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Title: How farmers "repair" the industrial agricultural system

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Abstract: Scholars are increasingly calling for the environmental issues of the industrial agricultural system to be addressed via eventual agroecological system-level transformation. It is critical to identify the barriers to this transition. Drawing from Henke's (2008) theory of "repair," we explore how farmers participate in the reproduction of the industrial system through "discursive repair," or arguing for the continuation of the industrial agriculture system. Our empirical case relates to water pollution from nitrogen fertilizer and draws data from a sample of over 150 interviews with row-crop farmers in the midwestern United States. We find that farmers defend this system by denying agriculture's causal role and proposing the potential for within-system solutions. They perform these defenses by drawing on ideological positions (agrarianism, market-fundamentalism and techno-optimism) and may be ultimately led to seek system maintenance because they are unable to envision an alternative to the industrial agriculture system.

Keywords: Agroecology, agriculture, nitrogen, non-point source pollution, ideology

Abbreviations:

N	Nitrogen
IA	Iowa
IN	Indiana
MI	Michigan

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Introduction

The industrial agricultural system—typified by its high capital intensity and low ecological diversity—causes significant levels of nutrient-related water-pollution across the world and is prone to soil erosion and degradation (Montgomery 2007; Veenstra and Burras 2015). It also contributes and is highly vulnerable to climate change (Schlenker and Lobell 2010). Within-system, technological fixes, provide the limited potential to significantly mitigate industrial agriculture's contributions to environmental degradation, neither do they achieve climate change resilience (Frison 2016). Consequently, scholars have increasingly called for addressing industrial agriculture's issues through system-transformation, toward a bio-diverse, low-input agroecological system that relies on ecologically-based management approaches (Altieri and Nicholls 2012; Delonge and Basche 2017; Ponisio et al. 2015).

If we assume the industrial system has the above noted inherent flaws, and that agroecological transition is a viable alternative, the critical question becomes: What are the forces that enable the persistence of this system? Most past work on the maintenance of the industrial agriculture system has focused on barriers to an agroecological transition in the United States at the macro-level, including: policy incentives and funding opportunities that reward and maintain the industrial system and its institutions (e.g. seed companies; Kloppenburg 2005; Mendez et al. 2013); federal crop insurance that supports the more vulnerable simplified, industrial system (USDA 2006); and a general technology fetish in agricultural production and society, that may privilege the high-tech solutions proposed to fix industrial agricultural issues (Altieri 1989; Montenegro de Wit and Iles 2016).

This macro-level attention misses an important area of consideration, the individual level. Past research on the individual-level has generally focused on why farmers are unable to adopt agroecological practices (Roesch-McNally et al. 2018a; 2018b). Few studies have explored if farmers in developed countries perceive agroecological approaches or a transition as necessary to address the issues of the industrial agriculture system, nor how they defend or critique the industrial system in response to its apparent faults (c.f. Dentzman and Jassaume 2017). We feel this research area demands further attention. In many cases, individuals can either (re)enact or deviate from structurally set patterns of behaviors. Individuals can thus be a source of 'bottom-up' change, as individual deviation at a significant enough scale is the precedent for system-level change (Archer et al. 2013; Bhaskar 1998). While the structural factors constrain or create the perception of constraint for some farmers, farmers' willingness to deviate from their industrial methods is a necessary (yet insufficient) precondition for the widespread transformation of the agricultural sector. Therefore, we must be attuned to the role farmers play in participating in or barring a transition to an agroecological system.

In this article, we focus on farmers' participation in the process of social reproduction. Our central intention is to develop a preliminary understanding of how farmers participate in perpetuating the industrial system, particularly as they become aware of its faults and their contributions to these faults and how they perform this support/critique. We give particular attention to how they maintain the systems' perceived legitimacy in the face of external threats.

Toward this end, we interviewed farmers who are deeply entrenched in the industrial agricultural regime: over 150 large-scale United-States midwestern corn-soy farmers, focusing on the use of and environmental effects of nitrogen (N) fertilizer. Drawing from Henke's (2008) theory of "repair," we explore support for system-maintenance at the individual level—how farmers' "discursively repair," or argue for the continuation of the industrial agriculture system as they acknowledge its flaws, its environmental impacts, and their role as contributors.

Conceptual background: a theory of repair

In Henke's (2008) *Cultivating Science, Harvesting Power*, he articulates his "repair" focused theory of social maintenance/change. Henke's first focus is to describe the nature of social-ecological systems of capital production. He sees systems, like industrial, capitalist agriculture as constantly threatened by disruptions: "anything from a dry year or a failed experiment to a budget crisis or a war" challenges the continued functioning of the industrial agricultural system (Henke 2008: 7). Disruptions, like the recognition of the system's environmental issues, provide the opportunity for system change. But whether change occurs, or the status quo is maintained depends on "repairs" undertaken by system actors (including farmers) in response to disruption. Repair "is the work of maintaining this system in the face of constant change" (Henke 2008, p. 10). Critically, repair is not a singular process; it involves distinct means of enacting repair and opposing strategies of repair can be pursued. Related to the means for enacting repair, Henke offers two: discursive and ecological.

Discursive repair deals with the social construction of issues and solutions: Do actors perceive a problem? If so, what do they see as its cause and the best solution? This is the realm of maintaining or eroding the legitimacy of the agricultural system. *Ecological repair* is the realm of action, where material changes to the system of relations are made. Related to these two repair practices are two larger strategies of repair to be pursued using them: maintenance or transformation. *Maintenance repair* refers to changes that are intended to keep the structure functioning as is. Modest adjustments to elements within an established structure or system are pursued when this strategy is followed. *Transformation* refers to complete alterations to the system, in "which the relationships between culture, practice, and environment are substantially reordered" (p. 11). This strategy is pursued when identified problems are seen to be endemic to an established system, thus indicating that system-level change is the required solution.

In his empirical application, Henke focuses on ecological repair and on the role that agricultural advisors play in ecological repair. We extend his model both conceptually and empirically by focusing on the realm of *discursive repair* and how farmers perform this activity to actively maintain the industrial agricultural system in response to disruptions. Below we provide additional conceptual background toward this end.

The ideological basis of discursive maintenance

Henke identifies three questions discursive repair addresses: (1) Does a problem exist? (2) What is the nature of the problem? (3) And what is the best way of solving it? As he states, "The answers to these questions represent practical attempts to shape the discursive frame for meaning and action, which, in turn, leads to ideas about what form a structure can or should take" (Henke 2008, p. 13). For our study, we borrow from the social movement framing literature and call responses to these questions the "tasks" of discursive repair (Benford and Snow 2000). Henke provides little detail on *how* actors perform these tasks. To accomplish the tasks of "discursive maintenance," we expect farmers will draw on more widely available ideological positions. In consequence, we pull from and describe addition theory on ideology and social reproduction (i.e. maintenance).

Although ideology takes "material" form in taken-for-granted practices structured by institutions (Althusser 1971), here we interpret *ideology* as the beliefs and worldviews that shape everyday thoughts and decisions. In many cases, these ideologies also match the "negative" Marxist definition (Larrain 1982), as they often conceal underlying contradictions about the dominant capitalist system (or in this case, the industrial [capitalist] agricultural system). Our broader definition here matches what is articulated by Therborn (1980), who also describes an ideological logic of change: to change the state of something one must 1) know that it exists, 2) decide if it is good or bad, and 3) believe there is an actual chance of changing it. The first two align well with Henke's (2008) questions of discursive repair. Here we also stress the importance of believing that another way is possible. This also relates to Marxist scholarship on social reproduction, or the purposeful and strategic maintenance of the current system by those in power (Wright 2010). Convincing people, as Margaret Thatcher famously stated, "there is no alternative" has been effective means of maintaining the status quo. Therefore, pursuing social transformation relies on overcoming these ideologies and confronting the forces of social reproduction/maintenance (Wright 2010).

Farmers in the industrial agriculture system face accelerating pressures to maximize profit and increase production (Ashwood et al. 2014; Hendrickson et al. 2019; Levins and Cochrane 1995). At the same time, public recognition and response to the growing environmental issues associated with industrial agriculture are expanding in our region of study (see below). Achieving production imperatives can be at odds with mitigating agriculture's environmental impacts (Magdoff et al. 2000; Roesch-McNally et al. 2018b). To deal with their limited capacity to meet environmental demands given production pressures, farmers develop specific ideologies that justify their continued practices, while also legitimizing and naturalizing the contradictions of the industrial agriculture system (Ellis 2013; Emery 2015; Cilia 2020; Dentzman and Jassaume 2017; Hendrickson & James 2005). For instance, Dentzman and Jassaume (2017) find that farmers use a "techno-optimist" ideological position to explain their faith in future chemical treatments to herbicide resistance, but they argue this framing is a means to cope with their limited capacity to enact less productivist, but more effective practices.

To return to Henke's framework, we use the term "discursive maintenance repair tasks" to refer to *ideological* responses to the questions: (1) Does a problem exist? (2) What is the nature of the problem (including the problem's *cause*)? (3) What is the best way of solving it? The tasks of discursive maintenance repair are to answer these questions in ways that reproduce the system through its legitimation of and/or naturalization. Reflecting Therborn (1980) and other scholars (Wright 2010), we also give attention to farmers' beliefs about (4) if alternatives are possible, or conversely not possible. In short, these discursive maintenance repair tasks frame[1] the problem and solutions in ways that naturalize and/or legitimate the system, thereby contributing to its reproduction.

Table 1 about here

Using this approach (see *Table 1*), we examine how farmers perform discursive maintenance in response to acknowledging water-pollution issues associated with the industrial corn-soy agricultural system's reliance on nitrogen fertilizer, focusing on the reasons they provide for system maintenance. Farmers face constrained choices in what practices they ultimately can pursue (Stuart, 2009), and moving away from nitrogen fertilizer is limited by numerous forces in the industrial agricultural system (Stuart et al. 2012; Stuart and Houser 2018; Stuart and Schewe, 2017). In this context, we expect farmers will have drawn on preexisting ideological positions that justify their continued support for industrial agriculture (and nitrogen use). More specifically, we expect these positions will be used to perform discursive maintenance repair tasks. Our application context is outlined below.

Application context

Synthetic nitrogen use and loss in the Midwest

Today's industrial agriculture system does not exist without synthetic nitrogen (N) fertilizer. The industrial agricultural system relies very little on organic sources of N (e.g. legumes, manure, compost) and instead meets crop requirement for N through the application of synthetic N fertilizer (Smil 2002). Synthetic N use is particularly prevalent in the United States midwestern "corn-belt" agricultural system. Corn receives the majority of N applied in the US. In total, about 96% of all US corn receives synthetic N application and approximately 50% of all applied N in the US is applied to corn (Cassman et al. 2002; ERS 2018).

Due to this high level of synthetic N use, the midwestern industrial system is inherently "leaky," as synthetic N is highly prone to loss (Drinkwater and Snapp 2007). On average, around

[1] Though similar to Goffman's (1974) notion of "frame," Henke's discursive repair concept points more directly to the significant role that individuals' or groups' construction of problems and solutions can have in system maintenance or transformation.

38% of all applied N being lost as environmental pollution (Gardener and Drinkwater 2009). Given this amount of loss, synthetic N from midwestern agriculture is associated with significant environmental issues (Robertson and Vitousek 2009; Riabudo et al. 2011). We focus on water pollution. N lost as nitrate pollutes fresh water, leading to eutrophication, or hypoxia (Conley et al. 2009). Most notably, synthetic agricultural N from the Midwest is *the* major contributor to hypoxia, or the "dead zone" in the Gulf of Mexico, contributing 41% of all N found in the dead zone (USGS 2017). Waterways and groundwater in Midwestern states like Iowa and Illinois have been found to contain some of the highest concentrations of N, particularly in agricultural areas (USGS 2010).

N pollution—a systematic issue

The possibility of mitigating the industrial corn-soy system's loss of synthetic N fertilizer via within-system technological solutions is frequently promoted (e.g. Flis 2017; Robertson et al. 2013; Ribaudo et al. 2011; 2012). However, reflecting the inherent, system-level flaws with an agricultural system based on synthetic N use, the potential of technologies to mitigate contributions to water pollution and N loss to the environmental overall are limited, with studies finding little to no reduction in agricultural N loss to waterways from their use (Blesh and Drinkwater 2013; Sprague et al. 2011). After their analysis of the impact of technological approaches in reducing N loss to waterway from midwestern corn-soy farms, Blesh and Drinkwater (2013, p. 1031) summarize: "Our results suggest that the dominant management emphasis on adjusting the timing and placement of [synthetic] N inputs (i.e. within-system approaches) has biogeochemical limitations in terms of the degree to which N retention can be increased." In other words, it is increasingly clear that significantly mitigating the issue of N water pollution requires agroecological approaches and eventual system transformation toward a much more ecological diverse approach to agriculture (Blesh and Drinkwater 2013).

Movement toward this approach is limited in the Midwest. For instance, cover crops were planted on only 2.5% of farmland acres in Iowa 2017 (Juchems 2018) and only 6% of Indiana's acres in 2018 (ISDA 2018). The vast majority of agricultural land in the Midwest produces only two crops—corn and soybeans—and this state of simplified agriculture has intensified in recent years, despite evidence of the benefits of a more diversified, agroecological approach (Plourde et al. 2013; UCS 2014).

We build on the past work that has examined barriers to agroecological transitions or practice adoption (see introduction) by focusing on how farmers might be active participants in constraining an agroecological response to the issues of the industrial agriculture system, like endemic N loss. We focus on how farmers justify their continued faith in the system (i.e. perform discursive maintenance) by drawing on multiple ideological positions. Our study provides preliminary evidence of farmers' active role in maintaining the industrial agriculture system in the realm of discourse, something few studies have previously addressed (c.f. Dentzman 2018; Dentzman and Jussaume 2017). We see this process to be (re)constructing an ideology that ultimately limits a more widespread emergence of agroecological practices/transitions to address N pollution, even in the preliminary state of farmers' interest/desire.

Methods

We examined qualitative data gathered from 154 interviews with corn farmers in three US states: 53 interviews in Iowa (IA), 51 in Indiana (IN) and 48 in Michigan (MI). Qualitative methods are ideal at providing insights into little-studied topics (Kreuger and Casey 2009) and these methodological benefits have been noted in past work in the agricultural context (Prokopy et al. 2017). Given that we have limited understanding of how US farmers defend the industrial agriculture system, we use a qualitative approach to develop a preliminary understanding of this process.

Interviews to assess farmers' N use decisions and the factors that shape them were conducted on a one-on-one basis between a researcher and the farmer between May 2014 and December 2014. The majority of interviews were done in person on-farm, with a small number conducted over the phone. Aside from one interview (in which the participant requested that we take hand notes only), all interviews were audio-recorded with the permission of participants. Initial interview participants were primarily recruited through University Extension and other state resource professionals, with a reliance on snowball sampling after initial contacts. Snowball sampling is considered a good method to contact subjects who are difficult to access (Faugier and Sargeant 1997). Across all three states, Extension was our main source of farmer contacts

(48%). All farmers interviewed were white, English-speaking males. Though not specifically asked to identify their age, very few farmers in our sample just started farming or were nearing retirement. These features generally match that of the broader US farming population (NASS 2012). Farm sizes of interviewed farmers ranged from 170 to 14,000 acres. Over 70% grew only corn or just corn and soybeans. Around 18% of interviewees were currently using cover crops to at least some extent, a much higher percentage than the general farming population in much of the Midwest (see above). This bias toward an agroecological approach likely reflects our contact strategy, i.e. Extension based. We feel this bias makes for a particularly telling study of farmers' maintenance of the industrial system. Even among our more environmentally minded sample, support for maintaining the industrial system was high. We give attention to the dissenters after our results section.

Interviews lasted between 22 minutes and 2.5 hours. Upon completion, interviews were transcribed and analyzed using NVivo software. Our analysis for this paper focused on farmers' responses to questions in the section of the semi-structured interview regarding their awareness and perception of N's contribution to water pollution, specifically (1) whether they had heard of or personally seen nitrogen related water pollution; (2) what they believe caused these environmental effects and (3) what they believed needed to be done to address these issues.

After identifying if farmers believed agriculture contributed to water pollution issues to any extent, coding focused on how they discussed the severity, nature and solutions to this problem to identify their discursive repair strategy (e.g. maintenance or transformation). Driven by the data, we focused on identifying the major points farmers made about N water pollution issues (*Eclectic Coding*; Saldana 2015), then performed a more specific process of thematic grouping from this initial list of points (code "mapping"; Saldana 2015). This thematic grouping was performed in two stages. First, farmer comments were categorized within Henke's (2008) discursive repair categories (e.g. maintenance or transformation). Following this initial grouping, we categorized codes considered as maintenance repair by "ideological position." While we were aware of past literature on farmer ideology, we aimed to let our positions emerge organically from the data. Initial electric and thematic coding was performed by a single coder, with the other study authors evaluating the thematic codes subsequently. Disagreements led to a discussion, and if necessary, a re-coding of a farmer's quote. We now turn to discussing the thematic ideological positions farmers evoked in their discursive repair that emerged during this analysis.

Results

Acknowledging a disruption to the industrial agricultural system

The year that our interviews took place was, in many ways, particularly well-suited to discussing water pollution from industrial agriculture in the Midwest. The Iowa Nutrient Reduction Strategy, a suite of policies aimed at reducing agricultural contributions to Gulf of Mexico hypoxia from the state, was in full swing, being implemented only two years prior (IASTATE n.d.). The city of Toledo's "Water Crisis" also occurred over our interview period. As Lake Erie was flooded with toxic algae blooms, local and national media sites were widely covering the issue of non-point source pollution from agricultural nutrient loss in the region (e.g. Wines 2014). Farmers were highly attuned to the issue and every farmer we interviewed was at least aware that agriculture was considered to contribute greatly to N pollution issues in local and national waterways—though as we discuss below, there was considerable variation in the level of responsibility farmers were willing to assign to agriculture.

Reflecting the "tasks" of discursive maintenance repair, after assessing if farmers were aware of N-related pollution in local or national waterways, we asked them to discuss what they felt was the cause of these issues and the solutions to them. This was where farmers began to preform discursive maintenance tasks. As one Indiana farmer put it, referring to nitrogen water pollution: "Yeah, nobody can deny that the problem is there, the argument is what's causing it" (IN06). In terms of our theoretical framework, though farmers (1) acknowledged there was a problem with N pollution, most responded to questions about N water pollution in ways that effectively performed two tasks of discursive maintenance repair—(2) denying agriculture's responsibility for causing these issues and/or (3) emphasizing that minor, within system solutions would or were solving what portion agriculture did contribute to N pollution. Farmers drew on ideological positions to achieve these maintenance tasks. Below we illustrate the three most common thematic positions farmers used in their performance of discursive maintenance.

Performing discursive maintenance: what ideological positions maintain the system?

Agrarianism: Responsibility denial via framing urban areas as the problem

Agrarianism refers to farmers' expressions of the belief that agriculture was relatively blameless as a source of environmental pollution, and instead urban activities were the culprits. Agrarianism captures a long-standing ideological position in American history that is prevalent enough that it has been called by many names including the "agrarian myth," (Hofstadter 1955), "the myth of the garden" (Smith 1950) or the "pastoral ideal," (Marx 1964) to name a few. To put it concisely, agrarianism is an ideology that frames agriculture, and rural life in general as "good," especially in comparison to urban, non-agricultural areas/citizens.

This position has long been held by and influential amongst American farmers, and when used by this group it particularly tends to frame farmers as distinct from and the victims of urban life/actors in cities. As Hofstadter (1955, p. 35) wrote about early to mid-20th century farmers, agrarianism led them, "to believe that they were not themselves an organic part of the whole order of business enterprise and speculation that flourished in the city [...] but rather the innocent pastoral victims of a conspiracy hatched in the distance." Similarly, Mooney and Hunt (1996, p. 183), in their historical analysis of US farmer social movements, identify that agrarianism is one of the most long-standing ideological framing of protests and reflects a "conflicting or exploitive relationship between certain townspeople and farmers," while also tending to portray agriculture and farmers in a positive light—that farming is the "natural life" and necessary for urban places to exist. There was and is then a tendency among farmers to depict agriculture in a highly positive light, especially compared to urban areas.

This appears to hold true for at least some farmers today. Among the 154 farmers in our sample, 53 expressed an "agrarianism" position as they considered industrial agriculture's contributions to environmental degradation. This position formed a basis for which to discursively maintain the industrial system by denying responsibility for the system's role in water pollution. Farmers expressing agrarianism acknowledged that agriculture contributed to N-related water pollution, but they argued this contribution was relatively minor compared to sources from urban areas. For the most part, farmers asserted that residential lawn care and golf courses were the primary cause. They frequently argued that N fertilizer was greatly over-used in these areas, compared to it being well managed by the vast majority of farmers. As one Indiana farmer put it:

> "I think the real polluters, of especially city water, is not us. It is because [city residents] sprinkle their lawn, it runs in the sewer, then it goes directly back to the [city water treatment plant]… Because that's how they collect the rainwater to fill the reservoir, from the sewer water. Well where's the nitrogen coming from? It's coming off that guy's yard, it ain't coming out of [agriculture]…The ground is a great filter of nitrates; it will filter out nitrates before it gets to a tile. Tiles goes in the river anyhow, and they don't drink the river" (IN14).

The numerous inaccuracies in this farmers' comment suggest how agrarianism masked several realities for farmers that enabled them to feel and position agriculture as relatively blameless compared to urban sources for N water pollution.

Farmers expressing agrarianism did not only tend to argue that urban areas were the major source of nitrogen that was polluting waterway, they expressed frustration for being blamed for this issue, arguing that the rural/agricultural areas were unjustly being negatively framed. This injustice component is especially well captured by one farmer in saying, "I get a little bit miffed when, you know, the subdivisions [i.e. suburban residents] that over-apply products from Greenlawn and all those places, and the golf courses, they seem to be immune to criticism in the press. And most farmers, honestly, I think, are trying to do a pretty good job" (IN40). Others commented similarly reflecting the presence of agrarianism (see *Table 2*).

Table 2 about here.

Other farmers evoked a relative form of agrarianism in arguing that agriculture was a major contributor of N to water-pollution, but that these contributions were already as minor as possible or were justified. One farmer's comment illustrates the relative form of agrarianism well. He rather accurately described the proportion of agricultural contributions (NRDC 2008) but seems to justify agriculture's role to some extent in saying: "I would say that agriculture is probably 70% [or more] of the total [cause], but if you look at the landmass […] the other 20 some percent that's not ag that does contribute to nitrogen [lawn care and golf courses, it] is not near as many acres" (IN07). Like this farmer, others acknowledged agriculture's significant role, but still evoked agrarianism in suggesting that the industrial agriculture system was actually very efficient, performing well especially compared to the inefficient urban sources (see *Table 2*).

Farmers may develop or draw on ideological positions that help them avoid cognitive dissonance given the conflicting pressures of maximizing production and the need to reduce N related pollution (Ellis 2013). One Iowa farmer passionately defended farmers and agriculture against evidence of its contributions to water pollution, emphasizing farmers' love for the land as a reason why agriculture could not be a significant source of N loss:

> "[N]o one values the soil more than a farmer. […] We wouldn't poison it, destroy it, or abuse it for anything. It is life. […] I wouldn't poison the Gulf [of Mexico] for nothing. I want that land, I want the soil [i.e. nutrients] on my land. I don't want it down there. And if anyone thinks that we're throwing this away on a whim, they believe in some agenda that does not exist. […] I know that I speak for the American farmer. Are there corporations out there that are abusing? Yes. Guess what? We hate them worse than you do" (IA38).

This heartfelt message is hard to ignore—farmers care deeply about the environment. But this does not change the fact that they are caught up in an agricultural system that has inherent flaws in its design. The industrial system will always be "leaky" when it comes to synthetic N loss (Drinkwater and Snapp 2007). As the above quote illustrates, agrarianism is one position that farmers draw on that enables them to continue to meet the challenge of accelerating production (often via using more N) without having to experience the cognitive dissonance from how this task contradicts their desire to also be environmental minded.

Toward discursive maintenance, the agrarianism position achieves the maintenance task of "responsibility denial" (Stuart and Worosz 2013). Responsibility denial is a means to de-attribute industrial agriculture's or farmers' role in causing pollution issues, and thereby to suggest that transformation change is not necessary, as the "problem" does not merit this type of solution. In denying the corn-soy agriculture's significant and inherently high contributions to water pollution through agrarianism, farmers are practicing discursive maintenance, as they are constructing a narrative that legitimizes the system even in contradiction to their personal beliefs about how that system should be.

Market Fundamentalism: Within-system solutions and responsibility denial via the invisible hand of the market

Another discursive strategy for maintenance repair was what we refer to as "market fundamentalism." Market fundamentalism describes the ideological position that the free-market, the "invisible hand" of capitalism (Smith 1776) will solve most social, economic and environmental problems (Malin et al. 2017). This self-correcting nature of the market has been argued to be a fundamental ideological element of the capitalist socio-economic system (Gladwin et al. 1997). When applied specifically to environmental issues, market-fundamentalism, or sometimes the "free-market ideology" (Heath and Gifford 2006), discourages acknowledgment of environmental degradation caused by capitalist production and eschews any environmental regulation. If a problem is acknowledged, this position is used to frame environmental degradation as solvable and being solved through price mechanisms that increase the costs of undertaking environmentally harmful activities (Shrivastava 1995). In our case, farmers were considered to be expressing market-fundamentalism when discussing how the market, economic system or price mechanisms would or had prevented agriculture from significantly contributing to N loss to waterways.

Farmers' widely drew upon a market fundamentalist ideological position (35 out of the 154 interviewees) when discussing if there was a need to address agriculture's role in N pollution issues. Their comments centered around the belief that the mechanism of the market—particularly the high cost of N—would ensure or already had ensured farmers were not inefficiently using N fertilizer[2]. In other words, market-fundamentalism was drawn upon to perform the latter two tasks of discursive maintenance: (2) *responsibility denial*, suggesting that N loss from agriculture could not be a major, systematic issue because the market had assuredly prevented an inefficient system (though again, these farmers did not deny the existence of N-related water pollution) or was a foundation for belief in (3) *within-system solutions*, positioning the market as the means to correct over-use of N if it was occurring. Though most farmers used market fundamentalism to deny responsibility for agriculture's role (see *Table 3*), occasionally market-fundamentalism was expressed to accomplish both the tasks of the denial of responsibility and the potential for within-system solutions simultaneously. One farmer

[2] However, there are several reasons why the price of nitrogen does not limit farmers to applying as little as possible. Indeed, it is sometimes considered economically rational for farmers to over-apply nitrogen (Sheriff 2005) or, if not national, at least the inefficient use of N is not a significant economic cost to farmers (Pannel 2017).

responded to the question about what should be done to address N loss from agriculture in a way that illustrates how market fundamentalism was paradoxically used to achieve both tasks:

> "[Farmers are] not going to spend more money than what's going to make them an economical return, so… Maybe this thing has been blown out of proportion, this runoff thing, maybe there is some runoff but maybe there isn't, I don't know. Why would a guy spend more money than his crop can use? That just doesn't make any sense to me."
>
> *Interviewer:* "So you sort of see this economics of the system taking care of it a little bit there?"
>
> "Sure. Yeah, I think so…The economics will definitely take care of the over-use of the stuff" (IN38).

As this suggests, this farmer espoused a market-fundamentalism position—that price mechanisms will prevent/solve environmental issues—in arguing that the profit-based nature of agricultural activities was ensuring (responsibility denial) or would ensure the best possible outcomes for all (within-system solutions), even if environmentalism is not the goal of individual farmers or the agricultural system itself. In describing how he defends the agricultural system and farmers to the public when discussing N-related water pollution, another interviewee expressed this particularly well:

> "I try to tell people this: it's not financially good for us to use any more [nitrogen fertilizer] than we have to […] I'm environmentally concerned but I'm more… I am profit driven, you know, which puts me in that same boat, you know, so I can't pat myself too hard on the back, because it's more about profit really. You know, but if you're truly profit driven, you're going to be environmentally driven because you're not going to [be an inefficient user of N]" (MI31).

In other words, farmers argued that the industrial agriculture system was blameless because N pollution from a profit-oriented activity was a market-impossibility and/or that this system was fixable because the market would ensure efficient use of N, thus eliminating what contributions agriculture makes to N-related water pollution. These sentiments were not only occasionally paradoxical but ignore the severity of agriculture's contributions and inherent leakiness of synthetic N. By masking these realities, farmers perform the aforementioned tasks of discursive repair and they do so through evoking positions that reflect the ideology of market-fundamentalism, a widely prevalent position among interviewed farmers (see *Table 3* for more evidence).

Table 3 about here

Techno-optimism: The basis of belief in within-system solutions

Many farmers were willing to offer solutions to agriculture's (perceived minor) contributions to water pollution. The potential of technological solutions to reform systems, solving environmental issues without changing the systems or requiring a change in human behavior has been previously referred to as "techno-optimism" (Weinberg 1966/1981) a position that has been previously identified to influence the views of row-crop farmers' related to their herbicide use (Dentzman et al. 2016) and climate change adaptation decisions (Gardezi and Arbuckle 2018), as well as large-scale beekeepers perspective on the viability of the industry (Cilia 2020).

In total, 28 of the 154 interviewed farmers expressed a techno-optimism ideology in positioning technological solutions as the most feasible and effective means to addressing N's contributions to water pollution issues (despite evidence to the contrary; Blesh and Drinkwater 2013). Farmers often pointed to the potential of current management technologies to limit N pollution, such as bio-reactors (i.e. catchment of N runoff) or equipment that allows for more efficient timing and placement of N applications (e.g. sidedress). They generally expressed optimism that this technology would be increasingly adopted/improved to curb whatever portion of N loss to water-ways agriculture did contribute. The following response to a question about what needs to be done to address N pollution issues was typical of this vein:

> "Timing. The nitrogen stabilizers. The timing. Give the farmer and the equipment people some credit, our ability to put the stuff on when it needs to be put on is light years ahead of where it used to be. I think we've come light years as far as where we place it, our timing for placing it and our ability to measure and control what we place. Much much. In the last 10 years that has changed a lot. And it will change that much again" (IA62).

Others focused more on the potential of future technologies to solve agricultural N run-off issues. In particular, farmers expressed the belief that corn plants would be developed by seed-companies that did not require N use:

> "I don't know a lot about it, I've just heard a little bit about it, about low, I don't even know what the word is for it, but corn that needs a lot less nitrogen, and I'd be all about that. I know that… I don't know that there's any on the market yet necessarily, but the way I understand it is the seed companies will eventually come out with some corn… And I'm sure you still have to put some nitrogen on just not… maybe you could cut it back 100 pounds or 50 pounds or something like that, and yeah, I'd be all the way in on that…" (IN15).

A techno-optimist position was present even as farmers questioned the practical, political limitations to this solution in the current, agro-business dominated system. As the above farmer continued on later: "…I don't know who's going to fund the university research on that. I suppose the seed companies will, but the fertilizer… Mosaic fertilizer sure as hell isn't going to, or Koch because that would piss them off, all of a sudden we don't need to use as much nitrogen." Other farmers expressed a similar faith in the development of this type of corn, or other similar technological solutions to N loss (see *Table 4*).

The degree to which farmers truly expected this "magic bullet" type of technology is well illustrated by one farmer. He notes how a technology that could read corn-tissue plants was previously proposed and this would eliminate over-use of N (though even this will not effectively curb N loss without agroecological approaches; Blesh and Drinkwater 2013). As he states, this technology, "never materialized" but he still felt like in response to industrial agriculture's contributions to N pollution, "They'll do something. They'll come up with something!" (IA57).

Tables 4 about here

Techno-optimism was a widely drawn upon ideological position among farmers in our sample. Farmers expressed a great amount of faith in the potentials of current or future technologies to reduce or eliminate industrial agriculture's contributions to N pollution. This position, therefore, performed the discursive maintenance task of proposing within-system solutions and framed system maintenance, rather than transformation, as the appropriate response.

Cracks in the system: Frustration and confusion in the face of recognizing system limits

Reflecting our conceptual model, disruptions such as recognizing the environmental consequences of industrial agriculture can also promote transformative discursive repair, where farmers point to the systematic nature of problems and call for new-system solutions, such as agroecological approaches. The performance of discursive transformation repair was limited. While discursive transformation repair is not our central focus, we provide some evidence on its occurrence below to suggest how environmental consequences can disrupt the ideological positions that are (re)structuring the industrial agriculture system.

Farmers in Iowa, in particular, were speaking out in opposition to the agrarianism position, saying instead that agriculture was the primary cause of N loss. Indiana and Michigan farmers rarely accepted the extent to which agriculture contributed to these issues. This may point to the impact of Iowa's Nutrient Reduction Strategy (ISU, n.d.) in catalyzing awareness among some farmers of their role in N-pollution. In particular, as farmers were enrolled in nitrate monitoring groups, it became more difficult for them to maintain their faith in an agrarianist position, that N loss was primarily from urban areas:

> "So I have nitrate awareness. If there is such a thing. Where most farmers don't. And I didn't until I started doing this [nitrate monitoring group]. Cause I thought where's all this nitrate coming from? But in reality, it's coming from my own farm. I always talked about, it's the golf courses, it's city people, it just washes off the lawns and goes down the gutter. But in this watershed, as I mentioned earlier, 88% of the acres in the watershed are agriculture. So the amount of nitrogen put on in the towns in minimal" (IA01).

Others performed discursive transformative repair by casting doubt on technological solutions (being "techno-pessimistic"). For instance, in discussing some technological approaches to reducing N loss, one respondent said, "You know, I think maybe on a short-term, but on a long-term basis, on a large-scale basis, I'm not sure that they are the answer" (IA17). Another farmer recognized the systematic nature of nutrient loss in the industrial system, focusing on its linear (inputs→outputs) nature:

> "You will always have to take some resource from some other place to replace what you've removed. You will always have to do that, and that's not sustainable because you have depleted that other source. And so many people don't get that; you know, they say

'well yeah, okay, I know, but…I'll tell you what, you know, we'll do this and then we'll spread seaweed!' Where the hell do you get the seaweed?! Where did that come from?" (MI09).

This farmer is correct in many ways—linear systems are fundamentally problematic, as Karl Marx pointed out in his now-famous "metabolic rift" critique of industrial agriculture (Foster 1999). Given this reasoning, the respondent felt that the industrial agriculture system was as "sustainable" as any other form of agriculture. These quotes are only illustrative. Particularly, more farmers expressed a recognition that agriculture was the primary culprit of N loss to waterways. But this acknowledgment rarely led to an outright performance of discursive transformation repair, with only five farmers expressing this view.

Another Way Is (Not) Possible

As we noted earlier, proposing outside the system solutions is a critical dimension of seeking transformation change. Among the already small group of farmers who saw agriculture as the primary culprit of N loss to waterways, only a very small group proposed agroecological approaches to address these issues:

> "From my way of thinking, I'm starting to shift from the idea of being, basically all we're doing is importing nutrients and exporting them. And I'm very interested in how to grow those nutrients at home with a diverse crop rotation, and I think there has to be a shift sooner or later away from commercial fertilizer and more towards what nature can produce for you" (IA13).

However, even among those who felt that the industrial system was not "maintainable," farmers commenting on the need to pursue agroecological changes were the exception. This group of farmers discussed the limited potential to solve the loss of N within the industrial agricultural system, i.e. they recognized that as long as synthetic N was being used, there would be problems, even if technologies were widely adopted. However, their performance of this discursive transformational repair rarely made it to proposing actual alternatives to the industrial agricultural system.

The limited number of farmers who felt like system-change was necessary to address industrial agriculture's contributions to N loss often concluded their statements with comments indicating their uncertainty of what the actual change could be (13 of the 154 farmers). As one respondent stated, "Well I think, the [nutrient] erosion situation needs to be addressed. […] the corn-soybean rotation is not the best way […]. But I'm…not quite sure what the answer [is]" (IA39). Similarly, the inability to see another type of system, a more wholistic society, and agrarian system, is illustrated by another comment from the above linear-system farmer, who felt that this is the only form an agricultural system can take: "As long as we bury people in cemeteries, as long as we have septic tanks and public sewer systems and all of those things we will never have sustainable agriculture. It's impossible!" (MI09). Lastly, one respondent explained that to address environmental problems the only solution is to "quit farming. Which isn't going to happen, people need to eat" (MI45). Even when problems are acknowledged, there was no recognition of alternative ways to produce food with less pollution. Farmers overlook that another system is possible, one where society-environment relations are remodeled in a way to enable a more fully incorporated and regenerative agriculture system (Frison 2016).

These comments reveal one of the most significant ideological positions promoting discursive maintenance: the inability to envision an alternative system (Wright 2010). Farmers have developed and can draw on multiple ideological positions to perform the tasks of discursive maintenance repair. At this point, however, they appear to be unable to draw upon an ideological position that enables them to envision a new-system solution to industrial agriculture's loss of N. In effect, they cannot offer discursive transformation repair at its fullest when they cannot see the solutions. Even as farmers begin to see the significant flaws in the industrial agriculture system, like the loss of N to waterways, their capacity to critique and pursue systematic change is *in part* constrained by their inability to think outside of the industrial system's positions and structure.

Discussion/conclusion

We explored how farmers actively participated in maintaining the industrial agricultural system, especially as they became aware of its environmental faults. In response to widely acknowledging the issue of N-related water pollution, we identified how farmers performed the tasks of discursive maintenance through drawing on a variety of ideological positions. Farmers defended the current system through evoking agrarianism and market-fundamentalism to achieve blame-shifting that denied agriculture's responsibility, and through expressing techno-optimism, a reliance on technological fixes that represent small tweaks to the current system. Even when serious issues with the current system were identified, farmers were unable to envision or articulate what an alternative might be, with some not believing a viable alternative existed.

Returning to Henke's (2008) questions related to discursive repair, we find that many farmers believe there is a problem with water pollution, yet the cause or nature of the problem is not perceived as related to farmers' actions or their responsibility. Ideologies that focus on the role of urban polluters (agrarianism), conceal the significant role of agricultural N loss. In terms of the best way of solving N pollution, farmers largely believed that technological changes could reduce pollution (techno-optimism). While some suggested that markets had already or were the best way to solve problems (market-fundamentalism), none proposed an increase in fertilizer price or a fertilizer tax as a solution – although this solution has been effective where adopted (Hamblin 2009)—nor did they consider other policies that would at least encourage a reduction in total N use (Kanter et al. 2015). Solutions proposed do not represent a significant transition towards ecological practices but justify maintaining the current system.

We enhanced Henke's (2008) framework by focusing on how ideology is drawn upon to achieve discursive maintenance. The ideological positions interviewed farmers drew upon to defend the legitimacy of the system reflect broader ideological frames (see above). Our results suggest these ideological contexts are both drawn upon and likely shape farmers' views, promoting their pursuit of system maintenance and the practices that align with this vision. This finding engages with long-standing and more recent literature that also reveals the significant role of ideology in farmers' decision-making (Ellis 2013; Emery 2015) and continues to build a case for the presence of two specific ideological positions in the agricultural context: techno-optimism (Dentzman 2018; Dentzman et al. 2016; Dentzman and Jussaume 2017; Gardezi and Arbuckle 2018) and agrarianism (Mooney and Hunt 1996).

Drawing from Therborn (1980) and Wright (2010), we can see how these ideological positions serve to prevent social transformation and maintain the current system, a finding that reflects prior work examining the role of agrarian ideologies as forces of social reproduction in the face of environmental changes (Dentzman 2018). In our case, a widespread belief that another way to produce food, with far less pollution, is not possible prevents farmers from engaging in transformative projects, be it agricultural or political. Whether large corporations selling seed, fertilizer, and other key components to the industrial system are propagating narratives that "there is no alternative" is beyond the scope of this paper, but others have identified that seed and fertilizer companies use information, marketing strategies and personal contact with farmers to encourage the use of their products (Bell et al. 2015), as well as the belief that "high yield" is the ultimate production goal (Stuart and Houser 2018; Stuart et al. 2018), despite evidence of persistently low prices due to over-production (Blank 2018). Given this evidence, it can be reasonably suggested that input giants strategically promote industrial and technological pathways that preserve the current system and at the same time ignore or refute the possibility of transformation toward an agroecological system. Regardless of the role of input companies, we find that farmers adopt ideological positions that rationalize their role in the current system and serve to maintain this system and fail to envision or consider agroecological alternatives that may more effectively reduce environmental degradation.

A lack of belief that another system is possible represents a considerable barrier to transforming the agricultural system to address environmental impacts. As Therborn (1980) explains, if one cannot see that there is a real possibility for change it will not occur. While technological fixes can reduce nitrogen loss (Robertson et al. 2013), nitrogen loss is a system issue and agro-ecological transition is required to adequately address it (Blesh and Drinkwater 2013). Given our findings, increasing awareness about agroecological practices and visions and policies for an agroecological system is a paramount first step in supporting efforts toward pursuing this transition.

For this study, we considered the widespread adoption of agroecological approaches "transformative" in the sense that it would radically alter how crops are grown in the industrial agriculture system. Yet, we recognize agroecological practices do not shift every dimension of the current agri-food system. The productivist values that are foundational to the industrial system (Hendrickson and James 2005) can accord with and even justify the adoption of agroecological approaches, as has been shown with other "sustainable" approaches to agriculture (Guthman 2004; Jaffee and Howard 2010). Relatedly, agro-ecological transformation of the industrial agriculture system will not address other key flaws in the global agro-food system, such as the unequal distribution of food, power, and profits. Addressing these issues likely requires more widespread efforts to reform (or replace) the broader political economy of capitalist production in which the food system is embedded (Magdoff et al. 2000; McMichael

2009). Our findings suggest that it is unlikely many US row-crop farmers are interested in calling for these more radical transformations yet. But, given the accelerating economic and environmental contradictions of industrial agriculture (Blank 2018; Houser and Stuart 2020), farmers' critique of not only the industrial method of production but the structural economic context it is embedded within, may emerge more forcefully. Future studies should build on our analysis by examining if these dynamics are giving rise to farmers' interest in more transformative critiques of and visions for the agro-food system.

Ethical approval: "All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (include name of committee + reference number) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards."

Informed consent: "Informed consent was obtained from all individual participants included in the study."

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Table 1: Conceptual framework for discursive repair		
Definition: The social construction of a system's issues and their solution, toward either maintaining or eroding the legitimacy of the system.		***Types*:** Maintenance or Transformation
Questions discursive repair is tasked with addressing*:	**Answers if performing *discursive maintenance repair*:**	**Answers if performing *discursive transformation repair*:**
1. Does a problem exist (Henke 2008)?	No; or if yes, then the problem is insignificant/easily solvable.	Yes, and it is significant.
2. What is the nature of the problem (including the problem's *cause*) (Henke 2008)?	The problem is not systematic/structural.	The problem is inherent given the design of the system.
3. What is the best way of solving it (Henke 2008)?	Minor adjustments within the current structure of the system.	The system must be replaced if the problem is to be addressed.
4. Is another system/solution actually possible (Therborn 1980; Wright 2010)?	No; or even if another way is desired, it cannot be envisioned.	Yes; can potentially articulate a vision for this system
*As we note, ideological positions will be drawn on and (re)created in actors' answers to these questions		

Table 2: Agrarianism as discursive maintenance (illustrative quotes)
"I have a tough time believing that the corn farmers in the Midwest is the cause of it […] I look at what a farmer applies on a per acre basis compared to what a lotta of people in town apply to their lawns or gardens in town. And oh, those rates are a lot more drastic and it doesn't get used, it doesn't get consumed necessarily […] to pin point it on the Midwest corn farmer or wheat farmer, take your pick, I have a tough time with that" (IA18).
"I think we need to realize that if they really tested things and went out here how much of this nitrate is really coming from the guy out here that spraying his lawn? There's a lot comes from that; it's not us" (IN13).
"We need to educate the public. And because the first thing, you know like the Lake Erie

situation, that's all coming back to the farmers, the farmers the farmers, and you probably understand it, 90% of the people, they only know what they're told, and whatever they're told they believe" (IN10). "They're finding out [farmers] calibrate and regulate what we put on soils, much more than somebody who goes to Earl May and buys a bag of lawn fertilizer and throws it on their lawns […] So they're finding, they have backed off a little bit that it was strictly agriculture. A lot of it was home owner and industrial use also" (IA20). "I think that ag is not the only source. You have golf courses, home owners, the amount of fertilizer that gets spread on lawns in towns, that's a huge industry, not only the people applying it, but the people selling it" (IA26). "I didn't feel as a farmer that I could be the solution to that problem. Because home owners and golf courses use a much higher level than I would ever dream of using in a farm situation" (IA30). "I think our municipalities are a lot to blame there. You know, electrics going out, sewer being dumped out over the river… You know, I think that's where we need to probably make more improvements then to think that coming back to the farmer's the big problem" (IN50).

Table 3: Market fundamentalism as discursive repair (illustrative quotes)
"You know, the free market determines" (IN34). "The fertilizer and seed is so expensive that, you know, we don't want to… We're not out here… This isn't a charity, we want to make money, you know, we don't have unlimited resources to throw out there, we just want to, you know, get the bang for our buck so to speak" (MI17). "No. I don't think anybody can afford to put gobs amounts on, too much" (IN08). "We're doing it because we want to save the money, and you know take good care of what we bought, not that were against the environment, but they both work pretty hand-in-hand" (IN07). "Yeah, I mean, how can you afford to do that? You can't afford to fertilize Lake Huron, or any other lake, the creek or whatever" (MI13).

Table 4: Techno-optimism as discursive repair
Current technologies as solutions (illustrative quotes)
"Protecting environmental quality…They're state-of-the-art sprayers now and the technology and the GPS has really attributed to this […] our planters are doing the same

thing, you know, it shuts off so that we're not over seeding and over fertilizing, because if the seed's going down the fertilizer's going down, in its setting that stuff off as it goes across the field, you know" (MI14).

"Well, I definitely think we need to do more sidedressing" (IA12).

"I think by using the nitrogen stabilizer, I think by several split application of nitrogen, different times throughout the season, would probably help" (IA16).

"Of course, with today's technology of guidance systems and those kinds of things, some of those things can be overcome" (IA38).

Future technologies as solutions (illustrative quotes)

"It's a big step in the right direction/ And you need technology. I'm hoping the technology will get better or easier to somehow predict what you need while you're going through the field. There are tools out there that will do that, but they're a little bit unwieldy. And weather depending too." (IA12)

"Well, yeah if we know where they might need nitrogen and if they need more nitrogen or if they… Hopefully we get some hybrids developed pretty soon that don't need as much nitrogen. I think that's the road they're trying to be going down, but whether we get there or not…" (IN17).

"If we could do automatic variable rate […], that would be great if they could come up with that" (IA57).

"They are working on better hybrids that will take less nitrogen to raise a big crop, and I think that will probably be the next thing in the works I'm thinking is the work on hybrids that won't need as much N, and I think that will be a biggie" (IN24).

"They're developing corn that's going to be a lot more efficient at utilizing nitrogen, so I would say their policies are going to drive that. Fertilizer companies, again, looking at denitrification inhibitors, that sort of thing, I think that's probably going to be a higher interest level, and there may be better products out. I think Instinct's probably better than NServe for example, so all that goes into the equation" (MI28).