Applying the principles of data feminism in agricultural research leads to more innovative outcomes (15 words)

# Abstract (70 words, at 80)

Agricultural systems reflect complex institutional structures that have historically had, and continue to have, power imbalances embedded within them. The seven principles of data feminism were developed to aid data scientists in identifying, examining, and addressing power inequities related to data generation, interpretation, and distribution. Here we interpret the principles in the context of agricultural research within three overarching discourses: power, reciprocity, and framing. We present evidence that working within these frameworks concomitantly fosters creativity and leads to more transformative outcomes.

Agricultural systems reflect complex institutional structures that have historically had, and continue to have, power imbalances embedded within them. Using the principles of data feminism as guides, we explore implications for agricultural research within three overarching themes: power, reciprocity, and framing. We present evidence that working within these frameworks concomitantly fosters creativity and leads to more transformative outcomes.

# Introduction (735 words)

Power can be defined as a relationship through which one is able to obtain one’s will even in the face of resistance from others (CITE). The explosion in capacity for societies to generate, store, and utilize data has prompted a global discourse on the intersection of data and power. Power interacts with every stage of the data lifecycle, from provenance to utilization, in complex ways that has demanded creation of new academic fields such as critical data studies, data justice, and techno-politics (e.g., data ethics (CITE), algorithmic accountability (CITE), critical data studies (CITE), techno-politics (CITE)), and have been focal points of numerous popular culture artifacts (CTE?). This attention is merited; without intentional examination of these issues, existing power differentials will compound (CITE, the covid paper?) and new ones will be created (digital divide?), a result many deem undesirable.

Research and data are intricately connected, and although scientists in technical fields work with data at many levels they have traditionally done so under the assumption of value-neutrality. While social scientists have long acknowledged this assumption to be false (ANGIE’S CITATIONS), technical researchers are increasingly acknowledging the potentially profound ethical and social implications of their work as it relates to data and power. To truly contribute to public good, researchers must now become adept at recognizing their role in enforcing, or challenging, power differentials. This need for awareness has been discussed deeply within certain technical domains such as technology and health care (CITE). We argue that despite being a salient theme within agriculture, there are few discussions within the physical sciences concerning the intersection of agricultural research and power. This gap has been acknowledged within the larger food studies community for decades (Allen and Sachs), and attempts to discuss and address power inequities are becoming codified within the field of agroecology (MacInnis et al. 2022, Wezel et al. 2009;). The Agroecology Research-Action Collective’s Principles and Protocols for scholar-activists is an excellent resource, but is framed primarily in the context of social science (Wit et al. 2021). Agricultural researchers working in the physical sciences may not self-identify as scholar-activists or agroecologists, and scientists working in the physical science realms may have unique needs with regards to guidance on these topics, which may hinder discussion (Longino 1988).

Data feminism principles provide guidance for approaching data with an explicit interrogation of the power imbalances the work is embedded within, and therefore foment reflection on ethical implications (CITEDIGNAZIOKLEIN). The principles are designed to be action-oriented and domain-agnostic, and D’Ignazio and Klein’s (2020) work has been highly cited by numerous disciplinary contexts. However, to our knowledge, it has had limited interpretation in the context of agriculture, though a recent study evaluated the National Agricultural Statistics Service (NASS) agency of the United States Department of Agriculture (USDA) on their data reporting practices through the lens of data feminism (CITERISSING).

Data feminism is rooted in social science’s empirical study of power and emphasizes intersectionality, or the inability to study dimensions of power in isolation (XX; please see supplementary material for a more complete overview of these topics). Due to agriculture’s complex power dimensions, we feel this framework is particularly suited to this application. The goal of this paper is not to simply reiterate the principles laid out by D’Ignazio and Klein (2020), nor to suggest one set of guiding principles is superior to another. Rather, as agricultural scientists, we found the principles helpful in guiding our own work, and we aim to offer a more bespoke interpretation. Many researchers already, perhaps unknowingly, apply these principles in their work, but we hope that providing this explicit framework in an agricultural context will make the work more intentional, visible, and in time, ubiquitous. As such, we present three overarching themes germane to physical agricultural research: power, reciprocity, and framing. Under each theme we provide an overview of its connections and relevance to agriculture, as well as tangible examples and evidence that their consideration leads to more impactful and transformative research outcomes. This is not meant to be a comprehensive review of power issues in agriculture, nor a thorough documentation of efforts to address those issues. Rather, our hope is that this effort supports technically trained agricultural scientists in connecting their work to its broader societal implications and in sculpting that work to contribute to a more equitable society. Our perspectives and examples are strongly framed by our collective experiences in the agricultural systems of the United States (US), and specifically of those in the maize-producing areas of the Midwest. However, while the specifics of a given system will vary, the topics discussed are universal and we present these themes with the goal of being generalizable.

# Theme 1: Examining and challenging power disparities

At its most fundamental level, agriculture involves the cultivation of land to produce food, which is an essential resource for human survival. Therefore, its very existence invokes potential for abuses of power: those who control access to land hold significant power over others’ access to food. Indeed, there is a large body of scholarly work suggesting the advent of agriculture played a pivotal role in the formation of social classes, and in shaping the dynamics of inequities and hierarchies in human societies (Isett and miller, diamond, against the grain, child, marx). Native land dispossession and enslaved labor have been intertwined with agriculture for thousands of years across civilizations; the global agricultural system today continues to rely upon labor exploitation (Milking in the shadows, J Lindsay Harrison 2006 political geography). Moreover, settler colonialism specifically relies upon the control of land, and thereby agriculture, through land seizures for agricultural production, plantation economies, land tenure systems, and self-serving infrastructure investments (CITE). The US implemented federal policies that simultaneously established agricultural educational institutions and legalized Native American land dispossession (Brayboy and Tachine 2021; Lee and Ahtone 2022; Nash 2019, CITE A NATIVE ACADMEIC; Stein 2017).

These historical trajectories continue to shape the broad features of agriculture today, presenting power inequities, and therefore abuse of power. For example, labor-intensive systems invite opportunities for labor exploitation, while highly industrialized systems exclude participants from exchanging labor for capital; large-scale environmental impacts can disproportionately burden certain communities; strong agricultural interest groups can influence public policies related to land use, taxation, trade, insurance, environmental standards, and subsidies; cultural hegemony built on agriculture can legitimize beliefs about landownership, property rights, stewardship, and can dictate which voices are marginalized (CITE). While it is important to recognize how modern systems legitimize or challenge both historical and present power artifacts, it is not reasonable to expect an agricultural scientist to be an expert in these topics. Data feminism’s application of Collins’ (1990) matrix of domination can aid non-experts in identifying where and how power inequities may be manifesting. To demonstrate the relevance of this tool, Table 1 presents an adaptation of the matrix representing the four domains through which power may be expressed or experienced, coupled with select examples from modern US agricultural systems. The examples provided in the table are not meant to be an exhaustive accounting of inequities in US agriculture; they were chosen to help agricultural scientists understand that oppression is real and quantifiable, and to assist in imagining how a given research topic may interact with each domain.

### Table 1. Domains through which power may be expressed and experienced (adapted from Collins 1990)

|  |  |  |
| --- | --- | --- |
| **Domains** | **Description** | **Select examples of power inequities in modern US agriculture** |
| **Structural domain** | Organizes distribution of power through laws and policies | Racially tiered implementation and funding of US land-grant university system (Croft 2019; Sharp 2004, Martin 2018)  Discriminatory design of US land heirship laws (Deaton 2007; Baily and Thomson 2022)  Gender biases of the USDA1 bureaucratic model (Viswanath 2022) |
| **Disciplinary domain** | Administers and manages distributions of power by implementing and enforcing (or not enforcing) laws and policies | USDA credit granting discrimination based on race and gender (Carpenter 2012)  Systematic exclusion of groups via USDA NASS2 census collection formats (Pilgeram et al. 2020; Dentzman et al. 2020)  Barriers to participation of American Indian lands in NRCS3 programs (Johnson 2019) |
| **Hegemonic domain** | Circulates ideas related to power | Preferential access to extension services for some groups (Ragasa et al. 2013, Krishna et al 2019)  Extension activities focused on top-down, technological solutions (Belshaw 1979)  Focus on Western science in agricultural curriculums (Snively and X 2001)  Barriers to implementing indigenous practices under NRCS cost-share initiatives (Johnson et al. 2021) |
| **Interpersonal domain** | Individual experiences, expression, and awareness of power | Gendered experiences of fieldwork and farmer interactions (Chiswell and Wheeler 2016; XX  Agricultural student biases (Basche and Carter 2020)  In- and out-group mentalities in agricultural practitioners (Kniss XXXX) |
| 1United States Department of Agriculture  2National Agricultural Statistics Service, an agency responsible for collecting and reporting information related to agricultural production within the USDA  3Natural Resource Conservation Service, an agency that provides technical and financial assistance to land owners | | |

In theory, performing publicly accessible research plays a crucial role in redistributing power within the hegemonic domain by democratizing access to knowledge and empowering diverse stakeholders with information needed to challenge existing power structures. However, conducting publicly accessible research alone is not enough to ensure that the research creates knowledge needed by the public, nor that those in need of the knowledge can access it. Furthermore, the reality is that public institutions may rely on funding sources that can compromise commitments to public good (CITE food and water watch report from Angie), and the institutions themselves are built upon and can perpetuate inequality at every level (CITE). There are notable efforts correct these issues, but in practice there are many barriers for public, agricultural research to serve its intended purposes. Many agricultural researchers may not see direct connections between their work and power domains (Table 1), or need help envisioning how their work may integrate into a larger effort to rebalance power in one or more domains. We therefore present three thematic opportunities with examples.

### Technical audits

As scientists, agricultural researchers are well versed in formulating hypotheses testable through the use of traditional data sources. Moreover, agricultural science is an applied science, meaning many scientists interface with the users of their work, rendering them privy to unique situational insights. However, these same characteristics can render agricultural scientists messengers, co-opters, or distributers of power. In short, agricultural scientists have the ability to weaponize science and knowledge. Conversely, by leveraging their scientific training, domain knowledge, and personal observations, agricultural scientists have great potential to contribute to documentation of issues in each of the four domains presented in Table 1.

A series of studies provide an example of creatively using agricultural domain knowledge to challenge power dynamics surrounding underground pipeline installations (Brehm and Culman 2022a; Brehm and Culman 2022b; Ebrahimi et al. 2022a; Ebrahimi et al. 2022b). By documenting significant soil degradation and crop yield losses following pipeline company remediation efforts, the research empowers landowners, farmers, and the public to object to proposed pipelines using scientifically-generated data. It also challenges the power of pipeline companies by shedding light on the true costs of their operation, and enables more informed decision-making regarding carbon capture, storage, and utilization efforts (Balaji and Rabiei 2022; <https://arxiv.org/abs/2403.17162>).

As another example, researchers assessed the statistical power of university-run nitrogen rate trials, exposing flaws in traditional experimental designs used to generate nitrogen recommendations and calling into question the appropriateness of the top-down, siloed, and opaque methods utilized by universities in producing these recommendations (Miguez and Poffenbarger 2022). This occurred against the backdrop of increasingly urgent conversations regarding the environmental degradation, compromised human health, and public costs born from over-application of nutrients on farmed land (CITE). As stakeholders increasingly demand more transparency and accountability with regards to nutrient management, in 2022 the state of Iowa launched an ambitious effort to democratize and support horizontal knowledge exchange in generating nitrogen recommendations (Iowa Nitrogen Initiative). As part of the initiative, farmers volunteer (see Reciprocity section) to perform nitrogen rate trials in their own production contexts, and the data is collectively pooled to drive transparently calculated recommendations and to support public model development. Similarly, in 2022 a grassroots farmer organization, Practical Farmers of Iowa, launched a regional program paying farmers (see Reciprocity section) to test nitrogen rates of their choice using replicated trials and sharing their individual and pooled results with the public (CITE).

These examples illustrate how traditional, technical agricultural research can be used to challenge established power structures, in the first by empowering the public to contest environmental degradation from pipeline installations, and in the second to demand transparency and accountability in nutrient management recommendations.

### Listening to and serving the margins

Conducting research that is inspired by and/or supportive of those who have been institutionally excluded marginalized or subjected to minority status within dominant systems is another effective means for agricultural scientists to challenge entrenched power structures. Marginalization in agriculture can manifest through multiple avenues. Individual characteristics such as gender, race, ethnicity, age, language, sexual preferences, formal education level, technology use and socioeconomic status can lead to systemic and/or cultural exclusion that can translate to exclusion from agricultural research activities (Leslie et al. 2019; Carter 2019; Pilgerum et al. 2022; Pfammatter and Jorgenden 2023; Shih and Fan 2009). Additionally, farm-level features such as the production system, the degree of farm mechanization, farm location, farm size, the market channels utilized, and even the long-term ambitions for the farm can render their needs less important in the eyes of agricultural scientists (Wheeler 2008; Belshaw 1979;). This represents an issue not only for redistribution of power in agriculture, but also for science: marginalization often compels innovation, and listening to and serving the margins can provide a wealth of ideas. In the Midwest, one of the most scientifically impactful long-term diversification experiments was inspired by an Iowan farmer’s low-input system (Davis et al 2012).

Women own almost half of the farmland in Iowa, yet they have been largely ignored by researchers regarding conservation decision-making (Carter 2019). Recent research has shown there are significant opportunities for improving agricultural outcomes through understanding women’s experiences (Mahajan 2019; Diiro et al. 2018; Zhang et al. 2021).

<<Stefan maybe you can say something about PFI’s Latino Engagement program, if that has had any benefits you could mention>>

Serving the margins is a way for agricultural researchers to leverage their privilege to help build legitimacy within the margins (de Wit and Alastair I think)

Needs work….

### Legitimizing other’s knowledge

The idea that there are ’multiple ways of knowing’ likely originated in epistemology, but has migrated into common vernacular as issues with positivism and objectivity have become more widely discussed (see Theme 3). At its most basic level, it recognizes the diverse means through which individuals and groups understand the world around them. This can include empirical observation and logical reasoning, but also intuition, personal experience, cultural traditions, and spiritual insights, among others. Scientists may dismiss others’ knowledge if it originates outside of traditional scientific methods. Therefore, scientists may inadvertently wield power by dismissing knowledge originating from non-conventional sources. While systematic observation and empirical evidence are crucial tools for scientific inquiry, the exclusion of alternative forms of knowledge overlooks their potential contributions to enrich scientific understanding. It also reinforces the dominance of a single scientific paradigm, which stifles innovation.

Utilizing non-traditional measurements is one way agricultural scientists can honor multiple ways of knowing within a scientific framework. A apposite example is USDA NASS measurement of a ‘workable field day’, defined as day where weather and field conditions allow producers to work in fields a major portion of the day (NASS <https://www.nass.usda.gov/Publications/National_Crop_Progress/Terms_and_Definitions/index.php#days>). While it is based on scientific principles relating to soil moisture (Earl 1997), it represents a personal interaction between the farmer and the land. Attempts to model it have shown acceptable accuracies on monthly timescales, but poorer performance on weekly time scales (Huber et al. 2023), indicating it is a personalized experience that cannot be explained by physical parameters alone. Perhaps because of the connection to personal experience, survey data on workable field days is often used in extension settings, but to our knowledge has not been extensively used within scientific frameworks. In an example of sharing the power of data collection, Practical Farmers of Iowa has launched a study wherein farmers will quantify their experiences with cover cropping through the use of workable field days (CITE). This effort does not detract from nor undermine the numerous scientific publications relating cover cropping to changes in soil-water relationships (CITE). Rather, it will enrich the scientific literature, and will produce results that are based on other ways of knowing which may be more meaningful in certain contexts (Robertson et al. 2001).

Technical audits, listening to the margins, and embracing multiple ways of knowing are three topics within the theme of power that can help guide research activities in distributing power within a given domain (Table 1) more equitably. For myriad reasons, we recognize researchers may not have the ability, resources, or authority to do research that perfectly aligns with their ambitions to challenge power. However, the *way* research is done can also present an opportunity to redistribute power more equitably. This is the subject of the remaining two themes.

# Theme 2: Reciprocity in farmer relations

For over a century, plots managed by researchers have been utilized for controlled experiments, allowing researchers to isolate variables and study specific phenomena while controlling for other factors. However, as agricultural research has evolved, there has been a growing recognition of the importance of conducting trials at the farm scale to better understand how research findings translate into real-world agricultural systems (Lacoste et al. 2021, Kravchenko et al. 2017; Koehler-Cole et al. 2023; Laurent et al. 2022). Furthermore, advances in the ability to organize and streamline data collection from farm environments has opened the door for more nuance in blending research plots with farm fields to answer novel research questions. There are significant opportunities for performing better, more statistically powerful, and more relevant public research in collaboration with farmers (igancio’s paper, laila’s, mother daughter stuff, participatory breeding thing; Stone 2016). However, these arrangements require careful consideration to support equitable and fair power relations.There are numerous guides for farmers on conducting on-farm research (Chaney 2017, Stefan’s list). However, to our knowledge, there are fewer resources suggesting best practices for the scientists, researchers, and organizations the farmers may be collaborating with in their research efforts. The Agroecology Research-Action Collective’s Principles and Protocols provide useful guidance on working with communities and organizations in general (de Wit et al. 2022). However, we feel the researcher-farmer collaboration merits explicit attention for agricultural scientists.

## Compensation

The context for farmer involvement in research can vary widely (Toffolini and Jeuffroy 2022; Jackson-Smith and Veisi 2023). The research goals, decision-making authority, degree of communication, and participant selection criteria are examples of factors used to describe the typology of collaborations (CITE). While much work has been done to describe collaboration contexts, the topic of compensation within those collaborations is less widely discussed. To our knowledge there are few studies looking at mechanisms for compensation, and even fewer exploring how those mechanisms influence collaboration dynamics. This omission is problematic; farmers should always be compensated, and the form this compensation takes is particularly germane to the topic of power.

In many on-farm research arrangements, farmers are compensated by ‘the experience and knowledge gained from the activities,’ ‘access to research findings,’ ‘better productivity’,

or a similarly non-tangible exchange. From a power perspective this practice is elitist, extractive, disrespectful, and in the authors’ opinions, unacceptable. Participating in research projects requires farmers to allocate significant time, resources, and land for experimentation and coordination of data collection. Projects should provide tangible compensation that acknowledges the farmer’s investments and sacrifices, ensuring fair remuneration for their professional contributions to the research process. Fair compensation also fosters mutual respect and builds more equitable partnerships that are more likely to be sustained in the long-term. Lastly, failing to provide compensation further exacerbates historical biases, favoring well-resourced farmers in access to on-farm research activities.

Monetary compensation is the most direct, and often preferable, form of compensation. Paying farmers for their participation in research has been shown to promote a climate of mutual respect between farmers and researchers (Thornley 1990). Many surveys of farmers involved in collaborative projects do not explicitly ask about compensation, but a desire to receive monetary compensation is voluntarily noted when asked about limitations and/or suggestions (Thompson et al. 2019; Pires et al. 2024). Since its inception in 1987, the grassroots organization Practical Farmers of Iowa has incorporated farmer payments in grant proposals for its on-farm research program, wherein a farmer received a set dollar amount for conducting an on-farm trial, and 1.5 times that amount if the trial included a farm tour open to the public (Liebig paper, Thompson and Thompson 1990). The farmer cooperator program is still in operation after more than 30 years with high retention rates and continued growth, fact attributed in part to their policy of monetarily compensating farmers for their participation in on-farm research (but see Metrics for Success section). The Iowa Nitrogen Initiative, for comparison, was not allocated money for farmer compensation, and they have capacity for more participants than they can secure. There are fair criticisms of using monetary compensation for farmer’s collaboration, include warping of incentives, and creating selection biases towards those who are not truly interested in the research. While these unintended artifacts are indeed possible, we feel they are minor compared to the power inequities invoked through non-payments.

Monetary compensation may often be preferable, but we recognize it may not always be possible. The reality of funding limitations and grant restrictions on how monies are spent necessitates exploration of other methods of compensation. ‘Work a day’ compensation, wherein researchers offered to work on the farm for some period of time in exchange for research collaboration, showed benefits to both participating farmers and university researchers (Liebig et al. 1999). In this same vein, the Agroecology Research-Action Collective identifies two practices within the principle of fair resourcing that directly mirror these views – that researchers should provide renumeration of partners for time and expertise, and that researchers should provide valuable work that could include digging fence holes (de Wit 2022). However, the high degree of mechanization on many farms and liability issues may restrict this to unique situations. A recent on-farm study comparing precision nitrogen management approaches found most farmers would not have participated without payment, but they also appreciated the technical training and assistance that accompanied the project (Laila’s paper). Alternatives such as formal training opportunities, technical assistance, provision of inputs, or in-kind support may be acceptable alternatives to monetary compensation, but should be considered carefully, and exact dollar values on the compensation should be calculated and communicated. Furthermore, giving the farmers the power to choose their compensation is an interesting and understudied facet of collaborative research. When farmers were provided with the option of having a researcher do work on their farm, some participants requested that the researcher simply give a presentation about university research at that farm (Liebig et al. 1999). These farmers valued ‘access to research findings’ above the offer of unskilled labor, but the element of choice likely played a part in their satisfaction with the arrangement. However, choice in itself may not always equalize power. Arrangements wherein a donation is made on behalf of the farmer to an entity of their choice as compensation should be approached with deep considerations of the context, transparency, cultural sensitivity, perceived influence, and perceptions of tokenism.

To assist researchers in compensating farmers in ways that equalize opportunities and power distributions, public funding sources and private sources committed to fair and equitable research activities should require remuneration of farmers for their participation in research projects and explicitly provide funding categories allocated to effort.

## Metrics for success

In addition to fair (preferably monetary) compensation, both researchers and farmers should aim for relationships defined beyond simple transactions (**Figure X**). We believe many researchers strive to build rich relationships with their farmer collaborators, however they often lack metrics that help them articulate and measure that success. Building on recommendations from the data feminism framework (D’Ignazio and Klein XX), we suggest the following four broad metrics be incorporated into project evaluations:

1. Was trust was built?
2. Were power and resources shared?
3. Did learning occur in both directions?
4. Were both entities transformed as a result of the collaboration?

Incorporating these metrics *a priori* can help guide activity planning, and help ensure anticipated outcomes are aligned within a relationship of reciprocity.

A collage of images of a farm and a building

Description automatically generated

***Figure X.*** *Expanding the metrics used to evaluate project success can aid in enriching the collaborative process for both farmers and researchers. (A) A simple, transactional, and un-equitable exchange of resources wherein the metrics of project success may be measured in ‘increase in knowledge’ by the collaborating farmers. (B) A richer relationship built on exchanges and associated metrics that promote fair, effective, and sustainable collaboration relationships.*

The success of this type of model can again be demonstrated by the longevity of the Practical Farmers of Iowa (hereafter shortened to Practical Farmers) on-farm research program, which has been in place since 1987. Practical Farmers has continually refined their post-program participation surveys, and through deep, critical reflection and constant iteration, their current survey successfully quantifies outcomes in the four metrics described above. Among other questions, Practical Farmers asks participants if they would recommend the program to a friend or other farmer (trust building), how effective the program was in helping the participant answer their questions (power and resource sharing), changes in knowledge (bi-directional learning), and whether participation spurred new ideas or observations on the farm (transformation). As these questions have become metrics for success, Practical Farmers has designed their program to support these metrics, resulting in highly satisfied participants (Can I cite something? A PFI report?) which translates to more consistent funding. Other researchers and entities likely utilize some form of these metrics, but to our knowledge they are not widely employed by granting agencies or at an individual researcher level. To support reciprocity in farmer collaborations, we provide the post-participant survey questions used by Practical Farmers in supplementary material as a resource (supplementary file).

In this section on reciprocity, we have concentrated on designing equitable farmer-researcher relationships. However, many of the ideas presented are not exclusive to these actors. All relationships contain the potential for power inequities, and intentional examination can lead to better collaborations, regardless of the form. While not specific to agriculture, researcher-researcher, researcher-student, researcher-employee relationships all have potential for power inequities based on seniority, discipline, perceived prestige, etc. Is this worth mentioning?

# Theme 3: Framing and the coexistence of multiple truths

Positivism is a philosophical perspective that states empirical evidence based on observable phenomena collected using the scientific method is the only valid foundation for acquiring knowledge. Scientific objectivity refers to the idea that the scientists using the scientific method are not, or should not be, influenced by personal perspectives, values, or vested interests. These ideas relate to data feminism in that they were developed by a narrow slice of human intellect, and their implementation has been entangled with colonialism, racism, and other forms of oppressions(Halpin 1989; Theses 2016;. The appropriateness of positivism for answering certain types of questions has been debated since its inception (CITE). The feasibility and even desirability of objectivity in science has been the subject of rigorous and long-lived philosophical debates, and as the diversity of scientists increases those debates have moved into mainstream dialogues (Reiss 2014; Becker 2021). As a corollary, the acknowledgement of how value systems impact approaches to problems, and perceived solutions has grown (Rykiel 2001).

A slew of paradigms have been introduced in response to these issues in an attempt to support a more nuanced and reflexive approach to scientific inquiry. Topics such as the importance of the role of interpretation, plurality of methods, critical reflexivity, and fallibilism are embraced as inherent in the pursuit of knowledge, while still valuing the foundations of empirical evidence and systematic investigation. While these ideas have been embraced and codified in social sciences (Ryan 2006; others), it has failed to deeply permeate other fields, including agriculture (Clark 2002 (nursing); Norton 2008 (ecology); Nicklay et al. XX; Pretty 1994; Ebel et al. 2020). Here, we collectively group these ideas into the acknowledgement that multiple truths can coexist. We stress that we are not claiming that all perspectives are equally valid, or that there are no objective truths. Instead, we emphasize how this mentality opens us up to diverse perspectives and leads to productive conservations in the field of agriculture. We argue that it is only by adding diverse sets of perspectives can we create a more complete, and just, picture of the ‘truth’.

## Agriculture and values

A book written to illustrate how underlying value systems shape individuals’ perspectives on solutions to complex global challenges unwittingly uses agricultural research as its backdrop. ‘The Wizard and the Prophet’ (CITE) explores the worldviews of Norman Borlaug and William Vogt, two white, Western men working on agricultural topics during the 20th century but coming from divergent backgrounds. Borlaug was raised on a Midwestern US farm, and his life was greatly impacted by the introduction of tractors. This experience likely influenced how he thought of solutions, and he is portrayed as a ‘wizard’, embodying a technocentric worldview the prioritizes technological innovation and human ingenuity as the means to address global issues. Vogt began his life in a rural area surrounded by unbuilt environments, but moved to the city and witnessed the urban development of his place of birth. Vogt is portrayed as a ‘prophet’, emphasizing the need to live within ecological limits. Borlaug researched ways to leverage technology to intensify agricultural practices and increase food production, an effort that contributed to a larger collection of innovations collectively referred to as ‘the Green Revolution’ and for which Borlaug won a Nobel Peace Prize (CITE). Vogt used science to formally develop the idea of carrying-capacity (CITE). He advocated for limiting population growth rather than increasing food production, and developed a model for environmental activism that is still used today. Both Borlaug and Vogt had valid results and conclusions based on using the scientific method to investigate questions that were motivated by their personal values and experiences. The differing motivations do not invalidate their truths, but rather demonstrate how multiple truths can co-exist at once.

In the context of policy making, the acknowledgement of contradictory realities, such as the coexistence of abundance and starvation, is understood as an inherent complexity in addressing multi-faceted issues (Stone 2022). In this context, the broader the set of realities that are available, the more complete the overall picture becomes, and concomitantly the possibility for more equitable solutions. For topics as fundamental to human survival as food production, incorporating the scientific contributions produced using diverse framings will undoubtedly lay the foundation for more equitable outcomes. Ironically, although the worldviews of the two example figures are divergent, they represent those of two American males of European descent as written by an American male of European descent. This demonstrates how even classical delineations such as race and gender portend very little in regard to value systems, and lends us to imagine the insight that would be gained from adding more framings. Today, an increasing availability of diversely framed reflections concerning the Green Revolution have led to significantly more nuanced understandings of the motivations, impacts, and XX of the Green Revolution (PBS series, https://www.pbs.org/wgbh/americanexperience/films/man-who-tried-to-feed-the-world/

others). As calls for a ‘second Green Revolution’ proliferate (XX), the ability of society to leverage diverse voices contributing to the discussion will be a great asset. Scientists who are able to acknowledge and navigate the existence of multiple truths are better equipped to provide solutions that do not preferentially disadvantage vulnerable groups (Jordan about world views paper).

While the set of framings represented in agricultural science is becoming more diverse. Examining how a particular set of values can influence scientific outcomes has produced productive conversations, as well as creative new lines of inquiry. For example, recent research has explicitly analyzed how various framings dictate weed management goals, exposing novel research questions that emerge only when new framings are taken seriously (MacLaren et al 2020; Weisberger et al. 2024). Comparative analyses, article responses, and commentaries are also avenues for productively exploring what analytical decisions are made, what may have motivated those decisions, and how they impact conclusions. Complex agricultural topics such as herbicide use (Kniss), climate impacts of ethanol production (Hill 2022), organic agriculture (Wilbois 2019; Swedish organic reviewer paper), tillage and soil carbon (Miguez/Schulte), and bioenergy (XX) are examples where conversations have benefited from dissecting how different framings may lead to different data analysis choices.

As an agricultural scientist, your background frames your work. We argue that by seeking to eliminate the influence of that framing, we insinuate it is possible, and are concomitantly quelling what our own experiences can proffer to our work. NEED MORE WRAP UP

Is this worth getting into?

On the flip side, researchers should respect that framings create data. There are numerous initiatives that advocate for free and open sharing of data generated by governments, industries, and research institutions ((CITE). The open science movement champions the ethos of transparency, collaboration, and accessibility in scientific research; as a corollary the movement promotes the unrestricted sharing of data (CITE). Indeed, the sharing of data has facilitated more efficient use of resources for research through data re-use (Piwowar), and in some countries freely available governmental data XXX both public and private entities leverage governmental data that is freely available (Piwowar). However, the open sharing of data also introduces risks regarding data misinterpretation or misuse. Data shared openly may be used out of context. By embracing our own framings, we concomitantly recognize the need to understand the framings of others. Failure to do so can result in gross misunderstandings (Cropscape data article, NASS data increasing women producers). Data should be treated within the gift culture of scholarship, in which goods are bartered between trusted colleagues rather than treated as commodities (Wallis).

# Conclusions

In this paper, using the principles of data feminism as our guide, we demonstrate how (1) agricultural scientists can uniquely contribute to examining and challenging power through technical audits, serving and listening to the needs of the minoritized, and embracing multiple ways of knowing, (2) building farmer collaborations with reciprocity metrics codified in the project leads to better outcomes for the farmers and researchers, and (3) embracing framing as an inevitable and positive attribute leads to more transparent, creative, and effective research. SOMETHING MORE.

Agricultural systems functions of complex institutional structures that have historically had, and continue to have, power imbalances embedded within them. The seven principles of data feminism were developed to aid data scientists in identifying, examining, and addressing power inequities related to data generation, interpretation, and distribution. We believe these principles provide an accessible but under-utilized framework for helping agricultural researchers understand and actively work towards mitigating power inequities prevalent in our discipline. Here we interpret the tenets of data feminism in the context of agricultural research within three overarching discourses: power, reciprocity, and framing. Many researchers already apply these principles in their work, but we hope that providing this explicit framework in an agricultural context will make the work more intentional, visible, and in time, ubiquitous. We present evidence that working within these three frameworks concomitantly fosters creativity and leads to more transformative outcomes for agriculture and sustainability as a whole.