Drivers and deterrents of small grain adoption in the Upper Midwest

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PREPARED BY

Lauren Asprooth, University of Wisconsin, Madison, asprooth@wisc.edu
Margaret Krome, Michael Fields Agricultural Institute, mkrome@sbcglobal.net
Alyssa Hartman, Artisan Grain Collaborative, ahartman@graincollaborative.com
Ashley McFarland, American Malting Barley Association, ashley@ambainc.org
Ryan Galt, University of California, Davis, regalt@ucdavis.edu
Linda Prokopy, Purdue University, lprokopy@purdue.edu

DESIGN

Jill Carlson Groendyk, Sift Consulting LLC, jill@siftconsultingllc.com
Coral Weinstock, Michael Fields Agricultural Institute, cweinstock@michaelfields.org

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Executive summary

Farms in the U.S. Midwest historically raised a range of farm products including corn, soybeans, small grains, pasture, hay, and livestock. These diversified production systems enhance economic opportunity and resilience for farmers and contribute to regional food system resilience. Over the last century, however, corn and soybeans have come to dominate agricultural production in the region.

Small grains such as barley, oats, rye, and wheat are an opportune way to re-diversify corn and soybean rotations and are shown to improve yields of corn and soybeans while enhancing soil health and water quality in diverse rotations.

However, farmers struggle to earn a profit from their small grains and have little incentive to plant them.

This research sought to identify the barriers farmers face to growing small grains and the factors that have helped some to be successful in their small grain production. We did so through a survey of 406 farmers and interviews and focus groups with 39 farmers and non-farming agricultural professionals who engage with or support grain production in the states of Iowa, Illinois, Minnesota, and Wisconsin in 2022.

A combination of farmer-reported results, correlation network analysis, and findings from focus groups and interviews show a myriad of interconnected reasons why row crop farmers do or do not incorporate small grains in their operations. We find that markets and prices, regional growing conditions, and added management were the primary barriers to small grain production on row crop farms. Access to equipment, improved small grain varieties, and timing of planting and harvesting were both drivers and barriers, depending on the farmer. Cost share programs, livestock, organic certification, the system benefits of small grains, and the synergies between small grains and cover crops were found to be drivers of production. Crop insurance and revenue supports (Price Loss Coverage, Agriculture Risk Coverage, and Marketing Assistance Loan program) for small grains, availability of neighbors growing small grains, availability of technical assistance for small grains, and access to a loan for small grain production were less important relative to the barriers and drivers listed above.

We conclude that small grains have the potential to create more diversified and resilient agricultural landscapes. However, more action is needed to support small grain production. To enable strong agricultural markets and support farmers to produce small grains, it will be important to 1) invest in market development, on- and off-farm infrastructure, and improved varieties; 2) level the playing field with corn and soybeans in terms of subsidies and supply mandates; and 3) leverage the drivers of existing small grain acreage—certified organic production, the integration of crops and livestock, systems thinking, and cover crop use.

KEY TAKEAWAYS

1. Across farmers who produced small grains and those who did not, the **market price, the availability of markets, and the distance from a farm to a buyer for small grains** were the greatest barriers to growing small grains.

2. The **timing of planting and harvesting** was a strong driver of small grains production but a barrier for non-small grain farmers. Small grains are planted and harvested at different times of the year than corn and soybeans, allowing for a longer growing season for cover crops and for the application of manure. On the other hand, weather conditions can make it difficult to plant in the spring and fall, and small grain production can impact a farmers' ability to tend to their corn and soybeans which are the primary cash crops for most row crop farms.

3. **Access to equipment and improved varieties** can both drive and deter small grain adoption. Small grains often require different equipment from corn and soybeans for planting, harvesting, cleaning, and storing which can be an added cost, if farmers don't have easy access. In addition, when available, strong genetics can help improve yield and manage the higher rainfall and humidity of the Upper Midwest.

4. Difficult **regional growing conditions**, and the **added management** compared to a simplified corn and soybean rotation were identified as barriers to small grain production.

5. **Policies and programs, availability of neighbors growing small grains, and availability of technical assistance** were not listed commonly as important to small grains production. Policies and programs included access to crop insurance, incentive programs, federal revenue support programs for small grains, and loans. However, among individual and farm-level factors statistically analyzed, **having cost share or incentive payments available for small grains has the strongest correlation** with whether a farmer grew small grains.

6. **Livestock**, whether on-farm or local livestock markets, can drive small grain production due to the ability to use small grains that do not find a food-grade buyer as feed and bedding for livestock. Farmers identified feed-grade production for local livestock operations as a viable market in the near-term while farmers' abilities to meet grade and markets for food-grade production develop.

7. **Organic certification** drives small grains production due to the extended crop rotation requirement, and organic certified small grain farmers were more likely to observe increases in profitability of their farming business as a whole after adding small grains to rotations.

8. Most farmers recognized the **system benefits** of small grains in rotations. The second most common use for small grains among farmers in the study was as a cover crop, and the most common reason for growing small grains was to improve soil health. Through statistical analysis we find that a farmers' belief that small grains in rotations improve the health of soils is strongly correlated with growing small grains.

9. Farmers identified **synergies between small grains and cover crops.** Cover crops act as a gateway to small grain production because once a farmer sees the soil health benefits of a small grain cover crop and gains some experience growing them, they will be more comfortable taking the leap to food or feed-grade production. At the same time, small grains in a rotation can act as a "nurse crop" for cover crops as they are harvested early enough in the season to allow time to establish a fall planted cover crop.

Introduction

Whether for cover crops, human consumption, or livestock production, growing small grains benefits farmers and the land. When planted in diversified rotations, small grains (also called cereals) such as barley, oats, wheat, and rye can benefit agricultural systems by improving profitability and ecological health while building resilient local food systems. Integrating small grains into cropping systems is one promising way to improve the diversity and resilience of our Midwestern agricultural landscape, currently dominated by corn and soybean production.

A growing body of evidence shows that corn and soybean rotations that include a small grain can improve the yields of corn and soybeans and increase combined net returns of the rotation[1,2,3,4] while enhancing soil health and water quality. As cool season crops, small grains increase surface cover and roots in the ground throughout more of the year, improving soil structure[4] and soil water storage[5]. Improved soil structure and water storage reduces soil erosion and leaching by increasing nutrient and sediment retention, which in turn reduces nitrogen and phosphorus losses and freshwater toxicity[6,7]. Farmers' bottom line and the environment also benefit from the natural disruption of cycles of weeds, pests, and diseases that diverse rotations bring by reducing the use of pesticides and herbicides[8].

Beyond improved ecological and agronomic conditions, small grains can diversify income and contribute a local source of grains that have been largely missing from the basket of local foods available to consumers. As a cash crop with the potential to sell into local or regional high-value food-grade markets, small grains incorporated into simplified systems offer greater enterprise resilience in addition to on-farm resilience[9]. A growing interest in high quality flours and emerging artisanal brewing and distilling sectors are creating a niche market for local and organic grains[10,11] .

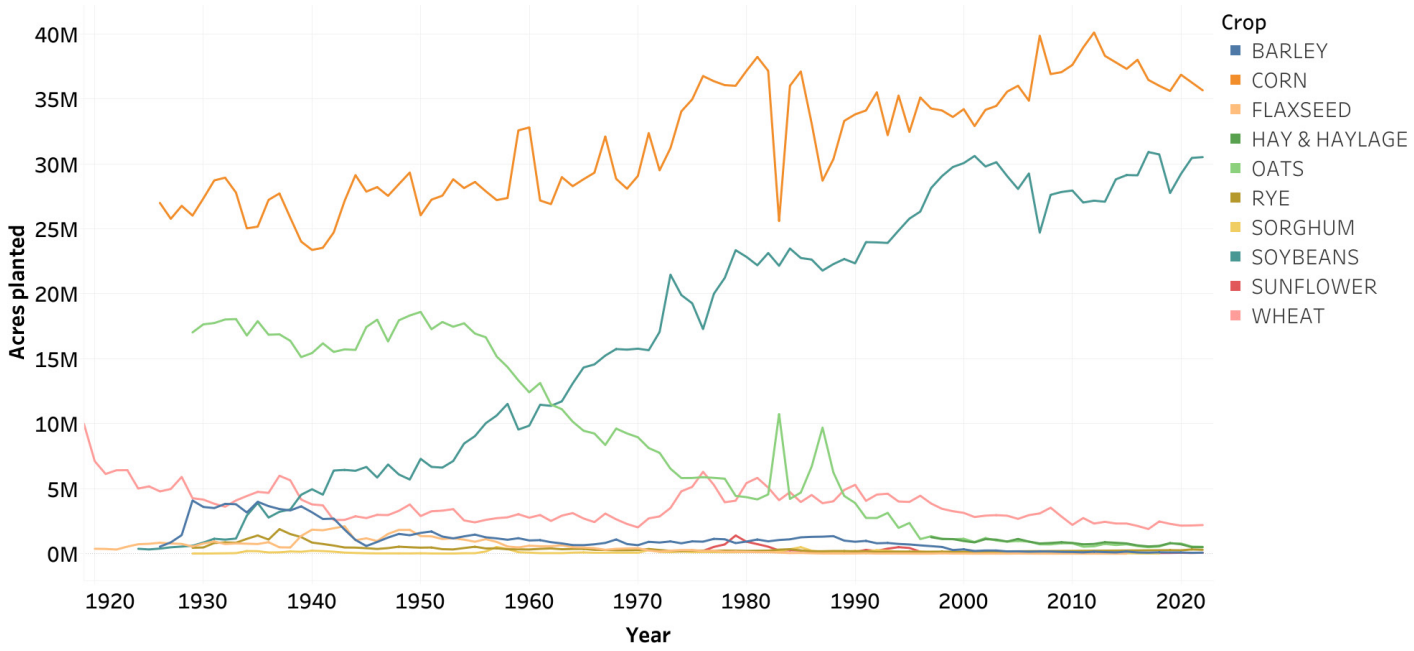
Despite their environmental benefits and emerging economic promise, most farmers in the region do not plant small grains, and as of 2022 corn comprised 48% of field crop acres in the Upper Midwestern states of Iowa, Illinois, Minnesota, and Wisconsin[12]. **Acres of cropland devoted to barley, oats, and rye have declined steadily in these states over the last century (Figure 1).** Oats, once a staple livestock feed, experienced the greatest loss, with planted acreage in the region falling by 97% from 1929-2022. During the same period, corn acreage grew over 37% and soybean acreage grew fiftyfold. Currently, small grains make up only 0.7% of total field crop acres planted in the region[12]. The simplified production of corn and soybeans has led to significant social and ecological repercussions including erosion[13], ground and surface water pollution[14], and loss of above- and below-ground biodiversity[15,16,17].

small grains make up only

0.7%

of total field crop acres planted in the region

Figure 1. Acres planted of small grains (barley, oats, rye, wheat), corn, and soybeans 1920-2022 (USDA NASS, 2022)



Most research on expanding small grain production considers field-level management constraints such as yield[18], nitrogen availability[19], pests and disease[20,21], weeds[22], and improved varieties[23,24,25]. In the U.S., only a few studies have explored the barriers and drivers of growing small grains past the farm gate. Baker and Russell[10] and Muckey[26] conducted qualitative studies focusing on supply chain development. Baker et al.[23] surveyed organic barley growers in the U.S. on the primary obstacles to growing the crop, and Weisberger et al.[27] surveyed Iowa farmers about their perceived barriers and benefits of small grains in extended rotations.

> **Building on the limited existing social-science research on small grain production, this research represents the first mixed methods study to attempt to holistically understand farmer decision making around small grains by exploring a range of biophysical, social, structural, operational, and individual factors.**

Responding to scholars noting the sparse exploration of the role of policies and programs in the adoption of conservation practices[28,29,30], and striving for practically applied results, we made a focused effort to include "actionable" factors in the study. These included 1) external structural factors that can be changed or supported at the policy level (i.e., Farm Bill policies, markets, technical assistance, and publicly funded research priorities) and 2) operational characteristics that can be changed at the farm level (i.e., organic certification, on-farm livestock, and tillage practices).

Moreover, due to privacy limitations of USDA Census of Agriculture data and a lack of other large-scale surveys of small grain farmers, there is currently little insight into the characteristics of farmers who grow small grains and their operations, their intended end-use for the grain, the kinds of support programs they use, and how they market their crops. This study provides this information to gain a better understanding of this group of farmers.

As one of the most agriculture-intensive regions in the nation with some of the highest continuous corn and soy cropping acres[31] shifting practices to diversified rotations that increase economic and environmental resilience is essential. Small grains have the potential to improve not only ecological health when incorporated into rotations, but to provide economic value to the farmer and food security to the community.

This research provides solutions for how small grains can be encouraged in the region, which is critical knowledge for developing evidence-based policy initiatives and programs that serve farmers and broader society.

Methods

This study uses a mixed methods design to triangulate and enrich the ways in which we understand farmer decision making and the factors that impact it. Integrating quantitative and qualitative methods uses their complementary strengths to reach deeper insights into reality[32]. We define small grains as barley (spring and winter), Kernza®, oats, rye (cereal and hybrid), triticale (spring and winter), spelt, and wheat (spring and winter). The study was collaboratively developed by researchers at the University of California, Davis, Purdue University, the Artisan Grain Collaborative (AGC), the Michael Fields Agricultural Institute, and a project advisory committee formed to provide guidance on the study. We focused on the states of Iowa, Illinois, Minnesota, and Wisconsin due to their significant potential for small grains production, and their growing artisan baking, distilling, and brewing sectors. This study received approval for research involving human subjects from the University of California, Davis, Institutional Review Board.

Farmer survey

DATA COLLECTION

A farmer survey was disseminated between January and April of 2022 during a time when farmers are most available in the region as they have finished harvesting and have yet to begin spring planting. The survey questions were focused on operational details, the barriers to and drivers of growing small grains, the support programs available to farmers, their beliefs about the benefits of small grains in rotations, and the most reliable sources of information regarding small grains. For those who currently grow or have grown small grains in the past, we asked about the kinds of markets and contracts they use for selling their grain, and any infrastructure limitations. The survey was developed in collaboration with the project advisory council and the Farmer Collaboration working group of the AGC (a peer group of farmers supporting food-grade small grain production) and piloted with several other farmers.

We disseminated the survey through several routes. First, we sent the survey to 3,125 farmers through postal mail and email using a stratified randomized sample of farmers purchased from DTN, a data analytics and technology company. We disseminated the survey through both postal mail and email to reach a broader population of farmers with varying access to the internet and comfort with email. We limited our sample to those who were farm operators, and to ensure we did not sample hobby farmers, we included corn and/or soybean farmers who farmed at least 40 operational acres (as opposed to land leased to others or land in pasture) and farmers growing small grains (those who did not grow corn and/or soybeans) who farmed at least 10 operational acres. To ensure equal representation from farmers who had and had not grown small grains, 50% of the sample was composed of farmers who grew corn and/or soybeans and no small grains, 38.5% of farmers who grew corn and/or soybean farmers with at least one small grain, and 11.5% of farmers who did not grow corn or soybeans but grew at least one small grain; these categories were constructed based on available farmer profile data from the DTN-provided sample. We targeted corn and soybean farmers due to their large impact on the landscape as the predominant cropping system in the region. We also included a proportionally oversampled subset of non-corn and soybean farmers who grew small grains to include a wider range of experiences with small grains, given the small number of farmers who grow them in the Midwest.

We sent out three waves of contact for each route following Dillman[33] as closely as possible given funding limitations. For postal mail surveys we sent the survey and two follow-up postcards. For the online survey, we sent an email with an invitation to take the survey through the digital survey software Qualtrics, one follow-up email, and one follow-up postcard. After excluding undeliverable addresses and those no longer farming, we received usable postal mail surveys from 219 farmers with a response rate of

25%, and 80 usable online surveys with a response rate of 4%. When excluding the online surveys from the sample, the results were almost identical. For this reason, despite the low response rate, we include these observations to add to the robustness of our results.

Next, after finding the initial results of the postal mail and email surveys to be lacking in organic farmers, we sent the survey through two additional online routes: to farmer email addresses from the USDA Organic Integrity database and through the University of Wisconsin Organic Grain Research and Information Network (OGRAIN) listserv, a network of farmers in the Upper Midwest growing organic grains. We collected email addresses from the USDA Organic Integrity database for those farming at least one small grain and sent an email invitation to take the survey, one follow-up email, and one follow-up postcard. We received usable surveys from 41 farmers for a response rate of 14%. In addition, we sent an email through the OGRAIN listserv inviting farmers to take the survey. We received responses from 27 farmers for a response rate of 4% using the number of farmers subscribed to the list. While the response rates are low for the organic-specific routes of dissemination, we believe that they are acceptable given the difficulty of reaching small grain farmers who are also organic. According to the most recent USDA census of agriculture, only 8% of farming operations in the states included in this study grow small grains and only 1% are organic[3,4]. **Our total sample size combining all dissemination routes is 406 farmers[1].**

406 farmers
total sample size

ANALYSIS

Several statistical analyses were used to understand determinants of adoption of small grains including descriptive statistics, correlational network mapping, and ordinal logistic regression. First, we used correlational network mapping to understand the factors associated with whether a farmer grows small grains. Correlation network mapping allows us to understand how the independent variables are associated with whether a farmer grows small grains, as well as to understand the statistical direction of the relationships between independent variables. This method also allows us to analyze all relevant independent variables, including those with small sample sizes which lack statistical power to meaningfully analyze in a regression.[2] We chose independent variables based on an iterative process including those that have been shown to be associated with the use of diversification practices and conservation practices in existing literature, those that were highly correlated with whether a farmer grows small grains, and through backwards and bidirectional stepwise selection. We use Pearson's correlation in the correlation network to compare coefficients across variables with the same measure of correlation. We tested the robustness of Pearson's correlation with non parametric measures of association fit for nominal variables including Kendall Tau and Spearman's rank correlation and Cramér's V.

The variable *grows small grains* is a binary variable where those who had not grown small grains in the last 6 years but had grown them in the past and those who grew small grains at some point in the last 6 years were given a 1. Those who had never grown small grains were given a 0. *Cost share available* measures

1 A conservative sample size calculation showed that we needed at least 384 responses of the estimated 146,326 population of farmers raising corn, soybeans, and/or small grain in the study states for appropriate statistical power using a 95% confidence interval and 5% margin of error.

2 This was the case for several of the policy variables, for which farmers were less inclined to answer on the survey.

whether the farmer reported that small grains cost shares or conservation incentive payments (e.g., Environmental Quality Incentives Program or Conservation Stewardship Program) to grow small grains were available to them where yes=1 and no=0. *Crop insurance available* measures whether the farmer reported that federal crop insurance was available for small grains in their county. If a farmer chose "yes", they were given a 2, if they chose "for only some of my small grains", they were given a 1, and if they chose "no", they were given a 0. For both *cost share available* and *crop insurance available*, those who chose "I don't know" were not included. Doing so removes the possibility that the variables may be correlated with *grows small grains* due to the likelihood that those who grow small grains are more knowledgeable regarding whether cost share or crop insurance for small grains is available to them simply because they already grow them. *Total acres* is the combination of acres owned (operated or rented to others) and rented or leased in 2021. *Percent acres owned* measures the percent of acres owned to the total acres operated (rented and owned) and ranges from 0-1. *Livestock on-farm* measures whether the farmer raised livestock, either for sale or for on-farm use in 2021. *Certified organic* measures whether all or some of the operation was certified organic, and *no-till/conservation tillage* measures whether all or some of the operation used no-till or conservation tillage practices in 2021.

Information source variables measure whether the farmer selected the source as one of the 3 most reliable information sources regarding small grains. Belief statements measure whether the farmer said that they believed the statement was true regarding small grains in rotations. These include: "they improve the health of soils", "they increase the yields of corn and soybean crops", "they reduce chemical requirements for pest and disease management" and "they mitigate risks".

Next, we ran an ordinal logistic regression to understand the change in profitability after adding small grains to an operation. We used an ordinal logistic regression model suited for ordered dependent variables. Change in profitability is measured as the change in profitability of the farming business as a whole after adding small grains to rotations (changes to input purchases, yields, revenue, etc.). Responses were: reduced my farm's profitability, very little change to my farm's profitability, and increased my farm's profitability (coded as 1, 2, and 3, respectively). Like the correlational mapping, we chose variables based on existing literature and correlational strength, as well as those that improved the model fit. Variables were tested for collinearity with other independent variables in the model and none was found to be problematic. Backward and bidirectional stepwise selection confirmed our choice of those added based on correlation and model fit. We include the state in which the farmer resides in each to control for biophysical variability that may impact a farmers' decision to grow a small grain.

Focus groups and interviews

DATA COLLECTION

To gain a more in-depth understanding of the survey results, better understand the causal direction of relationships, explore issues that may not have emerged through surveys, and identify opportunities to overcome barriers and build upon the drivers of adoption, we held a series of focus groups and interviews with farmers and non-farming agri-food professionals from July to September of 2022. Focus groups are a method of data collection that facilitate the development of innovative solutions through the sharing of personal experiences and insights among participants[35,36]. For this reason, we used focus groups when possible, and interviews when farmers were not able to join a focus group, or with non-farming agri-food professionals with few peers. While the summer in the Upper Midwest is a time when farmers are more engaged on-farm, we timed the interviews and groups to occur during off periods from planting and spraying across corn, soybean, and small grain production. Using Martí's[37] framework for sequentially integrated research designs in participatory research, farmer surveys informed the participant selection and identification of research questions for the focus groups and interviews. Fifteen farmers were recruited based on an indicated interest in participating on the farmer survey. The remaining farmers

were recruited through partner organizations to ensure representation from current, discontinued, and non-small grain farmers across all four study states. Non-farming agri-food professionals were purposefully selected to provide expert opinions based on the factors farmers identified as important to their decision making around small grains in the survey.

We created semi-structured interview and focus group protocols tailored to each type of key informant. Using the grounded theory principle that "data collection and analyses are interrelated processes"[38] as we gathered responses and formulated hypotheses, we added prompts or questions to test whether the theme was robust across participants. For current small grain farmers, we focused on farmers' experience growing small grains; for discontinued small grain farmers, we focused on why they stopped growing small grains; and for non-small grain farmers, we focused on their thoughts on small grain production. Discussions with farmers began with a general question on barriers and drivers of small grain production, and we then asked specific questions about the common barriers and drivers identified through the farmer survey including markets, infrastructure, government programs, and research and information that could support them to grow small grains.[3] Questions for non-farming agri-food professionals varied based on the sector of the participants, but generally gauged the barriers and opportunities for small grains production in the region and built upon findings from the survey. Thematic memos were completed mid-way and at the end of the period in which we conducted the interview and focus groups to summarize and reflect upon findings as data collection occurred. **A total of 39 individuals participated in 15 in-depth semi-structured interviews and five focus groups, including 22 farmers and 17 non-farming agri-food professionals.** Of the participating farmers, fourteen currently grew small grains, five had discontinued, and three never grew small grains.

15
in-depth interviews

5
focus groups

Non-farming agri-food professionals included a crop insurance salesperson, an agricultural lender, a small grain buyer, two small grain brokers, a small grain miller, two Cooperative Extension professionals who work with corn and soybean farmers, five academics researching small grain production, and three advocates working for national and regional NGOs that support small grain production. Interviews and focus groups were conducted either in-person, via Zoom, or by telephone and lasted between 25 to 102 minutes.

ANALYSIS

We used a combined deductive and inductive coding process to analyze qualitative data from focus groups and interviews. An initial codebook was developed with key themes that arose from surveys and the limited literature on the adoption of diversified farming systems (deductive) and key themes

3 Interview and focus group protocols are available on request from the first author.

identified after reading transcripts (inductive). Further "emergent" themes were added during the process of coding.

Audio recordings of focus groups and interviews were transcribed using TranscribeMe! transcription service. A total of 1,145 minutes were transcribed. Quality checks on the data were performed when transcripts were unclear and were edited as needed. Data was analyzed in NVivo software (version 1.6.2), and reoccurring themes were identified in farmer transcripts. Non-farming agri-food professional transcripts were analyzed to provide explanation or further detail to themes emerging from farmer transcripts, and to inform recommendations. Key themes were verified by conducting keyword searches of the transcripts. While a key theme did not need to be identified by all farmers in the sample[39], we were careful to note negative cases, or instances where a farmer had an opposing viewpoint to the majority[38].

Characteristics of surveyed farmers and their operations

Farmers were surveyed from the Midwestern states of Illinois (n=104), Iowa (n=107), Minnesota (n=109), and Wisconsin (m=86). Of the farmers we surveyed, 271 grew small grains as a cash crop or cover crop at some point in the last six years (categorized as "current small grain farmers" for the purposes of this report), 71 grew them in the past but not in the last six years (categorized as "discontinued small grain farmers"), and 64 never grew small grains (categorized as "non-small grain farmers").

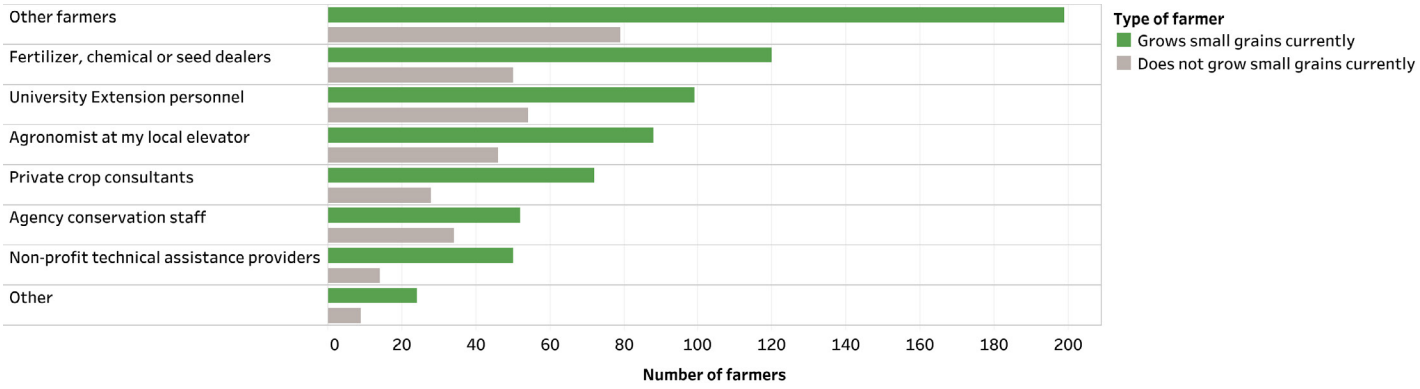
Table 1 displays the individual and farm characteristics of the surveyed farmers by type of farmer. The average age of farmers in the survey was 61 years old, the average farm size was 671 acres, and the median farm size was 340 acres. The geographic distribution, age, and average farm size of the sample are representative of the larger corn, soybean, and small grain farming population in these states[4]. The average farmer owned 65% of their land, and 47% of farmers raised livestock in addition to crops. In terms of farming practices, 20% of farmers were organic or transitioning to organic, and 50% used no-till or some form of conservation tillage.

Overall, current small grain farmers, on average, had larger farms, and a higher rate of livestock ownership and certified organic or transitioning to organic certification compared to the other two groups. Discontinued small grain farmers were on average older, had smaller farms, owned a higher proportion of their acres, and fewer listed non-profit technical assistance providers as a reliable information source compared to current and non-small grain farmers. Discontinued and current small grain farmers used no-till or conservation tillage at higher rates than non-small grain farmers. Fewer non-small-grain farmers listed fertilizer, chemical, or seed dealers as reliable information sources regarding small grains and more listed University Extension personnel and agency conservation staff compared to current and discontinued small grain farmers.

Figure 2 shows farmers' most reliable information sources regarding small grains disaggregated by whether the farmer currently grows small grains. From whom a farmer receives information can influence the type of farming system used and crops grown, and the most common response across all farmers in the sample was other farmers. This answer was particularly common among current small grain farmers. Fertilizer, chemical, or seed dealers was the second most reported response, followed by University Extension personnel.

4 According to a special tabulation requested through USDA, in the states of Iowa, Illinois, Minnesota, Wisconsin the average farm size of operations producing corn is 602 acres, soybeans is 617 acres, and small grains is 785 acres. The most commonly reported age of farmers producing corn, soybeans, and/or small grains was between 55-64 years.

Figure 2. The most reliable information sources regarding small grains by current small grain farmers and discontinued & non-small grain farmers



Note: farmers were asked to select the top 3 most reliable sources; Does not grow small grains currently includes discontinued and non-small grain farmers

Table 1. Characteristics of surveyed farmers by type of farmer

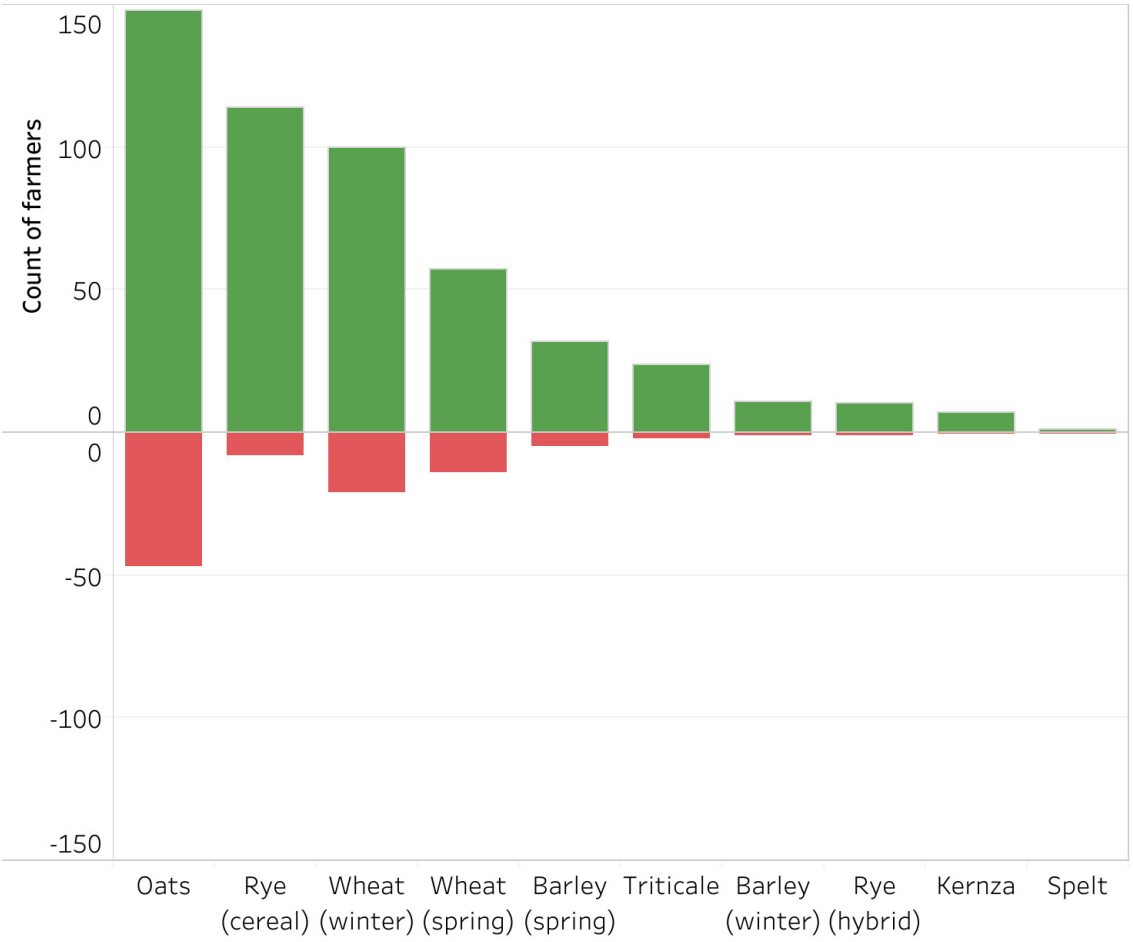
Characteristic	Total			Avg. Non small grain farmers			Avg. Discontinued small grain farmers			Avg. Current small grain farmers		
	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
Farmer age	61	14.77	375	59	15	57	68	11.55	64	59	15.09	254
Farm size	671.1	1042	393	667	700	64	542	602.8	69	706	1193	260
Proportion of acres owned	0.64	0.73	338	0.58	0.38	57	0.71	0.4	59	0.66	0.74	222
Y=1	**Total**			**Proportion Non small grain farmers**			**Proportion Discontinued small grain farmers**			**Proportion Current small grain farmers**		
Livestock	0.47	0.5	395	0.27	0.45	63	0.32	0.47	69	0.56	0.5	263
Organic or transitioning	0.2	0.4	406	0.05	0.21	64	0.03	0.17	71	0.29	0.45	271
Uses no-till/conservation tillage	0.5	0.5	405	0.38	0.49	64	0.57	0.5	70	0.51	0.5	271
Reliable information sources:												
Other farmers	0.75	0.43	371	0.75	0.44	52	0.65	0.48	62	0.77	0.42	257
Fertilizer, chemical, seed dealers	0.46	0.5	371	0.27	0.45	52	0.58	0.5	62	0.47	0.5	257
University Extension personnel	0.41	0.49	371	0.58	0.5	52	0.39	0.49	62	0.39	0.49	257
Agronomist at my local elevator	0.36	0.48	371	0.37	0.49	52	0.44	0.5	62	0.34	0.48	257
Private crop consultants	0.27	0.44	371	0.25	0.44	52	0.24	0.43	62	0.28	0.45	257
Agency conservation staff	0.23	0.42	371	0.35	0.48	52	0.26	0.44	62	0.2	0.4	257
Non-profit technical assistance	0.17	0.38	371	0.19	0.4	52	0.06	0.25	62	0.19	0.4	257
Other	0.09	0.29	371	0.08	0.27	52	0.08	0.27	62	0.09	0.29	257

Note: SD is the standard deviation and N is the number of farmers who responded to the question.

Small grain uses, markets, and infrastructure

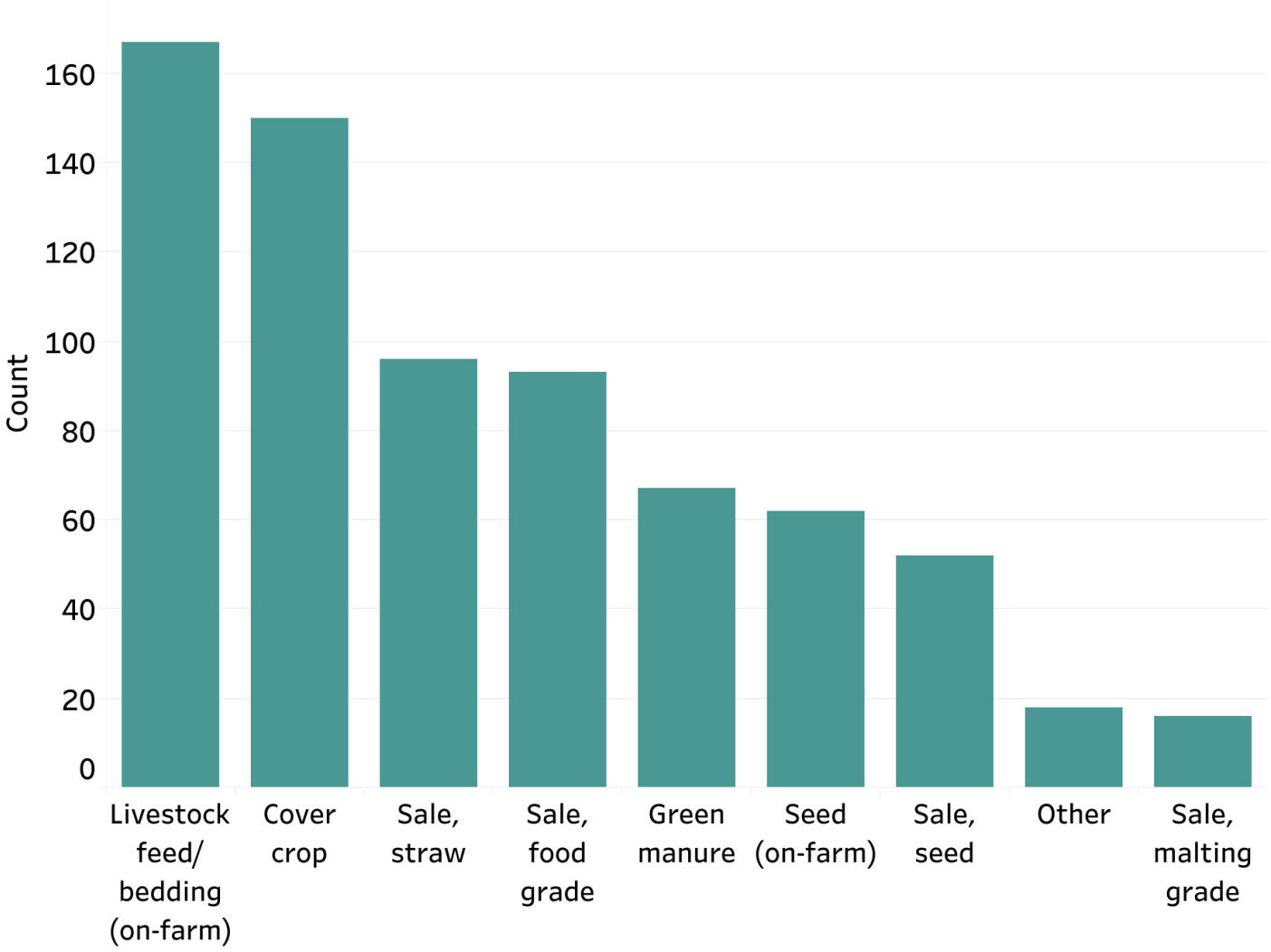
Figure 3 shows the use of small grain types by type of farmer (current or discontinued). Oats were the most commonly grown small grain and also the most commonly discontinued. Fifty-seven percent of small grain farmers in the sample planted oats at the some point in time, and 24%[5] stopped growing oats in the last six years. Cereal rye and winter wheat were the other most commonly grown small grains, although cereal rye had a lower rate of discontinuance (7%) compared to winter wheat (17%). Given our small sample size of discontinued farmers, numbers on discontinuance should be taken with caution.

Figure 3. Farmer-reported uses of various small grain types, current and discontinued small grain farmers. Green indicates current use and red indicates discontinued use



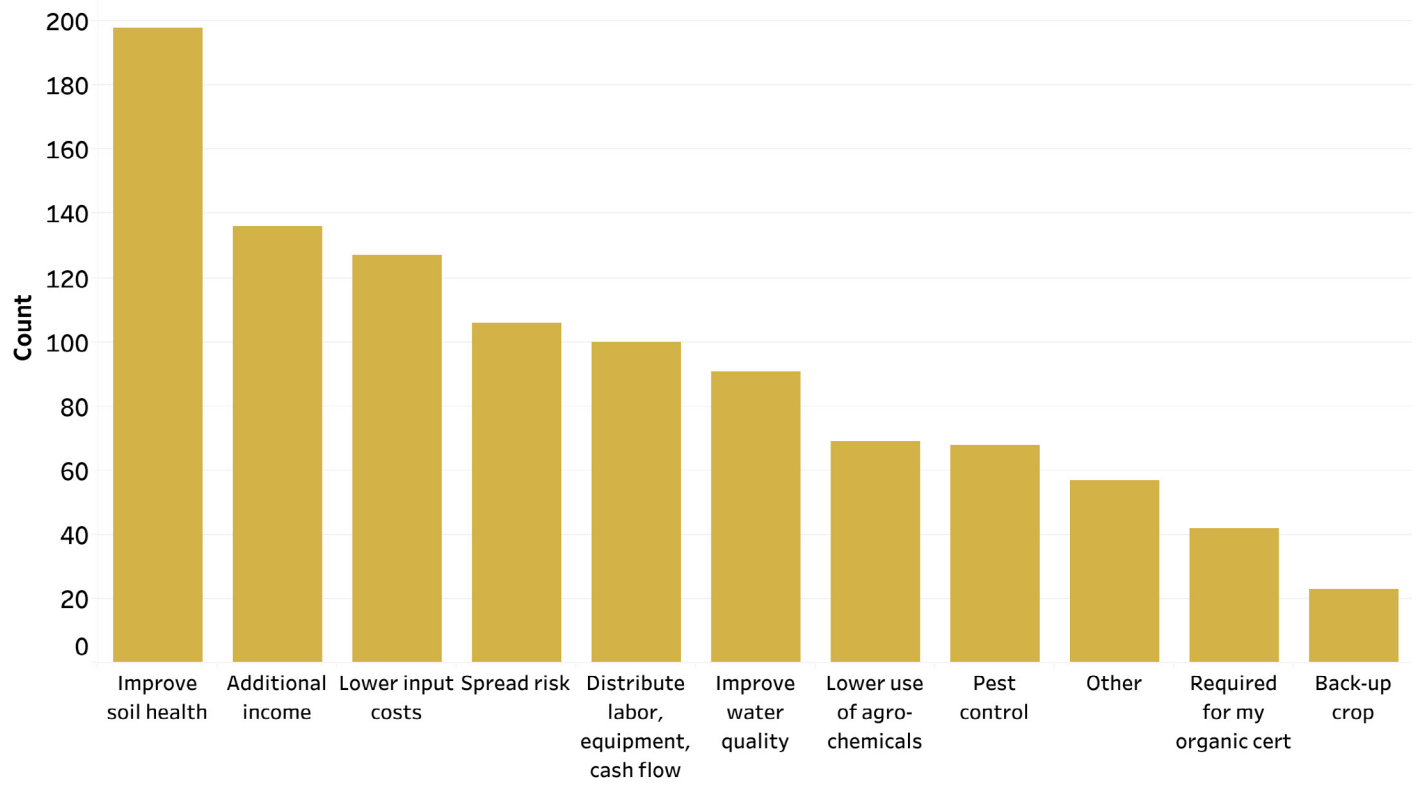
5 Calculated as a percent of the total number of users (current and discontinued)

Figure 4. Farmer-reported uses for growing small grains, current and discontinued small grain farmers



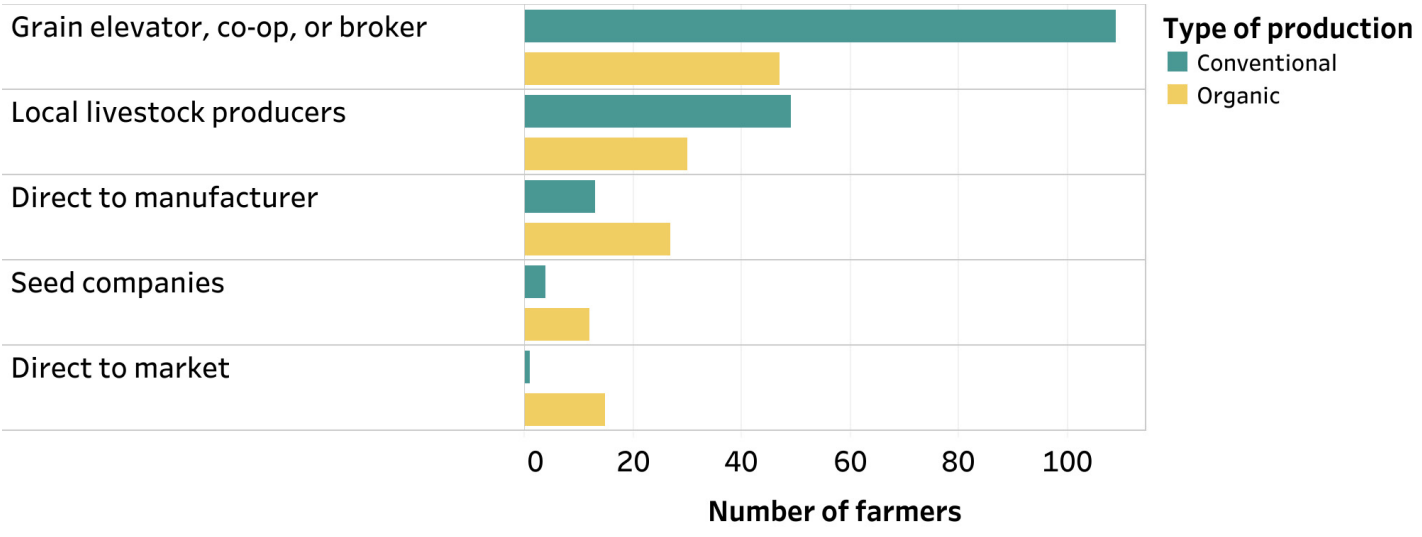
The most common use for which farmers grew small grains was on-farm for livestock feed or bedding (167), followed by use as a cover crop (150) (**Figure 4**). Out of the reasons why farmers grow small grains included in the survey, the most common response was to improve soil health (198) (**Figure 5**). Fifty-nine percent of farmers who answered this question included soil health as a reason why they grow small grains.

Figure 5. Reasons why farmers grow small grains, current and discontinued small grain farmers



When asked about market channels used to sell their small grains, farmers in the sample reported grain elevators, co-ops and/or brokers as the most common channels used in the last six years (**Figure 6**). Selling small grains to local livestock producers was also a frequently used channel, followed by direct to manufacturer. Less frequently used channels included seed companies and direct to market sales to consumer, restaurant, institutions and retail. Organic and transitioning to organic farmers relied much more on direct to manufacturing and direct to market opportunities than their conventional counterparts.

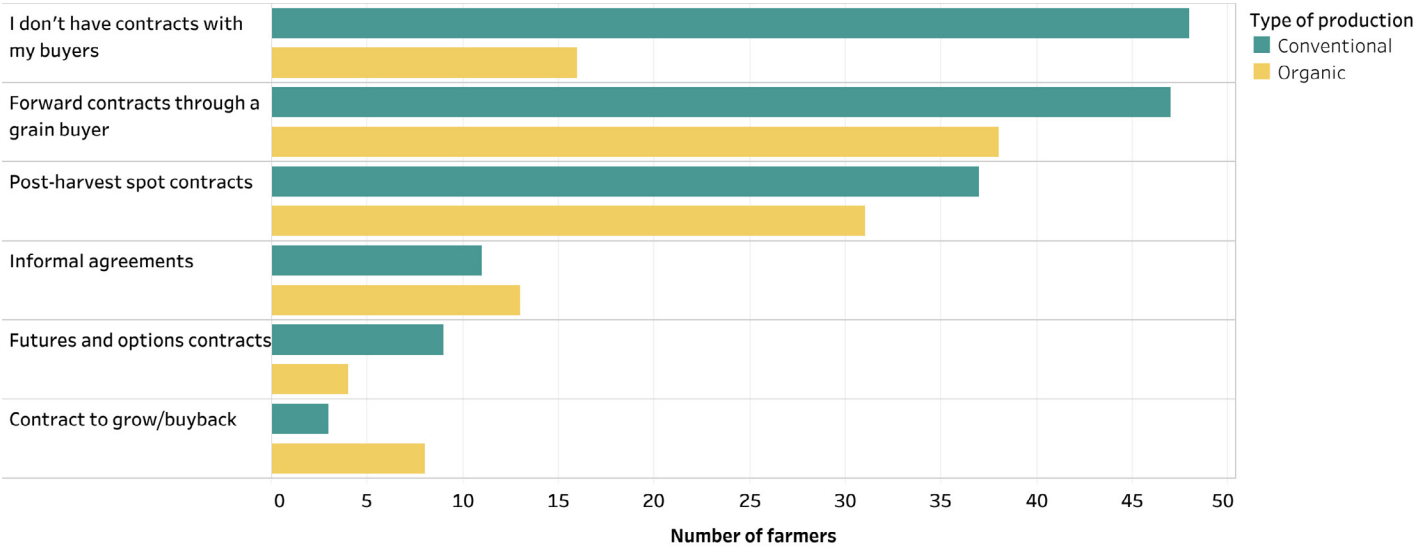
Figure 6. Market channels used by current small grain farmers in the last six years to sell their small grains, disaggregated by organic and conventional



Note: organic includes organic certified and transitioning to organic

Surveyed small grain farmers were also asked about the contracts used with their buyers (**Figure 7**). Farmers most commonly responded that they do not have contracts with their buyers. Of those who did use contracts, both organic and conventional farmers most commonly used forward contracts through a grain buyer, followed by post-harvest spot contracts to sell their small grains. Forward contracts are predetermined contracts between a buyer and seller at a set price and date of delivery or on-farm pick-up. Post-harvest spot contracts, on the other hand, are contracts for delivery or pick-up created once the product is harvested. Some farmers forward contract a portion of their crop and then play the spot market with the rest. Almost all the organic farmers in the study used several types of contracts with their various buyers. Organic farmers differed from conventional farmers in that far fewer organic farmers went without contracts, while not using contracts with buyers was the most frequently selected way that conventional farmers sold their small grains.

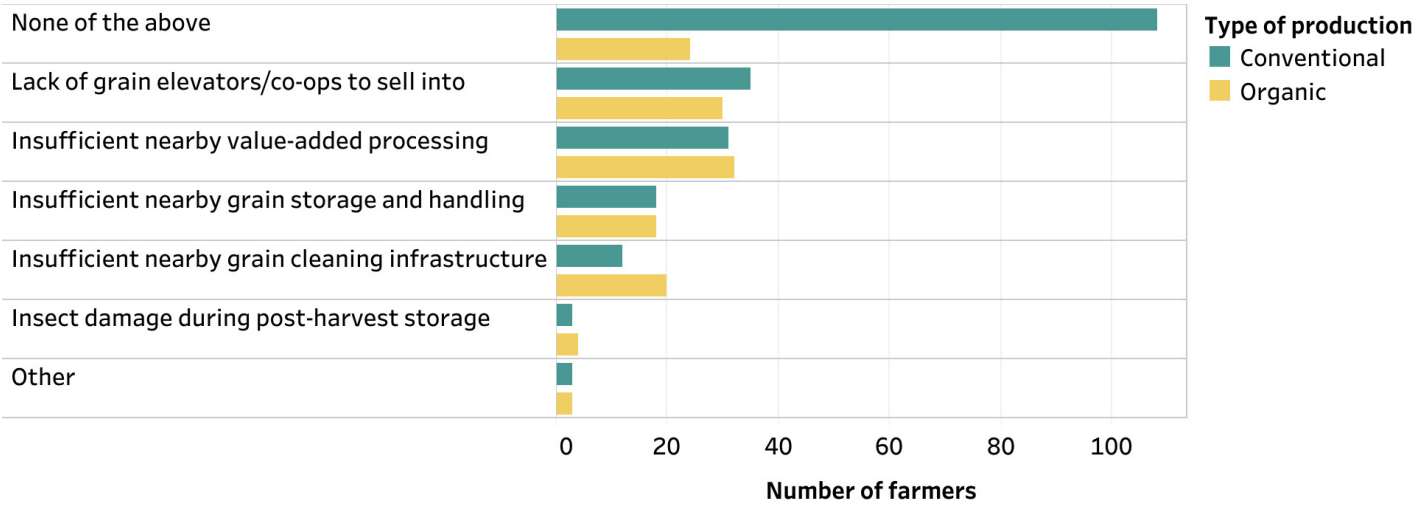
Figure 7. Contracts current small grain farmers used with their small grain buyers, disaggregated by organic and conventional



Note: organic includes organic certified and transitioning to organic

The availability of infrastructure to take small grains from farm to market can influence whether a farmer can grow a crop. **Figure 8** lists the farmer-reported infrastructure limitations to selling into small grain markets. The most common answer was none of the answer choices listed, likely because those who currently grow small grains have already navigated infrastructure limitations, while those who do not grow small grains find them to be a larger barrier. This is in line with farmer-reported survey results discussed below. A lack of grain elevators and co-ops to sell into and insufficient nearby value-added processing were the most common of the limitations listed. Limited grain cleaning, storage and handling were also reported as limitations. Farmers did not commonly report insect damage during post-harvest storage as a limitation. Substantially fewer organic farmers listed none of the above, suggesting that organic farmers either face more infrastructure limitations or that the ones they do face were more representative of those listed on the survey.

Figure 8. Infrastructure limitations current small grain farmers reported prevent them from selling into small grain markets, disaggregated by organic and conventional



Note: organic includes organic certified and transitioning to organic

Survey results: Determinants of small grain production and profitability

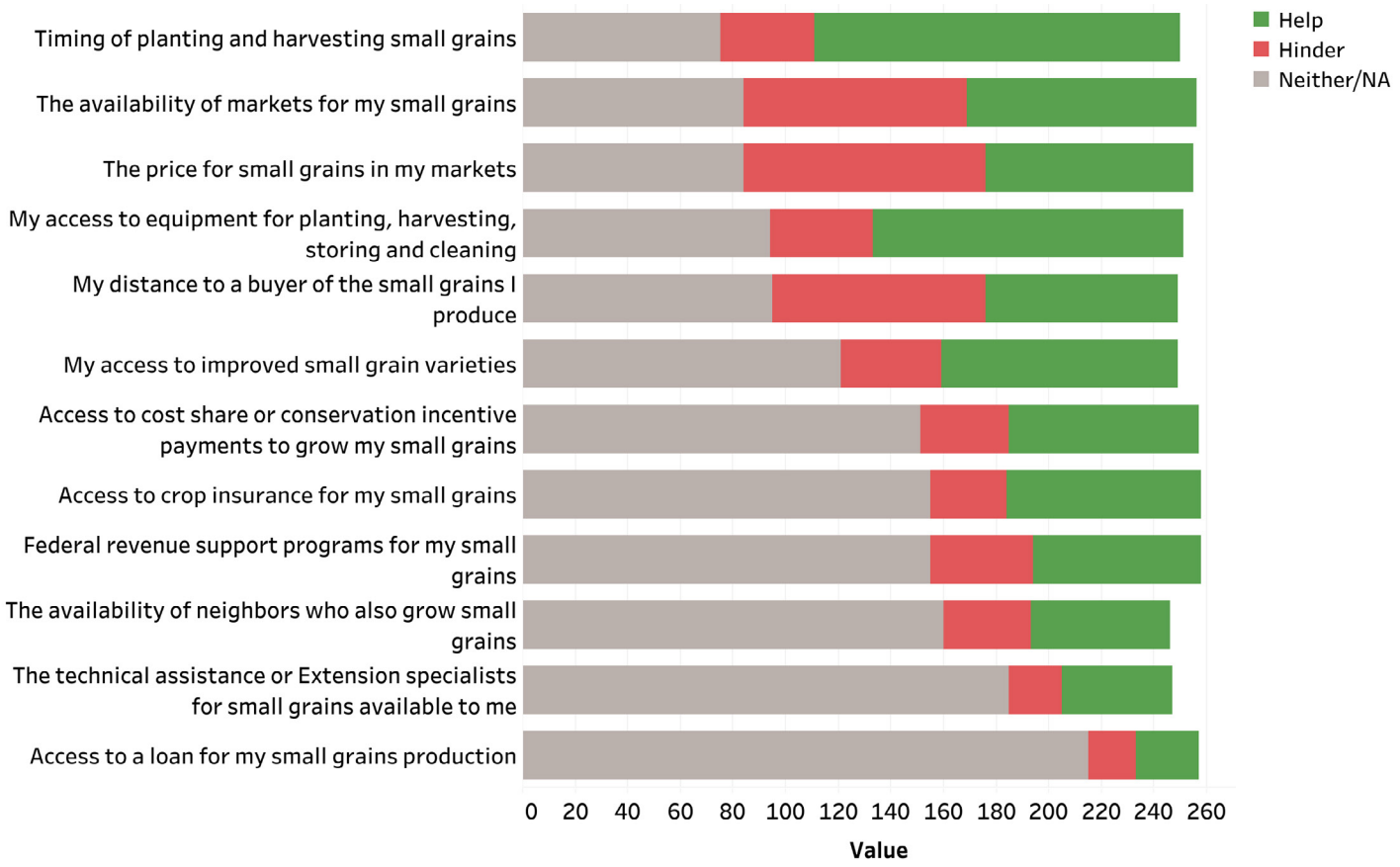
To understand what determines whether a farmer grows small grains, we used two main methods: 1) what farmers themselves reported as the barriers and drivers and 2) the associations found through statistical analysis between individual and farm-level variables and whether a farmer grows small grains. Each method allows us to analyze different but complementary factors that can provide a comprehensive analysis of the determinants of small grains adoption.

Farmer reported results

According to small grain farmers, economic factors—the price for small grains in their markets, the availability of markets, and the distance to a buyer of the small grains they produce—pose the largest hinderance to their ability or willingness to plant small grains, whether for sale or for on-farm use (**Figure 9**). Economic factors, however, can be both a helping and hindering force, and each were about as commonly selected as factors that helped farmers plant small grains (markets 34%; prices 32%; distance to a buyer 29%) as factors that hindered them (markets 33%; prices 36%; distance to a buyer 33%). The factors that farmers selected the most as helping were the timing of planting and harvesting small grains (56%), access to equipment for planting harvesting, storing, and cleaning small grains (47%), and access to improved small grain varieties relevant to their geographic area or desired markets (36%). The availability of neighbors who also grow small grains and the availability of technical assistance or Cooperative Extension specialists for small grains were not commonly listed as either helping (22%; 17% respectively) or hindering (13%; 8% respectively) farmers, suggesting that farmers generally do not see social support from other using similar practices or access to information and support as a key factor in their decision making around small grains.

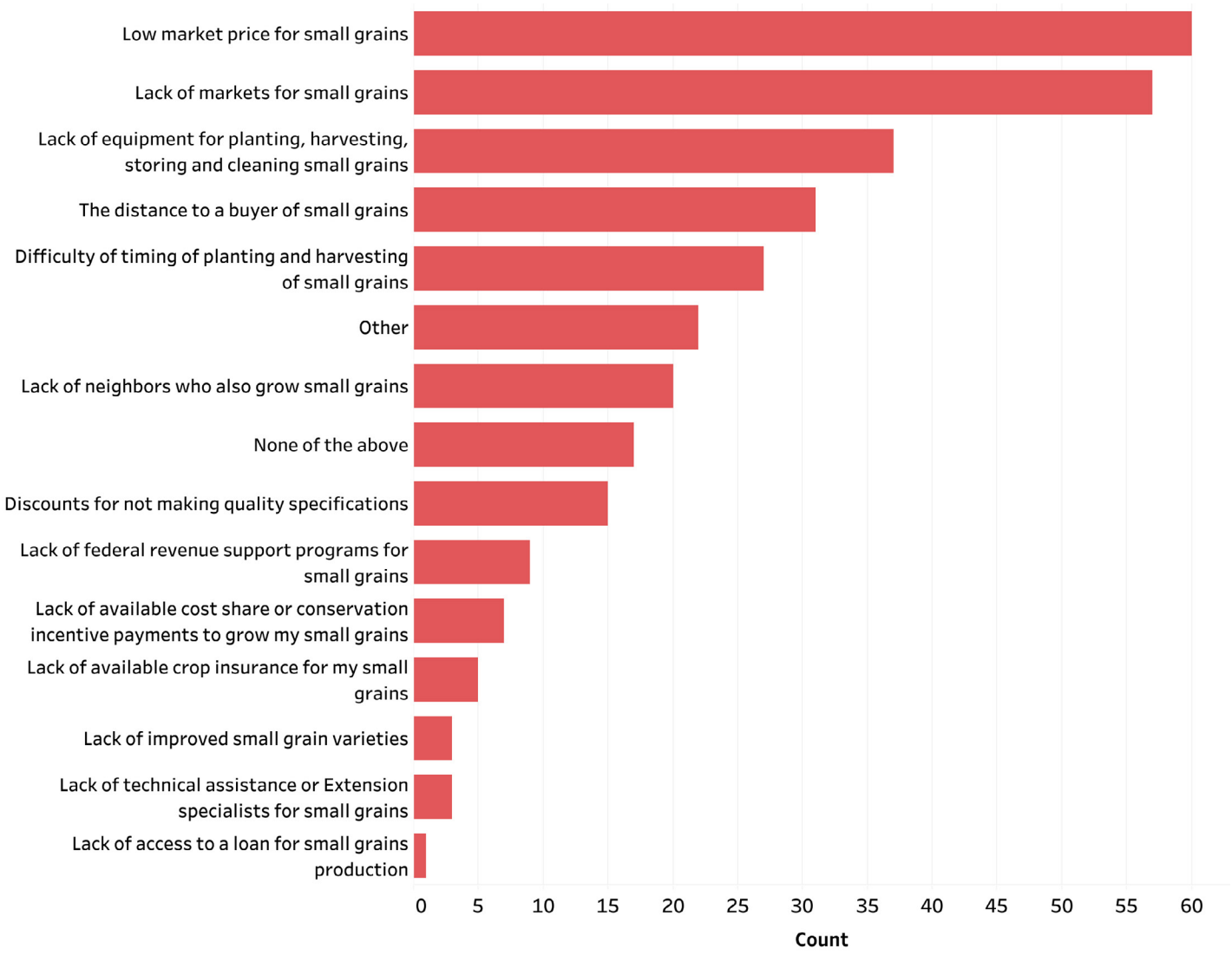
The policy factors, or those determined by the U.S. Farm Bill, were most commonly selected as neither helping nor hindering or not applicable, although each was more commonly listed as helping farmers (crop insurance 29%; cost share 28%; revenue support 25%; loans 9%) compared to hindering them (crop insurance 11%; cost share 13%; revenue support 15%; loans 7%). Access to crop insurance for small grains, access to cost share or conservation incentive payments for small grains such as the Environmental Quality Incentives Program (EQIP) or Conservation Stewardship Program (CSP), federal revenue support programs for small grains including Price Loss Coverage (PLC), Agriculture Risk Coverage (ARC), and the Marketing Assistance Loan program (MAL), and access to a loan for small grain production were listed as the seventh, eighth, ninth, and twelfth most important factors (out of 12), respectively, that helped farmers to grow small grains.

Figure 9. Self-reported factors that help or hinder the ability/willingness of current small grain farmers to plant small grains, whether for on-farm use or for sale



Farmers who discontinued their small grain production and those who never grew small grains reported that low market prices (46%) and a lack of markets (43%) for small grains were the most important barriers to production (**Figure 10**). Lack of equipment for planting, harvesting, storing, and cleaning (28%), distance to a buyer (24%), and difficulty of timing and planting small grains (21%) were also frequently listed as barriers. "Other" (16%), lack of neighbors growing small grains (15%), and discounts for not making quality specifications (11%) were in the middle of the most important barriers selected. Like current small grain farmers, discontinued and non-small grain farmers did not commonly select lack of federal revenue support programs (7%), cost share (5%), crop insurance (4%), technical assistance (2%), nor access to loans (1%) as barriers to production. Fewer current and discontinued small grain farmers selected access to improved varieties as a barrier (2%) compared to current small grain farmers (36%).

Figure 10. Self-reported barriers to small grains production among discontinued and non-small grain farmers



Note: The most common responses in the category "other" were lack of livestock, farmer age, and low profitability.

Correlation mapping and regression results

Farmer-reported results show that external economic factors such as availability of markets and market prices, shown in **Figures 9 and 10**, are important barriers to and drivers of adoption. While markets and prices may vary slightly depending on geographic location, many farmers with equal access to markets and similar available prices make different decisions regarding small grain use. To begin to understand what distinguishes these farmers, we used a correlation network to show the strength of the connections between growing small grains and the individual and farm-level factors that vary across farmers, as well how the factors are related to each other (**Figures 11 and 12**).

Figure 11. (A) Correlation network of individual and farm-level factors related to whether a farmer grows small grains. (B) Correlation network of individual and farm-level factors related to whether a farmer grows small grains with a minimum threshold of r = 0.2. Note: green indicates a positive relationship while red indicates a negative relationship. The strength of the correlation is signified by the thickness and opaqueness of the line.

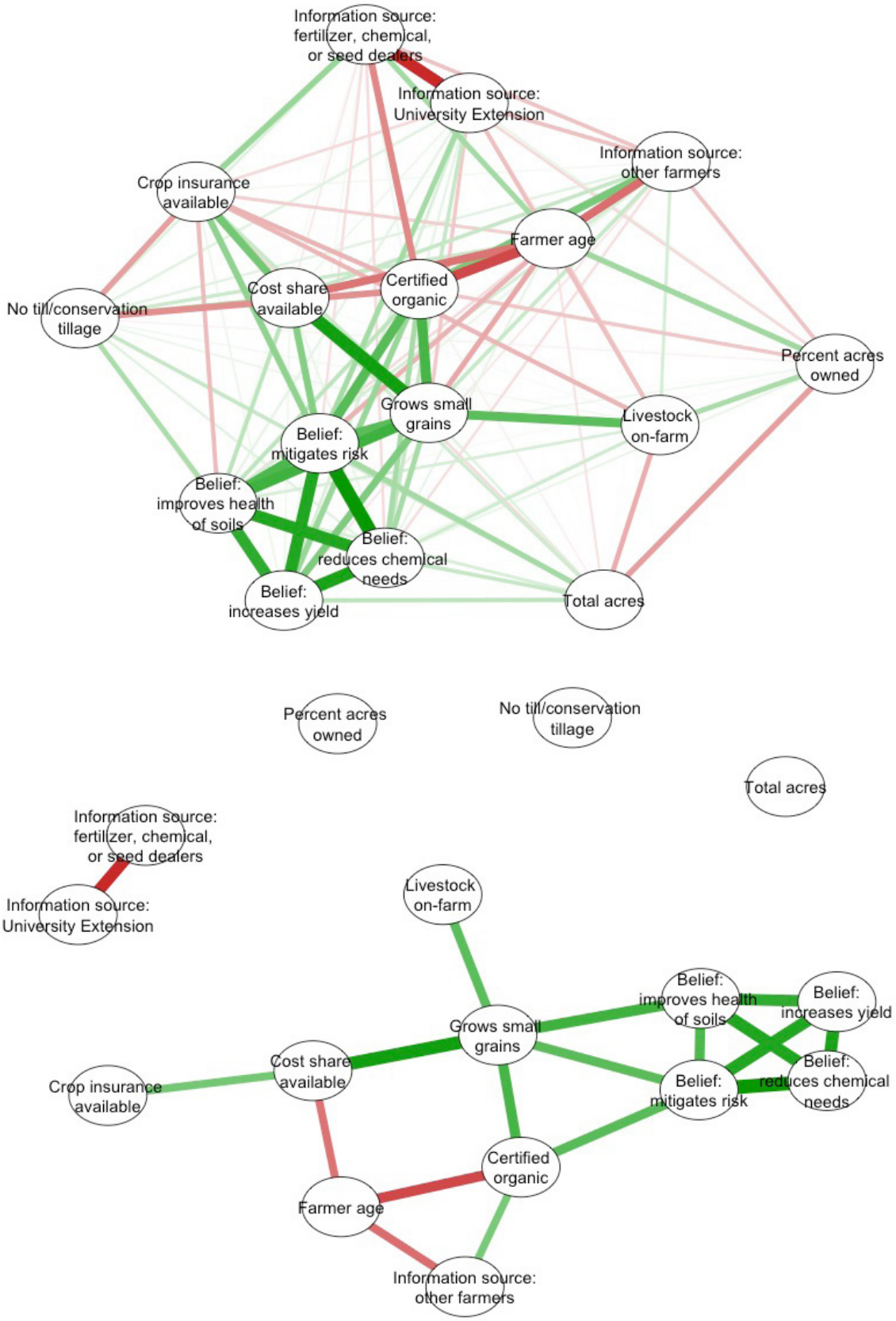


Figure 11 displays all correlations present across all variables, evidencing the complex interconnection between the factors that can influence farmer decision making around cropping choices. **Figure 12** shows only the strongest correlations with a threshold of r = 0.18. A threshold of 0.18 was chosen after finding two clear groups ranging from -0.08 to 0.09 and from 0.18 to 0.37, with the latter of the two showing the strongest correlations. We find that the factors most strongly associated with growing small grains are: reporting that cost share or conservation incentive payments (e.g., EQIP, CSP) for planting small grains were available (r = 0.369), believing that small grains in rotations improve the health of soils (r = 0.298), operations that were certified organic (r = 0.283), and operations with livestock for on-farm use or sale (r = 0.244). While a farmers' belief that small grains in rotations improve the health of soils is the belief variable with the strongest correlation with growing small grains, there are also strong correlations between the belief in the soil health benefits of small grains and beliefs that small grains mitigate risks, reduce chemical needs, and increase yields. These interconnections suggest that farmers who grow small grains appreciated them as a system with multiple overlapping benefits.

Besides connections between beliefs that small grains mitigate risk and improve the health of soils, there were no strong correlations between the factors strongly correlated with small grain use. Factors that were not strongly associated with growing small grains include the total acres of the farm, the percent of those acres that were owned, use of no-till or conservation tillage, the farmer age, the availability of crop insurance, and the information source where the farmer turns for small grain needs.

In addition to whether a farmer grows small grains, we tested what determines whether small grains are profitable in the operation (**Table 2**). The most important factor associated with profitability of the farming business as a whole after adding small grains to rotations is whether the farmer selected "other" as a top information source regarding small grains. Those who selected "other" as a top information source regarding small grains were the most likely to report either very little change or an increase in their farm's profitability compared to a decrease (p=0.004). The most common responses to "other" include resources accessed independently such as farm magazines, research reports, and online articles (7); a farmers' own experience through trial and error (5); and seed companies (3). Farmers with operations that were certified organic (p=0.040) and farmers who selected fertilizer, chemical, or seed dealers as a top information source regarding small grains (p=0.043) are also associated with greater profitability. Growing small grains for sale to food-grade markets is associated with reduced profitability (p=0.074). The number of years growing small grains, growing small grains for their soil health benefits, whether an operation had livestock, farmers who selected other farmers as a top information source regarding small grains, and the state in which the farmer is located are not associated with profitability.

Table 2. Ordered logistic regression predicting greater profitability after adding small grains to rotations

Independent variables:	***Dependent variable:*** **Change in profitability after adding small grains**
Number of years growing small grains	0.053 (0.183) p = 0.773
Certified organic (Y=1)	**0.965**** (0.468) p = 0.040
Use- sale, food-grade (Y=1)	**-0.905*** (0.505) p = 0.074
Use- soil health benefits (Y=1)	-0.176 (0.411) p = 0.669
Use- livestock (Y=1)	-0.403 (0.450) p = 0.371
Selected fertilizer, chemical, or seed dealers as a top information source regarding small grains (Y=1)	**0.802**** (0.395) p = 0.043
Selected other farmers as a top information source regarding small grains (Y=1)	0.136 (0.486) p = 0.780
Selected 'other' a top information source regarding small grains (Y=1)	**-2.887***** (0.996) p = 0.004
State	-0.102 (0.170) p = 0.548
Observations	**114**

Asterisks and bolding note statistical significance at or below the 10% level; * is <0.1; ** is <0.05, and *** is <0.01

Standard errors are listed in parentheses.

Note: All coefficients have been standardized; Farmers who have been growing small grains since the beginning of their operation or who haven't been growing small grains long enough to know were not included in the regression analysis.

Farmer focus group and interview results: Determinants of small grain production and profitability

Focus group and interview participants

Farmers shared their insights on the benefits to and challenges of growing small grains in the Upper Midwest through focus groups and interviews. Of the 22 farmer participants, 15 currently grew small grains, four had discontinued, and three never grew small grains and grew only corn and soybeans. Overall, participating farmers grew a range of crops including corn, soybeans, small grains, alfalfa, and peas. Four farmers were from Iowa, five from Illinois, six from Minnesota, and seven from Wisconsin. Eight of the farmers were certified organic, and ten raised livestock in addition to crops.

Focus group and interview results

In **Table 3** we identify the most common themes that arose from our conversations during interviews and focus groups with farmers, along with an illustrative example quotation. Overall, farmers' perspectives shared in the interview and focus groups focus on similar elements and significant relationships from the survey findings. Farmers re-iterated that price and markets, above all factors, were the largest barriers to the production of small grains in the region. They also echoed the importance of the timing of planting and harvesting small grains, equipment for small grain production, and improved small grain varieties. The presence of livestock, which was correlated with small grain use in our statistical analysis, also emerged as important during our conversations with farmers. Factors that were not listed on the survey, but were central during farmer discussions, were the system benefits of small grains, the synergies between cover crops and small grains, the difficult regional growing conditions, and the additional management needs of small grain production. As in the survey, farmers noted that support programs such as cost share, crop insurance, and revenue support programs did not drive their cropping decisions. However, a more nuanced explanation was shared by farmers, which is discussed in more detail in the Key drivers section below.

Table 3. The most important factors driving decision making around small grain production according to farmer focus groups and interviews

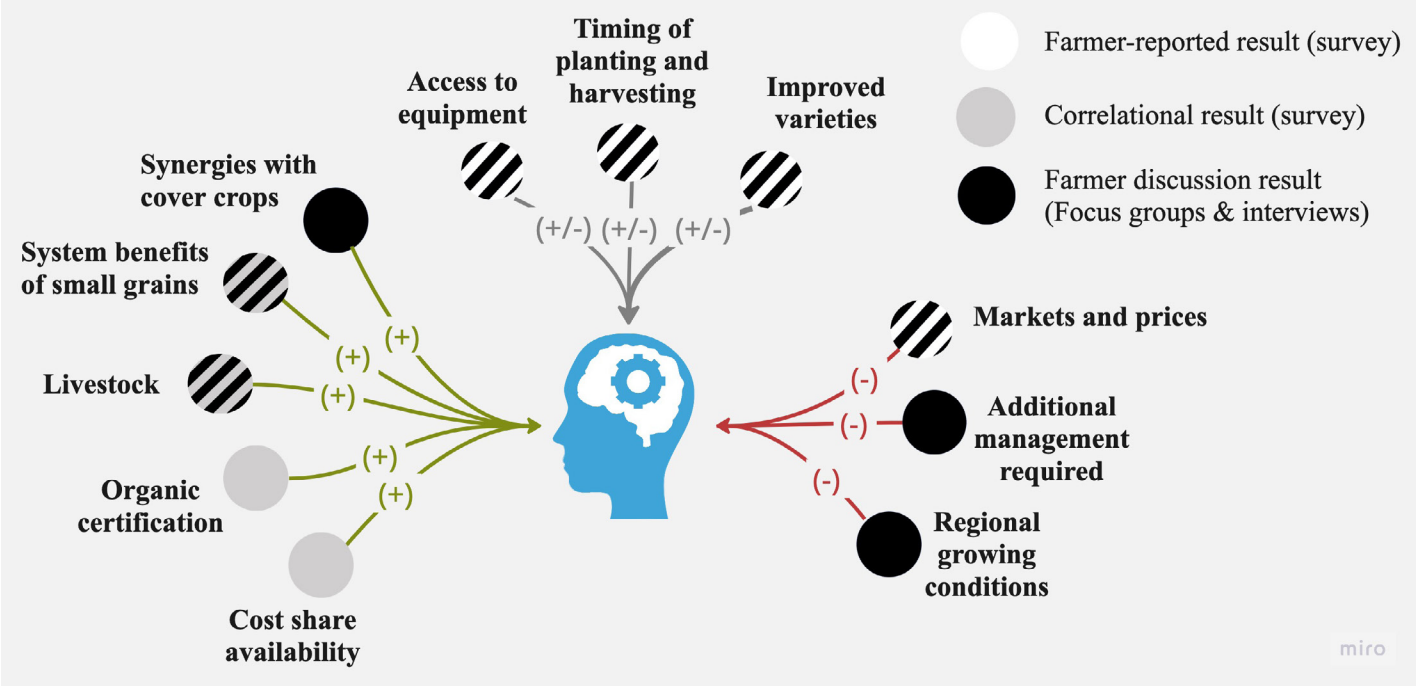
Prominent theme	Example
Price	"Unfortunately, I wish we could raise more and make money off it. But, yeah, there's other ways to make a better living farming than to raise wheat in this country."
Markets-access	"I guess it gets back to the markets, how difficult is it to market your cash crop. Corn and beans, of course, you just run them to wherever, ADM or local elevator or wherever and you get the market price. But with oats, it just wasn't that easy."
Markets-distance	"I'm sure it would help if you had a place to deliver it that wasn't far away. I mean, we are honestly spoiled right now. Our delivery for our corn is literally a mile and a half from our farm. So even though we store almost everything on-farm, when we go to deliver it, it does not take very much manpower or trucking to get it there."
Markets-consistency	"We had a good market for our straw for several years on small squares and we are producing three to five thousand small squares a year. And [the buyer] was taking 2,500 to 3,000 of them. All of a sudden, he decided [he] only wanted half that. And normally we would deliver him two, three hundred every two weeks, let's say. All of a sudden, we had 3,000 small squares of straw sitting in our shed and no home. That creates a problem. It only sits there so long and the mice and the rats and stuff get in it and it's cash tied up."
Timing-positive	"One of the reasons I like wheat right now, or like some of the small grains, is because we have a lot longer of growing season for that cover crop…Having a longer growing season before they're killed off by the winter cold coming makes a big, big difference."
Timing-negative	"[What] we run into up here just being wet springs. This year, it was a late year. You usually want to start planting around just say 20th of April. We didn't start anything until the 8th of May. So now all of a sudden, it's a tier like that. You didn't get anything seeded and your corn's not in the ground…It's like, do you want people spending time planting wheat, when all their corn should be getting in the ground. So it's just a complexity of timing issue."
Equipment	"We would have to buy some sort of machine to plant small grains because we don't have a grain drill anymore. At least not a grain drill that's usable. So we would need to invest in that equipment."
Regional growing conditions	"As a grower, you guarantee me the right week of [harvest] weather, and I'll have a whole lot of oats out here. But that just doesn't happen very often."
Improved varieties	"Private investment in breeding stock would be my number one because wheat yields haven't changed comparative to every other commodity out there. I mean take your corn and beans, even sugar beets over the last 20 years. I mean, as a kid, we raised 50, 55-bushel wheat. Today we're raising 60-bushel wheat. And you compare that in beans and corn or even sugar beets where we're at, and it's ridiculous the amount of advancement we've made; there's a stalemate in the wheat product."
Livestock	"The small grain paradigm evaporated when the livestock left farms. Every dairy farm used to grow its oats or barley and go in a rotation like that and now it's the big farms or the dairies and nobody else does it."
System benefits	"It's probably the one thing that keeps me from completely dumping spring wheat or barley or whatever on the farm there is, just there are some benefits to having that, in our case, fourth crop in the rotation. And you can't put a dollar figure on it right now, but there's an advantage to it. So we keep a little bit around for that reason."
Synergies between small grains and cover crops	"I don't have all the solutions, obviously, but I see that farmers know they need small grains. Even our conventional neighbors are planting cover crops. It won't be long to convince them, right? They're already planting rye as a cover. It's kind of getting there."
Additional management	"I mean, there's a few guys who are, "Yeah, I want the easy." Easy is corn and soybeans, and it really is, everything's all set up for it."

Bringing it all together: Key drivers of small grains production

Below, we discuss in further detail the key determining factors of whether a farmer grows small grains based on multiple methods (quantitative surveys and qualitative focus groups and interviews) and through multiple ways of knowing (farmer-reported results and correlational network mapping) (**Figure 12**).

We find that markets and prices, regional growing conditions, and additional management are current barriers to small grains production. Access to equipment, improved small grain varieties, and timing of planting and harvesting can be both drivers and barriers to production depending on the farmer. Livestock, cost share programs, the system benefits of small grains, the synergies between small grains and cover crops, and organic certification are found to be drivers of production. Crop insurance and revenue supports (ARC, PLC, MAL) for small grains, access to a loan for small grain production, and technical assistance for small grains are not found to be important to a farmers' decision to grow small grains. We include additional summary statistics and results from in-depth interviews and focus groups with non-farming agri-food professionals to understand how and why these factors impact small grain production.

Figure 12. Determinants of small grain production across multiple methods and ways of knowing



Note: Shading of circles indicate the method used to determine the result. Striped shading shows multiple methods supporting the same result.

Markets and prices

The most frequently noted barriers to growing small grains by farmers in the survey, interview and focus groups across current, discontinued, and non-small grain farmers were economic factors. Specifically, farmers reported that the **market price, the availability of markets, and the distance to a buyer were the key barriers to integrating small grains on their operation (Figures 9 & 10).** Weisberger et al.[27] and Baker[23] also found that economic factors were the biggest barriers to production among surveyed farmers. During focus groups and interviews there was a resounding sentiment that to grow more small grains, more local markets were needed with higher prices. A current small grain farmer from Iowa told us,

> **"In North Central Iowa, it's corn, soybean country. If we don't have a solid, dependable market, [small grain production] ain't going to happen. The $5 discount on the crop insurance—and they can do a little bit on ARC or PLC or whatever. But it's still not going to work if we don't have a solid market."**

Farmers explained that while small grains require fewer inputs, making them less expensive to raise, the return on investment of corn and soybeans is higher. Still, other farmers said that for them to plant more small grains, prices must be comparable to corn and soybeans. Harvesting the straw from small grains, in addition to the grain, was a strategy many of the farmers we spoke with used to increase the return on investment. Some farmers with livestock grew small grains for the straw alone to use as bedding. Still, straw requires fuel and specific machinery to harvest, and is an extra product to market. Another current small grain farmer in Iowa explained the situation, "At least in our neighborhood, to compete with corn or soybeans, the grain part of it gets you almost kind of maybe there, but the straw makes it attractive, but you only have so much market for straw. And yes, we can run the leftover rye or oats or whatever through the cows, but it's hard to move the straw at an economical price that pays for the baling and trucking."

Finding local buyers for small grains was also identified as a barrier, as farmers explained that their local elevators no longer buy small grains. A discontinued small grain farmer from Minnesota recounted that he had to haul his wheat over 100 miles to find a buyer "Because otherwise the local elevators won't even take it because it's a pain. Because they're all set up for corn and soybeans and where are you going to put a truckload of wheat?" Many farmers said that the distances required to haul their small grains was too far to make production economical. A current small grain farmer from Illinois explained: "You know, I think if we're going to grow wheat, or we're going to grow barley, whatever we can grow, I think you're going to have to look at a transportation problem…I have to go somewhere at a distance to us. So that's a problem." As a result of market access issues, several farmers we spoke with have had to sell their grains on conventional (if they were organic) or livestock feed markets at a lesser price after failing to find local buyers for their product.

Because small grain buyers are fewer, successful farm-gate sale requires looking beyond the local elevator and, subsequently, requires more time and effort. Despite these challenges, however, farmers saw growing demand for small grains and potential for future small grain markets. Indeed, when asked about customer preference for local grains, one miller we spoke with shared "There's definitely bakers in our region who want to be able to communicate [that the grain/flour is local] to their customer base. So their customer base must be asking. And our bakers then want to be able to communicate the message that it is local." Farmers and non-farming agri-food professionals suggested that building consumer markets by launching and building brands for diverse products, supporting more local milling and processing, promoting Midwestern-grown certifications, and developing farmer marketing coops are key to supporting small grain markets in the region. Policy levers such as tax incentives to both large-

and small-scale food companies and processors to source locally grown grain, and limiting small grain imports, can stimulate production and encourage latent markets.

Timing

Winter and spring cereals occupy a temporal niche in northern cropping systems, creating both opportunities and challenges for farmers. Timing of planting and harvesting was the most frequently selected factor that small grain farmers said helped them in their small grain operations (56% of the sample) (**Figure 9**), while 20% of non- or discontinued small grain farmers listed it as a barrier to production (**Figure 10**). During focus groups and interviews, farmers emphasized the importance of a new crop fitting well into their existing systems and explained several ways in which the **timing of small grains can be both beneficial and detrimental.**

Small grain farmers appreciated the window of time after small grains are harvested that allows for a longer growing season for cover crops. Livestock farmers noted benefits from the longer window of time to spread manure afforded by the earlier harvest of spring planted small grains compared to corn and soybeans. On the other hand, small grain and non-small grain farmers alike were concerned about small grains impacting their ability to tend to their main cash crops—corn and soybeans—especially given the widespread lack of labor.

Farmers also acknowledged that planting small grains in the spring and fall is not always easy given the variable weather conditions in the Upper Midwest. Wet springs, a late corn harvest, and an early frost can mean a small grain crop does not make it in the ground in time. According to a current small grain farmer in Illinois, getting a small grain planted in the fall was, "Great in theory, but we've had some years where we don't get done until it's snowing. So, in a perfect world then we're done by Halloween or first week in November. It'd be fine. But when we get those years where we're not done [with corn harvest] until Thanksgiving or later, then, all of a sudden, it's like, this isn't going to work. So that's probably another really big concern…is just getting the timing of some of that stuff done."

Equipment

Small grains require a different set of equipment to plant, harvest, store, and clean compared to corn and soybeans. Equipment for small grains was the fourth most selected factor that helped small grain farmers' ability or willingness to grow them (**Figure 9**). At the same time, lack of equipment was selected as the third most limiting factor for non and discontinued small grain farmers, just below markets and price. **This tells us that equipment, if accessible, can be a driving force for the adoption of small grains in the region.**

Currently, however, many farmers do not have equipment for small grains production and the equipment available is outdated, difficult to obtain, and expensive. One discontinued small grains farmer from Minnesota explained,

> **"They made the corn—feeding the corn to [livestock] so easy. I mean why would you do something else? Now all of a sudden you need another bin, you need a different planter, you need a different seed."**

A Wisconsin farmer acknowledged that if he didn't have a nearby neighbor to help clean their wheat, they didn't know where they would take it; "I haven't crossed that bridge and in that respect then it would be limited."

On-farm storage was an especially common issue among farmers. A current small grain farmer from Wisconsin explained, "We can't commit to any higher paying or more diversified contracts because we don't really have good storage... If we had more storage on-farm, that would definitely change the game a bit." Several farmers also suggested that they would grow more small grains if they had places to store them, which allows them to hold onto their product until they find a competitive price.

Regional growing conditions

Upper Midwestern weather makes growing small grains in the region more difficult to compete with production in the Central Plains, Western U.S., and Canada. Higher levels of rainfall and humidity impacts the ability of farmers to meet quality requirements specified for milling and malting. During focus groups and interviews, farmers discussed the trouble competing with more arid regions to the West that have fewer issues meeting standards of moisture content at harvest (important for proper storage), mycotoxin limits (secondary metabolites produced by molds that are toxic to humans and animals at certain thresholds), falling numbers (amount of pre-harvest sprouting), and test weights (heft of the grain). Because of these issues, farmers were often paid less than they expected for their small grains due to quality discounts, or had loads rejected, making their production a less reliable source of income compared to corn and soybeans—a risk that was often not worthwhile given their lower market prices and distant markets. When asked about what was needed to meet test weights on oats, a common problem for oat farmers, a discontinued small grain farmer from Iowa explained,

> **"Well, that gets into the agronomy department of developing oats, which I think they've worked on quite a bit since I was doing it, I hope. But it's still hard to overcome the climate, the weather, and things. That has a lot to do with it."**

Improved small grain varieties

Access to improved small grain varieties relevant to a farmers' geographic region or desired markets was the third most selected factor that *helped* small grain farmers' ability or willingness to grow small grains (**Figure 9**). Those farmers who have discontinued growing small grains and those who have never grown small grains did not commonly report a lack of improved small grain varieties as a barrier (**Figure 10**), although focus group and interview data suggest that this is due in part to non-small grain farmers inexperience with small grain varieties. During focus groups and interviews, the issue of genetics came up frequently, and **farmers told us that they did not have access to the small grain varieties, especially for organic production, that they need to be profitable.**

Improved varieties can help farmers increase yields and manage disease and toxins from mold and fungi such as vomitoxin and aflatoxin that are particularly challenging in the Upper Midwest due to relatively high levels of rainfall and humidity during the growing season. There was a particular focus on the need for varieties suited to the wetter conditions of the region to compete with farmers in the Dakotas and Canada, where much of the small grains are currently grown. A current small grain farmer from Illinois told us:

> **"I think there's profit to be made [in small grains]. We just need to be looking at different varieties…I'm not sure that we've really developed wheat, for our organic side. The problem with the organic side is that you have no rescue, you can't go in with fungicides, you can't go in with the herbicides, you can't go in with anything like that…I'd like to see maybe a little better, a little different breeding program…There needs to be some new characteristics in it. Some new varieties brought out. I mean, we're planting the same oats I did as a kid. You know, 45 years ago."**

Due to their limited acres and therefore limited profitability for private investment, small grains in the Upper Midwest are "orphan crops", or crops that receive little attention from the private sector despite their importance to food security, and therefore remain largely in public sector breeding programs[40,41]. Consequently, many of the more advanced biotechnologies related to plant breeding have not been applied. Public sector plant breeders rely instead on more traditional breeding methods that, while producing less costly seed, can take upwards of 10 years to bring a new line to market[42,43]. The small grain breeders we spoke with lamented that funding is lacking for public small grain breeding programs, a global issue among public breeding programs that has resulted in a decline in public plant breeders and public cultivar development[44,45]. They explained that more sustained, long-term funding for public plant breeding is needed along with efforts that can speed up the varietal development process at public institutions like the Small Grains Genomic Initiative[6].

Still, there was a sentiment amongst the breeders that varieties developed in the private sector with associated chemical input packages tend to be seen as modern or cutting edge by farmers and therefore more desirable. Most small grains, however, naturally require fewer inputs[46], in part *due* to their history in public breeding, and therefore it is possible that more of the profit goes to the farmer compared to agricultural input companies. This results in a better outcome for farmers' bottom lines as well as the environment. Promoting the low-input and low-cost nature of small grains can help reorient farmers to their inherent benefits compared to corn and soybeans.

Livestock

Results from the correlation network analysis (**Figures 11 & 12**) and focus groups and interviews showed that **livestock can help drive small grain production**. Regression results of the drivers of small grain profitability (**Table 2**) tell a similar story: farmers who sold for food-grade production are more likely to see a reduction in the profitability of the farming operation after adding small grains compared to those who don't grow for food-grade production. This is likely due to the synergies between small grain production and livestock: livestock acts as a secondary market for grain that does not find a buyer, and small grain silage and straw provides a source of livestock feed and bedding. In this way, **farmers "hedge" with their livestock to lower the risk of small grains production.**

Food-grade production of small grains in the Midwest is risky due to the difficulties of meeting quality grade specifications required by buyers (see Regional growing conditions section). A much higher percentage of farmers in the sample (70%) grew small grains for livestock, either for on-farm feed or bedding, sale as feed, or sale as straw, compared to those who grew for food or beverage-grade (38%). Livestock feed markets, on the other hand, have fewer quality requirements and several farmers stated

6 The Small Grains Genomic Initiative helps to increase the speed and efficiency of public sector small grain variety development through genomic selection.

that livestock feed and bedding are the most viable markets in the region. Many of them said that they would be more likely to grow more small grains if they had livestock markets around them or on-farm livestock.

Livestock, however, has spatially concentrated in certain areas as crop and livestock systems have decoupled in the U.S.[47]. Iowa farmers surveyed by Weisberger et al.[27] reported that the decline in integrated crop-livestock systems was a major barrier to small grain and forage production. Even in areas concentrated with livestock, however, markets for small grains as feed are no longer common. This is likely because, as heard in focus groups and interviews, farmers consider small grains as slower to fatten an animal and less palatable compared to corn and soybeans, and silage making of small grains involves more risk than corn and soybeans due to the uncertainty of when to harvest to optimize nutrients. A dairy researcher told us,

> **"Corn is the king, and alfalfa is the queen. And that's what it takes to make a kingdom...We've created such specialized, very intricate systems that rely on corn and legumes that complement each other in terms of what they give to the animals that it pushed away other possible feeds."**

Yet, replacing a portion of corn with small grains in feed rations can lower the cost of the ration and has been shown to support equivalent growth rates and feed efficiencies[48,49]. Echoing Muckey et al.[26], more research on feed-grade opportunities for small grains should be pursued. Promoting small grains in livestock rations and greater small grain varietal development suitable to livestock feed will help improve their potential as a livestock feed. Moreover, reversing geographic concentration of livestock production by re-integrating crop and livestock production on farms throughout the region will be key to providing feed markets for small grains and to encouraging small grain production for on-farm use.

Cost share programs

Farmers did not commonly report that cost share programs such as EQIP or CSP influenced their decision making (**Figures 9 & 10**); however, correlational network mapping showed that whether a farmer said that cost share for small grains was available to them was strongly correlated with whether they grew them (**Figures 11 & 12**). During focus groups and interviews, farmers explained that **while cost share programs don't drive their decision making, some said that the additional incentive helps.** A current small grain farmer from Wisconsin explained,

> **"If you got that seed money or that cost sharing or whatever, it definitely helped. Many times you got to jump through some hoops, but most of the time it's worth jumping through the hoops."**

An agronomist echoed,

> **"The biggest thing is the economic incentive has got to be there but not necessarily through the economic incentive of the actual crop. There has got to be some additional benefit whether that's soil heath, whether that's carbon sequestration, sustainability, traceability. Somebody has got to want to pay that farmer to grow that grain."**

Yet, our survey data shows that the majority of farmers weren't aware whether cost share was available to them (59% of the sample; 77% of non-small grain farmers). Those small grain farmers who said it was available, however, participated widely: 74% used a cost share program. The most common incentive program was EQIP, used by 47% of small grain farmers in the sample, compared to CSP, and nongovernmental sources such as Practical Farmers of Iowa. Of the small grain farmers who did not participate, the most common reason why was that they were not interested in financial assistance. That the qualification criteria were unclear, and the paperwork involved in the application excessive were also frequently selected. This was also a resounding sentiment during focus groups and interviews where farmers felt overwhelmed with the amount of effort required to participate. A current small grain farmer from Minnesota said: "It always seems like there is so much documentation and you have to go through so many hoops to do something simple, it always seems overwhelming when you sign up for a program." A current small grain farmer from Iowa commented that more flexibility in the programs was needed: "The timing of the cost share rounds do not line up well with planning and do not allow for much flexibility. Sometimes a field will be too wet after we sign up and we need to switch fields or sometimes we don't yet know which field we want to plant the small grains on. We wish there was more flexibility in the programs. Sometimes we plant the small grains and then it's too late to sign up for the programs because it's a practice we already did, simply because the timing didn't line up."

Other issues farmers brought to light during focus groups and interviews were that for EQIP and CSP, small grains can only be used as a cover crop, prohibiting farmers from harvesting the grain. Moreover, an herbicide is often applied to kill the small grains before planting, making its use difficult for organic farmers. Still other farmers said that they would like to participate, but that funds weren't available, and the programs had reached capacity in their area.

Cost share programs will be more effective for farmers if the application processes are simplified, and greater flexibility is afforded to participants. To realize the potential of cost share on adoption, more funding is needed to support the programs, especially given their strong association with whether a farmer grows small grains. The lack of awareness whether cost share for small grains was available to farmers suggests that it may be a missed opportunity to promote the use of small grains. More outreach to farmers about cost share and other incentive payments for small grains is needed, particularly non-small grain farmers who may be incentivized to begin testing small grains in rotations.

System benefits

While growing small grains for soil health benefits was not associated with profitability (**Table 2**), a farmers' belief that small grains in rotations improve the health of soils was strongly correlated with growing small grains (**Figures 11 & 12**). Additional strong correlations found between the belief in the soil health benefits of small grains, and the beliefs that small grains mitigate risks, reduce chemical needs, and increase yields re-enforce that farmers understand small grains as a system with multiple benefits. **While it is clear that economics are central to whether a farmer grows small grains (Figures 9 &**

10) and that farmers struggle to make small grains profitable, many farmers in focus groups and interviews said they grow them "on principle" due to their benefits in a rotation. One farmer from Iowa explained that growing small grains is part of his "conservation ethic" to ensure the health of his soils and local waterways. Other farmers discussed the positive impact small grains had on reducing pest and disease pressure and increasing water infiltration.

The benefits to soil health were particularly important to the farmers in our study. Surveyed farmers recognized the soil health benefits of small grains—46% grew small grains at least in part as a cover crop or green manure, 59% said that the reason why they grew small grains was in part due to the soil health benefits (the most selected reason), and 65% of respondents said that they believed small grains in rotations improve the health of soils. One current small grain farmer from Illinois said:

> **"I have noticed that when I took this farm over seven years ago, they were not doing hardly any small grains. And I have, you know, really stepped in to do it. And I find, I mean, we're doing less tillage. So, you know, especially in today's market and the price of fuel, everything that's got small grains on it, that soil seems to be much, much looser, a much nicer soil, better seed beds. So, I think we're gaining on the corn and soybean end of it also, gaining some production here."**

Thus, while stronger markets for small grains will do the most to incentivize their use, promoting their system benefits may also drive production, especially on marginal land. A researcher we spoke with summed up the sentiment: "Clearly small grains have lost ground to corn and soybeans in the last century…if you want to advocate for it you're not going to get it back into the system by comparing it in one dimension…you need to put it in a whole system context…this is how you are going to get farmers to say, yeah that makes sense."

Synergies between small grains and cover crops

Through focus groups and interviews, the unique synergies between cover crops and small grains emerged. Cover crops and small grains can feed into each other in ways that support each other's production. **Cover crops act as a gateway to small grain production; once a farmer sees the soil health benefits of a small grain as a cover crop[7], and gains some experience growing them, they will be more comfortable taking the leap to feed or food-grade production. At the same time, small grains in a rotation can act as a "nurse crop" for cover crops; they are harvested early enough in the season to allow time to establish a fall-planted cover crop.** Given that using small grains as a cover crop is the second most common use for small grains listed by farmers on the survey, this may be a promising strategy to encourage small grain production.

7 A crop used to cover otherwise bare soil to reduce erosion, increase organic matter, and suppress weeds[50]

A current small grain farmer from Wisconsin recounted,

> **"The original times that I grew wheat as a dairy farmer was as a cover crop. FSA was pushing it and basically, we had absolutely no intention of keeping it for a cash crop, it was going to be destroyed in spring, but all of a sudden you had a nice crop out there... Let's see if we can do something with it. And A and B leads to C, and it kind of falls in place."**

Rye and barley are two small grains commonly grown as cover crops in the Midwest, however, there are few buyers for these crops. A small grain broker explained, "There's always a little bit of an oversupply of those two, or lack of a market...It either goes into the feed market and some of it goes into the beverage industry or the food industry, but the vast majority of it's just grown for a cover crop because there's no market to support it really, or very little...I actually just think that there needs to be more market development...it's a little bit more about having a concerted effort then for bench-top development and research and development to really go into play. Rye could be used in a number of different capacities than what it's currently used today."

Organic certification

Farmers with operations that are organic or transitioning to organic were important to the profitability of small grain operations and to whether a farmer grows small grains (**Table 2; Figures 11 & 12**). Small grains are a viable and common way to fulfill the extended crop rotation requirement for organic certification. **Without the ability to spray chemical pesticides and fertilizers, small grains are a strong candidate for organic systems as they require less nitrogen fertilizer and naturally build fertility and manage pests and weeds in rotations[46].**

Still, organic farmers struggle to make a profit from their small grains. A current small grain farmer from Illinois shared that,

> **"The corn and beans are very profitable, the small grains portion of the operation is where we struggle to make money...The profitability on the corn and beans is what supports the organic operation, the small grains is what we do pretty much because we are required to have the three-crop rotation."**

Supporting the growing organic industry would allow more farmers to receive a premium for raising a product with resilient agricultural practices that include crop rotation.

Additional management

Extending a corn and soybean rotation to include a small grain means more planning and work, especially since small grains do not usually have set input packages nor the same technical or programmatic support. This is especially difficult as most farmers in the Upper Midwest no longer know how to grow small grains.

A non-small grain farmer from Illinois encompassed the sentiment we heard across non- and discontinued small grain farmers when he explained,

> **"I guess you get used to what you're doing sometimes. And maybe a better way to phrase it [is], until what we're doing isn't working might be when we would look to do something different...We want to be known as good farmers. So, it would have to still fit in that structure that we were getting stuff done timely, so. And it sounds weird, but you're throwing a third thing into the operation because, I know it's not just the planning of it. It's a different kind of spray...it's just a different part of our system in complexity that I don't know if it would work or not."**

An agronomist echoed the farmers' thoughts when they explained, "I just feel like one way or the other, corn and soybean production has become the most convenient...It's still like a level of complexity or inconvenience that [farmers] just don't want to tackle anymore." According to a small grains broker, more education and resources available to farmers on how small grains fit into rotations and what is necessary to meet quality standards would increase farmers' interest in growing small grains.

Crop insurance

Crop insurance was not commonly reported by farmers to influence their decision whether to grow small grains (**Figures 9 & 10**) nor correlated with whether a farmer grows small grains (**Figures 11 & 12**). This was reiterated during focus groups and interviews where **farmers told us that they don't make decisions based on insurance but based on what there is a market for**. A current small grain farmer from Illinois said in response to whether better crop insurance policies would make a difference in his choices:

> **"I don't think we would change our decisions. Even though the small grain portion of what we do is more difficult, we have struggled along and made it work. We've never had, other than the barley, a complete disaster growing wheat or oats."**

While crop insurance for small grains is not central to farmer decision making, it may be a missed opportunity to encourage production. Survey data shows that 50% of farmers said that they did not know whether crop insurance was available for small grains in their county. It is likely that farmers are not aware of crop insurance because it is less important to them in their decision making compared to economic factors, and therefore they have not taken the time to investigate it. However, the lack of awareness may also be explained by the failings of the current state of crop insurance for small grains.

Through focus groups and interviews with farmers and crop insurance agents, it became clear that there are several issues that make crop insurance for small grains less valuable compared to crop insurance for corn and soybeans. Farmers explained that crop insurance for small grains was too cumbersome, too complicated, and not worth the value offered. Farmers beginning to grow small grains lack the three-year yield history needed to determine the crop insurance price guarantee. Established base yields at the county level can be used in lieu of yield history, however, farmers pointed out that the yield was often lower than what they expected on their own operation. Moreover, since they are no longer commonly

grown in the region, few counties have established base yields for small grains, meaning the farmers must make a request to use yield data from other counties.

Crop insurance is further problematic for farmers who must take price guarantees based on Chicago Board of Trade prices, which are not reflective of organic prices or higher prices for food-grade production compared to feed-grade, or for specialty or identity-preserved small grain varieties. In addition, crop insurance is not available as of this writing in many counties for all small grains such as rye and Kernza® and cannot be used when double cropped with corn or soybeans.

Whole Farm Revenue Protection is a program that aims to provide insurance coverage for diversified farm systems and could make it easier to insure operations that grow small grains in diverse rotations. Yet, only 8% of farmers in the study used whole farm revenue insurance for their small grains, and most of those reported that the program was complicated to enroll in and must be streamlined for more farmers to use it.

These findings suggest that subsidized crop insurance for small grains could be better leveraged to support small grain production and that insurance policies for small grains need to be adjusted to make them worthwhile for farmers. As one current small grain farmer from Wisconsin explained about crop insurance premium discounts for growing cover crops such as small grains: "The $5 an acre on the crop insurance side probably, I mean it helps, but it's not probably the full ticket, but it definitely helps". More educational outreach regarding crop insurance for small grains is needed, especially to non-small grain farmers, to encourage adoption through this risk reducing policy mechanism. Moreover, more robust coverage, especially for less common small grains, will also be important to maximize the benefits of crop insurance for diversification.

Revenue supports

Revenue supports were not listed as important factors in decision-making in farmers' reported responses (Figures 9 & 10) nor in focus groups and interviews. Several farmers explained that revenue support programs like ARC and PLC were less useful compared to crop insurance because payments and re-assessment of base acres were often delayed several years. The latter is especially important for farmers who choose to diversify from corn and soybeans because they are paid for the crops they have historically planted instead of what they are currently planting. When asked whether revenue support programs impact their cropping decisions, a non-small grain farmer from Illinois replied,

> **"It's definitely important to help. I don't think it factors too much in our corn versus soybean decisions."**

RECOMMENDATIONS

A common issue identified throughout the study regarding how to encourage small grains production was the **"chicken or the egg" of building production supply, processing capacity, and market demand.** On the one hand, a larger and more consistent supply of small grains will likely make it more possible for intermediaries and processors in the Upper Midwest to integrate locally or regionally grown small grains into sourcing decisions. On the other hand, the development of established buyers and processing facilities will likely encourage more farmers to commit to small grains in their rotations. Rather than focusing on which comes first, both ends of the supply chain must be addressed simultaneously through an iterative process to create the greatest impact. The trajectory of soybeans in the early 20th century in the U.S. is one example to consider for small grains development, especially as it emphasizes the many ongoing stages of effort and multistakeholder engagement needed to bring a crop from seed to market (See **Box 1**).

Encourage markets for small grains.

Markets are the strongest driving force behind whether a farmer grows small grains. To "swing" acres from corn and soybeans to small grains, markets supporting strong prices must grow. Based on our conversations throughout this study, much opportunity to develop markets exists. A miller told us that there are more farmers with supply than they can purchase, and that their production is at max capacity. A broker told us of growing interest in the geographic origin of grains from a food and flavor standpoint among food and beverage companies. Policy levers such as tax incentives to both large- and small-scale food companies and processors to source locally grown grain can stimulate production and encourage latent markets. Greater research and development by private companies, NGOs, universities, federal agencies such as the National Center for Agricultural Utilization Research, and state organizations such as the Agricultural Utilization Research Institute in Minnesota into products that integrate small grains, especially less common grains such as rye and barley, can provide new market opportunities.

BOX 1. NEW CROP DEVELOPMENT: THE CASE OF SOYBEANS IN THE U.S.

Soybeans were introduced into the U.S. in the early 20th century and have since become the second most planted crop in the Midwest (**See Figure 1**). But soybeans did not make their way to the top on their own; one account of the "spectacular rise of the soybean"[51] explains the process in detail:

"The introduction of the soybean into U.S. agriculture involved the full spectrum of issues that will have to be addressed in the introduction of any crop. Plant breeders first had to develop adapted varieties by selection and breeding; agricultural advisors had to persuade farmers to raise the new crop and teach them how to do it well; engineers had to improve the available harvesting machinery and processing technology; and processors had to develop lucrative markets for the several co-products of soybean processing. Finally, the groups variously concerned with production, marketing and processing of soybeans had to organize their respective activities into a single coordinated industry with effective pricing mechanisms and with consistent relationships between the supply and demand of whole soybeans and of its products." (Lockeretz 1988, 155)

Increase technical assistance and financial support for small grain equipment and processing.

Non-small grain farmers and farmers who discontinued growing small grains cited a lack of equipment for planting, harvesting, cleaning, and storing small grains as the largest barrier to production following prices and markets. Moreover, many farmers said that their local elevators

no longer buy small grains, and a lack of grain elevators and co-ops to sell into and insufficient nearby value-added processing were the most common of the infrastructure limitations listed by current small grain farmers. When asked, most farmers told us that they would be willing to grow more small grains if there was a processing facility near them. More support for and awareness of programs that support purchases of equipment, on- and off-farm storage such as the USDA-FSA Farm Storage Facilities Loan Program, and local processing infrastructure such as cleaners, mills, and malthouses are needed to help farmers grow and sell a quality product. In addition, more technical support is needed for processors to help farmers meet quality specifications and regional grain processing facilities to sell grain as a food-grade product.

Promote small grains in feed rations.

Small grains are valuable livestock feed with different nutrient profiles than corn and soybeans. Promoting or requiring a minimum threshold of small grains in feed rations, especially for large meat processors, can help create markets for small grains that do not need to meet higher quality requirements of food-grade production. Because poultry producers tend to purchase their feed, while dairy and beef producers tend to grow their feed on-farm, promoting small grains in poultry rations would be especially beneficial to providing new markets for small grains. Educating animal nutritionists and Cooperative Extension professionals on using small grains in feed rations will be needed to support farmers to make the transition.

Limit or tax small grain imports.

Much of the small grain crop available for purchase in the U.S. are grown abroad in places like Canada and Eastern Europe. As of 2022, the U.S. was the largest importer of oats globally, and also a net importer of rye[52]. According to one small grain broker, many companies that import small grains are looking at how they can source their ingredients domestically, presenting an opportunity to build more localized and resilient supply chains. Policies that limit or tax imports of small grains to the U.S., alongside programmatic support to companies to identify local supply and help local farmers meet food-grade quality standards, will go a long way towards building local markets and meeting demand locally.

Eliminate corn ethanol mandates.

Since 2005, oil refiners are required to blend renewable biomass into transportation fuel in increasing increments as mandated by the U.S. Renewable Fuel Standard. The vast majority of biomass is supplied by corn, creating artificial markets for corn and increasing its price by up to 30%[53]. Moreover, research shows that current biofuel production does little to reduce greenhouse gas emissions and is likely more carbon intensive compared to gasoline[53]. While a sensitive subject for many farmers, several farmers in focus groups discussed the ethanol mandate as the "elephant in the room" when it came to diversifying from corn and soybeans. A small grain farmer from Iowa explained that the ethanol mandate was "geared towards helping the big grain farmer just get bigger. And it's not helpful towards a small farmer at all. And it's not helpful towards our communities here in rural Iowa." Removing the corn ethanol mandate within the Renewable Fuel Standard will likely lower the price of corn[54], and at the same time make production of other crops, such as small grains, more competitive. Additionally, distillers grains, a byproduct of ethanol processing, have replaced many small grains as a feed source over the past several decades. Less distillers grains on the market as a result of a revocation of the ethanol mandate would open up an opportunity for more small grains to be reincorporated in animal feed rations.

Simplify, and increase funding and awareness of cost share for small grains.

While farmers reported that cost share was not a core barrier to or driver of production, availability of cost share for small grains had the strongest correlation with whether a farmer grows a small grain. Farmers explained to us that while not as important as markets, cost share can help lower the initial risk of planting a new crop. However, there is a widespread lack of knowledge of available programs, more farmers that want to participate in these programs than available funds, and the programs that exist are difficult to navigate. Increased funding, simplification of the application process, and greater flexibility for implementation and end-use is needed. Moreover, more educational outreach on cost share and other incentive payments for small grains, in particular to non-small grain farmers who may be incentivized to trial a small grain in a rotation, will ensure the programs have the largest impact on adoption of small grains.

Improve and promote crop insurance for diversified production.

Most corn and soybean farmers rely on crop insurance to maintain income during dips in market prices and losses from severe weather. Small grains can similarly be promoted through risk reducing policy mechanisms such as crop insurance, however, crop insurance for small grains should be improved to maximize its potential to drive adoption. Farmers pointed to several issues with crop insurance as it currently exists that made it more difficult to insure small grains compared to corn and soybeans. Providing more flexibility and alternatives to yield history requirements, providing differentiated price guarantees for organic or higher value varieties, allowing double cropping, and streamlining paperwork for programs like Whole Farm Revenue Protection could be important to maximize the benefits of crop insurance for less common commodities. Additionally, given that the majority of farmers in our study did not know whether crop insurance for small grains was available to them, more outreach on the availability of crop insurance policies for small grains is needed.

Shift federally subsidized crop insurance to incentivize conservation.

While this research shows that crop insurance availability for non-core commodities like small grains is not a main factor in farmer cropping decisions, most farmers heavily rely on crop insurance for their cash crops—corn and soybeans. Crop insurance inherently lowers the use of agronomic means of distributing risk, including planting more types of crops and using conservation practices. Instead, it rewards farmers who plant common commodity crops and subsidizes ecologically risky behavior. To ensure crop insurance is consistent with goals of environmental conservation, crop insurance should reward farmers utilizing conservation practices that build on-farm resilience.

Encourage organic agriculture.

A core tenant of organic agriculture is the mandated minimum three-year crop rotation in which small grains become an integral part in the Upper Midwest, whether they are grown for the soil health benefits or as a food product. A more robust organic grain marketplace would allow more farmers to receive a premium for raising a product with resilient agricultural practices that include crop rotation.

Promote integrated crop-livestock operations.

Crop farmers with livestock in their operations can use small grains as a low-cost feed and have a built-in secondary outlet for grain that does not meet food-grade quality. Encouraging integrated crop-livestock operations can be achieved through more technical assistance and cost share through programs like EQIP as well as more research on the benefits of integrated crop-livestock systems.

Educate farmers on the system benefits of small grains.

The small grain farmers in the study recognized the ecological and agronomic benefits that small grains bring to their agricultural systems, whether as a cover crop, green manure, livestock feed or bedding, or as a cash crop. Greater educational outreach to non-small grain farmers via Cooperative Extension and other agricultural professionals is needed to emphasize the low-input, low-cost nature of small grains, their benefits in crop rotations, and to promote systems thinking in crop rotation and planning. Starting a small grain cover crop may be a promising way to introduce farmers to small grain production.

Increase research on small grains in crop rotations.

More research is needed to document the benefits of small grains for promoting soil health, improving water quality, and lowering pressure from weeds, pests, and disease. This research is needed for a diverse array of small grains and from both academic and non-academic sources. Particular attention is needed to quantify the economic benefits of diversified rotations that include small grains—the most common response when farmers were asked about research needs during interviews and focus groups. Farmers must know that it will pay to add small grains to a rotation in order to take the initial risk of adoption.

Increase long-term funding for small grains breeding.

Funding to small grain breeding is in decline, and improved varieties with traits specific to the Midwestern climate are needed to enable farmers to meet food-grade quality standards. More sustained, long-term federal funding to land grant universities and Agricultural Research Service (ARS) units is needed. Commodity association check-off programs support the breeding efforts of core commodity crops like corn and soybeans, however, are less common and less robust in the Midwest for small grains. Commodity associations for small grains could be developed or strengthened to provide check-off dollars for varietal development. Given the lack of acreage for many small grains, a broader, coordinated strategy that advocates across multiple types of small grains, such as the Maryland Grain Producers Association, may be a promising way to collectively support the small grain industry.

Support value chain coordination.

Regional networks like the Common Grain Alliance (Mid-Atlantic), Colorado Grain Chain, and Artisan Grain Collaborative (Midwest) provide value chain coordination capacity across the small grains supply chain, connecting and building relationships with stakeholders from seed to table. Continued funding for these initiatives to collectively engage the research and advocacy community along with farmers, processors, and end-users, can help to advance the adoption of small grains on the landscape and in the local food system.

Conclusion

Adding small grains in cropping rotations is one of the most logical ways that corn and soybean farmers can diversify their systems, concurrently reaping a broad suite of agronomic and environmental benefits. Yet, through multiple methods and ways of knowing to better understand causality, we find there are a myriad of interconnected reasons why farmers in the Upper Midwest primarily plant only one to two crops and why diversifying to additional crops, in particular small grains, is challenging. Farmers identified markets and prices as the most important, yet abundant markets and high prices for corn and soybeans did not occur on their own. They grew because they are high yielding due in large part to decades of public and private breeding, were subsidized and promoted by the federal government through direct payments[8] and crop insurance, and subsequently found outlets and accompanying processing as livestock feed, ethanol, sweeteners, additives, and a range of other products.

Over the last century of agricultural industrialization in the Midwest, we have made it easier economically and agronomically to grow corn and soybeans, and in turn harder to grow other crops, even those that were once as common in rotations as small grains. In the process, we have divorced crop and livestock production, a system that supported more diversified production. Each of the factors that went into making corn and soybeans easier to grow and market must be considered when understanding the drivers of the current agricultural system. **To level the playing field for small grains, it is clear that more robust markets are necessary. However, "you can't build the market without the product" as one Wisconsin farmer told us.**

The factors that enable strong agricultural markets and can support farmers to produce small grains including processing infrastructure, crop research and development, organic production, the integration of crops and livestock, federal crop insurance, and supply mandates will all play a role.

Each must be addressed to ensure that small grains have the same market potential as corn and soybeans in the Midwest.

8 Direct payments ended in the 2014 Farm Bill and were largely replaced by expanded support to federally subsidized crop insurance and to newly introduced commodity revenue and price support programs ARC and PLC [55, 56].

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