Supplemental Information to Support the NEPA Analysis for the Determination of Nonregulated Status of Dicamba-Tolerant Soybean MON 87708 and Dicamba- and Glufosinate-Tolerant Cotton MON 88701

Information regarding trends in tillage practices in corn, cotton and soybean

OECD Unique Identifiers: MON-877Ø8-9 (soybean) and MON-887Ø1-3 (cotton)
Monsanto Petition Numbers: 10-SY-210U (soybean) and 12-CT-244U/ 12-CT-244U-S (cotton)
USDA Petition Numbers: 10-188-01p (soybean) and 12-185-01p_a1 (cotton)

December 19, 2013

Submitted by:

Rhonda M. Mannion, B.S.

Monsanto Company
800 North Lindbergh Blvd.
St. Louis, MO 63167
Phone: (314) 694-8785
Fax: (314) 694-3080
E-mail: rhonda.m.mannion@monsanto.com

Prepared by:
J.K. Soteres, Ph.D. and R.M. Mannion, B.S.

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The undersigned submits this supplement under 7 CFR §340.6 to request that the Administrator make a determination that the article should not be regulated under 7 CFR Part 340

Rhonda Mannion, B.S.
Regulatory Affairs Manager
Tel: (314) 694-8785
Fax: (314) 694-8414

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Introduction

Recently there have been speculation and in some cases, reports, that the growth of conservation tillage acres and, in particular, no-till acres has slowed or is reversing in some parts of the country. Accordingly, Monsanto undertook an analysis of grower market research information from an independent market research company and follow up consultation with leading conservation tillage experts to understand more precisely current tillage trends and reasons for these trends in key soybean, corn and cotton growing areas.

Multiple factors could influence conservation tillage practices. Growth in the spread of glyphosate-resistant weed populations has been speculated or reported to be one such factor, because of the need for some farmers to incorporate more tillage into their farming operations in order to control some difficult to control weed species, such as Palmer amaranth. For example, where populations of glyphosate-resistant Palmer amaranth have grown large in areas such as Georgia, western Tennessee, and Arkansas, weed control experts recommend deep pre-plant tillage as one way to reduce the population before other weed control measures are applied (Culpepper, et al. 2013; Culpepper, et al. 2011; Price, et al. 2011). However, growers and leading conservation experts themselves report a range of factors other than weed management that can and do influence farmer practices relative to conservation tillage practices.

Materials and Methods

This analysis used market research data from an unpublished national grower survey conducted by a third party market research company. The data retrieved from this database included the number of crop acres planted conventionally, in a no-till system, or in a reduced tillage system. No-till acres are defined as those in which the farmer does not till the ground after the harvest of the last crop and before planting a new crop. Reduced tillage (reduced-till) is defined as situations where the farmer practices various types of reduced tillage after harvest of the last crop and before planting the new crop where significant crop residues (~15%-30%) are left on the soil surface. Examples of reduced tillage practices include ridge-till (planting row crops on permanent ridges), strip-till (planting crops directly in narrow strips that had been tilled), and mulch-till (any reduced tillage system that leaves at least 1/3 of soil surface covered with crop residue). Conventional tillage (conventional) is defined as situations where the farmer conducts several tillage operations such that the new crop is planted into soil with little to no surface residue.

The farmer market research data was sorted by crop (soybeans, cotton, and corn) and state. Selected states were combined into growing regions (East, Midwest, Southeast, Mid-South, and West, as indicated in Table 1). Data was retrieved for the period from 1998 through 2013 for soybeans and corn, and through 2012 for cotton (Note: 2013 cotton data from the market research company is not currently available). The estimated acreage of each tillage type for each crop and growing region was converted to percent of total crop planted acreage and submitted for statistical regression analysis over the designated time period. The data was analyzed to fit a linear or quadratic regression model at the 5% level of significance. Details of the statistical analysis are provided in the statistical report found in Appendix A.

To understand possible reasons for some of the changes observed in this data set, Monsanto worked with CTIC (Conservation Tillage Information Center, www.ctic.org) to conduct a survey of leading conservation tillage experts in select Midwest, Southeastern and Mid-South. (Note: experts from these areas were surveyed because they represent the major regions for the production of soybean, corn and cotton, and because they represent the areas with the highest levels of herbicide resistant weeds). In this survey, the experts were asked to indicate the level of importance of 11 different factors to farmers as they make decisions as to which tillage system and in general how much tillage they will use on their farm(s). Examples of factors included "manage excess crop residue," "manage existing weeds," "manage disease," "economics," and "prevent weed resistance." To rank the factors, a number from 1 to 4 was assigned to each response category, with 1 assigned to "not important or not mentioned" and 4 assigned to "extremely important". The experts were not limited in the number of factors to which they could assign an individual ranking. (i.e., the experts could rank all – or none – of the 11 factors as "extremely important"). The assigned number was multiplied by the number of responses from the experts and then added together for each factor. The factors with the 5 highest numerical sums are listed in Table 3 for each crop and region. The detailed results of this survey for corn, soybeans and cotton can be found in Appendix B.

Table 1. States in each Geographic Region

Region	Crop Focus	States
East	Corn, soybean	Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, West Virginia
Southeast	Corn, cotton, soybean	Alabama, Georgia, S. Carolina, N. Carolina, Virginia, Florida
Mid-South	Corn, cotton, soybean	Mississippi, Louisiana, Arkansas, Tennessee
Midwest	Corn, cotton, soybean	Ohio, Michigan, Indiana, Illinois, Wisconsin, Missouri, Minnesota, Iowa, Kentucky, Kansas, Nebraska, N. Dakota, S. Dakota
West	Corn, cotton, soybean	Arizona, California, New Mexico, Oklahoma, Texas, Colorado, Idaho, Montana, Nevada, Utah, Washington, Wyoming

Results and Discussion

A summary of the results of the grower market research data analysis on tillage trends can be found in Table 2. Key points are as follows:

- From 1998 to 2007, the conventional tillage acreage decreased and no-till acres increased across all crops and geographic areas. Likewise, reduced tillage acres generally increased during this time period, although for some areas and crops, no significant relationship between the tillage practice and time could be detected. The growth in no-till and reduced tillage acres coincides with, and was facilitated by, the growth in glyphosate-tolerant corn, soybean and cotton acres (Givens, et al. 2009a; Givens, et al. 2009b; McClelland, et al. 2000; Osteen and Fernandez-Cornejo 2013; Sankula 2006; Towery and Werblow 2010).

- Since 2007, however, some crops in some geographic areas have continued to see growth in no-till acreage, while other crops in other geographic areas have seen decreases in no-till acreage, accompanied by an increase in conventional and/or reduced tillage acreage. A more detailed, crop-by-crop discussion is presented below.

- **Corn:** From 1998 to 2007, the conventional tillage acreage decreased and no-till acres increased across all geographic areas. From 2007 through 2013, the trends varied across regions:
  - In the West and East, conventional tilled corn acres continued to decrease, and no-till acreage continued to increase. Reduced tillage acres also increased in the West, but there was no clear trend in the East.
  - In the Midwest, conventional tilled corn acres continued to decrease but there appeared to be a shift from strict no-till practices to reduced tillage acres where some tillage is practiced but significant (15% -30%) crop residues remain on the surface at planting.
  - In the Southeast, conventional tillage acres planted to corn tended to level off or increase while no-till acres tended to decrease.
  - In the Mid-South, there were no significant trends in conventional or no-till acreage, but reduced till acres increased throughout the time period.
- **Soybean:** From 1998 to 2007, the conventional tillage acreage decreased and no-till acres increased across all geographic areas. From 2007-2013, the trends varied across region:
  - In the West, conventional tilled soybean acres continued to decrease, and no-till acreage continued to increase. There was no significant trend for reduced tillage acres.
  - In the East, Midwest, Southeast and Mid-South regions, conventional tilled soybean acres were flat or increasing, while no-till acres were flat or decreasing. Reduced tillage acres in the Midwest increased during the same time period, but there was no clear relationship between time and reduced tillage plantings in the East, Southeast or Mid-South regions (not significant at the 95% confidence interval). Thus, in the Midwest, the reduction in no-till acres appears in large part to be offset by an increase in reduced tillage acres, but similar offsetting does not appear to be occurring in other regions.

- **Cotton:** From 1998 to 2007, the conventional tillage acreage decreased and no-till acres increased across all geographic areas. From 2007-2012, the trends varied across regions:

- In the West, conventional tilled soybean acres continued to decrease, and no-till acreage continued to increase. Reduced tillage acres also continued to increase.
- In the Midwest, Southeast and Mid-South, conventionally-tilled cotton acres tended to be flat or increase, while a clear increase was found in the Mid-South region. Reduced tillage acres increased in the Midwest and Southeast during this period, but both no-till and reduced tillage acreages decreased in the Mid-South region. Thus, in the Midwest and Southeast, the reduction in no-till acres appears in large part to be offset by an increase in reduced tillage acres, but similar offsetting does not appear to be occurring in the Mid-South.

Overall, changes in tillage practices from 2007 to 2012 (cotton)/2013 (soybean and corn) varied by crop and region relative to changes seen in the earlier period from 1998 to 2006 where consistent trends were observed across all the regions (i.e., increase in no-till and reduced tillage with a decrease in conventional tillage systems).

In order to understand the reasons growers adopt specific tillage practices, a survey was conducted of top conservation tillage experts across the Midwest (for corn and soybeans), Southeast and Mid-South regions (combined, for corn, soybeans, and cotton). In Table 3, the top 5 factors, according to conservation tillage experts, governing farmer decisions relative to which tillage practice they adopt for their farm are provided by crop and region of the country. Key findings included:

- Economics (i.e., the importance of cost of production and/or commodity prices), and managing soil moisture (i.e., less tillage conserves soil moisture) were top-5 factors across all the crops and regions.
- Seed bed preparation was a top-5 factor in 4 out of 5 crop x region segments.
- Managing excessive crop residue (i.e., excessive prior crop residue may require more tillage) and managing weeds (existing weeds or preventing weed resistance) were important factors in 3 out of 5 crop x region segments.
- Managing weeds was an important factor across all soybean and cotton regional segments, but was not a top 5 factor for corn in either regional segment. The difference between corn and the other crops is likely because growers have a broad range of herbicide options (including atrazine, dicamba and 2,4-D) that are effective against species that are difficult to control in soybeans and cotton, i.e., glyphosate resistant Palmer amaranth and waterhemp.

This survey of conservation tillage experts highlights that farmers consider multiple factors when making decisions as to what type tillage system to employ.

Conclusions

From 1998-2007, no-till acreage increased steadily across all crops and all regions, with an accompanying decrease in conventional tillage. A more complicated picture emerged after 2007, with some crops and regions continuing to experience increases in no-till and decreases in conventional tillage, while other crops and regions experienced decreases in no-till acreage, either accompanied by increases in reduced tillage acreage and/or in conventional tillage.

Based upon information provided by conservation tillage experts regarding the most important factors governing farmer’s decisions with respect to tillage practices, no one factor is driving these changes. Managing existing herbicide resistance and/or mitigating the potential for resistance to develop is a factor is some regions. For example, academics have been recommending more pre-plant tillage in parts of the Southeast and Mid-South (AR, western TN, and MS) in order to better manage glyphosate-resistant Palmer amaranth. But weed resistance management/mitigation does not appear to be a driver for other crops and regions. Indeed, the survey results indicate that higher corn and soybean grain prices, along with more focus on seed bed preparation, is likely to be a reason for some of switch to conventional tillage since a better stand (and thus higher potential yields) can usually be achieved in conventional tillage systems. Moreover, newer corn varieties can produce excessive crop residue, which may also be causing a move to more tillage and may be needed to optimize crop stands in this period of high grain prices.

Based upon the tillage trends seen over the last 5-6 years and with the information on the factors most influencing farmers’ decision on tillage practices, more study, appropriately directed research, education, and new technology from a weed management and crop production standpoint are needed to maintain and further grow conservation tillage practices. In some areas and for some crops, managing existing herbicide resistance and/or mitigating the potential for resistance to develop has been reported as an important factor in influencing farmer tillage decisions. DT soybean and DGT cotton are two new herbicide technologies that have the characteristics that can significantly assist in reversing stagnated and downward trends and promote new growth in conservation tillage acres. Weed management has always been a limiting factor for many farmers in determining whether to adopt no-till production practices because farmers had to rely primarily on soil residual herbicides. Glyphosate, in glyphosate-tolerant crops, with its broad spectrum post-emergence control provided a way to achieve consistent weed control in these situations and facilitated an increase in adoption of no-till and, in general, conservation tillage practices (Fawcett and Towry, 2002). The effectiveness of dicamba to provide post-emergent control of broadleaf weeds, suggests that it too will promote adoption of no-till and conservation tillage practices. Additionally, dicamba’s ability to control glyphosate resistant broadleaf weeds and its compatibility with glyphosate are characteristics that will facilitate the promotion of conservation tillage practices.

Table 2. Trends in Tillage Practices in Soybean, Corn and Cotton

Crop	**Geography**	**Tillage system**	**Trend**	
			1998-2007	2007-2012/13
Corn	West	Conventional	Dec	Dec
		No-till	Inc	Inc
		Reduced-till	Inc	Inc
	Midwest	Conventional	Dec	Dec
		No-till	Inc	Flat/Dec[1]
		Reduced-till	Dec	Inc
	Southeast	Conventional	Dec	Flat/Inc[1]
		No-till	Inc	Dec
		Reduced-till	NS	NS
	Mid-South	Conventional	NS	NS
		No-till	NS	NS
		Reduced-till	Inc	Inc
	East	Conventional	Dec	Dec
		No-till	Inc	Inc
		Reduced-till	NS	NS
Soybeans	West	Conventional	Dec	Dec
		No-till	Inc	Inc
		Reduced-till	NS	NS
	Midwest	Conventional	Dec	Flat/Inc[1]
		No-till	Inc	Dec
		Reduced-till	Dec	Inc
	Southeast	Conventional	Dec	Flat
		No-till	Inc	Flat
		Reduced-till	NS	NS
	Mid-South	Conventional	Dec	Inc
		No-till	Inc	Dec
		Reduced-till	NS	NS
	East	Conventional	Dec	Flat/Inc[1]
		No-till	Inc	Flat/Dec[1]
		Reduced-till	NS	NS

Table 2 (continued). Trends in Tillage Practices in Soybean, Corn and Cotton

Crop	Geography	Tillage system	Trend	
			1998-2007	2007-2012/13
Cotton	West	Conventional	Dec	Dec
		No-till	Inc	Inc
		Reduced-till	Inc	Inc
	Southeast	Conventional	Dec	Flat/Inc[1]
		No-till	Inc	Dec
		Reduced-till	Inc	Inc
	Midwest	Conventional	Dec	Flat/Inc[1]
		No-till	Inc	Dec
		Reduced-till	Inc	Inc
	Mid-South	Conventional	Dec	Inc
		No-till	Inc	Dec
		Reduced-till	Inc	Dec
NS=no significant trend at 5% Confidence Interval Inc= Increase Dec=decrease Flat=no change				

Source of data is propriety grower market research data (Monsanto, 2013).

[1]Where the trend is indicated as two phases (i.e. Flat/Dec), this means that statistically the trend is for no change over the designated time period but the slope over the last two years of the time period tended to be either reflective of an increase or a decrease.

Table 3. Top 5 Factors Governing Farmer's Tillage Practice Decisions

Factor	Midwest Corn (14 Experts)	Midwest Soybeans (13 Experts)	South Corn (6 Experts)	South Soybeans (6 Experts)	South Cotton (6 Experts)
1	Managing soil moisture	Excessive crop residue	Economics	Economics	Economics
2	Seed bed preparation	Seed bed preparation	Seed bed preparation	Managing existing weeds	Managing existing weeds
3	Economics	Economics	Excessive crop residue	Seed bed preparation	Availability of Labor
4	Excessive crop residue	Managing existing weeds	Improving water penetration	Managing soil moisture	Managing soil moisture
5	Managing soil temperature	Managing soil moisture	Managing soil moisture	Preventing weed resistance	Use of strip till / vertical tillage tools

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Appendix A: Statistical Analysis of Tillage Market Research Data

Summary of Statistical Analysis of Tillage Data

Purpose

Assess if tillage practices have significantly changed between 1998 and 2007, and between 2007 and 2013 (or 2012, for cotton).

Data Description

For the analysis PROC MEANS in SAS was used to calculate the acres that utilized each tillage type and total acres for each crop, region and year. The percent of total acres was calculated by dividing acres that utilized each tillage type by total acres.

Statistical Methods and Results

A quadratic regression model of the following form was fit for each crop, region and tillage type combination:

$$\text{Percent of total acres} = \beta_0 + \beta_1 * \text{Year} + \beta_2 * \text{Year} * \text{Year} + \varepsilon \quad (1)$$

in which β_0 is the intercept, β_1 is the linear slope, β_2 is the quadratic slope and ε is the residual error. PROC MIXED in SAS was used to fit model (1) separately for each crop, region and tillage type combination. Tests were performed to determine if the quadratic slopes of the regression lines were significantly different from zero. These tests are displayed in Table 1. Twenty of the 42 tests observed quadratic slopes that were significantly different from zero at the 5% level of significance.

In the 20 cases where the quadratic slopes were significant, a quadratic regression model was deemed appropriate. For the 22 cases where the quadratic slopes were not significant, a linear regression model of the following form was fit for each crop, region and tillage type combination:

$$\text{Percent of total acres} = \beta_0 + \beta_1 * \text{Year} + \varepsilon \quad (2)$$

in which β_0 is the intercept, β_1 is the linear slope and ε is the residual error. PROC MIXED in SAS was used to fit model (2) separately for each crop, region and tillage type combination. Tests were performed to determine if the linear slopes of the regression lines were significantly different from zero. These tests are displayed in Table 2. Fourteen of the 22 tests observed linear slopes that were significantly different from zero at the 5% level of significance.

In the 14 cases where the linear slopes were significant, a linear regression model was deemed appropriate. For the 8 cases where the linear slopes were not significant, there was no significant change in tillage practices over time.

Conclusions

In 8 of the 42 crop, region and tillage type combinations there was no significant change over time.

In 14 of the 42 crop, region and tillage type combinations the change over time can be described using a linear regression model.

In 20 of the 42 crop, region and tillage type combinations the change over time can be described using a quadratic regression model.

The regression parameter estimates for the crop and region combinations with a significant the change over time, are displayed in Table 3.

Plots of the percent total acres data and model fit are displayed in the Appendix.

Table A-1. Tests to Determine if the Quadratic Slopes of the Regression Lines Were Significantly Different From Zero

Crop	Region	Tillage_Type	P-value	
Corn	East	Conservation	0.1381	
Corn	East	Conventional	0.6663	
Corn	East	No-Till	0.1161	
Corn	MidSouth	Conservation	0.5547	
Corn	MidSouth	Conventional	0.1925	
Corn	MidSouth	No-Till	0.0582	
Corn	MidWest	Conservation	0.0218	*
Corn	MidWest	Conventional	0.5444	
Corn	MidWest	No-Till	0.0015	*
Corn	Southeast	Conservation	0.1322	
Corn	Southeast	Conventional	0.0038	*
Corn	Southeast	No-Till	0.0018	*
Corn	West	Conservation	0.9108	
Corn	West	Conventional	0.2174	
Corn	West	No-Till	0.1183	
Cotton	MidSouth	Conservation	0.0018	*
Cotton	MidSouth	Conventional	<.0001	*
Cotton	MidSouth	No-Till	<.0001	*
Cotton	MidWest	Conservation	0.2096	
Cotton	MidWest	Conventional	0.0017	*
Cotton	MidWest	No-Till	<.0001	*
Cotton	Southeast	Conservation	0.7367	
Cotton	Southeast	Conventional	0.0002	*
Cotton	Southeast	No-Till	<.0001	*
Cotton	West	Conservation	0.0539	
Cotton	West	Conventional	0.0582	
Cotton	West	No-Till	0.8615	
Soybeans	East	Conservation	0.4610	
Soybeans	East	Conventional	0.0051	*

Table A-1 (continued). Tests to Determine if the Quadratic Slopes of the Regression Lines Were Significantly Different From Zero

Crop	Region	Tillage_Type	P-value	
Soybeans	East	No-Till	0.0017	*
Soybeans	MidSouth	Conservation	0.5038	
Soybeans	MidSouth	Conventional	0.0003	*
Soybeans	MidSouth	No-Till	0.0013	*
Soybeans	MidWest	Conservation	0.0006	*
Soybeans	MidWest	Conventional	0.0056	*
Soybeans	MidWest	No-Till	0.0002	*
Soybeans	Southeast	Conservation	0.3208	
Soybeans	Southeast	Conventional	0.0495	*
Soybeans	Southeast	No-Till	0.0447	*
Soybeans	West	Conservation	0.1184	
Soybeans	West	Conventional	0.0921	
Soybeans	West	No-Till	0.7472	

Note: Twenty of the 42 tests observed quadratic slopes that were significantly different from zero at the 5% level of significance. The tests that were significant at the 5% level are marked with an ‘*’.

Table A-2. Tests to Determine if the Linear Slopes of the Regression Lines Were Significantly Different From Zero

Crop	Region	Tillage_Type	P-value	
Corn	East	Conservation	0.2078	
Corn	East	Conventional	<.0001	*
Corn	East	No-Till	<.0001	*
Corn	MidSouth	Conservation	0.0195	*
Corn	MidSouth	Conventional	0.4904	
Corn	MidSouth	No-Till	0.3690	
Corn	MidWest	Conventional	0.0011	*
Corn	Southeast	Conservation	0.0835	
Corn	West	Conservation	0.0011	*
Corn	West	Conventional	<.0001	*
Corn	West	No-Till	0.0114	*
Cotton	MidWest	Conservation	0.0210	*
Cotton	Southeast	Conservation	<.0001	*
Cotton	West	Conservation	<.0001	*
Cotton	West	Conventional	<.0001	*
Cotton	West	No-Till	0.0001	*
Soybeans	East	Conservation	0.1917	
Soybeans	MidSouth	Conservation	0.1896	
Soybeans	Southeast	Conservation	0.6675	
Soybeans	West	Conservation	0.1233	
Soybeans	West	Conventional	0.0067	*
Soybeans	West	No-Till	0.0002	*

Note: Fourteen of the 22 tests observed linear slopes that were significantly different from zero at the 5% level of significance. The tests that were significant at the 5% level are marked with an ‘*’.

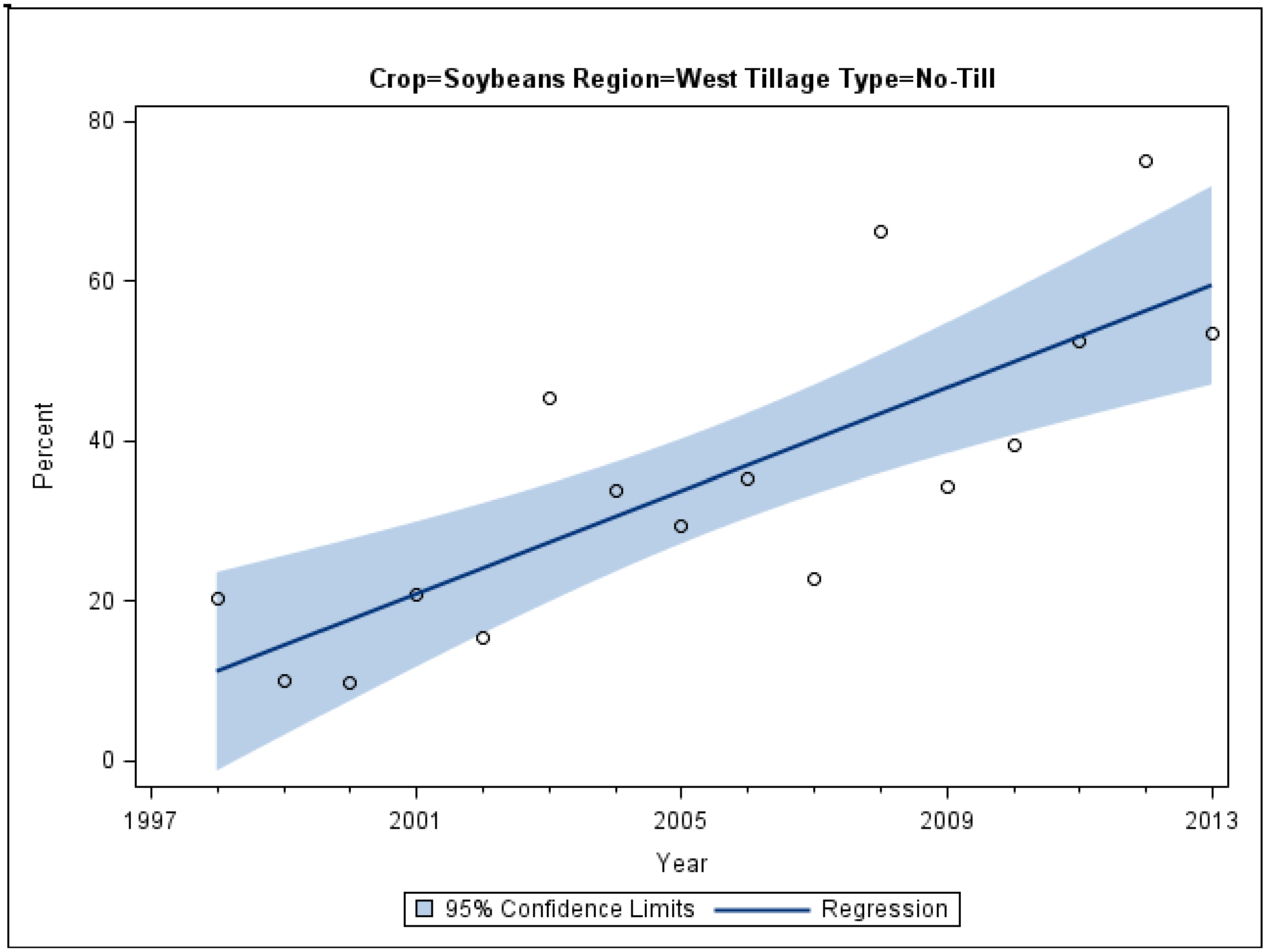
Table A-3. Regression Parameter Estimates for the Crop and Region Combinations with a Significant the Change in Tillage Over Time

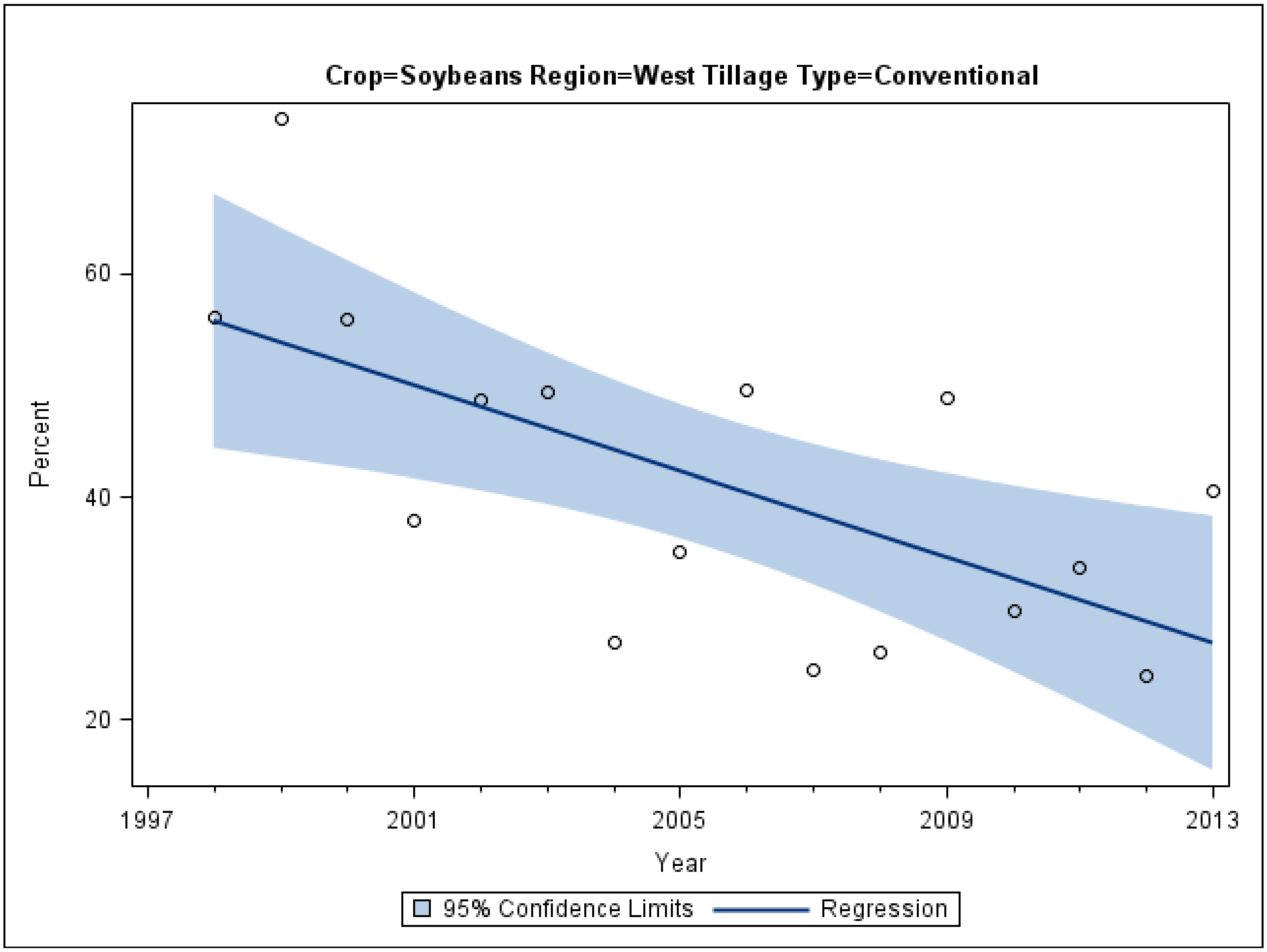
Crop	Region	Tillage Type	Intercept	Year	Year*Year
Corn	East	Conventional	3466.72	-1.7079	.
Corn	East	No-Till	-3039.87	1.5340	.
Corn	MidSouth	Conservation	-1769.03	0.8933	.
Corn	MidWest	Conservation	300587	-299.62	0.07467
Corn	MidWest	Conventional	1114.90	-0.5355	.
Corn	MidWest	No-Till	-383597	381.93	-0.09506
Corn	Southeast	Conventional	766604	-763.20	0.1900
Corn	Southeast	No-Till	-1202619	1198.66	-0.2987
Corn	West	Conservation	-2375.58	1.1991	.
Corn	West	Conventional	3782.79	-1.8592	.
Corn	West	No-Till	-1307.20	0.6601	.
Cotton	MidSouth	Conservation	-1044452	1041.04	-0.2594
Cotton	MidSouth	Conventional	2648507	-2639.72	0.6577
Cotton	MidSouth	No-Till	-1603955	1598.68	-0.3983
Cotton	MidWest	Conservation	-2277.83	1.1529	.
Cotton	MidWest	Conventional	1707629	-1701.22	0.4237
Cotton	MidWest	No-Till	-2295716	2289.07	-0.5706
Cotton	Southeast	Conservation	-3534.42	1.7786	.
Cotton	Southeast	Conventional	1405216	-1399.58	0.3485
Cotton	Southeast	No-Till	-1304016	1300.48	-0.3242
Cotton	West	Conservation	-2656.63	1.3372	.
Cotton	West	Conventional	4244.03	-2.0828	.
Cotton	West	No-Till	-1487.40	0.7456	.
Soybeans	East	Conventional	902937	-899.02	0.2238
Soybeans	East	No-Till	-1061879	1057.33	-0.2632
Soybeans	MidSouth	Conventional	1373279	-1368.84	0.3411
Soybeans	MidSouth	No-Till	-1208347	1204.77	-0.3003
Soybeans	MidWest	Conservation	387479	-386.03	0.09615
Soybeans	MidWest	Conventional	311116	-309.83	0.07714

Table A-3 (continued). Regression Parameter Estimates for the Crop and Region Combinations with a Significant the Change in Tillage Over Time

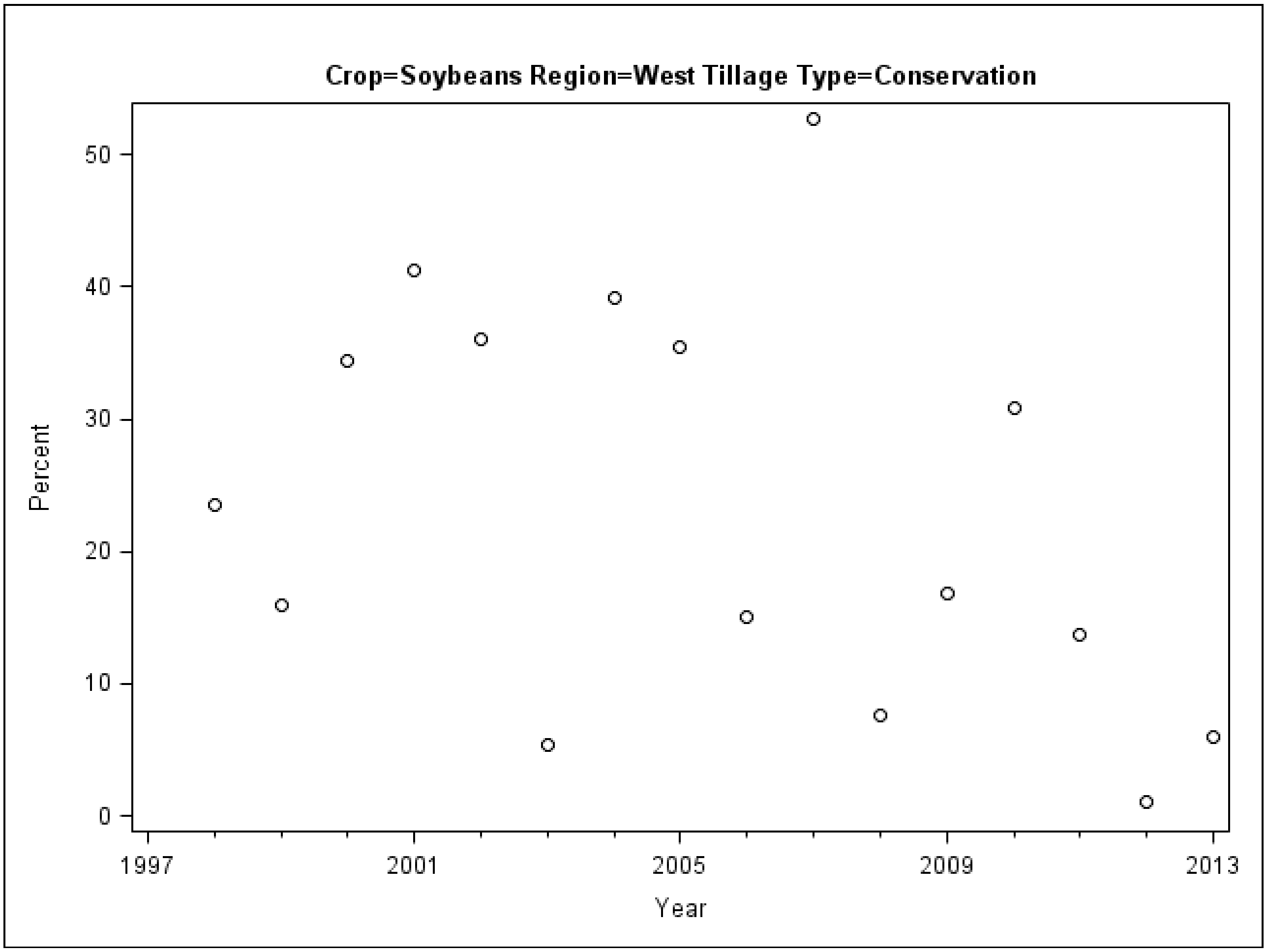
Crop	Region	Tillage Type	Intercept	Year	Year*Year
Soybeans	MidWest	No-Till	-698495	695.85	-0.1733
Soybeans	Southeast	Conventional	600500	-597.28	0.1485
Soybeans	Southeast	No-Till	-768636	765.12	-0.1904
Soybeans	West	Conventional	3901.95	-1.9250	.
Soybeans	West	No-Till	-6423.22	3.2204	.

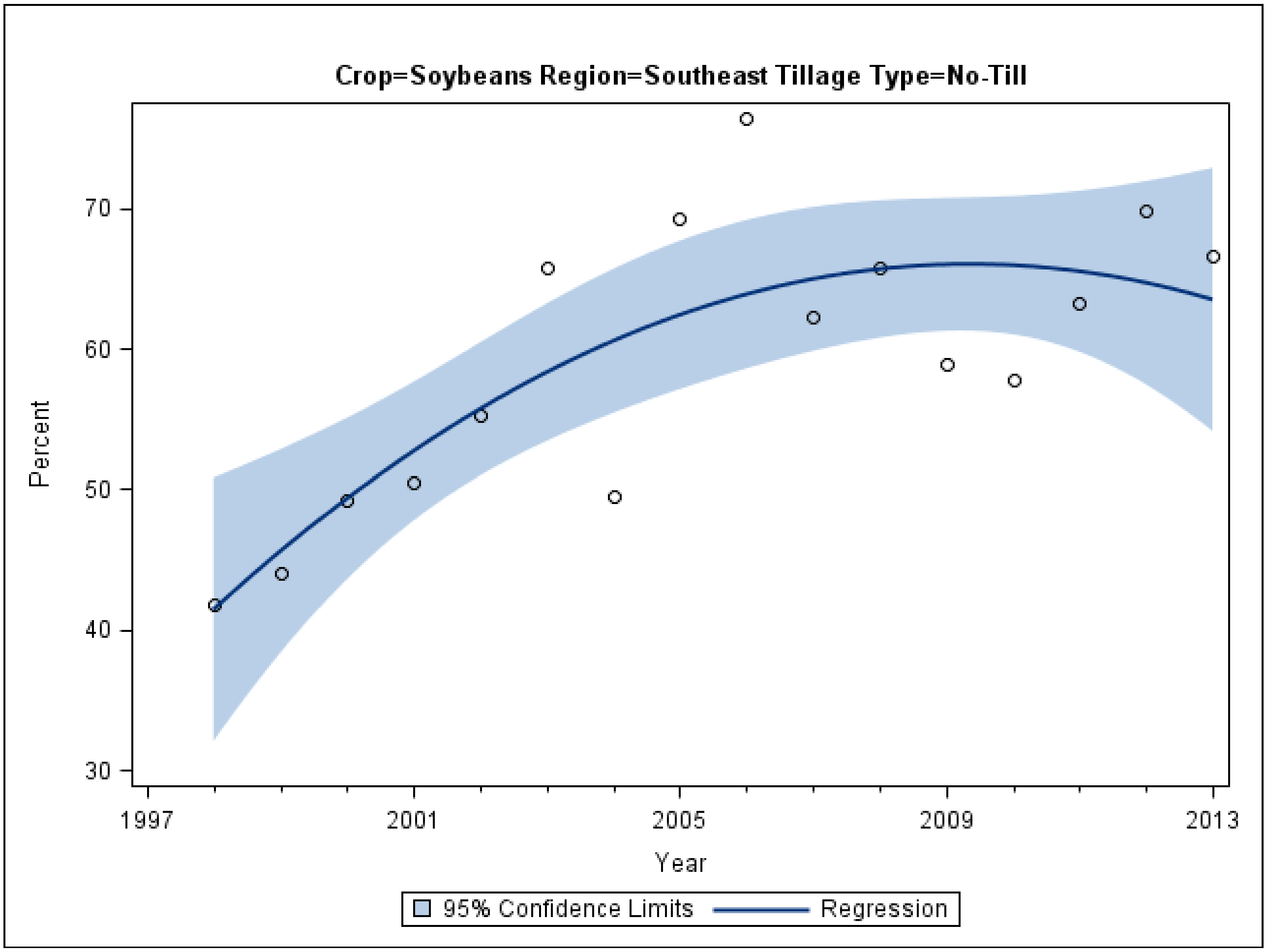
Appendix A Figures



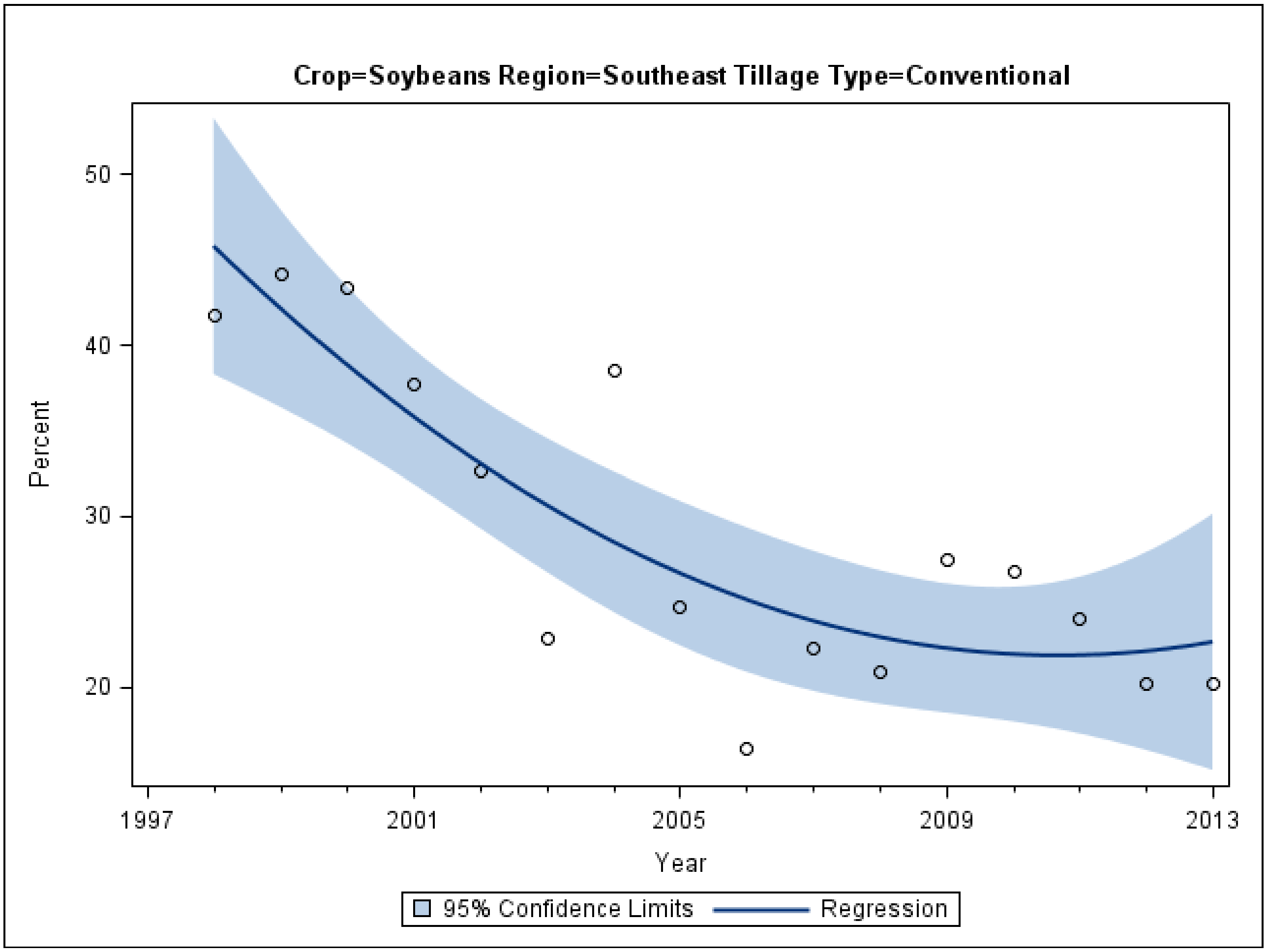


Crop=Soybeans Region=West Tillage Type=Conventional
Percent
60
40
20
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

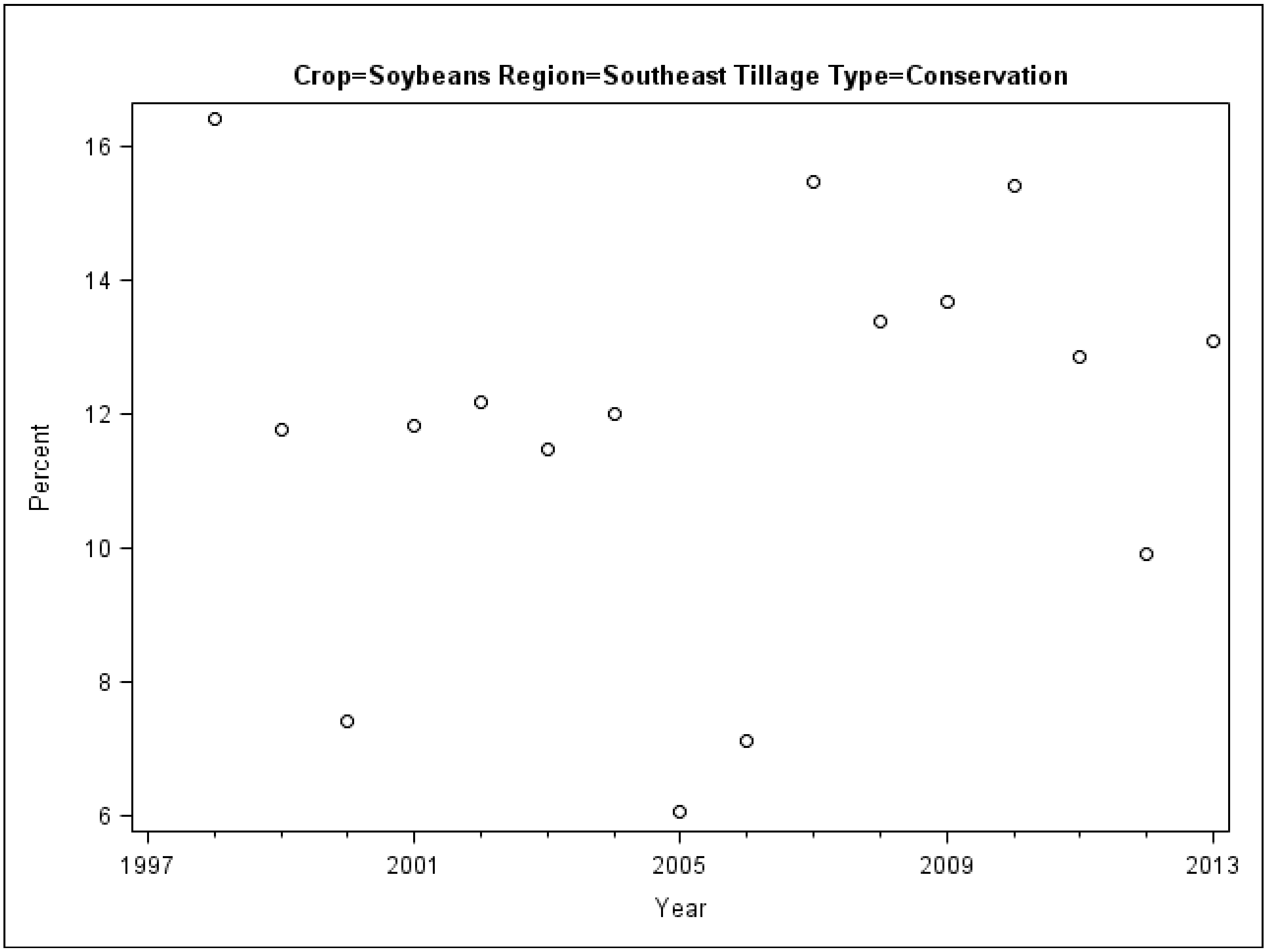

Crop=Soybeans Region=West Tillage Type=Conservation
Percent
0
10
20
30
40
50
1997
2001
2005
2009
2013
Year



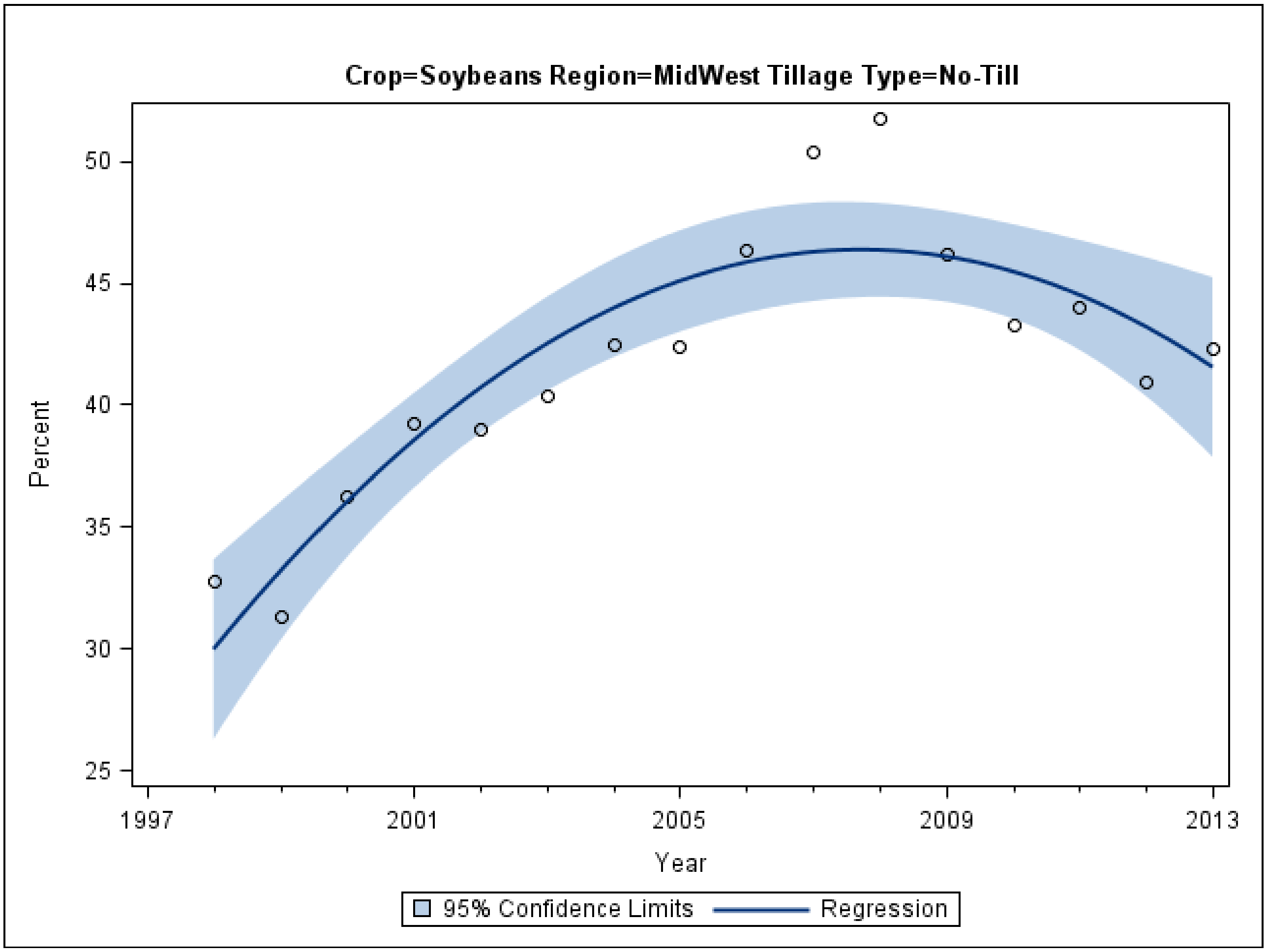
Crop=Soybeans Region=Southeast Tillage Type=No-Till
Percent
70
60
50
40
30
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

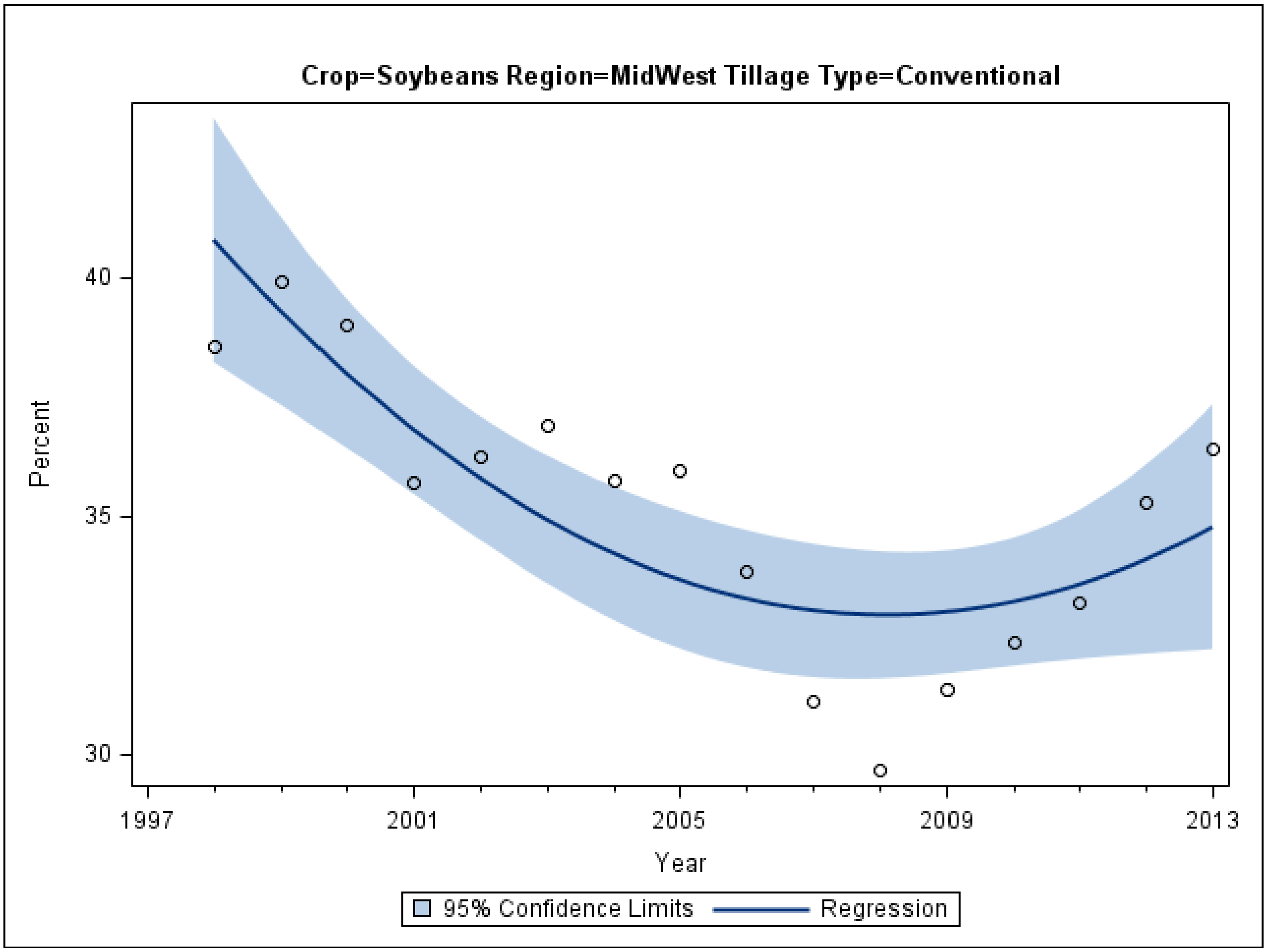


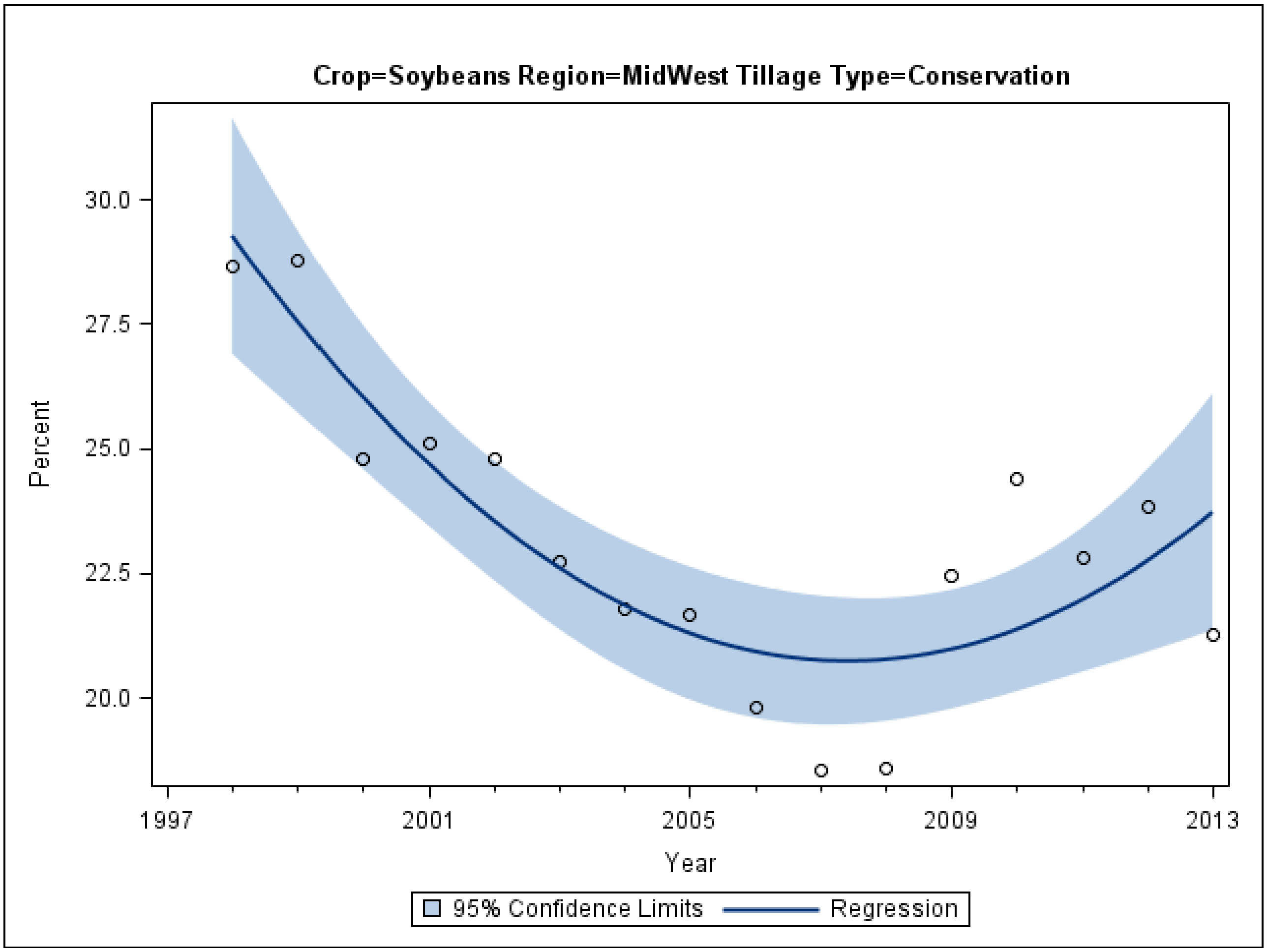
Crop=Soybeans Region=Southeast Tillage Type=Conventional
50
40
30
20
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression



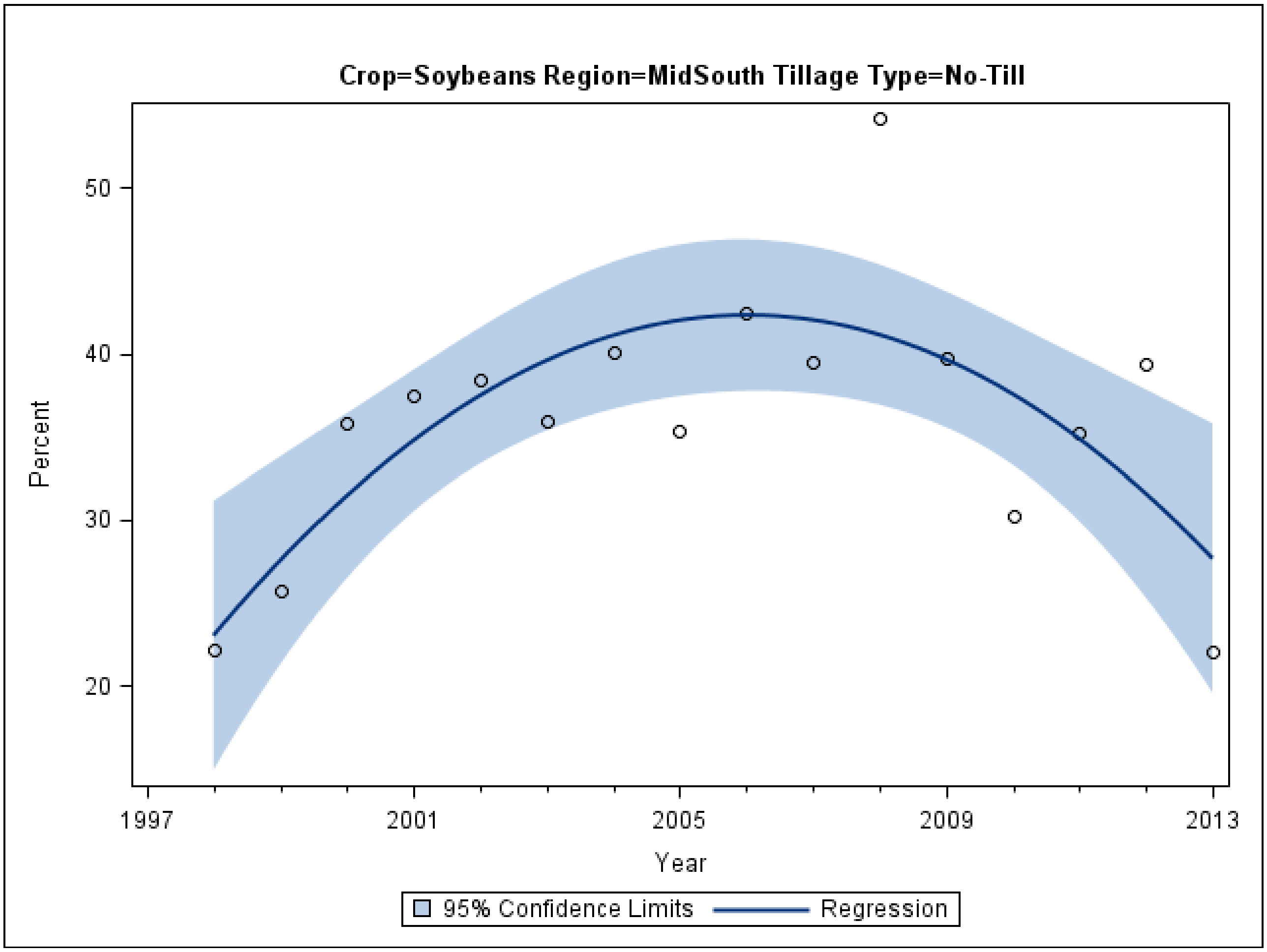
Crop=Soybeans Region=Southeast Tillage Type=Conservation
16
14
12
10
8
6
Percent
1997
2001
2005
2009
2013
Year

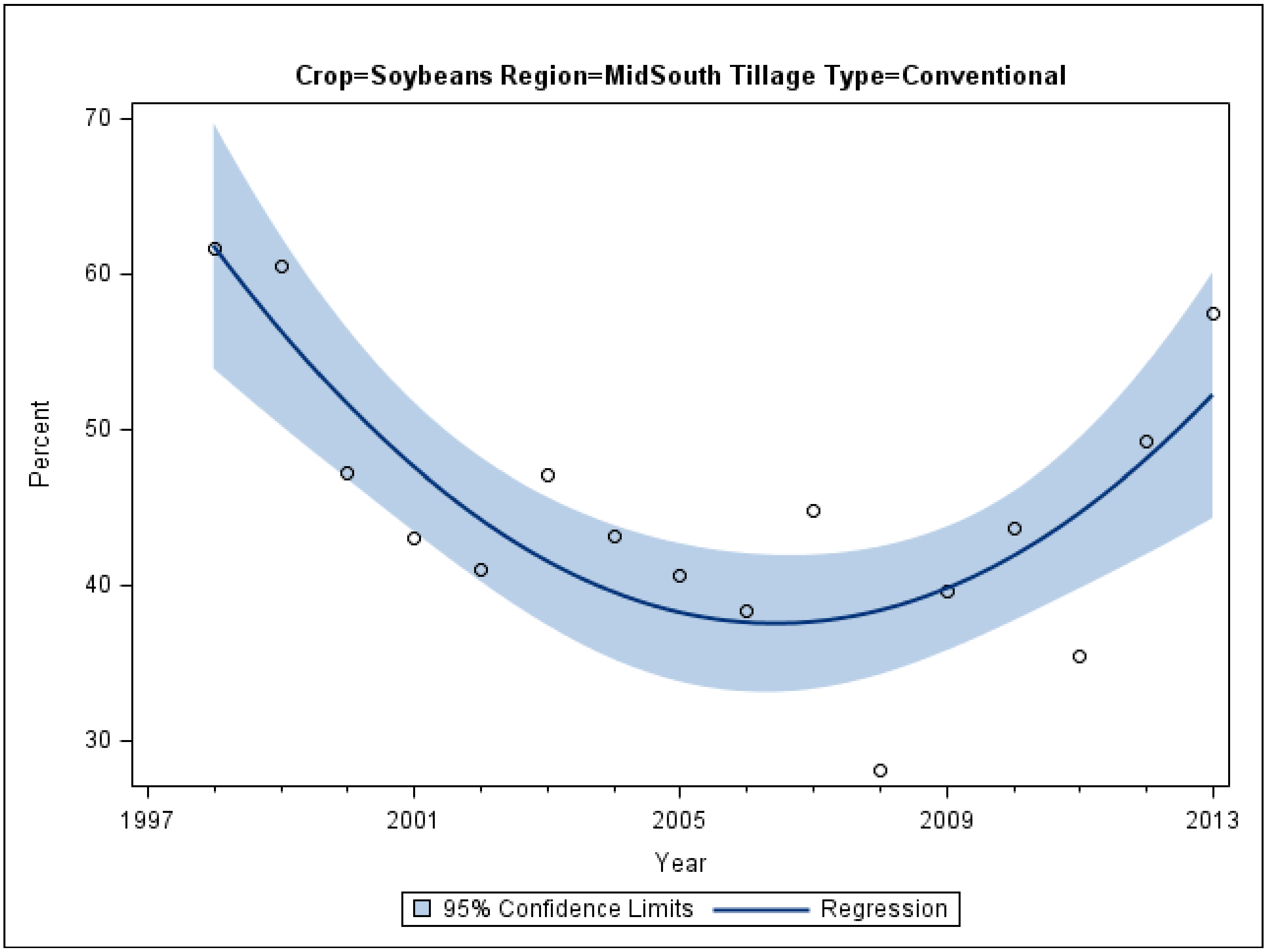

Crop=Soybeans Region=MidWest Tillage Type=No-Till
Percent
50
45
40
35
30
25
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

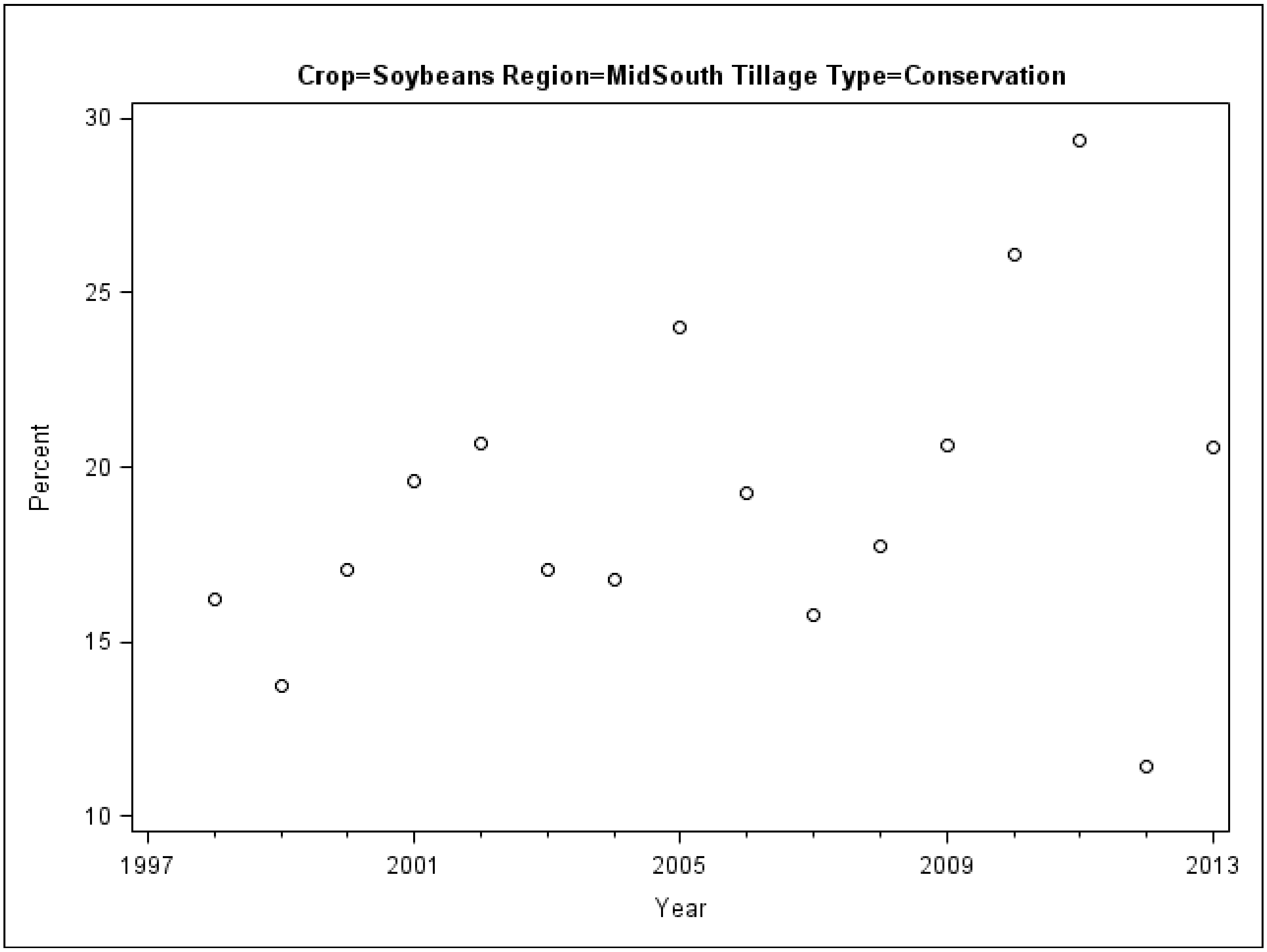

Crop=Soybeans Region=MidWest Tillage Type=Conventional
Percent
40
35
30
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

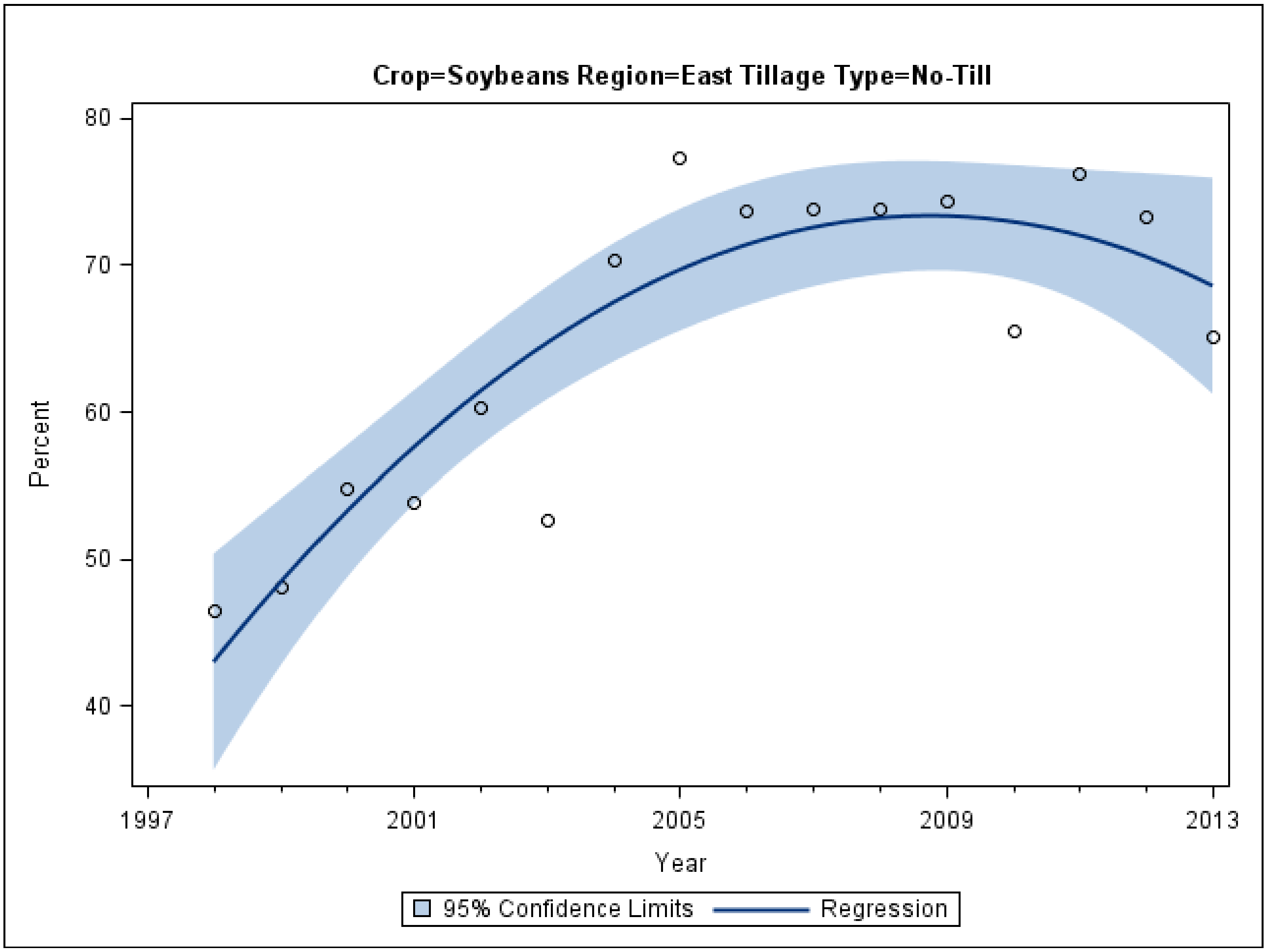


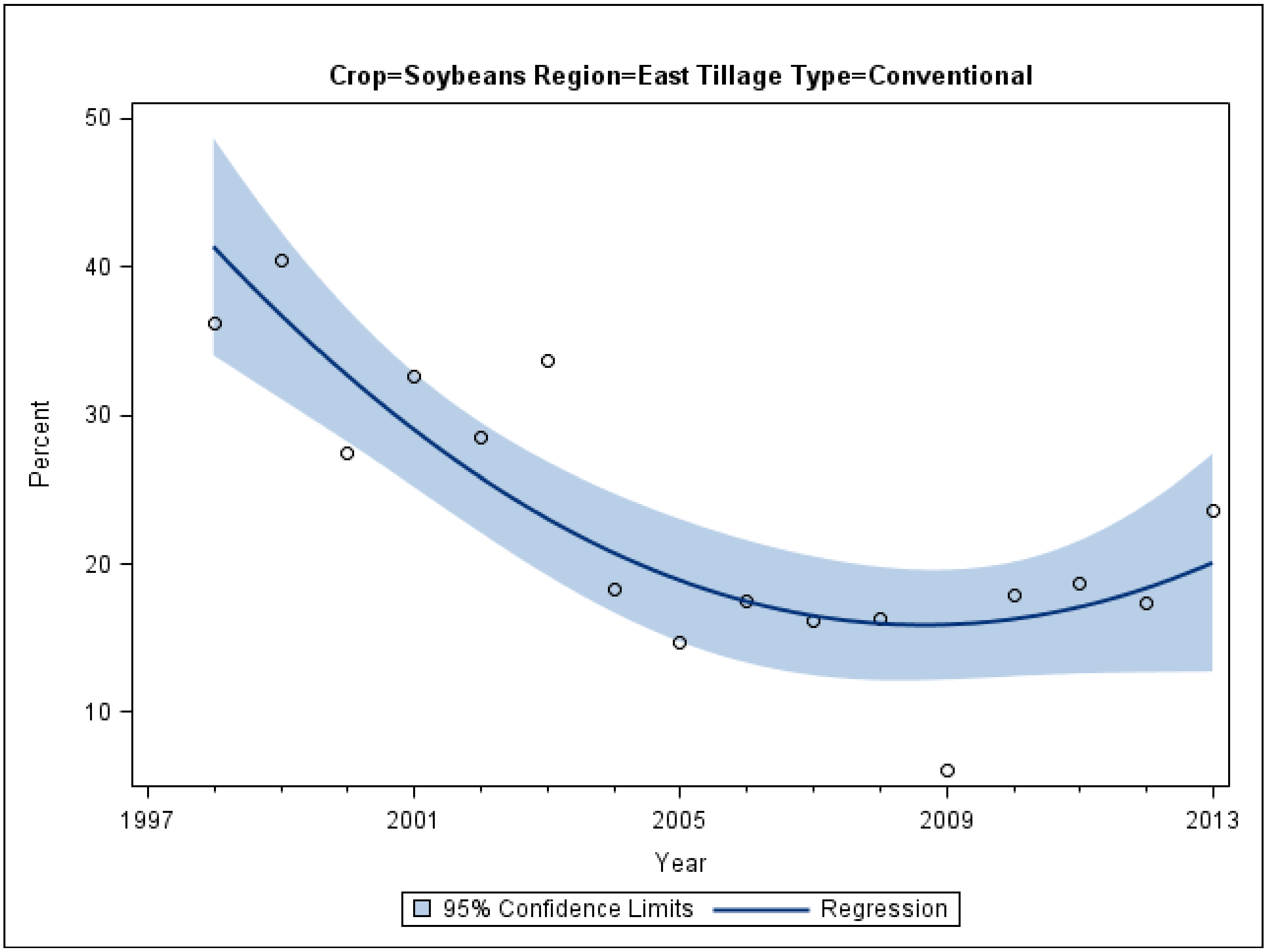
Crop=Soybeans Region=MidWest Tillage Type=Conservation
30.0
27.5
25.0
22.5
20.0
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression


Crop=Soybeans Region=MidSouth Tillage Type=No-Till
50
40
30
20
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

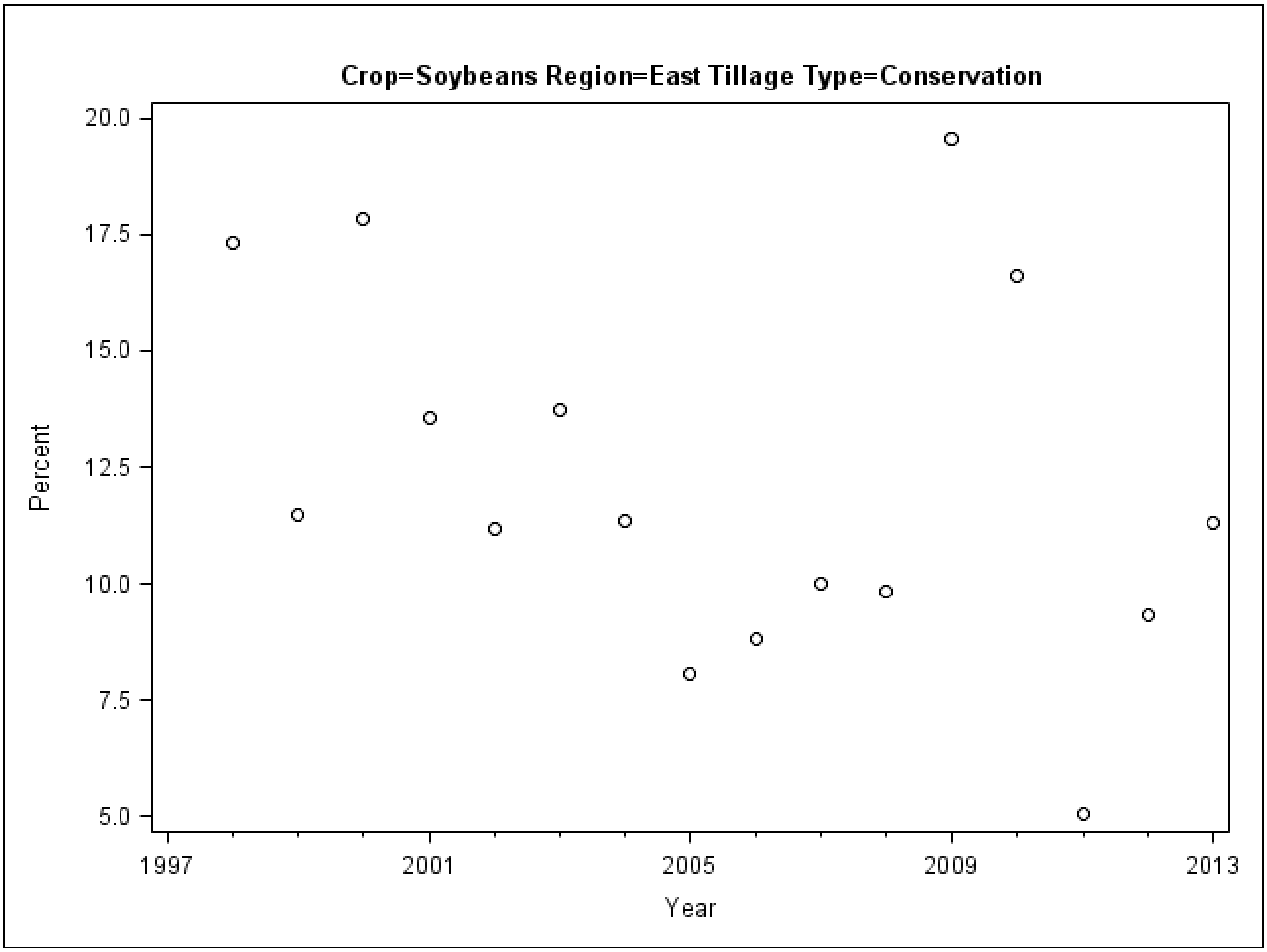

Crop=Soybeans Region=MidSouth Tillage Type=Conventional
70
60
50
40
30
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

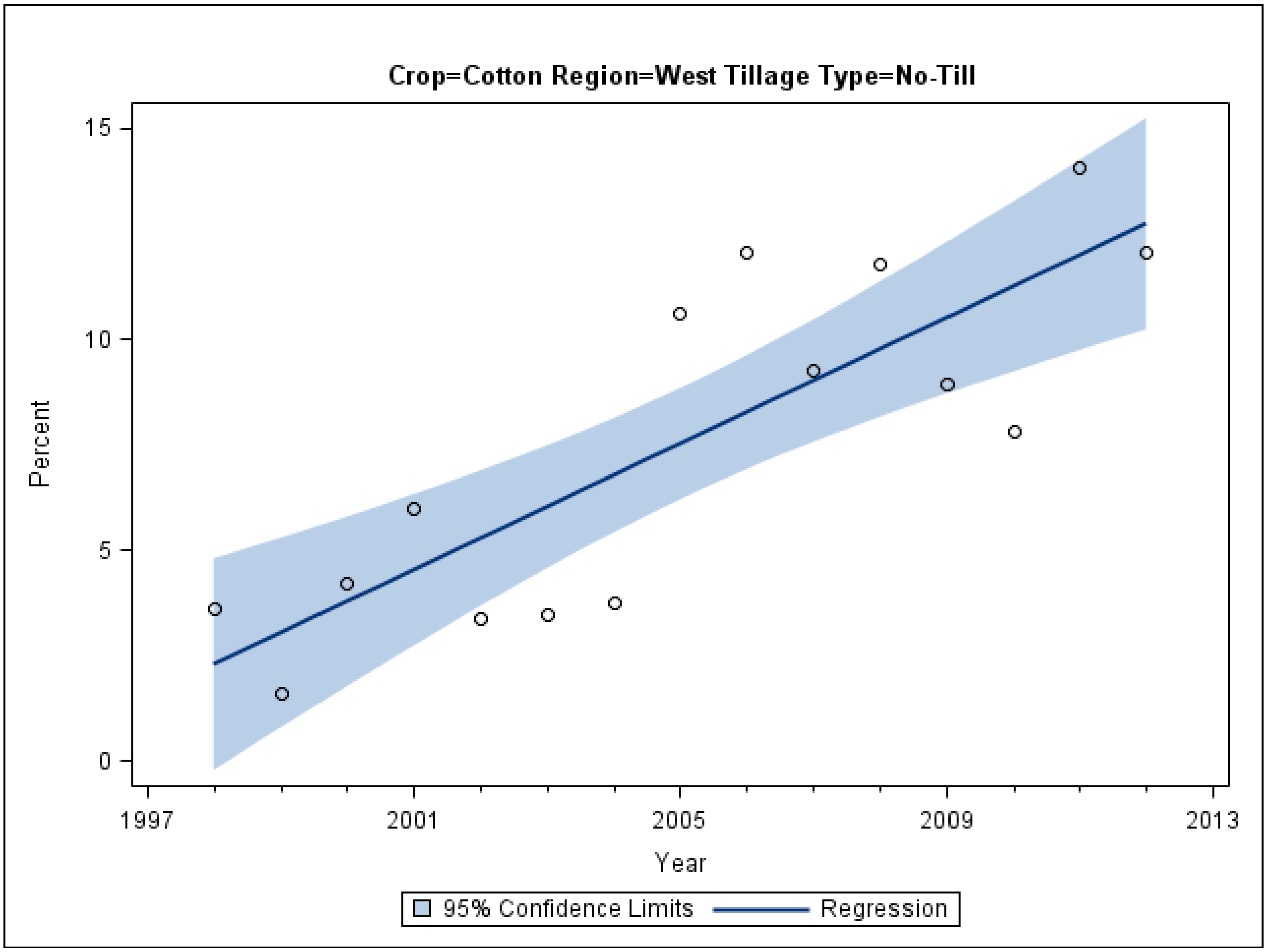

Crop=Soybeans Region=MidSouth Tillage Type=Conservation
Percent
30
25
20
15
10
1997
2001
2005
2009
2013
Year

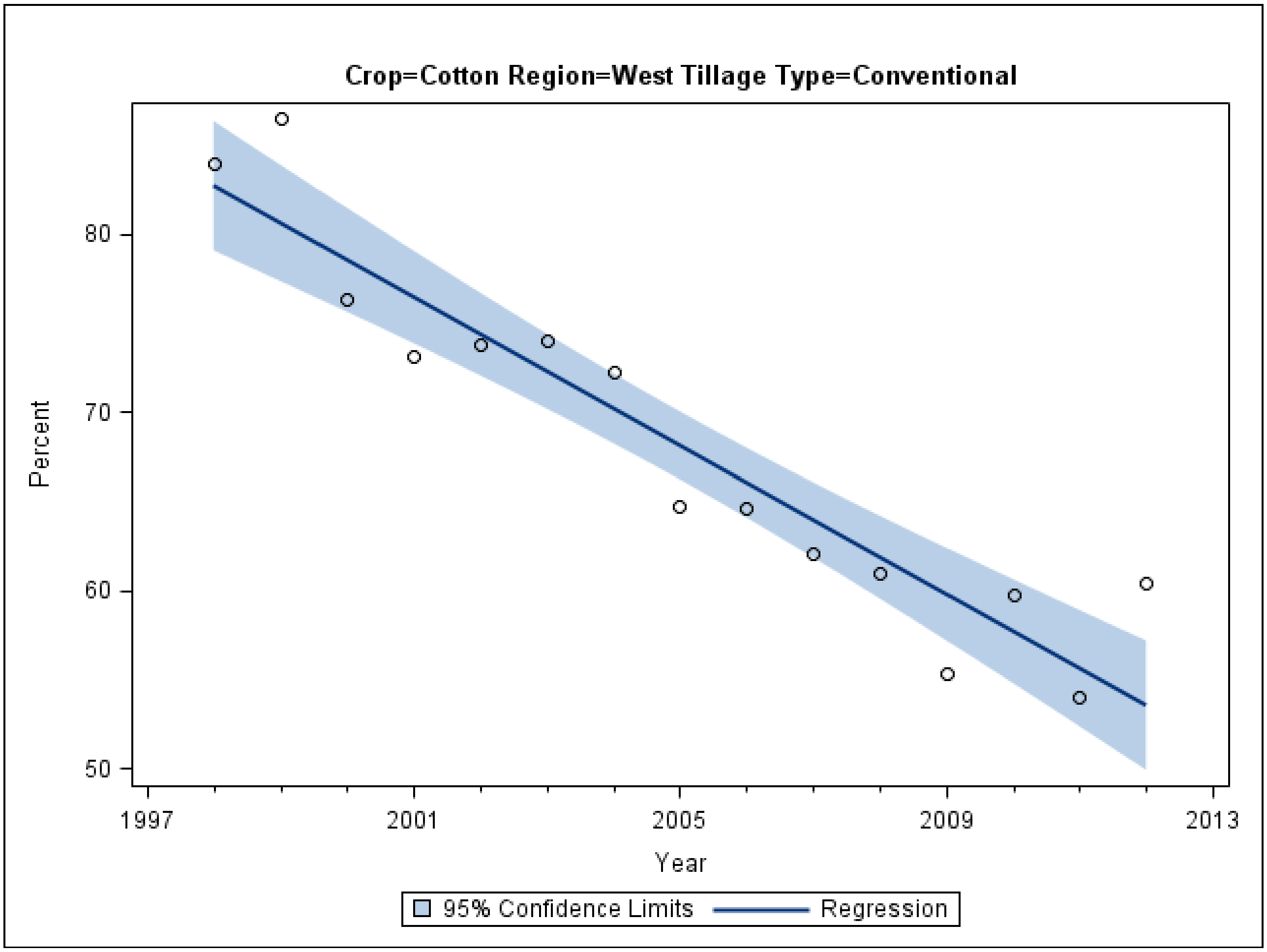

Crop=Soybeans Region=East Tillage Type=No-Till
Percent
80
70
60
50
40
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

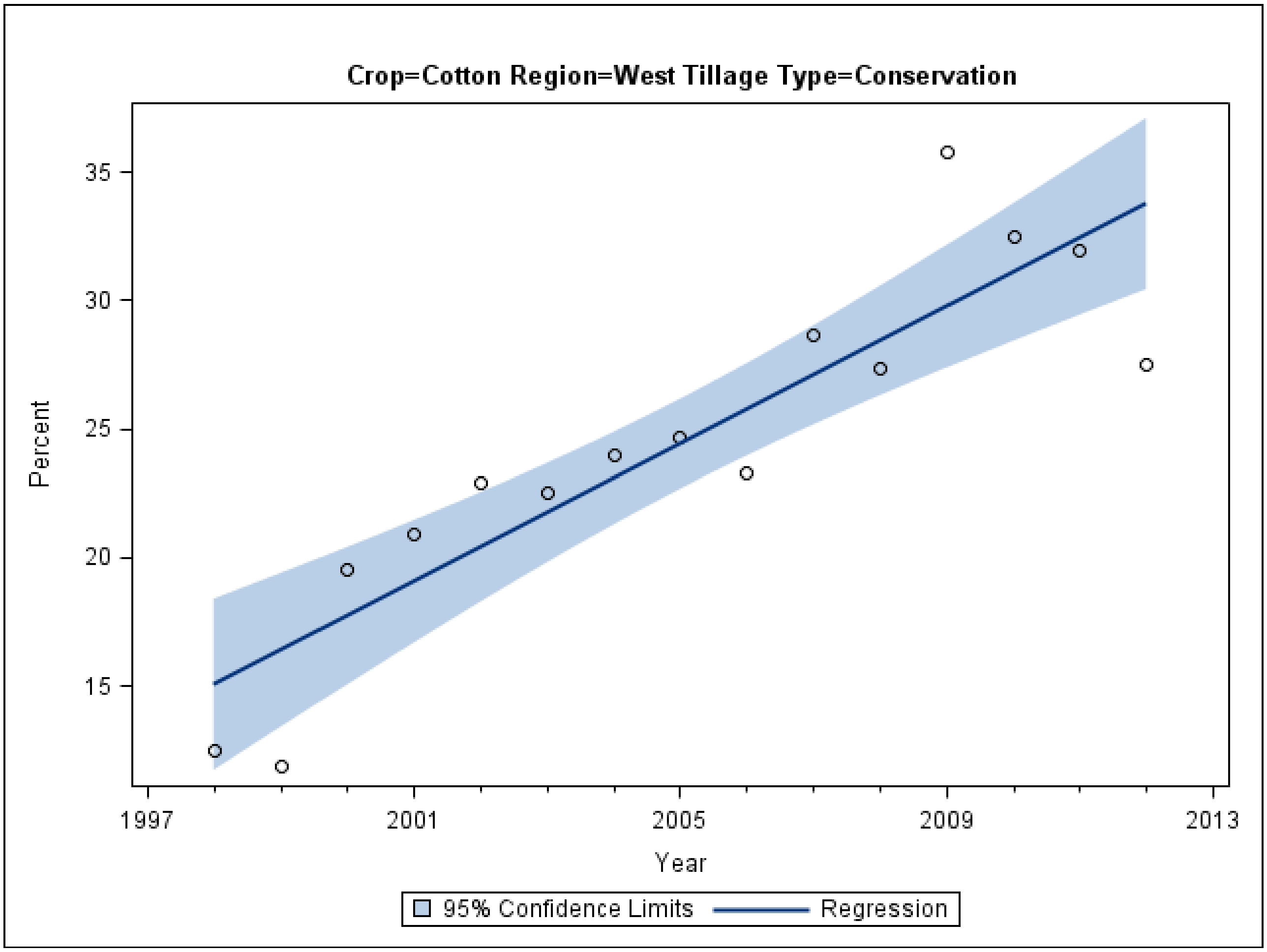


Crop=Soybeans Region=East Tillage Type=Conventional
Percent
50
40
30
20
10
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

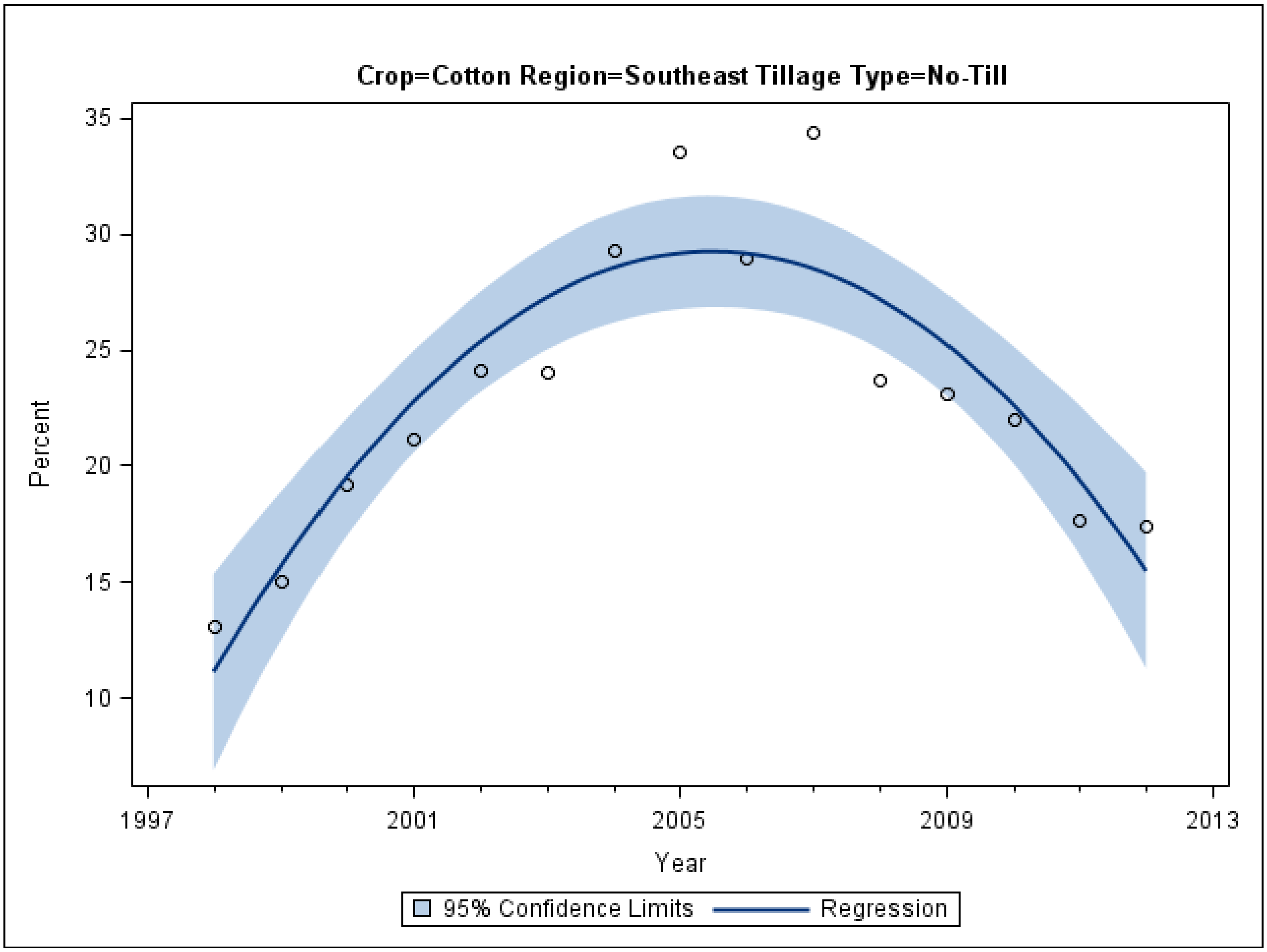

Crop=Soybeans Region=East Tillage Type=Conservation
Percent
20.0
17.5
15.0
12.5
10.0
7.5
5.0
1997
2001
2005
2009
2013
Year

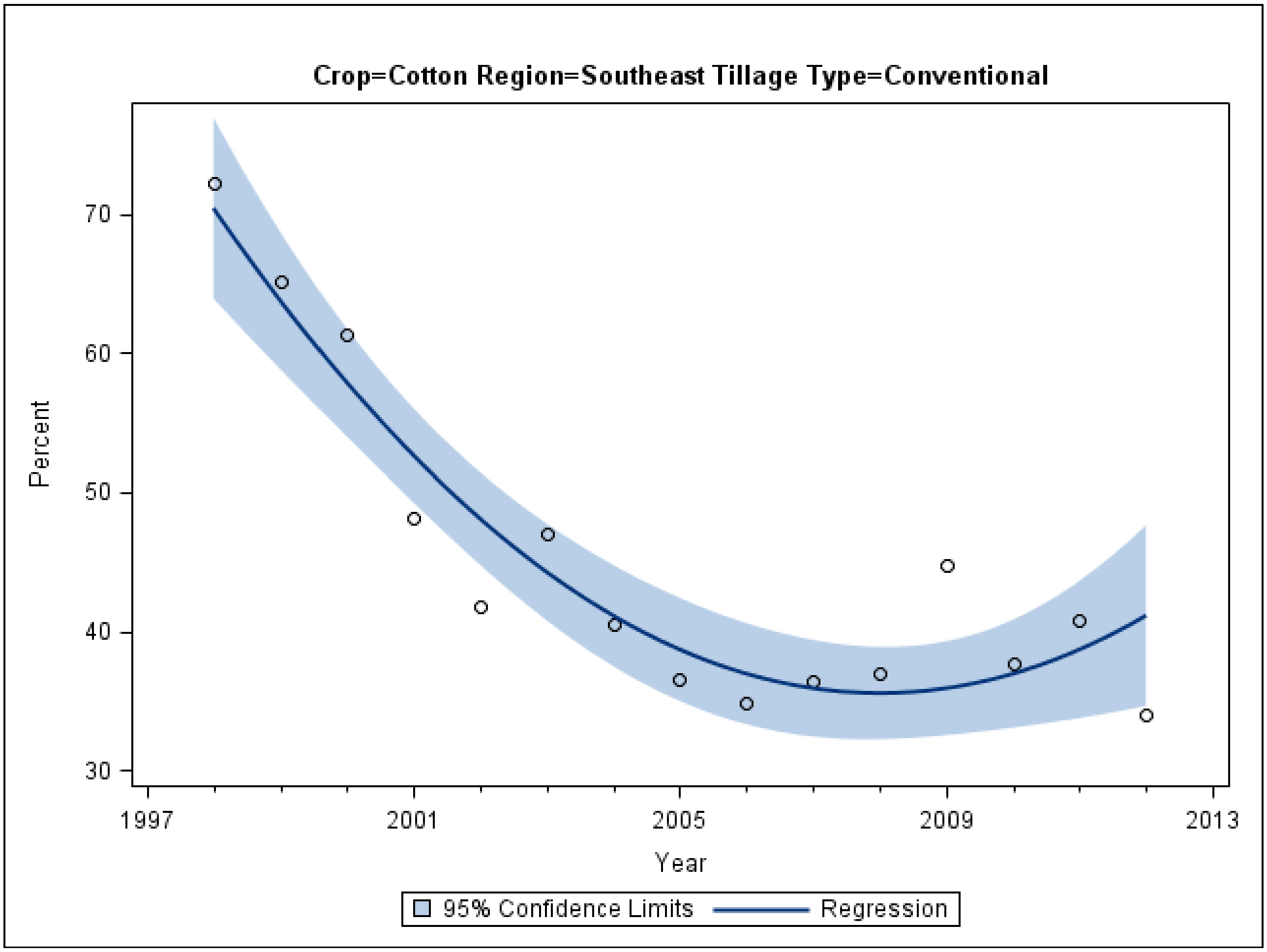

Crop=Cotton Region=West Tillage Type=No-Till
15
10
5
0
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

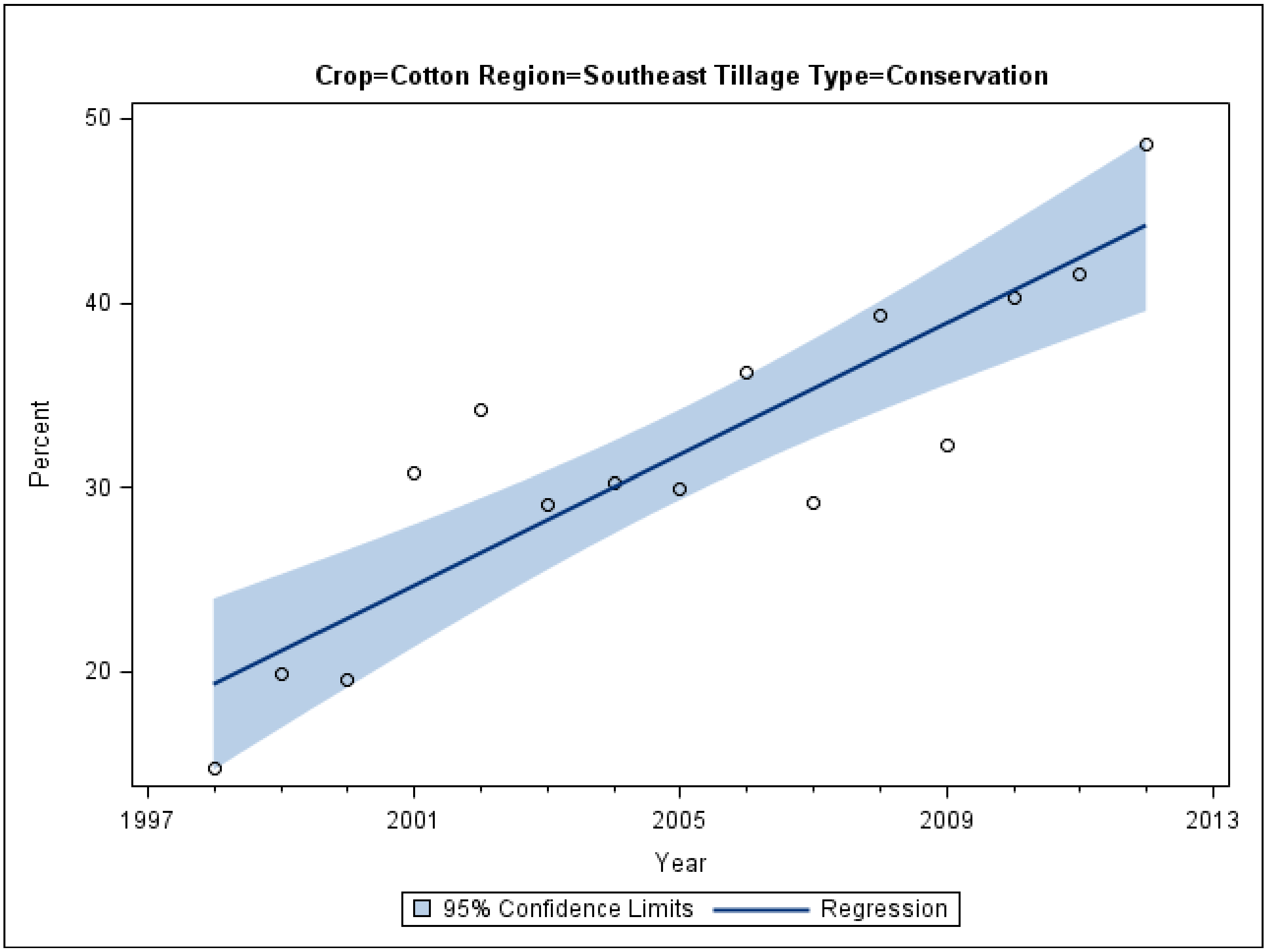

Crop=Cotton Region=West Tillage Type=Conventional
80
70
60
50
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

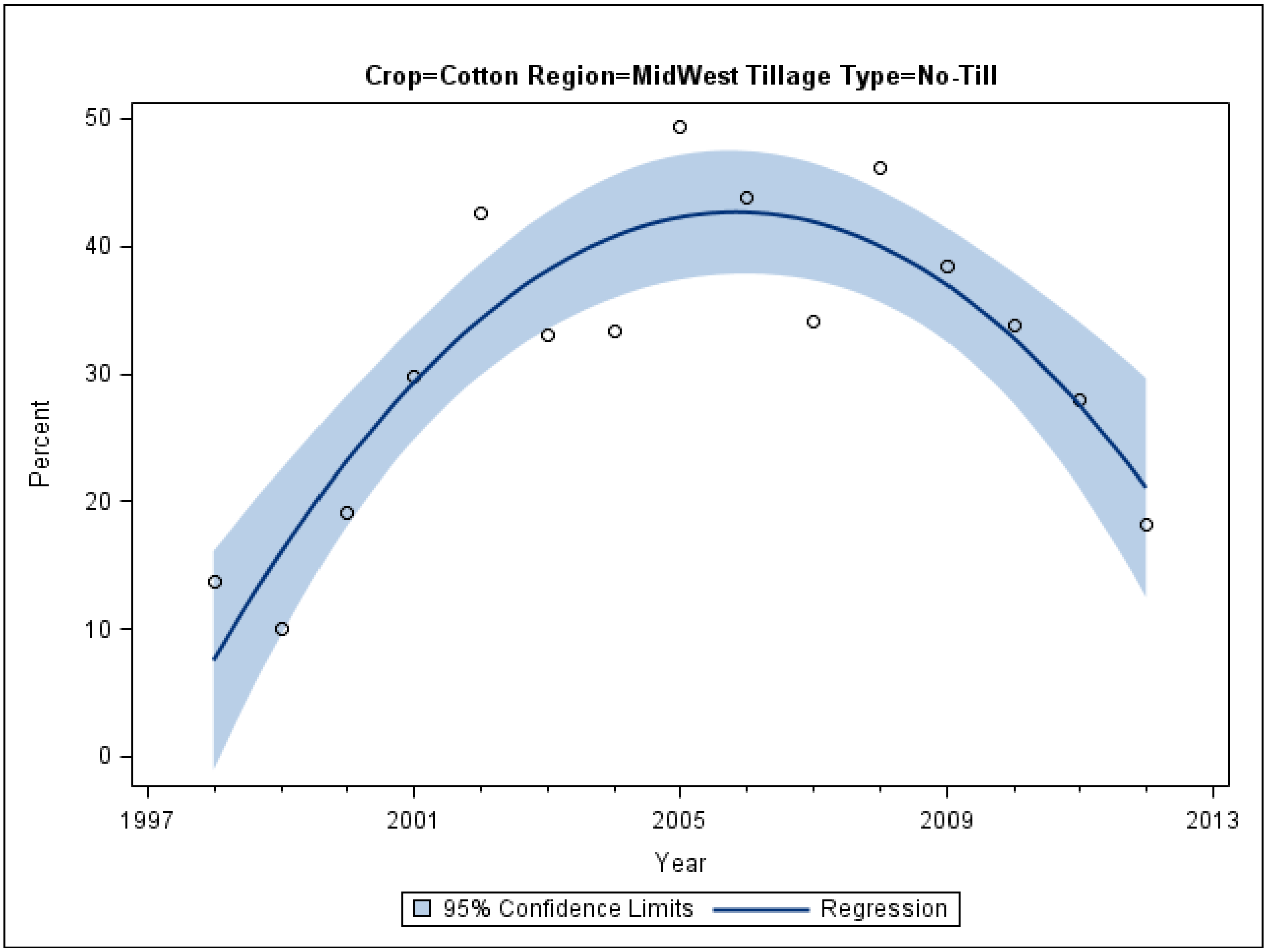


Crop=Cotton Region=West Tillage Type=Conservation
Percent
35
30
25
20
15
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

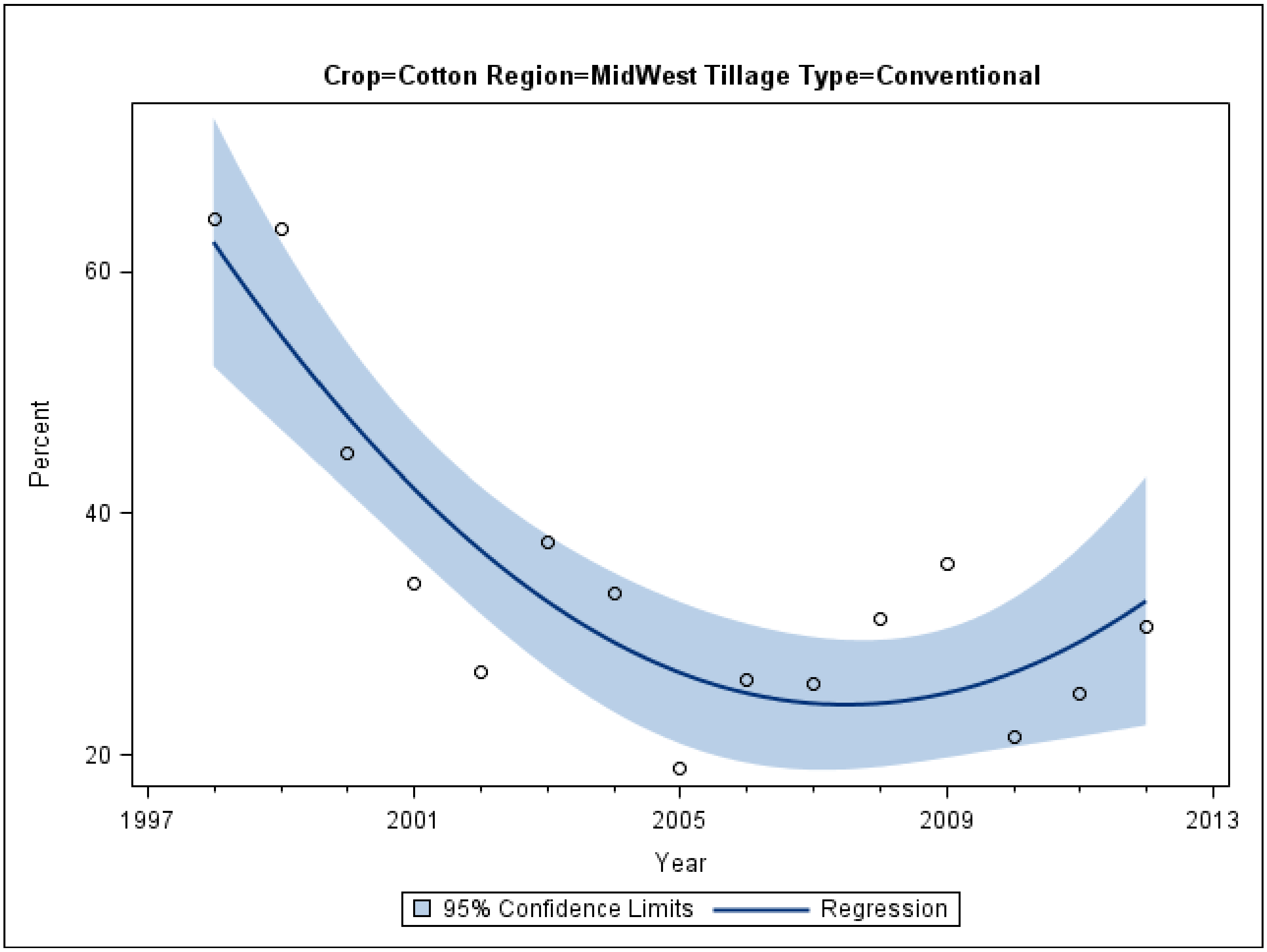

Crop=Cotton Region=Southeast Tillage Type=No-Till
35
30
25
20
15
10
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

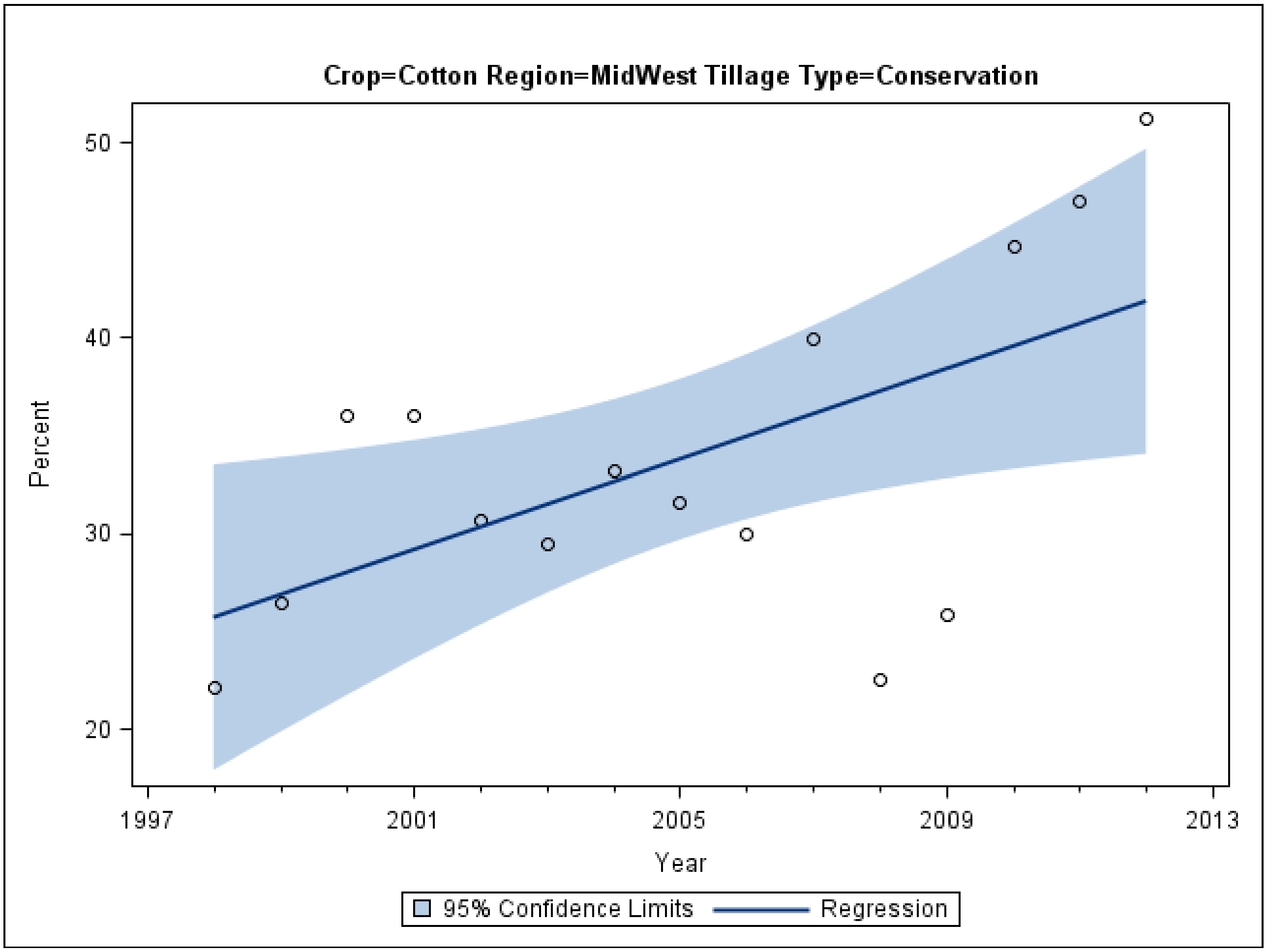

Crop=Cotton Region=Southeast Tillage Type=Conventional
Percent
70
60
50
40
30
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression


Crop=Cotton Region=Southeast Tillage Type=Conservation
Percent
50
40
30
20
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

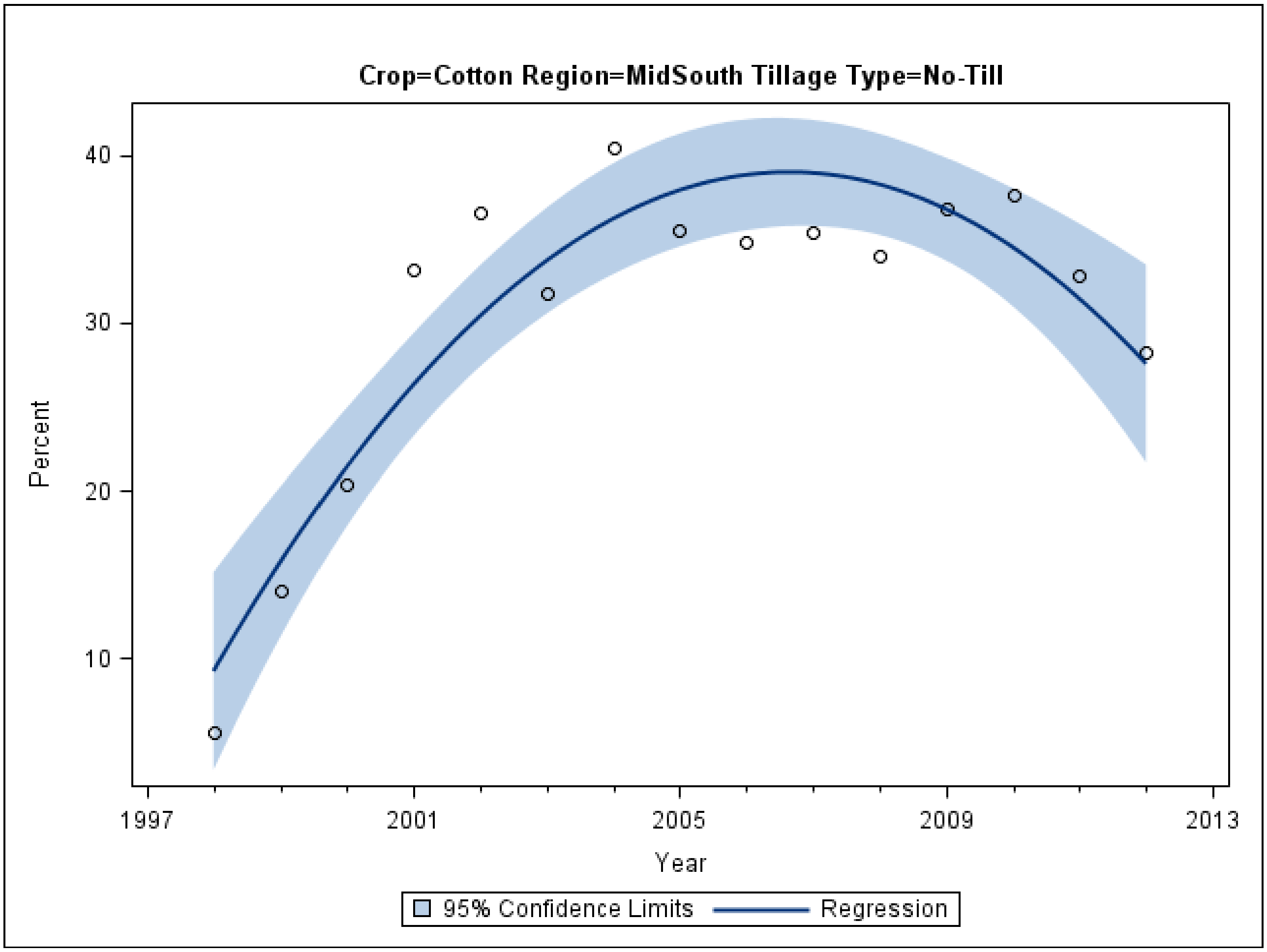


Crop=Cotton Region=MidWest Tillage Type=No-Till
Percent
50
40
30
20
10
0
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

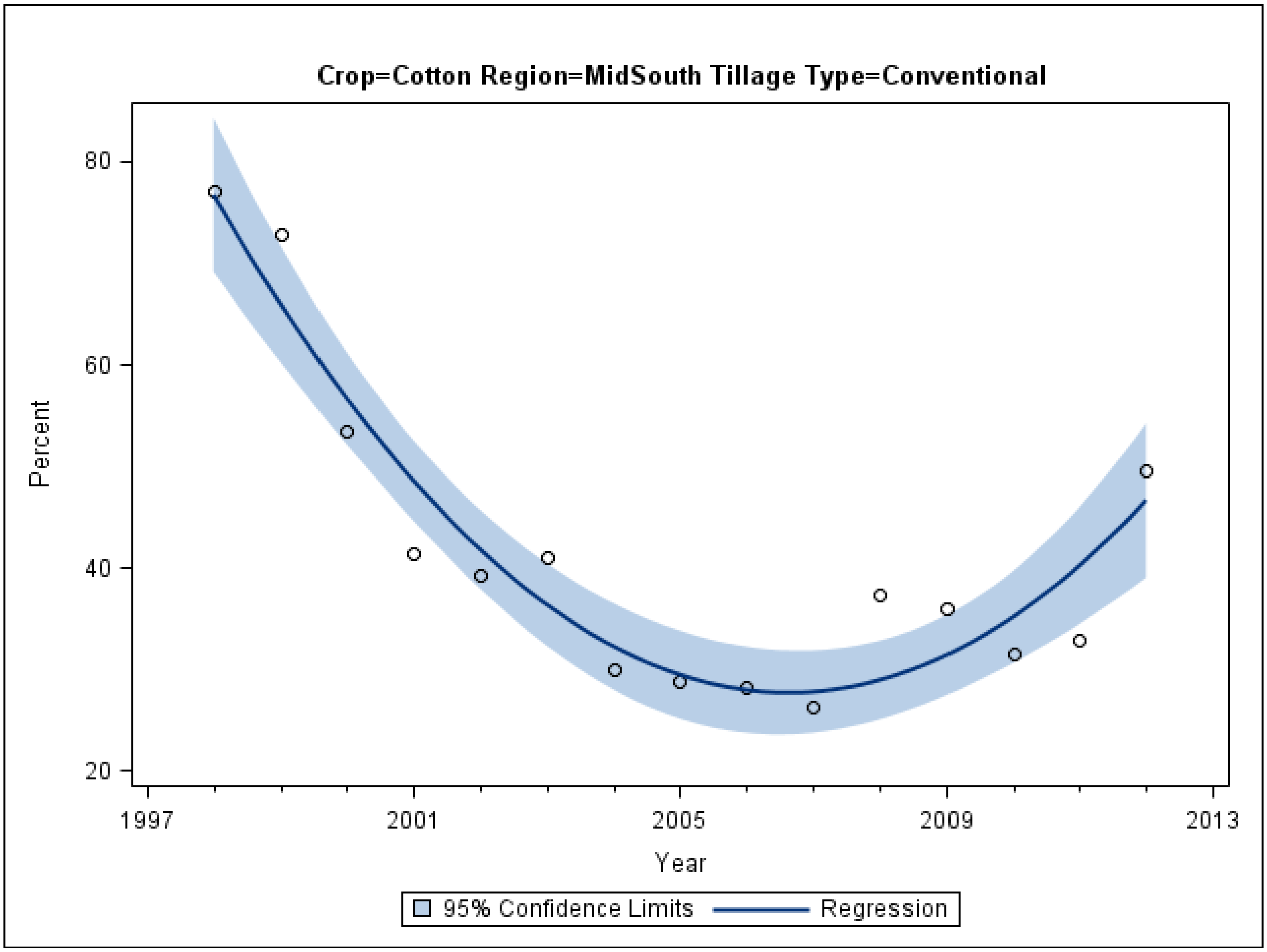

Crop=Cotton Region=MidWest Tillage Type=Conventional
Percent
60
40
20
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

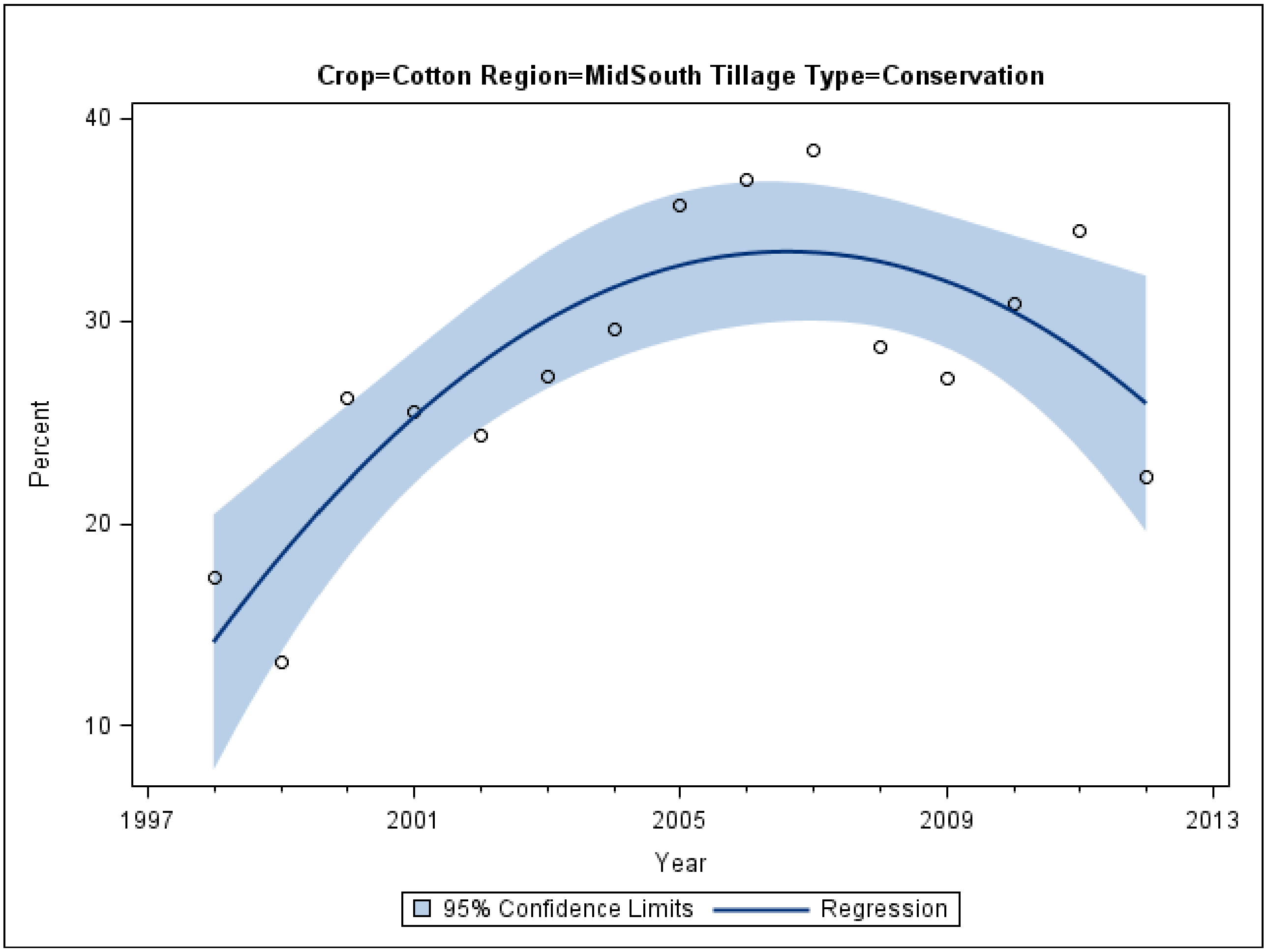


Crop=Cotton Region=MidWest Tillage Type=Conservation
50
40
30
20
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

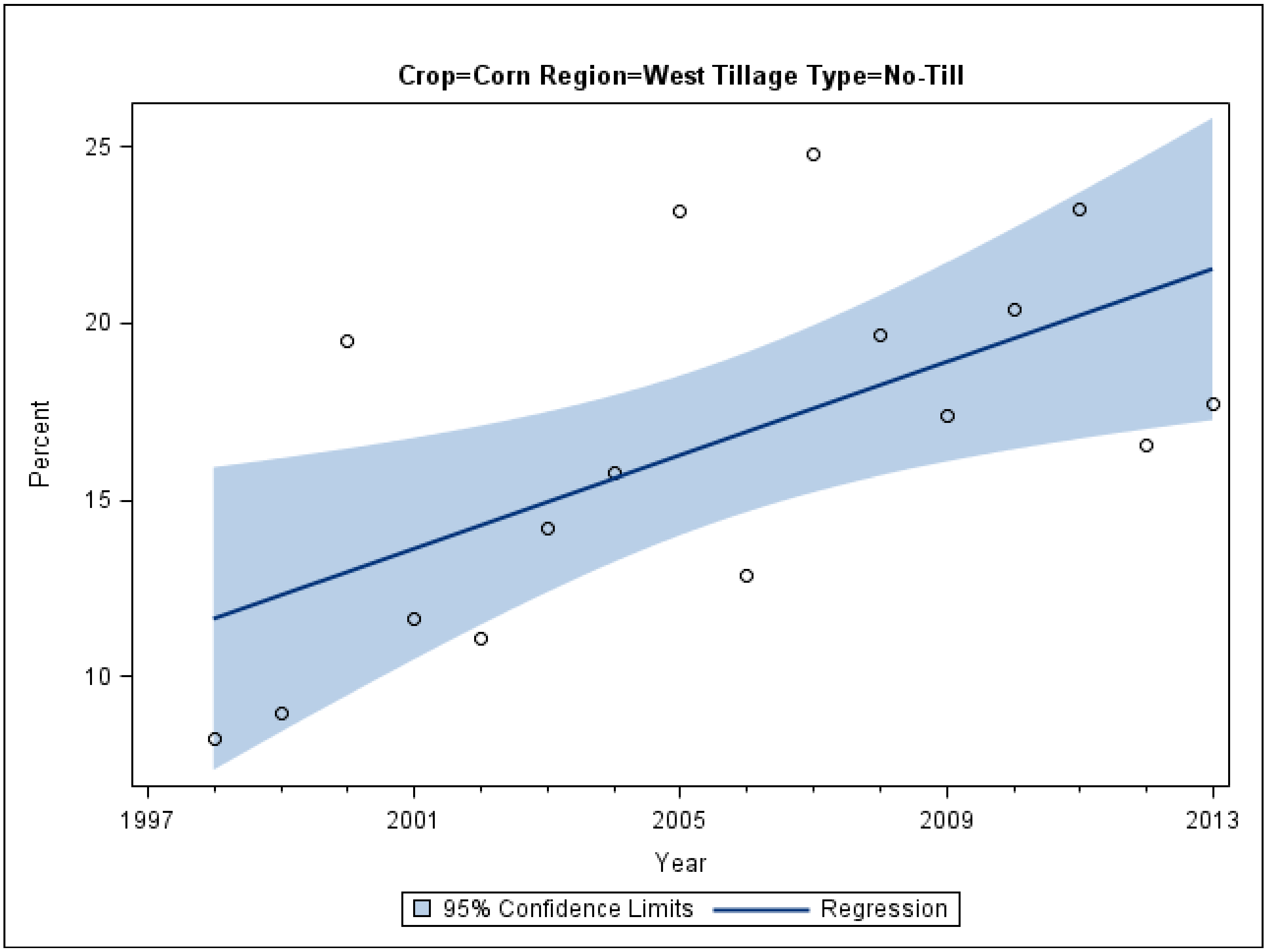


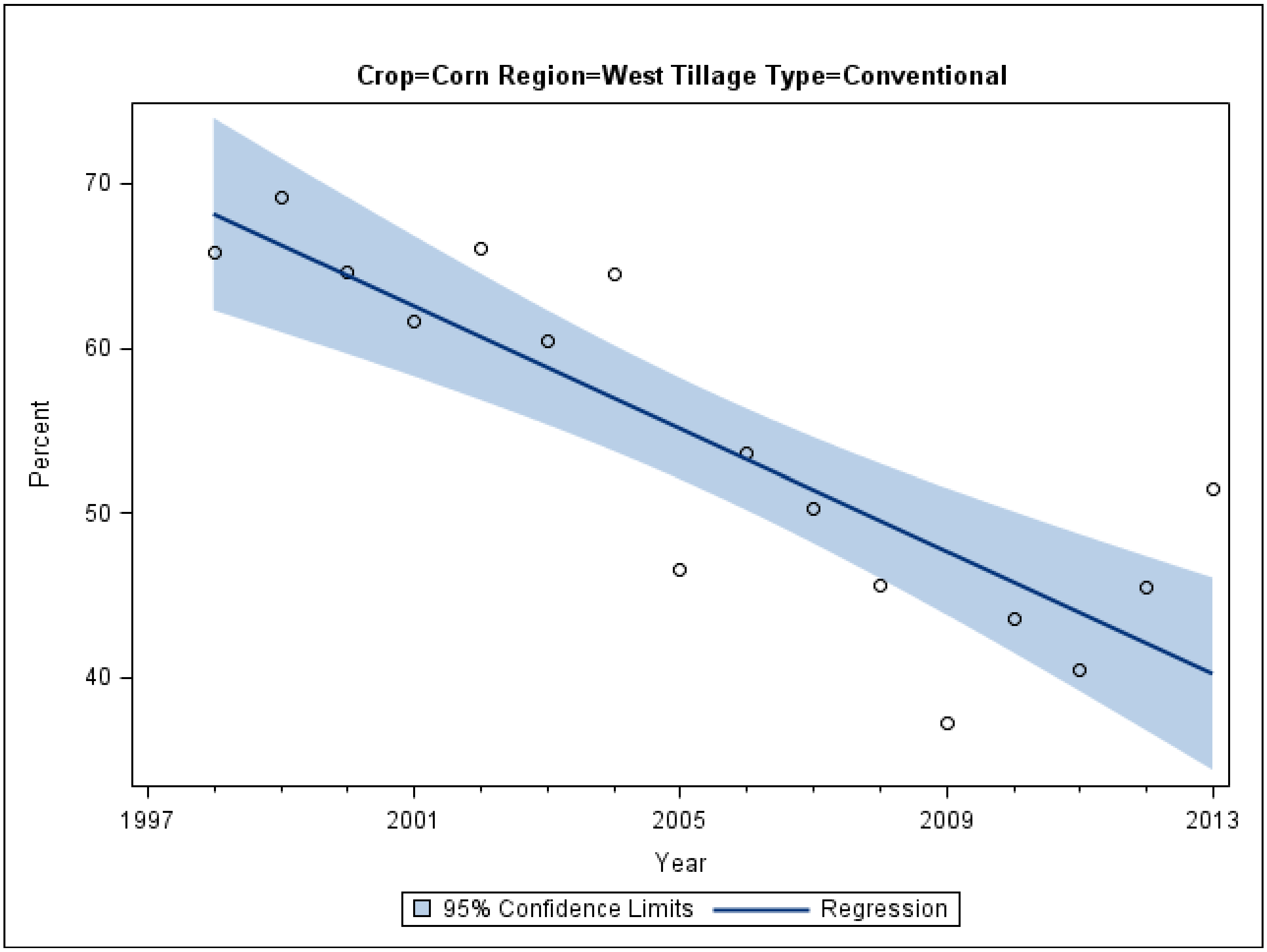
Crop=Cotton Region=MidSouth Tillage Type=No-Till
40
30
20
10
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

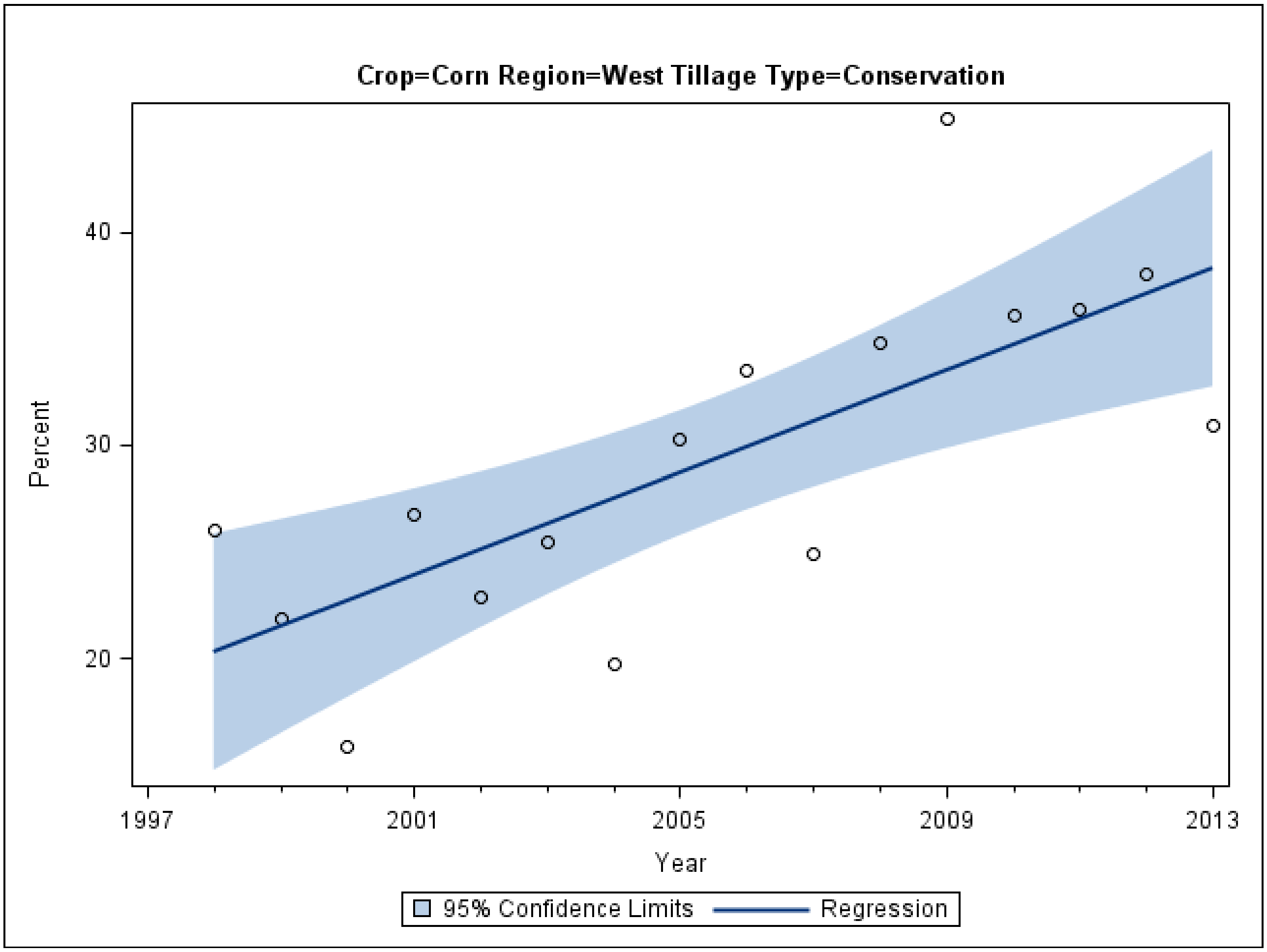

Crop=Cotton Region=MidSouth Tillage Type=Conventional
Percent
80
60
40
20
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression



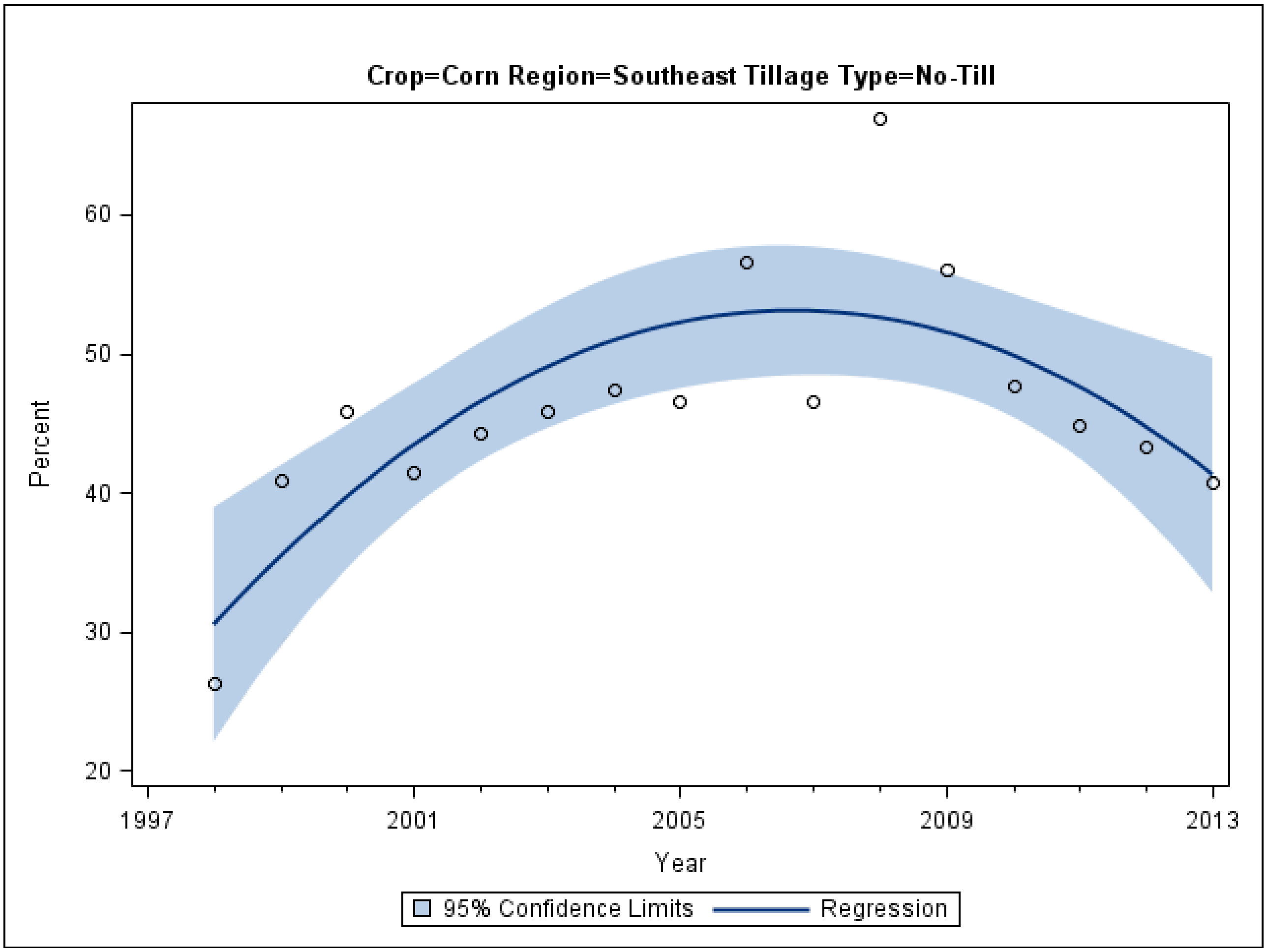
Crop=Cotton Region=MidSouth Tillage Type=Conservation
40
30
20
10
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression


Crop=Corn Region=West Tillage Type=No-Till
25
20
15
10
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

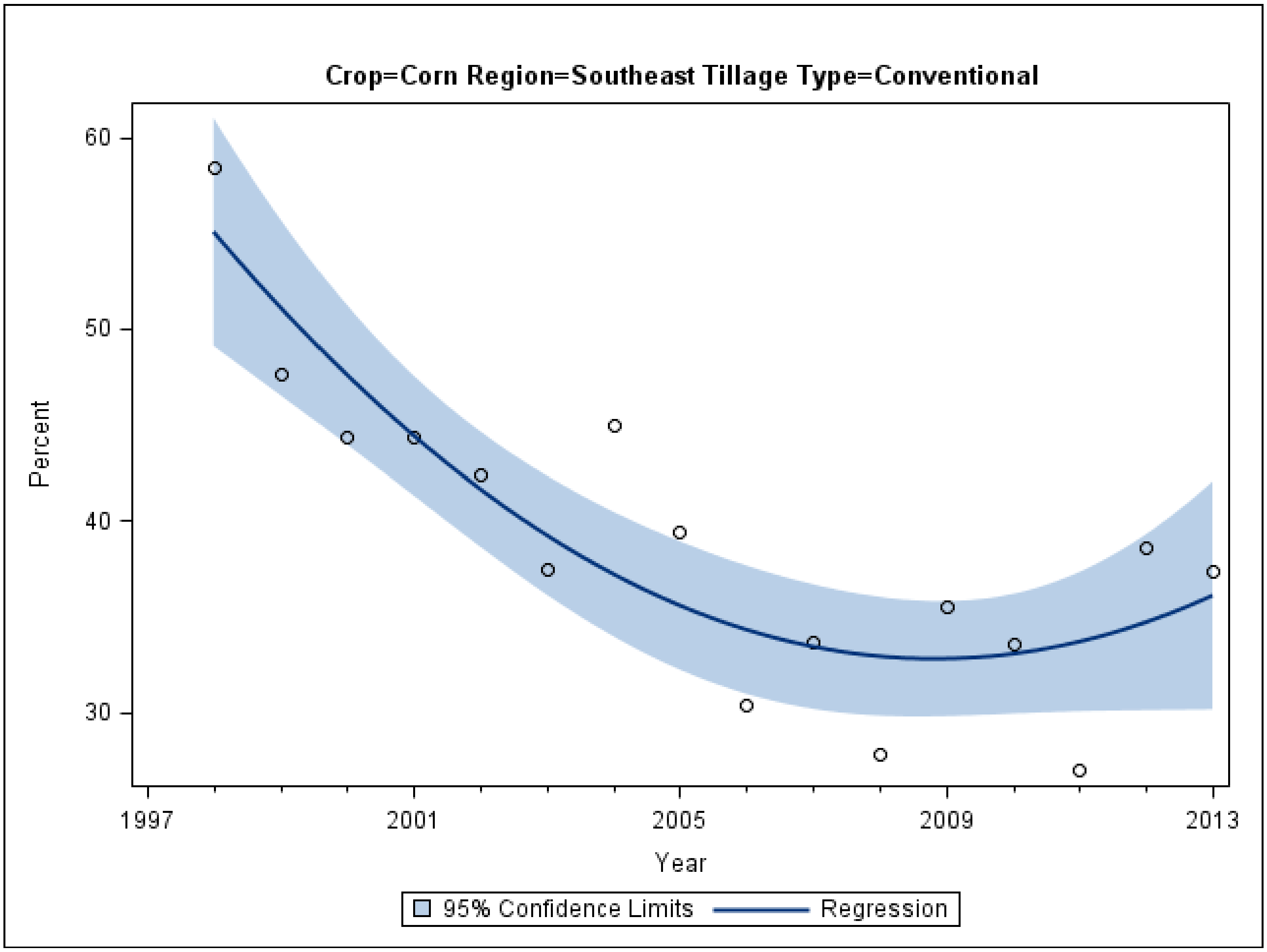

Crop=Corn Region=West Tillage Type=Conventional
70
60
50
40
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression



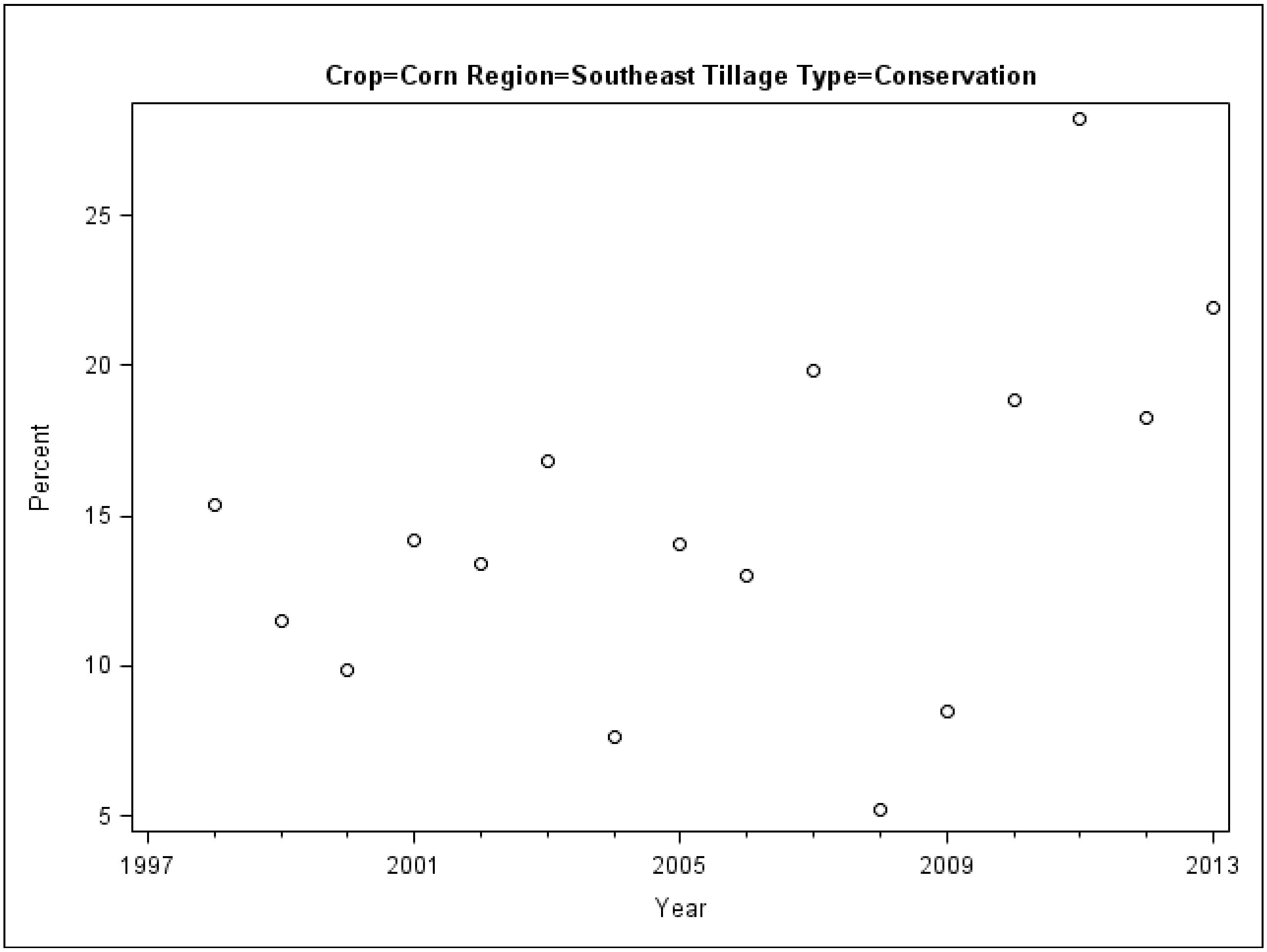
Crop=Corn Region=West Tillage Type=Conservation
Percent
40
30
20
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression



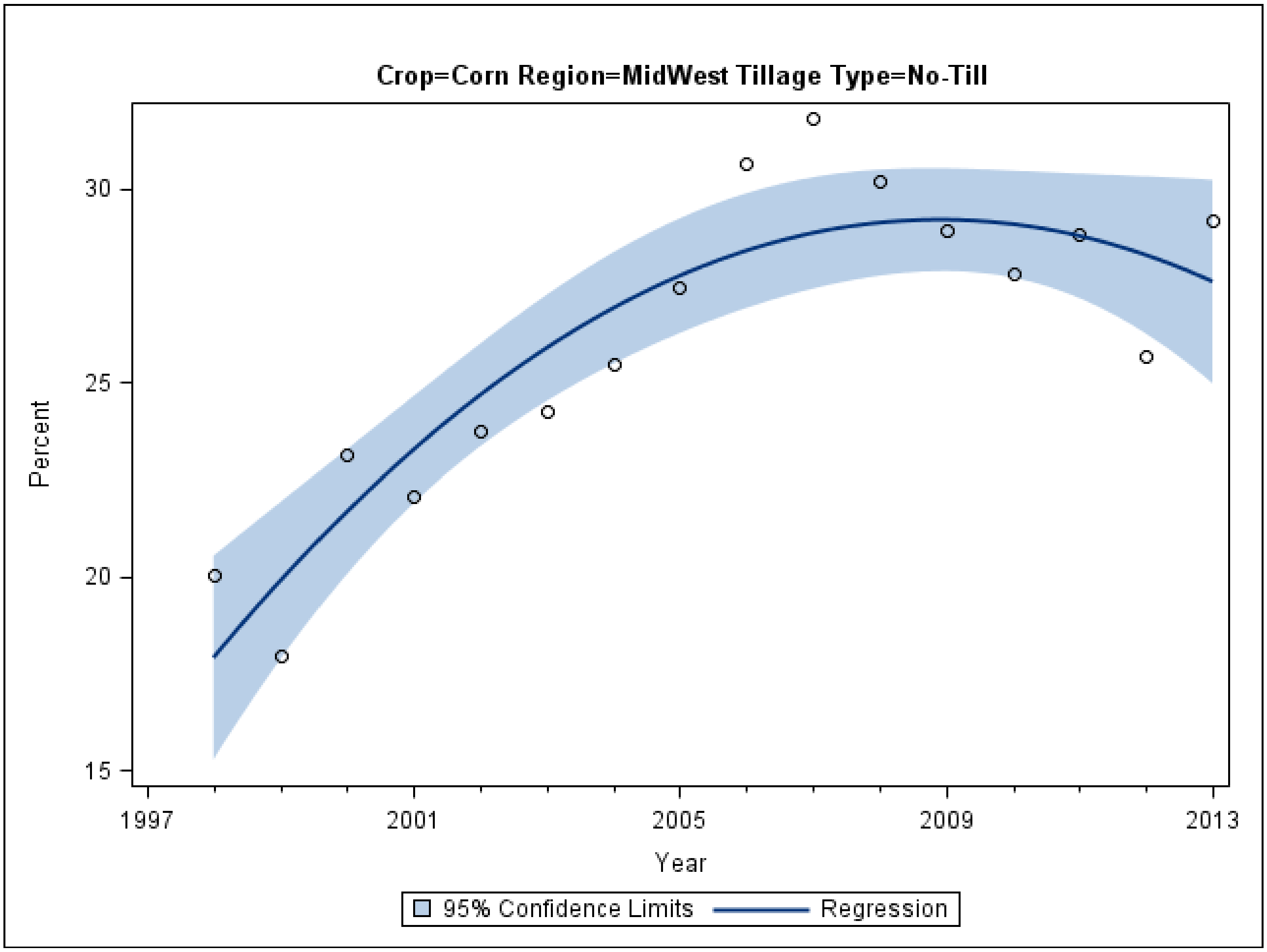
Crop=Corn Region=Southeast Tillage Type=No-Till
Percent
60
50
40
30
20
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

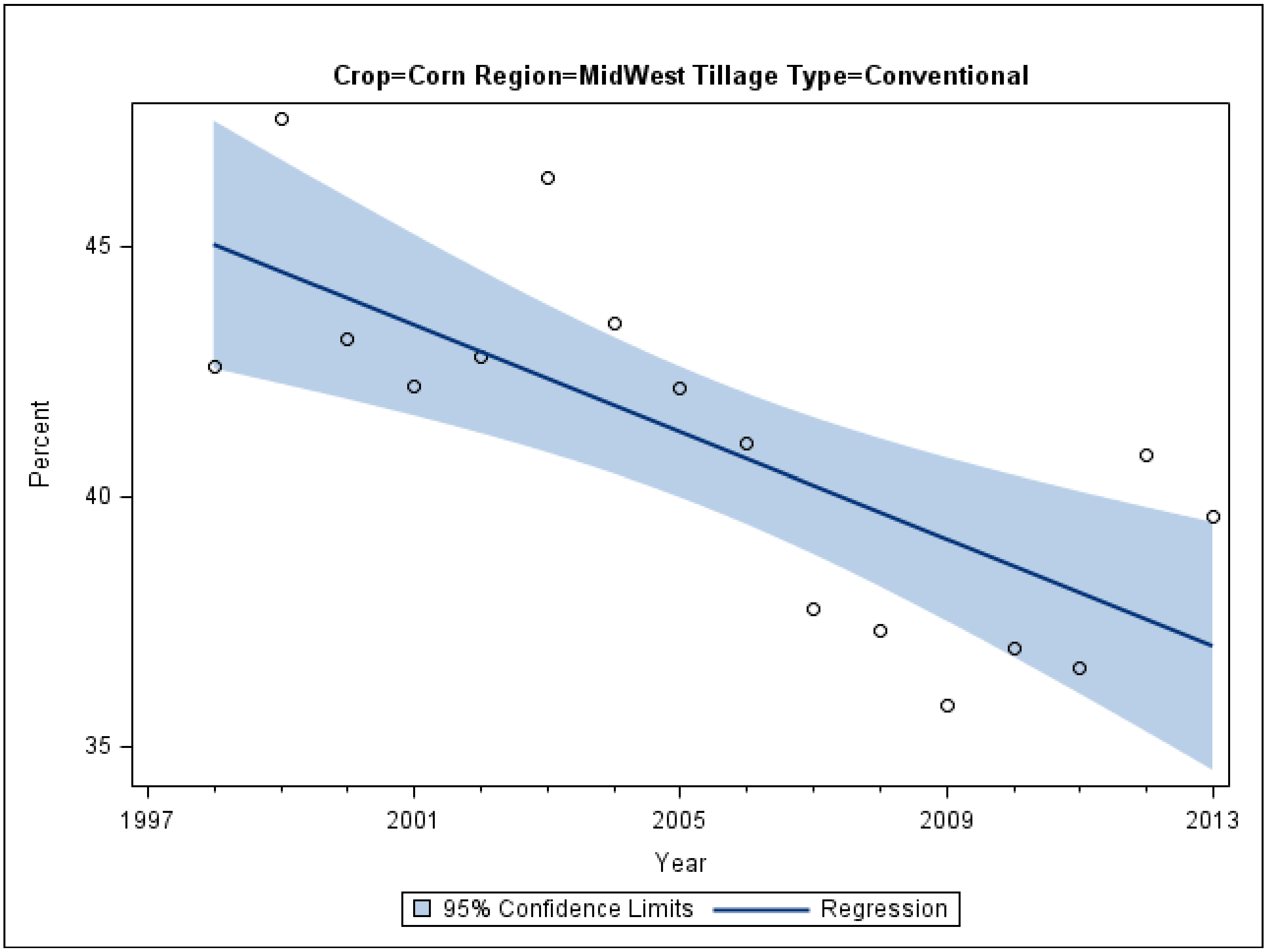


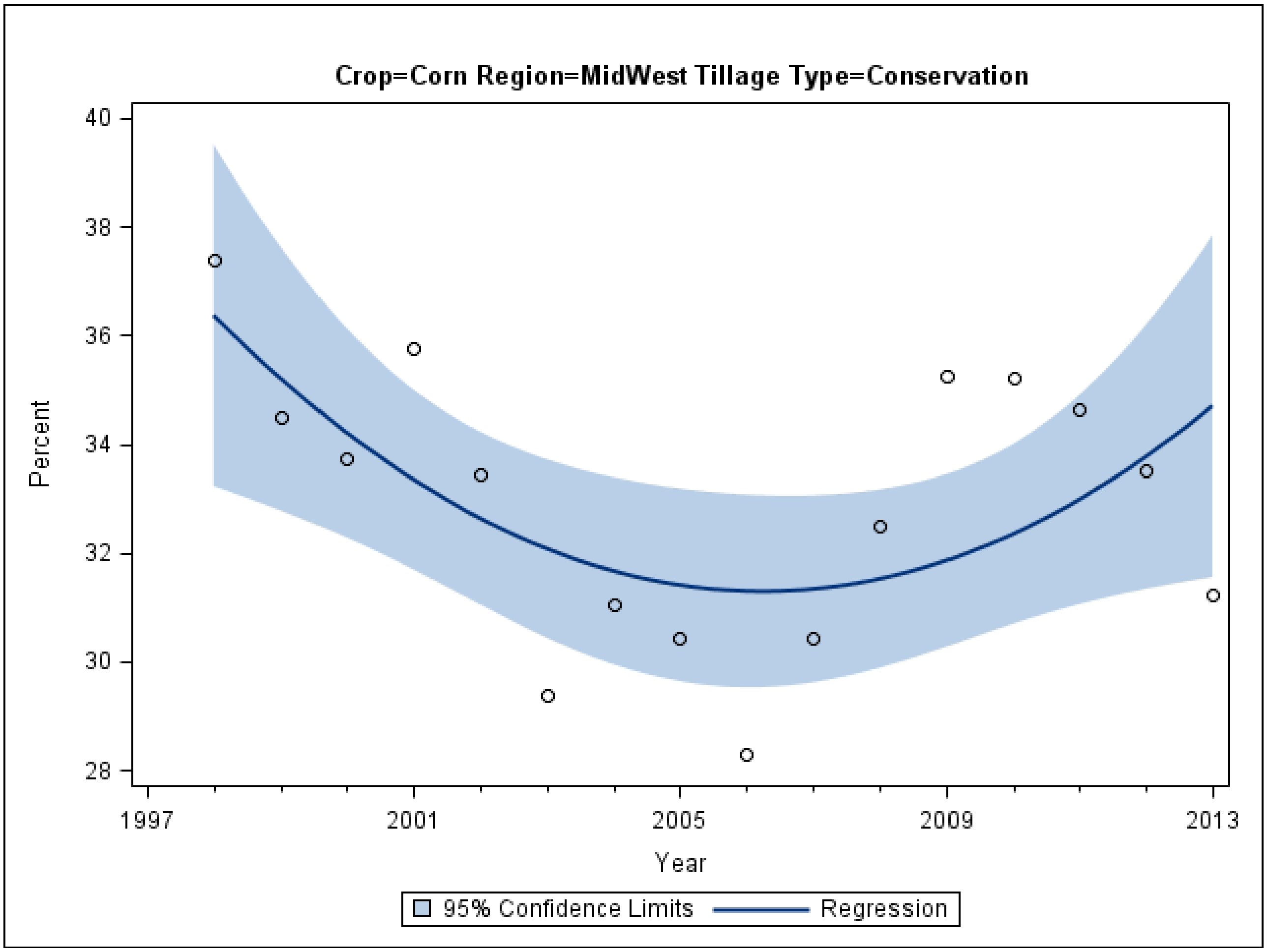
Crop=Corn Region=Southeast Tillage Type=Conventional
60
50
40
30
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression



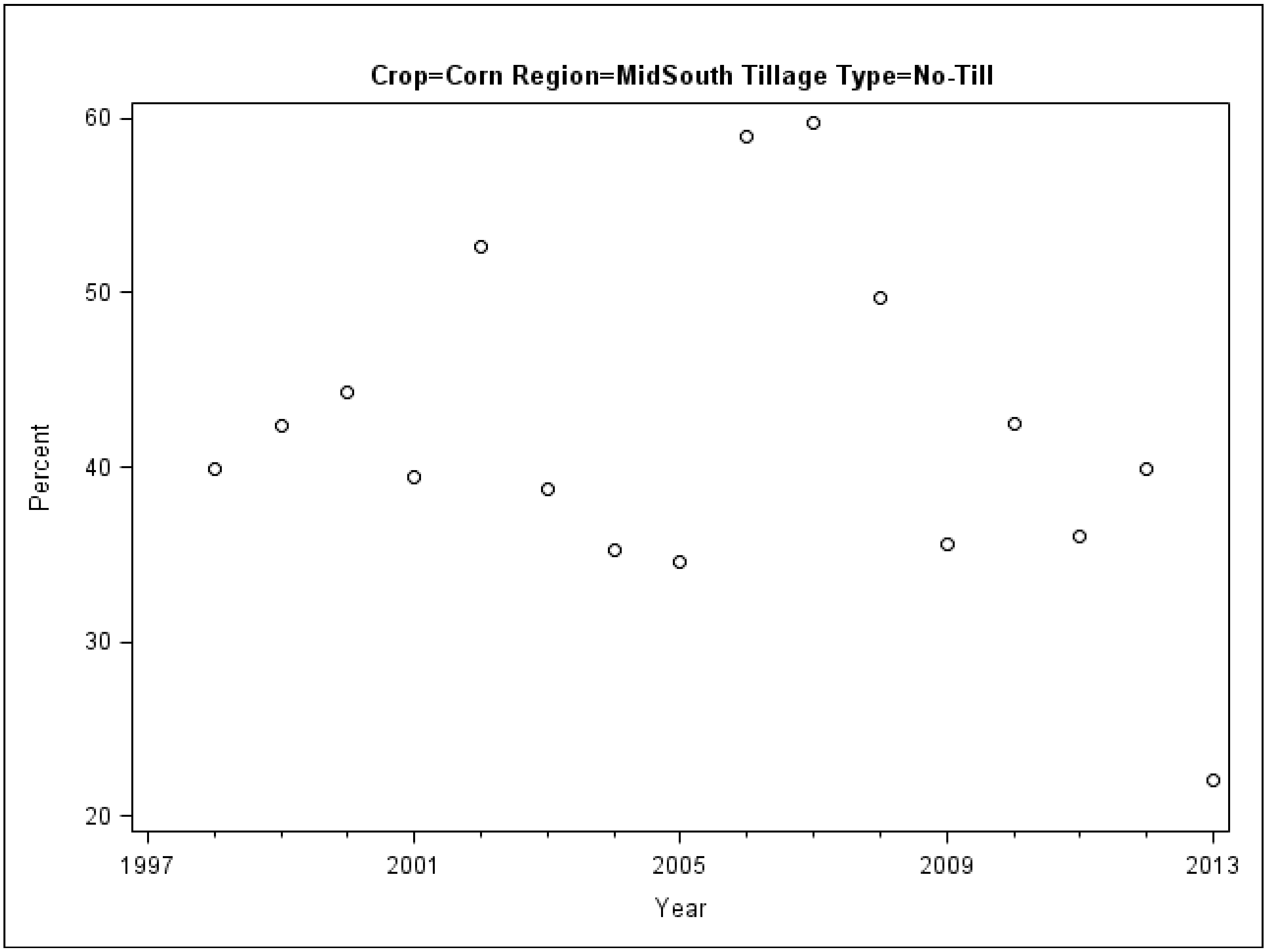
Crop=Corn Region=Southeast Tillage Type=Conservation
Percent
25
20
15
10
5
1997
2001
2005
2009
2013
Year

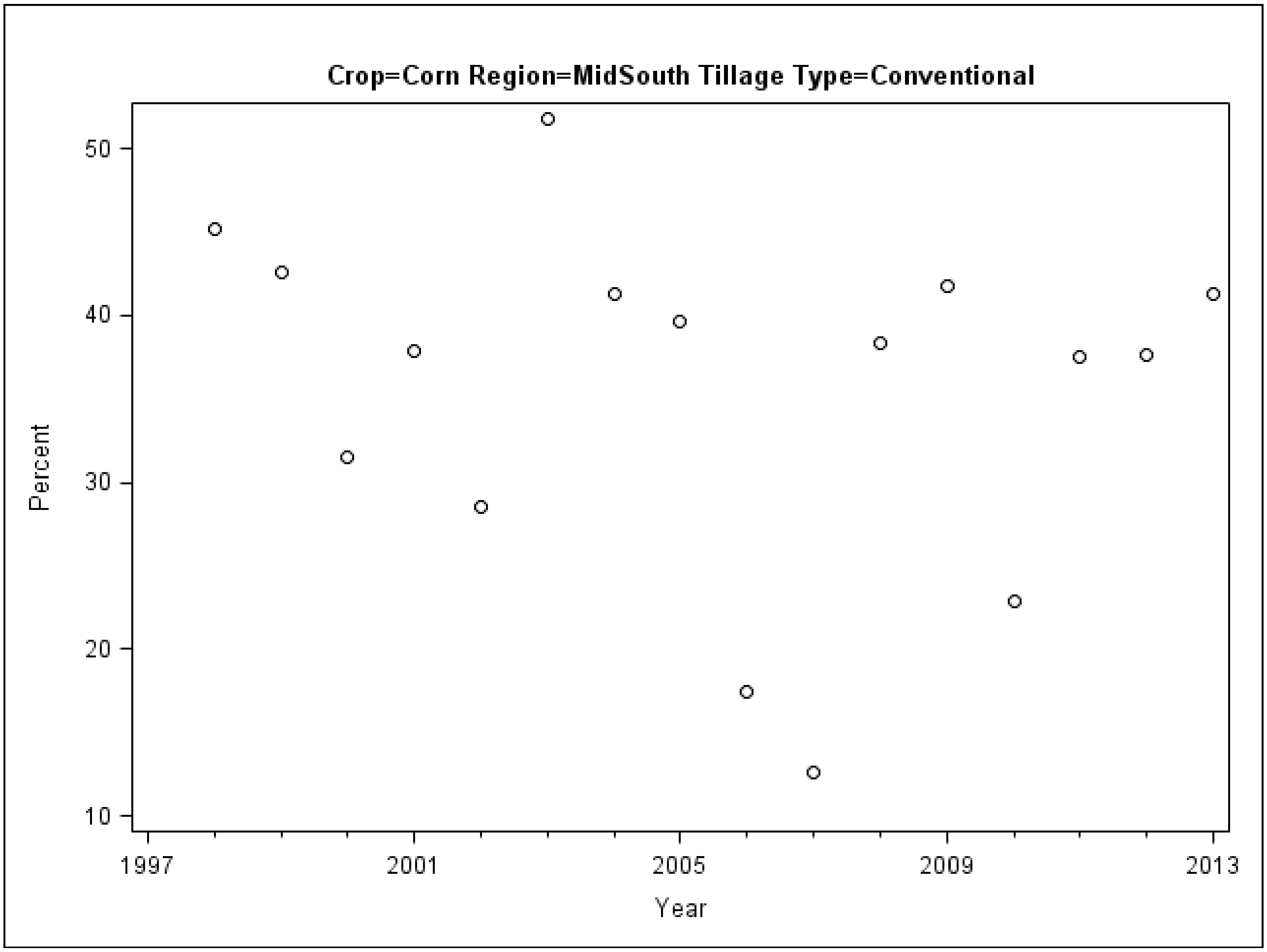

Crop=Corn Region=MidWest Tillage Type=No-Till
30
25
20
15
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

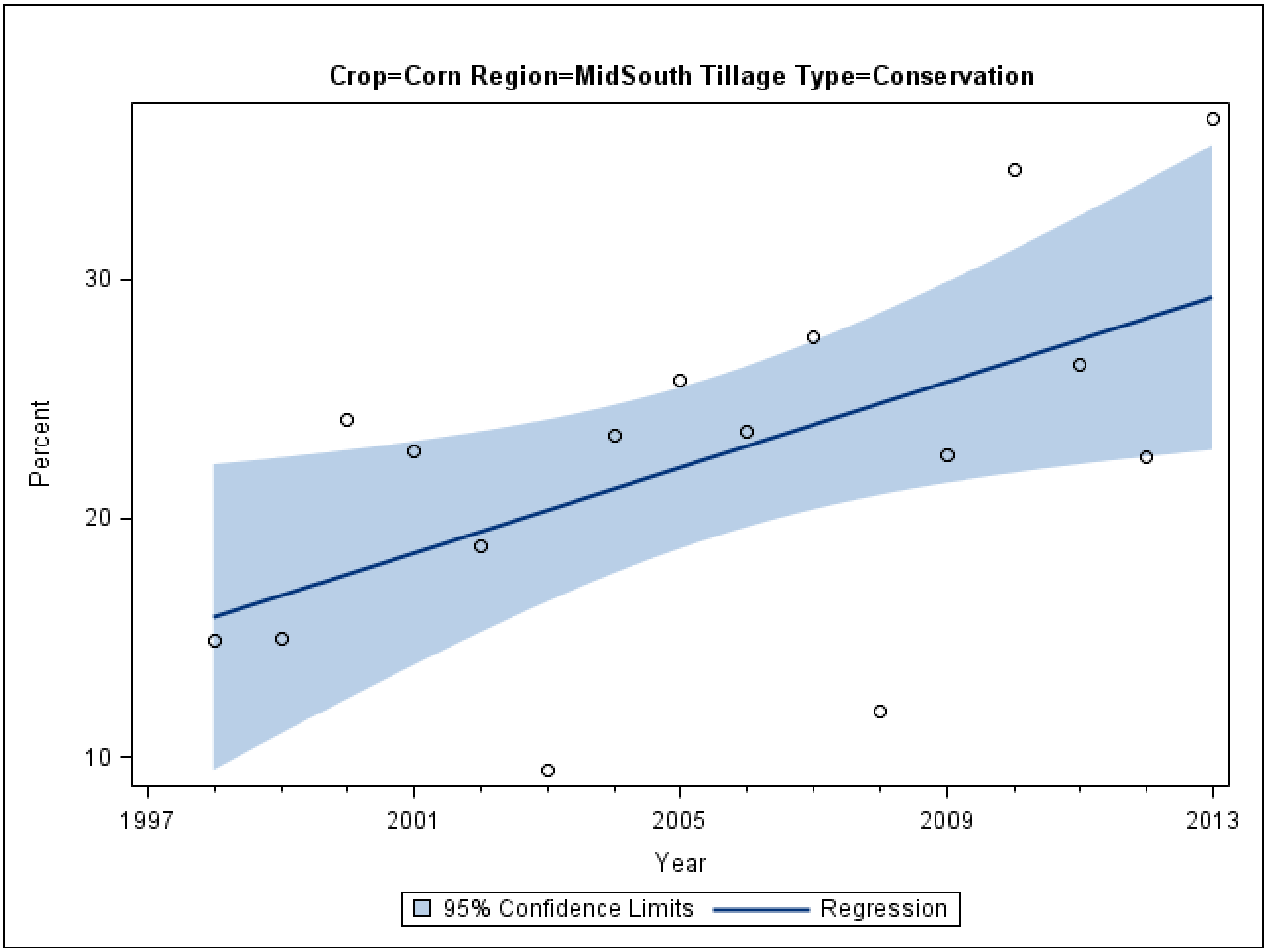

Crop=Corn Region=MidWest Tillage Type=Conventional
Percent
45
40
35
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

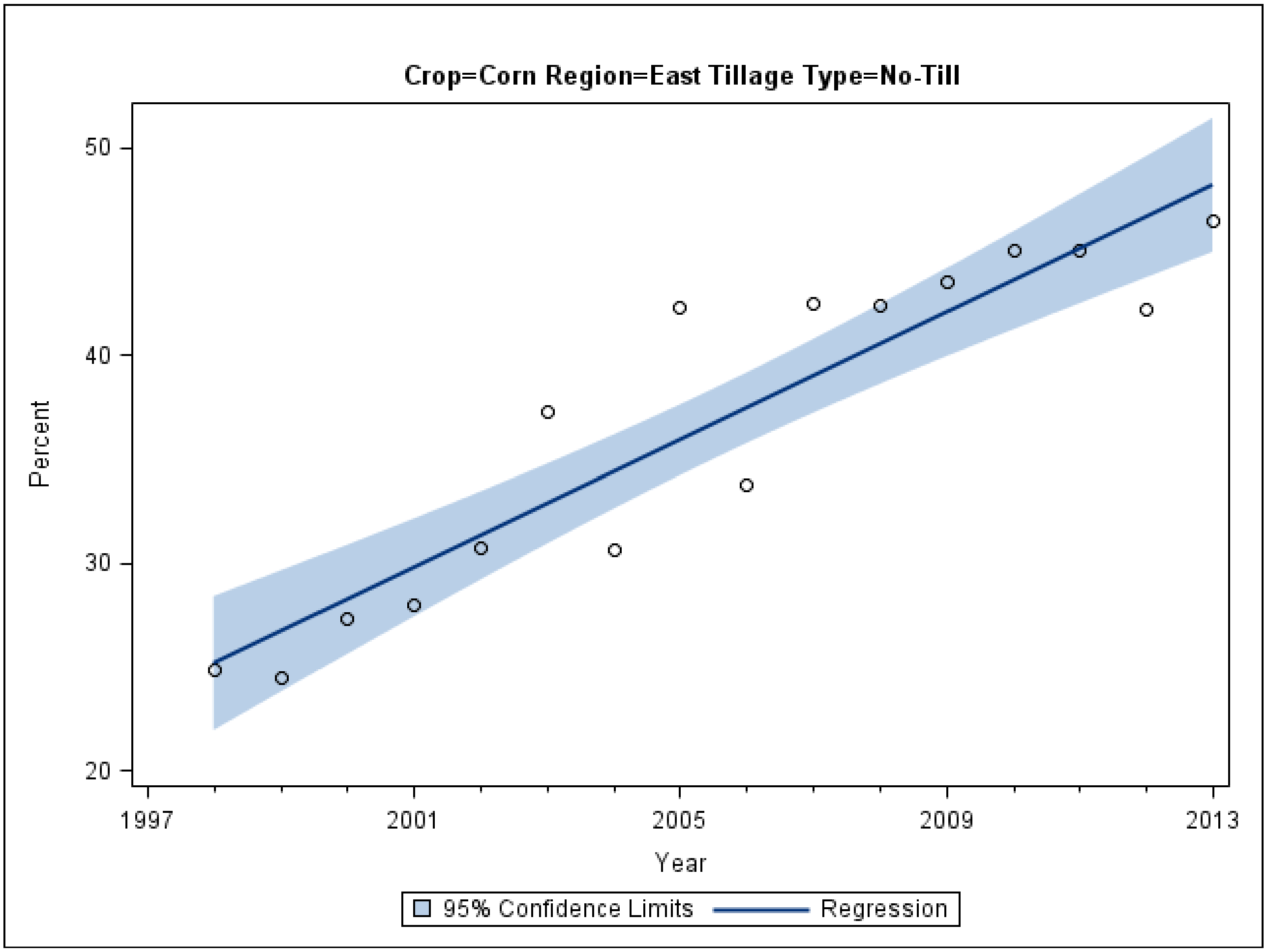


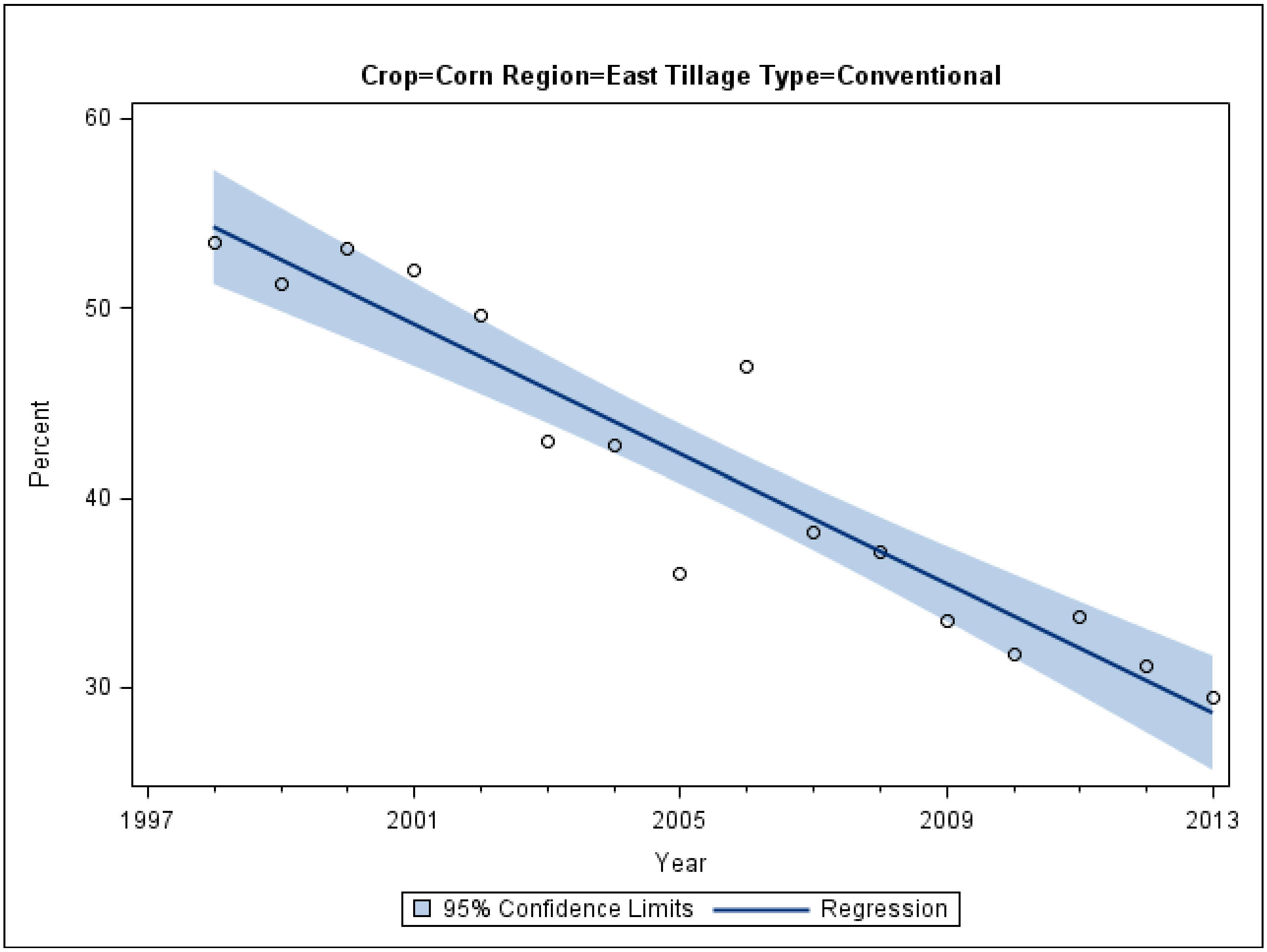
Crop=Corn Region=MidWest Tillage Type=Conservation
Percent
40
38
36
34
32
30
28
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

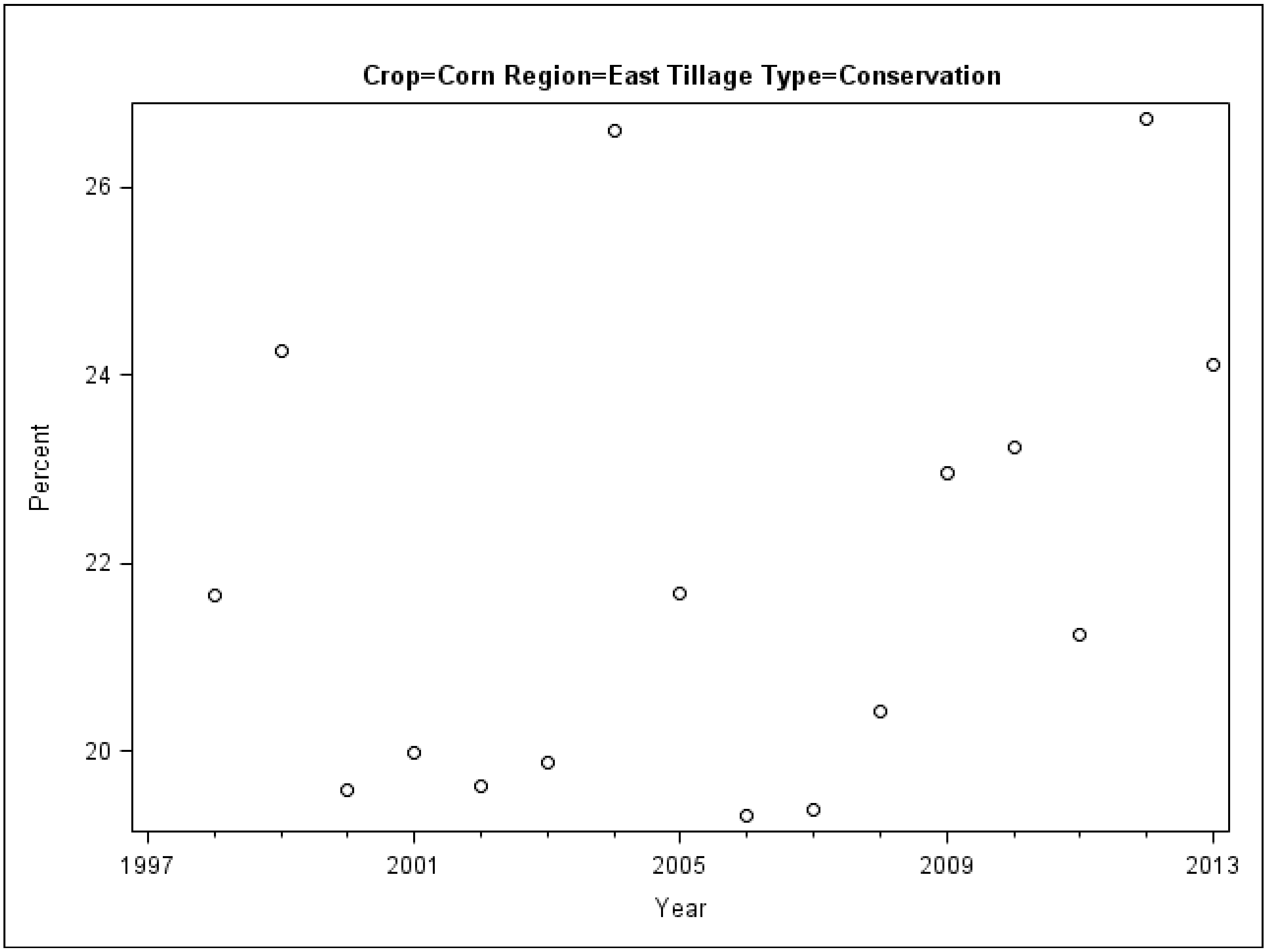

Crop=Corn Region=MidSouth Tillage Type=No-Till
60
50
40
30
20
Percent
1997
2001
2005
2009
2013
Year


Crop=Corn Region=MidSouth Tillage Type=Conventional
Percent
50
40
30
20
10
1997
2001
2005
2009
2013
Year


Crop=Corn Region=MidSouth Tillage Type=Conservation
Percent
30
20
10
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression


Crop=Corn Region=East Tillage Type=No-Till
Percent
50
40
30
20
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression


Crop=Corn Region=East Tillage Type=Conventional
60
50
40
30
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression



Crop=Corn Region=East Tillage Type=Conservation
Percent
26
24
22
20
1997
2001
2005
2009
2013
Year

Appendix B: CTIC Survey Results of Leading Conservation Tillage Experts

The following pages summarize the results of the CTIC (Conservation Tillage Information Center) survey of 21 total (14 in Midwest and 7 in South) leading conservation tillage experts across the key agronomic regions of the U.S. for soybean, corn and cotton production. These experts were asked to rate the importance of 11 factors that could influence tillage practices of growers in their region. Responses the the question below are summarized on the following pages.

Question: In general, how important are the following factors to the majority of the farmers in your region as they determine the total amount of tillage done to produce corn, regardless of whether the tillage is done prior to planting or done during the growing season? Choose the rating below that best reflects the importance of each factor in determining the amount of tillage being used.

Table B-1. Midwest Corn (14 total Experts)

	Number of Experts Responding										
	Manage excess crop residue	Manage existing weeds	Manage Disease	Manage Soil moisture	Manage Soil temperature	Prevent weed resistance	Seed bed preparation	Use of Strip till / vertical tillage tools	Economics	Availability of Labor	Water penetration
Not important / Not mentioned	4	6	4	4	4	8	4	6	6	8	6
Sometimes important	4	3	5	3	3	2	2	3	1	2	4
Quite important	2	2	4	5	5	2	3	2		3	2
Extremely important	4	3	1	2	2	2	5	3	7	1	2
Ranking Sum[1]	34	30	30	33	33	26	37	30	36	25	28

[1]Ranking Sum was calculated as follows, a number from 1 to 4 was assigned to each response category, with 1 assigned to 'not important or not mentioned' and 4 assigned to 'extremely important'. The assigned number was multiplied by the number of responses from the experts and then added together for each factor.

Table B-2. Midwest Soybean (13 total Experts)

	Number of Experts Responding										
	Manage excess crop residue	Manage existing weeds	Manage Disease	Manage Soil moisture	Manage Soil temperature	Prevent weed resistance	Seed bed preparation	Use of Strip till / vertical tillage tools	Economics	Availability of Labor	Water penetration
Not important / Not mentioned	6	4	7	3	5	6	4	10	4	2	4
Sometimes important	0	4	2	6	4	3	2	1	3	6	5
Quite important	1	2	2	2	1	2	3	0	2	3	2
Extremely important	6	3	2	2	3	2	4	2	4	1	1
Ranking Sum[1]	33	30	25	29	28	26	33	20	32	27	24

[1]Ranking Sum was calculated as follows, a number from 1 to 4 was assigned to each response category, with 1 assigned to 'not important or not mentioned' and 4 assigned to 'extremely important'. The assigned number was multiplied by the number of responses from the experts and then added together for each factor.

Table B-3. South Corn (6 total Experts)

	Number of Experts Responding										
	Manage excess crop residue	Manage existing weeds	Manage Disease	Manage Soil moisture	Manage Soil temperature	Prevent weed resistance	Seed bed preparation	Use of Strip till / vertical tillage tools	Economics	Availability of Labor	Water penetration
Not important / Not mentioned	2	2	3		1	2		2		1	2
Sometimes important	1	1	2	4	5	2	1	2	1	3	1
Quite important	3	1	1	2		1	4	2	2	1	1
Extremely important		1				1	1		3	1	2
Ranking Sum[1]	13	11	10	14	11	13	18	12	20	14	15

[1]Ranking Sum was calculated as follows, a number from 1 to 4 was assigned to each response category, with 1 assigned to 'not important or not mentioned' and 4 assigned to 'extremely important'. The assigned number was multiplied by the number of responses from the experts and then added together for each factor.

Table B-4. South- Soybean (6 total Experts)

	Number of Experts Responding										
	Manage excess crop residue	Manage existing weeds	Manage Disease	Manage Soil moisture	Manage Soil temperature	Prevent weed resistance	Seed bed preparation	Use of Strip till / vertical tillage tools	Economics	Availability of Labor	Water penetration
Not important / Not mentioned	3		4		2			1		1	1
Sometimes important	2	2	1	3	4	1	2	3	1	2	3
Quite important	1	3	1	2		4	3	2	3	1	1
Extremely important		1		1		1	1		2	1	1
Ranking Sum[1]	10	17	9	16	10	18	17	13	19	12	14

[1]Ranking Sum was calculated as follows, a number from 1 to 4 was assigned to each response category, with 1 assigned to 'not important or not mentioned' and 4 assigned to 'extremely important'. The assigned number was multiplied by the number of responses from the experts and then added together for each factor.

Table B-5. South- Cotton (6 total Experts)

	Number of Experts Responding										
	Manage excess crop residue	Manage existing weeds	Manage Disease	Manage Soil moisture	Manage Soil temperature	Prevent weed resistance	Seed bed preparation	Use of Strip till / vertical tillage tools	Economics	Availability of Labor	Water penetration
Not important / Not mentioned			3		2		1				2
Sometimes important	4	3	2	2	3	4	1	3		2	1
Quite important	1	1	1	3	1	1	3	2	4	3	2
Extremely important	1	2		1		1	1	1	2	1	1
Ranking Sum[1]	15	17	10	17	11	18	16	16	20	17	14

[1]Ranking Sum was calculated as follows, a number from 1 to 4 was assigned to each response category, with 1 assigned to 'not important or not mentioned' and 4 assigned to 'extremely important'. The assigned number was multiplied by the number of responses from the experts and then added together for each factor.