

Crop Residue Management Practices

Crop residue management (CRM), a cultural practice that involves fewer and/or less intensive tillage operations and preserves more residue from the previous crop, is designed to help protect soil and water resources and provide additional environmental benefits. CRM is generally cost effective in meeting conservation requirements and reducing fuel, machinery, and labor costs while maintaining or increasing crop yields. However, improved managerial skills are often needed to capture the full economic benefits of CRM. [See box, “Benefits from Crop Residue Management” on next page.]

Crop residue management practices include reduced tillage or conservation tillage, such as no-till, ridge-till, and mulch-till, as well as the use of cover crops and other conservation practices that provide sufficient residue cover to significantly reduce the erosive effects of wind and water. These practices can benefit society through an improved environment and can benefit farmers through enhanced farm economic returns. However, adoption of CRM may not lead to clear environmental benefits in all regions and, similarly, may not be economically profitable on all farms.

With fewer trips over the fields, equipment lasts longer and/or can cover more acres. In either case, machinery own-

ership costs per acre are reduced (Monson and Wollenhaupt, 1995). In addition, the size and number of machines required decline as the intensity of tillage or the number of operations is reduced. This can result in significant savings in operation and maintenance costs. Fewer trips alone can save an estimated \$5 per acre on machinery wear and maintenance costs (CTIC, 1996). While new or retrofitted machinery may be required to adopt conservation tillage practices, machinery costs usually decline in the long run because a smaller complement of machinery is needed for high-residue no-till systems. Conservation tillage equipment designs have improved over the last decade and these improvements enhance the opportunity for successful conversion to a CRM system. Farm equipment manufacturers are now producing a wide range of conservation tillage equipment suitable for use under a variety of field conditions (Sandretto and Bull, 1996).

Reducing the intensity or number of tillage operations also results in lower fuel and maintenance costs. Fuel costs, like labor costs, can drop nearly 60 percent per acre by some estimates (Monson and Wollenhaupt, 1995; Weersink and others, 1992). If fuel prices increase, conservation tillage practices become relatively more profitable.

Benefits from Crop Residue Management

Crop residue management practices, when appropriately applied, have been shown to provide the following soil, water quality, and economic benefits:

Soil Benefits: Tillage practices that leave substantial amounts of crop residue evenly distributed over the soil surface provide several soil benefits that increase crop yields. These practices reduce soil erosion, increase soil organic matter, improve soil tilth, increase soil moisture, and minimize soil compaction. These changes can maintain or increase the productivity of many soils, especially those that are fragile and subject to damage from soil erosion or compaction (CTIC, 1996).

Water Quality and Environmental Benefits: CRM practices keep more nutrients and pesticides in the soil where they can be used by crops and help to prevent their movement into surface or ground water. Surface residues intercept nutrients and chemicals and hold them in place until they are used by the crop or degrade into harmless components (Dick and Daniel, 1987; Helling, 1987; Wagenet, 1987). In addition, the filtering action of increased organic matter in the top layer of soil results in cleaner runoff by reducing contaminants such as sediment and adsorbed or dissolved chemicals (Onstad and Voorhees, 1987; CTIC, 1996). Studies under field conditions indicate that the quantity of water runoff from no-till fields varied depending on the frequency and intensity of rainfall events. However, runoff from no-till and mulch-till fields averaged about 30 and 40 percent, respectively, of the amounts from moldboard-plowed fields (Baker and Johnson, 1979; Glenn and Angle, 1987; Hall and others, 1984; Sander and others, 1989). Herbicide contaminants in the runoff were similarly reduced by no-till and mulch-till systems (Fawcett and others, 1994; Fawcett, 1987).

Intensive tillage contributes to the conversion of soil carbon to carbon dioxide, which, in the atmosphere, can combine with other gases to affect global warming. Increased crop residue and reduced tillage enhance the level of naturally occurring carbon in the soil and contribute to lower carbon dioxide emissions. In addition, CRM involves fewer trips across the field and less horsepower, reducing fossil fuel emissions. Crop residues reduce wind erosion and the generation of dust-caused air pollution (CTIC, 1996).

Farm Economic Benefits: Higher economic returns with CRM result primarily from some combination of increased or stable crop yields and an overall reduction in input costs. The changes in both input costs and yields depend heavily on characteristics of the resource base and management (Clark and others, 1994). Yield response with soil-conserving tillage systems varies with location, site-specific soil characteristics, local climate, cropping patterns, and level of management skills. The effects of increased organic matter, improved moisture retention and permeability, and reduced nutrient losses from erosion have beneficial impacts on crop yields. In general, long-term field trials on well-drained to moderately well-drained soils or on sloping land show slightly higher no-till yields, particularly with crop rotations, compared with conventional tillage (Hudson and Bradley, 1995; CTIC, 1996).

Choice of tillage system affects machinery, chemical, fuel, and labor costs. Decreasing the intensity of tillage or reducing the number of operations generally reduces machinery, fuel, and labor costs. These cost savings may be offset somewhat by potential increases in chemical costs depending on the herbicides selected for weed control and the fertilizers required to attain optimal yields (Siemens and Doster, 1992). The cost of pesticides with alternative tillage systems is not simply related to the total quantity used. Alternative pesticides (active ingredients) and/or different quantities of the same or similar pesticides are often used with different tillage systems. Newer pesticides are often used at a much lower rate but are quite often more expensive. This complicates the prediction of cost relationships between tillage systems. When one compares tillage systems, the cost calculation must be based on the specific quantity and price of each pesticide used.

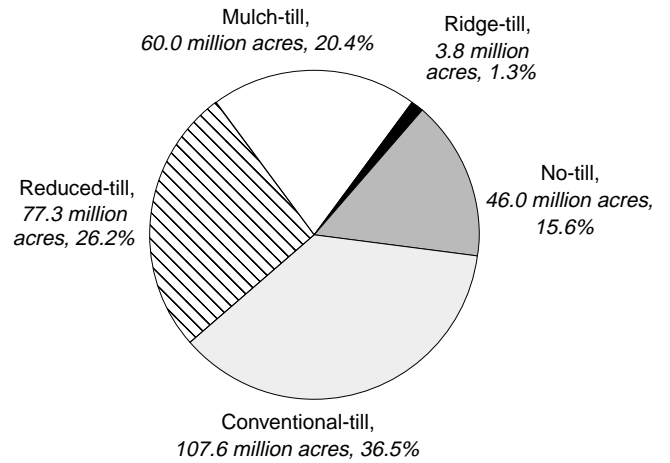
The reduction in labor requirements per acre for higher residue tillage systems can be significant and can result in immediate cost savings. Less hired labor results in direct savings, while less operator or family labor leaves more time to generate additional income by expanding farm operations or working at off-farm jobs. However, the benefits from tillage systems that reduce labor and time requirements may be greater than perceived from just the cost savings per acre. Consideration must be given to the opportunity cost of the labor and time saved. Farmers who spend less time in the field have more time for other aspects of the farm business, such as financial management, improved marketing, or other activities to improve farm profitability (Sandretto and Bull, 1996).

Crop Residue Management in the United States, 1997

Conservation tillage (no-till, ridge-till, and mulch-till), the major form of CRM, was used on almost 110 million acres in 1997, over 37 percent of U.S. planted cropland area (fig. 5A). [See box, “Crop Residue Management and Tillage Definitions,” p. 72.] Most of the growth in conservation tillage since 1990 has come from expanded adoption of no-till, which can leave as much as 70 percent of the soil surface covered with crop residues. Use of no-till practices increased as farmers implemented conservation compliance plans during 1990-95 as required under the Food Security Act and subsequent farm legislation.

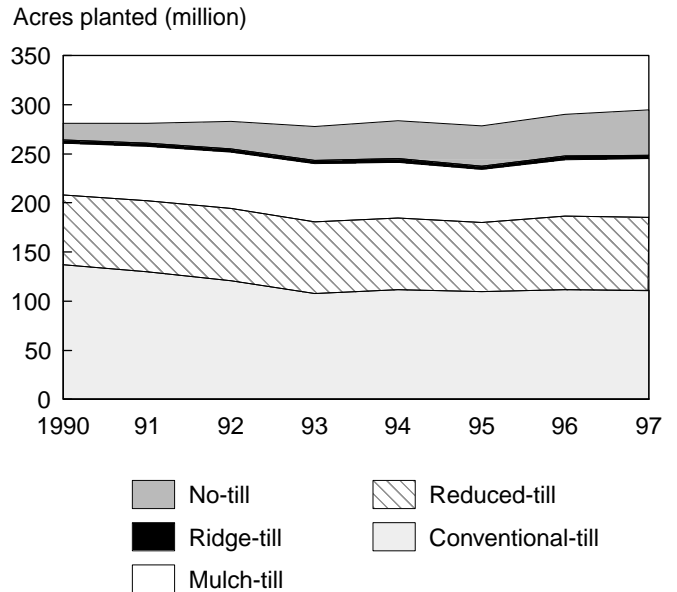
U.S. crop area planted with no-till expanded 2½ times to over 46 million acres between 1990 and 1997, while the area planted with clean tillage systems (less than 15 percent residue cover) declined by about one-fourth. Since 1990, no-till’s share of conservation tillage acreage has increased, while the share with mulch-till and ridge-till has remained fairly stable.

Figure 5A
Crop residue management in the United States, 1997



Represents 294.7 million acres planted to crops in 1997.

Trend in crop residue management use, 1990-97



Source: USDA, ERS, based on Conservation Technology Information Center data.

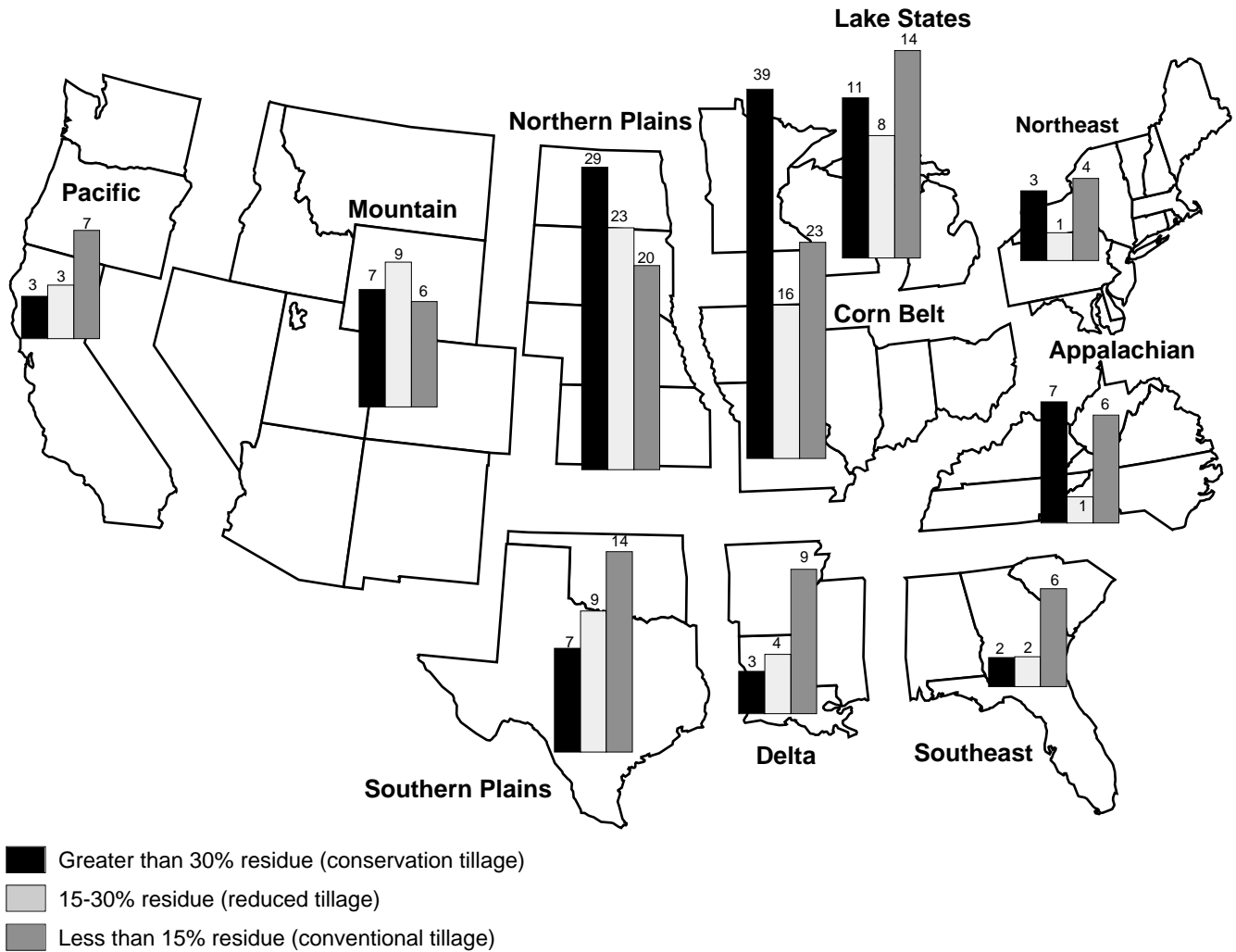
Crop Residue Levels on Planted Acreage by Regions, 1997

The Corn Belt and Northern Plains, with 51 percent of the Nation's planted cropland, account for three-fifths of total conservation tillage acres (map A and fig. 5B). These regions, plus the Lake States, Mountain Region, and Southern Plains, have substantial acreage with 15-30 percent residue cover which, with improved crop residue manage-

ment, has the potential to qualify for conservation tillage status (which requires 30 percent or more surface residue cover). Over half of the planted crop acreage in many counties in major agricultural regions used conservation tillage practices. The adoption of the practice is particularly high (exceeding 70 percent of the cropland) in the more erodible counties in Kentucky, Tennessee, Missouri, Iowa, and Nebraska.

Figure 5B

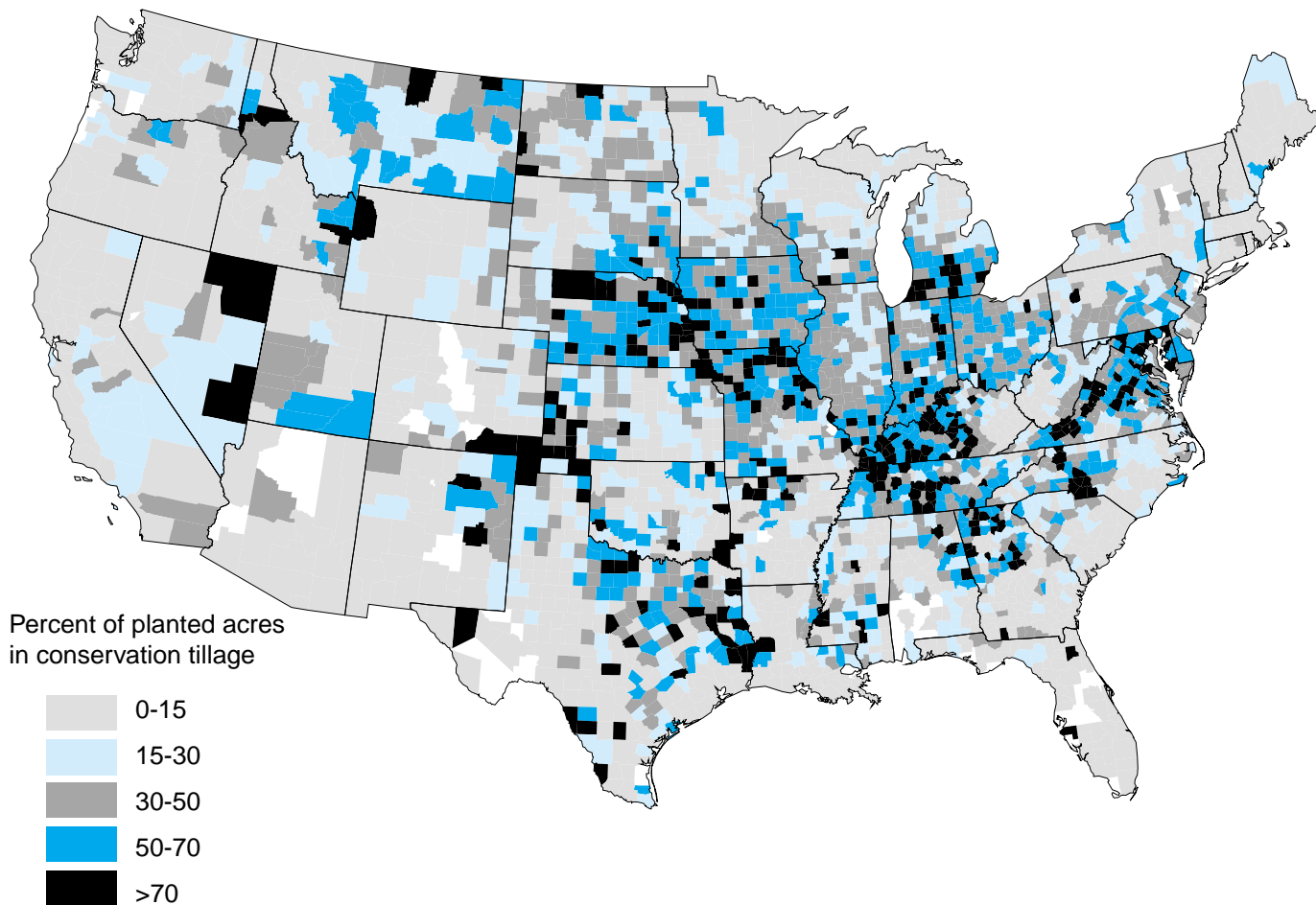
Crop residue levels on planted acreage by region, 1997 1/



1/ The value at the top of the bar is million acres with the crop residue characteristics.

Source: USDA, ERS based on Conservation Technology Information Center data.

Map A. Adoption of conservation tillage practices, 1995



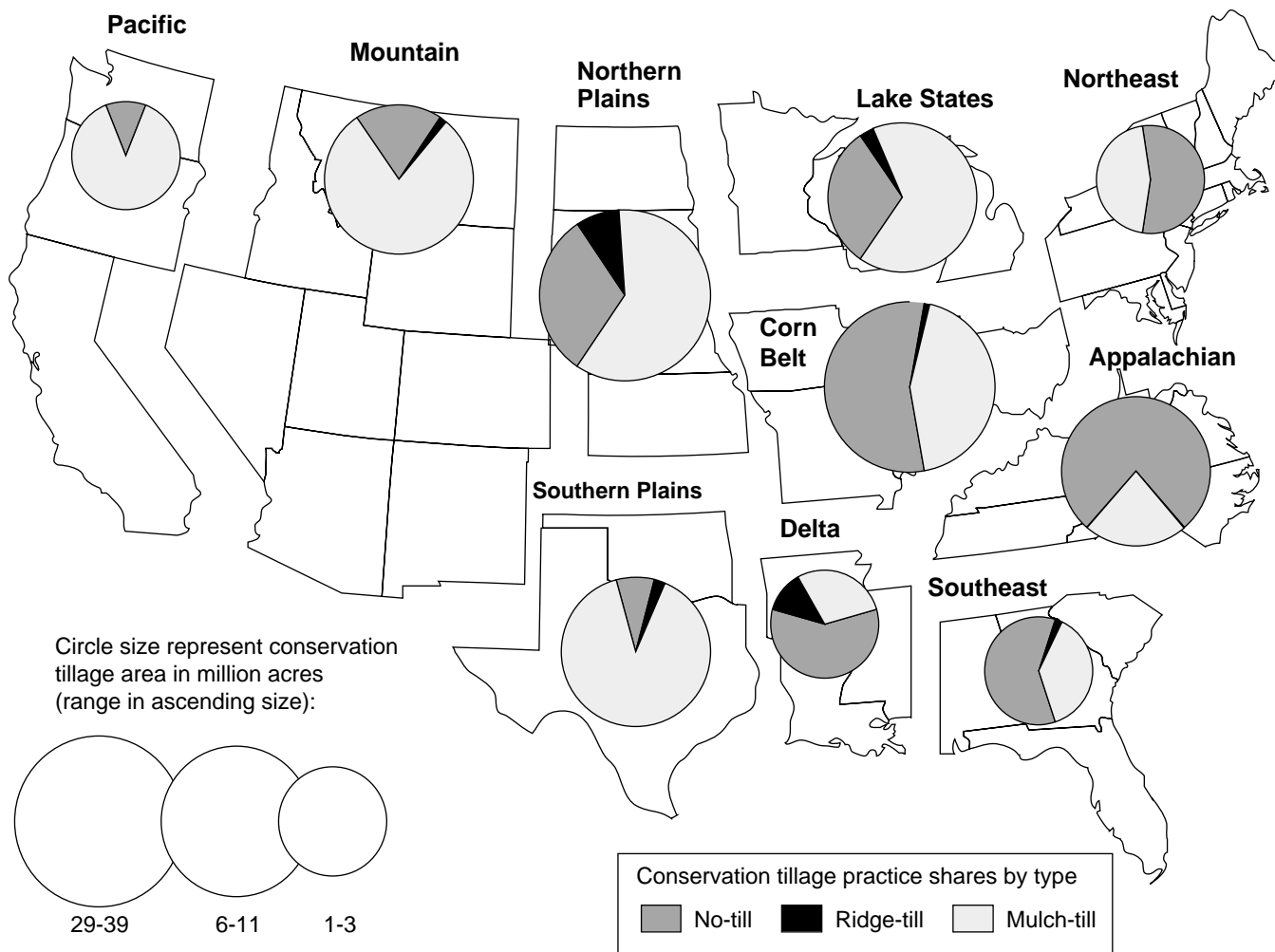
Source: USDA, ERS based on Conservation Technology Information Center data.

Applied Conservation Tillage Practices, 1997

No-till's share of conservation-tilled cropland was greatest in the southern Corn Belt area and in Tennessee and Kentucky (maps B, C, and D and fig. 5C). Mulch-till was more widespread in the northern Corn Belt and Plains regions. Ridge-till is a conservation tillage practice that is

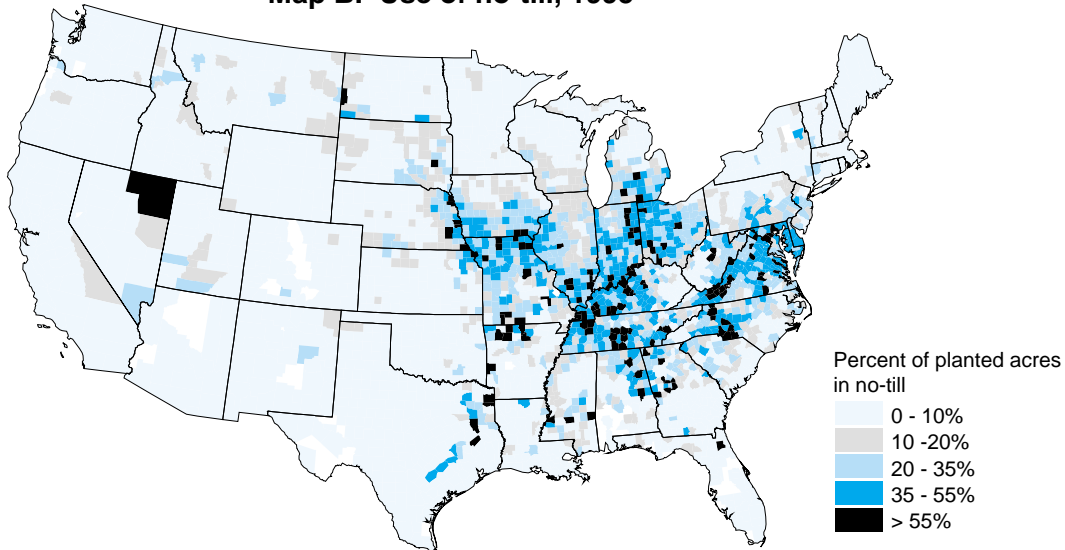
not widely used, except in portions of the Northern Plains where it was prevalent in areas with extensive continuous corn production, much of which was irrigated. For example, over one-fourth of the acreage in some counties in Nebraska use ridge-till.

Figure 5C
Applied conservation tillage practices, 1997

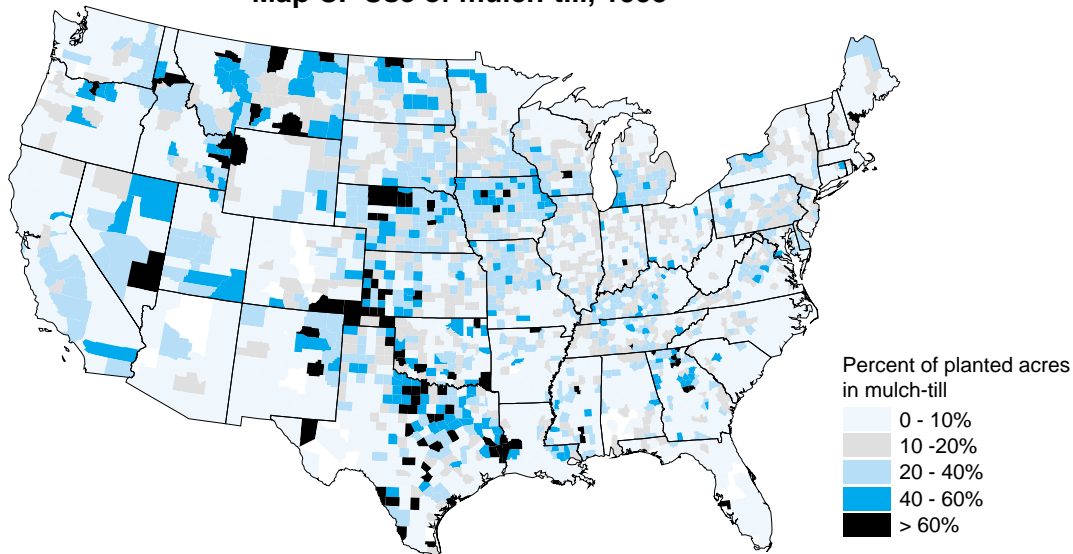


Source: USDA, NASS and ERS based on Conservation Technology Information Center data.

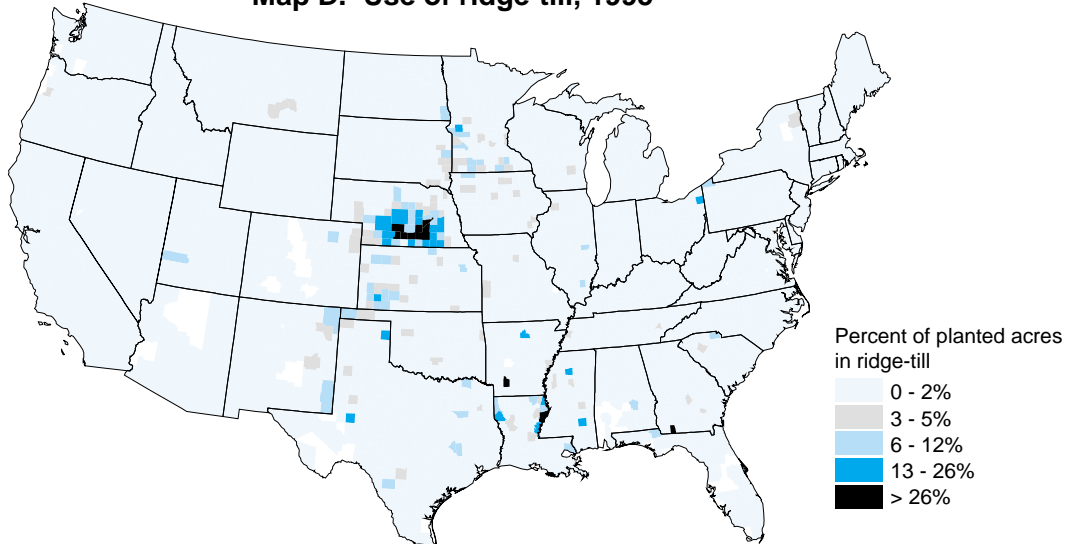
Map B. Use of no-till, 1995



Map C. Use of mulch-till, 1995



Map D. Use of ridge-till, 1995



Source: USDA, ERS based on Conservation Technology Information Center data.

Crop Residue Management and Tillage Definitions

Conventional tillage	Reduced tillage	Conservation tillage		
		Mulch-till	Ridge-till	No-till
Moldboard plow or intensive tillage used	No use of moldboard plow and intensity of tillage reduced	Further decrease in tillage (see below)	Only ridges are tilled (see below)	No tillage performed (see below)
< 15% residue cover remaining	15-30% residue cover remaining	- - - - 30% or greater residue cover remaining - - -		

Crop Residue Management (CRM) is a year-round conservation system that usually involves a reduction in the number of passes over the field with tillage implements and/or in the intensity of tillage operations, including the elimination of plowing (inversion of the surface layer of soil). CRM begins with the selection of crops that produce sufficient quantities of residue to reduce wind and water erosion and may include the use of cover crops after low residue-producing crops. CRM includes all field operations that affect residue amounts, orientation, and distribution throughout the period requiring protection. Site specific residue cover amounts needed are usually expressed in percentage but may also be in pounds. Tillage systems included under CRM are conservation tillage (no-till, ridge-till, and mulch-till) and reduced tillage.

Conservation tillage describes any tillage and planting system that covers 30 percent or more of the soil surface with crop residue after planting, to reduce soil erosion by water. Where soil erosion by wind is the primary concern, conservation tillage is any system that maintains at least 1,000 pounds per acre of flat, small-grain residue equivalent on the surface throughout the critical wind erosion period. Two key factors influencing crop residue are (1) the type of crop, which establishes the initial residue amount and its fragility, and (2) the type of tillage operations prior to and including planting.

Conservation Tillage Systems include:

No-till—The soil is left undisturbed from harvest to planting except for nutrient injection. Planting or drilling is accomplished in a narrow seedbed or slot created by coulters, row cleaners, disk openers, in-row chisels, or roto-tillers. Weed control is accomplished primarily with herbicides. Cultivation may be used for emergency weed control.

Ridge-till—The soil is left undisturbed from harvest to planting except for nutrient injection. Planting is completed in a seedbed prepared on ridges with sweeps, disk openers, coulters, or row cleaners. Residue is left on the surface between ridges. Weed control is accomplished with herbicides and/or cultivation. Ridges are rebuilt during cultivation.

Mulch-till—The soil is disturbed prior to planting. Tillage tools such as chisels, field cultivators, disks, sweeps, or blades are used. Weed control is accomplished with herbicides and/or cultivation.

Reduced tillage (15-30% residue)—Tillage types that leave 15-30 percent residue cover after planting, or 500-1,000 pounds per acre of small grain residue equivalent throughout the critical wind erosion period. Weed control is accomplished with herbicides and/or cultivation.

Conventional tillage (less than 15% residue)—Tillage types that leave less than 15 percent residue cover after planting, or less than 500 pounds per acre of small grain residue equivalent throughout the critical wind erosion period. Generally includes plowing or other intensive tillage. Weed control is accomplished with herbicides and/or cultivation.

Conventional tillage systems (as defined in the Cropping Practices Survey):

Conventional tillage with moldboard plow—Any tillage system that includes the use of a moldboard plow.

Conventional tillage without moldboard plow—Any tillage system that has less than 30 percent remaining residue cover and does not use a moldboard plow.

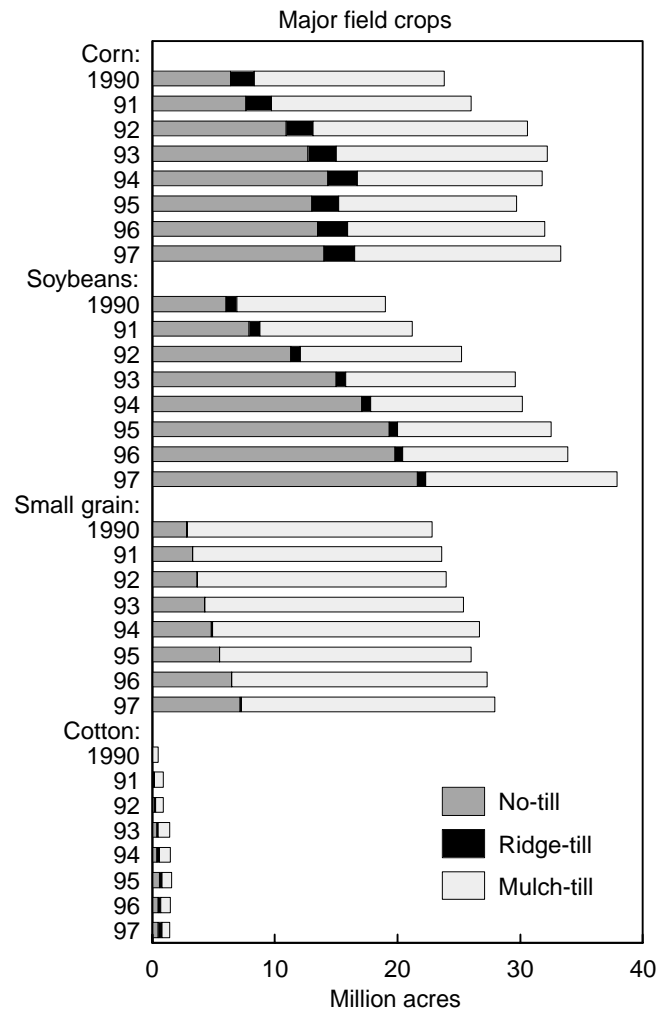
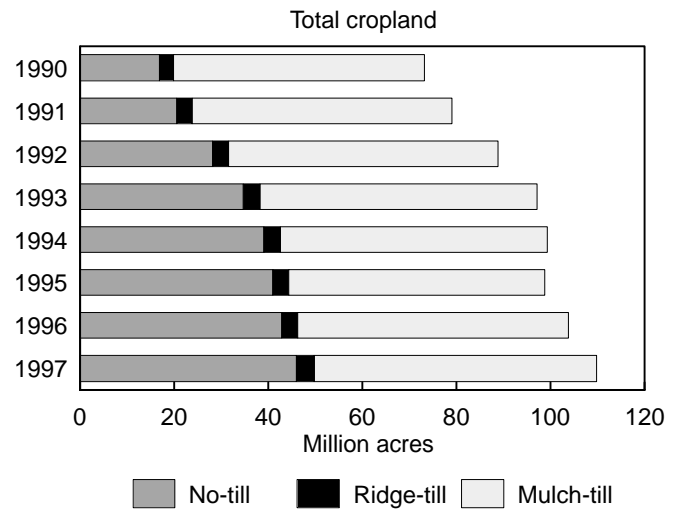
Sources: Bull, 1993, and Conservation Tillage Information Center, 1996.

Trends in Conservation Tillage Use, 1990-97

Conservation tillage was used mainly on corn, soybeans, and small grains in 1997. More than 47 percent of the total acreage planted to corn and soybeans was conservation-tilled (fig. 5D). Expanded use of no-till has been greater for corn and soybeans than for small grains or cotton. Fields planted to row crops tend to be more susceptible to erosion because these crops provide less vegetative cover, especially earlier in the growing season. On double-cropped fields, conservation tillage was used on more than two-thirds of soybean acreage, slightly less than half of corn acreage, and about one-third of sorghum acreage. The use of no-till with double-cropping facilitates getting the second crop planted quickly and limits potential moisture losses from the germination zone in the seedbed, allowing greater flexibility in cropping sequence or rotation.

Figure 5D

Trends in conservation tillage use, 1990-97



Source: USDA, ERS, based on Conservation Technology Information Center data.

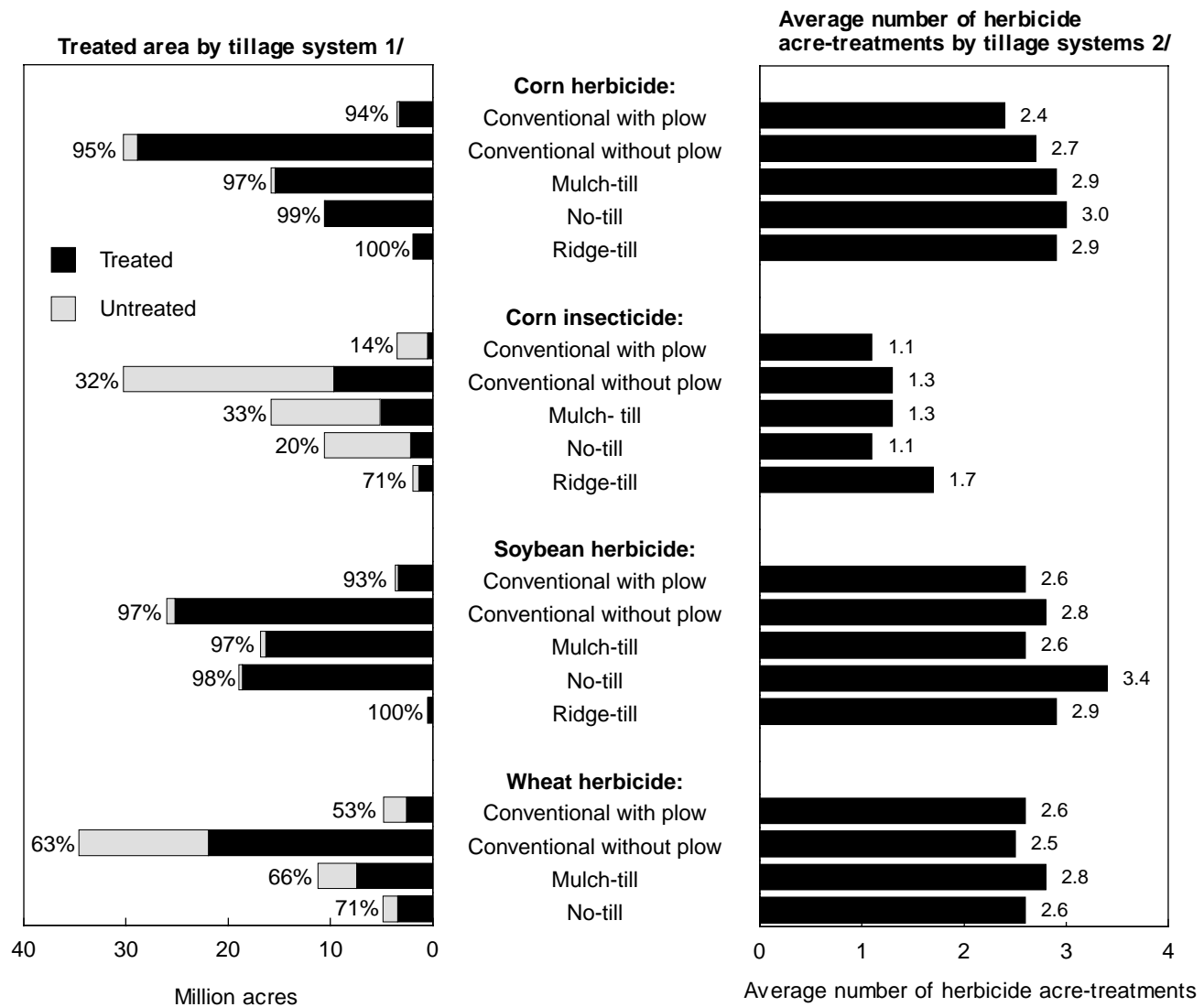
Pesticide Use by Tillage System, 1997

Pesticide use on major crops differs between tillage systems, but it is difficult to distinguish the effects related to tillage systems from differences in pest populations between areas and from one year to the next, and from use of other pest control practices (fig. 5E). Factors other than tillage that affect pest populations may have greater impact on pesticide use than type of tillage. The 1997 Agricultural Resource Management Study data for major field crops (USDA, NASS and ERS, 1996c) also illustrate that differences among tillage systems tend to be more in the combinations of active ingredients applied rather than in the overall proportion of acres treated, the number of pesticide applications per acre treated, or the amount applied per treated acre.

Nearly all corn and soybean acres under all tillage systems were treated with herbicides in 1997. The average number of corn and soybean herbicide acre-treatments was highest for no-till and lowest for conventional tillage with the mold-board plow. The reported higher level of herbicide acre-treatments with no-till is mostly due to the inclusion of an additional “burndown” herbicide treatment prior to planting as a substitute for mechanical weed control. Seventy percent of ridge-tilled corn acres were treated with insecticides while no-till had the lowest share of acres treated and the lowest average number of insecticide acre-treatments. Few soybean or wheat acres were treated with insecticides or fungicides.

Figure 5E

Herbicide use by tillage system, 1997



1/ The value at the end of each bar is the percentage treated.

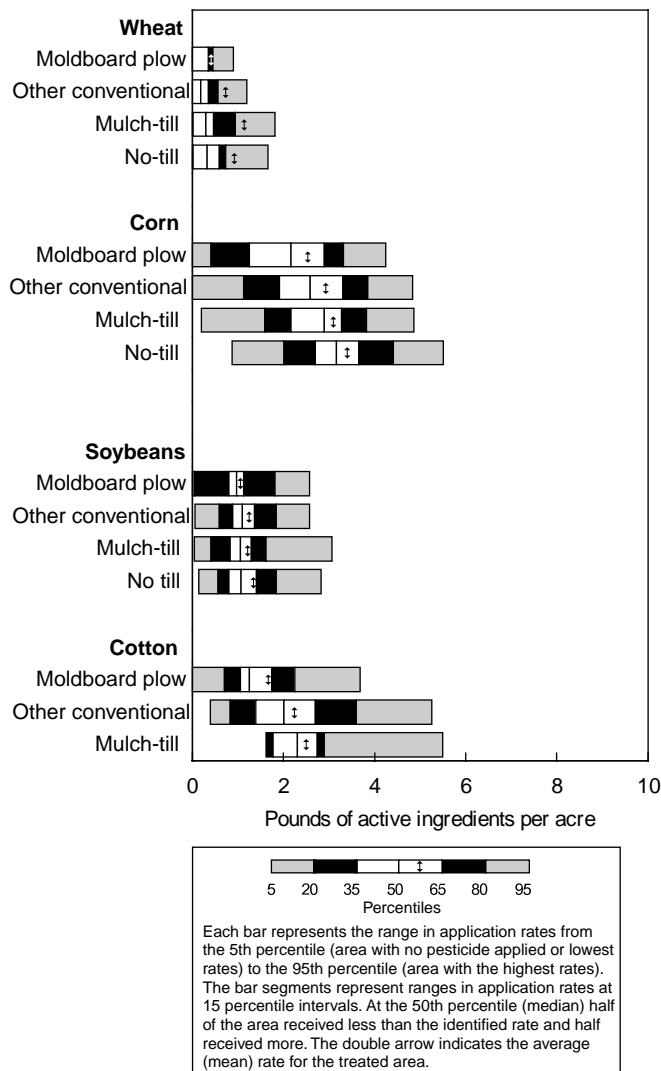
2/ The value at the end of the bar is the average number of herbicide acre-treatments per treated acre.

Source: 1997 Agricultural Resource Management Study

Herbicide Application Rate Variation between Fields, by Tillage Systems

Many factors other than tillage affect the quantity of herbicide applied per acre (fig. 5E1). The variation in herbicide application rates between fields is much greater than the variation that may result from the type of tillage system used. For corn and soybeans, the median (50th acreage percentile) and mean application rates were slightly higher for no-till, but the variability in rates between fields was similar for all tillage types.

Figure 5E1
Herbicide application rate variation between fields, by tillage class, 1997



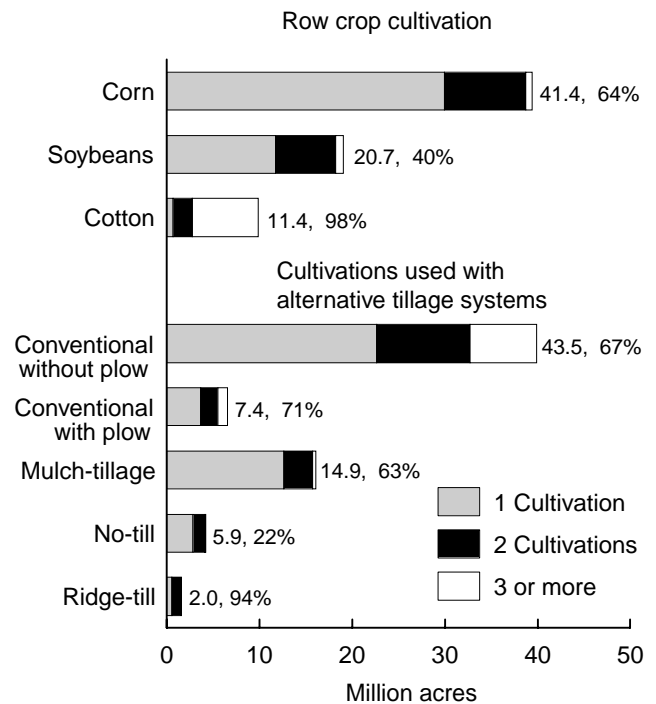
Source: 1997 Agricultural Resource Management Study.

Cultivation of Row Crops

The purpose of cultivating row crops is primarily to kill weeds, but it also loosens the soil (fig. 5F1). Farmers also cultivate to shape the surface for furrow irrigation or to maintain ridges in ridge-till systems. The 1995 Cropping Practices Survey data (USDA, NASS and ERS, 1995c) indicate that nearly all cotton is cultivated, and most cotton acreage is cultivated three or more times during the growing season. About two-thirds of the corn is cultivated, but generally only once or twice during the season.

Cultivation of row crops occurs with all tillage types, but the high level of residue left on the surface with no-till and mulch-till can make the practice difficult without causing some injury to the plants. Most of the acreage in all tillage types, except no-till, was cultivated at least once. Only 22 percent of the no-till acres received any cultivations.

Figure 5F1
Cultivation of row crops, 1994



Represents 128 million acres of corn, soybeans, and cotton.

1/ The first value at the end of the bar is the area cultivated one or more times, and the second value is the percentage of area cultivated one or more times.

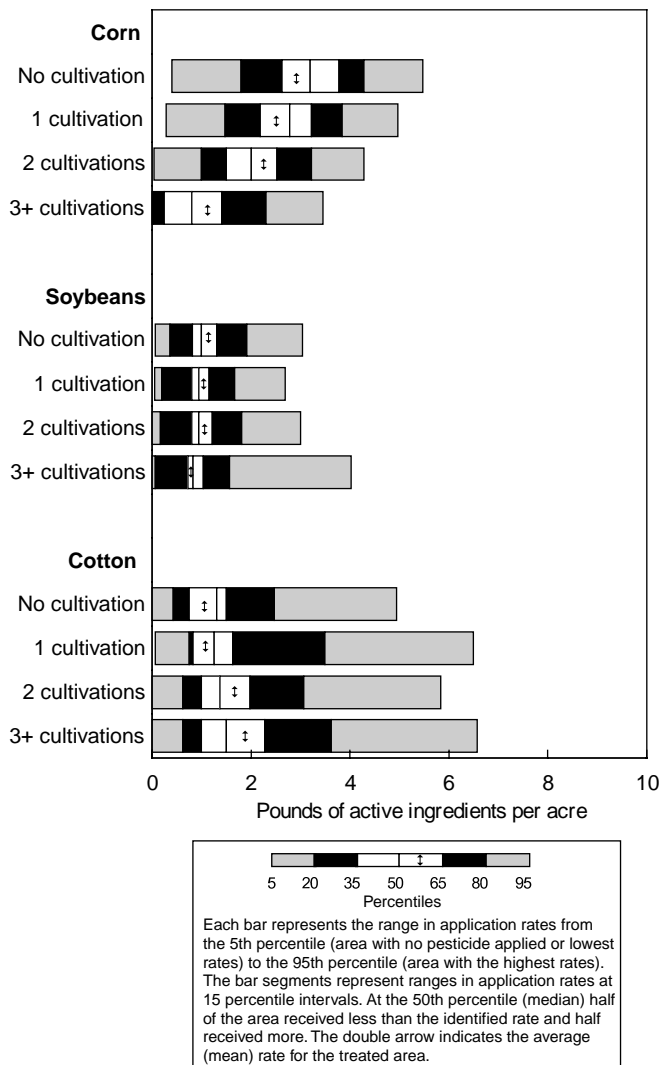
Source: 1994 Cropping Practices Survey

Herbicide Application Rate Variation between Fields, by Number of Cultivations

Increased use of row crop cultivation can control many weeds and reduce the need for herbicide treatments (fig. 5F2). Corn, soybean, and cotton acreage showed only small differences in the intensity and variation in herbicide use for fields that received two or fewer cultivations, but less herbicide use occurred on fields receiving three or more cultivations. For fields cultivated three or more times, a larger share of the acres received no herbicide treatments and the mean rate on the treated acres was lower.

Figure 5F2

Herbicide application rate variation between fields, by number of cultivations, 1994



Source: 1994 Cropping Practices Survey.