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Research Paper

A framework for conceptualizing agricultural diversification with a focus on the U.S. Corn Belt

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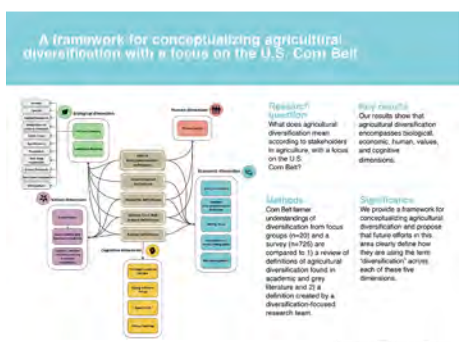
HIGHLIGHTS

- We examine the meaning of diversification according to agricultural stakeholders with a focus on the U.S. Corn Belt.
- Data from farmer focus groups and surveys are compared to academic and grey literature.
- Diversification encompasses biological, economic, human, values, and cognitive dimensions.
- We provide a framework for conceptualizing agricultural diversification for future efforts.

GRAPHICAL ABSTRACT



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ABSTRACT

CONTEXT: Diversification of agricultural production has been proposed to address interrelated social, ecological, and economic challenges. However, definitions of agricultural diversification vary, and there has been negligible research documenting what farmers consider to be diversification.
A shared understanding of agricultural diversification is needed to create common goals and support policies and programs that incorporate the vision of the agriculture community.
OBJECTIVE: We examine the meaning of agricultural diversification according to agricultural stakeholders with a focus on the U.S. Corn Belt.
METHODS: Data on farmer understandings of diversification from focus groups (n = 20 groups) and a survey (n = 725 respondents) across the U.S. states of Iowa, Illinois, and Indiana are compared to 1) a review of definitions

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of agricultural diversification found in academic and grey literature and 2) a definition created by a team of academics, Extension, and non-governmental professionals.

RESULTS And CONCLUSION: Five dimensions of agricultural diversity emerged: biological, economic, human, values, and cognitive. Across sources, diversification is typically discussed in biological and economic terms. Some sources mention values of conservation or sustainability as components of agricultural diversification and relatively fewer identify human dimensions. While the cognitive dimension of diversification did not emerge in the literature review, it was mentioned frequently by focus group participants.

SIGNIFICANCE: We provide a framework for understanding agricultural diversification and propose future efforts in this area define how the term is used across each of the five dimensions. Future outreach activities can leverage aspects of diversification that are compelling and achievable to farmers.

1. Introduction

In less than one hundred years across much of the world, the introduction of modern agriculture has resulted in the specialized production of a handful of high yielding crops and the loss of biodiversity in agricultural systems. Synthetic fertilizers, pesticides, high yielding varieties, mechanization, and subsidies for a select few commodities have allowed farmers to substitute rotational diversity in the short-term for increased productivity (Perfecto, 2009; Vandermeer, 2018). While highly efficient by the metric of yield per unit of land area, the cultivation of fewer crop species has generated profound negative impacts on the natural environment, while lowering economic and ecological resilience of farmers and rural communities (Rasmussen et al., 2024).

The decline in agricultural diversity has been especially marked in the Corn Belt region of the U.S. where, starting in the second half of the 20th century, corn (*Zea mays* L.) and soybeans (*Glycine* max [L.] Merr.) began to dominate agriculturally managed land in the region (Sulc and Tracy, 2007). Though corn was always prominent under European settlement—to the extent that the region was known as the “Corn Belt” by the 1820s (Bogue, 1968)—agriculture on these highly fertile soils had traditionally consisted of a mix of small grains, forages, and tubers as well as diverse livestock species (Bogue, 1968). By the 1920's, production of corn alongside its new companion in rotations—soybeans—began to soar, often at the expense of other field crops, and the region became the largest producer of corn and soybeans in the North American continent (USDA NASS, 2022; Warntz, 1957). The U.S. is now the world's largest exporter of corn and is responsible for nearly one-third of global corn and soybean grain production (Wang et al., 2020).

The simplified, spatially decoupled, and highly productive crop and livestock production systems have multiple external and internal costs, most notably compromised water quality from local (e.g., drinking wells) (Richards et al., 1996) to continental scales (e.g., costal dead zones) (Rabalais and Turner, 2019; Diaz and Rosenberg, 2008); loss of wetlands and grasslands that support biodiversity and environmental quality (Wright and Wimberly, 2013); lower air quality (Paulot et al., 2014; Luo et al., 2022), increased anthropogenic nitrous oxide (N_2O) emissions (Lin, 2011; Lawrence et al., 2021); economic and ecological vulnerability to shocks and stresses (Abson, 2019); soil erosion that has reduced crop yields (Thaler et al., 2021) and will impact future crop productivity (Kwang et al., 2023); decreased food security (Crossley et al., 2021); and poor nutritional and health outcomes from a concentration on energy-dense cereal and oil crops (FAO, 2019; Khoury et al., 2014). Simplification and spatially segregated crop and livestock production have led, globally, to “some of the world's most pressing sustainability challenges” (Garrett et al., 2020, p. 1).

The societal and environmental impacts of the loss of biodiversity in agricultural landscapes, often referred to as agrobiodiversity (Jackson et al., 2007), has spurred much discussion and research over the last several decades to identify means to re-diversify for greater functionality and resilience (Zimmerer and de Haan, 2017). A growing field of research has noted the impacts of input-intensive, monoculture production of crops and livestock and the potential benefits of more diversified farms and landscapes (Dainese et al., 2019; Tamburini et al., 2020). More biologically diverse farming systems can build greater resilience to pests and disease (Guinet et al., 2023; Peralta et al., 2018) and protect against climate fluctuations while building healthier soils through biological processes (Lin, 2011). Farmers can benefit economically from agricultural diversification through greater yield stability (Gaudin et al., 2015), increased yields (Bowles et al., 2020; Cardinale et al., 2012), spreading income throughout the year (Hendrickson and James, 2005), and similar or in some cases higher net profitability (Davis et al., 2012).

Due to these benefits, there has been increasing interest in agricultural diversification both conceptually and in practice. As one example, Scopus indicates that use of the term “agricultural diversification” in published literature increased significantly beginning in the early 2000s (Scopus, 2025). Despite this increasing focus on diversification or re-diversification as a means to address many of the core challenges facing agriculture, there is no shared understanding of what diversification means across the perspectives of various stakeholders in agriculture, noted in several studies (Barbieri et al., 2008; Hufnagel et al., 2020; Nickerson et al., 2001).

While it is clear what diversification is not—simplified production of crops and livestock—“there is no single template” for diversification (Berkley Food Institute, 2026) and definitions vary across academic and grey literatures. Perhaps more importantly, there has been no formal research documenting what farmers themselves consider to be diversification until a recent study in Tasmania (Tacconi et al., 2024) where authors documented what farmers conceived to be diversity at the farm-scale. The lack of a single, universal definition for agricultural diversification likely stems from the diverse realities and motivations of individual farmers and perspectives of agricultural practitioners. The fact that every farm operates within a unique set of circumstances (e.g., scale, location, environmental conditions, existing skills, market opportunities, farmers' goals) influences how a farmer defines and approaches diversification. Non-farming agricultural practitioners may also have differing visions of what a diverse agricultural landscape looks like according to how they believe diversification relates to social, economic, and environmental goals.

Taken together, we believe a shared understanding of the varied conceptualizations of agricultural diversification is both necessary and timely. Understanding what we mean by “agricultural diversification” as a global community of farmers, academics, agricultural professionals, and advocates can help create shared goals and common pathways towards agricultural diversification. In particular, understanding what farmers consider to be agricultural diversification can ensure educators and outreach professionals use terms and conceptualizations of diversity that resonate with farmers (e.g., Revoyron et al., 2022), increasing effectiveness of outreach and engagement while guiding research on technical obstacles and opportunities for diversification. Lastly, a comprehensive understanding of the many facets of agricultural diversification can support policies and programs that incorporate the vision of the agriculture community.

This research addresses these needs by examining the following research questions:

1) How do farmers in the U.S. Corn Belt (specifically Indiana, Illinois, and Iowa) define agricultural diversification?;

2) How do Corn Belt farmers' understandings of agricultural diversification align or misalign with the definitions typically employed by academics, non-governmental organizations (NGOs), intergovernmental organizations, and governmental agencies; and,

3) What are the implications of similarities and differences in definitions of agricultural diversification for research and outreach activities?

In the following sections, we describe each phase of our work to answer these questions. In the first phase, we categorized definitions of agricultural diversification from the academic literature, in publications from NGOs, and from agricultural-related governmental and intergovernmental entities. We then describe our preliminary framework of agricultural diversification created through a large-scale interdisciplinary project funded by United States Department of Agriculture National Institute for Food and Agriculture (USDA NIFA) called the Diverse Corn Belt through which the authors are involved. Qualitative and quantitative data collected as part of the Diverse Corn Belt project are then used to characterize farmers' perspectives on definitions of agricultural diversification in three states in the heart of the U.S. Corn Belt: Illinois, Indiana, and Iowa. These data broaden understandings of diversification beyond what is found in the existing literature. Next, we discuss and compare the multiple understandings of diversification (literature, our own preliminary model that guided our project, and those of farmers), finding commonalities and areas of disagreement. We then present a final framework and suggestions for shared language across stakeholders (farmers, academics, NGOs, governmental and intergovernmental organizations) moving forward. We conclude with thoughts on next steps for research and outreach in this area.

2. Literature review

2.1. Literature review methods

Through an expert literature review conducted by our interdisciplinary research team of social scientists, economists, and biophysical scientists, we describe how agricultural diversification is defined in relevant literatures and resources. This literature review was intended to be representative but not exhaustive. While it was not a systematic review, it was a more formalized process than typical literature reviews and therefore methods are briefly described.

In an effort to bring together a broad understanding of the concept across varied literatures, agricultural diversification for the purposes of this paper is encompassing of terms such as "agricultural diversity", "farm diversity", and "diversity in agriculture". In addition to expert identification of important papers defining these terms, a literature search was conducted from May to June of 2024. Through this combined process, we identified 47 relevant sources. For academic literature, searches were conducted in Scopus, Web of Science, Google Scholar, and Google using the search terms ("agricultural diversification" OR "agricultural diversity") AND ("definition" OR "meaning"). We did not limit the search by particular years or geographic area. For grey literature composed of NGO, intergovernmental, and governmental sources, we conducted targeted searches of materials on websites of known agricultural NGOs and government agencies. We did not limit the search by any date range. Due to the geographical context of this paper and its focused scope, we included only governmental and NGO sources from organizations located in the U.S. Sources were included that mentioned a given practice or attribute as a characteristic of agricultural diversification. We did not include aquaculture in the scope of this work and focus specifically on land-based agricultural production. We believe the works we reviewed are generally encompassing of each dimension we developed, as explained below.

2.2. *Agricultural diversification according to a review of academic and grey literature*

Table 1 lists the various practices and attributes, along with example references, that have been associated with agricultural diversification by sources described above. The ways in which agricultural diversification is defined in the context of agricultural landscapes has varied, but we identify several key dimensions in which understandings of diversification typically fall: biological, economic, human, and values. We refer to these dimensions throughout the paper to categorize various understandings of diversification across sources.

Diversification in reviewed sources is most frequently discussed in biological terms (*biological dimension*). A widely cited definition of agricultural diversification stems from a group of academics in the U.S. who identify "a farming system as 'diversified' when it intentionally includes functional biodiversity[1] at multiple spatial and/or temporal scales," (Kremen et al., 2012, p. 44). Researchers in the Diverfarming project, a multi-national research consortium including academic and industry partners, define crop diversification strategies to include intercropping (i.e., growing complementary crops from different families simultaneously on the same field), crop rotation (i.e., growing complementary crops in sequence over multiple years), and multiple cropping (i.e., growing complementary crops in seasonal succession within the same year) (Di Bene et al., 2022). Academic definitions reviewed share a focus on the role of biological diversity within the agricultural landscape to ensure the functioning of healthy and productive agricultural systems.

In conservation biology, biodiversity is measured across multiple scales including genetic, species, ecosystem, and landscape (Walker, 1992). In the case of agrobiodiversity, it has been similarly defined and measured at the genetic, species, and landscape levels. These include multiple genetic varieties (e.g., Hammer et al., 2003), multiple crop and livestock species (e.g., Johnston et al., 1995), mixed farming systems that combine crop and livestock production (e.g., Puech and Stark, 2023), and multiple types of land use over space and time (e.g., Estrada-Carmona et al., 2022). Some authors also draw distinctions between diversity at the field level and the landscape level, and between spatial (e.g., intercropping) and temporal (e.g., crop rotation) dimensions (e.g., Kremen et al., 2012; Renwick et al., 2019; Thornton and Herrero, 2014). While species diversity is most commonly discussed in broad terms, some sources identify particular practices as characteristic of species diversity including cover crops (e.g., Rosa-Schleich et al., 2019), agroforestry (e.g., Rasmussen et al., 2024), perennial crops (e.g., (Kremen et al., 2012), and non-crop vegetation (e.g. Lin, 2011). Conservation goals are embedded within much of this literature (e.g., Kremen et al., 2012), although some sources explicitly include elements of conservation (*values dimension*) in their definitions including conservation of soil and water, and organic agriculture (Rasmussen et al., 2024; Rosa-Schleich et al., 2019).

Within the realm of economics (*economic dimension*), agricultural diversification, most often referred to as farm diversification, goes beyond growing multiple crops in space and time to encompass a strategic shift in farm production aimed at optimizing economic outcomes. From an economic standpoint, diversification has been defined most commonly in terms of multiple enterprises, also referred to as livelihood diversity (e.g., (Barrett et al., 2001; Ilbery et al., 1998; Tacconi et al., 2022), a strategy used to minimize market risks such as price volatility and production risks that impact individual crops or livestock differently (Harwood et al., 1999; Mishra et al., 2004). Multiple enterprises can include diversification of both on- and off-farm income

[1] 'Functional biodiversity' refers to the idea that different organisms perform different functions, complementing one another in an ecosystem for greater stability and resilience to economic and environmental stresses (Petchey and Gaston, 2006).

Table 1
Meaning of agricultural diversification in academic literature, NGO and intergovernmental organizations, and governmental agencies working in agriculture.

Diversification practice/attribute	Examples of work supporting practice/attributes in agricultural diversification definition (+academic, ++NGO and intergovernmental, +++governmental)
Dimension of Agricultural Diversification: Biological	
Multiple genetic varieties of crops and/or livestock	+ Hammer et al., 2003; Isbell et al., 2017; Jackson et al., 2007; Kremen and Miles, 2012; Tacconi et al., 2024, Tacconi et al., 2022; Thornton and Herrero, 2014 ++FAO, 2019; IPES-Food, 2016 +++Janowiak et al., 2016
Multiple species of crops grown together spatially within a field—diversity in space	+ Carlisle et al., 2022; Corselius et al., 2003; Gaba et al., 2015; Goslee, 2020; Hufnagel et al., 2020; Isbell et al., 2017; Kremen and Miles, 2012; Lin, 2011; Rosa-Schleich et al., 2019; Spangler et al., 2022; Tamburini et al., 2020; Tacconi et al., 2024; Thornton and Herrero, 2014; Venter et al., 2016 ++IPES-Food, 2016
Multiple species of crops grown temporally within a rotation—diversity in time	+ Gaba et al., 2015; Goslee, 2020; Hufnagel et al., 2020; Isbell et al., 2017; Kremen and Miles, 2012; Lin, 2011; Renwick et al., 2019; Spangler et al., 2020; Tacconi et al., 2024; Tamburini et al., 2020; Thornton and Herrero, 2014 ++IPES-Food, 2016; Sustainable Food Lab, 2023 +++ Janowiak et al., 2016; USDA ARS, 2023
Integration of crops and livestock (mixed farming systems)	+ Corselius et al., 2003; Kremen et al., 2012; Puech and Stark, 2023; Rasmussen et al., 2024; Rosa-Schleich et al., 2019; Spangler et al., 2020; Szymczak et al., 2020; Tacconi et al., 2024, Tacconi et al., 2022 ++FAO, 2019; IPES-Food, 2016 +++ Janowiak et al., 2016
Cover cropping	+ Kremen et al., 2012; Rosa-Schleich et al., 2019; Spangler et al., 2022; Tacconi et al., 2024 +++ Janowiak et al., 2016
Agroforestry or growing trees and shrubs within agricultural spaces (e.g., hedgerows, live fences, silvopasture)	+Carlisle et al., 2022; Kremen et al., 2012; Lin, 2011; Rasmussen et al., 2024; Rosa-Schleich et al., 2019; Tacconi et al., 2024, Tacconi et al., 2022 ++ FAO, 2019; Patel-Weynand et al., 2017 +++ Janowiak et al., 2016
Perennial crops (e.g., fruit and nut trees, pasture)	+ Tacconi et al., 2022; Kremen et al., 2012 +++ Janowiak et al., 2016
Non-crop vegetation within-field (e.g., weed strips, prairie strips, buffer strips, hedgerows, vegetation banks)	+ Kremen et al., 2012; Lin, 2011; Spangler et al., 2022
Multiple types of land use within a landscape over space and/or time (e.g., fallow fields, pastures, prairies, meadows, woodlots)	+ Estrada-Carmona et al., 2022; Huber et al., 2020; Kremen et al., 2012; Lin, 2011; Pfeifer et al., 2009; Spangler et al., 2022; Tacconi et al., 2024
Dimension of Agricultural Diversification: Values	
Conservation (general)	+ Rosa-Schleich et al., 2019; Spangler et al., 2022 ++ NSAC, 2023
Soil conservation (e.g., cover crops, compost application; reduced tillage)	+ Carlisle et al., 2022; Kremen et al., 2012; Rasmussen et al., 2024; Rosa-Schleich et al., 2019
Water conservation	+ Rasmussen et al., 2024
Organic agriculture	+ Lin, 2011; Rosa-Schleich et al., 2019; Tacconi et al., 2024
Equitable access to land for diverse farmers	+ Demongeot et al., 2024 ++ NSAC, 2023
Dimension of Agricultural Diversification: Economic	
Multiple enterprises	+ Barrett et al., 2001; Bowler et al., 1996; Ilbery et al., 1998; Lange et al., 2013; McGehee and Kim, 2004; McNally, 2001; Mishra et al., 2004; Nguyen et al., 2019; Tacconi et al., 2024, Tacconi et al., 2022; Thornton and Herrero, 2014 ++IPES-Food, 2016 +++ Harwood et al., 1999; Janowiak et al., 2016
Value added (e.g., processing/packaging farm products)	+ Barbieri et al., 2008; Tacconi et al., 2024; Thornton and Herrero, 2014
Horizontal or vertical diversification	+ Barbieri and Mahoney, 2009; Stevens and Teal, 2024; Tacconi et al., 2022
Dimension of Agricultural Diversification: Human	
Diversity of people (e.g., race, ethnicity, gender, farm size)	+ Demongeot et al., 2024 ++ Fisher, 2021; NSAC, 2023

streams including non-agricultural production enterprises such as agrotourism and work for hire off-farm (e.g. (McGehee and Kim, 2004; Nickerson et al., 2001).

The reviewed sources from the economics literature distinguish between vertical and horizontal forms of diversification of the farm business (e.g. Barbieri and Mahoney, 2009; Stevens and Teal, 2024; Tacconi et al., 2022). Horizontal diversification focuses on expanding income sources within the same production system. Integrating high-value crops like fruits, vegetables, or specialty products can lead to greater profit margins compared to commodity crops alone (Barbieri and Mahoney, 2009). Vertical diversification, in contrast, involves expanding across different stages of the production chain by integrating up- or downstream income-generating activities such as seed production, processing of agricultural crops, and marketing. Within up-stream integration is another form of diversification defined as "adding value" to the farm operation by processing or packaging agricultural products on the farm and capturing more of the value of the product before it leaves the farmgate (Barbieri et al., 2008; Thornton and Herrero, 2014).

Some sources bring in social elements to defining diversification including human diversity and equity (*human and values dimensions*). Acknowledging the interconnectedness of ecological and human diversity, the National Sustainable Agriculture Coalition NSAC (2023) states: "A reference to diversification is fundamentally a reference to restoring the ecosystem function of farmland by allowing living organisms to reclaim roles that beginning in the mid-20th century have been assigned largely to synthetic chemicals or machines in conventional farming. However, as with all social-ecological systems, change in any part of the system necessarily requires or causes change in other parts of the system. Thus, diversification also relates to changing the function of the human elements of the system." An opinion piece by the president of the New York Farm Bureau (Fisher, 2021) broadens the human dimension of agricultural diversification by suggesting that diversity in agriculture can include farmers of different ages, genders, and ethnicities. NSAC (2023), as well as Demongeot et al. (2024), suggest that crop diversity necessitates more equitable access to land, especially for small- and mid-scale diversified farmers (*values dimension*).

2.3. Conceptualizing agricultural diversification according to the Diverse Corn Belt team

The Diverse Corn Belt is a USDA NIFA-funded multi-institutional and transdisciplinary project focusing research, extension, and education efforts towards diversification beyond corn and soybeans in the U.S. Corn Belt. The group is comprised of academics, extension professionals, and practitioners working in research, extension, and education in agriculture. Drawing from academic literature and substantial experience working directly with farmers to understand their perspectives on a variety of agricultural issues, the team created a preliminary framework during funding proposal development for what constitutes agricultural diversification in the Corn Belt. The framework was created to guide the Diverse Corn Belt project, with the idea to test and add to the working definition by conducting a formal study of what agricultural diversification means to the farmers in the region. The initial result was the distinction of diversification at three levels: farm, landscape, and market (See Fig. 1). This framework is intended to be refined through an iterative and reflexive process, considering the results of research as it becomes available to shape our understandings of diversification.

At the farm level, we define diversification as alternative farming systems that go beyond conservation practices such as using cover crops in simplified rotations. At a proposal-writing workshop in 2019, the group brainstormed possible future scenarios for the Corn Belt and identified key "low hanging fruit" systems including extended rotations with three or more crops over a three-year period or longer, energy and perennial crops, and forages with livestock. Based on further discussions, the group added agroforestry and horticultural production as options. Ultimately, the group defined farm level diversification to include extended rotations, perennial pasture/forage or perennial biomass crops, agroforestry, grazed livestock, and horticultural food crops (Fig. 2). Following most definitions of diversified agriculture at the farm level, we center the use of multiple species and types of crops and livestock. At the market level, we define diversification as a diversity of markets for both farmers and consumers and posit that broad adoption of diversified practices rests on fostering a diversity of markets that can ensure the needs of diverse people are met along the value chain—from landowners to farmers to laborers to consolidators to retailers to consumers. At the landscape level, we see diversification as the wide-scale adoption of alternative farming systems that are climate-smart, reach profit, yield, and ecosystem services goals leading to resilient intensification, and strive towards systems and services that are equitable for farmers and rural communities.

3. Methods

The data for this paper were collected through a qualitative/quantitative mixed-method approach using focus groups and a survey that comprise major components of the Diverse Corn Belt project's efforts to understand diversification from farmers' perspectives. The focus group and survey methods are discussed in detail below.

3.1. Focus groups

Focus groups were conducted with farmers in Indiana, Illinois, and

Fig. 1. The three pillars of diversification according to the Diverse Corn Belt project: farm level, market level, and landscape level.

Iowa between April 2022 and February 2023. Twenty focus groups were conducted—10 in Indiana, five in Illinois, and five in Iowa—with a total of 100 participants. We strove to recruit participants based on level of diversification in an effort to have the perspectives of both more and less diversified farmers represented. Participants were identified through local and regional agricultural organizations, an optional sign-up on the Diverse Corn Belt website, at agricultural conferences, and through personal networks of the Diverse Corn Belt partner organizations. Despite our attempts to homogenize each focus group by level of diversification, in some instances the focus groups comprised both more diversified and more specialized farmers (primarily due to farmer availability). As a result, six groups included mostly diversified farmers, five groups included mostly less diversified farmers, and nine included a mix of diversification levels.

Focus group conversations lasted between one to two hours. Eighteen of the focus groups were conducted in-person and two remotely via Zoom and telephone. The main question we asked participants relevant to this paper was "What does agricultural diversification mean to you?". Other questions included what is and is not working well in the current agricultural system in the Corn Belt and what participants see as the benefits and downsides of agricultural diversification. For further detail on our focus group methodology, see Traldi et al. (2025).

To examine similarities and differences in the way meanings of agricultural diversification were discussed by participants, we examined how often (by number of coding references, or coded text segments per code) each meaning overlapped with other meanings using Nvivo's matrix coding query. Overlap is calculated based on coding reference similarity, or the extent a coded text segment is double coded, or coded to both code a and code b.

3.2. Survey

A mail survey was conducted with a stratified random sample of Illinois, Indiana, and Iowa farmers in spring 2023. To ensure our sample was composed of farmers whose farming operations contribute substantially to household income and because larger farms operate disproportionately more acres (USDA NASS, 2024), we included only farmers with more than 40 crop acres or, if livestock were present, at least 10 head of livestock. The sample stratification was based on (1) farm population by state, (2) level of diversification measured by the number of crops and livestock, and (3) farm size. State-level proportional sampling was based on farm numbers per state provided in the Census of Agriculture (USDA NASS, 2019), with Iowa having the highest number and Indiana the lowest. To attain proportional representation of crop diversification, we referenced the USDA Agricultural Resource Management Survey (ARMS) statistics on crop and livestock production with at least 40 acres (USDA ERS, 2021) and grouped farms in the sample frame by diversification level, with 35% of the frame having three or more crops and 65% having fewer than three. To attain sufficient representation of different farm sizes, we arrayed the sample frame by farm size, with one-third of farms between 40 and 500 acres, one-third between 501 and 1000 acres, and one-third with greater than 1000 acres. The stratified sample was purchased from DTN, a data analytics and technology company that is a commonly used and relatively reliable source of farmer samples (Ulrich-Schad et al., 2022). The survey was mailed to 3,100 eligible farmers and a total of 725 usable surveys were received, for a response rate of 23%. More detailed information on our survey methodology can be found at Asprooth et al., 2025.

This paper presents data from survey questions that measured farmers' self-rating of their diversification status ("How diversified do you consider your operation to be?") and their use of a list of 13 agricultural practices ("Do you use any of the following practices on your farm?"). The 13 practices included the five core diversified systems (Fig. 2) plus an additional set of conservation-oriented practices common to the region that farmers and other agricultural stakeholders suggested during the survey design process. By comparing these two

Fig. 2. Preliminary farm level framework of diversification according to the Diverse Corn Belt project.

responses by each practice listed, we assessed what practices constitute diversification according to our sample of farmers. Wilcoxon rank sum tests were performed to examine the relationships between farmer-reported diversification status and binary variables measuring use/non-use of those practices. Wilcoxon tests are appropriate for testing differences between two groups where one of the variables is ordinal (de Winter and Dodou, 2019). Chi-square tests were used to examine the robustness of the results and similar results were found across all tests.

4. Results

We begin by providing an overview of the characteristics of focus group and survey participants including location, gender, age, farm size, and type of production. We then detail the results of how farmers conceptualize agricultural diversification according to each source of data.

4.1. Respondent characteristics

4.1.1. Focus groups

We held 20 farmer focus groups with 100 participants in Iowa ($n = 23$), Illinois ($n = 25$), and Indiana ($n = 52$). Overall, 14 participants identified as women and 86 identified as men. The average age of all participants was 66 years, with a range of 24–89. Ninety-six participants were farmers; the other four included a crop consultant, an agricultural input salesperson, a crop insurance provider and a nonoperating landowner. On average, focus group participants rented 726 acres and owned 361 acres. The most commonly grown crops were corn (83%) and soybeans (82%), followed by wheat (35%), hay (21%), and cattle (20%). Farmers also reported producing rye (14%), pumpkins (8%), apples (7%), hogs (7%), alfalfa (6%), oats (6%), and vegetables (6%), among other agricultural products.

4.1.2. Survey

We had 725 farmers respond to our survey in the states of Iowa ($n = 269$), Illinois ($n = 241$) and Indiana ($n = 209$). Overall, 7.2% of survey respondents identified as women and 92.8% identified as men (Table 2). The average age of all participants was 65 years, with a range of 23–95.

Table 2
Focus group and survey participant characteristics.

	Diverse Corn Belt focus groups ($n = 100$)	Diverse Corn Belt survey ($n = 725$)
Male (percent)	86.0%	92.8%
Female (percent)	14.0%	7.2%
Age (mean in years)	52.1	65.0
Acres rented (mean/median)	726/300	616.2 /200.0
Acres owned (mean/median)	361/187	667.6/400.0
Acres total (mean/median)	1059/700	1283.8/820.0

On average, survey respondents rented 687 acres and owned 679 acres and grew 663 acres of corn and 546 acres of soybeans in 2022. In terms of the use of the five Diverse Corn Belt project identified diversification practices described in detail in Fig. 2: 28.6% grazed livestock, 27.7% used agroforestry practices, 26.8% grew perennials, 23.8% used extended rotations, and 2.8% grew horticultural food crops.

4.2. Conceptualizing agricultural diversification according to farmer focus groups

When asked to describe what agricultural diversification meant to them, farmers discussed multiple forms of diversification. While farmers often referenced the key dimensions of diversification that emerged in the literature review, they also expanded upon them, adding nuances and meanings including adding a cognitive dimension to our understanding of diversification. Fig. 3 displays the most frequently discussed meanings that arose, including biological, economic, values, and cognitive dimensions. We discuss each key meaning in further detail in the sub-headings below.

It is also important to note that many participants thought of diversification as having more than one meaning and discussed multiple overlapping topics when answering what agricultural diversification meant to them. Fig. 4 displays the coding intersections between each of the common meanings described in Fig. 3. Coding intersections, or overlap in coded segments, were identified to understand when participants spoke about multiple themes simultaneously. Intersections were found across almost all of the identified meanings of diversification. One-third of the discussions around the economic dimension (33%) and smaller amounts of the discussions around the values dimension (29%) and the cognitive dimensions (7%) also involved discussions of the biological dimensions. We also found 19% coding similarity between the economic and values dimensions.

For the economic and biological dimensions, farmers' discussions of additions of crops and livestock to agricultural systems were discussed together with the idea of creating multiple income streams and market channels for a diversity of products, thereby spreading risk. While market diversity can mean more diverse markets for just one commodity, the cultivation of more types of agricultural products often necessitates access to different market channels. In terms of the values dimension around sustainability and interconnectedness of the farm system and the biological dimension, farmers explained how biological diversity inherently cultivates sustainability by providing ecosystem services and greater ecological resilience. As crop and livestock diversity begets market diversity, this concept works in tandem with the economic dimension of diversifying markets and stacking enterprises. Cognitive dimensions were mentioned alongside crop diversity (biological) by way of the mindset needed to try alternative crops outside of traditional corn and soybean farming.

4.2.1. Economic dimension

Economic diversity was the most frequently mentioned diversification strategy, suggesting that while diversification is largely understood to be biological in some sources, the business side is also an important component. Diversification was discussed as an economic strategy to add to and stabilize revenue. Farmer 1 said of diversification: "*It's covering the business so that if one thing does bad, you've got something else*

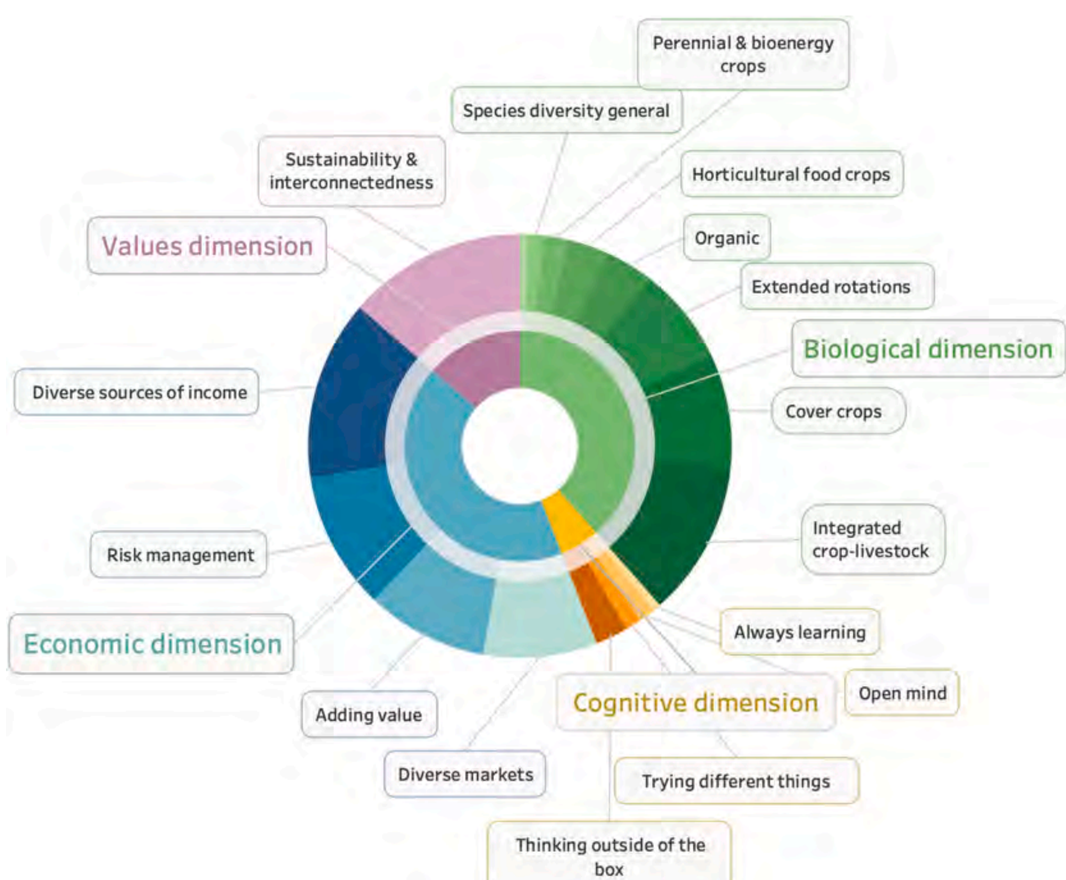

Fig. 3. Most frequently mentioned meanings of agricultural diversification according to farmer focus group results. *Note:* The inner rings are the core meanings of diversification that emerged through focus groups, and the outer rings are the sub-categories of each core meaning. The size of each category and sub-category is representative of the number of "coding references", or the number of times the particular meaning was coded across all transcripts. For example, the economic dimension, the largest slice of the inner pie, had the most coding references across all transcripts, and was discussed most frequently by participants.

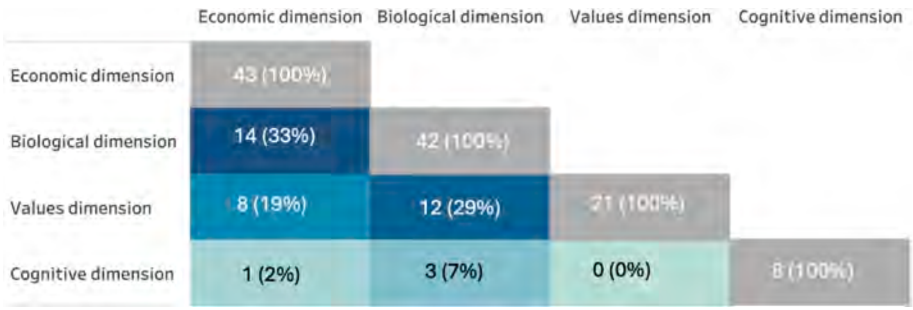

Fig. 4. Coding intersections between frequently mentioned meanings of agricultural diversification according to farmer focus group results. *Note*: Boxes indicate the number of "coding references" where both codes were coded in one text segment. Darker colors indicate greater overlap. The percentage listed in parentheses is the percent of coding overlap of the column within the row. For example, 33% of economic dimensions codes included biological dimensions.

that hopefully is doing good that picks up the slack and keeps you from being at the top in the really good years, but you're sure not at the bottom in the bad [years]…"

Farmers discussed economic diversification as comprising several key mechanisms: diverse sources of income; diverse market channels for agricultural products; adding value to the farm, and risk management. References to diverse sources of income included 1) adding income streams by cultivating multiple different types of crops or livestock with accompanying diversity of market channels, 2) off-farm jobs or "side gigs" such as custom work (i.e., seeding, harvesting, feeding cattle etc. for neighboring farms), agricultural lending, and selling crop insurance, and 3) "stacking enterprises", or layering production to add revenue with little cost. Farmer 72 described a thought process of what constitutes diversification that included crop *and* income diversification: "*… the basis of [diversification], I think, conceptually, it is more of the basic egg, crops, or livestock. But it can be more than that. It can dive down into different levels of that. What's your type of livestock? What's your type of crop? But then further beyond that diversification [off-farm]. What does the farm family constitute? What are spouses or siblings or children doing to bring in what might not be farm income? Did you diversify into ag lending and banking? Did you diversify into insurances?*" Farmer 17 told the group how they initially started doing custom work to pay off their equipment debt. When asked if they considered it a part of diversification they responded: "*Yeah. It had to be. Because otherwise, I wouldn't be able to have decent equipment. So, it was forced diversification, in a way. But yeah, in the end, once the equipment was paid off, we kept doing this, and then there's an extra income stream, right?*"

Diverse markets were typically mentioned in reference to accessing direct marketing opportunities in addition to wholesale, for example selling locally grown products via Community Supported Agriculture (CSAs). Farmer 3 illustrated both concepts of diverse income streams and diverse markets when they explained: "*So also diversifying your farm might be, whether it's grass-fed beef or adding a side business or taking one of your crops you raise to retail or direct to the consumer, all those things would be diversity for me.*"

Farmers also talked about adding value to the farm by growing higher-value specialty crops and growing a crop to meet higher-value markets such as organic, grass-fed, food/seed-grade, and non-GMO, in addition to diversifying vertically by doing their own processing and creating value-added products on-farm. Farmer 21 used their own operation as an example of adding value, diversifying market channels, and stacking enterprises: "*You can put poultry out with the cows while they're grazing and add an income revenue stream. We use hogs to compost the winter feeding of the cattle, so they're providing a service as well as an income stream. And diverse and direct marketing or trying to market in your community. The value-adding and marketing part is worth far more than the growing part.*"

Risk management was another common element in participants' conceptions of diversification, or as several farmers described it, "*not putting all of your eggs in one basket.*" Farmer 42 described a sentiment shared by many farmers that biological and economic diversification mitigates risk by providing a built-in safety net: "*I think diversification means spreading your risk. So, whether that's markets or environments or weather or whatever it is, the reason that any of us went out to add diversity to our operation would be to try to avoid some of the unexpected risks.*"

4.2.2. Biological dimension

Another frequently discussed definition of diversification was having a variety of crops and livestock on-farm. Farmer 17 exemplified the idea when they explained diversification as "*Doing a variety of different production systems and products being made and sold.*" Farmers most often mentioned the inclusion of livestock in row crop systems, in particular grazing livestock on perennial pasture and using manure for soil fertility. Grazing livestock was discussed in the context of "*stacking enterprises*" on farms, and creating a layered, complementary system (see more on sustainability and interconnectedness of the farm system in 4.2.3 Values dimension). At times, the discussion of diversification of crop and livestock went hand in hand with discussion of organic farming systems given the requirements of organic systems to have an extended rotation and mimic natural systems. While less frequent, some farmers associated diversification with the production of horticultural food crops and perennials.

The use of cover crops was also brought up, and some considered cover crops to be the "minimum" for diversification, and a "baby step" that can be implemented without drastic changes to the operations and additional equipment. Farmer 15 told us that cover crops were "*a good gateway drug*" into greater diversification. Cover crops were an important component of diversification particularly in the focus groups composed of mostly (over 80%) corn and soybean farmers, while groups with farmers growing a wider variety of crops did not see cover crops as a central component of diversification.

For most farmers in the Midwest, crop rotations consist of the summer annual cash crops of corn and soybeans. Farmers in the focus groups also mentioned diversity to be extending corn and soybean rotations to include other row crops such as small grains (e.g., wheat, oats, barley). "*When I think about diversification, I really think about having a variety of different plants available for pollinators and wildlife to sort of collaborate on the ecosystem there because that's how I farm. And then at a broader level, when I think of it, it makes me think anything that's not corn and soybean*" explained Farmer 28. As cool season annuals, small grains are planted and harvested at different times of the year, and farmers appreciated being able to spread cash flow and labor throughout the year as well as being less susceptible to the volatility of corn and soybean markets.

Most of the discussion of diversification was in reference to farm level diversification, although a handful of participants clarified that individual farmers could still specialize, and that diversity could be achieved at the community or landscape level where "*not everyone in a certain geographical location is doing the same thing*" (Farmer 22).

4.2.3. Values dimension

Environmental sustainability and interconnectedness of the farm system was also often referenced in relation to the meaning of diversification. Farmers discussed the ecosystem benefits of diversification in terms of naturally breaking up cycles of pests, disease, and weeds, providing habitat for wildlife, and building soil fertility. Soil health in particular was often raised as an important component of diversification. Across farmers, long-term systems thinking was apparent, highlighted by Farmer 63: "*Not only just diversification of revenue and diversification of crops but how the normal society sees normal grain farming as NPK [nutrient fertilizer], hammer it with nitrogen, spray fungicides, spray insecticides, kill everything except for the one crop in that field and that's the one thing that we've really figured out is we're not just focusing on solving that problem temporarily. We're trying to solve that problem long-term and not just with a chemical or whatever. We're solving a long term [problem] and helping the soil at the same time.*" Farmer 45 described their ethic of caring for the land as central to diversification: "*So it's just diversifying our risk in a lot of areas and then also trying to be good stewards to the land, and diversifying our practices that we implement to help ward off pests and so forth…So I think diversifying risk and practices, just want to mitigate our financial aspect, and then just taking care of the land.*"

To many farmers, diversification meant the individual elements of the farming system working together to create greater systems resilience. Farmer 21 explained a sentiment shared across many farmers we spoke with: "*You can talk about more diverse crops, inclusion of cover crops, livestock, but all those things need to work together*", while Farmer 64 echoed: "*I think an important part of diversity is patching up the holes or the weaknesses on the farm.*" Farmer 32 put the concept of interconnectedness into the context of stacking enterprises, also discussed above in economic diversity: "*You got your pasture, and you graze your livestock, and you've got honeybees over here that are feeding on the pasture or the blooms and…you've got multiple layers that are helping each other but not necessarily competing with each other.*"

4.2.4. Cognitive dimension

Many farmers' understandings of diversification were related to cognitive dimensions around a mindset of diversification, and farmer perspectives introduced several concepts that had not been previously identified in the literature review. Given the context of specialized agriculture in the Corn Belt, efforts to diversify often mean going against conventional knowledge and doing something different from peers. Thinking outside-of-the-box was a term and concept mentioned by participants as an important part of defining diversification, exemplified by several farmers below:

"*The fancy word is diversification. For us, it was thinking outside the box. Think outside of what it is now.*" (Farmer 27).

"*I think being diverse is always thinking out of the box on your farm… you have to think out of the box in tough years up there because just a normal corn bean rotation doesn't always work.*" (Farmer 3).

"*…It's just thinking outside the box, and looking at some alternative measures rather than just traditional corn and soybean farming* (Farmer 5)

Doing something different in the Corn Belt also requires some ingenuity, and some farmers conveyed that to them diversification meant keeping an open mind, using a learning mindset, and trying different things. In the words of Farmer 88: "*The biggest phrase that has always bothered me, especially since I got into no-till and trying to do things that are environmentally conscious, I hear farmers all the time say, 'That's not how we do it,' or 'This is how we've always done it.' So, to me, diversification means constantly learning, constantly doing something different.*" This overall mindset was often framed positively by diversified farmers as something they enjoyed in their day-to-day work.

4.3. Conceptualizing agricultural diversification according to farmer surveys

Within the survey sample, over half of respondents (53.27%, n = 375) considered their farm "somewhat diversified", 28.27% (n = 199) "not at all diversified", 14.49% (n = 102) "diversified", and 3.98% (n = 28) "very diversified". Practices adopted by at least 25% of respondents included in the options were: no-till (n = 504, 76.95%), cover crops that are "terminated" (killed before planting the cash crop) (n = 256, 39.08%), grazed livestock (n = 207, 29.15%), and perennial pasture, forage, or biomass crops (n = 180, 27.48%).

We found the most significant differences across levels of diversification and the use of cover crops (harvested or grazed) ($p < 0.000$), extended rotations ($p < 0.000$), grazed livestock ($p < 0.000$), and perennial crops ($p < 0.000$), each generally increasing with self-reported level of diversification (Table 3). This suggests these are the practices farmers consider to be most reflective of on-farm diversification. Horticultural food crops ($p = 0.002$), non-GMO crops ($p = 0.004$), windbreaks, shelterbelts, or hedgerows ($p = 0.007$), cover crops that are terminated ($p = 0.008$), certified organic production ($p = 0.02$), and silvopasture[2] ($p = 0.05$) were also statistically significant and all increased with levels of diversification. However, it is important to note that few farmers in our sample reported using certified organic production, horticultural food crops, or silvopasture, making it difficult to determine whether those practices may be indicative of diversification according to the farmers who use them.

The use of no-till and riparian forest buffers did not increase with reported levels of diversification and no statistically significant differences were found between the use of these practices and self-reported diversification status, suggesting that these are not defining characteristics of diversification according to farmers surveyed. Indeed, the majority (80%) of farmers who said that they were "not at all diversified" reported using no-till practices on their farm.

4.4. Conceptualizing diversification broadly

Through our analysis of literature, focus groups, and survey results, we identify five main dimensions of agricultural diversification: biological, economic, human, values, and cognitive. Fig. 5 shows a diagram of these five thematic dimensions of conceptualizing all definitions of diversity identified by the stakeholder groups referenced in this research. Each dimension offers distinct value and purpose, allowing readers to select and apply the categories most relevant to their specific context. Across sources, diversification is most commonly understood in biological and economic terms and literature from each stakeholder group includes mention of biological diversity and economic diversity. Biological diversity includes on-farm diversity (with a range of associated sub-elements and practices), as well as landscape diversity. Economic diversity includes multiple markets, multiple farm enterprises and sources of income, adding value, horizontal and vertical integration, and risk management. Many sources encompass values such as conservation, sustainability, and equity in their definition. Several sources include human diversity in their definition including academic and NGO literature and the Diverse Corn Belt project framework. However, human diversity was not a core theme that arose from focus groups, and we found no mention in sources from government entities such as the USDA. During focus groups, farmers brought an additional dimension into the meaning of diversity than was not present in the literature: cognitive elements around a mindset of diversification such as thinking differently than the status quo. The resulting framework is not meant to be conclusive as to what diversification means but offer a range of conceptualizations we have identified through our research and literature review.

[2] A type of agroforestry practice involving the integration of trees and grazed livestock.

Table 3
Farmer-reported production practices by reported diversification status: proportion who responded yes to each production practice (rows) by diversification category (columns).

		Self-reported diversification status (Y = 1; n = 704)					
Dimension of agricultural diversification	Practices selected (Yes = 1; n = 655)	Not at all diversified (n = 199)	Somewhat diversified (n = 375)	Diversified (n = 102)	Very diversified (n = 28)	z	p
Values dimension	Certified organic production (Y = 11)	0.01	0.01	0.02	0.12	−2.29	0.02**
Biological dimension	Cover crops that are either harvested or grazed (Y = 129)	0.05	0.21	0.31	0.39	−5.97	0.000***
Biological dimension	Cover crops that are terminated (Y = 256)	0.29	0.43	0.41	0.50	−2.65	0.008**
Biological dimension	Extended rotations (Y = 98)	0.06	0.15	0.24	0.27	−4.33	0.000***
Biological dimension	Grazed livestock (Y = 207)	0.06	0.33	0.55	0.42	−8.45	0.000***
Biological dimension	Horticultural food crops (Y = 15)	0	0.02	0.05	0.08	−3.17	0.002***
Biological dimension	Non-GMO crops (Y = 97)	0.08	0.16	0.18	0.27	−2.91	0.004***
Values dimension	No-till (Y = 504)	0.80	0.76	0.81	0.69	−0.462	0.6
Biological dimension	Perennial pasture, forage, or biomass crops (Y = 180)	0.06	0.31	0.46	0.39	−7.29	0.000***
Biological dimension	Riparian forest buffers (Y = 48)	0.04	0.09	0.08	0.04	−1.22	0.2
Biological dimension	Silvopasture (Y = 3)	0.00	0.00	0.01	0.04	−1.98	0.05**
Biological dimension	Windbreaks, shelterbelts, or hedgerows Y = 118)	0.12	0.19	0.22	0.31	−2.69	0.007***

Note: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$. Wilcoxon rank sum tests are used to test for significant difference between levels of diversification and the use of various production practices. All cropping systems and practices are as presented in the survey. The survey did not include definitions of crops and practices.

5. Discussion: comparing the conceptualizations of diversification across agricultural stakeholders

Through focus groups we gained an understanding of what agricultural diversification meant to farmers broadly and the language farmers used to discuss diversification. Using survey data, we examined which on-farm practices farmers considered to be diversification. In this section, we compare our empirical findings from farmers about what constitutes diversification to definitions from the academic, NGO, intergovernmental, and governmental literature to identify areas of consonance and/or dissonance.

5.1. Biological dimension

On-farm biological diversity is the most defining characteristic of agricultural diversification across the sources used for this analysis. Our literature review identified understandings of biological diversity to include genetic, species, temporal, and spatial diversity (e.g. Kremen et al., 2012), as well as integration of crops and livestock (e.g. Puech and Stark, 2023). Some literature makes specific reference to cover crops (e.g. Rosa-Schleich et al., 2019), agroforestry (e.g. Rasmussen et al., 2024), perennial crops (e.g. Kremen et al., 2012), and non-crop vegetation (e.g. Lin, 2011) as important components of diversified systems.

We found agreement across farmers (focus groups and surveys) and the Diverse Corn Belt project framework that on-farm biological diversity encompasses grazed livestock, extended rotations, and perennial crops. Focus group data also highlights that many farmers consider cover crops to be a first step towards crop diversification since they are less complex and require less commitment than other diversification options, and they can be readily integrated into current operations. These practices are likely more frequently mentioned as diversification because they can be considered the "*lower hanging fruit*" or the most plausible practices to integrate into row crop systems dominate in the Corn Belt. Agroforestry and horticultural food crops are also included in the Diverse Corn Belt project framework, however, mention of them were infrequent during focus groups. Survey results suggest some indication that farmers associate horticultural food crops and agroforestry practices including windbreaks, shelterbelts, hedgerows, and silvopasture with biological diversity, but further research on this may be needed.

We also note differences in species versus genetic or varietal diversity within biological meanings of diversification. While varietal diversity is included in many academic definitions of diversity, it was discussed by only a handful of farmers in focus groups. Instead, the focus was on crop and livestock species diversity. The farmers who did mention varietal diversity discussed the cultivation of different varieties of corn and soybeans including popcorn, high oleic soybean varieties, food-grade soybeans, and non-GMO varieties. In reference to non-GMO and food-grade soybeans, Farmer 42 said: "*I know it's only adding a little bit of diversity, but the bonus [premium] you get helps*." About 15% of the survey respondents indicated growing non-GMO crops and these were positively related to identifying their operation as more diversified. Conversely, growing non-GMO crops does not appear to be a key component of common definitions of diversification in the literature.

Landscape diversity, one of the three pillars of the Diverse Corn Belt definition, was mentioned by a handful of focus group participants as a key part of a broader diversification strategy. Landscape diversity was more common in the academic literature which considers multiple types of land use (i.e., fallow fields, pastures, prairies, meadows, woodlots) within a landscape as a component of diversification (e.g., Kremen et al., 2012; Spangler et al., 2022).

5.2. Economic dimension

Economic diversity is consistently a part of definitions of agricultural diversification from all stakeholder groups, and was the most frequently mentioned component of diversification in farmer focus groups. Definitions from farmers and academic, NGO, and governmental literature all center enterprise diversification, or creating multiple on and off-farm sources of income (e.g., (Harwood et al., 1999; IPES-Food, 2016; McGehee and Kim, 2004). This includes enterprises that add income streams such as higher value crops or livestock by diversifying horizontally and enterprises that expand across the chain of production or add value on-farm by diversifying vertically (Barbieri and Mahoney, 2009; Stevens and Teal, 2024). The Diverse Corn Belt project framework, as well as farmers, emphasize the need for a diversity of markets to support a more diversified array of crops and livestock.

5.3. Values dimension

The values dimension of agricultural diversification incorporates elements of conservation as well as aspects of social equity. Conservation and environmental sustainability were part of definitions of

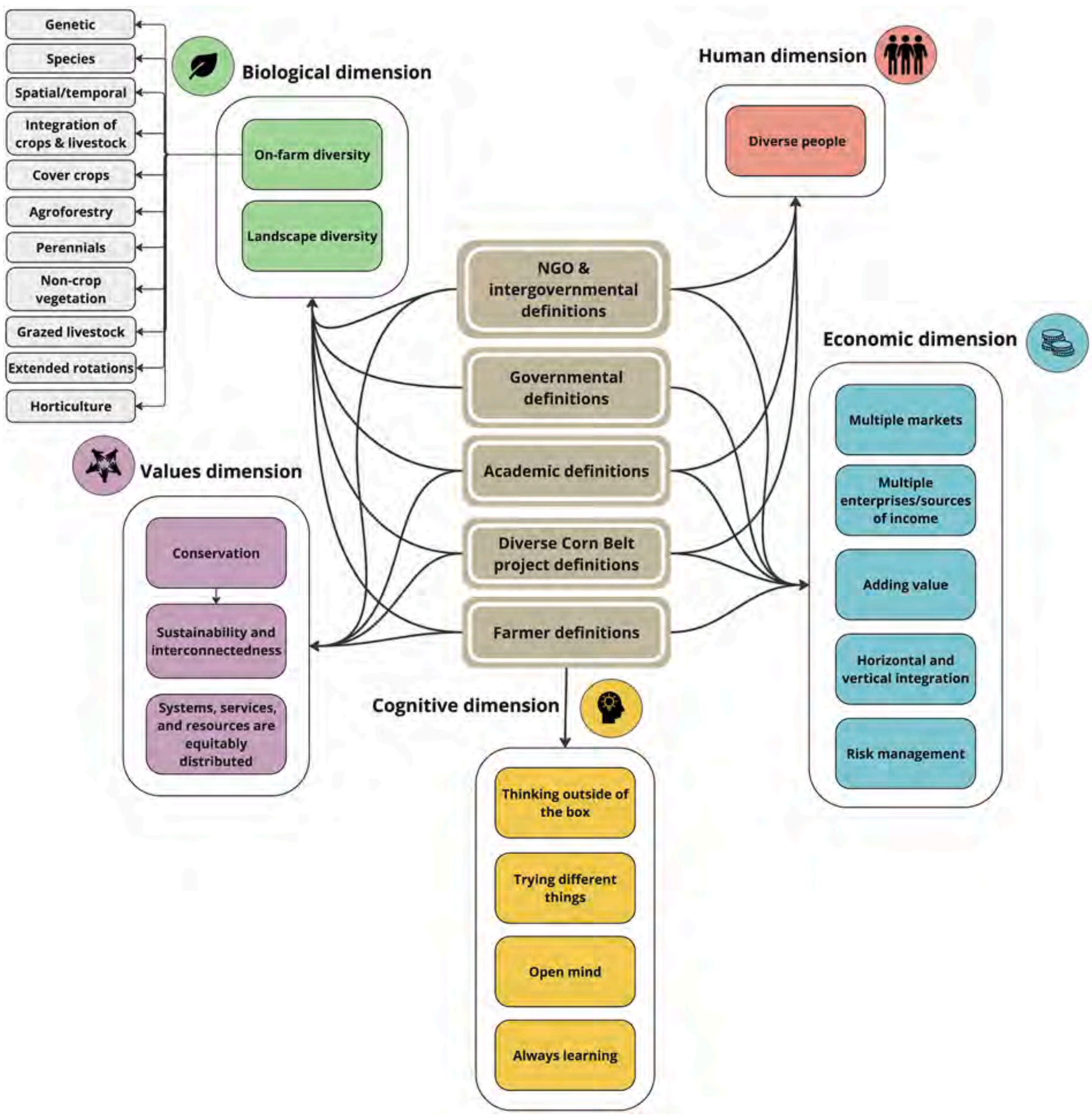

Fig. 5. Framework for defining agricultural diversification categorized into biological, human, economic, cognitive, and values dimensions.

agricultural diversification from academics, NGOs, the Diverse Corn Belt project framework, and from farmers. Some literature defines soil (e.g., Carlisle et al., 2022; Rosa-Schleich et al., 2019) and water (Rasmussen et al., 2024) conservation as components of diversification. During focus groups, farmers frequently discussed agricultural diversification in relation to its ecosystem benefits and the resilience of an interconnected farming system. While using one common conservation practice, low tillage, was not frequently mentioned as a core component of diversification during focus groups, it was discussed as part of a sustainable system in which diversification was a part. In the farmer survey, it was clear that farmers did not associate no-till practices with their self-reported level of diversification.

While some sources tend to presume that diversification is by definition ecologically “sustainable” and “resilient”, we note that from our results, diversification does not always mean ecologically sustainable. While the biological sciences rationalize diversification for its ecosystem benefits (e.g., Kremen et al., 2012), other literature in the field of economics identifies diversification as purely an economic strategy (e.g., Bowler et al., 1996). For some farmers we spoke with during focus groups, diversification was a path towards economic resilience: they began to diversify out of a need to gain more income and saw the ecological benefits as time passed. For others, difficulties of past diversification efforts led them towards specialization of production while maintaining a diversity of income from off-farm sources.

While less discussed, equitable access to systems and services for farmers, supply chain actors, and rural communities was raised by the Diverse Corn Belt project framework and access to land to accommodate a diversity of farmers was centered in one academic (Demongeot et al., 2024) and one NGO (NSAC, 2023) article.

5.4. Human dimension

Across stakeholder groups, human diversity is not commonly included, exhibiting a general lack of people-centered considerations in definitions of agricultural diversification. Diversity of people in agriculture was mentioned only once during farmer focus groups[3] and is discussed infrequently in the literature—three sources (Demongeot et al., 2024; Fisher, 2021; NSAC, 2023) mention some form of human diversity including diversity of ages, genders, ethnicities, and farm sizes.

5.5. Cognitive dimension

Farmers from the Diverse Corn Belt project focus groups generated an additional understanding of diversification than those found in existing literature: cognitive mindsets of diversification. In areas where simplified agricultural production is the norm, resources, existing knowledge, infrastructure, and markets are set up to facilitate this type of production. Trying alternative systems means thinking in a different way, trying different things, keeping an open mind, and always learning.

5.6. Future research needs and methodological limitations

While it is impossible to propose one singular definition of diversification that will work across all regions, or even in the U.S. Corn Belt, our deep dive into the current definitions being used in the academic literature, the grey literature, and by farmers themselves indicates a need for increased clarity on this topic. Based on our findings, we have identified several overarching research questions in need of further investigation. These include: (1) What are the definitions of agricultural diversity in other regions and according to other agricultural stakeholders (i.e., industry), (2) What are the outcomes resulting from prioritization of different types of diversification?, (3) To what extent are the identified dimensions and practices of diversification linked to environmental and economic sustainability?, (4) What does "people" diversification look like on the landscape and do farmers of different scales and types of production conceive of diversification differently?, and (5) How are cognitive dimensions shaped, and what is the role of "thinking outside of the box" and considering the farm as a system in fostering diversification on the landscape?

Although our literature review was extensive, a separate systematic review of the literature could provide a deeper analysis of diversification definitions. Additionally, our survey sampling focused on farms with more than 40 crop acres or at least 10 heads of livestock, therefore our survey findings primarily reflect mid - to large-scale commercial farmers' perspectives. Small-scale and beginning farmers who often pursue different diversification strategies including direct-to-consumer marketing, intensive horticultural production, and integrated systems may be less-represented in these results. However, our focus groups included farmers across a range of scales, providing a diversity of perspectives, including small farms. Future research could examine diversification definitions among small and large-scale farmers to understand if there are differences across the full spectrum of farm sizes.

6. Conclusion

The results from this mixed-methods paper provide insights into what agricultural diversification means according to several key stakeholder groups in agriculture, in particular in the U.S. Corn Belt. It is clear from our findings that diversification has no singular definition and encompasses many facets of the farm and agricultural landscape crossing biological, economic, human, values, and cognitive dimensions. We conclude that "diversification" is typically understood as multiple types of crops and livestock within farms and across the landscape. It implies a variety of market channels, sources of income, enterprises, and operational structures that help farmers manage risk. To some, diversification also represents conservation and sustainability, a diversity of people and farm sizes with resources to diversify distributed equitably, and a cognitive mindset.

Academics have traditionally defined agricultural diversification in biological and economic terms and this conceptualization is a throughline across all the sources in the study. We also find that many stakeholder groups include some mention of biological conservation or sustainability as a component of diversified agricultural production. There was some, but limited, mention of diversity of people in the sources included in this study. In areas such as the Corn Belt where simplified crop production is the norm, cognitive dimensions such as thinking outside of the box and trying different things are needed to conceptualize an alternative agricultural landscape.

It is important to meet farmers where they are when it comes to specifics of how they define diversification in their own regions. The vision of academics, governmental agencies, and advocates may be different than the diversified agriculture farmers envision. For example, when it came to species diversity, farmers in our study identified more of the "low hanging fruits" as diversification and fewer mentioned practices that require a greater shift in production such as horticulture and agroforestry. This suggests that a more incremental approach to setting diversification goals may be appropriate and that cover crops, extended rotations, integrated crops and livestock, and perennial production may be most feasible in row crop-dominated regions of production in the near-term. Future outreach activities should leverage the aspects of diversification that are compelling and achievable to farmers, while recognizing that engagement will need to be tailored to farmer conceptions of diversification in each region.

Through a mixed-method approach to help to triangulate and enrich the ways in which we understand agricultural diversification, we have identified a framework of five different dimensions of diversification. We propose that future efforts in this area clearly define how they are using the term "diversification" across each of these dimensions. For example, at the biological level, what species are they considering to be diverse? Are they looking at landscape diversity? Are they considering human dimensions? Economic dimensions? The cognitive and values dimensions? While the definitions of what practices constitute species diversity from farmers and the Diverse Corn Belt project framework are context-based, they are likely to be applicable to other regions, especially those with simplified or monocultural production systems. However, more place-based research is needed to understand how farmers and agricultural stakeholders in other regions define diversification based on the local environment and shared experiences and beliefs (Isaac et al., 2024), and how definitions of diversification may evolve. As the climate, agricultural policies, and global economy continue to change, so too will the needs, ideas, and feasibility of diversification strategies. Understanding conceptualizations of diversification among the agricultural community as an iterative and reflexive process will create the ability to adapt to the changing nature of agriculture and our society and inform future diversification-focused policy measures, and program development and implementation.

CRediT authorship contribution statement

L. Asprooth: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **R. Traldi:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **J. Arbuckle:** Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **S. Church:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition,

[3] Farmer 30: "The biodiversity is the first thing that comes to my mind [when asked what agricultural diversification meant to them] but also, I see diversity of people from different backgrounds, different interests, different sizes of operations, certainly. Yeah, different histories."

Farmer 31: "Yeah. Different-size farms is important to me too."

Farmer 32: "Till you said that, I forget how monocultural we are. In culture along with sizes and crops. I mean, yeah. We can use a lot of diversification."

Conceptualization. **K. Floress:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Conceptualization. **B. Gramig:** Writing – review & editing, Writing – original draft, Methodology, Funding acquisition. **S. Harden:** Writing – review & editing, Investigation, Funding acquisition, Conceptualization. **A.J. Margenot:** Writing – original draft, Writing – review & editing, Funding acquisition. **A. Thompson:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **A. Torres:** Writing – review & editing, Writing – original draft, Investigation, Funding acquisition. **E. DeaKyne:** Conceptualization, Data curation, Formal analysis. **L.S. Prokopy:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Ethics approval

This study was approved by the Purdue University Institutional Review Board under IRB-2022-151, and informed consent was acquired from all study participants.

Disclaimer

The findings and conclusions in this manuscript are those of the authors and should not be construed to represent any official USDA or U. S. Government determination or policy.

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Declaration of competing interest

The authors have no relevant financial or non-financial interests to disclose.

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Data availability

Published survey data used for this analysis can be found at Traldi et al., 2025.

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