

Appendices

for "Protecting the Breadbasket with Trees? The Effect of the Great Plains Shelterbelt Project on Agriculture" by Tianshu Li

A Additional Results

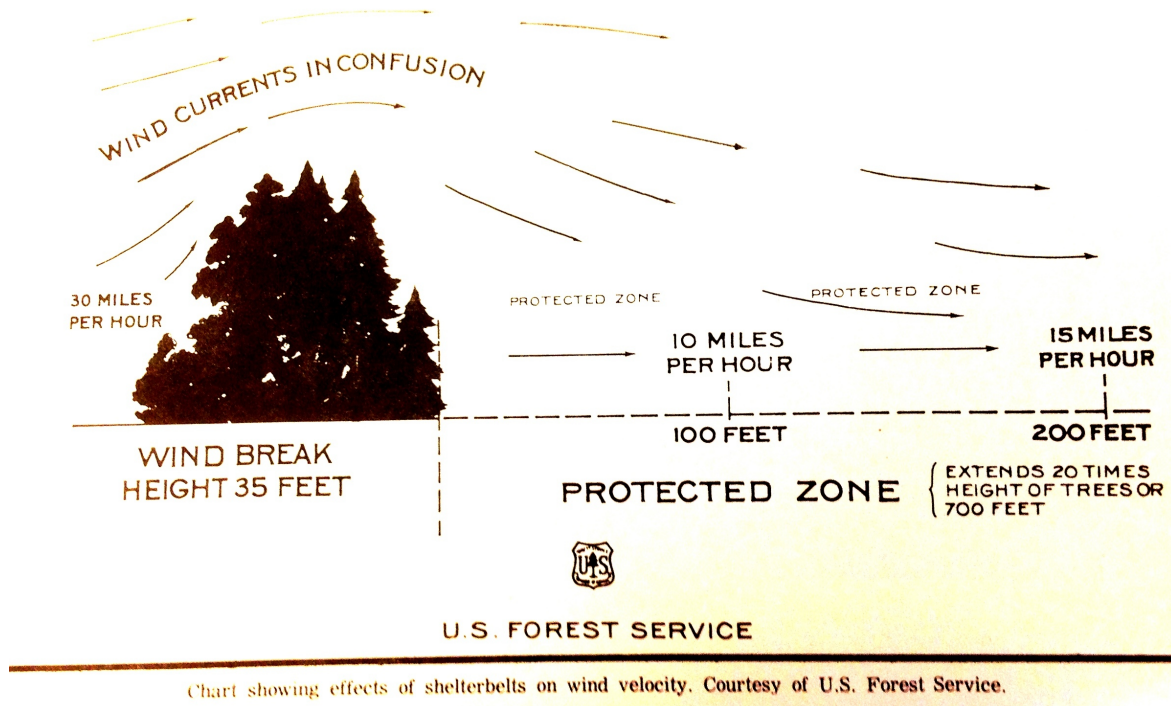
A.1 Heterogeneity by Different Erosion Levels

I examine the responsiveness to shelterbelt protection by different prior soil erosion levels during the 1930's Dust Bowl. The 2SLS regression results are shown in Appendix Table A.8 by four quartiles based on the fraction that was high- or medium-eroded at the county level.

Across all quartiles, it is consistent with the main results in Table 2 to have negative signs for the share of cropland in Column (1) since the 1950's and negative signs for crop revenue in Column (2) in earlier decades. However, only the results for the 2nd quartile are robust and statistically significant, which means that the counties with medium-low level of soil erosion are the most important drivers of the main results. As for the counties that were not quite suffered from the Dust Bowl in the lowest quartile, the effects of shelterbelts were limited and only statistically significant in the decrease in crop revenue in Column (2). This supports my hypothesis that this negative impact on crops is driven by the physical existence of shelterbelts impeding the adoption of subsequently appeared sprinkle irrigation appliances, irrespective of the region's low susceptibility to soil erosion. On the other hand, for the counties that were severely damaged during the Dust Bowl in the 3rd and 4th quartiles, the effects of shelterbelts were less obvious with mostly statistically insignificant results. Hence, it could be the case that the effects of shelterbelts were more indefinite for the region that had already been too damaged by wind erosion.

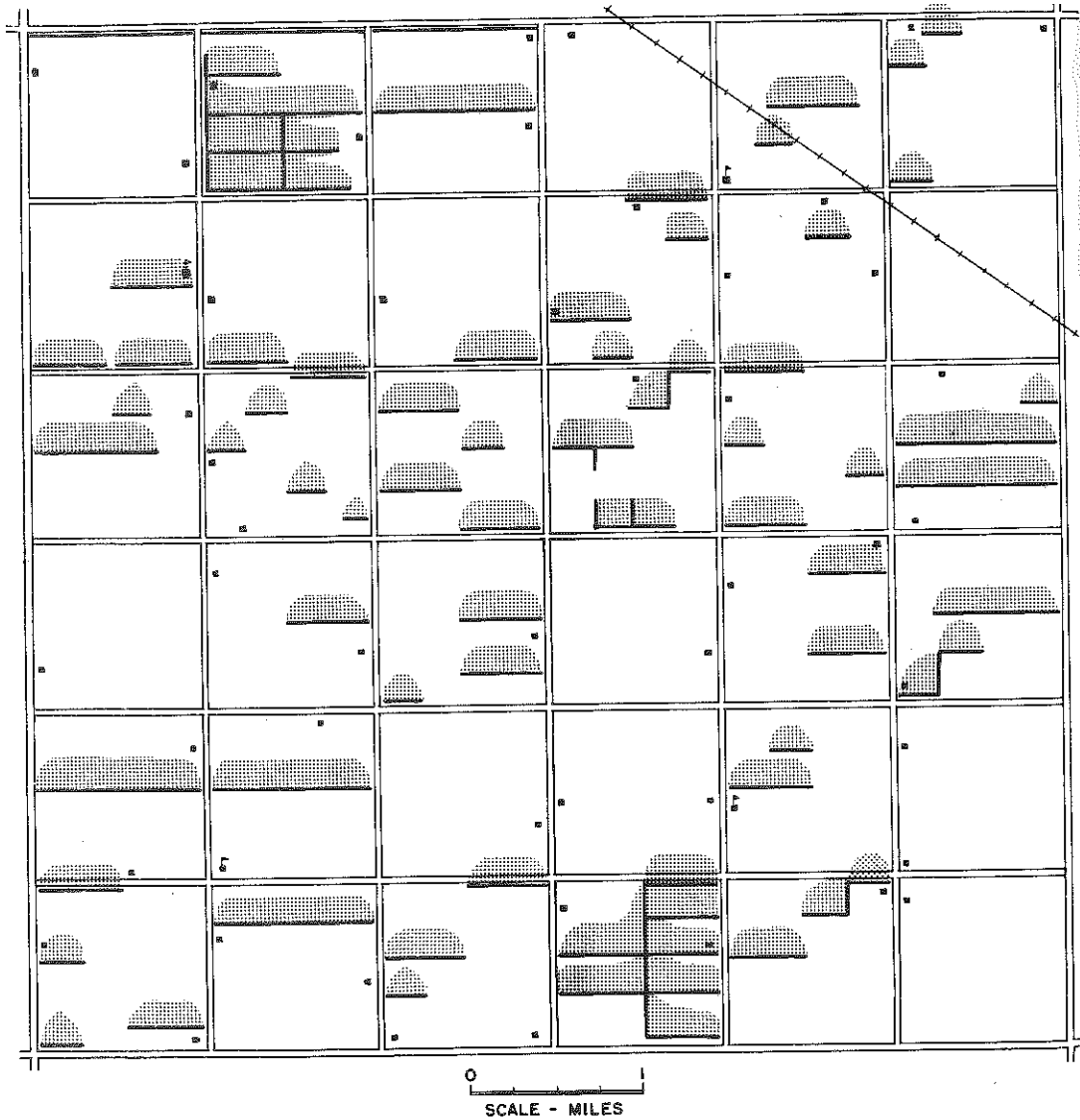
A.2 Other Figures and Tables

Figure A.1: The Effect of Windbreaks on Wind Velocity



(Source: US Forest Service; "Trees, Prairies, and People: A History of Tree Planting in the Plains States" by Wilmon Henry Droze (1977))

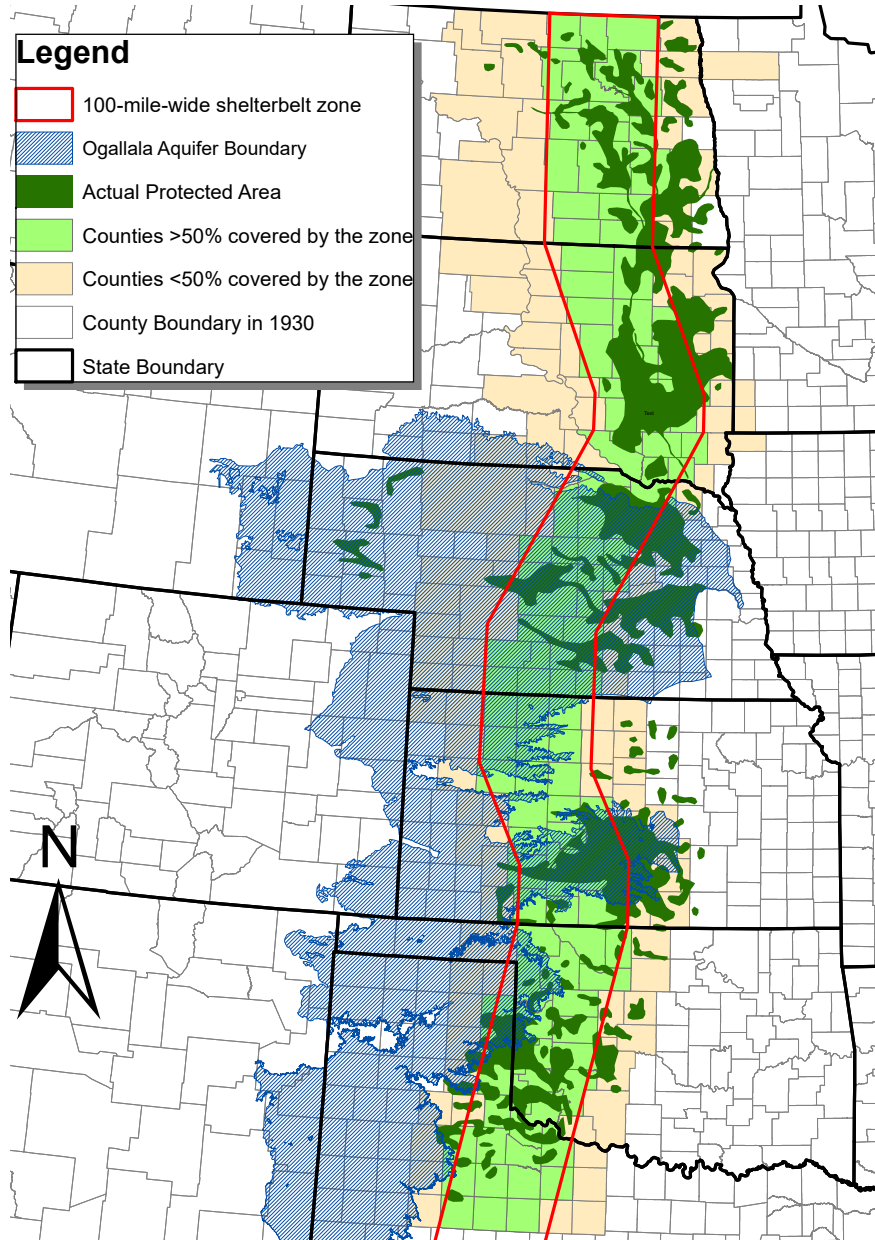
Figure A.2: An Example of Shelterbelt Planting



NOTE: Shaded areas show protected zone where wind velocity is reduced by 50%, assuming due south wind and 50 feet effective height.

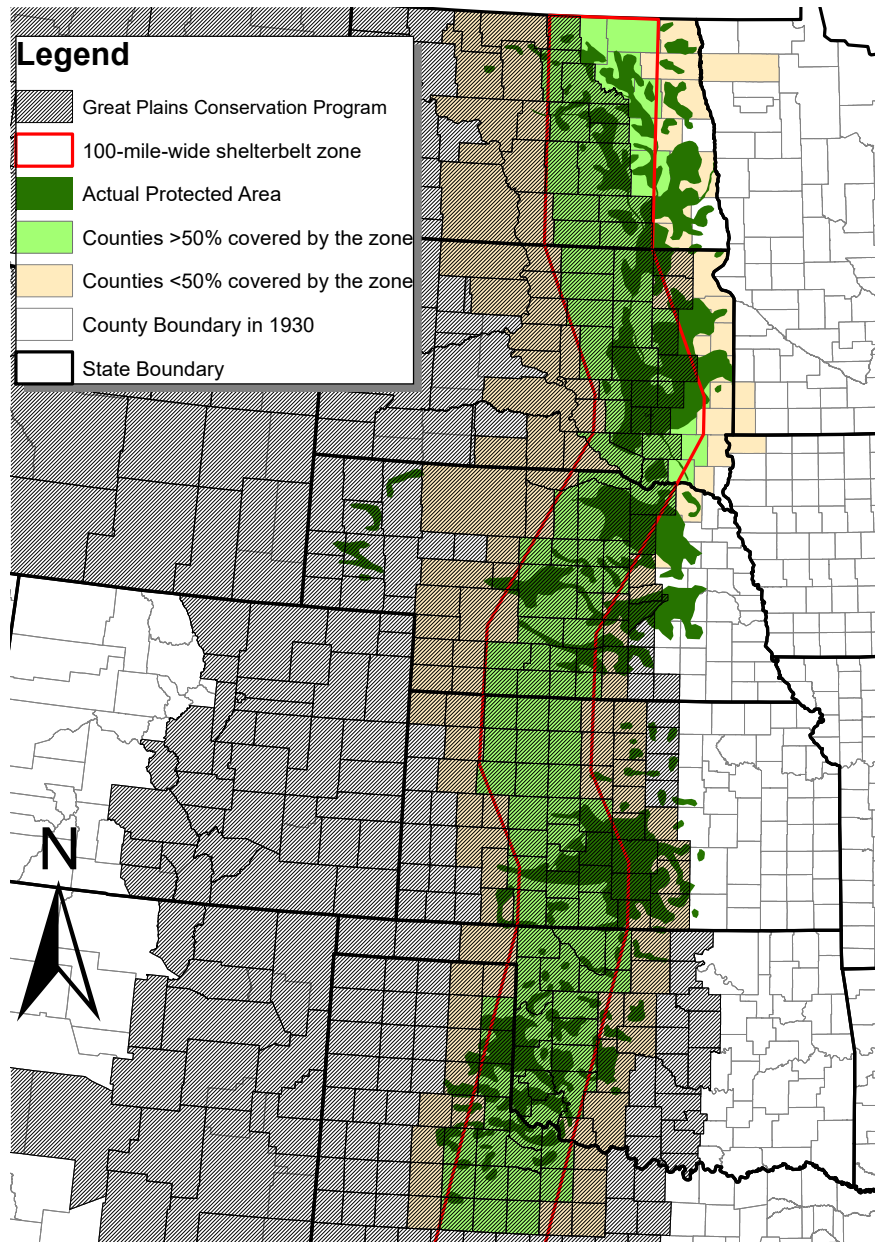
(Source: U.S. Forest Service; "Trees, Prairies, and People: A History of Tree Planting in the Plains States" by Wilmon Henry Droze (1977))

Figure A.3: The Location of the Ogallala Aquifer and the 100-mile-wide Belt



(Source: U.S. Geological Survey and U.S. Forest Service.)

Figure A.4: Designated Counties under the Great Plains Conservation Program



(Source: "The Great Plains conservation program", Washington, D.C.: U.S. Dept. of Agriculture, Soil Conservation Service, 1982; U.S. Forest Service.)

Table A.1: Windbreak Removal rates from the 1975 GAO report.

County	Number Standing	Number Removed	Percent Removed	Approximate Time Frame
Kansas	2,728	53	1.94	
Clay	18	-	-	1957-71
Pralt	687	11	1.60	1963-70
Reno	743	7	0.94	1963-71
Sedgwick	284	13	4.58	1963-70
Stafford	996	22	2.21	1963-70
Nebraska	4,060	245	6.03	
Holt	2,117	165	7.79	1967-74
Madison	1,240	41	3.31	1970-74
Merrick	560	20	3.57	1969-73
Seward	143	19	13.29	1965-70
Oklahoma	2,520	547	21.71	
Alfalfa	104	3	2.88	1961-73
Caddo	413	84	20.34	1935-72
Garfield	104	9	8.65	1961-73
Cranl	107	-	-	1954-73
Greer	663	140	21.12	1935-72
Kingfisher	263	10	3.80	1964-70
Washita	866	301	34.76	1935-74
Overall	9,308	845	9.08	

Source: Calculated from Orth (2004).

Table A.2: Comparison of Treated and Control Counties in 1930 (Cutoff at 40%)

Variables ⁱ⁾	More Treated			Less (or not) Treated			Difference ⁱⁱⁱ⁾
	Proportion within the 100-mile-wide shelterbelt zone >40%			Proportion within the 100-mile-wide shelterbelt zone <40%			
	Obs	Mean	s.d.	Obs	Mean	s.d.	
Proportion protected by shelterbelts	124	0.29	0.29	110	0.18	0.28	0.11 *
Other Right-hand-side Variables:							
Proportion medium-eroded ⁱⁱ⁾	124	0.43	0.36	110	0.36	0.33	0.07
Proportion high-eroded ⁱⁱ⁾	124	0.19	0.31	110	0.13	0.27	0.06
Proportion above the Ogallala Aquifer ⁱⁱ⁾	124	0.32	0.42	110	0.37	0.45	-0.05
Total precipitation in recent two years (mm)	124	1,121.59	167.33	110	1,110.24	242.79	11.35
Avg temperature in recent two years (°C)	124	10.63	4.31	110	9.64	3.99	0.99
Farmland/County area	124	0.91	0.08	110	0.89	0.09	0.02
Woodland/County area	124	0.01	0.02	110	0.02	0.04	-0.01
Cropland/Farmland	124	0.57	0.16	110	0.58	0.18	0.00
Population per 1,000 Acre	124	21.27	11.36	110	26.42	30.01	-5.15
Fraction of rural population	124	0.90	0.16	110	0.86	0.22	0.03
Fraction of farming population	124	0.62	0.11	110	0.58	0.17	0.04 *
No. of farms/1,000 Acre	124	2.64	1.23	110	2.63	1.52	0.01
Avg Farm Size (in Acre)	124	442.13	318.21	110	513.88	471.65	-71.75
Area of corn/Cropland	124	0.17	0.19	110	0.17	0.18	0.00
Area of wheat/Cropland	124	0.30	0.27	110	0.31	0.24	-0.01
Area of hay/Cropland	124	0.11	0.13	110	0.13	0.14	-0.02
Area of cotton/Cropland	124	0.13	0.25	110	0.05	0.13	0.08 *
Area of oat, barley, and rye/Cropland	124	0.12	0.11	110	0.16	0.12	-0.04 *
No. of cows/1,000 Acre	124	52.02	17.30	110	54.18	24.24	-2.16
No. pigs/1,000 Acre	124	50.87	62.07	110	59.42	77.93	-8.55
No. of chickens/1,000 Acre	124	239.62	155.96	110	247.92	193.95	-8.30

Note: i) Main data source from the USDA Census of Agriculture and Population. See Appendix B for more detailed definition of variables.

ii) Soil erosion data from Hornbeck (2012); data on the Ogallala Aquifer from Hornbeck and Keskin (2014).

iii) * means t-test with p-value<0.05.

Table A.3: The Effects of Shelterbelt-planting on Land Use and Revenue (OLS)

Variables	Cropland / (Cropland+Pasture)	log(Revenue from Crops / Farmland)	log(Revenue from Animal Products / Farmland)	log(Total revenue per acre)
	(1)	(2)	(3)	(4)
Prop. protected by shelterbelts *	-0.0217*	-0.353***	0.0177	-0.238***
1945-50	(0.0124)	(0.0770)	(0.0512)	(0.0493)
1954-59	-0.0507***	-0.440***	0.0620	-0.232***
1964-69	(0.0163)	(0.109)	(0.0762)	(0.0658)
1978-82	-0.0774***	-0.459***	0.0814	-0.193**
1987-92	(0.0193)	(0.116)	(0.111)	(0.0769)
	-0.0874***	-0.380***	0.151	-0.132
	(0.0235)	(0.128)	(0.163)	(0.0992)
	-0.0843***	-0.319**	0.250	-0.0724
	(0.0230)	(0.131)	(0.192)	-0.114
All control variables as in Table 2 ⁱ⁾	Yes	Yes	Yes	Yes
Observations	2,433	2,568	2,568	2,574
Number of counties	234	234	234	234

Note: i) "All control variables as in Table 2" include proportions of high- and medium- eroded areas, Proportion above the Ogallala Aquifer, rainfall and temperature, county- and year- fixed effects, outcome variables and all the other variables listed in Table 1 from 1910-30.

ii) Standard errors clustered at county level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A.4: Comparison of Other Reported Conservation Practices

Variable ⁱ⁾	Year	More Treated Proportion within the 100-mile- wide shelterbelt zone >50%			Less (or not) Treated Proportion within the 100-mile- wide shelterbelt zone <50%			Difference ⁱⁱ⁾
		Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	
Panel A: Agro-Ecological Suitability Value (rainfed, low input) ⁱⁱⁱ⁾								
for Cereal		117	2.7672	0.7122	117	2.8606	0.8520	-0.0933
for Alfalfa		117	6.3541	1.9633	117	6.0161	2.5436	0.3381
Panel B: Other Conservation Practices ^{iv)}								
Land in Strip Cropping (%)	1959	117	1.3329	1.8168	116	1.9908	2.3236	-0.6579 *
	1964	117	1.3945	1.8056	116	2.3410	3.1135	-0.9465 *
	1969	117	0.9452	1.3184	116	1.7837	2.9045	-0.8385 *
Cropland in Cover Crops (%)	1969	117	0.4204	0.4009	117	0.4708	0.9550	-0.0504
	1978	111	1.0706	0.5955	107	0.9800	0.5798	0.0906
	1982	110	0.7322	0.4853	100	0.6352	0.4231	0.0971
	1987	117	2.4895	1.3794	115	2.0768	1.4149	0.4126 *
	1992	113	2.5237	1.4357	111	2.2876	1.5295	0.2361
Cropland in Conservation Reserve Program (%)	1987	106	1.4492	1.3188	105	1.2667	1.1692	0.1825
	1992	117	1.2578	0.6525	116	1.2572	0.8211	0.0006
Cropland diverted under Acreage Adjustment Program (%)	1978	117	3.8777	1.9746	117	3.8580	2.4082	0.0197
	1982	117	2.1071	1.4170	115	1.9127	1.3694	0.1944
	1987	106	7.8889	3.9841	105	8.4325	4.7086	-0.5437
Land in Diverted Commodity Program (%)	1992	116	4.2483	2.7861	117	3.5774	2.6847	0.6708
Cropland in Summer Fallow (%)	1959	117	7.5012	7.6154	117	6.8438	7.8348	0.6574
	1964	117	9.6763	9.1578	117	9.0131	9.0902	0.6633
	1969	117	11.0191	9.7248	117	10.9012	9.6863	0.1179
	1978	116	7.8485	8.2327	116	7.8868	8.1849	-0.0382
	1982	112	6.6915	7.0554	111	7.0035	7.5155	-0.3120
	1987	115	8.5998	7.5301	111	9.3606	7.7842	-0.7608
	1992	110	5.8949	6.8785	116	6.1413	7.0556	-0.2463

Note: i) All variables weighted by the county's farmland area.

ii) * means t-test with p-value<0.05.

iii) Source: Global Agro-Ecological Zones by Food and Agriculture Organization of the United Nations (FAO) and the International Institute for Applied Systems Analysis (IIASA).

iv) Source: USDA Census of Agriculture. All variables in Panel B are divided by the county's farmland area for normalization.

Table A.5: The Effects of Shelterbelt-planting Controlling New Deal Payments (2SLS)

Variables	Cropland / (Cropland+Pasture)	log(Revenue from Crops / Farmland)	log(Revenue from Animal Products / Farmland)	log(Total revenue per acre)
	(1)	(2)	(3)	(4)
Prop. protected by shelterbelts *	-0.0161	-0.764***	0.131	-0.563***
1945-50	(0.0350)	(0.280)	(0.182)	(0.188)
1954-59	-0.145***	-1.196***	0.668**	-0.513**
1964-69	(0.0491)	(0.399)	(0.308)	(0.209)
1978-82	-0.261***	-1.051***	0.892**	-0.0423
1987-92	(0.0648)	(0.385)	(0.423)	(0.261)
	-0.324***	-0.777*	1.264**	0.393
	(0.0788)	(0.397)	(0.591)	(0.380)
	-0.302***	-0.600	1.295**	0.472
	(0.0745)	(0.414)	(0.656)	(0.431)
All control variables as in Table 2 ⁱ⁾	Yes	Yes	Yes	Yes
New Deal payments (1933–39) ⁱⁱ⁾	Yes	Yes	Yes	Yes
Observations	2,433	2,568	2,568	2,574
Number of counties	234	234	234	234

Note: i) "All control variables as in Table 2" include proportions of high- and medium- eroded areas, Proportion above the Ogallala Aquifer, rainfall and temperature, county- and year- fixed effects, outcome variables and all the other variables listed in Table 1 from 1910-30.

ii) "New Deal payments (1933–39)" are per capita measures at the county level divided into five categories: payments for the Agricultural Adjustment Act, public work spending, relief spending, New Deal loans, and mortgage loans guaranteed. Per capita amount in each category is interacted with each post-treatment year dummy to account for its long-term effect. Data come from Hornbeck (2012).

iii) Standard errors clustered at county level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.6: The Effects of Shelterbelt-planting and the Great Plains Conservation Program (2SLS)

Variables	Cropland /	log(Revenue from	log(Revenue from	log(Total revenue
	(Cropland+Pasture)	Crops / Farmland)	Animal Products /	per acre)
	(1)	(2)	(3)	(4)
Prop. protected by shelterbelts *	-0.0352	-0.820***	0.131	-0.569***
1945-50	(0.0313)	(0.270)	(0.178)	(0.181)
1954	-0.110***	-1.158***	0.622**	-0.649***
1959	(0.0411)	(0.367)	(0.263)	(0.231)
1964-69	-0.132***	-1.131**	0.730*	-0.314
1978-82	(0.0448)	(0.485)	(0.380)	(0.231)
1987-92	-0.217***	-0.938**	0.941**	0.0289
1954-59	(0.0514)	(0.373)	(0.432)	(0.260)
1964-69	-0.250***	-0.564	1.117*	0.497
1978-82	(0.0644)	(0.390)	(0.584)	(0.382)
1987-92	-0.241***	-0.398	1.020	0.537
1954-59	(0.0643)	(0.405)	(0.649)	(0.428)
GPCP Designation*	-0.0188*	-0.152	0.0896	-0.00998
1959-69	(0.0102)	(0.0936)	(0.0893)	(0.0497)
1978-82	-0.0380**	-0.258***	0.356***	-0.0417
1987-92	(0.0150)	(0.0897)	(0.137)	(0.0966)
1954-59	-0.0471***	-0.288***	0.556***	-0.0165
1978-82	(0.0161)	(0.0934)	(0.155)	(0.0997)
All control variables as in Table 2 ⁱ⁾	Yes	Yes	Yes	Yes
Observations	2,433	2,568	2,568	2,574
Number of counties	234	234	234	234

Note: i) "All control variables as in Table 2" include proportions of high- and medium- eroded areas, Proportion above the Ogallala Aquifer, rainfall and temperature, county- and year- fixed effects, outcome variables and all the other variables listed in Table 1 from 1910-30.

ii) Standard errors clustered at county level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A.7: The Effects of Shelterbelt-planting on Labor and Capital (2SLS)

Variables	log(Rural Population Density)	log(Value of Equipment per Acre)	Share of Farmland in the County	Share of Woodland in the County
	(1)	(2)	(3)	(4)
Prop. protected by shelterbelts *	-0.104	-0.437**	-0.0118	0.0257
1945-50	(0.137)	(0.192)	(0.0618)	(0.0183)
1954-59	-0.109		0.0108	0.00617
1964-69	(0.198)		(0.0546)	(0.0131)
1964-69	-0.0941	-0.312*	-0.0103	0.0148
1978-82	(0.251)	(0.187)	(0.0510)	(0.0109)
1978-82	-0.351	-0.418*	-0.0318	0.00613
1987-92	(0.279)	(0.233)	(0.0615)	(0.00904)
1987-92		-0.0644	-0.0463	0.0103
		(0.241)	(0.0686)	(0.00936)
Year and County Dummies	Yes	Yes	Yes	Yes
Outcome Variables in 1910-30	Yes	Yes	Yes	Yes
Other Control Variables ⁱⁱⁱ⁾	Yes	Yes	Yes	Yes
Erosion from the Dust Bowl ⁱⁱⁱ⁾	Yes	Yes	Yes	Yes
Proportion above the Ogallala Aquifer ⁱⁱⁱ⁾	Yes	Yes	Yes	Yes
Observations	1,170	1,170	2,574	2,310
Number of counties	0.866	0.994	0.513	0.526
R-squared	234	234	234	234

Note: i) Data for rural population only exist decennially, and is missing for 1990.

ii) log(Value of Equipment per Acre) in Column (2) is missing in the 1950s, 1964, and the 1980s.

iii) "Other Control Variables" include rainfall and temperature for each year and all the other variables listed in Table 1 from 1910-30;

"Erosion from Dustbowl" from Hornbeck (2012) include proportions of high- and medium-eroded regions as in Table 1;

"Proportion above the Ogallala Aquifer" is from Hornbeck and Keskin (2014).

iv) Outcome variables in 1910-30, other control variables, erosion from the Dust Bowl, and proportion above the Ogallala Aquifer are all interacted with year-dummies.

Table A.8: Heterogeneous Effects of Shelterbelt-planting by Quartiles of Wind Erosion (2SLS)

Variables	Cropland / (Cropland+Pasture)	log(Revenue from Crops / Farmland)	log(Revenue from Animal Products / Farmland)	log(Total revenue per acre)
	(1)	(2)	(3)	(4)
Prop. protected by shelterbelts				
x Q1 for high/medium eroded ⁱⁱⁱ⁾	0.0680	-0.947**	-0.145	-0.640**
1945-50	(0.0743)	(0.451)	(0.295)	(0.261)
1954-59	-0.0407	-1.505**	0.224	-0.572*
	(0.0987)	(0.640)	(0.511)	(0.294)
1964-69	-0.142	-0.461	0.749	0.266
	(0.131)	(0.614)	(0.738)	(0.379)
1978-82	-0.223	-0.700	1.995*	0.934
	(0.155)	(0.655)	(1.080)	(0.581)
1987-92	-0.166	-0.727	1.909	0.977
	(0.151)	(0.667)	(1.204)	(0.672)
x Q2 for high/medium eroded ⁱⁱⁱ⁾	-0.0577	-0.826**	0.231	-0.668***
1945-50	(0.0398)	(0.330)	(0.204)	(0.232)
1954-59	-0.135**	-0.590	0.828**	-0.395*
	(0.0584)	(0.387)	(0.369)	(0.223)
1964-69	-0.228***	-0.288	1.175**	0.268
	(0.0768)	(0.426)	(0.478)	(0.269)
1978-82	-0.273***	-0.0456	1.638***	0.814**
	(0.104)	(0.413)	(0.602)	(0.373)
1987-92	-0.232***	0.113	1.557**	0.719*
	(0.0873)	(0.421)	(0.618)	(0.390)
x Q3 for high/medium eroded ⁱⁱⁱ⁾	-0.104	-0.699	0.457	-0.403
1945-50	(0.115)	(0.458)	(0.381)	(0.327)
1954-59	-0.225	-1.036	1.317*	-0.268
	(0.175)	(0.632)	(0.699)	(0.381)
1964-69	-0.348	-1.544*	1.402	-0.138
	(0.241)	(0.814)	(0.934)	(0.509)
1978-82	-0.414	-0.832	0.913	0.0954
	(0.319)	(0.722)	(1.130)	(0.687)
1987-92	-0.420	-0.573	1.368	0.354
	(0.281)	(0.741)	(1.339)	(0.798)
x Q4 for high/medium eroded ⁱⁱⁱ⁾	-0.158	-0.738	0.457	-0.455
1945-50	(0.175)	(0.613)	(0.494)	(0.427)
1954-59	-0.336	-1.316	1.182	-0.560
	(0.272)	(0.902)	(0.921)	(0.509)
1964-69	-0.506	-2.350**	1.108	-0.591
	(0.369)	(1.155)	(1.285)	(0.710)
1978-82	-0.607	-1.380	-0.121	-0.560
	(0.470)	(1.017)	(1.688)	(0.996)
1987-92	-0.620	-1.016	-0.0688	-0.445
	(0.415)	(1.031)	(1.979)	(1.137)
Observations	2,433	2,568	2,568	2,574
Number of counties	234	234	234	234

Note: i) All columns control for proportions of high- and medium- eroded areas, proportion above the Ogallala Aquifer rainfall and temperature, county- and year- fixed effects, outcome variables and all other variables listed in Table 1 in 1910-30

ii) Standard errors clustered at county level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

iii) Quartiles are based on the total fraction of a county that was high- and medium-eroded during the Dust Bowl.

Q1 is below 16.8%; Q2 is between 16.8% and 58.2%; Q3 is between 58.2% and 99.9%; Q4 is above 99.9%.