Resilience in a Concentrated and Consolidated Food System

Article *in* Journal of Environmental Studies and Sciences · November 2014

DOI: 10.1007/s13412-015-0292-2

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Working Paper
November 2014

Abstract:

The current economic and social organization of our food system presents social, ecological and economic risks that threaten the long term capability of humanity to provide its food needs. To examine food system resilience it is necessary to see that ecological risks are bound up with the social and economic organization of society; that relationships between people and between people and their particular places are critical; and that issues of scale are keenly important. The current consolidated and globalized food system has resulted from horizontal and vertical integration in food system sectors and globalization of agricultural and food markets. This system constrains farmers (and others) in making choices that can fend off likely ecological and social disruptions while limiting their ability to accommodate change. It has eliminated smaller farms and businesses that provided a redundancy of role and function resulting in few failsafe mechanisms for the food system. A focus on efficiency, standardization and specialization has decreased the diversity of scale, form and organization across the food system. Finally, the dominant food system's inability to solve food insecurity and hunger within both rich and poor countries, coupled with an industrial diet that uses up a great many natural resources, makes the system precarious. While these risks are significant, by looking at social and ecological notions of resilience, new forms of agrifood system resilience that is connected to people and place can be proposed.

1. Introduction:

As the negative impact of a changing climate on the agriculture and food system becomes clearer, as soil degradation continues to increase across the globe, and as the world's population grows larger, there are a number of emerging risks in our dominant global food system. While the industrial agriculture paradigm has proved extremely productive over the past 150 years, primarily through a reliance on fossil fuels, the consequences of methods used to achieve this productivity have now turned into major risks for food security for future generations. One source of risk in the industrialized food system is its economic and social organization. A relatively small number of agribusiness firms, operating globally, have powerfully shaped who produces food, what is produced, how and where it's produced, and where and by whom it is eaten. According to the International Assessment of Agricultural Knowledge, Science and Technology for Development IAASTD), industrialized agriculture is simply not an option if we are to secure a sustainable food supply for the future (McIntyre et al 2009). To understand the resilience of our food system requires a focus on the real ecological risks of the social, economic and political organization of it, and an examination of the ways that resilience can be enhanced for everyone in the food system.

The dominant agrifood system, a system of high yielding mechanized agriculture characterized by capital intensive inputs, is rooted in the industrialization of agriculture and food systems over the last 150 years. As Lyson (2004) notes, mechanization, the use of chemicals, and biotechnology have made agriculture more specialized and centralized at both the farm and regional levels, thereby lifting food production and consumption out of connection to particular places and their communities. Combined with a revolution in transportation in the 19th century, the geographic scale of food production changed throughout the 20th century, leading to regional specialization in crops and livestock, and altering consumers' relationships with their own and others' ecologies. For example, the fresh leafy greens available all winter in US supermarkets are composed mostly of water, transporting a precious resource from areas of production in the arid Southwest to areas of the country with plenty of water, yet arguably the vast majority of consumers do not consider the impact of their consumption decision on the ecology of those places that produce these greens for us. Moreover, the widespread use of chemicals following World War II reduced our need for complex systems of ecological management in agricultural production. This has led to monoculture in many forms but the associated minimization of complexity and the rise of standardization have also allowed the development of industrial organizations that dominate today's agrifood system.

These changes (see also Weis 2007; Magdoff, Foster and Buttel 2000; Friedmann and McMichael 1989) have paved the way for the current social and economic structure of our agrifood system. We cannot understand the technological changes that have occurred, and the specific risks they may bring, if we overlook how they were adapted and applied by people within certain sets of political, economic and social relationships. Many of the risks associated with our current agrifood system should be examined from the standpoint of who makes decisions in food and agriculture – from where and what food will be produced, to who produces it and how to who will get to eat it. In the last few decades of globalization, decision-making about food has migrated from a more public arena (c.f. Weis 2007) into a an arena of private decision-making that largely involves those within the dominant firms, including their management teams, boards of directors and shareholders. We should question how well this process of relying on the decisions of self-interested individuals prepares our food system for social, ecological or economic shocks that could come about from climate change, rising inequality or political disorganization.

To illustrate, the research undertaken by my colleagues and I at the University of Missouri since the early 1990s show there has been an increase in concentration in almost all sectors of the agrifood industry in the U.S. (Hendrickson et al 2002; Howard 2009a). Research by the ETC Group (2013a), a Canadian non-profit, shows the trend accelerating at the global level as well. For example, in the U.S., one-quarter of the red meat slaughter industry was controlled by the four largest firms in 1967, doubling by 2007. In wet milling, the four largest corn milling plants controlled 68 percent of the market in 1967, but by 2007 that share increased to 83 percent (James 2013:3). Nearly three-fifths of proprietary seeds globally are controlled by four companies, three of which are global agrichemical firms as well (ETC Group 2013a). Bunge, ADM, Cargill and Louis-Dreyfus are the dominant grain traders and processors in North America, Brazil and China (Peine 2013; Hendrickson et al 2008). Global supermarkets such as Wal-Mart, Carrefour and Tesco have penetrated food markets around the globe, with standards for quality and safety of food being set by these and other transnational firms (Hatanaka et al 2006).

In this paper, I concentrate on outlining the social and economic structure of the dominant, industrialized agrifood system by examining the key firms involved, and explore the risks to a sustainable food system the dominant structure creates ecologically, socially and economically. To begin, I examine the ideas of resilience in the food system, and search for new way that will combine ideas of scale, structure and social relationships that can help us explore resilience in the face of a highly concentrated, centralized and globalized food system, which is documented in Section II. There are social, ecological and economic risks that are associated with these changes in the structure of food production and consumption that threaten the long term capability of humanity to provide enough food for its needs. While these risks are significant, by looking at social and ecological notions of resilience, we can propose new forms of agrifood system resilience that is connected to people and place. Even now, people around the world are engaged in developing food system resilience in the face of climate change, political instability, and resource degradation.

I. Materials and Methods[1]:

The Evolution of Resilience Thinking for Food and Agriculture

Three key concepts that emerge from the resilience literature are useful for examining the food system. Ecological risks are bound up with the social and economic organization of society; relationships between people and between people and their particular places are critical; and issues of scale are keenly important to consider when discussing resilience. These ideas can help build a concept of resilience with which to examine the current agriculture and food system for its risks, and contribute to thinking of ways that food and agriculture could become more resilient.

High yielding, industrialized, "conventional" agriculture systems have contributed to a decrease in ecological resilience through the application of modern productivity tools such as reliance on chemicals to manage fertility and pests, irrigation schemes, and diesel powered machines (King 2008). As King (p 122) points out, these systems are relatively young, roughly 150 years old, and owe their existence in large part due to dominant economic paradigms that have shaped them through "regulations, subsidies, trade negotiations, policies, and other

[1] Given that the original research contained in this publication is based on freely available secondary sources, no human or animal subject research was necessary.

'blockages.'" While this system has provided a great deal of food to an ever expanding and urbanizing population, it has also occurred in a period of relatively stable temperate climate, especially in North America, and has been shown to be accompanied by a number of negative ecological attributes, including soil degradation, soil salinization, nutrient run-off, monoculture with its associated decline in biodiversity, and unintended consequences of chemical use on other species. Moreover, the social and economic organization of agriculture and food cannot guarantee food security, even for American consumers where over 3,500 calories are available per day per person (Nestle 2007) yet approximately 15 percent of households are considered food insecure. For King and others, the risks of the highly productive technologies adopted by agriculture cannot be understood apart from the economic and social paradigm in which they exist. Conventional agriculture is part and parcel of an economic paradigm that has led to a highly concentrated, heavily industrialized food and agriculture system that faces ecological as well as social risks.

My own analysis of the structure of food and agriculture parallels King's and is rooted in a long tradition of both political economy of agriculture and Jeffersonian understandings of food and agriculture (for a summary see Bonanno 2009). In these analyses, the current structure of relationships in the food and agriculture system have created negative impacts on communities as well as economic and ecological consequences (Constance et al 2014). For example, Lobao and Stofferhan (2008) analyzed 51 studies on the relationship between agricultural structure and community well-being and found detrimental effects of industrialized farming on communities in 82 percent of them. These negative effects included greater income inequality or poverty; decreased retail trade and diversity of retail firms; population declines; and negative health effects of large livestock operations. In these analyses, the complex ecological systems of agriculture and food have been shaped and melded into rational, industrialized processes of production that replicate the factory and embeds the food system in capitalistic relationships of production and consumption (Weis 2007).

In contrast, initial understandings of the idea of resilience often focused on ecological systems only, ignoring their social and economic aspects (Adger 2000). Social scientists argue that politics and power relationships are lacking from much current articulation of the resilience concept, and suggest that the concept of resilience should focus on the question of '*resilience of what and for whom*' (Brown 2014; Cote and Nightingale 2012). As King (2008) points out the current 'conventional' agriculture production systems conform to the idea of *engineering resilience* with its focus on efficiencies, a return to a steady state or equilibrium, and assumptions of constancy and predictability. Such notions reflect 20th century theories of economy and science that posit the idea there can be objective understandings of ecological systems. The main point of these discussions is the necessity for scrutinizing how the ecology of the dominant agrifood system, and its associated ecological risks, is intertwined with its economic and social organization.

King bridges the gap between social and ecological notions of resilience with a model of 'adaptive resilience' allowing for instability and non-equilibrium states, and grounded in the idea that people are not separate from nature, but rather part of it. How humanity organizes its social and economic relationships both shapes nature and is shaped by it. In other words, the asymmetrical power relationships present between farmers, firms, consumers and communities in the agrifood system can create social, economic and ecological risks. The focus of adaptive resilience is on the capacity of systems to generate options and scenarios, through relationships and processes. King illustrates her model with forms of food production and consumption such as biodynamics, permaculture and community gardens that allow for the development of networks that enhance communication and allow for deliberate learning. These alternatives ground people in particular place and allow for the adaptive capacity to develop. These relationships between ecology, economy and society are always dynamic and transformations happen all the time as McManus et al (2012:21) document. Therefore resilience should be understood as embracing and adapting to change, with community engagement and a sense of belonging fundamental to this ability. The key idea here is that social and economic organization impacts the resilience of systems and that community engagement and relationships shape resilient adaptation.

In the articulation of her model, King chose to focus on localized scales of production. However, our present agrifood system has lifted production and consumption out of its ecological and social spaces, and elevated it to the global scale – but with processes and impacts mediated at the local level (Marsden and Murdoch 2006). Therefore, Folke et al's (2010) emphasis on conceiving of resilience as persistence, adaptability and transformability, particularly at different scales becomes important. People and nature are interdependent systems, but the scale at which those interactions take place is critical. Folke and his co-authors

(2010: no page number) observe that because humans are acting at the global scale, transformation of human behavior and organization is necessary for social-ecological resilience. In their view, our current system will be forced to transform, but that this transformation will happen at scales larger than what local actors will be able to influence. Considering different scales of resilience is crucial as we dissect the global political and economic forces that are at work in shaping the dominant agrifood systems, and to think about how those forces may shape the resilience of emerging alternatives.

From the above discussion it is clear that we need to consider three things as we focus on the resilience of agrifood systems. First, ecological risks in agrifood systems are bound up with the social, economic and political organization of these systems. Ecological impacts such as soil degradation in the American Midwest are directly tied to monoculture systems of production which are shaped by market forces and trade regimes in the United States and abroad. One way to think about how social, political and economic systems impact ecological ones in agriculture and food is to consider which actors have the ability (e.g. the power) to make decisions about where food is going to be produced, how, by whom and who will get to eat it. Second, issues of scale must be considered in thinking about risk and resilience within the agrifood system. As I document below, an industrialized, globalized agrifood system has developed that will take concentrated effort at developing resilience at multiple scales. Finally, resilience is perhaps best thought of as strengthening and redefining food system relationships between people and between people and their particular places.

Incorporating these ideas brings us to a potentially useful way to gauge if our dominant food system is resilient to the risks outlined in the next section. In a draft paper prepared for communities building resilience in terms of climate change, Movement Generation (2014) articulated five different dimensions of resilience that echo King (2008) and Folk et al (2010). These five dimensions (also shown in Table 4) include 1) resistance to disruption, or the capacity of a system to fend off disruption; 2) latitude to accommodate change, or the ability of the system to stretch and adjust without being disruptive; 3) redundancy of role and function, that is the number of overlapping systems that can back-up each other; 4) diversity of organizational forms, including diversity of scale, form and organization across the system; and 5) precariousness which indicates how vulnerable the system is to losing its core identity and transitioning to a new state. Using these five dimensions is also a good way to evaluate food system vulnerabilities. While these dimensions do not explicitly focus on the same kinds of relationships that King highlights, interdependent relationships between people and between communities and their ecology can be situated in all of these dimensions. Moreover, combined with the adaptive resilience model, these dimensions of resilience are comparable to the core concepts of sustainability – ecology, economy and community – advocated by those interested in sustainable food systems (c.f. Lyson 2004; Hendrickson and Heffernan 2002; Mount 2012; De Schutter 2010b).

Documenting Consolidation and Globalization in the Food System

The social and economic organization of our present food and agricultural system arises from three distinct trends that have occurred over the past century, which also have consequences for how land and water is used around the world, how biodiversity is maintained, how farmers and rural populations have changed, and how workers are faring. These trends are horizontal and vertical integration and globalization. My colleagues and I from the University of Missouri have documented horizontal integration for many years, using a combination of industry trade journals, company annual reports, and U.S. government data to compile the four-firm concentration ratio of a given industry or commodity, what we call the CR4 ratio. This measures the total percentage of a market controlled by the industry's four largest firms. Increasing concentration in one particular market is called horizontal integration. We also map which firms dominate within and across particular sectors, or vertical integration. The third trend, globalization, proves much difficult to measure concretely via data such as the CR4, but can be revealed through general tendencies documented by a number of analysts. In this section, I explore the results of these trends in order to examine the food and agriculture system from the five dimensions of resilience articulated above.

Table 1, taken from previous work by myself and colleagues (James et al 2013; Constance et al 2014) presents the CR4 for several agricultural commodity markets and food retailing in the United States, as well as names of the top firms if known, for a 20 year period between 1990 and 2011. Several important patterns revealed in the table have critical implications for food system resiliency – for example, the degree of speed with which the dominant firms can respond to ecological or social changes (latitude to accommodate change) or to what extent decisions about food production and consumption are tightly held within a private entity or sets of entities (diversity of organizational forms.. Clearly, the food sectors represented became more horizontally integrated over the period, and concentration occurred relatively rapidly in some sectors. For example, in pork production, the capacity of the four largest firms in the U.S. nearly doubled in a 10 year period of time. Economic changes are linked with ecological realities as this expansion was only possible through significant spatial transformations and management changes that led to much larger concentrations of swine in fewer places (Wise and Trist 2010; Rich 2008).

Horizontal integration of a particular sector can also be accompanied by vertical integration across sectors. For example, Cargill is a global firm which produces and processes an array of meats, provides feed and trades/processes corn and soybeans. Tyson, which started as a poultry company, now supplies a number of animal proteins including beef and pork. Tables 1 and 3 show how quickly firms can come to dominate their industry as we see a number of changes in the names of the four largest firms over time. For instance, Wal-Mart has moved from selling no groceries to the top spot in food retail in just over two decades while JBS acquired some of the dominant firms in the meat sector during the 2000s to become the largest meat packer in the world.

<Table 1 about here>

The third trend that has shaped food and agriculture in the last forty years is globalization. Some commodities have long been globally traded, with production in the Global South but with markets dominated by just a few firms from the Global North, e.g. exotic commodities such as tea, coffee, cocoa and bananas. De Schutter (2010a:2) shows that the CR4 in global coffee roasting is 45 percent, three companies have more than 80 percent of the world's tea markets, and four companies control at least fifty percent of cocoa grinding and confectionary manufacturing. However, concentrated agricultural markets have arisen across the globe for what were once considered less internationalized commodities. Since the early 1990s, there has been a rapid increase in the globalization of the protein and grain markets, a process where firms come to dominate similar markets in different countries and geographic areas. The five grain traders that dominate the soybean processing market in Brazil are dominant in US grain trading (Wilkinson 2002; De Schutter 2010a; see also Hendrickson et al 2008), with ADM and others investing heavily in soybean processing facilities in Paraguay, Uruguay, Brazil and

China in the early 1990s to compete globally (see Heffernan et al 1999). Cargill operates significant enterprises around the globe with grain trading activities in all major ports and significant processing facilities in China, where ADM, Bunge, Cargill and Louis Dreyfus have become the largest soybean processors (Peine 2013). Constance et al (2013) note that Tyson has significant meat operations in Mexico while Smithfield operates pork facilities in Brazil and Eastern Europe. US based firms are not the only dominant players either. JBS, based in Brazil, is currently the world's largest beef packer. Smithfield, the largest US pork processor, was acquired by a Chinese pork packer in 2013.

Rapid consolidation has also occurred globally in the agricultural inputs sector (see Table 2). ETC Group (2013a) estimates the top four fertilizer firms have close to a quarter of the global market, mainly in nitrogen, phosphorus and potassium that are either mined or depend upon fossil fuels for synthetic production. Soil fertility is not to be taken lightly as it has been one of the most vexing problems for agriculture throughout human history. Montgomery (2007) argues that soil degradation contributed to the collapse of advanced civilizations throughout history; while Foster and Magdoff (2000) show that the search for amendments to improve exhausted soils was directly connected to colonialist expansion in South America. Because synthetic fertilizers have become central in industrialized agriculture, the firms that control them can globally allocate them.

<Table 2 about here>

Seeds and breeds faced the same horizontal and vertical integration pressures as fertilizers. Howard (2009a) documents the rapid consolidation of the seed industry in the 2000s, paying particular attention to the consolidation that occurred after the introduction of Round-up Ready seeds (see also Hubbard 2009). Chemical giant Monsanto entered the seed industry at that point and became the dominant firm with the acquisition of more than 50 seed firms. ETC Group (2013a) estimates that the top four firms have almost 60 percent of the global proprietary seed market. Seeds have prompted more public attention than the concentration in the genetics of poultry, cattle and swine, but the tendencies are the same. Nearly all of global poultry genetics and close to two-thirds of cattle and swine genetics are controlled by four firms (ETC Group 2013a; see also Gura 2007). Agrochemicals are also highly consolidated with ETC Group (2013a) estimating that four firms account for over 60 percent of sales. What is perhaps more striking is that traditional agrochemical firms like Syngenta, Monsanto and DuPont moved into the seed industry in the 1990s and 2000s (UNCTAD 2006), and now six of those firms may account for three-quarters of private sector plant breeding, over half of the commercial seed market and over three-quarters of global agrichemical sales (ETC Group 2013a).

Many consumers may not understand or care that farms in their countries have been consolidated into larger holdings, but they are even less knowledgeable about the concentration along the agrifood value chain that shapes their own grocery shopping. Almost all consumers in the global North, and many urban dwellers in the global South, buy goods produced through the highly consolidated agrifood system, mostly in supermarkets. In the United States, the largest four grocers account for between 42 and 51 percent of grocery sales, depending on how the sales of the largest grocer, Wal-Mart, are estimated (see Table 3). The configuration of this industry has changed significantly in the last two decades, as Wal-Mart first entered the grocery market in 1989 and now has between a quarter and a third of US sales. But the rise of dominant grocers has occurred globally. Carrefour and Wal-Mart are key players in the Brazilian supermarket industry (Bauerova, Burritt and Oliveira 2010); Tesco is the largest grocer in the United Kingdom with a significant presence in Asia, (Datamonitor 2010) and ties to the Charoen Pokphand Group which provides feed and genetics for poultry and shrimp production in Asia (ETC Group 2013); Wal-Mart bought Massmart in South Africa under much criticism from that country's competition commission, and has begun partnerships with retailers in India (Dow Theory Forecasts, 2009). My point is to show that transnational grocers operating around the world have become a reality of the global agrifood system in the last fifteen years.

In the following section, I analyze how these significant changes in the structure of the agrifood system impact food and agricultural resilience, but two specific examples tie these sections together. While the transformations described are the outcome of processes that were initiated in the development of capitalist agriculture (Weis 2007), they have been furthered by neoliberal concepts of free markets and globalization. In a very recent work, Sinclair et al (2014:379) used a resilience lens to describe transformative changes that took place in the Australian dairy sector after it was deregulated to orient itself to a more neoliberal perspective. In the new system, increased competition between producers and the increasing power of the supermarkets to dictate terms led "producers to manage a system that carries increased risk in the physical environment and to animal health and welfare because of higher stocking rates and production per cow." Social and economic organization clearly impacted ecological resilience, while the decreased social capital of the producers limited their capacity to create alternatives, i.e. to participate in King's model of adaptive resilience.

Another example is the use of synthetic fertilizers and chemicals that has allowed farmers across the globe to farm more land, significantly changing their production practices. Once farmers become locked into Cochrane's technological treadmill, they become reliant on these technologies, the firms that provide them, and the capitalist relationships of production that frame their decisions (Cochrane 1958). The application of technologies changes the agroecosystems in which they are applied giving rise to new challenges that are then met with new technologies that end up reinforcing the treadmill. To wit, the development and application of Round-up Ready technology has given rise to over 30 different resistant weed species globally (www.weedscience.org). Because farmers in the US abandoned weed management practices such as cover crops and crop rotations as they adopted GM crops, the development of resistance to Round-up and other herbicides now threatens soil conservation gains as farmers turn back to tillage (CAST 2012). Farmers use stronger herbicide cocktails and wait for the next innovations in GM.[2] Cover crops and crop rotations are economically challenging for many farmers because the consolidation of commodity markets has closed out options on both the input side (seeds for cover crops and alternative crops) and output side (markets for alternative crops used in crop rotations) (Davis et al 2012).

II. Results:

Implications of Agrifood System Organization for Food System Resilience

I now turn to examining how the dimensions of resilience articulated above are influenced within the current dominant food system, especially with respect to the power asymmetries that we have identified above. What Sinclair and her co-authors presented is a specific and localized case study that links global processes and local adaptations in a focus on

[2] In September 2014, the USDA announced plans to deregulate Dow's Enlist soybeans, a variety that is resistant to multiple herbicides, including 2,4-D. Based on discussions with my agricultural students who come from farms and reading of the agricultural press, many growers believe such varieties are necessary to help them combat the effects of palmer amaranth, a very difficult to control pigweed that is resistant to glyphosate.

social and ecological resilience. In a similar attempt, I analyze the information presented in the proceeding section in light of the five dimensions of resilience noted above.

<Table 4 here>

Resistance to Disruption: Much like King (2008), Movement Generation (2014 p 4) makes the case that "nature can no longer tolerate globalized industrial production…change is inevitable." The IAASTD, a thorough assessment of the world's agriculture and food system by over 400 experts, offered a similar conclusion – that the current system of agricultural production must change, given that the world faces key resource constraints, including decreasing amounts of land available for agriculture and increasing scarcity of fresh water resources, both exacerbated by climate change (McIntyre et al 2009). In essence the IAASTD report concluded that the agrifood system had to change both its social and economic organization and the farming practices the dominant system promotes around the globe to address high food prices, hunger, social inequalities and environmental disasters. By bringing together over 400 experts on agriculture and food, the IAASTD report provides the most significant summary of the organization and consequences of the global agrifood system, and suggests this system is set to undergo significant transformations with the only questions what kind and how. In short, it is getting harder and harder for the agrifood system to *resist disruption* to its core identity of industrialized agriculture in the face of droughts, floods, soil degradation and social upheaval.

Redundancy of Role and Function: The dominant agrifood system has managed its growth and expansion based on the ideas of efficiency of labor and standardization. Standardization and specialization have both contributed to, and occurred because of, economic trends toward consolidation. This means that the necessary redundancy of role and function from ecological, social and economic perspectives has been eliminated. Fewer and fewer overlapping systems are in place – at least in the industrial system that feeds the global North and global urban dwellers.

For instance, commercial seeds and breeds have focused on a few traits in a few crops that become the basis for our global diet. Hoffmann (2004) estimated that 12 plant species and only five terrestrial animal species provide 70 percent of all human food supply. ETC Group in an extensively documented brief (2013b:2) states that farmers operating within industrialized agriculture systems grow about 150 crops, while subsistence farmers providing mostly for themselves or their communities grow approximately 7,000. As private approaches to crop and animal breeding take hold, the diversity within even these species is ever more narrowly constrained (ETC Group 2013a; Sligh and Lauffer 2004). Minor grain crops like sorghum, once considered a staple of crop rotations on Midwestern farms, and many indigenous crops suffer from limited investment in improvements from both public and private breeders. This results in a globally standardized food supply, decreasing species diversity at the global level while maintaining nationally "species rich" food supplies (Khoury et al 2014; see also Weis 2007). This decreasing diversity has self-reinforcing cycles. For instance, soil scientists are increasingly recognizing that the removal of native vegetation and replacement with crop monoculture began the decline in microbial community characteristics in the soil, and the implementation and use of commercial fertilizers has hastened this decline (Fierer et al 2013). That makes resilience of the soil microbial ecology very low just when it will be needed most.

Standardization and centralization also contribute to imbalances of nutrients in soils as well as uneven water resources, and are certainly a factor in agriculture's large contributions to greenhouse gas emissions. Crop rotations have almost disappeared in many agricultural regions because equipment, storage and processing facilities are oriented only to the region's predominant crop. Sunflowers, for instance, grow well in Missouri but the closest processor is hours away. Nitrogen fixing alfalfa is no longer planted on most Midwestern farms because they have no animals to utilize it. Smaller, more diversified crop and livestock farms have been displaced by fewer, very large scale crop production or confined animal production units.

Diversity of Organizational Forms: A focus on efficiency, specialization and standardization in the formation of the dominant agrifood system has also meant a decrease in diversity of organizational forms and the scale at which they operate. The development of national and global supply chains in the agrifood system leaves out the smallest and least resourced farmers and businesses because they cannot achieve the scale necessary to participate. These smaller players are often more nimble in responding to rapid change, leaving larger, more complex entities with slow response patterns in their place. Corporations that can operate in multiple locations with easy access to capital dwarf entrepreneurial sole proprietors, cooperatives or community-organized social enterprises competing in a capitalistic system. Even the latter two tend to get swallowed up in corporate forms once they become successful; for example, the alternative distribution and retail business operations developed by the North American organic movement have been incorporated into large-scale organic companies that operate within the transnational corporations identified above (Howard 2009b).

An example of the absence of this dimension is explored in DeLind and Howard's (2008) examination of the outbreak of *E. coli O157:H7* in spinach. They concluded this food safety failure resulted from the industry's drive to consolidate production land areas as well as processing centers. In this case, no diversity of organizational forms also meant no redundancy of role and function. They note the drive for efficiency, specialization and standardization that led to the disaster was exacerbated by a belief in humanity's ability to control nature and every food safety risk. Unfortunately, this belief in control over all forms of contamination in the food system is articulated in a global system of quality and safety standards privately enforced (Hatanaka et al 2006), a set of rigid controls that leave little room for ecological accommodations that could reduce or mitigate the impacts of new pests, diseases or contaminants, which leads us directly to the next dimension.

Latitude to Accommodate Change: Decisions about what food to produce, where to produce it, how it should be produced, who will produce it, and who gets to eat it, reside more and more within tightly connected *global production networks* (Wilkinson 2006; Hendrickson et al 2008) where managers, boards of directors and shareholders become key decision-makers. While some commodity farmers across the world have been successful in participating within these networks, the investment and knowledge required to compete reduces the flexibility of their operations. In the U.S. and elsewhere, poultry or hog growers have significant capital invested in single-use facilities. Crop farmers tied to large, extensive crop production rely on major investments in agricultural inputs or ever larger single-use machinery and storage facilities. The problem with consolidated global markets and the required capital outlays to participate in them is that farmers have few options if anything goes wrong.

This latitude to accommodate change is exacerbated by the constrained choices that these farmers have. Consolidation in these markets "constrains – as in limits or inhibits – the decisions of farmers by restricting choice options or the types of decisions they can make. … Second, it constrains – as in compels or obliges – the choices of farmers by forcing them into the kinds of decisions that they otherwise would not have chosen for ethical or other reasons" (Hendrickson and James 2005 p283; see also James and Hendrickson 2008). In essence, farmers lose the ability to exercise decision-making capacity over food production on their own land or the land they work. For instance, once a soybean farmer in the Midwest plants herbicide resistant seeds, the management package that goes with these seeds locks that farmer into a reliance on a particular herbicide. If most of the farmers in the community choose to adopt that specific seed, then it is difficult for any particular farmer to source non-herbicide resistant seed, or the necessary weed-fighting chemicals for a non-herbicide resistant soybean crop. Or consider that a farmer with a smaller piece of land might choose to enter a poultry production contract. Once that happens, the grower has no control over what breed of chicken to produce, when the chicks will arrive on the farm, what feed and veterinary care they will receive, and when they will be shipped to slaughter (Constance et al 2013). This lack of ability to make decisions about genetics, weed management, soil fertility, animal husbandry and other issues means it is harder for these farmers to situate their farming practices in their local ecologies, and as we saw above, has impacts further down the food chain, including food safety. Moreover, it reduces their latitude to accommodate change, which is then replicated at larger scales.

Precariousness: The biggest failing of our food system may be that within the system, we are using an astonishing number of resources while still facing hunger and food insecurity around the world. The amazing level of yield productivity in the dominant system has not yet provided a healthy and stable food supply to all people On a global scale, the advocacy organization ETC Group (2013b) claims that the industrial food system produces only 30 percent of the food we eat, using 70 percent of our agricultural resources, while the so-called "Peasant Food Web" produces 70 percent of the food and uses only 30 percent of our resources. The continued overuse of resources to produce food for the global few threatens the very identify of how we have organized the current system. In a scathing critique of modern food, Winson (2013) argues that the industrial diet that has emerged from the current political, social, economic and ecological organization of the food system provides too much of the wrong kind of food and negatively affects the health of millions of people globally. If the productivity of our current system has come at the expense of our natural and human resources, then the fact it cannot provide an adequate or healthy diet for all of humanity puts it at severe risk of losing its core identity and transitioning to something new.

III. Discussion

How Can Agriculture and Food Become More Resilient?

Are there ways that we can manage changes in the food system, or alternative models of food and agricultural production that will incorporate these five dimensions of resilience? And what does it take on the part of farmers, eaters, communities, policy makers and others to make the changes happen? There is no single approach at any given scale that will accomplish everything necessary to make the food system more resilient. Rather, it will be a combination of actions, strategies and policies at multiple levels that will help achieve food system resilience that is rooted in ecology, democracy, and economic and social equality. Sinclair et al (2014) suggest that a 'resilience lens' may have proved useful for Australian policy makers to adopt in shaping deregulation in the dairy sector. Such a lens might well have avoided some of the negative unintended consequences of the transformation to the industry, the people within it, and the physical environment. For King (2008) potential ways of organizing agriculture and food production that can increase resilience include permaculture, organic and biodynamic agriculture, farmers' markets, community supported agriculture and community gardens. These forms require people to be connected to a particular place and in that setting to "learn" their way to the kinds of resilient linkages that will work for them in that place and in that context. This approach results in a continued diversity of organizational forms, and which engenders a number of overlapping systems that can back up each other. Because of the centrality of relationships rooted in a particular place, there is a great deal of latitude to change.

In that sense, there a number of relatively small place-based initiatives that were often overlooked twenty years ago, but are being created or strengthened across the globe. For instance, in the United States, nearly five percent of farms had direct-to-consumer sales in the latest Census of Agriculture, and these sales increased another eight percent between 2007 and 2012 (USDA 2014), while sales of organic agricultural products almost doubled in the same time period. The area devoted to organic agriculture in the European Union is 9.6 million acres, up nearly 50 percent from 2002, and much greater than the 5.4 million acres in the US, where organic agriculture has just recently enjoyed policy support (European Commission 2013; USDA-ERS 2014). The United Nations (2008) found that organic agriculture can be equal or even better at providing food security in developing nations than most conventional systems because it builds up levels of natural, social, human, financial and physical capitals. Many of the policies suggested for governments around the world by the United Nations Environmental Program and FAO incorporate some aspect of agroecological or organic farming. Because these systems situate within the local ecology, they can fend off ecological disruption, and are less vulnerable to economic disruptions imposed from the outside.

My own work as an extension sociologist in Missouri has shown how local food systems can help to create a diversity of organizational forms (new markets and networks) that have a high degree of flexibility (latitude to accommodate change). In the 15 years from the late 1990s until now, farmers' markets have exploded across the state, larger towns have specialty and mainstream grocers offering a wide variety of regionally produced foods that scale beyond a face-to-face relationship, Mennonite and Amish farmers have established produce auctions that supply these stores, and school and hospital food services are using locally grown produce, meats, eggs and dairy (see Hendrickson 2009 for a detailed analysis of emerging food systems in Kansas City). These new food systems emerge from the creation of new relationships between producers and consumers, with support from educators, policy-makers and community leaders. These systems are decentralized and rooted in particular places and communities. Such decentralization ensures a diversity of organizational forms (e.g. individual vendors at farmers' markets operate within a collaborative public market space, cooperatives contract with distributors for school food services, and CSAs directly connect farmers and consumers outside a purely market relationship). Decentralization of spaces of production, and a reconnection of that production with consumption in a specific locale, provides redundancy in role and function across many parts of the food system. In my 15 years working in developing these new food systems, I saw a great deal of adjustment, alteration and innovation in production, marketing and consumption, proving the system has the latitude to accommodate change.

Moreover, these initiatives, and the systems that King identifies, are based on the principles of agroecology, where a site of agricultural production is thought of as an ecosystem with practices based on ecological principles and integrated into a sustainable food system (Gliessman 2006). The former United Nations Rapporteur on the right to food, Olivier de Schutter (2010b) proposed that agroecology is the only way to increase food security for the world's poorest and hungriest because agricultural systems based upon its principles are rooted in a particular place, use local markets that reduces reliance on middleman and financiers and contributes to broader economic development, serving people who live in that particular place.

The challenge is in scaling up these systems in multiple locales around the world – in other words of increasing scale in a holistic manner without the negatives of reductionist specialization and standardization that can increase risk in the dominant food system (see for example, Mount 2012). However, both DeSchutter (2010b) and IAASTD recommend specific strategies that policymakers at all levels can use to encourage more resilient alternatives.

While these alternative agriculture and food systems incorporate the persistence, adaptability and transformability that Folke et al (2010) find important for increasing resilience, the different scales in which they must be implemented is challenging for a variety of reasons. A significant barrier for many of these initiatives is that farmers and businesses must compete within the economic framework of the dominant system (see Hendrickson 2009; Mount 2012). At least in the United States, they are not always helped by consumers. Delind (2011) argues many local food advocates, even participants in CSAs, are complacent (perhaps also complicit) in the monetary exchange transactions that continue to undergird food production and consumption. She argues that citizens must engage in democratic organizational forms that have the potential to truly transform the food system – e.g. a CSA where farmers and consumers share risk, benefits and work, or a community garden that is created, managed and owned by the community. The dominant agrifood system, by contrast, has reduced democracy in the food system to "voting with your dollars" which excludes those without dollars. Overcoming the notion of people as consumers rather than citizens will be a significant challenge for transforming the dominant system to one that is based on ecology, community and economy – and thus is resilient.

Conclusions

The focus of this article has been to articulate the risks of a consolidated, industrialized agrifood system for our planet's ecology and our ability to guarantee a future food supply, while also considering how the food system might become more resilient. Middle class and affluent consumers around the world buy their food from a system that is standardized and specialized, relying on capital intensive inputs such as chemicals and fertilizers that are petroleum based, or proprietary seeds and breeds; and infrastructure such as complex cooling systems and long transportation distances. It is a highly productive system in terms of calories produced per labor hour, but less impressive if one measures energy in and energy out. Even with such high productivity, the system's economic and social organization ensures that large numbers of poor people go hungry or lack nutritionally adequate food. As documented above, much of our current agriculture system came into being during a period of relatively stable climate, when natural resources appeared to be abundant, and the human population was considerably smaller. We now know the former are finite resources that cannot be wasted.

I argue that this global agrifood system fails on most of the dimensions of resilience laid out above. The processes that have created globally similar food production and consumption systems lack resistance to disruption, the latitude to accommodate change, and diversity of organizational forms. It is a precarious system with few failsafe mechanisms (redundancy of form and function). It also has a number of social and ecological vulnerabilities that result from the consolidation of markets and resulting asymmetrical power. In terms of ecology, consolidation of agricultural commodity markets and agricultural input markets has led to decreased diversity of seeds and breeds; constrained biodiversity both above and below the soil due to a reduction in complex management systems; exhausted soils through monoculture and the application of synthetic fertilizers; and decreased the ability of farmers to make decisions relevant to their own ecological situation. In social and economic terms, consolidation in the agrifood sector has squeezed out smaller scales of farm and food businesses, and has led to the development of one organizational form – for-profit corporations – as the preferred vehicle for food production and distribution. Consolidation in agricultural markets across the globe has had negative impacts for those farmers and farm workers who were no longer needed.

The challenge for creating resilience in the agrifood system is that some actors, like transnational agrifood firms, have more power to make decisions and choices about the food production and consumption than others, like farmers, workers and consumers. Our industrialized agrifood system has created transnational firms that must operate on a for-profit basis, responsible almost solely to their shareholders, be it a private family as in the case of Cargill and C.P. Group, or to widely dispersed investors who are focused on increasing their capital for their own purposes – including the mutual funds that many Americans and others use to save for retirement. Farmers, workers, and even consumers, on the other hand, often have different goals and aspirations because they are rooted in particular places and in particular communities. Farmers and workers also look for profits in selling their products or their labor, but their goals usually expand beyond to social aims, such as staying in their community, improving their livelihoods, or taking care of family and community members. Because of the asymmetric power relationships that are at work in the agrifood system, the current organization makes it much more difficult for farmers, workers and consumers to make their own free decisions – rather than decisions based in constrained choice. Our current system is one that we don't particularly want to be resilient – in other words, the current system must be transformed for a more resilient food system to emerge.

Table 1: Concentration Ratios for Selected U.S. Agricultural Commodities			
Industry Sector	**1990**	**1999**	**2011**
Beef Slaughter – Steer & Heifer	69 percent • IBP • ConAgra • Excel (Cargill) • Beef America	79 percent • IBP • ConAgra • Excel (Cargill) • Farmland National Beef	82 percent • Cargill • Tyson • JBS • National Beef
Beef Production/ Feedlots	n/a • Cactus Feeders • ConAgra (Monfort) • J.R. Simplot Co. • Caprock (Cargill)	1,349,000 capacity • Continental Grain Cattle Feeding (405,000) • Cactus Feeders Inc. (350,000) • ConAgra Cattle Feeding (320,000) • National Farms Inc. (274,000)	1,983,000 capacity • JBS Fiver Rivers Cattle Feeding (838,000) • Cactus Feeders (520,000) • Cargill Cattle Feeders LLC (350,000) • Friona Industries (275,000)
Pork Slaughter	45 percent • IBP • ConAgra • Morrell • Excel	57 percent • Smithfield • IBP Inc. • ConAgra (Swift) • Cargill (Excel)	63 percent • Smithfield Foods • Tyson Foods • Swift (JBS) • Excel Corp. (Cargill)
Pork Production	n/a • Murphy Farms • Tyson Foods • Cargill • National Farms	834,600 sow capacity • Murphy Family Farms (337,000) • Carroll's Foods (183,600) • Continental Grain (incl. PSF) (162,000) • Smithfield Foods (152,000)	1,618,904 sow capacity • Smithfield Foods (876,804) • Triumph Foods (371,000) • Seaboard (213,600) • Iowa Select Farms (157,500)
Broiler Slaughter	45 percent • Tyson • ConAgra • Gold Kist • Perdue Farms	49 percent • Tyson • Gold Kist • Perdue • Pilgrim's Pride	53 percent • Tyson • JBS (Pilgrim's Pride) • Perdue • Sanderson
Turkey Slaughter	31 percent • Louis Rich (Philip Morris) • Swift (Beatrice/KKR) • ConAgra • Norbest	42 percent • Jennie-O (Hormel) • Butterball (ConAgra) • Wampler Turkeys • Cargill	58 percent • Butterball (Smithfield/Goldsboro) • Jennie-O (Hormel) • Cargill • Farbest Foods
Flour Milling	61 percent • ConAgra • ADM • Cargill • Grand Met (Pillsbury)	62 percent (*note CR3)* • ADM • ConAgra • Cargill Flour Milling	52 percent (*note CR3)* • Horizon Milling (Cargill/CHS) • ADM • ConAgra
Wet Corn Milling	74 percent • ADM • Cargill • A.E. Staley (Tate and Lyle) • CPC	74 percent • ADM • Cargill • A.E. Staley (Tate and Lyle) • CPC	87 percent • ADM • Corn Products International • Cargill
Soybean Processing	61 percent • ADM • Cargill • Bunge • Ag. Processors	80 percent • ADM • Cargill • Bunge • Ag Processing	85 percent • ADM • Bunge • Cargill • Ag Processing
Sources: Table is adapted from previous research reported in James, Hendrickson and Howard (2013) and Constance, Hendrickson and Howard (2014).			

Table 2: Global Input Markets	
Seeds (Proprietary Seeds)	CR 4- 58%. Firms - Monsanto, DuPont, Syngenta and Vilmorin
Fertilizers	CR 4- 24%. Firms – Yara, Agrium, The Mosaic Company, PotashCorp
Chemicals	CR 4- 62%. Firms – Syngenta, Bayer, BASF, Dow AgroSciences
Source: ETC Group (2013a)	

Table 3: Changes in Food Retail Consolidation in the U.S.

1997	2000	2011
Kroger Co.	Kroger Co.	Wal-Mart
Safeway	Wal-Mart	Kroger
American Stores	Albertson's	Safeway
Albertson's	Safeway	Supervalu
Ahold USA	Ahold USA	
CR5 = 24%*	**CR5 = 42%****	**CR4=42-51%**

Source: 1997 and 2000 data is from Hendrickson et al (2002). 2011 data is from James, Hendrickson and Howard (2013).

Table 4: Dimensions of Resilience for the Agrifood System		
Dimension	**Capacity**	**Current Vulnerability**
Resistance to Disruption	What is the capacity of a system to fend off disruption?	Agrifood production and processing overuse of soil and water; Greenhouse gas contribution to climate change
Latitude to Accommodate Change	What is the capacity of the system to stretch and accommodate change without it being disruptive?	Decreasing genetic resources for major crops and livestock; Single-use production facilities; Global production networks
Redundancy of Role and Function	Where are the overlapping systems that can back-up each other?	Farm and Geographic Specialization; Centralized Storage and Processing Facilities; Tight coordination and connections means few fail-safe mechanisms
Diversity of Organizational Forms	What is the diversity of scale, form and organization across the food system?	Focus on efficiency, specialization and standardization eliminates smaller and diverse forms of organization;
Precariousness	How vulnerable is a system to losing its core identity and transitioning to a new state?	Food insecurity and hunger globally and within rich countries; industrial diet uses a great many resources while failing to provide adequate and healthy food for the majority

Acknowledgements:

I would like to thank Evan Fraser, Rebecca Dunning, Lucie Knor and Geoffrey Lawrence for their significant help in improving this manuscript.

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