CropLife Foundation
Crop Protection Research Institute

THE VALUE OF HERBICIDES

IN U.S. CROP PRODUCTION

2005 UPDATE

June 2006

Leonard Gianessi
Nathan Reigner

Development of this report was made possible with funding from the member companies of CropLife America.

CropLife Foundation
1156 15th Street, NW #400 Washington, DC 20005
Phone 202-296-1585 www.croplifefoundation.org Fax 202-463-0474

CropLife Foundation is a 501(c)(3) tax-exempt charitable and research organization. CropLife Foundation was created in 2001 to promote and advance sustainable agriculture and the environmentally sound use of crop protection products and bioengineered agriculture. Through sound science-based discovery, the organization will help global agriculture economically produce safe, high quality, abundant food, fiber, and other crops, thus ensuring food security and alleviating poverty, suffering, and hardship.

The Crop Protection Research Institute (CPRI) is a research unit of the CropLife Foundation. Established in January 2004, CPRI is a non-advocacy research organization focused on the economic analysis of agricultural pests, pest management, and pesticide use and regulation in the United States.

Among CPRI's core projects are the National Pesticide Use Database, the development of a series of case studies describing the benefits of pesticides, promotion of the collection and use of pesticide use data in regulatory and policy decision making, and analysis of the impact of regulatory and policy decisions upon pest management in U.S. agriculture.

CPRI's goal is to inform the public discussion surrounding pest management policy, employing written reports, presentations, panel discussions, and web-based media to reach as broad an audience as possible. CPRI is dedicated to utilizing information from the public domain and making all of its completed work freely available to the public.

Crop Protection Research Institute Funders

United States Department of Agriculture
United States Environmental Protection Agency
United States Geological Survey

AMVAC ▪ Arysta ▪ BASF ▪ Bayer CropScience ▪ Cerexagri
Cheminova ▪ Chemtura ▪ Cropsolution ▪ Dow AgroSciences ▪ DuPont Crop Protection ▪ Gowan
ISK Americas ▪ Monsanto ▪ Nufarm ▪ Syngenta Crop Protection ▪ United Phosphorus ▪ Valent USA

CropLife America
CropLife International

Crop Protection Research Institute Staff

Leonard Gianessi, *Director*
Nathan Reigner, *Research Associate*
Bertina Su, *Research Assistant*

CropLife Foundation
1156 15th Street NW, Suite 400
Washington DC, 20005

Table of Contents

1.0 Introduction

2.0 Crop Production Data

3.0 Herbicide Use

4.0 Herbicide Cost

5.0 Herbicide Value Estimation

A. Economic Value

B. Labor Requirements

C. Soil Erosion

D. Fuel Use and Production

6.0 Organic Perspective

7.0 Summary and Conclusions

8.0 Reference List

1.0 Introduction

In 2003, the report *Value of Herbicides in U.S. Crop Production* was issued by the National Center for Food and Agricultural Policy (NCFAP).[1] The report estimated that if U.S. farmers did not use herbicides, crop production would decline by 21%, equivalent to a loss of 288 billion pounds of food and fiber valued at $13.3 billion. Under the no herbicide scenario, farmers would substitute hand weeding and cultivation at an increased cost of $7.7 billion. Overall, the value of herbicides was estimated at $21 billion. The NCFAP report was based on herbicide use patterns and prices, crop values, and cultivation and labor costs specific for the year 2001 and is referred to below as the "2001 report."

Significant changes in the costs of herbicides, labor, and cultivation have occurred since 2001. Herbicide use patterns have changed and crop values have fluctuated. CropLife Foundation (CLF) undertook a study to estimate the value of herbicides in 2005 in order to measure the impact of the changes in prices on the value of herbicides. The report for 2005 (referred to below as the "2005 report") relies on the same methodology and data sources that were used in the 2001 report.

2.0 Crop Production Data

The forty crops selected for the 2001 and 2005 Reports are listed in Table 1 and include field crops, vegetable crops, fruit, nut and berry crops and specialty crops. Table 1 summarizes 2001 and 2005 production and acreage estimates for each crop. Included crops totaled 255 million acres in 2001 and 250 million acres in 2005 with associated volume of production of 1.4 trillion pounds of food and fiber in both years. The combined value of the forty crops was $66 billion in 2001 and $80 billion in 2005. Table 2 shows the acreage and production data by state.

3.0 Herbicide Use

Table 3 summarizes national statistics on herbicide use for the forty crops. An estimate of the percent of crop national acreage treated with herbicides is included and is assumed to be the same in both 2001 and 2005. For thirty of the forty crops, the national acreage treated with herbicides exceeds 85%.

Table 3 also contains estimates of the pounds of herbicide active ingredients used in each crop in 2001 and 2005. Herbicide use on the forty crops totaled 410 million pounds in 2001 and 349 million pounds in 2005. Herbicide use in corn declined by 50 million pounds, largely due to the replacement of older high rate herbicides (butylate, cyanazine, EPTC, metolachlor) with new lower rate herbicides (flufenacet, mesotrione, rimsulfuron, s-metolachlor). Herbicide use on cotton went down by 11 million pounds due to the substitution of glyphosate for several older herbicides: MSMA, fluometuron, pendimethalin, and trifluralin.[7]

The herbicide use estimates shown in Table 2 are sums of use estimates of individual active ingredients by state for the forty crops. This data was drawn from national pesticide use databases for 1997 and 2002.[7] This dataset is available at:

http://www.croplifefoundation.org/cpri_npud2002.htm. The 1997 estimates were updated to 2001 for states and crops in which significant active ingredient use changes occurred between 1997 and 2001.[1] The 2005 estimates are unchanged from the database's estimates for 2002 since the 2002 estimates were largely based on the latest data available for each crop, including data representing 2004 pesticide use. A recent USDA survey report for 2005 for corn and soybeans shows exact agreement with the average national per acre herbicide use estimates listed in Table 3 for 2005.[19]

Table 4 displays herbicide use estimates for 2001 and 2005 by state.

4.0 Herbicide Cost

Table 5 contains cost estimates for herbicides and their application to each of the forty crops for 2001 and 2005. Cost estimate consists of three components: cost of the product, cost of application, and premiums for use of herbicide tolerant soybean, corn, canola, rice, and cotton seeds.

Product costs are determined by multiplying estimates of herbicide poundage applied by an average per-pound active ingredient price. The average per-pound price estimates are drawn from a 1996 report.[18] 1996 price estimates were updated to reflect 2001 and 2005 prices.[11]-[17] Nationally, it is estimated that growers of the forty crops spent $4.7 billion on herbicide products in 2001 and $4.4 billion in 2005. This reduction in herbicide expenditure was the result of major reductions in the cost of several active ingredients. Chief among these price reductions was glyphosate, the number one selling herbicide, whose price declined by 16% between 2001 and 2005. Table 5's estimated decline in aggregate herbicide sales between 2001 and 2005 is in agreement with the latest estimates from the market research firm Phillips McDougall (See Figure 1).

Application costs are calculated by assigning an average number of herbicide application trips to each crop by state (the same estimates are used for 2001 and 2005) and multiplying the number of trips by an estimate of the per trip cost. The per trip cost of herbicide application was estimated at $4.00/A in 2001 and at $5.21/A in 2005.[1][20] The sprayer used for herbicide applications is assumed to be a 60 foot self propelled boom sprayer. The total costs of herbicide application are estimated at $1.4 billion in 2001 and $1.9 billion in 2005.

Estimates were made of the number of herbicide tolerant crop acres by state for canola, corn, cotton, rice, and soybeans.[8][9] The number of herbicide tolerant crop acres in 2005 is estimated at 94 million which represents an increase from 66 million in 2001(see Figure 2). The herbicide tolerant rice acres are the result of crop breeding with conventional techniques which produce rice cultivars tolerant to imazethapyr (Clearfield). The number of imazethapyr tolerant rice acres is based on the number of rice acres estimated to be treated with imazethapy by state.[7] Herbicide tolerant cultivars for the other four crops are the result of genetic engineering (biotech crops). Farmers who purchase the herbicide tolerant seed generally pay a premium price. The premium for the use of the herbicide tolerant rice is estimated at $20/A.[11] Increased seed costs for the purchase of herbicide tolerant seed in 2005 were estimated at $13/A for canola, $6/A for

corn, $8/A for soybean, and $14/A for cotton.[9] The estimates for canola and corn are the same that were used in the 2001 report, while the cotton and soybean estimates represent increases from the previous estimates of $9/A and $6/A respectively. The total premium for planting herbicide-tolerant seed is estimated at $773 million in 2005, which represents an increase from $461 million in 2001.

Table 6 displays the herbicide cost estimates by state.

5.0 Herbicide Value Estimation

Estimates of the value of herbicides are made in terms of the economic value to growers and in terms of reduced labor requirements and soil erosion**.** The impacts on fuel consumption and crop production are also quantified. These estimates are based on a simulation of the non-use of herbicides by U.S. growers, the substitution of likely alternative practices, and cost and effectiveness comparisons between herbicides and alternative weed control practices (cultivation and hand weeding).

A. Economic Value

Table 7 identifies the likely substitution of hand weeding and cultivation for each crop if herbicides are not used. These values are assumed to be the same for the 2001 and 2005 simulations. Table 7 also specifies the cost of the alternatives. Each hour of hand weeding was estimated to cost $8.75 in 2001 which increased to $10.00 per hour in 2005.[10] The hand weeding labor cost includes wage, supervision and other costs associated with employing a crew of hand laborers. Each tillage trip was estimated to cost $4.50 per acre in 2001 increasing to $5.84 per acre in 2005.[20] Field cultivation cost is a weighted average based on acres under reduced and intensive tillage and associated operation costs for conventional and high residue six row cultivators. The tillage costs consist of fuel, maintenance and labor charges. By multiplying the per acre cost of the likely alternatives by the number of acres treated with herbicides, estimates are made of the total cost of the alternative weed control practices. These estimates are shown in Table 7. The national cost of the alternatives is estimated at $14.3 billion for 2001 and $16.8 billion in 2005.

Estimates of the likely impacts on crop yields of not using herbicides in favor of likely alternatives are shown in Table 8 and are assumed to be the same in 2001 and 2005. These estimates are drawn from a series of studies conducted by USDA, WSSA, and AFBF, and are documented in the 2001 report.[1] For thirty-five crops the yield loss estimates range from 5% to 67% without herbicides. For these crops the projected increase in hand weeding and cultivation is not sufficient to prevent yield loss. For four crops (celery, citrus, hot peppers and raspberries), no yield change is projected as the amount of tillage, hand weeding or other alternative practice is assumed to be sufficient to prevent yield loss. In addition, for grapes, the national loss is 1% which is a weighted average of no loss in California and a 12 to 35% loss in other states.

In total, as shown in Table 8, the non-use of herbicides and the likely substitution of alternatives would result in a loss of $13.3 billion in 2001 and $16.3 billion in 2005. Without herbicides the total loss in production would amount to 288 billion pounds in

2001 and 296 billion pounds in 2005, which represents approximately 21% of total production in both years.

Table 9 summarizes the economic impacts of the non-use of herbicides for the forty crops included in the study. The total impact estimated for 2001 is a loss of $21 billion which includes $7.7 billion in increased costs for weed control and $13.3 billion in yield losses due to less effective weed control. The total impact for 2005 is estimated at $26 billion which includes a reduction of $16 billion in crop production and an increase of $10 billion in weed control costs. Table 10 summarizes economic impact estimates by state. Table 11 includes a selected list of crop impacts by state. Table 12 summarizes production volume losses by state.

B. Labor Requirements

One of the major replacements for herbicides identified in this study is increased reliance on hand weeding. Field crops such as wheat, corn, and soybeans are projected to require 2 to 5 additional hours of hand weeding per acre. Most fruit and vegetable crops are projected to require 20 to 60 hours per acre of increased hand weeding. The additional costs of hand weeding are included in the impact estimates by crop in Table 9 and by state in Table 10.

The number of additional workers that would be required to carry out this increased hand weeding is estimated. Table 13 presents estimates of the total number of additional hours of hand labor that would be required by each crop. (These estimates are assumed constant between 2001 and 2005.) For the nation, an additional 1.2 billion hours of hand weeding would be required. These estimates are also shown in terms of the number of workers that would be required by assuming that the weeding would need to be done during a 4 week period for each crop. For the nation, an additional 7.2 million laborers would be required to provide weed control if herbicides were not used. Table 14 presents the labor requirement estimates by state.

The hand weeding requirements specified in this study are not sufficient to prevent yield losses. For major acreage crops, such as corn, approximately 10% of the labor necessary to prevent yield loss is actually specified as a replacement (5 hours vs. 60 hours). An approximate estimate of the amount of labor that would be required to prevent any yield loss in comparison to herbicides is ten times that specified in this study, or an additional 72 million workers at the peak time for hand weeding.

C. Soil Erosion

The USDA has recently reported that cropland soil erosion declined by 700 million tons per year (1.4 trillion pounds) between 1982 and 2003.[25] This reduction has coincided with adoption of practices that conserve soil. No-till crop production, in which the soil is left undisturbed by tillage, is the most effective soil-conserving system.[26] Elimination of tillage means that the grower must rely entirely on herbicides to control weeds.[27][28] In the 2001 report, it was estimated that the adoption of no-till on 52 million cropland acres had resulted in a reduction in soil erosion of 304 billion pounds. USDA data were used to estimate the average soil erosion rates by state for an average

acre receiving tillage and an average acre that received no tillage. These state estimates are shown in Table 15. The weighted average soil erosion rate for a no-till acre in comparison to a tilled acre is 3 tons or 6,000 pounds. No till acres increased to 62 million in 2004 (see Figure 3).[21] Applying the same soil erosion rates used in the 2001 report results in an additional 50 billion pounds of prevented erosion. The state results are presented in Table15. Without herbicides, U.S. growers could no longer practice no-till agriculture, which means that erosion would have increased by 304 billion pounds in 2001 and 356 billion pounds in 2005.

A recent article by economists at Iowa State University estimated that the external costs of eroded cropland soil ranged from $2.34 to $13.98 per ton.[22] The external costs include flood damage, lost reservoir capacity, increased water treatment costs, and cost impacts to waterway navigation and recreational activities. Using the midpoint of the range ($8.16/ton) implies that by reducing soil erosion from cropland by 356 billion pounds in 2005 (178 million tons), no-till reduces external damages by $1.5 billion per year.

D. Fuel Use and Production

The amount of diesel fuel used per acre for an herbicide application is estimated at 0.11 gallons, while the amount of fuel used to cultivate an acre is estimated at 0.45 gallons.[20] The total number of herbicide application trips currently made on treated acres is 367 million (1.47 trip/A), which implies the use of 40 million gallons of diesel fuel for herbicide application. The total number of cultivations that would be made as replacement for herbicides is estimated at 838 million (3.35/A), which implies a total diesel use of 377 million gallons for cultivation. The use of herbicides rather than cultivation results in an aggregate reduction of 337 million gallons of diesel. Table 16 displays the fuel use reductions by state.

Herbicides are derived from petrochemicals. Their demands on petroleum energy resources are primarily oil and natural gas raw materials from which they are made and the energy inputs required by the manufacturing process. Investigations of the energy inputs into the manufacturing of pesticides have resulted in a value of 11,000 kcal/pound.[32] A gallon of diesel fuel is equivalent to 37,000 kcal, which implies that manufacturing a pound of herbicide requires the equivalent of 0.30 gallon of diesel fuel.[33] In 2005, 349 million pounds of herbicides were used in U.S. crop production, which required the equivalent of 105 million gallons of diesel fuel.

The U.S. ethanol sector is projected to expand to 7 billion gallons in 2010.[24] Corn is the primary raw material for U.S. ethanol production. Without herbicides, U.S. corn production is estimated to decline by 20% equivalent to 152 billion pounds or 2.71 billion bushels. With a corn-to-ethanol conversion rate of 2.7 gallons per bushel, the corn production loss due to the non-use of herbicides is estimated at the equivalent to 7.32 billion gallons of ethanol.

6.0 Organic Perspective

Organic growers do not use herbicides to control weed populations. Organic cropland acreage in the U.S. increased from 1.3 million acres in 2001 to 1.4 million acres in 2003 (see Figure 4). North Dakota ranks first in the U.S. in the number of organic corn acres. Yields of organic corn in North Dakota are reported to be 25% lower than conventional yields.[30] The problem of controlling weeds without herbicides has been cited numerous times as the single largest obstacle that organic growers encounter. The following quotation from Earthbound Farms (the largest organic producer in North America) underscores the expense of doing without herbicides.[31]:

> Controlling weeds without herbicides takes a lot of time and is very costly for us. We do all our weeding by tractor or by hand, which is very labor intensive. Conventional farmers spend only about $50 an acre on herbicides that knock out every weed in sight. Organic farmers may have to spend up to $1,000 an acre to keep weeds under control.

Earthbound Farm's experience of doing without herbicides reinforces the findings of this study: the main alternatives to herbicides are hand labor and cultivation, and they are more expensive than herbicides.

7.0 Summary and Conclusions

Herbicides are chemical pesticides that kill weeds. U.S. farmers have sprayed herbicides on close to 90% of the nation's cropland acreage for the past thirty years.

The value of the use of herbicides in 2005 is estimated to have been $16 billion in increased crop yields and $10 billion in reduced weed control costs.

The use of herbicides greatly reduces the need for fuel and laborers on U.S. farms. If farmers did not use herbicides, the alternatives for weed control would be increased mechanical cultivation and increased hand labor to pull weeds. The need for fuel would be 337 million gallons higher, since twice as many cultivation trips would be needed to replace herbicide spray trips and cultivators use four times more fuel per trip than herbicide sprayers. A minimum of 1.1 billion hours of hand labor would be required at peak season for hand weeding, necessitating the employment of 7 million more agricultural workers. Even with the increased cultivation and hand weeding, crop yields would be 20% lower. Approximately 70 million workers would be needed to prevent any yield loss without herbicides.

The largest production loss would be in corn, with a reduction of 2.7 billion bushels. Corn is the main feedstock for U.S. ethanol production, a major alternative being developed to reduce dependence on oil. The corn production loss due to herbicides non-use is equivalent to 7.3 billion gallons of ethanol, which is equal to the entire projected capacity of U.S. ethanol production by 2010.

Without herbicides U.S. growers would have to abandon no-till production practices, which are effective and popular techniques for reducing soil erosion. Without tillage growers kill weeds with herbicides. If U.S. growers stop using herbicides and resume tillage on the 62 million acres that were not tilled in 2005, soil erosion would be 356 billion pounds higher than it is today. Soil erosion deposits sediments in streams and rivers resulting in downstream damages. The damage resulting from increased soil erosion due to farming without herbicides is estimated at $1.4 billion.

This report for 2005 is an update of a previously issued report for 2001. The same methodology was used in both reports, which makes it possible to report on fluctuations in the herbicide market and changes in the benefits of herbicides. Due to significant price decreases, U.S. farm expenditures for herbicides declined by $300 million between 2001 and 2005. The price decline for herbicides was outweighed by increases in the costs of applying herbicides due to higher labor and fuel costs (+$500 million) and increases in the premium prices paid for biotech herbicide-tolerant seed (+$312 million). Thus, the total cost of herbicides and their application increased by $512 million between 2001 and 2005.

Increased fuel and labor costs, however, also made the costs of alternatives to herbicides higher. The aggregate cost of cultivation and hand weeding as replacements for herbicides increased from $14.3 billion in 2001 to $16.8 billion in 2005, resulting in a net increase in weed control costs without herbicides from $7.7 billion in 2001to $10 billion in 2005. The value of the crops also increased significantly between 2001 and 2005, which means the 20% loss in production without herbicides is worth more in 2005 ($16 billion) than in 2001 ($13 billion). Overall, the value of herbicides increased from $21 billion in 2001 to $26 billion in 2005.

Three trends that occurred in crop production and weed control between 2001 and 2005 are noteworthy, especially those relating to no-till, biotech, and organic crop production. Two of these practices are dependent on herbicides and one is not. The number of no-till acres on which herbicides substitute for tillage increased from 52 million acres to 62 million acres. The number of biotech herbicide tolerant acres where herbicides are used with crops that have been genetically-engineered for tolerance increased from 66 million acres to 94 million acres. Meanwhile, the number of cropland acres grown according to organic standards where herbicides are not used increased by 100,000 acres to 1.4 million. Organic farmers substitute labor and tillage for herbicides, which is very costly. There is not likely to be a vast expansion in domestic organic acreage due to the high cost of labor in the U.S. in comparison to many developing countries.

This study is a simulation of the impacts U.S. farm production and cost of production if farmers did not use herbicides for weed control. There is nothing to suggest that U.S. farmers will not have effective herbicides to use for the foreseeable future. Thus, the study can best be viewed as a cautionary note to those who advocate that growers should stop using chemical pesticides.

Table 1: Acreage and Production by Crop						
Crop	**Acreage (*000*)**		**Production**			
			Volume (*million lbs*)		**Value (*$ million*)**	
	2001	**2005**	**2001**	**2005**	**2001**	**2005**
Almonds	525	580	1,354	1,800	732	2,724
Apples	430	378	9,628	9,771	1,477	1,767
Artichokes	8	7	100	84	58	38
Asparagus	77	58	208	182	230	161
Blueberries	24	22	75	58	23	35
Broccoli	141	135	2,042	1,979	504	564
Canola	1,494	1,095	1,998	1,493	176	140
Carrots	121	92	4,005	3,166	577	520
Celery	29	28	1,882	1,917	277	274
Citrus	1,094	939	34,806	22,718	2,638	2,389
Corn	75,752	81,568	736,000	777,848	19,209	21,037
Cotton	15,787	14,121	9,600	11,343	3,384	5,554
Cranberries	34	39	532	622	99	212
Cucumbers	59	63	1,089	1,073	212	233
Dry Beans	1,430	1,598	1,954	2,621	414	507
Grapes	930	930	13,104	13,920	2,921	2,996
Green Beans	210	186	1,397	1,388	112	105
Green Peas	217	188	774	650	102	90
Hops	36	30	66	52	126	103
Hot Peppers	33	17	311	301	88	47
Lettuce	306	333	10,053	10,271	1,907	1,982
Mint	98	94	8	8	96	104
Onions	167	167	6,708	7,173	703	888
Peaches	151	133	2,440	2,284	496	468
Peanuts	1,543	1,642	4,239	4,776	1,003	838
Potatoes	1,267	1,103	44,476	41,920	2,591	2,895
Raspberries	12	16	92	159	46	209
Rice	3,335	3,384	21,304	22,321	896	1,788
Sorghum	10,252	6,443	28,784	22,047	998	715
Soybeans	74,105	71,934	174,000	184,637	12,446	16,884
Spinach	15	5	284	68	17	9
Strawberries	47	55	1,666	2,328	1,085	1,390
Sugarbeets	1,371	1,293	52,000	55,170	1,113	1,101
Sugarcane	1,029	899	70,000	51,640	942	758
Sunflowers	2,653	1,990	3,480	3,081	317	339
Sweet Corn	733	654	9,050	8,436	772	810
Sweet Potatoes	98	91	1,435	1,579	210	310
Tomatoes	411	423	22,192	24,265	1,665	2,269
Wheat	59,617	57,229	120,000	126,280	5,553	7,140
Wild Rice	19	23	6	5	10	8
Total	**255,660**	**249,984**	**1,393,136**	**1,421,434**	**66,225**	**80,399**

Source:[2][3][4][5][6]

Notes: Corn for grain only, spinach, green beans, and green peas for processing only. Cucumbers- fresh only; Wild Rice- Minnesota only; Blueberries- Maine only.

Table 2: Acreage and Production by State						
State	Acreage (*000*)		Production			
			Volume (*million lbs*)		Value (*million $*)	
	2001	2005	2001	2005	2001	2005
Alabama	1,190	1,265	2,549	3,244	420	423
Arizona	544	511	4,498	4,162	725	823
Arkansas	6,943	6,253	21,939	20,993	1,330	2,020
California	4,712	5,143	69,903	74,986	10,335	13,969
Colorado	3,592	4,080	18,040	18,303	903	890
Connecticut	7	7	48	46	14	15
Delaware	432	411	2,158	2,252	106	99
Florida	1,619	1,509	61,933	46,734	2,899	2,970
Georgia	2,698	2,826	6,445	7,228	1,083	1,310
Idaho	1,975	2,136	28,514	29,023	1,292	1,327
Illinois	22,395	22,348	124,750	149,272	5,709	5,949
Indiana	11,693	11,703	68,249	80,294	3,064	3,197
Iowa	22,420	22,922	122,102	183,341	5,566	6,907
Kansas	18,188	19,613	60,985	73,132	2,526	3,159
Kentucky	2,611	2,926	13,161	15,479	576	688
Louisiana	3,254	3,033	38,819	30,465	924	1,112
Maine	93	85	1,745	1,674	155	175
Maryland	1,126	1,125	5,274	5,563	270	259
Massachusetts	27	27	304	282	67	84
Michigan	5,222	5,415	27,332	37,350	1,239	1,586
Minnesota	16,264	17,004	85,443	128,737	3,400	4,679
Mississippi	3,749	3,577	9,148	10,143	785	1,115
Missouri	9,152	9,488	35,872	38,297	1,802	2,052
Montana	4,297	5,470	8,506	14,354	392	780
Nebraska	14,960	15,633	85,719	111,450	3,582	4,060
Nevada	10	20	250	281	16	14
New Hampshire	5	4	40	31	11	11
New Jersey	236	240	1,283	1,211	156	164
New Mexico	580	831	2,762	2,453	218	233
New York	925	1,322	7,303	7,375	589	597
North Carolina	3,681	3,808	10,749	12,003	948	1,041
North Dakota	15,135	16,597	41,563	50,809	2,027	2,722
Ohio	8,716	8,859	40,325	49,150	2,015	2,323
Oklahoma	5,096	6,876	10,306	11,153	533	664
Oregon	1,118	1,191	6,885	8,530	529	661
Pennsylvania	1,646	2,017	8,092	10,898	466	571
Rhode Island	1	1	15	12	1	2
South Carolina	1,244	1,260	3,097	3,955	267	321
South Dakota	10,803	12,396	35,265	50,384	1,530	2,116
Tennessee	2,699	2,697	8,512	9,231	541	721
Texas	14,289	16,378	33,753	38,507	2,200	3,609
Utah	169	227	643	715	38	49
Vermont	4	4	46	40	11	11
Virginia	1,211	1,347	4,894	5,299	359	399
Washington	3,111	3,074	27,059	29,292	2,479	2,735
West Virginia	42	58	329	330	18	19
Wisconsin	4,712	5,949	28,453	40,531	1,330	1,686
Wyoming	250	319	2,299	2,440	70	81

Table 3: Herbicide Use by Crop						
Crop	**Acres Treated**				**Lbs./Year (*000*)**	
	2001[1]		**2005**		**2001[1]**	**2005**
	%	**(*000*) [3]**	**%[2]**	**(*000*) [3]**		
Almonds	86	452	86	499	1,229	1,342
Apples	63	271	63	238	1,530	760
Artichokes	58	5	58	4	12	8
Asparagus	91	70	91	53	213	187
Blueberries	95	23	95	21	14	23
Broccoli	51	70	51	69	211	147
Canola	99	1,479	99	1,084	718	662
Carrots	98	119	98	90	169	142
Celery	85	25	85	24	50	40
Citrus	95	1,039	95	892	7,879	5,626
Corn	98	74,237	98	79,937	206,052	158,547
Cotton	95	14,998	95	13,415	33,113	21,815
Cranberries	95	32	95	37	120	110
Cucumbers	60	35	60	38	252	227
Dry Beans	99	1,416	99	1,582	3,799	3,039
Grapes	75	698	75	698	1,831	1,779
Green Beans	96	202	96	179	743	627
Green Peas	94	204	94	177	245	161
Hops	95	34	95	29	71	28
Hot Peppers	95	31	95	16	111	29
Lettuce	62	190	62	206	290	394
Mint	95	93	95	89	375	268
Onions	88	147	88	147	568	662
Peaches	66	100	66	88	234	340
Peanuts	97	1,497	97	1,593	3,038	1,912
Potatoes	93	1,178	93	1,026	3,109	2,209
Raspberries	91	11	91	15	34	29
Rice	98	3,268	98	3,316	15,736	15,281
Sorghum	91	9,329	91	5,863	16,579	12,358
Soybeans	96	71,141	96	69,057	76,604	91,108
Spinach	90	14	90	5	37	11
Strawberries	39	18	39	21	75	53
Sugarbeets	98	1,344	98	1,267	2,398	1,258
Sugarcane	95	977	95	854	5,904	7,039
Sunflowers	95	2,520	95	1,891	1,841	1,634
Sweet Corn	90	660	90	589	1,890	1,446
Sweet Potatoes	70	69	70	64	71	69
Tomatoes	96	394	96	406	684	520
Wheat	55	32,789	55	31,476	21,789	16,933
Wild Rice	10	2	10	2	1	<1
Total	**(86)**	**221,181**	**(86)**	**214,986**	**409,619**	**348,823**

[1] From [1]
[2] Assumed same as 2001.
[3] Calculated using acreage data from Table 1.

Table 4: Herbicide Use by State		
State	Lbs./Year (*000*)	
	2001	2005
Alabama	2,867	2,690
Arizona	1,088	771
Arkansas	13,813	13,389
California	12,607	10,052
Colorado	2,691	2,145
Connecticut	124	41
Delaware	965	922
Florida	9,282	8,380
Georgia	6,056	4,210
Idaho	3,246	2,349
Illinois	44,263	39,653
Indiana	23,768	21,252
Iowa	51,095	37,314
Kansas	18,411	18,588
Kentucky	5,263	4,462
Louisiana	12,169	12,571
Maine	190	184
Maryland	2,366	2,318
Massachusetts	170	120
Michigan	10,353	9,086
Minnesota	22,596	21,928
Mississippi	9,344	6,625
Missouri	16,270	14,885
Montana	2,984	4,004
Nebraska	28,922	19,554
Nevada	10	8
New Hampshire	50	21
New Jersey	674	627
New Mexico	856	437
New York	4,688	3,156
North Carolina	6,311	6,035
North Dakota	13,775	12,912
Ohio	14,974	16,039
Oklahoma	2,601	1,517
Oregon	1,504	1,224
Pennsylvania	5,435	4,080
Rhode Island	10	9
South Carolina	2,889	2,100
South Dakota	14,646	11,951
Tennessee	4,384	4,260
Texas	18,510	12,832
Utah	184	133
Vermont	340	106
Virginia	2,803	3,055
Washington	4,393	3,222
West Virginia	269	164
Wisconsin	9,162	7,339
Wyoming	268	122

Table 5: Herbicide Cost by Crop (*$ 000*)						
Crop	**2001**[1]			**2005**		
	Total	**Product**	**Application & Seed Fees**	**Total**	**Product**	**Application & Seed Fees**
Almonds	20,533	16,921	3,612	20,439	15,242	5,197
Apples	17,715	16,610	1,105	9,615	8,324	1,291
Artichokes	419	401	18	335	313	22
Asparagus	2,833	2,282	551	3,035	2,486	549
Blueberries	652	472	180	814	593	221
Broccoli	2,398	2,109	289	3,128	2,767	361
Canola	30,603	13,278	17,325	26,253	9,929	16,324
Carrots	3,739	2,871	868	4,357	3,411	946
Celery	696	511	185	715	472	243
Citrus	80,607	72,365	8,242	61,738	52,433	9,305
Corn	2,265,353	1,823,501	441,852	2,634,093	1,875,382	758,711
Cotton	559,963	344,195	215,768	506,967	240,051	266,916
Cranberries	3,109	2,850	259	3,261	2,874	387
Cucumbers	3,505	2,701	804	3,451	3,002	449
Dry Beans	40,030	34,775	5,255	43,552	35,311	8,241
Grapes	27,932	24,691	3,241	26,678	22,392	4,286
Green Beans	6,548	5,108	1,440	8,143	6,291	1,852
Green Peas	4,051	3,366	685	3,745	2,823	922
Hops	1,201	1,065	136	896	750	146
Hot Peppers	1,547	1,475	72	535	451	84
Lettuce	8,477	7,955	522	13,220	12,316	904
Mint	10,392	9,648	744	7,849	6,921	928
Onions	8,268	7,149	1,119	13,596	12,031	1,565
Peaches	2,978	2,563	415	4,428	3,931	497
Peanuts	63,896	48,250	15,646	55,215	31,871	23,344
Potatoes	45,450	38,505	6,945	47,866	40,472	7,394
Raspberries	674	618	56	522	448	74
Rice	217,996	179,170	38,826	248,359	193,251	55,108
Sorghum	134,918	103,731	31,187	125,709	95,162	30,547
Soybeans	2,110,780	1,224,075	886,705	2,418,313	1,196,199	1,222,114
Spinach	471	414	57	322	278	44
Strawberries	1,420	1,210	210	1,246	959	287
Sugarbeets	138,163	118,434	19,729	128,231	103,573	24,658
Sugarcane	51,323	43,678	7,645	56,122	47,223	8,899
Sunflowers	26,347	18,408	7,939	27,019	17,192	9,827
Sweet Corn	16,134	13,700	2,434	16,767	13,694	3,073
Sweet Potatoes	1,664	1,390	274	2,319	1,987	332
Tomatoes	11,593	8,517	3,076	12,777	8,540	4,237
Wheat	649,779	503,606	146,173	544,346	329,278	215,068
Wild Rice	9	1	8	14	1	13
Total	**6,574,166**	**4,702,569**	**1,871,597**	**7,085,992**	**4,400,624**	**2,685,368**

[1] From [1]

Table 6: Herbicide Use and Cost By State								
State	**Lbs (*000/yr*)**		**Application & Seed Fees (*$ 000/yr*)**		**Product Cost (*$ 000/yr*)**		**Total Cost (*$ 000/yr*)**	
	2001	**2005**	**2001**	**2005**	**2001**	**2005**	**2001**	**2005**
Alabama	2,866	2,690	15,824	21,201	29,310	24,705	45,134	45,906
Arizona	1,087	771	6,552	5,985	13,899	9,734	20,421	15,719
Arkansas	13,812	13,389	74,160	101,089	150,187	171,012	224,347	272,101
California	12,606	10,052	34,167	44,137	166,999	113,006	201,166	157,143
Colorado	2,690	2,145	14,839	23,034	32,911	25,472	47,750	48,506
Connecticut	124	41	23	29	987	340	1,010	369
Delaware	964	922	3,594	4,348	12,925	13,500	16,519	17,848
Florida	9,281	8,380	13,756	16,664	82,774	74,105	96,530	90,769
Georgia	6,056	4,210	35,767	42,165	69,115	45,143	104,882	87,308
Idaho	3,246	2,349	12,292	17,186	73,184	46,318	85,476	63,504
Illinois	44,262	39,653	192,229	259,439	460,051	457,655	652,280	717,094
Indiana	23,768	21,252	103,780	142,658	235,261	236,479	339,041	379,137
Iowa	51,094	37,314	208,424	298,410	600,270	529,956	808,694	828,366
Kansas	18,411	18,588	80,868	117,765	151,625	180,320	232,493	298,085
Kentucky	5,263	4,462	21,819	32,319	69,084	58,245	90,903	90,564
Louisiana	12,169	12,571	36,249	44,358	121,741	133,111	157,990	177,469
Maine	189	184	466	559	3,478	3,840	3,944	4,399
Maryland	2,365	2,318	9,201	13,098	29,048	28,439	38,249	41,537
Massachusetts	169	120	144	204	2,386	1,815	2,530	2,019
Michigan	10,352	9,086	41,891	58,946	96,107	113,411	137,998	172,357
Minnesota	22,596	21,928	151,380	219,052	373,858	337,428	525,238	556,480
Mississippi	9,343	6,625	49,931	63,845	111,669	95,498	161,600	159,343
Missouri	16,269	14,885	81,614	124,581	190,929	191,425	272,543	316,006
Montana	2,983	4,004	16,397	27,111	38,148	74,137	54,545	101,248
Nebraska	28,922	19,554	110,914	171,507	272,656	230,910	383,570	402,417
Nevada	9	8	43	81	136	187	179	268
New Hampshire	49	21	13	16	384	138	397	154
New Jersey	674	627	1,961	2,597	11,984	9,581	13,945	12,178
New Mexico	855	437	2,398	4,759	7,387	5,015	9,785	9,774
New York	4,688	3,156	6,168	10,419	35,808	33,570	41,976	43,989
North Carolina	6,311	6,035	38,004	52,242	65,893	69,527	103,897	121,769
North Dakota	13,774	12,912	99,949	153,521	263,958	228,718	363,907	382,239
Ohio	14,973	16,039	74,478	102,497	152,534	176,671	227,012	279,168
Oklahoma	2,601	1,517	18,494	29,745	31,514	21,531	50,008	51,276
Oregon	1,503	1,224	6,327	8,911	23,370	17,805	29,697	26,716
Pennsylvania	5,434	4,080	12,564	19,874	43,120	42,483	55,684	62,357
Rhode Island	10	9	3	4	69	80	72	84
South Carolina	2,888	2,100	12,525	18,282	32,547	22,825	45,072	41,107
South Dakota	14,645	11,951	91,632	138,815	200,347	182,039	291,979	320,854
Tennessee	4,383	4,260	29,775	41,502	54,606	55,224	84,381	96,726
Texas	18,509	12,832	97,984	149,241	171,979	120,163	269,963	269,404
Utah	183	133	599	1,151	1,507	1,262	2,106	2,413
Vermont	339	106	11	14	2,337	510	2,348	524
Virginia	2,803	3,055	10,471	16,287	31,307	37,224	41,778	53,511
Washington	4,393	3,222	13,824	18,295	65,690	45,568	79,514	63,863
West Virginia	268	164	261	481	2,041	2,044	2,302	2,525
Wisconsin	9,161	7,339	37,190	64,985	109,403	129,045	146,593	194,030
Wyoming	268	122	1,229	1,957	6,043	3,431	7,272	5,388

Table 7: No Herbicide Use, Alternative Costs by Crop							
Crop	**Hand Weeding (*Hrs/A*)[1]**	**Tillage (*#/A*)[1]**	**Other (*$/A*)**	**Cost**			
				(*$/A*)[2]		**(*$ 000/year*)[3]**	
				2001	**2005**	**2001**	**2005**
Almonds	7	0	36[4]	97.25	106.00	43,957	52,873
Apples	20	2		184.00	211.68	49,864	52,469
Artichokes	23	0		201.25	230.00	1,006	974
Asparagus	5	5		66.25	79.20	4,638	4,174
Blueberries	5	0		43.75	50.00	1,006	1,059
Broccoli	20	2		184.00	211.68	12,880	14,657
Canola	0	2		9.00	11.68	13,311	12,662
Carrots	14	2		131.50	151.68	15,648	13,768
Celery	60	4		543.00	623.36	13,575	14,561
Citrus	0	0	400[5]	400.00	400.00	415,600	357,216
Corn	5	4		61.75	73.36	4,584,134	5,848,585
Cotton	13	7		145.25	170.88	2,178,459	2,290,722
Cranberries	20	0		175.00	200.00	5,600	7,429
Cucumbers	30	3		276.00	317.52	9,660	13,695
Dry Beans	16	2		149.00	171.68	210,984	271,567
Grapes	8	2		79.00	91.68	55,142	71,196
Green Beans	12	2		114.00	131.68	23,028	23,407
Green Peas	12	2		114.00	131.68	23,256	23,291
Hops	35	6		333.25	385.04	11,330	10,807
Hot Peppers	60	0		525.00	600.00	16,275	9,690
Lettuce	38	2		341.50	391.68	64,885	67,931
Mint	18	0		157.50	180.00	14,647	16,023
Onions	64	2		569.00	651.68	83,643	89,857
Peaches	6	0		52.50	60.00	5,250	5,642
Peanuts	10	2		96.50	111.68	144,460	178,853
Potatoes	10	5		110.00	129.20	129,580	131,824
Raspberries	43	9		416.75	482.56	4,584	6,887
Rice	0	4		18.00	23.36	58,824	76,729
Sorghum	0	3		13.50	17.52	125,941	102,722
Soybeans	5	4		61.75	73.36	4,392,956	5,082,068
Spinach	20	3		188.50	217.52	2,639	920
Strawberries	30	4		280.50	323.36	5,049	7,566
Sugarbeets	15	2		140.25	161.68	188,496	206,859
Sugarcane	25	3		232.25	267.52	226,908	228,475
Sunflowers	0	7		31.50	40.88	79,380	77,104
Sweet Corn	5	3		57.25	67.52	37,785	39,828
Sweet Potatoes	24	2		219.00	251.68	15,111	16,014
Tomatoes	37	8		359.75	416.72	141,741	169,433
Wheat	2	2		26.50	31.68	868,908	1,176,233
Wild Rice	0	0		0	0	0	0
Total						**14,280,140**	**16,775,772**

[1] Assumed to be the same for 2001 and 2005 [1]
[2] For 2001, hand weeding costs estimated at $8.75/hour; cultivation costs estimated at $4.50/trip. For 2005, hand weeding costs estimated at $10/hour; cultivation costs estimated at $5.84/trip.
[3] Cost per acre times number of acres treated with herbicides.
[4] Mowing, cover crops.
[5] Mowing, increased fertilizer and irrigation.

Table 8: No Herbicide Use, Production Impacts By Crop					
		Production			
Crop	% Yield Loss w/o Herbicides[2]	*Million Lbs*		*$ Million*	
		2001	2005	2001	2005
Almonds	5	58.2	77.4	31.5	117.1
Apples	15	909.8	923.4	139.6	167.0
Artichokes	16	9.3	7.8	5.4	3.5
Asparagus	55	104.1	91.1	115.1	80.6
Blueberries	67	47.7	36.9	14.6	22.3
Broccoli	14	145.8	141.3	36.0	40.3
Canola	45	890.1	665.1	78.4	62.4
Carrots	48	1,884.0	1,489.3	271.4	244.6
Celery	0	0	0	0	0
Citrus	0	0	0	0	0
Corn	20	144,256.0	152,458.2	3,765.0	4,123.3
Cotton	27	2,462.4	2,909.5	868.0	1,424.6
Cranberries	50	252.7	295.5	47.0	100.7
Cucumbers	66	431.2	424.9	84.0	92.3
Dry Beans	25	483.6	648.7	102.5	125.5
Grapes	1	98.3	104.4	21.9	22.5
Green Beans	20	268.2	266.5	21.5	20.2
Green Peas	20	145.5	122.2	19.2	16.9
Hops	25	15.7	12.4	29.9	24.5
Hot Peppers	0	0	0	0	0
Lettuce	13	810.3	827.8	153.7	159.7
Mint	58	4.4	4.4	53.0	57.3
Onions	43	2,538.3	2,714.3	266.0	336.0
Peaches	11	177.1	165.8	36.0	34.0
Peanuts	52	2,138.2	2,409.0	505.9	422.7
Potatoes	32	13,236.1	12,475.4	771.1	861.6
Raspberries	0	0	0	0	0
Rice	53	11,065.3	11,593.5	465.4	928.7
Sorghum	26	6,810.3	5,216.3	236.1	169.2
Soybeans	26	43,430.4	46,085.4	3,106.5	4,214.2
Spinach	50	127.8	30.6	7.6	4.1
Strawberries	30	194.9	272.4	126.9	162.6
Sugarbeets	29	14,778.4	15,679.3	316.3	312.9
Sugarcane	25	16,625.0	12,264.5	223.7	180.0
Sunflowers	16	529.0	468.3	48.2	51.5
Sweet Corn	25	2,036.2	1,898.1	173.7	182.3
Sweet Potatoes	20	200.9	221.1	29.4	43.4
Tomatoes	23	4,900.0	5,357.7	367.6	501.0
Wheat	25	16,500.0	17,363.5	763.0	981.8
Wild Rice	50	0.3	0.3	0.5	0.4
Total		**288,565.5**	**295,722.2**	**13,301.6**	**16,291.0**

[2] Assumed identical 2001 and 2005.

Table 9: Summary of No Herbicide Use Impacts by Crop (*$ 000*)						
Crop	**Weed Control Cost (+)[1]**		**Production Impact (-)[2]**		**Total Impact (-)[3]**	
	2001	***2005***	***2001***	***2005***	***2001***	***2005***
Almonds	23,424	32,434	31,500	117,100	54,924	149,534
Apples	32,149	42,854	139,600	167,000	171,749	209,854
Artichokes	587	639	5,400	3,500	5,987	4,139
Asparagus	1,805	1,139	115,100	80,600	116,905	81,739
Blueberries	354	245	14,600	22,300	14,954	22,545
Broccoli	10,482	11,529	36,000	40,300	46,482	51,829
Canola	-17,292	-13,591	78,400	62,400	61,108	48,809
Carrots	11,909	9,411	271,400	244,600	283,309	254,011
Celery	12,879	13,846	0	0	12,879	13,846
Citrus	334,993	295,478	0	0	334,993	295,478
Corn	2,318,781	3,214,492	3,765,000	4,123,300	6,083,781	7,337,792
Cotton	1,618,496	1,783,755	868,000	1,424,600	2,486,496	3,208,355
Cranberries	2,491	4,168	47,000	100,700	49,491	104,868
Cucumbers	6,155	10,244	84,000	92,300	90,155	102,544
Dry Beans	170,954	228,015	102,500	125,500	273,454	353,515
Grapes	27,210	44,518	21,900	22,500	49,110	67,018
Green Beans	16,480	15,264	21,500	20,200	37,980	35,464
Green Peas	19,205	19,546	19,200	16,900	38,405	36,446
Hops	10,129	9,911	29,900	24,500	40,029	34,411
Hot Peppers	14,728	9,155	0	0	14,728	9,155
Lettuce	56,408	54,711	153,700	159,700	210,108	214,411
Mint	4,255	8,174	53,000	57,300	57,255	65,474
Onions	75,375	76,261	266,000	336,000	341,375	412,261
Peaches	2,272	1,214	36,000	34,000	38,272	35,214
Peanuts	80,564	123,638	505,900	422,700	586,464	546,338
Potatoes	84,130	83,958	771,100	861,600	855,230	945,558
Raspberries	3,910	6,365	0	0	3,910	6,365
Rice	-159,172	-171,630	465,400	928,700	306,228	757,070
Sorghum	-8,977	-22,987	236,100	169,200	227,123	146,213
Soybeans	2,282,176	2,663,755	3,106,500	4,214,200	5,388,676	6,877,955
Spinach	2,168	598	7,600	4,100	9,768	4,698
Strawberries	3,629	6,320	126,900	162,600	130,529	168,920
Sugarbeets	50,333	78,628	316,300	312,900	366,633	391,528
Sugarcane	175,585	172,353	223,700	180,000	399,285	352,353
Sunflowers	53,033	50,085	48,200	51,500	101,233	101,585
Sweet Corn	21,651	23,061	173,700	182,300	195,351	205,361
Sweet Potatoes	13,447	13,695	29,400	43,400	42,847	57,095
Tomatoes	130,148	156,656	367,600	501,000	497,748	657,656
Wheat	219,129	631,887	763,000	981,800	982,129	1,613,687
Wild Rice	-9	-14	500	400	491	386
Total	**7,705,974**	**9,689,780**	**13,301,600**	**16,291,000**	**21,007,574**	**25,980,780**

[1] Current herbicide cost (Table 5) minus alternative cost (Table 7).
[2] From Table 8.
[3] In calculating total impact, an increase in net cost is considered a loss.

Table 10: Summary of No Herbicide Use Impacts by State (*$ 000*)						
State	**Weed Control Cost (+)**		**Production Impact (-)**		**Total Impact (-)**	
	2001	***2005***	***2001***	***2005***	***2001***	***2005***
Alabama	79,553	99,348	164,275	151,209	243,828	250,557
Arizona	47,639	54,982	84,058	100,952	131,697	155,934
Arkansas	144,688	166,223	671,917	1,091,295	816,605	1,257,518
California	359,213	483,528	899,173	1,213,979	1,258,386	1,697,507
Colorado	90,967	128,501	109,045	109,641	200,012	238,142
Connecticut	363	205	1,259	1,425	1,622	1,630
Delaware	4,850	6,020	36,195	33,957	41,045	39,977
Florida	356,060	328,008	485,132	669,613	841,192	997,621
Georgia	195,746	252,835	532,769	630,474	728,515	883,309
Idaho	42,712	93,088	402,178	402,190	444,890	495,278
Illinois	651,008	834,502	1,191,742	1,240,428	1,842,750	2,074,930
Indiana	356,875	449,553	446,818	463,769	803,693	913,322
Iowa	534,156	805,639	1,434,355	1,789,985	1,968,511	2,595,624
Kansas	257,506	343,713	221,626	265,489	479,132	609,202
Kentucky	45,285	90,925	102,390	128,042	147,675	218,967
Louisiana	146,439	142,344	353,432	429,916	499,871	572,260
Maine	4,887	4,392	35,206	43,811	40,093	48,203
Maryland	21,750	30,299	62,392	59,946	84,142	90,245
Massachusetts	1,473	2,067	18,654	26,783	20,127	28,850
Michigan	205,563	236,544	436,220	507,740	641,783	744,284
Minnesota	449,402	656,615	488,454	653,136	937,856	1,309,751
Mississippi	174,123	197,998	335,522	505,884	509,645	703,882
Missouri	244,315	338,998	632,296	746,449	876,611	1,085,447
Montana	57,399	67,407	95,622	200,359	153,021	267,766
Nebraska	448,457	627,872	444,856	507,833	893,313	1,135,705
Nevada	647	682	4,229	3,657	4,876	4,339
New Hampshire	357	242	759	895	1,116	1,137
New Jersey	1,288	5,670	67,381	69,576	68,669	75,246
New Mexico	28,461	39,559	27,779	31,397	56,240	70,956
New York	27,506	63,927	106,223	104,200	133,729	168,127
North Carolina	184,956	201,988	348,218	388,429	533,174	590,417
North Dakota	158,412	367,576	462,539	587,487	620,951	955,063
Ohio	251,037	301,599	586,622	666,128	837,659	967,727
Oklahoma	85,525	131,806	48,738	55,758	134,263	187,564
Oregon	33,294	48,051	165,956	223,447	199,250	271,498
Pennsylvania	41,600	79,455	61,567	74,970	103,167	154,425
Rhode Island	56	16	202	213	258	229
South Carolina	44,174	65,883	67,615	88,442	111,789	154,325
South Dakota	255,303	394,490	269,223	394,178	524,526	788,668
Tennessee	112,272	144,070	122,121	173,057	234,393	317,127
Texas	762,476	966,343	632,446	1,018,621	1,394,922	1,984,964
Utah	3,120	6,515	6,250	6,659	9,370	13,174
Vermont	367	-91	1,206	1,274	1,573	1,183
Virginia	35,747	44,596	70,950	86,800	106,697	131,396
Washington	84,970	131,955	654,552	702,532	739,522	834,487
West Virginia	490	1,508	1,387	1,608	1,877	3,116
Wisconsin	145,349	237,591	210,392	280,836	355,741	518,427
Wyoming	7,432	14,722	8,560	10,176	15,992	24,898

Table 11: No Herbicide Use, Crop Impacts by State (*% Yield Change*)	
State	**Selected Impacts**
Alabama	Cotton –25, peaches –10, peanuts –75, soybeans –45, tomatoes –30
Arizona	Corn –23, cotton –30, lettuce –13, sorghum –14, wheat –15,
Arkansas	Apples –15, corn –48, cotton –40, rice –53, soybeans –80, tomatoes –20
California	Broccoli –13, carrots –45, cotton –17, lettuce –13, onions –35, tomatoes –20
Colorado	Corn –20, dry beans –23, onions –23, potatoes –7, sugarbeets –10, wheat –6
Connecticut	Peaches –12, sweet corn –12
Delaware	Corn –45, potatoes –20, soybeans –35, sweet corn –30, wheat –50
Florida	Cotton –50, peanuts –33, potatoes –30, strawberries –55, sweet corn –17
Georgia	Cotton –65, onions –20, peaches –25, peanuts –60, soybeans –35
Idaho	Corn –35, dry beans –25, hops –25, onions –15, potatoes –35, sugarbeets –40
Illinois	Corn –22, green beans –10, potatoes –5, sorghum –15, soybeans –22
Indiana	Corn –15, cucumbers –59, mint –58, soybeans –15, tomatoes –23
Iowa	Corn –25, soybeans –29, wheat –5
Kansas	Corn –10, dry beans –12, sorghum –15, soybeans –15, wheat –10
Kentucky	Corn –15, sorghum –10, soybeans –28, wheat –8
Louisiana	Cotton –10, rice –53, sugarcane –44, sweet potatoes –30
Maine	Apples –45, blueberries –67, potatoes –15, sweet corn –15
Maryland	Apples –9, corn –31, peaches –14, soybeans –25, tomatoes –15, wheat –9
Massachusetts	Cranberries –50, potatoes –10, sweet corn –15, tomatoes –30
Michigan	Apples –35, asparagus –50, green beans –60, potatoes –50, soybeans –35
Minnesota	Corn –15, dry beans –10, green peas –15, soybeans –10, wheat –30
Mississippi	Corn –39, cotton –40, rice –53, soybeans –61, sweet potatoes –20
Missouri	Corn –30, cotton –40, grapes –25, soybeans –45, wheat –15
Montana	Corn –13, potatoes –15, sugarbeets –11, wheat –30
Nebraska	Corn –12, dry beans –25, potatoes –13, sorghum –13, soybeans –15
Nevada	Potatoes –30, wheat –25
New Hampshire	Apples –5, sweet corn –15
New Jersey	Cucumbers –50, lettuce –50, peaches –50, soybeans –55, spinach –50
New Mexico	Corn –20, cotton –32, onions –15, peanuts –23, wheat –10
New York	Apples –17, grapes –12, green beans –18, potatoes –30, sweet corn –20
North Carolina	Cotton –70, cucumbers –25, peanuts –66, soybeans –21, sweet potatoes –20
North Dakota	Canola –45, corn –10, potatoes –9, sugarbeets –24, wheat –30
Ohio	Corn –34, potatoes –52, soybeans –32, strawberries –35, tomatoes –25
Oklahoma	Corn –15, cotton –25, peanuts –40, sorghum –10, soybeans –20, wheat –5
Oregon	Grapes –15, green beans –30, mint –58, strawberries –25, sweet corn –15
Pennsylvania	Apples –20, corn –10, grapes –25, potatoes –22, sweet corn –20
Rhode Island	Apples –10, potatoes –20
South Carolina	Cotton –30, peaches –40, peanuts –52, soybeans –23, tomatoes –15
South Dakota	Corn –15, potatoes –21, sorghum –19, soybeans –18, sunflowers –16
Tennessee	Apples –27, cotton –25, soybeans –30, tomatoes –27, wheat –15
Texas	Carrots –25, corn –46, cotton –30, onions –25, peanuts –33, sorghum –45
Utah	Corn –35, dry beans –29, onions –22, potatoes –27, wheat –22
Vermont	Apples –17, sweet corn –15
Virginia	Corn –22, cotton –17, peanuts –22, soybeans –18, tomatoes –40
Washington	Apples –8, asparagus –55, green peas –20, potatoes –55, wheat –23
West Virginia	Apples –12, corn –5, peaches –25, wheat –17
Wisconsin	Corn –10, green peas –12, potatoes –33, soybeans –15, sweet corn –15
Wyoming	Corn –20, dry beans –23, sugarbeets –10, wheat –6

Note: Selected impacts only; assumed identical for 2001 and 2005. [1]

Table 12: No Herbicide Use, Crop Production Volume Impact by State		
State	**Production Loss (*Million lbs*)**	
	2001	**2005**
Alabama	826	966
Arizona	482	442
Arkansas	10,833	11,776
California	9,003	9,487
Colorado	2,241	2,446
Connecticut	4	4
Delaware	801	867
Florida	4,297	3,849
Georgia	2,476	2,877
Idaho	9,424	9,515
Illinois	26,121	31,525
Indiana	9,941	11,738
Iowa	31,012	46,260
Kansas	5,447	6,341
Kentucky	2,106	2,496
Louisiana	16,361	13,096
Maine	294	274
Maryland	1,317	1,447
Massachusetts	81	80
Michigan	9,800	12,130
Minnesota	13,552	20,084
Mississippi	3,956	4,775
Missouri	11,832	12,626
Montana	1,890	3,475
Nebraska	10,368	13,417
Nevada	67	72
New Hampshire	2	2
New Jersey	442	410
New Mexico	320	303
New York	1,181	1,152
North Carolina	2,652	2,813
North Dakota	9,527	10,624
Ohio	11,950	14,913
Oklahoma	607	695
Oregon	2,273	2,808
Pennsylvania	878	1,144
Rhode Island	2	2
South Carolina	708	991
South Dakota	5,992	8,619
Tennessee	1,756	2,005
Texas	10,158	12,168
Utah	112	123
Vermont	5	5
Virginia	886	994
Washington	9,427	10,164
West Virginia	21	21
Wisconsin	3,796	4,967
Wyoming	235	260

Table 13: No Herbicide Use, Labor for Hand Weeding by Crop, 2001				
Crop	**Acres (*000*)[1]**	**Hours/A[2]**	**Total Hours (*000*)**	**Total Laborers[3]**
Almonds	452	7	3,164	19,775
Apples	271	20	5,420	33,875
Artichokes	5	23	115	719
Asparagus	70	5	350	2,188
Blueberries	23	5	115	719
Broccoli	70	20	1,400	8,750
Canola	1,479	0	0	0
Carrots	119	14	1,666	10,412
Celery	25	60	1,500	9,375
Citrus	1,039	0	0	0
Corn	74,237	5	371,185	2,319,906
Cotton	14,998	13	194,974	1,218,588
Cranberries	32	20	640	4,000
Cucumbers	35	30	1,050	6,562
Dry Beans	1,416	16	22,656	141,600
Grapes	698	8	5,584	34,900
Green Beans	202	12	2,424	15,150
Green Peas	204	12	2,448	15,300
Hops	34	35	1,190	7,438
Hot Peppers	31	60	1,860	11,625
Lettuce	190	38	7,220	45,126
Mint	93	18	1,674	10,462
Onions	147	64	9,408	58,800
Peaches	100	6	600	3,750
Peanuts	1,497	10	14,970	93,563
Potatoes	1,178	10	11,780	73,625
Raspberries	11	43	473	2,956
Rice	3,268	0	0	0
Sorghum	9,329	0	0	0
Soybeans	71,141	5	355,705	2,223,156
Spinach	14	20	280	1,750
Strawberries	18	30	540	3,375
Sugarbeets	1,344	15	20,160	126,000
Sugarcane	977	25	24,425	152,656
Sunflowers	2,520	0	0	0
Sweet Corn	660	5	3,300	20,625
Sweet Potatoes	69	24	1,656	10,350
Tomatoes	394	37	14,578	91,112
Wheat	32,789	2	65,578	409,862
Wild Rice	2	0	0	0
Total	**221,181**	**(5)**	**1,150,088**	**7,188,050**

[1] Acres currently treated with herbicides.
[2] From Table 7.
[3] Calculated by dividing the total number of hours by 160, which is the equivalent to the number of hours needed in a four-week period.

Table 14: No Herbicide Use, Labor for Hand Weeding by State, 2001		
State	**# Hours (*000*)**	**# Laborers**
Alabama	11,290	70,566
Arizona	5,723	35,771
Arkansas	28,751	179,695
California	43,990	274,940
Colorado	11,107	69,422
Connecticut	50	317
Delaware	1,714	10,713
Florida	16,201	101,261
Georgia	27,633	172,711
Idaho	11,398	71,240
Illinois	105,573	659,836
Indiana	56,553	353,462
Iowa	108,719	679,500
Kansas	33,861	211,636
Kentucky	11,057	69,111
Louisiana	27,770	173,565
Maine	780	4,875
Maryland	4,891	30,574
Massachusetts	356	2,230
Michigan	30,114	188,216
Minnesota	80,984	506,150
Mississippi	28,795	179,971
Missouri	41,908	261,928
Montana	8,702	54,393
Nebraska	67,309	420,682
Nevada	68	428
New Hampshire	42	263
New Jersey	1,343	8,396
New Mexico	3,529	22,059
New York	6,246	39,041
North Carolina	25,280	158,004
North Dakota	43,344	270,900
Ohio	38,873	242,957
Oklahoma	10,243	64,024
Oregon	5,457	34,110
Pennsylvania	8,083	50,519
Rhode Island	8	53
South Carolina	7,696	48,104
South Dakota	42,204	263,777
Tennessee	16,730	104,567
Texas	87,632	547,706
Utah	433	2,710
Vermont	42	264
Virginia	6,660	41,630
Washington	13,919	86,997
West Virginia	222	1,388
Wisconsin	24,305	151,910
Wyoming	1,401	8,760

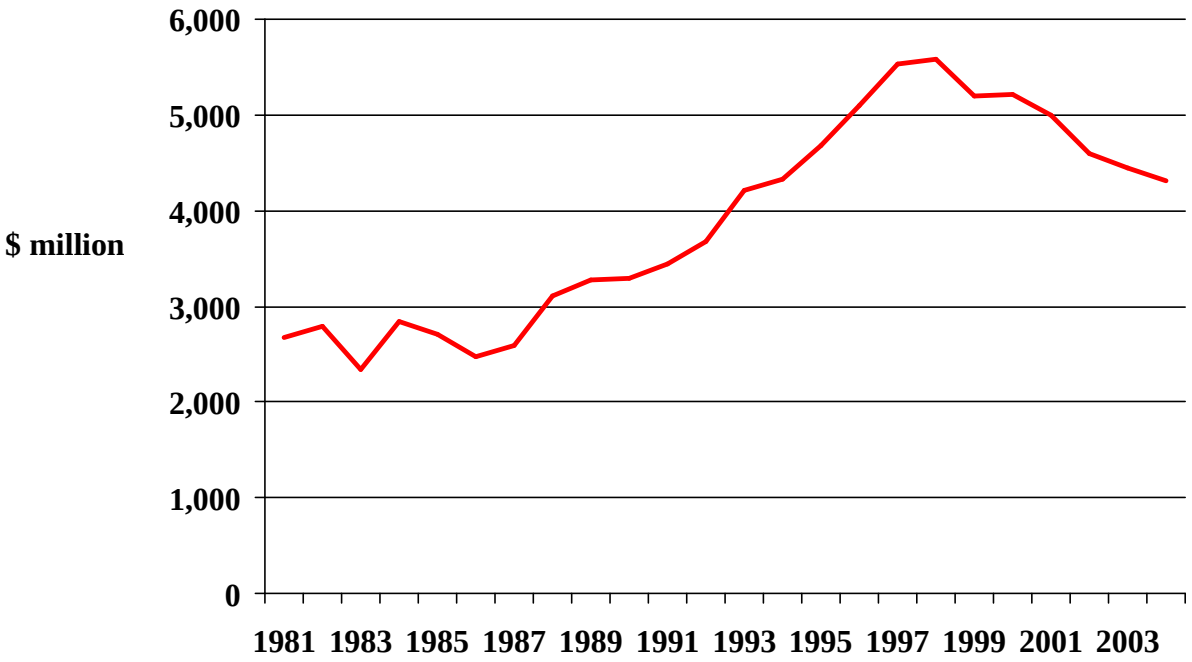
Table 15: Cropland Erosion by State							
State	**No-Till Acres[1]**		**Cultivated**	**Non-Cultivated**	**Difference**	**No-Till Erosion Prevention (*million lbs*)**	
	2001	***2005***	***Tons/Acre/Year***			***2001***	***2005***
Alabama	434,916	676,408	6.7	0.5	6.2	5,392	8,387
Arizona	4,100	1,700	.7	0.2	.5	4	2
Arkansas	755,413	804,252	3.5	0.6	2.9	4,381	4,665
California	12,692	17,957	.7	0.5	.2	5	7
Colorado	513,435	770,620	1.7	0.2	1.5	1,540	2,312
Connecticut	3,825	3,031	5.6	0.7	4.9	37	30
Delaware	233,775	175,844	2.0	0.4	1.6	748	563
Florida	53,856	64,504	1.8	0.5	1.3	140	168
Georgia	505,112	1,100,542	5.9	0.3	5.6	5,657	12,326
Idaho	233,781	180,824	3.4	0.4	3.0	1,402	1,085
Illinois	6,961,627	6,667,311	4.1	0.6	3.5	48,731	46,671
Indiana	4,908,432	4,555,530	3.0	0.9	2.1	20,615	19,133
Iowa	5,056,840	5,169,075	4.9	0.8	4.1	41,466	42,386
Kansas	3,154,908	4,224,926	2.2	0.4	1.8	11,357	15,210
Kentucky	1,784,529	1,954,391	4.4	1.2	3.2	11,420	12,508
Louisiana	240,186	478,833	3.3	0.6	2.7	1,297	2,586
Maine	672	347	3.9	0.3	3.6	4	2
Maryland	686,162	789,489	4.4	1.2	3.2	4,391	5,053
Massachusetts	4,080	0	4.5	0.1	4.4	35	0
Michigan	1,387,500	1,351,684	2.0	0.5	1.5	4,162	4,055
Minnesota	457,790	667,700	2.1	0.3	1.8	1,648	2,404
Mississippi	791,984	1,108,764	5.3	1.2	4.1	6,494	9,092
Missouri	3,170,081	3,114,316	5.6	0.7	4.9	31,066	30,520
Montana	1,115,249	2,011,552	1.9	0.3	1.6	3,568	6,437
Nebraska	3,468,978	4,320,627	2.9	0.5	2.4	16,651	20,739
Nevada	0	3,520	.2	0.0	.2	0	1
New Hampshire	600	0	3.5	0.4	3.1	3	0
New Jersey	84,277	88,220	5.6	0.6	5.0	842	882
New Mexico	110,931	63,914	.9	0.1	.8	177	102
New York	114,627	160,474	3.9	0.7	3.2	733	1,027
North Carolina	1,456,624	1,798,753	5.0	1.0	4.0	11,652	14,390
North Dakota	1,906,711	3,289,774	1.4	0.3	1.1	4,194	7,238
Ohio	4,204,204	4,407,606	2.6	1.4	1.2	10,090	10,578
Oklahoma	497,806	819,147	2.8	0.5	2.3	2,289	3,768
Oregon	165,115	218,133	3.1	0.4	2.7	891	1,178
Pennsylvania	515,273	654,069	5.1	1.2	3.9	4,019	5,102
Rhode Island	108	130	3.5	1.8	1.7	0	0
South Carolina	354,605	714,585	3.2	0.7	2.5	1,773	3,573
South Dakota	2,996,322	5,045,881	2.0	0.2	1.8	10,786	18,165
Tennessee	1,410,364	1,716,510	7.7	0.6	7.1	20,027	24,374
Texas	447,452	769,583	2.6	0.8	1.8	1,610	2,770
Utah	11,298	11,330	1.6	0.2	1.4	31	32
Vermont	3,550	5,894	3.1	0.7	2.4	17	28
Virginia	665,482	873,577	5.9	1.5	4.4	5,856	7,687
Washington	342,494	386,198	4.7	0.6	4.1	2,808	3,167
West Virginia	47,655	48,040	4.3	0.8	3.5	33	336
Wisconsin	876,734	1,175,263	3.7	1.2	2.5	4,383	5,876
Wyoming	28,869	14,543	1.1	0.1	1.0	58	29
Total	**52,181,024**	**62,475,371**				**304,483**	**356,646**

Note: Sheet and Rill Erosion

[1] Source:[21], data for 2000 and 2004.

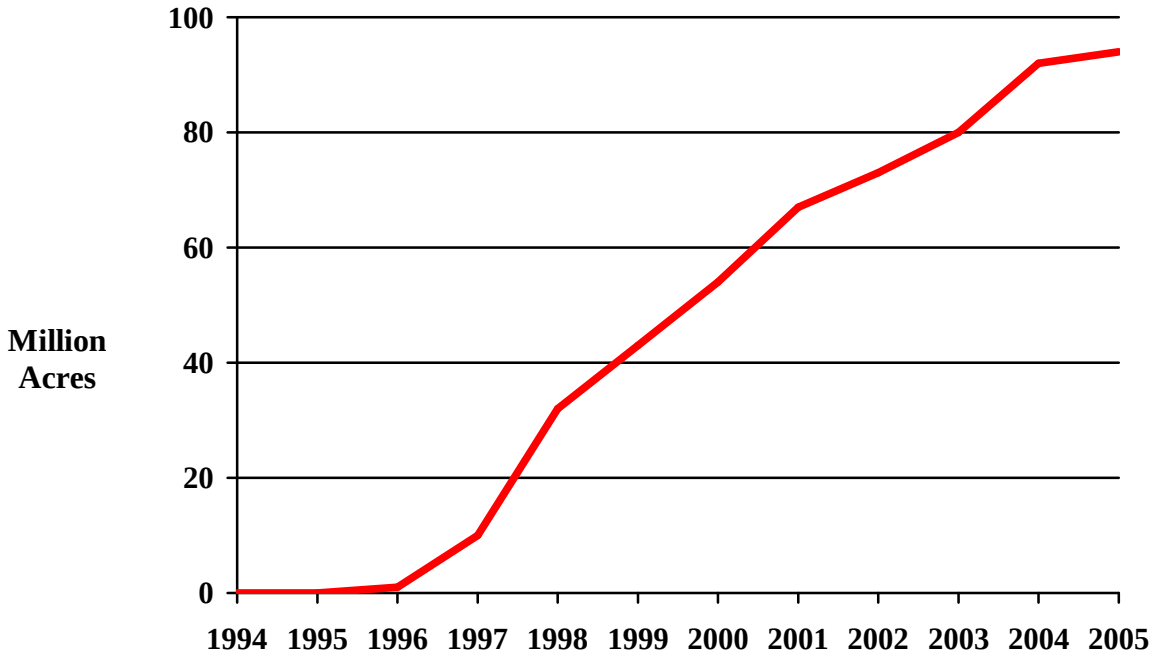
Table 16: Fuel Use for Weed Control by State					
State	**Herbicide Use**		**Tillage**		**Increased Fuel Use Without Herbicides (*gallons*)**
	# of Applications	**Fuel Use (*gallons*)**	**# of Cultivations**	**Fuel Use (*gallons*)**	
Alabama	2,425,341	266,788	5,723,650	2,575,643	2,308,855
Arizona	679,746	74,772	2,065,181	929,331	854,559
Arkansas	13,038,546	1,434,240	26,040,969	11,718,436	10,284,196
California	7,418,565	816,042	14,002,271	6,301,022	5,484,980
Colorado	3,787,785	416,656	10,053,744	4,524,185	4,107,528
Connecticut	5,610	617	14,652	6,593	5,976
Delaware	569,097	62,601	1,276,965	574,634	512,034
Florida	2,957,260	325,299	2,958,893	1,331,502	1,006,203
Georgia	5,618,448	618,029	11,996,376	5,398,369	4,780,340
Idaho	3,209,325	353,026	6,743,708	3,034,669	2,681,643
Illinois	36,447,709	4,009,248	84,516,515	38,032,432	34,023,184
Indiana	18,982,633	2,088,090	44,794,134	20,157,360	18,069,271
Iowa	39,478,308	4,342,614	89,081,016	40,086,457	35,743,843
Kansas	16,914,681	1,860,615	44,529,362	20,038,213	18,177,598
Kentucky	4,429,632	487,259	9,855,834	4,435,125	3,947,866
Louisiana	5,865,028	645,153	12,410,950	5,584,928	4,939,774
Maine	107,262	11,799	286,350	128,858	117,059
Maryland	1,726,194	189,881	3,832,379	1,724,571	1,534,689
Massachusetts	39,127	4,304	36,537	16,442	12,138
Michigan	8,332,333	916,557	18,461,734	8,307,780	7,391,224
Minnesota	30,373,488	3,341,084	61,704,494	27,767,022	24,425,939
Mississippi	6,981,840	768,002	17,345,330	7,805,399	7,037,396
Missouri	15,255,103	1,678,061	35,391,256	15,926,065	14,248,004
Montana	5,184,872	570,336	10,132,550	4,559,648	3,989,312
Nebraska	22,435,835	2,467,942	56,109,739	25,249,383	22,781,441
Nevada	15,631	1,719	48,675	21,904	20,184
New Hampshire	3,033	334	7,776	3,499	3,166
New Jersey	362,462	39,871	774,462	348,508	308,637
New Mexico	792,306	87,154	2,150,404	967,682	880,528
New York	1,771,749	194,892	4,563,567	2,053,605	1,858,713
North Carolina	6,201,562	682,172	14,797,730	6,658,979	5,976,807
North Dakota	23,082,986	2,539,128	37,654,100	16,944,345	14,405,217
Ohio	13,995,096	1,539,461	31,307,109	14,088,199	12,548,738
Oklahoma	4,482,394	493,063	12,067,550	5,430,398	4,937,334
Oregon	1,690,139	185,915	3,558,596	1,601,368	1,415,453
Pennsylvania	3,026,815	332,950	7,373,018	3,317,858	2,984,908
Rhode Island	840	92	2,703	1,216	1,124
South Carolina	2,088,766	229,764	4,870,403	2,191,681	1,961,917
South Dakota	18,238,752	2,006,263	42,618,450	19,178,303	17,172,040
Tennessee	4,561,695	501,786	11,526,842	5,187,079	4,685,292
Texas	18,970,118	2,086,713	58,140,440	26,163,198	24,076,485
Utah	189,298	20,823	502,038	225,917	205,094
Vermont	2,781	306	6,642	2,989	2,683
Virginia	2,100,939	231,103	4,816,818	2,167,568	1,936,465
Washington	3,454,425	379,987	9,343,243	4,204,459	3,824,472
West Virginia	74,175	8,159	186,550	83,948	75,788
Wisconsin	9,346,251	1,028,088	22,271,019	10,021,959	8,993,871
Wyoming	347,987	38,279	722,758	325,241	286,963
Total	**367,063,967**	**40,377,036**	**838,675,481**	**377,403,967**	**337,026,930**

Figure 1: U.S. Market for Crop Production Herbicides



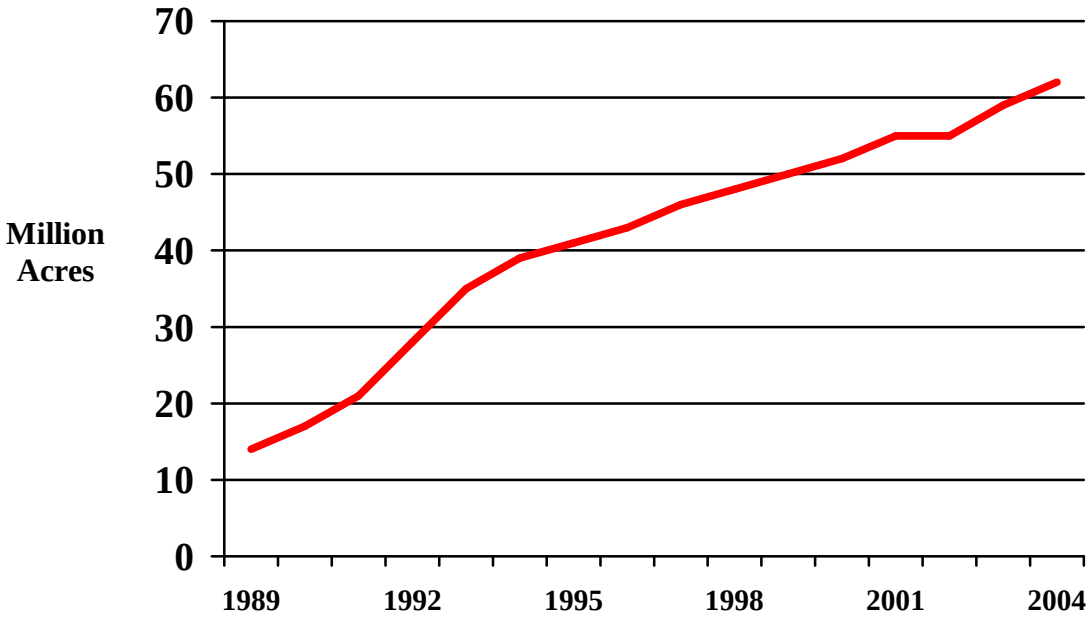
Source: Phillips McDougall

Figure 2: U.S. Biotech Herbicide Tolerant Crop Acreage



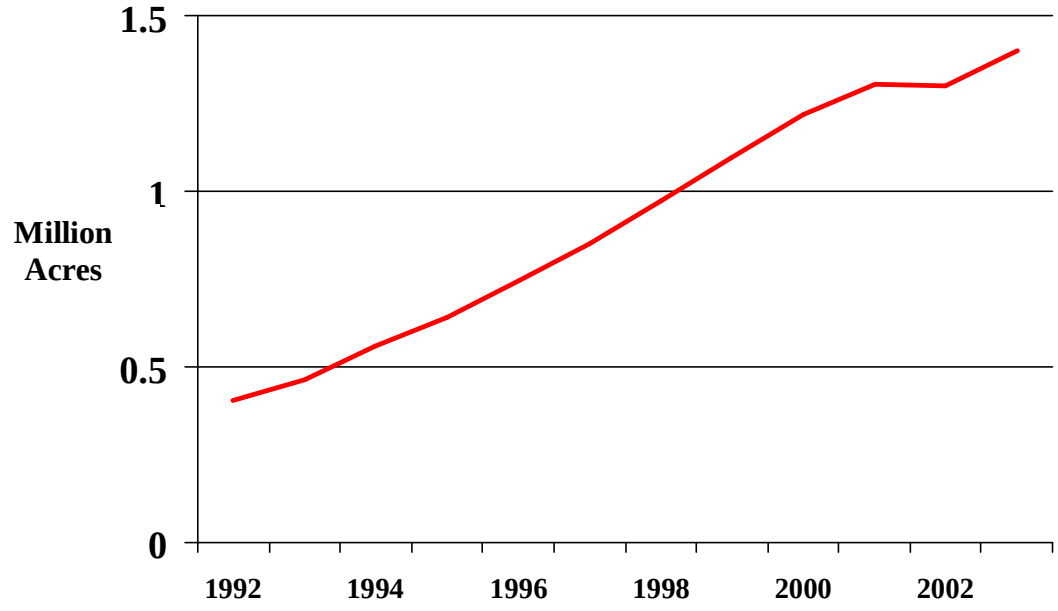
Source: USDA [8]

Figure 3: U.S. No-Till Acreage



Source: CTIC [21]

Figure 4: U.S. Organic Cropland Acreage



Source: ERS [29]

8.0 Reference List

1. Gianessi, Leonard and Sujatha Sankula, The Value of Herbicides in U.S. Crop Production, National Center for Food and Agricultural Policy, April 2003.

2. USDA, Crop Values 2005 Summary, National Agricultural Statistics Service, February 2006.

3. USDA, Non-Citrus Fruits and Nuts 2005 Preliminary Summary, National Agricultural Statistics Service, January 2006.

4. USDA, Vegetables 2005 Summary, National Agricultural Statistics Service, January 2006.

5. USDA, Citrus Fruits 2005 Summary, National Agricultural Statistics Service, September 2005.

6. USDA, Crop Production 2005 Summary, National Agricultural Statistics Service, January 2006.

7. Gianessi, Leonard and Nathan Reigner, Pesticide Use in U.S. Crop Production 2002, With Comparison to 1992 and 1997 Fungicides and Herbicides, CropLife Foundation, February 2006.

8. USDA, Acreage, National Agricultural Statistics Service, June 30, 2005.

9. Sankula, Sujatha, Gregory Marmon, and Edward Blumenthal, Biotechnology - Derived Crops Planted in 2004 – Impacts on U.S. Agriculture, National Center for Food and Agricultural Policy. December 2005.

10. CCOF, The Use and Importance of Handweeding in Organic Farming, letter, Jose H. Millan, 2004.

11. Salassi, Michael E. and Janis B. Breaux, Projected Costs and Returns: Rice Louisiana, Soybeans, Wheat, Sorghum, Southwest Louisiana, 2005, LSU AgCenter Research and Extension, January 2005.

12. USDA, Agricultural Prices, National Agricultural Statistics Service, April 2006.

13. Zollinger, R.K., 2005 North Dakota Weed Control Guide, North Dakota State University- NDSU Extension Service, January 2005.

14. Muraro, Ronald P. and W.C. Oswalt, Budgeting Costs and Returns for Central Florida Citrus Production, 2004-2005, University of Florida- IFAS Extension, September 2005.

15. Patterson, Paul E. and Robert L. Smathers, Idaho Crop Input Price Summary for 2004, University of Idaho, College of Agricultural and Life Sciences, November 2004.

16. Soybeans 2005 Planning Budgets, Mississippi State University, Department of Agricultural Economics, December 2004.

17. 2005 Cultural & Chemical Weed Control in Field Crops, University of Minnesota Extension Service.

18. Gianessi, L.P. and M.B. Marcelli, Prices of Pesticide Active Ingredients (1996), National Center for Food and Agricultural Policy, October 1996.

19. USDA, Agricultural Chemical Usage, 2005 Field Crops Summary, National Agricultural Statistics Service, May 2006.

20. Lazarus, William and Roger Selley, Farm Machinery Economic Cost Estimates for Late 2005, University of Minnesota Extension Service, August 2005.

21. 2004 National Crop Residue Management Survey: A Survey of Tillage System Usage by Crops and Acres Planted, Conservation Technology Information Center.

22. Tegtmeier, Erin M. and Michael D. Duffy, "External Costs of Agricultural Production in the United States", International Journal of Agricultural Sustainability, Vol. 2, No.1, 2004.

23. USDA, Summary Report 1997 National Resources Inventory, Natural Resources Conservation Service, revised December 2000.

24. Baker, Allen and Steven Zahniser, "Ethanol Reshapes the Corn Market", Amber Waves, Vol. 4, Issue 2, April 2006.

25. USDA, National Resources Inventory, 2003 Annual NRI, Natural Resources Conservation Service, May 2006.

26. Fawcett, Richard, and Dan Towery, Conservation Tillage and Plant Biotechnology, Conservation Technology Information Center, 2002.

27. Triplett, Glover B., Jr., and David M. Van Doren, Jr., "Agriculture Without Tillage," Scientific American, v. 236(1), January 1977.

28. Triplett, Glover B., Jr., "Principles of Weed Control for Reduced-Tillage Corn Production," in Weed Central in Limited Tillage Systems, Weed Science Society of America, Monograph Series Number 2, 1985.

29. USDA, Organic Production Data Sets, ERS, available at: http://www.ers.usda.gov/Data/Organic.

30. Swenson, Andrew, Brad Brummond, and Ron Haugen, "Projected 2003 Organic Crop Budgets South Central North Dakota," in Farm Management Planning Guide, January 2003.

31. Earthbound Organic, Organic Farming 101: Controlling Weeds Without Chemical Herbicides, available at: http://www.ebfarm.com/Organic/WeedControl.aspx.

32. Jones, D. Price, "Energy Consideration in Crop Production," in Outlook on Agriculture, Vol. 8, No. 3, 1974.

33. Handbook of Tables for Applied Engineering Science, 1973. 2nd ed. Chemical Rubber Co., Cleveland, Ohio.

CropLife Foundation
1156 15th Street, NW #400 Washington, DC 20005
Phone 202-296-1585 www.croplifefoundation.org Fax 202-463-0474