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Is Seeing Believing?
Applying a Realist Framework to Examine Agriculture and Climate Change

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Title:
Is Seeing Believing? Applying a Realist Framework to Examine Agriculture and Climate Change

Abstract

Agricultural production contributes to greenhouse gas emissions and global climate change. If the agricultural sector is to mitigate its contributions, farmers must actively adopt conservation practices. Recent studies have shown farmers' beliefs about climate change to be influential in their support for adopting these practices. This study explores how social groups and their climate change messages interact with regional biophysical expressions of climate change to influence farmers' climate change beliefs. We apply a recently revised realist framework to qualitative data from 104 interviews with corn farmers in Iowa and Indiana, United States (US). Our findings illustrate that many farmers are able to detect the biophysical expressions of climate change; however, their acknowledgement of the impacts of climate change in most cases does not translate into an acknowledgement of the anthropogenic nature of climate change. Conflicting social messages produce uncertainty about or disbelief in humans' causal role. These results show that realist frameworks, like the one applied here, can serve as useful guides for analyses and intervention related to climate change mitigation.

Keywords: Climate Change; Beliefs; Critical Realism; Agriculture; Climate Change Denial; Social-Ecological Systems.

Introduction

"[A]griculture is simultaneously deeply implicated in and threatened by climate change" (Weis 2010: 318). This quotation describes one of the most pressing environmental challenges of our time. While food production and supplies are increasingly impacted by changes in temperature and precipitation associated with climate change, agriculture also remains a significant source of greenhouse gas (GHG) emissions (IPCC 2007). Recent flood events and droughts have already resulted in regional crop loss, impacting global food supplies and prices. Meanwhile, industrial agricultural production systems continue to emit carbon dioxide, nitrous oxide, and methane, generating up to 15% of global GHG emissions (IPCC 2007). It is not surprising that an increasing number of scientists and policymakers are calling for mitigation measures in agriculture. These measures require changes in agricultural practices and depend on the management decisions made by individual farmers. Understanding these decisions therefore becomes imperative. The need to understand farmer decision-making and barriers to climate change mitigation in agriculture has been widely recognized (e.g., Dulal et al. 2011; Lal et al. 2011). However, while many publications mention the importance of addressing social barriers, most provide no empirical data and few details (e.g., in the IPCC report on agriculture: Smith et al. 2007). Overall, attention to barriers remains limited.

To address this gap, a growing number of studies have started to explore how farmers' reactions to climate change are related to their beliefs about climate change (Arbuckle, Morton and Hobbs 2013; Prokopy et al. 2015). Work on this topic has generally focused on whether farmers believe climate change is occurring, what they believe causes climate change and if these beliefs affect their support for adopting reactive conservation practices. But few studies

have explored what factors are influencing the development of farmers' beliefs (Houser 2016). Moreover, very few studies, even of the general public, have considered how social and biophysical processes interact to influence beliefs about climate change (Hamilton and Stampone 2013), particularly using qualitative data. To address these research gaps, this paper uses qualitative data to explore the question: how do social and biophysical factors combine to influence farmers' beliefs about climate change? Specifically, for reasons we will explain below, our emphasis is on (1) if farmers perceive trends in climate that match actual regional expressions of biophysical climate change and (2) how this perception interacts with social processes to influence their beliefs about climate change.

In this effort, we apply a realist framework (Carolan 2005; Carolan and Stuart 2016) to the context of Midwestern corn agriculture—specifically in the states of Iowa and Indiana. Responding to calls for more social-ecological research guided by theory (e.g., Lockie 2015, Stuart 2016), we adopt this theoretical framework as an analytic tool for our analysis. This approach allows us to engage with farmers' complex processes of translating the biophysical phenomenon of climate change into beliefs about its reality, causes, and effects using qualitative data. We apply this framework to illustrate how social processes and biophysical forces combine to shape farmers' beliefs, agricultural practices, and environmental outcomes.

To begin, we review past research on farmers' perceptions of climate change in the United States (US). We will then present our realist theoretical approach, drawing from the earlier work of Carolan (2005) and more recently Carolan and Stuart (2016). We briefly discuss relationships between climate change and Midwest corn agriculture before presenting qualitative data to explore how biophysical changes are perceived by farmers and processed along with social messages and influences. While this work focuses on US farmers in the Midwest, our

findings are also applicable to other regions and nations where agricultural producers (and the general public) similarly struggle to make sense of climate change among biophysical and social influences. We contend that a realist framework provides a useful approach to explore biophysical and social entities and processes together and encourage others to explore this and other theories that serve to ground social-ecological research.

Farmers' Beliefs about Climate Change

The majority of studies of farmers' climate change beliefs have focused on the developing world (Prokopy et al. 2015). Recently, a number of studies have emerged as an attempt to understand farmers' beliefs about climate change in developed countries (Barnes and Toma 2012; Eggar, Kayser and Isselstein 2014; Niles, Lubell and Haden 2013). These studies often explore two related questions: Do farmers believe climate change is occurring and if so, what do they believe is causing it to change? Climate change views and particularly the factors influencing them are likely highly contextual. Consequently, the remainder of this review focuses specifically on the geo-political context of this analysis, the US. See Houser (2016) for a more comprehensive review of the literature examining farmers' beliefs about climate change in developed countries. Studies specific to the US are geographically dispersed and cover a number of regions, including states in the South East, South West, Lower and Upper Midwest and West Coast (Arbuckle, Morton and Hobbs 2013; Haden et al. 2012; Rejesus et al. 2013). Together, these studies indicate only a small majority of US farmers believe that climate change is occurring and even fewer farmers believe that human activities are the primary driver (26-47%; Haden et al. 2012; Niles et al. 2013; Rejesus et al. 2013). Specific to Indiana and Iowa corn farmers, two studies (Arbuckle, Morton and Hobbs 2013; Arbuckle et al. 2013) show eight to 10% of Iowa farmers' attribute climate change mostly to human activities and 33–35% to half

human activities and half natural causes. Gramig, Barnard and Prokopy (2013) found that over 79% of Indiana farmers believed that climate change is a natural process while only 45% believed that human activities contribute to climate change.

Studies in the US using surveys, interviews, and focus groups indicate that farmers' beliefs about climate change play a very important role in shaping their willingness to participate in mitigation efforts (e.g. Arbuckle, Morton and Hobbs 2013; Arbuckle et al. 2013; Gramig Barnard and Prokopy 2013). Mitigation practices, such as conservation tillage practices, more efficient nitrogen fertilizer use and adjusting cattle feeding practices could substantially reduce the GHG emissions of carbon dioxide, nitrous oxide and methane from agriculture (Doll and Baranski 2011; USEPA 2015). Support for adopting mitigation strategies such as these is far higher among farmers who believe climate change is happening *and* is caused by human activity than those who do not believe either (Arbuckle, Morton and Hobbes 2013a; Abruckle et al. 2013, 2014; Haden et al. 2012). Therefore, belief in anthropogenic climate change and supportive attitudes of practices are considered key factors influencing the adoption of mitigation practices (Gifford 2011).

Factors influencing beliefs

Few studies have explored what processes influence US farmers' beliefs about climate change (Houser 2016). What research has been done offers some key insights, suggesting farmers' beliefs about climate change are influenced by a number of factors. Some studies have emphasized that farmers' exposure to certain information sources influences their beliefs about anthropogenic climate change. Arbuckle, Morton and Hobbs (2015) found that compared with farmers who trusted scientists, conservation organizations, and government agencies, those who

trusted agricultural interest groups were less likely to perceive climate change as human driven. Others have similarly argued that exposure to arguments from politically conservative groups likely reduces Midwestern farmers' beliefs in climate change and its connection to human activities (Houser 2016; Stuart, Schewe and McDermott 2012). Safi, Smith and Liu (2012) also found that political orientations and beliefs about climate change were all strong determinants of perception of climate change as a risk. They conclude that, in the US, climate change beliefs are largely in line with political orientations and that political divides are hindering responses.

In additional to the influence of social factors, the biophysical dimensions of climate change may also play a role in shaping farmers' beliefs. The role of the biophysical in influencing individuals' perceptions of environmental processes and settings has long been explored (e.g., Freudenberg, Frickel and Gramling 1995; Greider and Garkovich 1994; Stedman 2003). More recently, studies have found that the biophysical expressions and impacts of climate change may influence beliefs about the reality of climate change and anthropogenic nature (Hamilton and Stampone 2013; Howe et al. 2013; McCright, Dunlap and Xiao 2014). This is often discussed in analyses of the general publics' comprehension of climate change. Many of these studies emphasize the difficulty of "seeing" climate change as a barrier to believing in it (Schneider, Easterling and Mearns 2000). As Weber and Stern (2011: 317) comment, "The main causes of climate change (greenhouse gases) are invisible, its impacts are geographically and temporally distant for most Americans, and […] its signals are hard to detect" (citing Moser [2009] and NRC [2009]). Based on the public's non-scientific method of understanding this phenomenon, i.e. the need to actually believe they have seen it, regionally specific weather anomalies in the recent past can shape beliefs rather than future long-term scientific projections (Li et al. 2011a; Weber and Stern 2011).

For the general public, it appears that the difficulty of accurately perceiving climate change may present a barrier to believing; however, this may not apply to farmers as a distinct sub-population. Farmers, compared to the general public, are in a unique position to directly experience impacts related to a changing climate. With a daily routine that is governed by weather and a livelihood that is largely dependent on their capacity to anticipate and/or react to seasonal weather patterns, farmers not only have incentive to pay close attention to weather/climate, but indeed are often forced to. Moreover, the average US farmer is 58 years old (USDA NASS 2012), suggesting most have witnessed multiple decades of a changing climate in their region.

Only a small number of studies have explored the influence of farmers' personal experiences with the biophysical expressions of climate change on their beliefs and there is little agreement among these studies. Safi, Smith and Liu (2012) find the biophysical attributes of climate change make it difficult for land managers to detect given the "epistemic distance" (Carolan 2006) of the material phenomena in question, reducing the likelihood of climate change being perceived as a risk or as occurring. Other studies have found that farmers are experiencing perceived biophysical expressions of climate change and this perception does affect their beliefs. For example, when farmers perceive they have experienced the negative impacts of climate change, such as decreased water availability in California, belief in climate change and the perceived risk of climate change both increase among farmers (Haden et al. 2012; Rejesus et al. 2013). Clearly, further analysis is needed to understand if farmers are perceiving the effects of climate change and what impact this has on their beliefs and reactions. This is especially important given that farmers' participation in climate change mitigation efforts largely depends

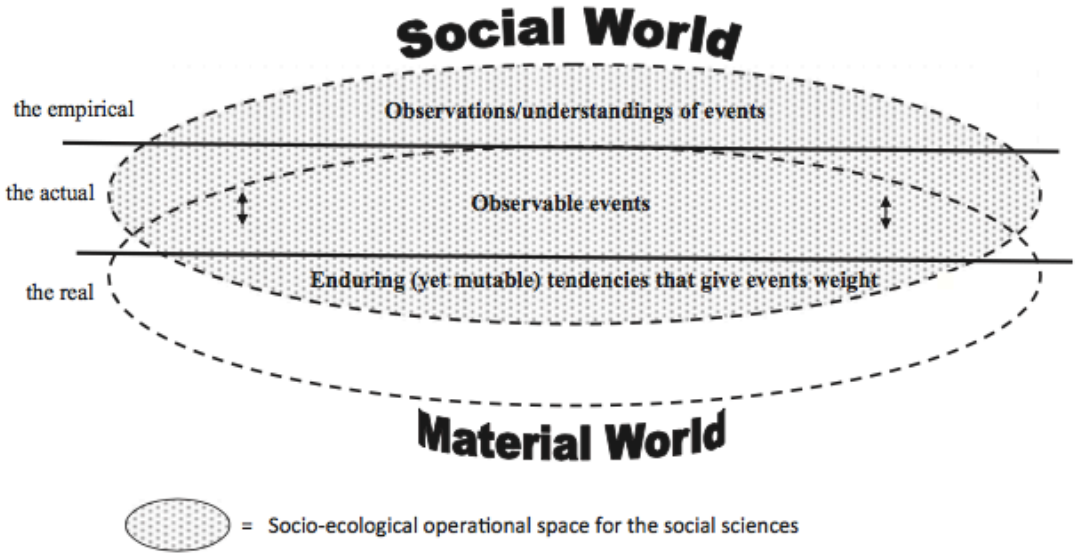
on their belief that anthropocentric climate change is a real phenomenon (Arbuckle, Morton and Hobbs 2013).

This literature review suggests beliefs about climate change is a critically important factor influencing farmers' support for and propensity to adopt mitigation practices. Yet, research attempting to understand what processes are influencing US farmers' beliefs about climate change is relatively sparse. Specifically, a better understanding of how farmers perceive the biophysical manifestations of climate change is needed. As social processes influence interpretations of biophysical changes (Freudenberg, Frickel and Gramling 1995), an analysis of this topic must include both biophysical changes as well as the social factors that influence the interpretations of these changes. To accomplish this, we adopt a realist theoretical approach to examine two questions: (1) Are farmers perceiving the regional biophysical expressions of climate change? And (2) if so, how does this perception interact with social factors, specifically climate change messaging, to influence farmers' beliefs about whether climate change is occurring and if human activity contributes to its occurrence. Put simply, we explore "if seeing is believing" or if other influences continue to mask the biophysical realities of climate change.

Conceptual Approach

To examine qualitative social science data alongside biophysical processes, we adopt a realist approach as an important middle ground to quell disputes between constructionists and realists and offered a more nuanced approach to understand social-ecological relationships. The starting point of this approach is critical realism, which illustrates how human knowledge and perceptions of the biophysical world may differ from reality: there is a difference between nature and our conceptions of it (Benton 1991, Dickens 1992, Murphy 2002). Many scholars have drawn from the work of Bhaskar (2008), who proposed a stratified account of reality with three

243 levels: the empirical, the actual, and the real. Extending the work of Bhaskar (2008) and Soper
244 (1995), Carolan (2005) proposed a framework that distinguished between three strata: "nature",
245 nature, and Nature. Carolan and Stuart (2016) recently revised this framework so as to better
246 equip it to interrogate socio-material phenomena, while taking additional steps to further distance
247 the approach to its original critical realist metaphysical moorings. As shown in *Figure 1*, the
248 three levels proposed by Carolan (2005) and Carolan and Stuart (2016) are translated into 1)
249 perceptions and understandings of reality (the empirical), 2) observable social-ecological
250 interactions (the actual), and 3) deep biophysical and social tendencies (the real). For the
251 theoretical origins and details of this approach, we refer readers to Carolan and Stuart (2016)
252 where they are discussed at length. In addition to answering the above questions, this paper can
253 serve as a testing ground to explore the usefulness of applying this framework to a specific case
254 study- something that (to our knowledge) has not yet been done (Stuart 2016).



255
256 *Figure 1: Stratified critical realist framework from Carolan and Stuart (2016).*

257

Before moving on, however, it would be worth speaking briefly as to why we believe a realist framework is the most appropriate for bringing the biophysical into social science research (and how this approach differs from critical realism), versus, for example, an actor network analytical approach, which is widely viewed as recognizing the significance of non-human entities in the constitution of the social. Our concern with actor network approaches lie with their foundations and assumptions. Elder-Vass (2015: 106) provides perhaps the most pointed criticism of Latourian-inspired analyses when he wrote,

> "The assemblages that populate Latour's universe are not the kind of things that populate the universe of common-sense realism. They are not bundles of matter, organized into particular forms, about which we may sometimes know things. Instead, they are bundles of associations, and those associations include *both* what conventional realists think of as referents and *also* what we think of as reference. […] For him, the elements or associations that combine to form assemblages are assemblages too—there is no simple object (whether physical or otherwise) that is available to be combined into an assemblage."

In other words, Latour is either going to extreme lengths to avoid talking about or he truly does deny the existence of the interiority of relations—what we could call realism. In either case, his writings project a world from without, a world that consists only of external relations. We can point directly to Latour's writings to support this line of argument, where he struggles to deny essentialism while hoping to maintain his grasp on realism. He has in/famously written the following: "Did ferments exist before Pasteur made them up? There is no avoiding the answer: No, they did not exist before he came along" (Latour 1999: 145). But then

elsewhere, regarding the claim that microbes did not exist before Pasteur, he wrote: "If you take it as a metaphysical argument, it's completely ridiculous' (Latour et al. 2011: 44)

The approach adopted here also deviates from the one articulated by Bhaskar. For Bhaskar (2008), reality is broken up into three *ontologically* distinct strata. By embracing what Carolan and Stuart (2016) have termed a "relational ontology", we see these strata as *analytic* categories. Critical realism, with this talk of a stratified reality, treads too close to what could be read as a hierarchy of being, whereby relational ontologies embrace an approach rooted in becoming. The above figure, then, with its "levels", should be understood as device to methodologically and analytically organize how we talk about the world and the relationships therein contained. We are not suggesting, for example, that deep social and biophysical tendencies are ontologically distinct form the processes that go into "seeing" them. In fact, it is imperative for us to understand the interrelationships across levels as much as the phenomena we analytically locate within them.

Examining relationships between agriculture and climate change represents an ideal opportunity to apply the above framework. Agriculture inherently involves both the biophysical and social worlds, as does climate change—an (global) environmental problem that crosses the nature-society divide perpetuated by (real) phenomena (e.g., bio-physical 'rules', momentum, and tendencies). It also represents a clear case where perceptions of environmental change, or lack thereof, shape future environmental outcomes. In this paper, we use an adapted version of the framework, relying on two of the three levels shown in *Figure 1* —the actual, and the empirical—as analytic concepts to guide our social-ecological examination of farmers' process of perceiving and reacting to climate change. While "the real" also represents an important layer in our understanding of climate change and agriculture (especially related to drivers), we leave it

303 out for now as we specifically examine the relationship between actual events/processes and the
304 perceptions of these events/processes.

305 These two categories provide the conceptual tools needed to discuss climate change as a
306 biophysical event in the Midwest and how farmers perceive it at an individual level. We
307 acknowledge that all three categories are in reality interrelated and inseparable; however, they
308 present a useful way to critically examine environmental phenomena and reveal overlooked
309 relationships. Having categories that we can discuss separately provides important descriptive
310 and explanatory value. In addition to offering findings relevant to climate change mitigation
311 efforts, we aim to demonstrate how the application of a stratified realist framework reveals
312 important insights and represents a promising approach to address the call for social scientists to
313 bring the biophysical into our work (e.g., Castree and Braun 2001; Goldman and Shurman 2000;
314 Haila 2000; Latour 1993; Norgaard 1994; Rice 2013). While an increasing number of
315 environmental sociologists have included both social and biophysical variables in quantitative
316 analysis (e.g., Dietz Rosa and York 2007; Fisher 2006; York, Rosa and Dietz 2003), this
317 framework could prove useful in accomplishing the more elusive task of combining qualitative
318 social science data with studies of the biophysical world.

319 ***Midwestern Corn Agriculture and Climate Change***

320 We apply the stratified realist framework above to examine both the biophysical and
321 social factors influencing farmers' beliefs and willingness to participate in climate change
322 mitigation. To discuss the biophysical dimensions of climate change specific to Iowa and
323 Indiana, we utilize a detailed review of the scientific literature examining current and future
324 impacts of climate change for these states and their corn agriculture systems. To explore farmers'
325 perceptions of and beliefs about biophysical climate change, as well as the climate change

messages influencing these views, we draw from 104 personal interviews (Iowa: N=53; Indiana: N=51) with corn farmers. Interviews with farmers were conducted between May 2014 and September 2014. A semi-structured interview guide included questions exploring: where farmers most often heard about climate change from; whether farmers believed if climate change was happening; if so, did they believe it to be human caused; and what, if anything, they believed farmers could do to address climate change. Our semi-structured approach enabled farmers to respond at length and interviewers to react with response-specific follow-up questions. This interview procedure provided detailed insight into factors influencing the development of a farmer's climate change views.

All farmers grew at least 100 acres of corn per year and total farm sizes ranged from 170 to 9,000 acres. In both states, initial contacts were generated through university extension, county Soil and Water Conservation District offices and various farmer associations. A snow-ball sampling technique (Coleman 1958), where initial respondents recruit secondary participants from among acquaintances, was used to generate further contacts. Snowball sampling methods have been used to contact farmers' in recent studies in both the US (e.g. Stuart, Schewe and McDermott 2012) and the United Kingdom (e.g. Feliciano et al. 2014) and is considered a good method to contact subjects who are difficult to access (Faugier and Sargeant 1997), such as farmers. All interviews were recorded and lasted between 25 minutes and 2.5 hours. Upon completion, interviews were transcribed and analyzed using NVivo software. This procedure enabled us to identify relevant patterns in climate change responses and quantify specific response categories across our sample to be used as descriptive percentages.

In the below sections we discuss how social and biophysical processes interact to influence the way in which climate change, as a biophysical process, is interpreted by farmers.

Our analysis begins at the "middle" of Figure 1 by describing social and biophysical dimensions of climate change at the "actual" level—as an observable biophysical phenomenon—and we then work our way "up," through the framework to identify the translation process of this phenomenon, as it is interpreted and held by individual actors as empirical beliefs. We do not analyze and discuss every possible entity and process. Relationships involved are complex and an exhaustive exploration would not fit within the confines of a single journal article. Instead we focus on the most relevant factors revealed in our analysis in terms of shaping farmers' perception of climate change and associated support for mitigation. Our narrative below, based on our literature review and interviews, describes important pieces of the social-ecological puzzle of how farmers come to hold certain beliefs about climate change. Using a stratified framework to put these pieces together reveals new connections, barriers, and opportunities relevant to the relationship between perceptions of climate change and the adoption of mitigation practices.

The Actual: Observable Events and Processes

The actual speaks of perceptible surface events and relationships, and is the site of most environmental research. Much is happening in the realm of the actual and it also happens to be what we can best observe and study. As it applies to climate change, this speaks to those human activities that are releasing GHGs into the atmosphere and where society faces the consequences of and responds to climate change. Specific to Midwestern corn agriculture, this is the realm where farmers' practices release GHGs, where farmers may change their practices for climate change mitigation, where farmers experience climate change, and where actors, often powerful political and economic ones, organize to shape relationships and information. In our discussion,

we focus on discussing the latter two elements: the observable biophysical impacts of climate change and the organization of political and economic actors around the issue.

The Impacts of Climate Change on Agriculture

Farmers in the US Midwest are already experiencing climate change. Throughout the Midwest, warming temperatures and rising humidity are contributing to changing weather patterns (IPCCAC 2008; Karl, Melillo and Peterson 2009; Pryor et al. 2014). Since 1980, heat waves in the Midwest have been more frequent than any other time in the century (other than the Dust Bowl) and the frost-free season has extended by nearly a week. The region has experienced a 31% increase in the frequency of very heavy precipitation events (defined as the heaviest 1% of all events) and heavy downpours are twice as likely as they were 100 years ago. The Midwest is the wettest it has been in a century (ICCAC 2008; Karl, Melillo and Peterson 2009).

Specific expressions of these trends vary in the states we studied. For the most part, Iowa's experience fits the general trend of the Midwest: precipitation totals have increased by 8% since 1873, frequency of precipitation extremes has increased, as has the state's temperature and humidity level. It has also experienced a change in when rain events occur. The majority of precipitation now falls in the first half of year, contributing to wetter springs (ICCAC 2008). Indiana's temperature and precipitation averages have remained relatively stable, but other changes have occurred that reflect the trend of the region: growing season duration has increased along with the intensity and number of "hydrological extremes," leading to droughts and floods (PCCRC 2008); Indiana has also experienced a 30% increase in the number of very heavy rain events over the last 100 years, with a particular spike in numbers during the last 3 decades of the 20th century (Groisman, Knight and Karl 2001; Groisman et al. 2004).

These changes have both positive and negative consequences for agriculture. Though the overall effect of climate change on crop production is unclear as climate-management interactions are unknowable, climate change certainly has affected crop production in the Midwest. Across the Midwest, where corn is being grown is changing due to climate. For example, farmers in Kansas have been planting fewer and fewer acres in corn every year. At the same time, the corn acreage in Manitoba, Canadian (the province just north of North Dakota and Minnesota), which is about 700 miles north of Kansas, has nearly doubled over the past decade due to weather changes and higher prices (Bjerga 2012). The agribusiness firm Cargill has begun investing heavily in northern US facilities, as corn production shifts northward. Specific to Iowa, changing CO_2 concentrations has altered the competitive advantage of different plant types, increasing soybean yields without changing corn yields. While overall increased precipitation may boost crop production, concentrated spring rain events in Iowa have a number of negative effects: Waterlogged soil contributes to reduced yields (IPCCAC 2008); increased N loss (Sawyer 2008); and as seen in 2008, can delay the planting date to beyond what is ideal to achieve maximum yield production (Pope 2008). Further, spring storm events force producers to delay in-season fertilization, which also reduces yield (Balkcom et al. 2003). Finally, more intense storm events cause soil erosion, nitrogen fertilizer loss, and soil fertility problems (Cox et al. 2011). For instance, due to increased precipitation and frequency of heavy rain events, in 2007 more than 10 million acres of Iowa farmland soil eroded at a rate faster than what is considered “sustainable” (Cox et al. 2011).

Data from Indiana on the effects of climate change on agriculture is sparse. Most research is projective, suggesting that extreme weather events may precipitate flooding during planting and harvest periods, leading to crop losses (PCCRC 2008). The relative lack of available data on

Indiana may be a reflection of state-level political apathy or outright backlash against the issue. For instance, in 2009 then Indiana Governor Mitch Daniels critiqued federal climate change mitigation policy as "imperialism" in an OpEd piece for the *Wall Street Journal* (Daniels 2009). While we'll speak more about the role of politics below, regional-level data is sufficient for our purposes in suggesting what may now be the effects of climate change on agriculture in Indiana. The benefits a longer growing season and rising CO_2 levels provide to crop production throughout the Midwest, have in many instances been offset by the increased prevalence of heat waves, and the "hydrological extremes" of droughts and floods noted above (Melillo, Terese and Gary 2014). In summary, the scientific literature suggests that the states of Iowa and Indiana have experienced significant impacts related to climate change, and that these changes present new scenarios related to plant growth, soil conditions, and water in agricultural production systems.

Exposure to Conflicting Messages About Climate Change

Indiana and Iowa farmers' perceptions of these *actual* expressions of climate change do not develop in a void of social influence. In addition to the biophysical expressions of climate change in Indiana and Iowa agriculture, a number of social processes occur at the actual level that influence farmers' beliefs about climate. This includes exposure to information and strategic messages related to climate change from a range of local and national sources.

Noted earlier, studies indicate the importance of exposure to messages from conservative (climate change denial) organizations. Generally speaking, repeated exposure to conservative media sources reinforces skeptical perspectives about climate change and inhibits proactive attitudes (McCright and Dunlap 2010; McCright 2011; Stuart, Schewe and McDermott 2012). A growing literature suggests this conservative message is voiced from an organized and well-

funded movement often referred to as the *climate change denial movement* (Dunlap and McCright 2015). McCright and Dunlap (2010) argue that this movement is an association of conservative media outlets, politicians and industries who wish to prevents public and political reactions to anthropogenic climate change through "manufacturing uncertainty" about its reality and causes. Uncertainty is created through their promotion of particular messages: that climate change is not happening or has not yet been proven; if climate change is occurring, it is not man-made; or that undertaking actions to address it would be catastrophic for the US economy or other values (Weber and Stern 2011). In effect, the need for a policy response is questioned, as well as the implementation of widespread mitigation actions. This movement is argued to be undertaken in an effort to maintain the interests of those who benefit from the perpetuation of industrial production, such as the fossil fuel industry (McCright and Dunlap 2010) and is well funded by conservative groups (Brulle 2014).

Farmers in Indiana and Iowa are exposed to conservative messages from a range of sources including: radio programs (e.g., Rush Limbaugh), TV news and programs (e.g., Fox News), farming organizations (e.g., Farm Bureau), politicians (like Indiana's former governor), and local social networks (e.g., morning coffee with other farmers at the McDonald's). Many of these sources of information repeat denialist messages that can contribute to uncertainty. Rush Limbaugh commonly interviews "contrarian scientists" (Dunlap and McCright 2015) who argue there is an ongoing scientific debate on the reality of anthropogenic climate change. In 2015, The *American Farm Bureau* (AFB) released a statement to US farmers related to their official stance on climate change, stating:

> "[The] Farm Bureau recognizes there may be an increase in occurrences of extreme weather […] it is not clear if this is due to natural global climate cycles or other factors,

such as GHGs. We do not believe unilateral action by the United States can make a difference on global temperatures or stop devastating weather events."

These messages contradict the majority of scientific evidence and expert opinions and are meant to deny the role of humans in climate changes and thwart any type of policy response.

In opposition to climate change denial are strategic messages to encourage beliefs in anthropogenic climate change and the adoption of GHG mitigation practices. Strategies to do both are increasingly being developed and deployed. Education programs are emerging across the US focusing on sharing information with farmers about climate change and practices for mitigation. These efforts are being led by government agencies, non-governmental organizations, and university agricultural extension services. These organizations have developed fact sheets about climate change for farmers and some have held workshops and discussion forums. As some results suggest, farmers who trust and utilize these organizations may be more likely to believe in anthropogenic climate change (Arbuckle, Morton and Hobbs 2015).

In Indiana and Iowa, farmers are exposed to information regarding the reality and threat of climate change from the *National Resource Conservation Service*, University Extension and the general (non-conservative) media. University Extension has been particularly prevalent in corn belt states. Extension educators relay scientific arguments about anthropogenic climate change to farmers and, regardless of farmers' beliefs, encourage urgent adoption of mitigation and adaption practices (Morton et al. 2016). For instance, since 2007, Iowa State University's *Climate Science Program* has given outreach presentations directly to farmers explaining the scientific consensus on climate change, its anthropogenic nature and its current and future consequences for Iowa agriculture. However, as we will illustrate below, information from individuals within these organizations can vary: one former Iowa State University Professor of

Agronomy and Extension Climatologist consistently repeated denialist messages to famers about climate change being explained by natural cycles.

The actual is the space where biophysical and social processes express themselves as observable events. As proponents of responses to anthropogenic climate change and the climate change denial movement are organized campaigns that communicate through multiple forms of "media" content, we feel that both are observable events/processes. In consequence we locate it in the actual level. We next move on to the empirical level of the model to explore to what degree there are linkages between events occurring in the actual and farmers' attitudes and beliefs about climate. To do this, we analyzed data from interviews with Iowa and Indiana farmers.

The Empirical: Perceptions and Understandings of Climate Change

The empirical is the realm of interpretation – where perceptions and understandings of biophysical or social events and processes come together. We address the former first, exploring farmers' perceptions of biophysical changes in the regional climate. We then examine how social influences may be shaping perceptions of climate change and how they may combine with perceptions of experienced biophysical changes.

Perceived Biophysical Changes

Farmers in both states illustrated that they are highly aware of changes in precipitation and temperature in their region. Throughout the interviews, many farmers cited climatic events as the most significant variable influencing crop production. As one farmer commented, "It's mother nature basically, things that mother nature throws at us are the variables that we have to fight (IA40)." Most farmers had been working their land for decades and felt that compared to the general public, they were more connected to the biophysical world, paying close attention to

changes that impacted the timing of planting and harvest, fertilizer application, and overall crop yields.

For 41% of the farmers interviewed, this attention to climatic conditions translated into a perception of a trend in an increasingly changing climate. Though we did not specifically ask all farmers to discuss their experience with biophysical climate change, these experiences were shared in response to our questions about if climate change was happening. As one farmer said, "The rain pattern, the precipitation patterns in the spring has changed from what it was 40 years ago (IA20)." Of the 53 Iowa farmers, 27 expressed that they perceived a changing trend in normal weather patterns/climate. Indiana farmers were less likely to mention seeing a difference, with 16 out of 51 noting a perceived changing trend. Indiana's lower rate of perceived changes may reflect the lessened impact of climate change on Indiana's agricultural production, or may be related to intervening social influences (discussed below). While rates of perceived change differed, farmers in both states commented on noticing similar differences: increased occurrence and severity of extreme precipitation events, changing temperatures and an overall less predictable ecological setting for annual crop production. While a few respondents mentioned less snowfall or slightly warmer temperature than in previous decades, farmers mostly agreed that there had been increases in extreme weather events rather than any specific trends in temperature or precipitation. One Indiana farmer explained at length why farmers are especially attentive to a changing climate:

> "I think everybody that I work with, that works in agriculture, we have a very close connection to the weather, but it's a regional connection, […] Whether or not the poles are getting warmer we don't notice, but we notice our patterns, and, you know, Midwestern patterns, those kinds of things. So we see those kinds of things, and the

> biggest thing that I think in general the consensus would be is that things have changed enough that the weather is more extreme, and there're more extreme events, I mean, just like for us this year 5 inches of rain in a week, and I've been farming 25 years, we're fourth-generation here, those kinds of things don't happen very often and, you know, so it's happened twice in the last month, you know, it just seems like we get more intense events and those kinds of things, so absolutely climate is changing (IN18)."

Other expressed similar opinions, explaining specific perceptions of climatic changes related to weather variability, heavier rain events, and the timing of rain events (*Table 1*). While a significant proportion of farmers felt they had experienced changes in climate (even if they only referred to less predictability), some who felt they had experienced biophysical changes did not feel they could identify a specific trend (N=8). For instance, one farmer explained: "The climate changes all the time. The climate is going to be different these 10 years than it was the last 10 years…(IA43)"

Table 1. Farmers' perceptions of the regional biophysical expressions of climate changes

"We've had a lot wilder weather the last few years (IA34)"
"I don't know any place that's not suffering more droughts than they used to or more extreme weather than they used to. Our weather is certainly more extreme. We're getting dumped on (IA9)."
"Well, there's more variability in [weather patterns] (IA1)."
"The rain events are larger, seems like we get more of them in the spring although this summer has been an aberration. The rain events are larger, the runoff, our creeks have gotten deeper. The creek channels have been stable for year and years and years and the last ten years they've gotten deeper (IA12)."

> "We've had some wild extreme here these last 5-7 years. When you can get, where we used to get a half inch to an inch of rain, now it's common to get 2-3-inch rain (IA16)."
>
> "I think we're getting longer no-frost periods to plant and harvest from when I was a kid (IN22)."
>
> "Wider swings, more variations, more extremes (IN46)."
>
> "I just think [the weather is] getting wilder… rain and tornadoes (IN29)."
>
> "[Climate] has changed from what I remember as a kid…The wildlife in the area has changed, which tells me that, you know, part of that climate impact is impacting the environment […] so I would be naïve to think that is has not change; it has (IN35)."

Overall, a significant number of farmers' in our sample *did* feel that they could "see" climate change. The climatic trends commented upon by the 43 Iowa and Indiana farmers generally matched the *actual* expressions of climate change in their states described above, suggesting their perceptions are based on actual biophysical events. The physical expressions of climate change may be difficult to detect for the general public (Weber and Stern 2011). Yet, in our sample, farmers' close attention to seasonal variability and long tenure adapting to weather conditions allowed many of them to notice the regional expressions of climate change.

However, these perceptions of actual events interact with social processes that influence how they are interpreted to form beliefs about climate change. Indeed, farmers' displayed a great diversity of beliefs about climate change, particularly about the role of humans. Below we explore the social influences that have led to so much uncertainty about climate change and then explore how Midwest farmers reconcile conflicting biophysical and social events and processes.

Evidence of Social Influences

In addition to how the biophysical manifestations of climate change influence perceptions, there are social influences that shape the interpretation of biophysical processes/events or may

590 determine if they are "seen" at all. As discussed above, there are multiple social groups
591 attempting to influence farmers' beliefs about climate change. Here we discuss farmers' beliefs
592 about climate change and the social forces that are influencing their perceptions and then explore
593 how these social influences may interact with perceptions of biophysical change.

594 In accordance with findings from other studies (Arbuckle, Morton and Hobbs 2013;
595 Arbuckle et al. 2013; Gramig, Barnard and Prokopy 2013), the majority of Iowa and Indiana
596 farmers in our sample believed climate change was occurring (90% total; 94% in Iowa; 86% in
597 Indiana). However, there was less agreement about the causes of climate change. As one farmer
598 said, "I don't know what's screwing [the climate] up, but something is (IN20)." Some felt they
599 could identify what this "something" was. When asked what is causing climate change, many
600 farmers made arguments that are consistent with those made prominent by climate change
601 denialist movements (e.g., see McCright and Dunlap [2010]; McCright and Dunlap [2011]). For
602 example, 47% of interviewed farmers stated that climate may be changing but that it is a "natural
603 cycle" or caused by non-anthropogenic factors. As one Iowa farmer explained, "We're in a
604 cycle. And I believe that global warming is part of the climate cycle (IA33)." Some farmers
605 explained that this natural cycle happened over 30-50 years while others stated that it was a cycle
606 that repeated over thousands of years. Supporting the "natural cycle" position, some farmers
607 added that climate change was God's will or that humans were unable to influence the climate
608 and it would be arrogant to believe otherwise.

609 Other related justifications for rejecting humans' causal role in climate change also
610 emerged. Approximately 11% of interviewed farmers expressed views indicating an overall
611 distrust of science, especially international scientists or government scientists. As described by
612 one Iowa farmer: "I believe, if memory serves me, a researcher in Europe, it was found that he

had fabricated much of the scientific data that had led to the scientific understanding of global warming (IA38).” Several other farmers referred to the “Climategate” scandal and repeated conservative political rhetoric about scientists falsifying data to show that climate change was occurring or was linked to human activities.

When discussing their beliefs, 19% of interviewed farmers overtly referenced or strongly indicated that their views were influenced by political orientation or conservative media. Related to media, several farmers explicitly referenced *The Rush Limbaugh show*, a popular conservative talk radio program. An Indiana farmer who often listened to the show commented, “I’m a [climate change] denier. Not that climate doesn’t change. Climate has changed basically as long as we’ve had climate. But [...] if [humans] wanted to set out and cause global warming, I’m pretty convinced we couldn’t do it (IN3).” Another stated his belief that climate change is not anthropogenic was influenced by a book authored by a former NASA climatologist, often a guest on *The Rush Limbaugh Show*, explaining that, *“*human activity is maybe half of 1 percent (IN34)” of the cause. Another cited a recent article he had read as evidence to justifying that polar ice cap melting is unrelated to anthropogenic climate change: “I just read a thing a few weeks ago, volcanic activity under the artic, melting [the ice caps] from underneath (IA1).” In many cases farmers cited explicitly conservative media sources that convey messages used to justify the denial of human influences on climate.

The influence of political orientation was also revealed through the expression of other commonly held conservative beliefs. Farmers in both states did not trust the government’s motives related to climate change action. This concern manifested itself in numerous ways. Farmers dismissed proponents of anthropogenic climate change, such as Al Gore, by questioning their motives. “Al Gore made two billion dollars on that whole [climate change] scam (IA21).”;

"People like Al Gore have gotten rich over the stuff that comes out of his mouth that can't be proven (IA32)." Others rejected the reality of anthropogenic climate change based on the perceived consequences of government regulations to mitigate GHG contributions: "I don't think [climate change is] something we should lose our freedoms over […] we don't even know what the facts are (IN13)." One farmer also questioned the motives of international treaties related to climate change: "The Kyoto agreement, it was a way to move funds around (IA02)." Interviews indicate that traditional conservative concerns, fear of government intervention and mistrust of politicians, influences Midwestern farmers' perceptions and acceptance of policy responses to climate change.

Despite the distrust in science described above, farmers were influenced by minority scientific opinions from local "experts" to support the denial of anthropocentric climate change. In Iowa, 10 of the 53 farmers mentioned a retired Iowa State University Professor of Agronomy and Extension Climatologist. Farmers reported that his presentations at farmers' meetings focused on tree ring evidence, which he argued indicates that climate changes in a cyclical pattern (the exact years of this pattern varied by farmer), with variations in severity and frequency of extreme weather events and temperature. Most farmers' comments indicate this Extension Climatologist argued climate change was occurring, but he rejected human contributions to climate change. For instance, "[The Climatologist] says that our climate is always changing, but whether it's man made or not, the last I talked to him he's not convinced (IA39)" However, one farmer who believed climate change was largely caused by humans also cited the Extension Climatologist's talks, but in reference to how increased weather variability was expected to be harmful to agricultural production. This affirms findings from Arbuckle et al. (2015) indicating that farmers' ideas bout climate change are influenced by trusted information

sources, but also suggests that their study's broad categorizations of "scientists" or "government" as sources providing evidence to support anthropogenic climate change may be challenged by denialists within these groups.

Almost half (47%) of the interview responses from Indiana and Iowa farmers reflect the general arguments of the climate change denial movement, indicating that many farmers in our sample are exposed to this movement's arguments through various means. Exposure to these argument appears to be influencing a large portion of our sample's farmers' beliefs about climate change.

Compared to the 47% of interviewed farmers whose comments suggested the influence of denialist messages, comments from only 22% of farmers directly or indirectly indicated they had heard about climate change from sources from which a scientific account could be expected to be provided, such as public radio, scientific reports, university conferences and democratic politicians. Sometimes these sources were used to justify belief in *anthropogenic* climate change. For instance: "Science is science and science is saying that there is something going on [with the climate and] I think fossil fuels are making the big difference (IA31)." Others referred to melting polar icecaps and recent news coverage of extreme weather events linked to climate change. For example, one farmer stated: "Scientists all over the world are talking about glacial melt, increases in carbon dioxide in the air… I mean, to me it's a no-brainer (IN26)."

Many farmers voiced their belief in anthropogenic climate change without directly or indirectly citing this evidence. Of the 18 "believers" (17% of the total sample), nine explicitly cited the above scientific organizations or claims about climate change to justify their belief. Believers not citing scientific evidence offered a number of other reasons to justify their belief. One farmer seemed to come to his opinion about human-driven climate change through

witnessing air pollution around cities. Another felt that if his farming practices could significantly alter the landscape, then the growing global population was surely capable of changing the climate. An Iowa farmer who felt strongly that "man has made an effect (IA61)" said he mainly heard about climate change in church. For these farmers, belief in human-caused climate change seemed to not rest on exposure to scientific evidence, but from personal experiences.

The final grouping of interviewed farmers we discuss is those who expressed sincere uncertainty regarding the role of humans in climate change (13%), or felt that both natural and human factors could cause or were contributing equally (19%) to climate change. We group these farmers together because we feel the nature/human dual-cause perspective and feelings of uncertainty are a result of exposure to *both* the climate change denialist messages and evidence based scientific arguments. Uncertain farmers simply felt confused based on the number of conflicting arguments they had heard about the reality of human's influence on climate. "You know, you can watch Al Gore's video or documentary and then you can look at some very credible scientists that are saying it's not really humans (IN11)." Another similarly commented,

> "I've seen pretty good data that says yes we crank out a lot of CO_2 out of our cars and everything else and [I've seen data that] one of the major volcano eruptions we've had in the last 20 years does more than we can do in 20 years in two days . . . I don't know how to balance that all out (IN18)."

The dual-cause farmers dealt with exposure to both arguments by integrating them: "I think some of [climate change] is just naturally cyclical. But yes […] the emissions from different industry has got to have some effect on it (IA20)."

As is clear from the above evidence, farmers' beliefs about climate change develop in an information rich environment. Below we explore how these climate change messages influence the beliefs of farmers' who perceived the bio-physical expressions of climate change.

Reconciling Biophysical and Social Events and Processes in Belief Formation

While studies have shown that farmers beliefs about climate change are influenced by social groups and their messages (Arbuckle et al. 2015; Houser 2016; Stuart, Schewe and McDermott 2012), how these social influences interact with perceptions of experienced biophysical change remains largely unexplored. As described above, over 41% of our total interview sample expressed comments indicating they had personally witnessed changing climatic trends, or "seen" climate change. As one farmer stated, "I think people are more willing to accept the idea that something is changing because we are having these extremes (IA31)." In addition to actually seeing trends, belief in its occurrence was supported by perceiving climate as an ever changing variable; a perspective which some farmers came to through direct observation. Beyond direct observation, believing that climate change was occurring was supported by both scientific arguments, as well as the natural cycle argument used by the climate change denial campaign. It appears that these numerous experiences and information sources converge to affirm or produce the belief that climate change is happening among a high percentage of Midwestern farmers in this study. This finding may help to explain why other studies have also found a high percentage of Midwestern farmers to believe that climate change is occurring (Arbuckle, Morton and Hobbs 2013; Arbuckle et al. 2013; Gramig Barnard and Prokopy 2013).

Though climate change as occurring was generally supported, 8% of interview respondents felt that due to their experience with regional weather variations, they doubted that the biophysical expressions they experienced were really a part of a larger "global warming"

727 trend. In this case, we see a combination of perceived biophysical changes combined with
728 arguments from conservative denial campaigns that dismiss the idea of global warming. In
729 accordance with arguments from conservative media sources, farmers interviewed used specific
730 weather events to argue that "global warming" was not occurring. Particularly, the Midwest
731 experienced a historically severe winter prior to the interviews for this study. Anomalies like this
732 affected the perceptions of Indiana and Iowa farmers in our sample. In response to whether he
733 personally believed climate change was happening, one farmer commented, "It doesn't seem to
734 me like anything's any different; we just came out of the coldest damn winter we've had
735 for…that I ever remember (IN15)." Some explicitly combined biophysical expressions and
736 denialist messages: "Last winter when it was colder than hell, I said where is Al Gore and his
737 damn global warming now (IN41)?" These comments illustrate the inherent difficulty of
738 accurately perceiving climate change trends for some farmers. Like many in the general public
739 (Hamilton and Stampone 2011), the views of farmers in our sample were influenced by
740 regionally specific and recent weather events.

741 As in other research, whether climate change is caused by humans was a contested belief
742 in our study. While over 41% of farmers interviewed expressed that they felt they had "seen"
743 climate change, only 21% expressed belief in human contributions to climate change. Almost
744 half of the interviewed farmers who had "seen" climate change believed it was caused entirely or
745 largely by natural factors (44% out of 43). When asked whether climate change's occurrence was
746 due to human activity, in many cases these farmers made comments that reflected the arguments
747 of the denialist campaign. For example, one farmer stated:

748 "We went through a lot harder winters when I was younger than what we have now. But
749 the global warming thing I think is a big farce. Our climate change is affected more by
750 the sun, sunspot activity, then it is anything we do here on earth (IN17)."

751 While biophysical experience may increase belief in climate change among farmers, this does
752 not translate into a belief that humans are causing climate change. Other farmers who had "seen"
753 climate change expressed sincere uncertainty regarding the role of humans in climate change and
754 brought up the very polarized arguments they are exposed to. For example, one farmer exclaimed,
755 "[Its either] we've got to do something, or it's the biggest hoax ever perpetuated on us. And there
756 is no middle ground (IA06)." Another farmer from IN stated: "Absolutely climate is changing.
757 Whether it's unnatural or not I couldn't tell you. I don't know (IN18)." While a growing number
758 of farmers may be able to perceive changes in precipitation and temperature, especially an
759 increase in extreme events, nothing that they experience in the biophysical world leads them to
760 believe that these changes are caused by human activities. They cannot "see" GHGs leaving their
761 fields or tractors and then heating the atmosphere. Therefore, while "seeing is believing" may be
762 true for climate change it does not apply to anthropogenic climate change. This leaves many
763 farmers open to the arguments from denialist movements regarding "natural cycles" and volcanic
764 eruptions to explain the changes they see.

765 We also found that a belief in anthropogenic climate change was not exclusively
766 associated with farmers who felt they had seen climate change. A small number of farmers (9%)
767 who did not mention witnessing or did not feel they witnessed its biophysical expressions
768 believed climate change was real and caused by humans. For instance, a younger Indiana farmer
769 who had recently graduated from college said, "The variability of weather patterns due to climate
770 change, will definitely affect us […] I don't think that's had a big impact yet (IN1)." While these

771 farmers may not have felt they were experiencing climate change, they believed that they soon
772 would and that mitigation measures were needed to prevent further change. This minority view
773 illustrates that in some cases farmers did not need to "see to believe" and felt they could trust
774 information from the majority of scientists and global governmental bodies.

775 While the above farmers' college experience may have motivated belief, we cannot
776 conclude that exposure to or belief in the scientific argument leads to believing in anthropogenic
777 climate change, even among farmers' who witnessed climate change. Of the 8 farmers who had
778 "seen" climate change and believed it was largely or entirely caused by human activity, only
779 three explicitly cited scientific sources as justification (whereas five of the 8 believed, yet did not
780 cite scientific sources). We don't believe this indicates the irrelevance of scientific sources as a
781 factor influencing farmers' belief in anthropogenic climate change. Rather, it may be that the
782 potential influence of scientific claims is significantly tempered by the social context through
783 which it must navigate to influence farmers' beliefs. Particularly, the prevalence of disbelief or
784 uncertainty regarding the role of humans described above appears to dissuade belief in
785 anthropogenic climate change. Many believers of anthropogenic climate change expressed
786 feeling isolated, a number of these farmers noting the prevalence of climate change skeptics
787 among their peers. "I drink coffee in McDonalds down there and we've got the deniers [laughs]
788 (IN26)." Another similarly stated, "Well, usually at any gathering of farmers […] the tone is
789 generally skepticism (IA09)," when discussing anthropogenic climate change. Isolation as
790 believers may create reluctance in these farmers to express their opinions to their friends, family
791 and fellow farmers. After claiming he believed in anthropogenic climate change, one Indiana
792 farmer quickly finished his statement with, "I don't want to step on anybody's feet here, but
793 that's my feeling (IN26)" Another apologized for the radicalism of his opinion that humans

contribute to CO_2 emissions: "Sorry, I'm kind of the extreme view (IA4)." This sense of isolation may discourage seriously considering the scientific argument, or publically expressing it if one does find it creditable and thus further perpetuates disbelief in anthropogenic climate change among Midwestern farmers.

As explained earlier, the level of "the real" was purposively bracketed off from this analysis to create space where we could more fully unpack the interview data and thus speak to the levels of the empirical and actual. It is worth adding, however, in light of the above discussion, that this bracketed level offers additional explanatory power in helping us understand why seeing is not always believing when talking about farmers who perceive climate changes yet who do not attribute those changes to (anthropogenic) climate change. According to Carolan and Stuart (2016: 79), the level of the real speaks to causality efficacious social phenomena, as captured in such frameworks and terms as "food regimes, the treadmill of production, metabolic rift, and neoliberalism." Perception is not innocent, but can be shaped deeply by the "world" one inhabits, neoliberal or otherwise. In the case of agriculture, there is evidence suggesting that farmers inhabiting spaces less-driven by productivist ideologies—agroecology and food sovereignty movements, alternative food networks, etc.—are more likely to perceive weather extremes as climate change than those inhabiting worlds populated with monocultures, agro-industrial firms, and large market inequities (see e.g., Jacobi et al. 2015; McMichael 2014). Further research ought to look more closely at how the imaginaries (the empirical) of producers align (or not) with not only what they *do* (the actual) but also with the forces that make those doings feel necessary and even in some cases natural (the real).

Conclusion

816 We believe there are many benefits to employing the realist framework in *Figure 1* to
817 guide social science and multidisciplinary research on agricultural and environmental issues.
818 Based on our analysis, we contend that applying this model can support a more comprehensive
819 understanding of social-biophysical relationships. We focused on how farmers experience the
820 events and processes associated with climate change in the US Midwest and how this translates
821 into their climate change beliefs. Our realist approach offers new insights in two ways: 1) rather
822 than focus on beliefs alone, as done in many other studies, we incorporate how events and
823 processes are interpreted and shape climate change beliefs, and 2) we include not only social
824 events and processes but also biophysical.

825 Our analysis reveals the relationships between what farmers are exposed to and what they
826 believe. While the majority of agricultural and environmental studies continue to focus narrowly
827 on "the empirical" or "the actual" and fail to make important connections, a broader and more
828 holistic framework improves our understanding regarding how events and processes interact to
829 shape beliefs and associated responses. Many studies use surveys to explore farmers' climate
830 change beliefs (e.g., Arbuckle, Morton and Hobbs 2013; Haden et al. 2012; Rejesus et al. 2013),
831 yet our understanding of how "actual" events and processes are understood and perceived has
832 been overlooked. Our findings reveal how farmers are interpreting the phenomena around them
833 to shape their beliefs about climate change. By explicitly examining both "the actual" and the
834 "the empirical" we can better understand how climate change opinions are formed and why a
835 significant disconnect remains linking humans actions to climate change.

836 Our approach also specifically includes both social and biophysical events and processes
837 revealing how biophysical changes related to climate change may be experienced and "seen," yet
838 in many cases do not result in a belief in anthropogenic climate change. Climate change beliefs

are complex with individuals processing both social and biophysical experiences. Previous studies overlook how both social and biophysical factors combine to shape what climate change means to farmers. Our analysis reveals how different farmers combine these experiences to form their opinions and that, in many cases, farmers "see" climate change but do not "see" humans causing it. By specifically including both biophysical and social influences, we gain a new understanding of how biophysical processes are experienced and interpreted and why so many farmers, who experience climate change, do not believe in anthropogenic climate change. In this way, our realist approach reveals a much more nuanced set of findings compared to previous studies. Having demonstrated how this analytic device might be used to interrogate socio-ecological phenomena, we hope further applications can build off of this analysis.

Our findings have important implications for efforts focused on climate mitigation in US agriculture. As reviewed above, scientific data shows that the Midwest corn belt region is experiencing significant changes in growing season, precipitation events, drought, and heat due to climate change. Farmers are experiencing and interpreting these events. This interpretation occurs through a filter of social influences, specifically climate change messaging and local social networks. In addition, how new information and arguments about climate change are perceived can be based on personal experiences with biophysical change. These interactions occur but remain difficult to understand. This study reveals that although farmers may agree that they are increasingly experiencing climate change, this may not counter denialist arguments that dismiss the role of humans in causing climate change. Farmers are experiencing these events and many are linking them to climate change. However, as events related to climate change increase we cannot assume that more farmers will believe in the human causes of climate change.

Our findings suggest that intervention strategies to address climate change need to be strategic. For example, increasing scientifically informed messages through education campaigns may be helpful to counter climate change denialist arguments to some extent; however, information is needed to help people interpret biophysical changes, such as unusually cold winters, as they try to make sense of conflicting experiences and messages. Our findings also suggest, as others have too (Morton et al. 2016), that climate change mitigation efforts will likely need to proceed in ways that do not depend on a belief in anthropogenic climate change. Unfortunately, waiting to adopt mitigation measures until farmers are convinced that humans play a role in climate change will likely be too late, as actions today have climate impacts well into the future. Future mitigation efforts focused on farmers may wish to explore strategies beyond education – for example, using incentive programs to gain participation from farmers who continue to believe that humans do not play a role in climate change. While people (especially farmers) are increasingly experiencing the biophysical impacts of climate change and this may increase the general belief that climate change is occurring, this will likely not translate into a belief in anthropogenic climate change. As we have illustrated, "seeing is believing" may only go so far.

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