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Make bloom and let wither: Biopolitics of precision agriculture at the dawn of surveillance capitalism

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1. Introduction

Anthropogenic climate change is altering and disrupting food production systems globally (Arnell et al, 2019). With high confidence, the Intergovernmental Panel on Climate Change (IPCC) asserts: "Observed climate change is already affecting food security through increasing temperatures, changing precipitation patterns, and greater frequency of some extreme events" (Mbow et al., 2019: 439). Climate change presents numerous challenges to achieving equity within food production systems—smallholder farmers, historically marginalized populations, and those regarded as vulnerable by climate intelligentsia bear a disproportionate burden of impacts (Mbow et al., 2019: 439; IPCC, 2014).

Increasingly, climate crisis discourses are being framed through the lens of securitization (Grove, 2010; King and Goodman, 2011; Parenti, 2012), wherein the vulnerability of the vulnerable is used to justify further surveillance and militaristic interventions (Thomas and Warner, 2019). Food insecurity and disruptions in food production related to climate change are also being framed through similar securitization discourses (Karlsson et al, 2018; McDonagh, 2014). Climate-food discourses frequently fuse with neo-Malthusian discourses that scapegoat the growing human population in the global South as threatening future food supplies for a planetary population of 9 billion in 2050 (Fouilleux et al, 2017; Ojeda et al, 2020; Shaw and Wilson, 2020). From this grounding, climate-related food security discourses establish the imperative of increasing agricultural productivity for securing human well-being (McDonagh, 2014; Fouilleux et al, 2017; Nally, 2011).

Under the aegis of population vulnerability, securitization provides a useful pretext for the vast dissemination of new capital-intensive technologies that seek to 'modernize' agrarian production systems (Stock, 2020; Dryzek, 2013). Undoubtedly the world's foremost authority on global ecological change, the IPCC has become a vocal advocate for climate-responsive technological innovations in agriculture: "Many [agricultural] practices can be optimised and scaled up to advance adaptation throughout the food system (*high confidence*)" (Mbow et al., 2019: 439). Ranging from biotechnology to artificial intelligence, numerous innovations in agriculture are currently being developed and implemented under the broad umbrella of 'climate-smart agriculture' that seek to facilitate a 'triple-win' of establishing food security, mitigating greenhouse gases and enhancing the adaptive capacity of farming communities (Suckall et al, 2014). However, many observers contend that 'smart' interventions promoted by authoritative institutions (e.g. UN Food and Agriculture Organization, Global Alliance for Climate-Smart Agriculture) are inadequate 'techno-managerial fixes' to the political causes of food insecurity that may exacerbate social inequalities (Nightingale et al, 2019; Karlsson et al, 2018; Taylor, 2018; Cavanagh et al, 2017).

1.1. Precision agriculture

Improving agricultural yields as a response to the looming climate crisis is a matter of global human welfare of great geopolitical importance. People and their production systems have become central objects for political management. For example, John Deere fits new tractors with sensors that passively mine field-level data about soil and crop conditions and then invites farmers (through subscription fees) to benefit from decision support systems (DSS) that can help inform their decisions about when to plant, spray and harvest (Bronson and Knezevic 2019). Within these logics, paramount to the practice of agricultural optimization for food security is collecting and processing data from all aspects of the food production system to ensure precision in the targeting of interventions, the application of inputs, tracking the outputs, and recording patterns of human, plant, and animal behavior. Such technologies, broadly referred to as *precision agriculture* (PA), are data-driven agricultural technologies that use localized farm data at the appropriate time and location to make 'precise' farming management decisions (Rossel and Bouma, 2016; Dreissen and Heutinck, 2015; Bongiovanni and Lowenberg-Deboer, 2004; Cox, 2002). PA or "farming by the foot" is largely made possible through the processing of big data

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or high-volume, high-velocity, multisource agriculture data (e.g. crop yields, digital soil information, reflectance information, elevation data) (Shannon et al., 2018; Clay et al., 2017; Vallentin et al., 2019). Technologies associated with PA are quite diverse, including but not limited to: yield monitors (Fig. 1), soil and water sensors, GPS units for self-driving tractors, robotic milking machines, drones (Fig. 2) and blockchain technologies. PA is also being integrated with technologies of artificial intelligence under the auspices of 'smart' agriculture. Artificial intelligence (AI) can be defined as present wherever machines can exhibit *some* level of intelligence (Russell and Norvig 2016; Smith, 2020). Through AI, PA is envisioned to be "delivering real value" to farmers (Smith, 2020) and steering society toward the "fourth industrial revolution" or agriculture 4.0 (Lele and Goswami, 2017). With help from satellites, drones, sensors and machine learning algorithms, PA technologies are helping farmers make various decisions by integrating information technology into farm machinery and management (Rossel and Bouma, 2016; Dreissen and Heutinck, 2015; Bongiovanni and Lowenberg-Deboer, 2004; Cox, 2002). For example, the adoption of Microsoft's Cortana Intelligence Suite is helping farmers find optimal planting dates for crops in India and Colombia (López and Corrales 2018), drones are being used by farm managers to scout and remove weeds from fields (Lottes et al. 2017; Fennimore 2017), and automated systems are milking cows in the dairy industry (Dreissen and Heutinck, 2015). Agritech firms increasingly position themselves as purveyors of technologies that respond to the climate crisis, yet market their products to farmers as solutions to challenges of falling profitability and biosecurity (John Deere, 2020). PA systems may increase farm profitability while ostensibly reducing negative impacts on the environment (Rossel and Bouma, 2016; Bongiovanni and Lowenberg-DeBoer, 2004; Banerjee et al. 2013; Smith, 2020). At the same time, the mechanisms of PA (e.g. data collection, infrastructures, data sharing, algorithms) present social and ethical issues such as potential privacy breaches or access and trust

Fig. 1. Yield monitor being used by a farmer inside the cabin of a combine harvester (courtesy: John McMaine).

Fig. 2. A farmer preparing to fly a drone over corn and soybean fields in South Dakota (courtesy: Deepak Joshi).

issues among farmers and other actors in the food system (Jakku et al. 2019). Recent social science research provides relief to uncertainties surrounding the social dimensions of PA, and specifically to big data applications for agriculture (Gardezi and Stock, 2021; Klerkx et al, 2019; Rotz et al, 2019a; Bronson and Knezevic, 2019). For example, Gardezi and Bronson (2019) explore the social determinants of farmers adopting PA technologies and their perceptions of biophysical risk associated with the new food production system. We build on this extant literature by situating the power relations between food system actors and institutions within a larger political economy of industrial agriculture and ask the following research question: *What are the sociopolitical effects of big data gathered from 'smart' agriculture interventions of farmers in South Dakota and Vermont?* In the next section, we provide texture to this question by examining the uses and effects of PA, a new paradigm of capital-intensive industrial agriculture that integrates digital technologies to improve crop yields and manage populations.

1.2. *Capital accumulation by data dispossession*

> "…computing and the rise of big data are not only implicated in new ways of living and being in the world, but also generate new 'industrial' landscapes of computing where flows of resources (energy and water), the presence (or absence) of connective infrastructure, and economic growth and livelihood provisioning are entangled in highly uneven development processes that collapse urban/rural and social/natural dichotomies" (Pickren, 2018: 238).

Producing a windfall of highly-valued big data, PA is an ecological modernization and accumulation strategy *par excellence.* Users of agricultural tech providers' technologies and software are generating torrential volumes of data on the food production system and their own consumer preferences and behaviors. Farmers sign user agreements, consenting for their data to be utilized by agritech firms. Tech providers harvest this data to "inform innovations and direct strategic investment," accumulating capital and information in the process (Fraser, 2019: 895). The data generated is privatized by the agricultural tech providers, protected through intellectual property rights law and users do not own nor are able to control this data (Rotz et al, 2019a; Carolan, 2017). Like architects of digital infrastructures in other industries, such as social media and online retail, agritech's "formal indifference and distance from 'users,' combined with its current freedom from meaningful regulation, sanction, or law, buffer it and other surveillance capitalists from the consequences of mistrust…the *coup des gens* introduces substantial new asymmetries of knowledge and power" (Zuboff, 2015: 83).

PA presents an unparalleled opportunity for agritech firms to engage in what some observers have called *data grabbing,* the dispossession of producers' quantified and monetized digital information generated in stealth through their use of the technologies (Fraser, 2019). Discursively framed as a 'smart' securitization of food systems affected by anthropogenic climate change, data grabbing for PA can be thought of as an iteration of *green grabbing,* dispossession in the name of sustainable development (Fairhead et al, 2012; Stock and Birkenholtz, 2019). Users of these agricultural technologies lose control of their data by way of agreeing to Byzantine user agreements that legally represent their abdication of privacy (Thatcher et al, 2016; Rotz et al, 2019a). Firms then construct digital profiles of each user—subjected to algorithmic entanglement and analysis by computational models—and then aggregate user profiles as commodity bundles for sale, grist for the advertising mill (Fraser, 2019). "In PA, acting, thinking, and doing are themselves subject to commodification via datafication" (Miles, 2019: 7). Advertisements for new products, related digital content, or upgrades to existing digital software produce yet more data from the original data generated (Fraser, 2020), a lucrative simulacrum of agrarian 'reality' (Beaudrillard, 1994).

New digital technologies are becoming ubiquitous interfaces of social participation within food production systems (Klerkx et al, 2019). PA is an experiment in corporate social engineering (Bronson and Knezevic, 2019), insofar as the preferences, habits and actions of users are digitally monitored and utilized to influence their behaviors within a food production system (Gardezi and Stock, 2021; Miles, 2019; Carolan, 2019). The repeated use of these technologies engenders a social dependency of users who "get something in return" for their generation of data (Fraser, 2019). These users are influenced by the technologies through targeted advertisements, services and prompts within the platform. Users become subjects of a powerful algorithmic rationality of agriculture (Miles, 2019)—part of an "emergence of social identities that are shaped by the adoption of PA itself" (Gardezi and Bronson, 2019: 16-17)—many of whom internalize the new logics of accumulation and modify their actions to fulfill the policies and ambitions of the agricultural tech providers (Gardezi and Stock, 2021; Fraser, 2019; Carolan, 2019; see Pickren, 2018), a process Foucault calls *governmentality* (Foucault, 1991). Recent studies in political ecology and cognate disciplines have extended the concept of governmentality to analyze subjectivities within the politics of the environment (see Cavanagh, 2018; Moulton and Popke, 2017; Birkenholtz, 2009). This study reveals that many PA users can exhibit a range of agri-algorithmic subjectivities. The subjectification of users to PA infrastructures (devices and digitalia) is part of a longer genealogy of capital-intensive technological interventions that transform the political economy of food production systems and the livelihoods of producers.

1.3. Back to the future of food: Precision agriculture in the longue durée

> "By the year 2050, U.S. growers will need to reach an impressive level of food production to help feed a growing world population. Fewer in number, they will operate multifaceted businesses with stunning new technology to increase efficiency on farms" (Syngenta, 2017a).

Agritech corporations temporally position their technologies as 'smart' and 'innovative' solutions to future crises of food security (Syngenta, 2017b). Discourses of ecological modernization are reproduced by development agencies that regard PA as "the future of food" (World Bank, 2019). Yet PA's future can be situated within a genealogy of capital-intensive accumulation strategies in agriculture. Miles (2019: 6) provides this useful historicization: "PA represents to the present what farm management, mechanization, hybridization and artificial inputs represented to the past: a movement to further transform objects (and now activities) into discrete commodities, to extend the reach of capital, and to accumulate entire new geographies of possibility to the market's logic." Industrial agriculture's 'digital turn' claims to provide a nimble socioecological fix to internal contradictions within capitalism that produce distinct crises of ecological degradation through production processes (e.g. climate change), while availing new investment opportunities for overaccumulated capital in the present and far into the future (Ekers and Prudham, 2015; Harvey, 1982). The data harvested now by PA will inform agritech's research and development efforts for years and decades to come, extending horizons of profitability by enclosing data, software and hardware as intellectual property.

Yet situating PA within a punctuated historicization of agrarian crises is disingenuous, insofar as these historically specific and contingent crises are sustained and temporarily resolved by firms. Capitalism adapts to long periods of crisis through restructuring the relations of production (Braudel, 1982). From this vantage point, it becomes necessary to jettison the misleading 'agriculture 4.0′ moniker (Lele and Goswami, 2017). Accumulation cycles within capitalism's *longue durée* transform agrarian spaces (Arrighi, 1994), often through technological innovation that seeks to 'modernize' production. Hence, agritech's assemblage of digital infrastructures must be situated within the 'long' Green Revolution (Patel, 2013)—characterized by agricultural innovations (e.g. mechanization, high-yield varieties, chemical inputs, biotechnology, financialization). Within the Green Revolution's present accumulation cycle in the *longue durée* of capitalism, PA effectively resuscitates the dominant Borlaugian telos of securing production through securing profit. Further, PA presents a novel problematique of the classic agrarian question, concerned with capitalism's transformation of the countryside and the role of agriculture in capitalism's development (Kautsky, 1988; Akram-Lodhi and Kay, 2010a). Through PA, agritech can establish new cyberspace frontiers to ensure the further penetration of capital into rural spaces unfettered by temporal limitations, reconfiguring labor arrangements in the process. "Farm consolidation will drive the need for more outside labor. Expect high-tech solutions like robotics to come to the rescue" (Syngenta, 2017a). The circuits of PA capital are rewiring farm work. Although agritech's future ambitions of labor displacement have been disclosed, the impacts upon and affectations of producers in the present remain unclear. PA systems add urgency to examinations of the agrarian question of labor, centering the survival strategies and politics of producers in capitalism's sustained crises and agrarian transformations (Bernstein, 2004; Akram-Lodhi and Kay, 2010b; Levien et al, 2018; Stock and Birkenholtz, 2019). This study will explore how the power of agritech capital is operationalized through the surveillance of data grabbed from producers who are threatened with proletarianization by PA.

1.4. Precision agriculture as biopolitics of surveillance capitalism

PA can be situated within a new logic of accumulation based in the commodification of personal data through digital interfaces (Fraser, 2019). PA is able to penetrate deeper into the personalization of agricultural management by accumulating, surveilling and curating data harvested from farm and farmer at little cost *ad infinitum* (Fraser, 2020; Miles, 2019). As opposed to earlier technological interventions within food production systems led mainly by the public sector or philanthropic institutions (Hetherington, 2020; Nally, 2011; McMichael, 2009), PA is driven by agribusiness corporations (e.g. John Deere, Monsanto) assisted by state actors and institutions (e.g. USDA) that serve as development brokers of agribusiness capital (Fraser, 2019; Carolan, 2017a; see Levien, 2018). Surveillance of data by agritech enables the sustained regularization of agriculture to corporate interests far into the future. Zuboff (2015: 75) defines *surveillance capitalism* as a "new form of information capitalism [which] aims to predict and modify human behavior as a means to produce revenue and market control" (see also Zuboff, 2019). By wielding the ability to commodify the personal datapoints (isolated and aggregated) from farmers as a means to accumulate capital and influence their behaviors, PA opens a new agrarian frontier for surveillance capitalism.

Profitable surveillance through PA *en masse* represents a seismic shift in the power to manage life itself. In the context of global environmental change, neoliberal states can exercise *biopower* on entire populations through agritech firms, "a power that exerts a positive influence on life, that endeavors to administer, optimize, and multiply it, subjecting it to precise controls and comprehensive regulations" (Foucault, 1978: 137). Prior to liberal capitalism, a sovereign state wielded the ability to take life and let live for the ostensible vitality of the polity (Machiavelli, 2013). Alternatively, biopower marks liberal capitalism's shift to a "make live and let die" calculation that asserts itself to manage population wellbeing through various mechanisms, such as (inter alia) statistics, demography, public health infrastructures and development schemes (Foucault, 2003). Against the backdrop of agrarian transformation in rural Indonesia, Tania Li (2010: 67) argues: "Make live interventions become urgent when people can no longer sustain their own lives through direct access to the means of production, or access to a living wage."

PA, an assemblage discursively articulated as a clever gambit against climate-induced future food insecurity, can be seen as a mechanism through which the regulation of life and the management of (more-than-human) populations is exercised by agritech firms. Specifically, the neoliberal state erects the statutory architecture necessary for agritech's capital accumulation by data dispossession. Regulatory frameworks are congealing but remain out of step with the rapidly advancing PA technologies, much to the chagrin of agritech: "Many new machines are currently equipped with the electronics to control operations with very little human interaction. However, the legal and regulatory issues surrounding robots must be bridged first" (Syngenta, 2017a). PA is a form of *biopolitics* through which the neoliberal state enables agritech firms to scientifically manage populations in a food production system—including human producers, companion crops, pests and weeds—as objects to study, improve and protect (Carolan, 2017; Nally, 2011). For an example of biopolitics in agriculture, Hetherington (2020) explores the biopolitical techniques of managing plant health to expand monocrop agriculture in the US and Europe and later exported to the global South during the period of the second Green Revolution (see Jasanoff, 2019).

We assert that the generation and capture of agricultural big data becomes a biopolitical calculation of "make bloom and let wither." More-than-human populations are entangled with capital-intensive devices of digital agriculture, deployed to "make bloom" certain monoculture crops and "let wither" other plant species (see Bronson 2020). Further, the biopolitical management of agricultural production systems is unevenly deployed throughout the planet's agrarian spaces (Hetherington, 2020; Fraser, 2019). Research shows that the high cost of many AI-based PA technologies is a known barrier to adoption among farmers (Gardezi and Bronson, 2019; Reichardt and Jürgens 2009), which disproportionately affects smaller operations that are already more vulnerable to financial risk. Agricultural tech companies develop the software and devices with data selection methods that establish algorithmic biases for largeholding farmers with a 'productivist' strategy growing cash crops across vast acreage, enabling novel opportunities for elite capture (Bronson and Knezevic, 2019). The reverse outcome of a biopolitical mechanism designed to "make live by making bloom" unfolds for users disadvantaged by algorithmic biases or intellectual property rights (Carolan, 2017; Bronson and Knezevic, 2019). Through blocked access or bias, a fate of "let die by letting wither" may transpire because "their [agrarian] labour is surplus in relation to its utility for capital" (Li, 2010: 68). Ironically, such widespread withering would exacerbate the world's marginal producers' vulnerabilities to climate-related food insecurities (Turhan et al, 2015). Controlling our interactions with nature through the uneven subjectification and commodification of life through digital abstraction and valuation becomes an existential imperative to secure the food supply against the crisis of climate change; PA can maximize capital accumulation and sustain geopolitical power relations in perpetuity through food production systems. Hence, biopower for the biosphere.

In this paper, we illuminate the biopolitical orbit and modalities of surveillance capitalism by examining the sociopolitical dimensions of PA interventions in the United States of America, focusing on heterogeneous production systems in South Dakota and Vermont. To do so, we rely on data gathered from focus group discussions and participant survey questionnaires of a diverse group of actors throughout the value chain of PA. Drawing on literature from political ecology, critical data studies and critical agrarian studies, we seek to advance debates on the asymmetrical power relations of PA and its (un)intended consequences for differently positioned actors throughout the value chain. As we demonstrate with this study, the accumulation strategies of PA restructure agrarian labor geographies. By conceptually integrating surveillance capitalism with biopolitics, we are able to situate PA within a deeper context of the extensification and intensification of digital architecture developed to open new frontiers of capital accumulation (present and future) and the broader stakes of widespread agricultural technology deployment as a 'smart' means of mitigating and adapting to climate change.

2. Methods and study areas

Fieldwork for this research was conducted in South Dakota and Vermont (USA) during Fall 2019 through a mixed methods approach that included focus group discussions ($n = 6$) and a follow-up participant survey ($n = 52$) involving diverse stakeholders in PA, including the following groups: 1) software and hardware developers, 2) state and field extension specialists, 2) non-profit agencies, 3) government agencies, 4) farmers (crop, livestock, dairy). We utilized a snowball sampling technique within groups, seeking to find actors with different agendas, goals, and perspectives. By conducting focus groups and surveys in two states, we were able to invite participants who represented different types of agriculture (e.g. corn and soybean versus diversified small crops) and different positions across different production systems in the US. South Dakota and Vermont are ideal locations to study the sociopolitical dimensions of PA because of their geographical and sociodemographic heterogeneity, as well as their diversity in food production systems. In terms of farm size, South Dakota contains a majority of medium and large-scale farms, whereas Vermont has a majority of small- and medium-scale farms (USDA NASS, 2012a; USDA NASS, 2012b). South Dakota farms largely produce commodity products (e.g. corn, soybean, wheat, sunflowers, beef) whereas Vermont farms often specialize in niche products (e.g. dairy, apples, honey, vegetables, sweet corn, maple syrup, Christmas trees) (Northeast Organic Farming Association, n.d.). Agriculture in South Dakota employs almost 30% of all jobs (South Dakota Ag Economic Contribution Study, 2014), whereas agriculture only accounts for 3.6% of the Vermont workforce (Agriculture in Vermont Highlights, n.d.). The disparities across the study sites enabled us to cast a wider net on perspectives of actors in the US food system whose livelihoods may be disrupted by PA interventions.

Focus group participants deliberated the risks and benefits of AI and machine learning algorithms for agronomic and financial decision-making in food production systems, the effectiveness of existing PA education, and how PA will impact rural communities and farms of different sizes. The focus group discussions were audio and video recorded and later transcribed along with unique codes for speaker name, affiliation and location of the workshop to ensure anonymity. Qualitative thematic coding was conducted to elicit in-depth reasoning for participants' responses using a repetitive inductive process that included coding for preliminary keywords (e.g. technology, security, labor) and organizing these keywords into broader themes (e.g. reconfiguration of labor arrangements, data dispossession). Participant surveys focused on gauging respondents' concerns or optimism of PA technologies. Quantitative survey data was numerically coded and then analyzed through standard descriptive and non-inferential statistical techniques.

3. Results

Agritech's grabbing of farmer and farm data is consolidating and homogenizing food production systems. A university extension worker in Vermont described PA as predominantly catering to large monoculture crops (e.g. corn, soybean): "I think one of the really big questions that comes up in my mind is *what are these tools being developed in order to optimize?* Most of the technological progress that we've seen in agriculture over the last century has been optimizing monoculture, optimizing commodity production, optimizing larger farms." PA developers choose to collect specific agronomic and environmental data for PA tools (e.g. big data, algorithms, decision support systems). These decisions are neither value-neutral nor without implications and grave consequences for food production systems and their more-than-human actors (Winner, 1986; Crawford and Boyd, 2012). Such choices determine which aspect of society and the environment are monitored and managed and which ones are not; *make bloom and let wither.* The mechanisms of biopower were identified by a PA hardware developer in Vermont: "In the industry, we're seeing, sort of, call it 'consolidation,' or monoculture emerging in the technologies as well. So, you know, row crops are the first target for precision ag because you have a ton of land you can manage all with the same method, all have the same big data set, to learn about it. And the small producers or the diverse producers are left out because it's not an attractive economic target. But it also reduces the resiliency to have people like John Deere or Monsanto or Syngenta, you know, playing such a large role in controlling so much production." An extension agent from Vermont echoed these concerns of corporate consolidation: "All of a sudden, all the best land gets concentrated in very few hands because they know the information of every sinkhole, they know every highly nutritious soil type."

PA technologies are exacerbating socioeconomic divides between commodity and specialty crop producers. A member of an agriculture NGO in Vermont highlighted how the technology sector may further reduce ecological diversity by prioritizing development of PA for certain types of fruits (e.g. strawberry) to reduce labor costs by replacing seasonal migrant labor at the expense of specialty crops (e.g. saffron, gooseberries): "In the last six months, there has been a National Geographic and the New Yorker special on the millions of dollars they have spent to replace workers in the strawberry fields, but what about the rest of the specialty crop area which gets nothing and falls into disuse and declines? That's what's happening with our agriculture, we're losing. That puts us at a competitive disadvantage with these specialty crops. If we could get climate change funded, we could learn a lot about how to grow them in a changing climate."

Writ large, PA assemblages enable new frontiers of capital accumulation through the digitization of information and the algorithmic entanglement of food production systems. A PA technology developer from a midwestern state imagined a world where it was possible to produce accurate PA software through mining a great quantity of data points at ever finer spatial scales: With high-intensity collection of field-level data, "…we were able to measure, in some reasonable square footage—probably every 10 square feet or whatever, maybe up to 100 square feet—poke-soil test in every single one of those plots on the field." This will further extend agritech corporations' ability to mine farmers' information as raw data in the hopes of packaging, predicting, and shaping their future behaviors and selling products.

Respondents across Vermont and South Dakota provided unique insights into their experiences, perceptions and governmental responses to PA's mechanisms of surveillance within the biopolitical mission of species and food systems optimization. Focus group participants discussed several concerns about data grabbing, including "who owns the data and who benefits from the data and how" (extension agent from Vermont). Specifically, participants were concerned with how private corporations and state agencies are accessing, collecting, and capturing data that 'belonged to the farmer.' An academic from Vermont linked the farmers' lack of access to data generated to the economic viability of the food production system: "I find it problematic that if I buy a John Deere piece of equipment and I generate a boat-load of data driving my field, my crops that I harvest, with my inputs that I cover, that I don't get that data without permission and access. And then that defines my degree of success." Most farmers in this study willingly consented to the harvesting of data by agritech by signing user agreements, adding complexity to their affectations to data grabbing. Although options are emerging for farmers who do not wish to enter user agreements with agritech firms, focus group participants were not using open source PA technologies. However, they were interested in implementing measures to ensure the data sovereignty of agritech technology users. According to an extension agent from Vermont, "…empowering people with the data would be extremely powerful in that landscape" because farmers would know where to put "the maximum amount of my purchase power or not to." Yet data sovereignty is anathema to agritech, whose accumulation of capital necessitates proprietary exclusions.

Issues regarding data rights, privacy, misuse of information and the overall intentions of the agritech corporations and government entities were highlighted as serious impediments to building trust through interactions with technologies and their providers (Fig. 3). In the focus groups, some participants highlighted that giving agritech corporations access to farm-level data for many users could enhance corporations' ability to manipulate the market and prices for seed, chemicals and commodities. Results from the survey show that 65% of respondents agreed or strongly agreed with the following statement: *Farmers are concerned that corporations will use data for their benefit and not farmers'.* In response to this statement, a university extension agent in Vermont cautioned: "You know speculators get ahold of that data and it changes what you're going to get when you go to market with your crop." Additionally, 78% of survey respondents agreed or strongly agreed with the following statement: *Farmers are concerned that corporations could use farmers' planting and harvest data to manipulate markets.* Big data enables agritech corporations to learn more about the farmers' use of inputs (e.g. chemical fertilizers, seeds, herbicides, pesticides) in order to manipulate prices accordingly. One farmer from South Dakota remarked how the lack of data ownership could annihilate farmers' economic bottom line: "…it's scarier in agriculture because it's not Target trying to sell you more diapers, it's all of a sudden your bottom line. If there's $1 sucked out of the market because a giant company with lots of money saw something coming before you did, that's hard."

Corporations' ability to provide data analytics depends not only on technical feats, such as higher quality data and more spatially explicit computational models, but also on how they frame their intentions to current and potential clients. For example, it may be more acceptable for PA to be framed as "augmenting farmers' observation and decision-making capacity" than simply replacing physical human bodies with robotics and machine learning algorithms. An academic from Vermont highlighted this phenomenon: "I think if the technology is seen as enhancing your observational skills as a farmer, then it's like, *Oh God, yeah, let me know. Let me let me bring that into my operations.* But if it is being seen as an extraction of information to which it goes to a citadel that I cannot access, then it seems as if this is a theft and a disempowerment." Concerns regarding trust, privacy, access and ownership of data are common in all endeavors of big data and AI (e.g.

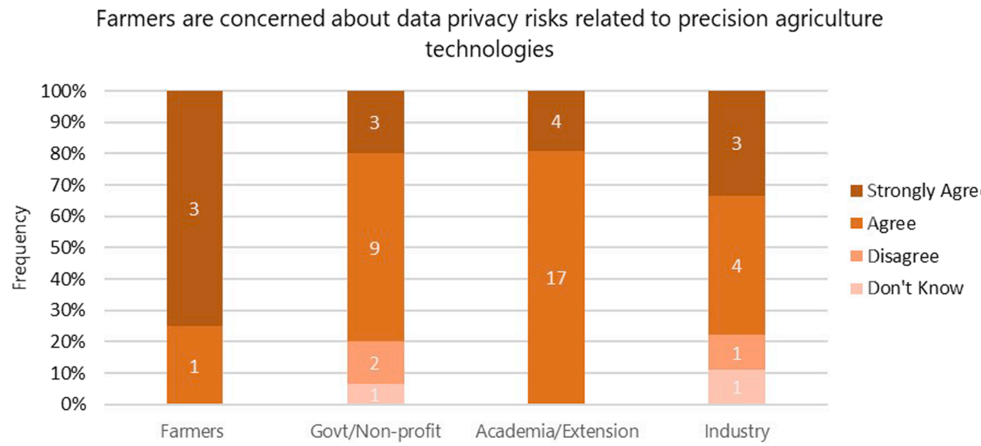

Fig. 3. Survey question gauging respondents' concerns about data privacy risks in precision agriculture.

autonomous vehicles, Blockchain technologies), but they assume urgency when food and agricultural security is at risk.

At present, US federal policy frameworks remain ill-equipped to govern the ever-expanding frontiers of AI. Executive Order 13859[1] aims to secure US hegemony in AI by ensuring the "sustained investment in AI R&D" and creating regulatory approaches that "reduce barriers to the use of AI technologies" (White House, 2019). Under this mandate, the Office of Management and Budget[2] has directed all federal agencies to "avoid a precautionary approach" to AI and "avoid regulatory or non-regulatory actions that needlessly hamper AI innovation and growth" (OMB, 2020). By advising all agencies and states against the regulation of technologies that fall within the category of AI (e.g. PA), the neoliberal state can enable agritech's sustained surveillance of grabbed data as an accumulation strategy with biopolitical applications for more-than-human populations within food production systems. Currently, VT and SD have no legislation to regulate AI technologies. The Vermont Artificial Intelligence Taskforce[3] held 15 meetings and 5 public hearings on responsible development and use of AI. In a final report that includes policy recommendations for the Vermont legislature, they conclude: "The Task Force does not recommend the promulgation of new, specific State regulations of A.I. at this time, however, the majority acknowledged that applications of A.I. are currently being regulated and that additional regulation will be needed in the future" (VT AI Task Force, 2020: 16). South Dakota has yet to launch a formal investigation into the development and use of AI. An extension agent in Vermont, concerned with ineffective AI policies, advocated for coordinated regulatory frameworks that protect the rights of users: "…we need a Bill of Rights, an AI Bill of Rights. You know, you need to have clarity around this and then there needs to be universal standards, global standards that are negotiated through treaties."

At multiple occasions during the focus group discussions, participants from all sectors provided examples of data privacy breaches. For example, the Cambridge Analytica scandal was quoted as something to avoid occurring in agriculture. Among all workshop participants, 66% agreed or strongly agreed with the survey question: *Farmers are concerned about data privacy risks related to precision agriculture technologies* (see Table 1). Survey data disaggregated by participants' primary work sector shows that 80% of the respondents from the industry agreed with the statement, compared with 100% of farmers and participants from academia and university extension. Another respondent from an agriculture NGO operating in South Dakota questioned the purpose of corporations collecting data and the values behind data grabbing: "Is this [data] going to be used just to sell more product? Or, you know, you were saying about fungicides, maybe we're going to make these recommendations based on the need to sell more product versus what's actually good for the farmer and for the farm. Do you trust an organization that you think is trying to sell you something even if maybe it is in your best interest, but how do you feel about if the purpose is trying to sell you something?" For other participants, the concern was whether the farmers would have to give up 'too much' privacy and data sovereignty in exchange for data analytics that can provide 'meaningful' recommendations. A farmer-academic from Vermont explained this dilemma: "Where is that line? I think it's a moving line. And that's what makes it so hard about this conversation, because I'm willing to give up a bunch of stuff to be more successful as a farmer. But I also don't want John Deere to sell my data. Just because they've done a bunch of remote sensing analysis. It's like, *excuse me, that's my property!"*

Despite widespread recognition and concern about data grabbing, focus group participants displayed a range of responses to agri-algorithmic subjectivities. Farmers are willing to take the risk of trusting machine intelligence based on the notion that technology can make correct recommendations only if it is implemented correctly. Thus, the onus of responsibility for technological excellence falls on the user (farmer) as well as on several confounding factors, such as a range of biophysical variables that intervene with social practices in various and intricate ways. A farmer from South Dakota briefly described this predicament: "So, there's too many weather, soil, all kinds of variables that always confound the data. You could make an argument that my yield map isn't right, my soil sample was not taken correctly, my remote sensing may not be true. Like, there's a reason to lack confidence [in these technologies], but at the same time, all those are very valuable if they're done correctly." Participants who questioned the trustworthiness of recommendations made by PA software and hardware gave examples of how they had to intervene to make decisions using their own expertise, representing a contestation of agri-algorithmic subjectivities. A farmer from South Dakota confessed: "When it came time to plant corn, I made a decision not based on data, not based on information. I

[1] On February 11th, 2019, US President Trump issued Executive Order 13859, "Maintaining American Leadership in Artificial Intelligence," 84 Fed. Reg. 3967 (February 14, 2019).

[2] As per OMB Memorandum M−21−06: "Federal agencies must avoid regulatory or non-regulatory actions that needlessly hamper AI innovation and growth. Where permitted by law, when deciding whether and how to regulate in an area that may affect AI applications, agencies should assess the effect of the potential regulation on Al innovation and growth. While narrowly tailored and evidence-based regulations that address specific and identifiable risks could provide an enabling environment for U.S. companies to maintain global competitiveness, agencies must avoid a precautionary approach that holds AI systems to an impossibly high standard such that society cannot enjoy their benefits and that could undermine America's position as the global leader in AI innovation" (OMB, 2020: 2).

[3] The Vermont Artificial Intelligence Task Force is a state-led AI task force and was established by No. Act 137 of 2018 and No. 61 of 2019.

Table 1
Summary statistics for the survey questions included in the analysis.

Survey question responses (1 = Strongly Disagree, 4 = Strongly Agree), *n* = 52						
Survey Item	Mode	Strongly Disagree (%)	Disagree (%)	Agree (%)	Strongly Agree (%)	Don't Know (%)
Precision farming technologies are only beneficial for big farms	2	23.08	50.0	15.38	1.92	0
Farmers are concerned about data privacy risks related to precision agriculture technologies	3	0	3.85	5.77	59.62	30.77
Farmers are concerned that corporations will use data for their benefit and not farmers'	3	0	3.85	5.77	59.62	30.77
Farmers are concerned that data from precision technologies could be used for regulatory purposes	3	7.69	7.69	50.0	34.62	7.69
Farmers are concerned that corporations could use farmers' planting and harvest data to manipulate markets	3	0	3.85	48.08	30.77	17.31

went with my gut. And instead of planting our typical 11–13,000 seed population, I went to 18,000. And then when it came time to put fertilizer on, I didn't go by what the soil samples said my area should have for fertilizer for our targeted corn yield. I put on an extra 100 units. So, while all my neighbors are super excited because they've had the best corn harvest they've ever had—120 to 130 [bushels]—I did 190 [bushels of corn]. I mean, that's something that no matter how the autonomy comes, that shoot-the-moon opportunity will be there."

In addition to data being legally enclosed as intellectual property, the proprietary logics that influence the creation of PA extend to modalities of repair. User agreements stipulate that users of PA technologies are prohibited from mechanically fixing or enhancing the technology and that all service to the technologies must be conducted by certified technicians. A software developer from Vermont provided insights into the logics of capital that undergird agritech's proprietary exclusions: "Our model is similar that you have to be a certified qualified tech to work on a robot…and a lot of that goes back to safety and proprietary, you know, investment, things that we've done that are secure." Agritech users who resented their inability to repair their own 'smart' machines (e.g. tractors) or learn about data collected by the machine are contesting their agri-algorithmic subjectivities by breaching contractual prohibitions, as explained by this farmer from Vermont: "If I got to go back to the company that I just spent $300,000 on buying their equipment to get permission to learn about my hogs, that is like, *really?* Now who wants to change a strut if I don't have to? But on the other hand, if changing the strut is going to enable me to work my system better, I can be more successful as a farmer." An academic from Vermont provided insights into future horizons of contestation between users and agritech: "…they say you can't tinker with it and change the oil, or do you want to figure out how to change the struts and do it yourself? There would be some resistance but seems like that may be coming down the pike as well."

Despite minor resistance to agri-algorithmic subjectivities of PA, most participants perform a green governmentality, acquiescing to the inevitability of big data and algorithmic rationality taking control and dominating agricultural activity at the farm or operations level (see Gardezi and Stock, 2021). This was evident in a conversation between three farmers from South Dakota: [Farmer 1]: "As much as I want us to stand up and scream freedom with liberty and I hate the idea of big data, I absolutely despise it as I sit here with my phone that is probably listening to everything that I said and I willingly put all my personal information into whatever website I have to in order to get the service or information that I want." [Farmer 2]: "You read the terms and conditions, don't you?" [Farmer 1]: "Oh, every one of them all the way down to the end." [Farmer 2]: "At the same time, you pretty much just accept that it's happening." [Farmer 3]: "There's not much we can do about it. It's going to happen. It scares me, but I don't know what I can do." Consenting to PA user agreements isn't always a conscious concession to perpetual data grabbing, but power asymmetries between firms and farmers can induce agri-algorithmic subjectivities fraught with fatalism.

A comment made by a crop and livestock farmer from South Dakota painted a dystopian picture of how PA technologies, such as big data and algorithms, exercise a governmental power where farmers internalize the external logics of PA, which allows agritech to actively surveil farms and farmers' identity and social practices for materializing profits: "Has anybody else read 1984? So here's the real difference between what actually happened the way it was projected in that book. In that book, the TV or the monitoring device that everyone had in their home, the government put it there. We buy our own and carry it with us. You know, how many times have you heard if power corrupts…then what about absolute power? And that's what big data is." In addition to exercising hegemony and producing governmental responses, different actors of the food system are concerned that the US government can collect and use the information against the farmers by levying regulations. Perhaps the strongest concern is from food system actors who worry that the availability of sensors and algorithms to process the remotely or in situ sensing data could be used to monitor how much pollutants are leaving farm fields and leaching into waterways and groundwater. In fact, 84% of participants agreed or strongly agreed with the statement. *Farmers are concerned that data from precision technologies could be used for regulatory purposes* (Table 1). Two-thirds of the respondents from the Government or NGOs agreed that data could be used for regulatory purposes (Fig. 4). One government representative from Vermont mentioned that "…a lot of farmers are thinking: Is this technology going to be used in the future to bring enforcement action against me?" As an actor of the state, his words give prophetic insight into how the neoliberal state (enabling agritech accumulation by dispossession) can surveil grabbed data to discipline farmers for hegemonic continuity of securing capital-intensive conventional agriculture as 'the future of food.'

4. Discussion

> "Surveillance capitalism is immune to the traditional reciprocities in which populations and capitalists needed one another for employment and consumption. In this new model, populations are targets of data extraction. This radical disembedding from the social is another aspect of surveillance capitalism's antidemocratic character. Under surveillance capitalism, democracy no longer functions as a means to prosperity; democracy threatens surveillance revenues" (Zuboff, 2015: 86).

Integrating foodscapes into cyberspace fissures nature-society relations in profound ways. Situated within the Green Revolution of the *longue durée*, agritech firms can exercise biopower through the surveillance of digital agriculture and the subjectification of more-than-human actors. Through PA, firms can extend their reach into rural spaces, inserting capitalist relations into the erstwhile nonexistent digital representations of a farming system. Agribusiness corporations' switch to surveilled sustainable agriculture as a way of sustaining profits necessitates the capture and representation of digitized human-environment information centered in landed property and labor (see Li, 2011). New

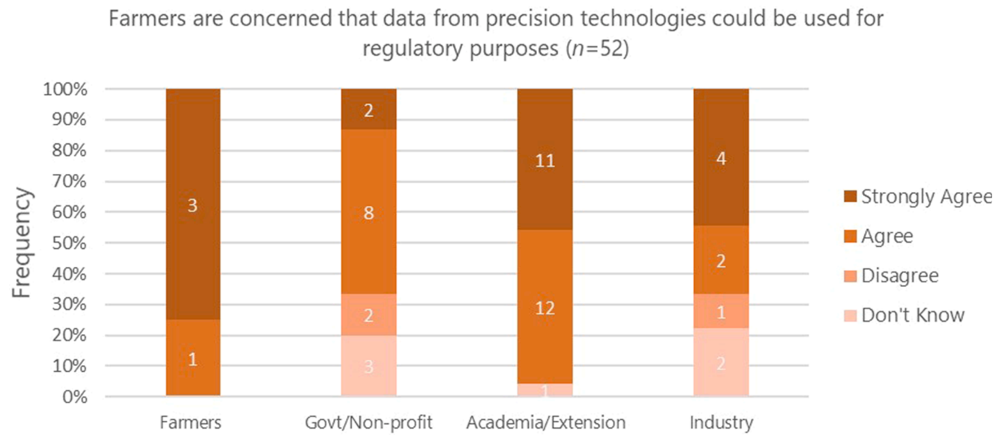

Fig. 4. Survey question gauging respondents' concerns about their data from precision agriculture technologies being used against them for regulatory purposes.

frontiers of agrarian cyberspace become privatized spaces of intellectual property, enclosures that virtually alienate producers from their data but still retain the biophysical property of the land itself, differentiating 'green' data grabbing from other forms of land grabbing that restructures food regimes (see McMichael, 2012; Cotula, 2012; Zoomers, 2010). Adding insult to injury, the artificially intelligent machines begin to replace the farmer.

PA is transforming labor geographies throughout the food production system. AI-assisted PA can be disruptive to the future of farm work and workers (President's Council of Advisors on Science and Technology, 2012; Erickson et al. 2018). The automation of farming through AI is displacing farm labor requirements (Carolan, 2019). Some farm work will be lost since the tasks can be more efficiently performed by machines. Previous social science research has shown that AI has the potential to disrupt not only mechanical work (e.g. moving heavy equipment) but also cognitive intelligence including thinking and feeling tasks (Rust and Maksimovic 2019). AI-based farm machinery can complete 'non-standardized' farming tasks (e.g. scouting for weeds, picking fruits and vegetables using machine vision) that were previously reserved for human workers (Marinoudi et al. 2019; Vougioukas 2019). AI can therefore reshape farmers' social identities by redefining what a farmer does and what it means to be one (Gardezi and Stock, 2021; Gardezi and Bronson 2019; Carolan 2017; Burton et al. 2012; Klerkx et al. 2019). For example, some farms can reduce up to 50% of labor costs by replacing human workers with automated orchard platforms that can use machine vision intelligence to harvest apples (Vougioukas 2019; Schupp et al, 2011; Growing Produce, 2014).

Surveillance capitalism's agrarian question demands we pay attention to the reconfiguration of labor arrangements, as well as the survival strategies and politics of farmers. Our study is generative towards theorizing the biopolitical machinations of surveillance capitalism for the agrarian question of labor. The focus groups in Vermont and South Dakota demonstrate that the heterogeneous technologies and modalities of PA trace the contours of extant social power, (re)producing winners and losers. According to Rotz et al (2019b: 119) "…it appears that the technophilic promise of agtech will likely displace existing agricultural labour hierarchies with a radically bifurcated labour market, where on the one side, highly-skilled, highly-trained workers use digital agricultural technologies to increase productivity and find evermore efficiencies, while on the other side, lower-skilled workers in the fields, greenhouses, processing plants and warehouses are subject to increased employer scrutiny and surveillance, further rationalization of their workplaces, and ever-escalating expectations of productivity." Despite PA's "make live by making bloom" biopolitical interventions, the potential risk of technological unemployment for already marginalized farm workers (e.g. undocumented immigrants) from AI-driven technologies is high, deepening their vulnerability to poverty, food insecurity and climate change (Weiler et al. 2017). In essence, "let die by letting wither."

The displacement of farm labor is predicated on creating new forms of digital labor. When agribusinesses enclose data-fertile virtual spaces, producers' agricultural labor is gradually rendered surplus to the reproduction of capital (Rotz et al, 2019b; see Li, 2010). As such, producers are partially proletarianized into *digital labourers* who are unremunerated for their work in generating data through their engagement with PA technologies (Rotz et al, 2019b: 117). One can conceptualize this as an exercise of surveillance capitalism's biopower to virtually "let die." Data is the new cash crop, yet not all equally enjoy this harvest. Farmers and users of the agritech assemblages of PA do not control the data being grabbed about their lives and livelihoods. If agribusiness corporations and the state truly strive for PA to secure food production against climatic changes, interventions must be rooted in principles of agrarian climate justice (Borras and Franco, 2018).

We assert that firms must extend access and ownership to users themselves, lest ignored cries for data sovereignty assemble into resistance movements that hack into precision agricultural systems and wield the data against the agribusiness purveyors of the landed 'green' data grab (Zoomers et al, 2016). Let to die, the digital laborers of surveillance capitalism will thwart PA's biopolitical withering and assert their own insurgent food politics (see Cavanagh and Benjaminsen, 2015). *Apropos* to resistance, "The challenge is to contest or *manipulate* PA with a view to achieving food sovereignty *without* contributing to the data grab" (Fraser, 2019: 907, emphasis in original). Farmers have begun to resist the surveillance and data capture of PA. For example, Carolan (2017) discusses the tactics of Farm Hack, a group dedicated to hacking proprietary agritech software and developing open source code and software as equitable alternatives. "Doing code together" becomes an affective resistance against digital alienation by automation from the means of production (Carolan, 2017; Carolan, 2019). Farmers contesting the proprietary exclusions of accessing their own data generated by PA systems presents an opportunity to pivot towards more equitable regulatory approaches (Keogh and Henry, 2016). Although not the focus of this paper, studying the heterogeneous modalities of resistance against the agritech sector promises to be a fruitful area of future PA research. Delivering data sovereignty to digital laborers demands a restructuring of the agrarian political economy and a redistribution of agritech capital; a farmer cannot survive on a diet of data alone. Thus, we echo Li's (2011: 282) clarion call: "…any program that robs rural people of their foothold on the land must be firmly rejected."

5. Conclusion

The automation of agriculture is discursively framed as a 'smart' innovation of sustainable agriculture, securing food systems against the climate crisis. Yet the assemblages of PA represent a biopolitical imperative to manage more-than-human populations by extending capitalist relations in agrarian spaces through new technologies of data surveillance, unencumbered by temporal limitations. PA's ability to generate and manipulate "big data does perhaps present an 'inward' turn of capital's spatial fix and a commodification of subjective experience" (Pickren, 2018: 234). Agritech companies engage in legally-protected data grabbing of users' information about their food production systems. Through engaging with the technological interfaces of PA, farmers' actions become digitized as preferences and behaviors, used by agritech companies to shape consumer behaviors. Agri-algorithmic subjectivity is performed and contested in these cyberspaces, producing new terrains of food politics and new neoliberal state-citizen relations.

In this paper, we explore the sociopolitical effects of PA, utilizing empirical data gleaned from focus groups and participant surveys with diverse actors throughout food production systems in South Dakota and Vermont. We conceptually integrate surveillance capitalism with biopolitics to situate PA within the broader political economy of industrial agriculture. In partial response to the agrarian question of labor, we analyze power relations, subjectivities, consequences and tactics of actors throughout PA's value chain. Agritech's virtually inexhaustible ability to harvest information about farm and farmer has altered local ecologies and reconfigured labor geographies. Enabled by the state through lax regulatory approaches and funding for research and development, the agritech firms of PA wield modalities of technological surveillance as an accumulation strategy with biopolitical provenance. Firms exercise hegemony over farm production systems and produce new agri-algorithmic subjectivities for users of PA, eliciting governmental responses where many farmers modify their conduct according to company logics. Repeating a South Dakotan farmer's insight into the process of governmentality in PA as a modality of surveillance capitalism is instructive here: "Has anybody else read 1984?…we buy our own [monitoring device] and carry it with us." Yet other farmers contest agri-algorithmic subjectivities by overriding the technology's prescribed indications and making decisions based on their 'gut' instincts.

The stakes of PA cannot be overstated. Differently positioned human actors of PA (e.g. technologists, users, bureaucrats) do not only dictate which data and technologies will be developed and used, but in this process, also carefully select which systems of crop production (e.g. grain crops, specialty crops) and labor configurations (e.g. migrant, seasonal) will prevail. This algorithmic entanglement of farm and farmer becomes a biopolitical calculus of "make bloom and let wither" for specific plant and pest species in the food production system. The asymmetrical power relations of PA become apparatuses of human population management for the reproduction of agritech capital, wherein "make live and let die" is determined through access to technologies, performance of subjectivities, and ability to financially afford system innovations. Yet withering the farmer to bloom food is neither a 'smart' nor sustainable approach to agriculture. The future of food is a political struggle waged in the cyberspace of foodscapes.

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