frontiers in Climate

ORIGINAL RESEARCH
published: 14 June 2021
doi: 10.3389/fclim.2021.662847

Product Diversification, Adaptive Management, and Climate Change: Farming and Family in the U.S. Corn Belt

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Specialty section:
This article was submitted to Climate Risk Management, a section of the journal Frontiers in Climate

Received: 01 February 2021
Accepted: 10 May 2021
Published: 14 June 2021

Citation:
Valliant JCD, Bruce AB, Houser M, Dickinson SL and Farmer JR (2021) Product Diversification, Adaptive Management, and Climate Change: Farming and Family in the U.S. Corn Belt. Front. Clim. 3:662847. doi: 10.3389/fclim.2021.662847

A variety of factors shape farmers' views as they face the rising effects of climate change and consider a range of adaptation strategies to build the resilience of their farming systems. We examine a set of related questions to explore farmers' perspectives on risks and potential shifts to their operations: (1) Relative to other environmental factors, how salient of a challenge is climate change and climate-related impacts to farmers? (2) Do farmers intend to adapt to climate impacts generally?, and (3) What factors shape their use of a specific and underexplored adaptive response—farm product diversification? The data come from a survey of 179 operators within a 30-county region of Indiana, Michigan, and Ohio. The region spans various rural-urban gradients. Respondents generally represent smaller operations [median of 80 acres (32 hectares)]. Because our selection methods aimed to over-sample from food-producing farms, 60% of respondents produced some type of food or value-added product, and 40% produced only commodity feedstocks and biofuels. Although the group as a whole indicated only "somewhat" of a concern about changing weather patterns, and half did not anticipate adapting their farming practices to climate change, farmers' responses to a write-in question denoted regional climate effects as challenges to their farms. Analysis of subgroups among the respondents, according to their views of climate change, adaptation, and further diversifying their agricultural products, distinguished farmers' family considerations, and gender. Methods to elicit subgroups included correlation, regression, cluster analysis, and an examination of the many respondents (29%) who indicated uncertainty about adapting practices. Women, who participated in 29% of responses, indicated more concern with changing weather patterns and more openness to adapting farming practices compared to men. Farmers with the most family relationships to consider, and those with the greatest aspirations to employ descendants, were the most receptive to adapting their farming practices. This was the case even when respondents' concern over climate change was low. Results point to the importance of family relationships as a factor in farmers' openness to implementing adaptive and potentially mitigative actions.

Keywords: climate decision-making, adaptation, uncertainty, agricultural diversification, family-owned farms, farm succession, social environment, gender

INTRODUCTION

Across the United States, climate change—in the form of higher average temperatures and increasingly frequent and severe extreme weather events—is already and will continue to present grave challenges to agricultural production and the farm families who operate within agricultural systems (IPCC, 2019). The climate change impacts that the US Midwest region faces are direct, as the weather becomes warmer and wetter, and indirect, through shifting habitat ranges (Winkler et al., 2014; Janowiak et al., 2016). Weather events, such as rain, hail, and windstorms, are becoming more frequent and intense and can directly harm plant and animal life (Pryor et al., 2014). Flooding is increasing and is only made worse as precipitation falls onto land that has been engineered for drainage and cannot soak into soils that are compacted by agricultural and other land management practices (Janowiak et al., 2016). Indirect impacts involve habitats becoming more hospitable to a wider range of diseases and pests that may depress agricultural productivity. In response to these risks, farmers can pursue adaptation strategies that include both practices and operational-level shifts that reduce vulnerability to climate change (Smit and Skinner, 2002; Howden et al., 2007). Given the important role farmers play in driving adaptation of agricultural systems (Ostrom, 2014; Jurt et al., 2015), researchers are increasingly focusing on US farmers' adaptation decision making, revealing that a variety of factors shape farmers' use of adaptation strategies and views of climate change risks (Arbuckle et al., 2013a; Schattman et al., 2016; Roesch-McNally et al., 2018; Houser and Stuart, 2019; Fletcher et al., 2020; Yoder et al., 2021).

As farmers respond to increasingly difficult ecological circumstances, they are also dealing with difficult economic circumstances. Over the past century, most U.S. farmers have closed their farm businesses and exited from a consolidating U.S. agriculture, such that direct agriculture now provides little employment in general, and off-farm income is a mainstay for farm families (Wood and Gilbert, 2000; MacDonald et al., 2018; USDA-ERS, 2021). In this paper, we examine how farmers' perspectives on climate change and adaptation relate to the social-relational priorities of the farm, making two contributions to knowledge of farmers' adaptation to climate change. First, we provide a robust literature review that integrates research about farmers' adaptation to climate change, agricultural diversification, and some of farmers' social priorities, in specific the role of family relations and gender in shaping farmers' decision-making and adaptation strategies. Second, we address the need for greater attention to farmers' qualitative understanding of climate change and their experiences with it through an innovative, mixed methods study.

Most research on farmers' adaptive responses to climate change has considered adaptation at the level of practice adoption, for example planting cover crops (e.g., Roesch-McNally et al., 2018; Houser and Stuart, 2019; Yoder et al., 2021). Much less has focused on what is sometimes called operational-level shifts (Smit et al., 1996) or "transformational" adaptation, where system shifts surpass the incremental adoption of a practice (Blesh and Wolf, 2014; Robertson and Murray-Prior, 2016; Panda, 2018; Roesch-McNally et al., 2018; Chenyang et al., 2021). Here, we consider the operational-level adaptive response of farm product diversification, a strategy that farmers can use to increase their capacity to deal with climate change (Hilimire, 2011; Hendrickson, 2015; Bowles et al., 2020).

Diversification aims to increase the economic and ecological diversity of the farm and the agricultural system, and thus their stability and capacity to accommodate fluctuations and shocks (National Resource Council, 2010; Lin, 2011; Gaudin et al., 2015; Rotz and Fraser, 2015). Defining diversification broadly, major analyses find that diversification holds more potential than most other food production and land management interventions for making progress toward global climate and societal goals, in specific the Sustainable Development Goals and the Nature's Contributions to People (Diaz et al., 2018; UN, 2018; McElwee et al., 2020). Agricultural diversification has been defined in a variety of ways and can include multiple elements of the operation (Iles and Marsh, 2012; Bowman and Zilberman, 2013; Heggem, 2014). Crop diversification is a critical definition whose implications for climate mitigation and adaptation are direct. Diversifying land covers can support biodiversity while potentially building soil and reducing pest pressures and farmers' chemical applications to their production systems (Bradshaw et al., 2004; Roesch-McNally et al., 2018; Merlos and Hijmans, 2020; Prokopy et al., 2020). Diversification via livestock and crop integration is another major approach to diversification (Garrett et al., 2017). We place our focus on a related definition, product diversification, through which farmers augment their mix of products. The clear priority in diversifying products is economic and stewarding the farm ecosystem is often a related priority (Barbieri and Mahoney, 2009; Hansson et al., 2013; Suess-Reyes and Fuetsch, 2016).

We give particular attention to the role of farmers' gender and family dynamics—two understudied factors in the agricultural adaptation literature, especially that which focuses on the United States and Midwestern region. Some work points to the importance of family relations in shaping farmers' adaptation decisions and specifically their decisions to diversify their products (de Rooij et al., 2013; Hansson et al., 2013; Suess-Reyes and Fuetsch, 2016; Valliant et al., 2017). For instance, farms' capacity for change appears to reflect family priorities such that farms with greater family involvement, both in the present and what is expected for the future, are more equipped to take on positive adaptations, or the addition of any business activity, including a new product (Inwood and Sharp, 2012). However, this sphere of influence has been given limited attention within the agricultural adaptation decision-making literature specifically. We seek to offer introductory insight into the importance of family relations to farmers' climate adaptation capacity.

Family interests contribute some of the "overarching motives" (Hansson et al., 2013) that often inform a farm's business and management decisions. Combined, the business and family interests of the farm have been framed as those of an "agrifamily system" (Bennett, 1982). Similarly, the broader family business literature (Suess-Reyes and Fuetsch, 2016) also integrates "the structural and social links between the family and the business" by theorizing and operationalizing "familiness" as a construct (Habbershon and Williams, 1999; Weismeier-Sammer et al., 2013, p. 168). The factors that influence farmers' management and adaptation decisions can be clarified by considering this frequent interdependence of the farm with family (Gray, 1998). Included among these positive adaptations are new business activities as well as revisions to the production system to adopt climate adaptive, or, better, dual purpose adaptive-mitigative agricultural practices (Beddington et al., 2011; Haden et al., 2012; Arbuckle et al., 2013b, 2015).

Related to our focus on the ties between farmers' family dynamics and their views on adaptation is a call to specify gender in research about agricultural perspectives on climate change in the global North (Alston, 2014; Walker et al., 2019). This "gender mainstreaming" strategy aims to interrupt "the invisible farmer problem" (Alston et al., 2018), or the historical exclusion of women from dialogues about agriculture. A gendered lens also acknowledges women as central actors in how farm families experience climate effects, and the many types of psychological, workflow, and economic adaptations families make in response (Fletcher and Knuttila, 2016)[1]. Gender is a consistent predictor of climate change belief in the general population, as well as supportive attitudes for pro-climate behavior and policy (McCright and Dunlap, 2011; McCright et al., 2016). Thus, our analysis incorporates gender of the respondent as an analytical factor. Calls by scholars who study climate change and Midwest farm operators state this need to understand how farms subdivide according to their demographic characteristics, and how these relate to the features of their operations and their views of climate change (Arbuckle et al., 2013a; Morton et al., 2015; Niles et al., 2015). We examine gender and family in relation to climate outlooks and adaptations by pursuing the question, how do family and gender factor into farmers' perspectives on climate change effects and adaptive practices?

[1] A parallel conversation is taking place about gender and forestry in the global North (UNECE/FAO, 2006; Reed et al., 2014; Holmgren and Arora-Jonsson, 2015).

In terms of how farmers' family situations may affect their capacity to adapt the operation to climate change, theories of the life course guide how inclined a farm business may or may not be toward positive adaptation. Along the life course, the productivity of an operation typically builds as the primary operator approaches midlife and declines after age 60 (Tauer, 2019). Mediating the farmer's life course is how the farm is approaching succession. Succession refers to the passing of the farming operation to the next generation. Succession takes many forms, within or between families. A transfer to the next generation or even just the anticipation of a successor in the queue can motivate farm families to prepare the farm to support additional family members (Chiswell, 2014). The objective of this "succession effect" is to build the farm's income to accommodate more personnel (Lobley et al., 2010; Lobley and Baker, 2012). The US Department of Agriculture observes that \$100,000 in gross cash farm income is needed to provide for every one-half to three farm jobs, depending on the scale of the farm (MacDonald et al., 2018). This is the economic scenario faced by farmers who would like for their farms to survive and continue on to the next generation. Most strategies to provide for more family members involve diversification in some fashion (Inwood and Sharp, 2012).

In this paper, we seek to contribute to these burgeoning literatures in a variety of ways. A review of research on farmers' climate change views suggests the need for greater attention to their qualitative understanding of climate change and their experiences with it (Soubry et al., 2020), echoing prior calls for more work on this subject (Doll et al., 2017; Houser, 2018). Here, we contribute to addressing this gap by first asking (1) Relative to other environmental factors, how salient of a challenge is climate change and climate-related impacts to farmers? We examine this through the approach of a qualitative survey question (i.e., a "write in" response), where farmers were asked to describe their most significant challenges related to the physical environment. We also consider if and how farmers may respond to climate change through adaptation, asking the related questions of: (2) Do farmers intend to adapt to climate impacts generally?, and (3) What factors shape their use of a specific and relatively underexplored adaptive response—farm product diversification? Because of the links between diversification and family, and the benefits of diversification related to climate adaptation, food security, and rural resilience, we focus particularly on how farmers' diversification perspectives and practices correspond with their gender and family patterns and their views of climate change adaptation.

MATERIALS AND METHODS

Regional Context: Climate Effects and Agricultural Diversification in the Southern Great Lakes Basin

The study area, a 30-county area of the U.S. states of Indiana, Michigan, and Ohio, presents a rural-urban gradient in a landscape with abundant freshwater (see **Figure 1**). Located at the southern margin of three of the Great Lakes, Erie,

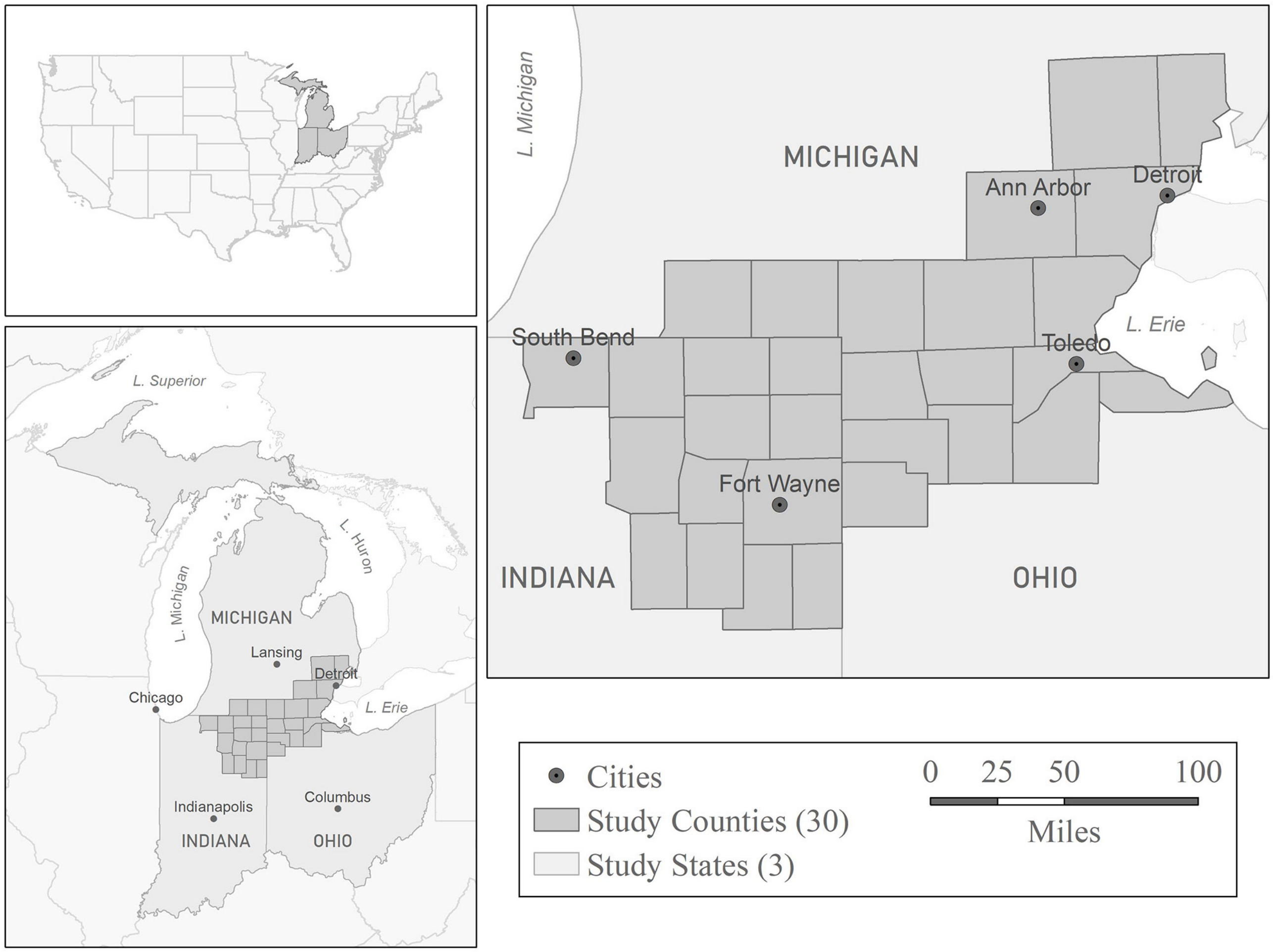

FIGURE 1 | Map of study site in Indiana, Michigan, and Ohio, USA.

Huron, and Michigan, the native ecosystem for the study site was once entirely made up of swamp or wetlands. It was engineered for drainage, and artificial undersurface drainage pipes (tile drains) remain widely in this area to this day (Dahl and Allord, 1997; USDA-NRCS, 2005; King et al., 2014).

We selected the study region as part of a larger project to explore farm product diversification along a geographic gradient from rural agricultural to metropolitan areas, and across state lines. The cities of Detroit and Ann Arbor, Michigan; Toledo, Ohio; and Fort Wayne and South Bend, Indiana provide markets and processing centers for a region where corn-soybean rotations are typical, to produce feedstocks and ethanol. Productivity of cereals is high enough for certain counties in the catchment to rank among the top 50 in the nation for soybean production and the top 225 for corn (USDA-NASS, 2012). The region is also a production and processing center for poultry and winter wheat and for diversified non-commodities such as seed corn, potato, tomato, duck, pickling cucumber, and gladiola (USDA-Census of Agriculture, 2014).

Corn Belt farmers face policy disincentives to diversifying their products (Bowles et al., 2020; Spangler et al., 2020). After a century of product specialization—the opposite of diversification—(Bradshaw et al., 2004), U.S. farms now produce an average of 1.2 products per year, indication that most now produce a lone product (Gardner, 2002; Dimitri, 2010). The U.S. ranks in the 29th percentile globally for crop diversity (Aizen et al., 2019) and its national plans for sustainable agriculture fall behind those of most other nations by placing little emphasis on agrobiodiversity (Bioversity International, 2019; Juventia et al., 2020). The lowest diversity in the nation is in the Corn Belt (Aguilar et al., 2015). In spite of this pattern of homogenization and specialization, eastern U.S. farmers have actually ranked product diversification as a feasible climate-adaptive strategy in some studies (Crane et al., 2011; Rejesus et al., 2013). However, other research finds diversification to be unrealistic for large grain farmers due to their high financial investment in current production models (Roesch-McNally et al., 2018). More broadly, farmers' inclination to implement many types of adaptations is limited by market and policy disincentives such as yield-based payments, crop insurance premiums on diversified rotations, production contracts, and financial pressure (Stuart et al., 2012; Prokopy et al., 2015; Houser and Stuart, 2019).

Survey Instrument

Data for this study come from a mailed survey which included questions about product mix and diversification; land tenure and management; environment and stewardship; social capital, family, and demographics. Survey questions (available in the **Supplementary Data Sheet 1**) were informed by prior qualitative interviews with 18 agricultural stakeholders, including five diversified farmers who maintained a commodity feed grain operation alongside non-commodity enterprises, and 13 service providers representing the Extension system, USDA Natural Resources and Conservation Service, Farm Bureau, agricultural cooperatives, and food hubs. Qualitative findings are published in Valliant et al. (2017). Prior to mailing the survey, the questionnaire draft was reviewed by three male farmers from within the target population and revised in response to their recommendations regarding content and clarity of the questions and their response options.

The sampling strategy aimed to over-sample from farms that sell food products into direct and/or intermediate markets. The sample was developed from two lists of farms in the study region. The USDA Farm Service Agency (FSA) provided one of the lists in response to a Freedom of Information Act request. Farms on the FSA list utilize FSA services in some way, which may include commodity payment, financing, conservation, and crop insurance programs (see www.fsa.usda.gov). The second list consisted of farms that are not in the FSA database because they do not participate in FSA programs, perhaps due to their small size or personal preferences. While FSA does extend credit to many small or beginning operations, analyses of FSA services find them to be less able to assist operations considered to be limited resource, economically disadvantaged, or higher risk (Dodson and Koenig, 2006; Dodson and Ahrendsen, 2016). Our assumption was that this "non-FSA" list would reflect farms that are more likely to be diversified than the farms on the FSA list (National Sustainable Agriculture Coalition, 2014; Bruce, 2016; Lusher Shute, 2016). The FSA list identified 23,194 unique farm contacts with in-state mailing addresses for the 30 counties. Seeking an even number of responses per state, the project budget allowed us to select a random sample of 184 Indiana farms, 183 Michigan farms, and 183 farms in Ohio, totaling 550 farms. To identify non-FSA farms in each state, the steps we followed were: 1. Contacting Extension headquarters in each state to invite relevant county offices to share their lists of small farms for this research purpose. Ohio State University Extension obliged. 2. Contacting farmer's market coordinators in the focus counties to request their lists of grower-vendors. 3. Visiting online lists of farms with direct-to-consumer marketing in the focus counties using the resources Local Harvest (www.localharvest.org) and MarketMaker (in.foodmarketmaker.com, mi.foodmarketmaker.com, oh.foodmarketmaker.com). These steps identified 567 farms, after removing duplicates that were also on the FSA list. From these, we selected 150 farms from each state in order to oversample from diversified farms because the larger research project aimed to learn from farms that produce food products instead of, or in addition to, the feed crops that dominate the landscape.

The survey was distributed by mail to 977 farms whose addresses were determined to be valid. Procedures followed a modified tailored design method, with a postcard-survey-postcard-survey series of mailings (Dillman et al., 2014). Every survey packet included a 10-page questionnaire with 86 questions, a cover letter, and return postage. The first survey mailing included a $2 bill as a cash incentive. Participants returned the surveys on a voluntary basis, and anonymity of responses was maintained. A total of 222 surveys were returned with sufficiently complete answers to be used in the study, with 19 responding online (9%) and 203 through the mail (91%). This amounted to a final response rate of 23% as a proportion of the number of surveys sent to eligible farmers excluding those that were returned undeliverable. Forty-three respondents (19%) did not respond to items about diversifying. This analysis considers the 179 respondents who did complete the items about diversifying.

Questionnaire Terminology About Climate Change

After interviewing farmers and service providers in the study area, we chose to follow their guidance and some from the literature by using terms other than "climate change" in the questionnaire (White and Selfa, 2013). As an example, one service provider discouraged use of the term climate change by saying, "The climate change debate has gotten so political that what is truth anymore?" Thus the instrument did not refer to climate change. Instead, two items used "changing weather patterns." The first such item was, "How concerned are you about changing weather patterns where you are?" Response options formed a 6-point Likert scale from "Not at all concerned" to "Extremely concerned." The second item was, "Do you anticipate changing your farming practices in response to changing weather patterns?" Its response options were Yes, No, and Don't know. These items were within a section that included several open-ended questions about farmers' practices to manage the farm ecosystem (Please see Section 5 Environment and Stewardship of the Survey Instrument in the **Supplementary Data Sheet 1**). This phrasing may have elicited a more overall positive response than if we had used "climate change" (Schuldt et al., 2017). Our language of "changing weather patterns" is consistent with the language that farmers use to discuss "climate change" (Doll et al., 2017; Houser, 2018; Fletcher et al., 2020).

Questionnaire Items About Family Involvement in the Farm and Gender

One section of the survey entitled "Your Farm Family" aimed to ascertain the place of family in the farm operation. This series of items sought to define the level of family involvement in the farm at the present time as well as respondents' expectations and hopes for family involvement in the future. To clarify present family involvement, respondents wrote in their number of adult siblings and descendants, and how many of these people were in partnership with them on the farm. Respondents also indicated whether the farm had belonged to their ancestors (Yes/No). To elicit respondents' perspectives on future family involvement, we asked how much of a priority it was for the farm to be able to employ descendants. Responses to this item were arranged in a 6-item Likert scale spanning "Not a priority" to "High priority." We also gauged future involvement by applying a framework for measuring respondents' expectations for the possibility of a family successor (Chiswell, 2014). This framework inquired whether a family successor was expected, and whether a family successor was actively moving toward management of the farm. The options for these succession items were Yes, No, and Don't know yet. To assess gender, the questionnaire asked whether one or more women were responding to the survey (Yes/No).

Operationalization of Agricultural Product Diversification

In our analysis, we attempted to define product diversification in the same way we heard farmers describe it in previous primary research in this region, when farmers framed their pursuit of alternatives to commodities as key to their viability, and to their capacity to employ additional members of the family (Valliant, 2012; Farmer et al., 2014; Bruce and Som Castellano, 2016; Morning Ag Clips, 2020). The definition we heard in the field distinguished farms that only raise "commodities," to use the farmers' term, from farms that raise anything other than, or in addition to, a commodity. Farmers used the term commodity to refer to undifferentiated agricultural products that are traded in bulk through mechanisms of global exchange (see Commodity Futures Trading Commission, 2010; Hajdu, 2018). Thus, we categorized respondents as non-diversified when they reported raising only commodities (examples given by the survey included corn, soybeans, and wheat). When these data were missing, farmers who only reported raising feed-grade corn and/or soybeans were counted as non-diversified.

We defined all other respondents as diversified. Either in addition to or instead of commodities, these respondents reported raising a product that was value-added (such as finished beef, baleage, jam), specialty crop (fruit, vegetables), differentiated (such as USDA certified organic wheat, non-GMO corn, "no antibiotics added"), direct marketed, or grown on contract (such as vegetables, flowers, seed corn) (Salvioni et al., 2013; USDA-AMS, 2015; USDA-FSIS, 2015; Agricultural Marketing Resource Center, 2016). Thus, we aimed to operationalize the appreciation farmers expressed for the contributions these product categories make to their economic, social, and ecological farm systems (Hayes et al., 2004; Che et al., 2005; Bramley and Kirsten, 2007; Fitz-Koch et al., 2017).

Analysis

Our analysis began by exploring responses to one structured, qualitative survey item to orient the balance of the analysis to how respondents expressed the greatest natural, physical challenges faced by their farms. From there, statistical analyses proceeded with correlation and regression analysis to determine variables that predicted the respondents' perspectives on diversifying their farms' products. Two subsequent analytical approaches explored further subgroupings among the respondents, to further explore farmers' perspectives on the inter-relationships between climate change, diversification, and the priorities of the farming family. These analyses first examined respondents' characteristics according to whether they expect to adapt their farming practices to climate change, and then combined these expectations with respondents' levels of concern about climate change and their outlooks on diversifying through a cluster analysis. Please see **Table 1** for a schematic of the analysis methods.

Responses to the paper surveys were entered manually into Qualtrics. IBM SPSS 23.0 was then used for data management including recoding variables and creating composite scores to prepare for analysis. Descriptive statistics were performed on each variable and assessed for Normality. Acres of land owned was positively skewed and transformed to a Normal distribution with a square root transformation. IBM SPSS was used for all statistical analyses.

Free List Analysis of Research Question 1: Relative to Other Environmental Factors, How Salient of a Challenge Is Climate Change to Farmers?

To explore how the respondents to this survey might mention the features of climate change in their own words, we interpreted responses to a write-in survey item as we would a free list. Free listing is a structured qualitative method from anthropology. Its utility is in clarifying how participants define and populate a domain in their own words, and it assesses variation across perspectives, or "intracultural variation" (Weller and Romney, 1988; Bernard, 2011). Using free list analysis, we interpreted respondents' lists of the "two greatest natural challenges posed by the physical environment to your farm" as a truncated, two-item list. Analysis involved first categorizing responses. Two of the authors categorized the full set of responses independently, and then met to compare and adjust the categories to cross-validate the process. Our analytical procedures were conservative in assigning responses to the climate change category. We included only responses that explicitly state climate change or one of its direct hallmarks (extreme events, seasonality, etc.) (USDA-ERS, 2012). When farmers listed natural perennial hazards of the region, such as drought or flooding, without mentioning increasing intensity, magnitude, duration, or frequency, we assigned these entries to other categories (such as precipitation). We then logged how frequently items/categories were mentioned (F) and whether respondents listed them first or second, to assess their mean position in the list (mP). From this we calculated a salience index (Sutrop, 2001). Salience (S) is a fraction, normed to vary between zero and one: $S = F/(NmP)$. The salience index assumes the items mentioned first and more frequently to be the more salient (Douglas et al., 2012; Campos et al., 2014).

Analysis of "Don't Know" or Uncertain Responses to Research Question 2: Farmers' Intentions to Adapt to Climate Impacts

Farmers responded to the item "Do you anticipate changing your farming practices in response to changing weather patterns?" with a no, don't know, or yes. We examined the patterns surrounding all three of these responses. We included in

TABLE 1 | Diagram of methods.

Data	Research question and Survey item(s)	Analytical method			
		Free list	Don't know	Regression	Cluster
Mailed survey ($n = 179$)	RQ1: What are the two greatest natural challenges posed by the physical environment to your farm? (Write-in)	✓		✓ (IV)	
	RQ2: Do you anticipate changing your farming practices in response to changing weather patterns? (Y, N, DK)		✓ (IV)	✓ (IV)	✓
	RQ3: Composite: Outlook on diversifying: 1. How much interest does your farm have in further diversifying? (1 = No interest to 6 = Strong interest) 2. To what degree is your farm considering making any changes at all to products or methods? (1 = Not at all to 6 = Actively making changes) 3. How feasible do changes to products or methods seem for your farm? (1 = Not at all feasible to 6 = Completely feasible)		✓ (DV)	✓ (DV)	✓
	RQ3: How concerned are you about changing weather patterns where you are? (1 = Not at all concerned to 6 = Extremely concerned)		✓ (IV)	✓ (IV)	✓
	RQ3: Diversified status (Commodity only vs. any non-commodity)		✓ (IV)	✓ (IV)	

our analysis "don't know" responsive, which routine analytical procedures might omit as non-substantive (e.g., Prokopy et al., 2015). We instead explored how "don't know" responses to this item were associated with respondents' characteristics and their responses to other items (Van Es et al., 1996; Groothuis and Whitehead, 2002; Browne-Nunez and Vaske, 2006). We became interested in "don't know" responses to the item after farmers who piloted the survey said they selected "don't know" to reflect uncertainty: a perspective closer to "maybe" or "perhaps," as opposed to lack of knowledge. Using histograms to plot the data showed an ordinal relationship between "yes," "don't know," and "no" responses, so the item was treated as a three-point scale (1 = no, 2 = don't know, 3 = yes) in correlation, regression, and cluster analyses. People who responded with no, don't know, and yes were compared using F-tests for patterns of association across their characteristics and responses to other items.

Regression and Cluster Analysis of Research Question 3: Farmers' Outlooks on Product Diversification

Pearson correlation and stepwise multiple linear regression were used to identify variables associated with farmers' perspectives on adapting their operations via diversification. The outcome variable in the regression analysis was the mean of a composite we formed from three correlated items about the prospect of diversifying (Cronbach's alpha = 0.806). This composite, "outlook on diversifying," represented the mean of one's responses to three six-item scales: 1. How much interest does your farm have in further diversifying? (1 = No interest to 6 = Strong interest), 2. To what degree is your farm considering making any changes at all to products or methods? (1 = Not at all to 6 = Actively making changes), and 3. How feasible do changes to products or methods seem for your farm? (1 = Not at all feasible to 6 = Completely feasible). We aimed for the composite to explore respondents' attitudes and intentions toward diversifying by integrating their levels of interest, the consideration they were giving to changing their products or methods, and how they viewed the feasibility of making changes. While one response option for one of the items did allow respondents to state that they were "actively making changes to products or methods," and 16 respondents selected this option, we included these responses in the composite since they could reflect non-diversified or diversified farms, which were distinguished by a different variable. A forward stepwise selection procedure was used to identify which of the respondents' characteristics and perspectives were most significant in predicting their outlooks on diversifying, or further diversifying, their products.

Cluster analysis was then used to identify subgroups across this set of farmer respondents, according to their differences on three variables of primary interest to this analysis. These were their: (1) level of concern about changing weather patterns, (2) level of anticipation of changing farming practices due to changing weather patterns, and (3) outlooks on diversifying. A two-step cluster analysis was first performed to identify the best number of clusters in the data based on Schwarz's Bayesian Criterion, which showed three clusters to be optimum. A K-means Cluster analysis was then performed to classify respondents into three clusters based on their responses to the three key questions. The respondents grouped into each cluster were then compared for patterns of association according to their characteristics and their responses to other survey items to describe the three different types of respondents identified. F-tests tested for significant differences between clusters. This cluster analysis complements other place-based typologies of farmers according to their views of climate change (Barnes and Toma, 2012; Arbuckle et al., 2014, 2017; Hyland et al., 2016).

Lastly, we conducted Chi-square (X^2) tests to explore the relationships between both (1) gender and the survey item about anticipation of altering future farming practices due to changing weather patterns, and (2) gender and cluster assignment. Specifically, we were investigating if men or women responded to the item differently or were sorted into clusters in significantly different ways.

RESULTS

Participant Profile

Sixty percent of respondents operated diversified farms; the other 40% we define as non-diversified (see section Operationalization of agricultural product diversification). Most of the diversified respondents listed their diversified products in a write-in survey item (63%). The top category was horticultural crops (45%). These were principally vegetables such as potatoes, green beans, peppers, hops, garlic, and tomatoes, and value-added products such as cider, jam, and bouquets. The second category was field grains (21%), which were primarily food-grade, seed, or differentiated (non-GMO or certified organic) corn and soybeans, and value-added products such as baleage, silage, straw, and flour. The third category was livestock and poultry products (16%), comprised of breedstock, fiber, and finished, often differentiated, meat. The fourth category was forest products (12%), comprised of wreaths, boughs, firewood, and maple syrup.

The questionnaire asked for the number of acres respondents farmed (sum of owned and leased land minus land rented out). While their operations ranged up to 4,850 acres, the median was 80 acres, and the mean was 320 acres (standard deviation = 720). The median respondent age was 61, with a range of 20–94. Respondents placed "moderate" priority on the farm being able to employ descendants (median of 4 out of 6, mean of 3.6). Mean and median responses to the composite "outlook on diversifying products" (see section Analysis of "don't know" or uncertain responses to research question 2: Farmers' intentions to adapt to climate impacts) were 3 out of 6. Women participated in 29% of responses ($n = 48$). Diversified farms were marginally more likely to have a woman respondent, compared to non-diversified farms. Among diversified farms, 34% of respondents were women. Among non-diversified farms, 22% of respondents were women ($p = 0.096$). These and other descriptive characteristics of the respondents are presented in **Table 2**.

Turning to respondents' perspectives on climate change, as a group their responses indicated that they were "somewhat" concerned about changing weather patterns (3 on a scale of 6). Nearly half of respondents (48%) did not anticipate changing practices in response to changing weather patterns, 23% did anticipate changing practices, and 29% checked the "don't know"

TABLE 2 | Descriptive statistics: Farmer survey respondent characteristics and perspectives on implications of climate change for agricultural practice.

CONTINUOUS VARIABLES

Item	Valid *N*	Median (Scale = 1–6)	Mean (Scale = 1–6)	Standard deviation (Scale = 1–6)
How do you rate the condition, or health, of your farm's physical environment?	172	5 "very good"	5.6	0.9
Climate: How concerned are you about changing weather patterns where you are?	172	3 "somewhat concerned"	3.0	1.5
Diversification: Outlook on Diversifying Product or Methods (3- item composite)	179	3	3.0	1.7
Family: Priority for farm to be something that children/grandchildren can do for a profession	174	4 "moderate priority"	3.6	1.9
	Valid *N*	**Median**	**Mean**	**Standard deviation**
Family: Number of adult family members in partnership with you on the farm (0 to 4)	160	0	0.6	0.9
Family: Likelihood of someone in the next generation to follow in running the farm (1 to 3)	174	2	2.0	0.8
Acres of land actively farmed ("worked")	170	80	320	722
Years since family began farm	170	44	54	42
Age of respondent (20–94)	164	61	59	14

CATEGORICAL VARIABLES

Item	Valid *N*	No		Don't know		Yes	
		N	%	*N*	%	*N*	%
Climate: Do you anticipate changing your farming practices in response to changing weather patterns? (1 = no, 2 = don't know, 3 = yes)	172	82	48	50	29	40	23
Diversification: Farm is currently diversified	179	72	40			107	60
Gender: Is one or more women completing the survey?	164	116	71			48	29
Family: Did you inherit/purchase the farm from your forebears?	172	89	52			83	48

option. Respondents reported the health of their farms' physical environments as very good (median of 5 out of 6, mean of 5.6).

Results for Research Question 1: Salience of Climate Change Relative to Other Environmental Factors

The terms most used by respondents for the top challenges that the physical environment posed to their farms were "weather" (20% of the 147 respondents to this item), "weeds" (10%), and "erosion" (9%). We grouped their responses into four broad categories: (1) weather/climate/precipitation (62%), (2) soil/water management (40%), (3) weeds/pests/disease (24%), and (4) terrain/conditions (e.g., topography, field size) (13%). Then, splitting categories for precision resulted in the seven groupings presented in **Table 3**.

Among this finer set of categories, climate change emerges as a challenge. Eleven percent of farmers listed a characteristic of climate change. The mean position of climate change ranked fifth of the seven categories. Climate change's higher mean position compared to the sixth and seventh categories indicates that respondents were more likely to list climate change as a top challenge than a secondary challenge. The salience index ranks the hallmarks of climate change as the seventh most salient class of natural challenge. Respondents who listed a feature of climate change did not differ from the group by gender or their level of family involvement in the farm.

Even though a minority of respondents used this structured qualitative item to write in a hallmark of climate change, we still present their responses in **Table 4** to share the local terminology elicited. The climate change characteristics the respondents listed most frequently had to do with seasonality and timing, and used the terms: late and early frosts, cooler summer temperatures, the timing of rains, and seasons changing earlier or later than expected. As for how participants said they were responding to the features of climate change that they named, the use of some type of technology to mitigate or lessen the challenges was mentioned most often (e.g., growing under cover, tiling, irrigation) (50%) (See **Supplementary Table 1**)

Results for Research Question 2: Farmers' Inclinations to Adapt Practices to Climate Impacts

To explore respondents' perspectives on implementing climate-adaptive agricultural practices in general, we examined their responses to one item: "Do you anticipate changing your farming practices in response to changing weather patterns?" This item produced three subgroups—those who did not expect to adapt practices, those who did, and those who didn't know if they would change their farming practices. We investigated these three groups and found that the "don't know" group fell in between the no and the yes groups on nearly all parameters,

TABLE 3 | Research question 1: Respondents' top two natural challenges posed by the physical environment to their farms: free list analysis of mean position and salience.

Category (etic terms)	Frequency (# of people mentioning)	Percentage (n = 147) (%)	Mean position (average rank)	Salience index
Weather	42	29	1.24	0.231
Soil/water management	39	27	1.38	0.192
Precipitation	33	22	1.24	0.181
Weeds/pests/disease	36	24	1.71	0.144
Soil itself (e.g., type)	20	14	1.40	0.097
Conditions/terrain	19	13	1.58	0.082
Climate change	*16*	*11*	*1.44*	*0.076*

TABLE 4 | Research question 1: Climate change-type responses, with frequency and rank in the lists.

Category (etic terms)	Responses (emic terms)	Frequency of mention	Rank #1	Rank #2
Seasonality	Late springs/late frosts/early frosts/cooler summer temps/spring rains—getting into the field	4	4	0
Events	Heavy rains/too much rain at one time/more severe damaging storms	3	1	2
General/unpredictability	Climate change/changing weather patterns/weather change/more unpredictable weather/uncertain weather	3	1	2
Extremes	Extreme weather changes/extremes of temp and precipitation/excessive dry weather	3	1	2
Timing	Rainfall timeframes/timely rain	2	1	1
Other	Losses in 2012 and polar vortex effects last winter to tree death	1	1	0
Subtotal		16	9	7

TABLE 5 | Research question 2: Do respondents anticipate changing farming practices in response to changing weather patterns? Analysis of their responses relative to other variables: Mean values.

	No	Don't know	Yes	Total sample	*p*-value
Climate: Anticipate changing farming practices in response to changing weather patterns (no/don't know/yes)	82 (48%)	50 (29%)	40 (23%)	172	–
Climate: Concern about changing weather patterns (1 "not at all concerned" to 6 "extremely concerned")	2.2	3.5	3.8	3.0	***
Diversification: Outlook on diversifying (3-item composite) (1–6)	2.6	3.1	3.9	3.0	***
Diversification: Currently diversified (yes/no)	51%	62%	82%	62%	***
Gender: Is one or more women completing the survey? (yes/no)	18%	49%	28%	29%	–
Family: Farm inherited/purchased from forebears (yes/no)	49%	56%	36%	48%	–
Family: Priority for the farm to be something children/grandchildren can do for a profession (1 "not a priority" to 6 "high priority")	3.1	3.9	4.2	3.6	***
Family: Number of family members in partnership with you on the farm	0.5	0.8	0.5	0.6	–
Family: Likelihood of someone in the next generation to follow in running the farm (1–3)	1.9	2.2	2.1	2.0	**
Age	62	61	53	59	***

**$p < 0.05$, ***$p < 0.01$.

for example, concern about changing weather patterns, outlook on diversifying, and likelihood of being diversified at present. Gender was one area where the "don't know" respondents stood out. "Don't know" respondents were the most likely to be women, such that the relationship between gender and whether or not respondents anticipated changing their farming practices in response to changing weather patterns was statistically significant ($X^2 = 13.06$, $p < 0.001$). Women represented only 29% of respondents overall, but 49% of the respondents who chose "don't know." In contrast, women made up just 18% of the group choosing "no" and 28% of the group choosing "yes." "Don't know" respondents were also the most likely to expect a family successor to the farm. The patterns associated with whether respondents anticipated changing their farming practices in response to changing weather patterns are presented in **Table 5**.

Results for Research Question 3: Factors Shaping Farmers' Outlooks on Diversification

Farmers' Outlooks on Diversification: Correlation and Regression Analysis

Pearson correlation analysis followed by linear regression models with a forward stepwise procedure were used to identify the best set of significant predictors of respondents' outlooks on diversifying. Results of in **Table 6**. The independent variables included in the full regression model were those that pertained to respondents' perspectives on climate change, and their gender, age, and family involvement in the farm. The dependent variable was the composite "outlook on diversifying" (see section Analysis of "don't know" or uncertain responses to research question 2: Farmers' intentions to adapt to climate impacts). In these models, gender was not associated with respondents' outlooks on diversifying. Respondents' outlooks on diversifying were correlated with whether their qualitative response mentioned a feature of climate change ($p < 0.10$), but in regression models this relationship was not significant.

The farm currently being diversified was most predictive of an increased outlook on further diversifying [$r = 0.437$, $p < 0.001$; beta $= 0.874$, $t_{(149)} = 4.70$, $p < 0.001$]. The other significant predictors involved respondents' perspectives on climate change, family involvement in the farm, and their ages. The anticipation of changing farming practices due to changing weather patterns [$r = 0.386$, $p \leq 0.001$; beta $= 0.253$, $t_{(149)} = 2.04$, $p = 0.048$], concern about changing weather patterns [$r = 0.327$, $p < 0.001$; beta $= 0.124$, $t_{(149)} = 1.96$, $p = 0.052$], and placing a higher priority on the farm's ability to employ descendants predicted a more favorable outlook toward further diversifying [$r = 0.338$, $p < 0.001$; beta $= 0.161$, $t_{(149)} = 3.20$, $p < 0.01$]. Younger respondents also had a more favorable outlook on diversifying [for every year of age $r = -0.350$, $p < 0.001$; beta $= -0.017$, $t_{(149)} = -2.58$, $p = 0.011$].

Farmers' Outlooks on Diversification: Cluster Analysis

Conducting a cluster analysis on the three parameters that represented respondents' perspectives on climate change and diversification revealed three cluster centers. The parameters used in the analysis were: 1. Concern about weather, 2. Anticipating changing practices due to weather, and 3. Outlook on diversifying. Results of the cluster analysis are presented in **Table 7**. Only three of the variables tested were not statistically different between clusters. Those that were not significant were gross farm income, acreage operated, and whether the farm raised livestock/poultry and/or meat/eggs/dairy. Those that were significantly different between clusters were: concern about changing weather patterns, anticipating changing farming practices in response to changing weather patterns, outlook on diversifying, whether the farm was currently diversified, gender, whether the respondent was farming an ancestor's farm, how much priority the respondent placed on the farm's ability to

TABLE 6 | Research question 3: Outlooks on diversifying: Correlated variables, coefficients, and levels of statistical significance (n = 179).

Parameter	Correlation (r)		Full regression (Beta)		Final regression (Beta)	
Intercept	–	–	2.178	***	2.139	***
Diversification: Farm is currently diversified	0.437	***	0.882	***	0.874	***
Climate: How concerned are you about changing weather patterns where you are?	0.327	***	0.075	–	0.124	*
Climate: Do you anticipate changing farming practices in response to changing weather patterns?	0.386	***	0.251	*	0.253	**
Climate: Write-in response denoted an effect of climate change	0.141	*	−0.096	–	–	–
Family: Priority for farm to be something that children/grandchildren can do for a profession	0.338	***	0.202	***	0.161	***
Family: Number of family members in partnership with you on the farm	−0.046	–	−0.101	–	–	–
Family: Likelihood of someone in the next generation to follow in running the farm (1–3)	0.142	**	–	–		
Gender: Women	0.093	–	0.047	–	–	–
Age	−0.350	***	−0.016	**	−0.017	**

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

TABLE 7 | Research question 3: Outlooks on diversifying: Results of cluster analysis to characterize respondents' perspectives on climate change and farm product diversification: Mean values for variables used in cluster creation and for other variables compared by cluster.

	Cluster			Total sample	p-Value
	1	2	3		
Number of cases	56 (31%)	42 (23%)	81 (45%)	179	–
Variables used in cluster creation					
Climate: How concerned are you about changing weather patterns where you are? (1 "not at all concerned" to 6 "extremely concerned")	4.8	2.2	2.0	3.0	***
Climate: Anticipate changing farming practices in response to changing weather patterns (1 = No, 2 = DK, 3 = Yes)	2.2	2.0	1.3	1.8	***
Diversification: Outlook on diversifying (3-item composite) (1–6)	3.6	4.3	1.9	3.0	***
Other variables compared by Cluster					
Diversification: Currently diversified (1 = yes, 0 = no)	9.80	0.79	0.36	0.60	***
Gender: Is one or more women completing the survey? (1 = yes, 0 = no)	9.40	0.28	0.22	0.29	**
Raises livestock/poultry or meat/eggs/dairy (1 = yes, 0 = no)	9.41	0.50	0.32	0.39	–
Family: Farm inherited/purchased from forebears (1 = yes, 0 = no)	0.36	0.49	0.57	0.48	**
Family: Priority for the farm to be something children/grandchildren can do for a profession (1–6)	3.9	4.3	3.0	3.6	***
Family: Number of family members in partnership with you on the farm	0.6	0.6	0.6	0.6	–
Family: Likelihood of someone in the next generation to follow in running the farm (1–3)	2.2	2.1	1.9	2.0	–
Acreage operated (acres)	236	609	215	320	–
Acreage operated ($\log_{10}$)	1.79	2.10	1.83	1.88	–
Gross farm income (1–9) 3 = \$10,000–\$49,999 4 = \$50,000–\$149,999 5 = \$150,000–\$349,999	3.5	4.5	3.6	3.8	–
Age (years)	58	53	64	59	***

**$p < 0.05$, ***$p < 0.01$.

employ descendants, and respondent age. Here, we describe the clusters.

Cluster 1 and Cluster 3 represent the poles. Farms in Cluster 1 were concerned with climate change. Their concern was high enough for their median response to be 5 on a scale of 6 ("concerned"), while in the other clusters the median level of concern was only 2 ("slightly concerned"). Cluster 1 farms were diversified (80%) and inclined to diversify further. Farms in Cluster 1 were most likely to have a woman respondent (40% of respondents relative to 28%/22%). Cluster 1 farmers were least likely to have inherited/purchased their farms from forebears (only 36% relative to 49%/57%).

Cluster 3 was the largest grouping, representing 45% of the sample. Cluster 3 tended to contain non-diversified farms (64%) with older operators. Cluster 3's mean operator age was 64, which in the other clusters was 58 and 53, respectively. Cluster 3 demonstrated the least concern with climate change and least inclination to adapt by diversifying (2 on a scale of 6).

The patterns for Cluster 2 were distinctive from those demonstrated by the other clusters and the regression analysis. In Cluster 2, concern over climate change was nearly as low as among the non-diversified farms that characterize Cluster 3. But diversified farms predominated in Cluster 2 (79% diversified) and Cluster 2 indicated the most favorable outlook among all clusters in diversifying further (4.3 on a scale of 6). Cluster 2 was also the youngest. This cluster placed the most emphasis on family: the farm being able to employ descendants was the highest priority among this cluster. The median response on this scale was high—5 on a scale of 6. Thus, the group that wanted the most for the farm to be able to employ family descendants had low concern with climate change, and yet they were the most open, among all respondents in the sample, to implementing one climate adaptation by further diversifying outputs.

DISCUSSION

These farmers as a group indicated only "somewhat" of a concern about changing weather patterns, such that nearly half of respondents (48%) did not expect to modify their farming practices in response to a changing climate. Even though this was the pattern for the group as a whole, subsets of respondents were more open to adapting their farming operations to climatic shifts, and subsets were inclined to diversify their products. Farmers who were more concerned about climate change, younger farmers, and those who had the most hope that their farms would employ their descendants showed the most inclination to adapt by diversifying. Here, we will explore aspects of the social-ecological farm systems that respondents are managing, and how these relate to their perspectives on climate adaptation. First we look at farmers' ecological challenges, and then two aspects of the social and family life of the farm, by looking at how gender and family relations distinguished the subgroups among the respondents.

Salience of Climate Change in Farmers' Qualitative Responses

The first research question we explored was: Relative to other environmental factors, how salient of a challenge is climate change and climate-related impacts to farmers? The data came from a qualitative item in the survey, in which respondents listed the physical challenges their farms face. Results are presented in Results for research question 1: Salience of climate change relative to other environmental factors and in **Tables 3**, **4**, and **Supplementary Table 1**. Climate change made up part of the "weather/climate/precipitation" category that was mentioned most often. When we pulled the features of climate change from this broader category to assess them on their own, climate change itself continued to represent a leading type of biophysical challenge. Climate change features were listed by only 11% of respondents, and yet, looking across all respondents' lists, the mean position of climate change in the lists outranked the immemorial challenges to agriculture of weeds/pests/diseases and terrain/conditions.

The specific climate change challenge that farmers listed the most was a shift in the timing of when seasons begin and end. The terms respondents used to express these seasonal shifts and other ways in which climate change challenges their farms are presented in **Table 4**. For example, their terms for seasonal shifts included "late springs," "late frosts," "early frosts," "cooler summer temps," and "spring rains—getting into the field." The other climate change characteristics they listed referred to weather events, unpredictability, extremes, the timing of rain, and generally changing weather patterns. The farmers' terms, listed in **Table 4**, suggest terminology to consider using in future inquiry in this region. These findings respond to calls for research to employ qualitative approaches (Soubry et al., 2020) to specify US farmers' firsthand observations about climate effects in their own words (Morton et al., 2015; Asplund, 2016; Doll et al., 2017; Wiener et al., 2020). Smaller qualitative inquiries such as this one can then inform larger confirmatory approaches to linking farmers' views of climate impacts to their perspectives on mitigation and adaptation measures (Arbuckle et al., 2013a; Liu et al., 2014). For the purposes of our inquiry, this set of responses allowed the analysis to begin by specifying some environmental factors that might inform farmers' views of adaptive and mitigative practices in this region (Clarke, 2013; Mase et al., 2017; Schewe and Stuart, 2017; Gardezi and Arbuckle, 2018; Fletcher et al., 2020).

Farmers' Intentions to Adapt to Climate Impacts Generally

We next examined our related questions of: Do farmers intend to adapt to climate impacts generally? and What factors shape their use of farm product diversification? The findings underscore the personal relationships that commonly go into operating a farm, and how these relationships might inform farmers' outlooks on adopting climate-adaptive practices. When asked whether they thought they would change their farming practices in response to changing weather patterns, 23% percent of respondents thought that they would change their farming practices, 48% thought that they would not, and 29% didn't know (**Table 2**). Here, we examine those three separate subgroups of respondents according to their inclination to adapt practices. We begin with the sizeable number of respondents who responded that they didn't know whether they would adapt practices. Those whose futures seemed more known to them are discussed below in the results of the cluster and regression analyses in section Factors that shape farmers' outlooks on farm product diversification.

Similar to prior work which has emphasized farmers' uncertainty about future climatic conditions and thus also their responses to them (Morton et al., 2017), numerous respondents (29%) used the "don't know" option when asked whether they anticipated changing their farming practices in response to changing weather patterns. The fact that more than one in four respondents selected this option may indicate uncertainty as a construct to continue to explore in research and service provision. "Don't know" was the response that women selected the most, statistically more than men (X^2, $p = 0.001$), but responses to this item were not predictive of a respondent's gender (F-test, $p = 0.103$). Women made up only 29% of the total sample but were 48% of the respondents who didn't know whether they would adapt practices to changing weather patterns.

If we consider the "don't know" response as an expression of uncertainty or an openness to potentially adapting agricultural practice, then perhaps women indicated more openness than men to the possibility of climate adaptation within their farming operations. In some ways, this conclusion is supported by the sociological research on public climate change views, which finds that when compared to men, women are often more supportive of, or at least less willing to resist, taking action on climate change (McCright and Dunlap, 2011; McCright et al., 2016). Related research in agriculture has found similar patterns (Liu et al., 2014). On the other hand, it may be that some women selected this response because the farm's management practices are more within the man's realm of decision-making, and not theirs, as can be common within North American agriculture (Perry and Ahearn, 1994; Fletcher and Knuttila, 2016). After all, "don't know" was the response that women chose the most and men chose the least. This pattern could reflect the dominant division of labor in farm women's and farm men's domains of decision-making (Reinsch, 2009; Bee et al., 2013; Eriksen, 2014).

The uncertain respondents were also the subset most likely to expect a family successor to the farm. Therefore, it's possible that people who chose "don't know" were reluctant to indicate a preference, knowing that the next generation would be making those decisions about their farm. They also may have been uncertain of their successor's perspective on climate adaptation. Future adaptive practices may have been less certain for farmers who anticipated more family involvement in the farm going forward.

Factors That Shape Farmers' Outlooks on Farm Product Diversification

The final two analytical approaches focused on one particular category of adaptation to climate change, product diversification. Farmers' outlooks on diversifying their products made up the response variable in the regression analysis and was one of three variables used to structure the cluster analysis. The other two variables employed in the cluster analysis were inclination to adapt practices generally and farmers' concern about climate change. Gender was not a statistically significant variable in the regression analysis; however, comparisons between the three clusters identified by cluster analysis did find significant or marginal gender differences (F-test $p = 0.03$, X^2 $p = 0.081$). Women were most likely to fall into Cluster 1 and men were most likely to fall into Cluster 3. Cluster 1 was concerned about climate change, likely to be diversified already and to adapt practices, and unlikely to operate an ancestral farm. In contrast, Cluster 3 was only "slightly" concerned about climate change, not inclined to diversify, and likely to be operating an ancestral farm. These distinctions between women's and men's patterns elicited by two of our three analytical approaches suggest an area for further and in-depth exploration, as research continues into North American farm families' prospects for implementing mitigation-adaptation practices.

Related to these findings around gender, a call for a more deliberate incorporation of gender into this context is found in the framework. Walker et al. (2019) provide for examining climate hazards in the global rural North in relation to intersectionality. This framework provides a guide for focusing on social identity categories such as gender, class, age, race, and ethnicity to understand the social, ecological and economic dimensions of climate risks and disasters. An even broader call is to incorporate a gender perspective into all climate research and intervention "in order to ensure that the concerns of all are addressed and that gender inequalities are not perpetuated through institutional means," a process referred to as gender mainstreaming (Alston, 2014, p. 287; Glazebrook et al., 2020). The role of gender among the subgroups in our sample is one aspect of the relational factors we turn to next.

Among the third subgroup from the cluster analysis, Cluster 2, concern with climate change was low and interest in diversifying was high. This pairing of characteristics diverged from the predominant pattern found by regression analysis, which was that concern with climate change, and intent to adapt practices, were predictive of a more favorable outlook on diversifying products. Nearly a quarter of farms fell into Cluster 2 (23%), mainly younger respondents who operated the most land. We could certainly attribute this cluster's inclination to further diversify to the fact that this group already produced diversified outputs. This would align with research that has found that diversified farmers expect to further diversify in response to climate pressures (Roesch-McNally et al., 2018) and that farmers generally expect to increase their use of current management practices in response to predicted climate change (Roesch-McNally et al., 2016). Cluster 2's interest in diversifying alongside their low concern about climate change could resemble other studies' findings that farmers' adaptive practices have less to do with climate change and more to do with management factors such as profitability, or indicators of self-efficacy and capacity (Niles et al., 2016).

A second way in which Cluster 2 was distinctive was that they had the highest hope that the farm would be able to employ descendants. The high priority that Cluster 2 placed on family indicates that farms whose considerations for the future encompass family more than other farms may constitute one group that is particularly receptive to communications about implementing adaptive and mitigative agricultural practices. These findings point to farmers' hopes for the future and may also tie into their hopes for their own legacies more broadly (Zaval et al., 2015; Grolleau et al., 2020). This pattern relates to prior research findings that family participation does appear to predispose farms to adaptations in general (Inwood and Sharp, 2012) and to diversifying specifically (Suess-Reyes and Fuetsch, 2016; Valliant et al., 2017). A useful focus for future inquiries is to further specify how farmers' current as well as hoped for levels of family involvement in the farm play into their perspectives on climate adaptation. This approach to understanding "individuals-in-relation," in contrast to individual farmers alone may better anticipate effects and responses around climate change (Robinson, 2011, p. 159).

This encouragement by Robinson (2011) to address climate change in conjunction with relations of care connects to our exploration above of how gender and intersectionality play a role in agricultural adaptation and mitigation. Relations of care that are central within agriculture include interpersonal care as well as the routines of care that go into farming. While our instrument asked only about undifferentiated farming practices, efforts to examine the distinct care practices that farming involves might specify how farmers view the prospects of climate change in terms of the activities of care that they perform. Such activities could encompass preservation, repair, rebuilding, domestic routines, and care of livestock, crops, and sources of energy, water, and food (Robinson, 2011; Bruce and Som Castellano, 2016). To further examine the interpersonal factors that played a role in our analyses, inquiries could consider farmers' networks of relationships and responsibilities. Some of these core relationships will be among family and/or the farm's operators. Recent changes to the US Census of Agriculture methodology will now facilitate a richer examination of on-farm relationships through national secondary data, now that the Census permits respondents to list up to four principal operators as well as their ages, gender, racial and ethnic identities, and other information (Pilgeram et al., 2020). Another entry point to exploring how relations of care intersect with farm family dynamics and climate adaptation may be to specify the spousal relations that are common on farms as a foundational care relationship (e.g., Hansson et al., 2013; Fischer and Burton, 2014; Riley, 2016). In our study, 77% of respondents were married, 8% widowed, 7% divorced, 6% single, and 2% partnered. Again, USDA research provides precedent in how its Agricultural Resource Management Survey incorporates questions about spousal involvement (USDA-ERS, 2016). Across our analytical approaches, the importance respondents placed on the farm's ability to employ descendants suggests that efforts to research and promote climate-adaptive agricultural practices might choose to emphasize factors surrounding family participation in the farm.

To summarize, our analysis focused on exploring some of the immediate social and ecological factors that may interact with and shape farmers' outlooks on adaptive practices, and their capacity to adopt them. To orient our focus on farmers' situations in this 30-county region, we led by coding the respondents' lists of the greatest natural, physical challenges faced by their farms. The objective of this exercise was to explore whether and how farmers would mention some regional climate change effects and ecological patterns that inform their outlooks. The effects of climate change did present as a salient category in the lists overall, and the exercise elicited local terminology for use in follow-up inquiry, for example these farmers' attention to shifting seasonality. Women indicated more openness to adapting practices to climate change. A final finding overall was that regardless of gender, farmers who hope for more family involvement in the farm are also more open than others to adapting practices and to diversifying their agricultural products. Specific to product diversification, an adaptation that helps to build food systems and ecological, economic, and social resilience, we find younger operators who intend for the farm to employ their descendants may be more open than others to diversifying products. Thus, on farms where future family involvement is more welcomed, farmers may be more open to adaptive and potentially mitigative actions. Farm businesses whose considerations for the future encompass family more than other farms may constitute a particularly receptive group to communications about adaptation and mitigation. This finding lends support to efforts to segment Corn Belt farmers so that Extension and other service providers might tailor their communications around climate change to emphasize certain persuasive themes based on particular farming audiences (Arbuckle et al., 2014, 2017). The influence of family in these findings also lends support to previous encouragement for climate change research and communications to emphasize the relationships and practices of care that go into farming, and among family members of the farm enterprise.

Limitations

These introductory findings represent the survey responses of 179 farmers in one 30-county area of the American Midwest. We expect that some of their views are specific to place, especially those presented in section Results for research question 1: Salience of climate change relative to other environmental factors. Further, the respondents were drawn through a two-pronged selection strategy that combined a random sample of farms that did participate in USDA-FSA programs with a second set of farms that did not participate in USDA-FSA programs. This strategy aimed to oversample from food producers and farms that add value to their products, to compare their views to those of farmers whose farms were not diversified. The purpose of this strategy was to explore farmers' views of diversifying products in relation to their views of climate change. Our sampling may generally represent the population of smaller, more diversified farms.

Shortcomings of our analysis illustrate ways in which we would revise some approaches in follow-on research. First, we would reconsider how we operationalized the definition of diversified farms. We sought to apply a definition we heard farmers using in the field. In the future we would experiment with a definition whose ecological implications for the farm system are more apparent. Second, we would explore revising some of the language we used for survey items, either to leave the emotion out of them, or to offer respondents more of an emotional range. We are aware that the effects of climate change can remain abstract and unable to evoke an emotional response until they become concrete (Weber, 2006). An emotional response to climate change may increase in relevance as individuals have proximate interactions with the effects (Haden et al., 2012; Lane et al., 2019). In hindsight, we wonder if using the term "concern" made one item emotionally or politically charged in a way we did not intend: "How concerned are you about changing weather patterns where you are?" An alternative could be to flip the sentiment to evoke a positive emotion by instead using questions about "security" (Moosa and Tuana, 2014). Similarly, other studies of farmers about climate concern and climate risk have complemented those items with others about opportunities and benefits that may arise from a changing climate (Haden et al., 2012; Niles et al., 2013). We would also ask about gender more clearly, by asking respondents to log the number of women and the number of men who were responding to the survey and provide more options for gender-non-conforming respondents. Our analysis would have been strengthened by a more critical and inclusive approach to understanding how gender expression and sexual identity shape farming relationships, family dynamics and decision-making (Leslie et al., 2019). Another item we might revise, to ensure it is no longer potentially double-barreled (Schutt, 2014), is "Do you anticipate changing your farming practices in response to changing weather patterns?" As we saw in the analysis of farmers' write-in lists, separating farmers' inclination to implement adaptive practices from the specter of climate change as the motivation for those adaptations will further clarify how better to communicate with farmers and incentivize practices to build the adaptive capacity of agriculture.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Indiana University Institutional Review Board. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

JF conceived of the study and acquired the funding. JV designed and conducted the study. SD, JV, and MH performed the formal analysis. JV wrote the original draft of the manuscript. AB, MH, and SD wrote sections of the manuscript. All authors contributed to the article and approved the submitted version.

FUNDING

This work was supported by the Indiana University Office of the Vice Provost for Research, the Indiana University Ostrom Workshop, and the Indiana University Sustainable Food Systems Science Emerging Area of Research.

ACKNOWLEDGMENTS

The authors wish to express gratitude to the participants in the study, to Kevin Naaman for managing the survey and entering data, to Erik Parker for assisting with data analysis, to Jennifer Meta Robinson, Dan Knudsen, and Burney Fischer for advising on the study, and to two reviewers and the editor of the special issue for their contributions to improving this work.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fclim.2021.662847/full#supplementary-material

Supplementary Data Sheet 1 | Survey instrument.

Supplementary Table 1 | Table for Research question 1.

REFERENCES

Agricultural Marketing Resource Center (2016). *USDA Value-Added Ag Definition*. Iowa State University. Available online at: http://www.agmrc.org/business-development/getting-prepared/valueadded-agriculture/articles/usda-value-added-ag-definition/ (accessed September 1, 2016).

Aguilar, J., Gramig, G. G., Hendrickson, J. R., Archer, D. W., Forcella, F., and Liebig, M. A. (2015). Crop species diversity changes in the United States: 1978-2012. *PLoS ONE* 10:e0136580. doi: 10.1371/journal.pone.0136580

Aizen, M. A., Aguiar, S., Biesmeijer, J. C., Garibaldi, L. A., Inouye, D. W., Jung, C., et al. (2019). Global agricultural productivity is threatened by increasing pollinator dependence without a parallel increase in crop diversification. *Glob. Change Biol.* 25, 3516–3527. doi: 10.1111/gcb.14736

Alston, M. (2014). Gender mainstreaming and climate change. *Womens Stud. Int. Forum* 47, 287–294. doi: 10.1016/j.wsif.2013.01.016

Alston, M., Clarke, J., and Whittenbury, K. (2018). Contemporary feminist analysis of australian farm women in the context of climate changes. *Soc. Sci.* 7:16. doi: 10.3390/socsci7020016

Arbuckle, J. G., Hobbs, J., Loy, A., Morton, L. W., Prokopy, L. S., and Tyndall, J. (2014). Understanding Corn Belt farmer perspectives on climate change to inform engagement strategies for adaptation and mitigation. *J. Soil Water Conserv.* 69, 505–516. doi: 10.2489/jswc.69.6.505

Arbuckle, J. G., Tyndall, J. C., Morton, L. W., and Hobbs, J. (2017). Climate change typologies and audience segmentation among Corn Belt farmers. *J. Soil Water Conserv.* 72, 205–214. doi: 10.2489/jswc.72.3.205

Arbuckle, J. G. Jr., Morton, L. W., and Hobbs, J. (2013a). Farmer beliefs and concerns about climate change and attitudes toward adaptation and mitigation: evidence from Iowa. *Clim. Change* 118, 551–563. doi: 10.1007/s10584-013-0700-0

Arbuckle, J. G. Jr., Morton, L. W., and Hobbs, J. (2015). Understanding farmer perspectives on climate change adaptation and mitigation: the roles of trust in sources of climate information, climate change beliefs, and perceived risk. *Environ. Behav.* 47, 205–234. doi: 10.1177/0013916513503832

Arbuckle, J. G. Jr., Prokopy, L. S., Haigh, T., Hobbs, J., Knoot, T., Knutson, C., et al. (2013b). Climate change beliefs, concerns, and attitudes toward adaptation and mitigation among farmers in the Midwestern United States. *Clim. Change* 117, 943–950. doi: 10.1007/s10584-013-0707-6

Asplund, T. (2016). Natural versus anthropogenic climate change: Swedish farmers' joint construction of climate perceptions. *Public Underst. Sci.* 25, 560–575. doi: 10.1177/0963662514559655

Barbieri, C., and Mahoney, E. (2009). Why is diversification an attractive farm adjustment strategy? Insights from Texas farmers and ranchers. *J. Rural Stud.* 25, 58–66. doi: 10.1016/j.jrurstud.2008.06.001

Barnes, A. P., and Toma, L. (2012). A typology of dairy farmer perceptions towards climate change. *Clim. Change* 112, 507–522. doi: 10.1007/s10584-011-0226-2

Beddington, J., Asaduzzaman, M., Clark, M., Fernandez, A., Guillou, M., Jahn, M., et al. (2011). *Achieving Food Security in the Face of Climate Change: Summary for Policy Makers from the Commission on Sustainable Agriculture and Climate Change*. Copenhagen: CGIAR Research Program on Climate Change, Agriculture and Food Security.

Bee, B., Biermann, M., and Tschakert, P. (2013). "Gender, development, and rights-based approaches: lessons for climate change adaptation and adaptive social protection," in *Research, Action and Policy: Addressing the Gendered Aspects of Climate Change*, eds M. Alston and K. Whittenbury (Dordrecht: Springer Netherlands), 95–108. doi: 10.1007/978-94-007-5518-5_7

Bennett, J. W. (1982). Of Time and the Enterprise: North American Family Farm Management in a Context of Resource Marginality. Minneapolis, MN: University of Minnesota Press.

Bernard, H. R. (2011). *Research Methods in Anthropology: Qualitative and Quantitative Approaches, 5th Edn*. Lanham, MD: AltaMira Press.

Bioversity International (2019). *Agrobiodiversity Index Report 2019: Risk and Resilience*. Rome: Bioversity International.

Blesh, J., and Wolf, S. A. (2014). Transitions to agroecological farming systems in the Mississippi River Basin: toward an integrated socioecological analysis. *Agric. Hum. Values* 31, 621–635. doi: 10.1007/s10460-014-9517-3

Bowles, T. M., Mooshammer, M., Socolar, Y., Calderón, F., Cavigelli, M. A., Culman, S. W., et al. (2020). Long-term evidence shows that crop-rotation diversification increases agricultural resilience to adverse growing conditions in North America. *One* Earth 2, 284–293. doi: 10.1016/j.oneear.2020.02.007

Bowman, M. S., and Zilberman, D. (2013). Economic factors affecting diversified farming systems. *Ecol. Soc.* 18:33. doi: 10.5751/ES-05574-180133

Bradshaw, B., Dolan, H., and Smit, B. (2004). Farm-level adaptation to climatic variability and change: crop diversification in the Canadian prairies. *Clim. Change* 67, 119–141. doi: 10.1007/s10584-004-0710-z

Bramley, C., and Kirsten, J. F. (2007). Exploring the economic rationale for protecting geographical indicators in agriculture. *Agrekon* 46, 47–71. doi: 10.1080/03031853.2007.9523761

Browne-Nunez, C., and Vaske, J. J. (2006). Predicting unsure responses to a proposed moose hunt in anchorage, Alaska. *Hum. Dimens. Wildlife* 11, 371–382. doi: 10.1080/10871200600897624

Bruce, A. (2016). *Labor of Love: Inequality and Participation in Alternative Agriculture.* PhD, Department of Sociology, Rutgers University.

Bruce, A. B., and Som Castellano, R. L. (2016). Labor and alternative food networks: challenges for farmers and consumers. *Renew. Agricult. Food Syst.* 32, 403–416. doi: 10.1017/S174217051600034X

Campos, M., McCall, M. K., and Gonzalez-Puente, M. (2014). Land-users' perceptions and adaptations to climate change in Mexico and Spain: commonalities across cultural and geographical contexts. *Reg. Environ. Change* 14, 811–823. doi: 10.1007/s10113-013-0542-3

Che, D., Veeck, A., and Veeck, G. (2005). Sustaining production and strengthening the agritourism product: linkages among Michigan agritourism destinations. *Agric. Hum. Values* 22, 225–234. doi: 10.1007/s10460-004 8282-0

Chenyang, L., Currie, A., Darrin, H., and Rosenberg, N. (2021). Farming with trees: reforming U.S. farm policy to expand agroforestry and mitigate climate change. *Ecol. Law Q.* 48:1–40. doi: 10.2139/ssrn.3717877

Chiswell, H. M. (2014). The importance of next generation farmers: a conceptual framework to bring the potential successor into focus. *Geogr. Compass* 8, 300–312. doi: 10.1111/gec3.12131

Clarke, J. (2013). "Renegotiating gender as farming families manage agricultural and rural restructuring in the Mallee," in *Research, Action and Policy: Addressing the Gendered Impacts of Climate Change*, eds M. Alston and K. Whittenbury (Dordrecht: Springer Netherlands), 123–131. doi: 10.1007/978-94-007-5518-5_9

Commodity Futures Trading Commission (2010). Agricultural Commodity Definition.

Crane, T. A., Roncoli, C., and Hoogenboom, G. (2011). Adaptation to climate change and climate variability: the importance of understanding agriculture as performance. *NJAS Wagenin. J. Life Sci.* 57, 179–185. doi: 10.1016/j.njas.2010.11.002

Dahl, T. E., and Allord, G. J. (1997). *History of Wetlands in the Conterminous United States*. Madison, WI: US Geological Survey.

de Rooij, S., Ventura, F., Milone, P., and van der Ploeg, J. D. (2013). Sustaining food production through multifunctionality: the dynamics of large farms in Italy. *Sociol. Rural.* 54, 303–320. doi: 10.1111/soru.12025

Diaz, S., Pascual, U., Stenseke, M., Martin-Lopez, B., Watson, R. T., Molnar, Z., et al. (2018). Assessing nature's contributions to people. *Science* 359, 270–272. doi: 10.1126/science.aap8826

Dillman, D. A., Smyth, J. D., and Christian, L. M. (2014). *Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method, 4th Edn.* Hoboken, NJ: Wiley.

Dimitri, C. (2010). Organic agriculture: an agrarian or industrial revolution? *Agric. Resour. Econ. Rev.* 39, 384–395. doi: 10.1017/S1068280500007383

Dodson, C., and Koenig, S. (2006). *Report to Congress: Evaluating the Relative Cost Effectiveness of the Farm Service Agency's Farm Loan Programs.* Washington, DC: US Department of Agriculture.

Dodson, C. B., and Ahrendsen, B. L. (2016). Beginning farmer credit and the farm service agencys role. *Choices*. 31:1–9. Available online at: http://www.jstor.org/stable/choices.31.4.04

Doll, J. E., Petersen, B., and Bode, C. (2017). Skeptical but adapting: what midwestern farmers say about climate change. *Weather Clim. Soc.* 9, 739–751. doi: 10.1175/WCAS-D-16-0110.1

Douglas, E. M., Kirshen, P. H., Paolisso, M., Watson, C., Wiggin, J., Enrici, A., et al. (2012). Coastal flooding, climate change and environmental justice: identifying obstacles and incentives for adaptation in two metropolitan Boston Massachusetts communities. *Mitig. Adapt. Strateg. Global Change* 17, 537–562. doi: 10.1007/s11027-011-9340-8

Eriksen, C. (2014). *Gender and Wildfire: Landscapes of Uncertainty*. Edited by J. H. Momsen and J. Monk, Routledge International Studies of Women and Place. New York, NY: Routledge.

Farmer, J. R., Epstein, G., Watkins, S. L., and Mincey, S. K. (2014). Organic farming in West Virginia: a behavioral approach. *J. Agric. Food Syst. Commun. Dev.* 4, 155–171. doi: 10.5304/jafscd.2014.044.007

Fischer, H., and Burton, R. J. F. (2014). Understanding farm succession as socially constructed endogenous cycles. *Sociol. Rural.* 54, 417–438. doi: 10.1111/soru.12055

Fitz-Koch, S., Nordqvist, M., Carter, S., and Hunter, E. (2017). Entrepreneurship in the agricultural sector: a literature review and future research opportunities. *Entrep. Theory Pract.* 42, 129–166. doi: 10.1177/1042258717732958

Fletcher, A. J., Hurlbert, M., Hage, S., and Sauchyn, D. (2020). Agricultural producers' views of climate change in the Canadian prairies: implications for adaptation and environmental practices. *Soc. Nat. Resour*. 34, 1–21. doi: 10.1080/08941920.2020.1823541

Fletcher, A. J., and Knuttila, E. (2016). "Gendering change: Canadian farm women respond to drought," in *Vulnerability and Adaptation to Drought: The Canadian Prairies and South America*, eds H. Diaz, M. Hurlbert and J. Warren (Calgary, AB: University of Calgary Press), 159–177.

Gardezi, M., and Arbuckle, J. G. (2018). Techno-optimism and farmers' attitudes toward climate change adaptation. *Environ. Behav.* 52, 82–105. doi: 10.1177/0013916518793482

Gardner, B. (2002). *American Agriculture in the Twentieth Century*. Cambridge, MA: Harvard University Press.

Garrett, R. D., Niles, M. T., Gil, J. D. B., Gaudin, A., Chaplin-Kramer, R., Assmann, A., et al. (2017). Social and ecological analysis of commercial integrated crop livestock systems: Current knowledge and remaining uncertainty. *Agric. Syst.* 155, 136–146. doi: 10.1016/j.agsy.2017.05.003

Gaudin, A. C., Tolhurst, T. N., Ker, A. P., Janovicek, K., Tortora, C., Martin, R. C., et al. (2015). Increasing crop diversity mitigates weather variations and improves yield stability. *PLoS ONE* 10:e0113261. doi: 10.1371/journal.pone.0113261

Glazebrook, T., Noll, S., and Opoku, E. (2020). Gender matters: climate change, gender bias, and women's farming in the global south and north. *Agriculture* 10:267. doi: 10.3390/agriculture10070267

Gray, J. (1998). Family farms in the Scottish borders: a practical definition by hill sheep farmers. *J. Rural Stud.* 14, 341–356. doi: 10.1016/S0743-0167(98)0 0010-2

Grolleau, G., Mzoughi, N., Napoléone, C., and Pellegrin, C. (2020). Does activating legacy concerns make farmers more likely to support conservation programmes? *J. Environ. Econ. Policy* 2020, 1–17. doi: 10.1080/21606544.2020.1807410

Groothuis, P. A., and Whitehead, J. C. (2002). Does don't know mean no? Analysis of 'don't know' responses in dichotomous choice contingent valuation questions. *Appl. Econ.* 34, 1935–1940. doi: 10.1080/00036840210128717

Habbershon, T. G., and Williams, M. L. (1999). A resource-based framework for assessing the strategic advantages of family firms. *Fam. Bus. Rev.* 12, 1–22. doi: 10.1111/j.1741-6248.1999.00001.x

Haden, V. R., Niles, M. T., Lubell, M., Perlman, J., and Jackson, L. E. (2012). Global and local concerns: what attitudes and beliefs motivate farmers to mitigate and adapt to climate change? *PLOS ONE* 7:e52882. doi: 10.1371/journal.pone.0052882

Hajdu, I. (2018). *Everything a Farmer Should Know About Commodity Trading*. Agrivi. Available online at: https://blog.agrivi.com/post/everything-a-farmer-should-know-about-commodity-trading-february2018 (accessed March 23, 2018).

Hansson, H., Ferguson, R., Olofsson, C., and Rantamäki-Lahtinen, L. (2013). Farmers' motives for diversifying their farm business: the influence of family. *J. Rur. Stud.* 32, 240–250. doi: 10.1016/j.jrurstud.2013.07.002

Hayes, D. J., Lence, S. H., and Stoppa, A. (2004). Farmer-owned brands? *Agribusiness* 20, 269–285. doi: 10.1002/agr.20018

Heggem, R. (2014). Diversification and re-feminisation of Norwegian farm properties. *Sociol. Rural.* 54, 439–459. doi: 10.1111/soru.12044

Hendrickson, M. K. (2015). Resilience in a concentrated and consolidated food system. *J. Environ. Stud. Sci.* 5, 418–431. doi: 10.1007/s13412-015-0292-2

Hilimire, K. (2011). Integrated crop/livestock agriculture in the United States: a review. *J. Sustain. Agric.* 35, 376–393. doi: 10.1080/10440046.2011.562042

Holmgren, S., and Arora-Jonsson, S. (2015). The Forest Kingdom - with what values for the world? Climate change and gender equality in a contested forest policy context. *Scand. J. For. Res.* 30, 235–245. doi: 10.1080/02827581.2014.1002216

Houser, M. (2018). Who framed climate change? Identifying the how and why of Iowa corn farmers' framing of climate change. *Sociol. Rural.* 58, 40–62. doi: 10.1111/soru.12136

Houser, M., and Stuart, D. (2019). An accelerating treadmill and an overlooked contradiction in industrial agriculture: climate change and nitrogen fertilizer. *J. Agrar. Change* 20, 215–237. doi: 10.1111/joac.12341

Howden, S. M., Soussana, J. F., Tubiello, F. N., Chhetri, N., Dunlop, M., and Meinke, H. (2007). Adapting agriculture to climate change. *Proc. Natl. Acad. Sci. U.S.A.* 104, 19691–19696. doi: 10.1073/pnas.0701890104

Hyland, J. J., Jones, D. L., Parkhill, K. A., Barnes, A. P., and Williams, A. P. (2016). Farmers' perceptions of climate change: identifying types. *Agric. Hum. Values* 33, 323–339. doi: 10.1007/s10460-015-9608-9

Iles, A., and Marsh, R. (2012). Nurturing diversified farming systems in industrialized countries: how public policy can contribute. *Ecol. Soc.* 17:42. doi: 10.5751/ES-05041-170442

Inwood, S. M., and Sharp, J. S. (2012). Farm persistence and adaptation at the rural-urban interface: succession and farm adjustment. *J. Rural Stud.* 28, 107–117. doi: 10.1016/j.jrurstud.2011.07.005

IPCC (2019). *Climate Change and Land*. Geneva: IPCC.

Janowiak, M. K., Dostie, D. N., Wilson, M. A., Kucera, M. J., Skinner, R. H., Hatfield, J. L., et al. (2016). *Adaptation Resources for Agriculture: Responding to Climate Variability and Change in the Midwest and Northeast*. Washington, DC: US Department of Agriculture.

Jurt, C., Burga, M. D., Vicuña, L., Huggel, C., and Orlove, B. (2015). Local perceptions in climate change debates: insights from case studies in the Alps and the Andes. *Clim. Change* 133, 511–523. doi: 10.1007/s10584-015-1529-5

Juventia, S., Jones, S., Laporte, M.-A., Remans, R., Villani, C., and Estrada-Carmona, N. (2020). Text mining National commitments towards agrobiodiversity conservation and use. *Sustainability* 12:715. doi: 10.3390/su12020715

King, K. W., Williams, M. R., and Fausey, N. R. (2014). Contributions of systematic tile drainage to watershed-scale phosphorus transport. *J. Environ. Qual.* 44, 486–494. doi: 10.2134/jeq2014.04.0149

Lane, D., Murdock, E., Genskow, K., Betz, C. R., and Chatrchyan, A. (2019). Climate change and dairy in new york and wisconsin: risk perceptions, vulnerability, and adaptation among farmers and advisors. *Sustainability* 11:3599. doi: 10.3390/su11133599

Leslie, I. S., Wypler, J., and Bell, M. M. (2019). Relational agriculture: gender, sexuality, and sustainability in U.S. farming. *Soc. Nat. Resour.* 32, 853–874. doi: 10.1080/08941920.2019.1610626

Lin, B. B. (2011). Resilience in agriculture through crop diversification: adaptive management for environmental change. *Bioscience* 61, 183–193. doi: 10.1525/bio.2011.61.3.4

Liu, Z., Smith, W. J. Jr., and Safi, A. S. (2014). Rancher and farmer perceptions of climate change in Nevada, USA. *Clim. Change* 122:313–327. doi: 10.1007/s10584-013-0979-x

Lobley, M., and Baker, J. R. (2012). "Succession and retirement in family farm businesses," in *Keeping It in the Family: International Perspectives on Succession and Retirement on Family Farms*, eds M. Lobley, J. R. Baker and I. Whitehead. (Farnham: Ashgate). p. 1–20.

Lobley, M., Baker, J. R., and Whitehead, I. (2010). Farm succession and retirement: some international comparisons. *J. Agric. Food Syst. Commun. Dev.* 1, 49–64. doi: 10.5304/jafscd.2010.011.009

Lusher Shute, L. (2016). "What's happening in Congress that's affecting you," in *37th Annual Conference of the Ohio Ecological Food and Farm Association* (Granville).

MacDonald, J. M., Hoppe, R. A., and Newton, D. (2018). *Three Decades of Consolidation in U.S.* Agriculture. Edited by Economic Research Service. Washington, DC: US Department of Agriculture.

Mase, A. S., Gramig, B. M., and Prokopy, L. S. (2017). Climate change beliefs, risk perceptions, and adaptation behavior among Midwestern U.S. crop farmers. *Clim. Risk Manage.* 15, 8–17. doi: 10.1016/j.crm.2016.11.004

McCright, A. M., and Dunlap, R. E. (2011). Cool dudes: the denial of climate change among conservative white males in the United States. *Glob. Environ. Change* 21, 1163–1172. doi: 10.1016/j.gloenvcha.2011.06.003

McCright, A. M., Marquart-Pyatt, S. T., Shwom, R. L., Brechin, S. R., and Allen, S. (2016). Ideology, capitalism, and climate: explaining public views about climate change in the United States. *Energy Res. Soc. Sci.* 21, 180–189. doi: 10.1016/j.erss.2016.08.003

McElwee, P., Calvin, K., Campbell, D., Cherubini, F., Grassi, G., Korotkov, V., et al. (2020). The impact of interventions in the global land and agri-food sectors on nature's contributions to people and the UN sustainable development goals. *Glob. Change Biol.* 26, 4691–4721. doi: 10.1111/gcb.15219

Merlos, F. A., and Hijmans, R. J. (2020). The scale dependency of spatial crop species diversity and its relation to temporal diversity. *Proc. Natl. Acad. Sci. U.S.A.* 117, 26176–26182. doi: 10.1073/pnas.2011702117

Moosa, C. S., and Tuana, N. (2014). Mapping a research agenda concerning gender and climate change: a review of the literature. *Hypatia* 29, 677–694. doi: 10.1111/hypa.12085

Morning Ag Clips (2020). *From 'Price Takers to Price Makers': Marketing Insights, Opportunities for Diversification, Increased Profits Focus of Reg.* Morning Ag Clips. Available online at: https://www.morningagclips.com/from-price-takers-to-price-makers/ (accessed January 17, 2020).

Morton, L. W., Hobbs, J., Arbuckle, J. G., and Loy, A. (2015). Upper midwest climate variations: farmer responses to excess water risks. *J. Environ. Qual.* 44, 810–822. doi: 10.2134/jeq2014.08.0352

Morton, L. W., Roesch-McNally, G., and Wilke, A. K. (2017). Upper Midwest farmer perceptions: Too much uncertainty about impacts of climate change to justify changing current agricultural practices. *J. Soil Water Conserv.* 72, 215–225. doi: 10.2489/jswc.72.3.215

National Resource Council (2010). *Toward Sustainable Agricultural Systems in the 21st Century*. Washington, DC: The National Academies.

National Sustainable Agriculture Coalition. (2014). *2014 Farm Bill Drill Down: Beginning and Socially Disadvantaged Farmers*. Washington, DC: In NSAC's Blog.

Niles, M. T., Brown, M., and Dynes, R. (2016). Farmers' intended and actual adoption of climate change mitigation and adaptation strategies. *Clim. Change* 135, 277–295. doi: 10.1007/s10584-015-1558-0

Niles, M. T., Lubell, M., and Brown, M. (2015). How limiting factors drive agricultural adaptation to climate change. *Agric. Ecosyst. Environ.* 200, 178–185. doi: 10.1016/j.agee.2014.11.010

Niles, M. T., Lubell, M., and Haden, V. R. (2013). Perceptions and responses to climate policy risks among California farmers. *Glob. Environ. Change* 23, 1752–1760. doi: 10.1016/j.gloenvcha.2013.08.005

Ostrom, E. (2014). A polycentric approach for coping with climate change. *Ann. Econ. Finan.* 15, 97–134. Available online at: http://aeconf.com/Articles/May2014/aef150103.pdf

Panda, A. (2018). Transformational adaptation of agricultural systems to climate change. *Wiley Interdiscipl. Rev.* 9:520. doi: 10.1002/wcc.520

Perry, J. E., and Ahearn, M. C. (1994). Farm women blend farm and off-farm work. *Rural Dev. Perspect.* 9, 24–31.

Pilgeram, R., Dentzman, K., Lewin, P., and Conley, K. (2020). How the USDA changed the way women farmers are counted in the census of agriculture. *Choices* 35, 1–10. Available online at: https://www.choicesmagazine.org/choices-magazine/submitted-articles/how-the-usda-changed-the-way-women-farmers-are-counted-in-the-census-of-agriculture

Prokopy, L. S., Arbuckle, J. G. Jr., Barnes, A. P., Haden, V. R., Hogan, A., Niles, M. T., et al. (2015). Farmers and climate change: a cross-national comparison of beliefs and risk perceptions in high-income countries. *Environ. Manage.* 56, 492–504. doi: 10.1007/s00267-015-0504-2

Prokopy, L. S., Gramig, B. M., Bower, A., Church, S. P., Ellison, B., Gassman, P. W., et al. (2020). The urgency of transforming the Midwestern U.S. landscape into more than corn and soybean. *Agric Human Values.* 37:1–3. doi: 10.1007/s10460-020-10077-x

Pryor, S. C., Scavia, D., Downer, C., Gaden, M., Iverson, L., Nordstrom, R., et al. (2014). "Chapter 18: Midwest," in *Climate Change Impacts in the United States: The Third National Climate Assessment*, eds J. M. Melillo, T. C. Richmond, and G. W. Yohe (Washington, DC: U.S. Global Change Research Program), 418–440. doi: 10.7930/J0J1012N

Reed, M. G., Scott, A., Natcher, D., and Johnston, M. (2014). Linking gender, climate change, adaptive capacity, and forest-based communities in Canada. *Canad. J. For. Res.* 44, 995–1004. doi: 10.1139/cjfr-2014-0174

Reinsch, S. (2009). "'A part of me had left': learning from women farmers in Canada about disaster stress," in *Women, Gender and Disaster: Global Issues and Initiatives*, eds E. Enarson and P. G. D. Chakrabarti (New Delhi: Sage Publications), 152–164. doi: 10.4135/9788132108078.n12

Rejesus, R. M., Mutuc-Hensley, M., Mitchell, P. D., Coble, K. H., and Knight, T. O. (2013). U.S. agricultural producer perceptions of climate change. *J. Agric. Appl. Econ.* 45, 701–718. doi: 10.1017/S1074070800005216

Riley, M. (2016). Still being the 'good farmer': (non-)retirement and the preservation of farming identities in older age. *Sociol. Rural.* 56, 96–115. doi: 10.1111/soru.12063

Robertson, M., and Murray-Prior, R. (2016). Five reasons why it is difficult to talk to Australian farmers about the impacts of, and their adaptation to, climate change. *Reg. Environ. Change* 16, 189–198. doi: 10.1007/s10113-014-0743-4

Robinson, F. (2011). *The Ethics of Care: A Feminist Approach to Human Security, Global Ethics and Politics*. Edited by C. Gould. Philadelphia, PA: Temple University Press.

Roesch-McNally, G. E., Arbuckle, J. G., and Tyndall, J. C. (2016). What would farmers do? Adaptation intentions under a Corn Belt climate change scenario. *Agric. Hum. Values* 34, 333–346. doi: 10.1007/s10460-016-9719-y

Roesch-McNally, G. E., Arbuckle, J. G., and Tyndall, J. C. (2018). Barriers to implementing climate resilient agricultural strategies: The case of crop diversification in the US Corn Belt. *Glob. Environ. Change* 48, 206–215. doi: 10.1016/j.gloenvcha.2017.12.002

Rotz, S., and Fraser, E. D. G. (2015). Resilience and the industrial food system: analyzing the impacts of agricultural industrialization on food system vulnerability. *J. Environ. Stud. Sci.* 5, 459–473. doi: 10.1007/s13412-015-0277-1

Salvioni, C., Ascione, E., and Henke, R. (2013). Structural and economic dynamics in diversified Italian farms. *Biobased Appl. Econ.* 2, 257–275. doi: 10.13128/BAE-13094

Schattman, R. E., Conner, D., and Méndez, V. E. (2016). Farmer perceptions of climate change risk and associated on-farm management strategies in Vermont, northeastern United States. *Elementa* 4:000131. doi: 10.12952/journal.elementa.000131

Schewe, R. L., and Stuart, D. (2017). Why don't they just change? Contract farming, informational influence, and barriers to agricultural climate change mitigation. *Rural Sociol.* 82, 226–262. doi: 10.1111/ruso.12122

Schuldt, J. P., Enns, P. K., and Cavaliere, V. (2017). Does the label really matter? Evidence that the US public continues to doubt global warming more than climate change. *Clim. Change* 143, 271–280. doi: 10.1007/s10584-017-1993-1

Schutt, R. K. (2014). *Investigating the Social World: The Process and Practice of Research. 8th Edn.* Thousands Oaks, CA: SAGE Publications.

Smit, B., McNabb, D., and Smithers, J. (1996). Agricultural adaptation to climatic variation. *Clim. Change* 33, 7–29. doi: 10.1007/BF00140511

Smit, B., and Skinner, M. W. (2002). Adaptation options in agriculture to climate change: a typology. *Mitig. Adap. Strateg. Glob. Change* 7, 85–114. doi: 10.1023/A:1015862228270

Soubry, B., Sherren, K., and Thornton, T. F. (2020). Are we taking farmers seriously? A review of the literature on farmer perceptions and climate change, 2007-2018. *J. Rural Stud.* 74, 210–222. doi: 10.1016/j.jrurstud.2019.09.005

Spangler, K., Burchfield, E. K., and Schumacher, B. (2020). Past and current dynamics of U.s. agricultural land use and policy. *Front. Sustain. Food Syst.* 4:98. doi: 10.3389/fsufs.2020.00098

Stuart, D., Schewe, R. L., and McDermott, M. (2012). Responding to climate change: barriers to reflexive modernization in U.S. agriculture. *Organ. Environ.* 25, 308–327. doi: 10.1177/1086026612456536

Suess-Reyes, J., and Fuetsch, E. (2016). The future of family farming: a literature review on innovative, sustainable and succession-oriented strategies. *J. Rural Stud.* 47, 117–140. doi: 10.1016/j.jrurstud.2016.07.008

Sutrop, U. (2001). List task and cognitive salience index. *Field Methods* 13, 263–276. doi: 10.1177/1525822X0101300303

Tauer, L. (2019). Farmer productivity by age in the United States. *Int. J. Agric. Manage.* 8, 74–80. doi: 10.5836/ijam/2019-08-74

UN (2018). *The 17 Goals*. Department of Economic and Social Affairs, Division for Sustainable Development Goals, United Nations. Available online at: https://sdgs.un.org/goals (accessed January 27).

UNECE/FAO (2006). *Time for Action: Changing the Gender Situation in Forestry*. Edited by UNECE/FAO Team of Specialists on Gender and Forestry. Rome: FAO.

USDA-AMS (2015). *What is a Specialty Crop?* Agricultural Marketing Service, US Department of Agriculture. Available online at: https://www.ams.usda.gov/services/grants/scbgp/specialty-crop (accessed August 25, 2016).

USDA-Census of Agriculture (2014). *Census by State*. US Department of Agriculture. Available online at: https://www.agcensus.usda.gov/Publications/2012/Full_Report/Census_by_State/ (accessed June 2).

USDA-ERS (2012). *Agricultural Adaptation to a Changing Climate: Economic and Environmental Implications Vary by* U.S. *Region.* Washington, DC: Economic Research Service, US Department of Agriculture.

USDA-ERS (2016). *ARMS Data: Agricultural Resource Management Survey (ARMS) Tailored Reports*. Washington, DC: Economic Research Service, US Department of Agriculture.

USDA-ERS (2021). *Farm Household Income and Characteristics*. Edited by Economic Research Service. Washington, DC: U.S. Department of Agriculture.

USDA-FSIS (2015). *Meat and Poultry Labeling Terms*. Washington, DC: Food Safety and Inspection Service, USDA.

USDA-NASS (2012). *Quick Stats*. National Agricultural Statistics Service, US Department of Agriculture.

USDA-NRCS (2005). *Western Lake Erie Basin Water Resources Protection Plan: Ohio, Indiana and Michigan*. Washington, DC: Natural Resources Conservation Service, United States Department of Agriculture.

Valliant, J. C. D. (2012). "The public health function of livestock: Perspectives on land and health from farmers in Indiana," in *PhD Dissertation, Health, Behavior and Society, Johns Hopkins University*.

Valliant, J. C. D., Farmer, J. R., Dickinson, S. L., Bruce, A. B., and Robinson, J. M. (2017). Family as a catalyst in farms' diversifying agricultural products: A mixed methods analysis of diversified and non-diversified farms in Indiana, Michigan and Ohio. *J. Rural Stud.* 55, 303–315. doi: 10.1016/j.jrurstud.2017.08.017

Van Es, J. C., Lorence, D. P., Morgan, G. W., and Church, J. A. (1996). Don't know responses in environmental surveys. *J. Environ. Educ.* 27, 13–18. doi: 10.1080/00958964.1996.9941470

Walker, H. M., Culham, A., Fletcher, A. J., and Reed, M. G. (2019). Social dimensions of climate hazards in rural communities of the global North: an intersectionality framework. *J. Rural Stud.* 72, 1–10. doi: 10.1016/j.jrurstud.2019.09.012

Weber, E. U. (2006). Experience-based and description-based perceptions of long-term risk: why global warming does not scare us (yet). *Clim. Change* 77, 103–120. doi: 10.1007/s10584-006-9060-3

Weismeier-Sammer, D., Frank, H., and von Schlippe, A. (2013). Untangling 'familiness': a literature review and directions for future research. *Entrep. Innov.* 14, 165–177. doi: 10.5367/ijei.2013.0119

Weller, S. C., and Romney, A. K. (1988). *Systematic Data Collection, Vol. 10, Qualitative Research Methods*. Newbury Park, CA: Sage Publications. doi: 10.4135/9781412986069

White, S. S., and Selfa, T. (2013). Shifting lands: exploring Kansas farmer decision-making in an era of climate change and biofuels production. *Environ. Manage.* 51, 379–391. doi: 10.1007/s00267-012-9991-6

Wiener, S., Roesch-McNally, G. E., Schattman, R. E., and Niles, M. T. (2020). Ready, willing, and able? USDA field staff as climate advisors. *J. Soil Water Conserv.* 75, 62–74. doi: 10.2489/jswc.75.1.62

Winkler, J. A., Andresen, J. A., Hatfield, J. L., Bidwell, D., and Brown, D. (2014). *Climate Change in the Midwest: A Synthesis Report for the National Climate Assessment.*

Wood, S. D., and Gilbert, J. (2000). Returning African American farmers to the land: recent trends and a policy rationale. *Rev. Black Polit. Econ. Spring* 27, 43–64. doi: 10.1007/BF02717262

Yoder, L., Houser, M., Bruce, A., Sullivan, A., and Farmer, J. (2021). Are climate risks encouraging cover crop adoption among farmers in the southern Wabash River Basin? *Land Use Policy* 102:105268. doi: 10.1016/j.landusepol.2020.105268

Zaval, L., Markowitz, E. M., and Weber, E. U. (2015). How will I be remembered? Conserving the environment for the sake of one's legacy. *Psychol. Sci.* 26, 231–236. doi: 10.1177/0956797614561266

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.