



A comprehensive review of the
regional, inter-disciplinary, trans-disciplinary, food security,
and systems facets of the EFSNE Project

Prepared by

Kate Clancy, Stephan Goetz, Anne Palmer, Christian Peters,
Kathryn Ruhf, and Kristen Devlin

May 30, 2018

*EFSNE was supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture,
under award number 2011-68004-30057.*

I. Introduction

We are happy to submit this report as a complement to the CRIS report mandated by NIFA/AFRI at the end of a project. The CRIS format is restricted in length and by what can be reported within its template. We have prepared this at the request of the national program leaders of the GFS/AFRI program, fully agreeing that there are a number of unique characteristics of the EFSNE project that need to be explained in more detail. We think that this detail can benefit both the members of the EFSNE team as they go on to conduct more research in the Northeast (NE), and interdisciplinary research/extension teams in entirely different research areas. We also believe that it will be of use to USDA research program personnel as they prepare new RFAs, and support new applicants who plan to utilize interdisciplinary and transdisciplinary systems tools.

The challenge of food security at all scales—from community to global—calls for understanding complex interactions among multiple processes (Ericksen et al. 2009). The Enhancing Food Security in the Northeast (EFSNE) project's objectives were to provide knowledge and analyses of the Northeast food system along with recommendations for improvements. It also modeled the processes, outputs, and outcomes of a large inter- and transdisciplinary project for current and future scientists and practitioners working in this arena.

The project merged two different food security concepts with the orienting goal of assessing whether greater reliance on regionally produced food in the long-term could improve food access for low-income communities, while also benefiting all the players in the food system. It ran from 2011 to 2018 and was composed of over 20 senior researchers and numerous other individuals, including significant numbers of students, working together to describe many different parts of the Northeast food system. The 80 different components range from calculations of the present regional self-reliance for a number of foods and possible climate change effects, to information from almost 2,000 shopper intercepts surveys in 14 stores located in low-income areas throughout the region. The project has included work with these communities and others on how to conceptualize the complexity of food access, and to make recommendations for improvements (see CRIS report for many details that are not presented here).

We start with some definitions of key aspects of the seven-year project with an explanation of why different approaches were important to this particular effort. We then describe the project's organization and activities that engaged all the team members. We describe the key details under each of the major aspects, followed by major systems outputs and outcomes. Lastly, we present a section on next steps, along with conclusions and recommendations regarding systems research on food systems topics.

II. Definitions and rationale

A. Regional

Food availability and accessibility are primary determinants of food security. A robust regional food system (RFS) has the potential to enhance food security for the entire region, including low-income or food insecure communities. There are well-established strategies, like food donations and subsidized purchases that improve the food security of these communities. However, the underlying mechanisms necessary to more broadly enhance community and household food security via mainstream markets are poorly

understood. More specifically social, economic, and biophysical constraints to RFS expansion, and the potential for changed systems to move regional foods from farms to consumers, have not been fully analyzed. The Northeast United States is characterized by mixed land-use, including a declining agricultural sector. The region is also challenged by expanding populations and growing pressure to develop. It thus represents a significant opportunity to evaluate how a more regionally-focused food system might enhance the food security of all of its residents over time.

The Global Food Security RFA (2010) required that “applications be focused on urban and/or rural self-defined geographic regions centered on ongoing local and regional sustainable food systems that include disadvantaged communities”. This requirement was a very good fit for our project because several team members had already been engaged with regional systems, and food security, for a number of years. Also, we realized that the Northeast already functioned as a region in multiple ways, making it a good candidate for regional level research and implementation.

B. Inter-and transdisciplinary research

The RFA also stated that projects must include a multistate, multi-institutional, and transdisciplinary team composed of public, private, for-profit and nonprofit sectors, including community-based organizations, universities, local governments, and foundations. Our team did not include members of local governments or foundations, but met all the other requirements - see Table 1 for lists of institutions across the region and disciplines across the agricultural and social sciences.

Table 1: Institutions and disciplines represented in EFSNE project	
Participating institutions	Disciplines represented within project
<ul style="list-style-type: none"> • Agricultural Research Service/USDA – Orono, ME and Beltsville, MD • Columbia University, Urban Design Lab • Cornell University and Syracuse Cooperative Extension • Delaware State University • Economic Research Service/USDA Washington, DC • Johns Hopkins University Bloomberg School of Public Health, Center for a Livable Future • Northeast Regional Center for Rural Development (PD) • Northeast Sustainable Agriculture Working Group • Tufts University, Friedman School of Nutrition • Penn State University • University of Vermont • West Virginia State University 	<ul style="list-style-type: none"> • Agricultural Engineering • Agricultural Economics / Economics • Agronomy • Architecture / Urban Design • Civil Engineering • Climatology • Communications • Community Development • Crop and Soil Science • Education • Food Policy • Food Systems • Public Health • Natural Resource Management • Nutrition Science • Sociology

Interdisciplinary studies are defined as:

“A process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline or profession... [It] draws on disparate perspectives and integrates their insights through construction of a more comprehensive perspective” (Klein and Newell 1997). It is also described as “science moving closer to application with regard to complex problems”.

Transdisciplinary research is an approach that includes multiple scientific disciplines (interdisciplinary) focusing on shared problems with the active input of practitioners from outside academia (Brandt et al. 2013). The project had some transdisciplinary components in that site leaders from each location worked with us on a number of components, and through Advisory Council members who offered important feedback over the course of the project, and information on various food and agricultural content and process insights.

C. Food systems

Food systems can be defined as the aggregate of food-related activities and the environment (political, social, economic, and natural) within which those activities occur (Pinstrup Anderson and Watson 2011 p.3). We studied elements of food supply chains all along the chains. We also conducted research on multiple social, economic, environmental, and policy factors involving food systems actors including consumers, and how they interact. Specific examples of these are given in the sections below.

D. Systems approaches

In 2010 the National Research Council Board on Agriculture report “Toward Sustainable Agriculture in the 21st Century” called for transformative approaches and research that addresses complex systems. Food systems are prime examples of complex systems in which social, economic and bio-physical systems are linked, and where the pieces that drive the system can’t be understood when considering them separately. The RFA requested applicants to assess social, environmental, and economic aspects of food systems and to provide feedback to improve the work being done in communities, and at larger scales.

E. Two different definitions of food security.

Because we were interested in the long-term food security of the entire region we melded two different concepts of food security in the project. The first is the food security of a region producing enough food to feed itself in the event of shocks such as crop failures or drought. The second is community food security in which all community residents have access (economic, physical, social) to adequate food supplies. It has been said that the primary function of every generic food system is food security – our emphasis, therefore, is on both the entire Northeast population and its food insecure residents, which in 2018 comprise about 11% of the region’s population.

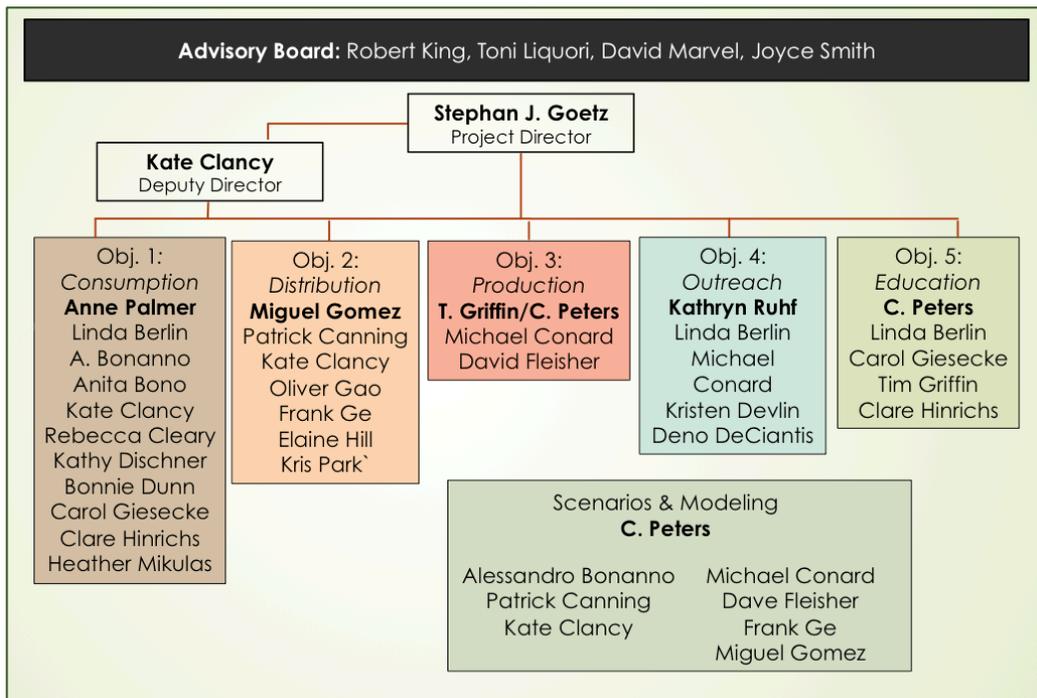
III. Project organization

A. Organizational chart

The external evaluation of the project (see below) noted that overall EFSNE emerged as a project that invested significant time, effort, and thinking into developing outstanding collaborative capacity. The evaluator pointed out also that the investment in time, interactive space (including travel), meeting agendas and notes, and multiple shared data platforms created important formal structures that enabled the team to advance its work.

The team created structures and processes that helped create a strong sense of buy-in. The organizational chart (Figure 1) illustrates the structure that provided a clear sense of delegation and organization. Each team with its leader worked on research projects related to their disciplinary specialties and interests. We utilized other activities and instruments to build and maintain discipline across all the teams. These activities included developing a glossary of terms (jargon) utilized by most of the disciplines, but often having different and confusing meanings. Team members from different teams and disciplines also made presentations together at conferences and meetings, and we instituted internal manuscript reviews of many publications so that the messages were clear and consistent. There were also many administrative arrangements and requirements that were shared and accepted by team members and their institutions. The director and deputy director oversaw the budget and contracts, and most of the activities of the project. There was an executive team composed of the directors and the team leads which made decisions together. There was also an advisory council of five members which provided support and encouragement, knowledge about systems research, and specific knowledge about communities and agriculture in the Northeast.

Figure 1



B. Activities that engaged all team members

While the teams worked on their own projects there were many activities that engaged individual team members in smaller or larger groups, over the seven years. These included:

- (1) the development of the original proposal including the identification of site locations and site leaders
- (2) the development of the Market Basket including the choice of foods and their rationale as well as the final items in the basket.
- (3) the development of the internal project evaluation work plan in concert with an outside expert
- (4) a monthly all-team conference call
- (5) annual face-to-face meetings
- (6) the development of yearly project plans and quarterly reports
- (7) internal manuscript reviews of all cross project papers and some other individual papers
- (8) a process evaluation of the project in year four
- (9) interviews conducted by the external project evaluator

IV. Details regarding the food systems components

Recognizing that food security issues require insights from multiple disciplines and knowledge-sharing between researchers and practitioners in communities, we used multiple quantitative and qualitative methods, a number of which were developed over the course of the project. We attempted to study entire food system components through analysis of primary data collected in communities, stores, and the supply chains that serve them, and of secondary data on the food system available from private and public sources. The production, distribution, and consumption teams conducted the research; each looking at one supply chain element (for example agricultural production), but working on sets of different research projects, and keeping the other teams apprised of their work and findings.

The outreach team disseminated knowledge and research insights to multiple audiences. Their activities delivered the projects findings through a number of different formats such as research briefs that translated manuscripts into clearly understandable summaries. There were 100 presentations, a workshop, a national conference, and an online newsletter that allowed users to see the breadth of food systems the project engaged. The community events also exposed attendees to a breadth of food system issues and helped them to build their capacity to broaden their efforts at the local level.

Students were engaged through all of the work over the entire course of the project. When surveyed, 90% said that the number one skill or competency they developed was having a much greater appreciation of the complexity of the food system.

V. Details regarding the choice of a regional approach

There are many reasons to engage food security at a regional level. It is an appropriate scale for addressing rural development, along with urban regeneration, agricultural food strategies, and producer and consumer reconnections (Kneafsey 2010). It offers a more ecological focus on population density, environmental conditions, and marketing.

We've engaged at the regional level for those reasons and more. It is a scale at which many ecological and social interactions occur, such as trade, migration, and rural-urban connections. There are many dimensions recognized as key in a regional project: food supply and demand are the starting points, especially the total caloric and nutritional needs of the population in the region. The natural resource base is of course critical in determining how much and what kinds of foods can be produced where. Availability and land-use decisions are essential, as is water. Economic development proceeds with multiple markets, new business models, and trade. Products can be differentiated by place and attributes. Biodiversity will tend to be greater in a larger region, especially in the Northeast, which crosses a number of latitudes. Greater biodiversity also supports food security and resilience (Ruhf and Clancy 2010).

Regionally focused food systems can contribute to resilience through various ways including reduced dependence on food imported from outside the region, increased food production within the region, more efficient and stable regional supply chains, maintaining a productive land base, and capitalizing on regional assets such as water and transportation (Ruhf 2015). Given the latter concerns brought on by climate change, studying mid-scale food systems (between local and national/global) took on greater relevance for the NE.

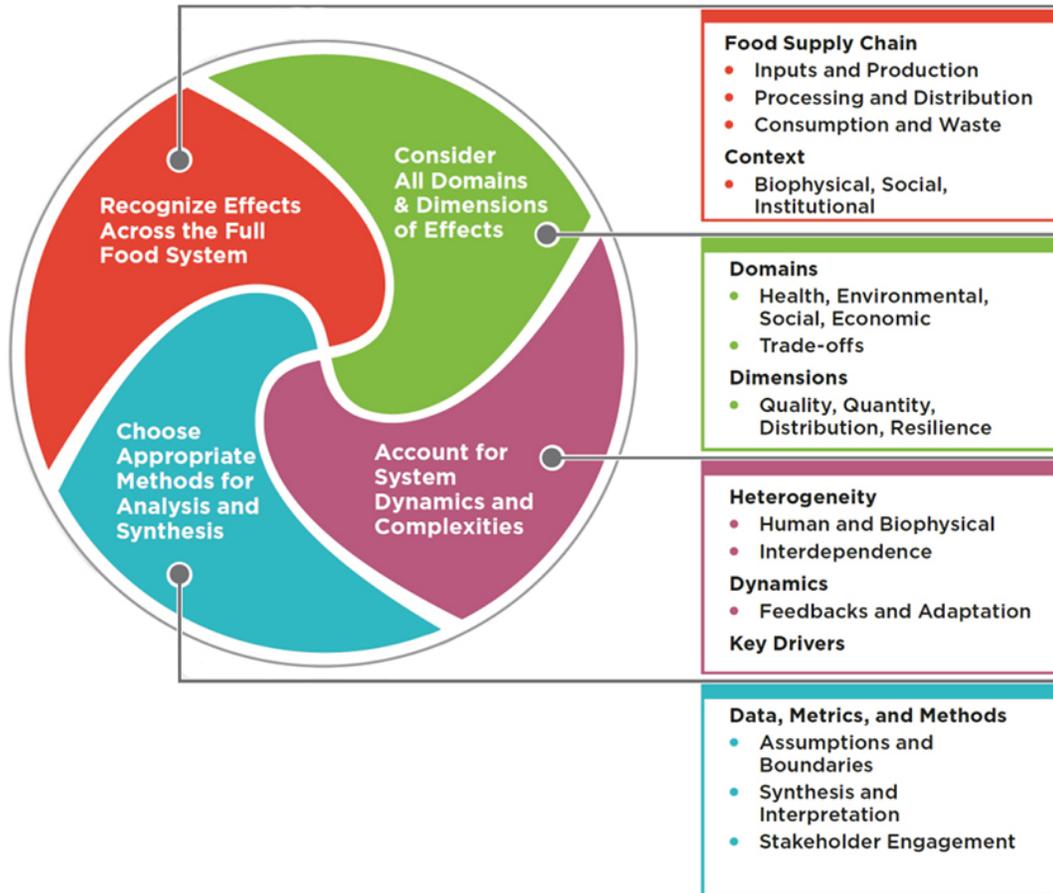
Finally, we studied the Northeast region because a number of team members had been working at the regional level for many years. This includes Stephan Goetz, the project director and the head of the Northeast Regional Center for Rural Development; Kathy Ruhf and Kate Clancy (the deputy director of the project), who under the umbrella of the Northeast Sustainable Agriculture Working Group had been studying and writing about regional food systems for some time; and Tim Griffin, Pat Canning and several others who, when the RFA came out, were in the process of developing a project to study vegetable production in the Eastern Seaboard.

In all cases the researchers employed data sets for their analyses that were collected through surveys in the project, had already been built in the Northeast, or were adapted from national data sets that encompassed only Northeast states and counties.

VI. Details regarding the systems elements used in the project.

Some team members were aware of and were utilizing systems approaches, including modeling, in their own teaching and research when we wrote the proposal. The IOM report on systems research did not appear until 2015 but its framework (Figure 2) is a useful tool to understand some of the characteristics of the project.

Figure 2



We looked at certain systems characteristics and chose the boundary for the project as the Northeast states and the District of Columbia (the USDA Rural Development Northeast region boundary entities). This choice also reflected the number of latitudes north to south in the region, which contribute to the rural self-reliance proportions we calculated as well as the environmental conditions. We were aware of the distinctions between very large population centers in the region and the rural areas in our analyses. And we paid quite a bit of attention to the food marketing infrastructure that exists in the region. All of this was predicated on choosing to do groundbreaking research on a mid-scale entity, a region, rather than smaller areas such as local geographies.

We carried out investigations that included the four different domains. Under the environmental rubric we looked at land use and climate change; in the economic realm we studied supply chain viability, food costs, distribution models, and many other factors; in the social realm we studied, among other things, food access, food environments, federal nutrition program participation; and in the health area we included healthier versions of some of the foods in our Market Basket and analyzed the different demographic characteristics of shoppers purchasing those foods.

We acknowledged in our analyses the heterogeneity/differences between supermarkets, between urban and rural populations, between lower income and non-low income

households, between various supply-chain actors, and many other comparisons. And we used strategies that are part of systems approaches, for example adaptive management principles that we followed throughout the seven years to deal with necessary changes, and the development of the Scenarios and Modeling (SCEMO) team in year two. It was originally formed so that we could know which types of models were being utilized by different teams. It then developed a set of framing questions and a set of modeling scenarios. In the last years it organized and managed the cross-project paper manuscript development and the submission processes to the two journals.

VII. Key details regarding interdisciplinary processes

A. Interdisciplinary work

As we moved through the project we developed, and understood at a much deeper level, many of the components and indicators of a successful inter/trans-disciplinary project. An external evaluation of the project conducted at the beginning of year six (see below) gave us high marks on our expertise/competence in communications which encompassed: (1) the choice of team members, cohesion among the members from regular calls and meetings, constant feedback, and orientation for new members; (2) practicing trust and demonstrating presence by the listening format of phone calls and meetings, and risk-taking facilitation that provided safe boundaries for team members to bring up issues; (3) spending time together at annual meetings, at the interim face-to-face meetings, having meals together, and being members of other networks; (4) dealing with discussions of jargon differences among the disciplines with the glossary and with people who served as translators across the disciplines; (5) reflexive talk in which we framed the questions and scenarios for the project, executed a process evaluation several years in and at the annual meetings; and (6) humor and shared laughter facilitated by the natural senses of humor of most team members, and opportunities to play together such as exchanging food products from our respective locations.

Two other very important factors to the team success were its leadership structure and a shared vision of the project's issues. Leadership of the project was shared among the project director, the deputy director, and the team leaders. Individual team members operated with autonomy and responsibility to their work and the rest of the project. The leadership engaged all team members in yearly planning exercises, communicated changes in activities, and recognized the facilitation expertise in team members. Troubleshooting with personnel was conducted by the project director and deputy director in private and tactfully. And most important, as pointed out by the evaluator, there was a lot of humility, honesty, and flexibility across the leadership and the entire team.

Something else embodied in the project was a shared vision of the issues the project was addressing. This occurred through a variety of avenues including the development of the long-term operating goal as the proposal was being written; the framing questions by the SCEMO team in year two of the project; discussions at annual meetings about how the separate team objectives could be looked at as a system; and working, as described above, to establish a true collaboration among all the team members. Most members of the project served on multiple teams, creating a well-integrated environment that encouraged collaboration and required communication across disciplines.

Building a team, establishing trust and friendships, and creating common language takes time. Reports in the literature from other interdisciplinary projects suggested that teams were ready to write up findings after 5 years and this proved to be the case for EFSNE. This is why it is so important that interdisciplinary projects are funded for longer periods of time – at least five years in our case which was extended to seven years. The work of combining results into the cross project papers in the last year and a half of the project was challenging. Most of those papers include research results from two or more of the teams, and from multiple research exercises from within teams covering elements of supply chains, community input on the food environment, etc.

Other elements of the project's disciplinarity are described in the sections that follow.

B. Evaluations

Due to resource constraints, and because of the presence on the team of researchers with extensive experience, most of the project's evaluations were done internally. We formed an evaluation team and hired a consultant at the beginning of the project to work with us to develop an extensive five-year evaluation plan. Then each year we conducted a number of team and project self-evaluations, gathering information on each team's accomplishments, problems, collaborations with other teams, changes in plans, etc. These reports formed the basis for the yearly reports and continuation proposals to USDA. In year three, we also conducted a process evaluation of all the team members to determine how well the individual teams and the project as a whole were functioning with regard to items such as communications, collaborations, and administration.

Other useful evaluations were (1) one conducted with the attendees at the researcher, storeowner and community leader workshop in 2013; and (2) a semiformal follow-up interview with the storeowners in year five to inquire about their reactions to the project.

As we approached the end of year five we were aware that EFSNE had functioned as a unique complex project in the food security area and wanted to record what we had learned for our own benefit, and for that of other researchers undertaking similar efforts. So we hired an expert in evaluating inter-/trans-disciplinary projects who was very pleased to conduct the evaluation herself. Many of her findings are described above. Another finding was that "after five years the EFSNE team members had a poor understanding of what could be done to assess progress in advancing inter-/transdisciplinary collaboration". We know much more after digesting the report and after spending two more years working together. Some of our learning has already been shared with researchers at several universities around the country, and we hope to do more coaching and training in the future.

VIII. Outputs that capture the systems components

In a new interdisciplinary project, many of the outputs are likely to be methods, protocols, baseline measures, and research results. In many of these categories, the elements were specifically disciplinary. What follows is a selective list of those that were multi-and interdisciplinary.

Methods to calculate regional self-reliance in food stuffs; and models showing productivity changes with shifting land uses.

Novel protocols for estimating the capacity for urban agriculture in New York City and for agriculture in the other urban areas in the project; for conducting supermarket case studies, including the supply-chains of market basket foods; and for describing urban, peri-urban, and rural locations of food supply-chain elements.

Baseline data regarding all crops and livestock (including animal feed) produced in the Northeast; food prints for the Northeast (the land requirements per capita for a complete diet), offering knowledge needed to initiate new crop and animal production strategies; and consumer perceptions of regional food systems.

A few examples of other outputs are the Local and Regional Food Systems Modeling Learning Community; the Community, Local, and Regional Food Systems Extension Community of Practice (eCoP), which the project initiated; network analyses of project members including their interdisciplinary collaborations; new courses on food systems in graduate and undergraduate university curricula; community readiness studies for pursuing food access improvements in project locations; and information from secondary data on consumer purchases across income, urban/rural, and North/South gradients.

IX. Outcomes that capture the systems components

A number of the outcomes of the project are described in the CRIS report. There are many others which can be classified as either internal or external to the project. Among the internal outcomes are (1) a much more informed view of what food access means and its complexities including real and perceived ideas about food access; (2) students trained in how to conduct systems research; and (3) greatly enhanced knowledge and capacity of all researchers in the project about transdisciplinary research and food security issues. The external outcomes include: (1) changes in several project stores' outreach activities to shoppers; (2) use of data by American Farmland Trust of New York State to describe what farmland loss means for future food production; (3) requests for consultation on methods and protocols regarding regional self-reliance; (4) use by the branding program of New York Department of Agriculture to better understand regional milk flow; (5) more Extension and other professionals sharing info via the eCoP; and (6) increased knowledge and connections among researchers across the country who are modeling local and regional food systems.

The project offers elements of a blueprint, or a strategic plan, to continue learning about the Northeast region's food systems, and to act as a vehicle for passing on all the knowledge we have compiled to regional actors as they work to enhance those systems. Some of the outcomes we foresee include: (1) enhanced understanding of the capacity for food production in the region and the role of the Northeast in the US food system; (2) the ability to see how land use changes for food production over time; (3) increased attention to and presence of regionally produced food in communities; (4) improvements in food stores serving low-income communities; (5) increased knowledge of how food systems work by community members and ability to identify and address policy issues; and (6) levers policy makers might use to make needed changes in regional food systems.

X. Next steps

A. Finishing up the EFSNE writing projects

Three papers are in the process of being completed for submission to the *Journal of Agriculture, Food Systems, and Community Development*. The first four papers submitted to that journal were published in December 2017 < <https://www.foodsystemsjournal.org/index.php/fsj/issue/view/29>>. Four papers are being prepared for submission to the *Renewable Agriculture and Food Systems Journal* for review and publication, we hope. And three other manuscripts are in various stages of preparation. We will also continue to give presentations on the project, including in June 2018 at the Agriculture Food and Human Values Society annual meeting.

B. New spinoff projects

Three project members have secured an AFRI grant to conduct an in-depth study of beef supply chains in the Northeast, after some early work was done on the topic as part of the EFSNE project.

Owing in large part to the success of EFSNE, the NERCRD received a total of \$1.7 million from the USDA's Agricultural Marketing Service to provide training related to the Farmers Market and Local Foods Promotion Programs nationally, as well as to explore online mapping services and to support developing state food systems. The Center is also participating in a project led by Rutgers University in the amount of \$350,000 dollars that examines knowledge and innovation spillovers in local clusters of different commodities.

C. Continuation of the website

The project website is the public repository for outputs including supply chain case studies, research briefs, links to published journal articles, and more. It is hosted by the Penn State-based Northeast Regional Center for Rural Development, and it will continue to be maintained by NERCRD staff going forward to provide ongoing public access to these and yet-to-be-completed EFSNE products.

D. Assisting new interdisciplinary proposals and projects

As mentioned earlier we think it appropriate to share the myriad lessons-learned from the project – both its content and processes. Some of this has occurred at the national conference in 2015, and with several groups and individual researchers around the country. We plan to add this report to the EFSNE website, and to solicit interest from other researchers in providing consultation and advice on how to develop successful inter-and transdisciplinary projects. There is a rich international and national literature on this topic to add to our experiences and growing expertise.

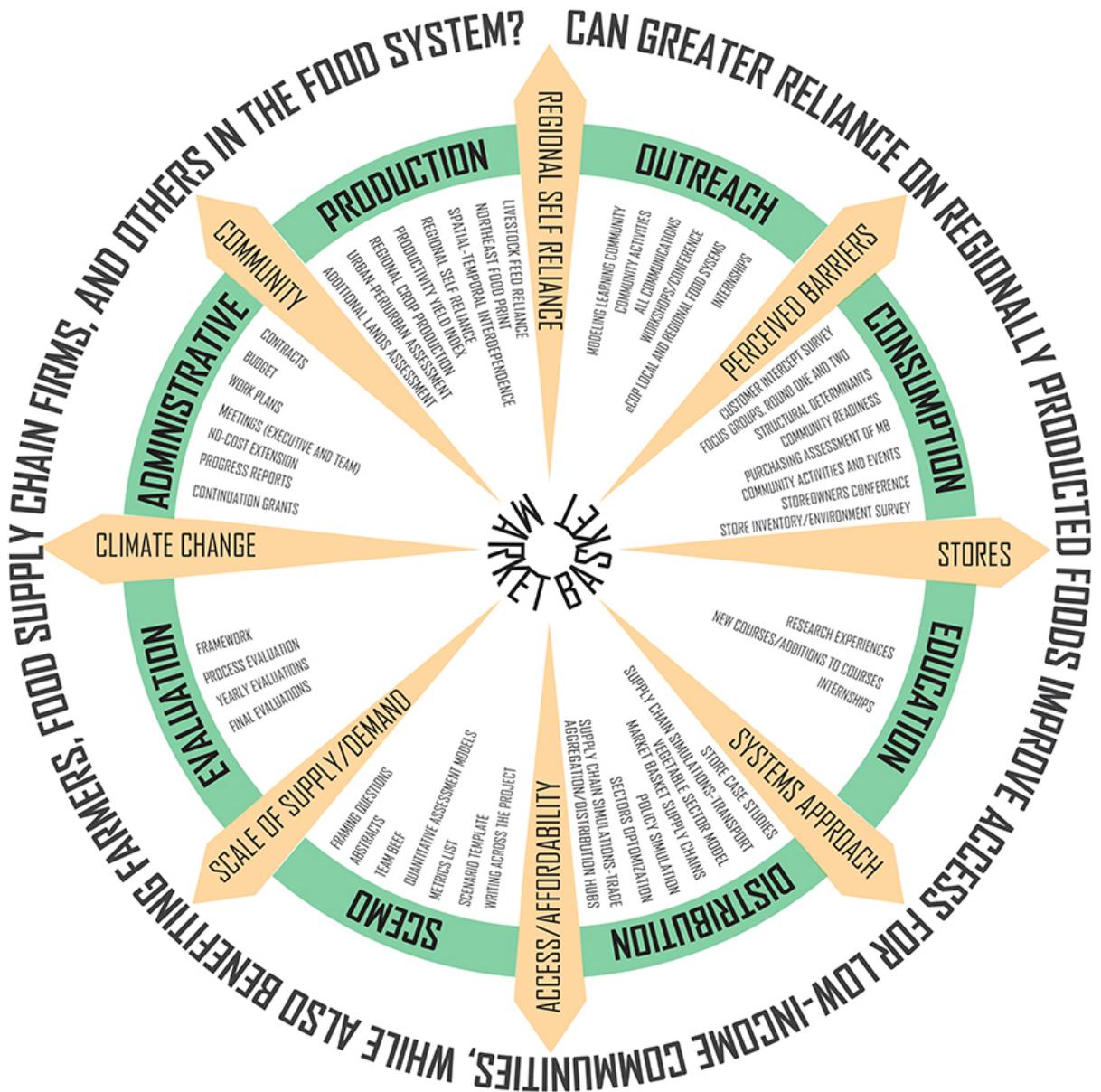
XI. Conclusions and recommendations

This report has described the unique and distinctive components of the EFSNE project. Those are (1) its focus on a region rather than on the national or local level; (2) its systems approach linking supply chain actors and other important components such as low-income communities; (3) its functioning as a successful interdisciplinary project and (4) its important contributions to the development of methods that make it possible now to understand components of food systems in much greater depth. We believe that all of the rich and diverse information that we obtained and integrated will enable us and others to continue improving food security and access in the Northeast and elsewhere.

What we learned about food access and food security in the region, as well as the wealth of knowledge and experience we gained regarding large interdisciplinary projects is limitless. In the latter category we particularly want to emphasize that projects of this type take time. The extraordinary commitment made by team members throughout the years and on the cross project papers was (a) made possible thanks to the NIFA grant that funded EFSNE and (b) subsidized by the time the faculty put in beyond the funded project effort. For large projects to work researchers need access to long-term large grants to support graduate student efforts, postdocs, travel, etc. And they need supportive home institutions.

We mentioned earlier that the 2010 Board on Agriculture report on sustainable agriculture in the 21st century was an inspiration and help to us. After the project began other critical reports appeared including, in 2015, the IOM report (mentioned in section II. D.) called “A Framework for Assessing the Effects of the Food System”; and the APLU report in 2017 titled “The Challenge of Change”. All of these reports, written by committees composed of scientists from myriad disciplines, urged universities and researchers to make a much stronger commitment to undertaking more systems and transdisciplinary research. AFRI itself, in its new Sustainable Agricultural Systems RFA, requires that applicants focus on approaches that will promote transformative changes in US food and agriculture over the next 25 years, and take a systems approach demonstrating current and future social, behavioral, economic, health, and environmental impacts (USDA/NIFA 2018). We see ourselves as pioneers in this effort regarding the US food security arena, and are grateful to the AFRI program for its long-term support.

Figure 3



XII. References

Association of Public and Land Grant Universities. 2017. The Challenge of Change: Harnessing University Discovery, Engagement, and Learning to Achieve Food and Nutrition Security.

Brandt et al. 2013. A review of transdisciplinary research in sustainability science. *Ecological Economics*.92:1-15.

Ericksen, P, Ingram, J., and Liverman, D. 2009. Food security and global environmental change: emerging challenges. *Environmental Science and Policy* 12(49):373-377.

Board on Agriculture National Research Council. 2010. *Toward Sustainable Agriculture Systems in the 21st Century*. National Academies Press Washington DC

Institute of Medicine and National Research Council. 2015. *A Framework for Assessing Effects of the Food System*. Washington, D.C: The National Academies Press.

Klein, J, and Newell, W. 1997. Advancing interdisciplinary studies In J. Gaff and J. Ratcliffe (Eds.) *Handbook of the undergraduate curriculum: a comprehensive guide to purpose, structures, practices, and changes* (pp. 393-415). San Francisco Jossey -Bass.

Pinstrup Andersen, P. and Watson, D. In *Food Policy for Developing Countries*. Cornell University Press. Ithaca and London. 2011.

Ruhf, K. and Clancy, K. 2010. It Takes a Region: Exploring a Regional Food Systems Approach. At NESAWG website.

Ruhf, K. 2015. Regionalism: A New England recipe for a resilient food system. *The Journal of Environmental Studies and Sciences*. 5(4):650-660.

NIFA/USDA. May 2018. *The Agriculture and Food Research Initiative – Sustainable Agricultural Systems*.