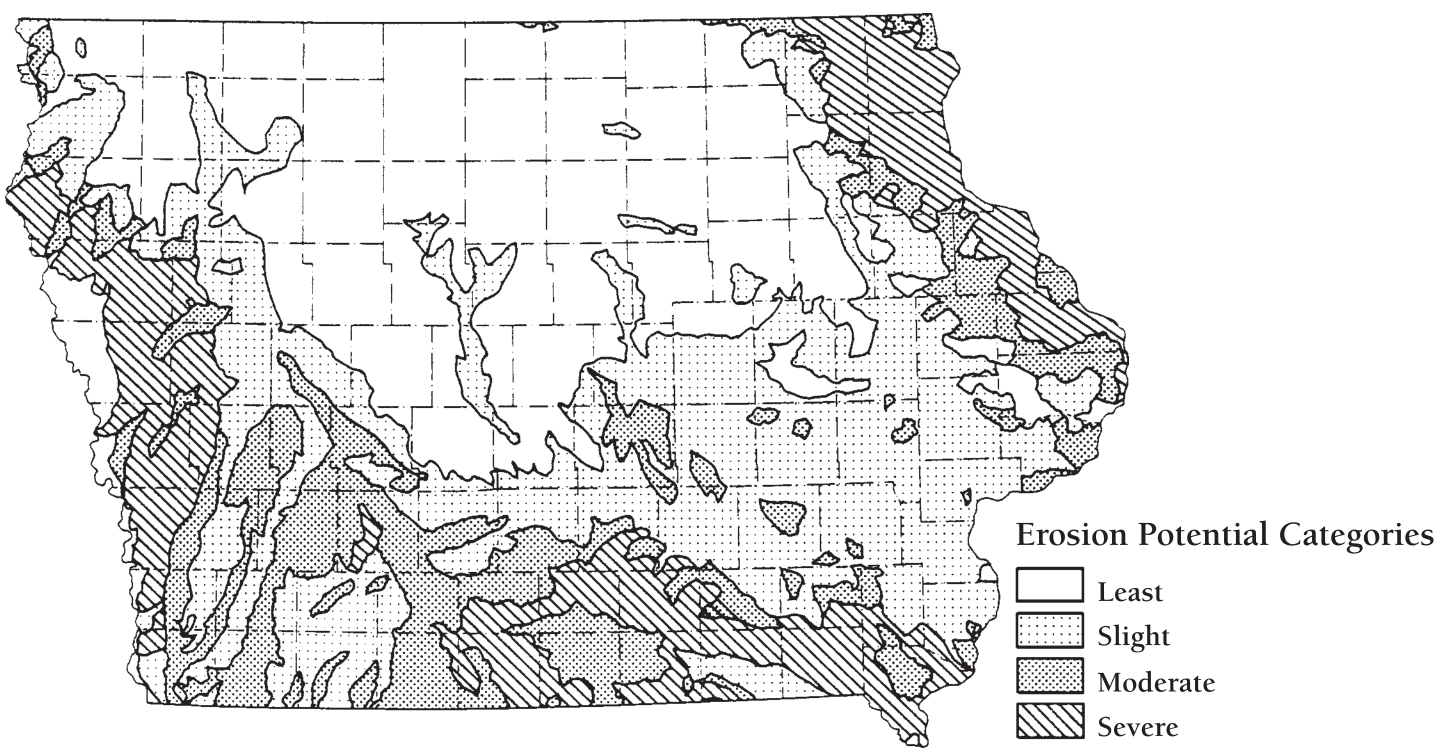
Three major cropland areas having severe erosion potential are identified in western, southern, and northeastern Iowa.

The western Iowa area includes upland soils formed in deep, friable loess up to 100 feet or more in thickness, which has subsoil material favorable for plant root penetration.

The southern Iowa area includes upland soils formed in loess of less than 8 feet deep on broad level summits over slowly permeable subsoils. Upland soils located on sideslopes are formed in paleosols or clay loam till. Most upland soils in this area have subsoils unfavorable for plant root penetration.

The northeastern Iowa region includes upland soils formed in loess on narrow ridge-tops. Loess thickness on ridge-tops is variable, ranging from 2 to 20 feet. Parent material on sideslopes may be 2 feet or less of loess or till, or

Figure 1. Erosion potential categories of Iowa cropland. Categories derived from Universal Soil Loss Equation calculations for sub-watersheds using fixed physical factors of rainfall, soil erodibility, slope steepness, and slope length under fallow conditions with no conservation practices. (Source: Modified from Erosion Sensitivity Map prepared by Iowa Department of Soil Conservation, 1978.)



bedrock. Many soils in the severe erosion potential area of northeastern Iowa are designated fragile soils due to the shallow depth of the plant rooting zone above bedrock.

The erosion potential categories shown in figure 1 do not mean that all land areas within a specific category have identical erosion hazards. Some land areas may have greater erosion potential than shown, while other land areas may have less.

The potential for soil erosion changes across landscapes. Different soil types generally have different potential soil loss values. Changes in slope length and steepness will result in differences in the erosion potential even for the same soil type. In general, if the **slope length** is doubled, the erosion potential increases one and one-half times. If the **slope steepness** is doubled, the potential increase in movement of soil particles is two and one-half times. In a local area, therefore, the potential soil loss usually differs from field to field as well as among farms.

Erosion Control Practices

For a given tract of land, an operator has little control over climate (such as rainfall or wind characteristics), the soil, and the topography or slope that affect soil erosion. However, the impact of these factors on soil erosion can be reduced by conservation practices. Where the erosion potential is low, the use of a single practice can provide adequate control. In most instances, however, a combination of practices will be necessary to provide the desired levels of erosion control. These practices include crop rotation, residue management, soil fertility management, timing of field operations, row spacing, contouring, strip cropping, terracing, grassed outlets and waterways, sediment control basins, and land use changes.

Crop Rotation

Erosion is low when the land is covered by permanent pasture or meadow. Sod-based rotations control erosion in areas adapted to meadow crops. Soil loss from a well-managed meadow is negligible; and, when the sod is plowed under, residual effects improve infiltration and leave the soil less erodible.

With good fertility management, average annual soil losses from a 5-year rotation of 3 years of corn, small grain, and meadow is less than half that of continuous cropping to corn. Additional erosion control can be achieved by planting the row crop directly into the sod instead of plowing under the meadow crop.

Table 1. Relative erosion hazards of selected crop sequences. (Continuous corn=100.)

Crop sequence[1]	Relative erosion hazard
Fallow	256
C-Sb	131
C-C-Sb	120
Continuous corn	100
C-C-C-Ox	74
C-C-Ox	64
C-Ox	46
C-C-C-O-M	49
C-C-O-M	36
C-C-O-M-M	28
C-C-O-M-M-M	26
C-O-M	18
C-O-M-M	15
C-O-M-M-M	13
C-O-M-M-M-M	10
Continuous Cover	~0

[1]C-Corn; Sb-Soybeans; O-Oats; Ox-Oats with green manure crop; M-Meadow.

Although there is much evidence that a sod-based rotation reduces erosion and that a good legume crop is a valuable source of nitrogen, the economics of modern agriculture have caused many Iowa farmers to shift to continuous row cropping, which further aggravates erosion and sediment problems. The erosion hazards of various crop sequences are determined by the proportion of close-growing crops to intertilled crops. Table 1 shows the relative erosion hazards of some common crop sequences used in Iowa.

Residue Management

Plant residues can aid in soil erosion control. Residues can protect the soil during the period after row crop harvest and before the succeeding crop has developed sufficiently to provide adequate canopy protection. Tillage operations will influence the amount and, more importantly, the distribution of plant residues on or near the soil surface.

Tillage practices that reduce the loss of soil or water as contrasted to traditional tillage systems of burying all residue and leaving a smooth surface are called conservation tillage systems. Conservation tillage systems can effectively control erosion on level to gently sloping land. On steeper lands, these tillage systems can enhance the effectiveness of other erosion control practices. The degree of effectiveness depends on the amount and distribution of residue on the soil surface and on the roughness of the resulting soil surface.

Among the many contributions of tillage implements and operations used to attain the benefits of conservation tillage, the most effective for controlling soil erosion is slot planting, or no-till. This is a once-over crop planting system where the seed is planted in a slot generally created with a coulter in an otherwise undisturbed soil surface.

This system makes maximum use of crop residue. Because of the lack of soil disturbances, however, infiltration capacity may be reduced and runoff will be relatively sediment-free because there is little opportunity for soil detachment. Slot planting reduces operator and machine hours, fuel requirements, and soil compaction caused by implement traffic.

When properly managed, conservation tillage is the most effective and least costly means of controlling soil erosion on cropland. Some form of conservation tillage can be adapted to all areas of Iowa. However, its successful use depends upon the ability of the operator to make appropriate changes that may be necessary in integrating tillage operations with other crop production concerns, especially those related to weed, insect, and disease control.

Soil Fertility Management
Improved soil fertility increases the amount of residue available to protect the soil surface from erosion. In addition, earlier and fuller crop canopy provides further soil protection.

Timing of Field Operations
Delaying tillage from fall to spring will significantly reduce soil erosion losses. This is especially critical following soybeans because of the limited amount and fragile nature of soybean residue. With fall tillage, the soil is exposed to the erosive forces of thaw and snowmelt runoff, early spring rain runoff, as well as late winter and early spring winds.

Row spacing
Where residues are present in amounts insufficient to control erosion, narrowing the rows can provide a measure of control. Narrow rows allow earlier development of a crop canopy that protects the soil from raindrop impact. The practical limits to which row spacing can be narrowed will be dictated by planting, cultivation, and harvesting equipment, and the anticipated effectiveness of chemical weed control.

Contouring
This is the practice of farming across the natural slope. This practice reduces the velocity of overland flow of water, and provides excellent erosion control for moderate rainstorms. However, it is ineffective if the capacity of the contoured rows to hold or conduct runoff is exceeded. Practicing contouring on moderate slopes, up to 9 percent, will reduce the average soil loss by 50 percent. On steep slopes or under high rainfall situations, the hazards of deep rilling are increased when row breakovers release water stored in the rows.

On long slopes, the effectiveness of contouring can be optimized by using it in combination with strip cropping, terraces, or runoff diversions.

Strip Cropping
Alternating contoured strips of sod with strips of row crop is more effective than contouring alone. The sod strips serve as filters when rows break, and much of the soil transported from a cultivated strip drops out of the runoff as it spreads within the first several feet of the sod strip. It is best adapted to areas where sod-based rotations can be used.

Terracing
This practice is more effective on long, steep slopes for erosion control than strip cropping and contouring because it permanently divides the slope into discrete segments. Although there may be soil movement within terrace intervals, most of this material accumulates behind the terrace. With some types of terraces, more than 95 percent of the transported soil remains in the terrace interval.

Terrace systems have the highest initial cost of all conservation practices. In addition, they require periodic maintenance. Terraces permit more intensive row cropping on sloping land without causing excessive erosion.

Grassed Outlets and Waterways
These are stabilized channels that receive drainage from contoured or graded rows or from terrace channels and remove excess water from the field. They are effective in controlling erosion only from such channels or drainageways. They require establishment and need to be maintained. In some soils, subsurface drains are needed to remove excess water.

Sediment Control Basins
These are short embankments or ridges and channels constructed across the slope and minor drainageways. These structures are generally used where topography is such that terraces cannot be installed and farmed with reasonable effort. In some cases, sediment control basins are necessary to reduce slope length and rate or volume of runoff.

Land Use Change
A change in use may be required on some land where agronomic, cultural, and structural measures to control erosion are often precluded by the lay of the land, economics, or operator preference. In such areas, desired erosion control can be achieved by converting cropland to permanent grass and legumes or timber.

The effectiveness of commonly used practices for controlling soil erosion is summarized in table 2.

Economic and Social Issues
Iowans have known, technologically, how to control soil erosion for many years. However, a major concern has been a lack of conserving soil through investment in terraces, less intensive

crop sequences, or production methods requiring high level management must be paid now. The benefits are earned in the future and may not accrue to individuals making the initial investments.

Farmers sell grain in a market system that does not recognize, and hence cannot reward, individual farmers for conserving the soil. A bushel of corn is the same price whether it is produced using soil conserving or soil exploiting practices. Even if society was willing to pay for soil conservation, our grain marketing system would not be able to get the message (or the money) to farmers practicing conservation.

If soil erosion is to be controlled, public action must be taken to create economic incentives that the market place is incapable of supplying. There are two major ways that public action can create these economic incentives.

The first approach relies on regulation, taxes, and subsidies. Regulations could require farmers to follow established production practices that limit erosion irrespective of their economic consequences. Soil loss taxes or subsidies could also be imposed on farmers until there were sufficient economic incentives to keep soil losses within predetermined limits. Economic incentives do not have to be punitive, however.

Table 2. Effectiveness of commonly used practices for controlling soil erosion.*

	Effectiveness for control of:			
Practice	**Water erosion**	**Water runoff**	**Sediment delivery**	**Wind erosion**
Permanent vegetation	3	2	2-3	3
Crop sequence	1-3	1-2	1-3	1-3
Strip cropping	2-3	1-2	2	2-3
Cover crops	2-3	2	2-3	3
Contouring	1-2	1-2	1	n.a.
Conservation tillage	1-3	1-2	1-2	1-3
Nutrient and pesticide management	0-1	0-1	0-1	0-1
Terraces, gradient	2-3	1	3	n.a.
Terraces, level	2-3	3	3	n.a.
Terraces, tile outlet	2-3	1	3	n.a.
Grassed waterway	1-2	0-1	0-2	n.a.
Grade stabilization structure	2-3	0-2	1-3	n.a.
Land use change	3	2	3	3

*Effectiveness scale:
0=not effective
1=slightly effective (less than 10% reduction)
2=moderately effective (11-50% reduction)
3=substantially effective (51-100% reduction)
n.a.=not applicable

Source: "A Technical Assessment of Nonpoint Pollution in Iowa." College of Agriculture, Iowa State University. March 1978.

Farmers could be subsidized to reduce soil erosion. Subsidies might take several forms. Farmers could be paid per ton of soil not eroded per acre. They could receive payments for adopting certain cropping practices or rotations. The government could make low-interest loans or set up cost-sharing procedures to encourage construction of terraces and other conservation practices.

The second approach relies on investing in research and education to provide advances in crop production practices that reduce the erosion problem. These advances in crop production practices would have to offer farmers economic returns that meet or exceed those of practices that contribute to excessive soil loss. Research and education efforts in conservation tillage are examples of this second approach.

There is no perfect solution to soil erosion. Effective public action will require a number of methods: regulation, financial assistance, research, and education. The success of these efforts will be determined by the ability of program administrators to deal with the equity and efficiency issues involved in conserving soil and water resources.

Impacts on the Farm Business

Adjusting crop production practices to control erosion will in some cases require adjustments to existing leasing, contract sale, or rental arrangements as well as other business practices. Implementing a conservation agreement may change production costs, returns, and risks borne by the landlord or tenant. For example, the underlying criteria for evaluating leases is still valid; revenue should be shared in proportion to the landlord's and tenant's contribution. The specifics of all business arrangements need to be considered during the implementation of the Iowa Soil 2000 Program.

Table 3. Definition of pertinent terms.

Agricultural land—Land suitable for farming.

Farming—The cultivation of land for the production of agricultural crops, horticultural crops, livestock, poultry, eggs, or milk.

Farm unit—A single contiguous tract of agricultural land, or two or more adjacent tracts of agricultural land located within a soil and water conservation district upon which farming operations are being conducted by a person who owns or is purchasing or renting all of such land, or by his or her tenant or tenants. If a landowner has more than one tenant, the land on which farming operations are being conducted by each tenant constitutes a separate farm unit. However, land owned or being purchased by the same tenant may, at the discretion of the commissioners of the soil and water conservation district, be considered as two or more farm units.

Contiguous tracts—Two or more tracts of land in the same legal section that have separate legal descriptions having at least a partially common boundary line between successive tracts.

Adjacent tracts—Two or more tracts of land in the same legal section or in touching legal sections having a common side corner between successive tracts.

Soil loss limit—The maximum amount of soil loss due to erosion by water or wind that can be allowed without causing adverse effects on soil and water resources. Soil loss limits have been established for each soil mapping unit by commissioners of every soil and water conservation district.

Iowa Soil 2000 Process

To assist Iowa soil conservation districts in achieving the goals of the Iowa Soil 2000 Program, the Iowa Code stipulates the sequential development of the Conservation Folder and the Farm Unit Soil Conservation Plan.

Conservation Folder

The Conservation Folder is a method of compiling information concerning the topography, soil composition, natural or artificial drainage characteristics, and other pertinent factors concerning a particular **farm unit**. Bold and related terms in this section are defined in table 3.

Each **farm unit** will be furnished a conservation folder by the soil and water conservation district in which the **farm unit** is located, not later than January 1, 1985, or as soon thereafter as adequate funding is available. An updated farm plan prepared for a particular **farm unit** since 1971 shall be considered an adequate replacement for the conservation folder for that **farm unit**. The soil and water conservation district will certify completion of the folder or adequacy of the existing farm plan in meeting the conservation folder requirement.

Farm Unit Soil Conservation Plan

This is a plan jointly developed by the owner, and the operator, if different from the owner, and the soil and water conservation district commissioners. The plan will be based on the conservation folder and will identify soil and water conservation practices that may be expected to control soil losses within applicable **soil loss limits**. If practical, the plan will identify alternative practices for attaining this objective. A Farm Unit Soil Conservation Plan will be prepared within 5 years after completion of the conservation folder for the **farm unit** or as soon thereafter as funds and technical assistance permit.

If the district commissioners' plan is unacceptable to the owner or operator, that person or those persons may prepare an alternative plan identifying practices that may be expected to achieve compliance with the **soil loss limit**. The plan will be submitted to the soil and water conservation district commissioners for their review and approval.

Figure 2 is a flow chart outlining the sequential development of the Conservation Folder and the Farm Unit Soil Conservation Plan.

Summary

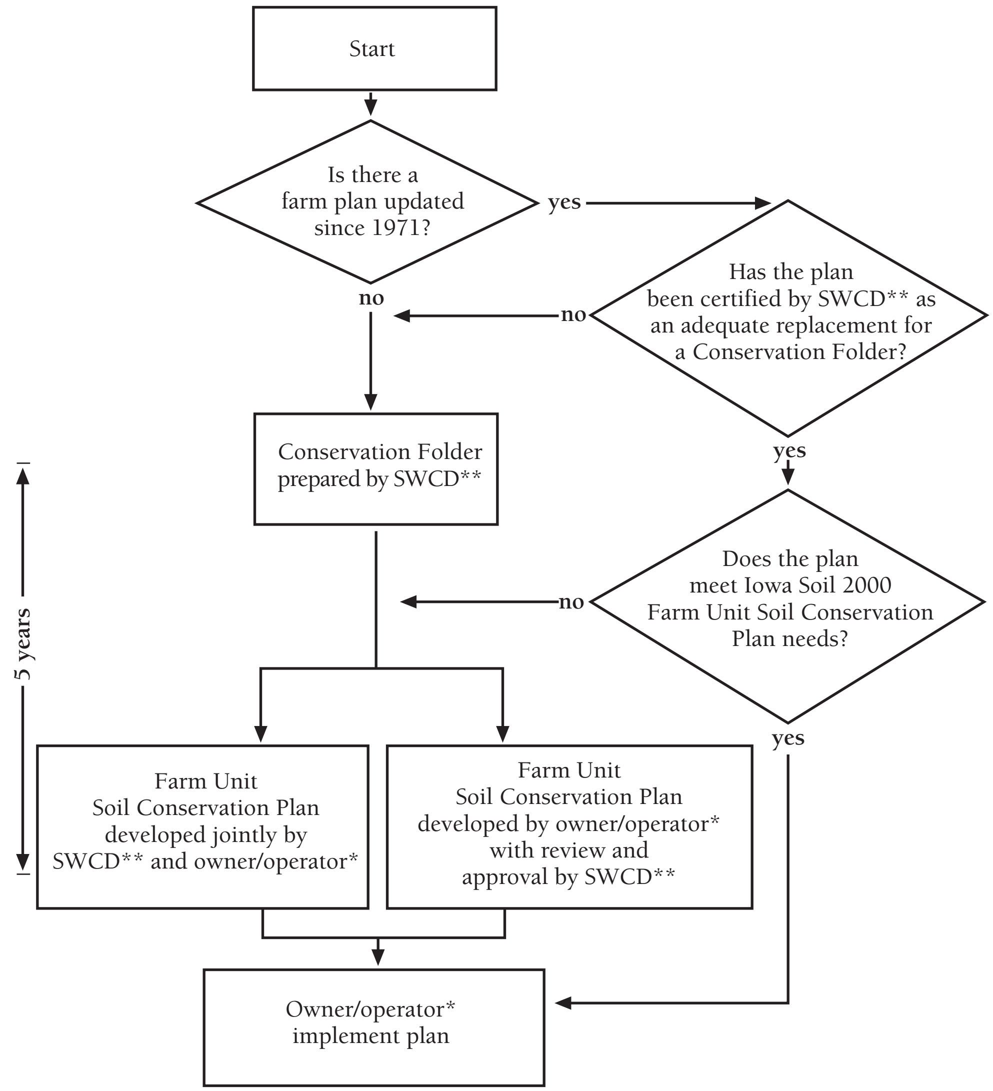
Soil erosion in Iowa is a major problem. It is estimated that the average annual soil displacement on cropland averages 9.9 tons per acre per year on more than 26 million acres planted to row crops, small grain, and forages for hay production.

The lack of economic incentives in the market place for soil conserving activities is a major obstacle to the adoption of soil conservation practices on potentially erosive lands. In addition, public funds for both cost-sharing and subsidies for soil conserving practices have been and probably will continue to be in short supply.

The Iowa Legislature recognized the need for maintaining the long-term productivity of Iowa's soil resources in view of the high potential erosion rates on cropland, the lack of economic incentives in the market place, and the scarcity of public funds for soil conserving activities. The Legislature established the Iowa Soil 2000 Program, which includes the Conservation Folder and the Farm Unit Soil Conservation Plan. The objective of this program is the development of a workable solution to soil erosion problems in Iowa.

The Iowa Soil 2000 Program will be carried out at the local level. Conservation district personnel will provide owners and operators of **farm units** pertinent soil conservation information on a timely basis. The Iowa Soil 2000 Program does not tell the landowner or operator which practices must be used. Instead, the program provides the landowner or operator with adequate information to develop an understanding and awareness of: (1) the impacts of excessive erosion; (2) the erosion on their land; (3) potential solutions for controlling erosion; (4) their obligations under Iowa law; and (5) availability of educational, technical, and financial assistance.

Figure 2. Flow chart of the necessary procedures and time table to follow for participation in the Iowa Soil 2000 Program.



*Owner/operator means the owner, and if appropriate, the operator.
**Soil and Water Conservation District.

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