they receive advice on soil and water conservation measures.

Since the 1960's, entomologists in the Extension Service, State experiment stations, and Agricultural Research Service have worked on integrated pest management systems. One of the objectives of these systems is to reduce the amount of chemicals used in insect control. At the same time, agronomists in these agencies have developed ways to use chemical nutrients so that there will be little runoff into surface water or seepage into the ground water.

SCS has worked with the Extension Service to develop recommendations in SCS's technical guides, usually one for each county, that will include information about where and when these chemicals can be used effectively, but in a manner that keeps movement to ground and surface waters to a minimum. These same technical guides also provide the basic information on soil and water conservation measures. The promise is for a better environment through greater cooperation within USDA and, hence, greater service to farmers.

Looking Forward
Concern over the environment seems to be a constant and prominent feature on the political landscapes of both the recent past and the near future. Farmers and the State and Federal agencies with which they work will live in this climate of concern. But in a larger sense the recent legislation is part of a longer quest for agriculture that fits the environment, in which the impetus for adaptation is not a response to legislation but an acknowledgment of the forces of nature.

Conservation Tillage and Environmental Issues

by David L. Schertz, National Agronomist, Soil Conservation Service, USDA, Washington, DC

The research and development of conservation tillage began in the early 1930's in the United States but did not gain popularity until the mid-1960's. Land users began accepting this practice in order to reduce soil erosion and to save fuel, time, and money, and by
1990, 26 percent of U.S. crop acres used some form of conservation tillage. The farm bills of 1985 and 1990 are expected to increase the 73 million acres currently in conservation tillage to 140 million acres by 1995.

**What Is Conservation Tillage?**
The basic principal of conservation tillage is to leave sufficient crop residue on the soil surface to significantly reduce soil erosion. More specifically, where water erosion is the primary concern, a farmer can meet the minimum requirement of conservation tillage by leaving 30 percent or more of the soil surface covered by crop residue.

Where wind erosion is the primary concern, conservation tillage requires that approximately 1,000 pounds of small grain residue equivalent be left on the soil surface during the critical wind erosion period. Leaving residue cover after harvest is the beginning of conservation tillage, but tillage operations in the spring often reduce residue to less than the amount required.

Conservation tillage includes no-till, ridge-till, and mulch-till. “No-till” means planting a crop in the undisturbed residue of an old crop; “ridge-till” means planting a crop in ridges that were developed during the growing season by cultivation and left undisturbed since harvest; and “mulch-till” is planting a crop where the total surface has been disturbed but at least the minimum required residue remains after planting. Also, where conservation tillage is used, many fields will have more than the minimum residue requirement—reducing erosion even more.

**Conservation Tillage Concerns**
Conservation tillage has not been without its critics. Some assume that additional pesticides, especially herbicides, must be used in order to obtain weed control similar to that of conventional tillage, resulting in increased surface and ground water contamination. Some believe that weed control is more difficult, crop yields may be reduced, or
more expensive equipment will be required with conservation tillage. Researchers have shown that these concerns are basically without merit.

One of the first concerns was that conservation tillage would reduce yields. However, conservation tillage has never been recommended for use on all cropland acres in the United States. By tailoring conservation tillage systems to site-specific conditions, crop yields do not decrease compared to conventional tillage; in fact, they may increase. Even if crop yields are equal, the reduction in tillage trips and savings in time will likely yield a higher net profit.

The concern that conservation tillage requires the use of pesticides, especially herbicides, can be answered by reminding those concerned that pesticides, especially herbicides, are used each year on the vast majority of the planted acres in the United States. Since only 26 percent of U.S. crops are grown under some form of conservation tillage, pesticides clearly are used on tillage systems other than conservation tillage. In fact, the majority of pesticides are applied on conventionally tilled acres.

Another concern is that conservation tillage requires the use of more pesticides than does conventional tillage. Some first-time users of conservation tillage may use more pesticides than they used under conventional tillage, but such a practice is often the result of an unfounded fear of poorer weed control or the use of a chemical burndown—which is not generally used in conventional tillage. When herbicide amounts are increased in the first few years of conservation tillage, they are often reduced as the land user becomes more familiar with the tillage system. Since herbicide incorporation is often limited in certain types of conservation tillage, the most common scenario is that the producer will change the pesticide type or the timing of

![Soybeans growing in corn residue in a no-till system of farming on a Jackson County, IA, farm. The residue helps retain water and reduces soil erosion. Gene Alexander/USDA IA-2853](image-url)
application, rather than increasing the amount of pesticide.

After experience has been gained with the system, it is not uncommon for those practicing conservation tillage to report using less total pesticides than those practicing conventional tillage. The complexity of site-specific conditions makes it impossible to generalize and say there is "more" or "less" pesticide used with either system. Pesticides are an added expense, so excess applications of them are carefully considered before use in either conservation or conventional tillage systems.

**Effects on Water Quality**

Many feel that conservation tillage increases the potential for surface and ground water contamination, primarily because of the assumed increase in the use of pesticides and application of pesticides and plant nutrients on the surface without incorporation in the soil, or with very little incorporation.

Incorporating agricultural chemicals reduces the chance of chemical runoff by surface flow. Incorporation requires additional tillage trips and buries more surface residue, thereby increasing the chance of greater soil erosion. If rainfall does not occur immediately following application, the chance for surface runoff of agricultural chemicals applied on the surface is greatly reduced.

Some chemicals applied to the surface, such as paraquat, are immediately tied up with clay and organic soil fractions and move off-site only as soil is eroded. In addition, postemergent herbicides (used in both conventional and conservation tillage) are applied to the plant foliage with very little contacting the soil surface. These types of chemicals pose little threat to surface or ground water.

The effects of macropores on soil-water movement in the soil profile, which develop under no-till, are hard for researchers to describe. The results to date of research related to the effect of

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An aerial view of stripcropping in South Carolina. Practices such as contouring, terracing, stripcropping, and use of grassed waterways are often used in combination with conservation tillage. Tim McCabe/USDA 91BW0333
macropores on ground water contamination are mixed, but work is continuing. Soils farmed with conservation tillage generally have increased soil organic matter in the upper few centimeters of the surface, especially with no-till, which results in increased biological activity that tends to tie up pesticides longer. This generally has the effect of reducing the half-life of pesticides, breaking them down faster than under conventional tillage. Pesticide solubility and soil permeability are very important considerations when planning pesticide application, especially where macropore formation is likely to occur.

In the concern over formation of macropores under no-till and the potential to facilitate the movement of soil water deeper through the profile, the beneficial effect occurring on the soil surface is often overlooked. All types of conservation tillage, especially no-till, leave significant amounts of crop residue on the soil surface after planting. This practice reduces runoff and soil erosion and decreases the potential for surface runoff of agricultural chemicals, compared with conventional tillage. Reduced soil erosion means less sediment entering lakes and streams.

The best way to curb soil erosion is through the use of permanent vegetative cover. Where row crops are grown, however, other conservation measures must be used. Conservation tillage is not a panacea for controlling erosion, but the practice warrants serious consideration when planning erosion control systems because of its effectiveness in reducing erosion. Other practices, such as contouring, terracing, strip-cropping, and grassed waterways, are often used in combination with conservation tillage.

Recent advances in herbicides have resulted in dramatically reduced amounts of active ingredients per acre. Improved post-emergent herbicides permit land users to target application only on those areas that are infested, resulting in less total amount applied compared to full-field coverage of a pre-emergent residual herbicide.

Pesticide use will of course vary from year to year depending on factors such as tillage type, crop grown, weather, and the particular pest problem that is present or anticipated. Wherever pesticides are used, however, they should be used judiciously and prudently, regardless of tillage type. Pesticides should always be applied by trained individuals who have a good understanding of the pesticides they are applying and the purpose for which they are being applied.

Conservation tillage technology will endure because it reduces erosion and cuts costs. Technological advances in tillage, plant-
ing equipment, and pesticides have been dramatic over the past two decades and should continue into the future. Many believe that growing crops using conservation tillage is more sustainable on sloping cropland than a conventional moldboard plow system that buries the protective crop residue and leaves the soil surface vulnerable to severe soil erosion.

How Research Improves Land Management

by L.D. Meyer, Agricultural Engineer, National Sedimentation Laboratory, ARS, USDA, Oxford, MS; and K.G. Renard, Hydraulic Engineer, Aridland Watershed Management Research Unit, ARS, USDA, Tucson, AZ

Productive soil is one of our Nation’s greatest natural resources, so maintaining land productivity and preventing environmental degradation from soil erosion are high-priority national goals. A century ago, essentially no soil conservation research was conducted in the United States; today America is the world leader. During the same period, American farming methods have changed tremendously, and soil erosion problems have expanded and intensified. The part that research has played in improving management of our billion acres of productive land is an important part of our agricultural history.

Rainfall and Erosion

Another key resource that makes land productive is rainfall. Between 100 million and 1 billion gallons of rain fall annually on each square mile of U.S. land. This water is essential for crop production, but it may also cause problems such as soil erosion and flooding.

Rain falls as drops averaging less than one-eighth inch in diameter, but each drop strikes the land as a tiny bomb. Every year throughout most of the United States, more than a quadrillion (1,000,000,000,000,000) drops strike each square mile of land with the impact energy of thousands of tons of TNT. The impact energy of rain falling on the State of Mississippi, for example, annually equals the energy of a thousand 1-megaton bombs or 1 billion tons of TNT.

When raindrops fall on unprotected soil, they start the erosion