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The Importance of Social Support and Communities of Practice: Farmer Perceptions of the Challenges and Opportunities of Integrated Crop–Livestock Systems on Organically Managed Farms in the Northern U.S.

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Abstract: Most U.S. farms today specialize in either crop or livestock production, failing to harness the potential economic and environmental benefits of integrated crop–livestock systems (ICLS). This specialization is particularly contradictory for organic operations, which aim to promote biodiversity and reduce reliance on outside sources of feed and fertility. This study investigated the challenges and opportunities experienced by farmers interested in integrating crops and livestock on organically managed farms in Iowa, Pennsylvania, and Minnesota. Qualitative methods, including focus groups and interviews, generated four categories of challenges: farming norms, complexity of management, biophysical conditions, and financial costs, and four categories of opportunities: increasing support for ICLS, financial and labor advantages, biophysical improvements, and animal welfare. Discussion of the data analysis demonstrates how most of the challenges of ICLS are mitigated by opportunities. For instance, increasing support for ICLS means there are growing communities of practice in which farmer-to-farmer knowledge exchange and peer support overcome obstacles to success in these systems. Unmitigated challenges that are beyond the control of farmers include regional infrastructure, financing and insurance, and long time horizon for returns. These three unmitigated challenges may require interventions such as policy support, economic incentives and social infrastructure to enable successful farm transitions to ICLS in this region.

Keywords: integrated crop–livestock systems (ICLS); best management practices (BMP); farm transitions; organic agriculture; small-scale farms; closed-loop; qualitative methods; barriers to adoption

1. Introduction

Historically, pastured livestock were an integral part of agricultural landscapes. These integrated crop–livestock systems recycled nutrients from pasture and crops produced on the farm, providing adequate soil fertility to sustain crop and animal production without the use of off-farm inputs [100,2]. However, following the green revolution in the latter half of the 20th century and continuing today, farms have become more specialized. Fewer and fewer U.S. farms produce both crops and livestock in a global agricultural system that offers scant incentives to do so [100,2,3,4,5].

Today, most farms in the U.S. rely on intensified monoculture cultivation; eighty-eight percent specialize in either crop or livestock production [6]. This loss of diversity extends to the type of crop or livestock. In 2015, only eight percent of farms reported income from more than four field crop species, while the percent of cattle produced on farms without crops has nearly doubled since 1996 [6]. While this tendency towards specialization is more prevalent in conventional agriculture, the trend is also evident among certified organic farms, especially at larger scales [7,8].

The historical trajectory away from crop–livestock integration towards specialization is a hallmark of basic capitalist tendencies in food production [5,9,10,11,12]. By producing only a few crops or one species of livestock, farms become more efficient, exploit economies of scale, and harness competitive advantages, buoyed by a supportive policy environment [100,4,13,14]. However, by focusing on either crops or livestock, farms fail to harness natural synergies that could improve their economic and environmental functions [2,15,16,17,18]. This agricultural specialization is especially contradictory for organic operations, which aim to promote biodiversity and reduce reliance on outside sources of fertility and feed [5,8,19,20,21,22].

Consumer demand for organic animal products in the U.S. has outpaced supply of domestic feed stocks for several years, and the demand is likely to increase [23,24]. Many specialized organic livestock producers are dependent on imported organic grains for feed. The specter of import fraud in these grain markets [25] and high costs for transportation due to a lack of domestic processing facilities [26] create an incentive for reevaluating the economic feasibility of spatially disarticulated, monoculture organic production.

In light of the potential benefits of integrated crop–livestock systems (ICLS), this interdisciplinary project examined the agronomic, environmental and economic effects of organically managed, integrated crop–livestock systems. The geographic focus encompassed three of the top ten states with the most certified organic farms in the country: Pennsylvania, Iowa, and Minnesota [27]. The project investigated crop–livestock integration at the farm level to provide evidence of the challenges and opportunities of a systems approach to integrated crop–livestock enterprises. The agronomic and economic research components measured the soil, crop, livestock, and farm economic consequences of grazing dairy and beef cattle on winter rye (*Seacle cereale*) and winter wheat (*Triticum aestivum*) cover crops in an organic cover crop—corn/soybean—pasture rotation [28]. The project's sociological component explored integrated crop–livestock rotations, as defined by farmers, including rotations with crops and livestock not considered in the agronomic portion of the project.

This study reports only on the sociological component of the larger interdisciplinary project. The sociological component examined the experiences of farmers in the study's region, addressing the following research questions.

1. What challenges and opportunities do farmers experience, or perceive, regarding integrating crops and livestock that are relevant to organically managed farms?
2. In what instances do the opportunities of integration mitigate the challenges?
3. Which challenges of integration are perceived, or experienced, as being unmitigated or beyond the control of farmers?

2. Literature Background

The examination of farm transitions to integrated crop–livestock systems is situated at the crossroads of three research lineages: (1) the microlevel consideration of adoption of conservation best management practices; (2) the macrolevel view of the political economy of food systems; and (3) integrative or network approaches to understanding farm systems.

2.1. Microlevel: ADOPTION of Best Management Practices

In a recent review of best management practice (BMP) adoption research, Liu and colleagues [29] (p. 19) reported, "certain factors, in isolation, show a clear and positive effect on BMP adoption;

these include access to credible information, government subsidies, environmental consciousness, and profitability of practices". Likewise, Baumgart-Getz and colleagues [30] (p.17) found that variables with the most impact were "access to and quality of information, financial capacity, and being connected to agency or local networks of farmers or watershed groups". However, the effects of characteristics such as "farm size, land tenure, diverse operation, farmer experience, education, age, gender, political views, and social political beliefs", remain "unclear or debatable" after more than 30 years of research [29] (p. 19).

This line of research on adoption of BMPs often implicitly rests on diffusion of innovations theory [31,32]. Loosely, this theoretical framework develops from the premise that researchers identify a science-based BMP and then extension initiatives target farmers who are most likely to adopt it, assuming that from these early-adopters, the BMP will spread. Perhaps due to a dearth of truly interdisciplinary agricultural systems research [33], or a fissure between extension and rural sociology [32], the trenchant and longstanding critiques of this theory [19,34,35,36] have not widely influenced researchers working on agricultural conservation behavior. In the 1990s [37,38] and in the mid-2000s [39,40], reviews concluded that this line of research found no common characteristics of farmers, farms, or contexts that predict conservation practice "adoption".

In response, the variables tested have expanded to include the influence of some macro and mesolevel factors such as norms, policies, markets, geography, risk, time-frames, and information networks, using more diverse methods to do so [29]. However, the most recent reviews again found no parsimonious set of variables with explanatory power to predict farmer conservation practice behavior or transitions to organic or alternative forms of farming [29,30]. Recognizing the field's repeated shortcomings, Prokopy [33] suggested that a move away from quantitative survey-based investigation searching for durable determinants towards more nuanced qualitative modes of inquiry into farm-level decision-making was needed.

2.2. Macrolevel: Political Economy of Food Systems

Building on the early (circa 1970s) critique of the microlevel view taken under adoption frames, political economy approaches to investigating farm-level decisions turned to understanding sweeping changes in the farm economy ushered in by the latter half of the 20th century. This body of literature details how individual farms are best understood in the context of the larger food system. Through this lens, capitalism and its related policy frameworks determine to a large extent the methods of farming that are viable and profitable [41]. Globalization, free trade agreements, transnational governing bodies and corporations reach deeply into rural communities, determining which crops and livestock are produced, where, and for how much they can be sold [42].

The political–economic structure of conventional U.S. agriculture is embodied in a productivist mindset corresponding to the dominant farming norms that dictate two overarching goals: higher yields and profits [43]. This constraining structure includes a bevy of factors shaping, and being shaped by, the food system. These factors include labor and immigration policy [41,44]; public and private agricultural research [42]; patenting regimes [45]; agricultural policy [46]; financial firms and retailers [47]; farming households [48]; marketing, tastes, and diets [49]; contracts and integrators [12]; and the transnational corporations where food system power and profits accumulate [11,43,50,51].

The dominant structure of U.S. conventional agriculture, bolstered by longstanding policy and economic support, undermines and usurps alternative forms of farming that intend to mitigate its environmental consequences [12]. For instance, Guthman and colleagues [8,52,53,54] outlined the political–economic constraints that led to the conventionalization of California organic agriculture. Organic production, which was originally premised on truly alternative practices and institutional arrangements, now resembles conventional agriculture in many U.S. locales through "rule-setting, intersectoral dynamics, and agronomic practices" imposed by powerful agri-business players [54] (p. 301). These macrolevel conditions drive industrialization and "undermine the ability of even the most committed producers to practice a purely alternative form of organic farming" [54] (pp. 301–302).

As large agribusiness firms, such as processors and retailers, have entered an organic market supported by institutional arrangements and policies that favor conventional production, they engender the conditions for large-scale industrialized organic farms to create and dominate global organic supply chains that squeeze farm gate prices for commoditized organic products [7]. The growth of this conventionalized organic production has led to a bifurcation of organic farming in the U.S. [7,54] and, arguably, in other industrialized countries [55,56,57]. Organic industry bifurcation happens when diversified agroecological farms cannot compete with specialized conventionalized organic commodity producers. The agroecological farms turn away from organic certification and national/international markets to focus on trust-centered values-based local markets built on community, while conventionalized certified organic farms relying on input substitution methods gain economies of scale that allow for competition on national or international organic commodity markets [7,22,54,58]. There is considerable contestation over the rigidity of bifurcation's suggested polarization; organic farms are more nuanced than the dualistic term suggests [59].

Recognizing that while there is considerable nuance, organic conventionalization and bifurcation do signal divergent suites of farm management practices. Conventionalized organic farms rely more on an input substitution framework, using approved organic pesticides and fertilizers in a manner akin to conventional farm management. These farms tend to be larger in scale, and can be split operations where some portion of the acreage is organically managed while the remainder is in conventional production using synthetic inputs [54,56,59]. Agroecological farms rely more on diversity and building soil health to produce crops and livestock. This spectrum of management strategies, from profit-driven conventional organic or "organic lite" to a closed-loop, values-driven "deep organic" are shaped by the food system within which they are embedded [54].

For organic livestock producers in the U.S., conventionalization and bifurcation combine with additional macrolevel forces to constrain the possibilities for profitable livestock production. Hinrichs and Welsh [12] detail the history of livestock integration and consolidation, questioning whether livestock farmers can choose to change production methods, given the confines within which they are embedded. Such macroscale factors significantly constrain microlevel conservation action on conventional and organic farms today [29,60,61].

2.3. Integrative Approaches: Networks and Farmer Identity

While political economy approaches identify the structural constraints on farm-level action, they do not often grapple with the interaction of farm particularities or farmer agency in the context of these larger structures [62]. More expansive, integrated approaches can recognize structural forces while also attending to farm-level influences on management decisions [63,64]. Blesch and Wolf [65] take an integrative approach to understanding farm transitions to agroecological systems, identifying the external and internal resources that enable or constrain the transition process. Internal resources, categorized as cognitive and ecological, are interconnected with the external resources of farmer networks, knowledge organizations, private service providers, and agricultural policy. They find that transitioning to agroecology is knowledge intensive, related to a shift in networks, identity and thinking. Similarly, in the examination of cover crop adoption, Roesch-McNally and colleagues [66] explicate structural and field-level barriers that are overcome through peer networking and experimentation, finding that farmers with a "whole system approach" and an explicit goal to promote soil health were more likely to use cover crops.

Social networks, knowledge networks, communities of practice, and other relationship driven models also provide an integrative or mesolevel frame for understanding farmer management decisions. Nelson and colleagues [67] found that during the transition period to rotational grazing, farmers relied on an extended network of social ties, returning to a truncated set of ties after the transition. Oreszczyn and colleagues [68] explicated a wide web of influencers that impact farm-level decision-making, finding that farmers individually push the boundaries of their networks to learn, whereas in other communities of practice only a select few engage in this boundary role on behalf of the group. Padel [69] found that early organic farmers taught themselves and one another in a farmer-led knowledge network that became a resource for others transitioning. Moraine and colleagues [17] designed a participatory research project in which farmers organized at the landscape-level to integrate crops and livestock in their geographic locales with the goal of promoting greater group-level farm sufficiency through direct farmer exchanges of knowledge and products.

Farmer identity and norms are embedded in these networks. Farmer identity and "good farmer" norms influence farm-level system shifts and on-farm practices [70]. For instance, new organic farmers are exposed to a novel set of values, such as the importance of animal welfare, soil health, and quality food; these values augment the typical production-orientation of a conventional farmer's "good farmer" identity [71]. Conventional farmers who transition to low-input "effectively-organic" systems to address economic pressures also often reshape their ideas of what it means to be a good farmer in light of the alternative organic farming values they encounter [71,72]. Augmenting norms is powerful because "pride and peer pressure" can motivate farmer conservation behaviors [39] (p. 44).

3. Methods

This study employed qualitative methods to explore farm-level decision-making embedded in a multilevel socio-ecological system. Focus groups and interviews generated the data presented. These methods were employed with an attunement to the roles of positionality, intersectionality, and power, seeking to minimize inequality in the research process [73,74]. All participants gave their informed consent before they participated. The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Iowa State University (project no. 16-348).

3.1. Data Generation

Participant farmers managed land in, or adjacent to, one of the three project states: Iowa, Pennsylvania or Minnesota, and were invited to participate either through an organic-oriented project field day or direct outreach through organic-oriented channels. Recruitment prioritized livestock farmers who were interested in or currently grazing cover crops. Recruitment also focused on certified organic farms, but participation from all farm types was allowed if the farmer was experienced or interested in integrating crops and livestock. An insufficient number of certified organic farm managers that were experienced in integrated systems enrolled in the study, reflecting anecdotal evidence of a small population of such farmers in this region; the broader recruitment strategy allowed for a better understanding of the challenges and opportunities for organically managed farms, regardless of certification status. The recruitment strategy's focus on organic-oriented outreach venues ensured that participants self-identifying as conventional farms were interested in, or utilizing, low-input organic techniques and organic management strategies.

Participants were primarily beef and dairy producers; some also raised hogs, poultry, goats, sheep or solely crops. The most common crops grown were corn and soybeans, reflective of the norm in the study's region. Participants also raised a variety of other pasture forages and crops, including alfalfa, rye, wheat, barley, vegetables, orchard fruits, and nuts.

The total number of participation incidences was 51 over two years: 21 focus group participants and 30 interviewees. However, the total number of research participants was lower, as an individual farmer may have participated in an interview and a focus group. To protect anonymity, an individual's participation in multiple research methods was not tracked.

3.2. Focus Groups

Three farmer focus groups (21 farmers total) were conducted between July and August 2016, (Table 1). This method was employed to generate and observe interactions among diverse farmers interested in or practicing integrated crop–livestock systems. The focus groups captured stated experiences on the given topic while also providing a space for the generation of meaning-making [75,76,77]. Focus groups offer a glimpse into the group level construction of novel ideas that may also serve as a germinating point for participants, from which ideas or behaviors may later develop [78].

Groups comprised of six to eight farmers were convened at each of the project's agronomic research field sites: The Rodale Institute in Kutztown, Pennsylvania; Iowa State University's Neely-Kinyon Memorial Research Farm in Greenfield, Iowa; and the University of Minnesota's West Central Research and Outreach Center in Morris, Minnesota. These ~90-min group discussions took place during a field day or soon after. Farmers who volunteered to join the group were paid 50USD for their participation.

Table 1. Participants in three focus groups (*n* = 21).

State/Group	Farm Type	Crops	Livestock
IA 1	organically managed	pasture	lamb, turkey, chickens
IA 1	conventional	row crops	hogs
IA 1	retired	-	sheep, cow-calf
IA 1	conventional	corn soybeans, pasture, cover crops	cow-calf, sheep
IA 1	organically managed	grass	dairy, cow-calf
IA 1	conventional (no-till)	corn, soybeans, hay, pasture	beef
IA 1	organically managed	vegetables	goats (future: sheep, pigs, broilers)
IA 1	conventional	corn, soybeans	cow-calf
MN 2	organically managed (in transition)	hay, pasture	beef (future: dairy)
MN 2	organically managed	pasture	dairy, beef, hogs
MN 2	organically managed	pasture, orchard, vegetables	beef
MN 2	certified organic	pasture, cover crops	dairy, beef
MN 2	certified organic	-	dairy
MN 2	-	pasture	beef
MN 2	certified organic	-	dairy
PA 3	organically managed	hay	beef
PA 3	organically managed (in transition)	dry edible beans, corn, rye, vetch, forage peas	-
PA 3	conventional	corn, soybeans, wheat, barley, hay	pastured chickens
PA 3	conventional	alfalfa, millet, pasture	beef
PA 3	organically managed	pasture	beef
PA 3	organically managed (in transition)	cash crops	-

3.3. Interviews

Open-ended, semistructured phone interviews (*n* = 30) were conducted with farmers from a range of different farm types (Tables 2 and 3). This style of interviewing is designed to elicit detailed information about participants' personal experiences regarding a directed topic [79,80]. Interviews held in 2016 engaged many farmers new to integrated crop–livestock systems, while the majority of 2017 interviewees were more experienced. Interview questions sought to understand a farmer's current system, experience with integrating crops and livestock, challenges and opportunities that were perceived or demonstrated regarding integration, how research could support their work, and preferred outreach methods and channels. Interview length varied from 30 to over 70 min.

Table 2. 2017 interview participants (*n* = 18).

State/ID	Farm Type	Crops	Livestock
IA 1	certified organic & transitioning	corn, soybeans, hay, small grains	sheep, hogs, poultry
IA 2	conventional	corn, soybeans, hay, small grains	beef
IA 3	conventional	pasture, small grains	beef
IA 4	organically managed	pasture	beef, hogs, poultry
IA 5	conventional	corn, soybeans, alfalfa, rye	dairy
IA 6	certified organic	vegetables, alfalfa, hay	beef, hogs, poultry

MN 1	conventional	pasture, corn, soybeans, wheat, small grains, alfalfa	beef
MN 2	organically managed	pasture, cover crops	dairy
MN 3	conventional	pasture, corn, cover crops	beef
MN 4	organically managed	potatoes, rye, vetch	beef
MN 5	certified organic	pasture, corn, small grains	dairy
MN 6	conventional	corn, soybeans, wheat	beef
PA 1	certified organic & organically managed	pasture, corn, soybeans, small grains	beef
PA 2	certified organic & organically managed	vegetables, pasture	beef, sheep
PA 3	transitioning	pasture, cover crops	dairy
PA 4	conventional	pasture, hay, corn	beef
PA 5	certified organic	pasture, hay	dairy
PA 6	organically managed	pasture, hay, cover crops	beef, sheep, hogs, poultry

Table 3. 2016 interview participants (n = 12).

State/Id	Farm Type	Crops	Livestock
PA 2	organically managed	pasture, turnips, oats, corn, small grains	beef
PA 3	certified organic	pasture, hay, feed grain	dairy
PA 4	certified organic	winter wheat, rye, spelt, hulless oats, corn, black beans, buckwheat	beef
PA 1	organically managed	pasture, hay	beef
PA 5	organically managed	pasture, hay, vegetables, wheat, rye	beef
IA 1	split certified organic and conventional	pasture, hay, corn, beans, oats, clover, rye	beef
IA 2	conventional	hay, corn, soybeans, rye, wheat, oats, pasture	beef
IA 3	conventional no-till	corn, soybean, rye, hay	beef
IA4	certified organic	corn, soybeans, wheat, alfalfa	n/a
MN 1	certified organic	pasture, alfalfa, oats, barley, wheat, triticale, corn, peas, edible beans, hay	dairy
MN 2	certified organic	corn, soybeans, oats, hay, pasture	beef
MN3	organically managed	corn, soybeans, cover crops	beef

3.4. Data Analysis

Interviews and focus groups were audio recorded and transcribed verbatim. The resulting transcriptions were analyzed using traditional qualitative coding techniques aided by the Dedoose [81] web application, which helped with organization and tagging of quotes and excerpts. A modified constructivist approach to grounded theory was employed, whereby the data generated the analytic structure presented [82]. Two broad categories of "parent" codes were predetermined: challenges and opportunities. All "child" codes emerged during data analysis. The emergent child codes appear as the themes described in the findings section, such as farmer partnerships or stocking density. Interim summative reports in 2016 and 2017, presenting themes and quote excerpts, were shared with all research participants and the research team. The purpose of sharing the report with farmer participants was both a means of member-checking, to demonstrate the credibility and authenticity of the conclusions [83], and as a tool for further engaging farmer participants in the research process.

4. Findings

Eight main categories emerged from the data: four challenges and four opportunities (Table 4). The main categories are populated by twenty-nine subcategory themes, which are italicized in the text and described with illustrative excerpted quotes.

Table 4. Challenges and opportunities of organically managed integrated crop–livestock systems.

Challenges	Opportunities
Farming Norms - dominant farming system - dominant markets - financing and insurance - regulatory environment	Increasing Support for ICLS - communities of practice - market trends - farmer partnerships
Complexity of Management - intensive management - livestock commitment - cover crop challenges - stocking density	Financial & Labor Advantages - economic resilience - efficient fertilization - less labor intensive - utilize marginal land
Biophysical Conditions - existing soil issues - soil health tracking - climate and weather	Biophysical Improvements - soil health - weed suppression - pest suppression - pollinator habitat
Financial Costs - infrastructure - time horizon for returns - decreased yields - perennial efficiency	Animal Welfare - extend grazing - forage production - pasture improvements

4.1. Challenges of Integration

4.1.1. Farming Norms

Farmers perceived that the *dominant farming system* engenders large acreage in a conventional corn-soybean rotation. The dominant livestock models are conventional beef feedlot, beef cow-calf, hog, or dairy operations. Participants discussed how unusual organically managed integrated crop–livestock systems are in their communities:

> "It's completely nontypical from farms anywhere that I know of. Basically, the way it's been for the last at least 35–40 years is there's crop farmers and there's livestock farmers. Nobody does both anymore".

Farm community norms around conventional, specialized agriculture are influential, presenting a challenge to widespread crops–livestock integration, even on organic farms. These norms are both descriptive, in that farmers observed the behaviors associated with these norms regularly, and injunctive, in that participants understood that these behaviors are accepted, while others, such as integrated models, are marginalized. These norms reach across farm fences and also into farm families, leading one farmer to assert

> "That's the challenge: overcoming 'that isn't the way my daddy did it".

Participants said that the notion of a "good farmer" is related to operating within these norms. For instance, the issue of unsightly weeds or cover crops continues to be a normative challenge for organic farms, as the following focus group exchange suggests

> Farmer: "He [the land owner] was mad when I told him I never sprayed [the beans]—you want to rent my land and you don't even spray?!... I'm a poor farmer."

> Responding farmer: "Socially the metrics on how we define a good farmer need to change."

An organic farmer operating an integrated crop–livestock system with cover crops is often aware of being at odds with the norms. Operating outside the norm results in farmer reports of challenges stemming from the *dominant markets*, which are developed in tandem with the dominant farming models. Reported market challenges for integrated crop–livestock systems included weak demand for this kind of meat or dairy product, inadequate pay price to cover expenses, and ill-informed consumers. Paradoxically, increasing organic demand means that some markets are saturated. Retail outlets are well-stocked with organic and grass-fed products, often not locally sourced. Farmers suspected that this suppresses demand for direct sales from local integrated farms.

Participants also suggested that the agricultural *financing and insurance* industries are invested foremost, or even solely, in the *dominant farming system*, not understanding or valuing integrated organic systems. While unlikely, some farmers reported that local agencies would only provide crop insurance for corn and soybeans; in effect, "that's all the banker would let them plant". While others talked of costly liability insurance to cover the potential for escaped pastured livestock causing damage. This financial infrastructure polices a farmer's ability to experiment with novel systems. As one farmer said

> "You can't have a banker breathing down your neck…you won't be able to try the things you should try."

These challenges make complex rotations and integration difficult and risky for organic farmers, especially because the *time horizon* for realizing the rewards of an integrated system are drawn-out beyond typical agriculture financing timelines. Another farmer was frustrated with his local banks, saying

> "Bankers have to realize that we are investing in the natural capital of the land, we're not necessarily going to pull a profit the first year…they still will not allow me to buy fertilizer to fertilize my cover crops in order to fertilize the next year's crop… The whole thing is, you have to pay back operating the year that you use it. With an organic system, that's unobtainable."

Relatedly, farmers perceived that the broader *regulatory environment*'s support for the *dominant farming system* disadvantages organic and integrated systems. For instance, the issue of crop insurance was perceived as a challenge, leading one farmer to say

> "I don't think that grass farming will ever become popular again until the government gets out of subsidizing row crops."

Cost-sharing programs supported by federal and state policy, such as the United States Department of Agriculture's (USDA) National Resource Conservation Service's Environmental Quality Incentives Program and Conservation Reserve Enhancement Program were experienced as supportive of integrated systems. At the same time, farmers felt that these programs are not adequately promoted, not robust and not adaptive enough to support the leading edge. As one farmer said

> "We learned that they're too far behind what we're doing."

Participants suggested that the organic label, a voluntary regulatory system administered by the USDA National Organic Program [84], is inadequate: it does not capture the practices and benefits of integrated organic systems. In this way, the organic standards are perceived as a challenge for integration because they do not signal all of the animal welfare and environmental benefits that integrated systems engender. Farmers suggested that the organic label houses substantively different kinds of organic farming systems, giving no indication of these differences to consumers, and hence no incentive for integrated crop–livestock systems, as evidenced by this farmer's statement:

> "The organic label would lump us in with people who fed grain to their cattle, that is something we're not particularly excited about."

Additional regulatory challenges included the difficulty of having a successful inspection of a moveable milking parlor, the challenges of spreading enough manure for fertility without conflicting nutrient management regulations, and the USDA quality grading of 100% grass-fed beef as less than "Choice."

4.1.2. Complexity of Management

There is a perception that integrated organic systems demand more complex and *intensive management* than nonintegrated systems. The intensity and complexity of management was a concern expressed by those interested in integrating, while experienced integrated farmers did not perceive this as a challenge, but as a fundamental trait of the system. Part of the complexity of integrated systems, beyond that which is inherent to all organic systems, arises from the need to discover the optimal crop and livestock mix to meet a farm's particularities. Farmers discussed the need for diverse crops and livestock; the problems associated with single species cover crops; and the complexity of multiyear rotation planning. Participants had different perceptions and experiences regarding appropriate breeds of cattle for grazing or meat quality, and some perceived that securing the right genetics played a vital role in successful outcomes. There was also a general perception that integration is more complex for dairy operations than for beef.

There is considerable knowledge needed to successfully raise and market one type of animal product, and yet several participants raised multiple livestock species. While this adds complexity to the system, such diversity may offer benefits, as one farmer described:

> "We like to keep the cattle and the sheep together because they help break each other's parasite cycles, they like different plants, there's a better point of grazing of a given paddock when there have been both bovine and ovine on there. The pigs we use to open up more pasture that we're able to take advantage of…"

There was a common perception among participants, especially for crop farmers, that *livestock is a commitment*, requiring more time, more complex management, and more physical stamina than crops alone. There was also a perception among some livestock farmers that the more intensive the rotational grazing, the more challenging in terms of time commitment. The issue of off-farm work enhanced this challenge; since most participants engaged in off-farm work, the time commitment was perceived as a considerable challenge to introducing livestock. In addition, some farmers who grazed livestock perceived perennial pasture as environmentally and economically superior to integrated systems that rely on annuals, partly because pasture is less time-consuming than annual cropping.

Several participants discussed the challenge of optimizing *stocking density* to manage pastureland intensively, spread enough manure evenly, or convert existing grassland to marketable product without harvesting (i.e., through livestock product sales). An inadequate *stocking density* led some participants to use both their own livestock's manure and additional purchased manure to maintain soil fertility. A challenge arose from an organic crop farmer on more than 700 hectares (1800 acres) who also managed a 4000 head conventional hog operation. His hogs, plus a neighbor's 3000, produced enough manure to fertilize only a third of the organic cropland. He suggested that a much larger herd would be needed to achieve a closed-loop integrated system on a farm this size. Other farmers suggested that a challenge for such large-scale organic farms is that they are too large to make integration viable, calling into question the environmental sustainability of excessively large organic operations. Conversely, livestock farmers who lack sufficient pasture noted that the cost of acquiring land is a challenge to integrated systems.

Adding to the intensity and complexity of management, participants discussed the many *challenges of cover crops*. Perceived and experienced *challenges of cover crops* included the seed cost (especially for multispecies mixes), the timing and type of seeding; fertilizing (in the case of inadequate soil fertility), weed pressure, compaction from grazing; the timing of grazing cover to ensure adequate nutrition and later regrowth, the timing of planting cover crops given weather and short growing windows, and the allelopathic effects of rye on some subsequent crops. A few experienced integrated farmers also discussed potential negative health effects for cattle grazing on cover crops, such as bloat and even calf death due to inadequate mineral balance in their early experiments grazing cover crop mixes.

4.1.3. Biophysical Conditions

Farmers were concerned about the negative effects of inherent or inherited *existing soil issues* on their land. In general, agricultural soils in the U.S. are depleted due to decades of intensive farming. While farmers perceive that integrated crop–livestock systems promote soil health, a challenge arises when farms start with low soil quality, as this farmer relates:

> "Unless you've got really high-quality soil… you probably won't ever get, in our experience so far at least, the production in terms of grazing dates from annuals as you do from perennials."

The time lag between implementing integrated practices and reaping soil health benefits was perceived as a considerable challenge. In addition, there is a perception among farmers considering integrating that soil compaction will be a challenge when grazing livestock on cropland. This perception was both allayed by experienced farmers who did not report yield losses due to compaction and also confirmed by other farmers who did report compaction.

Because integrated systems are often pursued with soil health as a goal, the need to better understand how soil reacts to new management practices is a challenge farmers would like to remedy. There was a perception that the available *soil health tracking* tests are either too expensive, not widely accessible, or not suited to farmers' needs. As one farmer said,

> "The biggest thing we struggle with here is soil testing… Our cover crops are harvesting nutrients, there's no soil test that will say how much of that is available [for the main crop]… The information we're getting from the common soil test does not work for us."

Participants also discussed their desire to learn basic soil chemistry and biology, because, in some instances, they felt that soil labs were not providing them with applicable information. In particular, farmers were interested in understanding the type and quantity of nutrients that an increase in soil organic matter will make available for their crops. Several participants suggested that simply tracking organic matter content would be an inexpensive, feasible method for accomplishing this, but few were regularly doing it over long periods.

An additional biophysical challenge arose with *climate and weather* issues specific to integrated crop–livestock systems beyond the challenges they present to all farms. Too much or too little rain, hard crusts on snow pack, and hot drought conditions all compound management challenges and complexity for the crops, livestock, and soil in these systems. For instance, one farmer discussed precipitation:

> "Spring grazing has been a little disappointing just because we typically have pretty wet springs in April and it's too wet or too muddy to have the cattle out on row crop ground, there's not enough rye out there to protect the soil, and we hate to compact the soil..."

Weather extremes and unpredictable climates are challenges for operations when one of the goals of integration is an economic savings from growing all inputs on the farm. However, some farmers related that their switch to an integrated system led to more resilience in the face of weather and climate challenges.

4.1.4. Financial Costs

Insufficient physical *farm and county infrastructure* poses challenges to integrating crops and livestock, particularly on organic farms. At the farm-level, farmers spoke of the cost and labor involved in stationary and portable livestock fencing, and the need for reliable water sources in all weather to all fields. Additional farm-level infrastructure challenges included barns or other protection for livestock, special seed drills, or other equipment to enable certain cover crop mixes. Participants also discussed the cost of farm equipment rising faster than inflation, which, while not confined to integrated systems, nevertheless poses a challenge to shifting how an operation functions. At the county-level, farmers recounted the need for organic processing facilities. Proximity to an organic livestock or grain processor was a challenge for many farmers in the three research states. Without the ability to have livestock processed as organic, some farmers, especially those without robust local direct-markets, viewed the premium price needed to cover costs in this system as unobtainable.

Even when physical infrastructure issues can be addressed, the *long time horizon* for returns was perceived as a considerable challenge. Farmers considering crop–livestock integration may become discouraged when the benefits of integration, in terms of animal welfare, soil health, or financial returns, do not appear quickly enough, as the following interviewee recounted.

> "A lot of the stuff we did, we had hoped to see immediate returns, and that does not happen. It takes time to fix tillable dirt just like it took time to fix the native prairie pastures that we fixed."

Some operations were not able to weather the time lag financially, and reverted to specialized systems to stay afloat. However, some also spoke of eventually achieving the desired results, over a longer timeframe than initially anticipated.

Several participants reported that integration resulted in *decreased yields* of crops, milk, or meat when compared to their previous specialized systems. However, as it was often buffered by a decrease in feed costs or an increase in farm gate price, those who experienced it did not necessarily view this decrease in yield as a challenge.

A challenge to the fundamental idea and system of integration arose from pasture-based livestock farmers, or graziers. Many committed graziers were uninterested in integration because they perceived that *perennial pasture is more efficient*; superior both environmentally and economically, to integrated systems. The cost savings on labor and equipment in a perennial pasture system was viewed as a disincentive to introducing cover crops for grazing. However, some graziers were implementing annual cover crops to renovate perennial pasture; a focus group exchange extolled the benefits of having some annuals in a perennial pasture based operation:

> Farmer: "I think at some point our goal would be to have almost all of those 320 acres as pasture, but then we'd give up the chance to have those warm seasons. Those warm season forage annuals fill a niche in July and August when it's too hot."
>
> Responding Farmer: "And in the winter."
>
> Farmer: "For the cool season pastures to grow and then in the winter it gives us a chance to have stockpile. Maybe in the long term we'll always reserve 10 or 20 acres maybe for growing some kind of small grain and then following it with legumes."

4.2. Opportunities of Integration

4.2.1. Increasing Support for ICLS

While locked-in infrastructure and a dominant system that challenges organic and integrated farms emerged, farmers also talked often about alternative and growing *communities of practice*. Participants noted that the *communities of practice* arising from leading edge integrated and organic farms exposed them to novel technologies and practices and lesser-known policy instruments, providing access to the tools, knowledge and peer support necessary to be successful with integrated crop–livestock systems. In many locales, these alternative networks are not obvious and must be sought out, as the following farmer relates.

> "We're kind of out there. We don't have the neighborly support system… but I think that's why Practical Farmers of Iowa has been so great since we've really found a diverse group of farmers that believe what we believe and we can communicate about that and we have peers. That community has been a lifesaver for us."

This community is virtual and physical, buoyed by informal farmer coalitions and nonprofit organizations that often transcend traditional geographic boundaries. As one farmer said,

> "The neat part is, as we've made the transition [to an integrated system], we've met more and more people nationwide that are way better friends than we had locally."

Longstanding sustainable agriculture organizations in all three states were mentioned often, as were specific individuals who speak and give workshops nationwide. Web-mediated discussion boards and information sharing groups were also noted as influential and supportive sources for knowledge exchange. This support system is nascent in some areas, but farmers perceived it as accessible and growing. Farmers demonstrated that these networks were critical when deciding to try an integrated system, and vital for ongoing success in such systems.

Participants discussed how current *market trends* provide increasing support for grass-fed, pastured, organic and local farm products. Novel and expanding markets were regarded as a primary opportunity encouraging farmers to transition to organic integrated crop–livestock systems. Farmers identified specific niche market opportunities for integrated farms in: pastured goat and lamb meat; renting goats for invasive species control; 100% grass-fed dairy; organic grains for local distilleries and bakers; and partnerships with local universities and other institutions. Participants demonstrated the marketing benefits of living in proximity to metropolitan centers to capture urban demand for local foods. They discussed how direct market customers are interested in food that is healthy, supports family-scale farms, is raised humanely, and promotes environmental health. Local food demand as an opportunity wanes for farms further from metro areas. However, Organic Valley's Grassmilk® program and their potential Grass-Fed US meat line were perceived as opportunities for integrated farms in some rural areas.

Participants suggested that there is an opportunity for farmers to create integrated crop–livestock systems at larger, landscape scales through novel *farmer partnerships*. Farmers spoke of matching graziers with crop producers to integrate annual crops with livestock in a given geographic locale. As one farmer explained:

> "If you are cold turkey, while grandpa had cows or something like that, it's not going to work out very well. You need to have somebody who has some knowledge and there's lot of guys like me that know how to do it, but don't have the land to do it. That's what I've been pushing, is finding some way to put guys like us together because there's crop farmers all around me but nobody grazes anything."

When a crop farmer works with a grazing farmer, both benefit from each other's experience to create an integrated system without necessarily having to acquire additional specialized knowledge. Participants perceived such partnerships as a "win-win-win", providing livestock with high quality feed, inexpensive fertility for crops, and improved soil health. However, such mutually beneficial partnerships would require high levels of communication, coordination and trust. Some Minnesota farmers identified a state-run website that connects cover crop farmers with custom graziers. A similar system does not appear to be in place yet in Iowa or Pennsylvania, but farmers in those states agreed that such a scheme might be beneficial.

4.2.2. Financial and Labor Advantages

Participants perceived or demonstrated that the economics of organic and integrated systems are often more viable than specialized conventional crop or livestock systems, especially at smaller scales. Farmers focused on cost savings and *economic resilience* as opportunities inherent to organically managed integrated crop–livestock systems. By using cover crops and grazing, costs are minimized due to nutrient recycling, water capture, and growing feed, resulting in fewer input purchases. Farmers discussed how animal health can improve in this system, reducing veterinarian care costs. The diversity of products marketed by an integrated farm was seen as a buffer to price shocks in any single market. The economic benefit of diversity was perceived as important and viable for smaller farms; integration and diversity are means for small-scale farms to become economically resilient, as the following participant said.

> "I just see so much difference in the people that I meet with that have diverse rotations, they have diverse marketing, if something fails, they have the ability to make money or at least make an income off of what does not fail and if you have livestock incorporated in that, that gives you other opportunities or marketing opportunities to not bust the bank."

Some participants mentioned that as demand for organic livestock feed is increasing, organic imports are depressing prices for locally grown grain and beans, challenging nonintegrated organic crop farms. This circumstance was viewed as an opportunity for crop farms to integrate livestock, sidestepping the depressed commodity markets and delivering a finished product in livestock rather than grain.

Integrated farmers use cover crops and on-farm livestock manure to enhance soil fertility with less effort than typical organic models where manure and fertilizer are purchased and applied. Participants discussed deliberately grazing livestock as a means to achieve *efficient fertilization* of pasture and crop fields, as this farmer relates,

> "You're not doing the labor spreading the manure, they're spreading it for you…it's just exciting to me to get natural nutrients into the system so easily."

Farmers talked about the soil health benefits that they perceived or experienced accruing to the land when providing *efficient fertilization*, as the following farmer said.

> "One piece of ground we've taken it from 1 percent organic matter up to 4.8 percent. That 3.8—basically 4—percent change in our organic matter, there's an extra 80 pounds of nitrogen there available to grow corn most agronomists won't tell you about."

Some participants viewed livestock as *less labor intensive* than other systems. Pastured livestock farmers experienced integrated systems as *less labor intensive* because livestock feed themselves while fertilizing fields. Even farmers who implemented seemingly complex rotational grazing systems did not report feeling burdened, as the following interview excerpt highlights.

> "As far as hours of labor or actual hard work to do this, it's very little. A normal day for me will take me an hour and fifteen minutes… I move the cows twice a day… we're doing that with close to 300 head now."

Many integrated crop–livestock and pastured livestock farmers reported having off-farm jobs made feasible by set grazing plans and easily implemented rotations. In addition, many livestock farmers expressed their enjoyment of raising animals as a quality of life enhancement that supports farm sustainability beyond simple cost-benefit accounting.

Grazing livestock was widely understood as a means to better *utilize marginal farmland*. Participants perceived this as an incentivizing opportunity for farms that do not currently have livestock; existing, underutilized farmland could be made productive. Enrolling marginal land in an integrated systems approach was viewed as an efficient means to diversify and increase production while generating fertility and soil health advantages with little added effort. This was particularly mentioned in the context of sloped land, land that floods, and other marginal tracts.

4.2.3. Biophysical Improvements

Building soil health emerged as an opportunity derived from integrated crop–livestock systems. Improving soil health was an explicit management goal for many participants. Specific benefits discussed by farmers included increased organic matter and its concomitant benefits such as increased water holding capacity, less compaction, improved soil texture, more resilient crops, higher feed quality, and reduced fertilizer needs. Farmers related experiences of cover crops reducing erosion and improving the land's resilience to weather stresses while feeding microbiota, which in turn provide nutrients for the main crop.

Farmers who experienced these benefits suggested that the effects of soil health on crop quality improvements may be a strong inducement for farms that do not currently have livestock to consider integrating. Participants noted that crops generally perform better following cover crops and/or grazing. One participant attested to a measurable increase in the nutritional content of corn due to the integrated system, while several others perceived this benefit but had not measured it. As one farmer said,

> "Every farmer knows you're probably going to get a good corn crop after an alfalfa plow down, right? But we don't even talk about it; we don't even want to talk about that anymore because it's like, what do I do with the alfalfa? Well—bingo!—put the livestock back into the system."

Relatedly, an agency personnel participant noted that, contrary to popular belief, they are finding that the cost-share offered for cover crops is not a necessity. Farmers that see the crop and soil health benefits find these to be enough incentive to continue the practice without the subsidy.

Some farmers discussed how their initial attraction to cover crops for *weed suppression* was a gateway to a systems approach to farming. Participants also discussed how the diversity of rotations and diversity in the cover crop mix are part of an overall *weed suppression* strategy resulting in beneficial labor and input cost reductions.

A *reduction in pest pressure* on the main crop was also noted by some farmers, and was perceived as an opportunity by participants considering transitioning to an integrated system. In addition, a few farmers reported an increase in beneficial insects, which were supported by their diverse integrated systems. Specifically, they discussed this system's potential for creating *pollinator habitat*.

4.2.4. Animal Welfare Benefits

Livestock farmers experienced animal welfare benefits after transitioning to integrated systems, and they perceived this as an opportunity to incentivize other livestock farmers to integrate grazing on annual crops. This benefit was mostly attributed *to extending the grazing season*, where livestock were pastured on high-quality forage for as much of the year as possible. In particular, farmers noted improvements in calf health and well-being by timing calving with the availability of forage, or by using cover crops to improve the physical conditions of a field for new calves. As the following farmer said,

> "It's a huge benefit because we get spring rains and it could make areas muddy and detrimental to the new born calves, [but] this rye is aggressive enough, and usually they have quite a few acres of it, then it keeps those calves clean and dry."

Integrated farmers discussed not only early-season grazing, but also late-season grazing and increased forage mass from grazing cover crops. Participants reported successfully grazing cover crops in late winter, early spring, late summer, late fall, and early winter. Graziers considering integrating perceived *extending the grazing season* as an opportunity. For certified organic dairy farmers, the season extension was seen by some as a necessity to meet organic standards for the number of grazing days and dry matter intake in climates, or on land, that otherwise could not support the requirements. This *increase in forage production* was noted as a key opportunity, as attested to by the following farmer.

> "I think with our diverse mixes and what we're doing we're seeing more than a 30 percent increase in forage production."

Farmers who grazed cover crops also reported *pasture improvements* as an opportunity derived from an integrated crop–livestock system. Grazing annual cover crops allows perennial pasture to regenerate between grazing rotations. In addition, some farmers were using cover crops to periodically renovate pasture with promising results for subsequent perennial forage production and quality.

5. Discussion

5.1. Most Challenges of ICLS Are Mitigated by Opportunities

The challenges and opportunities identified by farmers considering or managing integrated crop–livestock systems are presented in discrete categories in the findings section. Tables 5–8 present the same themes in a different structure, depicting how most of the challenges of integrated crop–livestock systems identified by some farmers are mitigated by opportunities identified by other farmers who participated in this study. Unmitigated challenges are marked by an asterisk (*) in the tables.

Table 5. Farming norms challenges mitigated by opportunities.

Norm Challenge	Mitigating Opportunities
dominant farming system	Growing communities of practice that provide an alternative normative environment where ICLS are supported.
dominant markets	Market trends where alternative markets create an opportunity for integrated systems based on consumer demand for animal welfare and local products.
financing and insurance	*Unmitigated challenge
regulatory environment	Mitigated somewhat by growing communities of practice that expose farmers to lesser-known policy instruments and labeling initiatives that benefit integrated systems.

Table 6. Complexity of management challenges mitigated by opportunities.

Complexity Challenge	Mitigating Opportunities
intensive management	Growing communities of practice where peer knowledge exchange and peer support aid management planning and/or through novel farmer partnerships connecting graziers with crop growers. Also mitigated by the experience of graziers who attest that livestock is less labor intensive.
livestock commitment	Novel farmer partnerships where crop farmers invite graziers onto their cropland, negating the need for crop farmers to commit to livestock. Also mitigated by the experience of graziers who attest that livestock is less labor intensive. And by the efficient fertilization providing by cropland grazing.
cover crop challenges	Growing communities of practice where peer knowledge exchange and peer support aid cover crop troubleshooting.
stocking density	Novel farmer partnerships where livestock producers connect with crop farmers to gain more grazing land, or vice versa to increase animal density on existing crop or pastureland.

Table 7. Biophysical conditions challenges mitigated by opportunities.

Biophysical Challenge	Mitigating Opportunities
existing soil issues	Building soil health addresses depleted cropland. Utilizing marginal farmland for grazing livestock addresses the issues of unsuitable cropland parcels.
soil health tracking	Some farmers report success with simple tracking of soil organic matter, learned in connection with growing communities of practice.
climate and weather	Building soil health provides resilience to environmental stressors. Also mitigated by extension of growing season, where annual cover crops provide forage in dry periods and protect soil in wet periods, thereby extending the grazing season.

Table 8. Financial cost challenges mitigated by opportunities.

Financial Challenge	Mitigating Opportunities
farm and county infrastructure	*Unmitigated challenge at the county level where processors for organic livestock and grain are insufficient to support growth for organic ICLS. At the farm-level this is mitigated by learning of underutilized policy instruments through growing communities of practice.

long time horizon for returns	*Unmitigated challenge for farms seeking to transition to ICLS, especially for those with existing soil health issues or undeveloped marketing channels.
decreased yields	Crop quality improvements garner premium prices by increasing crop, milk or meat quality and/or through animal welfare improvements, reduction in vet costs and animal losses. Also mitigated by cost savings and economic resilience and by utilizing marginal farmland to diversify production.
perennial pasture is more efficient	Pasture improvements experienced by graziers who renovate pasture with annual cover crops. Also mitigated by extending the grazing season beyond what pasture can provide.

As Tables 5–8 depict, 12 of 15 perceived or experienced challenges to integrating crops and livestock were mitigated by opportunities that farmer participants identified. Notably, the growing communities of practice around organic and integrated crop–livestock systems have the potential to mitigate many of the perceived challenges. Even for challenges that are not directly mitigated by such communities of practice, these communities act as knowledge-exchange venues where farmers learn about other mitigating factors. Since all mitigating opportunities were identified by farmers, a community of practice could be the forum for exchange of experiences between those successful in overcoming a challenge with those experiencing that challenge.

As reviewed in Section 2, research has found distinct social networks and communities of practice supporting alternative and agroecological forms of farming. These communities value direct observation; tacit, local knowledge; experimentation; collaboration and peer-to-peer learning [85,86,87]. These types of farmer networks produce and circulate highly valued knowledge within the networks, while also working to shift farming norms, especially as farmers seek to make practice changes [67,70]. The "activist" farmer identity, supported by such networks and communities of practice, is committed to "risk sharing and social learning" [88] (p. 80). Formal and informal organic learning networks direct newly enrolled farmers to value animal welfare, soil health, and quality food in their construction of what it means to be a good organic farmer [71]. The communities of practice that form around alternative agriculture norms are also influential in creating new markets outside of the dominant system for agroecological farm products.

Farmer participants spoke of formal groups, such as Practical Farmers of Iowa, and informal groups mediated through internet forums or national conference attendance, as being "life-savers" when navigating the transition to integrated crop–livestock systems. Whether learning about the best breeds for grazing, troubleshooting the many challenges of cover crops, or experimenting with novel soil heath testing, the growing communities of practice around integrated crop–livestock systems enable many farmers to overcome challenges that may otherwise be experienced as barriers. These communities can also serve as a venue to enable novel farmer partnerships between crop growers and graziers, thereby helping mitigate challenges related to system complexity, stocking rates, and livestock commitment through cooperative farming models and custom grazing exchanges.

As Peter and colleagues [70,89] have shown, social legitimization serves to enhance uptake of practices that either reify the destructive tendencies of the dominant form of agriculture or support the emergence of agroecological approaches. The norms of behavior associated with different farming identities are promulgated through networks of associated farmers. Since most of the farmer participants in this study managed their farms organically (or with low-input conventional strategies), they were aware of and often connected to alternative farming networks and communities of practice where the norms associated with integrated crop–livestock systems and organic farming are championed. In this way, existing attitudes, value systems, and available alternative normative environments are supportive for transitioning to integrated crop–livestock systems in the study's focus region, at least for the farmers who participated in this study. The bifurcation of organics in the U.S. [7,54] suggests that not all organically managed farms are connected to such communities of practice nor do they all share the same values orientation. Conventionalized organic farm operators utilizing input-intensive substitution systems are likely not embedded in communities of practice that foster low-input models such as ICLS. For these organic farms, and their conventional counterparts, a supportive normative environment for such a transition is likely lacking.

However, these growing communities of practice do not mitigate all challenges to integrated crop–livestock systems. As Oreszcyn and colleagues [68] pointed out, "farmers' communities of practice, networks of practice, and the wider web of influencers on practice within which they sit, represent the whole environment in which learning may occur" (p. 411). The "wider-web" here presents unmitigated challenges.

5.2. Unmitigated Challenges

Considering Blesch and Wolf's [65] categorization of the resources required for transitions to agroecological forms of farming, this study provides evidence of the existence and interconnection of internal—cognitive and ecological—and external—networks, organizations, and policy—resources that support transitions to ICLS. It also highlights insufficient external resources that thwart the potential for widespread uptake by farmers already interested in this system. Three challenges that can be categorized as external resources arose from the data that were unmitigated by emergent opportunities: *financing and insurance*; *long time horizons for returns*; and *county and farm infrastructure*. These three themes represent barriers to transition or success managing integrated systems for some farmers in this region.

These particular unmitigated challenges can be considered in the framework of the Theory of Planned Behavior. The Theory of Planned Behavior, which suggests that intention to engage in a behavior, such as transitioning to an integrated crop–livestock system, is based on beliefs about the merits of the behavior and the normative environment in which the behavior may be enacted, tempered by the extent of volitional control a person has to enact the behavior [90,91]. Four variables: intention, beliefs, norms and volitional control, are significant correlates for a range of health behaviors [92,93], and have recently been employed in the agricultural conservation BMP literature [40,60,94]. While the theory is a predictive model applied to individual behaviors, it is useful as a framework for considering this group-level transition to a novel form of farming, and specifically for understanding the three unmitigated challenges. Due to the recruitment strategy, the study's population of farmers is organically-oriented and already intends to integrate crops and livestock. Their aggregate attitudes and beliefs are represented in the opportunities and challenges presented. The dominant normative environment is a challenge that may be overcome by the growing communities of practice around organic and integrated systems.

Where some farmers perceived or experienced challenges, other farmers relayed opportunities that mitigated these challenges, suggesting that the integrated approach to farming may be within the volitional control of a farmer. This volitional control may be dependent on connection to a community of practice where a farmer experiencing or perceiving a challenge could learn from others who have overcome that challenge or who had been successful in generating an opportunity that negated the challenge. However, the three unmitigated challenges of *financing and insurance*, *long time horizons for returns*, and *county and farm infrastructure*, appear to be beyond the control of any single farmer or group of farmers. Opportunities do not mitigate these challenges. These challenges have yet to be overcome through established alternative communities of practice. The risks and costs of transitioning to integrated crop–livestock systems means that the shift may be unattainable, even for farmers with a strong intention to integrate and an established connection to a community of practice that provides a supportive normative environment.

These three unmitigated challenges arise from a dominant farming system that is at odds with integrated systems. Farmers' experiences and perceptions of a lack of financing and insurance mechanisms tailored for integrated systems are related to the comparatively long time horizons for returns in these systems. Dominant models of specialized agriculture are designed to reduce risk in a policy environment that supports risk reduction. Financial institutions draw on decades of data to offer products suited to the majority of farms that operate within the confines of a few types of roughly homogenous, specialized systems. There are far fewer integrated farms, which are more heterogeneous and complex, creating obstacles for widespread availability of financial instruments to support transitioning and operating in this system.

Nowak [95] made a compelling argument for why the nearly automatic reliance on financial incentives for agricultural conservation is often misguided. However, in this case, the durable challenges are financial obstacles that may most effectively be remedied by state intervention. As Roesch-McNally and colleagues [66] found when considering cover crop adoption, state cost-share arrangements are not essential on an ongoing basis, but they are necessary to cover the risk of the initial transition. In the same way, a state-level financing and/or insurance mechanism that supports shifting to an integrated system would potentially remedy two of the three unmitigated challenges: *financing and insurance* and *long time horizons for returns*.

The third challenge of county and farm infrastructure has two scalar components: farm-level and county-level. At the farm-level there were farmers who identified government programs, such as the USDA's Conservation Reserve Program Grasslands, that specifically helps individual farms overcome challenges related to livestock fencing or improving pasture mix. Specialized equipment, such as cover crop specific seed-drills, are initial transition costs that could be reduced through public cost-sharing arrangements. These challenges could also be mitigated through farmer equipment cooperatives and sharing arrangements at the local-level that could be managed through existing networks and communities of practice. However, the infrastructure challenge is unmitigated for organic livestock and grain processors at the county level. There are few abattoirs that accommodate small-scale organic livestock farms in the U.S. [12,96] and a limited number of organic feed grain processing mills constrain expansion [26]. Farmers experienced this lack of regional infrastructure as beyond their control, although there exist instances where farms have diversified into on-farm processing to meet this demand, at least in other regions. Processing facilities for organic livestock and grain could be incentivized through policy instruments aimed at increasing their prevalence either through commercial or cooperative means or by encouraging diversification of already existing organic farm enterprises.

Due to the lock-in and path dependency created by the dominant farming system [13,60], which has long been supported by state intervention [11], policy mechanisms to address the challenges that are beyond the volitional control of farmers appear necessary to create the total environment where integrated crop–livestock systems can be successful. These external resources are an integral component of enabling transitions to agroecological farming [65]. Particularly for farms that currently operate in a specialized model more akin to the dominant forms of conventional agriculture, supporting transitions to agroecological livestock systems will require macroscale "technological and economical solutions" specifically because these kinds of farms do not operate in an alternative framework that enables grassroots, or farmer-led, transitions [12,13]. The trend towards conventionalization and bifurcation of farms in the U.S erodes opportunities for these conventionalized organic farms to integrate crops and livestock because the normative environment and communities of practice necessary to enable the transition are aligned with agroecological and low-input farmers. Existing bifurcation suggests that ICLS is most salient and available as an option for agroecological or "deep organic" farmers, but also, following Sutherland [72] and Harris and colleagues [97] conventional low-input farmers who are "effectively organic" are also often embedded in the communities of practice that can support successful transitions to ICLS.

Policy support to create the external resources necessary to overcome obdurate challenges to ICLS appears necessary for all types of organically managed farms, however while policy support may close the gap to enable transitions to ICLS for low-input agroecological farms, it is insufficient to close the gap for conventionalized organic farms. This discussion of policy mechanisms to address unmitigated challenges only applies to farmers who intend to transition to an integrated system and who are embedded in a community of practice that provides a supportive normative environment. Without this supportive normative environment, it is unlikely that farmers intending to transition to integrated systems will be successful in doing so. As such, addressing financing and policy mechanisms to established groups of farmers, rather than individuals, interested in integrated crop–livestock systems is likely to be the most effective strategy. As Nowak [95] suggests, emphasis on the individual in the context of conservation behaviors has for too long obfuscated the generative power of groups. Policy and Extension efforts seeking to support transitions to integrated crop–livestock systems could also serve to connect interested farmers with supportive communities of practice, especially in areas where such networks are nascent.

6. Conclusions

Integrated crop–livestock systems may offer economic and environmental benefits that could help organic farmers become more resilient to market and environmental shocks, while enhancing the land-based resources on which they depend [2,15,16,18]. However, this approach to farming is far from the norm in the U.S. where the historical trend favors farm enterprise specialization. Nearly 90 percent of U.S. farms currently specialize in either crops or livestock [6]. While research has shown the potential for benefits to accrue at the farm-level, few farms today operate integrated crop–livestock systems. This qualitative study sought to investigate the challenges and opportunities of operating, or transitioning to, an organically managed integrated crop–livestock system in the U.S. states of Iowa, Pennsylvania, and Minnesota.

Prior research exploring farm-level decision making has tended to focus on either the micro-scale determinants of adoption of best management practices [29,39,40] or the macrolevel structure of the food system that constrains farm-level decision-making [8,11,43]. More integrative approaches seek to bridge the structural constraints with farmer agency on the ground [62,65,66]. This study supports evidence from these integrative approaches, suggesting that farmers' social networks and communities of practice play an important role in enabling farmer agency within the structural constraints of a global food system that reifies the dominant conventional model of agriculture [16,67,68,69,70,71].

Analysis of farmer interview and focus group data resulted in the emergence of eight main categories of challenges and opportunities regarding transitioning to, or managing, an integrated crop–livestock system. The challenges were (1) farming norms, (2) complexity of management, (3) biophysical conditions, and (4) and financial costs. The opportunities were (1) increasing support, (2) financial and labor advantages, (3) biophysical improvements, and (4) animal welfare. Twenty-nine subcategory themes were delineated, including challenges such as existing soil issues and dominant markets, and opportunities like building soil health and utilizing marginal farmland.

This study provides empirical evidence for the importance of mesolevel factors, particularly communities of practice and knowledge networks, while also underscoring the importance of external resources that are beyond the control of farmers, such as policy and county level infrastructure [65]. Discussion of the findings explicates how most of the challenges of transitioning to ICLS identified by farmers were mitigated by opportunities identified by other farmers. In particular, increasing support for integrated crop–livestock systems mitigates many of the perceived and experienced challenges of such systems. This support is physical and virtual, where farmers are embedded in growing communities of practice that value peer-to-peer learning, experimentation, and unconventional approaches to alternative agricultural management. Many crop–livestock farmers described formal groups and informal networks as essential to their transition to integrated systems and their continued success in them. This increasing support also includes favorable market trends and the advent or positing of novel farmer partnerships to integrate crops and livestock across farms, at the landscape scale.

Similar to other recent studies [29,98], mesolevel factors emerged as the most obdurate challenges to organically managed integrated crop–livestock systems. The three challenges that were not readily mitigated by opportunities were:

1. financing and insurance,
2. farm and county infrastructure, and
3. long time horizons for returns.

Recent research has shown how risk and time-frames impact conservation practices [29,98]. Here, these mesolevel economic factors, along with county level infrastructure, are the standout challenges to transitioning to a novel model of farming. These unmitigated challenges are related to macroscale constraints that shape the U.S. food system, but they are mesolevel factors that are beyond the volitional control of individual farmers or farm groups and may require policy intervention to remedy. Policy mechanisms to address insurance and financing needs could mitigate the risk associated with the long time horizon for returns typical when transitioning from a specialized system to an integrated system. In addition, policy to incentivize county-level infrastructure, such as organic grain and livestock processing facilities, may be necessary.

However, the conventionalization and bifurcation of organic farming in the U.S. [7,54] mediates the effect of policy mechanisms to aid organically managed farm transitions to integrated crop–livestock systems. While such policy remedies will likely help enable low-input agroecological farms to transition to ICLS, they will be insufficient to aid conventionalized organic farms to do the same because the latter are unlikely to be embedded in communities of practice that foster low-input strategies like ICLS. The normative environment engendered by a supportive community of practice is a necessary resource for successful integrated crop–livestock systems. Designing these policies to work with established groups of farmers, rather than with individuals, would ensure a framework for successful integrated crop–livestock systems that could even be promoted at the landscape-level rather than at the farm-level [17].

Additional research is warranted to investigate financial and insurance institutions, the products available for supporting integrated farming systems, and the level of community awareness of these products. Farmer participants in this study were largely unaware of financial institutions that create products for this type of farm system transition. In addition, a full economic analysis of the costs and benefits of ICLS practices, including a valuation of the environmental benefits accrued in such systems, would aid in supporting transitions to ICLS. Supplemental findings of this study also provoke investigation of the geographic distribution of organic grain and livestock processing facilities in comparison to the prevalence of integrated farm enterprises. Such a study may provide insight into how farmers remedy this infrastructure challenge, or if it proves to be an obdurate barrier to widespread integration of crops and livestock on organically managed farms in the U.S. Considering the sociopolitical constraints within with which all farms operate, it would also be beneficial to investigate transitions to ICLS through a cross-country comparison examining the U.S. context alongside developing countries where ICLS remains common, particularly in the context of water and other resource scarcity [99,100]. Likewise, deep ethnographic investigation of ICLS systems in situ through a case study approach would further aid understanding of these complex systems in differing contexts.

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