The Impact of the 1936 Corn-Belt Drought on American Farmers' Adoption of Hybrid Corn

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ABSTRACT

The severe drought in 1936 revealed an advantage of hybrid corn not previously recognized – its drought tolerance. This revealed ecological resilience motivated some farmers to adopt hybrids despite their commercial unattractiveness in normal years. But that response to climate change had a tipping effect. The increase in sales of hybrid seed in 1937 and 1938 financed research at private seed companies that led to new varieties with significantly improved yields in normal years. This development provided the economic incentive for late adopters to follow suit. Because post-1936 hybrid varieties conferred advantages beyond improved drought resistance, the negative ecological impact of the devastating 1936 drought had the surprising, but beneficial, consequence of moving more farmers to superior corn seed selection.

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A severe and sustained drought struck central North America during the 1930s. Centered on eastern Kansas, it extended north into the Canadian prairies, east to the Illinois-Indiana boarder, south to the Gulf of Mexico, and west into Montana and Idaho. See Figure 1. The seven-year period of low rainfall and high temperatures, 1932-1938, was unprecedented in the memory of the Euro-Americans who inhabited the region in its extent, severity, and duration. It has been described by climate scientists as "one of the most severe environmental catastrophes in U.S. history" [Schubert et al, 2004: 1855]. The period is best remembered for the "Dust Bowl" conditions created on the panhandles of Texas and Oklahoma, and adjacent parts of New Mexico, Colorado, and Kansas. See Figure 2. In that region at the southwest edge of the drought area, the native prairie grass had been removed and the top soil subjected to deep plowing. The desiccating climate conditions coupled with high winds produced devastating dust storms that precipitated an ecological and human disaster.[1] The human misery caused is now part of American folklore chronicled in John Steinbeck's *Grapes of Wrath*, photographed by Dorthea Lange, and reduced to bitter song lyric by Woody Guthrie.

My interest in this paper is – not with the Dust Bowl – but with the Corn Belt that lies to the northeast of the Dust Bowl. See Figures 3 and 4. Figure 4 overlays the outline of the Corn Belt on the drought map. As can be seen, the eastern portion of the Corn Belt (western Ohio, and Indiana) was largely outside the region struck by the severe drought. By contrast the western Corn Belt (southwest Minnesota, western Iowa, southeast South Dakota, and eastern Nebraska) was hard hit. This geographical contrast will allow me to explore the adaptations made by corn farmers to sudden climate change. The lens through which I will look is the adoption of hybrid corn in the 1930s.

[1] The Dust Bowl is not synonymous with the drought area as the two maps make clear. The Dust Bowl had a naturally semi-arid climate and was settled during an untypical period of favorable climatic conditions. The first farmers imposed a "system of agriculture to which the Plains are not adapted to bring into a semi arid region methods which, on the whole, are suitable only for a humid region." Arid conditions returned with the North American precipitation anomaly of the 1930s. For more detail see the *Report* of the President's Great Plains Drought Area Committee [August 27, 1936].

The suggestion that I make in this paper is that the severe drought of 1936 revealed an advantage of hybrid corn not previously recognized – its drought tolerance. This revealed ecological resilience motivated some farmers to adopt hybrids despite their commercial unattractiveness in normal years. But that response to climate change had a tipping effect. The increase in sales of hybrid seed in 1937 and 1938 financed research at private seed companies that led to new varieties with significantly improved yields in *normal* years. This development provided the economic incentive for late adopters to follow suit. Because post-1936 hybrid varieties conferred advantages beyond improved drought resistance, the negative ecological impact of the devastating 1936 drought had the surprising, but beneficial, consequence of moving more farmers to superior corn seed selection.

There is no doubt that the drought decimated corn crops in 1934 and 1936. One index of the impact is the fraction harvested of each year's acreage planted to corn. When the damage to the crop is extensive, it is not worthwhile to attempt a harvest. If the damage is total, there is no crop to harvest. Figure 5 presents the percentage of the corn acreage planted that was harvested in the state of Iowa for the years 1926 to 1950. The two years 1934 and 1936 stand out as quite depressed. Figure 6 displays the data for Illinois (top panel) a state that was less affected by the participation shortfall and with Kansas (bottom panel) a hard hit state to the southwest of Iowa and at the epicenter of the drought.

Another index of drought is the yield (in bushels of corn per harvested acre). Figures 5 and 6 also display the yield statistics.[2] As Figure 6 suggests the yield data is somewhat less satisfactory as an index. All we have for most counties and crop districts

[2] State level data on the percentage of corn acres planted to hybrids are available in various annual issues of *Agricultural Statistics*. I have relied on the volumes for 1945 (Table 46, p. 42), 1948 (Table 50, p. 48), 1950 (Table 49, p. 47), 1952 (Table 43, p. 40), 1954 (Table 38, p. 30), 1957 (Table 40, p. 39), 1959 (Table 43, p. 33), and 1961 (Table 43, p.33). Unpublished state and county level data on acreage planted and harvested was made available by Michael Haines.

is the yield per harvested, not planted, acres. In a state like Kansas only a very small fraction of the acreage was harvested, presumably located in areas that escaped the worst of the drought. On those privileged farms relative yields were depressed but not to the extent in percentage terms as in Iowa. In a state like Illinois the drought effect is more evident in the harvest-to-planting ratio than in the yield per harvested acre.

In a companion paper I have discussed the adoption of hybrid corn at length [Sutch 2008]. There, I present evidence based on the Iowa Corn Yield Tests that in 1936 there was no unambiguous economic advantage of hybrid corn over the traditional open-pollinated varieties. The small percentage improvement in yield was insufficient to compensate for the high price of hybrid corn seed in those years and to overcome the reluctance to adopt a variety that imposed the necessity to purchase new seed every year rather than to save seed from one year's crop for planting the next. In 1936 only 3.1 percent of the acreage planted to corn was sown with hybrid varieties. I argue that early adopters before 1937 were likely influenced by a sustained propaganda campaign conducted by the U.S. Department of Agriculture and echoed by the commercial seed companies who often subsidized selected model farmers in an attempt to persuade others.

In this paper I suggest that the rapid adoption of hybrid corn in 1937 and the following few years can be explained as a consequence of the drought of 1936. That experience revealed a hitherto unexpected advantage of hybrid corn: its drought resistance. What the droughts starkly demonstrated was that the *relative* yield of hybrid corn was greatest when the *absolute* yields were depressed. Figure 7 reveals the relationship using the Iowa Corn Yield Test results to illustrate the correlation. In the extreme drought conditions of the mid 1930s, the yield differences between the new and traditional varieties were stark. Edward May, President of the May Seed Company, recalled:

> Yield differences became plainly evident in 1936, which was also a severe drouth year in Iowa. At this time nearly all farmers who were

> testing hybrid seed corn planted only a limited acreage. Yields of hybrids under these conditions in many areas of the state were approximately double the yields of other corn grown on the farm. The results were so convincing that it marked the end of the vast efforts of initial adoption [May 1949: 514].

"Almost overnight, demand for hybrid seed exploded" [Culver and Hyde 2000: 149]. Big percentage point gains in adoption came in 1937: 22.3 percentage points accounted for by new adoptions in Illinois, 21.2 percentage points in Iowa, 18.3 points in Ohio, 17.4 in Indiana, 12.9 in Wisconsin

The relationship between the drought and the adoption of hybrid corn can be illustrated using crop district data for the years 1926-1960. For the purposes of reporting the data on the percentage of acreage planted to hybrid varieties and the statistics of acreage and output, the USDA partitioned each of the corn states into nine (or fewer) districts that aggregated contiguous counties. Unfortunately the data on acreage planted is not complete and the data on yields is available only for Ohio, Indiana, Illinois, Wisconsin, Iowa, Missouri, eastern South Dakota, and eastern Nebraska. Michigan and Kansas are not yet available.[3] Because the data on acreage planted is not available at the county or district level for most of these states, I use the yield per harvested acre as my measure of the severity of the drought in 1936. Specifically severity is measured as the percentage yield shortfall in 1936 when compared to the average yield for 1926-1935 excluding 1934. The distribution of 64 corn districts by the variable is plotted as a histogram in Figure 8.

The more severe the 1936 drought, the greater its depressing impact within a crop district, the faster we expect the adoption of the new drought-resistant hybrids would have been. Zvi Griliches collected annual data on the percentage of acreage planted in each crop district that was devoted to hybrid varieties [1957]. District-by-district he fit a

[3] The project to gather and code the agricultural data is still ongoing. I hope to extend the analysis to additional states when and if I can access that data.

simple three-parameter logistic curve to estimate the speed of adoption. We used the parameters that he published [Griliches, Table 2] to calculate the year that the district achieved a 30-percent adoption rate.[4] The results we report are not sensitive to the target adoption rate chosen since very few of the logistic curves cross each other.

We also conjectured that the eagerness to adopt the new varieties would also be correlated with the productivity of corn farming within the district. The higher the yield per acre in normal years, the larger will be the pecuniary advantage of the higher yields the new varieties seemed to offer. We thus performed a simple statistical calculation to predict the year that 30-percent adoption was achieved using the average yield reported for the 1926-1933 and 1935 period and our measures of severity and typical yield as regressors. The result is presented in Figure 9. Both variables have the expected sign and are measured with reasonable precision. We conclude that the drought of 1936 sped the process of adoption after it revealed the drought resistance of hybrid corn.

After that a new dynamic was set in motion. The explosion of demand for hybrid corn generated large profits for the major hybrid seed companies: Pioneer, Funk, and DeKalb. As a result prices of hybrid seed fell and the companies invested heavily in research with new hybrid strains. They not only perfected the drought resistance of the plant, but found ways to permit increased planning density, increase the resistance to lodging, and increase responsiveness to artificial fertilizer. The result was a steady improvement in the yields per acre that hybrid corn could achieve. See Figure 10. Once these post-1937 improvements were recognized adoption of hybrid corn became economically advantageous; before 1937 it had not been.

We can trace the diffusion of hybrid corn from district to district. The map in Figure 11 illustrates when the various districts achieved 30-percent adoption. The two

[4] A purest might prefer to use the original data rather than the fitted curves. I have yet to locate the original data. However, the fit of each curve as reported by Griliches is very high. Moreover, there is certain logic in using the fitted values since they create a continuous variable, smooth the data, and correct for noise in the original crop reporters' estimates.

crop districts in the center of the Corn Belt (Iowa District 6 and Illinois District 1) were the epicenter for the spread of the innovation. Fifteen districts, all located in a concentric ring around the two origin districts achieved that threshold in 1937 in the rush to achieve some protection in case another dry year were to follow. In 1938 eight districts to the east adopted hybrid corn. These districts were less affected by the drought of 1936. It is possible that a geographical contagion coupled with new and superior varieties introduced in 1938 explain this move into northern and central Indiana and Ohio.

The sociologists Bryce Ryan and Neal Gross, writing in 1950, studied the diffusion of hybrid corn in two communities located in Greene County, Iowa [Ryan and Gross, 1950]. In their view late adopters were farmers bound by tradition. They were irrational, backward, and "rural." The early adopters by contrast were flexible, calculating, receptive, and "urbanized." "Certainly," they summarized, "farmers refusing to accept hybrid corn even for trial until after 1937 or 1938 were conservative beyond all demands of reasonable business methods" [p. 672]. They drew a policy implication. "The interest of a technically progressive agriculture may not be well served by social policies designed to preserve or revivify the traditional rural-folk community" [p. 708]. In part this view was based on Ryan and Gross' (incorrect) belief that hybrid corn was profitable in the early 1930s [p. 668]. I have shown that this was not the case in the companion paper [Sutch 2008]. The map in Figure 11 should also give pause to the view that rural laggards delayed the adoption of hybrid corn. It would be hard to argue that the farmers in Iowa Crop Reporting District 6 and Illinois District 1 were predominantly forward-thinking leaders, attentive, and flexible, while those in Indiana and Ohio were predominately backward rustics trapped by inflexible folk tradition.

I think an implication of this study is that farmers (even those of rural America in the 1930s) are remarkably resilient and adaptive. Sudden and dramatic climate change induced a prompt and prudent response. An unexpected consequence was that an otherwise gradual process of technological development and adoption was given a kick start by the drought and the farmers' response. That pushed the technology beyond a tipping point and propelled the major Corn Belt states to the universal adoption of hybrid born by 1943. The country as a whole reached universal adoption by 1960.

While this process was driven by individual farmers and privately-owned seed companies, there was also a role played by the government. The USDA not only campaigned vigorously for hybrid corn from 1936 onward, but engaged in the years before 1936 in its own research, and subsidized the dissemination of knowledge and seed samples. That this engagement was to some extent promoted by the Secretary of Agriculture, Henry Agard Wallace, a hybrid researcher and the founder of the major commercial producer of hybrid seed, should not blind us from recognizing the importance of the government subsidizes in preparing the new technology for the leap forward.

Culver, John C.; and John Hyde. 2000. *American Dreamer: The Life and Times of Henry A. Wallace*, Norton, 2000.

Duvick, Donald N. 1992. "Genetic Contributions to Advances in Yield of U.S. Maize," *Maydica* (37) 1992: 69-79.

Griliches, Zvi. 1957. "Hybrid Corn: An Exploration in the Economics of Technological Change," *Econometrica* 25(4) October 1957: 501-522.

May, Edward. 1949. "The Development of Hybrid Corn in Iowa," *[Iowa] Agricultural Experiment Station Research Bulletin* 371(1) December 1949: 512-516.

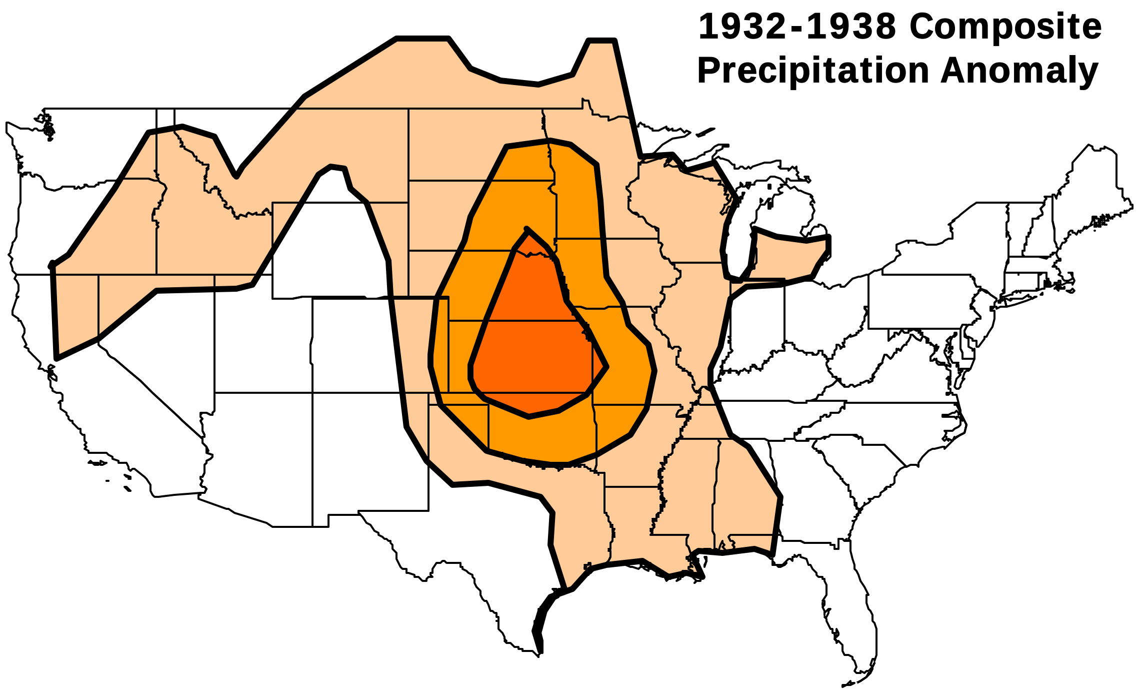
President's Great Plains Drought Area Committee, *Report*. August 27, 1936. http://newdeal.feri.org/Hopkins/hop27.htm.

Bryce, Ryan, and Neal Gross. 1950. "Acceptance and Diffusion of Hybrid Corn Seed in Two Iowa Communities," *[Iowa] Agricultural Experiment Station Research Bulletin* (372) January 1950.

Schubert, Siegfried D.; Max J. Suarez,; Philip J. Pegion; Randal D. Koster; and Julio T. Bacmeister. 2004. "On the Cause of the 1930s Dust Bowl," *Science* 303 (19 March 2004): 1855-1859.

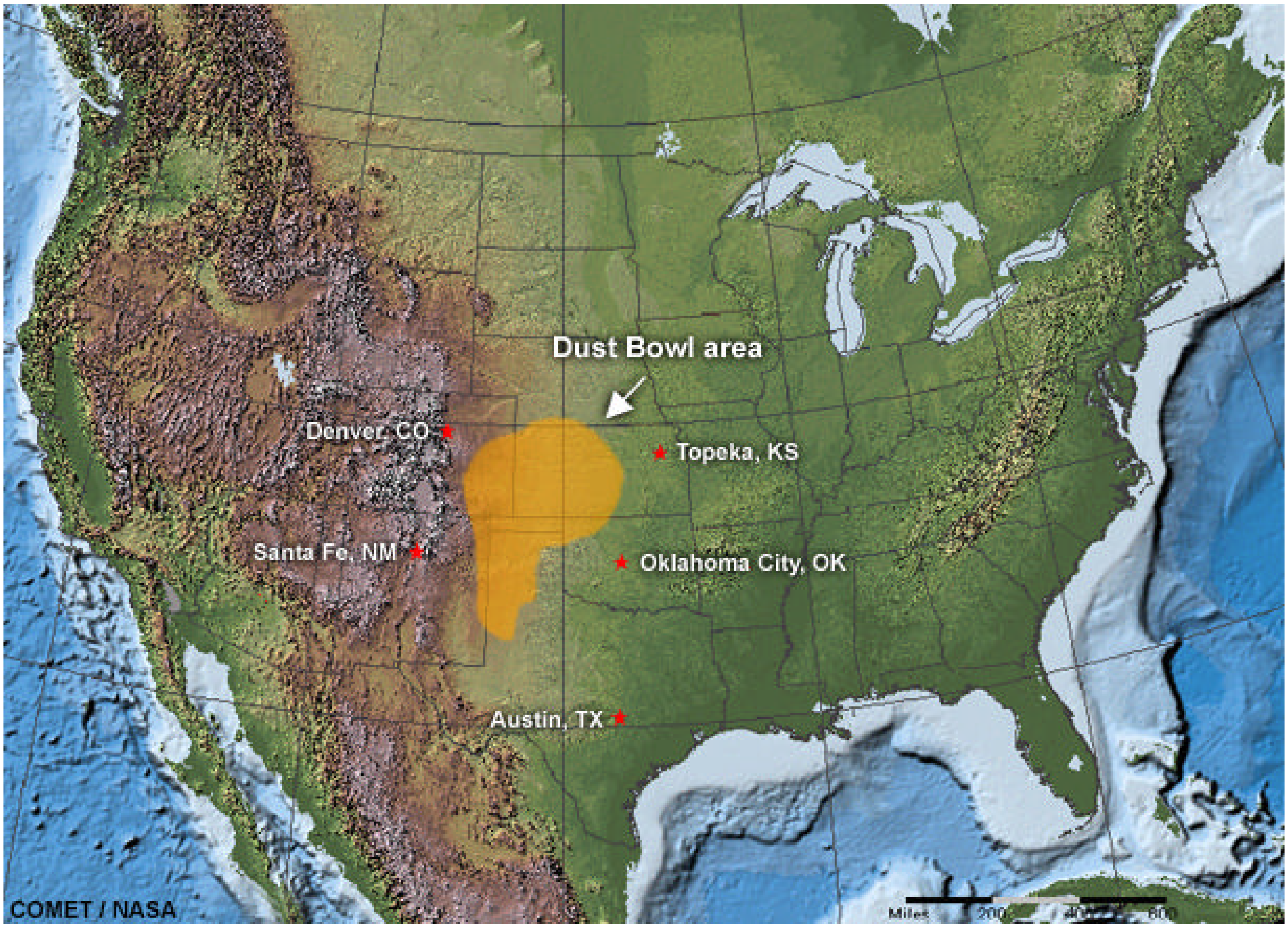
Sutch, Richard. 2008. "Henry Agard Wallace, The Iowa Corn Yield Tests, and the Adoption of Hybrid Corn," *National Bureau of Economic Research Working Paper*, Number 14141, June 2008.

University Corporation for Atmospheric Research, National Center for Atmospheric Research, http://www.meted.ucar.edu/index.htm



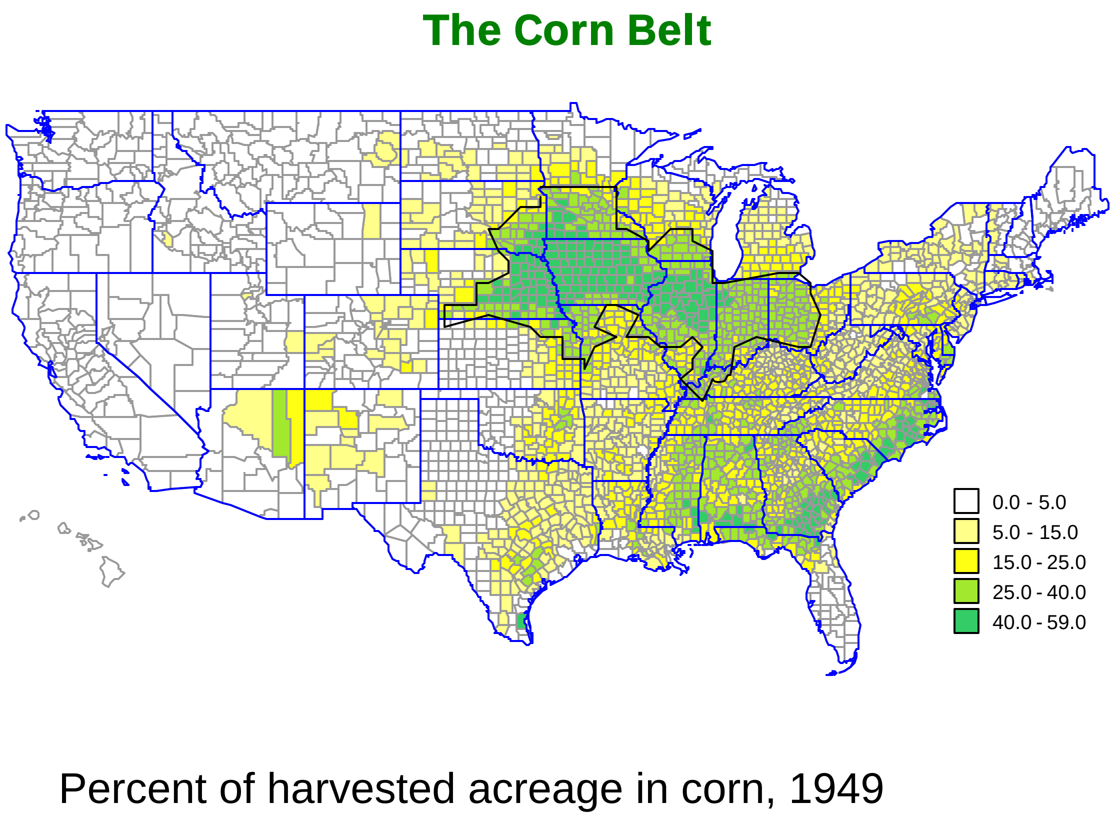
Based on Siegfried D. Schubert, Max J. Suarez, Philip J. Pegion , Randal D. Koster, and Julio T. Bacmeister "On the Cause of the 1930s Dust Bowl," ***Science*** **303, March 19, 2004, Figure 1, p. 1855.**

Figure 1



Source: National Atmospheric and Space Administration, University Corporation for Atmospheric Research, National Center for Atmospheric Research, http://www.meted.ucar.edu/index.htm

Figure 2



Source: Author's calculations based on the 1950 Census of Agriculture.

Figure 3

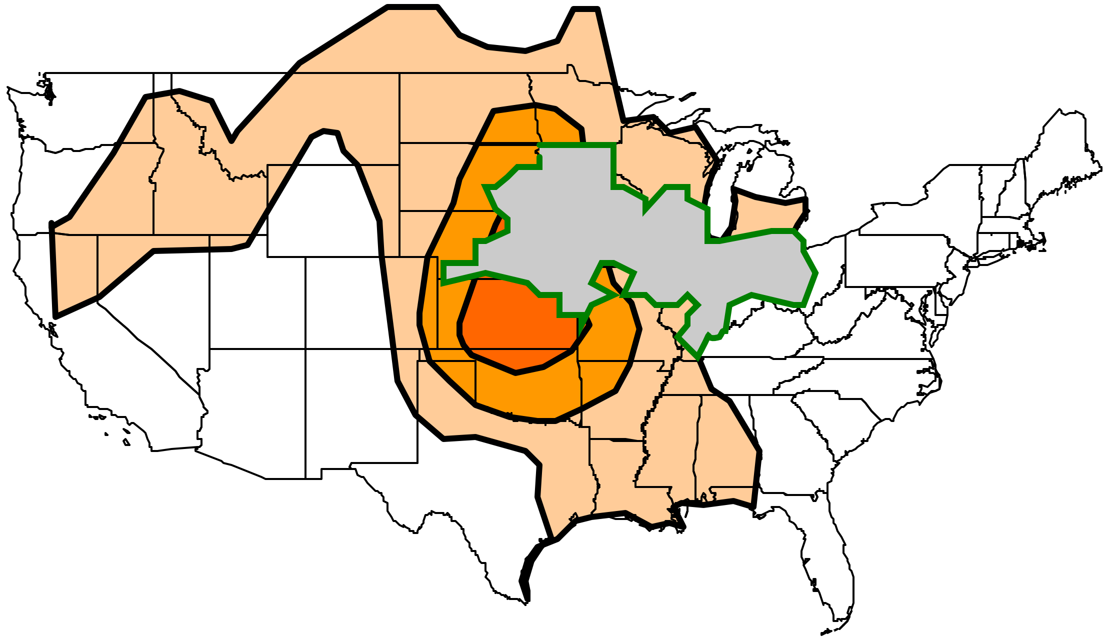


Figure 4

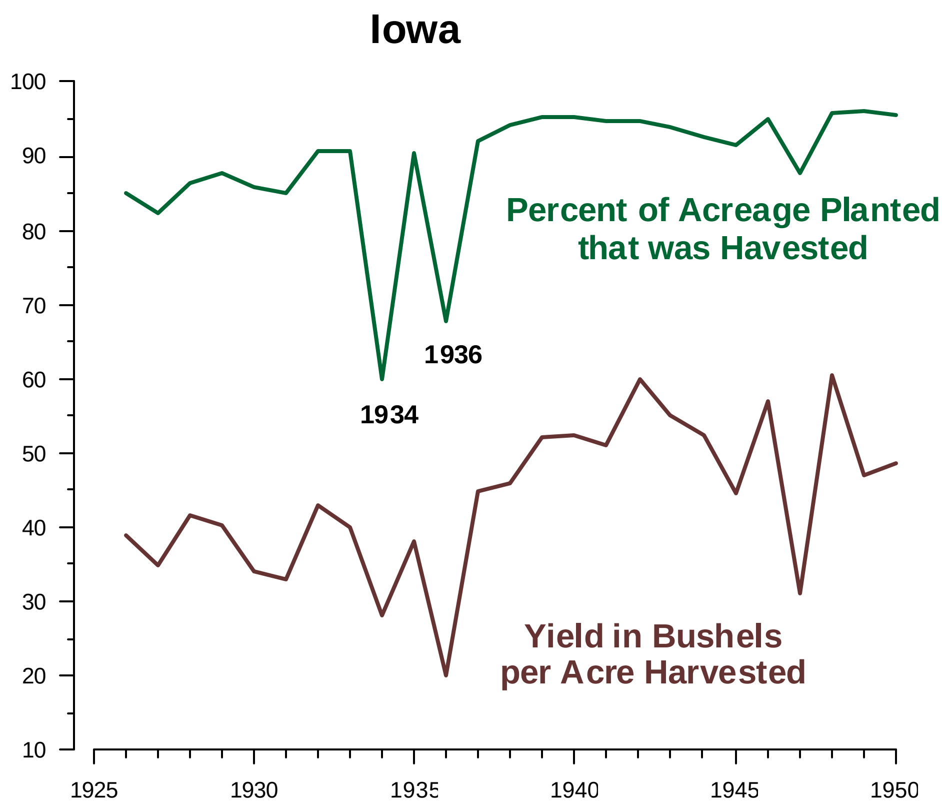
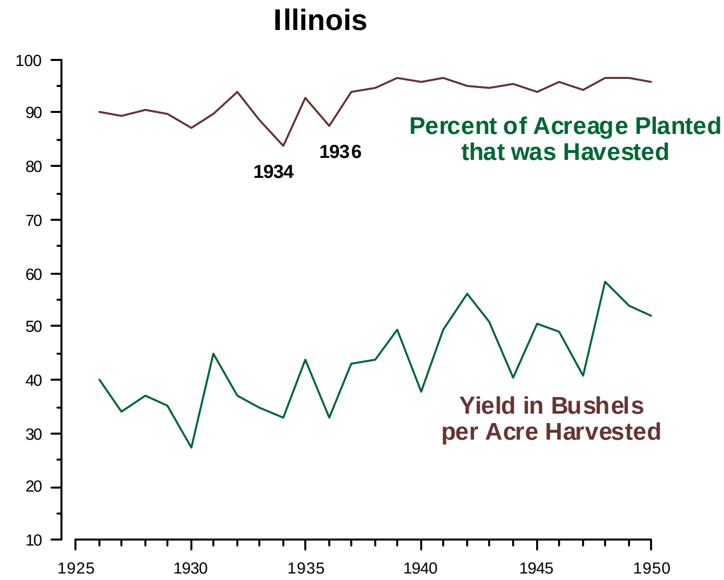

Iowa
100
90
80
70
60
50
40
30
20
10
1925
1930
1935
1940
1945
1950
Percent of Acreage Planted
that was Havested
1936
1934
Yield in Bushels
per Acre Harvested

Figure 5


Illinois
100
90
80
70
60
50
40
30
20
10
1925
1930
1935
1940
1945
1950
1934
1936
Percent of Acreage Planted
that was Havested
Yield in Bushels
per Acre Harvested

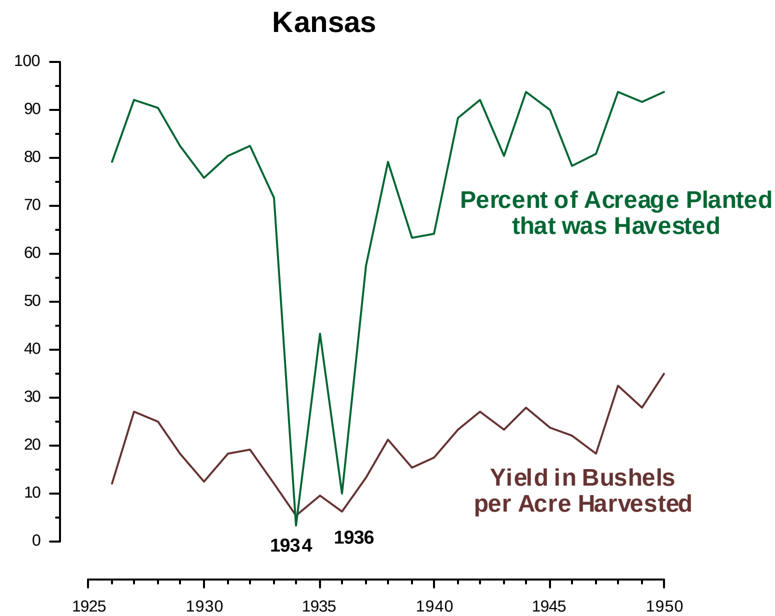

Kansas
100
90
80
70
60
50
40
30
20
10
0
1925
1930
1935
1940
1945
1950
1934
1936
Percent of Acreage Planted
that was Havested
Yield in Bushels
per Acre Harvested

Figure 6

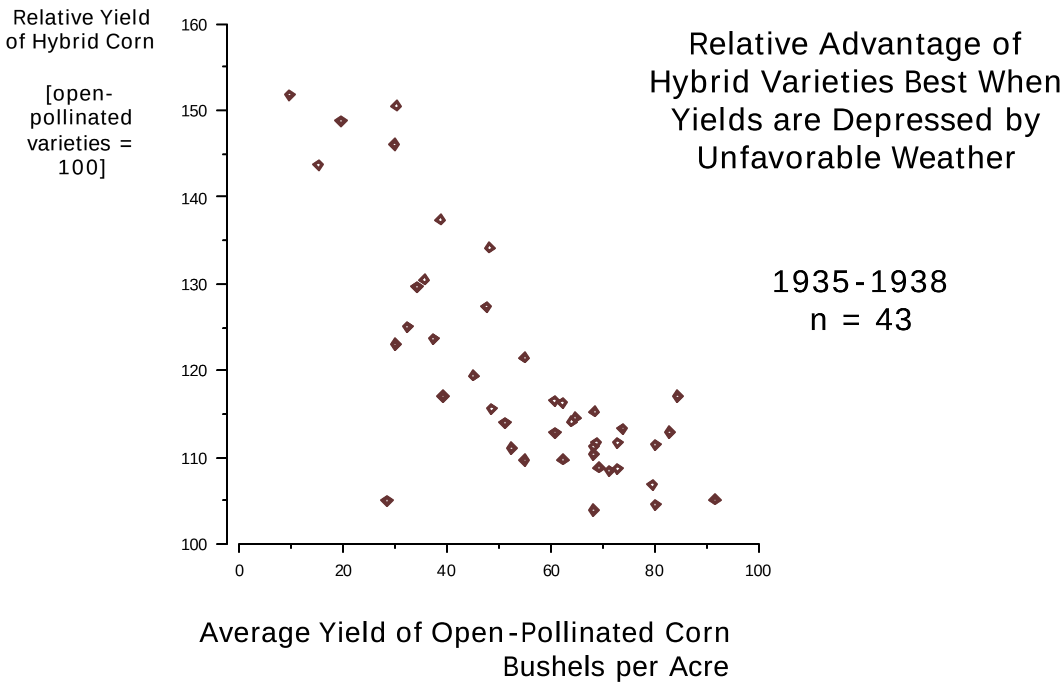

Relative Yield
of Hybrid Corn
[open-
pollinated
varieties =
100]
160
150
140
130
120
110
100
0
20
40
60
80
100
Relative Advantage of
Hybrid Varieties Best When
Yields are Depressed by
Unfavorable Weather
1935-1938
n = 43
Average Yield of Open-Pollinated Corn
Bushels per Acre

Figure 7

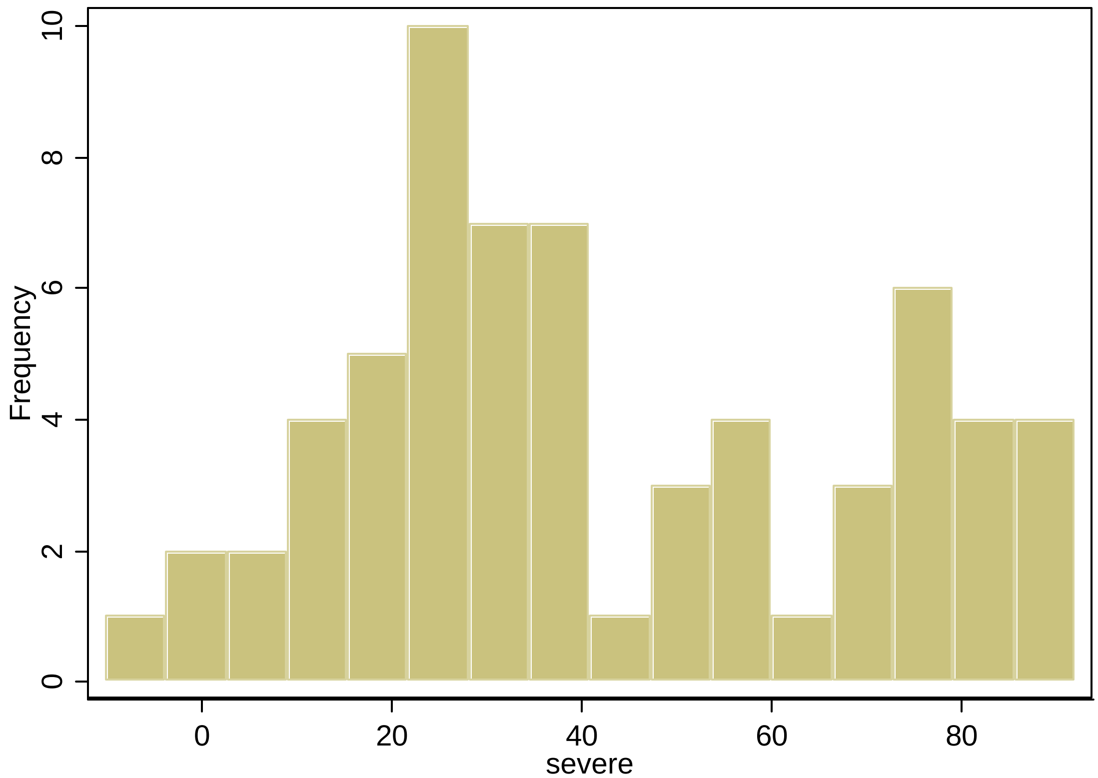


Figure 8

Regression

Dependent Variable is the Year that a 30-percent Adoption Rate was achieved, 64 Crop Districts in the Corn Belt

Number of observations = 64

	Coif.	Std. Err.	T	[95% Conf. Interval]	
yield	-.289	.0212	-13.7	[-.332	-.247]
severe	-.0182	.0053	-3.4	[-.0288	-.0076]
_cons	1949.2	.8	2315	[1947.5	1950.9]

R-squared = 0.7897

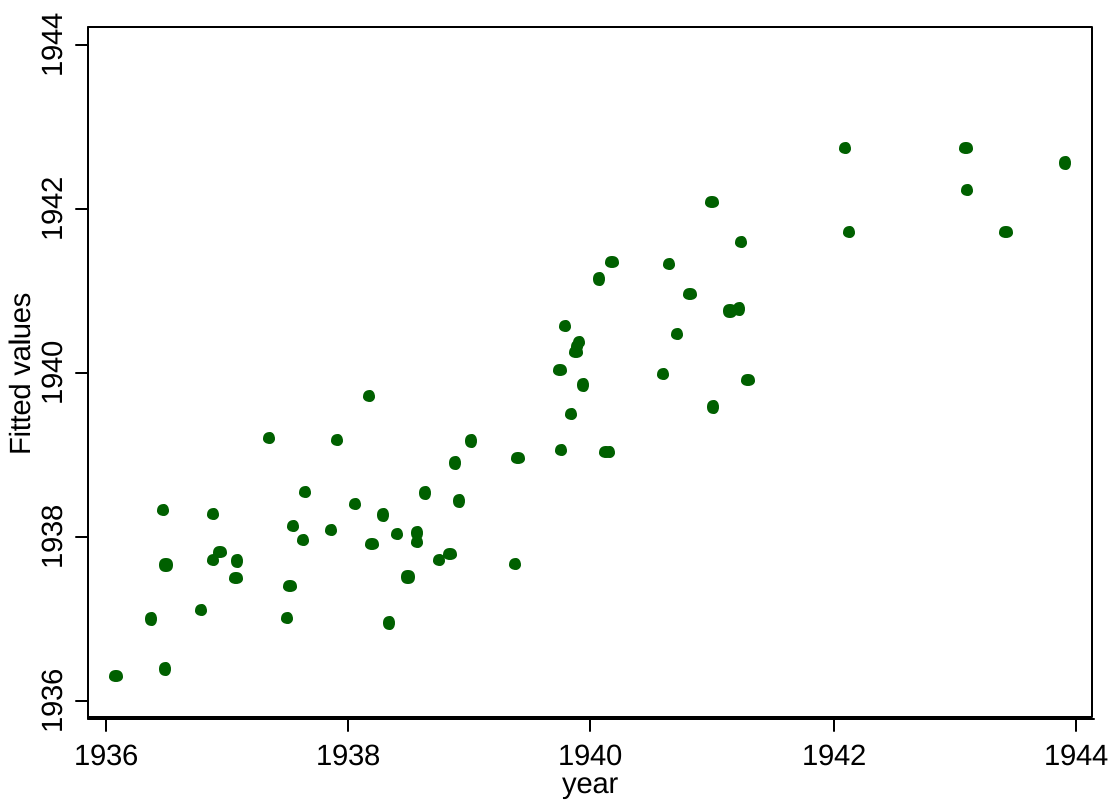
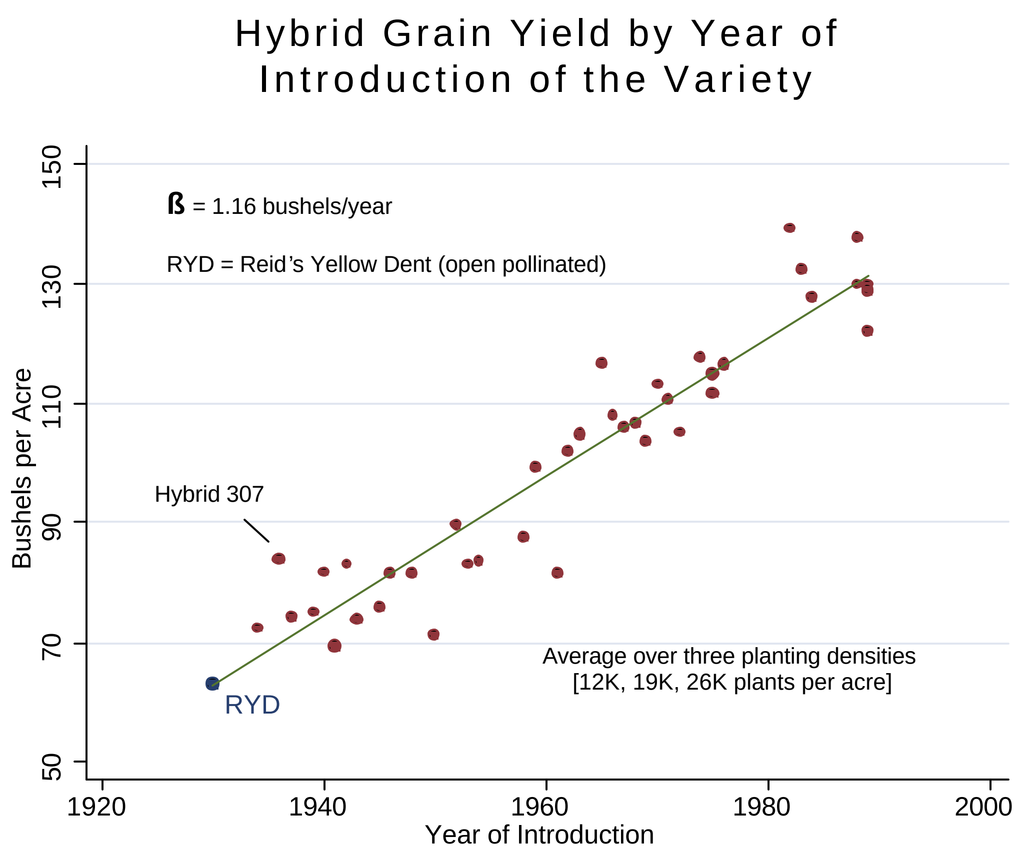


Figure 9



Source: Dan N. Duvick, "Genetic Contributions to Advances in Yield of U.S. Maize," *Maydica* (37) 1992: 69-79; Table 3, p. 73.

Figure 10

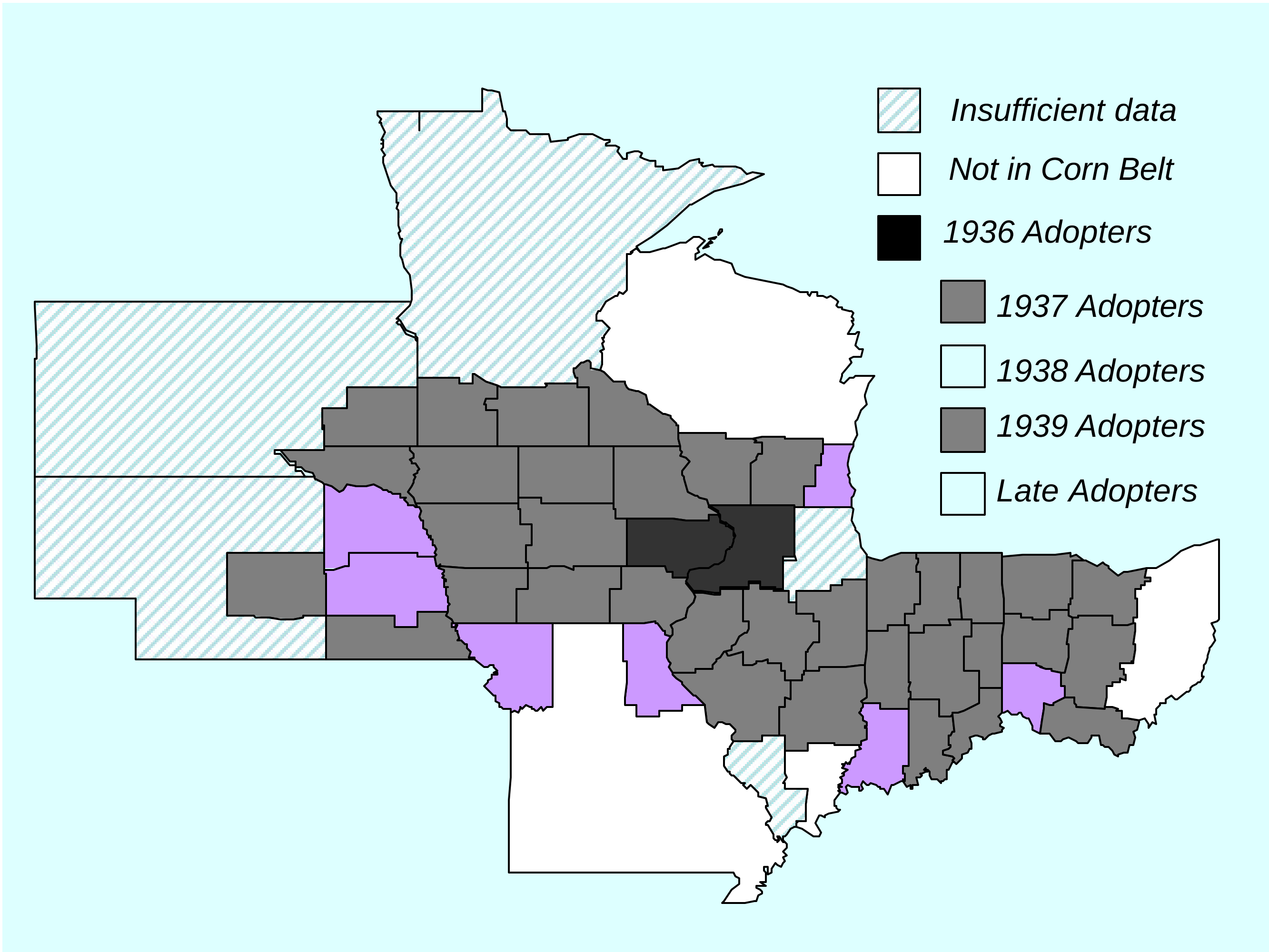

Insufficient data
Not in Corn Belt
1936 Adopters
1937 Adopters
1938 Adopters
1939 Adopters
Late Adopters

Figure 11