Illustrations and Challenges of Progress Toward Sustainability in the Northland Sheep Dairy Experience

Karl North, September 2008

"The separation of cropping and grazing has probably been the single most expensive decision modern Western man has made." – Allan Nation, editor, *The Stockman Grassfarmer*, June 2008.

The primary focus of this paper will be an attempt to justify the above statement by bringing to bear principles of sustainability, historical research and our experience of 25 years in sustainable design at Northland Sheep Dairy. Rather than an exhaustive thesis this will be a short essay that aims to provoke thought.

The paper will first provide my theoretical perspective, then look at influential historical models that embody this view, and finally explain the design and dynamics of the farm as they reflect the theoretical assumptions and historical models.

As I see it, a useful point of departure for thinking about the design of a sustainable agroecosystem is the question: how can it support the food and fiber needs of a given human population without exceeding its carrying capacity (CC).

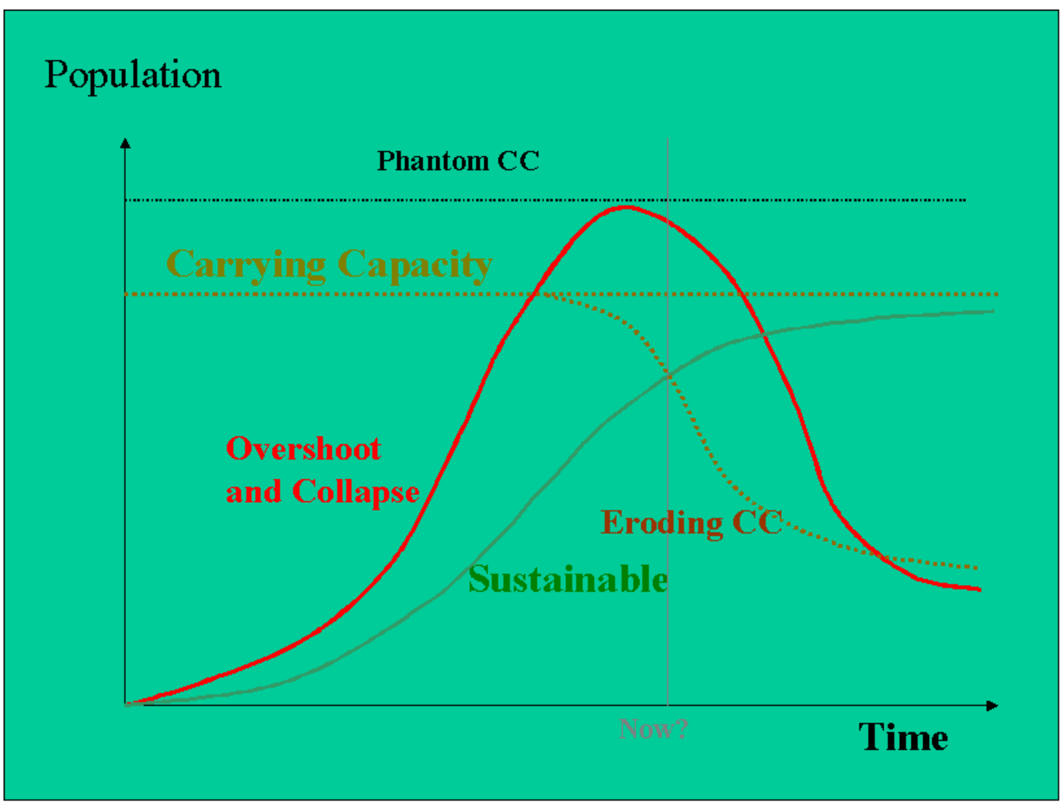


Figure 1

A working definition of CC might be: *the maximum indefinitely supportable ecological load*. For our purposes the load would be the human population at a specified quality of life that we want a farm or food system to support. A complex concept, the CC of a specific farm or regional landscape at a given historical moment can be far below its potential, as is true of much of the agricultural resource base whose CC industrial agriculture has eroded. On the other hand, human intervention can often rebuild CC and even improve it somewhat by making the ecosystem more efficient in the way its ecological services improve farm production. Also, "needs of a given human population" is a slippery term whose definition varies widely from one culture to another. Still, sustainable design to respect carrying capacity has effectively focused attention on the long-term health of four interrelated ecosystem processes:

1. The mineral or nutrient cycle
2. The water cycle
3. The energy flow
4. The dynamics of the biological community

This in turn has led to the development of principles or attributes of sustainable design to maintain the health of these ecosystem processes. Some of the widely accepted principles and their implications are:

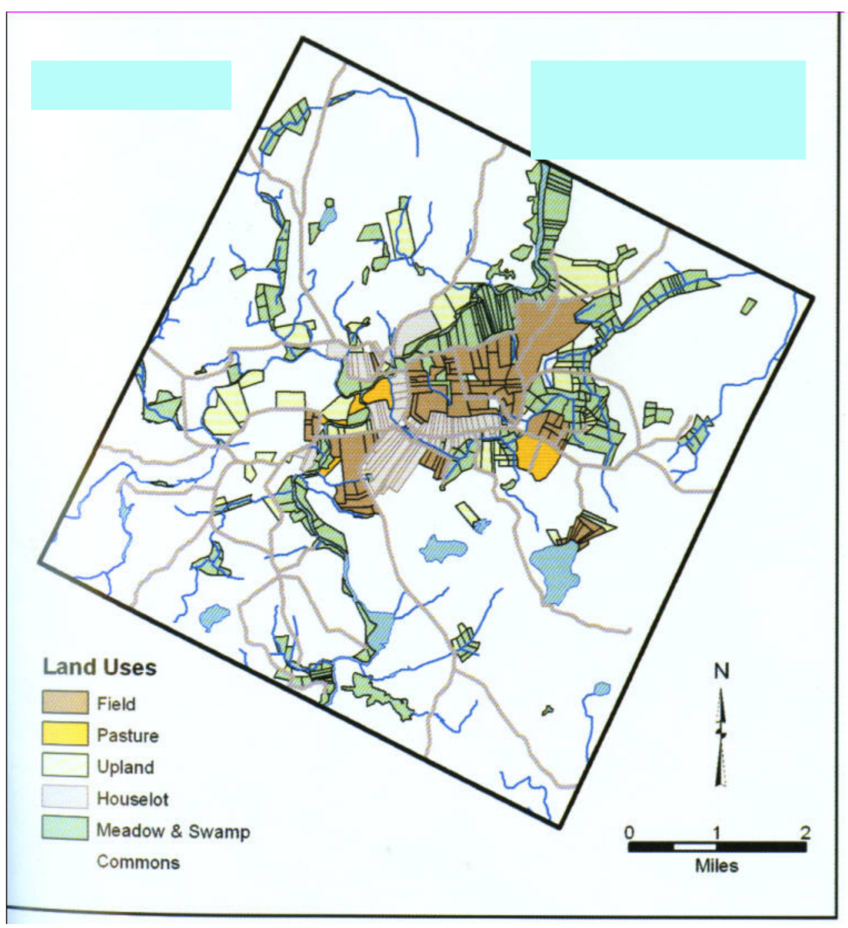
- Low external inputs - input self-sufficiency
- Low emissions - closed nutrient cycles
- Knowledge intensive - biodiversity that captures synergies, biologically controls pests
- Management intensive - labor intensive but other-resource efficient, to optimize sustainable yield: productivity/acre
- Local food self-sufficiency and national food sovereignty

Although sustainability is not only about energy, it is largely about energy, for the availability of that input governs access to most other agricultural inputs to which modern agriculture has become accustomed. Systems ecologist William Catton (1980) coined the term *phantom carrying capacity* nearly thirty years ago to characterize the temporarily high CC born of reliance on fossil fuels and other nonrenewable resources, and renewables consumed at above sustained yield rates. He said that phantom CC has allowed untenable levels of human population, and for some populations, unsustainable levels of material quality of life that he called The Age of Extravagance. Since Catton wrote, support for his claims increased slowly, and has now built into a flood (Kunstler, 2005. Heinberg, 2006). Unrelenting rising resource costs in recent decades suggest that resource use rates have bumped the ceiling of phantom CC, and quality of life is already being forced down as Catton predicted by eroding real CC, as in Figure 1. Moreover, research into the prospects of cheaply replacing much current energy consumption in the US with renewables at a societal scale reveals many obstacles, at least in the coming two or three decades. This perspective has led us to operate on the conservative assumption that the era of cheap energy may be permanently over. Consequently in this essay our first design goal for sustainable agroecosystems will be to aim toward zero energy and other external inputs, because this will frame the issues and limit the choices for the rest of the design effort.

Perhaps this is a good place to anchor the abstract concept of carrying capacity and its short-lived phantom decades to some indications of real world consequences: chickens coming home to roost in the present world of agriculture. Crop farms, including organic, are now seeing the *acceleration* of a decades-long rise in the cost of the external inputs that have artificially propped their productivity in the cheap energy era. The same is true of the great majority of livestock farms, especially those that rely on concentrate feeding, including organic farms. These are just two of many indications that suggest the validity of Allan Nation's assertion and recommend that we think seriously of repairing the divorce of cropping and grazing in modern agriculture (including most organic farms).

Learning to live off the sun in real time

Where should we look for models of sustainable agroecosystems? Reasonably, we could first look for historical models before the last two hundred years of cheap, concentrated energy, Catton's Age of Extravagance. A recent history of world agriculture (Mazoyer, 2006) conveniently approaches the subject as a history of agricultural *systems* and their milestone advances in productivity. A dynamic systems approach is essential to sustainable farm design because of the need to think about interdependencies of components at different spatial and time scales in the attempt to answer questions of sustainability like: How long can this configuration endure? How well can it adapt to changes in the environment? How resilient will it be to sudden shocks?



In many parts of the world traditional models of agriculture that integrated crops and livestock to various degrees have endured for many centuries in a range of climates. For our purposes, a most interesting improvement on these models developed in areas of Europe that have a cool, wet climate comparable to our situation in the Northeastern US. In their last agricultural revolution before the industrial age lowland European farmers created a model of animal/crop integrated farming that supported new levels of human population density. A fallow rotation had been necessary to renew fertility and supported a few livestock. The revolution consisted of intensive production of perennial and annual forage species for ruminants on the fallow rotation, which in turn allowed higher stocking rates, more barnyard manure, better utilization of pasture manure, and higher fertility and production on the whole farm. Enduring examples in other parts of the world of this increasingly tight integration between cultivation and animal breeding, using different configurations of plants and animals, underscore its advantages, which in the best cases use animals as multi-purpose tools to produce labor, fertility and food.

As early as 1650, colonists in New England had adapted animal integrated systems developed in lowland England (Donahue 2004). In colonial Concord, land use *policy* supported the needs of an integrated system (Figure 2). Riverine flood plain was a swamp commons mostly reserved for pasture and hay as it dried out during the growing season. Adjacent fertile land was allocated for cropping, but became a grazing commons after harvest. Upland was multi-purpose, with the higher land maintained in forest. As in parts of Europe, well-watered riverine meadows produced enough livestock feed, livestock, and manure to sustain the fertility of land in tillage.

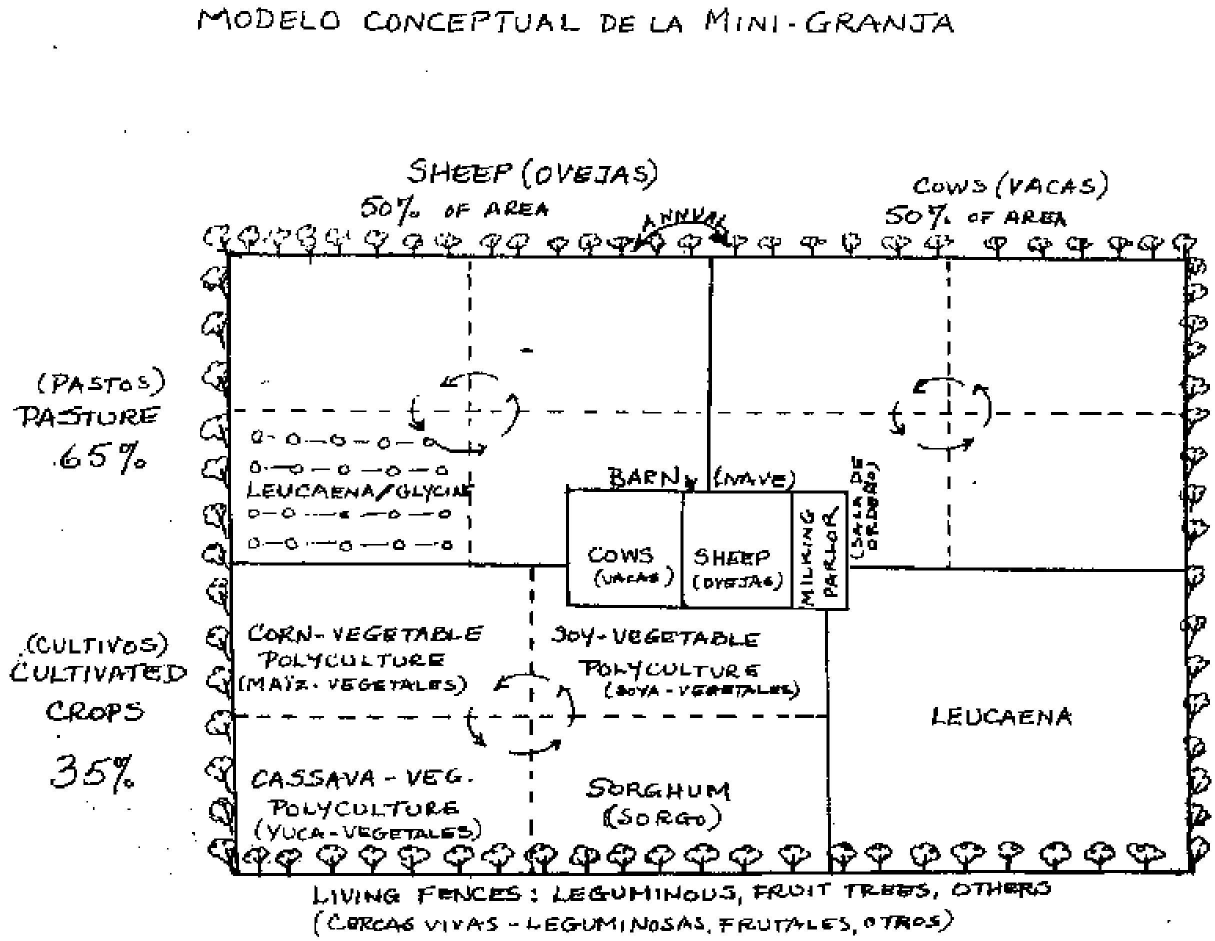
The next major revolution for our purposes was first documented in detail by the French farmer/scientist, André Voisin (1959). High organic matter soils are central to achieving healthy water and mineral cycles, and soils in humid temperate regions are exceptional in their ability to store organic matter and accumulate it over a period of years. Voisin's book *Grass Productivity* demonstrated fifty years ago that *pulsed grazing (see inset)* on permanent pasture is the fastest soil organic matter building tool that farmers have, at least in temperate climates.

Based on Voisin's methods, so-called 'rotational grazing' methods have spread among farmers in the US organic farming movement, but few have grasped the importance of Voisin's work to make intensively managed grazing the driving core of a crop/livestock agroecosystem that is highly productive with minimal external inputs. A notable exception is the group of Cuban agroecologists who came to the rescue of Cuban agriculture in 1989 when it lost access to the imports that its essentially high-input agriculture required. Building on Voisin's thesis, their research showed that a system with roughly 3 acres of intensively managed forage land

> Pulsed Grazing ***is a method of repeated grazing of paddocks in a pasture that controls stock density and timing of stock movement in and out of paddocks to maximize forage production over the growing season. This in turn maximizes manure production to build soil organic matter. Forage plants experience repeated pulses of growth and removal of biomass, both above and below ground, over the growing season.*** *Key points :*
>
> - ***Stock enter a paddock before forage growth proceeds from its vegetative stage to seed production, after which growth slows and leaf quality diminishes.***
> - ***Stock leave a paddock while there is still sufficient forage leaf area to jump-start regrowth.***
> - ***Grazing causes forage roots to die back, which adds soil organic matter from the dead root mass.***
> - ***Stock return to the same paddock when leaf and root regrowth have fully recovered vigor and abiity to recover from another grazing.***

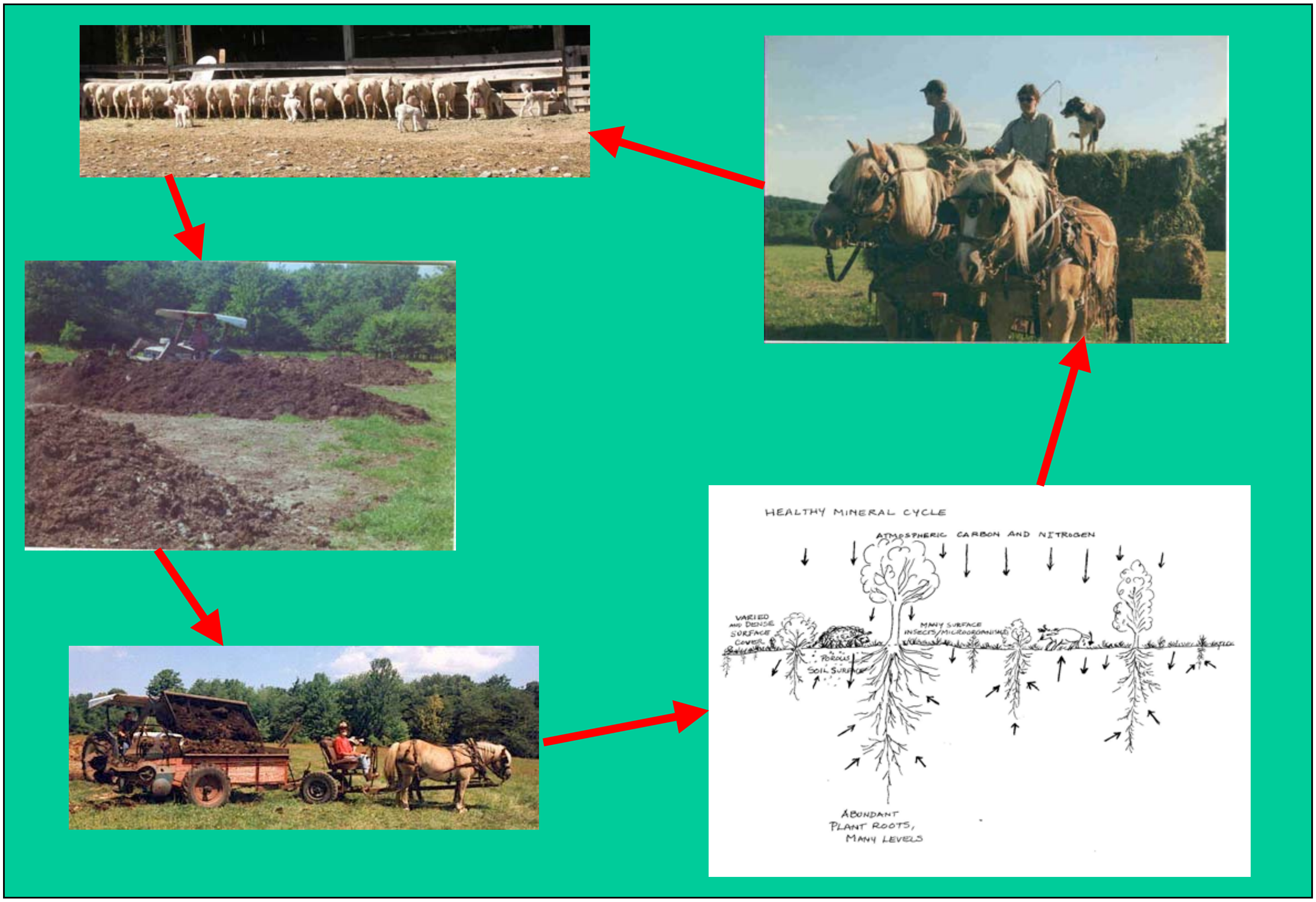
will both sustain itself in fertility and provide a *surplus* of fertility via vermicomposted manure to sustain roughly 1 acre of cultivated crops. Figure 3 shows a conceptual model that we developed with Cuban scientists to improve their original cow-based system by including multi-species grazing. The idea was to create a self-sufficient core system that would support a variety of subsidiary crop and animal production.

Figure 3



Designing a sustainable dairy

Like the Cubans, at Northland Sheep Dairy we have based our thinking on Voisin's research and tried to design our whole agroecosystem to adapt and improve on the natural grass-ruminant ecosystems that helped create the deep topsoils of Midwestern North America. Details of our design appear in earlier publications, but in summary the design focus is on three areas that are crucial to manage to maximize tight nutrient cycling (simplified in Figure 4):



- Pasture management for a wide variety of productive, palatable perennial forages, kept in a vegetative state via pulsed grazing throughout the growing season to maximize biomass production;
- Manure storage in a deep litter bedding pack under cover during the cold season to maximize nutrient retention and livestock health;
- Vermi-composting the bedding pack at a proper C/N (carbon/nitrogen) ratio during the warm season to maximize organic matter production, nutrient stabilization and retention, and spreading the compost during the warm season as well, to maximize efficient nutrient recycling to the soil.

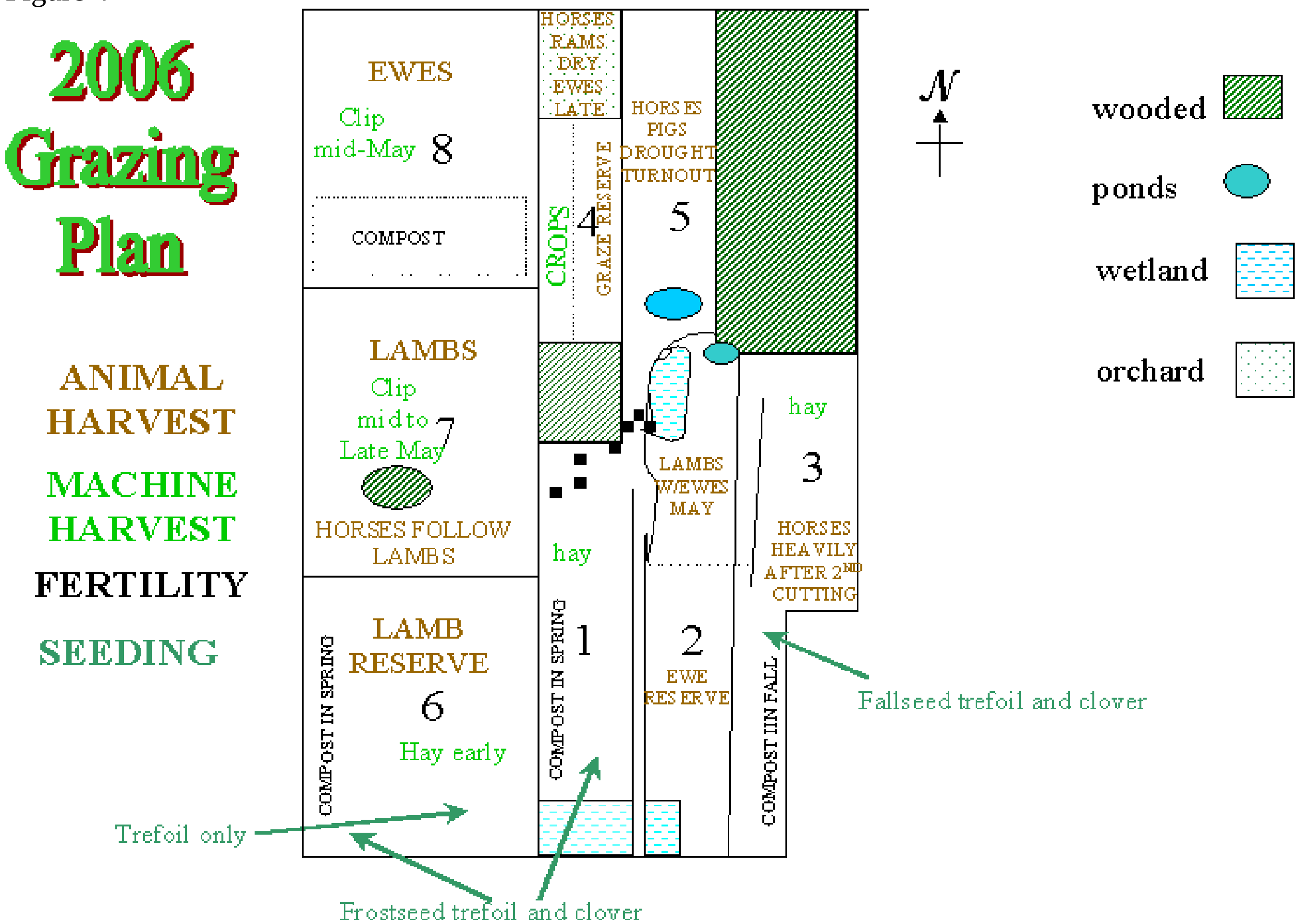
This design is working well on our farm and confirms Voisin’s thesis: in a few years forage production tripled and soil organic matter is slowly improving. The weakest link in the mineral cycle at this point is the losses to leaching in our wet climate.

Our solution was to design a sylvo-pastoral model for the Northeast (North, 2008): forage fields that will incorporate enough trees and other deep rooted plants to partially patch the leaching leak in the mineral cycle, still serve the other functions of the field (high quality hay and intensively managed pasture), and even capture synergies (shade, nitrogen, forage diversification) to make the system more productive and healthy than forest and pasture separately. We have seen such systems working well in Cuba, for orchard or timber production in pastures surrounded as well by live legume fence posts coppiced for forage. We can take our cue from the Cuban model, but we must solve problems of adaptation from the tropics to the temperate climate of the Northeast.

Our overall design goal for the farm is to maximize productivity while respecting ecological imperatives by making the biological and physical resources of the farm serve multiple functions, as they often do in unmanaged ecosystems that self-organized in the course of natural history. In this effort we look for opportunities for symbiosis, to capture synergies.

Like the historical models already evoked, we make significant use of draft animal power, which presents new opportunities to use animals as tools to provide ecological services. Our horses and mules add to the fertilizer production of the sheep flock, and used in multi-species grazing they allow more efficient use of pasture and better parasite control: they complement the sheep with different grazing habits, and their different internal parasites diminish the effective pasture parasite load for the sheep.

Figure 4



Our farmscape planning is complex (Figure 4): we plan annual rotations of sheep, lamb, and draft animal groups, machine forage harvesting, compost and other fertility amendments, and forage reseeding, over the farmscape.

Challenges of building a sustainable system

At this time, because most of our vermicompost goes to regenerate the forage land, the farm barely produces a surplus of fertility for gardens and orchard crops for our own use. Physical limitations of the site currently prevent the grazing subsystem from supporting more cultivated cropland, and a higher CC, as the Cuban model suggests is possible. A permanent limitation is our shallow soil, with its characteristic poor drainage and slow growth in the Spring and droughty period in midsummer. Our soil-building program will alleviate this problem somewhat but will take several decades, starting as it did with soil impoverished from previous farming.

Also, like virtually all farmers in the organic movement, we are stuck in a luxury model of sustainability, for economic reasons mostly beyond our individual control. Due to competition in a market economy that was politically constructed to reward profit maximization regardless of ecological and social costs, farms that actually bear some of these costs suffer relatively in net income, and competitively against the artificially cheap agricultural production that this political economy has spawned. So our farm income presently does not allow the ongoing investments needed to make up for the farm's physical limitations and replace existing unsustainable external inputs with inputs derived from the farm's own resource base.

Despite our investment in two ponds, the farm needs infrastructure that would achieve its water capture potential, a healthier water cycle, and consequent higher productivity and CC. The farm soil still needs significant regular external inputs of calcium and phosphorus, partly to make up for initial deficiencies, partly to offset leaks in the nutrient cycling that have yet to be closed, principally due to leaching, as we have described, and partly because the soil biological activity has yet to reach its full potential to unlock nutrients. While we have built effective passive solar farmhouses, even the lowest technology to realize the solar energy potential of the farm (small-scale solar and wind power, biogas) is unaffordable at present farm income levels.

Neither does the present food economy reward the much higher labor costs of a truly sustainable system (see Richard Heinberg's "fifty million farmers"). That system would require higher agrobiodiversity (to provide ecological services now covered by external inputs), higher enterprise and product diversity that can be supported as the organic matter surplus from the grazing subsystem improves, and more on-farm or at least local processing and retailing.

In sum, the devious notion of 'economic sustainability', which farmers can supposedly achieve in a political economy designed to externalize social and ecological costs, is only possible in a fundamentally restructured economy. Farmers must make a living in order to continue to farm and fill the food needs of society. In present circumstances they can do that only by disobeying many of the ecological and social imperatives that are the foundation of a sustainable human society.

References

Catton, William R. Jr. 1980. *Overshoot: The Ecological Basis of Revolutionary Change*. University of Illinois, Urbana. Illini Books Edition, 1982.

Donahue Brian. 2004. *The Great Meadow: Farmers and the Land in Colonial Concord,* New Haven.

Heinberg, Richard. 2006. Fifty Million Farmers. *Energy Bulletin, November 17, 2006.* http://www.energybulletin.net/node/22584

Kunstler, James Howard. 2005. *The Long Emergency*. Atlantic Monthly Press.

Mazoyer, Marcel, and Lawrence Roudart. 2006. *A History of World Agriculture: from the Neolithic age to the current crisis*. Monthly Review Press, New York.

North, Karl. 2008. Optimizing Nutrient Cycles with Trees in Pasture Fields. *LEISA Magazine, 24 (2), March 2008.*

Voisin, André. 1959. *Grass Productivity*. Philosophical Library, New York. Island Press Edtition, 1988.