

Executive Summary

An NSF Workshop was convened in Boulder, Colorado October 21-23, 2015 that brought together hydrologists, agronomists, economists, engineers, climatologists, ecologists, energy experts, and water resource planners to discuss the vulnerabilities of the present geography of agriculture. The workshop discussed whether information might be developed to assess the geography and agricultural sustainability in the context of the FEW goals and whether in the future the assessment might be used to guide private sector investments and government policy decisions that are needed to sustain production in the coming century. The workshop began the process of how the geography of sustainable production might be defined in terms of food, energy, and water metrics.

The workshop focused on the question of whether or not a planned (or subsidized) re-distribution of certain agricultural crops from their current configuration in the United States would be a viable strategy to mitigate climate variability and future climate change and associated food, water and energy disruptions facing the Nation. In order to evaluate the question, a number of metrics were suggested and science questions surrounding those metrics were developed.

The Boulder FEW Workshop was built around three overarching questions.

1. Should a geographical redistribution of agriculture be considered as a path to sustain agricultural production in the U.S.? This would be a path for coping with climate, water, energy and environmental pressures on agricultural production.
2. How can geographical sustainability be defined? That is, what metrics need to be considered? Can these metrics of sustainability be captured in a spatial mapping environment?
3. Of what use would be the geographical information to policy makers and the private sector?

The first day of the workshop was devoted to presentations focused on the vulnerabilities of the current system. The interrelationships of food, water, and energy informed these presentations. Topics included the current drought in the Western US and its context in the paleoclimatic record, distribution of water, agriculture and irrigation withdrawals in the current system, observed and potential response of producers to the western drought, the role of energy in food and fiber production, vulnerabilities associated with the current geography of agricultural production (e.g., the concentration of grain production in the Upper Midwest), and barriers to migration of agriculture to underutilized areas. A common theme of these presentations was that intense agricultural production and its associated energy use is not currently situated so as to take advantage of the availability of water and the energy supplies that depend on that water. Thus the current system is vulnerable to regional climate variability and change as well as other stressors such as environmental impacts and external economic forces. The current vulnerabilities provide an opportunity to increase agricultural production in areas less vulnerable to these forces (e.g., areas with larger amounts of precipitation, areas suitable for agriculture etc.).

The workshop then focused on the question of the viability of a subsidized or managed migration of agriculture to more sustainable areas, i.e., areas with suitable land plus abundant water and

energy supplies. The point was made that the migration is already occurring to a certain extent and that it would be advantageous to get ahead of the curve to ensure a sustainable U.S. food production system. Much of the discussion revolved around the metrics by which to measure the sustainability of any particular distribution of production and how those metrics could be displayed and transmitted to private investors and public policy makers. Particular crops that might be more amenable to migration were also discussed, especially in the context of climate and soil controls and water and energy usage. The consensus was that rice, grains and hay were the most viable crops to migrate whereas fruits and vegetables might remain concentrated in their current locations, while also being expanded in other locales. The point was made that agricultural policy in the United States does not take place in a vacuum and that the global food market plays an important role and must be considered in any policy changes in the U.S. The idea of capturing the sustainability metrics in a geographical mapping context was discussed and a number of speakers presented examples of how this could be accomplished. Metrics of sustainability include economic, environmental (including water availability), social, energy and programmatic indices. Each metric is placed in a food-water-energy relationship. The role of energy in the FEW equation is complex and crosscutting, energy is consumed in the production of food, in the transportation of the produce to markets, and there could be competition between the energy and agricultural sectors for water, particularly in the Southeastern US. Ethanol was cited as a unique crosscutting example as energy and water are both necessary for the production of ethanol, which in itself is an energy product. Metrics that might be captured spatially include economic (costs of production and transportation, net profit, etc.), environmental (nutrient export, water stress from competing users), social (rural poverty, employment) and energy usage/production. Potential barriers to migration, including eastern riparian water law and relatively sparse existing irrigation infrastructure in the east were also debated.

Lastly, the attendees discussed the science and technology issues surrounding the development and analysis of the sustainability metrics. It was agreed that significant work remains to be accomplished in areas such as the paleoclimatology of the US and associated hydrology, future stresses on US energy metrics associated with food production and distribution, environmental impacts of agricultural re-distribution, economic impacts on both the areas expanding agriculture and those possibly losing production (including employment), how any increases (or decreases) in net income might translate through the different social classes of the affected regions, how population migration might be impacted, and how the diets of the US and Global populations might affect the migration or in turn be impacted by the migration of agriculture throughout the US. The discussion also included an evaluation of the types of tools and models that would be needed to produce and analyze the metrics. Some existing models might be adapted to the tasks, either singly or in combination, while others would need to be developed as part of the research enterprise. However the attendees did agree that, while significant effort would be required, the prospects for success were high. **Given, the interest and response to the workshop and the discussions at the workshop there is a consensus among the participants that consideration of understanding of geographical sustainability is a worthwhile goal of NSF's FEW Initiative.**