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Tiny trees for trendy produce: Dwarfing technologies as assemblage actors in orchard economies

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ABSTRACT

Apple varieties boom and bust as the vogue for new flavors cycle through the market. Dwarfing rootstocks, an old but freshly blossoming orchard technology, allows growers to intervene in trees in new ways and keep up with shifts in consumer demand. They cultivate customization in apple orchards and facilitate emerging neoliberal trends in food systems. However, the rootstocks do more than entrench actors further into the whims of the market—they also shape economic agency in ways that have multiple expressions. Drawing on work on actor-networks and assemblages, this paper considers how technologies play a role in contemporary food politics through their material characteristics and the performances they inspire. Using apple production in the American Midwest as a case study, this paper discusses the ways that rootstock technologies both reproduce current power structures and conventional organizational forms in food, while providing a platform for an alternative type of assemblage. In doing so, it contributes theoretically to conversations about the role of materials in economic politics and substantively to an optimistic vision of the future of food.

Introduction

In the spring of 2012, I had just finished an interview with a grower when he offered to take me on a drive through the orchard. I wandered up to the enormous black truck and struggled to hoist myself up into the passenger seat. As we drove out in the orchard, I saw about an acre full of frail little whips, supported by a trellis. Their limbs were so thin they were vine-like and almost two-dimensional. He had only planted a year ago, and would be planting another block on a trellis soon. The trees would start producing apples the following year, which I found hard to believe given their current stage of development. They would be in full production within four years of planting. As we moved through the orchard, we passed trees in different constellations and at various stages of development. Some were trellised and their upper branches reached eight feet from the ground. Some were a bushy, vibrant green, launching outwards a foot from the trellis. Others were less lively, and seemed to keep close to the wires. As we kept driving, we entered a block with freestanding trees, taller, with branches growing out in all directions. These were old semi-dwarf trees that had been planted about twelve years ago. The patchwork of plantings, with some trees on a trellis and others free standing, was something I saw in many of the orchards I toured.

In the fall, months later, when many of those tall, trellised trees were about to be harvested, their branches were weighed down with apples. Their crowns were toppling over, heavy with apples pulling their thin limbs to the ground. It was an apple waterfall. Looking at their lower limbs, strung up and unable to bear the weight of the apples independently, made my own arms feel tired.

Orchards increasingly depart from the romantic vision of large, looming old apple trees, the upper branches only accessible with the use of a tall ladder or the ambition and dexterity of a youthful climber. Standard trees are a size that would grow naturally from seed, and they commonly grow to a height of over 18 feet, and can reach 18 feet wide as well. They match the mind's image of an apple tree, so that seeing their vine-like kinfolk is jarring, and the reliance on human maintenance makes them look weak. Yet, standard trees fill a lot of space, and each requires a lot of care and maintenance in terms of spraying and pruning. Whenever I went to a field day at an orchard with standard trees, the advice was the same: Get rid of them. Why would you keep them? The labor required to make them healthy is too costly. The amount of spray required to fend-off the pests would be too much, and the thick braches would end up pest free while much of the leaves and apples would be left defenseless, as the wood would end up blocking the spray. Harvesting is a nightmare, and hard on pickers who have to access tall and dispersed limbs. Planting standard trees in a commercial orchard would be considered madness by

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most of the grower community, while the slender dwarfing trees are commonly considered the stock of the future.

In addition to the growing prevalence of dwarfing rootstock, there is a second, related trend in apples. A heightened attention to apple varieties in the market requires quick orchard replantings. The lexicon of apple varieties is multiplying as foodies search for unique flavors and textures in apples, and consumers become captivated by new names entering the produce shelves. Distinction now reigns in the grocery aisle, and it is no longer limited to the exoticism of unusual fruit species from distant places, but also can mean identifying the unusual within the everyday. In response to these market pressures, club apples—patented varieties owned and marketed by cooperatives—are thriving. Pinata, SweeTango, Pink Lady, EverCrisp, and Cosmic Crisp are examples of varieties that have social and legal boundaries around them that influence the ways they are grown and enter the market. These clubs fit into broader economic trends in agriculture that are founded on generating some kind of closure around a product so that it can be controlled and distinguished in the market to gain social and cultural legitimacy.

In this paper, I draw on new theoretical approaches to technology, materiality, and markets to discuss how the politics of technologies and the politics of markets are co-produced through the practices of growers. Landscapes become pictures of agricultural markets: patches of different varietal ventures, grafted onto the root systems most productive on the soil. They are customized to the region, and customized to fluctuating and diverse markets. In this way, the dwarfing rootstocks create a landscape more entrenched in markets. Moreover, with the growth of niche markets and forms of branding, rootstocks and customization can provide a foundation for a type of flexible specialization among small and mid-sized growers. These orchard landscapes facilitate grower agency in diverse markets, experimentation with new varieties, and knowledge sharing. The relationships between technologies, landscapes, and markets discussed in this paper contributes to work on the political economies of materiality, while also contributing substantively to work on food system change.

Locating economic politics in agricultural technologies

The industrialization of agriculture has long been discussed as a process of rationalizing landscapes so that farms may become more like a factory floor: predictable and buffered from the irregularities of complex ecological life (Fitzgerald, 1991, 2003; Palladino, 2003; Murphy, 1994). These processes have been well documented, along with the role that technologies play in facilitating those changes (see Fitzgerald, 2003, 2001; Hendrickson and James, 2005). Much of the work on industrialization has been placed directly within political economy by suggesting that it participates in the maintenance of a food regime, perpetuating capital accumulation and labor exploitation (McMichael, 2013; Friedmann and McMichael, 1989). The diffusion of agricultural technologies during the green revolution, for example, increased farmer reliance on inputs that were controlled by large, global agri-businesses (McMichael, 2013, 2011). Batte et al. (1993) places technology more forcefully at the center of agricultural change by suggesting that mechanization had a direct impact on farm structure. The capital requirements and reduced labor value historically contributed to the dramatic increase in farm size observed in the 20th century. In short, technologies play an active role in changing economies in agriculture.

Recently authors have suggested we are moving beyond an industrial food regime to one Harriet Friedmann (2005) describes as corporate-environmental. In this emerging food economy, agro-food companies such as suppliers and retailers set production standards and participate in environmental regulation (Friedmann, 2005; Le Heron and Roche, 1995). These processes can be seen to dovetail with neoliberal trends in agriculture as state regulation is eclipsed by market governance (Burch and Lawrence, 2009). Within this recognition of new agricultural pressure, research has looked at the role of genetically modified organisms (GMO), patents, and neoliberal landscapes (McAfee, 2003; Prudham, 2007). The role of these technologies has been elaborated in the context of governance reproducing power dynamics within agriculture. In this paper, I contribute to this work on neoliberal landscapes, but take a more pragamatic materialist approach by focusing on how technologies shape action and economic agency via the culture of production. In doing so, I emphasize how dwarfing technologies reflect patterns of self-governance and expanding market control, but also provide a point of departure via the spirit they cultivate.

Mobilizing alternatives to a corporate-environmental agriculture is particularly important for maintaining mid-sized farms. Large farms and small farms are growing in number, while mid-sized farms are declining (Kirschenmann et al., 2008). The industrialization of agriculture has encouraged a hollowing of farm-size, so that large farms grow bigger and can continue to participate in increasingly demanding wholesale markets, while smaller farms can engage in labor-intensive and value-added production for niche markets. Outcomes of these shifts in farm size are a reduction of rural communities and declining wellbeing in those that remain (Lobao, 1990; Labao and Meyer, 2001; Lyson et al., 2001; Lyson and Welsh, 2005). The moments of technology adoption can offer insights to these ends.

The Midwest apple industry, which provides a case for this research, is small compared to Washington State and the East Coast, and characterized by smaller average farm sizes (Roosin, 1999). These growers struggle to compete with the massive production emerging from the irrigated desserts of Eastern Washington, but have a rich history of apple production and rely on quality claims to maintain an economic foothold, particularly in the context of recent retail conglomeration. The ways in which new technologies interact with these economic changes is important for imagining possible food landscapes in the future.

Markets for food are also changing, as foodies flourish (Johnston and Baumann, 2010; Weiss, 2012) and people become more interested in eating 'food from somewhere' (Campbell, 2009 see also: Marsden et al., 2000; Murdoch et al., 2000; van der Ploeg et al. 2000, Ilbery and Kneafsey 2000). These trends can also change the role of technologies. In many industries tied to the labor of land, technologies aim to liberate producers from the constraints of nature while opening up those actors to more freely participate in the ebb and flow of market supply and demand (Fitzgerald, 2003, 2001). Much of this emphasis on the unfurling of farming technologies has looked at broad patterns of homogenous commodity production and its role in capitalist economies (Otero and Pechlaner, 2005). Recent work has tied technology explicitly to neoliberal political economies, and considered how biotechnology perpetuates inequality in global food systems (Pechlaner and Otero, 2008). However, less work has considered how technologies operate at a mico-level to influence economic agency, which is important given the ideological features of neoliberalisms and amorphous features of its practice. By looking more specifically at economic action and politics from a materialist perspective, the enactment of technologies can be viewed as going beyond simply facilitating or congealing economic relations to potentially creating them.

A materialist approach can aid an understanding of new agri-food trends and illuminate points of system departure by explicating how different components of food economies practically come together in networks of coordinated action. The

technologies introduced into those networks are meaningful as they contribute to the production and reproduction of that economy. Moreover, some of the political–economic effects of technology, I argue, can be located in the technology itself. This perspective extends work that considers the sociality of objects, as object environments come to embody identities and promote forms of sociality (Cetina, 1997; Wittel, 2001; Lowe, 2004). Authors like Cetina, along with Callon (2008), Barry (2001), Preda (2006), Bennett (2009) and Marres (2009), to name a few, suggest taking a post-human, or post-social approach to economic markets, whereby objects are implicated and active. Within a political sphere, technologies come to embody intentions and entice forms of participation and engagement (Marres, 2009). They aid the performance of particular activities, promoting those activities, and rendering those technologies political (Marres and Lezaun, 2011; Barry, 2001; Barry and Slater, 2002; Bennett, 2009; Braun and Whatmore, 2010). As Callon suggested in an interview with Barry and Slater (2002) technologies participate in the stabilization of markets. They become the machinery of a production of reality, maintaining the practical efficacy of economic principles.

Work on assemblages would suggest that these realities are the product of various materials, constantly being woven together and unraveled in the performances of everyday life. Assemblage theories stress heterogeneity and relatively incoherent entanglements (Allen, 2011; Anderson et al. 2012), or "emergence, multiplicity, and indeterminancy" (Anderson and McFarlane, 2011: 124). Assemblages stress relational effects, as happenings become the product of human and non-human elements that lack a stable boundary or hierarchical order (Allen, 2011). Importantly, assemblages challenge ideas of states, regions, and territory as political, social, and economic action is approached as the product of relationships across vast spaces (Cowen and Smith, 2009; Allen and Cochrane, 2007; Sassen, 2006). Similarly, actor-network theory emphasizes the ways that agency is diffuse and action is viewed as the result of various materials' behaviors coordinating (Law, 2009). The introduction of technologies into an assemblage or network is important because it influences what actions are performed, and what actions seem possible. They can influence what actions seem possible as the materials are assembled into the landscape and built into practical habits.

Assemblages and actor-networks can show how heterogeneous materials generate effects through their connection, but by stressing the incidental functions of various nodes in a network too much, we may lose sight of the politics of materials and the broader relations they promote. Without agency, time, and place, the qualitative aspects of connections can become lost. This paper seeks to emphasize ways that technological materials can be vibrant and politically active, and in doing so, builds on Bennett's claims that things can have political power that is centered in their materiality, but expressed through their relations (see Bennett, 2009: 104–108). Proximity and physical embeddedness becomes relevant to the qualities of these relations, as Cloke and Jones (2001) describe in their discussion of dwelling, which highlights the ways that things can exist together spatially and temporally in lived practice (see also Jones and Cloke, 2002). Paying attention to these ongoing relations and the agency of things in those relations can provide insights into how things can be political, as their ongoing presence in the everyday resonates beyond moments of their enactment.

In the sense, things can have effects beyond their technological function, and beyond their design. Some form of agency can be attributed to the things rather than simply extending the agency of the designer or implementer. By implication, while assembling may be performed with a particular political agenda under a set of economic relations, the productive capacities of materials can transform the politics and relations of the project (Tsing, 2005; Lockie and Higgins, 2007; Braun, 2006; Cooper and Rosin, 2014). While agricultural technologies may support the emergence of a corporate-environmental food regime and neoliberalism more broadly, they may also have practical outcomes that complicate these trends and reflect on what may be "beyond neoliberalism" (Bakker, 2010). Giving agentic qualities to materials suggests that technologies can be crafted within a particular political–economic context, embodying those politics in spirit, while also having different practical effects.

Dwarfing technologies can be seen to perpetuate a neoliberal ideology by facilitating a more complete integration with market governance with a particular entrepreneurial flavor. They represent what Callon (2008) has called *habilitating* technology. The technology expands the possible range of actions an actor can take, and it can be associated with an expansion of agency. These technologies are in contrast to a prosthetic technology that essentially improves existing, prescribed activities. A similar model was used by Barry (2001) in his discussion of a disciplinary diagram and an interactive diagram, where we can imagine an actor at the center of a web of production that either mandates what activities the actor must perform to complete a task, or allows for the actor to choose the task and engage with the tools that will perform it. Murdoch (1998) also uses actor-network theory to describe *spaces of prescription* and *spaces of negotiation*. In each of these theoretical descriptions of technologically expanded agencies, there is the possibility of an affiliated spirit of self-governance and increased market pressure: when expanded production agency is paired with narrower buyer demands, the result would be simply that growers have more freedom to craft their activities more precisely.

In summary, technologies embody political interests. They are designed to ease the performance of particular economic actions, and through that easing, they encourage those activities. Yet, while technologies may be crafted in response to market pressures, embedding ethics of market governance into the landscape, they can also generate unforeseen effects in the organization of the industry. Technologically mediated assemblages may propel some economic ideals forward, such as market responsiveness, while also negotiating them and articulating them in new ways. The modern orchard not only brings market power into the landscape, but also brings landscape power into the market.

The Midwest apple industry

The data for this paper has been generated through qualitative research with growers in the Midwest. I draw my findings from interviews with 37 growers, and 6 other industry actors including breeders and marketers. Most of the growers that I interviewed, with the exception of one or two, were in the habit of visiting other orchards in the area, so interviews were often accompanied by a tour of the orchard. After the interview, growers would take me on a golf cart or truck to drive around their farm, explaining what they were doing and allowing me to ask questions about the various objects and arrangements in the landscape. I asked about changes to their orchards, why they had adopted a particular approach, and whether they had found it to be successful. Perhaps because of the custom of reciprocal orchard visiting, growers seemed comfortable and well-practiced when explaining things, and generally enthusiastic to show me what they were doing. There was likely some bias, in that those that would be willing to talk to me and discuss their orchard would be more likely to be excited about their operations. However, even growers who were disinclined to speak with me, or simply too difficult to get a hold of, were often very active in the broader grower community, and clearly participated in the types of visits that seemed to be characteristic of Midwest apple growers generally. In short, while

the growers I spoke to may be more engaged in the types of technologies and experiments that form the foundation for this paper, I have adequate evidence to suggest that these interviews were not uncharacteristic. Moreover, I interviewed all sizes of farms, ranging from a few acres to five hundred acres, and producers who engaged in wholesale and direct marketing. I interviewed people who were clearly leaders in the industry. I interviewed people who ran their own packing lines and had over a hundred employees, as well as people who had only recently entered the industry. In general, I did not get the sense that I was interviewing an unusual or overly experimental and modern population of growers that would be tangential to the functioning of a mainstream industry.

I also draw data from attendance at conferences, field days, and workshops. I attended small field days with 15–20 growers where they discussed things like spraying and pest management, and larger national conferences with 500 attendees like the USApple Crop Outlook Conference, or meetings of the International Fruit Tree Association. Furthermore, I read publications by American Fruit Grower and the Good Fruit Grower, and subscribed to their email lists. These conferences and publications further suggested that the conversations I was having with growers and the technologies I was seeing on their orchards was characteristic of the industry overall.

From dwarfing rootstocks to flexible specialization

The economic spirit of dwarfing rootstocks

To reproduce apple trees, scion wood, or shoots from an existing tree, are grafted onto roots, or rootstock. Since grafting began centuries ago, there have also been rootstocks that are developed separately from varieties. Horticulturalists have made a more concerted effort to develop rootstocks over the past 150 years, and the industry has now blossomed and become economically vibrant independently of apple variety breeding (Webster and Wertheim, 2003). Rootstocks can be disease resistant or react differently to different soils, but perhaps the most important variable aspect of rootstocks is their size. There's the Malling series rootstock, developed at the Malling Center in the UK, Budagovskys from Russia, and Genevas from New York. I encountered these three rootstocks most commonly in the Midwest, but there are countless, ever-multiplying numbers of rootstocks being developed and used. With increasing land prices and pressures to reduce fertilizer and pesticide use, managing and concentrating production through the manipulation of rootstocks has also become more appealing.

Smaller trees have three main rationalizing effects that generate predictability and control. Firstly, they increase output, although as I suggest below, this is both contested and considered largely secondary to the qualitative production assets associated with the technology. Plantings on standard rootstocks are about 100–200 trees an acre, semi-dwarf plantings could reach 500 trees an acre, but fully dwarfing trees on a trellis can reach upwards of 1500 trees an acre. While each tree might be less productive than a full standard tree, the overall production per acre could be higher. My research participants rarely elaborated on this point, and some even suggested that there was no increase in total yield. Instead, they often focused on the speed at which the smaller trees came into production, and the quality of fruit they could produce: the second and third rationalizing effects.

"I think the biggest benefit is not the ultimate production." Ben told me. "The in-plant production is probably the same, and once you get a big tree going it produces a lot of apples, but the benefit is, number one, the time to production is drastically reduced. By the third year, we'll have a pretty big crop. Second year we'll expect to get 10–15 apples per tree." Rather than waiting ten years for trees to produce apples, growers can reach full production within three years. Reaching full production faster is beneficial because it allows growers to get quicker returns on their investments, which is important given that other technologies, such as irrigation systems and plant patents, have increased the cost of planting. It also reduces the time between planting and harvesting. When there is a bigger gap between planting and harvesting, the economic context in which the orchard was planted could be drastically different from the economic context when the apples actually go on the market. The time in between makes planning and responding to changes in demand difficult: an environmental hurdle to be overcome as much as possible. The speed at which trees start producing and generating a return to growers is also valuable as it enables growers to capture the increased value that is associated with new varieties that have a higher demand and lower supply. In short, the rootstocks are immediately intended to position the orchard in the market by quickening the response to market pressures, and also enabling for a greater control over the apples.

One of the greatest assets associated with dwarfing trees is the quality of production. "So there, you say, a thousand trees per acre, you're going to want ten apples per tree." Ben remarked, mentioning the lower per-tree yield of dwarf trees. He went on to describe the qualitative differences facilitated by more grower intervention in the tree:

> "There's a little different thing with growing apples... You have to target exactly how big you want those apples to be. So what we target is to be in that 85–90% pack out with over half of those being 80 count [bigger apples]. Also, and largely as a response to the introduction of a trellis system, it is easier to produce uniform apples and other aspects of production can become more mechanized and efficient."

The trees expand the types of actions that growers perform, but competitive pressures also make the adoption of dwarfing rootstocks compulsive, along with the ideology of modern farming with which they are associated. When I asked Ben whether he was moving towards a more high-density orchard, he said, "Oh absolutely. Yeah anybody that's not planting trees on dwarfing rootstock is living way in the past, unless you had a strategy like you had a little orchard that was for pick your own and you just were going to have a bigger tree." Dwarfing trees are not just a material change, but they cultivate a spirit of productivism in which the grower's responsibility is to the market. The dwarfing tree is a symbol of being a serious, modern grower who is producing for a wholesale market, rather than running a small boutique operation. At an orchard workshop in the spring, I went to a talk on dwarfing rootstocks and high-density plantings. We stood in a forest of delicate, miniature young apple trees, strung along a set of wires. An extension agent was explaining, "you need to stop thinking about producing trees. You're not producing trees. You're producing apples." She continued to explain how high density plantings would be good for growers by channeling the energy the tree consumes into the apples. The less wood the better, she suggested. A similar comment was made to me on a bus during an orchard tour in New England. "We used to grow an tree forest that had fruit, and now we grow a fruit forest that has trees" These comments allude to shifting principles in the production that refocus attention away from trees and increasingly towards the commodity being produced.

Because that commodity and how it is valued is determined by the market, shifting attention to the apple also means orienting activities towards market-determined goals: the size and color of the apple that allocates economic value in retail institutions. The rationalizing effects lauded by growers demonstrates that they

are an embodiment of market metrics, and supports the types of market governance associated with new neoliberal food trends. Attempting to produce the apples most prized by consumers and required by retail markets, which are constantly changing, growers need to manage the ecological particularities of their orchard to produce a consistent, desirable commodity, and this requires practices of customization.

Customized landscapes

Dwarfing rootstocks are not simply a matter of replacing larger trees with smaller ones and making growers more responsive to the market. They also craft the nature of responsiveness, or the culture of production. Trellis systems expand economic action, exemplifying the type of habilitating aspects of production discussed by Callon (2008). Market standards have also become more stringent. Growers are expected to manage ecological differences on the farms and between farms so that the effects of those differences are not expressed in their apples. It is this spirit of localized and specialized assembling with the trees that produces what I call customized landscapes, and I suggest it is the clearest indication of the neoliberal ethic in production, where expanding options are paired with increasingly narrow market standards.

The dwarfing landscape is manufactured to generate aesthetically idealized apples that meet high market standards, using diverse environmental resources. That is, they are used to expand the methods through which growers can produce apples of a narrower quality. For example, when I asked Russell how the dwarfing rootstocks influenced his production, he stated:

> "Well it's the system. With the dwarfing root, we plant north and south rows. We manage the height to about ten or twelve feet, and it's what's called a slender spindle or a vertical axe. The point is, the tree is only about four feet wide, so that sun on the East shines through to the trunk in the morning, and on the West, it shines through to the trunk on the West side so that every apple gets sunlight, directly. The spur leaves get direct sunlight, so that they build the carbohydrates for the apple. The apple gets size and color."

An uninterrupted tree would grow with branches all around, spreading in every direction. For growers, dwarfing rootstocks enable more control over the orchard. There are more moments of decision-making, as trees can be more easily manipulated in the space to account for different ecological resources. Decisions that the tree would typically make, where it decides how quickly to grow, or how tall to grow, is replaced by the grower and this expands the possibilities to suit the direction of the sun or the constraints of human height for picking. There are also various techniques that would bring various materials together, such as sunlight, trellis systems, varieties, and types of rootstocks. How these materials were assembled was significantly different from one orchard to another, and even within orchards, many growers had a diverse patchwork of growing systems. The rootstocks did not just dictate what assemblage was formed, but how the assembling was undertaken.

Many growers use a technique called the slender spindle. In this technique, the tree is anchored along a central support, the branches pruned to be thin and grow horizontally, and the height encouraged to grow to about eight feet. There is a tall slender spindle and a super slender spindle, whereby growers plant closer together and make the tree to grow taller and less wide. In a spindle training system, only weak branches are kept that are 30–50% the width of a central trunk, or "leader," which is also quite thin. The effect is almost vine like, and "old wood" is constantly replaced with "new wood" that is highly productive. The branches are always tied down when the tree is young, often below a horizontal position. Tying the branches encourages the tree to produce apples more quickly.

Perhaps the newest training methods are the bi-axis or bi-baum, and the fruiting wall. In these systems, an incision is made near the base of the tree that encourages a branch to grow, or two incisions encourage two branches to grow. All other branches are pruned so that either the one or two other branches are encouraged to grow to the same diameter as the initial branch. Those branches are encouraged to become leaders, so rather that having one central leader that all branches emerge from, there are two or three leaders and either minimal branches, or none at all. The trees are packed closely together and they look the flattest of all the plantings. While the dwarfing rootstocks create the plant to more suitably reflect economic demands, like higher productivity and more efficient energy use, having smaller, more nubile branches also enables more manipulation of the plant and varied forms of grower intervention into their growth. The extended facility of plant manipulation would become important for planting trendy new varieties, and ensuring that despite their individual quirks, they could be quickly brought to a high standard of production.

Growers pull different facets of production together and weave them into a site-specific program. Actively participating in high-end apple production requires revising and replanting the orchard landscape, and quickly adapting orchard assemblages for production. For example, Walter explained how he had chosen rootstocks for his farm based on information and experience but needed to experiment with new crops. "This is on Bud-9. What we like to use is there. One of the bad things about [new] managed varieties is you jump into it not really knowing." He explained, pointing down a row of trees in the orchard. Bud-9, short for Budagovesky 9, grows to about 30% the size of a standard tree and is known to be precocious, or generate trees that are productive quite early, while also being winter hardy. "Bud 9 was really growing well in some soils. We have a lot of sandy loam here, so we need a strong rootstock. Our farm was afraid of an M-26 because of fireblight [a common apple disease], so we went with a Bud-9. And we have some on Nic-29. That's these here. They grew a lot better. Now these are two years older," he said, pointing to a dense row of green leaves, about a foot taller than me. "But those," pointing disappointedly to the row on Bud-9, scrawny and reaching about shoulder-height, "won't match these in two years. So it's really a learning process through everything." On many of my orchard tours, growers would have me spinning as they pointed this way and that way to various plantings, pointing out successes and failures. They would often note when they have found a combination of practices that worked well, but staying open to revision always remained and was key for grower success.

The trees are carefully spatially organized, they're trained thoughtfully, and varieties are selected for the specific sites. In some cases, growers discussed these actions explicitly as a way to keep up with markets, and produce the types of standard products deemed most valuable. Growing and marketing conventionally for retail was largely an exercise in honing customization for increasingly rigorous standards and fluctuating markets exemplifying the type of expansion of action paired with increasingly tight expectations. Paul, for example, discussed the pressure of investing in the types of dwarfing systems that the market demanded when trends shift so quickly.

> "The problem is, we have tremendous horsepower to produce anything in the agricultural environment. So, if we're just looking at apples, there's huge horsepower to take anything and produce it to levels that are beyond the demand... every variety would go through that economic curve where, if you're on the front end of it, of a good variety, you made money. If you

> planted on the tail end, you're now in the over-producing line and so every variety of any quality typically was destined to become non-profitable in a pure form... You're planting products in orchards that are, these days, in the 20,000 dollar an acre establishment costs. You're putting in varieties that take that level of investment and you are going to be the one that suffers, in the end, if it is going to be a very successful variety."

The 'increased horsepower' associated with technologies like high density planting can generate considerable risk and lead to the types of regional disadvantage cited by McKenna et al. (2001). The ability to respond to the market and plant varieties that have grown in popularity makes the market fluctuate more, and creates instability. The increased capital intensity associated with the rootstocks, the increased ability to respond to markets and manage production, and the volatility of price that would follow could exacerbate pressures on midsized growers. The customized orchard can be seen to increase grower market entrenchment.

Flexible specialization

While aspects of the dwarfing rootstocks reflect and reproduce a type of neoliberal ethic, where technological liberation leads to market constraint, the customized landscape can also provide a platform for new forms of agricultural organization. Customization and experimentation, facilitated by the rootstocks, were used to develop innovative and diverse market strategies and move away from large-scale commodity production. "You have to evolve as times change for both varieties and also for horticultural systems" Russell, a Michigan grower explained. Rather than simply responding to a single market, he, like many growers I interviewed, adopted diverse marketing angles around his apples. When I asked what varieties he was growing, he responded:

> "The big one is Honeycrisp, followed by Gala and Gingergold, and McIntosh. So Gala, Gingergold, McIntosh, or Gala and Gingergold more than Macs, but Macs should be kicking it up here pretty quick. Then I have a bunch of varieties I grow for the farm markets and for direct marketing. Zestar, Stanza, and Paula Red are our three early ones, along with Gingergold, but I only have a little of each of them, and then Gingergold we have a commercial amount. We just shipped 30 bins yesterday to the packinghouse, and we're to keep about 65 bins or 70 bins for ourselves to market to our grocery stores. We grow Cortland, and Jonagold, that we sell mostly through our farm markets, and to our grocery stores. And we grow a lot of Mutsu, same thing – we market those ourselves mostly. Then we grow the new ones that haven't produced yet. Let's see. I have Northern Spy – we've always grown some Northern Spy. I have a new Northern Spy planted on dwarfing root. Spy's are going out all over and I expect to be able to market those online to the nostalgic apple market. And then I have a block that hasn't produced yet that's just in it's second leaf, of Gravenstein, Spitzenberg, Cox's Orange Pippin and New Town Pippin, that I'm growing for the heritage group that I will also market online for, you know, shipping or whatever kind of buzz we can get out of it, in small quantities."

Different ways of managing varieties for different markets was typical. Interest in local foods and the growth of farm markets propelled alternative forms of marketing forward. For example, Kate, a mid-sized grower who operated a bake-shop on the orchard, noted that 10% of her apple production was sold at their retail store but it earned 50% of their income. The other 90% of her apples went to wholesale. Even farms that derived much more income from wholesale often saw direct markets as an important way to influence the industry and participate in the creation of regional brands. This effort to fragment the markets and shape market trends through new cooperative marketing methods can be seen as an example of a type of clustering and diffuse micro-regulation, commonly associated with flexible specialization.

Flexible specialization is often associated with high-end clothing manufacturing, and it became a hot topic among economic sociologists in the 1980s and 1990s. Flexible specialization was a mode of production that helped to explain why high-value production zones were maintained with a relatively large quantity of small or midsized producers, and it may help to consider how more high value production clusters could emerge regionally in agriculture. Unlike mass clothing production, high-end fashion requires a constant revision of the product and the quick adoption of new tools and labor to produce trendy clothes (Waldinger, 1986; Piore and Sabel, 1984; see also Collins, 2001, 2009). Large-scale mass production is ill-suited to such constant change, and so it is replaced by regional clusters of firms able to do short subcontracted production (Piore and Sabel, 1984; Hirst and Zeitlin, 1991; Zeitlin and Totterdill, 1989). Marketing strategies on orchards that manage multiple niche markets reflect patterns of flexible specialization. But flexible specialization relates to more than just marketing: it's an assemblage also tied to the way new products are created, knowledge is circulated, and growers exercise market power.

Growers experimented with new varieties that were regionally appropriate, novel for the market, and made use of the types of dwarfing technologies that reduced the time to production for new varieties. Many of them had experimental blocks that were not committed to a particular variety, but were involved with testing or breeding new varieties. These were cited as an important part of what it meant to be a modern grower. The dwarfing rootstocks ease the risks associated with experimentation by requiring less space for new varieties and quickening the time to production. The result is that fewer resources need to be spent on trying things out, and if a variety turns out to be inappropriate for the orchard, or simply undesirable, not so much is lost. Waiting for six years to see if a variety is good, and holding up 70 square feet of space in the meantime, is a much more onerous investment than a dwarfing tree for something that might not work out. The experimental blocks also emerged from a desire to customize trees and roots to a particular orchard climate. I asked Glenn, a large grower who also ran a packing line, how he chose new varieties. He described how traveling to other orchards and testing varieties became an integral part of his localized orchard program:

> "We were never going to be in a place where we could be the cheapest. I knew that if we were going to survive we had to do things that were different. We couldn't be a commodity producer, so we started way back when, testing a lot of new varieties from all over the world. Being here we're relatively isolated... If we were going to survive and understand the state-of-the-art technology, we were going to have to travel to see it...you asked how we pick out new varieties. We have, at any given time, last year I think we planted 60 some new test varieties from around the world. So it's become part of our core strategy."

Having a diversity of orchards oriented to the types of customization discussed in the previous section and forms of experimentation also contributed to knowledge-sharing communities, reflecting the types of clustering and knowledge sharing typical of industrial districts emerging from flexible specialization (Boschma and Lambooy, 2002; Hirst and Zeitlin, 1997). These collaborative relations are where new forms of flexible specialization among growers can be seen to take them away from common

narratives of neoliberalism. As Hirst and Zeitlin (1997: 226) argue, "regulatory requirements of flexible specialization are incompatible with a neoliberal regime of unregulated markets and cut-throat competition...[as it] depends for its long-term success on a minimum of trust and cooperation among economic actors... [that] depends in turn on rules limiting certain forms of competition," which we could see in the emergence of marketing co-operatives for particular apple varieties, and "collective institutions for the supply of nonmarket inputs such as technological information..." The exchange of information was often aided by university extension services, but also developed informally and formally through various grower organizations.

Growers visit each other's farms, and participate in a variety of local, regional, and sometimes national events. The International Fruit Tree Association (IFTA, previously the International Dwarfing Fruit Tree Association), for example, was developed "to promote an understanding of the nature and use of dwarf fruit trees through research, education and dissemination of information." While experimentation and knowledge sharing aren't new to agriculture, and certainly not specialty crops, the emergence and expansion of the IFTA as an association designed for the purpose of working with dwarfing trees exemplifies how the technologies encouraged those practices in a form that was not in existence previously. I attended two of their annual meetings, one of which was essentially a series of field trips to regional orchards. During these trips, growers would assemble in a building for a workshop before going out into the orchard and talking about the orchard in the context of the workshop topic. An observer could easily notice the discomfort growers felt about having a collection of others scrutinizing his or her orchard. Yet there is also a great advantage to amassing a collection of weathered experts and fresh minds on your orchard to talk about problems. On a tour organized by the International Fruit Tree Association, I was at an orchard where a young grower had recently moved onto high density planting. "I know there are a lot of experts here," he said. "Could one of you demonstrate how you prune? I'd like to see how you would do it." Several other growers noted how their experiences with high-density had been wrought with many mistakes and failures. The general consensus during the tours was that nobody gets it right the first time, but it's highly common to share successes and failures with other growers.

Having a lot of distinction between orchard and market practices encouraged this type of knowledge exchange. Take, for example, the experiences relayed by Ben, a mid-sized Midwestern grower selling for direct market and wholesale. "I think that the apple grower's association is good," he suggests, "The membership is high. That ranges from the little person that has ten trees, to the biggest ones. The chance to talk with those people as well as the really little orchards is invaluable. Even here, we have, you know—our discipline of doing it varies. We get together for breakfast the first Tuesday of every month. And that happened long before any networks or anything. That was just a bunch of farmers getting together for breakfast. To share ideas and share how we do things, and really work on being open with one another, and work on changes in our philosophy. We are not in competition. Sure maybe from the retail side, we've got markets down the road from us, but what we do is different. What's good for them is probably good for us and what's good for us is probably good for them." Ben described a historical context in which people were less willing to talk to one another, and changes in an economic philosophy away from the competitive coveting that can happen under conditions of tight competition.

Growers consistently visited each other's orchards, and many were in daily contact with others during busy orchard seasons. They knew about each other's markets, as well as their varieties and the types of plantings they used. They also knew how their contacts were doing that season, and it would be fairly common for growers to buy apples from each other for either the direct market or wholesale. Several growers recounted experiences of selling their excess high demand apples to a farm market down the road, or purchasing apples when their shelves ran empty. Another grower noted that they had an ongoing arrangement with a neighbor to fill a contract at a local supermarket.

The diverse markets being accessed and influenced, the orchard experimentation, and the development of community knowledge networks could be seen as flexible specialization and affiliated forms of regional clustering. While it may be fueled by the growth of new foodie markets, the customized orchard developed by growers can be seen to provide a material foundation for this new way of orcharding for the market. By promoting crafted, individualized, and farm-specific practices, there is less of a concern about giving away cultivation secrets, as beneficial practices will vary so much by farm, and greater interest in regional niche markets and market cooperation to expand the number of apple consumers. "We're not competing against each other" Doug told me, "we're all competing against Coca-Cola and Frito-Lay."

Increasingly, growers would join marketing cooperatives to grow "managed varieties," which are patented varieties owned by the cooperative. A cooperative can, among other things, discuss and negotiate a price with retailers and suppliers, and influence demand through collective variety marketing. These practices are consistent with those observed in flexible specialization clusters (Sabel, 1999). Two of the clubs that were present in the Midwest grew from collaborative, informal relationships that growers had already established. One of them developed from conversations that people had during meetings for the International Fruit Tree Association. One of the growers I spoke to, Grant, suggested that the idea of managed varieties came from conversations with growers at the IFTA. "So they're starting at some of these get-togethers and tours," he said. "There's a fair amount of barroom discussion about, you know, what are we going to do about this?" He was referring to unfair economic conditions and decline of Mid-sized growers. "What we really had to do was elevate ourselves beyond the commodity marketplace. We had to start to behave like brands...so that really, those discussions became the start of the whole notion of managed varieties." Another cooperative, the Midwest Apple Improvement Association, developed when a research station was shutting down its breeding program and needed to find a home for their breeding stock. A group of growers took trees onto their experimental blocks in their orchards, and formed the organization. The organization continues to share tree materials, and maintains an open membership with a $100 joining fee. The main requirement is that new trees are shared with the group. As these cooperatives grow, they allow smaller growers to access larger markets and engage in collaborative market strategies.

From customization to flexible specialization: the orchard assemblage and possible futures in food

While there has been much to suggest that the new corporate-environmental food regime may be emerging in ways that would challenge the survival of diverse farm sizes, it is also possible that alternatives are developing that can be fruitful for different types of growers. One of those features is the dwarfing technologies that can increase marketization by compelling customization on the orchard, while also encouraging something akin to flexible specialization. It may be the spirit of customization combined with its associated economic pressures that propel these new organizational forms and their character. In doing so, they illustrate some stickiness to the ways that food production is assembled and

disassembled, and how the character of a technology can become vibrant and active in those processes.

As a habilitating technology, expanding a range of activities that can be undertaken on the farm, dwarfing rootstocks can be seen as a mascot for neoliberalism. They liberate in a way that invites market constraint. For commodity production destined for large wholesale markets, customization on the orchard is an embodiment of these neoliberal processes. However, for mid-sized growers, the customization can take on a different character and relate to processes of experimentation, collaboration, and ultimately economic cooperation. Those different features of production relate to one another, and can be seen to hold each other together and aid in the reproduction of the network. The rootstocks ease processes of experimentation. Their use is highly localized and diverse, and paired with experimental practices, contribute to knowledge sharing and collaboration. Finally, customization, variety experimentation, and collaborative relationships, supports the development of cooperative approaches to markets, which in turn also supports those other aspects of production. These aspects of production do not always neatly and seamlessly fit together—certainly there is conflict between growers in a cooperative, or conflicts between various markets that growers are trying to participate in—but this paper aims to suggest that alternative farming is possible as tools are assembled and reassembled into production processes.

While a corporate-environmental food regime is visibly emerging, this paper aims to highlight some possible pathways towards an alternative. While these forms of flexible specialization I describe in the apple industry are not a cure-all for the types of environmental and social ills observed with the industrialization of agriculture, some of their features can be used as a site of optimistic attention in an effort to make revolution in our living rooms (or orchards), as Gibson-Graham (2006) suggests. While the toppling of small whip-like trees, overburdened with apples, may make the orchard guest weary with reminders of productivist pressures, we may not need to confront the additional trial of uprooting that which is already planted in the ground. If we can derive inspiration from the ways in which the trees themselves cultivate fruitful economies, and aid them in their efforts, we may find a less daunting way to flourish.

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