The Park Place Economist

Volume 28 | Issue 1 Article 14

September 2021

Agricultural Conservation Practice Adoption Across Midwest Counties: A Review and Analysis of Determinants

David Werner
Illinois Wesleyan University

Agricultural Conservation Practice Adoption Across Midwest Counties: A Review and Analysis of Determinants

Abstract

The environmental degradation contemporary Midwestern agricultural practices cause through negative externalities are immense; these realities have led to a greater focus on the introduction of conservation practices. Such practices are sustainable both for the farm operator and the environment, allowing for increased productivity while protecting the environment from undue harm. Focusing on over a thousand counties across the 12 Midwestern states, this paper analyzes various county farm level, producer level, and information level factors that influence conservation practice adoption. Constructing Midwestern farmers as a bounded, rational actor under the bounded rationality theory, results reflect the importance of information in the adoption of these practices. Most notably, counties with a higher proportion of young producers, internet access, and farmers whose primary occupation is farming are found to be significantly more likely to adopt conservation practices. Additionally, farms with colonies of honeybees, representing environmental consciousness among farmers, are found to be significantly more likely to adopt conservation practices studied. These results indicate the need to incentivize younger Americans to work in the agricultural sector and the need to better educate farmers on the importance of environmental sustainability.

AGRICULTURAL CONSERVATION PRACTICE ADOPTION ACROSS MIDWEST COUNTIES: A REVIEW AND ANALYSIS OF DETERMINANTS

David Werner

Illinois Wesleyan University

Economics Senior Paper

‘

Introduction

Despite contributing less than 1% to GDP in the United States, agriculture remains an important sector whose practices have immense impacts on the rest of the economy and society.[1] More than in many developed countries, agriculture in the United States relies heavily on industrial practices.[2] Such practices are marked by their scale and intensity; crops are predominantly grown separately in rows and synthetic pesticides, herbicides, fungicides, and fertilizers are used liberally.[3] Livestock production is similarly industrialized, with the injection of antibiotics and growth hormones into animals in overcrowded facilities a reality across the country.[4] Industrialization has, historically, gone hand-in-hand with the growth of larger and larger farms; according to Patron-Cano, "[t]he average US farm size nearly doubled in acreage between 1982 and 2007 from 589 to 1,105 acres."[5]

These practices are a response to, and in many cases the cause of, contemporary export-oriented production, under which food is, above all, a commodity. As Varble et al. (2015) describe, "[t]he export driven model of globalized agriculture requires huge increase[s] in transport infrastructures —roads, ports, airports, energy grids—often constructed at the expense of nature and in defiance of global energy shortages."[6] The justification of such globalized agricultural production is the need to produce enough food for an ever-growing population. But these intensified operations consume fossil fuel, water, and topsoil at unprecedented rates and create an enormous amount of waste.[7,] Such practices lead to an overabundance of nutrients in

[1] U.S. Bureau of Economic Analysis, "Value Added by Private Industries: Agriculture, Forestry, Fishing, and Hunting as a Percentage of GDP," *FRED, Federal Reserve Bank of St. Louis*, (2020), October 8, 2020, https://fred.stlouisfed.org/series/VAPGDPAFH.
[2] Tony Weis, "Breadbasket contradictions: The unstable bounty of industrial agriculture in the United States and Canada," in *Food Security, Nutrition and Sustainability* (2010): 27-40.
[3] Gerardo Patron-Cano, "Modern capitalism and food commoditization: The limitations of industrial agriculture and the challenges of sustainable alternatives," *University of Denver* (2015).
[4] Weis, "Breadbasket contradictions," 29.
[5] Patron-Cano, "Modern capitalism and food commoditization."
[6] Sarah Varble, Silvia Secchi, and Caroline Gottschalk Druschke, "An examination of growing trends in land tenure and conservation practice adoption: Results from a farmer survey in Iowa," *Environmental Management* 57, no. 2 (2016): 318-330, https://doi.org/10.1007/s00267-015-0619-5.
[7] Brenda B. Lin et al., "Effects of industrial agriculture on climate change and the mitigation potential of small-scale agro-ecological farms." *Animal Science Reviews* no. 69 (2012), https://doi.org/10.1079/PAVSNNR20116020.

waterways, large vats of animal waste and byproducts that leak into surrounding soils and groundwater, and carbon emissions that account for about 10% of total global anthropogenic emissions.[8] Looking further along the supply chain reveals a large amount of food waste, which raises serious doubt to the legitimacy of industrial agriculture's claim in efficiently "feeding the world".[9,10]

In regard to the climate crisis, industrial agriculture has been established as a serious perpetrator. However, because of agriculture's dependent relationship on the climate and weather phenomena, it is also a victim to the irregularities brought about by the climate crisis.[11] The need for contemporary agriculture to become more environmentally sustainable is necessary both to minimize its own impacts on the environment and to best adapt to the realities of a changing climate. Sustainable agriculture — referred in the literature as climate-smart agriculture and best management practices (BMPs) — address the problems caused by contemporary industrial agriculture through the use of diverse conservation practices. Many of these practices increase biodiversity, productivity, and decrease carbon emissions.[12,13,14]

Of the varied factors that influence adoption of these practices, information factors are hypothesized to have the most significant impacts on adoption. Following bounded rationality theory, it is believed that without adequate information regarding the feasibility and benefits of adoption, many farmers will continue to produce food in the way they have been.

---

[8] Ibid.

[9] Kevin D. Hall et al., "The Progressive Increase of Food Waste in America and Its Environmental Impact," *PloS one* 4, no. 11 (2009): e7940–e7940, https://doi.org/10.1371/journal.pone.0007940

[10] Andrew Kimbrell (ed.), *The fatal harvest reader: The tragedy of industrial agriculture*, (Island Press, 2002).

[11] Joseph J. Molnar, "Climate change and societal response: livelihoods, communities, and the environment." *Rural Sociology* 75, no. 1 (2010): 1-16, https://doi.org/10.1111/j.1549-0831.2010.00011.x

[12] M. Baranski et al., "Agricultural conservation on working lands: Trends from 2004 to present," *Office of the Chief Economist*, USDA, Washington, DC (2018), October 8th, 2020, https://www.usda.gov/sites/default/files/documents/USDA_Conservation_Trends.pdf.

[13] Giacomo Branca et al., "Climate-smart agriculture: a synthesis of empirical evidence of food security and mitigation benefits from improved cropland management," *Mitigation of climate change in agriculture series 3* (2011): 1-42, October 8th, 2020, http://www.fao.org/3/i2574e/i2574e00.pdf.

[14] Mahesh K. Gathala et al., "Tillage and crop establishment affects sustainability of South Asian rice–wheat system." *Agronomy Journal* 103, no. 4 (2011): 961-971, https://doi.org/10.2134/agronj2010.0394.

Overview of Midwest Agriculture

While these industrial practices are present throughout the United States, many of these operations are concentrated in the regional Midwest.[15,16] Referred to as the Breadbasket of America, according to the USDA, the "Midwest represents one of the most intense areas of agricultural production in the world and consistently affects the global economy."[17] Since the nation's founding, more than 80% of Midwestern natural perennial vegetation has been converted to intensive agricultural production of row crops, where single variety crops are planted in orderly rows separate from different crops.[18] Producing nearly 60% of the nation's corn and 55% of its soybeans, the Midwest contributes one-third and one-quarter to the global supply of these crops, respectively.[19,20,21] These two crops, alongside wheat, account for 65% to 70% of cropland in the United States, making the Midwest an important region to focus studies on.[22] A large proportion of the grown corn and soybean is not for direct human consumption; around 70% of U.S. soybeans and around 35% of corn is used as animal feed.[23] For corn specifically, the recent rise in demand for ethanol leads some farmers to re-convert lands previously enrolled in the Conservation Reserves Program (CRP) back to corn production while

---

[15] The early adoption of industrial agriculture into the Midwest amidst the post-WWII Green Revolution is explained by Mapes (see: note 15): "industrial agriculture… threatened to undermine the rural Midwest as a supposedly classless and homogenous place of family farms where hard labor on the land and communal ties in the countryside fostered equality and democracy." The usurpation of this admittedly romantic portrayal of quaint rural living by industrial practices relying on low-paid and high-risk migrant and child labor is difficult not to lament.

[16] Kathleen Mapes, *Sweet Tyranny: Migrant Labor, Industrial Agriculture, and Imperial Politics*, (Urbana, IL: University of Illinois Press, 2009).

[17] USDA Climate Hubs, "Agriculture in the Midwest," *USDA*, October 20th, 2020, https://www.climatehubs.usda.gov/hu bs/midwest/topic/agriculture-midwest.

[18] Ryan C. Atwell, Lisa A. Schulte, and Lynne M. Westphal, "Linking resilience theory and diffusion of innovations theory to understand the potential for perennials in the US Corn Belt," *Ecology and Society* 14, no. 1 (2009), https://doi.org/10.5751/es-02787-140130.

[19] FAOSTAT, "Crop Production Database," F*ood and Agriculture Organization Statistics Division* (2015), https://faostat3.fao.org/browse/Q/QC/E .

[20] USDA-NASS, "Quick-Stats," *USDA* (2015), https://quickstats.nass.usda.gov/#C5600DC7-112D-345FBD43-1C73E0E4F539.

[21] Matthew Houser et al., "Farmers, information, and nutrient management in the US Midwest," *Journal of Soil and Water Conservation* 74, no. 3 (2019): 269-280, https://doi.org/10.2489/jswc.74.3.269.

[22] M. Baranski et al., "Agricultural conservation on working lands."

[23] Jonathan Foley, "It's time to rethink America's corn system." *Scientific American* (2017), November 11th, 2020 https://www.scientificamerican.com/article/time-to-rethink-corn/.

others shift away from crop rotation in favor of continuous corn production.[24,25] Such realities only perpetuate the continued degradation of farmed lands across the region.

Despite the importance of agriculture to this region, there is a lack of awareness and urgency regarding the adoption of sustainable practices. Although the climate crisis has already caused warmer annual temperatures and an increase in extreme rainfall events across the region, many Midwest farmers do not view climate change as a serious threat to their operations.[26,27] Well aware of the vagaries of weather patterns both between and within seasons, many farmers are not concerned with long term, gradual changes in climate, and among the majority who believe in climate change, few believe it is anthropogenic in nature. According to a 2012 survey of Midwestern farmers by Arbuckle et al., "66% of farmers believed climate change is occurring (8% mostly anthropogenic, 33% equally human and natural, 25% mostly natural), while 31% were uncertain and 3.5% did not believe that climate change is occurring,"[28] This is particularly concerning because of farm operations' own impacts on the environment; as Rabalais et al. (2002) observe, "the formation of a "dead zone" in the Gulf of Mexico… [is] a consequence of nutrient pollution moving from Midwestern farms into the Mississippi River."[29] That such adverse externalities exist within contemporary Midwestern agriculture speaks to the need for further education and promotion of sustainable practices across the region.

Conservation Practices and Their Adoption: A Review of the Literature

---

[24] The CRP is a federal program that pays farmers to remove environmentally sensitive land from agricultural production. Contracts run between 10 to 15 years in length with the goal of re-establishing wildlife habitat and valuable land cover.

[25] Diana Stuart and Sean Gillon, "Scaling up to address new challenges to conservation on US farmland," *Land Use Policy* 31 (2013): 223-236, https://doi.org/10.1016/j.landusepol.2012.07.003.

[26] Julie E. Doll, Brian Petersen, and Claire Bode, "Skeptical but adapting: What Midwestern farmers say about climate change," *Weather, Climate, and Society* 9, no. 4 (2017): 739-751, https://doi.org/10.1175/WCAS-D-16-0110.1.

[27] J. Gordon Arbuckle et al., "Climate change beliefs, concerns, and attitudes toward adaptation and mitigation among farmers in the Midwestern United States," *Climatic change* 117, no. 4 (2013): 943-950, https://doi.org/10.1007/s10584-013-0707-6.

[28] Ibid, 943.

[29] Nancy N. Rabalais, R. Eugene Turner, and William J. Wiseman Jr., "Gulf of Mexico hypoxia, aka "The dead zone"," *Annual Review of Ecology and Systematics* 33, no. 1 (2002): 235-263, https://doi.org/10.1146/annurev.ecolsys.33.010802.150513.

While differing regions demand differing approaches to sustainable agriculture, any and all practices that are considered “climate-smart” must meet certain criteria. As defined by the Food and Agriculture Organization (FAO) of the United Nations, climate-smart agriculture is “agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes GHGs (mitigation), and enhances achievement of national food security and development.”[30] This study focuses on application rates to the Environmental Quality Incentives Program (EQIP) as well as conservation practices considered climate-smart identified in the USDA Census of Agriculture

EQIP, the largest federal working lands program, is overseen by the Natural Resources Conservation Service (NRCS) under the USDA.[31] Originally the program focused on improving soil and water quality but has since expanded to the restoration of wildlife habitats, improvement of air quality, and water use efficiency. Offering applying farmers technical, cost-share and/or rental payments through one to ten-year long contracts, farmers in turn adopt an array of regionally specific conservation practices.[32] In this way, EQIP application rates are an umbrella measurement for the adoption of general conservation practices.

The USDA Census of Agriculture is a complete count of all U.S. farmers and their operations reporting over $1,000 or more of products raised and sold. Focusing on land use practices, demographic information of operators, and expenditures and income of operations, this census is taken once every five years and is the prime source of US agricultural information.[33] Specific practices documented — rotational or management intensive grazing

---

[30] FAO, *FAO-Adapt: Framework Programme on Climate Change Adaptation*, (United Nations, Rome, 2011), October 2nd, 2020, http://www.fao.org/3/a-i2316e.pdf.

[31] USDA-NRCS, “Environmental Quality Incentives Program,” *USDA* (2020), November 8th, 2020, https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/.

[32] Adam P. Reimer, Ben M. Gramig, and Linda S. Prokopy, “Farmers and conservation programs: Explaining differences in Environmental Quality Incentives Program applications between states,” *Journal of Soil and Water Conservation*, 68(2) (2013): 110–119, https://doi.org/10.2489/jswc.68.2.110.

[33] USDA-NASS, “United States 2017 Census of Agriculture Volume 1, Chapter 2: County Level,” *USDA*, Washington, DC (2017). November 13, 2020, https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/.

(MIG), forms of agroforestry, cropland planted to a cover crop (excluding CRP), and reduced or no-till practices — are all considered climate-smart conservation practices as defined by the FAO above. A brief overview of these practices is presented below.

Rotational or MIG refers to grazing practices wherein livestock are allowed to graze only on specific portions of pasture so as to allow other portions to recover and rest. Such practices have found both to increase soil carbon sequestration rates as well as increase profitability and efficiency among dairy farms.[34,35] Increasing soil carbon sequestration is important to reducing carbon emissions, as carbon is allowed to be stored in the soil undisturbed.[36] Agroforestry, marked by the integration of trees and shrubs in cropland and pastures, promote similar soil improvements; the sequestration of carbon and a greater cycling of nutrients are among the key improvements brought about through agroforestry.[37] Cover crops, on the other hand, are specific crops planted to cropland that protect soil from erosion, retain nutrients, and improve water storage.[38] These crops are typically planted after the harvest season so land does not go fallow during the fall and winter seasons. Reduced and no-tillage practices promote similar soil improvements. These practices are marked by less disturbance or turnover of the soil when

---

[34] Richard T. Conant, Johan Six, and Keith Paustian, "Land use effects on soil carbon fractions in the southeastern United States. I. Management-intensive versus extensive grazing," *Biology and fertility of soils* 38, no. 6 (2003): 386-392, https://doi.org/10.1007/s00374-003-0652-z.

[35] B. A. Dartt et al., "A comparison of profitability and economic efficiencies between management-intensive grazing and conventionally managed dairies in Michigan," J*ournal of Dairy Science* 82, no. 11 (1999): 2412-2420, https://doi.org/10.3168/jds.S0022-0302(99)75492-5.

[36] Rattan Lal, "Soil carbon sequestration to mitigate climate change," *Geoderma* 123, no. 1-2 (2004): 1-22, https://doi.org/10.1016/j.geoderma.2004.01.032.

[37] Jo Smith, Bruce D. Pearce, and Martin S. Wolfe, "Reconciling productivity with protection of the environment: Is temperate agroforestry the answer?" *Renewable Agriculture and Food Systems* 28, no. 1 (2013): 80-92, https://doi.org/10.1017/S1742170511000585.

[38] T. C. Kaspar and J. W. Singer, "The use of cover crops to manage soil," in *Soil management: Building a stable base for agriculture*, eds. J.L. Hatfield and T.J. Sauer (Madison, WI: American Society of Agronomy and Soil Science Society of America, 2011): 321-337.

planting crops through the creation of narrow slots for crop seed.[39] Disturbing soil less increases the population density of soil macrofauna and increases carbon sequestration.[40,41]

To understand under what circumstances such practices are adopted, Knowler and Bradshaw (2007) identify a few categories of determining factors: farmer and farm household characteristics, farm biophysical characteristics, farm financial/management characteristics, and exogenous factors.[42] The most frequent variables considered within these categories include age and education of farmers, tenure of farm, off-farm activities/income, farm size, and rainfall. However, there is little agreement in the literature about the significance (or direction) between these variables and adoption as Knowler and Bradshaw write,

> As the number of incidences [analyses of determinants of adoption] increases there should be a convergence towards one or another of the results, e.g. significantly positive coefficient, significantly negative or insignificant. There is some evidence of such a pattern amongst the most commonly used variables, but it is weak… Other common variables… show an even less convincing pattern.

Following these findings, Liu et al. (2018), in their synthesis of research on determinants of conservation practices, outline even more categories which factors fit into: information and awareness, financial incentives, social norms, macro factors, farmer's demographics, knowledge and attitudes, farmer's risk and time preferences and uncertainty, farmer's environmental consciousness, characteristics of farms, characteristics of BMPs, and interactions of BMPs.[43] Echoing much of what Knowler and Bradshaw found, Liu et al. write

> Certain factors, studied in isolation, show a clear and positive effect on BMP adoption; these include *access to credible information*, government subsidies, environmental consciousness, and profitability of practices. The effects of some other factors, including

---

[39] David J. Pannell, Rick S. Llewellyn, and Marc Corbeels, "The farm-level economics of conservation agriculture for resource-poor farmers," *Agriculture, Ecosystems & Environment* 187 (2014): 52–64, https://doi.org/10.1016/j.agee.2013.10.014.

[40] Alexandra C. Wilson-Rummenie et al., "Reduced tillage increases population density of soil macrofauna in a semiarid environment in central Queensland," *Environmental Entomology* 28, no. 2 (1999): 163-172.

[41] W. Deen and P. K. Kataki, "Carbon sequestration in a long-term conventional versus conservation tillage experiment," *Soil and Tillage Research* 74, no. 2 (2003): 143-150, https://doi.org/10.1016/S0167-1987(03)00162-4

[42] Duncan Knowler and Ben Bradshaw, "Farmers' adoption of conservation agriculture: A review and synthesis of recent research," *Food policy* 32, no. 1 (2007): 25-48, https://doi.org/10.1016/j.foodpol.2006.01.003.

[43] Tingting Liu, Randall JF Bruins, and Matthew T. Heberling, "Factors influencing farmers' adoption of best management practices: A review and synthesis," *Sustainability* 10, no. 2 (2018): 432 https://doi.org/10.3390/su10020432.

> farm size, land tenure, diverse operation, farmer experience, education, age, gender, political views, and social political beliefs, were unclear or debatable [emphasis added].

As these papers analyzed research written about farms in varying regions across the world, the authors recommend future research focus on specific regions and localities. It is unlikely that the reasons that motivate private farmers to adopt conservation practices will be uniform across different cultures, regionalities, climates, and countries. From these recommendations, and findings that credible information appears to be significantly related to adoption, follows my own research into the Midwest, as the realities farmers face are similar across the several states of this region.

Theory

Although this study focuses on county-level agricultural statistics and not individual farm statistics, microeconomic considerations remain the most relevant to this study. Whether or not Midwest counties are more or less likely to adopt conservation practices is dependent on individual, private farmers' choices that aggregate to the county-level; it is thus important to first construct farmers as actors within the model of rational choice theory. Rational choice theory states that economic decisions are made after a calculation between the costs and benefits of differing courses of action. The rational actor then decides which action to pursue based on their own preferences.[44] Such preferences are those which maximize the individual's profit/utility at a given point following the decision.

There are a number of assumptions inherent in this theory; for the sake of this paper, it is adequate to identify two main assumptions: actors 1) *have access to adequate information regarding decisions available to them* and 2) *have the necessary computational [cognitive]*

---

[44] John Scott, *Rational Choice Theory* in "Understanding Contemporary Society: Theories of the Present," (2000): 671-685.

ability to determine the best course of action.[45] Even as an abstract theory, these assumptions are difficult to defend; when applied to Midwest farmers, they are unable to be satisfied. Agricultural decisions are often made *without* adequate knowledge of future conditions such as adverse weather phenomena, pests, and/or disease that result in crop [livestock] failure [death].[46] Contemporary Midwest farmers face the additional climate crisis which many do not believe is anthropogenic nor a serious threat to their operations.[47,48]

Given these shortcomings, the theory of bounded rationality is more suited for this analysis. Arising from many of the shortcomings with rational choice theory identified above, bounded rationality theory attempts to construct a more realistic rational actor. Simon writes that the "uncertainty about the consequences that would follow from each alternative, incomplete information about the set of alternatives, and complexity preventing the necessary computations from being carried out" *bounds* an otherwise rational actor in their pursuit of available actions.[49] While the actor is still interested in pursuing their preferences, this theory allows for constraints on rationality that are not well accounted for in rational choice theory. In considering Midwest farmers' adoption of conservation practices, there are identifiable bounds on their decision to adopt: time-constraints inherent to a finite growing season, unpredictability of adverse weather conditions, risk aversion to the introduction of new practices, cash restraints on investment in conservation practices, neighbors' attitudes and adoption of practices,

---

[45] Herbert A. Simon, "Theories of bounded rationality," *Decision and organization* 1, no. 1 (1972): 161-176.
[46] Beverly Fleisher, *Agricultural risk management*, (Lynne Rienner Publishers Inc., 1990).
[47] Arbuckle et al., "Climate change beliefs, concerns, and attitudes toward adaptation," 943.
[48] Emily Pechar Diamond, Robert Bonnie, and Elizabeth Rowe, "Rural Attitudes on Climate Change: Lessons from National and Midwest Polling and Focus Groups," *Nicholas Institute for Environmental Policy Solutions,* Duke University (2020), October 11th, 2020, https://nicholasinstitute.duke.edu/sites/default/files/publications/Rura l-Attitudes-on-Climate-Change-Midwest_1.pdf.
[49] Simon, "Theories of bounded rationality," 169.

emphasis on adoption and support (financial or otherwise) by the county/state, and the dispersion of information regarding the profitability of practices.[50,51,52,53,54]

Many of these bounds have to do with the dismissal of negative environmental externalities caused by contemporary agriculture. The theory of economic externalities — additional costs or benefits arising from production that are not captured in the final price of a commodity — lends itself to the focus on environmental degradation caused by contemporary agriculture at the center of this analysis.[55] As Patron-Cano writes, "[m]arket prices should not ignore the climate, local ecology, and local community in the name of seeking profits and fictitiously low short-term food prices for one crop at a time."[56] Prices must internalize these externalities and such internalization is a primary goal of sustainable agriculture, though it isn't always obvious how or why individual farmers internalize these added costs to their operations.. Although not the central theory to this paper, an understanding and recognition of externalities is critical.

Methodology & Empirical Model

Research begins with county-level data across Midwestern states for the most recent year of the USDA Census of Agriculture (2017). The 12 Midwestern states combined contain 1054 counties; around 20-30 counties are dropped from the final regressions because of missing information. Further county information is gathered on EQIP application rates from USDA-

---

[50] Knowler and Bradshaw, "Farmers' adoption of conservation agriculture," 25-48.

[51] Liu, Bruins, and Herbeling, "Factors influencing farmers' adoption," 432.

[52] François J. Dessart, Jesús Barreiro-Hurlé, and René van Bavel, "Behavioural factors affecting the adoption of sustainable farming practices: a policy-oriented review," *European Review of Agricultural Economics* 46, no. 3 (2019): 417-471.

[53] M. D. Tomer et al., "A decade of conservation effects assessment research by the USDA Agricultural Research Service: Progress overview and future outlook," *Journal of Soil and Water Conservation* 69, no. 5 (2014): 365-373, https://doi.org/10.2489/jswc.69.5.365.

[54] Reimer, Gramig, and Prokopy, "Farmers and conservation programs," 110-119.

[55] James Edward Meade, *The theory of economic externalities: The control of environmental pollution and similar social costs*, (Vol. 2. Brill Archive, 1973).

[56] Patron-Cano, "Modern capitalism and food commoditization."

NRCS 2017 data and rural-urban continuum codes from USDA-ERS 2013. There is no indication that county codes have changed between the years 2013 and 2017.

This paper runs a multivariate OLS regression to determine the impacts of several independent variables on a number of different conservation practices. Separate models will be run for each dependent variable considered (EQIP application rates, rotational or management intensive grazing (MIG), cover crops, forms of agroforestry, and no-till or reduced tillage practices). Independent variables, following from those factors identified in the literature, will be categorized as county farm factors (F) (median acreage of farms, irrigated cropland, producer factors (P) (tenure, age, primary occupation), and land enrolled in crop insurance), and information factors (I) (internet access, colonies of honeybees, categorization of county as metro or non-metro). Tables A - D describe the variables in greater detail, as well as the expected impact (positive or negative) the variables will have on the rate of conservation practice adoption. The formula is given below:

$$Y_i = \beta_0 + \beta_1 F_0 + \beta_2 P_i + \beta_3 I_i + +\varepsilon_i$$

Many of the independent variables included as county farm factors and producer factors were chosen based on those identified in the literature. Research has shown that the size of farms, age (represented through the proportion of county producers younger than 35), tenure, and crop insurance have varying impacts on adoption.[57] Larger farms have less bounds in terms of economic and information constraints, but smaller farms are more environmentally conscious and are more motivated by non-economic incentives.[58] Older producers are typically more

[57] Knowler and Bradshaw, "Farmers' adoption of conservation agriculture," 38
[58] Robert L. Ryan, Donna L. Erickson, and Raymond De Young, "Farmers' motivations for adopting conservation practices along riparian zones in a mid-western agricultural watershed," *Journal of Environmental Planning and Management* 46, no. 1 (2003): 19-37, https://doi.org/10.1080/713676702.

experienced farmers that are used to adapting to environmental conditions; however, many are used to farming in environmentally damaging ways and are resistant to change. Whether a farm operator owns or rents the land worked on relates to adoption as owners are more future oriented. At the same time, renters may be willing to assume greater future risk through the adoption of new practices. A larger share of farmland with crop insurance protects operators against unexpected losses, though may discourage innovation because *some* income is guaranteed.[59] On the other hand, insurance reduces the risk to the operator of adopting new practices. Proportion of land in cropland is a control variable to help alleviate differences in the dominance of agriculture across counties.

Information factors, following from bounded rationality theory, are expected to positively influence adoption of conservation practices. Proportion of county farms with internet access and with colonies of honeybees represent access to general knowledge and environmental knowledge, respectively. The four variables categorizing counties as metropolitan, urban adjacent to metropolitan areas, urban not adjacent to metropolitan areas, and rural represent the impacts distance from information centers have on adoption. Comparing the former three categories to rural, the expectation is that metropolitan and urban counties adjacent to metropolitan areas will be more likely to adopt conservation practices. It is not clear how urban counties that are not adjacent to metropolitan areas will compare to rural counties, as both are similarly remote from information centers.

Table A: Description of Conservation Practices (Dependent Variables)

Variables	Description	Expected Direction

[59] "Crop Insurance: A Torn Safety Net." *Land Stewardship Practice* (2018). November 8th, 2020 https://landstewardshipproject.org/repository/1/2465/crop_insurance_report_final_3_12_18.pdf.

eqip_application_pr	Proportion of county producers applying to EQIP *	NA
rotational_grazing_f	Proportion of county farms practicing rotational or management-intensive grazing †	NA
cover_crop_f	Proportion of county farms planting cover crops (excluding CRP land) †	NA
agroforestry_f	Proportion of county farms practicing alley cropping, silvopasture, forest farming, or had riparian forest buffers or windbreaks †	NA
reduced_till_a	Proportion of county cropland on which no-till or reduced tillage practices are used †	NA

* USDA-NRCS 2017
† USDA-NASS 2017

Table B: Description of County Farm Factors (Independent Variables)

Variables	Description	Expected Direction
median_farm	Median acreage of county farms †	Unknown
cropland_a	Proportion of county land that is cropland †	Unknown
crop_insurance_a	Proportion of county farmland enrolled in crop insurance programs †	Unknown

† USDA-NASS 2017

Table C: Description of Producer Factors (Independent Variables)

Variables	Description	Expected Direction
tenant_f	Proportion of county farms with tenant producers †	Negative
young_pr	Proportion of county producers under the age of 35 †	Unknown
primary_occupation_pr	Proportion of county producers whose primary occupation is farming †	Positive

† USDA-NASS 2017

Table D: Description of Information Factors (Independent Variables)

Variables	Description	Expected

		Direction
internet_f	Proportion of county farms with internet access †	Positive
bees_f	Proportion of county farms with colonies of honeybees †	Positive
metro	Metropolitan counties with populations fewer than 250,000 to populations larger than 1 million §	Positive
urban_adj	Urban counties with populations between 2,500 and more than 20,000, adjacent to a metro area §	Positive
urban_not	Urban counties with populations between 2,500 and more than 20,000, not adjacent to a metro area §	Unknown
rural	Rural counties or counties with populations less than 2,500, either adjacent or not adjacent to metro areas §	NA

† USDA-NASS 2017
§ USDA-ERS 2013

Results and Discussion

The results of the regression analyses can be found in Table E. In total, 5 separate regressions are run to determine the impacts of producer factors, county farm factors, and information factors on various conservation practices. Few of these factors have consistent impacts across all conservation practices; only young producers, internet access, and primary occupation as farming have consistently positive impacts across the discrete models. All factors considered were significant, albeit in different directions, with the exception of the categorical variable representing urban counties that are not adjacent to metropolitan areas. The adjusted R-squared value differs substantially across the models; in predicting EQIP application rates, the regression explains only 13% of the variance, while the same regression explains around 59%, 9%, 23%, and 74% of MIG, cover crop, agroforestry, and reduced or no tillage adoption, respectively. That the same regression model explains such varied percentages of the variance in the conservation practices studied implies that investigation into other factors influencing adoption is necessary; at the same time, the large variance produced by the same regression suggests "conservation practices" are not thought of or prioritized equally by farm operators, nor should they be considered as such by researchers or policy-makers.

To investigate the heterogeneous adoption of the considered conservation practices, a series of f-tests is run to compare average adoption rates between practices. We find that reduced or no-tillage practices are the most popular followed by rotational or MIG, cover crops, EQIP application, and forms of agroforestry.[60] Following conclusions by Erenstein et al., the more popular practices may result in more immediate and recurring profitability.[61] Other reasons for heterogeneous adoption are proposed by McCann et al.:

> if results of a practice are easily observable with the naked eye, or easily perceived using other senses (rather than requiring laboratory tests or sophisticated modeling), the linkage between the action and the result is obvious and/or the chain of causality is short/direct, the process is non-stochastic, the result occurs with a minimal time lag, and the practice is less complex, then the farmer would be more likely to adopt the practice, all else equal.

County Farm Factors

In measuring the size of the typical farm across the counties, median acreage is a better measure than average acreage for capturing a “normal” size farm because of the large discrepancy between the two values across counties. A majority of counties’ average values were more than twice the median values, implying a few very large farms operating in each of the counties observed. The median acreage of farms were found to be positive and significant for MIG and EQIP application and negative and significant for cover crops, agroforestry, and

Table E: Regression Results

[60] One reason agroforestry may be so unpopular is due to the habitat space shrubs and trees create for wildlife. Although there is slim evidence to suggest wildlife transfers pathogens to food that result in foodborne illnesses, some food safety standards recommend the removal of such vegetation and habitats. See the creation of new food safety standards by the produce industry without consultation with the NRCS or EPA in California (note 24).

[61] Olaf Erenstein et al., "On-farm impacts of zero tillage wheat in South Asia's rice–wheat systems," *Field Crops Research* 105, no. 3 (2008): 240-252, https://doi.org/10.1016/j.fcr.2007.10.010.

Variables	eqip_application_pr	rotational_mig_f	cover_crop_f	agroforestry_f	reduced_till_a
Constant	-0.002 (-0.014)	**0.146***** (0.016)	**0.031*** (0.017)	**-0.009*** (-0.005)	0.068 (0.042)
median_farm	**0.00001***** (0)	**0.00004***** (0)	**-0.00002***** (-0.00001)	**-0.00001***** (-0)	-0.00002 (-0.00001)
cropland_a	**-0.015**** (-0.007)	**-0.030***** (-0.008)	-0.001 (-0.008)	**-0.006**** (-0.003)	**0.170***** (0.021)
crop_insurance_a	-0.011 (-0.008)	**-0.160***** (-0.009)	**0.023**** (0.01)	**-0.015***** (-0.003)	**0.601***** (0.0125)
tenant_f	**0.097***** (0.025)	-0.004 (-0.029)	**-0.066**** (-0.03)	-0.015 (-0.01)	0.082 (0.076)
young_pr	**0.095***** (0.031)	**0.283***** (0.035)	**0.276***** (0.037)	**0.019*** (0.012)	-0.006 (-0.093)
primary_occupation_pr	-0.0002 (-0.013)	**0.060***** (0.015)	**0.037**** (0.016)	-0.003 (-0.005)	-0.013 (-0.04)
internet_f	**0.040**** (0.018)	-0.01 (-0.02)	0.006 (0.021)	**0.041***** (0.007)	-0.073 (-0.054)
bees_f	**0.176***** (0.063)	**-0.194***** (-0.072)	**0.341***** (0.077)	**0.146***** (0.024)	**1.137***** (0.201)
metro	**-0.017***** (-0.004)	**0.011***** (0.004)	-0.006 (-0.004)	**-0.002*** (-0.001)	**0.022**** (0.011)
urban_adj	**-0.009***** (-0.003)	0.002 (0.004)	0.002 (0.004)	0.001 (0.001)	0.011 (0.01)
urban_not	-0.004 (-0.004)	-0.005 (-0.004)	0.003 (0.004)	0.001 (0.001)	-0.017 (-0.011)
rural	-	-	-	-	-
Observations	1,035	1,035	1,035	1,035	1,019
Adjusted R2	0.128	0.59	0.093	0.234	0.743
F Statistic	14.762*** (df = 11; 1023)	136.143*** (df = 11; 1023)	10.681*** (df = 11; 1023)	29.677*** (df = 11; 1023)	268.731*** (df = 11; 1007)

Note: *Significant at α = 0.10 ; **Significant at α = 0.05 ; ***Significant at α = 0.01.

reduced or no tillage. In regard to MIG, the findings detailed may simply be a reflection of the fact that more land is needed for pasture and only [larger] farms with pasture land would adopt MIG.[62] That the size of a farm positively impacts application to EQIP is noteworthy, as EQIP application is used as a proxy for an umbrella of differing conservation practices and techniques.[63] On the other hand, cover crop, agroforestry, and reduced/no tillage adoption is worsened through an increase in the median acreage of farms. These contradictory results are well reflected in the literature which finds no clear relationship between farm size and the adoption of conservation practices.[64]

Crop insurance is found to have diverse impacts across the models considered. Crop insurance is one of the most popular policies utilized by farms and is itself often a required condition for access to credit.[65] Therefore, many different operations have at least some of their land insured, making it difficult to draw any conclusions regarding the direct impact of insurance on the adoption of conservation practices.

Producer Factors

The coefficients for farms that are principally run by renters are found to be significant in EQIP application and cover crop adoption, though in different directions. That tenants are positively associated with EQIP application confirms previous findings by Reimer et al. in their research on EQIP application rates.[66] This is not surprising considering EQIP, unlike other federal working lands programs, allows tenants to apply. That tenant farmers are less likely to adopt cover crops implies that renters are less future-oriented than landowners. Hypothetically, tenants are more easily able to work different land in different locations than are landowners,

[62] Dave Merrill and Lauren Leatherby, “Here’s How America Uses Its Land,” *Bloomberg* (2018), November 8th, 2020, https://www.bloomberg.com/graphics/2018-us-land-use/.
[63] USDA-NRCS, “Environmental Quality Incentives Program.”
[64] Knowler and Bradshaw, "Farmers’ adoption of conservation agriculture,” 35.
[65] John Newton, “Majority of Crop Acres Covered by Crop Insurance,” *Farm Bureau* (2019), November 8th, 2020 https://www.fb.org/market-intel/majority-of-crop-acres-covered-by-crop-insurance.
[66] Reimer, Gramig, and Prokopy. "Farmers and conservation programs,” 110-119.

disincentivizing tenants from investing in the future productivity of land they work . There may also be greater financial restraints on tenants compared to owners, or differing levels of experience farming.

That young producers have a significantly positive impact across four models (EQIP application, adoption of rotational or MIG, cover crops, and forms of agroforestry) is noteworthy. It is not surprising that the age group most worried about climate change is more likely to adopt conservation practices on farms.[67] Apart from these demographic considerations, young producers may be more future-oriented in their operations and more willing to adopt conservation practices that will pay-off in the long-run.

Similarly, producers whose primary occupation is farming are found to have significant and positive impacts on both rotational or MIG and cover crop adoption. Both of these practices are highly visible and offer a wide range of benefits to producers, particularly those relying predominantly on income generated from farms. Outside of productivity or profit raising concerns, these findings suggest the ill-effects of absentee landowners and farmers who have sources of revenue outside of farming.[68] Producers whose livelihoods are dependent on positive farming outcomes must search for the best management practices available, such as those considered in this research.

Information Factors

Although internet access is not often considered in the literature, it is a good proxy variable for access to information by farms. Via the internet, operators can research for themselves conservation practices without having to rely solely on extension service agents and

[67] RJ Reinhart, "Global Warming Age Gap: Younger Americans Most Worried," *Gallup* (2018), November 8th, 2020, https://news.gallup.com/poll/234314/global-warming-age-gap-younger-americans-worried.aspx.
[68] Dan Charles, "How Absentee Landowners Keep Farmers From Protecting Water And Soil," *NPR* (2020), November 8th, 2020, https://www.npr.org/2020/07/14/890449857/how-absentee-landlords-keep-farmers-fr om-protecting-water-and-soil.

farm industry suppliers and dealers.[69] This research finds internet access to have a significant and positive impact on EQIP application rates and the adoption of forms of agroforestry. These results support the hypothesis that information factors impact conservation practice adoption.

Number of colonies of honeybees is best understood as a proxy for farmers environmental consciousness. Alongside other species negatively impacted by climate change and contemporary agricultural practices, the honeybee is an emblem of environmental conservation.[70,71] Farms with colonies of honeybees are positively and significantly likely to apply to EQIP, adopt cover crops, forms of agroforestry, and reduced or no-tillage practices. Only in rotational or MIG are colonies of honeybees found to be significantly negative, though this may be due to a reluctance of mixing grazing livestock with stinging insects. That greater environmental consciousness comes, at least in part, from greater awareness and information regarding climate change and the negative externalities brought by contemporary farming is a fair assumption. Therefore, these results mostly support the hypothesis regarding the importance of information to adoption of conservation practices..

The four categorical variables classifying counties as metropolitan, urban adjacent to metropolitan, urban not adjacent to metropolitan, and rural introduces a geospatial consideration into the analysis. Compared against rural counties, urban and metro counties are not conclusively more likely to adopt conservation practices. Both metro and urban adjacent counties are significantly less likely to apply to EQIP while significantly more likely to practice reduced/no tillage; metropolitan counties are additionally more likely to adopt MIG. There

---

[69] Matthew Houser et al., "Farmers, information, and nutrient management in the US Midwest," 269-280.

[70] The development of the honeybee (a foreign, possibly invasive pollinator) into this emblem is ironic in that many are used for the pollination of commercial crops in areas where local pollinators have been killed as a result of the overuse of pesticides and other aerosols (see note 64). Honeybees, for all intents and purposes, should be thought of as any other kind of livestock; it is only the persistent environmentally friendly imagery surrounding them which prevents this understanding.

[71] Ferris Jabr, "The Mind-Boggling Math of Migratory Beekeeping," *Scientific American* (2013), November 8th, 2020, https://www.scientificamerican.com/article/migratory-beekeeping-mind-boggling-math/.

appears to be some geospatial element to adoption, but the presented county categories poorly capture these supposed influences.

Conclusion, Implications, and Suggestions for Future Research

` Following the theory of bounded rationality, this research finds several bounds that impact farms' adoption of conservation practices at the county level. Most notably, young producers, producers whose occupation is primarily farming, and internet access have consistent, significantly positive impacts on conservation practice adoption. Further, farms with colonies of honeybees are significantly more likely to adopt 4 of the 5 conservation adoptions studied. As colonies of honeybees are used as a proxy for environmental knowledge, those under 35 are more likely to be worried about climate change, and internet access represents access to general knowledge, these results support the theoretical approach and the hypothesis that access to information binds the decision to adopt conservation practices.

The need to support younger producers on farms is supported by this research and contemporary trends regarding farmer demographics; the average age of producers across the counties considered is 56 and just over 10% of producers are under the age of 35.[72] To best realize the widespread adoption of conservation practices, incentivizing young people to farm is policy worth pursuing. It is likely young people will continue to overlook the agricultural sector as a viable career option without financial assistance; such assistance is required to reinvigorate an industrial system of agriculture over-reliant on synthetic inputs and contractual agreements between producers and large agribusinesses.[73] This is not necessarily recommending increased aid to agriculture, as this sector is heavily reliant on government subsidies already. However, most of government aid is channelled to large farms without requirements to adopt important

[72] Across the US, the average farmer has steadily gotten older but more experienced, implying a lack of new producers and longer years working on farms for current producers.
[73] Erik J. O'Donoghue et al., "Changing farming practices accompany major shifts in farm structure," *USDA* (2011), https://doi.org/10.22004/ag.econ.120792.

conservation practices.[74] Such changes in how the government finances agriculture is policy worth pursuing to attract younger farmers and to encourage the adoption of conservation practices.

Increasing farms' internet access (and access to other forms of information) is critical. As Liu et al. suggest, "farmers who rely on the internet for conservation information may be more advanced in their use of technologies and might be considered adoption leaders."[75] The findings of this analysis support these claims. Without information on the credibility of adopting conservation practices, farms are likely to continue farming in environmentally unsustainable ways. Findings regarding the impacts farms with colonies of honey bees have on the adoption of conservation practices should not conclude that there is a need for more farms to invest in beekeeping; rather, such results represent the importance of knowledge through environmental consciousness in the adoption of conservation practices. That so many farmers across the Midwest are skeptical of anthropogenic climate change is a tangible problem that must be overcome through education. Having extension service agents emphasize the impacts of climate change on Midwest agriculture while introducing producers to conservation practices is essential.

While this study is intentionally limited to the Midwest, there are many options for future research. Conducting geospatial analyses across counties may lead to interesting results — are counties neighboring other counties with high rates of conservation practice adoption more likely to adopt conservation practices quicker than non-neighboring counties? Such results would represent the importance of inter-producer interaction in distributing knowledge related to conservation.

Other factors not addressed in this study include the status of farms — individual/family vs company — and the impacts this has on adoption. Similarly, what adoptions are the very large

[74] Atwell, Schulte, and Westphal, "Linking resilience theory and diffusion of innovations theory."
[75] Liu et al., "Factors Influencing Farmers' Adoption of Best Management Practices," 432.

operations that have skewed the average size of farms pursuing, if any? Are such "mega farms" more or less likely to adopt conservation practices? Pursuing these questions is important to restructuring the agricultural system in the United States, a system that is all too often overlooked at the expense of the environment, vulnerable laborers, and consumers.

Bibliography

U.S. Bureau of Economic Analysis. “Value Added by Private Industries: Agriculture, Forestry, Fishing, and Hunting as a Percentage of GDP.” *FRED, Federal Reserve Bank of St. Louis*. (2020). October 8, 2020. https://fred.stlouisfed.org/series/VAPGDPAFH.

Arbuckle, J. Gordon, Linda Stalker Prokopy, Tonya Haigh, Jon Hobbs, Tricia Knoot, Cody Knutson, Adam Loy et al. "Climate change beliefs, concerns, and attitudes toward adaptation and mitigation among farmers in the Midwestern United States." *Climatic change* 117, no. 4 (2013): 943-950. https://doi.org/10.1007/s10584-013-0707-6.

Atwell, Ryan C., Lisa A. Schulte, and Lynne M. Westphal, "Linking resilience theory and diffusion of innovations theory to understand the potential for perennials in the US Corn Belt," *Ecology and Society* 14, no. 1 (2009), https://doi.org/10.5751/es-02787-140130.

Baranski, M., H. Caswell, R. Claassen, C. Cherry, K. Jaglo, A. Lataille, and K. Zook. "Agricultural conservation on working lands: Trends from 2004 to present." *Office of the Chief Economist*, USDA, Washington, DC (2018). October 8th, 2020. https://www.usda.gov/sites/default/files/documents/USDA_Conservation_Trends.pdf.

Branca, Giacomo, Nancy McCarthy, Leslie Lipper, and Maria Christina Jolejole. "Climate-smart agriculture: a synthesis of empirical evidence of food security and mitigation benefits from improved cropland management." *Mitigation of climate change in agriculture series* 3 (2011): 1-42. October 8th, 2020. http://www.fao.org/3/i2574e/i2574e00.pdf.

Charles, Dan. “How Absentee Landowners Keep Farmers From Protecting Water And Soil.” *NPR* (2020), November 8th, 2020. https://www.npr.org/2020/07/14/890449857/how-absentee-landlords-keep-farmers-from-protecting-water-and-soil.

Conant, Richard T., Johan Six, and Keith Paustian. "Land use effects on soil carbon fractions in the southeastern United States. I. Management-intensive versus extensive grazing." *Biology and fertility of soils* 38, no. 6 (2003): 386-392.

https://doi.org/10.1007/s00374-003-0652-z.

"Crop Insurance: A Torn Safety Net." *Land Stewardship Practice* (2018). November 8th, 2020. https://landstewardshipproject.org/repository/1/2465/crop_insurance_report_final_3_12_18.pdf.

Dartt, B. A., J. W. Lloyd, B. R. Radke, J. R. Black, and J. B. Kaneene. "A comparison of profitability and economic efficiencies between management-intensive grazing and conventionally managed dairies in Michigan." *Journal of Dairy Science* 82, no. 11 (1999): 2412-2420. https://doi.org/10.3168/jds.S0022-0302(99)75492-5.

Deen, W. and P. K. Kataki. "Carbon sequestration in a long-term conventional versus conservation tillage experiment." *Soil and Tillage Research* 74, no. 2 (2003): 143-150, https://doi.org/10.1016/S0167-1987(03)00162-4

Dessart, François J., Jesús Barreiro-Hurlé, and René van Bavel. "Behavioural factors affecting the adoption of sustainable farming practices: a policy-oriented review." *European Review of Agricultural Economics* 46, no. 3 (2019): 417-471.

Diamond, Emily Pechar, Robert Bonnie, and Elizabeth Rowe. "Rural Attitudes on Climate Change: Lessons from National and Midwest Polling and Focus Groups." N*icholas Institute for Environmental Policy Solutions,* Duke University (2020). October 11th, 2020. https://nicholasinstitute.duke.edu/sites/default/files/publications/Rura l-Attitudes-on-Climate-Change-Midwest_1.pdf.

Doll, Julie E., Brian Petersen, and Claire Bode. "Skeptical but adapting: What Midwestern farmers say about climate change." *Weather, Climate, and Society* 9, no. 4 (2017): 739-751. https://doi.org/10.1175/WCAS-D-16-0110.1.

Erenstein, Olaf, Umar Farooq, R. K. Malik, and Muhammad Sharif. "On-farm impacts of zero tillage wheat in South Asia's rice–wheat systems." *Field Crops Research* 105, no. 3 (2008): 240-252. https://doi.org/10.1016/j.fcr.2007.10.010.

FAO. *FAO-Adapt: Framework Programme on Climate Change Adaptation,* (United Nations, Rome, 2011). October 2nd, 2020. http://www.fao.org/3/a-i2316e.pdf.

FAOSTAT. "Crop Production Database." F*ood and Agriculture Organization Statistics Division* (2015). https://faostat3.fao.org/browse/Q/QC/E .

Fleisher, Beverly. *Agricultural risk management*. (Lynne Rienner Publishers Inc., 1990).

Gathala, Mahesh K., J. K. Ladha, Vivak Kumar, Yashpal S. Saharawat, Virender Kumar, Paradeep Kumar Sharma, Sheetal Sharma, and Himanshu Pathak. "Tillage and crop establishment affects sustainability of South Asian rice–wheat system." *Agronomy Journal* 103, no. 4 (2011): 961-971. https://doi.org/10.2134/agronj2010.0394.

Hall, Kevin D., Juen Guo, Michael Dore, and Carson C. Chow. "The Progressive Increase of Food Waste in America and Its Environmental Impact." *PloS one* 4, no. 11 (2009): e7940–e7940. https://doi.org/10.1371/journal.pone.0007940 .

Houser, Matthew, Sandra T. Marquart-Pyatt, Riva CH Denny, Adam Reimer, and Diana Stuart. "Farmers, information, and nutrient management in the US Midwest." *Journal of Soil and Water Conservation* 74, no. 3 (2019): 269-280. https://doi.org/10.2489/jswc.74.3.269.

Jabr, Ferris. "The Mind-Boggling Math of Migratory Beekeeping." *Scientific American* (2013). November 8th, 2020. https://www.scientificamerican.com/article/migratory-beekeeping-mind-boggling-math/.

Johnson, D. Gale. "World agriculture, commodity policy, and price variability." American *Journal of Agricultural Economics* 57, no. 5 (1975): 823-828. https://doi.org/10.2307/1239087

Kaspar, T. C. and J. W. Singer. "The use of cover crops to manage soil." in *Soil management: Building a stable base for agriculture*, eds. J.L. Hatfield and T.J. Sauer (Madison, WI: American Society of Agronomy and Soil Science Society of America, 2011): 321-337.

Kimbrel, Andrew (ed.). *The fatal harvest reader: The tragedy of industrial agriculture*. (Island Press, 2002).

Knowler, Duncan and Ben Bradshaw. "Farmers' adoption of conservation agriculture: A review and synthesis of recent research." Food policy 32, no. 1 (2007): 25-48. https://doi.org/10.1016/j.foodpol.2006.01.003.

Lal, Rattan. "Soil carbon sequestration to mitigate climate change." *Geoderma* 123, no. 1-2 (2004): 1-22. https://doi.org/10.1016/j.geoderma.2004.01.032.

Lin, Brenda B., Michael Jahi Chappell, John Harry Vandermeer, Gerald Ray Smith, Ivette Perfecto, Eileen Quintero, Rachel Bezner Kerr, Daniel M. Griffith, Stuart Ketcham, Steven C. Latta, Philip McMichael, Krista McGuire, Ronald Nigh, Diana Rocheleau, and John Soluri. "Effects of industrial agriculture on climate change and the mitigation potential of small-scale agro-ecological farms." *Animal Science Reviews* no. 69 (2012). https://doi.org/10.1079/PAVSNNR20116020.

Liu, Tingting, Randall JF Bruins, and Matthew T. Heberling. "Factors influencing farmers' adoption of best management practices: A review and synthesis." *Sustainability* 10, no. 2 (2018): 432. https://doi.org/10.3390/su10020432.

Mapes, Kathleen. *Sweet Tyranny: Migrant Labor, Industrial Agriculture, and Imperial Politic*s. (Urbana, IL: University of Illinois Press, 2009).

Marré, Alexander. "Rural education at a glance, 2017 edition." *USDA*. (2017).

Meade, James Edward. *The theory of economic externalities*: *The control of environmental pollution and similar social costs*. (Vol. 2. Brill Archive, 1973).

Merrill, Dave and Lauren Leatherby. "Here's How America Uses Its Land." *Bloomberg* (2018). November 8th, 2020, https://www.bloomberg.com/graphics/2018-us-land-use/.

Molnar, Joseph J. "Climate change and societal response: livelihoods, communities, and the environment." *Rural Sociology* 75, no. 1 (2010): 1-16, https://doi.org/10.1111/j.1549-0831.2010.00011.x

Newton, John. "Majority of Crop Acres Covered by Crop Insurance." *Farm Bureau* (2019).

November 8th, 2020 https://www.fb.org/market-intel/majority-of-crop-acres-cov ered-by-crop-insurance.

O'Donoghue, Erik J., James C. MacDonald, Utpal Vasavada, and Patrick Sullivan. Changing farming practices accompany major shifts in farm structure. *USDA* (2011). https://doi.org/10.22004/ag.econ.120792.

Pannell, D., Llewellyn, R., and Corbeels, M. "The farm-level economics of conservation agriculture for resource-poor farmers." *Agriculture, Ecosystems & Environment* 187 (2014): 52–64. https://doi.org/10.1016/j.agee.2013.10.014.

Patron-Cano, Gerardo. "Modern capitalism and food commoditization: The limitations of industrial agriculture and the challenges of sustainable alternatives." *University of Denver* (2015).

Rabalais, Nancy N., R. Eugene Turner, and William J. Wiseman Jr. "Gulf of Mexico hypoxia, aka "The dead zone"." *Annual Review of Ecology and Systematics* 33, no. 1 (2002): 235-263. https://doi.org/10.1146/annurev.ecolsys.33.010802.150513.

Reimer, Adam P., Ben M. Gramig, and Linda S. Prokopy. "Farmers and conservation programs: Explaining differences in Environmental Quality Incentives Program applications between states." *Journal of Soil and Water Conservation*, 68(2) (2013): 110–119. https://doi.org/10.2489/jswc.68.2.110.

Reinhart, RJ. "Global Warming Age Gap: Younger Americans Most Worried." *Gallup* (2018). November 8th, 2020. https://news.gallup.com/poll/234314/global-warming-age-ga p-younger-americans-worried.aspx.

Ryan, Robert L., Donna L. Erickson, and Raymond De Young. "Farmers' motivations for adopting conservation practices along riparian zones in a mid-western agricultural watershed." *Journal of Environmental Planning and Management* 46, no. 1 (2003): 19-37. https://doi.org/10.1080/713676702

Scott, John. *Rational Choice Theory* in "Understanding Contemporary Society: Theories of the Present." (2000): 671-685.

Simon, Herbert A. "Theories of bounded rationality." *Decision and organization* 1, no. 1 (1972): 161-176.

Smith, Jo, Bruce D. Pearce, and Martin S. Wolfe. "Reconciling productivity with protection of the environment: Is temperate agroforestry the answer?" *Renewable Agriculture and Food Systems* 28, no. 1 (2013): 80-92. https://doi.org/10.1017/S1742170511000585.

Stuart, Diana and Sean Gillon. "Scaling up to address new challenges to conservation on US farmland." Land Use Policy 31 (2013): 223-236, https://doi.org/10.1016/j.landusepol.2012.07.003.

Tomer, M. D., E. J. Sadler, R. E. Lizotte, R. B. Bryant, T. L. Potter, M. T. Moore, T. L. Veith, Claire Baffaut, M. A. Locke, and M. R. Walbridge. "A decade of conservation effects assessment research by the USDA Agricultural Research Service: Progress overview and future outlook." Journal of Soil and Water Conservation 69, no. 5 (2014): 365-373. https://doi.org/10.2489/jswc.69.5.365.

USDA Climate Hubs. "Agriculture in the Midwest." *USDA*. October 20th, 2020. https://www.climatehubs.usda.gov/hu bs/midwest/topic/agriculture-midwest.

USDA-NASS. "Quick-Stats." *USDA* (2015). https://quickstats.nass.usda.gov/#C5600DC7-112D-345FBD43-1C73E 0E4F539.

USDA-NASS. "United States 2017 Census of Agriculture Volume 1, Chapter 2: County Level." *USDA*. Washington, DC (2017). November 13, 2020. https://www.nass.usda.gov/Publi cations/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/.

USDA-NRCS. "Environmental Quality Incentives Program." *USDA* (2020). November 8th, 2020. https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/fina ncial/eqip/.

USDA-NRCS. "NRCS Contract and Application Data from FY 2009 to FY 2020." *ProTracts Program Contracts System* (2020).

Varble, Sarah, Silvia Secchi, and Caroline Gottschalk Druschke. "An examination of growing trends in land tenure and conservation practice adoption: Results from a farmer survey in Iowa." *Environmental Management* 57, no. 2 (2016): 318-330. https://doi.org/10.1007/s00267-015-0619-5.

Weis, Tony. "Breadbasket contradictions: The unstable bounty of industrial agriculture in the United States and Canada." in *Food security, nutrition and sustainability (*2010): 27-40.

Wilson-Rummenie, Alexandra C., Bruce J. Radford, Les N. Robertson, Gordon B. Simpson, and Kerry L. Bell. "Reduced tillage increases population density of soil macrofauna in a semiarid environment in central Queensland." *Environmental entomology* 28, no. 2 (1999): 163-172.