Received: 10 August 2022 | Accepted: 1 June 2023

DOI: 10.1111/soru.12445

Sociologia Ruralis Journal of the European Society for Rural Sociology

ESRS

ORIGINAL ARTICLE

Farmers who tinker: Grounded alternatives to incrementalism and the growth imperative

Matt Comi PhD[1,2]

[1]Department of Behavioral Sciences, Utah Valley University, Orem, Utah, USA

[2]National Farm Medicine Center, Marshfield Clinic Research Institute, Marshfield, Wisconsin, USA

Correspondence
Matt Comi PhD, Department of Behavioral Sciences, Utah Valley University, Orem, UT, USA.
Email: mattjcomi@gmail.com

Funding information
National Science Foundation's Science, Grant/Award Number: 1946941

Abstract

While hop yards have historically been small-acreage operations with high levels of infrastructure, North American hop growing has increasingly followed a neo-plantation model of high-acreage and high-automation farms. These large hop yards often have highly developed marketing and breeding components, and these growers' practices have reshaped the hop marketplace. Within this landscape are a scattered group of mostly small-to-medium-scale farmers who also grow this labour-intensive, high-cost, high-infrastructure agriculture good. These farmers eschew many of the normative methods employed by large-scale hop growing, breeding and marketing operations and instead *tinker* with inputs and infrastructure to improvise meaningful ways to maintain viability without growing larger. While many of these operations are medium-sized growers, their ability to rethink the growth model of agriculture by engaging in immediate-term on-farm innovation and *tinkering* solutions illustrates an alternative approach to *incrementalism* when considering stepwise solutions for improving financial and environmental sustainability in quality-focused fruit, vegetable and herb production in North America, Europe and elsewhere.

KEYWORDS
agriculture, environment, hops, sustainability, tinkering

INTRODUCTION

How do farmers negotiate technological change and market pressures on the farm? For many farmers, including those in this study, tinkering with inputs to produce immediate improvements and adaptations is a key strategy, with critical lessons for rural and agri-food researchers. Technological innovation in agriculture over the last half-century has become a contested and politicised domain that has been shown to often produce environmental and social harms in pursuit of immediate gains in productive capacity (Bronson, 2019; Esteva, 1996; Jasanoff, 2007; Kloppenburg, 1988). However, gains in farmer autonomy and involvement of large farmers as directors of breeding programmes and other technology innovations have resulted in case-specific gains in environmental adaptive capacity and farmer profitability (Comi, 2020b; Stock & Forney, 2014). Hop growers in the Yakima Valley are one such group that have directed their own breeding programmes and produced a more profitable and somewhat more environmentally resilient model for an agriculture of scale in their region (Comi, 2020b). This change has also had impacts on an industry that was previously dominated by small, low-earning farms obliged to sell on the global commodity market. While this new arrangement has many benefits, hop farmers' innovation show that farmer-directed involvement does not contravene many of the problematics involved in the neoliberal marketplace; most notably, farmer innovation in hop growing has exaggerated the already-dominant growth imperative in Amer-European agriculture (Legun et al., 2022).

Within this landscape, a small group of hop growers contravene this trend. Studying this group is a lesson in diversity of farming operations. In my results, I examine the governing values and material relations of a variety of these farms; specifically, I examine how farms 'tinker' with hop material and emphasise alternative values in the resulting hops to increase profitability on a hop market governed by novelty and aesthetic value. I also examine small farms that negotiate local relationships to carve out niche opportunities in a brewing segment with commitments to sustainability and locality. Below, I describe a tinkering framework situated in rural studies and science and technology studies cases, highlighting how tinkering approaches connect to environmental and rural considerations on sustainable transitions and incrementalism (Higgins et al., 2023). Then, after providing background framing for the hop industry as a whole, I highlight empirics from qualitative research with contemporary hop growers, focusing on a subset of tinkering hop farmers who rethink their agri-environmental worlds and re-value the materials they interact with to produce new farming opportunities that do not emphasise growth and do result in the opportunity for improvements to environmental outcomes. Finally, in the discussion and conclusion, I provide greater qualification, highlighting some of the shortcomings of these farmers while drawing out lessons for future research in sustainable agri-food transitions.

BACKGROUND

Tinkering: Small-scale innovation not incrementalism

Tinkering is a direct, social engagement in the material world to produce more augmented outcomes for the tinkerer. Tinkering is also an act of care (Mol et al., 2010). Tinkering is improvisational, local, specific and often small. Tinkering involves paired social and material interventions into the immediate technologies and arrangements with whom stakeholders (both humans and nonhumans) interact (Donati, 2019; Higgins et al., 2023). This process is relational and involves

direct relationships between implements, technologies, plants and other materials involved in the farm in the production of food and other agri-environmental outcomes/externalities (Alarcon et al., 2020). One central component of tinkering relationships is that plants and other actors involved in agriculture are the recipients of *care* and that *care* is produced by both affective and material action. This socio-material arrangement of care is the subject of widening discourse in agri-food studies on how care in agriculture settings (re)produces new outcomes and possibilities (Alarcon et al., 2020; Stock, 2016). Care, notably, is not an unfettered political good: As Martin et al. suggest, the contents of care, including 'affection, happiness, [and] attachment' (p. 719) are not neutral, and care can 'render a receiver powerless or otherwise limit their power' (Martin et al., 2015, p. 627). When we discuss tinkering, we do not discuss care applied to agriculture but rather *collaborative care* in the context of *material relations* in agriculture. This combination explains how positive outcomes from agriculture, including rural/agricultural pleasure, enjoyment, health outcomes and autonomy are possible for farmers, human rural inhabitants and a variety of nonhumans including plants and animals (Stock & Forney, 2014).

This study nests the concept of tinkering within the broader question of how socio-material *assemblages* of agriculture may be engaged with by people (e.g., farmers) in ways that do (or do not) support more sustainable outcomes (Bronson & Knezevic, 2016; Carolan, 2010; Comi, 2020a). Assemblages are sets of socio-material relationships that reproduce outcomes—they are flat and messy hierarchies that eschew traditional social science categorical domains (Deleuze & Guattari, 1987; Müller, 2015; Müller & Schurr, 2016). The material relations that form such assemblages are the flows by which tinkering interventions occur, and the approach explores how affective stances, like care, attention and intention occur from a materialist standpoint (Mol et al., 2010). When the farmers of this study *tinker*, they are improvising new material arrangements for the farms and markets with which they interact. By revising how they trellis, or whether they cover-crop, or by finding and saving wild hop bines or building their own hop picker, they are introducing and modifying the material actors in the agri-environmental assemblage and reshaping the relationships in their specific agricultural assemblage. This directive work involves care-level decisions—obliging farmers to make directive technical interventions based on their values (Alarcon et al., 2020). This has implications for other social science research on small farming operations, such as on grape growers for wine operations, who also have the freedom to improvise novel engagements with plant material on the farm (Alarcon et al., 2020; Parga Dans et al., 2019). It is not necessarily true that large farmers *cannot tinker*, and some of the farmers in this study do have fairly sizable operations. Rather, small farmers who lack systematic autonomy are more able to tinker and reshape the material arrangements in direct, *care-ful* and improvisational ways with greater consistency and success.

A range of literature examines farmers as actors in diverse socio-material landscapes who are engaged in (re)arranging assemblages of agriculture to produce new outcomes, possibilities and futures (Carolan, 2008; Darnhofer, 2020; Goodman, 2001). For example, Carolan's work comparing the ontological and material worlds of seed banks to the Seed Savers Exchange in Decorah, IA, reveals how diverging ontologies over what seeds are and how one should interact with them produces dynamic and alternate agri-environmental futures. Notably, by recognising that other materials are active in the system, the Seed Savers Exchanges collaborates with their own seed stock, maintaining lineages of seeds that are planted and replanted—undergoing subtle genetic variation that continues to adapt and respond to a range of environmental actors. Tinkerers on the farm are like the Seed Savers Exchanges, engaging with other actors on the farm, but these farmers are either unable or opt not to engage in politics of control within the agri-environmental assemblage.

Tinkering as applied to farmer-innovators also pushes forward a small but important thread of literature on farmer-inventors and farmer-innovators. Less has been done on the politics of farmer-driven innovation, but the body that exists highlights how scientific communities and agri-business interests have often ignored the innovations and open-source ethos of many farmer-inventors (Carolan, 2017b; O'Flynn et al., 2018; Shutes, 2003). While people are themselves, never entirely systematic, the tinkerers described in this study more intentionally engage in improvisation, drawing inputs and resources from heterodox sources. At times this means tinkerers draw on natural and applied plant science, but at other times chance their *en situ* knowledge prevails—meaning that the innovations of specific tinkering farmers as described in this article have not been widely adopted as standard practice and are unlikely to be adopted as standard practices—this is partially the point of tinkering solutions though—to produce situated and heterogeneous outcomes suited to particular problems in particular places.

The arrangement of tinkering contrasts with the material/social/economic arrangements indicative of neoliberalism. The latter flexibly take up materials, commodifies those materials and translates their value into a range of social worlds (Carolan, 2017a; Centeno & Cohen, 2012; Stock et al., 2014). It is well known that as with capitalist structures, this neoliberal model results in a growth imperative that emphasises unsustainable economic expansion and material extraction (Moore, 2017). This differentiation from a technocratic capital-focused approach to innovative systems changes sets tinkering approaches apart from the more top-down biological innovations imagined by eco-modernists over the last three decades (Asafu-Adjaye et al., 2015; Spaargaren, 1997). Instead of a theory for innovating our way out of ecological disaster—I suggest that tinkering shows how grassroots and grounded innovation developed by and for farmers and other stakeholders can be a useful 'tool in the toolbelt' when considering suites of policy and social alternatives for more just futures. Put differently, tinkering is one improvisational and immediate way a more sustainable future may be possible—but it is part of a diverse and heterodox field of innovations that encourage a more just future.

To better situate how tinkering contributes to a range of approaches for considering and working towards more socio-ecologically equal and sustainable futures, I place this concept in relation to the discourse and transitions. Troubling the growth imperative, production treadmills and seeking alternatives have been a core consideration in rural as well as environmental social science for the last 40 years (Alexander, 2020; Bronson, 2019; Buttel, 2016; Catton, 1980; Gould et al., 2016; Spaargaren, 1997). Exploring alternatives, ranging in scale, approach and style is a productive avenue for scholarly inquiry and the (re)consideration of what is possible, what works and what does not, from agro-ecology to degrowth, to 'smart' agriculture (Agrimonti et al., 2021; Alexander, 2020; Andrew, 2012; Callon, 2015; Cusworth et al., 2021; Kallis & March, 2015; Krüger et al., 2022; Saj et al., 2017). Stock and Szrot (2020) make the case that just food transitions, as a function of *justice*, are socio-politically bound up in care, whether conceptualised as stewardship or through directive action, which is an integral component in the development of more just and inclusive agri-environmental arrangements. Therefore, a consideration of the material interventions that couple care with ecologically embedded practices is essential for imagining sustainable transitions in food production, particularly in the US. Less so as an ideal type but rather because such a theoretical framing renders visible the practices of these farmers. Tinkering is one such practice that embeds growers in environments and experiments with other members of those local environments to maximise outcomes for local communities and practitioners.

Departing from the trend, differentiating kinds of hop farms in the US

Hop farms in a global sense are in flux, and in the US, the rapid concentration of hop farms is no such exception (Comi, 2020b; Cordle, 2011). Calling one kind of hop farming a norm is a contestable statement. For the purposes of this article, I look at hop farmers who depart from a major trend towards concentration and growth in the US in some sense. Because a small number of farmers are responsible for this large amount of production in the US, I avoid referring to these growers as the norm. Rather, I consider this as a trend towards concentration in farming operations and plantation-style agriculture techniques. Those who grow small farms are necessarily *resisting* a marketplace increasingly concentrated in fewer growers' hands.

While over 70 operations report area harvested for hops, only 52 growers are registered with the Washington Hop Growers Commission, and large growers estimate that less than 40 farmers make up over 90% of the state's total production, which accounts for upwards of 70% of the total annual US output by acreage (USDA-NASS, 2020). Other states reflect this trend, with large growers in Idaho and Michigan reporting that less than nine and only two large operations make up the lion's share of those states' production, respectively. Many of these small reporting operations are relatively young, for example, in Washington state, less than 40 operations were reporting hop acres cultivated in 2003 (USDA-NASS, 2020). Every small operation (< 10 acres) interviewed during this study was less than 10 years old. Because of their short tenure in the growing community, evidence of long-term viability/sustainability is difficult to assess. However, how these young and small growers engage with (re)imagining local hop foodways and market value remain an interesting case example in searching for sustainability as a small farmer.

Large hop farmers in the US have altered global hoping growing practices. Yakima Valley growers have concentrated not just on the acreage of their farms but have also tended towards vertical integration—with many growers having ownership stakes in hop breeding or hop merchant companies (Comi, 2020b; Legun et al., 2022). This allows these large farmers to exert a remarkable amount of power over the hop material that gets selected at the research and development stage alongside the eventual hop flowers that are selected at the brewer side. The large marketing apparatuses controlled by these farmers help identify and define the chemical compounds that brewers use to assess the flavour and offer the qualitative tasting assessments to promote new varietals, build interest in large-acreage and profitable varieties and reduce and divert interest from varieties that these growers feel have become redundant, underproductive or less worthwhile than other hops.

Framing tinkering: Regenerative agriculture, Agriculture 4.0 and sustainable transitions

As in the US, the need for resilient, adaptive and sustainable agriculture practices is becoming clear around the globe. Moreso than in the US, a robust conversation in Europe has developed, including practitioners, policymakers and scholars, on the character and direction of sustainable transitions in agriculture. One result is a proliferation of categories for sustainable practices, many of which are then adopted or shared by the nascent discussions of these same practices in North America and elsewhere. Concepts like regenerative agriculture, resilient agriculture, Agriculture 4.0, agro-ecology and climate-smart agriculture have received increasing cachet over the last 10 years (Buitenhuis et al., 2022; Charatsari et al., 2022; Giller et al., 2021; Gordon et al., 2022; Landers

et al., 2021; Schulte et al., 2022). Of these, regenerative agriculture and Agriculture 4.0, which both refer to suites of technologies and practices, have particular relevance to this study.

In the below results, 'tinkering' farmers are shown experimenting with regenerative agricultural practices. However, more central than the links to one particular target practice, tinkering is here framed as a practice in transition—highlighting that policy interventions common in these discourses often struggle to consider pathways between the so-called 'conventional' agriculture and the many 'alternative' agricultures needed for a warming planet (Ibrahim & Johansson, 2021; Knook et al., 2022; Landers et al., 2021). Reconsidering pathways for sustainable transitions is key in European contexts where such discourses have cachet in policy circles. I suggest that this US example of farmer practices offers grounded insights into how pressures and responses deployed by small farmers have lessons for how to support alternative agriculture, much in the vein of those who have conducted research with small farmers and woman farmers in the UK, Sweden, Australia and elsewhere (Bryant, 2022; Cusworth et al., 2021; Smith, 2022; Varga, 2017).

METHODS

This project uses mixed qualitative methods with 22 total participants, including on-site interviews that include on-farm observation and in-person interviews ($n = 16$) who identify as (one of) the primary decision-maker(s) for hop-growing operations. Further research using distance methods due to the Covid-19 pandemic targeted key growers in other markets outside of Yakima ($n = 6$, total $n = 22$). These participants' inclusion was limited to interviews only because of health concerns. Because these operations range in size and scope, these individuals were usually either owners or employed/contract hop-yard managers (or both). This group of participants includes a significant segment ($n = 14$) of hop growers in the largest hop-growing region of the US, the Yakima Valley, where roughly 40 large growers produce over 30% of the globe's total annual hops by acre. This inquiry, however, relies primarily on another subset of diverging experiences of outlying participants ($n = 9$) who do not grow in this region and/or whose methods do not conform to the prevailing model for hops growing as laid out in recent research on the contemporary hop-growing industry (Comi, 2020b). Data used in the empirics include interview transcripts, field notes and photographs. Quotes deployed in the results are from recorded interview transcripts, while photos and additional details are drawn from field notes.

Participants for this study were identified through their affiliation with either the Washington hop growers' association roles or through publically available web presences in their respective states. The researcher contacted every member of the Washington hop commission grower's roles at least once to request their participation in this study, along with every grower for which contact information could be identified by the researcher in Michigan, Iowa, Nebraska and Kansas. An additional out-of-Washington grower, who the researcher was referred to by several participants, was also interviewed. Because hop growing is a highly concentrated industry with few growers and because this study presents findings on growers who diverge from the norm, a complete table or additional information is not reproduced in this method in order to protect the anonymity of participants. All participants recruited through this research were informed of the project goals and consented to participate in the research. Participants for distance and in-person interviews were interviewed using the same open-ended interview guide, and in-person interviews included a day of observations on the farm site, which were documented through photographs and field notes but were not recorded. This process was approved and overseen by the University of Kansas Institution Review Board (IRB# STUDY00143772).

I take an exploratory approach to these data that emphasise *gathering* over *sorting* (Law, 2004) and aim to describe the multiplicity of socio-material arrangements outlined by these farmers' experiences. Questions and 'themes' used in the interview guide focused on farmers describing the material processes on their farm—emphasising what they do and make when— and this avoids presupposing particular values or hierarchies, though the researcher often followed up with additional questions when participants introduced these issues. Because these data report on farmers who diverge from the norms, and by necessity do so *differently* from one another, these themes are not the result of triangulated outcomes. Like all exploratory research, these themes are not to be treated as empirical proofs but rather empirical provocations: evidence from specific cases that demonstrate social phenomena.

Findings

These findings are reported in three sections. In "Tinkering on a tiny farm", I outline how small farmers tinker with their infrastructure, tools and implements—I show how these ultimately technical engagements with material actors re-shape outcomes for these farmers and result in a wider range of financial autonomy. Then, in "Finding free hops and new soil…" I outline how small and medium farmers tinker by identifying, describing and re-imagining the meanings of wild-found hop varieties and use this to produce a market niche with brewers. This action is compared to the programmatic farmer-driven breeding programmes of large Yakima growers, such as Hop Breeding Company (HBC) and is shown to be a useful example of plant–human tinkering relationships. Building on this, in "Tinkering on medium and large farms…" I outline how medium-size farmers in the Northwest and some large farms are engaged with rethinking how plants and agro-ecosystem health is assessed. Using the case example of Sap Analysis, a newly popular technique that is growing in popularity among a small group of hop growers as an alternative to petiole analysis, farmers try to more responsively adjust soil nutrition. I show how sap analysis operates as yet another plant–human tinkering relationship that results in more beneficial agri-environmental outcomes.

When you cannot afford a hop picker you build one: Tinkering on a tiny farm

Tinkering is a complex task. It involves improvising with the material world in a collaborative way: responding to immediate problems to care for the participants that surround an actor. One of the most obvious ways that small farmers in this study *tinker* is through modifying, building and rethinking the on-farm implements and infrastructure required for hop growing. Because hop-growing infrastructure is expensive both as an initial investment and in continued upkeep and petroleum costs, small hop farmers can accrue significant financial benefits by identifying and pursuing alternative infrastructure solutions. This has led some small hop farmers to DIY solutions for otherwise expensive materials. Patrick, for example, is starting a small two-acre operation in Eastern Washington, outside of the primary Yakima Valley growing region. Without a real deal on a used hop picker available to him, he found the pricing of new pickers or competitively priced out-of-town used pickers to be unsustainable financially. Instead, he opted to build his own picker (see Figure 1)—an approach he has used with much of his infrastructure from his micro-kiln to his home-modified pelletiser and harvesting stand.

FIGURE 1 Homemade Hop Picker, Patrick removes plywood cover to show interior picking teeth and belt mechanisms. Manufactured hop pickers for 10 acres or less often cost ~$10,000 and up. Patrick reports building this picker for less than $1500.

FIGURE 2 Trellis made from unfinished, felled lumber. This row of hops is a 'wild' variety found in the Palouse Hills and propagated by the growers Hannah and Jason.

Tinkering may also involve the repurposing of other goods—as with Patrick's operation, startup costs are a large inhibiting factor for other small growers; Hannah and Jason address some of this startup cost issue by forgoing telephone pole trellising and logging their own trellis (see Figure 2). Hannah and Jason did not rely on home-built implements like Patrick and were able to find inexpensive pelletiser and contract picking services. This mirrors Levi who also found

secondhand small hop equipment well below the market value. For all three of these growers, one key commonality is that the hop field is not currently their primary source of income. Patrick and Cheryl envision their hop field as a retirement hobby. Turning a profit is important but only as a subsidiary income—Patrick notes that if they do not turn a profit in 5 years, he plans to quit.

> I think for at least 5 years, and if we can't make a profit, I'm going to sell it or lease it because my back's starting to go bad, and I don't have [good] health. It's so painful. I can't explain how painful it is to go out [crosstalk 00:16:01] back and do that stuff that has to be done, and I'm not getting it all done, but it's starting to happen. It's slowly coming and people find out about you slowly. And it takes 3 years for the hop to be matured in the first place. So last year was our third year, and we had our first sales. (Patrick)

Floyd also operates a brewery and fruit farm. Their hops function as a brewery-supporting experiment more than a particularly profitable endeavour. Hannah and Jason do claim they hope for this to become a primary part of their income, but this remains aspirational. Like many small growers, there is a time limit on this endeavour, and each of these three operations faces significant obstacles to achieve their goal of long-term sustainability. This is particularly true as they try to responsively adapt to market demands for the local brewers they seek to supply.

For these small farms, tinkering with infrastructure is a method to provide local goods at a low cost. This responsive involvement on the farm is a method for being able to provide responsive market-service arrangements. Many small growers see their niche as being able to provide a high level of service to local small brewers that do not have access to direct-to-grower contracts elsewhere in Yakima or high levels of influence over merchant company sales desks.

> One of the biggest things was with the brewers here, they're smaller brewers, right? So one of them had a contract with Yakima. They're the only big enough to do that. So the other ones just buy on the spot market. They don't always get what they want and that's kind of what triggered a lot of this too. One of the brewers said he ordered something, he was going to Yakima to pick it up. And they called him when he was driving there and said, 'We don't have your hop anymore. We have this one if you want that'. And I go, 'Aren't you guys… You kind of base your beers off what kind of hops you're getting, right?' And he was like, 'Well yeah'. And I said, 'So you really get dumped on, you get hops, whatever you can get'. And they're like, 'Yeah, that's how it is'. I said, 'So what if we grow you what you want every year on a smaller scale?' (Hanna)

By staying small, these growers aspire to offer a more flexible kind of growing arrangement. However, these small growers continue to face difficulties arising from high labour and financial costs associated with perennial plants even after accounting for cost-lowering with tinkering solutions. Additionally, while they may be responsive in many ways to local growers' needs, they struggle to produce desirable hops for the ever-changing craft beer marketplace. This requires a second kind of tinkering, one that occurs with and between members of the agri-environmental landscape as well as at the mechanical and technological level.

Finding free hops and new soil: Tinkering with what you grow on small and medium farms

> We're competing against fifth and sixth-generation farms that have been growing since the Civil War and things like that. So, although we can't match them on price, we're trying to figure out other ways that we can stand out or be alluring. Yeah. I mean, we're really focusing on our brand, all of our graphic design work, and then trying to figure out different ways that we can offer our products. So, the Kanook rebranding, which people do the same thing in Michigan, they call it Michigan Chinook or whatever, but for us, the biggest issue was not wanting to grow something and then delivering it to a brewer thinking that they were going to get traditional Chinook, so we just put a little twist on it just to kind of display that it's a little bit different when grown here in Kansas. (Wade)

Large farms in the Yakima Valley control over 70% of US hop acres and are both historical hop-growing entities and at the vanguard of hop-growing trends and new techniques in the industry (Comi, 2020d; Larsen, 2016). How to compete against these vertically integrated growers who also involve themselves in the co-production of taste and desirability in the brewing industry is a vital problem for small, local and/or emerging growers trying to carve a niche in an industry transitioning from conventional commodity dynamics to craft desirability dynamics. Wade responds to this by seeking unused, sometimes public, varieties that can be (re)branded. He describes that regional differences between the US Midwest and US Northwest produce predictable variations in the aroma profiles of other varieties, especially the popular public variety Chinook. Like big brewers and breeders who simultaneously produce a brand along with a new genetic profile, this small brewer skips over the new genetic profile and instead uses branding to make a compact container for local, unique hop aroma profiles singular to their isolated Midwestern hop farm—a variety they call Kanook (a conflation of Chinook and Kansas).

This farm has likewise explored unique public varieties such as southern Brewer and wild *neomexicanus* varieties (which are the source of many popular new aroma varieties, such as HBC's recent release of Sabro).

> Okay. So, Southern Brewer…was a pretty low-yielding plant…we decided to rip that out after, I think, 3 years. Then the other *neomexicanus* varieties, native to the Southwestern US, mostly grown in New Mexico, kind of at really high elevations, 7000 or 8000 feet, traditionally found growing in the wild kind of alongside creek beds. So, obviously, here in Kansas, completely different growing environment, much lower latitude, heavy clay soils here, and tried to do that for about 3 years, 2 or 3 years on those, got some really cool harsh citrus notes out of those varieties. One was more kind of lemon-lime. The other one was more like orange and grapefruit. Just the same as the Southern Brewer, it just didn't yield very well…From an agronomic standpoint, they were really hard to grow for us, so ended up pulling those out as well. [Wade]

Regional differentiation produces obstacles as well as opportunities. It foreclosed this Midwestern farmer from accessing a genetic lineage of wild hops that has been a profitable avenue for other growers seeking fruity flavours in their hop output that are desirable for craft beer applications.

It also produces potential benefits. The branding of Kanook is a way to tinker with the wide and complex interaction of soil chemistries and plants to quantify the resulting flavour or terroir. This practice is common among many local growers seeking to carve out a niche in the craft beer market whose demand for hops is often linked to novelty and flavour compounds more than locality or regionalism.

> Hannah: It's a low soil. We've dug down 5 feet, and we haven't hit a rock yet. So we have just… It's pure soil, no rock, very filled with nutrients. I mean it's a good quality soil and I think that's what Walla Walla is touted for. It's well known for our soil here.
>
> Jason: Yeah, that's our slogan. It's all about the dirt. That's kind of what we're setting ourselves apart from Yakima in our soil is…
>
> Hannah: And with the soil and stuff, we're hoping we get to see a little… Everybody touts the grapes and the terroir where they're growing this stuff. So I've read a couple articles on… People have written about the hops in terroir, and so we're hoping we get to see a little different results from our area than other people do. And even in our, I believe it's in Tettnang, we had some higher alpha readings then what's normal.

This husband-and-wife operation seeks to maintain relationships with local brewers in a way that mimics Southern Washington's relationships between vineyards and vintners. These relationships are more tightly connected than hop growers are to individual beer makers. Often, growers may also be winemakers, and in cases where growers contract with winemakers, the relationships are often more tightly maintained and long-term. This is somewhat more intuitive in wine, an industry where taste is culturally linked to terroir, tradition and consistency more than novelty—as the hops industry has become over the last 10 years of craft beer innovation and growth. Hannah and Jason seek to alter this trend in a local sense—tinkering both with what genetic lineages they plant and with the market-end relationships they sell to by investing in 'terroir' and by identifying novel ways of integrating brewer investment in the farming operation, borrowing in this case from agritourism and winery contracts to market brewers' local investment in small hop-growing operations

> Hannah: I'll always give you [the brewers] what you want. And so that's kind of how that all start too. So end of the day, brewers picked out what we planted.
>
> Jason: Well, and it's similar in the vineyards, the wineries will have their name on a row. And so granted, we're not big enough to have a name of a brewery for a whole row.
>
> Hannah: Well that's our plan.
>
> Jason: Yeah, they know that that's theirs.
>
> Hannah: One row is going to go to two breweries, we'll have both their names on the post. So all our posts will eventually have all the breweries…
>
> Jason: And they can come out anytime and check on them

> Hannah: Yeah, because they want to come out too so they can bring people and be like, 'Hey, here's our rows and here's our…'. That's how the vines are treated in the wine scene. And everybody loves that. So I want to do that, and it's not done anywhere else that we know of, so.

Tinkering with what you grow is in many ways the simplest kind of on-farm modification a grower can make—but in this case, the practice is complex. Small growers are tasked with something of an impossible demand—taste drives the craft beer hop selection process and unlike wine grapes where taste is assessed by long-held ideals about the quality that largely centre on history, consistency and terroir—hops are assessed for novelty, creativity and rarity. This approach that favours either the trendy popularity of well-known new varieties or the cachet of novel relatively unknown varieties presents a problem for small growers of an expensive perennial plant. While hop growers might be able to be immediately responsive to brewer's self-assessments for demand, most brewers are hesitant to enter into long-term contracts, and without such backing, brewers are likely to adjust their demand for particular hops between years and even within years—this presents a real difficulty to growers. Hannah and Jason are attempting to reshape an aesthetic valuation by tinkering with what they grow and how the aesthetics of their hops are assessed: They are trying to convince brewers to consider terroir, locality and ownership as important attributes that supersede novelty. In this way, they tinker with what they grow as well as how that product is assessed, and the cultural values that inform their hops.

> Hannah: We gave them a list of what we could source, and we said, 'Here's what we can do. You tell us what you want'. So that's kind of another unique thing where, same with the second acre we said, 'Hey, here's what we can get. You tell us what you want'.
>
> Jason: Yeah, we want to sell out. That's our goal is to…
>
> Jason: Basically your small, I'm small, we could do this.

Tinkering with hops is a practice on larger farms as well; Karly and Kyle run a larger Yakima farm and run smaller informal breeding programme or contract with breeders elsewhere to produce experimental crosses. This small farm is the original grower of El Dorado, which is technically an 'open' unpatented variety that arose as part of a portfolio of hop varieties this grower maintains.

> We have a… I don't know, what I would say is a breeding-like program, and so, we worked with a couple of different people. It's a variety we had. There's lots of different varieties out there that are fairly easy to acquire. So, it's a variety we had since 1998, but we just kept it kind of in the background. It was meant to also be an alpha variety… And so, when the craft came, we just brought it forth because we knew it had unique aromas.(Kyle)

Craft beer is a quickly changing marketplace, however, and growers who do not have systematic breeding programmes often seek alternative methods for maintaining relevance with a buyership whose aesthetic for taste has largely been driven by a sense of novelty in the last 10 years. To identify and maintain control over potential new varieties, this grower has to keep El Dorado

alternatives on hand. They work with contract breeders and catalogers to keep a portfolio of potential new varieties viable so they can identify and grow 'the next thing'.

> We have a large *neomexicanus* collection, which is a different species, actually. And so, we worked with a gentleman down… in New Mexico, and bought his whole collection. He had 80 different unique varieties. So, we have a bunch of those in the wings, we have several others that we could bring forth; recently, there's lots of private breeders that have shown up. We're working with a private breeder out of San Diego that's doing some crosses for us, as well. So, we don't have a big standalone breeding programme, no, but we have access to new varieties. And so, at this point, the growth of El Dorado and some of our *neomexicanus* is kind of more than we can almost sustain at this point. So, we're really trying to just focus on those, you know? (Kyle)

This kind of tinkering emphasises materialist components of the relationships, highlighting how the identification and in/exclusion of particular things are key in-the-field considerations with down-the-line impacts on the kind, character and economic profitability of agricultural arrangements.

Tinkering on medium and large farms: The case of sap analysis and regenerative agriculture

Tinkering is small—an effort of care—but it is not exclusive to small farms. Medium and large farms in Yakima and elsewhere borrow care-based modes of restructuring socio-material relationships to produce more financially and environmentally sustainable outcomes that free actors in the agri-environmental assemblage. One grower I spoke to operates a mid-sized (less than 1000 acre) hop-growing operation in Idaho and has sought to improve their long-term sustainability in both financial and environmental sense by tinkering with a variety of growing techniques ranging from cover-cropping and inter-grazing along with other regenerative agriculture techniques as well as through the marketing of wild hop varieties and smarter methods for testing nutrition and plant health. One space where these farmers *tinker* is by rethinking their primary way of testing plant health. Industry norms for plant health testing involve petiole sampling; however, these growers identify jokingly as being part of a 'secret club' of growers who believe that sap analysis provides a more accurate sampling of what is actually moving in the plant and what farming decisions need to be made to improve plant health more immediately. Another large farmer who is considering switching from primarily petiole sampling to sap sampling reports:

> I think we're trying to decide whether tissue or sap makes more sense. I'm kind of the opinion to say sap makes more sense, but we need more data points to make that… Intuitively, it's a better representation of what's flowing in the plants: I don't want to look at a sink I want to look at what is actively happening, what is actually flowing in the plant. Because a sink can be misleading. you might have 5% nitrogen in a leaf that's accumulated but that doesn't tell you like you know what is actually moving in the plant. So tissue analysis could tell you you are fine, but you could be deficient in the sap movement. (George)

This large farmer sees sap analysis as a different, more precise way to 'know' their plant which in this case more accurately considers the plant's dynamic positionality as a living organism that is responsive, adaptive and active. To borrow a term, sap analysis could be described as an approach that *cares* about hopbine's *plantiness* (Head & Atchison, 2016; Head et al., 2014). A different farming operation that promotes sap analysis saw this approach of tinkering with how they 'know' their plants as part of a larger rethinking of their farming operation. They operate a larger farm (one of the largest in Idaho but mid-sized by Yakima Valley standards), they are women-operated and have academic and professional training in regenerative agriculture practices, which they bring to their farm. Notably, this approach emphasises farming better, with long-term sustainability in mind and diverse profit-making as an outcome instead of short-term growth as an immediate goal.

> Yeah. Well, another thing too that we started doing … My sister, Sam, went to graduate school for plant and soil science at Colorado State in Fort Collins. That's where they have their main ag campus. And at that, she took a bunch of courses on regenerative ag just because that was one of the focuses that we knew, coming in, with her coming back to the farm, we wanted to start to pursue. We just didn't know what we were doing at all. She recommended a book by Gabe Brown called *Dirt to Soil* and I read that. And then years go by, whatever, they actually put on a Soil Academy, Gabe and his fellow colleagues in the same field. We went to that last December. And we had already been doing cover-cropping and had already had some direction in that, but it really helped us to figure out what we needed to do and how to do it, gave us the right tools and mindset. (Susan)

Starting cover-cropping, switching to organics for pest control and fertiliser or producing grazing plans is a complex task on any size farm, and it requires a distributed network of actors to enable this kind of 'tinkering' approach. Complexity as an obstacle arises as the tinkering approach gets scaled up—while this is a difficulty, in one sense, it provides a range of opportunities for those able to leverage local resources to develop a strong team that enables regenerative agriculture or de-growth alternatives in their farming models.

> In the Soil Academy, they talk about sap as well and how it works and why you should do it. And with that arsenal of knowledge, we just found our fertiliser company or chemical company, Simplot, here. We contacted them and were like, 'Hey, this is the direction we want to go. You guys have tons of organic products, let's … ' because we have a great field man that we work with there, and really progressive and forward-thinking. A lot of guys just want us to lay fertiliser. And they're like, 'Don't worry about anything else'. And he definitely sees the big picture of why that's not always ideal. We've used them and then we also work with a super generatively based company in Washington called Soilcraft. And they've done a ton of regenerative, ton of organic. And they're an offshoot or a competitor to John Kemp, who runs his own consultancy firm and has his own line of products as well. But it's all within the auspices of regenerative ag. (Susan)

In some ways, this approach is actually the result of a long practice of tinkering and long-held tenets for sustainable agricultural practices. Regardless of whether these practices are exclusively or normatively 'good', here tinkering provides an experimental and collaborative method by which

farmers' human values and the socio-material assemblage of actors involved in agriculture more directly relate to and inform one another in the co-production of farming outcomes. This then results in practice outcomes that allow for incomplete steps, partial transitions and interplay between conceptualisation and material realisation.

> I mean, even dad and great-grandpa, he used to have sheep. I think there's always been pieces and bits regardless of the generation. And we want to be good stewards to the land, want to have a nice, tidy farm, we want to grow exceptional hops. And that's been, through the generations, our goal. And now we just have a few different tools in the toolbox than what maybe prior operators had because of science. We've had advances in technology that my grandpa never would've dreamed that we could figure this stuff out. (Susan)

Here, Susan highlights how their decisions connect to lineages of practices (e.g., grazing), the experimentation of reviving and revising practices alongside the inclusion and exclusion of particular technologies. This tool-in-the-toolbox approach emphasises that material agricultural practices, which often seem monolithic, may have more significant room for improvisation than often considered—this is particularly relevant when considering policy-level transitions for goal practices such as regenerative agriculture or agro-ecology. These practices diverge from the sustainability practices of many of their peer farms that tend to focus on incremental and top-down systematic approaches in many ways. Such as one large-growers self-imposed metrics for assessing environmental friendliness.

> We also have some type of an audit to kind of see how sustainable we are, so that's through a Yakima Chief program called GreenChief. My nephew, Tyler, kind of oversees the information on that data. They're working on our pesticide applications with the … They've worked with one app, but now they're using a different type of application called Ag World. (Jerry)

This approach does not alter inputs or exchange kinds of technologies but rather provides an interpretative frame for understanding the environmentally (un)friendly practices of large plantation-style hop farms. It differs from the range of tinkering practices described above and provides a useful empirical counterpoint for framing the below discussion and conclusion.

DISCUSSION: TINKERING AND SUSTAINABLE TRANSITIONS

These findings demonstrate how both large and small farmers in the study population engage in mutual relational approaches to making ends meet that have the capacity to improve environmental outcomes. Such approaches are not scale-dependent, but the effort on a large operation may require a more self-conscious or policy-governed imperative, while for these small farmers, such acts are viewed as acts of necessity. This is primarily because in the absence of direct interaction with a range of material actors, care relationships become overly mediated. Taking the example of Greenchief, a set of voluntary policies as a place of comparison for the many tinkering practices described in our empirics can be a useful way to discuss and consider the differing outcomes of these tinkering practices as opposed to conventionally incremental practices. Tinkering on small hop farms is an act of care that reorients socio-material actors in relation to the farmer

to maximise benefits for the farm and the farmer themselves. The results are not always environmentally friendly. However, the tinkering approach differs fundamentally in character and results from the above incrementalist approach often employed by large farms and other lan–duse industries to perform environmental friendliness or enact less onerous changes often at the expense of systems-level improvements.

Both cases can result in more environmentally sustainable outcomes. However, the key difference between these two examples is that tinkering represents a small shift that reorients the farming practices in total. It is direct and experimental in the way actors are shifted within the assemblage not dissimilarly from the way that *variables* are shifted in experimental approaches to science. This differs from the incrementalist approach, which sets limits or otherwise addresses the margins of practice but leaves the farming practice in total largely intact. It would be almost accurate to say that tinkering is incrementalism with experimentation, though I suggest this pairing would hide the ways in which the addition of experimentation augments the character and kinds of interventions that are possible. Looking at this fine-grained differentiation in stepwise interventions in agricultural systems is helpful for considering how immediate steps can be made towards more environmentally sustainable arrangements for vegetable, herb and fruit agriculture. This provides lessons for transitions towards more just arrangements of growth-alternative farm and industry models. It also shows how technology change can be part of sustainable transitions while providing an explanation for why many large-scale techno-fixes often reify problems in agriculture instead of solving these problems (Fairbairn & Guthman, 2020; Guthman & Zurawski, 2020).

Agricultural models that eschew growth imperatives vary widely but have not typically lent themselves towards incremental approaches to such transitions—representing ideologically and materially different approaches than conventional commodity and/or neoplantation style agricultures. This is particularly true of agro-ecology and regenerative agriculture whose ecological basis is rooted in de-growth philosophies and whose agricultural landscapes result in ontologically different approaches to what a farm is and can be (Alexander, 2020; Gordon et al., 2022; Paola, 2017; Saj et al., 2017). Because of this, policy interventions and scholarship on just transitions have had difficulty imagining pathways from contemporary conventional farms to alternative agricultural practices that could include agro-ecology, perennial agriculture, regenerative agriculture, smallholder farming and so forth. However, by translating the findings on small farms to those large farms engaging in regenerative agriculture in particular, this study sheds light on how *tinkering* provides an alternative model to *incrementalism* as a pathway for stepwise transitions towards models of agriculture outside the growth imperative.

Take regenerative agriculture, which has received increased attention in European policy circles, as a specific case of a tinkering outcome as exemplified by the reports of Sarah in the results. While Sarah operates a medium-sized hop farm, her approaches borrow from the small farmers' who tinker in direct ways. Like those farmers who build out implements, rethink trellising and experiment with novel hop varietals, Sarah is engaged with rethinking the material arrangement of her farm. She is not 'thinking big' for such a transition but rather 'thinking small'. What I mean by this is that she engages in regenerative agricultural transitions as a matter of everyday care and involvement in her land. She does not begin grazing as part of an over-arching plan to eventually end up as a maximally sustainable farm but rather as a stepwise plan. Tinkerers engage in immediate care by reorganising material actors for immediate-term benefits and experimentation. Sarah might get many aspects of regenerative agriculture wrong, but these mistakes are not particularly worrisome because she scales at the immediate, improvisational level. For small farmers such as Saul, the impacts of tinkering may be riskier because of the low financial overhead, but the impetus is also higher.

CONCLUSION: DIRECTIONS FORWARD FOR TINKERING SCHOLARSHIP

Tinkering does not necessarily result in more just outcomes or more sustainable farms, just as care is not an unfettered good in every instance; however, its orientation towards experimentation with relationships between actors produces more flexible, responsive and adaptive outcomes. Particularly by comparison to mainline incrementalist transitions, this more experimentalist approach has value. In this study, tinkering approaches tended to produce more resilient farms and opens the door towards many policy and extension interventions that encourage sustainability. Tinkering shows that large-scale transitions may be achieved in the aggregate at the grassroots. However, for this to occur, cultures of innovation and safety nets for mistaken experiments should be considered at a policy level. Put differently, more just sustainable pathways towards more equal agri-environmental practices and a more resilient food system should consider that adaptive and beneficial frameworks can most easily be cultivated by those directly involved in specific ecosystems. As such, policy stakeholders, applied researchers and networks of ag-supporting infrastructure such as LGU systems should consider interventions that support small and medium farmer experimentation. This experimentation, tinkering, is an essential component alongside a suite of other environmental and agricultural policy and research in pursuing more sustainable food futures in North America, Europe and elsewhere.

From a social science perspective, future research, particularly that which takes a materialist or relational approach to exploring agri-food problems, would benefit from considering the particularities of our participant's approaches to the assemblages with which they work. In addition to work that pushes concepts of care and tinkering forward (Lundström & Lindblom, 2021; Mol et al., 2010), there is already a somewhat scattered body of work calling for the reintroduction of intentionality, into assemblage approaches such as the case with Dwiartama's negotiation of materialist scholarship and the importance of resilience thinking (Dwiartama, 2016; Dwiartama & Rosin, 2014). Beyond pushing forward disciplinary framings for appropriate social science considerations, this work highlights alternative ways scholarship on alternatives and sustainable transitions may handle multiplicity and grassroots change in agricultural praxis. Questions for future research arise, such as whether tinkering approaches can diffuse or scale or questions about how to identify transferability for those tinkering experiments that appear successful. These questions will have relevance to scholarship ranging from de-growth to agro-ecology to other forms of alternative agriculture and scholarship interested in understanding the obstacles and opportunities for more sustainable transitions beyond incrementalism.

ACKNOWLEDGEMENTS

This article was supported by a number of colleagues including Paul Stock and members of the University of Kansas–Department of Sociology along with Florence Becot and Casper Bendixsen at the National Farm Medicine Center. This article originated from feedback for a separate paper during a workshop with the Science and Technology Studies Food and Agriculture Network (STS-FAN) workshop—a special thanks to STS-FAN members for their insights, feedback and collegiality. This research received funding from the National Science Foundation's Science, Technology, and Society program (NSF 1946941). The author received support from the Frank and Betty Koller Postdoctoral Fellowship during the preparation of this study.

CONFLICT OF INTEREST STATEMENT

The author declares no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

REFERENCES

Agrimonti, C., Lauro, M. & Visioli, G. (2021) Smart agriculture for food quality: facing climate change in the 21st century. *Critical Reviews in Food Science and Nutrition*, 61(6), 971–981. https://doi.org/10.1080/10408398.2020.1749555

Alarcon, M., Marty, P. & Prévot, A.C. (2020) Caring for vineyards: transforming farmer-vine relations and practices in viticulture French farms. *Journal of Rural Studies*, 80, 160–170. https://doi.org/10.1016/j.jrurstud.2020.08.029

Alexander, W. (2020) Agroecological principles and elements and their implications for transitioning to sustainable food systems. A review. *Agronomy for Sustainable Development*, 40, 40. https://doi.org/10.1007/s13593-020-00646-z

Andrew, S.M. (2012) An essay on agriculture and population pressure. *Nutrition and Health*, 21(1), 6–16. https://doi.org/10.1177/0260106012437546

Asafu-Adjaye, J., Blomqvist, L., Brand, S., Brook, B., Defries, R., Ellis, E., Foreman, C., Keith, D., Lewis, M., Lynas, M., Nordhaus, T., Pielke, R. Jr., Pritzker, P., Roy, R., Sagoff, M., Shellenberger, M., Stone, R. & Teague, P. (2015) *An ecomodernist manifesto*. http://www.ecomodernism.org/manifesto-english

Bronson, K. (2019) Looking through a responsible innovation lens at uneven engagements with digital farming. *NJAS–Wageningen Journal of Life Sciences*, 90-91, 100294. https://doi.org/10.1016/j.njas.2019.03.001

Bronson, K. & Knezevic, I. (2016) Big Data in food and agriculture. *Big Data & Society*, 3(1). https://doi.org/10.1177/2053951716648174

Bryant, L. (2022) Farming women, distress and drought: intra-actions and entanglements with matter. *Sociologia Ruralis*, 62(3), 459–484. https://doi.org/10.1111/soru.12388

Buitenhuis, Y., Candel, J.J.L., Termeer, K.J.A.M. & Feindt, P.H. (2022) Reconstructing the framing of resilience in the European Union's Common Agricultural Policy post-2020 reform. *Sociologia Ruralis*, 62(3), 564–586. https://doi.org/10.1111/soru.12380

Buttel, F.H. (2016) The treadmill of production. *Organization & Environment*, 17(3), 323–336. https://doi.org/10.1177/1086026604267938

Callon, M. (2015) How to design alternative markets: the case of genetically modified/non–genetically modified coexistence. In: Roelvink, G., St. Martin, K. & Gibson-Graham, J.K. (Eds.) *Making other worlds possible: performing diverse economies*. Minneapolis, MN: University of Minnesota Press.

Carolan, M. (2008) The multidimensionality of environmental problems: the GMO controversy and the limits of scientific materialism. *Environmental Values*, 17(1), 67–82. https://doi.org/10.3197/096327108X271950

Carolan, M. (2010) *Decentering biotechnology: assemblages built and assemblages masked*. Burlington, VT: Ashgate.

Carolan, M. (2017a) Agro-digital governance and life itself: food politics at the intersection of code and affect. *Sociologia Ruralis*, 57(S1), 816–835. https://doi.org/10.1111/soru.12153

Carolan, M. (2017b) 'Smart' farming techniques as political ontology: access, sovereignty and the performance of neoliberal and not-so-neoliberal worlds. *Sociologia Ruralis*, 58(4), 745–764. https://doi.org/10.1111/soru.12202

Catton, W. R. (1980) *Overshoot: the ecological basis of revolutionary change*: Champaign, IL: University of Illinois Press.

Centeno, M.A. & Cohen, J.N. (2012) The arc of neoliberalism. *Annual Review of Sociology*, 38(1), 317–340. https://doi.org/10.1146/annurev-soc-081309-150235

Charatsari, C., Lioutas, E.D., Papadaki-Klavdianou, A., Michailidis, A.& Partalidou, M. (2022) Farm advisors amid the transition to Agriculture 4.0: professional identity, conceptions of the future and future-specific competencies. *Sociologia Ruralis*, 62(2), 335–362. https://doi.org/10.1111/soru.12364

Comi, M. (2020a) The distributed farmer: rethinking US Midwestern precision agriculture techniques. *Environmental Sociology*, 6(4), 403–415. https://doi.org/10.1080/23251042.2020.1794426

Comi, M. (2020b) Other agricultures of scale: social and environmental insights from Yakima Valley hop growers. *Journal of Rural Studies*, 80, 543–552. https://doi.org/10.1016/j.jrurstud.2020.10.041

Cordle, C. (2011) *Out of the hay and into the hops: hop cultivation in Wealden Kent and hop marketing in Southwark, 1744–2000*. Hertfordshire, UK: University Of Hertfordshire Press.

Cusworth, G., Garnett, T. & Lorimer, J. (2021) Agroecological break out: legumes, crop diversification and the regenerative futures of UK agriculture. *Journal of Rural Studies*, 88, 126–137. https://doi.org/10.1016/j.jrurstud.2021.10.005

Darnhofer, I. (2020) Farming from a process-relational perspective: making openings for change visible. *Sociologia Ruralis*, 60(2), 505–528. https://doi.org/10.1111/soru.12294

Deleuze, G. & Guattari, F. (1987) *A thousand plateaus: capitalism and schizophrenia*. Minneapolis, MN: University of Minnesota Press.

Donati, K. (2019) 'Herding is his favourite thing in the world': convivial world-making on a multispecies farm. *Journal of Rural Studies*, 66, 119–129. https://doi.org/10.1016/j.jrurstud.2018.12.008

Dwiartama, A. (2016) Resilience thinking, fluidity and the agency of a quasi-actant. *Dialogues in Human Geography*, 6(1), 28–31. https://doi.org/10.1177/2043820615624064

Dwiartama, A. & Rosin, C. (2014) Exploring agency beyond humans: the compatibility of Actor-Network Theory (ANT) and resilience thinking. *Ecology and Society*, 19(3), 28. https://doi.org/10.5751/ES-06805-190328

Esteva, G. (1996) Hosting the otherness of the other: the case of the Green Revolution. In: Apffel-Marglin, F. & Marglin, S.A. (Eds.) *Decolonizing knowledge: from development to dialogue*. New York: Oxford University Press, pp. 249–278.

Fairbairn, M. & Guthman, J. (2020) Agri-food tech discovers silver linings in the pandemic. *Agriculture and Human Values*, 37(3), 587–588. https://doi.org/10.1007/s10460-020-10052-6

Giller, K.E., Hijbeek, R., Andersson, J.A. & Sumberg, J. (2021). Regenerative agriculture: an agronomic perspective. *Outlook on Agriculture*, 50(1), 13–25. https://doi.org/10.1177/00307270211998063

Goodman, D. (2001) Ontology matters: the relational materiality of nature and agro-food studies. *Sociologia Ruralis*, 41(2), 182–200. https://doi.org/10.1111/1467-9523.00177

Gordon, E., Davila, F.& Riedy, C. (2022) Transforming landscapes and mindscapes through regenerative agriculture. *Agriculture and Human Values*, 39(2), 809–826. https://doi.org/10.1007/s10460-021-10276-0

Gould, K.A., Pellow, D.N.& Schnaiberg, A. (2016) Interrogating the treadmill of production. *Organization & Environment*, 17(3), 296–316. https://doi.org/10.1177/1086026604268747

Guthman, J. & Zurawski, E. (2020) "If I need to put more armor on, I can't carry more guns": the collective action problem of breeding for productivity in the California strawberry industry. *The International Journal of Sociology of Agriculture and Food*, 26(1), 69–88. https://ijsaf.org

Higgins, V., van der Velden, D., Bechtet, N., Bryant, M., Battersby, J., Belle, M. & Klerkx, L. (2023) Deliberative assembling: tinkering and farmer agency in precision agriculture implementation. *Journal of Rural Studies*, 100, 103023. https://doi.org/10.1016/j.jrurstud.2023.103023

Ibrahim, M.A. & Johansson, M. (2021) Attitudes to climate change adaptation in agriculture—a case study of Öland, Sweden. *Journal of Rural Studies*, 86, 1–15. https://doi.org/10.1016/j.jrurstud.2021.05.024

Jasanoff, S. (2007) *Designs on nature: science and democracy in Europe and the United States*. Princeton, NJ: Princeton University Press.

Kallis, G. & March, H. (2015) Imaginaries of Hope: the utopianism of degrowth. *Annals of the Association of American Geographers*, 105(2), 360–368. https://doi.org/10.1080/00045608.2014.973803

Kloppenburg, J. (1988) *First the seed: the political economy of plant biotechnology*. New York: Cambridge University Press.

Knook, J., Eastwood, C. & Pinxterhuis, I. (2022) Understanding mechanisms that agricultural producers apply in response to evolving social pressures. *Journal of Rural Studies*, 89, 306–315. https://doi.org/10.1016/j.jrurstud.2021.12.009

Krüger, T., Eichenauer, E. & Gailing, L. (2022) Whose future is it anyway? Struggles for just energy futures. *Futures*, 142, 103018. https://doi.org/10.1016/j.futures.2022.103018

Landers, J.N., De Freitas, P.L., De Oliveira, M.C., Da Silva Neto, S.P., Ralisch, R. & Kueneman, E.A. (2021) Next steps for conservation agriculture. *Agronomy*, 11(12), 2496. https://doi.org/10.3390/agronomy11122496

Law, J. (2004) *After method: mess in social science research*. New York: Routledge.

Legun, K., Comi, M. & Vicol, M. (2022) New aesthetic regimes: the shifting global political ecology of aroma hops. *Geoforum*, 128, 148–157. https://doi.org/10.1016/j.geoforum.2021.12.004

Lundström, C. & Lindblom, J. (2021) Care in dairy farming with automatic milking systems, identified using an Activity Theory lens. *Journal of Rural Studies*, 87, 386–403. https://doi.org/10.1016/j.jrurstud.2021.09.006

Martin, A., Myers, N. & Viseu, A. (2015) The politics of care in technoscience. *Social Studies of Science*, 45(5), 625–641. https://doi.org/10.1177/0306312715602073

Mol, A., Moser, I. & Pols, J. (2010) *Care in practice: on tinkering in clinics, homes and farms* (1. Aufl ed.). Bielefeld: Transcript-Verl.

Moore, J.W. (2017) The Capitalocene, part I: on the nature and origins of our ecological crisis. *The Journal of Peasant Studies*, 44(3), 594–630. https://doi.org/10.1080/03066150.2016.1235036

Müller, M. (2015) Assemblages and actor-networks: rethinking socio-material power, politics and space. *Geography Compass*, 9(1), 27–41. https://doi.org/10.1111/gec3.12192

Müller, M. & Schurr, C. (2016) Assemblage thinking and actor-network theory: conjunctions, disjunctions, cross-fertilisations. *Transactions of the Institute of British Geographers*, 41(3), 217–229. https://doi.org/10.1111/tran.12117

O'Flynn, T., Macken-Walsh, Á., Lane, A. & High, C. (2018) Farmers doing it for themselves: how farmer-inventors are frustrated by their interactions with the Agricultural Knowledge and Innovation System. *13th European IFSA symposium - Farming systems: facing uncertainties and enhancing opportunities, 1–5 July 2018, Chania, Crete*.

Paola, M. (2017) Converging and diverging principles and practices of organic agriculture regulations and agroecology. A review. *Agronomy for sustainable development*, 37, 63. https://doi.org/10.1007/s13593-017-0472-4

Parga Dans, E., Alonso González, P. & Macías Vázquez, A. (2019) Taste and knowledge: the social construction of quality in the organic wine market. *Human Ecology*, 47(1), 135–143. https://doi.org/10.1007/s10745-019-0051-1

Saj, S., Torquebiau, E., Hainzelin, E., Pages, J. & Maraux, F. (2017) The way forward: an agroecological perspective for Climate-Smart Agriculture. *Agriculture, Ecosystems & Environment*, 250, 20–24. https://doi.org/10.1016/j.agee.2017.09.003

Schulte, L.A., Dale, B.E., Bozzetto, S., Liebman, M., Souza, G.M., Haddad, N. & Arbuckle, J.G. (2022) Meeting global challenges with regenerative agriculture producing food and energy. *Nature Sustainability*, 5(5), 384–388. https://doi.org/10.1038/s41893-021-00827-y

Shutes, M. (2003) Real milk from mechanical cows: invention, creativity, and the limits of anthropological knowledge. In: M.L. Davies & M. Meskimmon (Eds.) *Breaking the disciplines: reconceptions in knowledge, art and culture.* London: I.B.Tauris, pp. 61–84.

Smith, K. (2022) Scaling up civic food utopias in Australia: the challenges of justice and representation. *Sociologia Ruralis*, 63(1), 140–159. https://doi.org/10.1111/soru.12368

Spaargaren, G. (1997) The ecological modernization of production and consumption: essays in environmental sociology. PhD thesis, Department of Environmental Sociology WAU, Wageningen. http://library.wur.nl/WebQuery/wurpubs/36666

Stock, P. (2016) Contradictions in hope and care: technological utopianism, biosphere II, and the Catholic worker farms. In: Le, Heron, R., Campbell, H., Lewis, N. & Carolan, M. (Eds.) *Biological economies*. New York, NY: Routledge, pp. 51–66.

Stock, P. & Szrot, L. (2020) Justice. In: Duncan, J., Wiskerke, J.S.C. & Carolan, M.S. (Eds.) *Routledge handbook of sustainable and regenerative food systems*. New York, NY: Routledge, pp. 98–112.

Stock, P.V. & Forney, J. (2014) Farmer autonomy and the farming self. *Journal of Rural Studies*, 36(Supplement C), 160–171. https://doi.org/10.1016/j.jrurstud.2014.07.004

Stock, P.V., Forney, J., Emery, S.B. & Wittman, H. (2014) Neoliberal natures on the farm: farmer autonomy and cooperation in comparative perspective. *Journal of Rural Studies*, 36, 411–422. https://doi.org/10.1016/j.jrurstud.2014.06.001

USDA-NASS. (2020) *USDA National Agricultural Statistics Service*. Available at: https://quickstats.nass.usda.gov/

Varga, M. (2017) Small farms survival and growth: making investments despite credit constraints. *Sociologia Ruralis*, 57, 641–660. https://doi.org/10.1111/soru.12149

How to cite this article: Comi, M. (2023) Farmers who tinker: Grounded alternatives to incrementalism and the growth imperative. *Sociologia Ruralis*, 63, 823–842. https://doi.org/10.1111/soru.12445