4.1 Crop Residue Management

Crop residue management (CRM) practices are increasingly used to conserve soil and water. CRM systems meeting conservation tillage requirements were used on 97 million acres in 1993, about 37 percent of U.S. planted crop area. No-till, which leaves the most protective residue, is expanding more rapidly than other types of conservation tillage.

USDA aims to mitigate environmental problems while maintaining agricultural profitability and competitiveness. The 1985 Food Security Act implemented new programs to conserve soil resources. The 1990 Food, Agriculture, Conservation, and Trade Act further strengthened the Federal role of protecting soil and water resources. (See chapter 6 for more information on conservation programs.) USDA farm conservation plans, developed to meet Farm Act requirements, frequently specify the use of crop residue management systems to reduce soil loss and protect water resources from agricultural contaminants (see boxes, "Crop Residue Management System Definitions and Survey" and "Environmental Effects of Conservation Tillage").

National and Regional Use of Crop Residue Management

Crop residue management systems include conservation tillage practices such as no-till, ridge till, and mulch till and other conservation practices that provide sufficient residue cover to protect the soil surface from the erosive effects of wind and water. According to the annual Crop Residue Management Survey, farmers practiced conservation tillage on over 97 million acres in 1993, up from 89 million acres in 1992 and 72 million acres in 1989 (table 4.1.1). Conservation tillage now accounts for 37 percent of U.S. planted crop acreage (fig. 4.1.1). Increased use of no-till and mulch-till practices will likely continue as farmers use crop residue management to implement their conservation compliance plans.

Besides providing soil-conserving benefits, crop residue management practices are adopted in many instances for their cost-effectiveness. Fuel and labor savings, lower machinery investments, and long-term benefits to soil structure and fertility are commonly cited advantages of crop residue management systems over conventional systems. While new or retrofitted machinery may be required to adopt crop residue

Table 4.1.1—National use of crop residue management practices, 1989-93[1]

Item	1989	1990	1991	1992	1993	1994	1995
				Million acres			
Total area planted	279.6	280.9	281.2	282.9	278.1	283.9	
Area planted with:							
No-till	14.1	16.9	20.6	28.1	34.8	39.0	
Ridge till	2.7	3.0	3.2	3.4	3.5	3.6	
Mulch till	54.9	53.3	55.3	57.3	58.9	56.8	
Total conservation tillage	71.7	73.2	79.1	88.7	97.1	99.3	
Other tillage types:							
15-30% residue	70.6	71.0	72.3	73.4	73.2	73.1	
< 15% residue	137.3	136.7	129.8	120.8	107.9	111.4	
Total other tillage types	207.9	207.7	202.1	194.2	181.0	184.6	
				Percent			
Percentage of area with:							
No-till	5.1	6.0	7.3	9.9	12.5	13.7	
Ridge till	1.0	1.1	1.1	1.2	1.2	1.3	
Mulch till	19.6	19.0	19.7	20.2	21.2	20.0	
Total conservation tillage	25.6	26.1	28.1	31.4	34.9	35.0	
Other tillage types:							
15-30% residue	25.3	25.3	25.7	25.9	26.3	25.8	
< 15% residue	49.1	48.7	46.1	42.7	38.8	39.3	
Total other tillage types	74.4	73.9	71.9	68.6	65.1	65.0	

[1] For tillage system definitions, see box "Crop Residue Management System Definitions."

Source: Conservation Technology Information Center, National Crop Residue Management Surveys.

Crop Residue Management System Definitions and Survey

Crop Residue Management (CRM) is a conservation practice 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). This practice is designed to leave sufficient residue on the soil surface to reduce wind and/or water erosion.

CRM is a year-round system that includes all field operations that affect the amount of residue, its orientation to the soil surface and prevailing wind and rainfall patterns, and the evenness of residue distribution throughout the period requiring protection. This may include the use of cover crops where sufficient quantities of other residue are not available to reduce the vulnerability of the soil to erosion during critical periods.

Conservation Tillage--Any tillage and planting system that maintains at least 30 percent of the soil surface covered by residue after planting to reduce soil erosion by water; or where soil erosion by wind is the primary concern, maintains at least 1,000 pounds (per acre) of flat, small grain residue equivalent on the surface during the critical wind erosion period. Two key factors influencing crop residue are (1) the previous crop, which establishes the initial residue amount and determines its fragility, and (2) the type of tillage operations prior to and including planting.

Conservation Tillage Systems (as defined in both the Crop Residue Management Survey and the Cropping Practices Survey)

Mulch till--The soil is disturbed prior to planting. Tillage tools such as chisels, field cultivators, disks, sweeps, or blades are used. The Cropping Practices Survey assumes any system with 30 percent or more residue after planting that is not a no-till or ridge-till system is a mulch-till system.

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.

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, inrow chisels, or roto-tillers.

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 and does not use a moldboard plow.

Other Tillage Systems (as defined in the Crop Residue Management Survey)

Reduced till (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.

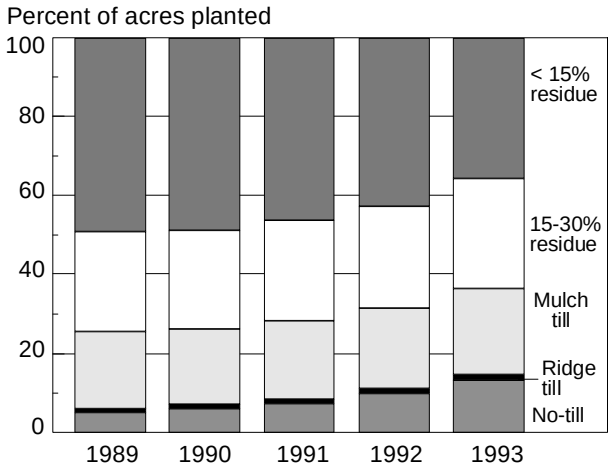
Conventional till (less than 15% residue)--Tillage types that leave less than 15 percent residue cover after planting, or less than 500 pounds per acre of small grain residue equivalent throughout the critical wind erosion period.

Crop Residue Management Survey

The Crop Residue Management (CRM) Survey, conducted by the Conservation Technology Information Center, provides State and national statistics on adoption of alternative crop residue management systems for all U.S. planted cropland. The CRM Survey provides estimates on five different tillage systems: no-till, mulch till, ridge till, reduced till (15-30 percent residue), and conventional till (less than 15 percent residue). A panel of local directors of USDA program agencies and others knowledgeable about local residue management practices complete the survey each summer. These local judgments about the use of practices are summarized to provide State, regional, and national estimates.

management systems, fewer trips over the field and reduced fuel and labor requirements can result in immediate cost savings. Machinery cost usually declines in the long run because a smaller machinery complement is needed. Farmers apply conservation tillage mostly at their own cost; only 600,000 acres were cost-shared in 1993 under the Agricultural Conservation Program, USDA's major cost-sharing program.

Figure 4.1.1
National use of crop residue management, 1989-93

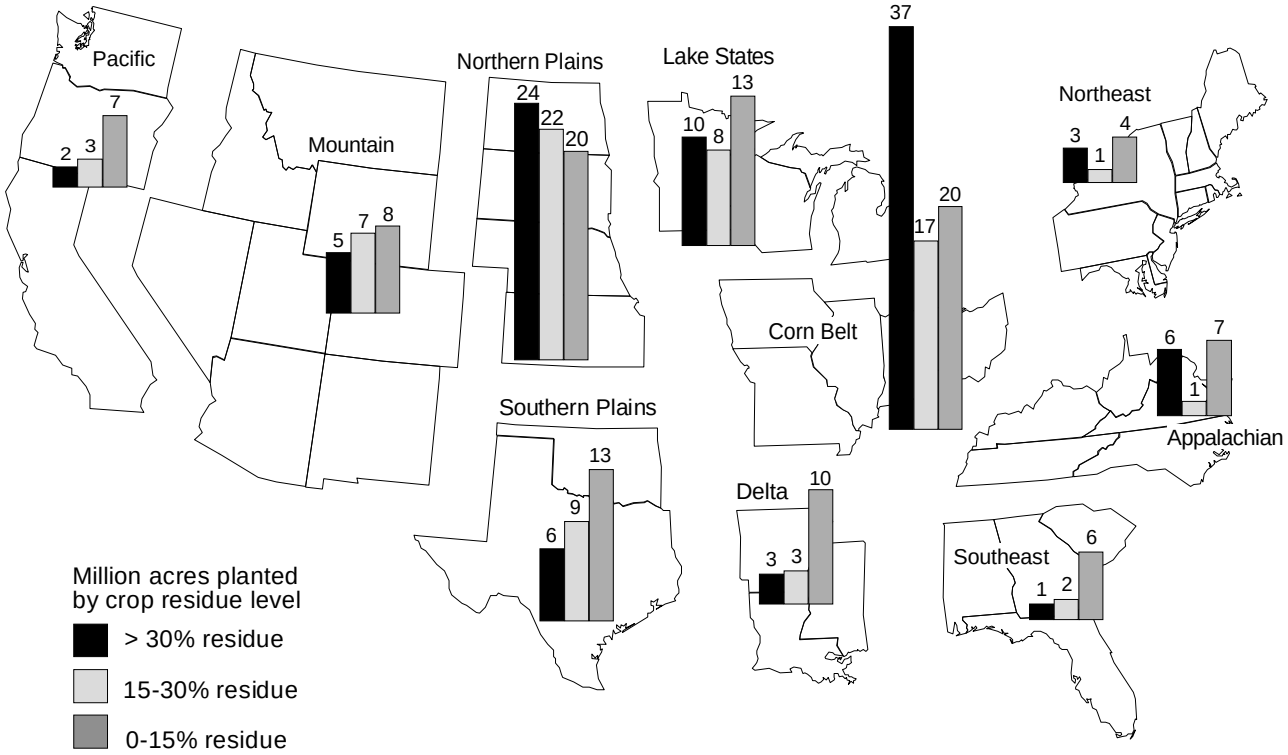


Source: Conservation Technology Information Center data.

The Corn Belt and Northern Plains had the most planted cropland in 1993 and accounted for nearly 63 percent of total conservation tillage acres (fig. 4.1.2). These regions, plus the Lake States, Mountain region, and Southern Plains, have substantial acreage with 15-30 percent residue cover. Much of this area (15-30 percent residue cover) has the potential to qualify as mulch till with increased surface residue from adoption of improved crop residue management.

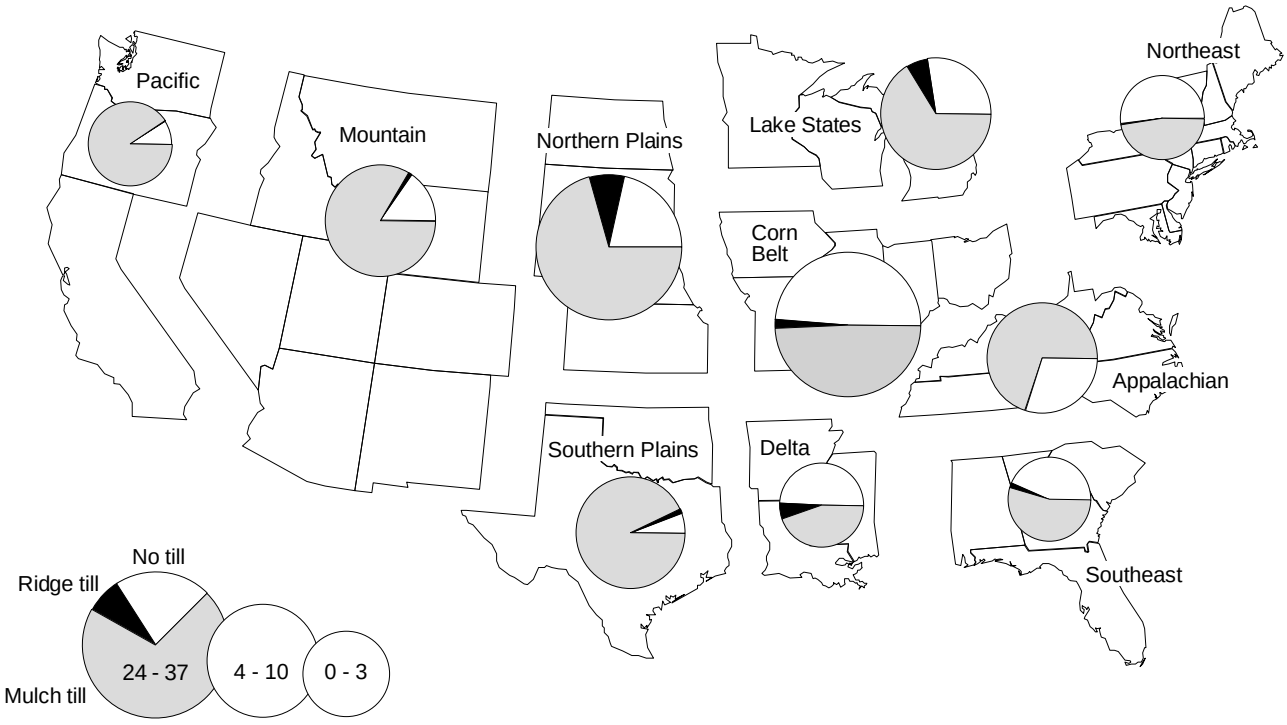
U.S. crop area planted with no-till has increased by about 2.5 times since 1989 to nearly 35 million acres in 1993. No-till's share of conservation tilled area is greater in the six eastern regions than elsewhere (fig. 4.1.3). Increased use of high-residue types of tillage has resulted in no-till and ridge till accounting for almost 40 percent (more than 38 million acres in

Figure 4.1.2
Crop residue levels on planted acreage by region, 1993



Source: Conservation Technology Information Center data.

Figure 4.1.3
Applied conservation tillage practices, 1993



Circle size represents conservation tillage area in million acres (range in ascending size).

Source: Conservation Technology Information Center data.

1993) of U.S. acreage with conservation tillage. This demonstrates a shift away from clean tillage (less than 15 percent residue) (table 4.1.1). High-residue types of tillage can leave as much as 70 percent or more of the soil surface covered with crop residues.

Tillage Systems Used on Major Crops

Conservation tillage was used mainly on corn, soybeans, and small grains in 1993. Almost 46 percent of the total acreage planted to corn and soybeans was conservation-tilled. Where double-cropping occurred, about 65 percent of soybean acreage, 48 percent of corn acreage, and 42 percent of sorghum acreage was farmed using conservation tillage systems. The widespread use of no-till with double-cropping captures several benefits such as timeliness in getting the second crop planted and limiting potential moisture losses from the germination zone in the seedbed. This allows greater flexibility in cropping sequence or rotation (Conservation Technology Information Center, 1993).

The 1988-93 Cropping Practices Surveys (see box, p. 127) provide additional detail on residue levels and tillage systems for major crops and producing States. Five tillage systems are estimated from survey data based on the use of specific tillage implements and their residue incorporation rates (Bull, 1993). These annual surveys indicate a decline in the use of conventional tillage both with and without the moldboard plow and an increase for all conservation tillage types (table 4.1.2, app. tables 4.1.1-4.1.5). Less than 10 percent of the surveyed area in major producing States used a moldboard plow in 1993, down from 19 percent in 1988 (fig. 4.1.4).

Corn

The three conservation tillage systems (mulch till, no-till, and ridge till) were used on 42 percent of the 1993 corn acreage, up from 21 percent in 1988 (table 4.1.2). The average amount of crop residue after planting increased accordingly from about 19 percent in 1988 to 29 percent in 1993. Mulch till, which fulfills the erosion protection requirements under many conservation compliance plans, is the most common type of conservation tillage used on corn. Its share of total corn acreage increased from 14 percent in 1988 to 24 percent in 1993. Acreage under

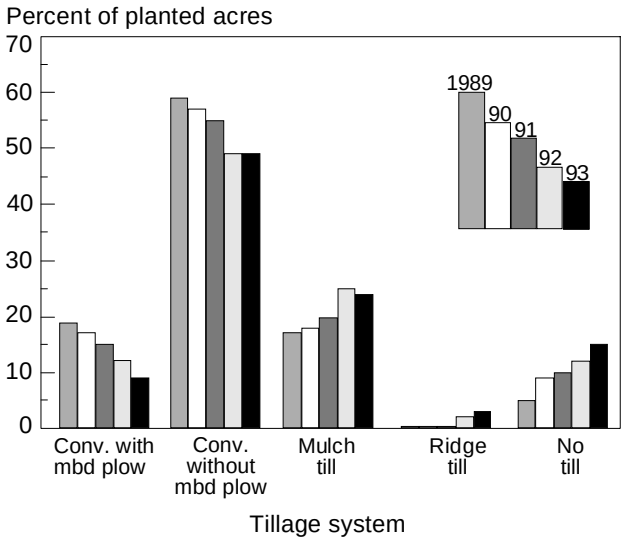
Table 4.1.2—Tillage systems used in field crop production in major producing States, 1988-95[1]

Item	Unit	1988	1989	1990	1991	1992	1993	1994	1995
Corn (10 States)	*1,000 acres*[2]	53,200	57,900	58,800	60,350	62,850	57,350	62,500	
Residue remaining after planting	*Percent*	19	19	22	24	27	29	30	
Tillage system:	*Percent of acres*								
Conv. with moldboard plow		20	19	17	15	12	9	8	
Conv. w/out moldboard plow		60	59	57	55	49	49	49	
Mulch till		14	17	18	20	25	24	23	
Ridge till		*	*	*	*	2	3	3	
No-till		7	5	9	10	12	15	17	
Northern soybeans (7 States)	*1,000 acres*[2]	36,550	37,750	36,400	38,850	38,150	42,500[3]	43,750[3]	
Residue remaining after planting	*Percent*	17	19	19	25	28	35	36	
Tillage system:	*Percent of acres*								
Conv. with moldboard plow		28	26	23	18	12	8	9	
Conv. w/out moldboard plow		55	51	51	48	47	44	38	
Mulch till		14	18	21	25	26	25	26	
Ridge till		*	*	*	*	1	1	1	
No-till		3	4	6	10	14	22	26	
Southern soybeans (7 States)	*1,000 acres*[2]	12,200	13,380	11,850	10,800	10,480	NA	NA	
Residue remaining after planting	*Percent*	14	15	19	17	18	NA	NA	
Tillage system:	*Percent of acres*								
Conv. with moldboard plow		3	4	4	3	3	NA	NA	
Conv. w/out moldboard plow		85	82	78	80	76	NA	NA	
Mulch till		5	5	7	6	8	NA	NA	
Ridge till		*	*	*	*	id	NA	NA	
No-till		7	10	12	11	14	NA	NA	
Upland cotton (6 States)	*1,000 acres*[2]	9,700	8,444	9,730	10,860	10,200	10,360	10,023	
Residue remaining after planting	*Percent*	2	2	3	3	3	2	3	
Tillage system:	*Percent of acres*								
Conv. with moldboard plow		28	15	14	21	12	16	10	
Conv. w/out moldboard plow		72	84	84	76	88	83	89	
Mulch till		id	id	1	1	id	**	**	
No-till		id	id	1	1	id	1	1	
Winter wheat (12-15 States)[4]	*1,000 acres*[2]	32,830	34,710	40,200	34,180	36,990	37,210	34,590	
Residue remaining after planting	*Percent*	17	17	18	17	19	18	18	
Tillage system:	*Percent of acres*								
Conv. with moldboard plow		15	16	12	12	11	6	8	
Conv. w/out moldboard plow		67	68	69	72	68	76	75	
Mulch till		16	15	17	13	18	14	12	
No-till		1	1	3	3	3	4	5	
Spring/durum wheat (4-5 States)[5]	*1,000 acres*[2]	12,280	19,580	18,900	16,500	19,550	18,900	19,700	
Residue remaining after planting	*Percent*	18	22	22	24	23	25	25	
Tillage system:	*Percent of acres*								
Conv. with moldboard plow		14	8	10	7	8	8	7	
Conv. w/out moldboard plow		63	60	63	59	60	57	57	
Mulch till		22	31	25	31	26	28	30	
No-till		1	1	2	3	6	7	6	
Total acres surveyed	*1,000 acres*[2]	156,760	171,764	175,880	171,040	178,220	166,320	170,563	
Tillage system:	*Percent of acres*								
Conv. with moldboard plow		19	17	15	14	11	8	8	
Conv. w/out moldboard plow		63	62	62	60	58	57	55	
Mulch till		13	17	17	19	21	21	21	
Ridge till		*	*	*	*	1	1	1	
No-till		5	4	6	7	9	13	15	

id = Insufficient data. * = Included in no-till for these years. ** = Less than 1 percent. NA = Not available.

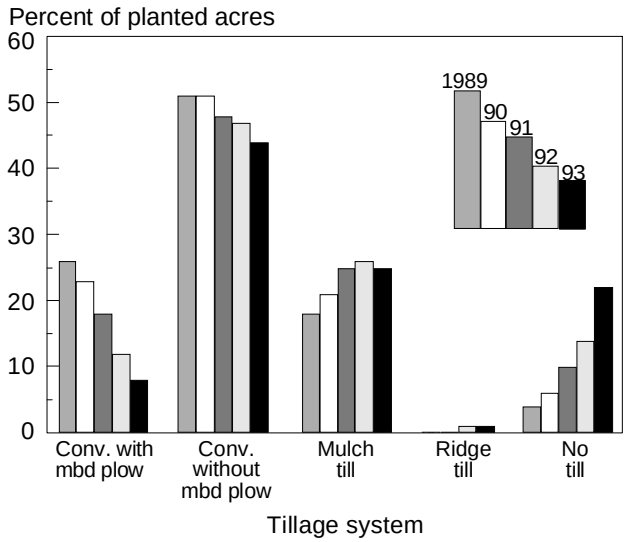
[1] For the States included, see box "Cropping Practices Survey." For tillage system definitions, see box "Crop Residue Management System Definitions and Survey." [2] Preliminary. Planted acres, except for winter wheat (harvested). [3] Arkansas in 1993 and 1994 is included in Northern area. Previously, Arkansas was included with GA, KY, LA, MS, NC, and TN (not surveyed in 1993 and 1994) to comprise Southern area. [4] Winter wheat includes 15 States in 1988-89 and 1991-92; 12 States in 1990; and 13 States in 1993-95. [5] Spring wheat includes 5 States in 1988-89 and 4 States in 1990-95. Durum wheat includes only ND.

Figure 4.1.4
Corn tillage systems, 1989-93



Source: USDA, ERS, Cropping Practices Survey data.

Figure 4.1.5
Northern soybean tillage systems, 1989-93



Source: USDA, ERS, Cropping Practices Survey data.

no-till, which maintains the largest amount of crop residue on the soil surface, tripled from 1989 to 1993 and now accounts for almost one-third of all conservation tillage used on corn. Ridge-till systems are mostly used in Nebraska, Minnesota, and South Dakota and account for 3 percent of the total surveyed corn acreage.

Soybeans

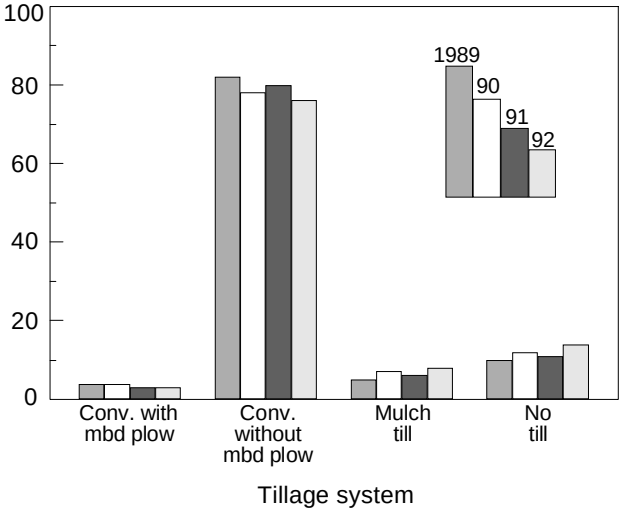
The increase in conservation tillage for Northern soybeans has been even faster than for corn. Nearly half of Northern soybeans are produced with conservation tillage methods (fig. 4.1.5, table 4.1.2). In 1989, less than 20 percent were produced using conservation tillage. The amount of crop residue increased from 17 percent in 1988 to 35 percent in 1993. Estimates of conservation tillage for Southern soybeans are not available for 1993 because most Southern soybean States were dropped from the Cropping Practices Survey. However, estimates through 1992 indicate that growth of conservation tillage systems in the Delta and Southeastern States has been much slower than in the Northern States (fig. 4.1.6).

Cotton

Nearly all cotton (99 percent in 1993) in the six major cotton States is produced using Conv. tillage methods (fig. 4.1.7 and table 4.1.2). Although most land remains in Conv. tillage, use of the moldboard plow has decreased to nearly half of the 1988 level. Some States require that farmers dispose of cotton plants after harvest to eliminate the winter food source for bollworms and boll weevils. Using Conv. tillage systems to dispose of cotton plants precludes current conservation tillage methods.

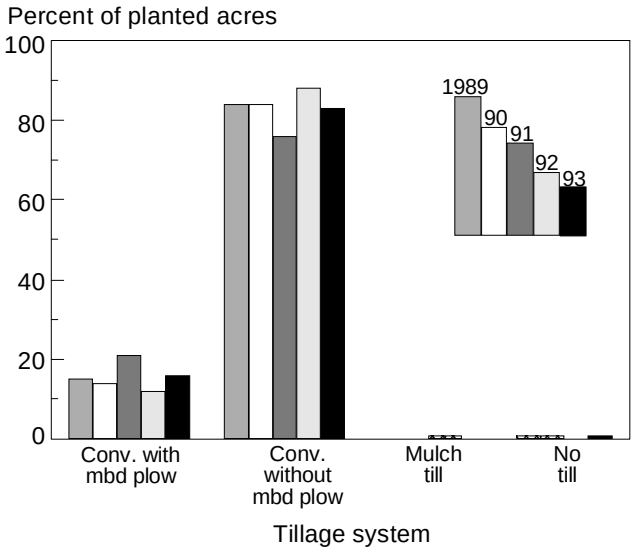
Research is being conducted on tillage and other cultural practices that provide both effective erosion and pest control on cotton. For example, "stale seed-bed" systems include (1) fall tillage to create beds, (2) a cover crop or natural vegetation growth over winter, and (3) spring time application of a burn down herbicide to kill the vegetation. The cotton is

Figure 4.1.6
Southern soybean tillage systems, 1989-92



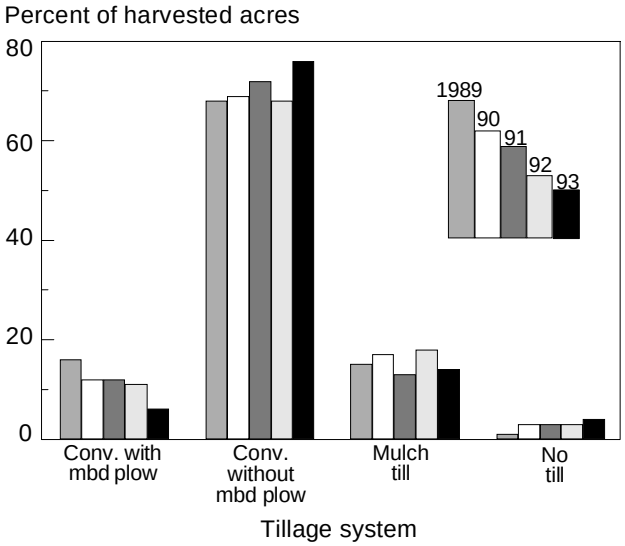
Source: USDA, ERS, Cropping Practices Survey data.

Figure 4.1.7
Cotton tillage systems, 1989-93



Source: USDA, ERS, Cropping Practices Survey data.

Figure 4.1.8
Winter wheat tillage systems, 1989-93



Source: USDA, ERS, Cropping Practices Survey data.

then directly seeded into the residue, similar to no-till systems.

Winter Wheat

Use of the moldboard plow in winter wheat has declined since 1988 (table 4.1.2). However, unlike corn and soybeans, most of this acreage was replaced with other Conv. tillage systems (fig. 4.1.8). Conservation tillage was used on 18 percent of winter wheat in 1993, about the same as in 1988. Since the growing winter wheat crop covers the soil surface during critical erosion periods, no large increase in conservation tillage acreage is expected as remaining conservation compliance plans are implemented.

Tillage on Highly Erodible Land

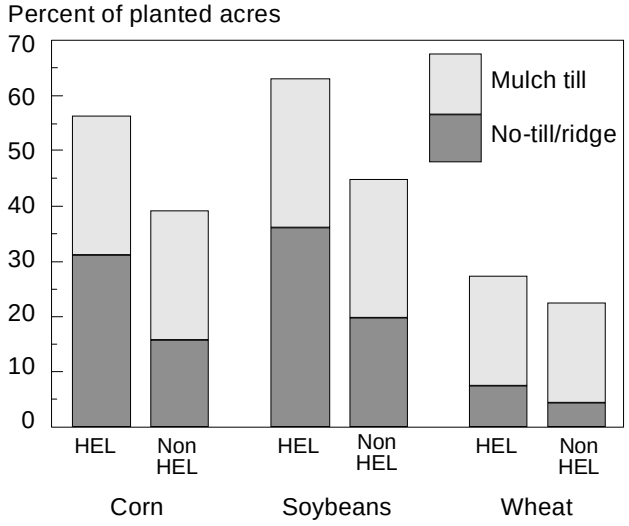
Tillage operations and amount of previous crop residue on the soil surface after planting are important indicators of soil erosion potential. To be eligible for most USDA program benefits, farmers must implement by 1995 an approved conservation plan on all highly erodible land (HEL). About 75 percent of the acreage in these plans includes some form of crop residue management.

The tillage trends on HEL are generally the same as for all land, but a larger share of HEL acreage uses conservation tillage, particularly no-till (fig. 4.1.9, table 4.1.3). Large reductions in moldboard plow use occurred for all crops on HEL except cotton.

About one-fifth of the 1993 corn acres in the Cropping Practices Survey were designated as HEL, 56 percent of which were planted using conservation tillage (table 4.1.3). The moldboard plow was used on only 7 percent of HEL acres in 1993, down from 16 percent in 1989. The share of HEL using no-till or ridge-till systems increased from 7 percent in 1989 to 31 percent in 1993.

About 63 percent of northern soybean HEL acres were planted using conservation tillage in 1993, up from 28 percent in 1989 (fig. 4.1.9). The increase in conservation tillage can primarily be attributed to the adoption of no-till. Tillage systems used on southern

Figure 4.1.9
Conservation tillage systems on highly erodible lands (HEL) versus non-HEL, 1993



Source: USDA, ERS, 1993 Cropping Practices Survey data.

Table 4.1.3—Tillage systems in field crop production, highly erodible and non-highly erodible lands[1]--continued

	Non-highly erodible						
Item	1989	1990	1991	1992	1993	1994	1995
Corn - planted acres (1,000)[2]	41,020	43,230	44,480	46,880	43,355	48,580	
(percent of total planted acres)	71	74	74	75	75	78	
Tillage system (percent of acres):							
Conv. with moldboard plow	19	18	15	12	9	9	
Conv. w/out moldboard plow	61	57	58	52	52	52	
Mulch till	15	18	18	24	23	23	
Ridge till	*	*	*	2	4	3	
No-till	5	8	9	10	12	13	
N. soybeans - planted ac. (1,000) [2,3]	29,193	27,450	29,930	29,680	33,625	34,800	
(percent of total planted acres)	77	75	77	78	79	80	
Tillage system (percent of acres):							
Conv. with moldboard plow	29	26	20	15	9	10	
Conv. w/out moldboard plow	49	49	48	48	46	44	
Mulch till	18	20	23	26	25	25	
Ridge till	*	*	*	1	1	1	
No-till	4	5	9	12	19	21	
S. soybeans - planted ac. (1,000)[2,3]	10,088	9,160	8,810	8,170	3	3	
(percent of total planted acres)	76	77	81	78	3	3	
Tillage system (percent of acres):							
Conv. with moldboard plow	2	3	2	3	3	3	
Conv. w/out moldboard plow	88	80	84	81	3	3	
Mulch till	4	8	6	8	3	3	
Ridge till	*	*	*	id	3	3	
No-till	6	9	8	8	3	3	
Cotton - planted acres (1,000)[2]	4,956	6,930	7,590	7,030	7,063	6.363	
(percent of total planted acres)	59	71	70	69	68	63	
Tillage system (percent of acres):							
Conv. with moldboard plow	9	10	17	7	9	9	
Conv. w/out moldboard plow	90	88	82	92	91	78	
Mulch till	id	1	1	id	id	10	
No-till	id	1	nr	nr	nr	3	
Winter wheat - harv. ac. (1,000)[2,4]	21,672	25,660	21,940	23,990	23,130	12,995	
(percent of total harvested acres)	62	64	64	65	62	64	
Tillage system (percent of acres):							
Conv. with moldboard plow	20	13	14	12	7	8	
Conv. w/out moldboard plow	66	70	72	70	78	78	
Mulch till	13	15	12	15	12	10	
No-till	1	2	2	3	3	3	
Spring wheat - planted ac. (1,000)[2,5]	12,557	12,010	10,800	13,960	13,055	12,910	
(percent of total planted acres)	76	76	80	80	77	75	
Tillage system (percent of acres):							
Conv. with moldboard plow	6	13	7	9	11	8	
Conv. w/out moldboard plow	64	64	61	59	55	59	
Mulch till	30	21	29	24	27	30	
No-till	id	2	3	8	7	4	
Durum wheat - planted ac. (1,000)[2,5]	2,217	2,505	2,345	1,970	1,670	2,155	
(percent of total planted acres)	71	81	78	90	86	86	
Tillage system (percent of acres):							
Conv. with moldboard plow	4	3	5	8	3	1	
Conv. w/out moldboard plow	49	62	53	50	54	60	
Mulch till	46	34	38	39	39	33	
No-till	1	1	4	3	4	6	
Total (1,000 acres)[2]	121,703	126,945	125,795	131,680	121,898	26,803	
(percent of total surveyed acres)	71	72	74	74	73	74	
Tillage system (percent of acres):							
Conv. with moldboard plow	18	16	14	11	9	9	
Conv. w/out moldboard plow	63	62	61	59	58	58	
Mulch till	16	17	18	21	21	21	
Ridge till	*	*	*	1	2	1	
No-till	3	5	7	8	11	11	

See table 4.1.2 for footnotes.

Table 4.1.4—Herbicide use by tillage system in major producing States, 1990-93[1]

Item	Conv.		Conservation		
	With mbd. plow	W/out mbd. plow	Mulch till	No-till	Ridge till
Corn:[2]					
Acreage treated	*Percent of planted acres treated*				
1990	90	96	94	96	100
1991	91	96	97	96	94
1992	95	97	97	99	98
1993	92	98	98	99	98
Amount applied	*Pounds a.i. per treated acre*				
1990	3.03	3.37	3.01	3.27	2.47
1991	2.73	2.98	3.05	3.25	2.11
1992	2.69	3.05	2.92	3.30	2.19
1993	2.48	2.99	2.82	3.42	1.87
Northern soybeans:[3]					
Acreage treated	*Percent of planted acres treated*				
1990	97	97	95	94	100
1991	95	97	98	94	100
1992	99	99	99	98	100
1993	97	97	98	98	100
Amount applied	*Pounds a.i. per treated acre*				
1990	1.57	1.32	1.35	2.21	1.14
1991	1.30	1.23	1.28	1.52	1.00
1992	1.13	1.14	1.09	1.33	0.72
1993	1.09	1.04	0.95	1.40	1.21
Southern soybeans:[4]					
Acreage treated	*Percent of planted acres treated*				
1990	89	93	90	96	nr
1991	86	92	92	95	nr
1992	78	95	97	98	nr
Amount applied	*Pounds a.i. per treated acre*				
1990	1.21	1.19	1.05	1.94	nr
1991	1.21	1.12	0.89	1.99	nr
1992	1.37	1.16	1.15	1.40	nr
Winter wheat:[5]					
Acreage treated	*Percent of planted acres treated*				
1991	40	27	22	36	n/a
1992	48	34	23	28	n/a
1993	53	43	40	43	n/a
Amount applied	*Pounds a.i. per treated acre*				
1991	0.23	0.31	0.37	0.68	n/a
1992	0.30	0.33	0.35	0.35	n/a
1993	0.38	0.32	0.42	0.48	n/a

nr = none reported. n/a = not applicable

[1] For the States included, see box "Cropping Practices Survey." For tillage system definitions, see box "Crop Residue Management System Definitions and Survey." [2]See app. table 4.1.6 for more detail and test results on significance of differences in amounts applied. [3]See appendix table 4.1.7 for more detail and test results on significance of differences in amounts applied. [4]See appendix table 4.1.8 for more detail and test results on significance of differences in amounts applied. [5]See appendix table 4.1.9 for more detail.

Source: USDA, ERS, Cropping Practices Survey data.

soybean HEL acreage changed only slightly from 1988 to 1992; however, over half the reported acreage used conservation tillage in 1992.

Over one-third of the 1993 winter wheat was harvested from HEL. One-fourth of this acreage used conservation tillage systems, compared with 15 percent of non-HEL.

Pesticide and Fertilizer Use Under Different Tillage Systems

While conservation tillage systems reduce soil erosion and may enhance productivity, the effect on fertilizer and pesticide use is less certain. The Cropping Practices Surveys (CPS, see box) from 1990 to 1993 provide some information about the quantities of pesticide and fertilizer applied with different tillage systems. These relationships, however, are not conclusive.

In general, the CPS data indicate that users of no-till systems applied more herbicide and less insecticide per acre than other tillage systems (tables 4.1.4-4.1.5). Mulch-till system users, however, often applied less herbicide than Conv. systems not using the moldboard

Table 4.1.5—Corn acres treated with insecticide by tillage system in major producing States, 1990-93[1]

Item	Conv.		Conservation		
	With mbd. plow	W/out mbd. plow	Mulch till	No-till	Ridge till
Planted acres treated:	*Percent*				
1990	35	32	37	31	48
1991	29	30	35	27	63
1992	28	28	32	25	60
1993	27	26	32	22	58
Number of treatments:	*Number*				
1990	1.04	1.10	1.12	1.05	1.27
1991	1.05	1.10	1.13	1.17	1.88
1992	1.01	1.06	1.11	1.08	1.48
1993	1.06	1.04	1.06	1.01	1.18
Amount applied:	*Pounds a.i. per treated acre*				
1990	1.16	1.12	1.11	0.95	1.34
1991	1.00	1.10	1.12	0.87	1.11
1992	1.08	0.93	1.00	0.83	0.90
1993	1.10	0.96	0.92	0.75	1.13

[1] For the States included, see box "Cropping Practices Survey." For tillage system definitions, see box "Crop Residue Management System Definitions and Survey." For more detail, see appendix table 4.1.6.

Source: USDA, ERS, Cropping Practices Survey data.

plow. Ridge till, while not widely used, generally used the least herbicide. The differences in quantity of pesticide applied between tillage systems were usually small and often were not statistically significant.

These results suggest that conservation tillage systems do not consistently use more total pesticides than Conv. tillage systems. Higher use might be true for a specific crop, tillage system, or particular year. Crop rotation, moisture availability and timing, nonchemical pest management practices, and other factors influencing pest populations also affect pesticide use in annual crop production.

The per-acre quantity of pesticide used on corn and soybeans declined between 1990 and 1993. This is true across most tillage systems for most years. More recent pesticide products often use lower application rates.

A farmer's conversion to no-till may increase weed problems in the first few years. New adopters often use more herbicide and combination mixes in response to this problem (Bull and others, 1993). Because much of the current no-till acreage is new, this could obscure a long-term downward trend in pesticide use.

Research on long-term no-till suggests fewer weed problems and less need for herbicides. With annual tillage, both new weed seeds on the surface and dormant seeds deeper in the soil are brought into the germination zone and provide a continual source of weeds (Martin and Wicks, 1992). Continuous no-till without row cultivations eliminates this weed seed mixing and increases surface mulch. Therefore, weed problems are expected to decrease after several years of continuous no-till.

Corn

No-till corn, except in 1990, received a higher rate of herbicide application than did any other tillage system (table 4.1.4 and app. table 4.1.6). Ridge till,

Cropping Practices Survey

The Cropping Practices Surveys collect annual data on fertilizer and pesticide use, tillage systems, crop sequence, and information on other inputs and cultural practices. Fertilizer information has been reported from these surveys since 1964. In the mid-1980's, pesticide use, tillage operations, and prior crop questions were added to the survey. Integrated pest management and nutrient management questions have recently been included.

The 1993 surveys included corn, cotton, soybeans, wheat, and potatoes and represented about 167 million acres. This area includes the acreage in major producing States, which account for about 80 percent of the total U.S. acreage for these crops. Because of priority data needs and available survey funds, the number of crops and States and types of data have varied from year to year. Crops and States surveyed for data on tillage systems and crop sequence include:

Corn:	IL, IN, IA, MI, MN, MO, NE, OH, SD, and WI
Soybeans:	Northern: IL, IN, IA, MN, MO, NE, and OH. Also AR in 1993; Southern, 1988-92: AR, GA, KY, LA, MS, NC, and TN
Cotton:	AR, AZ, CA, LA, MS, and TX
Winter wheat:	CO, IL, KS, MO, MT, NE, OH, OK, TX, and WA. Also AR, CA, ID, IN, and OR in 1988-89; AR and SD in 1990; AR, ID, IN, OR, and SD in 1991-92; and ID, OR, and SD in 1993
Spring wheat:	MN, MT, ND, and SD. Also ID in 1988-89
Durum wheat:	ND.

The sample consists of fields containing a random acre selected through a stratified sampling procedure. Respondents are asked to provide field-level information for the fields containing the sample acre. The operator of the selected sample field is asked to report all fertilizer and nutrient treatments, all tillage operations prior to planting, crops planted in the previous 2 years, and data on other inputs and cultural practices. The operator also identifies whether the field has been designated as highly erodible land (HEL) by the Soil Conservation Service and whether the farm unit participates in Federal price support programs.

representing less than 3 percent of the acreage, used the lowest amount of herbicides. Acreage tilled with the moldboard plow used slightly less herbicide than mulch till or Conv. tillage without the moldboard plow. Reported differences in herbicides applied per acre were not always statistically significant. Other elements, such as weather, soil type, tillage system experience, and inherent weed problems, could be more influential factors than tillage type.

About the same herbicide ingredients were used on all tillage types (Bull, 1991). Atrazine, alachlor, cyanazine, and metolachlor accounted for over 80 percent of active ingredients (a.i.) applied with any tillage system (NASS, 1993). EPTC was frequently used with Conv. and mulch tillage. Because EPTC must be incorporated into the soil to prevent loss by volatilization, it is not normally used with no-till or ridge till.

In contrast to herbicide use, insecticide use on corn was consistently less per treated acre under no-till than under other tillage systems (table 4.1.5). None of the differences were significant, probably due to the small sample size (low incidence of insecticide use).

The CPS indicates lower nitrogen application rates on land using the moldboard plow. This appears to be offset by the greater incidence of manure application (app. table 4.1.7). The greater use of nitrogen and lesser applications of phosphate and potash with ridge till are probably related to higher fertilization on soils with higher yield potential, higher incidence of irrigation, and continuous corn cropping where ridge till is most prevalent. Nitrogen management (including rate, timing, and placement) has been found to be more crucial for controlling nitrate loss through leaching than the type of tillage system (Baker and others, 1987).

Soybeans

No-till soybeans in both northern and southern regions received higher herbicide application rates than any other tillage systems (table 4.1.4 and app. tables 4.1.7-4.1.8). Differences among other tillage systems were small and not consistent between years. Like corn, other factors in addition to tillage determine herbicide treatments for soybeans.

Unlike corn, the type of a.i. applied did vary across tillage systems in soybean production. Trifluralin was the most widely used a.i. in both Conv. tillage systems and mulch tillage. Trifluralin is applied before planting and incorporated into the soil with a tillage tool (see box, "Crop Residue Management System Definitions").

For no-till and ridge-till systems, no single a.i. or combination mix was dominant in the northern region before 1990. Since 1990, imazethapyr has become the most widely used a.i. in northern no-till soybeans. Imazethapyr can be applied preplant incorporated, preemergence, or postemergence. It controls many broadleaf weeds and certain grasses. For southern soybeans, the most commonly used a.i. with no-till were glyphosate and fluazifop. Glyphosate is applied before the soybeans emerge to kill existing vegetation and fluazifop is a postemergence treatment.

It is, therefore, not appropriate to compare only the total quantity of herbicide applied between no-till and another tillage system. The a.i. content and properties such as leaching potential and persistence would be quite different.

Pesticides other than herbicides are not frequently applied to soybeans under any crop residue management system. Insecticides were applied to less than 3 percent of soybean acres across all tillage systems. Fungicide applications were made on less than 1 percent of soybean acres. Almost 25 percent of soybean acreage is planted with seed that has been treated with an insecticide and/or fungicide.

The incidence of fertilizer use is much less for soybeans than for corn (app. tables 4.1.6-4.1.8). The application rates show some variation between tillage systems and between years. Southern soybeans tended to use more fertilizer for no-till than for the other systems, while northern soybeans showed no consistent differences. Many southern no-till soybeans are double-cropped and, therefore, require more fertilizer.

Cotton

Cotton acreage is nearly 99 percent Conv.ly tilled. Differences in fertilizer and pesticide use reflect regional differences rather than differences caused by tillage system. Parts of Texas, Arizona, and California have "plow-down" laws requiring that the cotton plant be disposed of to eliminate the overwinter food source for bollworms and boll weevils.

Winter Wheat

The percentage of winter wheat acreage treated with herbicides is greater for Conv. tillage with the moldboard plow than for other tillage systems (table 4.1.4 and app. table 4.1.9). Herbicide use per acre is

greatest for no-till and is associated with a greater number of treatments. Glyphosate and 2,4-D were used more extensively with no-till. This may indicate an initial burndown treatment that did not always eliminate the need for subsequent treatments.

Winter wheat also showed some variation in fertilizer use across years and tillage systems (app. table 4.1.9). However, as with corn and soybeans, this was probably related more to regional differences (including soil and rotations) than to differences in tillage systems.

Mechanical Cultivations

Mechanical weed control cultivations may be used as a pest control alternative to herbicides. However, these cultivations do have disadvantages. Cultivation interrupts the buildup of organic matter and the activity of earthworms and microorganisms. It also tends to till the soil, which brings up dormant weed seeds and stirs up seeds near the surface and loosens soil particles, which can then be dislodged by wind and water erosion.

The percentage of no-tilled corn acres that received mechanical weed control cultivations was much less than for other tillage systems (table 4.1.6 and app. table 4.1.6). Of the cultivated acres, the number of cultivations averaged 1.2-1.5 for all tillage systems except for ridge till, at 1.7-1.8. Ridge-till systems normally use mechanical cultivations during the season to maintain the ridges in addition to controlling weeds.

Mechanical cultivation for weed control on soybeans is feasible only on those planted with a row planter. About 75 percent of soybean acreage is row-planted.

Environmental Effects of Conservation Tillage

Conservation tillage systems reduce soil erosion, water runoff, and the potential for surface water contamination from agricultural pollutants. Under normal circumstances, the potential for ground water contamination is no greater than for other tillage systems. A change to conservation tillage systems to meet USDA program goals should contribute to a net decrease in total potential water quality degradation.

Tillage practices that leave substantial amounts of crop residue evenly distributed over the soil surface defend against the potential of rainfall's kinetic energy to generate sediment and increase water runoff. Several field studies (Baker and Johnson, 1979; Glenn and Angle, 1987; Hall and others, 1984; Sander and others, 1989) conducted under natural rainfall on highly erodible land (14 percent slope) have compared erosion rates between tillage systems. Compared with moldboard plowing, no-till generally reduced soil erosion by more than 90 percent, mulch till and ridge till by about 70 percent.

Increased surface residues also filter out and trap sediment and sediment-adsorbed chemicals (fertilizers and pesticides) and result in cleaner runoff (Onstad and Voorhees, 1987). The increased organic matter associated with crop residue management intercepts these chemicals and holds them in place until they are used by the crop or degrade into harmless components (Dick and Daniel, 1987; Helling, 1987; Wagenet, 1987). The presence of increased crop residue usually reduces the volume of contaminants entering surface waters by constraining runoff (including dissolved chemicals and sediment) and enhancing infiltration (Baker, 1987; Fawcett, 1987; Wauchope,1987).

Enhanced water infiltration associated with greater surface residue provides additional soil moisture to benefit crops during low rainfall periods, but raises concerns about potential leaching of nitrates and pesticides to shallow ground water (Baker, 1987; Wauchope,1987). However, increased volume of infiltration normally dilutes the concentration level of contaminants in the percolate to groundwater. Scientific evidence suggests that, under normal climatic and hydrologic conditions, conservation tillage systems are no more likely to degrade ground water quality than other tillage systems (Baker, 1980; Baker, 1987; Edwards and others, 1993; Fawcett and others, 1994; Wagenet, 1987).

While conservation tillage systems often require different herbicide treatments, all tillage systems use a broad spectrum of herbicides for weed control. Many factors, including the type of chemical applied, application methods and timing, soil properties, weather, and the crop residue effects on compaction and macropores, can affect the fate of applied nutrients and pesticides (Bull and others, 1993). Chemicals applied prior to heavy rainfall events and that have high water solubility, low adsorption to soil, and resistance to degradation are most likely to impair water quality (Dick and Daniel, 1987; Fawcett, 1987; Wauchope and others, 1992; Weber and Warren, 1993).

This percentage is consistent across tillage systems except for ridge till, which must be row-planted.

Mechanical weed control cultivations on the acres that were row-planted and cultivated averaged about 1.5 times for the northern soybean area across all tillage systems, with ridge till being higher in some years (table 4.1.6 and app. table 4.1.7). The southern soybean area averaged about 2 cultivations for all tillage systems. A smaller percentage of no-tilled acres were cultivated than for other tillage systems.

Table 4.1.6—Weed control cultivation by crop and tillage system in major producing States, 1990-93[1]

Item	Conv.		Conservation		
	With mbd. plow	W/out mbd. plow	Mulch till	No-till	Ridge till
Corn:					
Acreage cultivated	*Percent of planted acres*				
1990	74	73	69	29	97
1991	69	71	70	31	100
1992	76	77	78	32	100
1993	65	57	55	21	92
Average cultivations			*Number*		
1990	1.4	1.3	1.3	1.5	1.8
1991	1.3	1.3	1.2	1.3	1.7
1992	1.4	1.2	1.3	1.2	1.8
1993	1.3	1.2	1.2	1.2	1.7
Northern soybeans:					
Acreage cultivated	*Percent of row planted acres*				
1990	89	86	85	26	100
1991	87	83	87	15	84
1992	86	79	81	22	96
1993	74	62	63	13	66
Average cultivations			*Number*		
1990	1.6	1.6	1.4	1.5	1.8
1991	1.5	1.4	1.4	1.6	2.5
1992	1.5	1.3	1.3	1.5	1.4
1993	1.3	1.4	1.3	1.4	1.2
Southern soybeans:					
Acreage cultivated	*Percent of row planted acres*				
1990	79	75	60	11	nr
1991	71	74	43	16	nr
1992	78	75	45	10	nr
Average cultivations			*Number*		
1990	2.1	2.2	2.2	2.2	nr
1991	2.0	2.3	1.8	1.7	nr
1992	2.2	2.3	1.9	1.9	nr

nr = none reported.

[1] For the States included, see box "Cropping Practices Survey." For tillage system definitions, see box "Crop Residue Management System Definitions and Survey." For more detail, see appendix tables 4.1.6-4.1.8

Source: USDA, ERS, Cropping Practices Survey data.

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Appendix table 4.1.1—Tillage systems and crop rotations used in corn production by major producing States, 1993

Item	IL	IN	IA	MI	MN	MO	NE	OH	SD	WI	Area
Planted acres (1,000)[1]	10,500	5,600	12,000	2,500	6,300	2,200	8,100	3,350	3,400	3,400	57,350
						Percent of acres [2]					
Tillage system:[3]											
Conventional with mbd plow	3	7	3	22	19	4	1	19	4	39	9
Conventional without mbd plow	58	53	45	42	56	60	35	42	52	43	49
Mulch-till	17	19	34	21	20	19	27	12	29	12	24
Ridge-till	1	nr	1	1	3	nr	17	nr	2	nr	3
No-till	19	21	17	14	2	17	20	27	13	6	15
						Percent of soil surface covered					
Residue remaining after planting:											
Conventional with mbd plow	2	2	3	2	2	1	1	2	2	2	2
Conventional without mbd plow	16	16	19	14	15	15	18	15	17	17	17
Mulch-till	38	39	37	40	37	37	39	39	37	41	38
Ridge-till	34	nr	46	41	48	nr	53	nr	41	nr	51
No-till	64	65	63	74	59	65	67	67	72	75	66
Average	28	30	32	26	19	27	39	30	30	17	29
						Hours per acre					
Tillage time:											
Conventional with mbd plow	.6	.5	.7	.6	.8	.9	.5	.7	.7	.9	.7
Conventional with mbd plow	.3	.4	.3	.4	.3	.4	.4	.5	.3	.6	.4
Mulch-till	.2	.3	.2	.3	.3	.3	.3	.4	.2	.4	.3
Ridge-till	.1	nr	.2	.3	.2	nr	.2	nr	.1	nr	.2
No-till	.1	.1	.1	.1	.1	.1	.1	.2	.1	.2	.1
Average	.3	.3	.3	.4	.4	.3	.3	.4	.3	.6	.3
						Number					
Times over field:											
Conventional with mbd plow	4.0	3.5	4.1	3.4	3.9	4.0	3.8	3.8	3.4	3.7	3.8
Conventional without mbd plow	3.1	3.1	2.9	3.0	3.2	3.1	3.1	3.3	3.2	3.3	3.1
Mulch-till	2.3	2.3	2.3	2.7	2.5	2.1	2.4	2.7	2.3	2.4	2.3
Ridge-till	1.0	nr	2.0	1.5	1.5	nr	1.8	nr	1.0	nr	1.7
No-till	1.0	1.0	1.0	1.0	1.0	1.0	1.3	1.0	1.0	1.0	1.0
Average	2.6	2.6	2.4	2.7	3.1	2.5	2.3	2.7	2.6	3.2	2.6
						Percent of acres [2]					
Three-year crop sequence:											
Continuous corn	18	23	21	35	14	10	59	14	10	34	25
Continuous other row crops	76	68	72	39	63	68	32	54	38	19	58
Small grains with row crops	2	id	id	id	10	1	2	2	40	8	5
Idle in rotation	2	6	4	24	11	18	5	28	8	3	8
Hay or other crops in rotation	2	3	3	3	2	3	2	3	4	37	5

id = Insufficient data.
nr = None reported.
[1] Preliminary.
[2] May not add due to rounding.
[3] For tillage system definitions, see box "Crop Residue Management System Definitions and Survey."
Source: USDA, ERS, 1993 Cropping Practices Survey data.

Appendix table 4.1.2—Tillage systems and crop rotations used in soybean production by major producing States, 1993

Item	AR	IL	IN	IA	MN	MO	NE	OH	Area
Planted acres (1,000) [1]	3,500	9,100	4,900	8,500	5,600	4,200	2,500	4,200	42,500
				Percent of acres [2]					
Tillage system: [3]									
Conventional with mbd plow	nr	4	10	7	25	**	nr	15	8
Conventional without mbd plow	82	44	36	36	34	55	41	42	44
Mulch-till	7	24	16	38	33	22	44	12	25
Ridge-till	nr	**	**	1	2	**	3	**	1
No-till	12	28	38	18	6	22	12	31	22
				Percent of soil surface covered					
Residue remaining after planting:									
Conventional with mbd plow	nr	3	3	3	3	2	nr	2	3
Conventional without mbd plow	8	17	19	18	20	15	20	15	16
Mulch-till	43	39	40	41	40	41	41	38	40
Ridge-till	nr	56	56	56	56	56	56	56	56
No-till	75	72	71	75	74	69	75	69	71
Average	18	37	41	36	26	33	37	33	33
				Hours per acre					
Tillage time:									
Conventional with mbd plow	nr	.6	.5	.6	.6	.6	nr	.8	.6
Conventional without mbd plow	.4	.4	.4	.4	.4	.4	.3	.5	.4
Mulch-till	.3	.3	.3	.3	.4	.3	.3	.4	.3
Ridge-till	nr	.1	.1	.2	.2	.2	.2	.1	.2
No-till	.1	.1	.1	.1	.1	.1	.1	.1	.1
Average	.4	.3	.3	.3	.4	.3	.3	.4	.3
				Number					
Times over field:									
Conventional with mbd plow	nr	3.7	3.6	4.1	4.2	4.0	nr	4.2	4.0
Conventional without mbd plow	5.0	3.9	3.2	3.8	4.0	3.5	2.8	3.5	3.8
Mulch-till	3.0	2.9	2.8	2.8	3.2	2.2	2.5	3.0	2.8
Ridge-till	nr	1.0	1.0	1.5	2.0	2.0	1.9	1.0	1.7
No-till	1.0	1.0	1.0	1.0	1.1	1.0	1.1	1.0	1.0
Average	4.4	2.8	2.3	2.9	3.5	2.6	2.5	2.8	3.0
				Percent of acres [2]					
Three-year crop sequence:									
Continuous soybeans	21	1	3	**	**	22	1	11	6
Continuous other row crops	7	91	88	96	85	47	90	62	76
Small grain with row crops	32	**	**	**	13	4	**	1	5
Idle in rotation	3	4	4	3	1	9	6	22	6
Hay or other crops in rotation	**	**	3	**	**	2	1	3	1
Double-cropped soybeans	37	3	3	nr	nr	17	**	2	6

** = Less than 1 percent.
nr = None reported.
[1] Preliminary.
[2] May not add to 100 due to rounding.
[3] For tillage system definitions, see box "Crop Residue Management System Definitions and Survey".
Source: USDA, ERS, 1993 Cropping Practices Survey data.

Appendix table 4.1.3—Tillage systems and crop rotations used in upland cotton production by major producing States, 1993

Item	AZ	AR	CA	LA	MS	TX	Area
Planted acres (1,000)[1]	330	1,030	1,030	890	1,380	5,700	10,360
				Percent of acres [2]			
Tillage system: [3]							
Conventional with plow	42	nr	1	nr	nr	26	16
Conventional without plow	58	99	98	100	97	73	83
Mulch-till	nr	1	1	nr	nr	**	**
No-till	nr	nr	nr	nr	3	1	1
				Percent of soil surface covered			
Residue remaining after planting:							
Conventional with mbd plow	0	nr	0	nr	nr	0	0
Conventional without mbd plow	0	2	1	2	2	3	2
Mulch-till	nr	50	32	nr	nr	40	40
No-till	nr	nr	nr	nr	34	18	24
Average	0	2	1	2	3	3	2
				Hours per acre			
Tillage time:							
Conventional with mbd plow	.9	nr	2.2	nr	nr	.8	.8
Conventional without mbd plow	1.3	.6	1.4	.6	.6	.7	.7
Mulch-till	nr	.3	.6	nr	nr	id	id
No-till	nr	nr	nr	nr	.2	.2	.2
Average	1.2	.6	1.4	.6	.6	.7	.7
				Number			
Times over field:							
Conventional with mbd plow	8.8	nr	9.0	nr	nr	6.5	6.6
Conventional without mbd plow	7.6	6.1	8.0	6.0	5.9	5.9	6.2
Mulch-till	nr	3.0	5.0	nr	nr	id	id
No-till	nr	nr	nr	nr	1.0	2.0	1.6
Average	8.1	6.1	7.9	6.0	5.8	6.0	6.2
				Percent of acres			
Three-year crop sequence:							
Continuous cotton	74	83	54	88	79	48	60
Continuous other row crops	1	11	11	10	19	42	29
Small grains with row crops	3	3	4	nr	1	1	2
Idle in rotation	15	nr	22	2	1	6	7
Hay or other crops in rotation	7	3	9	nr	nr	2	3

id = Insufficient data. nr = None reported. ** = Less than one percent.

[1] Preliminary.

[2] May not add to 100 due to rounding.

[3] For definitions, see box, "Crop Residue Management System Definitions and Survey."

Source: USDA, ERS, 1993 Cropping Practices Survey data.

Appendix table 4.1.4—Tillage systems and crop rotations used in winter wheat production by major producing State, 1993[1]

Item	CO	ID	IL	KS	MO	MT	NE	OH	OK	OR	SD	TX	WA	Area
Harvested acres (1,000)[2]	2,550	850	1,550	11,300	1,400	2,500	2,100	1,000	5,500	860	1,400	3,700	2,500	37,210
							Percent of acres [3]							
Highly erodible land	54	56	38	29	45	59	30	13	20	45	32	19	55	34
Tillage system:[4]														
Conventional with mbd plow	nr	11	id	6	id	1	6	4	10	36	id	nr	6	6
Conventional without mbd plow	75	75	61	76	66	83	79	69	85	44	68	85	69	76
Mulch-till	25	7	9	16	8	15	12	4	5	18	25	13	22	14
No-till	nr	8	28	2	24	id	2	23	nr	id	5	1	4	4
							Percent of soil surface covered							
Residue remaining after planting:														
Conventional with mbd plow	nr	2	id	2	id	id	2	1	1	2	id	nr	2	2
Conventional without mbd plow	16	9	16	13	17	14	15	14	12	15	18	11	14	13
Mulch-till	40	45	39	35	39	40	37	35	43	37	42	40	42	39
No-till	nr	63	56	63	53	id	35	52	nr	id	58	72	33	54
Average	22	15	29	17	27	19	17	23	13	14	26	16	20	18
							Hours per acre							
Tillage time:														
Conventional with mbd plow	nr	.5	id	.5	id	id	.7	.8	.7	.8	id	nr	.7	.7
Conventional without mbd plow	.4	.5	.3	.5	.3	.4	.6	.4	.5	.5	.4	.5	.6	.5
Mulch-till	.2	.4	.3	.3	.3	.2	.4	.4	.3	.5	.2	.3	.2	.3
No-till	nr	.1	.1	.1	.1	id	.1	.1	nr	id	.1	.1	.1	.1
Average	.3	.4	.2	.5	.3	.3	.5	.3	.5	.6	.3	.5	.5	.4
							Number							
Times over field:														
Conventional with mbd plow	nr	4.4	id	5.8	id	id	6.5	3.3	5.9	5.7	id	nr	5.1	5.6
Conventional without mbd plow	5.3	3.9	2.6	5.3	2.5	4.8	5.6	2.5	5.2	4.4	4.7	4.8	6.2	5.0
Mulch-till	4.0	3.5	2.3	5.0	2.3	3.1	3.5	2.4	3.8	3.9	3.8	3.8	3.9	4.1
No-till	nr	1.0	1.0	1.0	1.1	id	1.0	1.0	nr	id	1.0	1.0	1.0	1.0
Average	5.0	3.7	2.1	5.2	2.2	4.5	5.3	2.2	5.2	4.7	4.2	4.6	5.4	4.7
							Percent of acres [3]							
Three-year crop sequence:														
Continuous wheat	9	12	3	48	21	4	10	nr	94	nr	9	58	15	38
Continuous other small grain	1	nr	nr	nr	nr	nr	nr	nr	nr	4	nr	nr	**	
Row crops with small grains	3	16	89	5	70	nr	4	92	4	2	7	11	6	15
Fallow or idle in rotation	88	70	9	47	7	95	84	8	2	98	80	31	79	48
Hay or other crops in rotation	nr	1	nr	nr	2	nr	1	8	nr	nr	nr	nr	**	**

id = Insufficient data. nr = None reported.

[1] Arkansas and Indiana not included in 1993.

[2] Preliminary.

[3] May not add to 100 due to rounding.

[4] For definitions, see box, "Crop Residue Management System Definitions and Survey."

Source: USDA, ERS, 1993 Cropping Practices Survey data

Appendix table 4.1.5—Tillage systems and crop rotations used in spring and durum wheat production by major producing State, 1993

Item	Spring wheat					Durum wheat
	MN	MT	ND	SD	Area	ND
Planted acres (1,000) [1]	2,500	2,650	9,700	2,100	16,950	1,950
			Percent of acres [2]			
Tillage system: [3]						
Conventional with mbd plow	35	nr	5	5	9	3
Conventional without mbd plow	43	78	56	52	57	57
Mulch-till	18	17	32	22	26	36
No-till	3	5	6	21	7	5
			Percent of soil surface covered			
Residue remaining after planting:						
Conventional with mbd plow	2	nr	3	2	3	3
Conventional without mbd plow	12	16	16	15	15	18
Mulch-till	35	46	41	44	41	44
No-till	62	72	57	64	61	61
Average	14	24	26	31	24	29
			Hours per acre			
Tillage time:						
Conventional with mbd plow	.4	nr	.3	.4	.4	.5
Conventional without mbd plow	.2	.3	.3	.3	.3	.4
Mulch-till	.3	.2	.2	.2	.2	.2
No-till	.1	.1	.1	.1	.1	.1
Average	.3	.3	.2	.2	.2	.3
			Number			
Times over field:						
Conventional with mbd plow	4.0	nr	3.3	2.7	3.7	4.7
Conventional without mbd plow	3.7	4.7	4.0	3.2	4.0	4.5
Mulch-till	2.4	2.4	2.4	2.1	2.4	2.4
No-till	1.0	1.0	1.0	1.0	1.0	1.0
Average	3.5	4.1	3.2	2.5	3.3	3.5
			Percent of acres [2]			
Three-year crop sequence:						
Continuous wheat	12	15	17	3	14	12
Continuous other small grains	12	1	16	7	12	12
Row crops with small grains	63	nr	30	74	36	11
Fallow in rotation	12	84	33	14	35	62
Hay or other crops in rotation	nr	nr	5	2	3	3

id = Insufficient data. nr = none reported.

[1] Preliminary.

[2] May not add to 100 due to rounding.

[3] For definitions, see box, "Crop Residue Management System Definitions and Survey."

Source: USDA, ERS, 1993 Cropping Practices Survey data.

Appendix table 4.1.6—Corn acres treated with pesticide, fertilizer, and cultivated for weed control by tillage system for major producing States, 1990-93[1]

Item	1990					1991				
	Conventional [2]		Conservation			Conventional		Conservation		
	With plow	Without plow	Mulch till	No till	Ridge till	With plow	Without plow	Mulch till	No till	Ridge till
Planted acres (1,000)	10,072	34,253	9,556	4,026	893	8,778	33,518	12,027	5,074	953
Percent by tillage system	17	57	18	7	2	15	56	20	8	2
Percent residue remaining	2	16	38	67	48	2	16	37	67	46
Herbicide use:										
Percent of planted acres treated:	90	96	94	96	100	91	96	97	96	94
Percent of planted acres with:										
0 treatments	10	4	6	4	0	9	4	3	4	6
1 treatment	60	59	57	62	66	67	62	60	65	61
2 treatments	27	33	33	30	30	23	32	35	27	30
3 or more treatments	3	4	3	4	4	1	2	2	4	3
Acres treated (1,000)	9,047	32,934	8,962	3,846	893	7,949	32,150	11,674	4,895	894
1,000 pounds a.i.[3]	27,455	111,036	27,005	12,584	2,204	21,573	95,681	35,588	15,910	1,885
Pounds a.i. per treated acre	3.03	3.37	3.01	3.27	2.47	2.73	2.98	3.05	3.25	2.11
Significance tests[4]	ac	abd	be	f	cdef	abce	adf	bg	cdh	efgh
Number of treatments	1.38	1.43	1.42	1.40	1.39	1.27	1.38	1.40	1.39	1.38
Significance tests[4]						abcd	a	b	c	d
1,000 acre-treatments[5]	12,484	46,962	12,753	5,400	1,238	10,123	44,366	16,323	6,802	1,235
Percent with:										
Single ingredient	61	50	56	37	56	50	52	46	34	43
2-way combinations	36	46	39	45	42	42	43	50	51	52
3-way & 4-way combinations	3	4	5	18	2	8	5	4	15	5
Pounds a.i. per acre-treatment	2.20	2.36	2.12	2.33	1.78	2.13	2.16	2.18	2.34	1.53
Insecticide use:										
Percent of planted acres treated:	35	32	37	31	48	29	30	35	27	63
Percent of planted acres with:										
0 treatments	65	68	63	69	52	71	70	65	73	37
1 treatment	33	30	33	30	35	28	28	31	23	24
2 treatments	2	2	4	1	13	1	2	3	3	27
3 or more treatments	0	0	0	0	0	0	0	1	1	12
Acres treated (1,000)	3,525	10,960	3,535	1,248	430	2,546	10,055	4,209	1,370	600
1,000 pounds a.i.[3]	4,089	12,275	3,913	1,186	576	2,546	10,658	4,377	1,192	666
Pounds a.i. per treated acre	1.16	1.12	1.11	0.95	1.34	1.00	1.06	1.04	0.87	1.11
Number of treatments	1.04	1.10	1.12	1.05	1.27	1.05	1.10	1.13	1.17	1.88
Weed control cultivations:										
Percent of planted acres cultivated	74	73	69	29	97	69	71	70	31	100
Percent of planted acres with:										
0 cultivations	26	27	31	71	3	31	29	30	69	0
1 cultivation	49	52	47	16	22	50	54	57	21	31
2 cultivations	21	18	20	13	72	16	15	13	10	67
3 or more cultivations	4	3	2	1	3	3	1	1	0	2
Cultivated acres:										
Average no. of cultivations	1.4	1.3	1.3	1.5	1.8	1.3	1.3	1.2	1.3	1.7
Fertilizer use:										
Percent of planted acres applying:										
Manure	32	14	16	7	20	35	16	18	10	7
Nitrogen	94	97	96	98	100	94	97	97	98	100
Phosphate	87	85	81	82	96	85	83	78	81	70
Potash	83	78	72	65	49	79	75	68	67	36
Average commercial fertilizer application rate for those applying:										
Nitrogen	109	138	134	132	145	106	132	130	129	155
Phosphate	57	61	64	62	32	56	63	59	59	47
Potash	81	84	87	90	52	77	83	78	84	52

See footnotes at end of table.

Continued—

Appendix table 4.1.6 (continued)—Corn acres treated with pesticide, fertilizer, and cultivated for weed control by tillage system for major producing States, 1990-93[1]

Item	1992					1993				
	Conventional[2]		Conservation			Conventional		Conservation		
	With plow	Without plow	Mulch till	No till	Ridge till	With plow	Without plow	Mulch till	No till	Ridge till
Planted acres (1,000)	7,543	30,862	15,383	7,652	1,410	5,060	27,946	13,719	8,865	1,760
Percent by tillage system	12	49	25	12	2	9	49	24	15	3
Percent residue remaining	2	16	37	64	45	2	16	37	65	50
Herbicide use:										
Percent of planted acres treated:	95	97	97	99	98	92	98	98	99	98
Percent of planted acres with:										
0 treatments	5	3	3	1	2	8	2	2	1	2
1 treatment	69	59	53	68	70	67	63	61	59	68
2 treatments	24	36	39	27	26	22	32	35	33	id
3 or more treatments	2	2	5	4	2	3	3	3	7	id
Acres treated (1,000)	7,191	29,828	14,878	7,541	1,379	4,659	27,262	13,423	8,764	1,717
1,000 pounds a.i.[3]	19,369	90,948	43,421	24,852	3,016	11,542	81,498	37,802	29,965	3,208
Pounds a.i. per treated acre	2.69	3.05	2.92	3.30	2.19	2.48	2.99	2.82	3.42	1.87
Significance tests[4]	abce	af	bdg	cdh	efgh					
Number of treatments	1.30	1.41	1.51	1.35	1.30	1.31	1.39	1.42	1.48	1.43
Significance tests[4]	ab	ac	cde	d	e					
1,000 acre-treatments[5]	9,329	42,004	22,408	10,206	1,789	6,109	37,833	18,997	12,961	2,451
Percent with:										
Single ingredient	47	48	50	32	41	51	45	49	31	34
2-way combinations	49	45	45	54	57	42	47	44	46	63
3-way and 4-way combinations	4	7	5	14	2	7	8	7	23	3
Pounds a.i. per acre-treatment	2.08	2.17	1.94	2.44	1.69	1.89	2.15	1.99	2.31	1.31
Insecticide use:										
Percent of planted acres treated:	28	28	32	25	60	27	26	32	22	58
Percent of planted acres with:										
0 treatments	72	72	68	75	40	73	74	68	78	42
1 treatment	28	26	30	23	38	26	25	30	21	48
2 treatments	0	2	1	2	17	0	1	2	1	10
3 or more treatments	0	0	1	0	5	1	0	0	0	0
Acres treated (1,000)	2,112	8,641	4,923	1,913	846	1,353	7,318	4,453	1,932	1,027
1,000 pounds a.i.[3]	2,281	8,036	4,923	1,588	761	1,424	6,853	3,994	1,350	1,164
Pounds a.i. per treated acre	1.08	0.93	1.00	0.83	0.90	1.05	0.94	0.90	0.70	1.13
Number of treatments	1.01	1.06	1.11	1.08	1.48	1.06	1.04	1.06	1.01	1.18
Weed control cultivations:										
Percent of planted acres cultivated	76	77	78	32	100	65	57	55	21	92
Percent of planted acres with:										
0 cultivations	24	23	22	68	0	35	43	45	79	8
1 cultivation	53	61	56	26	22	46	46	47	16	35
2 cultivations	19	15	20	5	77	17	10	8	5	51
3 or more cultivations	4	1	2	1	1	1	1	0	0	6
Cultivated acres:										
Average no. of cultivations	1.4	1.2	1.3	1.2	1.8	1.3	1.2	1.2	1.2	1.7
Fertilizer use:										
Percent of planted acres applying:										
Manure	37	15	12	10	6	39	18	15	10	10
Nitrogen	93	97	96	98	99	95	97	96	98	97
Phosphate	84	84	80	79	96	89	84	81	83	78
Potash	79	74	69	68	33	84	74	68	73	27
Average commercial fertilizer application rate for those applying:										
Nitrogen	106	129	133	127	143	95	127	122	122	149
Phosphate	51	58	58	57	41	54	59	57	50	29
Potash	73	81	81	77	50	76	85	75	71	36

[1] States include IL, IN, IA, MI, MN, MO, NE, OH, SD, and WI. [2] For definitions, see box "Crop Residue Management System Definitions and Survey." [3] Active ingredients. [4] Pounds a.i. applied per treated acre or number of treatments for the tillage systems above the same letter (within same year) are significantly different (t-test) at the 5-percent level. Others are not significantly different. [5] Acre-treatments = acres treated times number of treatments.
Source: USDA, ERS, Cropping Practices Survey data.

Appendix table 4.1.7—Northern soybean acres treated with herbicide, fertilizer, and cultivated for weed control by tillage system for major producing States, 1990-93[1]

Item	1990					1991				
	Conventional [2]		Conservation			Conventional		Conservation		
	With plow	Without plow	Mulch till	No till	Ridge till	With plow	Without plow	Mulch till	No till	Ridge till
Planted acres (1,000)	8,306	18,516	7,588	1,637	353	6,896	18,549	9,583	3,470	351
Percent by tillage system	23	51	21	4	1	18	48	25	9	1
Percent residue remaining	2	16	39	73	51	2	17	38	73	50
Herbicide use:										
Percent of planted acres treated:	97	97	95	94	100	95	97	98	94	100
Percent of planted acres with:										
0 treatments	3	3	5	6	0	5	3	2	6	0
1 treatment	52	61	52	39	50	61	61	52	46	46
2 treatments	40	31	38	46	50	33	32	41	40	37
3 or more treatments	5	5	5	9	0	1	4	5	9	17
Acres treated (1,000)	8,034	17,988	7,192	1,543	353	6,583	17,966	9,397	3,275	351
1,000 pounds a.i. [3]	12,643	23,807	9,692	3,415	404	8,583	22,136	12,002	4,975	639
Lbs. a.i. per treated acre	1.57	1.32	1.35	2.21	1.14	1.30	1.23	1.28	1.52	1.00
Significance tests [4]	abcd	ae	bf	cefg	dg		a		ab	b
Number of treatments	1.52	1.42	1.52	1.70	1.50	1.38	1.42	1.53	1.61	1.82
Significance tests[4]		a		a		abc	def	ad	be	cf
1,000 acre-treatments[5]	12,246	25,523	10,943	2,630	529	9,065	25,485	14,422	5,274	639
Percent with:										
Single ingredient	63	59	67	41	51	65	57	64	53	75
2-way combinations	27	29	23	40	43	25	32	28	30	16
3-way and 4-way combinations	10	12	10	19	6	10	11	8	17	9
Pounds a.i. per acre-treatment	1.03	0.93	0.89	1.30	0.76	0.95	0.87	0.83	0.94	0.55
Weed control cultivations:										
Percent of planted acres planted with row planter:	80	75	79	44	100	80	74	73	42	100
Percent of row planted acres that were cultivated:	89	86	85	26	100	87	83	87	15	84
Percent of row planted acres with:										
0 cultivations	11	14	15	74	0	13	17	13	85	16
1 cultivation	39	50	51	13	25	46	54	58	6	29
2 cultivations	44	33	31	13	66	37	27	27	9	38
3 or more cultivations	6	3	3	0	9	4	2	2	0	17
Cultivated acres:										
Average number of cultivations	1.6	1.6	1.4	1.5	1.8	1.5	1.4	1.4	1.6	2.5
Fertilizer use:										
Percent of planted acres applying:										
Manure	8	7	5	4	20	10	5	6	4	3
Nitrogen	13	16	11	18	12	14	16	13	11	30
Phosphate	18	23	14	27	21	18	21	15	18	36
Potash	25	28	17	42	30	20	25	17	24	27
Average commercial fertilizer application rate for those applying:										
Nitrogen	15	24	19	38	19	31	22	23	28	11
Phosphate	39	50	47	53	48	53	48	46	56	39
Potash	87	83	81	109	109	86	80	76	89	42

See footnotes at end of table.

Continued—

Appendix table 4.1.7 (continued)—Northern soybean acres treated with herbicide, fertilizer, and cultivated for weed control by tillage system for major producing States, 1990-93[1]

Item	1992					1993				
	Conventional[2]		Conservation			Conventional		Conservation		
	With plow	Without plow	Mulch till	No till	Ridge till	With plow	Without plow	Mulch till	No till	Ridge till
Planted acres (1,000)	4,681	16,816	11,130	5,292	231	3,492	15,822	10,511	8,849	326
Percent by tillage system	12	44	29	14	1	9	40	27	23	1
Percent residue remaining	2	17	39	70	53	2	17	40	71	55
Herbicide use:										
Percent of planted acres treated:	99	99	99	98	100	97	97	98	98	100
Percent of planted acres with:										
0 treatments	1	1	1	2	0	3	3	2	2	0
1 treatment	59	59	54	44	83	55	59	53	33	41
2 treatments	37	37	41	44	8	40	33	41	51	47
3 or more treatments	3	3	4	10	9	2	5	4	14	12
Acres treated (1,000)	4,619	16,555	10,967	5,161	231	3,383	15,361	10,291	8,657	326
1,000 pounds a.i. [3]	5,234	18,855	11,986	6,869	165	3,703	16,017	9,775	12,117	395
Lbs. a.i. per treated acre	1.13	1.14	1.09	1.33	0.72	1.09	1.04	0.95	1.40	1.21
Significance tests [4]	a	b	c	abcd	d					
Number of treatments	1.42	1.43	1.50	1.67	1.27	1.46	1.46	1.50	1.86	1.70
Significance tests [4]	ab	cd	ac	bde	e					
1,000 acre-treatments [5]	6,581	23,719	16,466	8,601	293	4,955	22,467	15,477	16,067	555
Percent with:										
Single ingredient	65	55	62	56	64	67	56	63	46	44
2-way combinations	26	34	29	26	26	25	33	29	34	50
3-way and 4-way combinations	9	11	9	18	10	8	11	8	20	6
Pounds a.i. per acre-treatment	0.80	0.79	0.73	0.80	0.56	0.75	0.71	0.63	0.75	0.71
Weed control cultivations:										
Percent of planted acres planted with row planter:	80	66	74	23	100	73	64	69	23	100
Percent of row planted acres that were cultivated:	86	79	81	22	96	74	62	63	13	66
Percent of row planted acres with:										
0 cultivations	14	21	19	78	4	26	38	37	87	34
1 cultivation	50	56	57	18	55	50	44	48	8	51
2 cultivations	32	21	23	4	41	22	14	13	5	15
3 or more cultivations	4	2	1	0	0	2	4	2	0	0
Cultivated acres:										
Average number of cultivations	1.5	1.3	1.3	1.5	1.4	1.3	1.4	1.3	1.4	1.2
Fertilizer use:										
Percent of planted acres applying:										
Manure	10	5	9	9	8	9	7	7	5	0
Nitrogen	14	13	11	15	26	12	15	9	13	29
Phosphate	20	22	14	21	21	17	23	12	22	17
Potash	22	26	17	30	18	22	29	16	31	21
Average commercial fertilizer application rate for those applying:										
Nitrogen	13	18	26	20	26	13	18	15	20	17
Phosphate	37	46	49	50	16	43	45	44	52	34
Potash	67	75	78	85	5	82	81	84	87	54

[1] States include IL, IN, IA, MN, MO, NE, and OH.

[2] For definitions, see box, "Crop Residue Management System Definitions and Survey."

[3] Active ingredients.

[4] Pounds a.i. applied per treated acre or number of treatments for the tillage systems with the same letter (in 1992) are significantly different (t test) at the 5-percent level. Others are not significantly different.

[5] Acre-treatments = acres treated times number of treatments.

Source: USDA, ERS, Cropping Practices Survey data.

Appendix table 4.1.8—Southern soybean acres treated with herbicide, fertilizer, and cultivated for weed control by tillage system for major producing States, 1990-92[1]

Item	1990				1991				1992			
	Conventional[2]		Conservation[3]		Conventional		Conservation		Conventional		Conservation	
	With plow	W/o plow	Mulch till	No till	With plow	W/o plow	Mulch till	No till	With plow	W/o plow	Mulch till	No till
Planted acres (1,000)	417	9,148	845	1,440	302	8,703	617	1,178	297	8,321	420	1,442
Percent of total planted acres	4	77	7	12	3	81	6	11	3	79	4	14
Percent previous crop residue	1	8	43	74	1	7	42	72	1	6	43	65
Herbicide use:												
Percent of planted acres treated:	89	93	90	96	86	92	92	95	78	95	97	98
Percent of planted acres with:												
0 treatments	11	7	10	4	14	8	8	5	22	5	3	2
1 treatment	54	48	50	50	52	50	65	39	63	45	53	40
2 treatments	28	35	33	36	30	35	27	38	15	35	39	43
3 or more treatments	7	10	7	10	4	7	0	18	0	15	5	15
Acres treated (1,000)	370	8,505	758	1,379	260	8,041	566	1,126	233	7,882	407	1,414
1,000 pounds a.i.[4]	449	10,104	792	2,678	315	9,019	506	2,238	320	9,175	467	1,985
Pounds a.i. per treated acre	1.21	1.19	1.05	1.94	1.21	1.12	0.89	1.99	1.37	1.16	1.15	1.40
Significance tests[5]	a	b	c	abc	a	bc	bd	acd		a	b	ab
Number of treatments	1.47	1.61	1.52	1.58	1.44	1.55	1.29	1.82	1.19	1.72	1.50	1.78
Significance tests[5]					a	bc	bd	acd	abc	ad	bde	ce
1,000 acre-treatments[6]	543	13,691	1,151	2,182	376	12,504	732	2,048	277	13,589	611	2,527
Percent with:												
Single ingredient	53	67	67	53	53	60	43	46	61	62	62	53
2-way combinations	45	27	24	32	44	33	40	36	39	31	31	31
3-way and 4-way combinations	2	6	9	15	3	7	17	18	0	7	7	16
Pounds a.i. per acre-treatment	0.83	0.74	0.69	1.23	0.84	0.72	0.69	1.09	1.15	0.68	0.76	0.79
Weed control cultivations:												
Percent of planted acres planted with row planter:	86	76	62	61	82	76	76	88	76	75	73	63
Percent of row planted acres that were cultivated:	79	75	60	11	71	74	43	16	78	75	45	10
Percent of row planted acres with:												
0 cultivations	21	25	40	89	29	26	57	84	22	25	55	90
1 cultivation	20	17	13	3	20	15	18	8	19	13	9	2
2 cultivations	35	32	29	3	30	31	15	6	28	36	29	6
3 or more cultivations	24	26	18	5	21	28	10	2	31	26	7	2
Cultivated acres:												
Average number of cultivations	2.1	2.2	2.2	2.2	2.0	2.3	1.8	1.7	2.2	2.3	1.9	1.9
Fertilizer use:												
Percent of planted acres applying:												
Manure	2	1	3	8	9	2	14	3	7	2	2	1
Nitrogen	41	25	27	25	45	20	17	27	54	19	36	26
Phosphate	53	38	34	33	47	33	17	37	66	35	40	37
Potash	55	39	35	31	50	36	17	32	63	36	44	39
Average commercial fertilizer application rate for those applying:												
Nitrogen	18	23	40	58	26	22	43	57	18	25	29	39
Phosphate	41	45	56	65	44	42	50	62	37	47	68	61
Potash	66	68	76	82	69	70	56	76	66	73	74	82

[1] States include AR, GA, KY, LA, MS, NC, and TN. [2] For definitions, see box, "Crop Residue Management System Definitions and Survey." [3] No ridge tillage reported. [4] Active ingredients. [5] Pounds a.i. applied per treated acre or number of treatments for the tillage systems above the same letter (within same year) are significantly different (t test) at the 5-percent level. Others are not significantly different. [6] Acre-treatments = acres treated times number of treatments.
Source: USDA, ERS, Cropping Practices Survey data.

Appendix table 4.1.9—Winter wheat acres treated with herbicide and fertilizer by tillage system for major producing States, 1991-93 [1]

Item	1991				1992				1993			
	Conventional [2]		Conservation		Conventional		Conservatio		Conventional		Conservation	
	With plow	W/o plow	Mulch till	No till	With plow	W/o plow	Mulch till	No till	With plow	W/o plow	Mulch till	No till
Planted acres (1,000)	4,171	24,893	4,099	1,017	3,962	25,266	6,499	1,263	2,064	28,374	5,206	1,566
Percent of total planted acres	12	73	12	3	11	68	18	3	6	76	14	4
Percent previous crop residue	1	13	38	58	1	14	38	58	1	13	38	54
Herbicide use:												
Percent of planted acres treated:	40	27	22	36	48	34	23	28	53	43	40	43
Percent of planted acres with:												
0 treatments	60	73	78	64	52	66	77	72	47	57	60	57
1 treatment	38	25	17	29	45	30	20	22	47	40	34	32
2 treatments	2	2	4	6	3	3	3	6	2	3	5	7
3 or more treatments	1	*	0	1	1	*	*	0	3	*	2	4
Acres treated (1,000)	1,684	6,680	887	370	1,919	8,480	1,477	353	1,084	12,180	2,079	674
1,000 pounds a.i. [3]	392	2,077	324	253	569	2,820	520	125	407	3,871	872	322
Pounds a.i. per treated acre	0.23	0.31	0.37	0.68	0.30	0.33	0.35	0.35	0.38	0.32	0.42	0.48
Number of treatments	1.09	1.09	1.19	1.21	1.10	1.12	1.15	1.21	1.19	1.09	1.21	1.37
1,000 acre-treatments [4]	1,837	7,300	1,060	448	2,104	9,519	1,702	426	1,286	13,262	2,507	920
Percent with:												
Single ingredient	76	55	49	53	63	58	60	63	60	47	37	49
2-way combinations	11	38	41	38	23	28	35	25	13	38	51	24
3-way & 4-way combinations	13	7	10	8	14	14	5	12	27	15	12	27
Pounds a.i. per acre-treatment	0.21	0.28	0.31	0.56	0.27	0.30	0.31	0.29	0.32	0.29	0.35	0.35
Fertilizer use:												
Percent of planted acres applying:												
Manure	1	4	3	6	2	3	1	4	2	2	2	3
Nitrogen	97	85	73	84	94	87	71	96	92	86	82	95
Phosphate	55	49	42	70	53	49	36	83	48	49	32	82
Potash	15	23	18	48	13	22	16	54	17	17	10	59
Average commercial fertilizer application rate for those applying:												
Nitrogen	65	67	55	71	74	67	51	75	69	64	52	80
Phosphate	33	40	41	48	34	38	33	49	41	36	36	49
Potash	38	54	52	75	37	49	39	65	38	46	32	67

* Less than 1 percent.

1 States include AR, CO, ID, IL, IN, KS, MO, MT, NE, OH, OK, OR, SD, TX, AND WA in 1991 and 1992. AR and IN not surveyed in 1993.

[2] For definitions, see box, "Crop Residue Management System Definitions and Survey."

[3] Active ingredients.

[4] Acre-treatments = acres treated times number of treatments.

Source: USDA, Cropping Practices Survey data.