Toward sustainability: monitoring farm progress

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Northland Sheep Dairy is a small grass-based dairy farm currently supporting a flock of fifty dairy ewes, their lambs, and four draught horses on relatively poor upland soils in New York hill country U.S.A. Its commercial products are cheese, meat, sheepskins, yarn and knitwear, and occasionally apple cider. We have been managing the farm since 1985, and during its development we have become interested in how to measure our progress towards sustainability.

Many different tools are currently being developed for measuring sustainability. One of the most interesting of these tools is the one using web graphs for visually summarising sustainability patterns. These graphs are multi-dimensional, containing as many axes as there are sustainability indicators that the farmer thinks are important to measure (Figure 1). This technique was found being used in Cuba, trying to capture the dynamics of progress toward sustainability in farms redesigned to be integrated agroecosystems. The case presented by Fernando Funes and Marta Monzote in LEISA Magazine (vol. 18-2), for example, included indicators such as milk production (measured in tons/ha) or wildlife diversity (in total number of species). Their idea was to capture an easily read visual measure of the overall progress of a system with a small number of variables. These variables are usually defined so that a move along an axis away from the centre indicates progress in that indicator. In this way, an increase in the area of the web indicates overall progress.

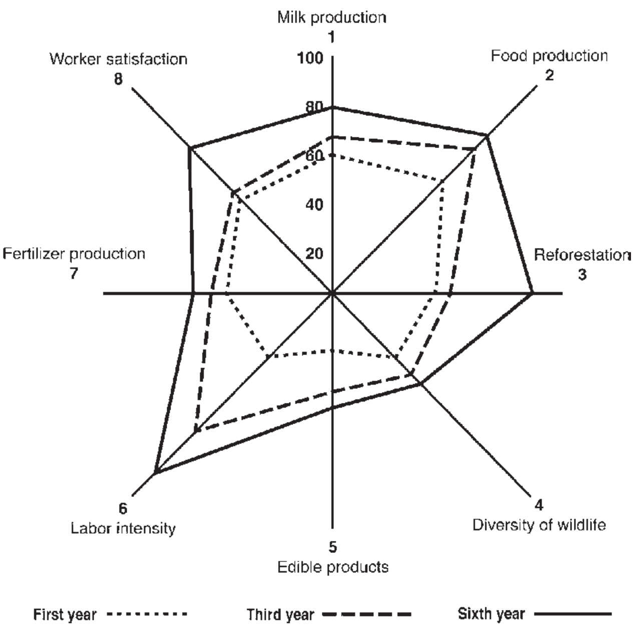

Figure 1: Web graph of progress in sustainability on a Cuban farm.

These graphs can be based on a rough set of estimates, easily sketched at any given moment. Indicators are measured with a 1-100 scale on each axis, an approach that enables qualitative measures like "farmer satisfaction" to be included. The Cuban graph, although derived from absolute numbers and careful calculation, shows a common scale for all indicators, and is thus more reader-friendly.

This tool forces a number of management issues out into the open. First, it shows whole system progress/regress over time, something crucial to understanding how systems work. The web graph forces us to see and think about the changing relationship of all indicators, and is a reminder that all these variables *are* interdependent. It also shows how important it is to consider what to measure, and through which units. The indicators the Cubans chose, for example, reflect a particular approach to input self sufficiency, considering energy efficiency and disregarding monetary profit.

A web graph for our farm

Trying to apply the same technique, we soon realized that there is an almost limitless number of things you could use to measure sustainability. We began by listing more than twenty indicators, including references to soil organic matter production, soil fertility, plant diversity, cheese and lamb production, financial profit, animal diversity, and reforestation. To make a representative graph we tried mixing and matching several indicators at a time, considering how they relate to each other, how they reflect other measures that could be left out, and most important, how they demonstrate what we feel are the most important aspects of sustainability for our operation. By a process of trial and error we gradually came up with indicators we thought fitted our farm and goals very well.

1. Farm productivity. Farm income is often used to represent productivity, but we wanted to avoid this as our farm income comes from an economy that does not reward sustainability, and therefore puts prices on our products that may be different from how useful they are. Our farm plan compensates this with off-farm income, low inputs, efforts at labour efficiency and value-added products. Since cheese is our most important product, we settled on pounds of cheese/acre as a convenient indicator for productivity.

2. Sheep health. Next we considered animal health: if it can be maintained or improved while reducing medical intervention, excessive labor, and expensive inputs, we are achieving some measure of sustainability. Animal health also directly reflects our efforts to build soil fertility and forage diversity because our livestock are almost totally dependent on our own forage. We chose the percentage of ewes and rams without health problems in a given year as a measure of sheep health.

3. Lamb growth. Since in our sheep dairy we wean lambs to pasture at 3-4 weeks, we have managed to grow only a portion of the lamb crop to market weight in a single season. The rest are sold as feeder lambs, at considerable economic loss. Lamb growth is important to overall farm productivity. In addition, we thought lamb growth, measured by percent of lambs reaching market weight in one season, would combine a number of other sustainability concerns, including control of farm internal parasite populations, ewe fertility and mothering ability, pasture health and forage nutritional quality.

4. Input self-sufficiency. We express this with an indicator that shows progress in reducing the major purchased inputs: hay, custom hay work, medical expenses, seed, livestock feed supplements, maintenance, and fertilizer. Despite our concerns with the use of market values, we decided to gauge input self-sufficiency by net income achieved as a percentage of gross income. In so doing we are also tracking an important indicator of profitability.

Table 1. Units, scale, and progress in sustainability indicator.

	Indicator	Units	raw scale	relative scale	% 1992	% 1996	% 2002
1.	Farm productivity	lb. of cheese/acre	0-50	0-100	62	70	48
2.	Sheep health	% without health problems	0-100	0-100	79	78	94
3.	Lamb Growth	% reaching market weight (70 lb)	0-100	0-100	40	19	23
4.	Input self-sufficiency	$ net income as % of gross income	0-100	0-100	28	42	36
5.	Fertilizer production	Spreader loads of compost/acre	0-15	0-100	16	20	17
6.	Energy self-sufficiency	Animal traction hrs as % of energy $ spent	0-50	0-100	26	14	10
7.	Labor efficiency	hours/day/acre of land under management	0.48-0.12	0-100	63	83	98
8.	Worker satisfaction	% of quality of life values satisfied	0-100	0-100	60	65	70

5. Fertilizer production. We agree with the Cuban view that to make farming sustainable we must maximize on-farm fertilizer production. We decided to indicate this separately from overall input self-sufficiency because of its importance. Our unit of measure is spreader loads of compost per acre, as a percentage of the fertilization rate we estimate we need to maintain our soil at its maximum fertility potential.

6. Energy self-sufficiency. Here again we created a separate indicator because energy drives all activity and is of paramount importance. While the ratio of calories produced to calories consumed in farm production seemed good, we chose a simpler, although less accurate indicator: hours of animal traction used as a percentage of dollars of energy purchased. For now we are rather arbitrarily setting the ideal benchmark at 100 percent. Despite the lack of dimensional equivalence we think this adequately tracks our efforts toward energy self-sufficiency in the near future, hoping to develop a more accurate measure later.

7. Labour efficiency. While a sustainable management of biological systems commonly requires more labour than when following industry-based methods, we can lessen and perhaps even overcome these losses in labour efficiency by finding sustainable ways to put nature to work. We can monitor this fairly easily by tracking changes in the hours worked/day/acre, estimating an ideal total. An upper benchmark of 0.12 hours/day/acre was found considering that 2 people should be able to run our 100 acre farm working 6 hours a day each. Since these two people cannot work more than 48 hours/day, we set the lower benchmark at 0.48.

8. Worker satisfaction. The survival of agriculture requires an adequate quality of life for the farmers, but worker satisfaction is perhaps impossible to quantify. We measured it by estimating how well our farming activities satisfy quality of life values in our holistic goal, and representing that on the web graph as a percent of 100 percent satisfaction.

into account the averages over several years. On the other hand, the decrease in lamb growth over ten years accurately reflected a gradual increase in the sheep parasite populations on the farm. This came from a tactical decision that has kept us in business since 1985: our wish to maximize dairy production, our main income source, even when it is much more difficult to implement our parasite control plan with a sheep stocking rate that is too high.

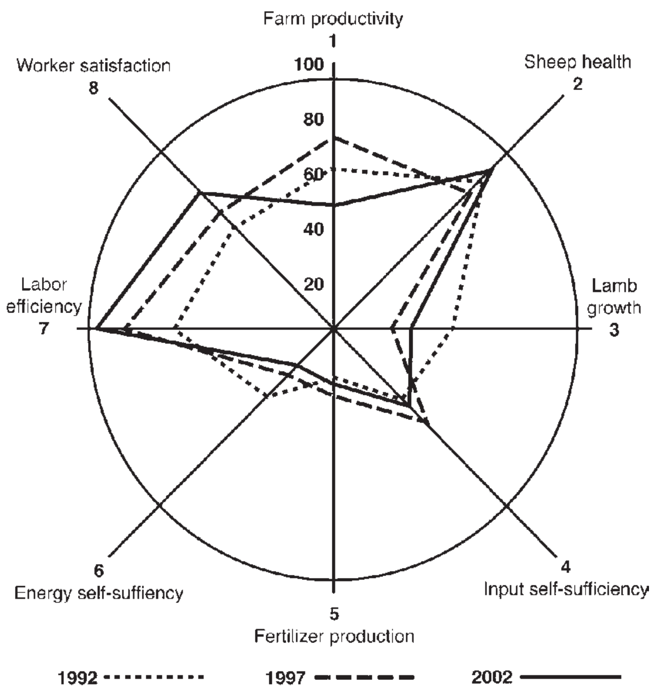

Figure 2: Web graph of progress in sustainability on Northland Sheep Dairy.

These indicators, even if their units of measurement are quite basic, they nevertheless serve the function intended: to show rough trends in the variables and even patterns of interdependency that stimulate better management. Table 1 shows the measurement units for each indicator, the upper and lower limits in the units shown, how the raw data relates to the 0-100 scale, and the percent of the ideal achieved in the years 1992, 1997, and 2002. This is all summarised in Figure 2.

Sustainability at Northland Sheep Dairy

Our web graph failed to show the steady outward progress toward sustainability which was clearly visible in the Cuban example. This had different explanations. Some of our indicators, like sheep health and lamb growth, are sensitive to annual changes in weather and other factors, so general trends should better take

But there are more general reasons for the variations found over the years. Our land had not been productive for decades, after many previous decades of extractive agricultural practices. We were practically beginning farming there, while there were no models of milking sheep for us to follow in this country. We often undertook farming practices that were risky because they had been rarely tried in the region, or because they might build a sustainable system in the long run, even if it meant slow progress in the first few years.

Even so, the graph shows some progress on many indicators from 1992 to 1997. A later decrease in certain indicators is due to our decision to use the same indicators for 2002, when we began to rent land that almost doubled our total farmland. The data for 2002 shows that indicators behave differently when measured on a per acre basis. The increase in the land base throws farm productivity and fertilizer production, both measured per acre, into regression, at least temporarily. Measuring these variables another way might still show progress, for in absolute terms we are still increasing both. By measuring them per acre we remind ourselves of the challenge of achieving both the sustainable production potential on the new acreage, and a restoration of its ecological capital, which we had already partially attained on the original property.

At the same time, labour efficiency, also measured on a per acre basis, increased in 2002 almost to the ideal, because we worked twice as much land with only a little more labour than before. The challenge revealed here is to maintain this somewhat artificial labour efficiency as we build production to its full potential on the new land. Can we design management practices that save labour or add labour-saving devices without losing ground in other indicators like input self-sufficiency? This indicator lost ground in 2002 as we began to invest in the new acreage in ways that will yield results only in the long term.

Our indicator of energy self-sufficiency, hours of animal traction as a percentage of purchased energy inputs, shows a steady drop over the time period of the web graph. By measuring only animal traction among farm-generated energy products, we give a deceptively low value to this indicator, although by original design the farm was remarkably energy efficient in comparison to most farms. Nevertheless, this indicator accurately portrays a failure to compensate for rising energy prices with increases in farm energy production.

Finally, worker satisfaction, though improving slightly, still measures far below the ideal, despite high quality of life on the farm. This is due to the holistic nature of the indicator, reflecting not just what happens in the minimum whole that we can control, but the state of the nation and other larger wholes as well, reflecting our understanding of the ultimate interdependence of all these. In our estimation, the state of the nation and the world became a lot worse over the ten year time period, offsetting high and increasing quality of life on the farm.

Benefits to farm management

The simple decision to use a sustainability monitoring tool helped us plan our activities, aiming at making progress in the indicators we chose for the initial model of the web graph. Over the years, our farm saw some changes as a result of our reflections. The inclusion of an indicator for on-farm fertilizer production, for example, sharpened our focus on making compost. We now add sawdust bedding in the horse barn to improve the quality of the compost end product by increasing the carbon component. This will not only add more carbon to the soil, but also improve the retention of nutrients in the composting process. Although it is an input to the farm, sawdust is a plentiful and cheap by-product of the local lumber industry.

Similarly, we have several plans for progress toward farm energy independence that came from thinking about that indicator. We are gradually shifting from draught horses to mules because mules do more work per unit of feed. We are planning large and small-scale use of wind power to generate electricity (10 kW) and to pump water from ponds. We dug a second pond to collect surface water for gravity feed provision to livestock, and to minimize deep well pumping. On a smaller scale, we plan to collect rainwater to irrigate some of the greenhouses and gardens. A cheese cave currently in construction will reduce our electricity use for refrigeration. We are considering an ice house and a smoke house to further reduce reliance on energy inputs.

Reflections on how to maintain and build soil fertility without increasing inputs led to a project to plant trees in forage fields. In the long run we hope their deep roots will recapture soil nutrients that currently leach below root levels of our forage species. So far we have planted honey locust (*Gleditsia triacanthos*), a legume tree that should also increase nitrogen fixation. We are doing trials to discover the tree spacing and density that will allow machine harvest of forage to continue and provide shade for livestock, but spread the manure from resting livestock widely around the field. We are considering coppicing the trees to keep some of their vegetation within reach of the livestock for feed.

A final change in farm management since we began using the web graph addresses the indicators of livestock health and productivity. We now use the Famacha eyelid indicator more than fecal analysis to get better measurement of sheep parasite loads. And since the addition of rented land we can keep the parasite-vulnerable lambs on worm-free pasture from birth to market.

Conclusions

Despite increasing attention, a survey of the literature on sustainability assessment suggests that this topic is still in its infancy. Our attempts to create a tool are also not finished, so we have therefore not made quantitative measurements of the effects of the changes described above to add a new web to the graph, preferring to rethink what indicators work best and what measurement units could be better suited.

The area of sustainable social relations may be where the web graph needs the most revision. We need a more comprehensive measure of social health than worker satisfaction. We believe that building and maintaining social capital is important to sustainability. For example, we need a local community of neighbours who will eat our products without the shipping and packaging that we do now. Proper indicators must measure not only the health and welfare of people on the farm and their relations, but also the strength of the farm's relations to the surrounding community and the health of its social and economic order.

Graphic display of changes in important sustainability indicators on a single page reveals not only progress/regress in the whole, but also some of the dynamics of interdependence in the variables. In this way it helps us to make decisions that benefit the whole, rather than some parts to the detriment of others. Accurately quantified web graphs are a way for scientists who take a systems approach to evaluate on-farm research experiments over time. Used in a simplified, rough-and-ready fashion, they can help farmers think more holistically in their management, as we have tried to show in a first attempt of a web graph of progress toward sustainability at Northland Sheep Dairy.

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