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IMPACT OF PRECIPITATION, TEMPERATURE, AND TECHNOLOGY ON ILLINOIS SOYBEAN YIELDS

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By

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A Research Paper
Submitted in Partial Fulfillment of the Requirements for the
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CHAPTER 1

Introduction

The two main things that affect soybean yields in the state of Illinois are weather and technology. Although prior research has looked into how those two factors affect soybean yields, the results are mixed. One of the main reasons that researchers cannot agree on the results is that there are so many variables that can affect yields. Some of these are “soil quality, planting date, disease, insects, and technological improvements from seed genetics, fertilizers, and producer management techniques” (Tannura, Irwin, and Good 2008). While yield enhancing research is clearly important to the economic well-being of Illinois soybean producers, it is important to be able to justify these research efforts in the broader context of societal welfare and rural benefits. In this research, we set forth to quantify the economic impact of improved soybean yields on economic development. An assessment of the overall economic impact will help to understand the benefits of basic research on soybean yields.

Previous research on technology and weather that looked into the problem was Tannura, Irwin, and Good (2008) who examined weather and technology and how it affected corn and soybean yields in Illinois. While Taylor and Koo (2011) looked into soybean projections for the next 10 years and what affects yields. Research in soybean technology is important because Illinois is a leading producer of soybeans in the United States. The United States produces 28% of worlds soybeans followed by Brazil (21%) and Argentina (18%). With increased technology, soybeans are having an ever expanding role in what they can do and that is just one reason why soybeans are experiencing an increase in demand. According to Taylor and Koo (2011), “China is the main reason for increased world soybean production. In 1995, China consumed 517 million bushels of soybeans and produced 640 million bushels. By 2009, China consumed 2.0 billion bushels and produced 631 million bushels. In 2009, China imported 60% of the soybeans traded in the world market" (p. V). Also another reason for the increase in demand which is not expected to slow within the next 10 years is "U.S. domestic processing is projected to increase by 21% from 1.7 billion bushels in 2010 to about 2.0 billion bushels in 2020. Feed and other uses are expected to increase by about 16%. Total domestic consumption is expected to increase by about 24% during the forecast period" (Taylor and Koo, 2011, p. V).

This paper will look at technology and how it affects Illinois soybean yields. The research will try to hold constant other exogenous variables and capture on the direct impact of technology through a trend variable see (Tannura, Irwin, and Good 2008). This research will look at the impact of technology on all 9 Illinois agricultural reporting districts. The benefits of this project will accrue to the Illinois Soybean Association and other agencies or groups that fund soybean related research. Investigators will have an accurate measure of the past contributions of technology to Illinois soybean yields plus an estimate of the economic benefits possible from future improvements. In the process of justifying research expenditures to stakeholders, it is important to quantify past success and future benefits on a state and local level.

CHAPTER 2

LITERATURE REVIEW

Soybean yield research can be complicated because soybeans are a hardier plant than some other crops. That is why when conducting soybean research many factors need to be considered to get the most accurate and complete picture. Many of the articles used in this report are needed because they support and add to various topics covered in this research.

Our research follows other research that was done using trend variables in determining technology's impact on crop yields (Tannura, Irwin, and Good, 2008); Cai, Bergstrom, Mullen, Wetzstein, and Shurley (2011). This research will look to confirm the conclusions of Tannura, Irwin, and Good. "This research provided strong evidence that precipitation, temperature, and a linear time trend to represent technological improvement explained all but a small portion of the variation in corn and soybean yields in the U.S. Corn Belt" (p. 40). Tannura, Irwin, and Good's (2008) article is a bit more extensive than our research because they look at corn as well as soybeans and they compare their data to Thompson's (1990) research. We are using Tannura, Irwin, and Good, (2008) regression model as well as models from Kestle (1982) in creating our model. We are hypothesizing that our results will confirm that of Tannura, Irwin, and Good's (2008) because our research methods will mirror theirs. One of our shared hypotheses are; "Weather and technology are the main drivers of corn and soybean yields in the U.S. Corn Belt. This research provided strong evidence that precipitation, temperature, and a linear time trend to represent technological improvement explained all but a small portion of the variation in corn and soybean yields in the U.S. Corn Belt" (p. 40). While our research parallels that of Tannura, Irwin, and Good (2008) mainly because we use the same model, while Cai, Bergstrom, Mullen, Wetzstein, and Shurley (2011) use a Principal Component Regression (PCR) model. Cai, Bergstrom, Mullen, Wetzstein, and Shurley (2011) use a PCR model that is a bit more complex and tells the researcher more about the data. Also regressions models are not innovative when applied to crop data while PCR models at the time Cai wrote his paper was somewhat new. "In this research, we conducted an econometric analysis of weather factors influencing crop yields using county level data from major producing states for corn, soybeans, cotton and peanuts" (Cai, Bergstrom, Mullen, Wetzstein, and Shurley 2011 p. 19). However, one major difference between our research paper and their work is that they developed a model to help determine future yields based on current and past data; whereas, this research focuses on the technological benefits across disaggregate regions.

Attavanich (2011) was instrumental in helping determine how weather affects variables. One factor that the paper identifies is that there is a statistical difference when weather is favorable. It will be important to look at his work and use it to help steer our conclusions when we look at how weather affects our variables. While Changnon (1965) uses weather to help predict yields in central Illinois. We are not going to try to predict actual yields in our data, however, it will be interesting to hypothesize about future yields and these two papers will help create an outline in that regard. Sheppard and Irwin (2009) also look at how weather affects the yields in Illinois and if they are changing. The authors conclude that “the results of this research provide evidence that weather plays a significant and important role in determining yield” (p. 7).

We will be using papers from Hagedorn, Irwin, and Good, (2004) as well as both papers from Masuda and Goldsmith (2009), and Taylor and Koo (2011). These three papers will bolster why research into soybean yields are important. Hagedorn, Irwin, and Good's (2004) paper will provide evidence for us in determining how well soybeans perform in the world market and both papers will give us information as to who is buying and selling soybeans in the international market. Masuda and Goldsmith's (2009) research will be used to help show why soybean research is so important. “Soybeans are one of the most valuable crops in the world and are characterized by their multi-purpose uses: food, feed, fuel and other industrial usages such as paint, inks, and plastics” (p. 2). With increased uses for the soybean plant it is important to increase supply; Masuda and Goldsmith (2009) say that it is possible but yields need to keep increasing to match growing demand. Taylor and Koo (2011) look at world soybean demand and how the U.S. will keep up with said demand. “Much of the production growth has been in harvested acre since yield growth has been moderate. Highest soybean yields are in Nebraska, followed by Iowa and Illinois. The yield growth is fastest in Nebraska (29.5%), followed by the South region (21.4%), and Illinois (18.0%)” (p. 10). In this research we will extend the existing literature by examining the technology trends in 9 regions in Illinois and examining the differential benefits accruing to different production regions.

CHAPTER 3

DATA

The State of Illinois lies just east of the Mississippi river with few natural blockages for storms, winds, and many other natural weather occurrences. Illinois has a great climate to grow many crops but in particular soybeans; that is why Illinois is one of the leading producers in the U. S. and the U.S. leads the world in soybean production. Like all farmable crops, soybeans need correct precipitation and temperatures to maximize yield potential. According to Tannura, Irwin, and Good (2008) “soybean yields were most affected by technology and the magnitude of precipitation during June through August (and especially during August)” (p. 39). Our research will verify this and likely find the greatest correlation of precipitation and temperature to yields through the months of June, July, and August.

No matter how much technology evolves over time, water is still needed for plant growth. Precipitation is not only important for feeding the crops but it is also important to refill the groundwater that many farmers rely on to irrigate their farms. “Irrigation can be either from surface water or groundwater sources” (Brozovic and Islam, 2010, p. 1). Rainfall is an important part in many different aspects that farmers use to water their crops. Illinois goes through droughts and floods like any growing region and when these natural occurrences happen it has drastic impacts on the yields. As one can see in Figures 1-5, it is clear that there was a drought during the summer of 1988; when a drought occurs excess groundwater is used up which then is needed to be replenished in following years. Data taken from Jha, Arnold, Gassman, and Gu (2004) show that slight changes in the climate can have major and sometimes devastating impacts in future scenarios. “Then the results found here, for increased precipitation scenarios, would indicate that future Mississippi River and tributary flooding episodes could intensify relative to current events... results also clearly show that significant decreases in streamflows could also occur if climatic trends were to go the opposite direction of what is currently being forecast” (p. 23). We know that in 1988 yields fell for Illinois and the United States as well, as seen in Figures 1-4.

Our yield data came from the *United States Department of Agriculture-National Agricultural Statistics Service,* which is the most reliable site to gather data. Soybean yields are reflected by the final yields for each year as well as total production divided by harvestable acre and represent the most accurate data that is available to researchers.

Our weather data was provided to us by Tannura of T-Storm, LLC, this is the same weather data that is used by Tannura, Irwin, and Good (2008). Although it is safe to say that weather is expected to change from year to year, it is interesting to note that the data does show a slight but not insignificant rise in temperature over the 60 years of data, (see Figure 7). The cause of this increase is beyond the bounds of this research, whether it is from global warming or other outside forces. The data does not appear to have a trend between temperature and precipitation, (see Figure 9). With weather being so random and little to no evidence of a trend it is safe to conclude that “monthly weather observations in Illinois, Indiana, and Iowa were random and generally poor indicators of weather in future months” (Tannura, Irwin, and Good 2008, Pg. 9). “Unstable temperature and precipitation will cause unpredictable variations in crop yields. Overall, temperature and precipitation are the two most important weather factors affecting crop yields" (Cai, Bergstrom, Mullen, Wetzstein, and Shurley, 2011, (p.6).

Precipitation Variables

The relationship of precipitation is well documented, even many non-farmers would be able to tell you that temperature and rainfall have an effect on crops; however, that is where most of the common knowledge ends. Most people could tell you that not enough water will have adverse effects on yields but would they know that too much water can cause flooding and low sunlight? Along the same lines, having extreme temperatures can cause undue stress on crops. Another major factor for precipitation is when the rainfall happened. As stated earlier, the months of June through August are where it is most crucial to have stable weather. Tannura, Irwin, and Good (2008) argue that "soybeans can recover from particularly low or high precipitation during May because weather during June through August has a much more significant impact on yield potential" (p. 12).

Temperature Variables

Just as in precipitation most people outside of farmers do not know much about the exact details concerning temperature and crops. Unlike precipitation however, temperature and yields do not have as strong a correlation. Precipitation levels can influence farmer's yields greatly while temperature fluctuations do not have as great of an effect on yields. However it is much easier to predict temperature swings because the volatility is much lower. Tannura, Irwin, and Good (2008) explain “monthly temperatures from May through August were substantially less variable than precipitation variables” (p. 12). High temperatures will affect soil moisture levels which could possibly decrease soybean yields if water supply is not sufficient (Mitchell, Manabe, Meleshko, and Tokioka 1990).

Technology Variables

When looking at the yield data that we are using, (see Figure 1) it is quite easy to see that over the last 60 years there has been quite a bit of improvement in soybean yields. This is due mainly to the increase of technology which includes but is not limited to seed genetics, production improvements, and fertilizers (Tannura, Irwin, and Good 2008). When we aggregate the technology variable it will include all changes and improvements in technology and will be our broadest variable. “Technology change has an important role in long-run crop yield changes since it improves the crop yields over time” (Cai, Bergstrom, Mullen, Wetzstein, and Shurley, 2011, p. 10.). The only data that will not be included in the technology variable is the weather data which will be represented by the precipitation and temperature variables. To collect our technology variable we used a trend variable which was the same way that Tannura, Irwin, and Good (2008) used in their research. As a maintained hypothesis, the trend variable is measuring gains in yield due primarily to technological improvements.

CHAPTER 4

METHODS AND PROCEDURES

We are going to use a linear regression model to isolate the effect of technology on yields while keeping weather effects constant. In simple terms, we will look at how precipitation, temperature, and technology affect soybean yields; however, we will proxy the technology variable with a trend variable to gauge the impact technology has on yields. In this research we will be using the same regression approach that Tannura, Irwin, and Good (2008) used in their research.

Equation (1)

$$
\begin{aligned}
Yield = {} & \beta_0 Constant \\
& + \beta_1 Precip.April + \beta_2 Temp.April \\
& + \beta_3 Precip.May + \beta_4 Temp.May \\
& + \beta_5 Precip.June + \beta_6 Temp.June \\
& + \beta_7 Precip.July + \beta_8 Temp.July \\
& + \beta_9 Precip.Aug. + \beta_{10} Temp.Aug. \\
& + \beta_{11} Precip.Sept. + \beta_{12} Temp.Sept. \\
& + \beta_{13} Technology\ Trend
\end{aligned}
$$

In equation (1), April precipitation will be hypothesized to be negative because too much rainfall will affect planting and flooding is a potential issue. April temperature does not have a great impact on yields because during this month there will be nothing up and out of the ground. In general, April is not considered a major planting month and we would hypothesize that it won't likely have a significant impact on yields. The month of May is included because a very late or early planting could impact yields. June is the first month that is considered to be very important in the growing season, therefore, we would hypothesize that precipitation will be positive and have an impact as well as temperature being negative.

July and August are the prime growing months and according to that theory it would be safe to hypothesize that these two months will have the greatest impact on the development of yields. Precipitation for both months should be positive reflecting the moisture needed. While the temperature is negative as hot weather impedes growth. These are the most important months and we should expect to see the most significance coming from these two months. August is associated with the crucial pod-filling stage, and a particularly hot month would have a negative impact on yields. Therefore, as temperatures rises and begins to dry out the precipitation it will have a negative impact and in doing so we expect yields to drop as temperatures rise. During the month of September most harvesting has already taken place; or is in the process of and should not have a significant impact either way on yields. Although, a warm September may allow for full crop development.

Data are available for the United States, Illinois, and the nine agricultural reporting districts in Illinois. We will be able to create equations for each region we will be looking at and insert all the data and estimate the contribution that technology has on yields. In this equation we will only be using weather data from April through

September; our research showed that these were the months that most impacted the yields and is widely considered to be the growing season. “May through August was examined for inclusion in the modified model since it is widely understood that weather during these months most influences growth and yield potential” (Tannura, Irwin, Good 2008 p. 11). Weather variables and measures of technology improvement will be used to explain year-to-year fluctuations in state yields over the last 60 years. This will allow for general statements on the relative impact of weather and technology on yield performance. The results will provide a benchmark for evaluating future yield improvements relative to those seen in the past. For instance, it might be the case that technology has provided a 0.10 bushel per acre increase in yields since 1990. Future research efforts can then be measured against this past performance. Moreover, the estimates from the model will provide a baseline for evaluating the economic benefits accruing to yield enhancement. This will be helpful when looking at how Illinois stacks up compared to the U.S. as well as the global market. Once data is calculated to determine how technology affects soybean yields then one will be able to determine how affective research and development is on the soybean market.

Yields can be further disaggregated down by regions of the state to see if the benefits are equally spread across Illinois’ diverse growing regions. This will be enabling us to look at how each of the growing regions benefits from the technology increase. It would be reasonable to think that not all nine districts will benefit the same from the technology.

CHAPTER 5

RESULTS

Precipitation, temperature, and technology all had a large impact on soybean yields. In this research we used a multiple regression model that used precipitation and temperature as well as a dummy trend variable to capture the impact of technology on soybean yields. This is the most efficient and accurate way to determine technology trends on yields (Tannura, Irwin, and Good 2008 Pg. 38).

The model estimates show positive precipitation values on average helped farmers cultivate greater yields and high temperature values during the same months lowered yields (Table 1). Table 1 shows the most significant month for precipitation and temperature was in August and followed closely by July. This is also supported by the data in Tannura, Irwin, and Good (2008) who say that “Soybean yields were most affected by technology and the magnitude of precipitation during June through August (and especially during August). The magnitude of July and August temperatures on soybean yields was also important, but less so than precipitation” (p. 39). Table 1 shows that when the data are statistically significant, precipitation is always increasing yield values with no exceptions, while temperature is always decreasing except in April, when higher temperatures allow earlier planting and September where higher temperatures extends the growing season. “Results of this research provide evidence that weather plays a significant and important role in determining yield” (Sheppard and Irwin, 2009, p. 7).

In Table 1, the United States is in the first column with the estimated coefficients over the p-values. In this research, we chose the significance at the 10% level and shaded each box that was statistically significant. When looking at the U.S. the only significant months were July precipitation, and temperature, and then August precipitation, and temperature. July precipitation's beta value is positive 0.403 which means for every one inch increase in rain during the month of July, soybean yields increase by 0.403 bushels per acre. Then in July temperature, a 1 degree Fahrenheit increase in temperature will lead to 0.307 bushels per acre drop in soybean yields. Then in August, a one inch increase in precipitation leads to a 0.420 increase in bushels per acre. While a one degree increase in temperature for August results in a decrease of 0.320 bushels per acre.

As one can see in Figures 1-5, yields are increasing over time and it is not due just to precipitation and temperatures. Our data, as well as Figure 1, suggests that technology is having a positive impact on bushels per acre. With soybean prices at $11.30 in 2010, we can start to calculate the dollar amount that technology impacts the area. One can see the results in Map 2; SouthEast is by far the greatest beneficiary of the technology followed by the NorthWest and the Central. The districts that are impacted the least by technology are the West SouthWest and the East SouthEast and they are still gaining $3.90 and $4.00 per acre per year in revenue at 2010 prices (Map 3). When looking at maps 2 and 3 one can start to see where technology is having the greatest impact. The NorthWest, West, Central, East, SouthWest, and SouthEast are all experiencing over $4.50 increase per acre due to technology (Map 3). The smallest gains are in the East SouthEast and West SouthWest. It is not clear why these regions lag the others. When the increase in value per acre is overlapped with Map 4 (soil fertility map) one can see that there is no obvious relation between technological increases and soil productivity.

It is important to note if the technologies are statistically different from one another. One can look at Table 2 and see which crop reporting districts are statistically different from one another. This is important because it allows the researcher to determine which districts are different from one another. Reading the inequalities from the column heading to the row heading, Illinois has a statistically greater trend than the West SouthWest region of the state. This is important when looking at which areas are the greatest producers of soybeans so determine what areas have the greatest benefit from the technology. From Table 2, we can say that the West SouthWest region tends to benefit statistically less than the rest of the state and the Central, NorthWest, and SouthEast in particular. Conversely, the SouthEast region benefits more than the East SouthEast and NorthEast regions.

CHAPTER 6

CONCLUSION

The results have revealed that technology in fact does have a large impact in Illinois soybean yields. The data also shows that precipitation and temperature in July and August have a significant impact on yields. Even though technology acts as a stabilizing factor in year to year yield trends, due to the variability of weather variables, soybean yields are rather volatile. Poor weather conditions, especially during prime growing months, can negatively impact soybean yields. Still, with on-going technological advances yields will only continue its current trend rise in coming years.

The United States as whole has a technological impact of 0.380 (bushel/acre/year) which is surpassed by the state of Illinois with a technological impact of 0.413 (bushel/acre/year). It should be comforting to know that as one of the largest producers of soybeans in the United States, Illinois is also getting a higher return from technology improvements. The regions that show higher yields due to technology above the state average are in order; SouthEast, NorthWest, Central, and the East. The rest are below the state average of 0.413(bushel/acre/year); (SouthWest, West, NorthEast, East SouthEast,) and the district that receives the least from technological improvements is the West SouthWest. However, the state of Illinois should not lose the fact that six of the 9 crop reporting districts are receiving higher yields due to technology than the national average.

When looking at the state of Illinois as a whole, they have a beta coefficient of 0.413: with prices of $11.30 the average per acre is $4.67. If we take that multiplied with 9.050 million harvested acres, it comes out with a technological benefit of $42.3

million dollars per year. In theory, without the benefits of technology, that $42.3 million would not exist. In 2009-2010 the Soybean Check-off program spent $8.3 million on research; however, the gross benefit to Illinois farmers is over 5 times what they are spending. This does not take into account of the research expenditures or loss associated with using the technology.

When farmers purchase farmland they look at many different factors but most would not have an idea about how technology affects their land that they are about to purchase. With technology having different impacts across the state then it could lead to changes in farmland values based on the district it is located. Districts that see the greatest technology gains may have more rapidly increasing land values.

Overall, the state of Illinois is benefiting from increases in soybean yields. Future research will be required to accurately measure the net benefit accruing to farmers and rural communities.

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Table 1

Statistical Increases Due to Technology

	U.S.	Illinois	Central	East SouthEast	East	NorthEast	NorthWest	SouthEast	SouthWest	West SouthWest	West
Constant	31.018	28.594	19.304	92.307	44.631	-8.696	-5.033	12.445	40.395	81.526	31.798
	0.054	0.153	0.490	0.000	0.126	0.727	0.852	0.628	0.069	0.000	0.154
April Precip.	0.321	-0.055	-0.003	0.033	0.281	-0.455	-0.137	-0.490	-0.084	0.015	0.014
	0.232	0.844	0.993	0.896	0.391	0.301	0.717	0.034	0.711	0.943	0.956
April Temp.	0.057	0.054	0.010	**0.233**	-0.019	0.051	-0.030	0.018	0.126	0.073	0.006
	0.558	0.656	0.951	**0.104**	0.914	0.785	0.864	0.901	0.342	0.564	0.961
May Precip.	-0.009	-0.164	0.064	-0.102	-0.385	-0.460	-0.192	-0.167	0.018	-0.274	0.103
	0.969	0.475	0.810	0.633	0.244	0.176	0.494	0.402	0.924	0.164	0.606
May Temp.	0.109	0.076	0.138	-0.032	0.051	0.184	0.199	0.124	0.126	0.111	0.145
	0.269	0.499	0.339	0.810	0.732	0.217	0.218	0.393	0.366	0.356	0.255
June Precip.	0.074	0.326	0.152	-0.223	0.398	**0.685**	0.400	0.425	0.273	0.100	0.047
	0.770	0.204	0.540	0.283	0.141	**0.025**	0.148	0.118	0.238	0.622	0.827
June Temp.	0.119	0.174	0.245	-0.095	0.168	0.183	0.343	0.197	0.172	-0.055	0.163
	0.389	0.287	0.245	0.609	0.472	0.430	0.158	0.334	0.339	0.733	0.358
July Precip.	**0.403**	**0.980**	**0.500**	**0.734**	0.459	0.398	0.091	**0.767**	**0.729**	**0.664**	0.328
	0.091	**0.002**	**0.097**	**0.004**	0.144	0.300	0.790	**0.006**	**0.003**	**0.003**	0.140
July Temp.	**-0.307**	-0.049	-0.063	**-0.647**	-0.246	0.209	0.076	0.312	0.002	**-0.644**	-0.149
	0.051	0.806	0.807	**0.006**	0.408	0.447	0.775	0.200	0.992	**0.001**	0.469

Note: Shading is statistically significant at the 10% level.

Table 1 Continued

Statistical Increases Due to Technology

	U.S	Illinois	Central	East SouthEast	East	NorthEast	NorthWest	SouthEast	SouthWest	West SouthWest	West
August Precip.	0.420	0.883	0.655	0.661	0.937	0.703	0.558	0.613	0.486	0.624	0.233
	0.102	0.002	0.028	0.037	0.003	0.004	0.019	0.020	0.092	0.029	0.282
August Temp.	-0.320	-0.501	-0.552	-0.395	-0.571	-0.236	-0.310	-0.580	-0.662	-0.412	-0.553
	0.017	0.003	0.009	0.043	0.018	0.283	0.163	0.007	0.001	0.012	0.002
Sept. Precip.	-0.247	-0.077	-0.004	0.172	-0.043	-0.071	0.110	-0.259	-0.007	0.203	0.009
	0.226	0.709	0.984	0.509	0.867	0.736	0.626	0.358	0.975	0.292	0.956
Sept. Temp.	0.187	0.103	0.299	-0.073	0.293	0.066	0.118	-0.011	-0.010	0.063	0.309
	0.139	0.507	0.163	0.673	0.212	0.788	0.621	0.950	0.953	0.693	0.087
Technology Trend	0.380	0.413	0.430	0.354	0.414	0.357	0.446	0.450	0.405	0.345	0.404
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R^2	.926	.903	.842	.840	.807	.781	.835	.869	.868	.869	.871

Note: Shading is statistically significant at the 10% level.

Table 2

Statistical Differences Between Regions

	U.S	Illinois	Central	East SouthEast	East	NorthEast	NorthWest	SouthEast	SouthWest	West SouthWest	West
U.S		.	.	.	.	.	.	.	.	.	.
Illinois	.		.	.	.	.	.	.	.	.	.
Central	.	.		.	.	.	.	.	.	.	.
East SouthEast	.	.	.		.	.	.	.	.	.	.
East	.	.	.	.		.	.	.	.	.	.
NorthEast	.	.	.	.	.		.	.	.	.	.
NorthWest	.	.	.	>	.	.		.	.	.	.
SouthEast	>	.	.	>	.	>	.		.	.	.
SouthWest	.	.	.	.	.	.	.	.		.	.
West SouthWest	.	<	<	.	.	.	<	<	.		.
West	.	.	.	.	.	.	.	.	.	.	

When looking at Table 2, read from the side to the top. For example, the SouthEast is statistically different and greater than the United States while West SouthWest is less than Illinois.

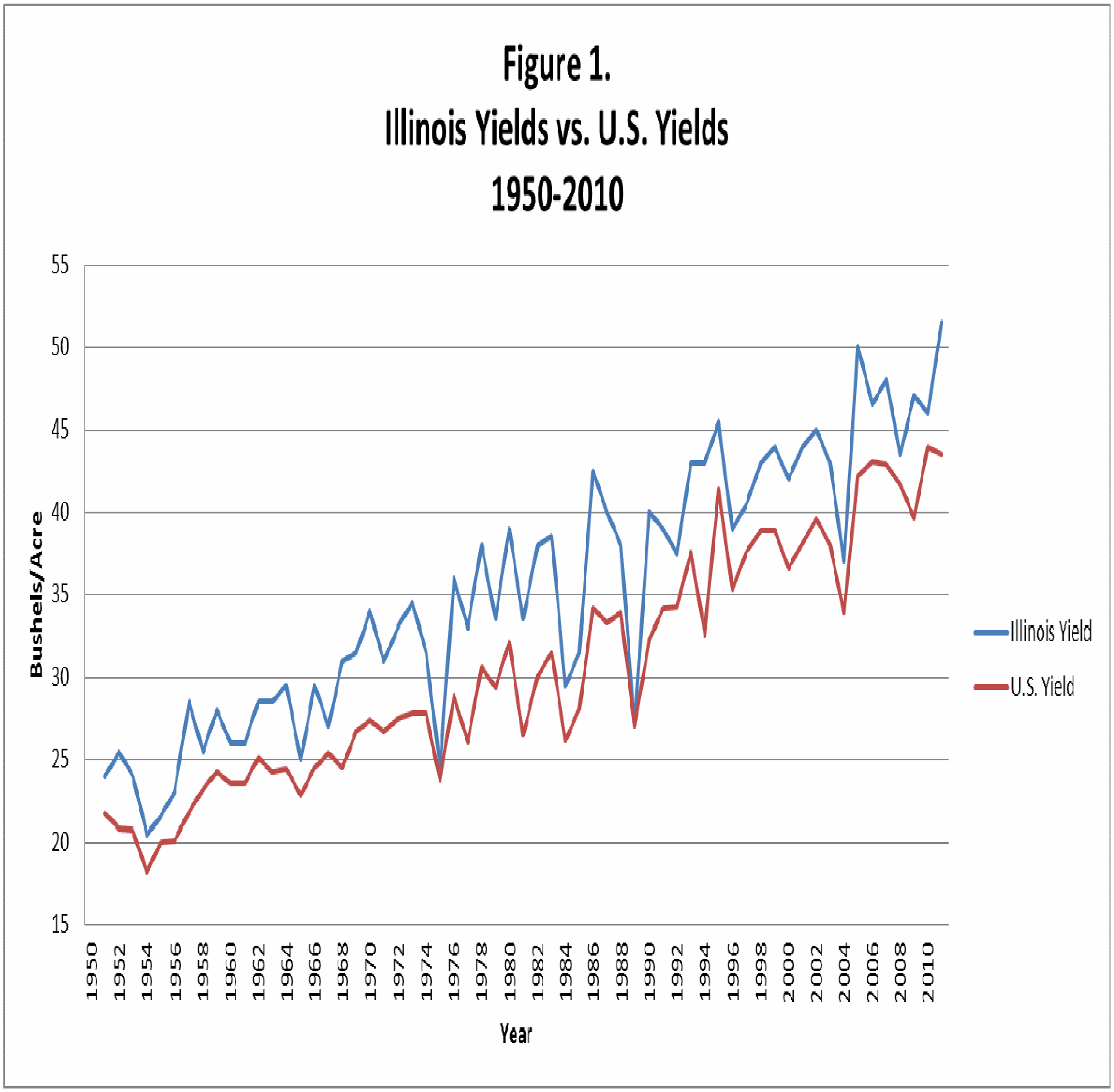


Figure 1.
Illinois Yields vs. U.S. Yields
1950-2010
55
50
45
40
35
30
25
20
15
Bushels/Acre
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year
Illinois Yield
U.S. Yield

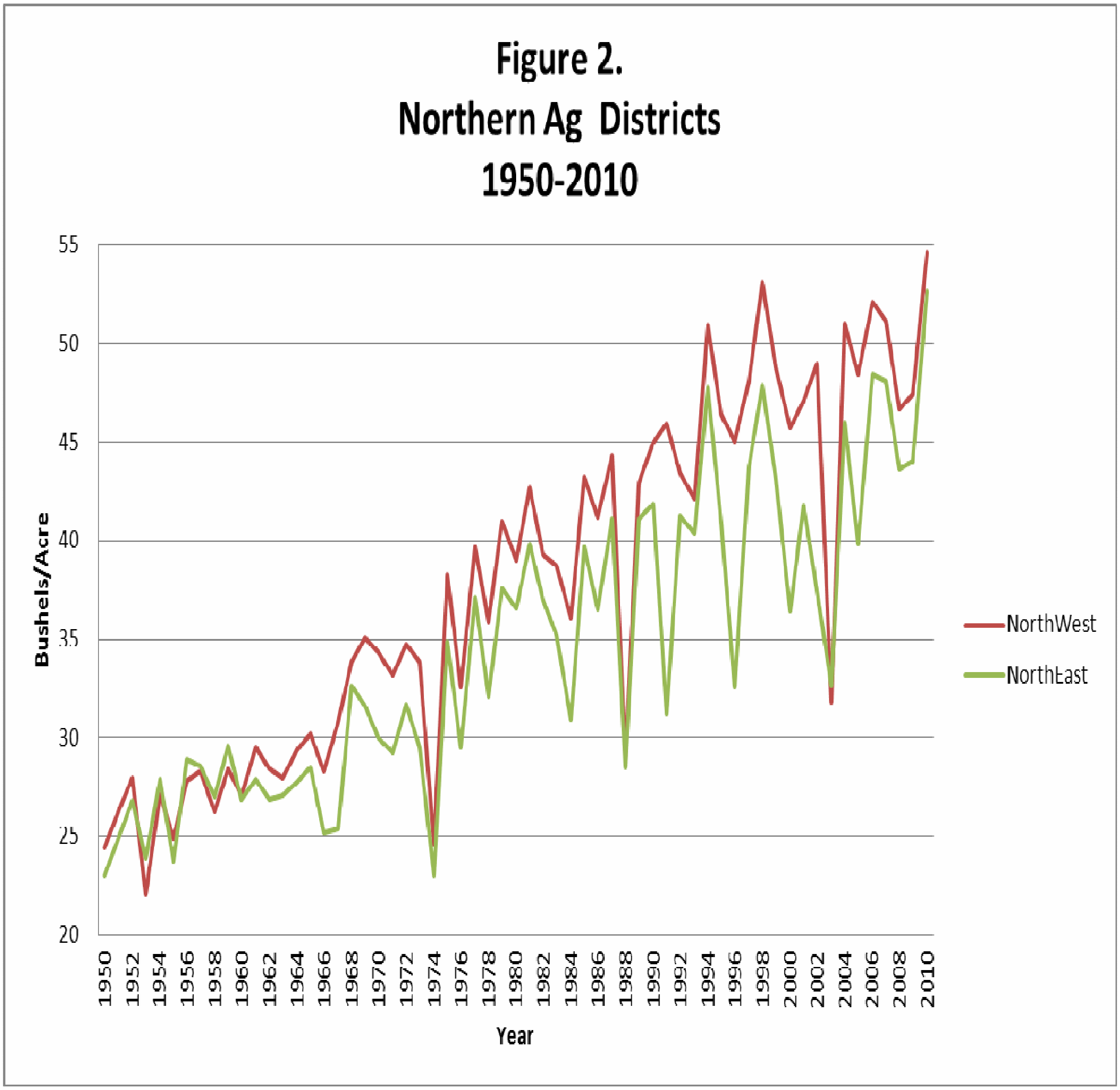


Figure 2.
Northern Ag Districts
1950-2010
Bushels/Acre
55
50
45
40
35
30
25
20
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year
NorthWest
NorthEast

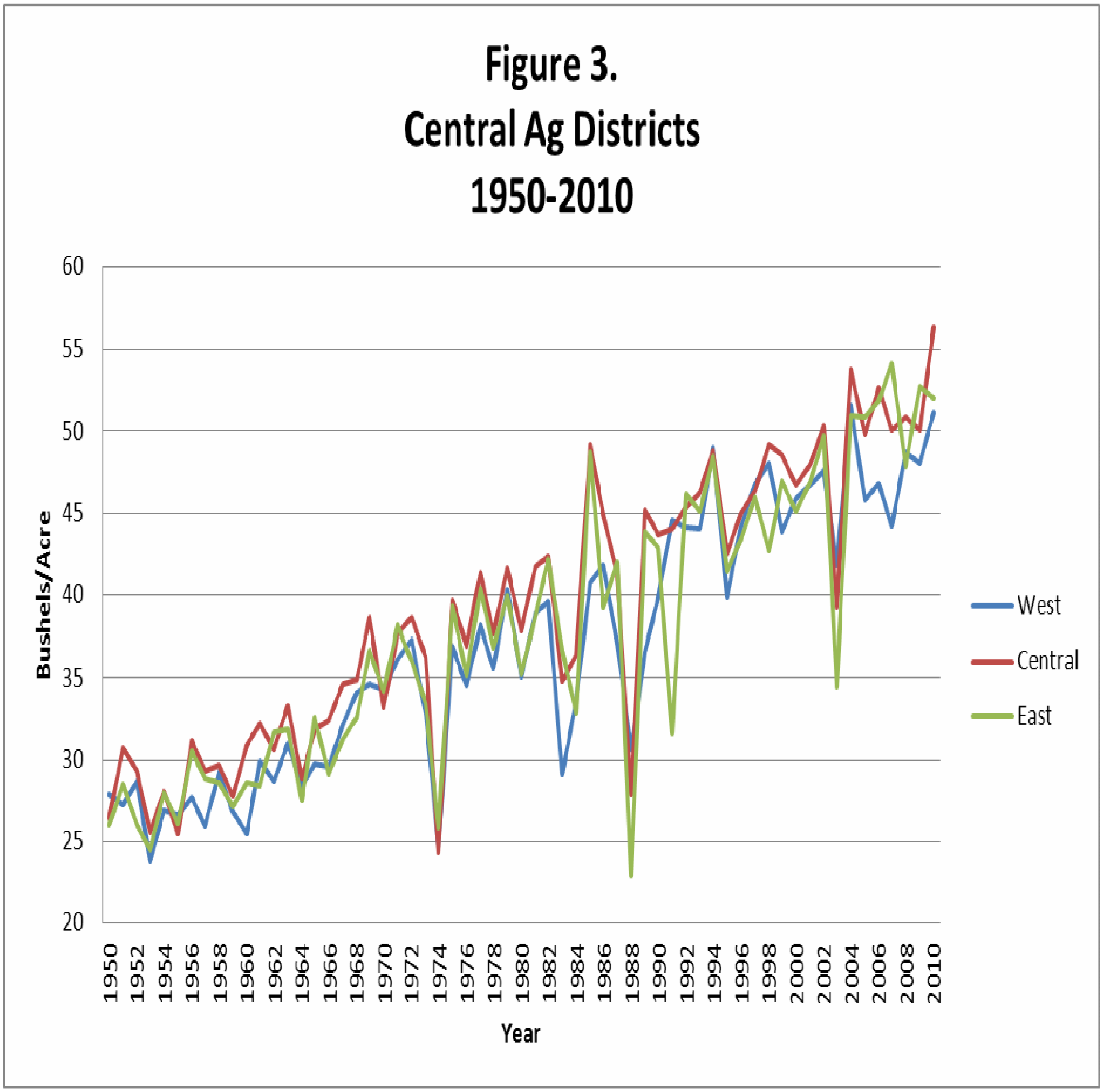


Figure 3.
Central Ag Districts
1950-2010
Bushels/Acre
60
55
50
45
40
35
30
25
20
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year
West
Central
East

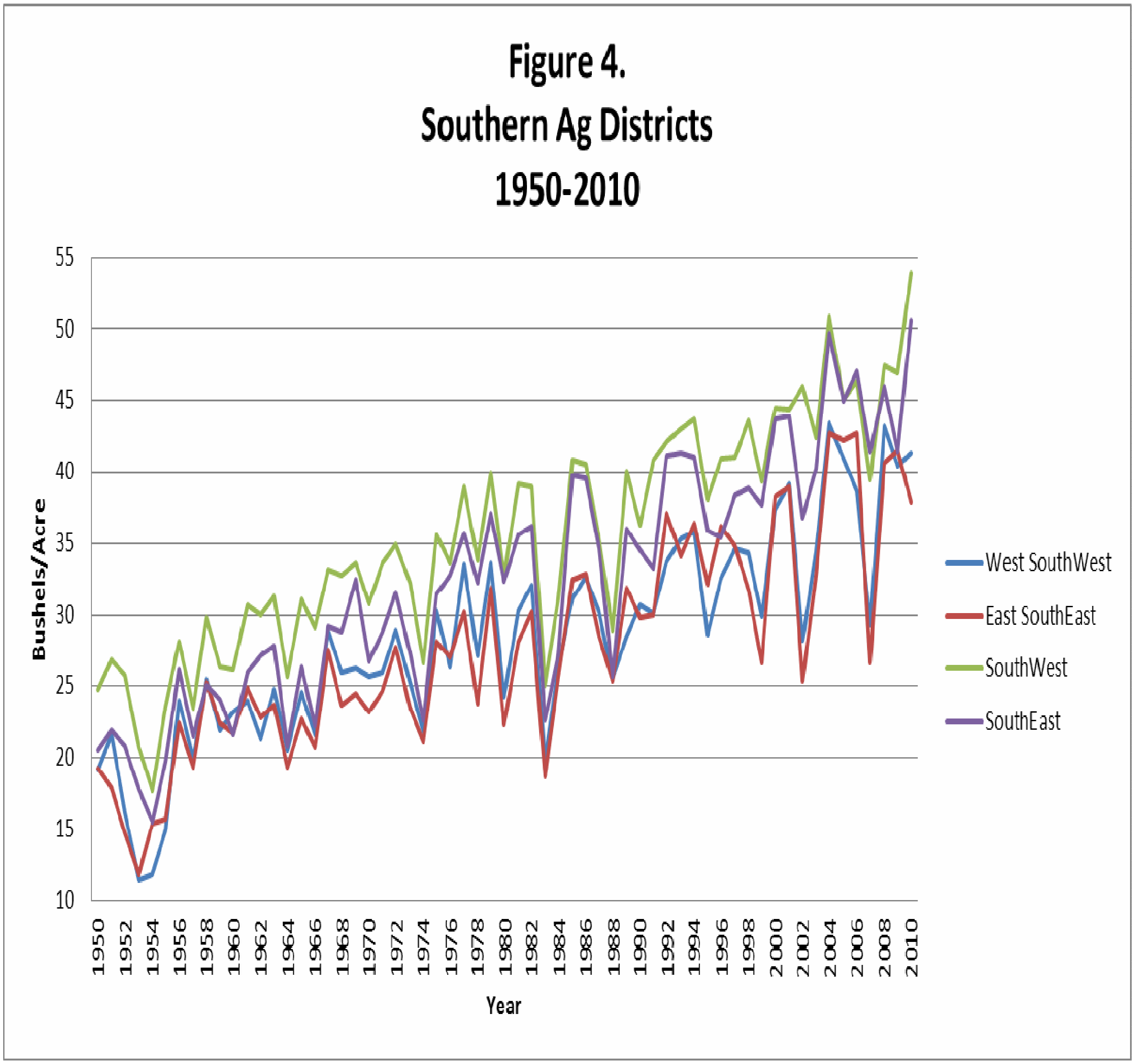


Figure 4.
Southern Ag Districts
1950-2010
Bushels/Acre
55
50
45
40
35
30
25
20
15
10
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year
West SouthWest
East SouthEast
SouthWest
SouthEast

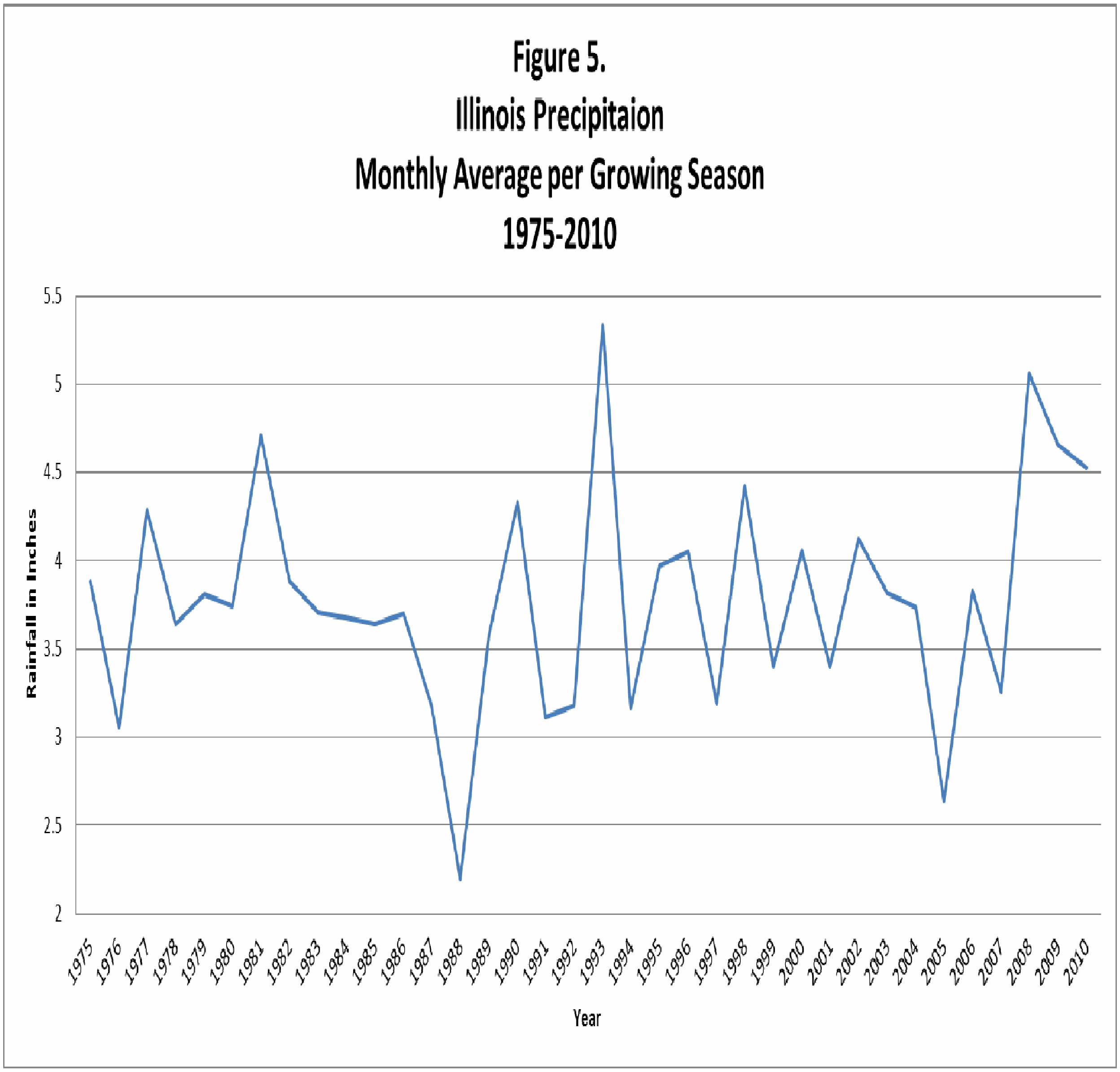


Figure 5.
Illinois Precipitaion
Monthly Average per Growing Season
1975-2010
Rainfall in Inches
5.5
5
4.5
4
3.5
3
2.5
2
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

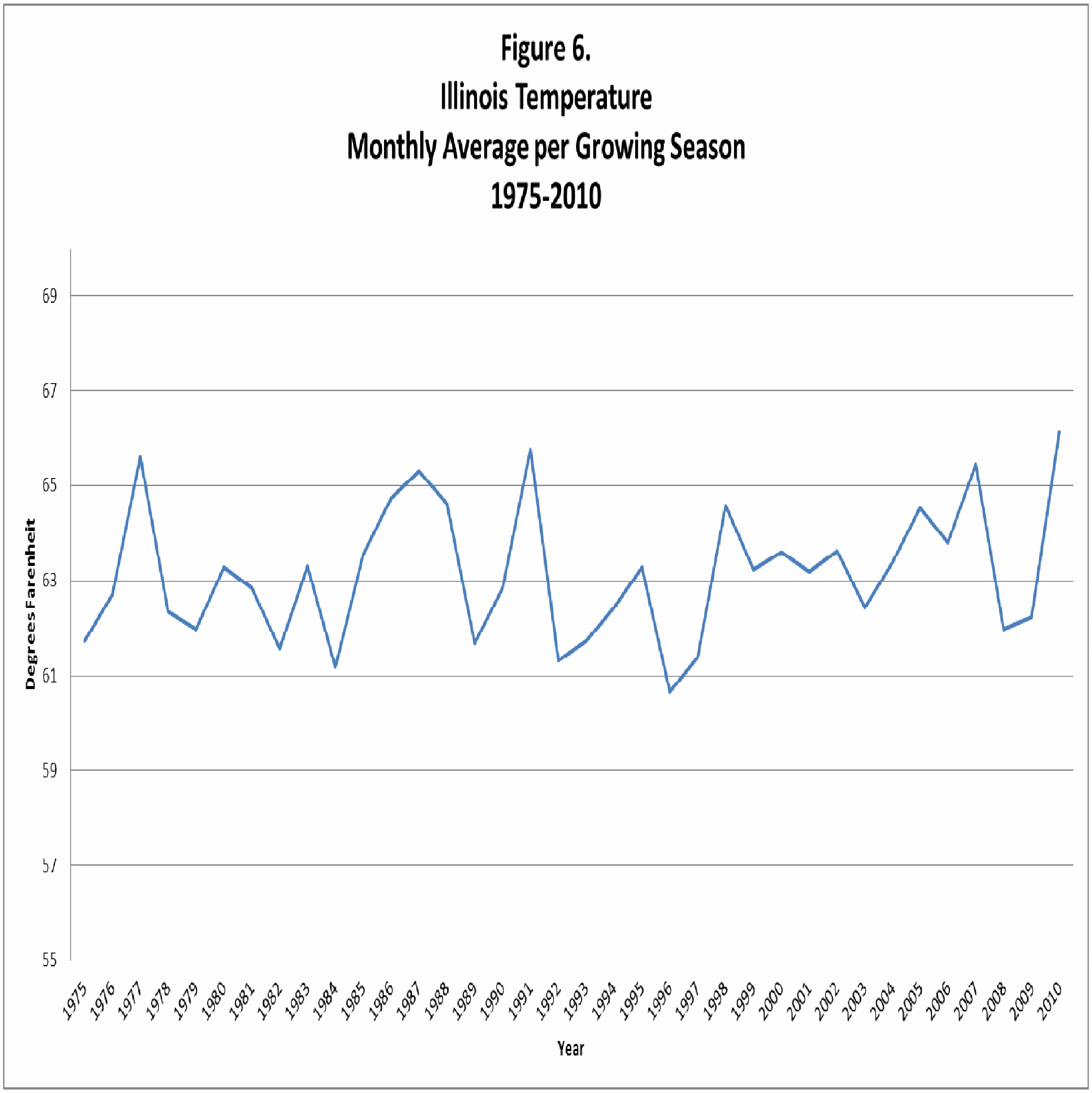
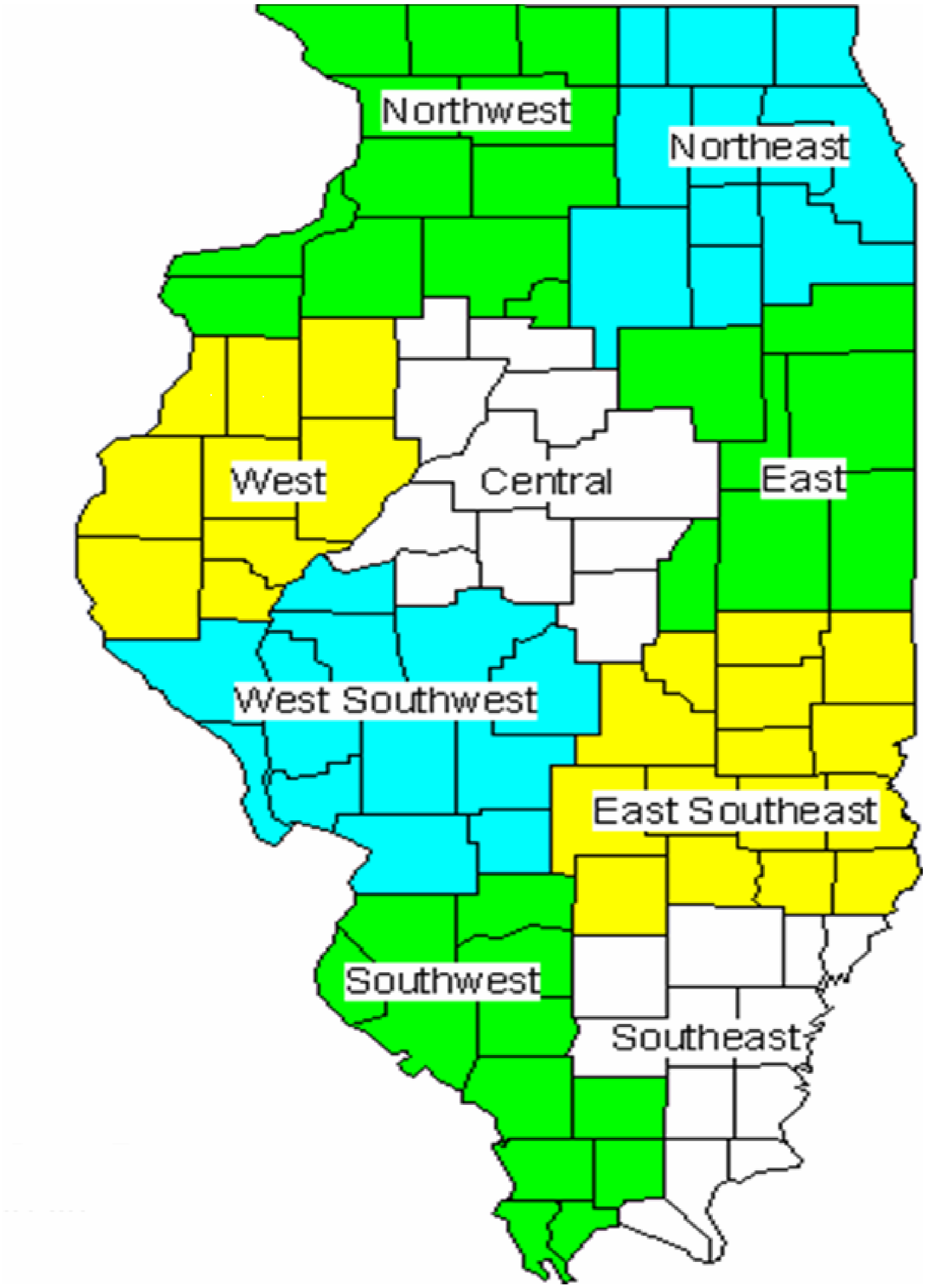


Figure 6.
Illinois Temperature
Monthly Average per Growing Season
1975-2010
Degrees Farenheit
69
67
65
63
61
59
57
55
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

Figure 7

Illinois Crop Reporting Districts



Illinois State Water Survey

Figure 8

Increase Due to Technology

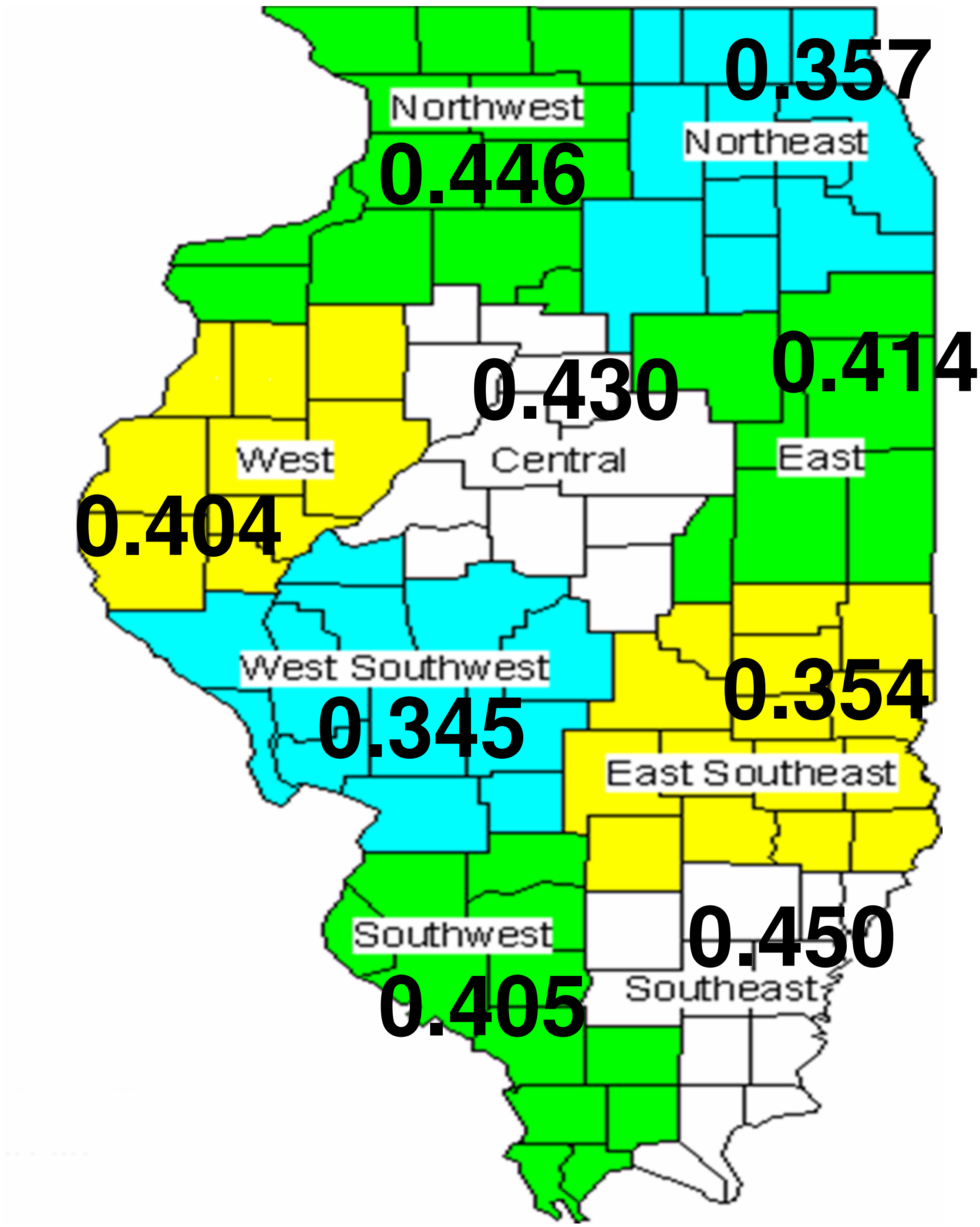
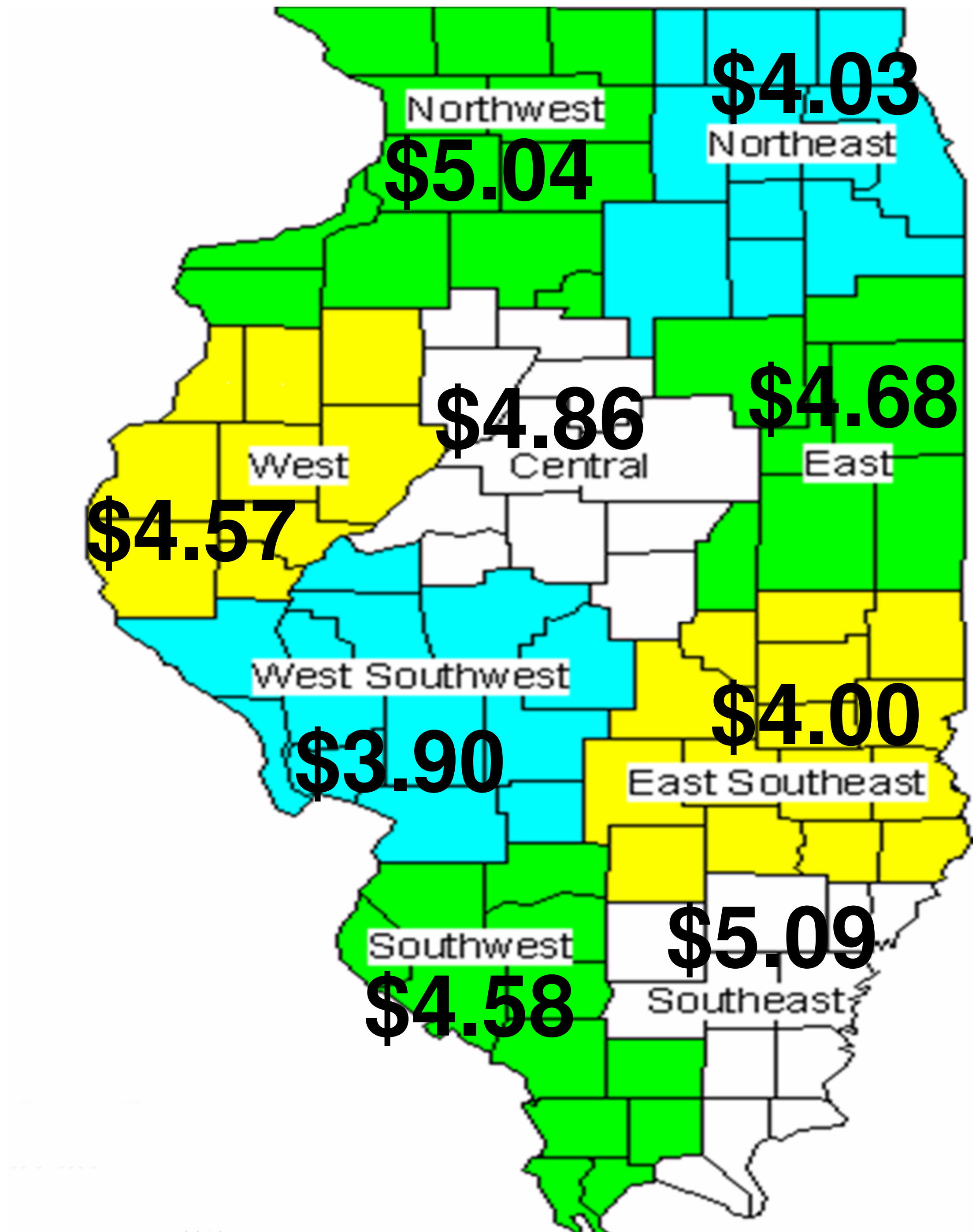


Figure 9
Increase in Dollars per Acre
Due to Technology in 2010

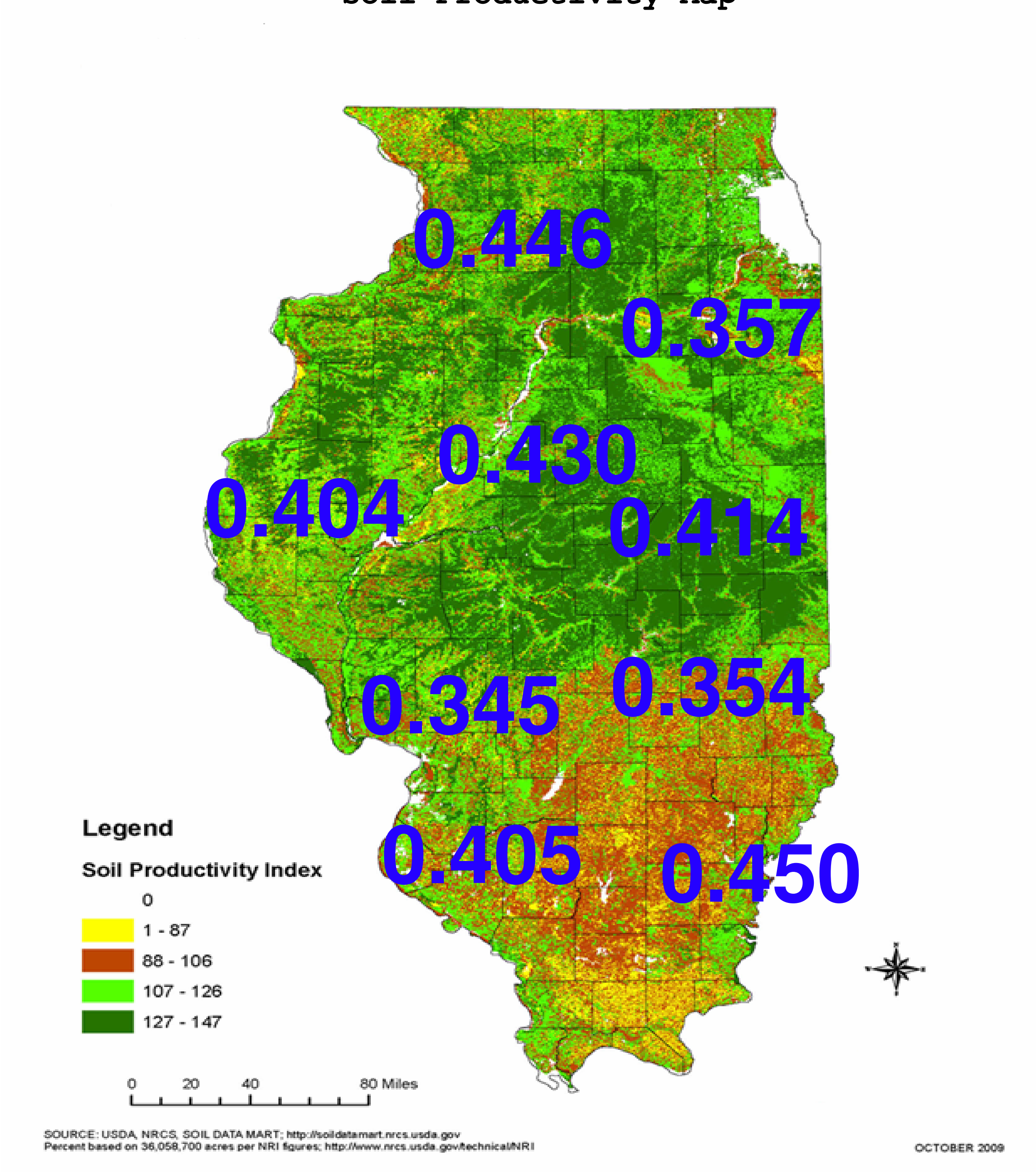


Yield Challenge 2010 Illinois

Dol. per Acre = Tech. Trend * Price of Bushel

Values are in 2010 Dollars and Prices

Figure 10
Soil Productivity Map



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IMPACT ON ILLINOIS SOYBEAN YIELDS

Major Professor: Dwight R. Sanders