Designing a Resilient Agriculture for a Changing World:
How Land Grant Universities Can Help[1]

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The world at the close of the 20th century is a fundamentally different world from the one in which the current scientific enterprise was developed.

---Jane Lubchenco (Lubchenco, 1998)

As Jane Lubchenco pointed out in her presidential address to the annual meeting of the American Association for the Advancement of Science on February 15, 1997, we are on the cusp of entering into a very different world from the one we have lived in for the past century. And while most of us, including the scientific community, have been reluctant to anticipate these changes, they are now rapidly imposing themselves upon us, and our food and agriculture systems will be among the first to be affected. Among the many challenges that our new "contract" will need to recognize, as Lubchenco pointed out, is "the extent of human domination of the planet."

Lubchenco made these observations based on an awareness of the "problems of the coming century." At least half of the "problems" that Lubchenco outlined are directly related to agriculture. Among those many problems is the fact that "more atmospheric nitrogen is fixed by humanity than by all natural terrestrial sources combined."

Any farmer interested in farming successfully, and any government, interested in a secure food system for the decades ahead, must anticipate these impending changes and begin designing an agriculture that can adapt to them.

This redesign will need to be differential—a paradigm shift! Simply modifying or intensifying the current system will not meet the challenges ahead. In the "adaptive cycle" language proposed by the Resilience Thinkers, we are entering the "reorganization" phase which is characterized by "uncertainty, novelty and experimentation." (Walker and Salt, 2006)

In fact Ernest Schusky suggests that we are about to enter a new "era" of food production that will, of necessity, be significantly different from the food system we designed in the early 20th century. This will, in fact, be another "cultural" shift, which "consists of everything that humans have, do, or think." It will of necessity be a shift similar to our transition from the hunter-gather era to the Neolithic Revolution, and the shift from the Neolithic (agrarian agriculture) era to, what Schusky calls, the "neo-caloric" era. The "neo-caloric era" which evolved in the early 20th century, (and adopted on a large scale after World War II), was made possible by fossil energy, which not only changed agriculture, but our "whole way of life." The "Neo-caloric Revolution has converted rural societies into urban societies and altered international relations while bringing pollution and erosion to such heights that life itself is now threatened." (Schusky, 1989)

Schusky argues that the Neo-caloric era will of necessity be a VERY short period in the time-line of human history because it is entirely sustained by "old calories." We are rapidly using up those calories, and once they are gone, that way of producing our food will no longer be possible. These "old calories" consist of fossil fuels, fossil water, rock phosphate, potash and other critical minerals. (Klare, 2012)

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Once these “old calories” are gone (some argue in another hundred years, but realistically in much less time given the rate at which we are depleting them) we will no longer be able to “sustain” an agriculture system which is totally dependent on them. Of course, long before these “old calories” are gone, they will become prohibitively expensive. In fact, increasing costs are already affecting our food and farming system, and would likely already render it dysfunctional were it not for various subsidies. Consequently, the neo-caloric era is, essentially, already over!

Of course, as Schusky points out, it is not just the loss of the old calories, but also the social and ecological damage which this industrial economy has caused, that now renders it unsustainable. In fact the resultant damage is so extensive that it now “threatens life itself” and therefore necessitates the transition to a new “post neo-caloric” era. Included in this resulting ecological and social damage is soil loss and soil degradation, loss of biodiversity and genetic diversity, loss of fresh water, devastating climate change (which ensures more unstable climates), the loss of human capital (farmers) and the loss of community services, as well as the loss of a sustaining community culture.

As Marjory Kelly has pointed out we have now created a culture which fosters an “extractive” economy (which motivates individuals to extract as much wealth as possible for themselves out of their communities), rather than a “generative” economy (which motivates people to work toward the common “flourishing of life” within their communities). (Kelly, 2012)

It is the “loss” of all of these resources—old calories, self-renewing ecologies, flourishing communities—which were used up or destroyed by the industrial economy of the past century, that now requires the design of a new economy, and a new agriculture. Since food and water are the essentials of life, designing the new agriculture is the most urgent task before us in this new, post-neo-caloric era!

So how shall we now proceed?

First, I think it is important to recognize that, as a species, we humans do not have a compelling record demonstrating a capacity to predict the future or to foster the changes necessary to create a new future. We do, however, have a record of some civilizations which were able to anticipate the changes coming at them and getting a head start preparing for them. In fact, based on his extensive research of past civilizations, Jared Diamond concluded that the reason some civilizations in the past thrived while others collapsed was due to that capacity. Those civilizations that anticipated the changes coming at them and got a head start preparing for them tended to thrive, while those that failed in that exercise tended to collapse. (Diamond, 2005)

Consequently we would probably be wise to use less of our potency trying to get farmers and other entrepreneurs in the food industry to change, and more in helping them to anticipate the changes coming at them and how they might prepare for those changes.

So let’s imagine that 10 or 20 years from now crude oil will be $300 barrel, that we have twice the number of severe weather events, half the amount of fresh water available, and fertilizers that cost 5 times what they cost today. What kind of agriculture could we put on the landscape that would be “sustainable?”

Clearly, it would not be the high input, specialized monocultures that served us so well during the neo-caloric era! It would more likely be an agriculture that is more ecologically sound— more diverse, redundant, self-renewing and self-regulating—an agriculture, in short, that mimicked nature. (Benyus, 1997)

Fortunately, if this is the most effective way to prepare for the changes coming at us, we have a lot of resources available to us. First, there is the wisdom of the past.

We know there were many agriculturalists that were reluctant to adopt industrial agriculture when it first emerged in the early 20th century. Sir Albert Howard, Rudolph Steiner, Lady Eve Balfour, Aldo Leopold, and many others, perceived the inherent deficiencies of industrial agriculture and urged an alternative that was more consistent with nature's prototype. Sir Albert Howard, in fact, referred to the "N,P,K mentality", (as he called the industrial system) as a form of "banditry" since he saw that it would deplete the biological health of the soil which he knew would steal the inherent capacities of the soil from future generations.

So we have this wisdom from the past which we can now marry with the science of ecology and evolutionary biology to design a new agriculture for the future, an agriculture that would be much more self-renewing and self-regulating, and therefore less dependent on the "old calories" of the neo-caloric era. Some now refer to this new, emerging agriculture as a "new agrarianism."

There are, in fact, a new generation of farmers and researchers who are already anticipating the changes coming at us and exploring alternatives. The February, 2013 issue of the John Deere "The Furrow" magazine, for example, was entirely devoted to stories about farmers and soil scientists who are "building better soils." These farmers are discovering that by adopting alternative management strategies, like incorporating cover crop mixtures into their corn/soybean rotations, they can reduce fertilizer and pesticide inputs by more than 70 percent and still sustain high yields. A farmer near Bismarck, ND reported that before he introduced these new management practices his soils could only absorb "a half-inch of water per hour. Now they'll take in 8 inches." Clearly he sees this as one way to anticipate and prepare for a future with more droughts and floods. (*The Furrow*, 2013)

A team of soil scientists working with NRCS are discovering similar results working with farmers and incorporating cover crop mixtures into cropping systems. (National Soil Health and Sustainability Team, Greensboro, NC). A video featuring farmers who have made this transition can be viewed at https://www.youtube.com/watch?v=nWXCLVCJWTU&feature=player_embedded.

Matt Liebman, weed ecologist at Iowa State University, has conducted 9 years of research comparing conventional corn-soybean rotations with rotations that added a year of small grains, red clover and/or alfalfa. Compared to the conventional two-crop monocultures, the more diverse rotations greatly reduced the need for fossil fuels, chemicals and synthetic fertilizers, and maintained comparable yields and profitability. Liebman and others have also conducted research which demonstrates potential production and eco-systems benefits from other examples of incorporating diversity into production systems in the Midwest. (Liebman, 2013), (Asbjornsen, H, et. al., 2013), (Liebman, M. et. al., 2013)

There are also numerous permaculture farming operations, like Takao Furuno's in southern Japan (Furuno, 2001) and agro-forestry enterprises which show similar ecological and economic benefits. All of these alternatives are based in diversity, soil health, and biological synergies which reduce energy inputs, reduce pest pressure, and increase food production. (Perfecto, et. al. 2010)

The United Nations has also published four reports in the past five years (*Agriculture at a Crossroads, Save and Grow, Toward the Future We Want*, and *Agro-ecology and the Right to Food),* and while each of these reports feature some unique ideas, a common theme is evident. While new technologies and increased yields may play a role in solving the problem of hunger, the central issues that must be addressed are the empowerment of local, small-holder farmers practicing agro-ecological methods, food

accessibility for all, investment in agricultural knowledge adapted to local ecologies, multi-stakeholder participation, and the empowerment of women.

Perhaps the most important example of anticipating the changes coming at us and getting a head start preparing for them, is taking place in Salina, Kansas. Thirty years of research at the Land Institute is producing another option which will become available to farmers in the not too distant future—*perennial crops*! Perennial crops will save significant energy inputs. Crops only need to be planted once every 5 or 6 years instead of every year, deeper root systems help to restore the biological health of the soil, enable plants to access moisture from deeper in the soil profile, and sequester significant quantities of carbon. The combination of those benefits will go a long way toward addressing most of the challenges coming at us in the post-neo-caloric era.

These are all encouraging innovations that can serve us well in anticipating the changes coming at us and getting a head start in preparing for them. However, as Schusky and Lubchenco have both pointed out, we also have a "cultural" problem that must be addressed. The Enlightenment culture of individualism fostered the notion that humans were somehow separate from nature and that humans could (in fact "must") dominate the planet. That sense of domination, together with the industrial economy which taught us that maximum, efficient production for short term economic return was an essential economic paradigm that every farmer and food entrepreneur must incorporate into their businesses to be economically successful, has now become the predominant paradigm which is deeply entrenched in our economic culture.

However, as we have learned from the science of ecology, we are not separate from the rest of nature, and nature is not a collection of objects that we can dominate, but a dynamic community of interdependent subjects of which we are an intimate part. Consequently we are *not* the "conquerors" of the land-community; we are simply "plain members and citizens" as Aldo Leopold reminded us. Leopold was, of course, deeply troubled by the dilemma of the conflict between sound ecological stewardship of the land community and the economic pressure to use land as a commodity to achieve maximum economic returns.

Leopold finally concluded that the only way to overcome this predicament was to cultivate an "ecological conscience" which "in turn reflects a conviction of individual responsibility for the health of the land. Health is the capacity of the land for self-renewal. Conservation is our effort to understand and preserve this capacity." (Leopold, 1949)

Of course, Leopold had no magic-bullet solution for developing such a "conscience." Consequently, the need to cultivate this deeper understanding of the human/nature relationship continues to be part of our mission as we anticipate the changes coming at us.

In this regard it is inspiring to see an increasing number of a new generation of young people who seem to have overcome their "nature deficit disorder" and are now determined to "leave no child inside." (Louv, 2007) This new generation is re-connecting to nature, to soil, and to farming and increasingly they are choosing careers in farming.

In addition, another cultural transformation is underway among food customers. This transformation is gradually turning passive recipients of food, into *active food citizens*, a phenomenon that is now fostering the emergence of "food hubs." These "hubs" consist of food citizens who in their own "food sheds" are determined to develop regional food systems in which the majority of the food is produced *by* people in the hub, *for* people in the hub, and exports and imports become the second priority. This

phenomenon is gradually developing a new food culture which consists of a diversity of people, including farmers, bankers, educators, food entrepreneurs, Cooperative Extension personnel, and ordinary citizens, all devoted to creating a new food network which provides regional communities with healthy, affordable, nutritious food for all in the community. These new food hubs have the potential to significantly reduce energy inputs, restore ecological and human health as well as the pleasure of good eating, all of which can serve to enhance the flourishing of life.

Together, these various innovations can be the beginnings of the potential to create the new food system that will be essential in our new world.

Of course, the big elephant in the room is climate change. We need to scale up all of these ecologically sound systems before "biospheric entropy" changes our world in ways that question the survival of the human species. (Wessels, 2006)

So, how can our Land Grant Universities play a more significant role in anticipating the changes coming at us and getting a head start in preparing for those changes, especially with respect to food and agriculture?

First, LGU's can play a role in shaping the alternative science that Lubchenco alluded to. As Liebman, Perfecto and others have acknowledged, much of our science today is devoted exclusively to intensifying our current technologically-driven, energy intensive agriculture. Meanwhile, it may well be the science of ecology and evolutionary biology that is more relevant to designing the resilient systems that will be essential in our future. It would seem wise, therefore, to devote at least some of our limited resources to the application of these post-enlightenment sciences to agriculture.

Joe Lewis and his colleagues with the USDA ARS provided us with a poignant example of this shift in the use of science with respect to pest management. In a game-changing article which they published in the *National Academy of Sciences Proceedings*, they articulated exactly the kind of new "contract" with science that Lubchenco alluded to. (Lewis, et. al. 1977)

After a half century of attempting to solve pest problems in agricultural production, using intensive technological methods, (which they referred to as "single tactic, therapeutic intervention") they acknowledged that such methods were "not sustainable." Using such methods one never gets rid of all of the target pests, thereby unintentionally evolving pest resistance. Furthermore, with such single tactic interventions one never *only* destroys populations of the target pest, but also *other* biological organisms, some of which previously served as predators, consequently causing pest resurgence. As a result Lewis and his colleagues suggested a transformation in the way we use science—shifting from "single tactic, therapeutic intervention" to "natural systems management." Instead of asking "how do I get rid of the pest" science should ask "why is the pest a pest?" Such a shift would lead science to use its knowledge to understand what causes pests to emerge and how to manage natural systems to reduce such emergence, rather than developing technologies in a futile attempt to eliminate pests. Such a shift would lead to the development of a science that cooperates with nature rather than the failed attempt to dominate nature.

A second, related shift that our LGU research and extension scientists might consider is to devote more of their resources to restoring soil health instead of intensifying technologies to substitute for healthy soil. As pointed out above this effort is already underway by the Natural Resources Conservation Service, working with some farmers and the results are now even featured in magazines like John Deere *The Furrow*. Given the early demonstrated results; reducing energy, fertilizer and pesticide inputs;

decreasing nutrient leaching; increasing carbon sequestration, and water absorption and storage capacity, while maintaining good yields. It would seem that a decision to redirect at least 30 or 40% of our research efforts in our LGU's to strategies that enhance soil health, would be a wise investment and make a significant contribution toward preparing for the changes coming at us.

A comparable shift in resources toward restoring biological and genetic diversity could make similar contributions. As demonstrated above, the research featuring the addition of perennial legumes, weaving in strips of prairie vegetation, and growing prairie vegetation, has potential to significantly increase biological diversity. As the authors of these studies acknowledge, "Politically such a move may be difficult. Ecologically, we feel it is necessary to insure that agroecosystems are both agronomically and environmentally sustainable." (Liebman et. al. 2013)

One might add that as part of anticipating the changes coming at us and getting a head start preparing for them, such efforts to increase biological diversity might be both economically and ecologically necessary! As the Prince of Wales recently pointed out, "Biodiversity is absolutely crucial. You cannot simplify Nature's system and expect it to carry on operating in the way it did before. There is nothing in Nature's elaborate system which is not necessary, to take one participant out of the dance leads to the dance breaking down and, sooner or later, this will have a serious impact on the state of human health. (Juniper, T. 2013) This will be especially true in our post neo-caloric era.

Similar efforts are underway in a few of our LGU's to enhance heirloom varieties of grain and horticulture crops to improve food quality. Some LGU's are even cooperating with farmers to form farmer seed breeding clubs to help farmers produce seeds that are more adapted to their local ecologies. Often these ventures create interesting collaborations among farmers, researchers, chefs and other entrepreneurs. Encouraging such collaborations might be another initiative our LGU's could consider.

A fourth role that our LGU's could play in helping farmers and others anticipate the changes coming at us might be to reinvent the Cooperative Extension Service.(CES) It seems almost self-evident that as the many "old calories" which sustained the "neo-caloric era" get used up we will need to shift from a technologically driven food system to a knowledge intensive system. Engaging "the people" to provide them with the knowledge necessary to achieve their goals in food production and preparation was part of the original vision of the CES. Now that we will be transitioning to a more knowledge intensive food production system, such services will become more critical than ever before.

Unfortunately, as our food system has become more technologically driven, and more of the technologies have been developed by the private sector, the private sector has assumed the task of conveying the results of its research to the public, causing the CES to increasingly be regarded as irrelevant.

This is extremely unfortunate because as we enter the post-neo-caloric era it is evident that the CES will have a more important role to play than at any time in its history, namely leading the knowledge-intensive transformation of our food system. Preparing the CES to assume these critical new responsibilities is something our LGU's could do now to help farmers and others in our food system prepare for the changes coming at us and getting a head start. Providing farmers with the knowledge to restore the health of their soils and the biological and genetic diversity of their farms is but one example of the immediate need to assume the responsibility and opportunity of this new knowledge intensive CES.

Finally, our LGU's could begin to engage entrepreneurs in the private food and agriculture business sectors to begin preparing for the changes coming at them. A good example of how to begin such preparations can be found in a recent article by Michael Porter and Mark Kramer. (Porter et.al. 2011)

Porter and Kramer remind us that given the new future we are entering, businesses, (if they want to be successful), have to significantly change their business strategies. "The traditional playbook calls for companies to commoditize and exert maximum bargaining power on suppliers to drive down prices . . . more recently, firms have been rapidly outsourcing to suppliers in lower-range locations." "Today some companies are beginning to understand that marginalized suppliers cannot remain productive or sustain, much less improve their quality."

They go on to point out that this business transformation is about more than wealth redistribution— "fair trade is mostly about redistribution . . . shared value focuses on improving growing techniques and strengthening the local cluster of supporting suppliers and other institutions to increase farmers' . . . sustainability." They also point out that the traditional playbook which tends to externalize environmental and social costs will also no longer work, since our social and natural capital is now so compromised that such externalized costs will soon come back to haunt the business that externalized them.

These are but a few of the new directions that our LGU's might consider in helping us prepare for the changes coming at us.

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