Applying the principles of data feminism in agricultural research leads to more innovative outcomes

# Abstract

Agricultural systems are a function 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 for data scientists to aid them 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, acknowledge, and address power inequities prevalent in our discipline. Here we present three themes in which we interpret the tenets of data feminism specifically in the context of agricultural research: 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 this work more intentional, visible, and ubiquitous. We posit that applying these principles concomitantly fosters creativity, leading to better and more transformative outcomes for sustainable agriculture as a whole.

# Introduction

## Issues and concerns with data and power in general

In a broad sense, the intersection of data and power has become a focal point of global discourse and concern (CITE). Issues arise along the entire data lifecycle, from data provenance to utilization, and include a suite of complex interactions that require novel ethical, technical, and regulatory considerations (CITE). The emergence of novel issues surrounding data and power has catalyzed the creation of innovative academic fields dedicated to understanding and addressing these complex dynamics. Fields such as data ethics (CITE), algorithmic accountability (CITE), and critical data studies (CITE) interrogate the ethics and power structures embedded within algorithms. Data justice (CITE) and techno-politics (CITE) explore how data and power intersect within socio-political contexts. These themes have not been isolated to academic realms; numerous books, films, series, and art pieces grapple with tensions between power distribution in data-driven societies. Many of these concerns arise from the understanding that without intentional examination of these issues, existing power differentials will likely be exacerbated, and new ones will be created (CITE). In a time when human ingenuity is arguably most needed (CITE), this could further deny vast numbers of people the ability to fully realize their potential contributions to society (CITE).

## Technical researchers’ role

Researchers and scientists in technical fields have traditionally operated under the assumption of value-neutrality, relegating ethical considerations to separate domains while technical advancement is pursued independently from such considerations. However, researchers are increasingly having to contend with the potentially profound ethical and social implications of their work as it relates to data and power (I`CITE). As such, researchers must become adept at recognizing their role in either reinforcing or challenging existing power differentials. This new awareness has been primarily discussed within the context of domains such as technology, health care, and criminal justice (CITE). We argue that despite power being a particularly salient theme within the agricultural sector, less awareness has been built within the technical agricultural research community concerning the intersection of agricultural research, data, and power.

## Agricultural research

Like all research, agricultural research is built upon data.

TALK MORE ABOUT HOW PEOPLE HAVE THOUGHT ABOUT DATA ISSUES IN THE PAST IN AG.

However, it is only recently, and mostly in the context of ‘big data,’ that agricultural researchers have begun to reflect on ethical issues. Discussions about ‘big data’ and/or ‘data science’ in agriculture start to appear in the literature in the 2010s. Many of the highly cited papers mention data privacy issues, but ethical or power-related implications are not discussed in depth, if at all, and to our knowledge little guidance is given regarding *how* to consider such implications (e.g., XXXX). There is an implicit assumption that those considerations remain outside the scope of technical agricultural research.

This gap has been acknowledged within the larger food studies community, and methods for addressing concerns about power distribution and fairness are becoming codified within the field of agroecology (MacInnis et al. 2022, Wezel et al. 2009;). The Agroecology Research-Action Collective has published an excellent resource with Principles and Protocols for scholar-activists, but are framed in the context of social science (Wit et al. 2021). Agricultural researchers 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 (Longino 1988).

The tenets of data feminism were developed in response to a need for tools that foster awareness about the interactions between power and data science (D’Ignazio and Klein XX). The principles provide guidance on how to approach data science with an explicit acknowledgement of the power imbalances the work is embedded within, and therefore foment reflection on the ethical implications of the work. The principles are designed to be domain-agnostic, and the book has been highly cited by a range of disciplinary contexts. However, to our knowledge, it has had limited interpretation in the context of agriculture. A recent study evaluated the United States Department of Agriculture’s National Agricultural Statistics Service data reporting practices through the lens of data feminism, demonstrating the utility of such approaches for fostering creative problem solving in agricultural institutions (Rissing).

The goal of this paper is not to reiterate the principles laid out by D’Ignazio and Klein (XX). Nor do we intend to suggest one set of guiding principles is superior to another. Rather, our aim is to offer our interpretation of the principles of data feminism specifically in the context of agricultural research involving the physical sciences. In this paper we interpret the principles within three themes of power, reciprocity, and framing. Under each theme, we provide evidence that their consideration leads to more impactful and transformative research outcomes. 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 Midwestern US. The topic of power inequities is universal, and while the specifics of a given system will vary, we arranged these themes with the goal of being generalizable. Our hope is that this effort sparks additional contributions from diverse viewpoints on the topic of power in agricultural research. A statement of positionality from each author is presented in supplementary material.

# Theme 1: Examining and challenging power disparities

Agriculture has a unique relationship to power inequities compared to other domains. At its most fundamental level it involves the cultivation of land to produce food, which is an essential resource for human survival. Therefore, its very existence invites potential power inequities: 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 pivot 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). Slavery has been intertwined with agriculture for thousands of years, with several civilizations relying heavily on slave labor to cultivate crops.

Moreover, many mid-century colonialism efforts were agriculturally motivated, marking the emergence of oppressive practices and policies such as land seizures for agricultural production, plantation economies, land tenure systems, and self-serving infrastructure investments (CITE). Plantation economies motivated some of the largest slave trades in history, and were notorious for their brutal practices and conditions. While most countries have enacted formal abolitions of slavery, human trafficking still occurs and many of those practices (e.g., coercion, debt-bondage) are mirrored in modern forms of exploitation of agricultural migrant workers. In the US, agricultural educational institutions were established using state-sponsored systems of Native dispossession (Nash 2019, CITE A NATIVE ACADMEIC; Stein 2017). The study of how historical legacies of power imbalances are expressed in modern systems falls under various academic disciplines.

Even without considering historical trajectories, it is important to acknowledge how broad features of modern agriculture will continue to present opportunities for 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. Conceptual tools such as [give more examples], and the matrix of domination (XX) have been developed to aid non-experts in dissecting where and how power inequities may manifest.

To demonstrate the relevance of these domains in modern agriculture, Table 1 presents the four domains with select examples from modern US agricultural systems. This table is not meant to be exhaustive, but rather to help agricultural scientists understand that oppression is real, and to aid in understanding how their research may interact with each domain.

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

|  |  |  |
| --- | --- | --- |
| **Domains** | **Description** | **Select modern US agricultural examples of power inequities** |
| **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 USDA Weberian bureaucracy (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 NASS census collection formats (Pilgeram et al. 2020; Dentzman et al. 2020)  Barriers to participation of American Indian lands in NRCS 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 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) |

Agricultural researchers may not see direct connections between their work and power domains (Table 1). Here we present thematic opportunities for agricultural researchers to integrate their work into a larger effort to address inequalities related to agriculture. This is not meant to be an all-inclusive list, and rather than constrain future efforts we hope it provides inspiration, as well as demonstrates the utility of utilizing such research framings.

### Technical audits

As scientists, agricultural researchers are well versed in formulating hypotheses testable through the use of data. Moreoever, agricultural science is by definition an applied science, meaning many scientists interface with the users of their work, rendering them privy to unique situational insights that can provoke interesting queries related to power. By leveraging their scientific training, domain knowledge, and personal observations, agricultural scientists have great potential to contribute to documentation of power inequities in modern agriculture. Many of the examples shown in Table 1 are the results of agricultural scientists contributing to technical audits to document power inequities. Working on teams , can practice data feminism through technical audits...

A series of studies provide an example of creatively using agricultural domain knowledge to interrogate the costs of environmental degradation resulting from underground pipeline installations (Brehm and Culman 2022a; Brehm and Culman 2022b). Using paired fields, the soil scientists found significant soil degradation and crop yield losses following pipeline company remediation efforts, suggesting land owners, farmers, and the public bear significant costs from pipeline installations on all land, but particularly on agricultural land (Brehm and Culman 2022a). These types of studies provide quanitifiable data to support true-cost accounting of carbon capture, storage, and utilization efforts (Balaji and Rabiei 2022; https://arxiv.org/abs/2403.17162).

As another example, in a literal interrogation of power researchers assessed the statistical power of university-run nitrogen rate trials, finding them underpowered and calling in to question many institution’s top-down, opaque systems for generating these recommendations (Miguez and Poffenbarger XX). In an effort to democratize and support horizontal knowledge exchange when generating nutrient management recommendations, the state of Iowa has launched an ambitious project wherein farmers perform nitrogen rate trials in their own production contexts while contributing data to inform transparently calculated state-wide recommendations and support public model development (Iowa Nitrogen Initiative; but see Reciprocity section). Similarly, Practical Farmers of Iowa has launched a regional program paying farmers to test nitrogen rates of their choice using replicated trials and sharing their results with the public (CITE). Recognizing and documenting the limitations of small-plot science helps to dismantle disciplinary, hegemonic, and interpersonal domains of power inequities (Table 1).

There are numerous examples of creative XXXX

nother example of leveraging domain knowledge to document inequities

Brehm and Culman 2022

### Listening to and serving the margins

Conducting research that is inspired by or supportive of those who have been marginalized or subjected to minority status within dominant systems is an effective means for challenging 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 invite minority status in the eyes of agricultural scientists (Wheeler 2008; Belshaw 1979;).

In the Midwest, one of the most impactful long-term diversification experiments was inspired by an Iowa farmer’s low-input system (CITE).

The margins are often doing creative things.

Bacillus thuringensis, mechanical weed control,

“We should be creating new knowledge and new designs from the margins”

Krishna Veetle 2022 – Crop breeding for the margins

Organic ag breeding, etc.

Lending legitimacy (Montenegro de Wit and Iles 2016

Rice et al. 2018 extension to reduce marginalization

In theory, public research itself plays a crucial role in redistributing power by democratizing access to knoweldge and empowering diverse stakeholders with information needed to challenge existing power structures. It is also meant to operate independently from commercial interests and XX. Unfortunately, the reality is that public institutions themselves are built upon and can perpetuate inequeities at every level, including who built them, whos values they embody, where they are located, who they employ, who they serve, and how they are funded (CITE). There are excellent efforts in place to correct these issues, but XXX. Therefore, while simply doing public research should respresent challenge power inequities, there are real barriers to achieveing this ideal.

The question "Did you grow up on a farm?" holds significance beyond mere curiosity when posed to individuals engaging with farmers. In agricultural communities, farming often extends beyond a livelihood; it's deeply intertwined with identity, culture, and tradition. Asking about one's upbringing on a farm isn't just about gathering information; it's a subtle way of assessing trust and credibility.

Listening to farmers

One of the most impactful, long-term research sites in the Midwest was

This minortization could be based on gender, race.

This approach …creativitiy.

A highly impactful research approach for challenging entrenched power structures involves conducting research that is both inspired by and supportive of individuals who have been marginalized or subjected to minority status within prevailing systems.

Women land owners, organic farmers, Matt Liebman’s Marsden Farm, Tom Kaspar (maybe I’ll cite my podcast!). David might have some examples from the south.

### Legitimizing other’s knowledge

Scientists may dismiss others’ knowledge if it originated outside of traditional scientific methods.

Systematic observation, experimentation, and empirical evidence are valuable tools for creating knowledge, particularly for scientists. However, dismissal of knowledge generated through other means overlooks valuable insights and perspectives that could serve to inspire and enrich scientific understanding. Particularly in agricultural research, a pre-requisite to performing plot-scale experiments is an acknowledgement that it is an imperfect attempt to simulate production-scale conditions. There are numerous examples in the literature describing how farm-scale results differ from those obtained under institutionally-managed plots (Kravchenko et al. 2017; Koehler-Cole et al. 2023; Laurent et al. 2022)

inform more holistic approaches to problem solving. forms of knowledge generation should be acknowledged, anThis dismissal can

systematic observation, experimentation, and empirical evidence as the foundation of knowledge

Disparities between university and farmer field trials (Andrea’s cc thing, Seig Snapp’s thing, Anabelle Laurent’s thing). Stefan’s field workable days, iowa nitrogen project, others…

Scientists may dismiss others' knowledge if it originated outside of traditional scientific methods, such as through indigenous or experiential knowledge, due to a bias towards empirical evidence and peer-reviewed research. This dismissal can stem from a lack of understanding or appreciation for alternative forms of knowledge production, leading to a disregard for valuable insights and perspectives that could enrich scientific understanding and inform more holistic approaches to research and problem-solving.

Additionally, information in itself can

The

The concept motivating the establishment of public agricultural research is to provide unbiased, scientifically grounded information to support evidence-based decision-making in agriculture. This ensures that agricultural practices, policies, and innovations are informed by rigorous research rather than influenced solely by commercial interests.

Top of Form

Including agricultural scientists in technical audits can contribute to

can uniquely contribute to

Agricultural scientists

Francis et al. 2022 Black land loss

Identifying areas of inequities requires domain knowledge...Andrea Rissing’s NASS paper?The Canada soil inequity paper (Richmond 2020)

***Random notes and thoughts, ignore***

***Future NRCS staff are not trained to think about women as land owners. Impacting their education while also understanding women’s conservation needs.***

***Shifting the power to the farmers to collect data that is meaningful to them.***

***Listening to minoritized farmers.***

***When working on an agricultural problem, it is imperative to understand the relations of power Who owns land, who manages land, who works the land***

***Identifying who is being minoritized, and amplifying their challenges, their perspectives, and their needs is a baller thing to do. For example, the national narrative in the United States is that land is owned by white men. Technical audits are useful tools for separating power narratives being . The Midwestern United States contributes XX of the world’s maize and soybean production on a yearly basis, and contains some of the most productive and expensive arable land in the US. A recent estimate showed XX% of this land is owned (and an additional xx% co-owned) by women (CITE). In XX NASS allowed for more than one person to identify as a farmer-operator, data suggested XX% of farm operators were male, Women were not permitted to own land until XX, and culturally are often not seen as capable of making farming decisions***

***Women land-owners represent a minoritized group. By using a technical audit to examine power***

For myriad reasons, researchers may not have the ability, resources, or power to do research that aligns with their desires to directly challenge power. However, the way you do research can also present an opportunity to redistribute power more equitably. The next two sections present guidance relating to the way in which research is done.

# Theme 2: Reciprocity in farmer relations

*RA Fischer’s launch of statistics in agricultural research plots…issues with his context could be discussed.*

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, others). 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 coexistance 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 picture of the ‘truth’.

framing in agricultural research as a strength, and one that more evenly distributes power in the realm of agricultural knowledge generation. We stress that by embracing framing and multiple ways of knowing, one is 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 the ability to recognize that different truths can coexist.

The recognition of framing, its consequences for research, and the coexistence of multiple truths has led to productive conversations in the field of agriculture.

Bias and framing are

Acknowledging the existence of multiple ways of knowing doesn't necessarily mean that all perspectives are equally valid or that there are no objective truths. Instead, it emphasizes the importance of being open to diverse perspectives and recognizing that different truths can coexist, enriching our understanding of the complexities of the world.

observable phenomena and empirical evidence, emphasizing the scientific method

Rasmussen et al. 2006

As the generation of knowledge becomes democratized (

The dominant reaction from the scientific community has been to measure bias with the goal of eliminating it. We argue that by seeking to eliminate bias, we are insinuating it is possible, and are concomitantly quelling what our own experiences can proffer to our work. Following the ideas put forth in Data Feminism (CITE), we argue there is a difference between bias and framing, and that it is only by adding diverse sets of framings can we create a more complete picture of the ‘truth’. Agriculture is inherently laden with the values and perspectives, and by embracing this fact we open up to more honest, inclusive, diverse, and creative research.

”Acknowledging the existence of multiple ways of knowing doesn't necessarily mean that all perspectives are equally valid or that there are no objective truths. Instead, it emphasizes the importance of being open to diverse perspectives and recognizing that different truths can coexist, enriching our understanding of the complexities of the world. This approach encourages humility, curiosity, and interdisciplinary dialogue, as well as a deeper appreciation for the richness and diversity of human experiences and knowledge systems.”

## 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 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, and advocated for limiting population growth rather than increasing food production. 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 multiple 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 beyond those of two Western men 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.

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).

## Multiple ways of knowing

The idea that there are ’multiple ways of knowing’ likely originated in epistomology, but has migrated into common vernacular as the aforementioned issues with positivism and objectivtiy have become more widely discussed. 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, spiritual insights, among others.

Robertson et al. 2001 Environmental Narratives and the Need for Multiple Perspectives to Restore Degraded Landscapes in Australia

What is a ‘workable field day’? Let them decide for themselves.

Code 2018 (different ways of knowing, organic ag).

Nick Jordan’s paper (2020) about scientists joining politics of constructive activism requires “a shared vision of a desirable future and a feasible pathway to that future”. I’d argue this requires a scientist to frame.

Scientific objectivity expresses the idea that scientists themselves are not, or should not be, influenced by

Since its inception, objectivity in science has always been surrounded by rigorous philosophical debates concerning both its attainability and desirability (Reiss 2014; XX). More recently those debates have expanded outside of the field of philosophy as scholars and activists draw attention to the historical roots of scientific objectivity and its entanglement with colonialism, racism, and other forms of oppression.

STOP

What is a ‘workable field day’? Let them decide for themselves.

In , we draw a distinction between ‘biases’ and ‘framings’. The life experiences an individual researcher carries with them into their work

By seeking to eliminate bias, we are insinuating it is possible, and are concomitantly quelling what our own experiences can proffer to our work.

We argue that adding a more diverse set of framings creates a more complete picture of the ‘truth’. Uhh this needs help.

# 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 and serving and listening to the needs of the minoritized, (2) building farmer collaborations with reciprocity metrics codified in the project leads to better outcomes for the farmers and researchers, and has resulted in long-term viability of an on-farm research program and (3) embracing framing as an inevitable and positive attribute leads to more transparent, creative, and effective research. The majority of this work is drawn from experiences and contexts in the United States, however the themes are universal.