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Conservation & Crop Insurance Research Pilot

February 7, 2023

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Contents

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Foreword

Federal crop insurance is a key risk management strategy for most commodity crop producers. In 2021, more than 444 million acres of farmland and $150 billion in crop and livestock value were covered by federal crop insurance. Crop insurance is also one of the largest expenditures under the farm bill, representing about 37% of the total farm portion of the farm bill or around $10 billion per year. The AGree Coalition, an initiative housed at Meridian Institute, has sought to better understand the risk reduction benefits of agricultural conservation practices and how these benefits are accounted for in the Federal Crop Insurance Program (FCIP).

In 2019, excessive moisture and flooding prevented planting on 19 million acres of farmland, resulting in more than $4 billion in crop insurance claims. On tens of millions of additional acres, planting was delayed by multiple weeks, with potential yield reductions from late planting. During this time, we heard anecdotal reports from farmers that on fields where they practiced cover-cropping and no-till, they were able to plant, or plant earlier, than neighboring fields with conventional tillage and planting. This situation created a natural experiment to test the impact of conservation practices on prevented planting claims.

In partnership with the University of Illinois at Urbana Champaign and USDA, AGree developed the Conservation and Crop Insurance Research Pilot to analyze data from six states—Indiana, Illinois, Iowa, Missouri, Minnesota, and South Dakota—to better understand how use of cover crops and tillage practices affected corn and soybean planting dates, the number of prevent plant acres, and crop yields in that extremely wet spring of 2019. A secondary objective of this project was also to test whether data collected by USDA on conservation practice adoption and crop insurance indemnities could be combined with external satellite datasets to conduct rigorous scientific research in a way that protects producer's personally identifiable information.

This paper summarizes important insights about how cover crops and no-till impact agricultural risk, which can be used to strengthen the FCIP, improve farmers' economic outcomes and support working lands resilience.

Farmers' investments in practices like cover cropping and no-till that improve soil health have the potential to increase resilience to severe weather events, reduce environmental impacts, and increase productivity over time. Yet, while conservation practices have the potential to impact both producer profitability and the environment, more work must be done to fully understand how conservation practices reduce risk and how to best reflect those risk reduction benefits in crop insurance and conservation policy, data innovation efforts, and rating models. AGree's work is intended to support and inform the work of the Risk Management Agency—as well as other USDA agencies such as the Farm Services Administration (FSA) and Natural Resources Conservation Service (NRCS)—to promote climate-smart agriculture through federal crop insurance and other programs. We hope you find this paper to be a useful resource.

Todd Barker
CEO, Meridian Institute

Executive Summary

In 2019, 19.6 million acres of cropland were not planted due to extremely wet spring weather conditions, resulting in prevent-plant insurance claims totaling over $4 billion. To better understand how cover crops and tillage affected prevent-plant acres, corn and soybean planting dates, and crop yields in 2019, USDA, the University of Illinois, and the Meridian Institute collaborated on a pilot data analysis. The Conservation and Crop Insurance Research Pilot analyzed USDA and other datasets in the six-state area of Minnesota, South Dakota, Iowa, Illinois, Indiana, and Missouri. Those six states represent the heart of the Corn Belt and contained roughly half of the record 19.6 million acres of prevent-plant claims in 2019.

The project provided substantive data from thousands of fields on the positive impact of conservation practices for reducing crop production risk. Across the 6-state region, consistent use of cover crops and no-till resulted in a 24% reduction in the odds ratio of prevent-plant loss in 2019. This impact also depends on other physical features (e.g., soil type, slope, etc.), and thus varies from field to field, and would also vary across other years' growing conditions.

> Across the 6-state region, consistent use of cover crops and no-till resulted in a 24% reduction in the odds ratio of prevent-plant loss in 2019.

In addition to the clear impact in reducing the risk of being prevented from planting, cover crops and no-till usage also had a notable impact on planting dates in 2019. Data from the six pilot states showed that fields with cover crops and/or no-till were planted somewhat later in the early part of the planting season, particularly in early April. However, for the critical late portion of the spring planting window, cover crops and no-till fields had earlier planting dates compared to conventional fields. This result is particularly notable because the key time period for yield impacts is the last few weeks of the spring planting window. Management practices that allow earlier planting in that time window reduce the likelihood for insurance claims and reduce yield risk.

The results of this research pilot can be used to improve technical information about conservation practices by demonstrating the effects of cover crops and no-till on risk management. The pilot is also intended to further agency missions by demonstrating how USDA datasets across multiple agencies in conjunction with other available third-party data sets can be analyzed together to unlock important new insights about conservation activities and risk management. In addition, the pilot results show how datasets across multiple USDA agencies relate, as well as where data gaps exist thereby informing USDA's efforts to improve its data collection, integration, and analytic capacities.

Research Methods

An intensive data organization and analysis process was undertaken at University of Illinois to evaluate the impacts of cover crops and no-till/reduced-till along with weather, soil and other factors on 2019 prevent-plant losses. Data management and detailed econometric methods are more fully described in the full report. Through an agreement with USDA, the project used data from the Risk Management Agency (RMA), Farm Service Agency (FSA) and Natural Resources Conservation Service (NRCS) in combination with public, private, and other institutional data procured separately. These data sets provided information on insurance claims, crop management practices, and relevant soils, topology, land use and weather. In addition to management practices collected by USDA agencies, remote sensing data were used to fill in certain gaps in available data. To maintain producer privacy, only the University of Illinois research team had access to the raw data and all individual identifiers were stripped from the data early in the process. All data reporting is at the aggregate level. Preparing and analyzing the USDA and U.S. Geological Survey (USGS) datasets included the following activities:

1. Developing the common base layer geographic unit tessellation. 2019 Common Land Units (CLUs) were used for the majority of the intersections of geo-units
2. Mapping insurance records to geographic units
3. Conducting geospatial analyses to extract soil and topological features
4. Creating and scaling weather-specific data (precipitation, event duration, temperature, etc.) related to planting season intervals in 2019
5. Collating and assigning conservation practice data from FSA/NRCS to field-level units along with third-party sources, including remote sensing data on actual field practices
6. Designing models and identification strategies used in the analysis

Using this approach, the research team successfully mapped prevented plant claims against weather events, adoption of cover crop and tillage practices, and physical and topological features. Different regions experienced different rates of cover crop and tillage practice adoption, planting date, and insurance rates, creating distinct patterns of losses. This is the first known large-scale application of such detailed CLU-level integration and shows considerable promise for further incorporation of geocoded information into farm and field-level decision making, crop performance tracking, and insurance assessment.

Not surprisingly, soils, topology, and weather explain the majority of the risk of a prevent-plant claim. When controlling for these factors, the analysis shows that fields with recent histories of no-till and/or reduced tillage and cover cropping show statistically significant reduction in the likelihood of a prevent-plant claim. **An important feature identified in the data was that cover crops and no-till were more used more frequently on fields with lower productivity indexes and with more slope. The lower productivity fields are ones that can be presumed to be more likely to have crop insurance claims because of less inherent soil resilience to weather extremes. Therefore, the fact that cover crops and no-till further reduced prevent-plant claims is particularly notable.**

This is the first known large-scale application of such detailed CLU-level integration and shows considerable promise for further incorporation of geocoded information into farm and field-level decision making, crop performance tracking, and insurance assessment.

Data recommendations

To support ongoing efforts at USDA to improve data management, the research team was also asked to evaluate the completeness and complementarity of USDA data related to conservation and crop insurance. As expected, the researchers found gaps in the USDA data due to the enormity of the task, capacity limitations and historically determined data priorities as data systems evolved over time. For example, annual cover crop acreage is collected systematically in some counties, occasionally in others, and rarely or never in remaining counties. No-till/reduced till data are most extensively gathered once every five years as part of the Census of Agriculture. Some information on no-till/reduced till is collected for specific fields enrolled in specific NRCS programs, but that captures just a small portion of the fields using those practices. There were also challenges in matching the specific geographic units on which data were collected and the time period that date-referenced data refer to. For example, cover crops planted in the summer or fall may not show up in the next year's reporting, making it difficult to ascertain the time period the cover crop was in the field or to which crop year its effect may have been relevant.

Some key data recommendations were identified through the pilot process and are offered constructively, understanding that funding limitations and other factors may prevent implementing best practices. Exploration of the data challenges and rationale for these recommendations is included in the full report that follows.

Data Recommendation #1

USDA should determine an effective method for collecting annual cover crop and no-till usage data on a field-by-field basis, either through more robust and consistent data collection efforts through local USDA offices (eg., using existing data entry format on cover crops), or by use of remote sensing data with some verification of the remote sensing analysis through on-the-ground observations.

Data Recommendation #2

USDA should evaluate how to develop more consistency in gathering relevant data at the geographic unit and reporting with the same geographic identifiers, with cross-compatibility between agency databases tied to the geographically identified unit for each mapping layer of interest.

Data Recommendation #3

USDA should pursue standardization and synchronization of time stamps for reported crop management practices and results in terms of yields. Given the wide and effective availability of satellite imagery, standardized Crop Data Layer (CDL) systems, and third-party verification through image processing, this recommendation could substantially reduce complexity in collection and reduce costs. It could also improve understanding of which practices were effectively implemented alleviating reliance on complex surveys of stated intentions for a crop or practice.

Data Recommendation #4

USDA should explore use of robust available sources of weather data to match annual weather conditions to geographic land unit by constructing appropriate data layers in their system and/or support third party efforts to do so.

Data Recommendation #5

USDA should ideally develop an approach that leads to one common data set for each land unit (e.g., CLU, field, latitude/longitude grid, etc.) so that USDA staff and cooperators have accurate and consistent information including conservation activities and measures of crop performance.

Data Recommendation #6

USDA should consider developing a process that researchers can use to access a broader cross section of USDA data while maintaining producer confidentiality. USDA ideally could provide a standard data format that is accessible to other external groups so that internal USDA data are better connected to external data sources and the data can be of greater public benefit.

Addressing these data issues would help progress agriculture data research for the public benefit, provide much needed insights into conservation and risk management policies and practices, and improve program implementation. USDA has made critical strides to evolve and improve the various types of USDA data available.

These recommendations are intended to be complimentary to ongoing efforts. Better data and more thorough analysis of farm data will lead to better decisions for research, education, management, and better inform policy that will benefit not only producers but all those that depend on American agricultural productivity and prosperity.

Project Background

The Meridian Institute worked with USDA and collaborators from University of Illinois and University of Missouri to develop a pilot project evaluating conservation and crop insurance data specific to unique weather events in 2019. In that year, an extremely wet spring occurred over much of the upper corn belt, preventing crop planting on sizable fraction of corn and soybean acreage and delaying planting by as much as two months on tens of millions of acres. The number of acres that were ultimately declared "prevent-plant" as part of crop insurance claims amounted to 19.6 million acres with associated indemnity payments of $4.2 billion dollars.

Anecdotal reports indicated that farmers who had been using conservation practices in 2019, particularly cover crops and no-till, were in many cases less affected by the excessive spring rainfall. Supporting data on this point are available from the SARE/CTIC National Cover Crop Survey conducted in the spring of 2020 about the 2020 crop year.[1] Overall, 473 farmers answering a question about planting date impact of cover crops in 2019 were almost twice as likely to report that cover crops helped them plant earlier than later (34.3% earlier vs. 18.4% later with the remainder indicating no difference)—these results were for all farmers with cover crop planting experience, whether first-time or experienced users and whether or not they were in areas of high spring rainfall. For farmers who planted cash crops green into living covers, 54.3% reported planting earlier and only 9.7% reported planting later.

The unique weather circumstances of 2019 and sizable crop insurance claims created an opportunity to better evaluate how conservation was impacting farmer risk and crop insurance. Coincidentally, the 2018 Farm Bill called for a pilot project by USDA to better evaluate the intersection of conservation and crop insurance from a data perspective.

> The unique weather circumstances of 2019 and sizable crop insurance claims created an opportunity to better evaluate how conservation was impacting farmer risk and crop insurance.

Given the above, Meridian Institute and its scientific collaborators proposed a pilot to USDA to examine the following research questions in the six-state area covering IA, IL, IN, MN, MO, and SD[2] which were particularly affected by excessive rainfall in spring of 2019:

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[1] Conservation Technology Information Center. 2020. Report of the 2019-20 SARE/CTIC National Cover Crop Survey. West Lafayette, IN.

[2] Of the 19,620,758 acres of declared prevent-plant for the 2019 crop season, almost half of the acres were in the six-state pilot area. South Dakota had the most prevent-plant acres at 3,947,988 acres declared. The other states, in descending number of prevent-plant acres, were Illinois—1,507,591 acres, Missouri—1,400,930 acres, Minnesota—1,171,420 acres, Indiana—943,709 acres, and Iowa—463,337 acres. Corn was the primary crop being declared prevent-plant nationally, with 11,433,459 acres, and was also the main crop declared prevent-plant in each of the six states evaluated for the project.

1. How did cover crop and no-till practices, particularly when used for multiple years, impact the timing of planting for commodity crops on selected fields in 2019?
2. How did cover crop and no-till practices, particularly when used for multiple years, impact whether a commodity crop was planted or whether the field was declared "prevented plant" for 2019?
3. How did cover crop and no-till practices, particularly when used for multiple years, impact yield-related insurance claims on selected fields in 2019?

A second goal of the pilot effort was to identify where there were data gaps or other constraints in the USDA data set for answering the types of questions outlined above. Data gaps were acknowledged by USDA staff at the outset of the project, reflecting different data collection methods among agencies, historical approaches not always in alignment with current needs, and limited staff and funding resources. These inherent limitations significantly impacted the amount of data collected and how data systems are structured and managed in USDA data sets.

Dr. Bruce Sherrick, Director of the TIAA Center for Farmland Research at University of Illinois led the efforts to collect, assess, organize, and evaluate data from relevant sources at USDA. Dr. Rob Myers, Director of the Center for Regenerative Agriculture at University of Missouri, provided expertise on cover crop and no-till/reduced till management and overall agronomic considerations. Primary data used for the pilot project from within USDA came from the Risk Management Agency (RMA) and the Farm Service Agency (FSA). Additional data was provided by the Natural Resources Conservation Service (NRCS).

Throughout the process, confidentiality of farmer data has been of the utmost priority. The only office to access the raw data has been the University of Illinois team led by Dr. Sherrick. His research team removed all personal identifiers from the data at the project outset. Summary results are provided only at the aggregate level to protect privacy, and the data were further anonymized in a manner that ensures no possible recreation of the original data associated with individual producers.

This important research project would not have been possible without the efforts of several staff from multiple agencies at USDA. Paul Chevalier (USDA-FPAC) served as the primary point person for most of the data requests and put significant time into facilitating data access; his efforts were instrumental to being able to evaluate relevant USDA data.

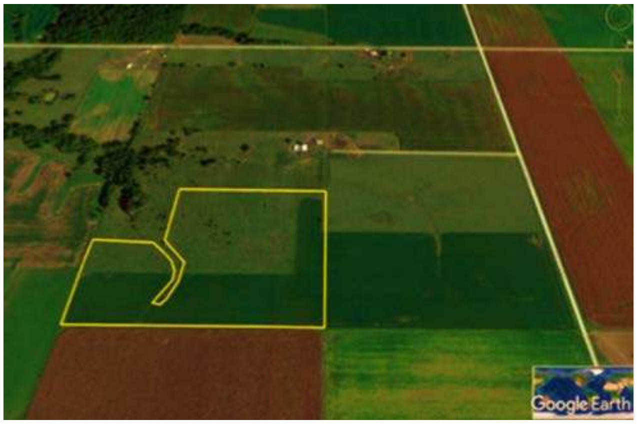
Data Compilation & Collation

The work of data assembly involved linking USDA's RMA, FSA, and NRCS agency records along with PRISM weather data and third party geo-referenced data layers. All data were associated with geospatial boundaries and projected onto a common frame to address the possibility that changing record/field/farm/policy identifiers over time occurred. No producer identifying information was maintained or used in any of the analyses.

The geographic unit used was a version of the CLU created to correspond to FSA records as of 2019. CLU identifiers from RMA exist within the PASS data system in the Land Record (P-27) which, along with internal table keys, allowed all other elements needed from RMA to be commonly associated including insurance details (P-14), premiums (P-11), and losses (P-21).

The FSA cropping practice records were associated from each years' data (2017-2019) through listed state, county, farm number, field number, and subfield numbers and matched to RMA Land Records. The NRCS data included identifiers allowing matching to relevant fields. Two notes of importance are: i) Land Records often represent production fields, several of which can occur within or among CLU units, i.e., CLUs are not coincident in terms of area or precise location with producers' fields; and ii) not all Land Records have unambiguous CLUs identified, effectively dropping them from geospatial analysis henceforth.

Specifically, there were 5,763,987 Land Records in the original dataset covering six states. Of these, 3,864,929 had CLU identifiers, including 2,581,841 Land Records that were unique and associable with data from the other providers. Thus, many CLU boundaries encompass several production fields and/or fields with multiple policies for different producers in rental relationships and other arrangements. A land usage review was performed and determined that the remaining sample is most representative of the conservation pattern of interest. These acres were overwhelmingly contained within regions of commercial crop production.



Depiction of Common Land Unit (CLU) field designation not necessarily matching up with actual field boundaries.

FSA and NRCS data were available for 2017-2019 reporting years. As noted earlier, the 2019 CLU boundaries were used for all analysis going forward, including any prior year information in a CLU with the same identifier, but possibly different area, from prior years. Importantly, alternative geospatial identification systems are also available to apply, and in many cases would be preferred, but this decision allows linkage back to other USDA concurrently and in the future.

The RMA, FSA, and NRCS datasets were provided as text files. These data were imported into on-premises databases (PostgreSQL) to facilitate linking by common database keys and geographic information. FSA-administered common land unit (CLU) data were provided in a GeoDatabase formatted file, which was converted to PostgreSQL as well. The datasets were then arranged into a single new on-premises database, utilizing the architecture of software developed by Soil

Diagnostics. The LabCore system provided a structure to associate each CLU "field" with further geospatial data using analysis algorithms already available in LabCore. In this way, the CLU geographic units could be analyzed with the combined data from RMA records, FSA and NRCS practice records, and field-specific geospatial and processed topological data at a more meaningfully disaggregated scale.

Due to the limited number of fields that could be definitively identified in USDA data as having had both cover crops and no-till in recent years, remote sensing data were also obtained from Indigo Ag for the 6-state pilot area. Overlaying the set of fields for which RMA data was available with the fields for which remote sensing indicated cover crop and/or no-till, there were 42,706 fields with at least one year of cover crop and at least one year of no-till. Fields that had at least three consecutive years of cover crops and no-till numbered 3,433—a much smaller but still substantial sample of fields.

Geospatial Processing & Collation of Weather Data

A stand-alone instance of the LabCore software was initialized to hold the project data and maintained in a fully isolated and encrypted environment. The system is built primarily in Python and has undergone years of development to organize agricultural data. Publicly available datasets, such as USDA SSURGO soils database, are then easily added to the private data set for each field to analyze influences on outcomes and patterns in data related to soils and other map unit-based layers of information. All computing, software, and storage devices were run locally, without exposure to external networks.

Several additional layers of geographic information were associated with each CLU, including:

- **Topography** Slope, Slope Length, Stream Power Index (SPI), Topographic Index (TCI). Source: USGS National Elevation Dataset, 30 m resolution.
- **Soils** NCCPI-3 Productivity Index, Water Holding Capacity. Source: USDA SSURGO Soils database.
- **Crop Rotation** Source: USDA-NASS Cropland Data Layer.
- **Weather** Precipitation intensity metrics. Source: PRISM climate information, Oregon State University supported by RMA.

Most of the geospatial data were calculated by clipping the input data layer to the CLU units and summarizing using zonal statistics such as area weighted mean, standard deviation, minimum and maximum values. Note that the CLU would **not** be the natural unit of identification in most modern systems analyzing geospatially related shape files, but CLUs were maintained in this case for use within the existing data systems provided.

The PRISM weather data were handled somewhat differently. This weather information is available as 4 km pixel grids of daily temperature, precipitation, and vapor pressure deficit (humidity) for the continental US. Each of these grids for 2019 was downloaded, imported into the database, and available for querying and summarizing for any pixel in the grid. Because PRISM has somewhat low spatial resolution, no intersection was done to handle CLU boundaries crossing multiple PRISM pixels. Instead, each of the CLUs was assigned an identifier linking its centroid to the intersecting PRISM pixel. Weather characterizations used as input variables in modeling included 30-day average precipitation prior to June 1, 2019, and 60-day average precipitation prior to June 1. (Additional summaries of potential evapotranspiration, GDDs, and soil moisture have not been fully processed due to computational complexity but are being done for later analysis. Importantly, the micro-scale PRISM data are also being used as an assignment layer for future work and to provide an aggregation/disaggregation framework for more refined future analysis and reporting independently of any original data.)

Conservation Practice Information

Available management data included cover crop practices reported to both NRCS and FSA along with no-till/ reduced tillage practice recorded as part of conservation programs to NRCS. The timing of these practices was somewhat difficult to assign to a unique crop season. The NRCS data included a creation date for the program record. To determine what program year a creation date implied, the NRCS cover crop data were regressed on the FSA cover crop data to identify the largest overlap between the two datasets and assigned the intervals accordingly. Typically an NRCS program year is the calendar year following the year in which the NRCS record was created.

The FSA records are associated primarily with a calendar year value, and do not have extensive "as of" date information. Cover crops planted after a rotationally appropriate crop, along with the incidence of cover crop usage following prevent-plant claims in 2019 was extensively investigated. Much of the roughly fourfold increase in FSA cover crop records in 2019 appears to be due to incentives introduced through programs following prevented planting, and related programs developed that fall. Available management practice information from FSA and NRCS were scored as binary/categoric values of 1=does or 0=does not have the practice in each CLU and used in classification analyses for both confirmation and prediction purposes.

Data Analysis & Modeling

A number of assumptions and modeling treatments were required as part of the analysis. The distribution of T1927 Land Records whose areas corresponded identically to the CLU boundary area is slightly over 86%. In "complete record" cases, the correspondence of the entire CLU unit to the insurance, claims, practices, and geospatial information in this subset is assumed to be 1:1 and not involve additional unidentified area within the CLU.

The NRCS and FSA practice data were used to construct a proxy "true positive" data set. There is not an unambiguous or clear way to pair this dataset with a true negative set of fields that controlled for geography or producer, and importantly by expected crop within the prevented plant fields. The most natural method was to identify all producers who constituted the true positive dataset, and then identify all the producers' fields from RMA that excluded the true positive set. This set was used as the true negative control dataset. Extensive sensitivity analysis was conducted (and continues) around this and alternative specifications. Alternative extent definitions are also employed to help determine efficacy of reporting and most likely correspondence with visual processed CDL related data.

Prevent-plant claims are relatively unambiguous within the possible set of insurance claim identifiers and planted date alternatives are assumed to be the correct calendar plant date for crops that were grown in 2019. The analysis included all policy types (e.g., enterprise, basic, optional policies) and other causes of loss were cross correlated to determine if any systemic relationship remains across alternative claims.

Indigo Ag Inc. (Boston, MA) shared a dataset from their Atlas product that identified tillage and cover crop practices using remote sensing information. This dataset provided an alternative way to determine treatment and control fields and allows very conservative (highly accurate) subsets of the data to be used to establish practice cases, although future work indicates that time frame consistency will be important to establish and refine rather than use calendar years, crop years, or activity dates depending on the variable use case. Although Indigo's remote sensing data set is privately held, other use of remote sensing for cover crop detection has proven effective as cited in the literature.[3]

The data were also evaluated using tabulations of the co-occurrence of reported NRCS and FSA cover crop reports, as well as their cross tabulations with the Indigo Atlas data. RMA prevent-plant claims were tabulated with respect to reported cover crop / tillage data against imputed control fields. Finally, the as-reported planting dates were plotted for those fields with and without reported practices in the NRCS and FSA datasets.

Although the original goal of the research had been to focus on fields where there were three consecutive years of cover crops and no-till prior to 2019, it was determined this would restrict the size of the data set significantly without necessarily gaining any additional insights. Instead, conventional fields were compared to fields with at least one year of cover crop and at least one year of no-till in the prior three years. However, future research of this type should endeavor to evaluate more fully multi-year use of these conservation practices.

While the classification of whether a cover crop was used or not was fairly straightforward in this project, it was more challenging to identify fields that were truly "continuous no-till" as compared to fields that had some form of reduced tillage. NRCS data was generally provided in a classification that included reduced till with no-till. The remote sensing observations from Indigo that were used as the data source for no-till have been ground-truthed to look for levels of disturbance. Indigo identified fields that are essentially no-till but acknowledged it was difficult to distinguish a field with a minor amount of tillage, such as vertical tillage, from one with no-tillage based on remote sensing.

Explanatory geospatial information, including weather, and practices were used in a logistic regression framework to compare to prevent-plant claims and planting date as well as to isolate the incremental effect of practice usage against physical features of production units and weather in the 2019 pre-planting time windows. Physical parameters as well as practice indications are then able to be separately and accumulatively assessed in prospective manners as well to model impact on claims under this unique natural experiment of 2019.

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[3] Hagen, S.C.; Delgado, G.; Ingraham, P.; Cooke, I.; Emery, R.; P. Fisk, J.; Melendy, L.; Olson, T.; Patti, S.; Rubin, N.; Ziniti, B.; Chen, H.; Salas, W.; Elias, P.; Gustafson, D. Mapping Conservation Management Practices and Outcomes in the Corn Belt Using the Operational Tillage Information System (OpTIS) and the Denitrification–Decomposition (DNDC) Model. *Land* ***2020***, *9*, 408. https://doi.org/10.3390/land9110408

Results

1 Did use of cover crops and no-till impact the likelihood of a prevent-plant insurance claim on corn and soybeans in 2019?

Key finding

Using both cover crops and no-till/reduced-till reduces prevent-plant loss significantly; specifically, the prevent-plant loss likelihood was reduced by 24%.

These effects depend on other physical features and thus vary field to field. At the average loss rate in 2019 across the 6-state region, use of no-till and cover crops contributed to a 24% reduction in the odds ratio for prevent-plant loss.

Results of particular importance that include physical variables alone—such as SPI, available water storage, hydrological convergence (water accumulation potential) and precipitation accumulation prior to planting—result in a model that is 78% accurate in predicting loss likelihood. (n=721,670). If with no other controls, the analysis is restricted to only fields in which practice data are available (observed and inferred - n=58,805) reducing accuracy slightly to 75%. Addition of management practice data then stably improves the prediction case accuracy by ~2%.

Cover crop and no-till adoption across the six-state pilot area varies by county but for purposes of this project the regional adoption percentage of the cover crops is not believed to have impacted outcomes of the analysis.

An important trend uncovered in the data analysis is that cover crops and no-till were more likely to be used on fields with lower productivity indexes and with more slope. The lower productivity fields are ones that can be presumed to be more likely to have crop insurance claims because of less inherent soil resilience to weather extremes. Therefore, the fact that cover crops and no-till were reducing prevent-plant claims is all the more notable.

There are important interactions between usage of cover crops and tillage, and the producer's decisions for adoption (expected first where most impactful). Moreover, the historic use of cover crops is highly related to normal crop rotation, and thus the reclassification of expected soybean acres as corn prevent-plant needs to be further accounted for in the analysis. Against the complexity of estimation, a promising key result is that in the sample as observed, use of both reduced tillage and cover crop reduces the loss odds by ~18%. The low frequency observation issue would be expected to result in understating the impact, and a time accumulative effect is likely that was omitted given the short time series available for analysis.

The question may arise as to whether the observed effect of cover crops and reduced tillage on reduced prevent-plant claims is due to causation or correlation. The authors feel that strong evidence indicates a causal relationship. A number of scientific reasons support this causal relationship, including the following aspects of cover crop and no-till/reduced till use:

- More macropores are present in the soil from earthworm channels and extra roots that have decomposed, leading to faster rainfall infiltration[4]
- Improved soil aggregate structure provides for greater water holding capacity in the soil, contributing to less surface ponding[5]
- Higher residue levels on the soil surface lead to interception of rain drops that otherwise act to seal shut the surface layers of the soil through microaggregate dispersion when silt and clay are present in the top soil horizon[6]
- Cover crops allowed to grow longer in the spring, often through a "planting green" approach of planting a cash crop into a still actively growing cover crop, can help reduce excess soil moisture through evapotranspiration[7], and
- Other studies have also shown that cover crops can reduce crop risk, such as a paper[8] by Aglasan and coauthors (2021).

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[4] https://acsess.onlinelibrary.wiley.com/doi/full/10.1002/agg2.20105

[5] https://acsess.onlinelibrary.wiley.com/doi/abs/10.2136/sssaj2004.9350

[6] https://acsess.onlinelibrary.wiley.com/doi/full/10.2136/sssaj2016.03.0084

[7] https://www.nrcs.usda.gov/sites/default/files/2022-09/CoverCropBeforeSoybeans.pdf

[8] Aglasan, S. Rejesus, R.M., Hagen, S.C. and W. Salas. 2021. An Analysis of Crop Insurance Losses, Cover Crops, and Weather in US Crop Production. Selected Paper prepared for presentation at the 2021 Agricultural & Applied Economics Association Annual Meeting, Austin, TX, August 1-August 3.

2 Did use of cover crops and no-till impact planting date in 2019?

Reflecting the reduced occurrence of prevent-plant claims, **data showed cover crops and reduced tillage contributed to earlier planting in the critical late planting window.** This is documented by the data shown in Figure 1 where cover crops and no-till prove to be an advantage for earlier planting during the final weeks of the spring planting season for corn and soybeans. The later into that 2019 late planting window, the more cover crops and no-till were helpful. This is critically important because the later corn and soybeans are planted, the more their yield is likely to be reduced.

Considering cover crops and no-till fields were also less likely to be declared prevent-plant and tended to be fields with lower productivity indexes, the effect of these soil health management practices was particularly significant in overcoming risk from poorer soils and the fact many conventional fields simply weren't planted due to the excessively wet spring in 2019.

Figure 1 shows that early in the spring of 2019, cover crop and no-till fields were on average having delayed planting during the first few weeks of planting. Importantly, in many cases this delay in early planting is likely because cover crop farmers tend to want their cover crops to grow longer in the spring. Thus, they purposefully delay planting during the first few weeks of the spring planting season. However, delays in planting corn and soybeans in the first half of typical spring planting windows does not normally lead to yield loss the way that late spring planting does. This relationship is consistent with late planting provisions in crop insurance which systematically reduce yield estimates in the guarantee with the passage of time.

Crop variety was not evaluated for this pilot because it was not believed to be agronomically important to the overall analysis, as corn and soybean variety choices could be expected to be similar for both cover crop and no-till systems.

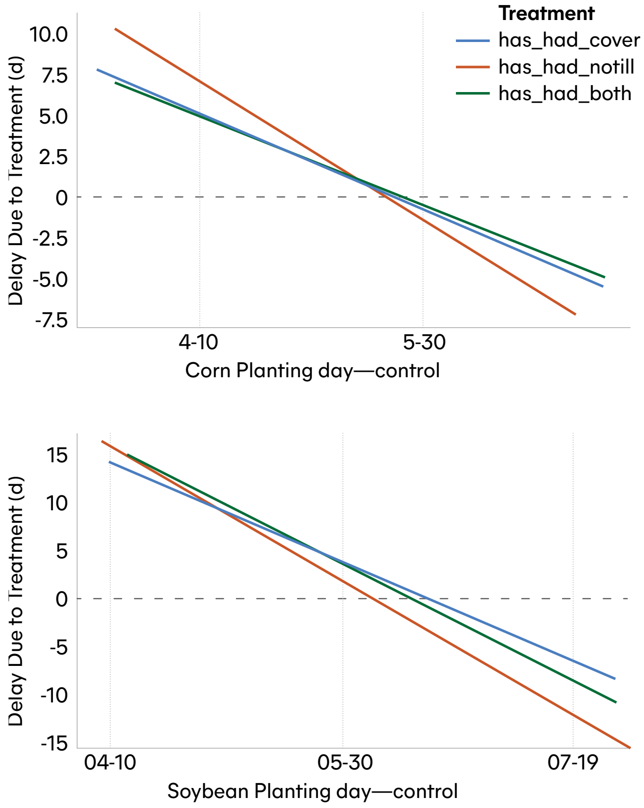

Figure 1 Planting date impact of cover crops and no-till on corn and soybeans in 2019. Shaded areas next to the linear regression lines show the 95% confidence interval for the date responses.

Photo from Oklahoma in spring of 2019 showing standing water in a conventional field on the right and how the long-term use of cover crops and no-till on the left side of the road allowed rainfall infiltration with the potential for earlier planting. Photo courtesy of Russ Jackson.

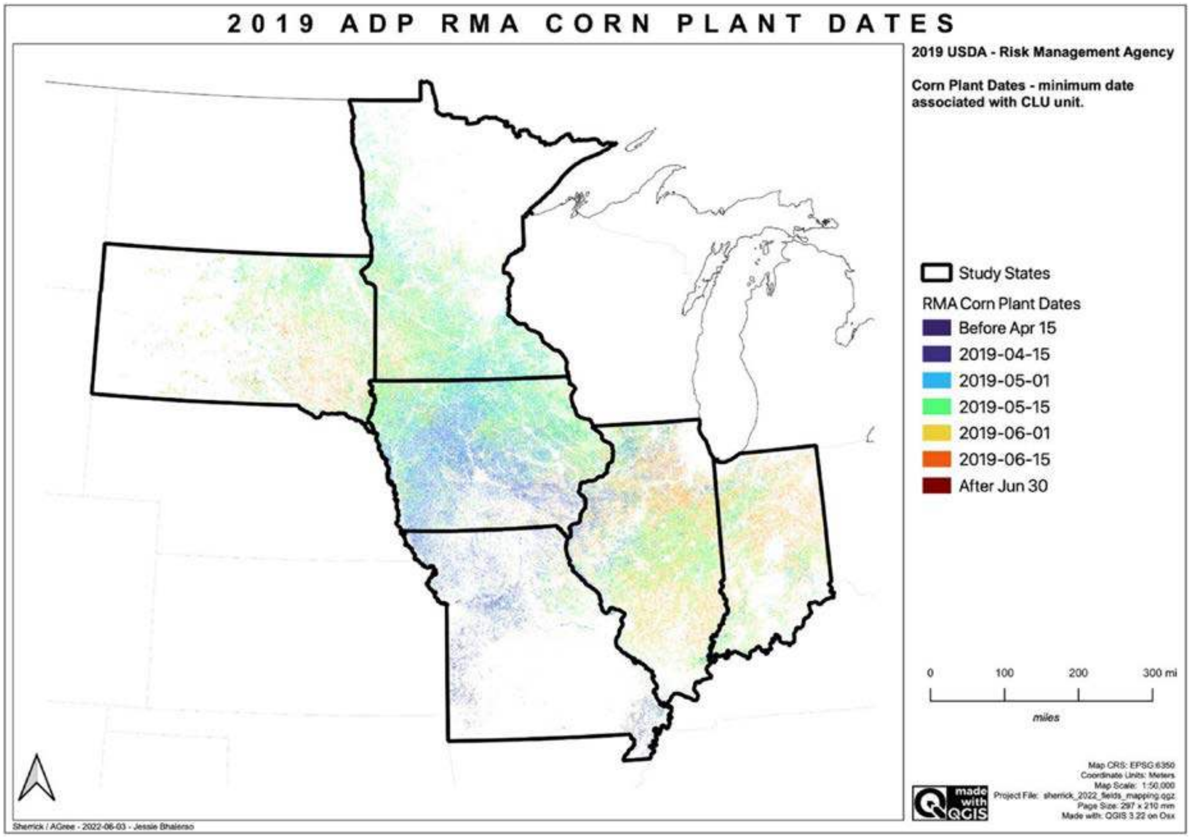

Figure 2 Pattern with corn planting dates in 2019 for six-state pilot area.

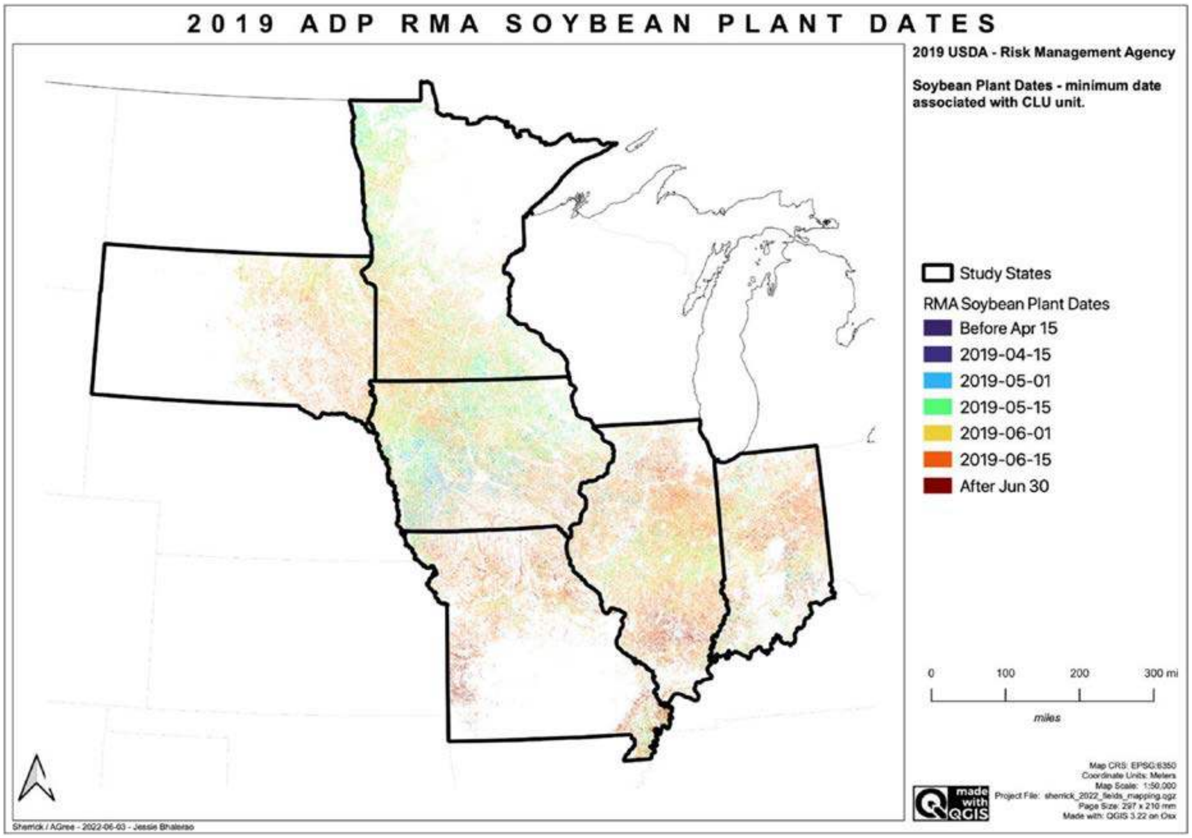

Figure 3 Pattern with soybean planting dates in 2019 for six-state pilot area.

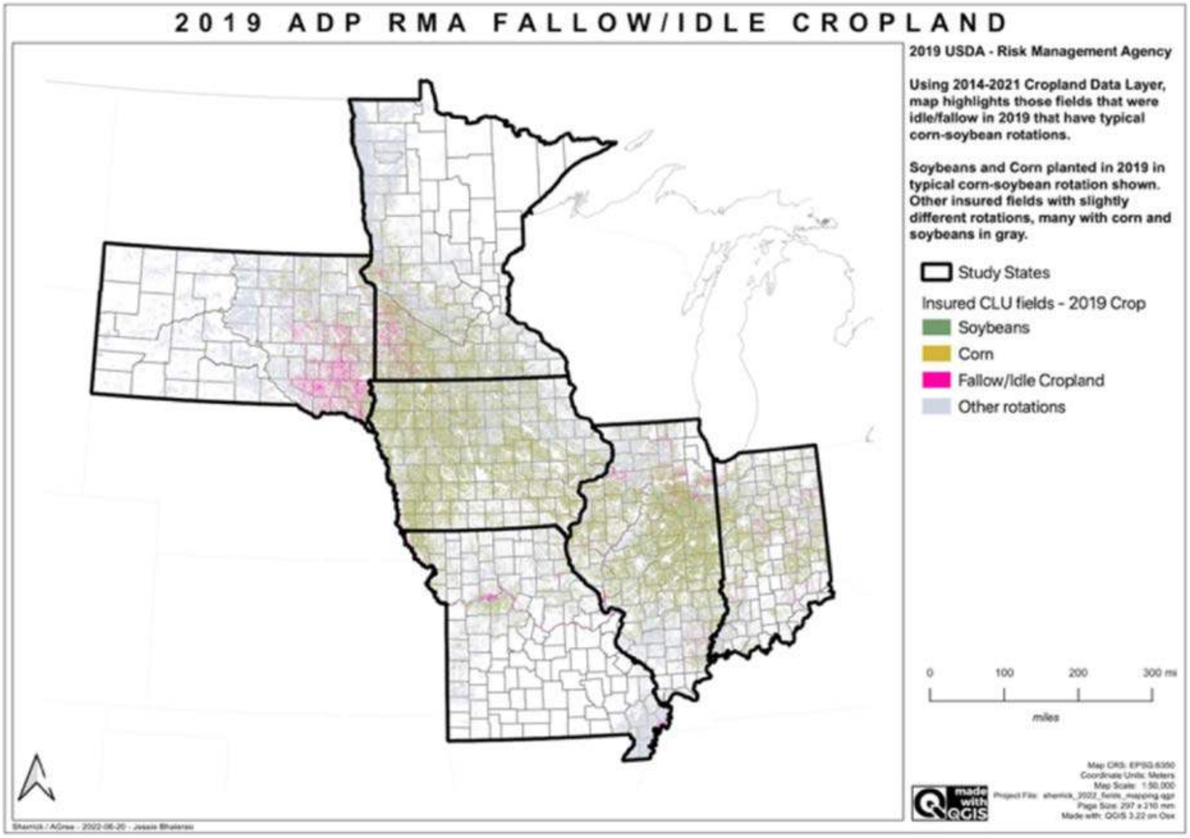

Figure 4 Areas with high incidence of fallow/idle cropland in 2019 shown in pink.

1 Did cover crops and no-till impact yields in 2019?

This question unfortunately cannot be answered due to lack of appropriate data. RMA yield data arrive the year following an insurance year, and the only yield data provided was through 2018. County-level data are not adequate to identify impacts. Actual Production History (APH) data through time would be most suitable to further extend this analysis and assess yield impacts in 2019 for cover crops and no-till/reduced-till. However, the expected yield values from RMA within policy records for earlier periods can be used to show the positive impact of use of cover crops on yields. This cover crop yield impact result is based on using a direct assessment within policy-level tests between deviations from expected yields between fields with and without relevant practices. Hopefully, future analysis of 2019 yields can be conducted.

Recommendations Regarding USDA Data

The USDA staff worked diligently to obtain and transmit data approved for release to the pilot project, ensuring privacy protocols. The research team is incredibly grateful for their assistance. From the outset of the research, it was recognized that there would be gaps in USDA data needed to answer the pilot project questions and alignment challenges between data sets from various agencies. Some limitations and constraints experienced with the USDA data set, in part reflecting historical data practices and budget limitations, were as follows:

Constraint #1

Availability of annual data on conservation practice implementation

The data available on cover crop planting in the six-state pilot effort is incomplete and inconsistent through time. This outcome was not unexpected as only a fraction of FSA offices regularly collect farmers' cover crop acres, and of those that do, some neglect to query all farmers about their cover crop practices, due to the priority on commodity crop data collection. Some farmers have also been reluctant to provide cover crop data, particularly in past years when there was more concern about whether use of cover crops would impact crop insurance eligibility. Even where planting intentions for cover crop were gathered, the current system does not identify whether cover crop establishment and subsequent growth was achieved, or whether stands of cover crops were sufficient to provide soil benefits.

Collection of no-till data is even more limited. While both no-till and cover crops are part of the USDA Census of Agriculture data collection conducted once every five years, and some no-till data are obtained in periodic NRCS Agricultural Resource Management Surveys (ARMS), there has never been any annual data collection evaluating which fields are no-till. As indicated earlier, processed image data provide highly promising and cost-effective potential resolution to this issue.

Thus, given the limitations in systematic and annual data collection on cover crops and no-till, the Meridian team relied heavily on remote sensing data to supplement available USDA data on cover crop and no-till acres.

Data Recommendation #1

USDA should determine an effective method for collecting cover crop and no-till usage data on a field-by-field basis, either through more robust and consistent data collection efforts through local USDA offices (eg., using existing data entry format on cover crops), or by use of remote sensing data with some verification of the remote sensing analysis through on-the-ground observations.

Constraint #2

Geographic units for data

For a variety of reasons, crop data are not always collected at the same geographic scale. Most often, CLUs are the targeted geographic unit, but sometimes other scales are used that may involve multiple CLUs or partial CLUs. This fact makes matching field practices with planting dates, yields, insurance information and other data difficult to implement.

Part of the challenge is how farmers maintain their records and share information with USDA, sometimes lumping "fields" and sometimes splitting an area that was formerly managed as one crop field into two crop fields. These changes can occur due to changes in land ownership, convenience in managing the relevant land area, or just the convention of the producer in how they track their own information. Furthermore, crop insurance policy data often exist at a level of aggregation that covers a crop in multiple fields that differ year to year due to rotational practices.

Recognizing the challenges in associating a fixed unit of land defined as a field that persists from year to year, a principle to apply is to attribute as many data layers as possible to the smallest practical unit of geography. For example, a farmer may grow crops on what they refer to as five separate "farms" (the farms could each be owned by a different person but all farmed by one operator, or they could simply refer to the location of the set of fields). Each of these farms may consist of as little as a single field, a few fields, or many fields. The farmer, for convenience, may have traditionally reported the entire corn production on a farm as one data point, but in reality had multiple fields each managed somewhat differently for that farm including rotations. For example, if there were five fields, only one may have had cover crops but all were recorded no-till, whereas on a different farm the same operator did not use no-till or cover crops.

Consequently, a system is needed where multiple base layers of data can be combined, even if the geographic size of the units varies by layer. Whether this means more consistency in data reporting at the CLU level or having other geographic identifiers for the relevant land parcels on which data is being collected, a better means is needed for matching up the geographic aspects of relevant data layers, particular for crop grown, crop management (including conservation practices), and insurance coverage and claims.

Data Recommendation #2

USDA should evaluate how to develop more consistency in gathering relevant data at the geographically identified boundary level and report with the same geographic identifiers, with cross-compatibility between agency databases tied to the geographically identified unit for each mapping layer of interest.

Constraint #3

Timestamping and sequencing date data

Another challenge in matching up data sets for agronomic practices and crop performance results is the timing of data collection and tagging the data for the relevant period. For example, data exists on reported crop planting intentions, but a farmer may change the crop to be planted in a field. In other cases, the timing in which a cover crop was reported may not match the year in which it was planted. For example, a winter annual cover crop would be planted in the fall preceding the year in which the cover crop is recorded. In the case of prevent-plant situations, a cover crop may be planted during the summer on a field that has been declared prevent-plant, and then a different cover crop planted that fall (or the cover crop planting may be a mixture of warm season and cool season covers that can collectively extend the effective cover crop period from mid-summer through the next spring). These possibilities raise questions about how cover crop incidence should be recorded. Such simple questions as whether the crop year should be based on the cover crop planting date or the crop year in which terminated are complex if not time stamped. Likewise, no-till is an on-going practice that is sometimes temporarily interrupted, such as tillage to address compaction from harvesting in wet weather. Other farmers use no-till only after some crops in their rotation, which is usually referred to as rotational no-till.

Data Recommendation #3

USDA should pursue standardization and synchronization of time stamps for reported crop management practices and results in terms of yields. Given the wide and effective availability of satellite imagery, standardized Crop Data Layer (CDL) systems, and third-party verification through image processing, this recommendation could substantially reduce complexity in collection and reduce costs. It could also improve understanding of which practices were effectively implemented alleviating reliance on complex surveys of stated intentions for a crop or practice.

Constraint #4

Matching CLUs to available weather data

Although USDA does not have its own weather station network, other weather data sets such as PRISM data are available that can be matched to CLUs to improve evaluation of crop management and performance in relation to weather data. In particular, better matching of available weather data to crop management will allow more in-depth analyses of factors leading to insurance claims and crop performance.

Data Recommendation #4

USDA should explore use of robust available sources of weather data to match annual weather conditions to geographic land unit by constructing appropriate data layers in their system and/or support third party efforts to do so.

Constraint #5

Combined or centralized data sets

USDA agencies generally manage their own data, using their own data management and storage systems. This makes it difficult to conduct analyses using data from multiple agencies, as was done for this project. Time and resources are needed to adapt the data to a common format that is interoperable (can be used and managed from any in- or endpoint. In some cases, data are not usable because it is not possible to match data due to differences in land unit definitions, relevant time periods, or other differences in data characteristics.

Data Recommendation #5

USDA should ideally develop an approach that leads to one common data set for each land unit (e.g., CLU, field, latitude/longitude grid, etc.) so that USDA staff and cooperators have accurate and consistent information including conservation activities and measures of crop performance.

Constraint #6

Public research access to USDA data

While some USDA data are publicly available and widely used by university and government researchers, an opportunity exists to do more analysis with data that are not regularly made publicly available. For data perceived to have restricted access, it would be helpful to design a standardized process for providing access to researchers while maintaining producer confidentiality.

Data Recommendation #6

USDA should consider developing a process that researchers can use to access a broader cross section of USDA data while maintaining producer confidentiality. USDA ideally could provide a standard data format that is accessible to other external groups so that internal USDA data are better connected to external data sources and the data can be of greater public benefit.

This report is being provided to relevant USDA staff and administrators in an effort to be helpful to the department. The authors fully understand that multiple factors, including budget limitations and past agency policies, have led to the current data collection methods at USDA. The recommendations in this report are offering constructively with an understanding that some improvements in the data system will be easier to achieve than others. Addressing these data issues will greatly improve agricultural data research for the public benefit by providing much needed insights into conservation and risk management policies. Improvements in the data system will also help with improving USDA conservation and risk management program implementation.

A key recommendation is that USDA should integrate more data sources, some of which may be external, such as weather data and in particular remote sensing data. Whether USDA develops an in-house team to do remote sensing evaluation of crop data or contracts with such information with external partners, remote sensing technology can clearly help fill in some of the USDA data gaps. Broad scale use of remotely sensed data and other "big data" sets are already being deployed by the private sector. Adopting best practices from some private sector data systems can help inform how to address producer concerns regarding privacy in a way that benefits both producers and taxpayers.

USDA has made critical strides to evolve and improve the various types of USDA data available. These recommendations are complimentary to ongoing efforts. Better data and more thorough analysis of farm data will lead to better decisions for research, education, management, and policies benefitting not only producers but all those that depend on American agriculture productivity and prosperity.

Appendix I. Data Sources Used in the Pilot Project

This document provides a comprehensive list of all the data used in this pilot project, its source, and derivatives produced within the project

All data was standardized to a Postgres database format for tabular, vector and raster data. Raw rasters for large public datasets like the digital elevation maps were stored as GeoTIFFs on disk.

All data was organized using the geospatial data platform LabCore, (Soil Diagnostics Inc, Champaign, IL) running locally on commercial compute and storage hardware running on a local network, not accessible from the Internet.

Primary data

1. RMA Insurance data 2019.
2. RMA CLU boundaries 2017-2019.
3. NRCS practice data 2017-2020.
4. FSA practice data 2017-2019.
5. Atlas remote sensing data from Indigo Ag.

Public data sources

LabCore includes access to the following data sources, but for the purpose of increasing efficiency of computation, these data were downloaded and processed locally.

6. **USDA SSURGO data** (Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture.) A copy of the entire 2019 dataset was purchased from USDA in 2019.
7. **USGS 10m Digital Elevation Maps** (United States Geological Survey, 10m National Elevation Dataset, accessed 2021.)
8. **USDA Cropland Data Layer** (USDA National Agricultural Statistics Service, datasets downloaded for the crop years 2014 to 2021.)
9. **PRISM climate data** (PRISM Climate Group, Oregon State University, https://prism.oregonstate.edu, downloaded for the 2019 year). This data service is supported by the USDA Risk Management Agency.
10. **GRACE-FO Soil Moisture data** (NASA Gravity Recovery and Climate Experiment—Follow On, https://nasagrace.unl.edu, accessed 2022, downloaded for 2019.
11. **2017 Census of Agriculture Data** (USDA National Agricultural Statistics Service Publication A-17-A-51, 2019.) including tabular data by county.
12. **US Counties Boundaries** (US Census Bureau, https://catalog.data.gov/dataset/u-s-county-boundaries updated 2019, accessed 2021.)
13. DeriveLD (Plat map) data (US Bureau of Land Management, Cadastral Special Services). Access available but not used in any specific analysis.

Private data sources

Indigo ATLAS (https://www.indigoag.com/atlas-insights). Our collaborators at Indigo ATLAS kindly provided *ex gratia* access to a proprietary dataset that included predictions for cover crop and tillage status for the crop years 2017-20 for all the study states. This dataset in turn used weekly multispectral, remote-sensed imagery from the Landsat and Sentinel satellite missions. (personal communication)

Derived Data Sets

The following datasets were derived by combining one or more of the datasets listed above during the course of this project.

14. **10m slope dataset**, processed using GDAL—(GDAL/OGR contributors, GDAL/OGR Geospatial Data Abstraction software Library, version 3.2, Open Source Geospatial Foundation, 2022, https://gdal.org)
15. **Stream Power Index and Topographical Convergence Index datasets** using GRASS—(Neteler, M., Bowman, M.H., Landa, M., Metz, M., 2012. GRASS GIS: A multi-purpose open source GIS. Environ Model Soft 31, 124–130.) https://grass.osgeo.org
16. **Averaged and accumulated PRISM precipitation datasets** for the period from April 1 2019 to June 1 2019.
17. **Soil moisture cluster dataset**, obtained via a K-means clustering analysis conducted on the GRACE surface soil moisture data to partition the study area based on similar soil moisture conditions
18. **Crop Rotation prediction dataset**, used CDL land use changes from year to year to infer the crop that would have been planted in 2019 in the absence of the prevent-plant situation. This data was used to visualize the CDL detected fields that were not planted

(fallow/idle cropland) and to suggest where there were discrepancies between the expected rotation commodity and claimed commodity in the claim.

19 **SoilDx Field Boundaries** Using multiple years of Cropland data from 2014 to 2021 and a proprietary machine learning algorithm, a new dataset was constructed that infers field boundaries based on public land use data alone. This dataset was used to determine the number of distinct fields based on management data within a specific CLU.

Miscellaneous references

These reports were referenced when comparing our observations or analysis with independent third-party reports.

20 **CTIC / SARE / ASTA Cover Crop and Tillage Survey Data** (2017-20) (Conservation Technology Information Center, USDA Sustainable Agriculture Research and Education, and American Seed Trade Association, data used for comparative plots. https://www.ctic.org/.

21 **ISDA Cover Crop and Tillage Transect Data** (2019) Indiana Department of Agriculture Cover Crop and Tillage Transect Data for 2019, accessed 2022. https://www.in.gov/isda/divisions/soil-conservation/cover-crop-and-tillage-transect-data/ Data used for comparative plots.

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The AGree E2 Coalition drives adoption of agricultural conservation practices by developing concrete federal policy recommendations, commissioning research, and developing tools and frameworks related to agricultural data innovation, crop insurance, and agricultural finance. Its members represent a diverse range of interests, including farmers, researchers, academics, former officers of the U.S. Department of Agriculture (USDA), former Congressional staff, and NGO leadership.

CFAD works to enact federal climate policy that is ambitious, durable, and proportionate to the urgency and scale of climate change. CFAD members are farmers, food and agriculture company leaders, former USDA officials and Congressional staff, and civil society organizations who believe that climate change demands ambitious and durable federal policy solutions. Together, CFAD members develop bipartisan policy ideas and inform decision-makers in the Administration and Congress.

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