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REVIEW

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Midwestern specialty crop impacts on the environment and health: a scoping review

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Abstract

Introduction The United States food system mainly relies on monoculture farming, leading to negative impacts on human and environmental health. Transitioning to specialty crop production (fruits, vegetables, and tree nuts) could alleviate challenges. The goal of this scoping review was to understand environmental and health impacts of locally distributed specialty crops in the Midwest.

Methods Researchers searched databases for peer-reviewed literature and agricultural websites for grey literature. Inclusion criteria were specialty crop production; environmental, economic, or health outcomes; Midwest location; and local distribution. Researchers charted data based on the reach, effectiveness, adoption, implementation, and maintenance framework.

Results Grey (n = 9) and peer-reviewed (n = 19) sources met inclusion criteria. Sources reported specialty crops reached diverse populations through community gardens and farmers' markets with positive impacts on nutritional intake. Effectiveness of production practices on soil and plant quality and greenhouse gas emissions was mixed.

Conclusions Local specialty crop production shows promise, but more rigorous study designs with long-term follow-up are needed.

Keywords Specialty crops, Fruits, Vegetables, Midwest, Climate change, Soil health, Local food, Health, Nutrition

Introduction

The United States (U.S.) food system, with its reliance on large-scale monoculture, leads to negative impacts on both human health and the environment [1, 2]. Monocropping (i.e., single crops grown continuously, such as corn and soybeans) was initiated to feed the growing U.S. population during the 20th century and resulted in increased yield and reduced costs [1–3]. However, these advances led to long-term negative impacts on both human and environmental health [1, 4].

First, related to human health, monocropping has been shown to decrease dietary diversity and contribute to the overconsumption of nutrient-deficient staple crops [5]. The reduced availability of diverse, nutrient-rich foods contributes to increased intake of nutrient-poor, high-calorie foods, which increases risk of chronic disease [6]. As well, monocropping depletes soil nutrients over time, leading to reduced nutrient availability in the food supply [7].

Second, as for environmental health, monocropping systems can cause significant erosion and alter the

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microbial landscape of the soil [8]. To counteract soil nutrient depletion, synthetic fertilizers are often added to monocrops to encourage plant growth [9]. Production of these fertilizers relies on fossil fuels, which contribute to greenhouse gas (GHG) emissions and can leave harmful residues that accumulate in the soil and leech into water systems [10, 11]. In addition, farming practices commonly associated with monocropping such as mechanical tillage and use of heavy equipment can cause soil compaction and contribute to erosion, eventually resulting in a loss of soil fertility and reduced carbon sequestration [10]. Furthermore, compaction can reduce water absorption and increase runoff, which leaves soils prone to drought [8].

Transitioning to specialty crop production and away from monocropping has the potential to help alleviate these challenges and mitigate the impacts of climate change. Specialty crops are defined as fruits and vegetables, tree nuts, dried fruits, and horticulture and nursery crops that are produced for human use (as compared to monocrops, which are produced primarily for animal feed and biofuels, as well as highly processed foods for human consumption) [12]. Producing specialty crops diversifies agricultural production systems and could enhance impacts on both human health and the environment.

In addition, there is growing interest in local food systems as a method of distributing specialty crops [13, 14]. While there is no universal definition of "local food systems", the 2008 Food, Conservation, and Energy Act considers foods that were produced within 400 miles of where they are marketed to be "local" [14]. Local food systems have the potential to increase access to nutritious foods and improve environmental and health outcomes, but these benefits depend on the supply chain, product type, and local context [14]. Distributing specialty crops locally could potentially benefit human health and the environment through decreasing transportation outputs [13, 14]. However, little is known about the environmental and health impacts of specialty crops, including those that are distributed locally [13, 14].

To begin answering these questions, focusing on the Midwest region of the United States is key. The Midwest (Michigan, Ohio, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Missouri, Kansas, Nebraska, South Dakota, and North Dakota) is the primary agriculture-producing region in the U.S., with the highest number of acres operated and highest gross output compared to other regions [15]. However, the Midwest is especially suited for corn and soy production, and there is a disproportionate share of acreage between monocrops and specialty crops [16, 17]. Seventy-five percent of the 127 million acres of agricultural land in the Midwest is used to produce monocrops, such as corn primarily for animal feed and ethanol feedstock, while the other 25% is used to produce specialty crops including apples, asparagus, grapes, cherries, cranberries, blueberries, and pumpkins, along with multiple other types of fruits and vegetables [18].

New practices are needed to respond to agricultural and practical challenges. For example, as electric vehicles become more common, the demand for corn ethanol will decrease alongside a decreased demand for gasoline [19]. Given the unpredictability of the future of this market, farmers would benefit from diversifying with higher value crops to remain viable [20]. However, major changes to agricultural systems typically occur first on small scales before diffusing across the country [4]. Thus, beginning with a focus on the Midwest, with its reliance on monocrops and related challenges to specialty crop production, could lead to implications for other regions of the U.S. and expanded specialty crop production across the country.

Taken together, a deeper understanding of the potential environmental and health impacts of locally distributed specialty crops in the Midwest is necessary to inform next steps for expanding specialty crop production. Thus, the goal of this study was to understand environmental and health impacts of locally distributed specialty crops in the Midwest.

Methods

Scoping review methodology was used to examine links between diverse fields of study (agriculture, environment, human health and nutrition) and provide flexibility in investigating complex relationships between factors across disciplines [21–23]. PRISMA-ScR (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews) guidelines were followed (see Supplementary File) [24]. Data are available upon reasonable request to the authors.

Data sources

The scoping review of peer-reviewed and grey literature was conducted from March to April 2023. The search for peer-reviewed literature was conducted through searching the databases Cab Direct, PubMed, Environment Complete, and Academic Search Complete for search terms developed in consultation with a research librarian. Key search terms focused on the agricultural production practices (e.g., local food systems, short food supply chains, specialty crops, and alternative food networks), location (Michigan, Ohio, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Missouri, Kansas, Nebraska, South Dakota, and North Dakota), and impacts (e.g., nutrition, health, chronic disease, economic benefit, rural development, environmental impact, and climate change), see the Appendix for the complete search strategy.

The search for grey literature was conducted through a customized internet and database search [25–28]. Search terms were modified from the peer-reviewed literature search, as the website and database search engines do not have the ability for complex search syntax. Thus, we searched for "specialty" or "local" or "supply chain" in the Land-Grant Impact Statements database, North Central Sustainable Agriculture Research and Education (SARE), USDA Agricultural Marketing Service, Center for Rural Affairs, and Specialty Growers' Associations and Cooperative Extension System websites for each of the Midwest states. Searches were adapted based on each website's area of focus and search function capabilities; for example, the Land Grant Impact Statements database allowed filtering by region, and the SARE website included search parameters for specific commodities and year of publication, see Table 1 for details. Events, staff member biographies, and marketing posts were removed from initial search results.

Study selection

Peer-reviewed literature and grey literature sources were included if they (1) focused on specialty crop production (i.e., fruits and vegetables, tree nuts, dried fruits, horticulture, and/or nursery crops including floriculture) [29], (2) included environmental (biodiversity, climate change, soil health, water quality, tillage practices, and soil fertility) or health outcomes (fruit and vegetable intake, food security, and chronic disease), (3) took place in the Midwest (MI, OH, IN, IL, WI, MN, IA, MO, KS, NE, SD, and ND) [30], (4) included local product distribution (as defined by the authors), (5) were written in English, and (6) were published between 2004 and 2023 (to align with the initiation of the Specialty Crops Competitiveness Act of 2004) [29].

Two authors independently reviewed each peer-reviewed publication's title for inclusion or exclusion. Authors met to resolve discrepancies and used a senior researcher to assist with resolving, if necessary. Next, for the included articles, two authors reviewed each publication's abstract, coded for inclusion/exclusion, and resolved using the same process. Finally, for the included articles, two authors reviewed the full text, determined inclusion/exclusion, and resolved. As grey literature typically does not contain a descriptive abstract, we used a simplified approach. Two authors independently reviewed the title of each grey literature publication, coded for inclusion or exclusion, and met to resolve discrepancies. For included grey literature, two authors reviewed the full text, determined inclusion/exclusion, and resolved.

Data charting

Data were extracted using a coding guide based on the RE-AIM (reach, effectiveness, adoption, implementation, and maintenance) Framework, which was developed to speed the translation of research to practice by considering both the individual and organizational factors that determine overall impact of interventions in real world settings [31]. RE-AIM dimensions assess intervention *reach* (number, proportion, and representativeness of individuals who participate or are influenced), *effectiveness* (impacts on primary outcomes), *adoption* (number, proportion, and representativeness of staff or settings willing to initiate), *implementation* (cost and consistency of delivery), and *maintenance* (long-term impacts on primary outcomes and long-term institutionalization within organizations) [31]. Operationalization of each dimension for this study is detailed in Table 2.

Critical appraisal of the evidence was not included due to the pragmatic nature of the research, inclusion of grey literature, and broad nature of the research topic [22, 32]. Two authors independently coded two sources and met to discuss and resolve discrepancies. The data charting form was then refined based on items that were deemed unclear. Next, two authors independently coded and met to reconcile the remaining sources, consulting with a senior researcher as a "critical friend" [33] as needed. Finally, to synthesize results, peer-reviewed and grey literature sources were organized by their primary outcomes (environment or health and nutrition) and summarized by RE-AIM dimension.

Results

Selection of sources

The initial search for grey literature sources yielded 1184 articles. Article titles were screened and 461 were excluded, because they did not focus on specialty crop production (n = 283), were duplicates (n = 153), were not reported in English (n = 10), took place outside the Midwest (n = 9), did not report environmental or health outcomes (n = 4), did not focus on products that were locally distributed, or were inaccessible (n = 1). This left 723 articles that underwent full text screening, and 714 were excluded, because they did not report environmental or health outcomes (n = 545), were not focused on specialty crops (n = 132), did not focus on products that were locally distributed (n = 12), were duplicates (n = 10), were inaccessible (e.g., behind a paywall, n = 8), or took place outside of the Midwest (n = 7). The screening process resulted in nine articles that were eligible and included in this review (see Fig. 1).

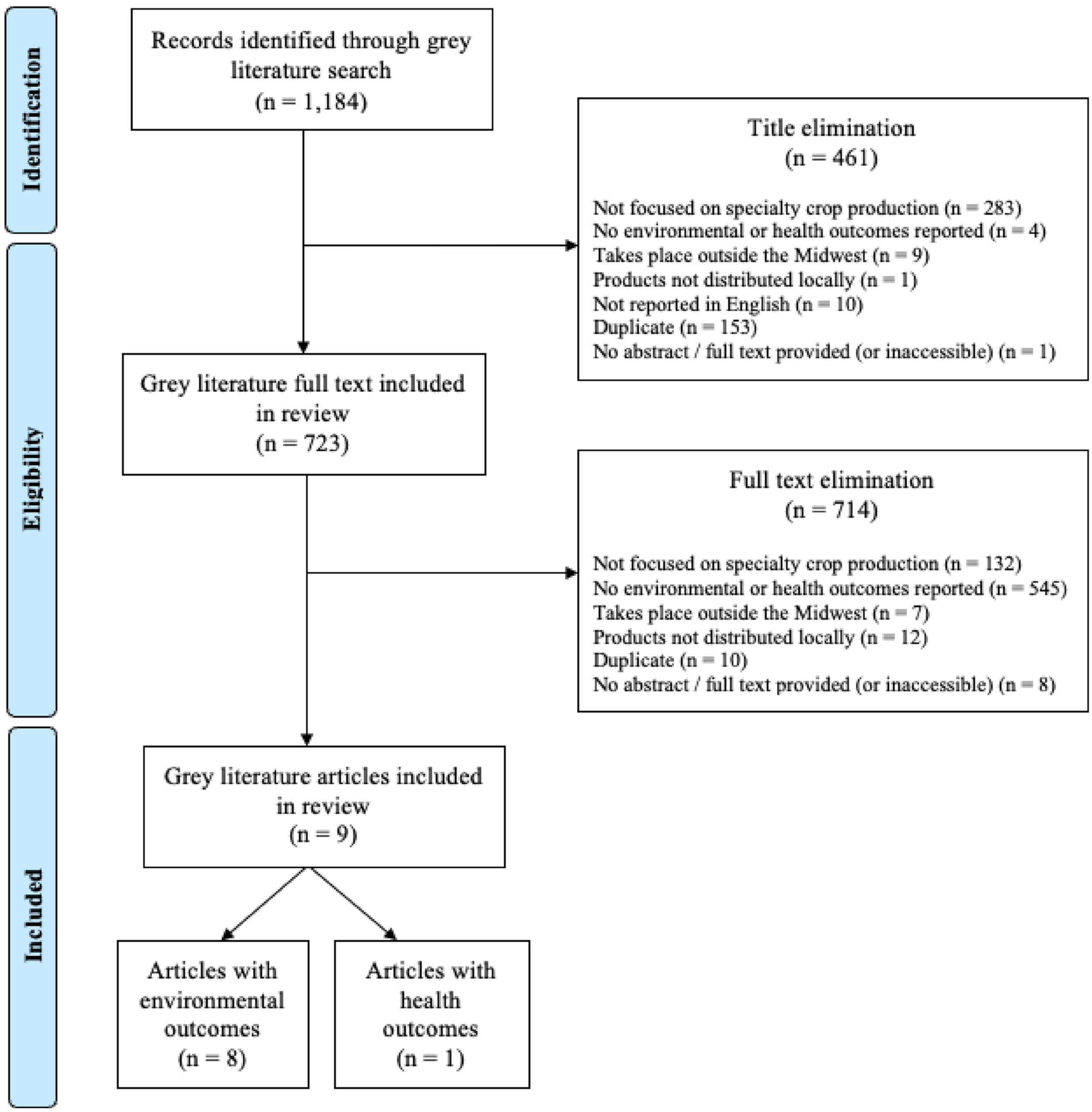

Fig. 1 Eligibility and inclusion of grey literature in scoping review

The initial search for peer-reviewed literature yielded 3189 articles. Study titles were screened, and 2550 articles were excluded, because they were not focused on specialty crop production (n = 2201), they took place outside the Midwest (n = 179), they did not report environmental or health outcomes (n = 137), or were duplicates (n = 33). This left 639 article abstracts that underwent screening, and 578 were excluded, because there were no environmental and health outcomes reported (n = 260), they were not focused on specialty crop production (n = 194), they took place outside of the Midwest (n = 68), were inaccessible (n = 37), were systematic reviews (n = 14), were duplicates (n = 3), or did not focus on products that were distributed locally (n = 2). Abstract screening left 61 articles that underwent full text screening, and 42 were excluded, because they did not report environmental or health outcomes (n = 16), were not focused on specialty crop production (n = 13), took place outside of the Midwest (n = 6), did not focus on products that were locally distributed (n = 4), were systematic reviews (n = 2), or were inaccessible (n = 1). The screening process resulted in 19 articles that were eligible and included in this review (see Fig. 2).

Finally, during the data charting phase, the included articles and reports (herein, "reports" is used to refer to both) were classified into either environmental impacts or health and nutrition impacts based on the study outcomes. Of the grey literature reports, eight included environmental impacts and one included health and nutrition impacts. Of the peer-reviewed articles, five included environmental impacts and 14 included health and nutrition impacts. Thus, for data charting and analysis, reports were organized by environmental impacts (n = 13) and health and nutrition impacts (n = 15).

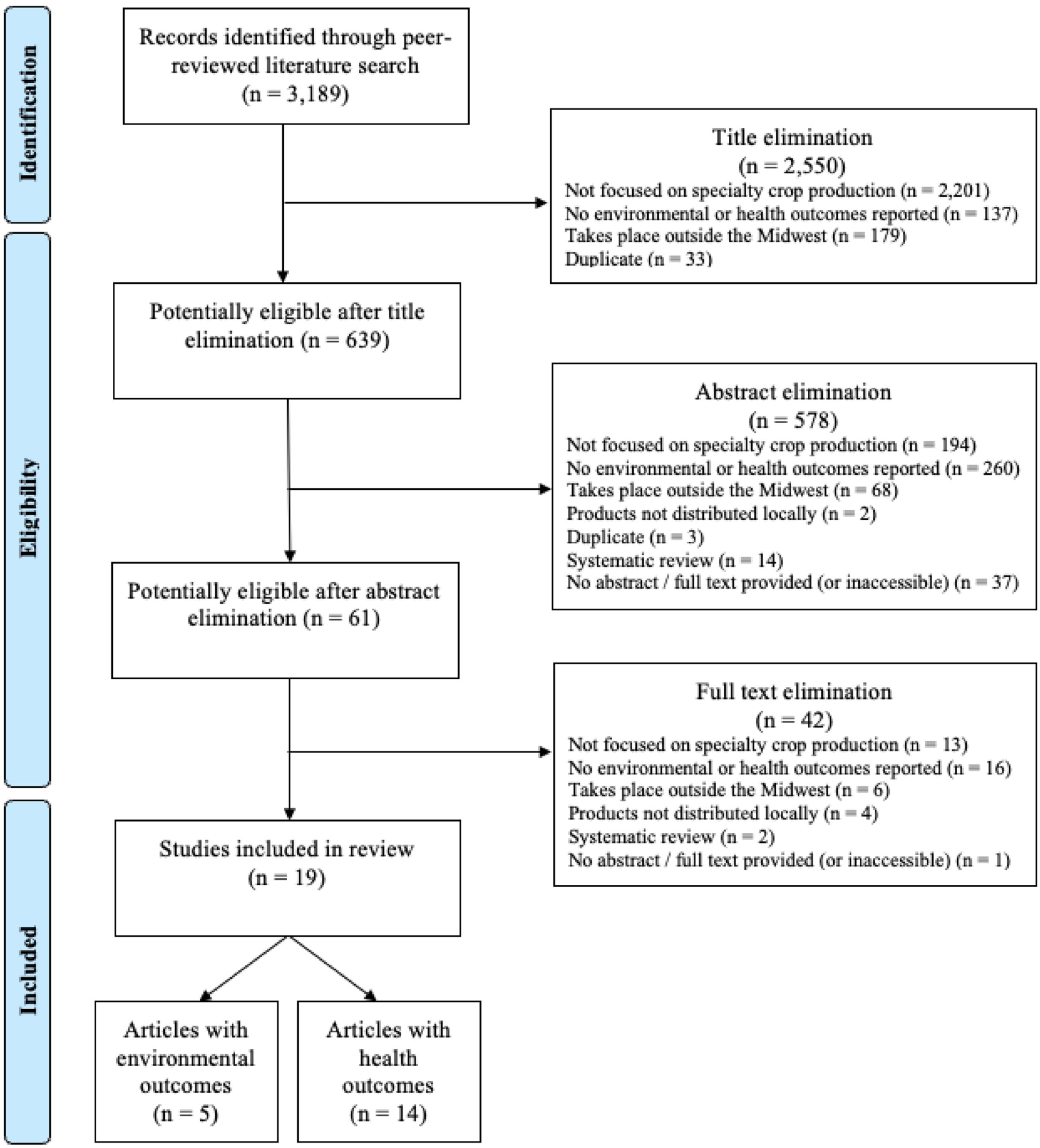

Fig. 2 Eligibility and inclusion of peer-reviewed literature in scoping review

Peer-reviewed and grey literature are presented together to consolidate all available evidence [34]. Scoping review data is organized by RE-AIM dimension for reports detailing environmental impacts, followed by reports detailing health and nutrition impacts. Results by RE-AIM dimension for comprehensive data (i.e., reported in most sources) are detailed in Tables 3–6.

Characteristics of sources

Environmental impacts

Reach. Studies took place across the Midwestern states: Minnesota [35], Indiana [36, 37], Wisconsin [38], Michigan [39, 40], Ohio [41–43], Missouri [44, 45], and Illinois [46, 47]. Consumer distribution channels varied across studies. Most commonly, channels included gardens (private, community, and institutional) and farmers' markets [35, 42, 43, 47]. Less commonly, studies described other methods of distribution, including food system venues [37], urban farms [35, 47], Community Supported Agriculture (CSA) [36], you-pick operations [44, 45], restaurants [44], food pantries [46], cooperatives [38, 46], and campus dining halls [40]. Overall, there was much variation in the channels used to distribute specialty crops to consumers.

Effectiveness. The 13 included studies varied in their aims and research designs. Study aims included assessing home and community gardens [35, 42, 43, 47], specific production practices (e.g., hoop houses or high tunnels) [37, 40], amendments (biochar or other organic amendments and decomposition specialty fungi) [36, 38, 44–46], pest control (e.g., copper fungicides) [39], and food waste reduction practices [41]. No studies compared environmental outcomes of specialty crops compared to monoculture/commodity crop systems. Research designs were observational and experimental, with approaches including paired comparison [35, 36, 38, 39, 42–46] and pragmatic pre–post or single timepoint assessment designs [37, 40, 41, 47].

The studies focused on diverse environmental outcomes, including soil health and quality, GHG impact, and plant quality. Soil health and quality was assessed through measures including chemical, biological, and physical properties including texture [35, 42, 43], density [35], aggregate stability [35], nutrients [35, 38, 39, 43, 45, 47], pH [35, 38, 43, 45, 47], organic matter [35, 38, 42, 43, 47], heavy metals [43], water infiltration rate [35, 43], hydraulic conductivity [35], microbial activity [38, 42], nematode trophic composition [42, 47], and insect biodiversity [35]. GHG impact was primarily assessed indirectly through these soil measures (i.e., soil's ability to store GHG that would otherwise be released into the atmosphere) as well as by measuring reduction of food waste and comparison of carbon dioxide emitted through production in different climatic zones [40, 41]. Plant quality was assessed through plant size and productivity, disease presence and management, and pest issues [36–39, 42, 44, 46]. Finally, two studies assessed crop diversity, one among community gardens and one among high tunnel users [37, 43]. Overall, there are a variety of research questions asked related to the effectiveness of specialty crops, and multiple methods of answering these questions.

As for the study results, soil health and quality outcomes were mixed, depending on the production practices used. Improvements to soil pH were found through the use of biochar and copper-resistant soil bacteria [39, 45, 46], while other studies found no difference in soil health using practices including biochar, wine cap mushrooms as a soil amendment, or hyperaccumulating plants (alfalfa) [36, 38]. As for other observations of home and community gardens, two studies found mixed properties of soil health in urban home food gardens [43], while another found that assessing existing soil quality when establishing new food production sites in urban areas is more important than applying specific amendments [35]. One study found a reduction in food waste by working with farmers to use seconds and between-market produce to create value-added products [41].

Regarding plant quality, primarily positive outcomes were found through the use of specific production practices, including worm casting; azomite; and soil, copper, and biochar amendments [36, 38, 39, 46]; combined amendments (e.g., pine bark and coffee grounds) produced mixed results [44]. Yields were improved through [37] worm casting and azomite in greenhouses and gardens as well as use of high tunnels [36, 37]. Crop diversity was high among urban home food gardeners and farmers with high tunnels [37, 43].

Adoption. Several reports examined multiple farm plots, gardens, or hoop houses [37, 41–43, 47], whereas others focused on a single operation [36, 38, 44–46]. The amount of land dedicated to specialty crop production ranged from small urban gardens to a 40-acre commercial farm [36, 38, 42, 43, 47]. The number and characteristics of producers were not typically specified; production teams included small teams of two, family-run farms, and operations including multiple owners and full-time workers [36, 44–46]. Overall, characteristics of farms and gardens varied widely across reports.

Implementation. Production practices varied broadly between reports, with the most common practice being the use of cover crops [35, 38, 45, 46]. Both tillage and no till approaches were described. No till or minimal till practices were highlighted in three reports [38, 46, 47], while tillage strategies were discussed in two [40, 45]. General strategies around increasing soil nutrients were also reported, including soil enrichment [36, 45]; nutrient cycling, nutrient management, and use of organic fertilizers [38, 43]; soil amendments such as biochar and basalt [36, 45]; and compost practices [40, 47]. Few reports provided information about whether their production was organic or not; two mentioned using both organic and conventional production [39, 40], and one mentioned growing organic fruits and vegetables [36].

To reduce climate change challenges, multiple reports detailed efforts to find innovative and sustainable ways to continue to grow Midwest specialty crops, such as blueberries [41, 44, 45], cabbage [35, 36, 41, 43], and strawberries [36, 41]. As for cost, many of the projects were funded by SARE grants through the USDA [35, 36, 38, 39, 41, 44–46]. While the grant amount was reported for each SARE-funded project (and ranged from $7,496 to $198,529, depending on scope), the full costs of the studies or new production practices were not provided.

Maintenance. Maintenance was underreported across the included reports, with one detailing actual long-term results [39]. Two reports shared plans to continue data collection and develop additional goals following their initial findings [41, 44]. In addition to extracting data on maintenance of long-term production practices, data were also captured on producers' efforts to disseminate their work to scale practices to their peers. Multiple reports described sharing the concepts and results of research through multiple means, including lectures, workshops, media, research presentations, and organization- and community-wide educational outreach [38, 39, 44–46].

Health and nutrition impacts

Reach. Reports focused on health and nutrition impacts also took place across the Midwestern states: Missouri [48–50], Illinois [51], Ohio [41, 42], Minnesota [52, 53], Wisconsin [54], and Michigan [55]. One report detailed a study that took place in a small city in the Midwest with no mention of the city or state name [56]. Food access points and interventions detailed in the reports primarily reached consumers through community gardens [48, 50, 52, 56–59] and farmers' markets [51, 53–55, 57, 60]. Other distribution channels included a CSA [57], a local food hub (including a local produce market and healthy food café) [61], Fresh Stops (farmers' markets organized by community-based organizations) [62], and a sliding scale cooperative grocery store [49].

Reports indicated that specialty crops reached diverse populations through food access points, including community members from racial and ethnic minority groups and those experiencing food insecurity. Of those that reported demographics, four studies primarily served African American residents [50, 55, 60, 61], one was implemented in a Marshallese community [56], and one surveyed a community of refugee and immigrant families (including Karen, Bhutanese, Hmong, and Lisu) [52]. The number of participants reached ranged from 120 community gardeners [58] to 1320 community members receiving SNAP (Supplemental Nutrition Assistance Program) benefits who participated in a farmers' market Electronic Benefits Transfer (EBT) program [54].

Effectiveness. The majority of the 15 included reports aimed to understand the association between a specific food access point (e.g., a community garden) or intervention (e.g., financial incentives to use a farmers' market) and fruit and vegetable consumption [48, 51–60]. Less commonly, studies aimed to test innovative local food distribution models (e.g., turning a large neighborhood lot into a market garden to supply food to a cooperative grocery store) [49, 50, 61, 62]. Research designs were observational and experimental, including quasi-experimental [59, 61], parallel [56], pre–post [52, 60], and cross-sectional or post-test only designs [48, 51, 53–55, 58]. Mixed methods studies were also conducted, although the outcomes of interest (i.e., impacts on community members' health or nutrition status) were typically captured through quantitative (pre–post or cross-sectional surveys) rather than qualitative methods [50, 57, 62].

As for study outcomes, 11 assessed fruit and vegetable consumption and five examined food security [48–55, 57, 58, 60–62]. Outcomes were typically assessed through self-report survey items, with nine studies using validated measures (e.g., the Healthy Eating Index Score, USDA Household Food Security Module, or Behavioral Risk Factor Surveillance Survey) [48, 50–52, 54, 55, 57, 58, 60, 61]. Of studies that assessed participants' fruit and vegetable intake [48, 50–54, 58, 60, 62] or food security [49, 50, 58, 61], most found positive results. This included both studies that aimed to understand impacts of food distribution points and studies examining impacts of specific interventions.

Implementation. Reports detailing health and nutrition impacts included limited implementation data. Little information on study funding was provided, with three projects receiving funds through the USDA (e.g., the Healthy Food Financing Initiative [54, 62]) and others from SARE [49, 61]. Only two reports used a theory, framework, or model to guide intervention development or evaluation [56, 59]. Finally, as for the specialty crops available to study participants, most sources mentioned fruits and vegetables without details on specific types [49, 53, 55–59, 61].

Maintenance. Most reports provided little or no detail on long-term individual-level maintenance or program sustainability, with only one reporting that most intervention components were not maintained [61]. Others reported sustainability challenges, including a need for funding and more supportive policies [54, 57, 60].

Discussion

This scoping review used the RE-AIM framework to synthesize both peer-reviewed and grey literature on the environmental and health impacts of locally distributed specialty crops in the Midwest. Overall, the available evidence was primarily from peer-reviewed (vs. grey) literature and related to environmental (vs. health) impacts. Here, we highlight key findings and future directions related to achieving beneficial impacts on both the environment and human health and nutrition, including improved synergy between producers and food access practitioners to achieve these outcomes.

Environmental impacts

First, the review aimed to understand specialty crops' environmental impacts. Results indicate that specialty crops *reach* consumers through a variety of distribution channels; have varying *effects* on soil health and quality, GHG impact, and plant quality; are *adopted* by farms of diverse size and structure; and are *implemented* through practices designed to improve soil health and alleviate climate challenges. Little is known about long-term *maintenance* plans. As the RE-AIM framework defines the overall impacts of an intervention as the combination of each dimension, more information on effectiveness and maintenance is needed to determine the extent to which specialty crops improve the environment, and whether improvements are maintained over time.

Effectiveness was difficult to determine because of variation in research designs, aims, outcomes, and results. For example, the effectiveness of amendments on soil health and plant quality were mixed. While some studies found that plant quality was improved (e.g., through biochar or a combination of pine bark and coffee grounds), overall environmental benefits varied. In addition, multiple studies examined effectiveness of production practices on soil health and found mixed results. Soil health was measured through various methods including chemical, biological, and physical properties. Because of these mixed findings, tools and technology that allow producers to measure soil health at scale and in real time are recommended for future studies. These tools should be affordable and adaptable to differing types of specialty crop production in diverse geographical regions.

In addition, more direct measures of GHG emissions are needed to better understand effectiveness. Specifically, there is a gap in practical use among specialty crop producers to measure environmental impact due to specialized food production and varying inputs that are different from traditional agricultural methods. Life cycle assessments (LCAs) can be useful to model the processes from farm to fork and food waste management and identify areas that impact the environment [63]. Yet, there is a lack of specialized LCAs for specialty crop production, and no reports included in this review used LCAs. To enhance existing measures and increase practical use for formal measures of GHG emissions, literature suggests the need to "identify food-tailored methods in LCA" and a combination of LCA methods to be applied to individual farm and larger scale food productions [63, 64]. As well, there is a need to identify standardized measures with strong correlation to GHG emissions that are feasible and acceptable for producers (e.g., GHG calculators that have been developed through LCAs tailored to specialty crop production). Researchers, funders, and policymakers could support producers by increasing research and funding (e.g., through the Environmental Protection Agency (EPA) or National Institute of Environmental Health Sciences) to conduct context-specific LCAs and identifying practical ways to measure environmental impact and GHG emissions [63, 64]. This could also increase the prevalence of longitudinal study designs assessing emissions, which can be challenging, expensive, and hard to control without appropriate measures [65].

Finally, more information is needed on adoption and organizational-level maintenance. While much has been studied about the dissemination of agricultural interventions [66], data detailing specific reasons for adopting specialty crop production was limited in the scoping review, and could aid future efforts in expanding production. More investigations are needed on which dissemination sources and channels are most effective for producers to share and receive reliable information on production practices (e.g., how to manage specific insect and disease outbreaks or develop fruit and vegetable varieties suitable for local conditions) [67, 68]; this could also lead to improved implementation and maintenance of specialty crop production.

Health and nutrition impacts

Second, as for health and nutrition impacts, findings indicate that specialty crops *reached* diverse populations through multiple food access points and were *effective* in increasing fruit and vegetable consumption and improving food security, while little is known about *implementation* or *maintenance*. Again, more complete information is needed to fully assess the public health impacts of specialty crops. First, reporting implementation data (fidelity, adaptations, and cost) is important to understand whether interventions are implemented as intended, what adaptations could improve fit and delivery, and whether costs are reasonable for long-term integration in systems [31].

Next, related to maintenance, this review also uncovered several barriers to the sustainability of food access interventions across the Midwest, with limited funding being the most occurrent. Moreover, many reports suggested that innovative approaches to dedicated funding and buy-in from the community members were needed for long-term program sustainability and expansion. According to Kim, 2016, little public funding is available for the research and development of specialty crops [67]. And most recently, on August 23, 2023, USDA announced funding for the 2023 Specialty Crop Block Grant Program (SCBGP), which provides grants to state departments of agriculture to fund programs that enhance the competitiveness of specialty crops [69]. With this grant, funding will be distributed to state programs across the U.S. to address the needs of specialty crop producers [69]. In addition to funding, building evidence to show successful outcomes and developing policy-level support have been identified as facilitators to sustaining food access interventions [70].

Finally, while effectiveness data was present, use of validated nutrition security measures [71] are needed, as nutrition insecurity remains a challenge for community members facing health disparities. The food access interventions found in this review reached individuals who received federal food assistance from programs such as SNAP or WIC (Special Supplemental Nutrition Program for Women, Infants, and Children), suggesting that specialty crops are reaching community members facing health disparities; however, the extent to which nutrition security was improved is unknown. More robust study designs (beyond cross-sectional or post-test only) are also needed. Ideally, these designs assess maintenance of primary outcomes 6 months or more after completion of the intervention to gauge long-term benefits. However, individual-level, long-term maintenance is rarely reported for food access interventions, due in part to additional resources (i.e., staffing and funds) needed for maintenance-related efforts and loss of attrition, especially when working with limited resource audiences [72, 73].

Synergy between agriculture and health sectors

More synergy between the agriculture and health sectors is also warranted to enhance the impacts of specialty crop production on human health and nutrition. Programs that connect food system actors from food production to food waste management can optimize the potential to positively impact both the farming and greater community by increasing access to locally grown fruits and vegetables. For example, this review found that food access practitioners reached community members through community gardens and farmers' markets, but there was little mention of alternative distribution methods, such as food hubs or other innovative local distribution models [74].

One example is the USDA National Institute of Food and Agriculture's (NIFA) investment in nutrition incentive (NI) programs that increase access to fresh fruits and vegetables and boost economic support for local farmers. Since the Food, Nutrition, and Conservation Act of 2008 [75], the USDA NIFA has piloted and continued to support NI projects that connect populations with diet-related health conditions (e.g., heart disease) or receiving SNAP benefits with various incentives to purchase fresh fruits and vegetables through the Healthy Incentive Pilot (HIP), Food Insecurity Nutrition Incentive (FINI) grant program, and most recently, the Gus Schumacher Nutrition Incentive Program (GusNIP) [76]. In general, NI projects offer incentives for program participants to purchase more fruits and vegetables, e.g., a SNAP household that purchases $10 of produce using their SNAP benefits will receive an additional $10 to spend on produce at a participating location like a farmers' market or grocery store.

Further, invested parties involved in food production can "close the loop" by increasing food recovery in various ways. Reducing food waste is a promising practice to reduce GHG emissions and a priority area for the USDA and EPA [77]. However, food waste was only examined in one study in this review [41]. Given that food loss and waste is a major contributor to GHG emissions (primarily the generation of methane, a more harmful GHG than carbon dioxide) when food waste ends up in landfills [78], future research and practice could engage supply chain companies and food brands in identifying opportunities to reduce food loss and waste by diverting food waste that can be used in other ways. The EPA provides guidance for sustainable food waste management and prioritizes a hierarchy of the most to least preferred recovery methods: reduce food loss and waste at the source (e.g., during food production); if food is still edible, use the food to feed people instead of throwing it away; if inedible, divert food to feed animals; create other methods or reusing food waste, such as through industrial uses (e.g., anaerobic digestion) or composting; and finally, discard food at the landfill [79].

Reducing food waste and adopting food recovery practices may also have positive impacts on human health outcomes, such as diverting still-edible food to populations in need and increasing access to food that might have been thrown away instead. For example, organizations such as Upcycled Foods and Imperfect Foods work with producers across the country to develop processes to divert potential food waste (e.g., spent grains) into new products, which becomes an added distribution channel for growers to gain additional income [80–82]. If food recovery methods are adopted or desired, communities could gauge the demand for "ugly produce" and upcycled products that are still perfectly edible. This may involve conducting targeted marketing approaches or social marketing campaigns to increase awareness and demand for produce or products that are recovered. Based on communications research, this could include the environmental, resource-saving, and nutritional value of upcycled foods to boost consumers' interest in their consumption of upcycled foods [83].

Since distribution channels vary by market and producer needs, communities should identify opportunities to recover food through local avenues. This would require funding to support research and development of secondary markets and opportunities for local collaboration. These partnerships could involve local food producers, food access practitioners, food businesses interested in purchasing locally grown produce, and municipal entities that oversee regulations related to business or organic waste management. As an example, a farm in Orlando, Florida receives local food scraps from a composting company and wood chips from local arborists to create their own compost [84].

In addition, a potential area of improvement is the idea of refining the efficiency of the food supply chain by connecting actors across the food system [85]. Often, small producers lack processing or cold storage facilities to take advantage of broader market opportunities [86]. Supply chains can be strengthened with the integration of food hubs that connect rural, mid-sized, and large farmers to increase market opportunities for local farmers [87]. While producers can identify secondary markets by selling to restaurants or other institutions [88], they can also connect with community organizations that might have funding to purchase local produce or are able to receive donations that are unsalable but still edible through "Farm to Food Bank" programs [89]. These examples can support producers and practitioners who distribute emergency food simultaneously. Overall, more ways to use imperfect or blemished foods at the packer and processor level are needed.

Future directions

Further investigation of agricultural practices with high potential to contribute to environmental health and adapt to climate change is critical, ideally through large-scale studies with robust designs and evaluation methods. Standardized measures and tools assessing environmental and health outcomes (i.e., soil health, GHG emissions, and food security) are necessary to monitor the success of specialty crop production and food access programs. Multisector efforts such as food waste recovery should be explored for their potential to impact both human health and the environment. This could include research on supply chain infrastructure to assess the limiting factors for harvesting, processing, storing, and distributing specialty goods; and the role of food retailers to address food access while maximizing supply chain effectiveness. Future research could also explore consumer interest in regional food sources; for example, the "Buy Fresh, Buy Local" movement could potentially become "Buy Regenerative, Buy Regional."

Limitations

As with any scoping review, results are limited by the databases and search terms used, which may not have captured all relevant peer-reviewed and grey literature. In addition, limiting the area of focus to the Midwest may have excluded important insights into environmental and health impacts of specialty crops from other areas of the country. For example, only one study included in the scoping review examined local versus distant specialty crop production, but no health or nutrition outcomes were included [40], making it difficult to understand whether local produce is better for health. Studies directly comparing the impacts of local versus non-local foods or specialty crops versus conventional row crops could provide valuable insight into ways to improve environmental and health outcomes. Related, the methodological limitations of the included reports contributed to this difficulty, as many were cross-sectional, single-timepoint assessments or pragmatic pre–post designs. As such, observer bias, self-selection bias, or recall bias could have occurred [90]. Finally, the scoping review methodology aimed for breadth of findings, and as such it was difficult to compare results across studies. For example, we could not quantify the diversity of soil types, textures, or production methods in the included reports**.** Overall, it is difficult to assess direct impacts of specialty crop production because of complexities of the food system, and more research is needed to answer specific questions.

Conclusion

This scoping review aimed to understand environmental and health impacts of locally distributed specialty crops in the Midwest. Related to environmental impacts, results indicate that specialty crops reach consumers through a variety of distribution channels; have varying effects on soil health and quality, GHG impact, and plant quality; are adopted by farms of diverse size and structure; and are implemented through practices designed to improve soil health and alleviate climate challenges. As for health and nutrition impacts, findings indicate that specialty crops reached diverse populations through multiple food access points and were effective in increasing fruit and vegetable consumption and improving food security, while little is known about implementation or maintenance. More synergy between the agriculture and health sectors is warranted to enhance the impacts of specialty crop production on human health and nutrition. Taken together, specialty crop production shows promise for positively impacting environmental and health outcomes, but more research is needed.

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

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Author contributions
LB and AY conceptualized the study and acquired funding. LB developed methodology with assistance from ES, KN, DV, and JD. LB, ES, KN, MI, and DV collected data. LB, ES, WFU, KN, MI, LN, and JD analyzed and synthesized data. LB, ES, WFU, KN, and LF wrote the original draft; MI, DV, and AY reviewed and edited. All authors read and approved the final manuscript.

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Availability of data and materials
The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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