



Economic Research Service
U.S. DEPARTMENT OF AGRICULTURE

Economic
Information
Bulletin
Number 293

March 2026

Persistence of Cover Crop Use in Crop Production in the United States, 2012–2022

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Economic Research Service

www.ers.usda.gov

Recommended citation format for this publication:

Pratt, B., Paul, L., Bowman, M., Messer, K., & Ferraro, P. (2026). *Persistence of cover crop use in crop production in the United States, 2012–2022* (Report No. EIB-293). U.S. Department of Agriculture, Economic Research Service.



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Persistence of Cover Crop Use in Crop Production in the United State, 2012–2022

Bryan Pratt, Laura Paul, Maria Bowman, Kent Messer, and Paul Ferraro

Abstract

Despite extensive research on cover crop use, little research has been done on the repeated use, or persistence, of cover crops in the crop production process. To examine the persistence of cover cropping, this report uses four panel data sources: (1) the U.S. Department of Agriculture’s (USDA’s) 2012, 2017, and 2022 Censuses of Agriculture; (2) crop acreage submitted by farmers through the USDA, Farm Service Agency’s Form 578 for crop years 2013–19; (3) an on-the-ground, in-person “windshield” survey by the Indiana Conservation Partnership for crop years 2014–19; and (4) the USDA Agricultural Resource Management Survey (ARMS) Phase 2 from 2015, 2016, 2018, 2019, and 2021. The percentage of land under cover crops differs by data sources, but overall, cover crop use has increased over time. However, in the majority of data sources, this increase over time masks a significant share of fields and operations reducing or disadopting cover crop use. Results also indicate the levels of cover crop use and its persistence are positively correlated across regions but do not substantially differ across crop rotation or when livestock are present on the operation.

Keywords: Adoption, conservation, cover crop, crop rotation, persistence

Acknowledgements

The authors would like to thank the USDA, Farm Service Agency; USDA, National Agricultural Statistics Service; and the Indiana State Department of Agriculture (ISDA) for providing data used in the report. The authors thank anonymous reviewers for their feedback, including reviewers from USDA, Farm Production and Conservation Business Center; USDA, Farm Service Agency; USDA, Office of the Chief Economist; USDA, National Agricultural Statistics Service; and USDA, Natural Resources Conservation Service; as well as an internal USDA, Economic Research Service (ERS) reviewer and a reviewer from academia. In addition, the authors appreciate the support of the USDA, ERS Peer Review Coordinating Committee and the staff in the USDA, ERS Information Services Division, Publication Services Branch for editing and designing this report.

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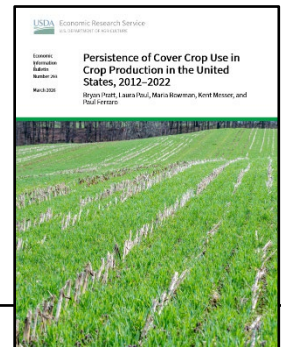
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A report summary from the Economic Research Service

Persistence of Cover Crop Use in Crop Production in the United States, 2012–2022

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Key Points

- Using four data sources (explained in detail below), cover crop use ranges from well below 1 percent to more than 10 percent of crop fields or operations included in the samples or administrative records in this study. Cover crop use varies based on year, relevant population, and definition of cover cropping.
- Cover crop use increased over time in all four data sources, but the rate of increase differed by source.
- The trend of increasing cover cropping levels over time generally masks the large turnover of fields and operations into and out of cover crops. Across three of the four data sources, a majority of fields or operations with cover crops in one year no longer report cover crops over a subsequent 5-year period and the majority of fields or operations with cover crops at the end of the 5-year period were not adopters at the beginning of that period.
- Across two of three data sources with annual statistics, no more than 54 percent of fields with cover crops in a given year report cover crops again in the following year.
- Four data sources were used to report cover crop use and persistence measures in the United States: (1) the USDA, National Agricultural Statistics Service's (NASS) Census of Agriculture, (2) the USDA, Farm Service Agency's (FSA) Crop Acreage Reporting Database (CARD), (3) an in-person "windshield" survey conducted by the Indiana Conservation Partnership, and (4) the USDA Agricultural Resource Management Survey (ARMS).

Why Does This Matter?

USDA funding for cover crops and producer adoption of this practice has risen substantially in the past two decades. This report examines the use and persistence of cover cropping within operations and fields over time, with a focus on the practical challenges of measurement in existing data sources. While the USDA, Natural Resources Conservation Service (NRCS) provides a definition of cover cropping in its practice standards, what producers and observers consider to be cover cropping varies considerably along with the benefits of the practice. From a practical perspective, this range of definitions and outcomes leads to

measurement challenges. The existing literature on cover crop use predominantly measures cover crop use in aggregate trends and levels. However, the existing literature does not generally address whether a field or operation that uses cover crops in a given crop year continues to use cover crops in subsequent crop years. Understanding persistence is important for three reasons: many benefits of cover crops vary with the frequency of use; aggregate trends may mask nuanced trends in adoption with implications for future aggregate trends; and estimates of persistence are necessary to fully understand the impacts of USDA conservation programs, including targeting, cost-effectiveness, and long-term environmental outcomes.

A Few More Details

Data Sources

The field- and operation-level data sources used in this report are linked as longitudinal data panels and represent producer-reported USDA, FSA administrative data (CARD), producer-reported survey data (Census of Agriculture and ARMS), and professionally observed survey data (Indiana windshield survey), providing a range of methodologies and definitions. Each data source is national, except for the Indiana windshield survey which is conducted at the State level. With respect to ARMS, this report uses the crop history table from the Phase 2 survey. The crop history table represents a retrospective panel provided at a single point in time, such that the 2021 corn survey, for example, includes data from 2017–21, and the data for each Phase 2 survey are unaffiliated with data in other Phase 2 surveys. This report uses the 2015 and 2019 cotton, 2016 and 2021 corn, and 2018 soybeans surveys.

Each of these sources allow us to measure cover crop use within a field or operation over time.

- While CARD is a highly accurate source for commodity plantings, cover crop use appears to be underreported in USDA, FSA administrative data during the period of this research. Reported levels of cover cropping are substantially lower within CARD compared to all other sources. However, the FSA administrative data allow tracking of more fields with cover crops than any other source.
- Both CARD and the windshield survey showed that among fields with reported cover crops in 2014, between 29 and 40 percent of fields did not report cover crops again in the period 2015–19. Under a different measurement framework, ARMS respondents reported much higher rates of persistence. Among fields reporting cover crops in the oldest year of each survey’s historical crop table, between 6 and 16 percent of fields report either 0 or 1 year of cover crops in the subsequent 3 years of data (the comparable measure of 0 or 1 year of persistence would be between 47 and 61 percent of fields for CARD and the windshield survey).
- In CARD and the windshield survey, between 4 percent and 24 percent of the fields with cover crops in 2014 report cover crops again in every year from 2015 through 2019. In ARMS, between 57 and 76 percent of fields with cover crops in the oldest year report cover crops in all years of reported data.
- In CARD and the windshield survey, among fields with reported cover crops in 2014, between 33 and 54 percent of fields report cover crops in 2015. Within ARMS, the comparable figure is between 63 and 86 percent.
- The Census of Agriculture measures cover crop use at the operation level rather than at field level, but it provides similar estimates to CARD and the windshield survey. Among operations reporting cover crops in 2012, 48 percent report cover crops again in 2017 and 27 percent report cover crops again in 2022.
- There is substantial variation in both use and persistence across regions in the Census of Agriculture and CARD, with persistence highest in the Northern Crescent. Persistence has also risen in the Heartland over time in the Census of Agriculture, from 43 percent between 2012 and 2017 to 48 percent between 2017 and 2022.
- There is no evidence of economically significant differences in persistence across crop rotations or livestock affiliation.

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Persistence of Cover Crop Use in Crop Production in the United States, 2012–2022

Background

Cover crops are plants that are grown to cover the soil instead of being planted for harvest. They improve soil health and are often adopted jointly with other conservation practices, such as continuous no-till practices, fertilizer application, and crop rotation (Canales et al., 2020; Gong et al., 2021; Lee & McCann, 2019; Wallander et al., 2021). U.S. Department of Agriculture (USDA) funding for conservation programs that incentivize cover crop adoption, such as the Environmental Quality Incentives Program (EQIP) and Conservation Stewardship Program (CSP), has grown over the past three decades (Wallander et al., 2021). Despite this growth and extensive literature on factors influencing cover crop adoption, there is limited knowledge about how producers make decisions about cover crop use over time and what persistence of cover cropping looks like on farming operations in the United States. Do producers begin using cover crops and then expand cover crop use to their whole operation? How many producers begin cover cropping and then stop? Are producers making decisions about whether to plant a cover crop based on annual economic and agronomic conditions, much as they would other agricultural management decisions?

Understanding persistence and producer decision making about cover crops over time is important for several reasons. Many benefits of cover crops (e.g., soil carbon sequestration or reduced erosion because of improve soil structure) vary with the frequency or duration of use (Bergtold et al., 2019; Cai et al., 2019). Without an understanding of how likely producers are to continue using cover crops, or how often, we may over- or underestimate the benefits of cover crop use in the future based on assumptions about trends in cover crop adoption and use. Similarly, the largest USDA conservation programs provide financial assistance for cover crops for a limited number of years and only for fields that were not previously cover cropped (Wallander et al., 2021). Understanding cover crop persistence patterns with and without participation in USDA programs—and what producers are likely to do after receiving financial assistance from State or Federal programs—is critical to estimating the long-term environmental impacts of USDA conservation programs, as well as informing how programs might be cost-effectively structured or targeted to achieve maximum benefits.

This report aims to assess and to inform regarding two challenges: the measurement of cover crop use and the persistence of cover crop use within actual operations and within fields. These two challenges are related, as persistence can only be characterized to the extent that it can be reliably measured within operations and within fields over time. This report contributes to the objectives of the Foundations for Evidence-Based Policymaking Act of 2018 by providing statistical evidence of the persistent use of cover crops over time.

Defining Cover Crops and Persistence

When attempting to measure cover crops and the persistence of their use on fields and within operations, it is important to understand the factors involved in defining what does—and does not—count as cover crops. Cover cropping broadly describes any planting of living cover between commodity seasons. Cover crops can have a range of purposes and can include a broad range of plant species. The two most common species are cereal rye and winter wheat (Bowman & Wallander, 2022). Cover crops can be planted throughout the year but are typically planted between main cropping seasons, most frequently in the fall around harvest. The potential use and method of termination is relevant to distinguish a cover crop. For example, harvesting the cover for commercial benefit is not usually considered consistent with cover cropping, but grazing or harvesting the cover crop for forage or on-farm use is compatible with USDA cover crop termination guidelines, and grazing or harvesting for forage is common on livestock operations that cover crop (Bowman et al., 2024). There are two primary components this study focuses on to define cover crops:

- 1) Purpose: Why are the cover crops planted? What are the objectives of the producer in implementing this practice?
- 2) Use and termination methods: What happens to the cover and when?

According to USDA, Natural Resources Conservation Service (NRCS) Conservation Practice Standard 340 (Cover Crops), the purposes of cover crops include reducing erosion, increasing organic matter content, reducing water quality degradation, interrupting weed and pest pressure, improving soil moisture, and minimizing soil compaction (USDA, NRCS, 2014). The cover itself can be any of a variety of species or a mix of many. Potential plantings include species not generally used for commercial purposes, such as clover, or species which may commonly be harvested for grain, such as wheat or other small grains. There is substantial variation in the cover crop species, how those species are grown and terminated, as well as location- and time-specific factors, such as soil, moisture, and temperature. The variations in these characteristics can result in environmental and productivity impacts of plantings.

Regarding termination methods, harvesting for sale or other off-farm use might not count as cover cropping. This is in part because those termination methods might reduce the overall benefits from cover cropping because of removal of plant biomass. There are still benefits that accrue from grazed cover crops, but removing the cover biomass may reduce benefits (Blanco-Canqui et al., 2013; Ruis & Blanco-Canqui, 2017) or may have no impact on the benefits of the cover (Blanco-Canqui et al., 2015). These variations in cover crop plantings and termination methods complicates pinning down a single definition.

Another potential component of measuring and defining cover crops is the cropping system that a planting exists within. For example, a field may feature forage production or grazing in the winter between commodity row crop production. The distinction between a cover crop system tailored to livestock benefits and a field rotation that mixes row crop production and livestock production may be difficult to define (for more information on cover crops and livestock, see Bowman et al., 2024).

Many available estimates of cover cropping are based on reporting by the farmer or by an observer, each of which may have different criteria for cover cropping. For example, two farmers may disagree on whether the same practice is a rotational grazing practice or a cover crop. Furthermore, an

independent observer can know neither the method of termination nor whether the planting will be harvested and sold. In this study, we identified cover crops primarily using the definitions available within each dataset. We describe in more detail which datasets allow us to identify which cover crop characteristics were used.

The persistence of cover crop use can be defined as the continued use of cover crops after initial use or after use at any point in time. Persistence can range on a spectrum from rare or occasional continued use to use in every year after adoption. Pannell and Claassen (2020) differentiate between alternating use, continuous use and opportunistic use to draw attention to the time component of conservation practice use. Some studies consider continuous users to be those who use cover crops in each year of the past 5 years (Dunn et al., 2016). For the purposes of this report, we refer to use in every subsequent year as complete persistence, and no use in any subsequent observed year as complete non-persistence. There remains a spectrum of persistence between these two extremes.

After initial adoption, subsequent use of cover crops constitutes persistence. However, the frequency of continued use required for optimal benefits is uncertain and likely dependent on the local environment and cropping system. While the predictors of adoption of conservation practices have been widely studied (see, for example, the reviews by Prokopy et al. (2019) and Ranjan et al. (2019)), little is known about the persistence or nonpersistence of cover crop use (Dunn et al., 2016; Jackson-Smith et al., 2010; Claassen and Ribaud, 2016). For example, farmers note that the timing of different crops can lead to challenges with cover crops ahead of specific crops in the rotation, as different crops may conflict with or complement the requirements for cover crop plantings (Roesch-McNally et al., 2017). Some studies that examine what happens after the initial adoption decision report on behavioral intentions to continue use rather than actual behaviors (Kuhfuss et al., 2016; Ramsdell et al., 2016). Intentions can be poor proxies for actual behavior because of potential biases in reporting, such as social desirability biases. Other studies report on observed persistence of conservation practices and have come to conflicting conclusions (Jackson-Smith et al., 2010; Roberts and Lubowski, 2007; Smart et al., 2015; Wallander et al., 2018). The conflicts stem from substantial differences in how the authors define persistence, as well as differences in data units, sample sizes, and analytical methodologies.

Sawadgo and Plastina (2022) recently attempted to measure persistence via broad county-level changes in total adoption rates. Their county-level aggregation, however, can mask trends in subsequent field- and operator-level turnover in cycles of new adoption and disadoption. With the benefit of Census of Agriculture microdata, we can observe that operator-level non-persistence and the aggregated measures used in Sawadgo and Plastina (2022) exhibit low or even negative correlation.¹

Measuring continued use of cover crops after initial adoption contributes to understanding the impact of different incentive programs, because practice adoption and associated benefits may or may not continue after the payments end (Bowman and Lynch, 2019). These incentive programs' additionality, or whether a producer would do the practice in the absence of the program, is also relevant for

¹ The correlation coefficient between operator-level non-persistence in the microdata across regions and the share of counties with disadoption is 0.0636. The correlation coefficient between operator-level non-persistence and the disadoption ratio from Sawadgo and Plastina (2022) is 0.198. Looking at a specific region example, the Fruitful Rim appears to be the most significant region for disadoption based on the Sawadgo and Plastina (2022) classification, but as shown in figure 13 of this report, operator-level persistence in the Fruitful Rim is slightly higher than the national average.

considering the efficacy of payment programs (Gong et al., 2021; Mezzatesta et al., 2013; Pannell and Claassen, 2020; Sawadgo and Plastina, 2021).

We measure persistence of cover cropping in this report in two numerical measures. The first is the number of years with cover crops after an observed year of cover crops. This leads to an ordinal intensity measure of persistence, but it is not necessarily to suggest that twice as many years of subsequent cover cropping could be considered twice as persistent. Most notably, this measure also does not address whether that persistence occurs in a consistent way or with any trend. The second measure is the observed use of cover cropping within a particular year after an observed year of cover crops. This measure provides a binary indicator of persistence within a field or operation for set intervals. By combining the two measures, it may be possible to roughly infer trends in persistence and the dynamics of how fields with cover crops do or do not continue the practice.

Overview of Cover Crop Data

We used several datasets to identify cover crop adoption and persistence within fields or operations over time. Each dataset has different characteristics, including the time span, the unit of observation, the geography covered, and how the data were elicited. Table 1 presents an overview of each dataset and its characteristics. Table 1 presents the datasets (columns) and their characteristics (rows). Except for the Census of Agriculture, all years are presented as crop years, which extend from October 1 through September 30. Crop year 2014 began on October 1, 2013. Over-winter cover crops are uniformly assigned to the crop year containing the following over-summer commodity crop. For example, cover crops planted in September of 2013 are assigned to crop year 2014. For the Census of Agriculture, the question only asks about the calendar year, such that acreage reported in 2017 may be planted before or after the 2017 commodity season. Tables A.2 and A.3 provide weather and agronomic conditions for the baseline year and comparison years.

Our study uses data generated from three different methods of measuring cover crops: FSA administrative reporting by farmers, field observations by experts, and survey self-reports by farmers. These methods each present different strengths and weaknesses. A fourth method of measuring cover crop use is remote sensing technologies, both aerial (i.e., planes or drones) and satellite imaging. Using remote sensing to measure cover crops is difficult because cover crops and production crops often are indistinguishable in remote sensing images (Barnes et al., 2021; Thieme et al., 2020; 2022; Wang et al., 2023; Zhou et al., 2022). Consequently, in this study we do not use remote sensing-based datasets. However, it is an area for potential future contributions as these technologies continue to improve.

Table 1
Overview of data sources

	USDA Census of Agriculture	USDA Crop Acreage Reporting Database (CARD)	Indiana windshield survey	USDA Agricultural Resource Management Survey (ARMS) Phase 2
Years	2012, 2017, 2022	2013–19	2014–19	2015, 2016, 2018, 2019, 2021
Unit (magnitude)	Operation (500,000)	Field (8,960,201)	Field (31,020)	Field (848–2,083)
Geography	National	National	State (Indiana)	Regional, by survey
Cover crop elicitation	Self-reported (survey)	Self-reported (administrative)	Observer-reported (State employees)	Self-reported (survey)
Longitudinal linkage	Can link some operations over time	Can link fields over time	Can link fields over time, observer-reported	Retrospective within field, not linked across surveys

Note: The table includes only those surveys or time periods of each data source which are presented in this report. CARD is recorded annually at the level of the Common Land Unit (CLU), which are assigned to “panel fields” defined by USDA, Economic Research Service (ERS). USDA, ERS-defined panel fields are CLUs or parts of CLUs, created by using the boundaries of CLUs across time. The USDA, National Agricultural Statistics Service, Agricultural Resource Management Survey (ARMS) includes multiple questions regarding cover crops, but our report examines only the crop history table in Phase 2. It is not possible to link fields in one ARMS Phase 2 survey with those in another ARMS Phase 2 survey. Each ARMS survey, such as 2015, provides information over 4 years, such as 2012–15.

Source: USDA, Economic Research Service analysis of data from USDA, Farm Service Agency; USDA, National Agricultural Statistics Service; and the Indiana Conservation Partnership.

Census of Agriculture

The objective of the USDA, National Agricultural Statistical Service (NASS) when conducting the Census of Agriculture is to make a complete count of U.S. farms and ranches and their operators. The Census of Agriculture occurs once every 5 years and collects data on land use and ownership, operator characteristics, production practices, income, and expenditures. For our study, we use operation-level data for 2012, 2017, and 2022 Censuses of Agriculture which includes information from respondents representing approximately 500,000 operations with any cropland in all 3 years.² The magnitude of the dataset is an important feature, as is the opportunity it provides to link operations over two time

² The number of operations represented is calculated based on the 2022 Census of Agriculture weights. The total of 500,000 is the sum of weights associated with the operations responding in all 3 years, reporting any cropland harvested or failed in 2022.

periods when data is collected.³ Producers can complete the Census by mail or online, and the majority of operations in the United States participate.

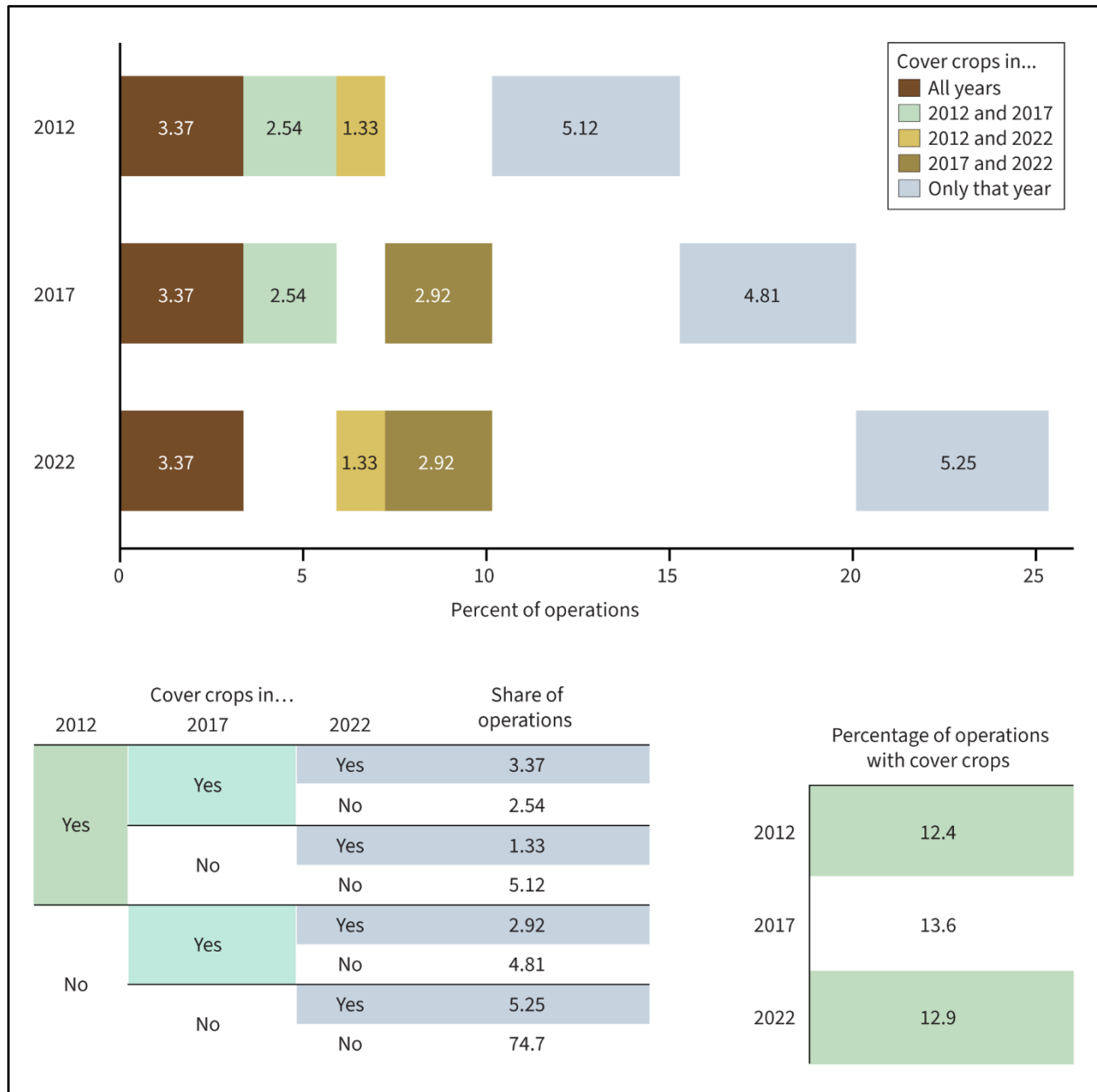
The Census of Agriculture asked one question regarding cover crops in 2012, 2017, and 2022. In 2012, the question asked, “How many cropland acres were planted to a cover crop? Exclude CRP acres” (USDA, NASS, n.d.). In 2017, the question was similar but provided the following parenthetical definition of a cover crop: “Cover crops are planted primarily for managing soil fertility, soil quality, and controlling weeds, pests, and diseases.” The 2022 form is the same as 2017, including the parenthetical. There is no further clarification in the included instructions in any year, but each year the supplemental report form describes cover crops as “planted primarily for managing soil fertility, soil quality, and controlling weeds, pests, and diseases.”

Figure 1 provides the level of use of cover crops among operations in 2012, 2017, and 2022, as well as transitions by operations into and out of cover crops. Among operations observed in all 3 years, 12.4 percent reported cover crops in 2012, 13.6 percent reported cover crops in 2017, and 12.9 percent reported cover crops in 2022. Approximately 3.4 percent of operations linked across all 3 years had cover crops in all 3 years. This represents approximately 27 percent of those operations reporting cover crops in 2012. On the other hand, 41 percent of operations with cover crops in 2012 (5.12 percent of all operations) do not report cover crops again. This is similar to the share of operations reporting cover crops only in 2017 (4.81 percent) or 2022 (5.25 percent).

While these estimates represent only three snapshots in time, the responses are for any cover cropping on the entire operation. There exist only two possibilities under which an operation could be classified as cover cropping in one year and not cover cropping in a subsequent year. Either they stopped engaging in the practice, or they engage in cover cropping in a rotation or under a regimen such that they did not cover crop on any field throughout their entire operation in the year without cover crops reported. For example, if an operation only cover crops every other year or every third year, or if an operation only cover crops under certain weather, they may be persisting but not labeled as cover crops in both or all 3 years. When combining the small increase in the share of operations with cover crops (0.5 percentage points over 10 years) with the fact that more than 60 percent of operations with cover crops in 2012 did not report cover crops in 2022, it is clear that the modest increase in total usage masks substantial exit from and entry into the practice. For further analysis of cover crop use by USDA, ERS Farm Resource Region, see section “Regional Differences in Cover Crop Use and Persistence.”

³ Note that the Census of Agriculture is sent to all producers who meet the minimum definition of farms set forth by USDA, National Agricultural Statistics Survey (NASS). However, not all producers complete the census. Producers which are observed in only 1 or 2 of the 3 years may have entered or exited agriculture, or they may have refused or neglected to respond in one year.

Figure 1
Cover crop use and transition shares for operations between the 2012, 2017, and 2022 Censuses of Agriculture



Note: This figure contrasts numbers of operations transitioning among different use statuses across the three Censuses of Agriculture. The transition matrix (bottom left) provides the numeric value of each of these trajectories, and the use table (bottom right) lists the use rates in 2012, 2017, and 2022. The sample represents approximately 500,000 operations that appear in 2012, 2017, and 2022.

Source: USDA, Economic Research Service analysis of the 2012, 2017, and 2022 USDA Censuses of Agriculture.

USDA, Farm Service Agency Crop Acreage Reporting Database (CARD)

This study uses panel fields constructed using the USDA, Farm Service Agency’s (FSA) Common Land Unit (CLU) dataset connected to CARD. The panel fields are generated using CLU boundaries from 2013 through 2019.⁴ All producers are required to file a Form 578 on an annual basis in order to participate

⁴ For context, the mean acreage of “panel field” is 43.7, while the median acreage is 9.07.

in USDA programs and receive financial support from USDA.⁵ The data generated through this process is compiled in CARD, and this record serves as the official record of planted acreage for a variety of purposes. Reported plantings include a variety of useful information, including the acreage planted to a specific crop and the intended use of the planting, such as harvesting for grain (GR), planting for forage (FG), or cover only (CO). This data is considered the standard for measuring commodity plantings and serves as the reference truth for the Cropland Data Layer (CDL), but it is important to note that, unlike commodity plantings, it is not required for producers to report cover crops (Boryan et al., 2011). The data from Form 578 are linked to the panel fields.

Cover crops, when they are reported, can be identified in CARD through stated intended use of a planting. Before the 2017 crop year, cover crops were recorded through a variety of intended use codes, depending on the purpose of the planting. The USDA, FSA Acreage and Compliance Handbook (2-CP) provides the instructions for providing this information through USDA, FSA Form 578. Before the 2017 crop year, the cover only (CO) use code is defined as follows:

Intended not for harvest, but to be used for field cover only. The crop is destroyed intentionally and is not incorporated into the soil. Typically used for erosion control or other environmental benefits.

Note: If the crop is to be grazed (GZ), hayed for forage (FG), left standing (LS), or plowed in for manure (GM), report as such. Do not report as Cover Only (CO). (USDA, FSA, 2-CP (Rev. 15), Exhibit 11)

Beginning with the 2017 crop year, cover crops were assigned a crop code (0319, COVRC) and were meant to be reported as cover only, rather than hayed for forage, grazed, left standing, or plowed in for manure. With this shift, reporting cover only on Form 578 also required, according to USDA, NRCS guidelines, that the planting not be harvested for commodity production (“termination”). Acceptable termination methods include grazing or incorporation into the soil, as well as being left standing and allowing the cover crop to die naturally before or after commodity planting, including because of frost.

Given the changing nature of reporting, this report provides statistics for two primary measures of cover cropping during the period from 2013 through 2019.⁶ First, using the most recent definition, we measure cover cropping as any fields reporting a cover only planting. Second, using the older instructions, we measure cover cropping as any fields reporting a cover only planting and any fields reporting a planting for forage, plowed in for manure, grazed, or left standing while also reporting a planting for grain (GR) or silage (SG) in the same crop year. We also consider fields with a planting for grain and a planting for silage to be cover cropping under this definition, as such silage plantings may be reasonable characterizations of cover cropping under the pre-2017 framework.

⁵ The FSA Form 578 is the Report of Acreage, used for producers to officially report plantings. It serves as the basis of the FSA crop acreage reporting and is used for program implementation and compliance.

⁶ While outside the scope of the data shown in this report, reporting was impacted by the introduction of new incentives in 2021. In the 2021 and 2022 reporting years, producers with cover crops that meet the cover only guidelines were eligible for a crop insurance subsidy of \$5 per acre under the Pandemic Cover Crop Program (PCCP). Before this incentive, there was no benefit to the producer from reporting cover crops, and many producers may have perceived reporting as an unnecessary burden. Unlike commodity plantings, it is not mandatory under Federal law to report cover crop plantings. As a consequence, reporting of cover only increased dramatically with the introduction of this incentive.

We characterize the first measure as a narrow definition and the second measure as a broad definition. Each measure has some drawbacks. For the narrow definition, there is evidence that, before 2021, cover only is substantially underreported in CARD, relative to the Census of Agriculture, leading to many false negatives, where a field is characterized as not cover cropping despite actually cover cropping. Appendix table A.4 compares public aggregate reporting for CARD and the Census of Agriculture to illustrate the differences in relative reporting. While the broad definition is likely to capture a large portion of fields with cover crops which are not being recorded as cover only, it may also capture both false negatives and false positives (something that is not a cover crop being labeled as a cover crop). This broad definition may also capture practices that are oriented towards commercial production more than conservation purposes.

To align the CARD data analysis with the windshield survey data analysis (see next section), we examine cover cropping in crop years 2014 through 2019.⁷ All results in this section are for fields that reported cover cropping in the 2014 crop year, which generally describes a cover crop planted during fall of 2013 for the winter of 2013–14.

Table 2 shows the share of fields reporting cover crops in CARD. The table includes usage shares for both the narrow and broad measures of cover crops within two groups. The first and third columns present the share of fields reporting cover crops using the narrow measure, while the second and fourth columns present the share of fields under the broad measure. The first two columns present the share of all fields reporting cover crops, while the third and fourth columns present the cover crop reporting rate among fields with any grain (GR) plantings 2013–18.

Table 2
Cover cropping reported to USDA, Farm Service Agency in its Crop Acreage Reporting Database (CARD), percent coverage by crop year

	All fields		Fields with grain crops	
	Narrow definition	Broad definition	Narrow definition	Broad definition
2014	0.27	1.28	0.44	2.39
2015	0.33	1.32	0.53	2.48
2016	0.43	1.46	0.71	2.68
2017	0.64	1.62	1.12	2.97
2018	0.69	1.68	1.11	3.06
2019	1.21	2.71	2.43	4.39
<i>Fields</i>	<i>8,960,201</i>		<i>3,107,585</i>	

Note: The all fields sample includes all fields reporting to CARD in 2013–19. The fields with grain crops include only those fields that report at least one planting for grain during that time period. The narrow definition share is those fields that report a planting of cover only, while the broad definition of cover crops includes cover only, forage, grazing, green manure, and left standing when planted in the same year as a planting for grain or silage. For context, the median acreage of a panel field is 9.07, and the mean acreage is 43.7.

Source: USDA, Economic Research Service analysis of USDA, Farm Service Agency, Crop Acreage Reporting Database.

⁷ For the purposes of USDA and this report, a crop year begins after fall harvest and ends with the following fall harvest. The year assigned to a crop year represents the calendar year when the crop year comes to an end. The 2014 crop year, for example, spans from late autumn 2013 through early autumn 2014.

The reporting of cover cropping is lower in CARD than in any other data source within the 2014–19 period. This is true under both definitions and within both samples, all fields and only fields with any grain. Additionally, while not presented in table 2, reporting increased substantially when the Pandemic Cover Crop Program (PCCP) introduced incentives for reporting. Thus, the historical underreporting of cover crops in CARD relative to the three other data sources here, and CARD during PCCP, is an important limitation of the data. However, while cover cropping is reported at low levels in CARD, the spatial and temporal scope of the dataset is an asset for analysis, and CARD represents the only administrative record of cover crops in the United States that includes unfunded cover crops. The total set of fields covers approximately 9 million fields throughout the country, while the fields with grain crops subset includes approximately 3 million fields.

According to CARD, about 40 percent of fields reporting cover crops in 2014 never report cover cropping again during crop years 2015 through 2019 (figure 2). For the narrow definition, there is a steady decline in the share of fields by number of years of observed persistence, with more fields reporting cover crops in 1 out of 5 years and the fewest fields reporting cover crops in all 5 years. A similar pattern is observed with the broad definition, with the exception of a larger share of fields with complete persistence—cover crops in all subsequently observed 5 years. This discrepancy may be due to the inclusion of practices which fall within this broad definition of cover crops, such as using cropland for livestock grazing and forage, which may form the basis of a permanent production strategy.

In addition to the years of cover cropping within field, figure 2 provides the aggregate share of fields reporting cover crops in 2014 that then reported cover cropping in each of the subsequent 5 years. Specifically, the top row provides histograms for the share of 2014 cover crop fields with the labeled number of subsequent years in cover cropping, out of a possible 5 in total. Notably, the share of such fields cover cropping declined immediately, such that only about one-third of the fields cover cropping in 2014 report cover cropping again in 2015.

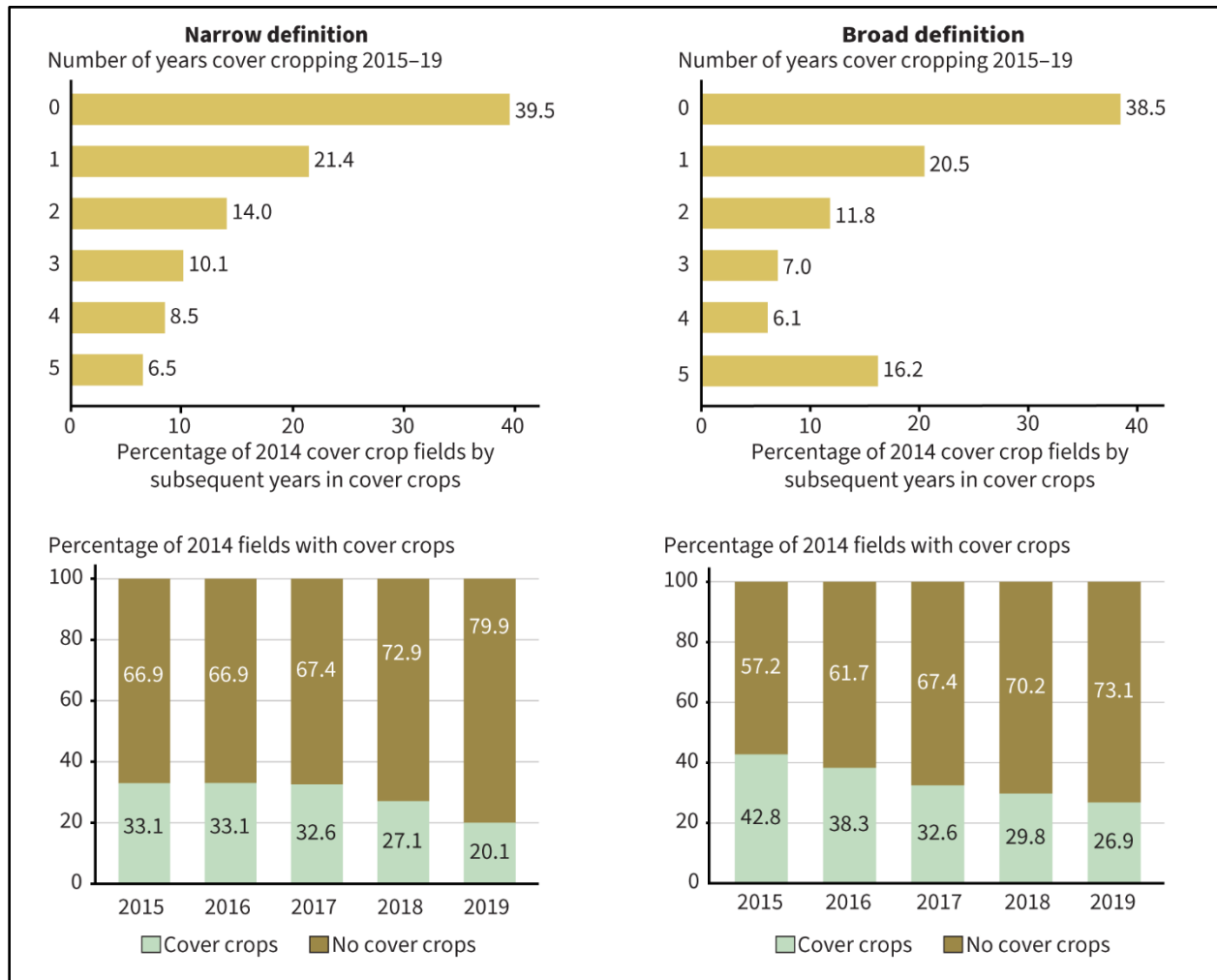
Figure 3 replicates the analysis in figure 2 for the subset of fields that reported at least one planting for grain during the time period. The goal of restricting to this subset is to ensure that the estimates are only for those fields which might reasonably be expected to implement cover cropping. However, some fields producing a commodity crop may be excluded if they omit the intended use when reporting. In a subsequent section, we examine persistence by crop rotation.

When restricting only to fields with at least one planting for grain, persistence appears to be higher. This result suggests that the lowest persistence fields may be those where reported cover cropping is occurring outside the conventional commodity crop production framework.

Connecting figures 2 and 3, the data indicate substantial turnover and movement into and out of cover crops. Given the steady and substantive increase in reported cover cropping over time, the persistence results imply that a large share of these fields reporting cover crops are new or relatively new to the practice in any given year, with new entrants more than compensating for the fields exiting. This pattern of modest increases in the aggregate use of the practice masking substantial entry and exit is similar to the findings for the Censuses of Agriculture.

Figure 2

Persistence in reported cover cropping among fields reporting cover crops in 2014, USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD)

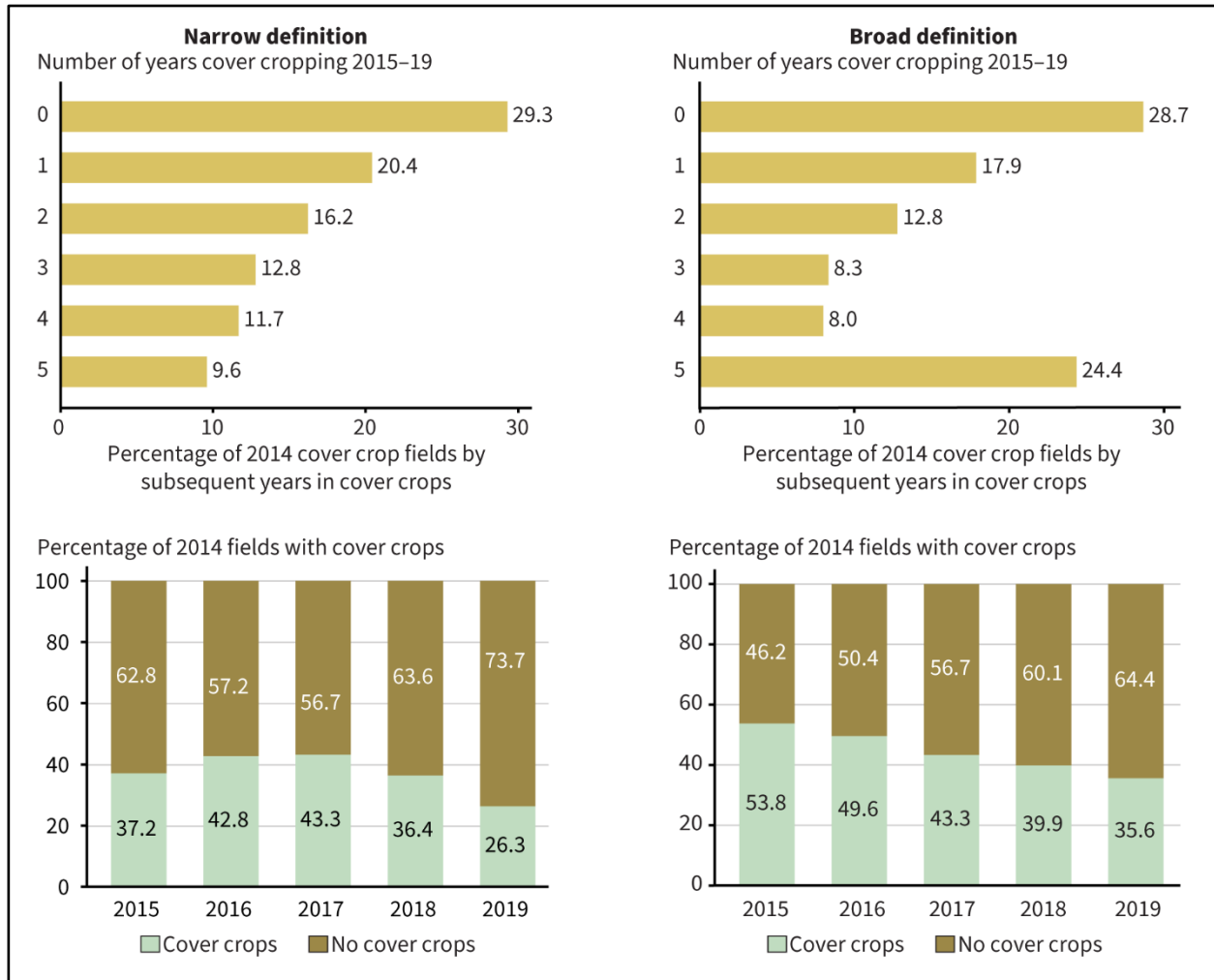


Note: The top row presents histograms for the share of fields by number of years reporting cover crops during the 2015–19 period, among only those fields reporting cover crops in 2014. The bottom row presents the share of fields reporting cover crops each year during the 2015–19 period, among only those fields reporting cover crops in 2014. The narrow definition is those fields that report a planting of cover only, while the broad definition includes cover only, forage, grazing, green manure, and left standing when planted in the same year as a planting for grain or silage. The sample is comprised of only those fields reporting cover crops in 2014. For the narrow definition, this is 24,011 of 8,960,201 fields present in all years of the data. For the broad definition, this is 114,431 fields.

Source: USDA, Economic Research Service analysis of USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD).

Figure 3

Persistence in reported cover cropping among fields reporting cover crops in 2014, USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD), using only fields with at least one grain planting



Note: The top two charts present histograms for shares of fields by number of years reporting cover crops during the 2015–19 period, among only those fields reporting cover crops in 2014. The two bottom charts present the share of fields reporting cover crops each year during the 2015–19 period, among only those fields reporting cover crops in 2014. The narrow definition is those fields that report a planting of cover only, while the broad definition includes cover only, forage, grazing, green manure, and left standing when planted in the same year as a planting for grain or silage. The total set of fields in each case is restricted to those fields with at least one grain planting. The sample is comprised of only those fields with grain reporting cover crops in 2014. For the narrow definition, this is 13,550 of 3,107,585 fields present in all years of the data. For the broad definition, this is 74,308 fields.

Source: USDA, Economic Research Service analysis of USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD).

To compare the CARD results to the Indiana windshield survey results, we report the cover crop use statistics for Indiana. Table 3 makes it clear that there is lower reporting in Indiana before 2019 than nationally. Notably, there was a large increase in reporting in 2019, likely related to a temporary change in policy specific to that year. In 2019, producers affected by natural disasters who filed prevented planting claims were able to then plant cover crops and become eligible for a \$15 per acre payment (USDA, Farm Service Agency, 2019). This appears to be associated with a geographically concentrated spike in cover only reporting.

Table 3

Cover cropping reported to USDA, Farm Service Agency in its Crop Acreage Reporting Database (CARD) for Indiana, percent coverage by year

	All Indiana fields		Indiana fields with grain crops	
	Narrow definition	Broad definition	Narrow definition	Broad definition
2014	0.10	0.92	0.10	1.03
2015	0.08	0.81	0.03	0.88
2016	0.18	0.98	0.19	1.12
2017	0.30	1.05	0.34	1.19
2018	0.12	1.10	0.12	1.26
2019	1.76	2.74	1.98	3.12
<i>Fields</i>	<i>309,192</i>		<i>237,245</i>	

Notes: The all fields sample includes all fields in Indiana reporting to CARD throughout the time period. The fields with grain crops includes only those fields which report at least one planting for grain during that time period. The narrow definition share is those fields that report a planting of cover only, while the broad definition includes cover only, forage, grazing, green manure, and left standing when planted in the same year as a planting for grain or silage.

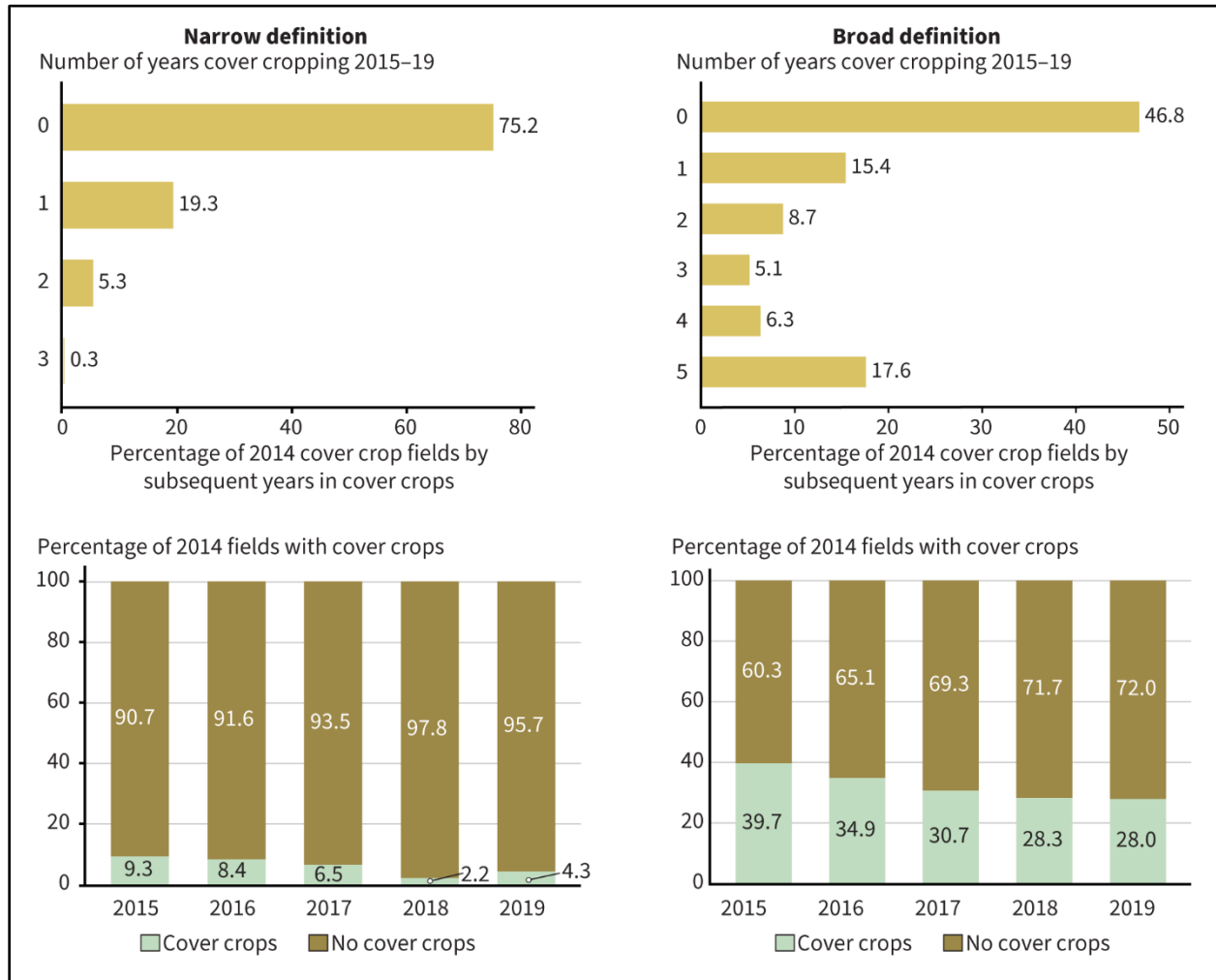
Source: USDA, Economic Research Service analysis of USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD).

Figure 4 presents rates of persistence of cover-cropping in Indiana. Specifically, the top row provides histograms for the share of 2014 cover crop fields with the labeled number of subsequent years in cover cropping, out of a possible 5 in total. The bottom row provides the share of such fields cover cropping in each of the 5 subsequent years. Notably, Indiana's rates are lower than the national ones (figure 2). No fields in Indiana with cover crops in 2014 reported cover crops in more than 3 out of the subsequent 5 years, within the narrow definition. Under the broad definition, a smaller share of the fields overall persisted in using cover crops (47 percent of fields never cover crop again, relative to 38 percent nationally). However, 18 percent of fields cover crop every subsequent year, relative to 16 percent nationally. Extending to the frequency of cover cropping by year shown in the bottom row of figure 4, the trends are similar to those nationally but the levels are much lower. This trend may be related to the overall low reporting rate in table 3.

Figure 5 replicates figure 4 for only those fields with at least one planting for grain during the relevant time period. As in the national data (figure 3), Indiana's persistence rates are slightly higher for the grain-crop fields.

Figure 4

Persistence in reported cover cropping among fields reporting cover crops in 2014, USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD), Indiana

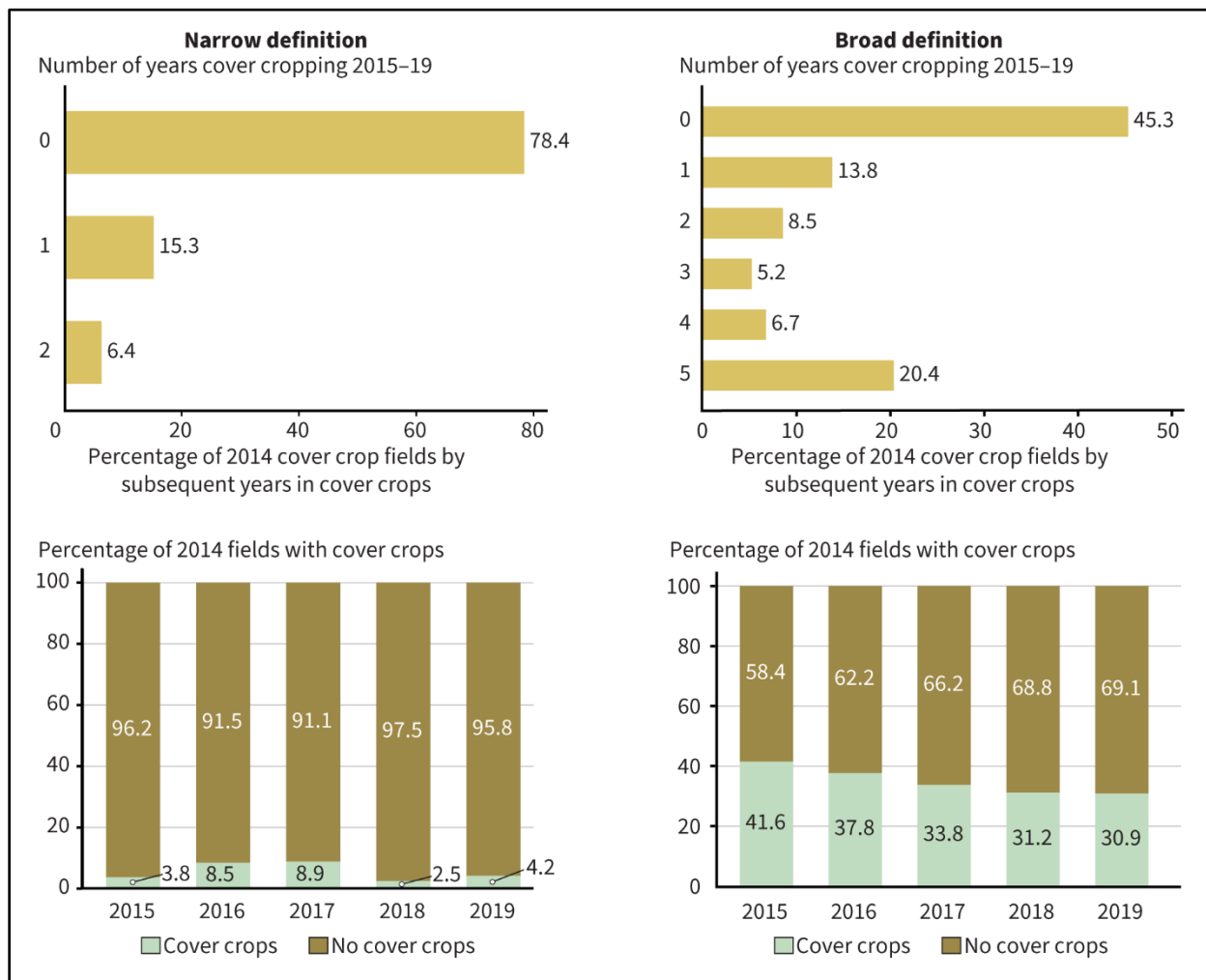


Note: The top two charts present histograms for the share of fields by number of years reporting cover crops during the 2015–19 period, among only those fields reporting cover crops in 2014. The bottom two charts present the share of fields reporting cover crops each year during the 2015–19 period, among only those fields reporting cover crops in 2014. The narrow definition is those fields that report a planting of cover only, while the broad definition includes cover only, forage, grazing, green manure, and left standing when planted in the same year as a planting for grain or silage. The total sample of fields is restricted only to those fields in Indiana reporting cover crops in 2014. For the narrow definition, this is 322 out of 309,192 such fields. For the broad definition, this is 2,838 fields.

Source: USDA, Economic Research Service analysis of USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD).

Figure 5

Persistence in reported cover cropping among fields reporting cover crops in 2014, USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD), Indiana, only fields with at least one grain planting



Note: The top two charts present histograms for the share of fields by number of years reporting cover crops during the 2015–19 period, among only those fields reporting cover crops in 2014. The bottom two charts present the share of fields reporting cover crops each year during the 2015–19 period, among only those fields reporting cover crops in 2014. The narrow definition is those fields that report a planting of cover only, while the broad definition includes cover only, forage, grazing, green manure, and left standing when planted in the same year as a planting for grain or silage. The total sample of fields is restricted only to those fields in Indiana with at least one grain planting reporting cover crops in 2014. For the narrow definition, this is 236 out of 237,245 such fields. For the broad definition, this is 2,450 fields.

Source: USDA, Economic Research Service analysis of USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD).

Indiana Windshield Survey Data

This study also uses windshield data collected by the Indiana Conservation Partnership, which consists of the USDA, Natural Resources Conservation Service; the Indiana State Department of Agriculture; Indiana’s Soil and Water Conservation Districts; Purdue University Extension; and Earth Team volunteers. The Indiana Conservation Partnership conducted a windshield survey in all counties annually from 2014 to 2019. The survey is conducted by county agents who drive the same route and observe land cover at set points along the routes. Some stopping points were dropped from the survey and others were added over the course of the survey; however, most points have at least two annual observations and the total number of points has been increasing over time. The Indiana survey

is completed in two phases, the fall and spring. Windshield surveys provide richly detailed data, including the types of winter cover crops and summer cash crops planted on each georeferenced field. Cover crops are identified by conservation professionals during the fall, and during these years, the observers recorded the specific planting, such as annual ryegrass, brassica, cereal rye, or legume.⁸ The survey also recorded the percent of residue on the field and tillage method. Termination method is not observed, because of the fall observation.

This study uses panel data from this windshield survey from 2014 to 2019 that includes 211,773 field-year observations of 37,140 total fields. Of these, 31,020 fields have an observation in every year of available data and only these fields are included in the results shown here. A subset of 29,809 fields had at least one grain planting. This dataset contains data from transects done in the fall, post-harvest, for most counties in Indiana.⁹

As shown in table 4, 8.4 percent of fields in 2014 had some cover. Of those fields, 32 percent were reported to never have cover crops again during the crop years of 2015 through 2019. As seen in CARD (figure 5), the frequency of observed persistence decreases with each passing year. Twenty-seven percent of fields that had any cover in 2014 had a cover crop one more time during 2015–19, while only 4 percent had a cover crop each year between 2015 and 2019.

Table 4
Cover cropping reported by Indiana windshield survey reporters, percent of fields by year

	Cover crop use	
	All fields (percent)	Grain (percent)
2014	8.4	8.7
2015	10.8	11.3
2016	10.2	10.6
2017	8.6	8.9
2018	8.8	9.1
2019	9.3	9.7
Fields	31,020	29,809

Note: Annual cover crop usage rates for all fields in the balanced panel of the Indiana windshield survey data. Only fields observed in all years are included.

Source: USDA, Economic Research Service analysis of Indiana windshield survey.

Figure 6 also presents persistence in two ways. The left chart presents a histogram of the share of 2014 cover crop fields by the number of subsequent years with cover crops observed. The right chart presents the share of 2014 cover crop fields that are cover cropping in each subsequent year. As shown in figure 6, about one-third of fields observed with a cover crop in 2014 are never observed with a

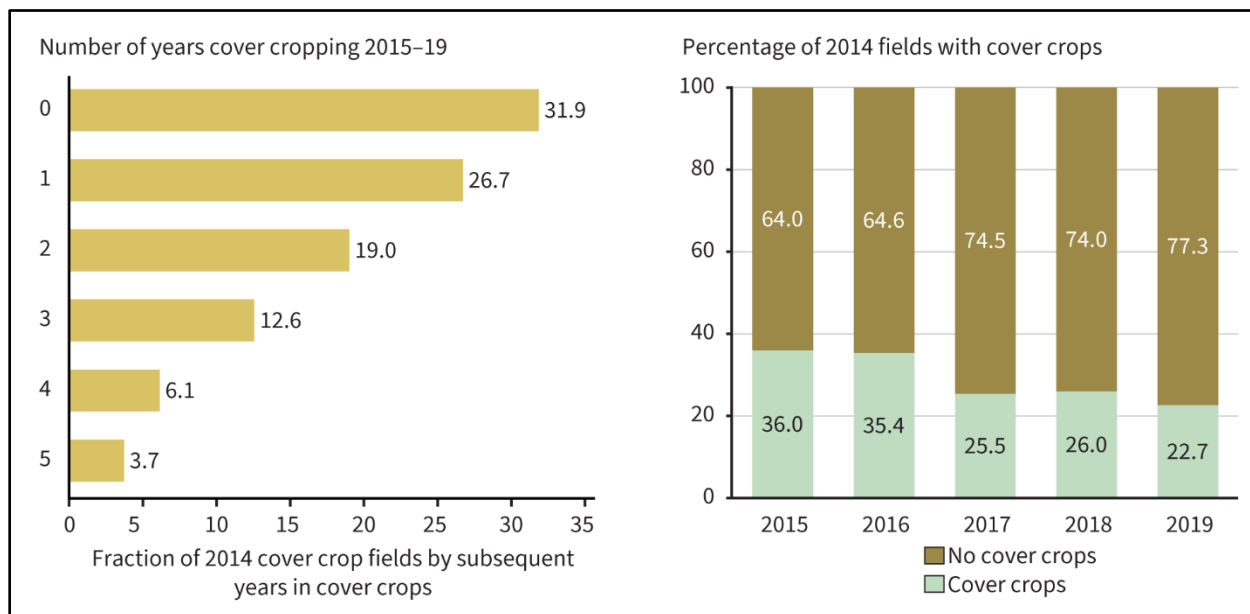
⁸ The full set of possible recordings is as follows: annual ryegrass; brassica (radish, turnip, rape); cereal rye; winter grains (cereal rye, wheat, barley), which is recorded only if the observer cannot observe which grain; legume; spring oats; wheat; barley; summer (dead) mix (e.g., sudan, millet, etc. after winter wheat); or none. The observer can record as many of them as apply, as well as a plus indicator to describe a mix that goes beyond the given categories.

⁹ Data is missing for 2019 for 10 of 91 agricultural counties: Brown, Clay, Crawford, Decatur, Floyd, Franklin, Jefferson, Kosciusko, Sullivan, and Vermillion. Marion County, home to Indianapolis and Indiana’s most populous county, is excluded from the windshield survey for lack of agricultural land use.

cover crop again within the survey period. In addition, usage in any subsequent year for 2014 cover crop fields is at or below 36 percent. As seen with CARD, collectively, the data show substantial turnover and movement into and out of cover crops.

Figure 6

Cover crop persistence in the Indiana windshield survey (all fields that report cover crops in 2014)



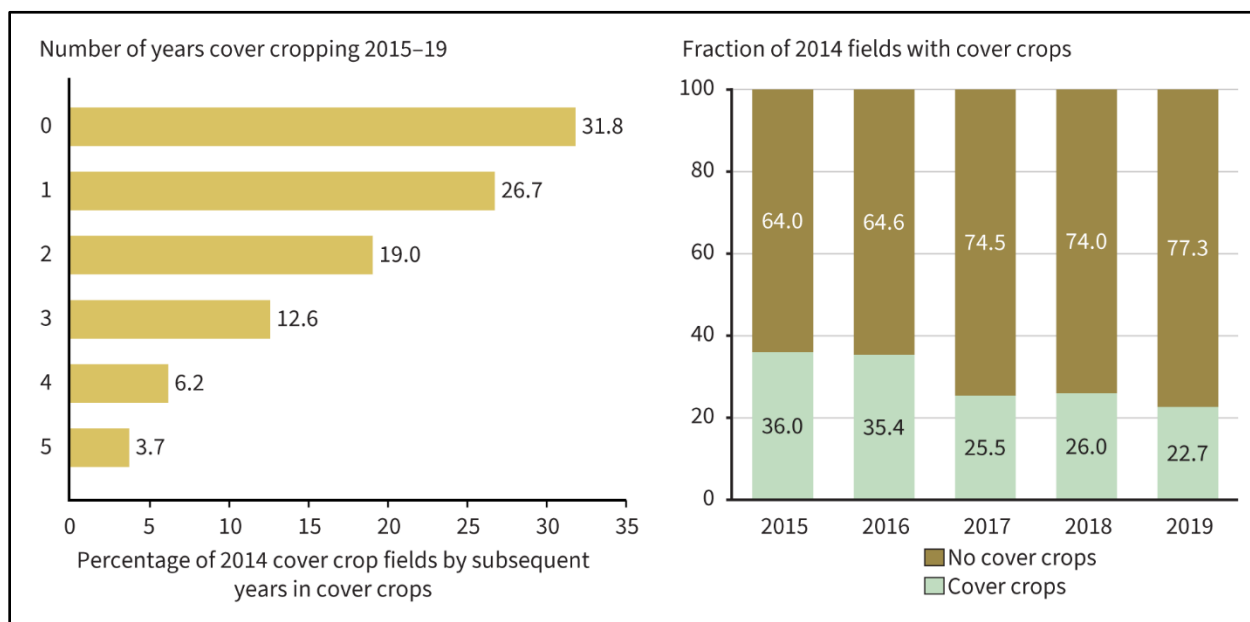
Note: The left chart presents the share of Indiana fields by number of years reporting cover crops during the 2015–19 period, among only those fields reporting cover crops in 2014. The right chart presents the share of Indiana fields reporting cover crops each year during the 2015–19 period, among only those fields reporting cover crops in 2014. The sample for each graph includes 31,020 fields observed in all years of the data.

Source: USDA, Economic Research Service analysis of Indiana windshield survey.

Figure 7 provides the same estimates but for only the fields in the Indiana windshield survey data that ever had a grain (corn, soybeans, and small grains) as the primary crop. It reveals similar patterns: a slight decrease in complete nonpersistence compensated with a small increase in persistence. As with figure 6, combining this information with the trends in table 4 suggests substantial turnover and that fields newly entering cover crop use are driving aggregate trends.

Figure 7

Cover crop persistence in the Indiana windshield survey (only fields with a grain planting)



Note: The left chart presents the share of fields by number of years reporting cover crops during the 2015–19 period, among only those fields reporting cover crops in 2014. The right chart presents the share of fields reporting cover crops each year during the 2015–19 period, among only those fields reporting cover crops in 2014. Fields are included only if they were observed with a grain planting (i.e., corn, soybeans, and small grains). The sample for each graph includes 29,809 such fields observed in all years of the data.

Source: USDA, Economic Research Service analysis of Indiana windshield survey data.

Agricultural Resource Management Survey (ARMS) Phase 2

ARMS is an ongoing survey conducted by the USDA’s Economic Research Service (ERS) and National Agricultural Statistics Service (NASS). It consists of three phases: Phase 1 is a screening survey, Phase 2 is a survey of production practices and costs, and Phase 3 collects farm business and farm household information. This study uses information collected from several Phase 2 surveys.

ARMS Phase 2 data differ from the other data used in this study in several ways. First, each year’s ARMS Phase 2 survey studies a target crop and is conducted only with agricultural operators who produced that year’s target crop. The target crops are major commodity crops and are rotated on a multiyear cycle. Another key difference from the Census of Agriculture and CARD is that the ARMS Phase 2 survey does not survey all States. Instead, each year’s survey is limited to specific States that produce the target crop and are selected to represent at least 90 percent of production of the target crop. Each ARMS survey is identified by the year in which it was conducted and the target crop that year. ARMS data are collected by self-administered mailed questionnaires to the targeted producers and through enumerator-conducted personal interviews using several types of questionnaires. For some components of the survey, producers are allowed to complete hard copies returned by mail or to complete the questionnaires online. Given the length of the survey and limited scope of eligible fields, the survey is much smaller than the other data sources discussed in this report.

In this study, we use data collected about cover crops from only Phase 2 of ARMS. Specifically, we present results based on the crop history table of Phase 2, where the survey asks about the plantings over the previous four winters and previous four summers on an individual field. The form includes a question about whether each planting is a cover crop and some other relevant information. Only the crop history

table provides the opportunity to examine persistence, as very few ARMS responses can be connected over time. The crop history table, as part of Phase 2, is enumerated by USDA, NASS representatives.

Table 5 estimates shares of the fields included in each year’s survey that were planted with cover crops by survey (identified by crop and year) and year. The estimates are based on data from the crop history table, reflecting responses by operators who produced cotton in 2015, corn in 2016, soybeans in 2018, cotton in 2019, and corn in 2021, respectively.¹⁰ The table indicates that cover crop usage increased over time within each survey, and reporting levels are substantially different across commodity. It is notable that, among respondents reporting no cover crops in the oldest year of the crop history table, cover cropping in subsequent years never exceeds approximately 6 percent. These results largely reproduce the estimates from Wallander et al. (2021), which plotted trends in cover crop use.

Table 5
Share of respondents (in percent) reporting cover crops in the crop history table, by survey and year of crop history, ARMS Phase 2

	Share of fields with...									
	Cotton (2015)		Corn (2016)		Soybeans (2018)		Cotton (2019)		Corn (2021)	
2012	12.0		2013	5.4	2015	5.2	2016	17.1	2018	8.4
2013	13.0		2014	6.2	2016	5.9	2017	16.5	2019	9.1
2014	14.4		2015	7.2	2017	8.1	2018	18.3	2020	10.4
2015	15.5		2016	10.0	2018	9.8	2019	19.6	2021	11.9
<i>Observations (fields)</i>	848		1,985		2,083		849		984	
<i>Fields represented (thousands)</i>	118		1,680		1,546		167		1,352	

Note: Shares are survey-weighted and reflect the share of the number of fields, rather than the share of acreage. The total number of fields represented by the observed fields is shown in the bottom row, in thousands of fields. Respondents are restricted to those with a non-missing reported Spring/Summer crop for the previous 3 years.

Source: USDA, Economic Research Service analysis of USDA, National Agricultural Statistics Service, Agricultural Resource Management Survey (ARMS) Phase 2, 2015, 2016, 2018, 2019, and 2021.

Results presented in this report only include those respondents which fill out the crop history table for all years and seasons. The number of respondents with complete crop history information varies by survey, as shown in table 5, ranging from 848 to 2,083 total responses. Table 5 demonstrates that the number of survey respondents reporting cover crops in the earliest year of the crop history table is between 5.23 and 17.1 percent of those complete responses. Accordingly, the persistence results rely on only between 86 and 134 observations per survey, as these are the respondents with cover crops in the earliest year of the survey.

Figure 8 graphically illustrates the reported persistence of those respondents with cover crops in the oldest year of the crop history table.¹¹ Specifically, each graph represents a histogram for the share of

¹⁰ Table 5 includes only those respondents with a non-missing reported spring/summer crop for the previous 3 years.

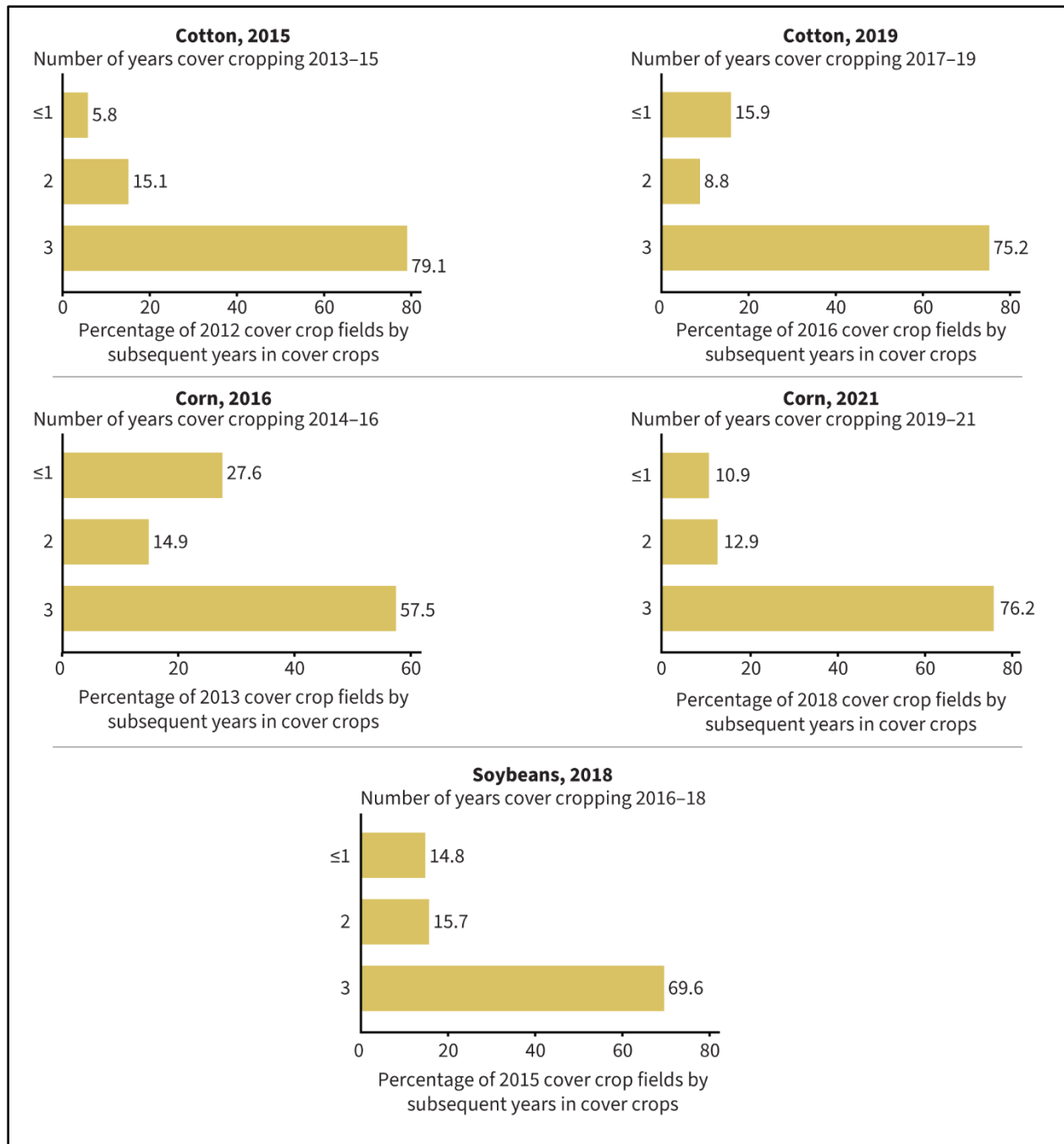
¹¹ For example, the chart for cotton in 2015 shows the persistence of fields reporting cover crops in 2012, in terms of the number of subsequent years reporting cover crops. Likewise, the chart for cotton in 2019 shows the persistence of fields reporting cover crops in 2016.

oldest year cover crop fields with the labeled number of subsequent years in cover cropping, out of a possible three in total. Across all surveys presented, complete persistence, meaning cover cropping in all years if cover cropping in the earliest year, is the most commonly reported behavior. The 2016 corn survey reported the lowest share of complete persistence, with 57 percent of respondents with cover crops in 2013 reporting cover crops in 2014, 2015, and 2016. The share of respondents reporting cover crops in the oldest year of the crop history table who report cover crops in 0 or 1 of 3 subsequent years is less than 30 percent in all surveys, as shown in figure 8.

Compared to the other three sources presented in this report, the information from the crop history table(s) implies higher persistence and less entry into cover crops after the reference year. However, it is important to recall that the crop history table data come from a very small number of producers, both because of the overall size of the ARMS Phase 2 sample and because many respondents did not completely fill out the crop history table. Furthermore, the crop history table asks respondents themselves to think retrospectively rather than linking information reported each year.

Figure 8

Reported persistence of cover crops on a field in the ARMS crop history table for respondents reporting cover crops in the oldest year of the crop history table, USDA, National Agricultural Statistics Service, Agricultural Resource Management Survey (ARMS) Phase 2

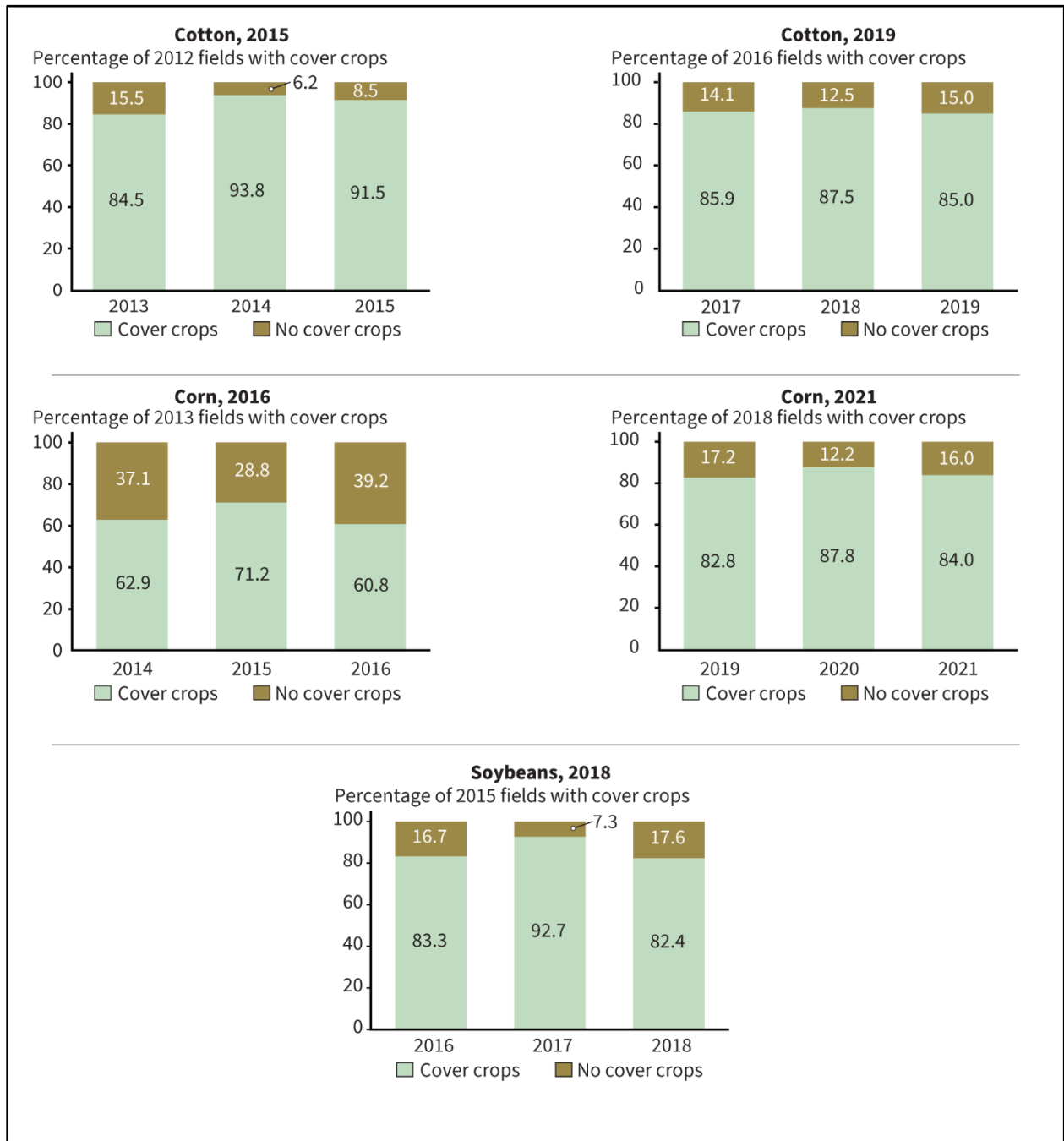


Note: Each chart presents a histogram of the share of fields by years of cover cropping reported in the second through fourth years of the crop history table, for those fields reporting cover crops in the oldest year of the crop history table. Each chart is specific to a survey, and the years in time are specific to each survey. The total number of observations are: 86 observations for cotton in 2015, 134 observations for corn in 2016, 115 observations for soybeans in 2018, 113 observations for cotton in 2019, and 101 observations for corn in 2021. Shares are survey-weighted using weights specific to each survey. Survey weights are defined by USDA, National Agricultural Statistics Service (NASS) with the intent of adjusting statistics to represent the relevant sample of fields.

Source: USDA, Economic Research Service analysis of USDA, National Agricultural Statistics Service, Agricultural Resource Management Survey (ARMS) Phase 2 2015, 2016, 2018, 2019, and 2021 data.

Figure 9

Reported usage of cover crops on a field in the ARMS crop history table for respondents reporting cover crops in the oldest year of the crop history table by year and survey, USDA, National Agricultural Statistics Service, Agricultural Resource Management Survey (ARMS) Phase 2



Note: Each graphic presents the share of fields reporting cover crops in the second through fourth years of the crop history table, for those fields reporting cover crops in the oldest year of the crop history table. Each panel is specific to a survey, and the years in time are specific to each survey. Shares are survey-weighted using weights specific to each survey. Survey weights are defined by USDA, National Agricultural Statistics Service (NASS) with the intent of adjusting statistics to represent the relevant sample of fields.

Source: USDA, Economic Research Service analysis of USDA, National Agricultural Statistics Service, Agricultural Resource Management Survey (ARMS) Phase 2 2015, 2016, 2018, 2019, and 2021 data.

Crop Rotation and Persistence

In addition to the overall statistics on usage and persistence, we present statistics specifically by three major crop rotations used by producers in 2013 through 2018. This analysis defined continuous corn as fields in which corn was planted in at least 4 of 6 years. Continuous soybean is likewise defined as fields in which soybeans were planted in at least 4 of 6 years. Corn-soy rotation was defined as fields in which, during the 6-year period, corn was planted in at least 2 years and soybeans were planted in at least 2 years.¹²

Crop rotations are hypothesized to impact cover cropping, as there are agronomic impacts of cover cropping that depend on both the following and preceding commodity crops (Pannell and Claassen, 2020). A field that is planted to corn in one year and soybeans the next has different planting and termination windows, and the impact of any nitrogen-fixing qualities of a cover crop may be different relative to a field with soybeans in the preceding year and corn in the following year.

This section attempts to identify whether there are observable differences in cover crop persistence between fields in different crop rotations. To make this comparison, we only use the USDA Crop Acreage Reporting Database (CARD) and the Indiana windshield survey, as these sources provide all fields regardless of crop rotation and fields can be associated with a commodity crop in each year they are observed in these data sources. While the two data sources provide slightly different results in terms of patterns of persistence, there are no consistent, evident differences in patterns of persistence by crop rotation.

Table 6 provides usage rates by year, by crop rotation, and cover crop definition. Cover cropping rates are relatively comparable across crop rotations. However, continuous corn does have the lowest cover crop use, and continuous soy and corn-soy rotations show similarly higher usage rates, with fields in a corn-soy rotation exhibiting the highest usage rate.

¹² Fields are assigned to corn-soy rotation if the rotation classification is met, even if those fields also meet the continuous corn or continuous soybean classifications.

Table 6

Field-level cover cropping reported to USDA, Farm Service Agency, by crop rotation and definition, USDA, Crop Acreage Reporting Database

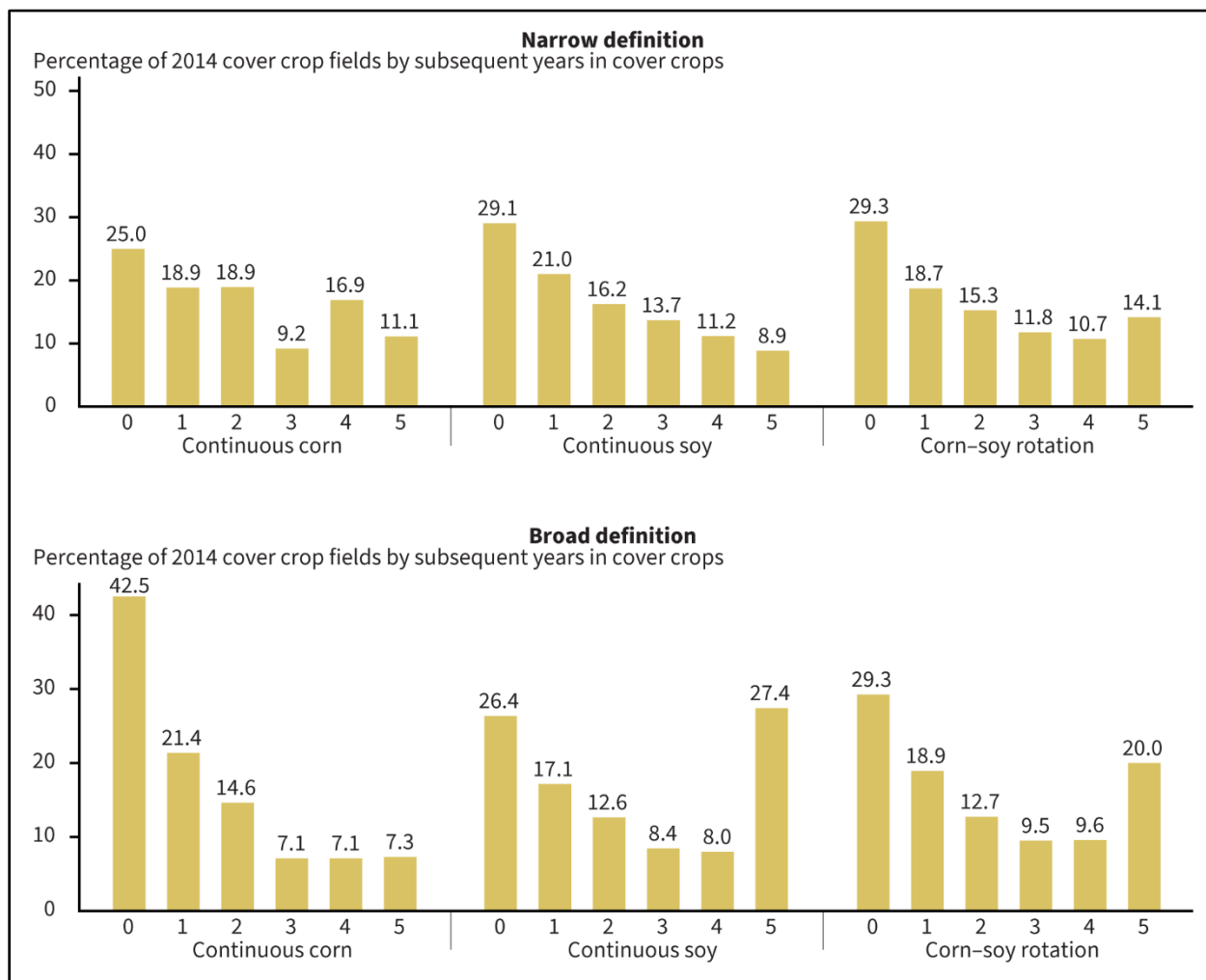
	Narrow definition			Broad definition		
	Continuous corn	Continuous soybeans	Corn-soy rotation	Continuous corn	Continuous soybeans	Corn-soy rotation
	<i>Percent of fields</i>					
2014	0.34	0.45	0.66	1.56	2.60	2.89
2015	0.50	0.54	0.71	1.60	2.72	2.85
2016	0.70	0.71	0.98	1.83	2.93	3.06
2017	1.14	1.14	1.39	2.04	3.22	3.50
2018	1.26	1.10	1.40	2.18	3.26	3.71
2019	1.69	2.68	2.64	2.53	4.84	4.99

Note: The narrow definition refers to fields that report a planting of cover only, while the broad definition includes cover only, forage, grazing, green manure, and left standing when planted in the same year as a planting for grain or silage. Crop rotations are defined by previous year plantings, 2013–18. Continuous corn fields were planted to corn in at least 4 of 6 years, while continuous soybean fields were planted to soybeans in at least 4 of 6 years. Corn-soy rotation fields were planted to corn at least 2 of 6 years and to soybeans at least 2 of 6 years. This sample includes only fields with at least one planting for grain during the period.

Source: USDA, Economic Research Service analysis of USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD).

While the aggregate statistics reported previously include all fields reporting to USDA, FSA, figure 10 presents estimates of persistence for fields planted to continuous corn, continuous soybeans, or a corn-soybean rotation. Notably, the level and pattern of persistence is relatively similar across crop rotations. Across all crop rotations, at least 25 percent of fields reporting cover crops in 2014 never report cover crops again in the 5-year period. Within the narrow definition, persistence is relatively high in the continuous corn rotation, but the differences by crop rotation are limited. Within the broad definition, persistence is relatively low in the continuous corn rotation, and there is more heterogeneity across crop rotations. Under the broad definition of cover crops, a relatively high share of continuous soy fields (27 percent) report plantings classified as cover crops every year in the subsequent 5-year period.

Figure 10
Persistence in reported cover cropping among fields reporting cover crops in 2014, USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD), by select crop rotation



Note: Each graph represents a histogram of number of years in cover crops (out of 5) among fields with cover crops in 2014, within each crop rotation. Crop rotations are defined by previous year plantings, 2013–18. Continuous corn fields were planted to corn in at least 4 of 6 years, while continuous soybean fields were planted to soybeans in at least 4 of 6 years. Corn-soy rotation fields were planted to corn at least 2 of 6 years and to soybeans at least 2 of 6 years. This sample includes only fields with at least one planting for grain during the period.

Source: USDA, Economic Research Service analysis of USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD).

Table 7 and figure 11 present crop rotations for fields in Indiana. The data show that Indiana’s results are similar to the results for the national sample but with a lower rate of persistence overall. The most notable result is the pronounced difference in persistence based on the definitions used. For example, only under the broad definition do any of the fields report cover crops more than twice more during the period. In addition, complete nonpersistence is higher for continuous corn with the broad definition but lower for continuous soy with the broad definition. Complete nonpersistence (never reporting cover crops again) is lowest for the corn-soy rotation.

Table 7

Field-level cover cropping reported to USDA, Farm Services Agency (FSA), by crop rotation and definition, CARD, Indiana

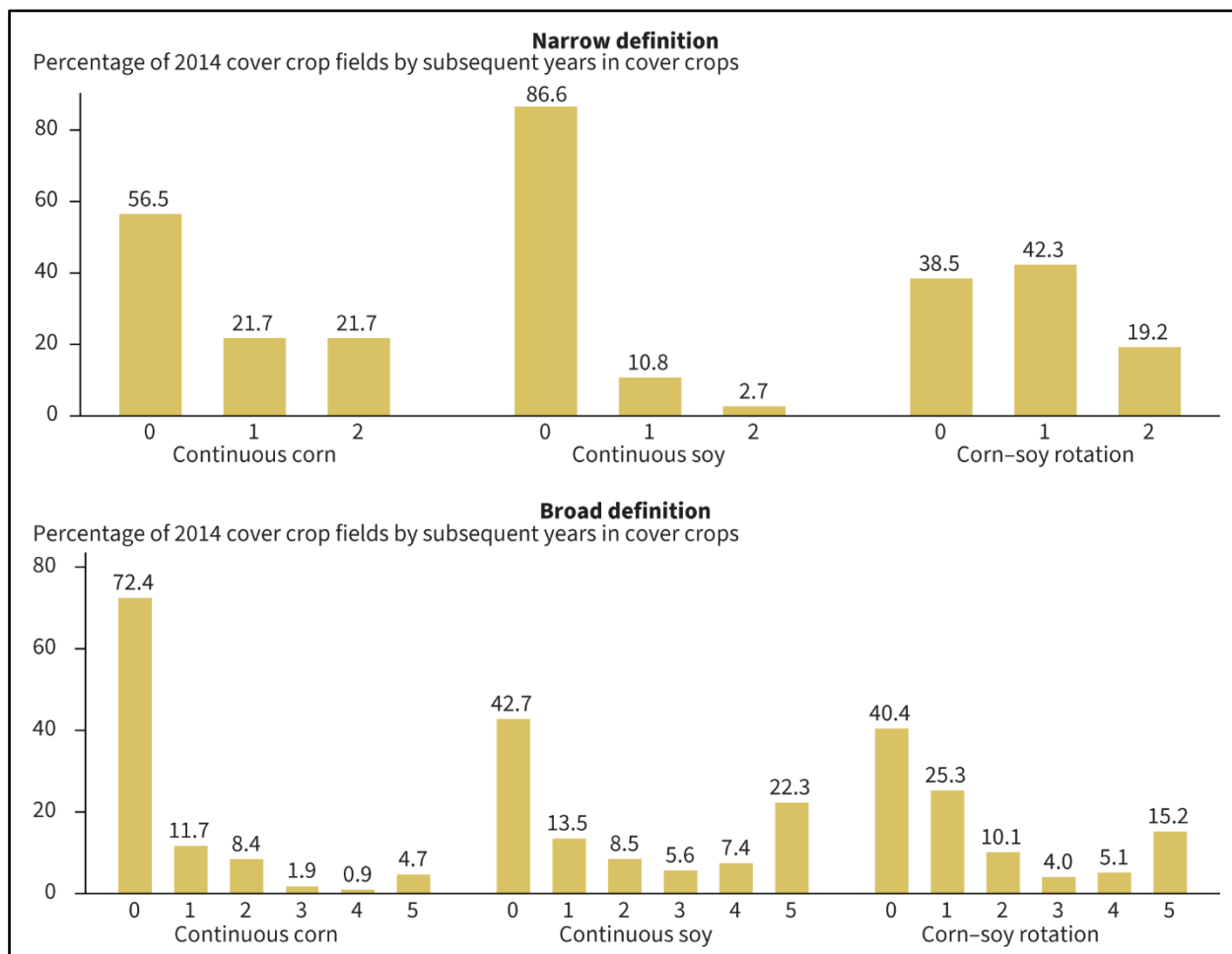
	Indiana narrow definition			Indiana broad definition		
	Continuous corn	Continuous soybeans	Corn-soy rotation	Continuous corn	Continuous soybeans	Corn-soy rotation
	<i>Percent of fields</i>					
2014	0.11	0.09	0.25	1.06	1.04	0.96
2015	0.04	0.03	0.08	0.42	0.94	0.62
2016	0.31	0.18	0.15	0.86	1.16	0.86
2017	0.34	0.33	0.51	0.82	1.22	1.21
2018	0.15	0.11	0.20	0.92	1.31	0.96
2019	2.57	1.92	2.02	3.33	3.10	2.97

Note: The narrow definition refers to fields that report a planting of cover only, while the broad definition includes cover only, forage, grazing, green manure, and left standing when planted in the same year as a planting for grain or silage. The sample is restricted only to fields in Indiana with at least one planting for grain during the period.

Source: USDA, Economic Research Service analysis of USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD).

Figure 11

Persistence in reported cover cropping among fields reporting cover crops in Indiana in 2014, USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD), by select crop rotation



Note: Each graph represents a histogram of number of years in cover crops (out of 5) among fields with cover crops in 2014, within each crop rotation. Crop rotations are defined by previous year plantings, 2013–18. Continuous corn fields were planted to corn in at least 4 of 6 years, while continuous soybean fields were planted to soybeans in at least 4 of 6 years. Corn-soy rotation fields were planted to corn at least 2 of 6 years and to soybeans at least 2 of 6 years. The sample is restricted only to fields in Indiana with at least one planting for grain during the period.

Source: USDA, Economic Research Service analysis of USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD).

Comparing these results to the Indiana windshield survey, table 8 provides the observed usage reporting rates by year and crop rotation for that data set. Note that the Indiana windshield survey reports the prior crop harvested before the cover crop, and this categorization differs from CARD. This analysis uses the same definitions for continuous crops and crop rotations. The other column reflects observations in which cropping did not adhere to those definitions (only 7.5 percent of total observations). The table shows that the windshield surveys identified substantially higher rates of cover crop usage than CARD, but they are consistent across crop rotations. Fields outside the three primary crop rotations exhibit higher levels of cover crop use.

Table 8

Field-level cover cropping, percent coverage by year by crop rotation category, Indiana windshield survey

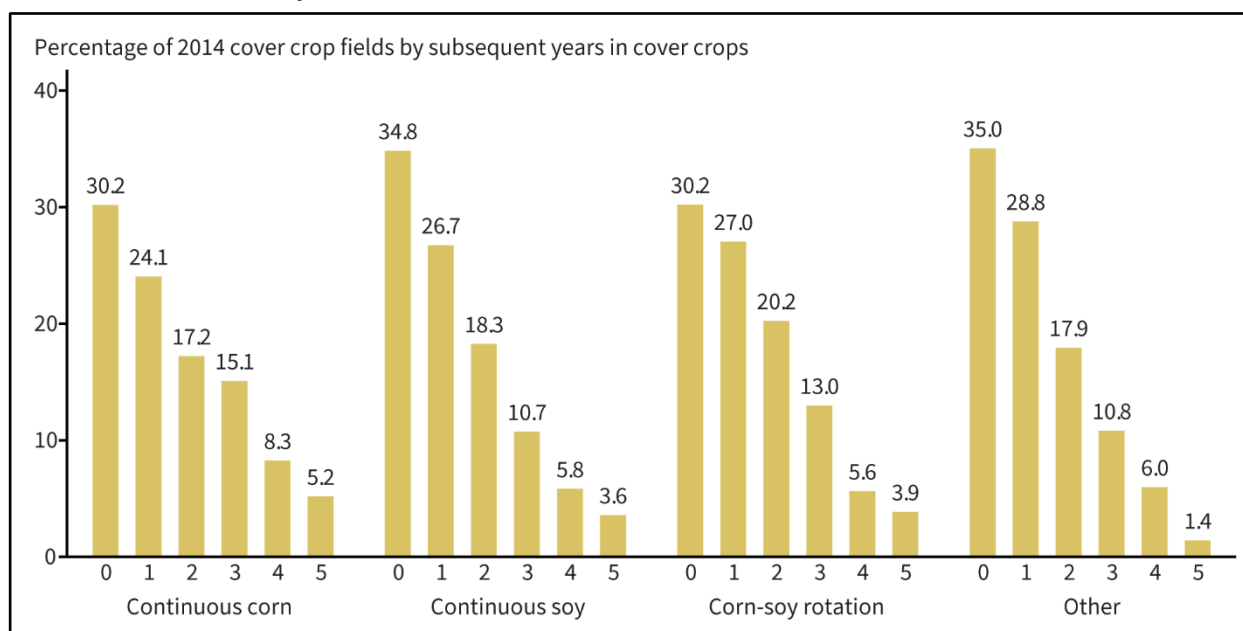
	Continuous corn	Continuous soybeans	Corn-soy rotation	Other rotation
2014	7.96	7.78	8.38	15.69
2015	10.14	10.86	10.89	17.62
2016	9.91	10.95	10.06	14.66
2017	8.24	9.56	8.27	13.10
2018	9.35	10.41	8.26	10.37
2019	7.87	11.35	9.29	11.58

Note: Crop rotations are defined by previous year plantings, 2013–18. Continuous corn fields were planted to corn in at least 4 of 6 years, while continuous soybean fields were planted to soybeans in at least 4 of 6 years. Corn-soy rotation fields were planted to corn at least 2 of 6 years and to soybeans at least 2 of 6 years. This table reports fields that ever have a grain planted.

Source: USDA, Economic Research Service analysis of Indiana windshield survey.

Figure 12 presents persistence estimates for Indiana fields planted with cover crops in 2014 from windshield survey data. The most notable difference is that persistence of any extent is higher in the windshield data than in the Indiana subset of CARD, more comparable to the national CARD estimates. The statistics are relatively similar across crop rotations for the windshield data.

Figure 12

Persistence in reported cover cropping among fields reporting cover crops in 2014 by select crop rotation, Indiana windshield survey)

Note: The graph provides a histogram of number of years in cover crops (out of 5) among fields with cover crops in 2014, within each crop rotation. Includes fields that have ever cropped grains. Crop rotations are defined by previous year plantings, 2013–18. Continuous corn fields were planted to corn in at least 4 of 6 years, while continuous soybean fields were planted to soybeans in at least 4 of 6 years. Corn-soy rotation fields were planted to corn at least 2 of 6 years and to soybeans at least 2 of 6 years.

Source: USDA, Economic Research Service analysis of Indiana windshield survey data.

Livestock and Persistence

One of the plausible drivers of cover crop profitability and, by extension, persistence, is the ability to use cover crops to feed livestock. If a cover crop can be grazed or otherwise used as feed for livestock while maintaining the on-farm and off-farm benefits of off-season cover, the operator can either earn revenue or reduce costs for the livestock component of the farm (Bowman et al., 2024). The hypothesis would be that cover cropping and cover crop persistence would be higher within operations with livestock. In order to test this, we examine the persistence in CARD for operations with and without livestock components. We observe fields with cover crops in 2014 and categorize them by whether they are part of a farm operation with any grazing or forage plantings at any time during the 6-year time period.

Table 9 presents the results of regressions that test for differences in cover crop persistence between fields within operations with a livestock planting and fields within operations without a livestock planting, using CARD. All observations are for fields with cover crops in crop year 2014, measuring persistence in crop years 2015–19. The coefficients presented in the table are from 14 separate regressions. For example, the coefficient for “Share with 2 years” and “Narrow definition” represents the estimated difference in the share of fields with cover crops in 2 years (within the period of 2015–19) under the narrow definition—across livestock operation affiliation—conditional on fixed effects for administrative county. A positive coefficient indicates higher values for fields with livestock operation affiliation. The fixed effects are designed to remove bias driven by spatial variation in livestock operation affiliation. Appendix section “Regression Specifications” provides full details.

The estimates in table 9 indicate that there is slightly higher persistence among fields within operations with a livestock operation, but this effect is small relative to baseline values and marginally significant for the narrow definition. The effect is larger and more statistically significant for the broad definition, though still small relative to baseline values.¹³ In addition, the broad definition may classify some rotational systems that include a mix of cropping and livestock as cover cropping, but these systems may not fall within some definitions of cover cropping.

¹³ The baseline number of years is 1.86 for the narrow definition and 1.99 for the broad definition.

Table 9

Differences in persistence of reported cover cropping on fields, by livestock affiliation and cover crop definition, USDA, Farm Service Agency, Crop Acreage Reporting Database, 2014–19

	Narrow definition	Broad definition
Share with 0 years	-0.00647 (0.00758)	-0.0379*** (0.00752)
Share with 1 year	-0.00872 (0.00816)	-0.0176** (0.00818)
Share with 2 years	0.0180** (0.00768)	0.0185** (0.00781)
Share with 3 years	-0.0137** (0.00697)	0.000448 (0.00724)
Share with 4 years	-0.0121* (0.00666)	0.000527 (0.00691)
Share with 5 years	0.0230*** (0.00598)	0.0360*** (0.00623)
Number of years	0.0527* (0.0276)	0.203*** (0.02833)

Note: Each row represents the coefficient estimate of a regression generating a conditional difference in means between fields that do and do not belong to farms with some grazing or forage reporting. For each row measuring the “Share with...,” the outcome is the share of fields with the named number of years of reported cover cropping in the years 2015–19, for those fields reporting cover crops in 2014. The categories are mutually exclusive and not cumulative, such that fields with 2 years of experience are not included in the share with 1 year. The coefficient measures the difference between fields with any livestock affiliation, specifically measured as being associated with an operation with forage or grazing fields, and those with no livestock affiliation, conditional on county. The row measuring “Number of years” estimates the difference in the number of years that a field reports cover crops in the years 2015–19, among fields reporting cover crops in 2014. Because of the spatial correlations between livestock and cover crop trends, the results without conditioning on county are biased towards less persistence among livestock-affiliated fields. The narrow definition is those fields that report a planting of cover only, while the broad definition includes cover only, forage, grazing, green manure, and left standing when planted in the same year as a planting for grain or silage. This sample includes only fields with at least one planting for grain during the period. Asterisks represent statistical significance of coefficients, relative to a null hypothesis of zero, at the 90 (*), 95 (**), and 99 (***) percent levels.

Source: USDA, Economic Research Service analysis of USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD).

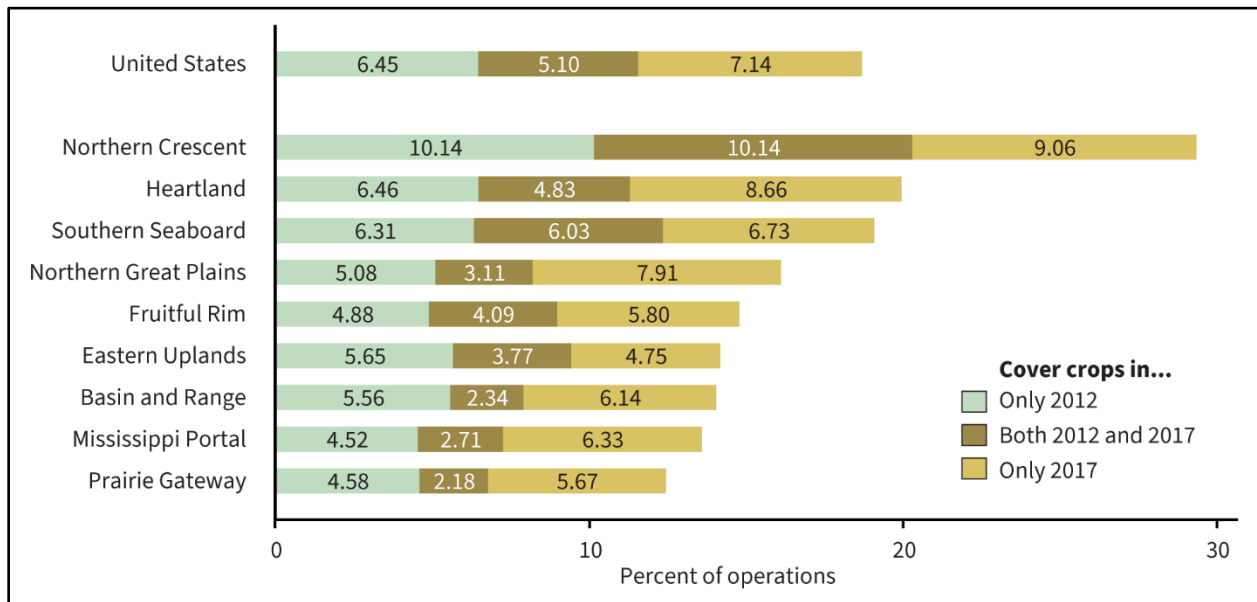
Regional Differences in Cover Crop Use and Persistence

Using the Census of Agriculture and CARD, this report also provides a broader understanding of how cover crop use and persistence vary across space using data from the 2012 and 2017 Censuses of Agriculture and USDA, ERS Farm Resource Regions. Persistence in the Census of Agriculture data is measured only at the operation level and in terms of whether an operation reported cover crops anywhere on the operation in both 2012 and 2017. Also, the sample of operations is only those operations reporting in both 2012 and 2017. Figure 13 provides a breakdown of the usage and persistence figures from figure 1 by USDA, ERS Farm Resource Region (see figure A.1 for the spatial extent of each region). Cover crop use and persistence are highest in the Northern Crescent and Southern Seaboard regions. Persistence is much lower in the Basin and Range, Mississippi Portal, Northern Great Plains, and Prairie Gateway regions. Cover crop use and persistence are correlated at the region level.

Appendix section “Census of Agriculture Statistics by Region” provides the same figure for the 2017 to 2022 and 2012 to 2022 spans, as well as replicating figure 1 by USDA, ERS Farm Resource Region. The share of operations persisting from 2012 to 2017 is similar to the share of operations persisting from 2017 to 2022, but the share is lower from 2012 to 2022, potentially because of the longer time period spanned. The rankings of region by persistence are similar but not fixed across time. Furthermore, when analyzing across 2012, 2017, and 2022, the majority of operations with cover crops in any of 3 survey years report them in only 1 of the 3 years, in all regions.

Figure 13

Cover crop use and persistence among operations in the 2012 and 2017 Censuses of Agriculture, by USDA, Economic Research Service Farm Resource Region



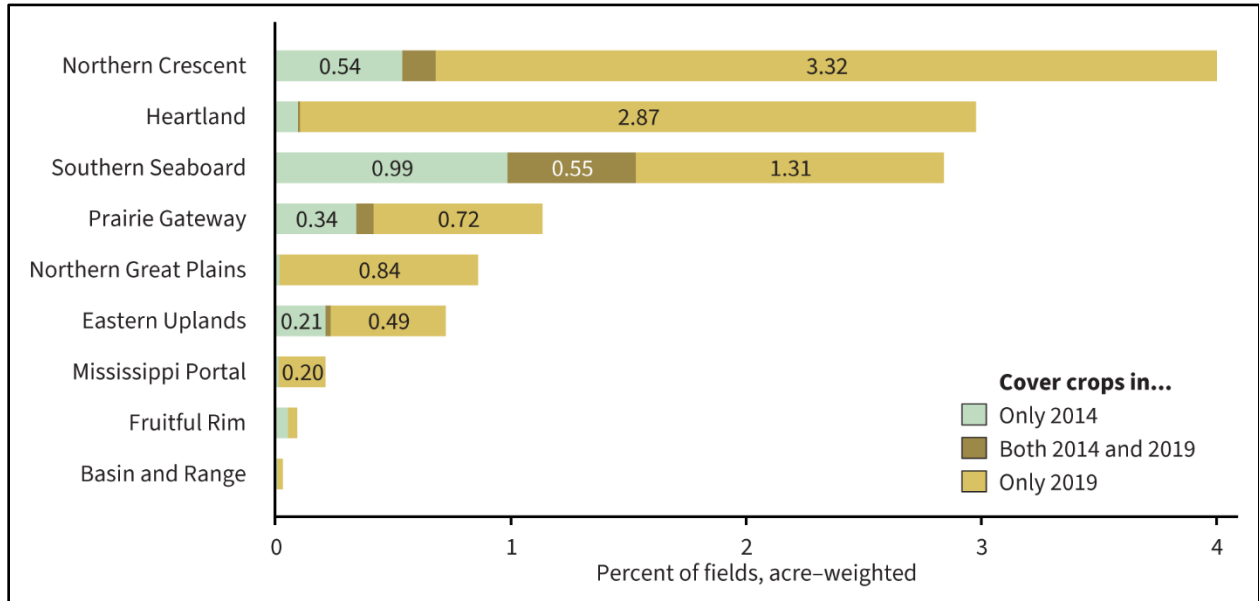
Note: The green (leftmost) bar represents those operations which report cover cropping in 2012 but not 2017. The amber (rightmost) bar represents those operations which report cover cropping in 2017 but not in 2012. The brown (middle) bar represents those operations which report cover cropping in both 2012 and 2017. Total cover crop reporting in 2012 is the sum of the first (green) and second (brown) bars. Total cover crop reporting in 2017 is the sum of the second (brown) and third (amber) bars. Only operations with cropland responding in both years are included. All statistics are weighted based on the 2017 Census of Agriculture. Due to the broad inclusivity of the definition of cropland harvested in the Census of Agriculture, the total population of operations includes operations without commodity crop plantings, which may influence the results.

Source: USDA, Economic Research Service analysis of the 2012 and 2017 Censuses of Agriculture data.

Figure 14 extends the regional analysis to the CARD data. In order to mirror the 5-year period in the Censuses of Agriculture data structure, we present cover crop use in 2014 and 2019. In every region, cover crop use reported only in 2019 substantially exceeds the share of fields reporting cover crops in both years. The USDA, ERS Farm Resource Regions are again sorted by the share of fields with cover crops in at least 1 of the 2 years, in descending order. The patterns are similar to those observed in the Census of Agriculture, including the measure of persistence being highest in the Southern Seaboard and Northern Crescent regions. Figure 15 replicates figure 14 for only those fields with a planting for grain at some point during the relevant period.

Figure 14

Field-level cover crop use and persistence by USDA, Economic Research Service Farm Resource Region, 2014–19, USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD)

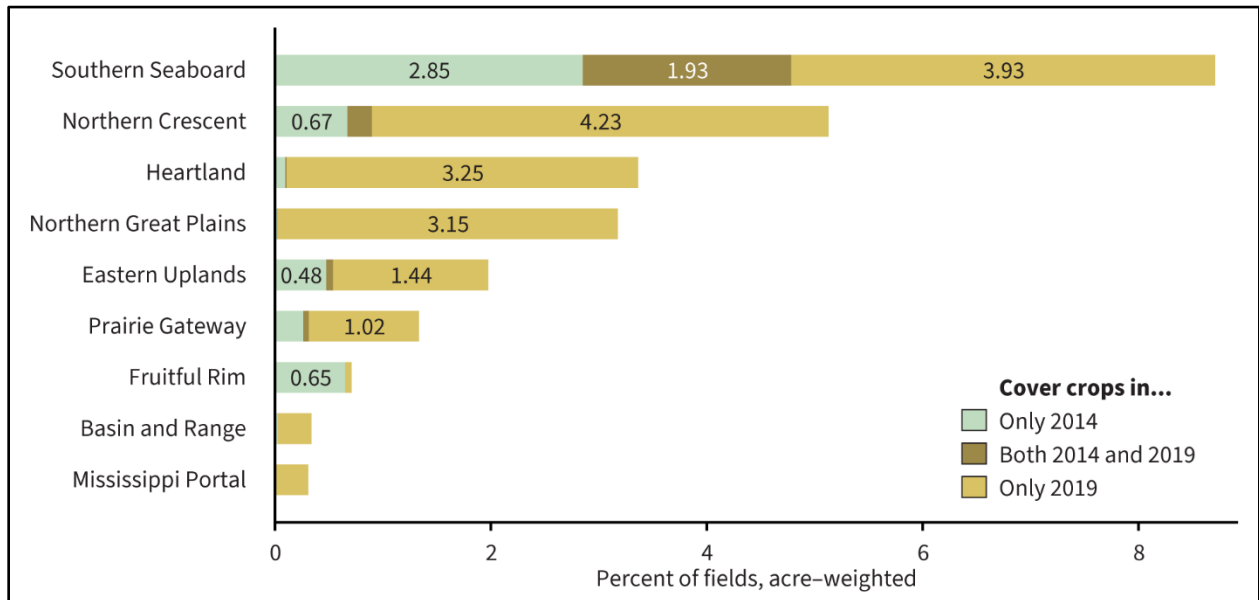


Note: The green (leftmost) bar represents those operations which report cover cropping in CARD in 2014 but not 2019. The amber (rightmost) bar represents those operations which report cover cropping in 2019 but not in 2014. The brown (middle) bar represents those operations which report cover cropping in both 2014 and 2019. Total cover crop reporting in 2014 is the sum of the first (green) and second (brown) bars. Total cover crop reporting in 2019 is the sum of the second (brown) and third (amber) bars. Results shown for the narrow definition only.

Source: USDA, Economic Research Service analysis of USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD).

Figure 15

Field-level cover crop use and persistence by USDA, Economic Research Service Farm Resource Region, 2014–19, USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD), ever any grain only



Note: The green (leftmost) bar represents those operations which report cover cropping in CARD in 2014 but not 2019. The amber (rightmost) bar represents those operations which report cover cropping in 2019 but not in 2014. The brown (middle) bar represents those operations which report cover cropping in both 2014 and 2019. Total cover crop reporting in 2014 is the sum of the first (green) and second (brown) bars. Total cover crop reporting in 2019 is the sum of the second (brown) and third (amber) bars. The sample is restricted to only those fields with a planting for grain at some point during the same period. Results shown for the narrow definition only.

Source: USDA, Economic Research Service analysis of USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD).

Conclusion

Measures of cover crop use and persistence in the United States vary by datasets. In this report, we examine cover crop measurements from four data sources: the USDA Census of Agriculture; the USDA, Farm Service Agency, Crop Acreage Resource Database (CARD); a windshield survey of Indiana; and USDA, National Agricultural Statistics Service's Agricultural Resource Management Survey (ARMS). We focus exclusively on data sources and reporting methodologies that provide an opportunity to measure cover crops within a single field or operation over time.

Across these four data sources, reported cover cropping increased over time. Reporting is the lowest in CARD, where there is underreporting as discussed in further detail in the appendix. Due to mandatory reporting, CARD is a highly accurate source of data for commodity acreage but cover crops do not have the same reporting requirement in CARD. This lack of a requirement for cover crops may be the reason cover crop reporting is lower in CARD than in the other three data sources analyzed in this study. Reported cover crop use levels differ substantially by survey in ARMS Phase 2, which represents differences in cover cropping by crop and also any potential changes in reporting behavior. In CARD and the Indiana windshield survey, recorded cover crop use is similar across crop rotations. Within CARD and the Census of Agriculture, there is substantial variation by USDA, ERS Farm Resource Region. Cover crop use is highest in both sources in the Southern Seaboard and Northern Crescent regions.

Three of the four data sources explored in this report suggest that between one-quarter and one-half of fields and operations with cover crops do not continue to engage in the practice over time. While the exact magnitude of persistence differs across data sources, two of three field-level sources (CARD and the windshield survey) indicate that there may be essentially three broad categories which may be roughly equal in share. The categories include: (a) those fields which never cover crop again during the observed period, (b) those fields which cover crop again but less often than half of the years, and (c) those fields which cover crop more than half of the years.

Persistence as a binary indicator is ultimately a normative and subjective designation, as it requires applying a threshold, above which a field or operation is categorized as persisting. However, persistence is also a spectrum, and the interpretation of a field's trajectory may influence that understanding. Fields reporting cover crops in 2014 are more likely to report cover crops in the following 3 years than in the fourth and fifth years. Given the available data, it is not possible to know if this trend reflects intermittent or sporadic cover crop use or a temporary or permanent departure from cover crop use among these fields.

Importantly, the year-to-year transition frequencies for fields reporting cover crops suggest limited persistence in both CARD and the Indiana windshield survey. Notably, the frequency of cover cropping within any single subsequent year is less than or equal to 54 percent for CARD nationally, less than or equal to 42 percent for CARD in Indiana, and less than or equal to 37 percent for the Indiana windshield survey.

We observe limited evidence that persistence varies by crop rotations or livestock use. In CARD, persistence is lowest for continuous corn when applying a broad definition of cover cropping, and relatively comparable across crop rotations when applying the narrow definition. In the Indiana

windshield survey data, there are no notable differences across crop rotations. In both ARMS and CARD, we find evidence that persistence is higher among fields with any livestock on the operation.

In both the Census of Agriculture and CARD, there is a notable difference in both use levels and persistence across regions. Persistence is positively correlated with use levels across USDA, ERS Farm Resource Regions within these data sources. The Southern Seaboard and Northern Crescent regions both feature higher use, as noted previously, and higher persistence.

While there is a wide range of data sources for measuring cover crops, each source has flaws and challenges. For example, cover crop reporting in CARD is low relative to other sources. Furthermore, each dataset contains limitations for linkages across time. The ARMS Phase 2 crop history table includes reported use over 4 sequential years, but this is asked as a recall question from the perspective of a single year. Given the survey methodology, it is generally difficult to link respondents across multiple ARMS Phase 2 surveys, and any matched sample would be limited in size and representativeness. The Census of Agriculture provides exceptional coverage in a robust survey framework, but the survey is conducted only once every 5 years, and the survey instrument only asks operation-level use rather than field-level.

The Coronavirus (COVID-19) pandemic has impacted the data landscape in ways that are outside the scope of what was presented in this research. Many surveys were postponed or conducted by unconventional means during 2020 and 2021. This creates challenges for tracking fields over time, such as with the Indiana windshield survey. On the other hand, the Pandemic Cover Crop Program (PCCP) provided farmers with a crop insurance subsidy payment of \$5 per acre if they report a cover crop planting to USDA, Farm Service Agency in 2021 and 2022. This created a strong incentive to report these plantings, and the result was an over tenfold increase in the prevalence of cover crop reporting in CARD. In addition to this national program, which existed in 2021 and 2022, state-level programs preceded PCCP and continue to exist which provide incentives through crop insurance in Illinois, Indiana, and Iowa, with incorporation of CARD reporting (IDALS; IDOA; ISDA).¹⁴ If crop insurance incentives continue and remain tied to CARD reporting, the issue of underreporting in CARD may cease. However, there is currently no robust methodology for extending this to previous years. As a result, the findings of this research and those of subsequent research focusing on later years may or may not align.

Another development in the data landscape is the ongoing evolution of remotely sensed cover crop detection. There are multiple groups that have advanced the evolution of remotely sensed cover crop detection (Seifert et al., 2018; Deines et al., 2023; Chen et al., 2022). Remotely sensed cover crop detection is very different from many of the methods we rely on to measure cover crops. Because remotely sensed cover crop detection is driven entirely by observed biomass, there is no way to consider the intended use of the planting, which is important, as cover crops are generally not supposed to be harvested and sold. Remotely sensed methods also do not identify cover crops that fail to grow, and there is reason to believe that actual biomass accomplished may be more important than intentions. However, planting and intent are important aspects of cover cropping. Ideally, our

¹⁴ The Iowa program has the longest history, dating back to 2018, while the Illinois program began in 2020 and the Indiana program began in 2021. Unlike the PCCP, these programs have a maximum budget before they are exhausted for the year. While the Illinois and Indiana programs require CARD reporting of cover crops as part of the application process, it is only strongly encouraged in the Iowa program.

methods of measurement would be able to identify planted and failed cover crops, as these efforts lead to costs for the producer without any off-farm or on-farm benefits.

In the past few decades, cover crop use has expanded in alignment with an expansion of federal and state government support for cover crops. The largest of these programs, the NRCS Environmental Quality Incentives Program (EQIP), restricts eligibility to fields with no history of prior use of a given practice and sets a maximum number of years with payments, typically 3 years for cover crops. There exist other policies, such as the Pandemic Cover Crop Program (PCCP), which pay for cover crops regardless of whether a field or producer has a history of using cover crops, typically at a much lower payment per acre compared to programs restricted to fields with no history of cover crop use.

One of the potential motivations for a policy with eligibility restrictions is to maximize additionality – the extent to which adoption funded by the program would not occur in the absence of the policy. The policy choice of determining eligibility based on historical use can promote additionality by excluding those fields or producers which have demonstrated that they are willing to engage in the practice in the absence of a program. Such programs target new adoption, and their long-term impacts depend on the persistence of these new adopters after program funding ends. The evidence presented in this report suggests that many of these new adopters may not continue with the practice, but we do not directly look at persistence after funded adoption, nor do we compare this to persistence after unfunded adoption. Rosenberg et al. (2025) find that there is meaningful persistence for fields adopting through NRCS programs within priority watersheds.

This question of how additionality differs with the inclusion of fields with a history of cover crop adoption also depends on trends in persistence. Specifically, policies that pay for cover crops regardless of historical use will have low additionality if such fields are highly likely to persist and continue using cover crops. However, if such fields are unlikely to persist, the policies will have higher additionality. As the likelihood of cover cropping conditional on previous cover cropping approaches the likelihood of cover cropping in the full population, any additionality penalty from including these fields disappears.

In the majority of data sources, the probability that a field or operation with a cover cropping history will cover crop again in the current year is typically below 50 percent. This remains high enough that there is an additionality penalty, but it also suggests that eligibility restrictions on historical use may not have a large impact on additionality. While a policy without such eligibility restrictions would pay for some cover cropping that would exist in the absence of policy, it would also be expected to increase persistence among fields and operations that would otherwise exit or reduce cover cropping. In the same vein, the ecological benefits of cover cropping are maximized when cover crops are planted and maintained continuously or at regular intervals in a rotation (Bergtold et al., 2019; Cai et al., 2019; Wood & Bowman, 2021). The evidence from three of the four data sources in this report (Census of Agriculture, CARD, and the windshield survey) suggests that most fields with cover crops are not engaged in continuous cover cropping or cover cropping at fixed points within a regular crop rotation. Rather, the majority of fields enter or exit the practice or engage in irregular adoption. It may therefore be valuable to examine how to ensure persistence in order to maximize the ecological benefits from cover cropping. The reasons farmers may not continue to use cover crops vary, including sequencing in a crop rotation; direct costs, like seed and machinery; indirect costs, such as impacts on the commodity crop; weather; the ability to use cover crops for profitable purposes, such as grazing; social perception; and other factors (Roesch-McNally et al., 2017 and Dunn et al., 2016).

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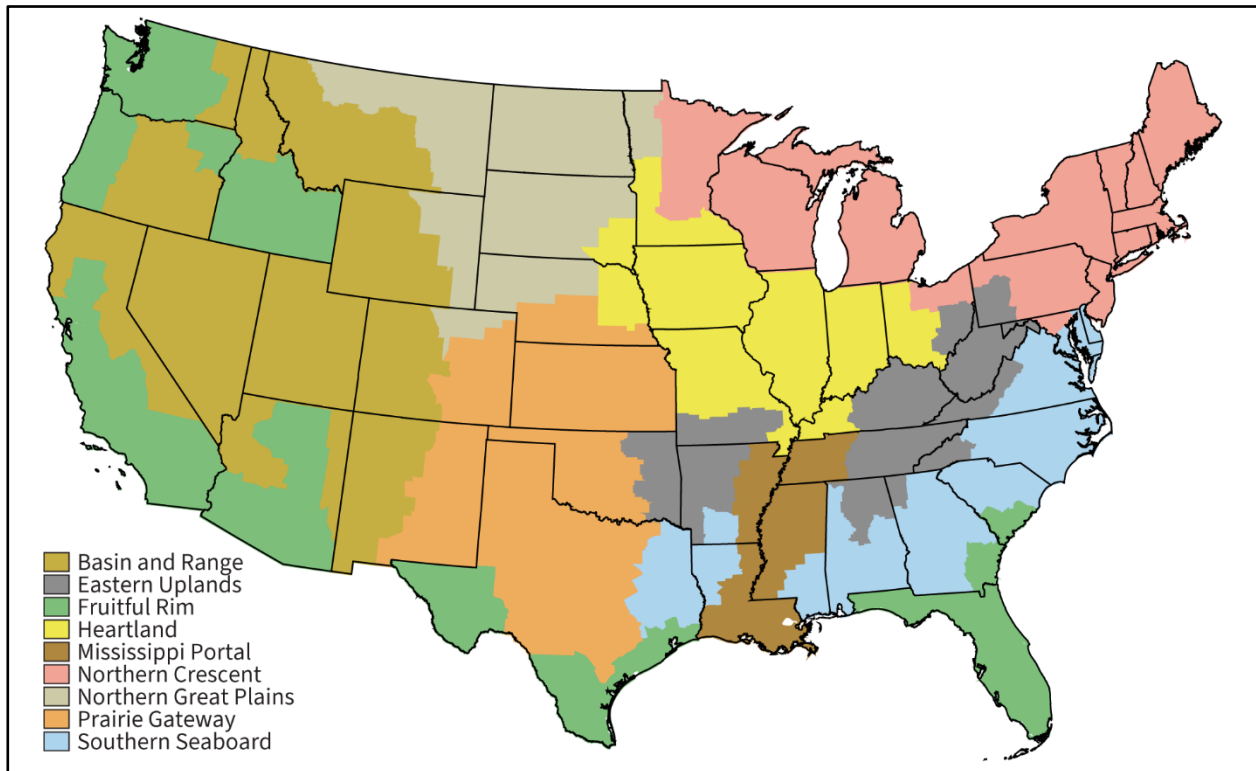
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Appendix

ERS Farm Resource Regions

Figure A.1 provides a map of USDA, Economic Research Service Farm Resource Regions, as a reference for figures 13, 14, and 15. Heimlich (2000) presents the underlying methodology for determining the regions.

Figure A.1
Map of USDA, Economic Research Service Farm Resource Regions



Note: USDA, Economic Research Service Farm Resource Regions depict geographic specialization in production of U.S. farm commodities. They identify where areas with similar types of farms intersect with similar physiographic, soil, and climatic traits. Alaska and Hawaii are not included in Farm Resource Regions.

Source: USDA, Economic Research Service (ERS) Farm Resource Regions, developed and characterized by USDA, ERS Agricultural Information Bulletin No. 760 (Heimlich, 2000)

Farm-level Statistics for CARD

Cover crop reporting is conducted at the field level in Crop Acreage Reporting Database (CARD), but all fields are associated with a USDA, Farm Service Agency (FSA) farm number. USDA, FSA farm numbers are administrative identifiers for agricultural operations. These identifiers are unique over time but not unique across administrative counties. Administrative counties refer to the county where an operation conducts its business with USDA, FSA, such that the fields associated with a farm may be located in one or more different counties. Analyzing CARD on the basis of farm numbers is an imperfect way to consider the behavior of operations, as it may not reflect the unit of decision making. A single operator may conduct business under multiple different farm numbers, especially when reporting for fields in different counties or States. Farms may also change over time. We restrict our sample to farms that filed a crop acreage report (FSA-578) every year from 2014 through 2019, but we do not require the

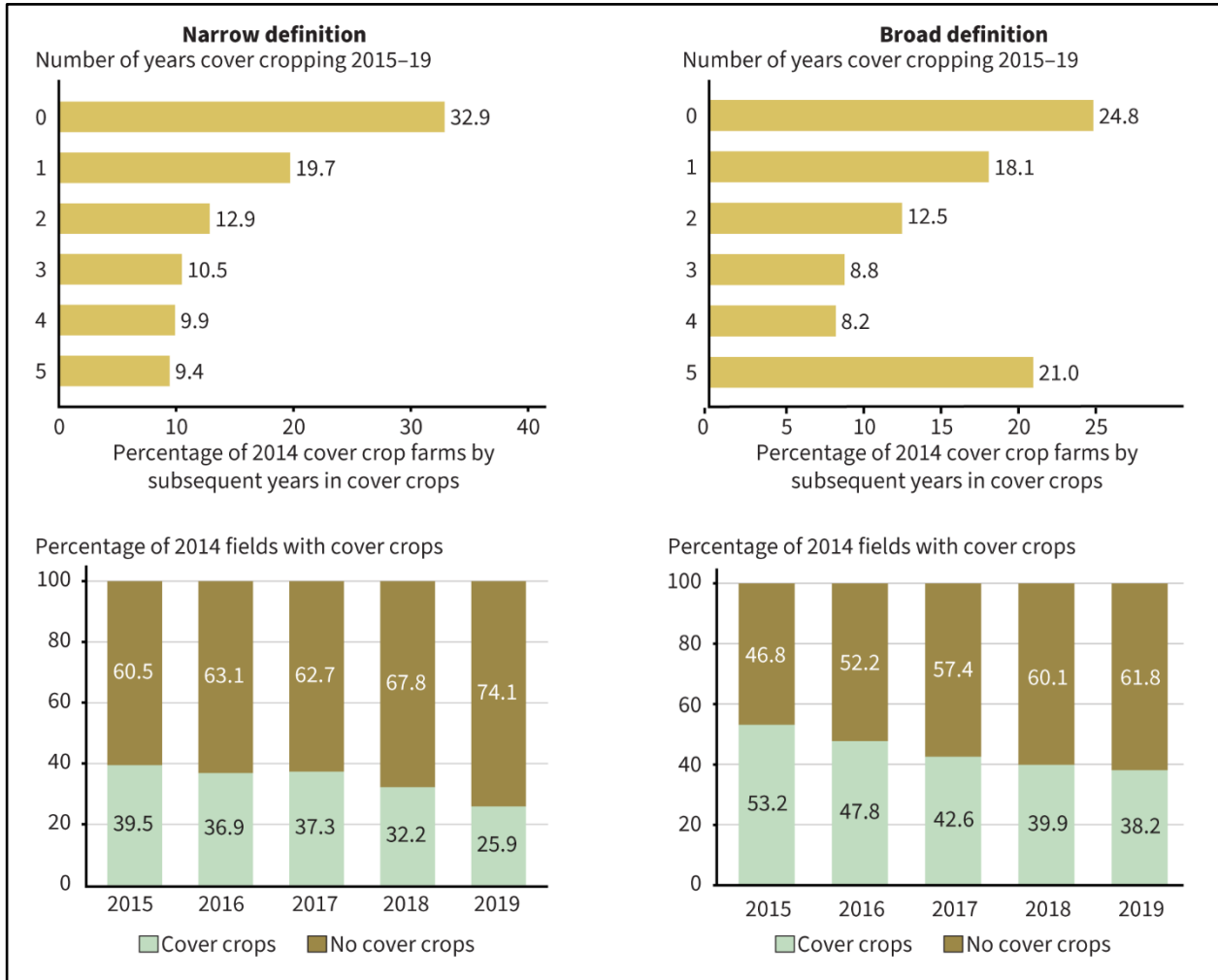
farm to report the same fields in each of those years. With these caveats and restrictions in mind, it is possible to replicate the field-level analysis for CARD presented in figures 2 and 3 with an operation-level analysis in figures A.2 and A.3.

The statistics for USDA, FSA farms are similar to the statistics for fields. Among USDA, FSA farms reporting cover crops in 2014 under the narrow definition, 33 percent never report cover crops from 2015–19, compared to 30 percent of fields. Among farms reporting cover crops in 2014 under the narrow definition with at least one planting for grain during the overall period, 30 percent of such farms never report cover crops from 2015–19, compared to 29 percent of fields. These statistics are slightly lower under the broad definition, at 25 and 23 percent of farms, respectively. These estimates are lower than those for fields, at 38 and 29 percent of fields, respectively.

The estimated share of operations with 3–5 out of 5 years of persistence is higher than the estimated share of fields. For the narrow definition, this is 29 percent of operations and 24 percent of fields. Among those with a grain planting, this is 38 percent of operations and 35 percent of fields for the narrow definition. For the broad definition, this is 38 percent of operations and 29 percent of fields. Among those with a grain planting, this is 46 percent of operations and 40 percent of fields for the broad definition.

Figure A.2

Persistence in reported cover cropping among farms reporting cover crops in 2014, USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD)

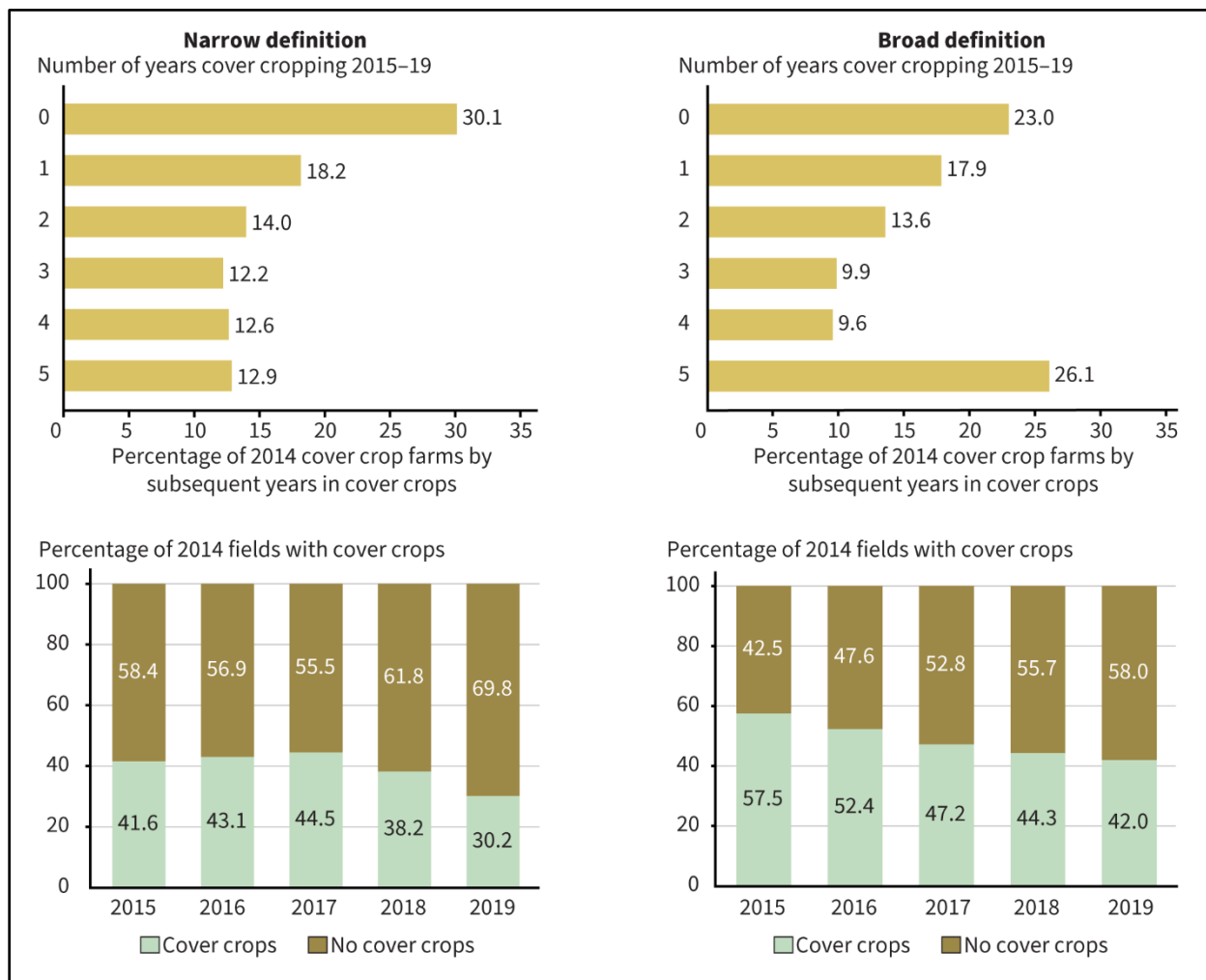


Note: The top row presents histograms for the share of farms by number of years reporting cover crops during the 2015–19 period, among only those farms reporting cover crops in 2014. The bottom row presents the share of farms reporting cover crops each year during the 2015–19 period, among only those farms reporting cover crops in 2014. The narrow definition is those farms that report a planting of cover only, while the broad definition includes cover only, forage, grazing, green manure, and left standing when planted in the same year as a planting for grain or silage. The sample is comprised of only those farms reporting cover crops in 2014. For the narrow definition, this is 9,038 of 1,608,595 farms present in all years of the data. For the broad definition, this is 67,691 farms.

Source: USDA, Economic Research Service analysis of USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD).

Figure A.3

Persistence in reported cover cropping among farms reporting cover crops in 2014, USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD), only farms with at least one grain planting



Note: The top two charts present histograms for shares of farms by number of years reporting cover crops during the 2015–19 period, among only those farms reporting cover crops in 2014. The two bottom charts present the share of farms reporting cover crops each year during the 2015–19 period, among only those farms reporting cover crops in 2014. The narrow definition is those farms that report a planting of cover only, while the broad definition includes cover only, forage, grazing, green manure, and left standing when planted in the same year as a planting for grain or silage. The total set of farms in each case is restricted to those farms with at least one grain planting. The sample is comprised of only those farms with any grain plantings reporting cover crops in 2014. For the narrow definition, this is 5,989 of 896,056 farms present in all years of the data. For the broad definition, this is 53,776 farms.

Source: USDA, Economic Research Service analysis of USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD).

In addition to a comparison with the field-level analysis, we can compare the statistics at the USDA, FSA farm level to the statistics for operations in the Census of Agriculture. Table A.1 illustrates that there is a strong increase in cover crop reporting from 2014 to 2019 among USDA, FSA farms. However, the trends in persistence are otherwise similar to the evidence from the Census of Agriculture, with the majority of USDA, FSA farms reporting cover crops in 2014 not reporting cover crops in 2019, despite the increase in overall reporting.

Table A.1

Cover crop reporting transitions at the USDA, Farm Service Agency (FSA) farm level

Panel A: Narrow definition of cover crops, only farms with a grain planting, 2014–19

	Percentage of operations...	2019			Percentage of operations with cover crops
		Cover crops - Yes	No		
2014	Cover crops - Yes	0.20	0.47	2014	0.67
	No	3.7	95.6	2019	3.9

Panel B: Cover crop reporting transitions at the USDA, FSA farm level, broad definition of cover crops, only farms with a grain planting, 2014–19

	Percentage of operations...	2019			Percentage of operations with cover crops
		Cover crops - Yes	No		
2014	Cover crops - Yes	2.5	3.5	2012	6.0
	No	6.6	87.4	2019	9.2

Note: Each panel provides statistics on the transitions of USDA, FSA farms, mirroring the statistics that can be calculated from the Census of Agriculture. The narrow definition is those farms that report a planting of cover only, while the broad definition includes cover only, forage, grazing, green manure, and left standing when planted in the same year as a planting for grain or silage. The total set of farms in each case is restricted to those farms with at least one grain planting. There are 896,056 farms represented.

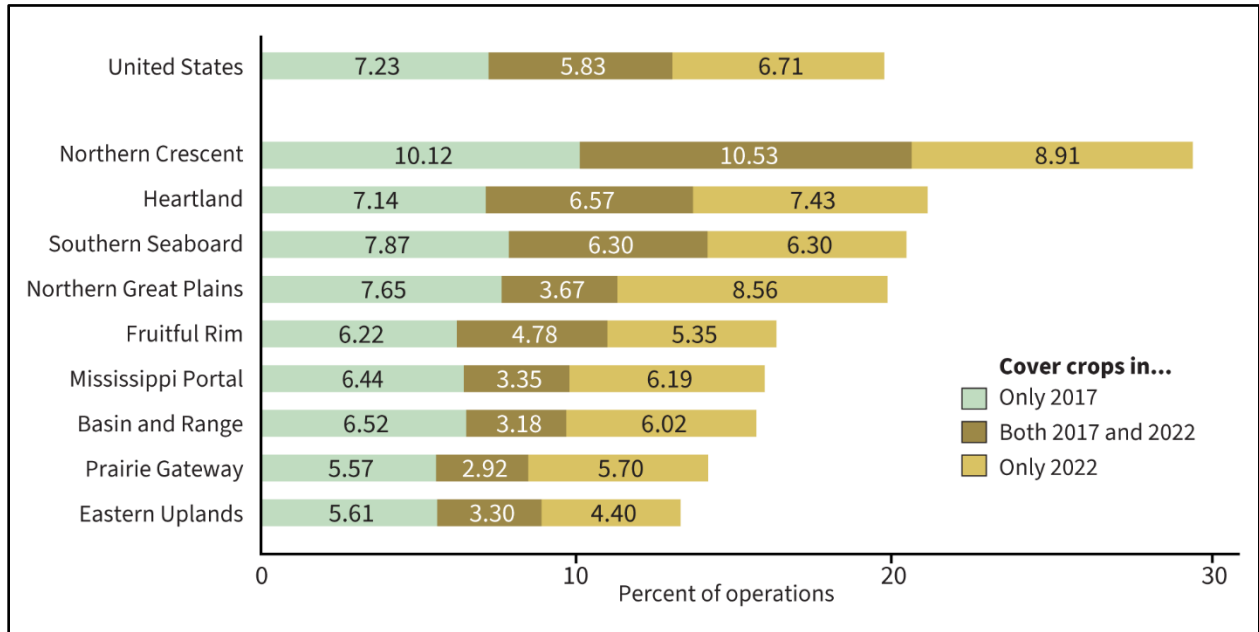
Source: USDA, Economic Research Service analysis of USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD).

Census of Agriculture Statistics by Region

Figures A.4 and A.5 replicate figure 13 with different time periods. Figure A.4 presents cover crop use and persistence between 2017 and 2022, while figure A.5 does the same for use and persistence between 2012 and 2022. The results are largely comparable across each year pairing, with the exception that the 10-year span of 2012–2022 features a lower share of operations reporting persistence within the snapshot measure. Specifically, the share of operations with cover crops in 2022 (37 percent) is much lower than the share of operations with cover crops in 2017 (44 percent), among those with cover crops in 2012. By contrast, the snapshot statistic for persistence spanning 2017–22 is 45 percent, comparable to the period spanning 2012–17.

Figure A.4

Cover crop use and persistence among operations in the 2017 and 2022 Censuses of Agriculture, by USDA, Economic Research Service (ERS) Farm Resource Region

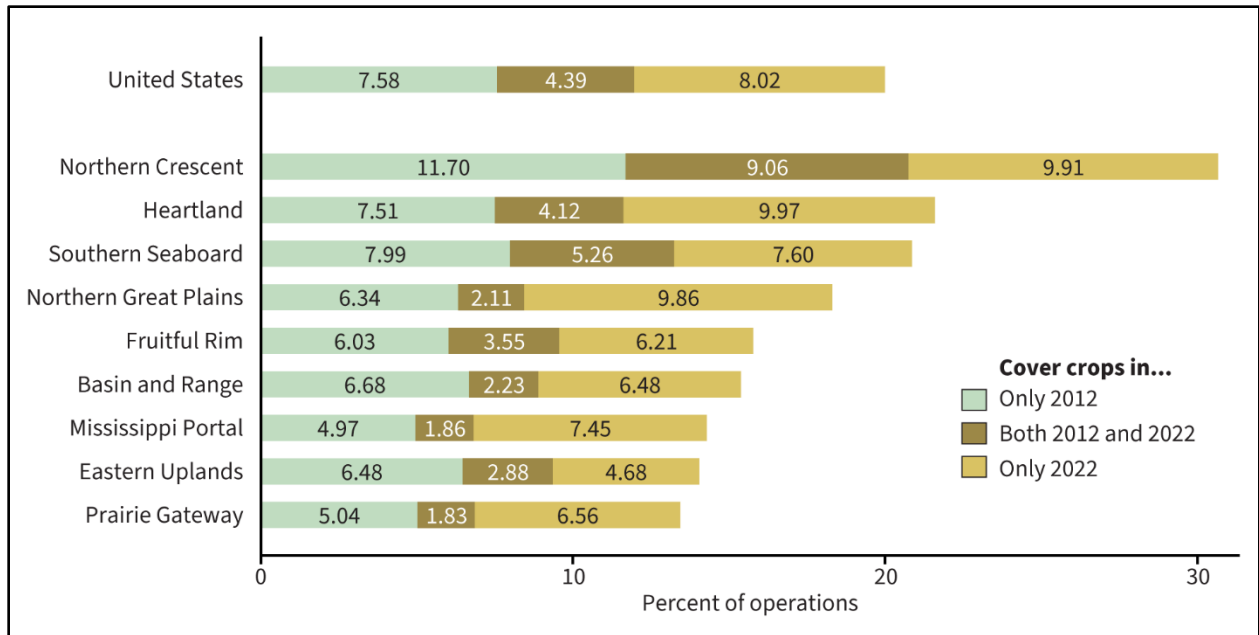


Note: The green (leftmost) bar represents those operations which report cover cropping in 2017 but not 2022. The yellow (rightmost) bar represents those operations which report cover cropping in 2022 but not in 2017. The brown (middle) bar represents those operations which report cover cropping in both 2017 and 2022. Only operations with cropland responding in both years are included. All statistics are weighted based on the 2022 Census of Agriculture.

Source: USDA, Economic Research Service analysis of the 2017 and 2022 Censuses of Agriculture data.

Figure A.5

Cover crop use and persistence among operations in the 2012 and 2022 Censuses of Agriculture, by USDA, Economic Research Service Farm Resource Region



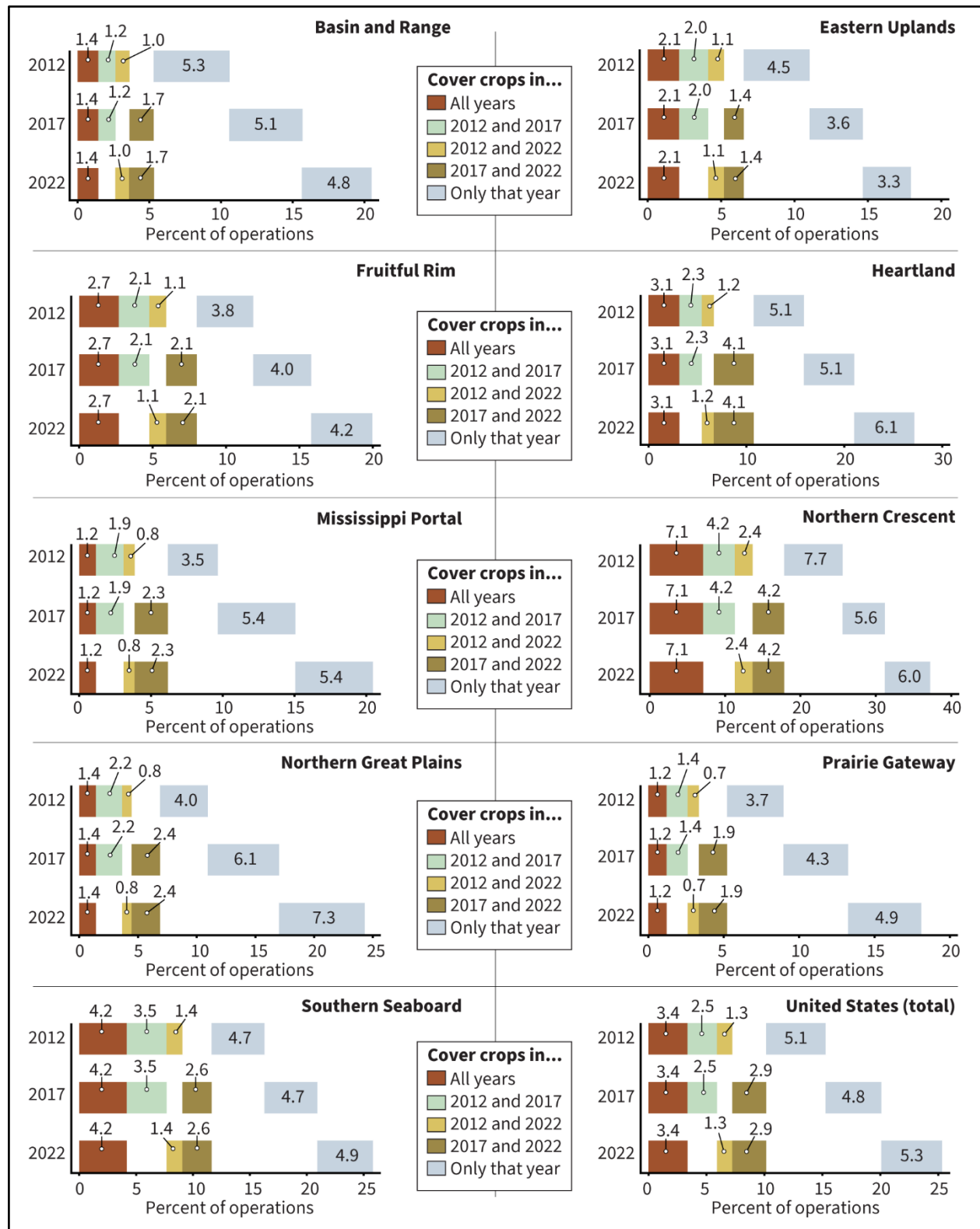
Note: The green (leftmost) bar represents those operations which report cover cropping in 2012 but not 2022. The yellow (rightmost) bar represents those operations which report cover cropping in 2022 but not in 2012. The brown (middle) bar represents those operations which report cover cropping in both 2012 and 2022. Only operations with cropland responding in both years are included. All statistics are weighted based on the 2022 Census of Agriculture.

Source: USDA, Economic Research Service analysis of the 2012 and 2022 Censuses of Agriculture data.

Figure A.6 combines the statistics from the 2012, 2017, and 2022 Censuses of Agriculture. The sample is smaller, as operations are only included if they can be linked to responses in each of the 3 years. However, figure A.6 reinforces the general themes of figures 13, A.4, and A.5, highlighting that while rates of persistence and adoption vary across regions, the majority of operations with any cover crops in any of 3 survey years report them in only 1 of the 3 years. Persistence varies by region, with operations reporting cover crops in all 3 years more prevalent in the Northern Crescent and Southern Seaboard, in particular, followed by the Heartland and Fruitful Rim.

Figure A.6

Cover crop use for operations across the 2012, 2017, and 2022 Censuses of Agriculture, by USDA, Economic Research Service Farm Resource Region



Note: The columns represent mutually exclusive groups of operators reporting cover crops in at least 1 of 3 years of the Census of Agriculture. The leftmost (red) bar represents the share of operators reporting cover crops in all 3 years. Only operations with cropland responding in all 3 years are included. All statistics are weighted based on the 2022 Census of Agriculture.

Source: USDA, Economic Research Service analysis of the 2012, 2017, and 2022 Censuses of Agriculture data.

Regression Specifications

Equation 1 provides the regression equations estimated in table 9. The sample for all estimations is the set of fields reporting cover crops in crop year 2014 and having at least one planting for grain during crop years 2015–19.

$$(1) \quad NYearsCoverCrops_i = \alpha_c + \beta \cdot FarmEverGZFG_i + \epsilon_i$$

The variable *FarmEverGZFG* is a binary indicator for whether field *i* belongs to a farm that had at least one planting for grazing or forage during crop years 2015–19. Table 9 estimates $\hat{\beta}$ for 12 binary definitions and 2 integer definitions of *NYearsCoverCrops*, 6 binary and 1 integer per definition of cover crops. We estimate this specification for each of these 14 versions of *NYearsCoverCrops* separately. The variable construction depends on the number of years and the definition of cover crops. For example, the estimation of the “share with 0 years” under the “narrow definition,” *NYearsCoverCrops* is equal to 1 if the field reports cover crops, under the narrow definition, in the 2014 crop year but not in crop years 2015–19. The six possible number of years are mutually exclusive and comprehensive. The two integer definitions represent the total number of subsequent years in cover crops during the period between 2015 and 2019. The α_c represents fixed effects by administrative county of the field.

The interpretation of $\hat{\beta}$ for binary definitions of *NYearsCoverCrops* is the difference in the share of fields reporting a given number of years of cover crops between fields in farms with any grazing or forage and fields in farms with no grazing or forage. These shares are among fields which reported cover crops in the baseline year (2014). For example, the coefficient for “share with 2 years” represents the difference in share of fields reporting exactly 2 years of cover crops between 2015 and 2019, after reporting cover crops in 2014. For the narrow definition, this is 1.8 percentage points.

Contextual Statistics

The data provided in this report require the use of one or more years as the initial year for the purposes of measuring persistence. The Census of Agriculture statistics rely on 2012, while CARD and the Indiana windshield survey rely on 2014. ARMS Phase 2 includes an array of baseline years, including 2012, 2013, 2015, 2016, and 2018. Table A.2 provides aggregate national statistics for a decade of years relevant to these baseline years regarding hydrological conditions, as defined by the U.S. Drought Monitor (2024). The national aggregate conditions featured the most drought severity in 2012, which is the baseline year for the Census of Agriculture findings. However, 2014 and other baseline years featured no drought anomalies.

Table A.2

Aggregate drought conditions for the continental United States, 2011–20

Year	None	D0–D4	D1–D4	D2–D4	D3–D4	D4
2011	59.8	40.2	28.2	19.5	12.4	6.1
2012	32.3	67.7	50.0	30.4	13.6	3.6
2013	39.6	60.4	45.7	29.9	11.6	3.2
2014	51.2	48.8	34.1	21.6	9.7	2.9
2015	52.5	47.5	29.2	17.0	8.8	3.0
2016	59.0	41.0	18.9	8.1	3.9	1.6
2017	68.2	31.8	13.1	3.9	1.2	0.2
2018	52.0	48.0	29.3	15.5	6.1	1.2
2019	76.4	23.6	10.3	3.4	0.5	0.1
2020	55.8	44.2	27.5	14.6	6.5	1.4

Note: Each column represents the share of the continental United States experiencing a specified level of drought each year. The drought columns are cumulative, such that the D3–D4 column includes the share in D4 and the share in D3. Drought categories D1 through D4 are defined by the U.S. Drought Monitor. D1 represents Abnormally Dry conditions. D2 represents Moderate Drought conditions. D3 represents Extreme Drought conditions. D4 represents Exceptional Drought conditions. The None category represents the share not experiencing any drought conditions.

Source: USDA, Economic Research Service using U.S. Drought Monitor data.

Table A.3 provides context of the crop insurance indemnities and loss ratio over the same decade. Correlated with the results in table A.2, 2012 featured the most crop insurance indemnities and highest loss ratio. Other baseline years were relatively normal for the decade.

Table A3

Aggregate crop insurance indemnities for the United States, 2011–20

Year	Total indemnities (billions of dollars)	Loss ratio
2011	10.9	0.91
2012	17.5	1.57
2013	12.1	1.02
2014	9.1	0.91
2015	6.3	0.65
2016	3.9	0.42
2017	5.4	0.54
2018	7.3	0.74
2019	10.7	1.04
2020	9.2	0.90

Note: The first column references the total indemnities paid for crop insurance losses across all crop insurance programs. The second column provides the ratio of losses to premium paid, which provides a reference of the losses scaled to the value of all insured agricultural production.

Source: USDA, Economic Research Service using USDA, Risk Management Agency data.

Table A.4 provides the share of acreage reported in cover crops in CARD and in the Censuses of Agriculture across 2012 through 2023, as published. Reporting of cover only experiences two discrete increases, in 2019 and 2021. There were policies in each year incentivizing planting or reporting cover crops. In 2019, there was an incentive to plant and report cover crops as part of the Dairy Margin

Coverage Program. In 2021 and 2022, there was an incentive to report and to plant cover crops under the Pandemic Cover Crop Program through crop insurance. After 2021, reporting in CARD remains elevated above prior levels. There are also state-level programs, discussed in the conclusion, which may influence reporting in the later years. The overall trends in cover crop reporting across the two data sources indicate that cover crops were underreported in CARD prior to the introduction of these programs. Note also that the denominator for CARD in table A.4 is acreage in plantings for grain, which may be smaller than acreage in cropland, as the two data sources do not directly measure and classify acreage in the same way.

Table A.4

Share of acreage reported in cover crops in USDA, Farm Service Agency, Crop Acreage Reporting Database (CARD) and Census of Agriculture, 2012–2023

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
CARD	0.21	0.33	0.36	0.43	0.56	0.86	0.98	2.53	1.05	6.23	5.28	3.77
Census	2.64					3.88			4.70			

Note: The CARD row provides the reported acreage in cover only as a share of the reported acreage in grain, by crop year, in the Crop Acreage Reporting Data. For example, 0.86 in 2017 represents 0.86 percent of grain acres in cover crops. The Census row provides the reported acreage in cover crops as a share of the reported total cropland acreage, by year Census year, in the Census of Agriculture reporting. Census data are public aggregate numbers separately calculated for each year.

Source: USDA, Economic Research Service using USDA, Farm Service Agency Crop Acreage Data, FOIA Frequently Requested, and USDA, National Agricultural Statistics Service, Census of Agriculture, 2012, 2017, and 2022.