The Oil Drum
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The Food System and Resilience

Posted by Jason Bradford on January 26, 2010 - 10:10am
Topic: Environment/Sustainability
Tags: agriculture [list all tags]

Note: This is my second post based on a portion of my presentations at the recent Association for the Study of Peak Oil conference in Denver. The first post is here. Go to the ASPO web site for the complete slide deck. Readers may also appreciate this article by Stoneleigh for more theoretical background.

> Ecosystem resilience is the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes. A resilient ecosystem can withstand shocks and rebuild itself when necessary.
> *Resilience Alliance*

For something as critical as food, it is common sense that society should design for resilience. Reliability in food production in the face of change requires a system capable of rapid evolution. Resilience is therefore a core principle of sustainability. Unfortunately, our daily bread relies on a food system that is not resilient. As I have explained before, this state of affairs is an outcome of government policies, financial pressures, cheap fossil fuels, and market forces in play over the past several decades. The result is a food system dominated by relatively few large actors, which creates conditions of rigidity and brittleness. This post is a brief review of:

- the basic science of resilience,
- how our current food system lacks a resilient structure, and
- an overview of what a more resilient food system would be like

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Food Webs

Resilience is a concept from the science of ecology. Ecologists study what are called food webs, which are feeding relationships among populations. A simple food web might be a plant eaten by a browsing animal, which is eaten by predator. When animals die a scavenger eats those bodies. And the poop is eaten by microbes that make the nutrients available to the plants again.

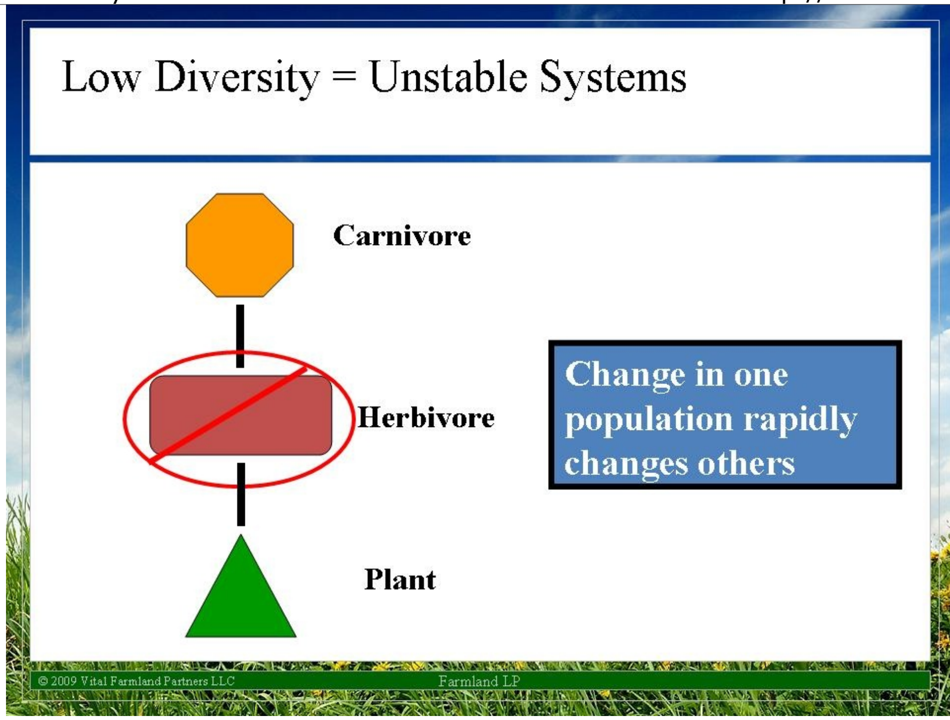
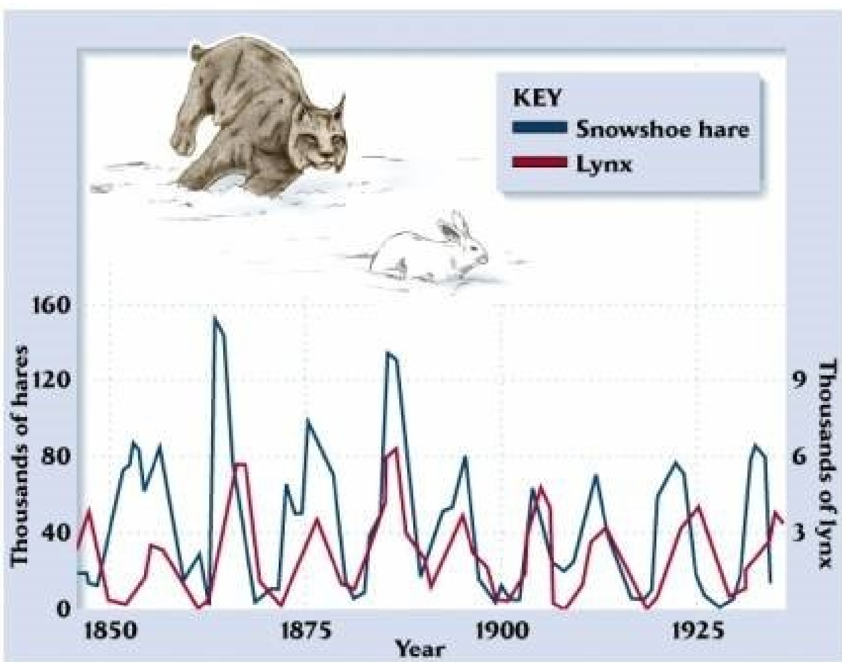


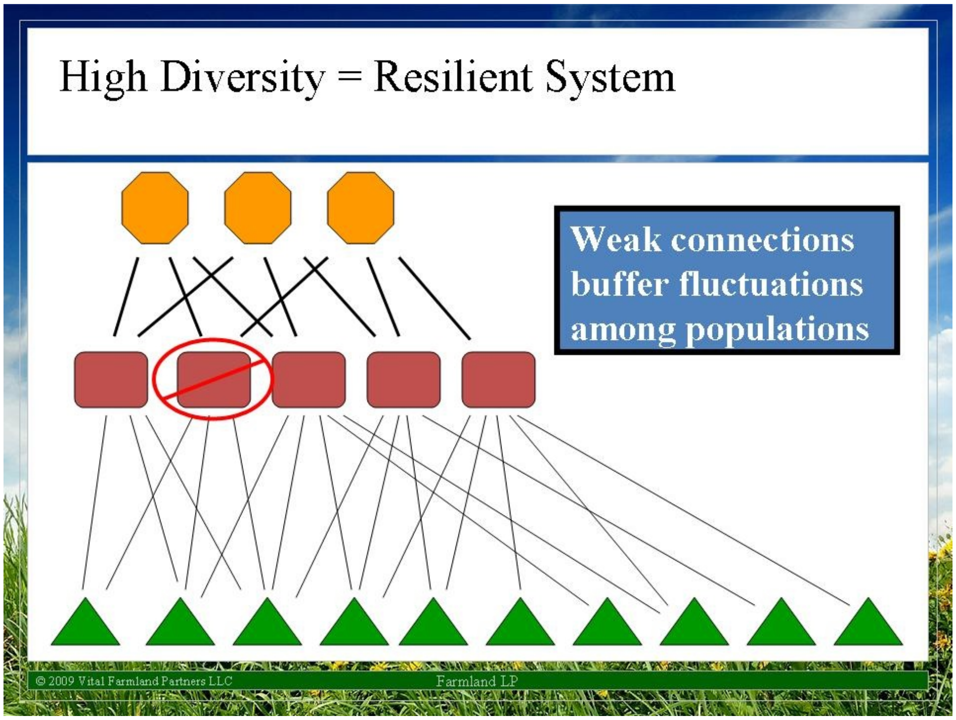
Diagram of a simple food web with lines indicated feeding relationships among populations of plants, herbivores and carnivores. A low diversity food web has strong connectivity between parts. Therefore, the loss of one part (as shown by the red cross mark through the herbivore) has big effects on other parts of the food web.

Ecologists have found some important relationships between food web structures and their properties. When food webs are very simple, meaning they have few parts that are connected to each other in straightforward ways, the system often shows unstable dynamics, such as widely fluctuating population sizes. It is easy to see how this happens. If a predator is dependent upon one prey, a decline in that prey will starve the predators.



An early and classic study of a low diversity food web. With only a few, strong connections, volatile dynamics result.

By contrast, diverse food webs have many parts, and often the relationships among parts are weak and not so simple. For example, instead of a few plant species there are many, and there are several herbivores that have a choice of feeding on different plants. The same is true all the way up the food chain, with predators being able to feed on a variety of prey. More diverse systems are more stable because if any particular plant or animal population goes into decline, feeding relationships are plastic and can adjust so that the loss of one part doesn't cause havoc with others.



High diversity food webs have weaker connectivity among parts and therefore built in redundancy. This permits parts to adjust to losses, effectively buffering against volatility.

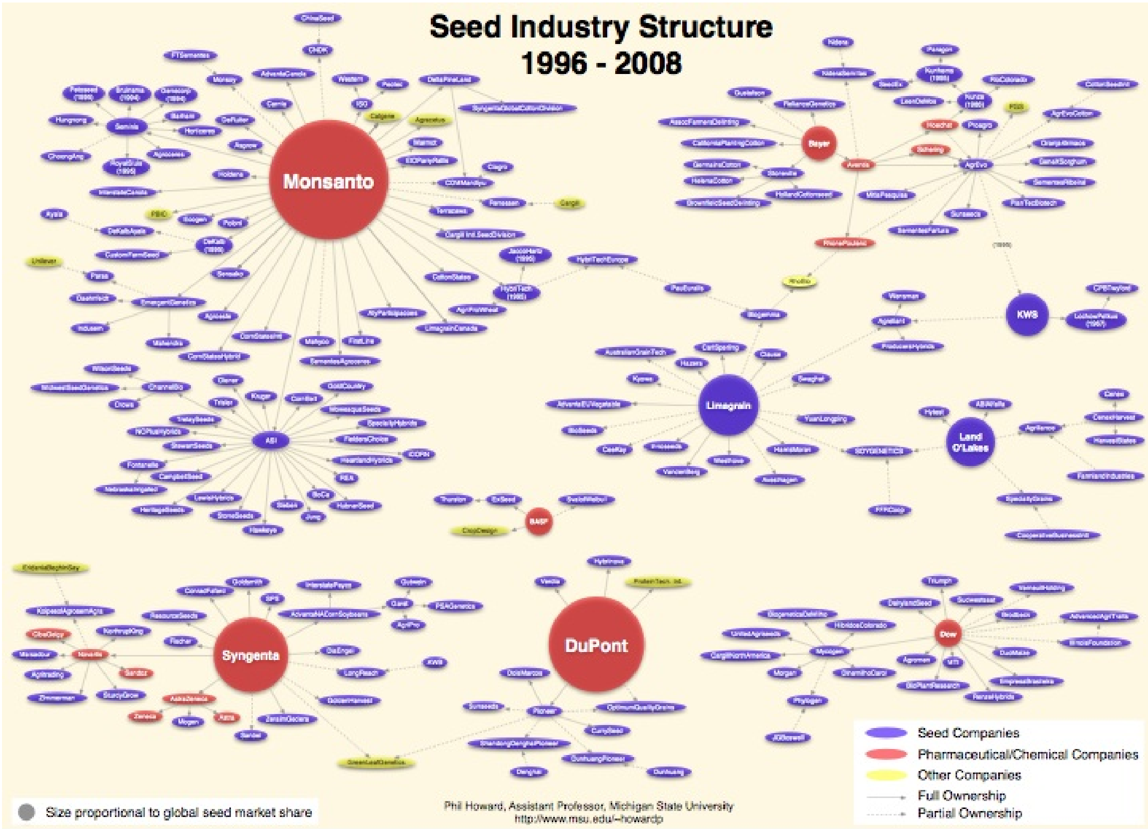
The Low Diversity Food System

Farms in the U.S. have become highly specialized to produce a narrow range of products. In the Midwest, for example, corn and soy dominate. In the Willamette Valley of Oregon, grass seed is king.

Crop	Acreage (million)	% Acres
Soybean	77.5	24%
Corn	87.0	27%
Wheat	63.1	20%
Total U.S.	320.9 million	

In 2009, 71% of U.S. cropland consisted of just three species (source USDA).

Low diversity at the farm level is magnified by low diversity all along the input and supply chains. Because of consolidation, few seed companies remain. And when it comes to getting paid after harvest, there are fewer buyers for farm commodities, and fewer distributors and retailers too. Few parts with strong connections among them preconditions the system for high volatility.



Seed industry consolidation 1996-2008 from Phil Howard of Michigan State University. Reaction to this issue via antitrust litigation is now occurring.

A Context for the Future

The fundamental emergent properties and core functions of a resilient system remain stable even as rapid change is occurring, whether from external forces or the ebb and flow of individuals and populations that make up an ecosystem. For the food system this means being able to produce, store and distribute food even when critical conditions alter dramatically, such as a credit crisis, energy shortfalls, or extremes in weather. Cheap transportation fuels have obviously been key in the development of our current food system, which emphasizes producing crops with high regional comparative advantages in yields, labor, or mechanization, and exporting them.

If we foresee a future with continued and possibly greater economic, resource and environmental volatility, then reconfiguring the food system for resilience is a smart strategy. Principles for doing so can be found by studying the structure of ecosystems.

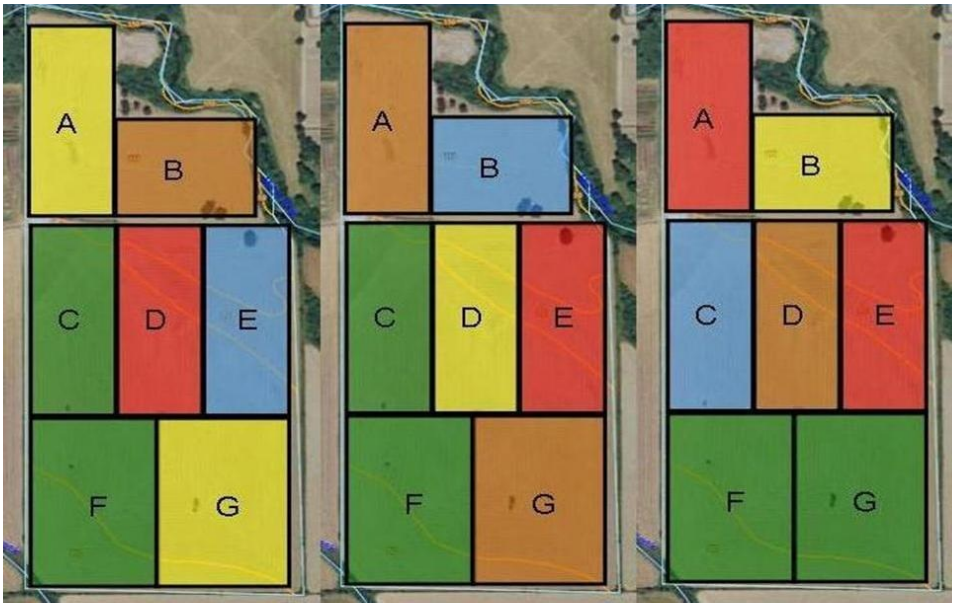
The Resilient Farm Strategy

> Natural systems are inherently resilient but just as their capacity to cope with disturbance can be degraded, so can it be enhanced. The key to resilience in social-ecological systems is diversity. Biodiversity plays a crucial role by providing functional redundancy. For example, in a grassland ecosystem, several different species will

commonly perform nitrogen fixation, but each species may respond differently to climatic events, thus ensuring that even though some species may be lost, the process of nitrogen fixation within the grassland ecosystem will continue. Resilience Alliance

A resilient farm has diversified operations to buffer against volatility. The benefits of diversity accrue in many ways.

Organic and especially agroecological farms are less dependent upon outside inputs that can change in price rapidly and unpredictably. Crop rotation plans include many species of plants and animals that are complementary in functions, such as legumes fixing nitrogen, grasses building soil carbon, and animal manures making nutrients more readily available to plants. Instead of buying mechanized services or fertility inputs, the farm integrates the functional diversity of life to create synergies.



A farm layout and field rotation pattern based on agroecological principles. Colors represent different classes of production: green is pasture, brown is legumes, yellow is grains, red is cover crop, and blue is other seed crop. Each image shows a different year of land-use.

Inherent diversity means no single crop failure will ruin the farm, and soil imbalances are prevented. The focus is on soil health, with all fields going through periods of planting in perennial and deeply rooted species to build soil organic matter and mobilize minerals such as phosphorus from deep layers. Fungi associating with roots locate source rock and solubilize minerals that are trans-located to leaves. Topsoil fertility is therefore built from below.

Plant breeder Wes Jackson of the Land Institute (right) compares the root system of wheat (left) with that of a perennial wheat under development (right).

Landscape structure is created to provide habitat for native and naturalized species that participate positively in the farm food web, such as pollinators and predators. No need to buy pesticides when raptors have homes in the trees, predatory wasps have nectar sources, frogs can breed in clean water, and ground beetles have zones of refuge from tillage, for example.

While the emphasis is on letting the biology do the work, renewable energy infrastructure also creates resilience. Farms are often ideal places for wind and solar technologies, and on-farm biofuels are likely to have positive energy returns.

Operations and Structure	Conventional Farm	Sustainable Farm
Fertility	Buy tons of compost or inorganic NPK products	Use nitrogen fixing cover crops, compost animal bedding, and recycle local organic waste
Seeds	Buy commercially developed and patented seeds	Select open pollinated seeds and save those that perform best, buy from regional seed developers when necessary
Energy	Buy liquid fuels and electricity for equipment to perform tasks	Whenever possible let biological processes do necessary work, seek local renewable energy options otherwise
Managing biodiversity	Buy chemicals to combat unwanted organisms	Focus on the health of the soil and the appropriate soil biology to grow healthy crops. Know weed and pest biology well enough to keep them in check through smart management of the whole farm. Create habitats for beneficials along field edges.
Landscape diversity	Low, usually specializing in one class of food, e.g., grains, dairy, vegetables	High, usually adapting production to the landscape and rotating crops as needed.
Distribution	National to global via commodity markets	Local to regional via fair trade and direct to consumer channels

The many differences between conventional and sustainable farming systems are compared.

Food System Resilience

Most farms in the U.S. operate for purposes of exchange, not self-reliance. A resilient farm therefore needs to consider how it connects to the rest of the economy. Do farms have few or multiple choices in the sources of seeds, fertilizers and other inputs? Do these inputs come from far away mines and seed companies, or from local businesses? Are farmers beholden to a dominant buyer or do many potential buyers exist for their products?

To have a resilient food system the associative farm economy needs diversity too. Since this is typically not the case anymore, transforming the food system, both on and off farm, takes time, coordination among actors, patient financial investment, and the ability to adapt.

Different economic arrangements are competitive at different periods of history. I believe we are entering a time when the diminishing returns on previous investments will open up opportunities for new actors. Because of economic volatility, what works going forward will be different than what worked in the past. This is an age of great innovation where agroecological farming and local food system development will emerge as a natural and smart response to pressures of resource depletion, protection and enhancement of natural capital, and financial and job insecurity.

What will this new food system look like? It will be organized akin to an ecosystem, or food web. Farms and renewable energy infrastructure occupy the level of primary producers, with businesses acting as conduits for feeding omnivorous humans. In contrast to our current food system, which is linear in structure, the future food system will cycle nutrients back to the farm. This structural constraint will mean that much more food is grown for local populations.

Nutrients will still leak from landscapes, and so maintaining long-term fertility will require replacing what is lost. In forests of the Pacific Northwest, salmon migrations brought the mineral wealth of the ocean back to the land. Restoring migratory fish habitat therefore aligns with the needs of agriculture. Harvesting of kelp deposits on beaches and salt deposits from tidal zones and transporting them inland is another viable means of supporting the mineral richness in soils.

Bernie Winters of Clare Island, Ireland, harvests kelp from rocky beaches to remineralize the soils on his farm.

I hope this post has clearly framed the issue of food system resilience and the general principles involved. Many examples exist that align with the goals of resilience, including novel distribution systems, farmer training programs, and specialists on soil restoration. Please share other examples you know of, and discuss aspects of the challenges involved in more detail.