

**ARTICLE ABSTRACTS**  
**JOURNAL OF ENVIRONMENTAL STUDIES AND SCIENCES**  
**SYMPOSIUM ON AMERICAN FOOD RESILIENCE**

(Articles with an asterisk have already been published online when this list was compiled. Their abstracts are final. Articles without an asterisk are not yet in final publication. Details of their abstracts may change before final publication.)

***Part 1 (Journal of Environmental Studies and Sciences, Vol. 5, Issue 3)***

**\*Gerald Marten (EcoTipping Points Project), Nurcan Atalan-Helicke (Skidmore College)**

**Introduction to the Symposium on American Food Resilience**

The resilience of the American food supply – the ability of the food system to withstand shocks or stresses that could lead to disruption or collapse – is a matter of genuine concern. While all seems well with supermarkets stocked to the brim, changes in the food system and our environment during recent decades have created risks that are no longer hypothetical possibilities. They are with us now. The 27 articles in the JESS symposium on American Food Resilience explore the vulnerability and resilience of food production and distribution from a diversity of perspectives. Four central questions provide a framework for the exploration:

- What are the main lines of vulnerability?
- What are leverage points for reducing the risks and improving the capacity to deal with breakdowns if they occur?
- What is already being done by government, civil society, and the private sector to reduce the risks?
- What can scientists, teachers, and other environmental and food-system professionals do through research, education, community action, or other means to make the food system and food supply more resilient?

Some of the articles use case studies that highlight various kinds of disturbances: influenza pandemic, war, nuclear-reactor catastrophe, natural disasters (e.g., floods and earthquakes), and crop failure due to drought or other climatic perturbations. Lessons for improving resilience are drawn from the experiences. Other articles examine the significance of globalization, food-system consolidation, diversity, and food storage; the interplay of efficiency, adaptive capacity, sustainability, and resilience; the potential and limitations of local or regional food systems to compensate for shortcomings in the mainstream food system; organizational learning and networking, integrating local food systems with the mainstream, channeling promising innovations into the mainstream; success stories and the lessons they offer. The articles afford a wealth of material that can be mined by researchers, teachers, practitioners, and policy makers for application to their own circumstances.

**\*Krystina Stave (University of Nevada, Las Vegas), Birgit Kopainsky (University of Bergen)**

**A System Dynamics Approach for Examining Mechanisms and Pathways of Food Supply Vulnerability**

Understanding vulnerabilities in complex and interdependent modern food systems requires a whole-system perspective. This paper demonstrates how one systems approach, system dynamics, can help conceptualize the mechanisms and pathways by which food systems can be affected by disturbances. We describe the process of creating stock-and-flow maps and causal loop diagrams from the graphical representation of a problem and illustrate their use for making links and feedback among the human

health, food, and environmental health sectors visible. These mapping tools help structure thinking about where and how particular systems might be affected by different disturbances and how flows of material and information transmit the effects of disturbances throughout the system. The visual representations as well as the process of creating them can serve different purposes for different stakeholders: developing research questions, identifying policy leverage points, or building collaboration among people in different parts of the system. They can serve as a transition between mental models and formal simulation models, but they also stand on their own to support diagrammatic reasoning: clarifying assumptions, structuring a problem space, or identifying unexpected implications of an unplanned disturbance or an intentional policy intervention. The diagrams included here show that vulnerability of a national food system does not only or automatically result from exogenous shocks that might affect a country. Rather, vulnerability can be either intensified or reduced by the interaction of feedback loops in the food system, and buffered or amplified by the structure of stocks and flows. Keywords: Causal loop diagram; conceptual models; dynamic complexity; modern industrialized food systems; stock-and-flow diagram; systems mapping, structural insights.

**\*Andrew Huff, Walter Beyeler, Joseph McNitt (Sandia National Laboratories); Nicholas Kelley (University of Minnesota)**

### **How Resilient Is the United States Food System to Pandemics?**

Rarely have studies focused on the second and third order effects of pandemics. Limiting the disruption of critical infrastructures during a pandemic is important for the survival and health of society (i.e., electricity, water, and food) as most medical and public health responses to a pandemic depend on these infrastructures. The studies that have looked at this issue have highlighted alarming gaps in preparedness. This study used a system dynamics model to demonstrate the likely effects of a pandemic on the United States' food system. The model reveals that a severe pandemic with greater than a 25% reduction in labor availability can create significant and widespread food shortages. The Ebola epidemic that began in 2014 has caused severe food shortages in West Africa, which are similar to the effects that this model predicts in the U.S. The likely effects of the reduction in the amount of available food are difficult to specifically predict; however, it is likely to have severe negative consequences on society. The resilience of the food system must be improved against this hazard and others.

**\*Laura Lengnick (Appalachian Sustainable Agriculture Project)**

### **The Vulnerability of the U.S. Food System to Climate Change**

The climate change vulnerability of a food system is a function of the exposure of the system to specific climate effects, the sensitivity of the system to those effects and the capacity of the system adapt to those effects in order to maintain system integrity. A synthesis of recent literature conducted to explore the vulnerability of the United States (U.S.) food system to climate change suggests that the interaction between regional climate change effects and the geographic specialization and concentration of agricultural production in the U.S. increases the vulnerability of the U.S. food system to climate change. Vegetable and fruit production in the Pacific states are particularly sensitive to reduced water supplies, warmer winters and more variable spring weather. Grain production in the Great Plains and the Midwest are sensitive to more variable weather, warmer winters, heatwave and hot summer nights and flooding caused by more frequent heavy rains. The concentration of beef, pork and poultry production in confined animal feeding operations located in the southern Great Plains and the Southeast are particularly sensitive to increased frequency and intensity of extreme weather and interruptions in feed, water and power supplies associated with interactions between land, water and energy use that amplify climate change effects. There is evidence that climate change is already causing disruptions throughout the U.S. food system. Farmers and ranchers in the U.S. report that increased weather variability and more frequent and intense weather extremes have increased the costs and complexity of food

production. Businesses operating in the U.S. agricultural supply, processing, distribution and retailing sectors are actively managing supply networks to reduce disruptions associated with climate change effects. Food systems that rely on external or distant resources and specialized production, supply and marketing chains appear to be particularly vulnerable to global environmental change. These characteristics, widely recognized as critical challenges to the sustainability of the U.S. food system, take on new importance as barriers to climate resilience.

**\*Daniel Keppen (Family Farm Alliance), Tricia Dutcher (Nevada Department of Wildlife)**

### **The 2014 Drought and Water Management Policy Impacts on California's Central Valley Food Production**

Water is a scarce resource in the West, creating intense competition among user groups. The problem is compounded by climate change. During 2014 and 2015, California experienced one of the worst droughts in 160 years of record keeping. The U.S. Bureau of Reclamation announced zero water allocation for Central Valley Project agricultural water service contractors—with a devastating impact on food producers. Many farmers have fallowed their fields because there was not enough water to meet their needs, and thousands of acres of citrus, almond, and other perennial crops have been ripped out. The reduction in irrigation water supply has forced farmers to draw on underground water, which is expensive and unsustainable. Water managers have to decide between supplying water for cities, agriculture, and environmental services (e.g., water flow through the San Francisco Bay-Delta). Farmers perceive the collapse of their water allocation as, in part, a “regulatory drought” brought on by political decisions about who should have the water. The growing demands of other sectors have been met at the expense of agriculture. Uncertainties in the current political process not only undermine the reliability of the agricultural water supply but also diminish the industry's ability to make long-term adaptive decisions. The implementation of environmental laws and policies has been particularly distressing to farmers because of the large quantity of water designated for environmental use and the apparent weakness of scientific evidence to justify it. The realization of supposed benefits, such as restoration of endangered fish populations, has not been convincing. Moreover, information is lacking on alternative management options that might be more effective. Two recommendations are presented as a means to increase the resilience and reliability of the water supply for all user groups: (1) a mediated settlement generated by all stakeholders involved in water use sectors that bear upon the comprehensive and long-term management of the San Francisco Bay-Delta and threatened and endangered species that depend upon it; and (2) an increase in water storage infrastructure to buffer future fluctuations in snowpack runoff.

**\*Amy MacMahon, Kiah Smith, Geoffrey Lawrence (University of Queensland)**

### **Connecting Resilience, Food Security and Climate Change: Lessons from Flooding in Queensland, Australia**

The Australian food system is often assumed to be largely secure in the face of global environmental challenges such as climate change. In 2010/2011 serious flooding in Queensland left towns isolated, major roads and highways cut, and incurred significant loss of life and property. In terms of food security, large areas of agricultural land were inundated and food supply chains, including both long and short chains, were affected in significant ways. The impacts included increases in food prices, deterioration in food quality, reduced consumer access to food, and disruption to the sourcing, transportation, and distribution of food, grocery and other items. Examining the discourses and policies surrounding food supply during and after the floods, this paper asks, what lessons for building a more resilient food system have emerged from the 2011 floods? To explore this question, we consider policy documents, media reports, interviews and fieldwork with key stakeholders. We find evidence of strong collaboration

of state government and long supply chain operators, but to the general exclusion of civil society-based community supported agriculture networks. Long chains provide the vast bulk of food to Queensland consumers, but are vulnerable when roads are cut; community supported agriculture showed resilience, but remained marginal to the food needs of most Queensland consumers. Both resilience and vulnerability were present within both long and short food supply chains. Yet, there is limited evidence that food security issues, beyond productivity enhancement, are being considered in discussions and policies for climate change and natural disasters. We suggest that a broader view of climate change, beyond disasters and food production, has yet to be fully integrated into food security policy - and supply chain governance and practice - in Australia.

**\*Alesia Maltz (Antioch University)**

**“Plant a Victory Garden: Our Food is Fighting:” Lessons of Food Resilience from World War**

Today the high ideals of local food production reverberate as a model of self-sufficiency and food security. In the US and Great Britain during WWI, local food production was envisioned as ammunition to win the war. To what extent have the food policies and slogans of World Wars I and II influenced current ideas of the value of local strategies of food security in maintaining resilience, and what lessons does the history of war offer about food resilience? During World War I, German and British military strategists developed plans to win the war by leveraging actions to destroy their enemy’s civilian food system. This history triangulates the food resilience of a country that imported food (Great Britain) with one that grew its food locally (Germany), and one that exported surplus (the United States) to examine the strengths and limits of local food production. During World War I, Germany suffered over a million fatalities from famine, while the US and Great Britain raised their national nutritional status by the end of the war. The tragic German experience led directly to the rise of WWII, a war initiated with a “Hunger Plan.” Nineteen million civilians died, many of starvation. A long historical time frame is needed to construct lessons about resilient food systems. This brief sketch of the dismantling and reconstruction of food systems in WWI and WWII draws from secondary sources to suggest novel ideas about the interplay between local production, national co-ordination, and international networks for humanitarian aid. Using the food policies of three countries—Great Britain, the United States and Germany—this history provides an opportunity to consider the characteristics of resilient food systems, and to suggest what is required to reconstruct a large-scale food system following a crisis. War, a disrupter of food systems, also provides a model of how food systems can be reconstructed.

**\*Alex Belyakov (Ryerson University)**

**From Chernobyl to Fukushima: Risks for Food Security Policies after Nuclear Disasters**

This comparison of government disaster management and public communications after the Chernobyl and Fukushima nuclear accidents seeks to create a framework for disaster management that enhances food resilience (the ability of food systems to withstand perturbations that could cause disruption of food supply); and in the specific case of nuclear disasters, the avoidance of contaminated food and provision of alternative foods. This paper integrates food security, emergency management, and risk communications perspectives. Misinformation and incomplete information can bias decision-making and political actions. When risk communication is inadequate, the public reacts with fear, mistrust, panic and stress. People have difficulty deciding what they can safely eat and what they should not eat. Many choose to reject all food from affected regions, which can compromise food security. Lack of proper information may lead to such extremes in behavior as avoidance of dairy products and consumption of untested foods, which may in fact have high levels of radioactivity. The measures taken by the USSR after the Chernobyl disaster lacked consistency and clarity and were not effective in providing food security for the affected people. The government also demonstrated a lack of attention to social justice in its dealings with people who moved back to the contaminated area, ignoring government policy that

they should stay out. Those people still suffer from food insecurity. In Japan, food that met government safety levels was available, but many consumers nonetheless questioned the safety of food supplies and farmers often were confused about production and marketing. In both the Chernobyl and Fukushima cases, the evacuation of affected people was aimed at reducing exposure to radiation and did not sufficiently consider psychological and physical health impacts of resettlement, nor the security and safety of food supplies. Government responses would have been more effective in some regions if a timely distribution program of adequate, safe alternative foods (especially radioprotectors) from non-affected areas had been initiated.

**\*Mary Hendrickson (University of Missouri)**

### **Resilience in a Concentrated and Consolidated Food System**

The focus of this article is 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. 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 by whom it is eaten. To examine food system resilience one must see that ecological risks of agriculture (e.g. monoculture, overuse of fertilizer and chemicals, lack of genetic diversity) are intertwined with its social and economic organization; that relationships between people and between people and their particular places are critical to situate food decisions within ecology; and that issues of scale in a global food system are keenly important and challenging to resolve. Our highly concentrated global 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 there is no single approach at any given scale that will accomplish food system resilience, a combination of actions, strategies and policies at multiple levels that are rooted in ecology, democracy, and economic and social equality is necessary to move forward.

**\*Peter Jacques (University of Central Florida)**

### **Civil Society, Corporate Power, and Food Security: Counter-Revolutionary Efforts that Limit Social Change**

Food is produced, processed, packaged, transported, and sold in a stable, organized system, or food regime. The current food regime is focused on calories empty of substantial nutrition designed primarily for the growth of capital and corporate power, fostered through the lax, often corporate-designed, regulatory environment of neoliberalism. The neoliberal food regime is responsible for systemic malnutrition and erosion of the ecological preconditions for food production, as a regularity of the system itself. Consequently, a main line of food vulnerability is the political system that insulates the current food regime from social forces demanding change. This insecurity is contrary to the public or larger human interest, but this unsustainable system remains in place through a stable arrangement of government prescriptions that follow corporate elite interests. To understand this structural problem, this essay examines the power of the food industry which requires the manufactured consent of civil society. The paper finds that counterrevolutionary efforts, which are anticipatory and reactive efforts that defend and protect capitalist elite from social change, stabilize the neoliberal food regime through

covert tactics meant to undermine public interest critics and activists. As a result of these elite-led interventions, true civil society has become less powerful to articulate a public interest that might otherwise intercede in the operation and structure of the food regime. Thus, one leverage point in this political problem is the capacity of civil society, once it is independent of corporate interests, to remove consent to an abusive system and to debate and demand a food system that neither systematically starves whole groups of people nor destroys the ecological systems that make food possible. Building food security, then, requires recapturing a semi-autonomous civil society and eliminating domination of the corporate elite, and replacing it with a politics aligned with a public and ecological affinity. Scholars, educators, and the public, can reduce the food vulnerability by becoming aware of corporate interests, and creating strategic alliances to form a new system with more humane and ecological priorities.

**\*Evan Fraser, Alexander Legwegoh, K.C. Krishna (University of Guelph)**

### **Creating a More Resilient Food System: A Critical Evaluation of Food Storage as a Way of Maintaining Stability in Light of Climate Change and Economic Shocks**

Many are worried that the global food system is entering a period of intense volatility driven by a combination of climate change and population growth. One way to address this problem is for governments and the international community to store more food as a buffer against crisis. The purpose of this paper is to explore the role of food storage as a component of a robust food security strategy in the 21st century. We do this by first drawing on historical evidence and examples from ancient Rome and China, where pre-industrial government designed extensive systems that ensured adequate food storage to keep food systems stable. Next, we review the links between food storage and price volatility in the last 20 years and demonstrate that the size of food stores (and in particular grain reserves) directly relates to price volatility. Third, we explore three different types of policies designed to promote grain reserves, the U.S.'s 'ever-normal granary' policy, the EU's Common Agricultural Policy, and Strategic Grain Reserve in Africa. In this third section, we show how there has been a decline from state owned strategic grain reserves in favor of a more market-oriented approach that is dominated by a handful of powerful corporations who maintain sophisticated supply chains. Because data on the amount of food supply these corporations hold in storage are proprietary secrets, it is impossible to assess how resilient or vulnerable this makes our food system. Finally, we conclude that over time food storage has fallen in and out of favor, criticized for being expensive yet often shown to play an important role in protecting poor consumers in times of food crisis. Given the lack of data on current levels of supply chain and household storage, more research is needed to evaluate the scale at which food storage systems should be implemented to ensure food system resilience as well as mechanisms to govern and manage them.

**\*Sarah Rotz, Evan Fraser (University of Guelph)**

### **Resilience and the Industrial Food System: Analyzing the Impacts of Agricultural Industrialization on Food System Vulnerability**

The purpose of this paper is to explore how socio-economic and technological shifts in Canadian and American food production, processing and distribution have impacted resilience in the food system. First, we use the social ecological systems literature to define food system resilience as a function of that system's ability to absorb external shocks while maintaining core functions, such as food production and distribution. We then use the literature to argue that we can infer food system resilience by exploring three key dimensions: (1) the diversity of the food system's components, (2) the degree to which the components are connected, and (3) the degree of decision-making autonomy within the food system. Next, we discuss the impacts of industrialization on these three factors within Canada and the US. Specifically, we show how processes of corporate concentration, farm-scale intensification,

mechanization, and the ‘cost-price squeeze’ have led to a decrease in ecological and economic diversity, a high degree of spatial and organizational connectivity, and a diminished decision-making capacity for individual farmers. While this analysis is qualitative and heuristic, the evidence reviewed here leads us to postulate that our food system is becoming less resilient to external shocks such as climate change. We conclude by discussing four possible strategies to restore resilience, and suggest a more transformational shift in food system politics and practice. Specifically, we argue that publicly led multifunctional policies may support more diversified production while programs to promote food system localization can increase farmer autonomy. However, these shifts will not be possible without social-structural corrections of current power imbalances in the food system. This policy discussion reinforces the value of the social ecological framework, and specifically its capacity to produce an analysis that interweaves ecology, economy, and power.

**\*Jennifer Hodbod, Hallie Eakin (Arizona State University)**

### **Adapting a Social-Ecological Resilience Framework for Food Systems**

The purpose of applying social-ecological resilience thinking to food systems is twofold: First, to define those factors that help achieve a state in which food security for all and at all scales is possible. Second, to provide insights into how to maintain the system in this desirable regime. However, the resilience of food systems is distinct from the broader conceptualizations of resilience in social-ecological systems because of the fundamentally normative nature of food systems: humans need food to survive, and thus system stability is typically a primary policy objective for food system management. However, society also needs food systems that can intensify sustainably i.e., feed everybody equitably, provide livelihoods and avoid environmental degradation while responding flexibly to shocks and uncertainty. Today’s failure in meeting food security objectives can be interpreted as the lack of current governance arrangements to consider the full and differential dimensions of food system functions – economic, ecological and social – at appropriate scales: in other words, the multifunctionality of food. We focus on functional and response diversity as two key attributes of resilient, multifunctional food systems; respectively, the number of different functional groups and the diversity of types of responses to disturbances within a functional group. Achieving food security will require functional redundancy and enhanced response diversity, creating multiple avenues to fulfill all food system objectives. We use the 2013-15 drought in California to unpack the potential differences between managing for a single function – economic profit – and multiple functions. Our analysis emphasizes how the evolution of the Californian food system has reduced functional and response diversity and created vulnerabilities. Managing for the resilience of food systems will require a shift in priorities from profit maximization to the management for all functions that create full food security at multiple scales.

## ***Part 2 (Journal of Environmental Studies and Sciences, Vol. 5, Issue 4)***

**Molly Anderson (Middlebury College)**

### **The Role of Knowledge in Building Food Security Resilience across Food System Domains**

Food systems are social-ecological systems essential for human life. Many food systems are in parallel operation globally, differing in their practices, impacts, use of knowledge and resilience. Those that are adapted to local constraints and assets and intentionally use and preserve ecosystem services result in lower environmental impacts and are less prone to lead to catastrophic environmental thresholds. Actors within food systems are constantly changing their practices to adapt to pressure and perturbations. Changing activities are correlated with changes in knowledge systems as well. Contributions to the resilience of social-ecological systems have been identified and evaluated, primarily based in ecosystem studies. Many of these attributes (e.g., memory, learning, self-organization) have to do with forms of knowledge. This paper suggests characteristics of "resilient knowledge" and links it with enabling power to make needed changes. How can this enabling power allow social organizations from the community to the national scale to build resilience into their food systems, and create the knowledge systems that resilience requires? This paper compares knowledge generation, transmission, access and use in four food system domains (Global Industrial, Independent Commercial, Local & Sustainable, and Fair Trade) discriminated on dimensions of globalization and multifunctionality. The objective of these comparisons is to understand connections among the resilience of food systems, food security and knowledge systems. The paper concludes with a case study of the Committee on World Food Security (CFS), hosted by the United Nations Food & Agriculture Organization. The CFS embodies and facilitates many of the attributes of resilient knowledge generation and access; some of the tensions within the CFS reflect whether knowledge used by the Committee will have attributes of resilient knowledge. I argue that forms of knowledge generation, transmission and access must be participatory, multi-actor, iterative and transparent in order to build food security resilience. I also argue that knowledge at multiple scales must be resilient and interlocking, in order to protect social organizations from food shortages and impaired food security.

**Seona Candy, Che Biggs, Kirsten Larsen, Graham Turner (University of Melbourne)**

### **Modeling Food System Resilience in Australia**

This paper outlines a process for exploring food system vulnerability and resilience using scenario modelling with the Australian Stocks and Flows Framework (ASFF). The capacity of ASFF to simulate how diverse shocks and stressors affect food system behavior across multiple sectors – with diverse, interconnected and dynamic variables shaping system response – renders ASFF particularly suited for exploring complex issues of future food supply. We used ASFF to explore the significance of alternative agricultural policies for land use, crop production, livestock production, fisheries, food processing, transport, food waste, and ultimately food supply. Policies in different scenarios varied with regard to the timetable for reducing greenhouse gas emissions, the degree of government participation or regulation in the food system, and the scale of solutions (varying from centralized and global to decentralized and local). Results from the scenarios suggest that Australia does not have the ability to maintain a domestic surplus of foods required for a nutritious diet. In particular, the health of the current food system is highly vulnerable to constraints in oil supply; and increased food production threatens to precipitate a drastic decline in critical water supplies. We conclude by outlining a proposed method for using ASFF to delve deeper into the dynamics of the food system, probe the consequences of various adaptive responses to food production and supply challenges, and devise potential indicators for food system resilience. Shocks and stressors to be added to the next phase of scenario modelling include soil salinity, climate extremes, and credit scarcity. The ASFF methodology should be applicable to



other parts of the world, although appropriate recalibration and adjustment of model assumptions would be required to reflect regional differences.

**Laura Lengnick (Appalachian Sustainable Agriculture Project)**

### **Metropolitan Foodsheds: A Resilient Solution to the Climate Change Challenge?**

The 21st century challenges of climate change and resource scarcity bring a new urgency to the widely recognized sustainability challenges of the US food system. The degradation of environmental and social resources, coupled with the geographic specialization and concentration of the U.S. food system degrade the nation's capacity to adapt to changing climate conditions. Sustainable development, including sustainable food systems, has been widely recognized as a promising strategy for the development of integrated solutions to 21<sup>st</sup> century challenges. A consensus seems to be emerging in sustainable food systems research and practice that two fundamental changes - a transformation of production methods (from industrial to sustainable) and geography (from regional specialization to regional diversity) - are needed to enhance the resilience of U.S. food system to climate change and other 21st century challenges. A nationally-integrated network of sustainable food systems oriented to major metropolitan areas – a metropolitan foodshed - has been proposed as a more resilient alternative to the existing US food system. Three key qualities are associated with resilience in natural and social-ecological systems: diversity, modularity, and a balanced portfolio of natural and human assets — natural, human, social, financial and technological. These qualities promote the capacity of the system to respond, to recover, and to change in ways that reduce the damaging effects and take advantage of the opportunities created by climate change. The structural changes required to transform the existing US food system to the metropolitan foodshed model appear likely to enhance the climate resilience of the US food system. Case study research with leading sustainable farmers and ranchers who have managed food production at the same location for at least 25 years offer proof of concept: they have been resilient to the dynamic changes associated with a period of intense concentration and consolidation of the US food system, produce multiple benefits to the communities they serve, manage impressive diversity, and are well-integrated into supply chains serving local, regional and national markets. Although more empirical evidence is needed, it appears likely that sustainable farmers and ranchers, with the help of many others working to promote sustainable food over the last 30 years, have been laying the foundation for a new climate resilient US food system.

**Robert Dyball (Australian National University)**

### **From Industrial Production to Biosensitivity: The Need for a Food System Paradigm Shift**

Urban consumers in affluent cities are typically divorced from the landscapes and farmers that produce their food. Most food is made available to these consumers via global retail systems, operating within an overarching paradigm of industrial commodity production. This paradigm induces one way flows of resources from rural hinterlands to cities, with farmers undercompensated for their services—a process which is inherently unsustainable and unjust. By unwittingly eroding processes upon which they are utterly dependent, urban consumers are making themselves vulnerable. Potentially, this vulnerability could be reduced if urban food consumption was linked to regional production, but for many cities the volumes of food required does not match regional output. Framed using a human ecological systems-based template, this paper presents case studies of three cities that have contrasting relationships with their regional food producing landscapes. Canberra, Australia, could not consume all its regional production and so is in food surplus. Tokyo, Japan, could not meet its consumption needs from its region and so is in food deficit. Copenhagen, Denmark, could probably meet its needs from its region but chooses to reduce its food producing land area and focus production on high-value meat products from pigs fed on imported low-value grains. Despite their differing food procurement strategies, producers and consumers in all three cases remain co-dependent upon each other and vulnerable to the processes

being driven by the industrial paradigm. Consequently a shift to a new 'biosensitive' paradigm is required, within which the social and environmental aspects of food production and consumption would be respected. This paradigm shift would reduce food choice and convenience, and likely increase cost, so what would motivate consumers to support it? The answer suggested is that consumers could embrace the new food system if it had features that they valued sufficiently to compensate for the forgone values of the old system. Features that consumers could positively value include personal skills in the creation of meals, knowledge of the provenance and production standards of ingredients, and convivial relationships with producers. Pragmatically, these values are most likely to arise from consumers interacting with local food systems. Hence, it is argued, the primary value of local food systems lies not in the absolute volumes of food that they produce but in their educative capacity to foster a shift to a biosensitive paradigm. This new paradigm could extend concern to all food producing landscapes and farmers, wherever on the planet they were located.

### **Casey Hoy (Ohio State University)**

#### **Agroecosystem Health, Agroecosystem Resilience, and Food Security**

This paper lays out the relationships between three mutually reinforcing concepts associated with agroecosystems: 1.) agroecosystem health, the extent to which an agroecosystem can meet human needs for all of its residents over time; 2.) resilience, the capacity of a system to adapt, reorganize and maintain key functions in the face of turbulent and unpredictable change in its environment; 3.) food security, sufficient quantity and quality of food for everyone at all times. Agroecosystem health has been defined by a number of properties including: stability, sustainability, equitability, productivity, and autonomy, each in the context of specific spatial and temporal scales. Indicators that characterize biophysical and social conditions including soil health, biodiversity, topography, farm economics, land economics, and social organization can be combined using analytical hierarchy process to map agroecosystem health across a landscape. Resilience and agroecosystem health overlap largely because both rely on diversity, in biological and physical as well as human cultural, social, and economic terms. Research to measure agroecosystem health and estimate the potential for and benefits of greater diversity can provide incentives for diversification. The Agroecosystems Management Program at The Ohio State University has approached research and outreach to improve agroecosystem health, resilience, and food security by encouraging self-organizing social networks for economic development around local and regional agricultural supply chains, encouraging farm enterprise diversity at a wider range of farming scales, and conducting research to monitor and estimate the benefits of such diversification. Social media tools have been explored for connecting entrepreneurs at the planning stage, with the ultimate goal of improving the economic support for more diversified enterprises in agroecosystems. Although challenging, such adaptive management experiments may create and encourage new opportunities for managing agroecosystem health, and with it resilient food production and security.

### **\*James Ward (University of South Australia)**

#### **Can Urban Agriculture Usefully Improve Food Resilience? Insights from a Linear Programming Approach**

Rising food prices and economic stagnation mean that access to affordable, nutritious food is a real problem, even in high income countries such as the USA and Australia. It is claimed that urban agriculture (UA) reduces food costs and therefore has a role in improving household resilience during

economic hardship. However, there is scant data to suggest that UA can appreciably improve household self-sufficiency in a crisis. This paper addresses the gap between claims and reality when it comes to UA actually reducing food costs. Using Linear Programming (LP), factors such as crop yields, food prices and inputs (such as irrigation water) can be quantified realistically, and an objective (e.g. overall diet cost) can be optimised. Constraints are applied to force the UA production regime to conform to a balanced diet. Subject to these constraints, optimisation yields a best-case estimate of the outcome, so can be seen to provide a “cautiously optimistic” result. The model is run for a case study in Adelaide, South Australia, and results suggest a typical high meat consumer could reduce their food cost by approximately 10% with substantial home food production (including intensive poultry rearing for meat). Meanwhile, a shift in diet towards vegetarianism would deliver twice the saving, with a further 10% achievable through UA. In the context of resilience, the results suggest that households could save a modest amount of money through dietary change and by growing some of their own food. The modelling revealed a trade-off between cost-saving and self-sufficiency (measured as percentage of home-grown dietary protein), but growing 10-15% of dietary protein on 40 m<sup>2</sup>/person appears plausible without sacrificing financial savings. Optimisation represents a quantitative framework that is suitable for a variety of extensions to help ground claims being made around UA and local food production, such as investigating the potential for reducing dependence on transport by provisioning food from within and around a city. The model would be greatly improved with more accurate data on yield, water and fertiliser inputs.

**Nurcan Atalan-Helicke (Skidmore College)**

#### **Seed Exchange Networks and Food System Resilience in the United States**

There is a growing concern about the increase of the food system's vulnerability as a result of loss of agricultural biodiversity both globally and in the United States. By containing within itself the means for its own reproduction, the seed is a carrier of valuable genetic resources. Farmers' ability to replant, exchange, and distribute saved seed is a way to minimize their dependence on commercial suppliers, thereby maintaining control over farming practices. Seed saving is also crucial for conservation because the process of choosing, replanting, and exchanging seeds relies on and increases diversity on the farm and in communities. Seed exchange is a multidimensional issue with social, political, economic and agricultural implications. By examining different risks and vulnerabilities in the seed systems and the activities of seed exchange networks in the United States, from civil society initiatives and seed libraries to private companies, this paper argues that the formalization of the initiatives by different actors to maintain, improve and make open-pollinated varieties of cereals and vegetables available to farmers and gardeners is crucial in order for seed saving and exchange practices to build resilience in the food system.

**Rebekah Green, Gigi Berardi (West Washington University)**

#### **Does the Global Food System Have an Achilles' Heel? How Regional Food Systems May Support Resilience in Regional Disasters**

Much has been written about the importance of regional food supplies as a way of increasing adaptive capacity to threats, but little in terms of dramatic food interruptions. Today's domestic United States food production is the result of an industry optimized for competitive, high-yielding, and high-growth production for a globalized market. Yet, industry growth may weaken food system resilience by reducing the diversity of food supply sources. The purpose of this paper is threefold. First we will explore shifts in food consumption patterns towards reliance upon complex and long-distance food distribution, food imports, and out-of-home eating. At the same time, in Washington State alone, nearly a fifth of households rely in part on food pantries, themselves supported by federal supplies trucked into a region

in a complex food distribution system. Secondly, we discuss how large-scale, rapid onset disasters may shape food access for both food secure and insecure households, given changing realities of consumption. Thirdly, we consider whether and how regional food production might support regional food resilience, at least in terms of high-protein calories during disasters. To illustrate these issues, we examine the case of western Washington, a region rich in agricultural production, but also threatened by a large-scale, rapid-onset disaster — a Cascadia Subduction Zone earthquake and tsunami. Such an event is expected to disrupt transportation and energy systems on which the dominant food distribution system relies. With limited household food stockpiling beforehand, and difficulty moving food supplies into disaster-impacted communities, can survivors reasonably turn to food produced locally? The results of our research indicate that the potential for a greater contribution of regional farm production into mainstream supply, especially in the interests of food system resilience, could be substantial. Perhaps regional or area producers, small in scale and flexible, can readily turn potential system shocks and threats, in terms of disruptions to food supply, into opportunity. Multiple and diverse food sources and distribution channels are important for resilient regional food systems, able to maintain supply during possible interruptions and to support especially vulnerable populations in a regional disaster. Yet, in order for local foods to provide significant calories in a crisis, we need to have in place a robust and regionally-appropriate food resilience strategy. This needs to be a strategy that re-balances our dependence on imported vs. nationally-sourced foods, as well as increasing our reliance on regional food sources.

**Janet MacFall, Steve Moore (Elon University); Todd LeVasseur (University of Charleston); Jennifer Walker, Joanna Lelekacs (North Carolina State University)**

#### **Toward Resilient Food Systems through Increased Agricultural Diversity and Local Sourcing**

Biological and agricultural diversity are connected to food security through strengthened resilience to both anthropogenic and natural perturbations. Increased resilience to stress via increased biodiversity has been described in a number of natural systems. Diversity in food production can be considered on three levels, a) genetic diversity as reflected in the range of cultivars which can be selected for production, b) species diversity, captured through production of a wide range of crops on each farm, and c) broad ecosystem diversity, described by the diversity of production between farms and within the broader food system. A network of locally based food producers and entrepreneurs provides opportunity for high diversity at each network stage, with increased adaptive capacity and the ability for rapid response to disturbance. We argue that production techniques that use carefully planned diverse plantings, such as Biointensive cultivation, increase resilience by increased water use efficiency, yield and nutrient retention while reducing pressure from pests and pathogens. We present a model for a diverse, distributed food system in the North Carolina Piedmont, and analyze an existing distributed network by a food hub in South Carolina. Through these models, we argue that a shift in the food network has the potential to increase local food security by having food more reliably available where it is needed and by contributing to local resilience through community economic development. The shift in food production and distribution systems serves multiple goals: When crop loss occurs, other crops still contribute to overall harvest, reducing net loss. Diverse on-farm production can support a more distributed network of food aggregators, processors and markets than the current approach of large-scale consolidation. Finally, a distributed food supply network supported with diverse agricultural products can increase resilience by providing access to diversified markets for producers and improved food access to consumers with more food choices, while expanding the need for skilled jobs supporting the regionally based food industry.

**Kathryn Ruhf (Northeast Sustainable Agriculture Working Group)**

#### **Regionalism: A New England Recipe for a Resilient Food System**

Regionalism is a framework for economic, policy and program development that responds to regional characteristics, differences and needs, and encourages regional approaches and solutions. This paper suggests that acting regionally contributes to food system resilience. The author discusses attributes of regionalism and regional food systems and how they build capacity to withstand disruptions in the food system. Food system resilience entails reducing vulnerability to risks of disruption to the food supply, and increasing capacity to withstand or adapt to such disruption. Regions are an effective scale to promote resilience through enhanced diversity, stability and flexibility, appropriately scaled supply chains and infrastructure, and strong foundational relationships. These attributes are important to resilience in that they decrease dependence on "external" variables such as long-distance transport of foods, and increase "internal" capacity to provide for the region and withstand natural and manmade disruptions. The region is a powerful scale to respond to disruption in that it: addresses supply (volume and diversity) better than local; is more nimble and flexible than nationally and globally sourced food (even accounting for global supply chain "substitution"); and effectively fosters relationships, communication and trust which are foundational for responding to change (disruption). This paper focuses on the New England region whose six states have a history of working together. It is also a region that exemplifies an area's ability to respond to disruption based on real and felt interconnectedness of rural and urban interests. As such, it is an ideal learning laboratory for applying regional approaches to food system resilience, approaches that can be of use elsewhere both nationally and internationally. The paper describes several initiatives in New England that exemplify regional thinking applied to food systems and how such thinking can foster resilience. Initiatives focusing on regionally focused food supply chains, increased regional production, access to farmland, and food system Public policies illustrate how government, civil society and the private sector can collaborate to strengthen food resilience.

**Brett Tolley (Northwest Atlantic Marine Alliance); Regina Gregory, Gerald Marten (EcoTipping Points Project)**

### **Promoting Resilience in a Regional Seafood System: New England and the Fish Locally Collaborative**

This article explores problems and solutions in the New England groundfish fishery, where social, economic, environmental, and food-system sustainability are major challenges. With industrialization of fishing during the past century, managers have turned a blind eye to issues of scale (e.g. industrial scale vs. community scale), which has led to chronic overfishing. There have been recurring stock collapses of favored species (e.g., cod) during the past fifty years despite federal government management of the fishery during most of that period. Small- and medium-scale fishers—with better local knowledge, motivation for local sustainability, and smaller ecological footprints—have increasingly been displaced by large-scale operations, especially during recent years with policies that are privatizing fisheries access and consolidating the fleet. Coastal fishing communities and the fishery have suffered. The Fish Locally Collaborative (FLC)—an international decentralized network of fishers and their allies—is promoting a paradigm shift. Its efforts to keep the small and medium-scale boats afloat and support local communities include economic and political strategies. Defining value with quadruple bottom line accounting (i.e., assessing social, economic, environmental, and food-system impacts), the FLC promotes a shift from high volume/low value production to low volume/high value. The FLC has reestablished local food chains with community-supported fisheries, public seafood markets, and “boat-to-hospital” and “boat-to-school programs” based on procurement contracts that specify local and sustainable catch. The FLC also promotes the consumption of lesser-known fish species to motivate more balanced and ecologically sustainable fishing. Politically, the FLC continues to build the strength of the network and participates in policy discussions at local, national, and international levels.

**Michelle Miller, Jeremy Solin (University of Wisconsin)**

**The Power of Story for Adaptive Response – Marshaling Individual and Collective Initiative to Create More Resilient and Sustainable Food Systems**

What can environmental scientists and teachers do to make our food system more resilient? One low-resource, low-cost and high-impact way is through storytelling. Facilitating individuals and groups in telling their personal stories about farming and food is one of the most powerful tools available to help people understand their role in our food system. This article offers four cases in different contexts that illustrate how we can facilitate storytelling as an adaptive response and what outcomes could be expected. In these cases, narratives based on personal experience helped people understand their role as a central actor in the food system and make conscious their responsibility for the health of the system. Storytelling empowered people to act individually and collectively to make our food system more resilient within their spheres of influence and built the skills necessary for effective civic engagement on complex issues. Storytelling provides interdisciplinary learning for students and professionals alike. It connects the classroom to the community, students to professionals, and research disciplines to stakeholders in a powerful way. As food system disruption risks increase due to extreme weather, economic disparity, urbanization and other system disturbances, the role of educators and scientists in engaging people to share their stories of adaptation becomes that much more urgent.

**\*Rebecca Dunning, Dara Bloom, Nancy Creamer (North Carolina State University)**

**The Local Food Movement, Public-Private Partnerships, and Food System Resiliency**

Concentration and consolidation in production, distribution, and retailing have arguably reduced the diversity of US food supply and distribution channels, thus introducing vulnerabilities into the food system. This paper addresses the question of what can be done to make the system more resilient to shocks that can disrupt food supplies. We suggest that the interest connected to the local food movement extant in a wide-ranging set of public and private groups, as well as among a widening base of consumers, creates a unique opportunity to strengthen food system resiliency. We specifically focus on the supply and distribution systems of supermarket retailers. Supermarkets are major drivers of the modern food system, with US and global consolidation positioning grocery retailers as both oligopolistic sellers and oligopsonistic buyers of food. We discuss the opportunities and challenges to diversifying supermarket procurement and distribution through localization, and suggest that such a shift can be most successful if it is facilitated by public/private partnerships to address the logistical challenges and system changes needed. We provide an example of one such public/private partnership in the context of the work of the Center for Environmental Farming Systems (a collaboration between two North Carolina land grant universities) which has partnered with a regional supermarket to facilitate and promote the sourcing of local products. The substantive activities of the partnership—capacity-building training for growers and buyers; networking and peer learning activities and site tours; support for MBA research teams and undergraduate internships; piloting and subsequent evaluation of novel distributional techniques—are ones that can be enacted by researchers, instructors, and advocates in partnership with supermarkets and other food businesses to build more resilient systems of food procurement and distribution. Discussion of the project provides tangible examples of how public and private entities holding shared interests in local agriculture can partner as part of a holistic approach to diversifying and strengthening the food system.

Keywords: food system, local food, resiliency, public-private partnerships, social change, supermarkets, university

**Gerald Marten (EcoTipping Points Project)**

**Conclusions from the Symposium on American Food Resilience**

This article will draw upon messages from all symposium articles to enumerate key issues, probe questions that they raise, and outline key concepts and action strategies for improving American food resilience.