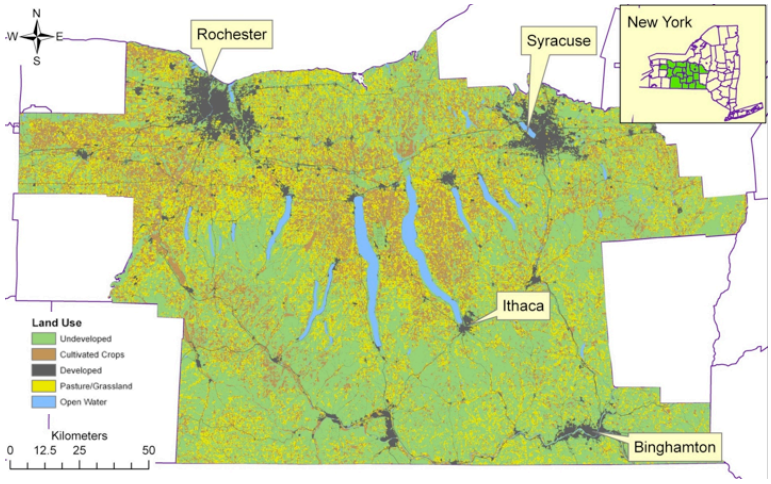
Toward the Selection and Measurement of Indicators of Local Food System Performance and/or Ecoagriculture Landscape Performance in the Finger Lakes Region of NYS

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Cornell University
Ithaca, NY
May 2009

Contents

0. **Introduction** 3

1. **Spatial Analysis: Land Use-Land Change,** Courtney Wallace 4

2. **Soil Organic Matter and Active Carbon,** Sam Bosco 11

3. **Conservation Agriculture and Water Quality,** Chris Bentley 21

4. **Farming Practices as Indicators,** Kelley McCrudden 26

5. **Community Supported Agriculture,** Natalie Thomson 37

References 46

0. Introduction

The Finger Lakes Ecoagriculture Working Group is currently exploring whether a food system in the Finger Lakes is helping to stimulate the development of an ecoagriculture landscape. As the first step to developing a case study on local food systems and ecoagriculure in this region, we are currently engaged in a multidisciplinary search for indicators. Through this exercise we hope to uncover synergistic relationships between the two frameworks—local food systems and ecoagriculture. In addition to heterogeneous indicators, we are interested in integrative indicators that may be developed and tracked to provide concrete evidence, cost-effectively, for how a local food system and an ecoagriculture landscape are co-performing. The ultimate goal is to bring additional understanding to the challenges of developing integrated approaches to securing food supplies in an ecologically sound and socially just way, and to use such insight to drive policy and motivate further research.

We framed our exploration of indicators around the Landscape Measures Framework for Understanding Ecoagriculture (Buck, et al., 2007) and the online Landscape Measures Resource Center (LMRC), http://landscapemeasures.org. Our search for viable indicators falls within five categories: 1) Land use-land cover change, 2) soil health, 3) conservation agriculture and water quality, 4) farming practices, and community supported agriculture. We discuss each in turn, below.

1. Spatial Analysis: Land Use-Land Change, Courtney Wallace

According to the Landscape Measures Resource Center (LMRC) "as the proportions of land uses change over time—natural habitat, agriculture, human settlement in rural and urban areas, and others—so, too, will the potential to conserve wildlife, maintain ecosystem services, and produce agricultural goods." Therefore, a major aspect of our analysis is to observe changes in landscape pattern. Land use and land cover (LULC) is a key integrative indicator, telling us about layout of natural resources, agricultural and industrial activities, residential and commercial development, and other landscape features. Comparison of LULC information between years, too, can be particularly useful in identifying trends.

The objective of this portion of our exercise is to quantify recent changes in LULC, and this analysis has two main components: First, maps of Tompkins County were sourced from CUGIR and manipulated through GIS software to suit our needs. The most useful data came from 1995 and 2007, thus these are the years we compare in our analysis. While the data for Tompkins County are highly useful, this is not the case for the adjacent counties and therefore only Tompkins County is used in the present analysis.

Second, we measure changes in economic values of agricultural land uses and practices. Using data gathered from the Bureau of Economic Analysis' Regional Economic Accounts, we compare Tompkins County in 1997 and 2006 (the years closest to our maps that have useable data) in order to more fully describe the landscape.

Selecting Indicators

Four LMRC criteria were chosen to frame the LULC indicator. The first three pertain to the mapping exercise while the last one is associated with the economic portion:

1. Criterion C5: natural areas and aquatic resources are not degraded by productive areas and activities (conservation criterion).

   Productive agricultural areas have a tendency to leak soil, chemicals, weedy plants, and foraging livestock into nearby non-farmed areas and waterways

2. Criterion P4: production practices have a neutral or positive impact on wild biodiversity and ecosystem services in the landscape (production criterion).

   By emphasizing the use of biological inputs, crop rotations, soil cover, and diverse assemblages of plants, while limiting chemical inputs, and also by strategically locating production systems in the landscape, habitat values can be conserved and ecosystem service delivery can be enhanced.

3. Criterion P5: species and varietal *diversity* of crops, livestock, fisheries and forests is adequate and maintained (production criterion).

   Agrobiodiversity is conserved globally, but is managed locally to enhance and sustain agricultural production.

4. Criterion P2: production systems are financially viable and can adapt to changes in input and output markets.

   Financially viable production systems imply that there are positive returns to producers.

   Indicator 1: net profit

   Examples of Measurement Units: net income per ha per head of livestock, net income per unit of labor

   Indicator 2: adaptability to market changes

   Examples of Measurement Units: number of sources of income, % of income from internal vs. external sources

Measurement Plan for the Indicators Selected

For the mapping exercise, the unit of analysis is land use-land cover. Our sampling strategy is to use the maps with the most useable data that already exist: Tompkins County, 1995 and 2007. Using ArcGIS and Excel software, we spatially illustrate the area and generate statistics. The first set of maps produced will portray general LULC, with the following classification: agriculture, barren or disturbed, commercial, inactive agriculture, industrial, public/institutional, recreation, residential, transportation, vegetative cover, water, wetlands. The second set of maps will portray a further breakdown of agricultural LULC, with the following classification: cropland, cattle, horse farm, fishery, high intensity cropland, inactive, orchards, pasture, tree farm, vineyards, other farm. We hope, if new information becomes available or we have the capacity to generate new information ourselves, to develop new raster layers (for example, the area of sustainable vineyards and/or orchards).

For the economic exercise, the two units of analysis are net profit and adaptability to market changes. Net profit is measured, for example, by net income per hectare per head of livestock, or net income per unit of labor. Adaptability to market changes may be measured by the number of sources of income and/or percent of income from internal (farm) versus external (government subsidies, off-farm work) sources. The years 1997 and

2006 are compared to highlight trends, and, because of the constraints of the mapping exercise, data is only pulled from Tompkins County. However, useable economic data are available for the counties of interest adjacent to Tompkins (Broome, Cayuga, Schuyler, Seneca) and a logical extension of the economic exercise is to compare Tompkins to the other counties. The tool of this exercise is Microsoft Excel, used to record data and generate statistics.

Results

Landscape pattern analysis has two components: 1) landscape composition, and 2) landscape structure. The maps produced, and the statistics thusly generated, will provide information on both of these aspects.

Landscape composition describes "what is happening" in the landscape.[1] That is, how much area there is of each category of the classification (agriculture, wetlands, developed, etc.). By comparing landscape composition between years, we can begin to understand general landscape dynamics as well as identify more specific LULC changes. For example, we might observe that there is an overall increase in residential area as well as an increase in vineyards, but an overall decrease in agricultural area that could be partially explained by an increase in inactive agriculture.

One method of recording information is to use a matrix that plots LULC against the chosen criteria. Below is one depiction of such a matrix, where the areas of particular interest are emboldened.

The second component, landscape structure, tells us about the size, shape, number, and position of LULC elements and other features. In other words, measures of landscape structure quantify the spatial relationship among the composition features in the landscape.[2] Proximity, connectivity, and graininess are important characteristics to observe. For example, do wetlands buffer agricultural areas? Are forest areas fragmented or connected in greenways? Are agricultural areas "mosaic" in nature, with many different uses, or a monocrop culture? What do these structural relationships imply? Using these examples respectively, how are those agricultural areas managed for runoff into wetlands? Are these greenways useable for migrating megafauna? How important are the ecosystem services provided by one agricultural use to an adjacent?

Matrix to collect information of LULC related to the selected criteria

		C5	P4	P5
	AREA	*eco-friendly farming*	*eco-friendly farming*	*biodiversity*
LAND USE				% of TOTAL AREA
Agricultural				
orchard				
sustainable				
vineyards				
sustainable				
commodity crops				
sustainable				
Conservation				
Wetlands				
Developed				
high density				
low density				
Forest				
Transition				
TOTAL				

Following are charts and brief discussions that describe percent change in LULC—general and then agricultural—as an example of a helpful statistic generated by this analysis. After the maps were manipulated to serve our purposes (that is, LULC was generalized from the very specific classification that CUGIR used), ariel data were collected from each year, charted in Excel, and the following equation used to calculate percent change for LUCL between the years:

$$\% \text{ change} = (2007 \% \text{ area} - 1995 \% \text{ area}) / (1995 \% \text{ area})$$

From this data, we see that the largest decrease is in barren/disturbed and inactive agriculture, and the largest increase is in commercial and residential. From here, we might progress, then, to an investigation of development pressures and the policy or tax environment. We would also want to know by what is the barren/disturbed land and

inactive agriculture being replaced. Similarly, we would want to understand what types of LULC are being replaced by commercial and residential development.

General LU	% of Total_07	% of Total_95	% change
Agriculture	21.1	24.3	-13.2
Barren or Disturbed	0.2	0.4	-34.8
Commercial	0.5	0.4	28.6
Inactive Agriculture	4.4	6.1	-27.6
Industrial	0.5	0.5	3.0
Public/Institutional	0.6	0.6	0.3
Recreation	0.8	0.7	13.2
Residential	8.2	6.8	19.7
Transportation/Transmission	0.3	0.2	6.3
Vegetative Cover	56.7	53.5	5.9
Water	3.5	3.4	2.5
Wetlands	3.2	3.0	7.1
	100.0	100.0	

Understanding patterns of land conversion is essential to describing whether the landscape is moving towards ecoagriculture as well as being critical to policy analysis.

Ag LULC	% of Total 07	% of Total 95	% change
Cropland	55.6	57.8	-3.7
Cattle	15.3	18.1	-15.5
Horse Farm	0.5	0.5	8.1
Fishery	0.7	0.6	22.6
High intensity cropland/horticulture	0.3	0.3	15.5
Inactive	11.8	9.9	18.3
Orchards	0.5	0.4	26.8
Pasture	12.9	10.7	20.9
Tree Farm	0.1	0.1	43.8
Vineyards	1.2	0.7	75.4
Other farm	1.1	1.1	1.7
	100.0	100.0	

From these data, we see that the largest decrease is in cattle farming, although it is a small decrease. The largest increases are in vineyards, tree farms, and orchards, though several of the other types are increasing as well. In general, then, we might say that overall agricultural land is decreasing in area (garnered from previous table) but that the composition of the agricultural land is changing. The progression from here might be to delve deeper into the composition of the vineyards—how many hectares are sustainable?

What are these vineyards replacing? A 75% increase is dramatic, and the trends of this industry might mirror the trends of agriculture as a whole (e.g., organic) so this sector could prove cost-effective to study.

Similarly, following is an example to illustrate how the economic data might be used:

Types/categories of Ag/farms	**1997**	**2006**	**difference**	**% change**
Cash receipts from marketing	51689	56785	5096	9.9
Other income	1936	3077	1141	58.9
Production expenses	49373	59305	9932	20.1
Value of inventory change	(L)	591	n/a	n/a
Derivation of farm labor and proprietors' income				
Total cash receipts and other income	53625	59862	6237	11.6
less: Total production expenses	49373	59305	9932	20.1
Realized net income	4252	557	-3695	-86.9
plus: Value of inventory change	(L)	591	n/a	n/a
Total net income including corporate farms	4212	1148	-3064	-72.7
less: Net income of corporate farms	90	176	86	95.6
Total net farm proprietors' income	4122	972	-3150	-76.4
plus: Farm wages and perquisites	6788	6896	108	1.6
plus: Farm supplements to wages and salaries	1220	1256	36	3.0
Total farm labor and proprietors' income	12130	9124	-3006	-24.8

(L) Less than $50,000, but the estimates for this item are included in the totals.

Among these data, the amount of "other income" might be particularly useful to examine when measuring the adaptability to market changes. We can see that this source of external funding has increased, perhaps telling us about the amount of government support or, on the other hand, suggesting that it has become increasingly necessary for farmers to supplement their own income by, for example, working part-time in town. Likewise, it is interesting to note that though cash receipts and income have increased, production expenses have increased even more—has the price of production gone up or have the traditional, less-expensive practices been replaced by more expensive practices (that are more sustainable? because of new laws or regulations?)? Economic data can begin a story that is rich and telling, and help us to determine the ecoagriculture-ness of the Finger Lakes food system.

Conclusions

In the results section, I outlined some of the ways this analysis would be useful, lent examples of the kind of information that tracking these indicators might provide, and briefly presented what this insight might lead to as a next step in the analysis. However, perhaps the richest knowledge will be gained when all indicators of the larger Finger Lakes case study are woven together. For example, information about farming practices together with LULC spatial information allows us to more fully understand who is doing what and where.

That the analysis I have presented in this paper is highly meaningful is evident, but so too is it highly feasible and cost-effective. Data are, for the most part, freely accessible through CUGIR and BEA, and though ArcGIS requires special knowledge, there are many practitioners and students available who are capable of doing the kind of work I propose. Perhaps the most difficult task is to procure new data to develop new raster layers for the maps. Areal information on sustainable viticulture, one could argue, is essential to track because of the increasing importance of winemaking on the region's landscape pattern and economy.

Tracking changes in landscape pattern is a crucial component of the broader analysis. Highly meaningful, cost-effective, and generating rich insight, LULC is an important integrative indicator that can provide concrete evidence for how a local food system and an ecoagriculture landscape are co-performing in the Finger Lakes.

2. Soil Organic Matter and Active Carbon, Sam Bosco

Introduction

The purpose of this protocol is to provide guidance in how to identify, measure, track and interpret indicators that can provide useful information about a landscape where goals for sustainable food production, ecosystem health and service delivery, and livelihood security are being pursued. The underlying thesis is that certain measurable aspects of the economy and environment are particularly useful in shedding light on the behavior of people, the flow of goods and services, and the integrity of ecosystems and managed environments in complex landscapes. Certain indicators can be selected, measured, and tracked over time and analyzed in concert to determine whether or not, or to what degree, an 'ecoagriculture' landscape is `moving in the right direction' (Buck et al, 2007). The example used in the protocol is in the Finger Lakes region of New York State, however it can be adapted and applied in any region where agriculture is practiced.

Soil Organic Matter (SOM) and Active Carbon (AC) are two particularly useful indicators to monitor. This protocol establishes the importance of soil carbon in ecoagriculture landscapes, describes how to establish a 'baseline' for the region by measuring the parameters in a variety of agricultural systems as well as natural habitats, and how to track changes in soil carbon in relation to management. The area of interest is the entire Finger Lakes region, however due to cost and resource constraints, pilot studies and proof-of-concept work will be carried out in the area immediately surrounding Ithaca, NY.

Selecting Indicators

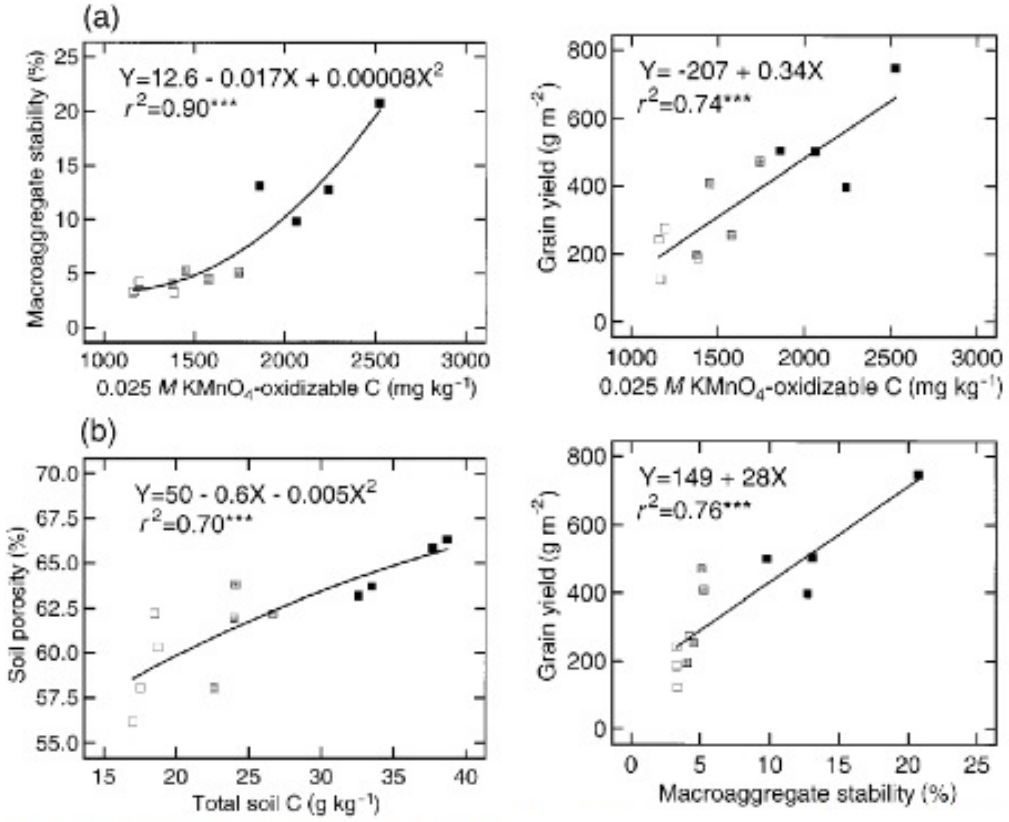
Since soils are continuous bodies, an ecosystem set within a mineral material, their integrity and health mainly reflect what is done to them. Economies affect soil through management. Thus, in an agricultural setting, soil based indicators could lend information about the state of farming, and how sustainable it is.

Because crop production can be viewed as a modified or managed soil ecosystem, it is helpful to use what is known about improving soil ecosystem services in an agricultural setting. %OM is an indicator that reflects management and which directly affects biological, chemical, and physical properties of soils. SOM encompasses all organic components in a soil such as living biomass, plant tissues, and amorphous colloidal organic substances (humus). Total OM can be divided into three pools based on their recalcitrance in the soil: Active SOM (1 – 2 year half life), Slow SOM (15 – 100 years), and Passive SOM (500 – 5000 years). The beneficial effects of SOM include increased aggregate stability, increased water holding capacity, increased water infiltration rate, increased cation exchange capacity, increased buffering capacity, and a source of slow release nutrients, as well as others.

The most readily decomposable organic material, known as Active Carbon (AC), serves as the foundation for the soil food web. The integrity and health of the soil ecology is an important prerequisite for soil functions such as nutrient cycling and disease suppression. Therefore, in addition to the quantification of total SOM, AC is also a very important indicator for soil health and ecoagriculture landscapes.

Because SOM is generated through the return of organic matter to the soil, agricultural soils may have considerably lower SOM content than comparable lands under natural vegetation. Land converted to crops will export a considerable portion of the organic matter as harvest and tillage, and will expose more surface area of organic matter to microbial attack and oxidation. Increases in agricultural SOM and AC come from changes in management such as (taken from Brady and Weil, 2008): a continuous supply of plant residues, adequate nitrogen, eliminated or reduced tillage, and perennial vegetation. These are some of the ways in which agricultural land managers can increase on-farm SOM. Thus the persistence of SOM and AC are related to the delivery and conservation of ecosystem services.

Figure 1. The graphs below illustrate the responses of physical characteristics (macroaggregate stability, soil porosity) and plant performance (yield) to increasing amounts of AC and Soil Organic Carbon (SOC, a part of SOM). From Stein and Weil, 2002.



With reference to the Landscapes Measures Resource Center (LMRC) (www.landscapemeasures.org), the use of SOM and AC indicators are particularly pertinent to Criteria C4 (The landscape provides locally, regionally, and globally important ecosystem services) and C5 (Resilience to degradation).

It is important to recognize that there is no ideal amount of SOM or AC and that appropriate SOM and AC content is highly dependent upon climate and inherent soil physical characteristics such as texture. Therefore, the occurrence of farms with high SOM or AC (relative to most other farms and approaching that of soil under native vegetation in the region), or farmers who are aware of the importance of SOM and AC, would be good indicators of an ecoagriculture landscape.

Measuring the Indicators

1) *Units of Measurement and Analysis.* SOM can be divided into separate moieties (portions, parts, shares) based on their chemical structure, biological interaction, and half-life (based partially on their chemical nature and partly on their physical orientation within the soil matrix). Measuring total SOM and AC can provide two indicators from a single sample. Knowing the total SOM would give an indication as to "how much money is in the bank", which can be tracked over long periods of time (decades) to observe changes in the soil carbon storage equilibrium. Quantifying the active pool of SOM (AC) indicates the amount of biologically active OM (carbon), which is important for soil biota communities and nutrient cycling.

    a. Total SOM is measured by the "loss-on-ignition" (LOI) method. Loss on ignition compares the mass of sieved (2 mm) and oven dried (105°C overnight) soil before and after combustion (360°C for 2 hours). Unit of measurement is percent (%) organic carbon in the soil by weight.

    $$\text{LOI } (g \cdot kg^{-1}) = [^{(\text{oven dried soil weight} - \text{soil weight after combustion})}/_{\text{oven dry soil weight}}] \text{ x1000}$$

    b. Active Carbon is measured by the amount of carbon that can be oxidized by 0.02M $KMnO_4$. This method allows for in field testing that is as accurate as laboratory testing and it effectively reflects changes in management that are sensitive to biological aspects. The unit of measurement is active carbon $mg \cdot kg^{-1}$ or parts-per-million (ppm).

Figure 2. Shows the precision between testing AC in the field and in the laboratory. From Weil et al., 2003.

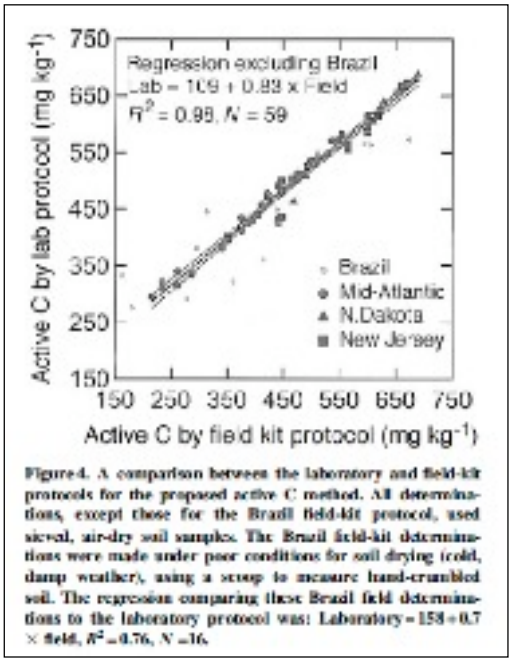


Figure 4. A comparison between the laboratory and field-kit protocols for the proposed active C method. All determinations, except those for the Brazil field-kit protocol, used sieved, air-dry soil samples. The Brazil field-kit determinations were made under poor conditions for soil drying (cold, damp weather), using a scoop to measure hand-crumbled soil. The regression comparing these Brazil field determinations to the laboratory protocol was: Laboratory = 158 + 0.7 × field, R^2 = 0.76, N = 16.

3) *Sampling Strategy*. The sampling strategy will be a combination of purposive and random methods. To quantify differences between management practices, purposive sampling is necessary to create a sufficient database from which comparisons can be made based on taking into account which management practices are being contrasted. This will involve choosing specific farms or sites to sample from. However, in-field sampling should be random but also differences in soil type, management practices, and crop growth and yield. The objective is obtain a representative sample and so irregular portions of the field, such as a low spot, should be avoided. In some cases one sample from a single field may be sufficiently representative, in others where soil type, management, and crop performance are diverse, the field should be split into different sampling units.

4) *Getting the Samples*. A trowel, shovel, or soil probe are all appropriate tools for obtaining a soil sample. It is important to get the same amount of soil for each depth sampled so as to not create a bias. Other simple accessories such as zip lock bags for keeping the samples in, a 5 gallon bucket for mixing sub-samples, and a marker for labeling the bags may be helpful. The samples should be kept out of the sun and if possible kept in an on-field cooler. They should be kept refrigerated until ready for laboratory analysis.

Interpreting the Results

Determining Significance. Comparing SOM and AC measures over time would be one way to determine its significance. It also would be insightful to compare values associated with different management practices to help gauge whether a practice degrades or aggrades SOM, and other biological responses (microbial respiration, microbial biomass, etc.). Furthermore, as a baseline, farmland SOM can be compared to the SOM of the corresponding native ecosystem such as forests or grasslands (or whatever the ecosystem was prior to agriculture). The "critical value" for SOM is highly dependent upon climate, soil type, and management and there are no broad sweeping generalizations in terms of

amount needed for a specific function. However, when these factors are accounted for, relevant ranges of SOM and active carbon can be delimited and "critical values" can be inferred. This is currently being done through Cornell University's Soil Health Program.

The Cornell Soil Health Test Report (see: http://www.hort.cornell.edu/soilhealth/) will give output that rates various soil characteristics based upon laboratory analysis and then further rates the soil as a whole from the sum of its parts:

- **Section 1** gives the background information of where the soil came from and includes the grower's name, date soil was collected, crops, management practice, and soil characteristics such as slope, texture, and taxonomy.

- **Section 2** lists the Soil Health indicators that can be analyzed as also includes the units of measurement.

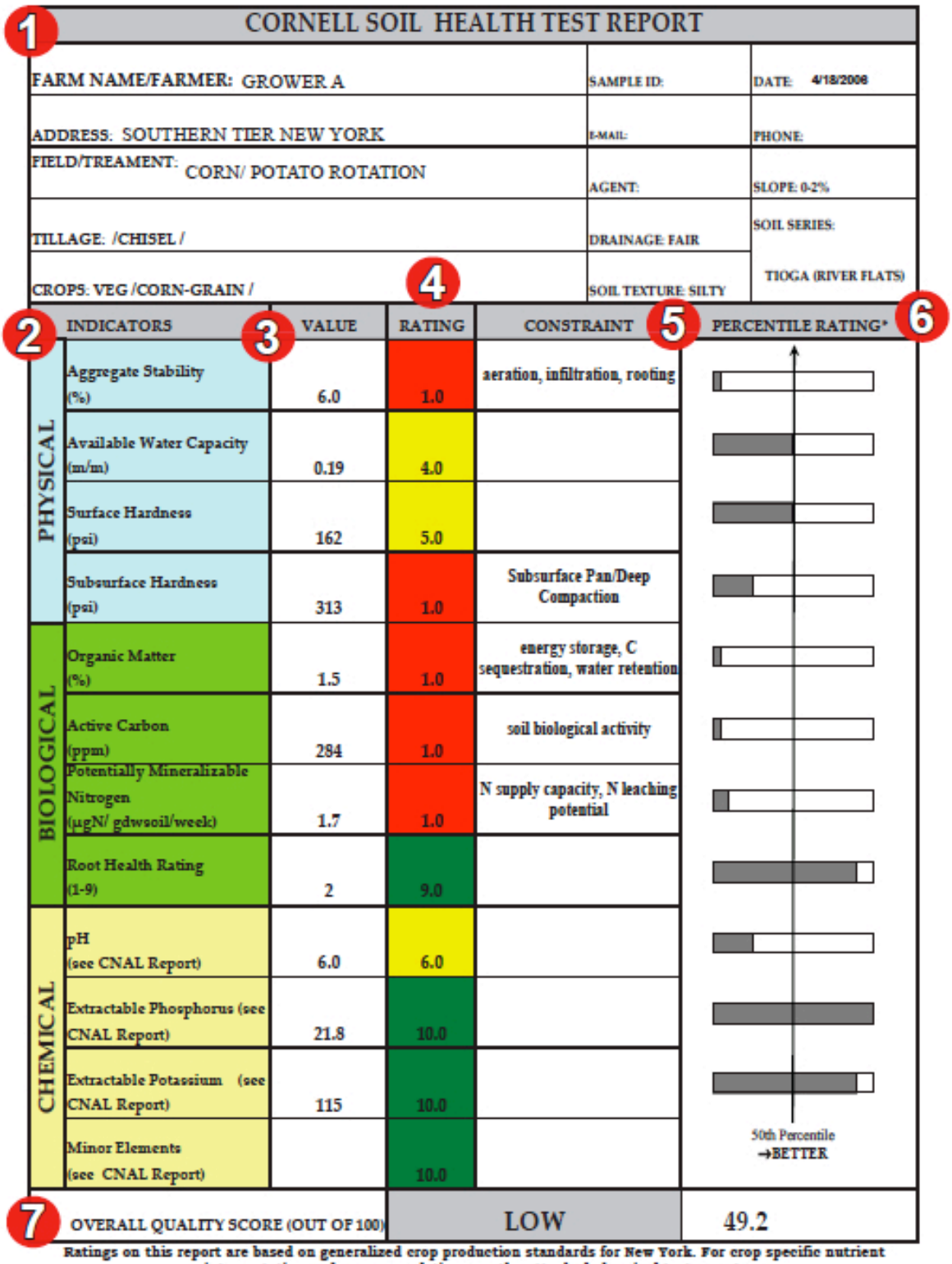
- **Section 3** gives the value for each indicator in its respective unit, for instance Active Carbon values are listed in the unit of ppm.

- **Section 4** gives the rating of each indicator. The rating system seeks to convert each specific value into a unitless score from 1 – 10. The scores are calibrated for each indicator individually and are based on each indicator's range of values and values needed for certain soil functions. Across all indicators, scores less than 3 correspond to a "Low" rating and are indicated by the color red; scores between 3 and 8 are considered "Medium" and is indicated by a yellow color; finally scores above 8 are considered "High" indicated by a green color.

- **Section 5** lists the aspects of soil health that a "Low" rating will limit and thus constrain optimal plant growth or nutrition.

- **Section 6** shows how each indicator in the particular test report compares with all of the other values in the database and represents a comparison to other New York soils.

- **Section 7** shows the overall performance of the soil on a per-cent scale, and can be thought of as an index of total soil health. A qualitative description is given to portions of the scale: Less than 40% corresponds with "Very low", 40 – 55% is "Low", 55 – 70% is "Medium" 70 – 85% is "High" and scores over 85% are considered "Very high".



CORNELL SOIL HEALTH TEST REPORT

FARM NAME/FARMER: GROWER A	SAMPLE ID:	DATE: 4/18/2008
ADDRESS: SOUTHERN TIER NEW YORK	E-MAIL:	PHONE:
FIELD/TREAMENT: CORN/ POTATO ROTATION	AGENT:	SLOPE: 0-2%
TILLAGE: /CHISEL /	DRAINAGE: FAIR	SOIL SERIES:
CROPS: VEG /CORN-GRAIN /	SOIL TEXTURE: SILTY	TIOGA (RIVER FLATS)

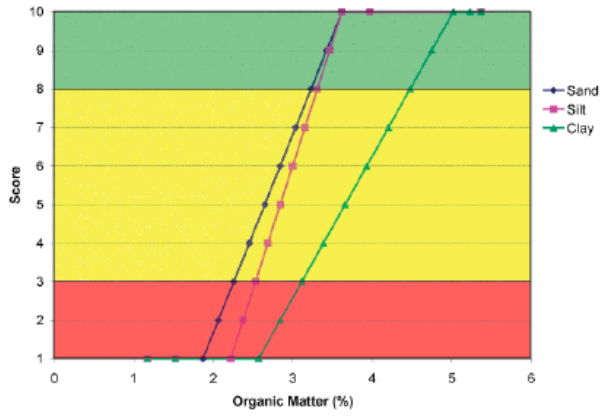
	INDICATORS	VALUE	RATING	CONSTRAINT	PERCENTILE RATING*
PHYSICAL	Aggregate Stability (%)	6.0	1.0	aeration, infiltration, rooting	
	Available Water Capacity (m/m)	0.19	4.0		
	Surface Hardness (psi)	162	5.0		
	Subsurface Hardness (psi)	313	1.0	Subsurface Pan/Deep Compaction	
BIOLOGICAL	Organic Matter (%)	1.5	1.0	energy storage, C sequestration, water retention	
	Active Carbon (ppm)	284	1.0	soil biological activity	
	Potentially Mineralizable Nitrogen (µgN/ gdwsoil/week)	1.7	1.0	N supply capacity, N leaching potential	
	Root Health Rating (1-9)	2	9.0		
CHEMICAL	pH (see CNAL Report)	6.0	6.0		
	Extractable Phosphorus (see CNAL Report)	21.8	10.0		
	Extractable Potassium (see CNAL Report)	115	10.0		
	Minor Elements (see CNAL Report)		10.0		

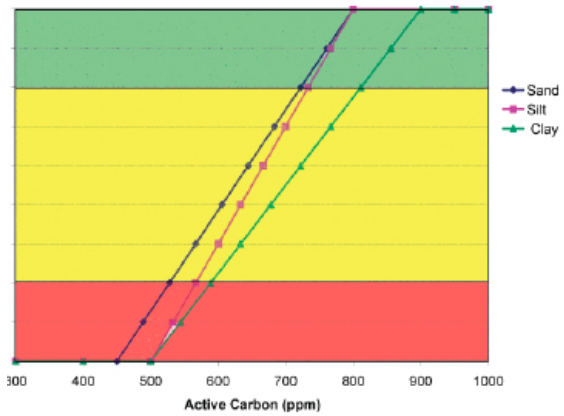
50th Percentile
→BETTER

OVERALL QUALITY SCORE (OUT OF 100)	LOW	49.2

Ratings on this report are based on generalized crop production standards for New York. For crop specific nutrient interpretation and recommendation, see the attached chemical test report.

Total SOM and Active Carbon are considered "more is better" indicators, meaning that qualitative scores (low, medium, high) have a positive linear relationship to the actual measured value for both indicators.





Score	Organic Matter (%)		
	Sand	Silt	Clay
1 (worst)	≤ 1.9	≤ 2.2	≤ 2.6
10 (best)	≥ 3.6	≥ 3.6	≥ 5.0

Score	Active Carbon (ppm)		
	Sand	Silt	Clay
1 (worst)	≤ 450	≤ 500	≤ 500
10 (best)	≥ 800	≥ 800	≥ 900

As described above in the *Units of Measurement and Analysis* section, the two indicators are measured on different scales: AC is measured in $mg \cdot kg^{-1}$ (equivalent to ppm) and SOM is measured as a percent. The above graphs show the calibration curves separated by the major soil textural groups (sand, silt, and clay). Soil texture has profound effects on the ability of a soil to express the benefits of an indicator as well obtain certain amounts of an indicator. For instance, sandy soils generally have a lower accumulation rate and limit compared with silt and clay soils under the same climate and slope due to the inherent physical and chemical properties of sand compared to those of silt and clay. Because of this, a sandy soil may have a "lower standard" meaning that it needs less SOM to reach a score of 8 (~2.8%) compared with a clay soil (~4.5%). In this case a sandy soil and a clay soil both with a score 8 benefit equally from their SOM content with soil texture taken into consideration.

A "Low" score for both AC and SOM have similar constraints and indicate potential limits in soil structure, microbial food source, and plant nutrition. Some additional indicators of poor function would be reflected in water quality (poor), microbial biomass (low), microbial respiration (low), aggregate stability (weak), infiltration rates (slow), crop productivity (poor), density (high), cation exchange capacity (low), and others. An increase in SOM will have visible effects in the soil structure (physical properties), color (darker,

more distinct from subsurface soil), crop response (response to improved soil chemical and physical properties), and soil biota (micro-, meso-, and macrofauna).

Assessing Rates of Change

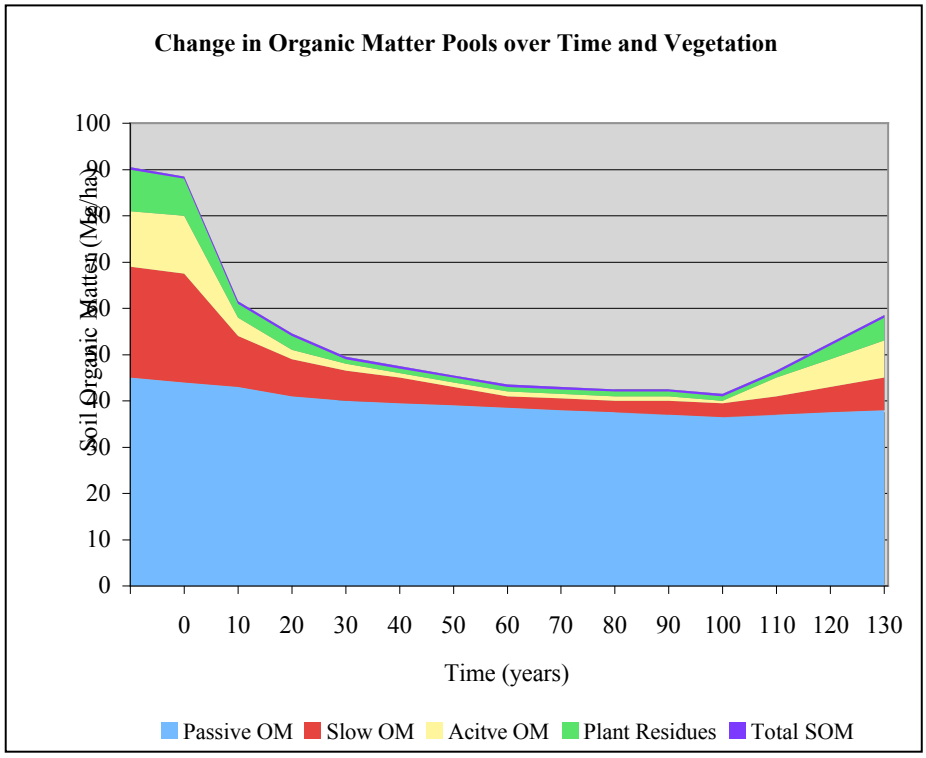
As mentioned above, the individual chemical and physical properties of SOM and AC largely determine the rate at which they degrade and/or accumulate. Total SOM is comprised of many parts and different types of organic matter, each with their own quality and degradation rate. Furthermore, it comprises a much larger portion of soil (on a mass basis) than AC, and shows a slower rate of change. AC on the other hand is only the organic carbon that is readily available to microbial decomposition. It will therefore show a much more rapid response to change over time. In addition to the inherent characteristics of SOM and AC, management can heavily induce changes in the SOM and AC "stocks" of a soil – either accumulating more, degrading what is there, or both simultaneously. Rates of accumulation and degradation depend on a host of factors that range from properties of place: climate, slope, soil texture, mineralogy, to those affected by management: tillage, amendments/fertilizers, cover crops, cropping system, etc. Because of this, rates of accumulation and degradation are highly site specific.

According to Coulter et al. (2009), 8 years of continuous corn vs. corn-soy rotation at 3 sites in Indiana resulted in no significant change in SOC at 2 of the 3 sites, but significant differences in Particulate Organic Matter (POM, often synonymous with AC) in 2 of the 3 sites. The continuous corn cropping system increased soil carbon (SOC and POM) in all cases due to the fact that it produces more biomass of lower quality (higher C/N ratio) compared to soybeans.

Machado et al. (2006) compared different cropping systems in Oregon ranging in age from 6 – 73 years. The different cropping systems included: winter wheat with conventional tillage and fallow, grass pasture, and unfertilized and fertilized winter wheat, spring wheat and spring barley, all three with and without tillage. The treatments were compared to grass pasture and to winter wheat under conventional tillage with fallow. Compared to 1931, SOC in grass pasture increased by 6 $Mg \cdot ha^{-1}$ to 31 $Mg \cdot ha^{-1}$ (in the 0 – 10cm depth) while SOC is winter wheat under conventional tillage and fallow had the lowest levels of SOC at all depths (16 $Mg \cdot ha^{-1}$ at the 10cm depth). Regardless of fertilization, conventional tillage on a continuous cropping system depleted SOC stocks in the 0 – 10 and 20 – 40cm depths, but increased them in the 10 – 20cm depths. Carbon sequestration at the 10 – 20cm depth was correlated with straw biomass. The study concluded that a higher cropping frequency coupled with less tillage encouraged carbon sequestration (and thus SOM content) and that no-till accumulated carbon faster than conventional till.

The graph below is a reproduction from Brady and Weil (2007) that represents virgin land being brought under cultivation. The initial total carbon stock was about 91 $Mg \cdot ha^{-1}$, half of which (44 $Mg \cdot ha^{-1}$) resided in the Passive SOM pool. After 40 years of

cultivation the Passive pool declined only by about 11% while the active pool (initially comprising 16% of Total SOM) suffered a 90% reduction. The Active fraction also showed the most gain after 100 years at which improved organic matter management practices were adopted. The active fraction, while being the most susceptible to change, can account for the majority of benefits of SOM, and helps explain why a relatively small reduction in total SOM can have large effects on soil properties.



SOM in the Landscape

Sampling for organic matter should occur in many places in a landscape due to the high heterogeneity of soil. To make meaningful comparisons between land uses and land use change, sampling in both managed environments and native ecosystems is important. To make meaningful comparisons between treatments, it may be necessary to sample down to a meter or more depending upon what is being investigated. The OM on a slope will be different than OM in a depression or summit, and if a change in OM is being investigated samples should be taken near previous samples to maintain similar soil characteristics. Mature ecosystems such as perennial grasslands and mature forests may not exhibit significant changes in OM, especially when compared to cultivated soils. The mature ecosystems can provide a foundation from which to compare the effect of different land uses on carbon stocks.

OM building should be done in places that suffer from a lack of sufficient OM. This may be on slopes or on mismanaged arable land. Building organic matter can help to supply nutrients, adsorb water, aid in disease suppression, as well as a host of other benefits already described. Repeated sampling will be required to track changes in OM concentration and quality. As mentioned before, the different chemical and physical properties of AC and SOM affect the rate at which they accumulate and degrade in the soil. As demonstrated, ACresponds very quickly to changes in management and a researcher would benefit from sampling at least every year, perhaps more, depending on the research question and rate of change in the landscape. Total SOM, on the other hand, displays a very slow rate of change and could be sampled every 10 years or more depending on the state of the ecosystem. In practical terms, it may not make much sense to segregate the sampling or analysis of AC and SOM since they can be derived from a single sample and costs do not differ.

Both the 0.02M $KMnO_4$ Active Carbon test developed by RayWeil (2003) and the SOM determined by LOI costs approximately 5.00 USD per sample, however that figure is subject to change.

Conclusion

Measuring and tracking SOM and AC can be very useful in indicating the sustainability of an ecosystem or managed ecosystem. Measures of these indicators enable useful comparisons between natural ecosystems and cultivated land, as SOM and AC are vital for the maintenance and bolstering of important soil properties that directly affect plant growth and thus livelihoods. SOM and AC are easy and inexpensive to measure and return precise, repeatable results. The advent of the field test kit for AC is especially helpful in the ease and portability of the AC test. When interpreting SOM and AC measures, it is important to recognize that these soil properties are part of a whole soil material and significant insight may be generated when these parameters are analyzed in association with other indicators. For instance, Wilson et al (2001) found that potentially minerizeable nitrogen (PMN) was closely associated with POM. From this one may see that SOM and AC can tell a lot about current management but they can also help predict future crop health and management requirements by their impact on soil physical, chemical and biologic properties.

3. Conservation Agriculture and Water Quality, Chris Bentley

Introduction

Measuring landscape performance is not a simple task. The ecological systems that make up a landscape's physical component are wrought with complexities, as are the equally important systems of economics and institutional support. In our conceptual framework, such manmade systems were distinguished from natural systems by dividing up the major components of a functioning ecoagriculture landscape into three "legs of the stool" (Fig. 1). Linking conservation, production and livelihoods are institutions.

Our goal was to identify indicators for each component of this conceptual framework that could be measured to evaluate landscape performance. If ecological and economic productivity are shown to increase together, and if we can link these increases to certain agro-environmental practices, then we have established a working framework.



Figure 1: The "Ecoagriculture Stool"

First, it is important to determine the scale of the landscape in question. Our definition of a landscape is 'problem-based,' instead of explicitly geographic. Since the regional landscape is dominated by the Finger Lakes, and many local dairy operations are in close proximity to tributaries that make up the Cayuga Lake watershed, the Cayuga Lake watershed was seen as an appropriate landscape, based on the environmental problems of run-off and nutrient loading in Cayuga Lake.

Currently, all of the Finger Lakes are listed as threatened, stressed, or impaired in the DEC Priority Water bodies List with some also on federal 303D List; Cayuga Lake is right in the middle when the extent of its ecological damage is compared to the other Finger Lakes (Halfman and Bush 2006). Further studies confirm that while the public values farmland in the region, such a landscape's capacity to maintain local natural resources is limited (Pfeffer and Lapping 1995).

This is in part because current agricultural production techniques contribute significantly to nutrient flows that adversely affect ecosystem health in the watershed — in Cayuga, Tompkins and Seneca counties, more than half of the soils tested by Ketterings et al. (2005) were determined to be "high or very high" in phosphorus, generally corresponding with areas of high intensity diary and vegetable agriculture. The Chesapeake Bay Report Card (Eco-Check 2008) acknowledged chlorophyll as a means for measuring phytoplankton activity since excess nutrients (specifically nitrogen and phosphorous) stimulate the growth of phytoplankton, leading to a reduction in dissolved oxygen. However, our study focused on quantifying the capacity for nutrient loading itself.

Ketterings et al. (2005) had little doubt as to the principal cause of phosphorous loading in this region, citing "Farming practices in the past 40 years" as a key contributor. An unpublished article by Swink et al. (2009) determined that 69% of manure phosphorus originated from dairy cows.

Selecting Indicators

There are a number of ways to measure environmental phosphorus content. With the goal of linking farming practices to environmental consequences, several different measurements were proposed. **Cropland phosphorus** may be a telling indicator. According to Steinhilber et al. (2004), from which Swink et al. (2009) gleans most of its phosphorus data, "P-removal is available from many sources, although no source is comprehensive."

Ultimately, not all phosphorus left in the system will make its way into the watershed. It is estimated that 90% of phosphorus exports come from less than 20% of the watershed (Czymmek et al. 2003). Therefore, it is important to consider the **P transport factor** of the farms being monitored to assess their potential for phosphorus export. This information is available as part of the farm's P index, a standardized measurement proposed by Cornell's departments of crop and soil and sciences, and biological and environmental engineering (Czymmek et al. 2003).

To link potential phosphorus loading events to observable environmental changes, **total phosphorus** in streams and tributaries and **deep-water soluble reactive phosphorus** (SRP) in Cayuga Lake should be measured. Fall Creek and Cayuga Inlet (including flow from Six Mile Creek) empty into the southern end of Cayuga Lake (Fig. 2). Combined with the effluent from two waste-water treatment plants, this has a significant impact on the shallower water in this part of the lake, contributing to a gradient in water quality across the body of water (Fig.3).



Figure 2 - The south end of Cayuga Lake

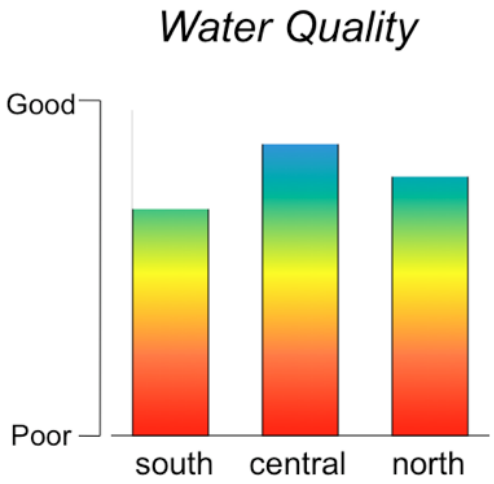


Figure 3 – Water Quality in Cayuga Lake. Source: Stedman (2008)

As concentrations of orthophosphate (as reflected in the SRP fraction) increase, it can be inferred that phosphorus is either not needed by the algae or that it is being supplied at rates faster than it can be taken up by the biota. Since P is limiting nutrient in Cayuga lake, we can tend towards the latter (Fallone 2004, Stedman 2008).

Because there is much more biological activity near the surface, low levels of SRP there could simply mean that there are a lot of organisms removing it from the water, not necessarily that there is less SRP available there (Fallone 2004). Measuring deep-water soluble reactive phosphorus may help account for the gradients in water quality and depth across Cayuga Lake. Since depth is not as much of an issue in tributaries and streams, total phosphorus can be measured as opposed to only soluble reactive phosphorus.

Measurement Plan

Most of the current monitoring efforts are focused on the lake itself, especially the southern part of the lake — Stedman (2008) found that monitoring efforts were lacking in the central and north regions of the lake.

Fallone (2004) has previously conducted a total phosphorus survey of tributaries in Cayuga County (Fig. 4).

Measuring units will vary for each indicator: soluble reactive phosphorus (υg/L), total phosphorus (mg/L), and cropland phosphorus (lbs/acre). A **spatial sampling** strategy is advisable given the distinct spatial gradient in water quality. However, there may be a need to use **random sampling** methods to deal with confidentiality and data availability issues.

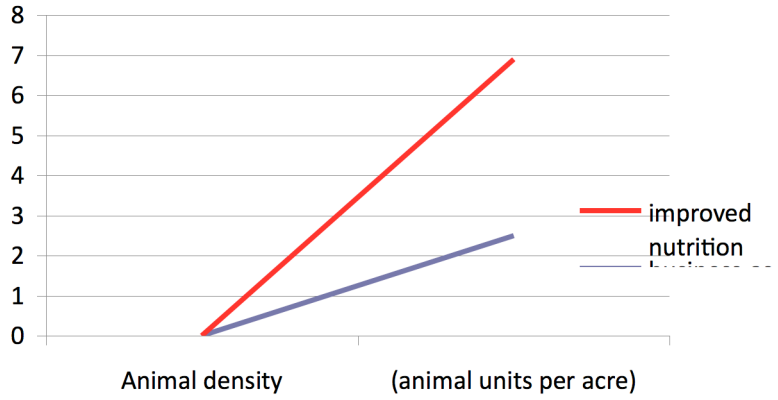
Table 2. Cayuga Lake Watershed Sampling locations

Site #	GPS Location	Tributary	Site Location
C-5	N 42°53'43.1" W 076°41'46.0"	Yawger's Creek	Sample from bridge on Townline Rd.
C-15	N 42°48'28.5" W 76°42'06.2"	Great Gully Creek	Sample approximately 50' upstream of Rt. 90 bridge
C-20	N 42°49'01.4 W 76°38'27.1"	Great Gully Creek	Use The Nature Conservancy access; site is downhill, then left into stream
C-25	N 42*38'05.9" W 76*32'43.9"	Little Salmon Creek	Little Salmon Creek upstream from the convergence with Big Salmon Creek
C-30	N 42°38'07.1" W 76°32'44.3"	Big Salmon Creek	Big Salmon Creek upstream from the convergence with Little Salmon Creek
C-31	N/A	Salmon Creek	25 yards downstream of convergence of Big and Little Salmon Creeks; sampled when the water level of Little Salmon is too high to ford
C-35	N 42°34'31.9" W 76°31'45.4"	Locke Creek	Locke Creek on Salmon Creek Rd., south of Lockerby Rd.
C-40	N 42°36'56.4" W 076°17'15.0"	Fall Creek	Sample from bridge on Groton City Road
C-45	N 42°39'46.8" W 076°17'10.4"	Fall Creek	Sample from bridge on Peth Road
C-50	N 42°40'24.3" W 076°17'50.7"	Fall Creek	Approx. 200 yards downstream from Lake Como. Sample from a beaver dam in the Dorothy McIlroy bird sanctuary off of Lake Como Rd.
C-55	N 42°40'54.1" W 076°18'20.3"	Fall Creek	Approx. 20 yards upstream of Lake Como. Sample from bridge on Branch Road off of Lake Como Road.

Figure 4 – Source: Fallone (2004)

Results

Over a long enough period of time, we would expect a decline in cropland phosphorus to precipitate declines in total phosphorus in streams and tributaries, and subsequently a decline in deep-water soluble reactive phosphorus in Cayuga Lake. To achieve this decline, a number of agricultural practices are suggested. Improved herd nutrition (see chart below), and improved on-farm nutrient management — for example through precision manure application that avoids spreading at locations with a high potential for nutrient export — are two ways (Swink et al.2009).



It will be important to consider the data in context. According to the United States Environmental Protection Agency (EPA), the recommended criteria for total phosphorus is 14.75 ug/L (0.01475 mg/L) for lakes and reservoirs and 33.00 ug/L (0.03300 mg/L) for rivers and streams in the Oswego River Basin.

Conclusions

While the indicators suggested here seek to provide environmental information on nutrient loading in the context of agro-environmental practices, phosphorus is by no means the exclusive measure of water quality. Data on nitrogen runoff, sedimentation, other particulates and pathogens, amongst other things would be a significant contribution. Furthermore, although land use is a key driver of nutrient loading to lakes, the extent to which it influences water quality can vary with watershed transport capacity (Fraterrigo and Downing 2008). Flow data on each tributary would add to the phosphorous data collected and enable better analysis and correlation of the phosphorous levels.

Within a larger ecoagriculture framework, however, improved on-farm nutrient management impacts all three 'legs of the stool' by improving water quality, soil health for farm productivity and enhancing livelihoods by contributing to the long-term sustainability of the dairy industry.

Considering the scope of the work already being done in this field by the Nutrient Management Spear Program and the Cayuga Lake Watershed Network, to name just two, there is considerable precedent for such data monitoring. The key, however, to making the data relevant will be simultaneously obtaining data on farm management, economics and agricultural productivity to help contextualize questions of environmental quality within an ecoagriculture landscape.

4. Farming Practices as Indicators, Kelley McCrudden

Introduction

Agriculture begins on the farm. The success of a farmer extends far beyond the food he provides to market, but in the command he has over the numerous facets of his operation. To achieve this command, a farmer must be cognizant of the complex dynamics of his operation, and have a clear vision for the farm's future. Producing crops requires an awareness of the many intricacies of one's habitat, including the ecological composition of the landscape, the agricultural market, and the communities of which one is a member. The farming practices, utilized by farmers to address these elements are a mix of ancestral, cultural, and innovative techniques. From merely taking a deeper look into the actions of a farmer on his land, much can be learned about the vision of this farmer, the history, and the cultural motivations that exist in both the local and global agricultural systems.

Ecoagriculture is a term that conveys a vision of agricultural operations that conserve biodiversity and ecosystem services, in addition to enhancing rural livelihoods, and creating a more productive and sustainable food system. To find evidence within these systems of an ecoagriculture approach, whether merely beginning or well established, there exist indicators that can be measured and evaluated. The sustainability in an ecoagriculture system is not only centered on the ability to address environmental challenges, but the ability to endure the test of time as the agricultural system evolves. Certain farming principles have been continuously applied through history because of their functionality and continued bearing on modern production, whereas many new practices are just now being developed with the aid of improved technologies. Sustainable agricultural practices such as these that have served both ecological and production purposes that have subsisted throughout time are indicators of an ecoagriculture system.

Motivations

Each agricultural community is unique, varying in both the type of farms it is composed of, and the physical characteristics of the area. Agricultural concerns on farms will differ in temperature, weather, geography, ecology, and various other biological factors. Each landscape is unique to which would be most effective agriculturally and environmentally. These differences prevent us from making specific generalizations to which agricultural practices are best used in an ecoagriculture landscape. However, parallels can be made within the various motivations behind farming practices based on their overall function. These motivations include the overall reduction of inputs and unintended outputs from both petrochemicals and animal waste, the efficient utilization of water, the strengthening of soil health through the building of organic and microbial rich matter, reduced soil compaction and erosion, protection of key habitats, reduction of farmland in production, and the use of land for community use and outreach. Each of these key motivations can be distinguished within the agricultural practices of a farm as indicators of ecoagriculture and should be examined periodically to assess the overall

development of a community in conjunction with the local food system.

Reduction of inputs and outputs of both petrochemicals and animal waste is key to tackling many of the environmental, social, and economic impacts that plague the current agricultural system. Current estimates of the environmental and social costs of pesticide use total approximately eight billion dollars annually. Agricultural practices, such as the use of IPM (integrated pest management) crops and utilization of beneficial organism can significantly reduce the need for pesticides and herbicides in addition to cutting the costs of these applications. For example the cost of pest control in Oregon with an IPM program averages from $160 to $200 per acre, compared to $450 or more for a conventional program (Brenner, 1991). The use of innovative alternative practices to achieve the same desired effects of these inputs and reduce negative externalities is a key sign of a healthy ecoagriculture system.

Water supply, use, and quality throughout the world is often negatively linked with agriculture as a source of degradation. Ecoagriculture systems will utilize this resource in a way that prevents waste and contamination. Practices involving soil moisture and weather monitoring, crop choice (varieties that do not require irrigation), laser leveling, furrow dyking, conservation tillage, drip irrigation, and water runoff or rainwater collection are but few of the many practices used on farms to address issues of water loss and utilization (Texas Water Development Board, 2001).

The strengthening of soil health through the building of organic and microbial matter is a key element of producing higher yielding crops and well drained, moist, rich nutrient retaining soils. Historically, agriculture in the US has had a tradition of achieving soil fertility by short-term measures through the use of chemicals and intense tillage of the land. These practices have destroyed soil fertility, causing many areas to become uncultivable. The use of practices like cover crops and compost are signs of an efficient agricultural system, but also a system that enhances the future of soil health, thus preserving farmland.

Erosion and soil compaction are two negative side effects linked to agriculture that often results in environmental degradation, often causing the land be both inhabitable for native wildlife and unusable for agricultural purposes. Tillage is an important practice for both conventional and organic growers, used to suppress weeds, reduce soil compaction, and ease the planting of crops. However, the practice is notorious for initiating soil erosion, causing agricultural inputs to enter the water system. There are methods of reduced and conservation tillage that are both practical and inhibits farmland erosion. Traditional tilling will lead to a reduction of crop residues that build soil organic matter, and will dramatically reduce fuel costs.

Agriculture can be found in areas of particular ecological importance, such as watersheds and grasslands. There are practices used on farms to address many of the specific needs of native species within their rural area. For example in the case of the Columbia County, NY agricultural research, vernal pools were measured on a number and size basis during the course of the wet spring season. By keeping wetlands and areas close

to streams on farms, out of production, the farmers enabled the growth of these vernal pools, which in turn provided proper habitat for many native and a few endangered species.

Keeping rotations of land in use and out is a sign of regard toward the future of the agricultural area. It will be important to note the size of farm and how much land is currently in use, and how much is not, including buffer areas such as forest or wetland. Keeping land fallow is a traditional practice that has a number of soil revitalizing and habitat building effects. The farmer makes an economic sacrifice when keeping his land fallow, but is rewarded in long-term benefits on its overall production.

The final motivation involves the "rural development" aspect of ecoagriculture, where many farmers have geared their operations toward community use. Agricultural land is not only preserved for purposes of beauty but also for educational purposes. Many working farms have recently opened their doors to community member to not only expose them to agricultural production, but also teach about the food system, and the historical elements of agriculture. In addition to educational programs, many farms have catered their systems toward the widespread growth of agro tourism. "You Pick" operations, "farmers markets," and many other direct market productions have not only embraced the economic benefits of agro tourism, but have also been a leading driver in the popularity of local foods.

Each practice used on a farm has a key purpose that may demonstrate a strength or weakness of a certain area ecologically, socially, culturally, or economically. It may also show how farmers in the area are likely to prioritize agricultural and community issues in the context of their production system. An ecoagriculture perspective considers the farmer as a visionary, and by looking into the practices used on farms, we are also exposed to the many innovations either invented or adopted by farmers. This information would be critical to assess the agricultural community as either an established or developing local food system or an ecoagriculture hot spot.

Measuring Indicators

The existence of an indicator, or an agricultural practice used to address one or more of the motivations discussed previously, is only the first sign of an ecoagriculture system. In order to address the overall success of the agricultural community as an ecoagriculture system, is is necessary to assess the degree of effort applied to each practice, and the frequency with which the practice is applied (how common, or how widely distributed across the landscape of interest?). There are two possible ways to measure the agricultural practice indicators within an area, depending on the amount of time and resources available to be invested in the assessment. A more direct measurement of the degree of each successful practice creates complications, as it is difficult to quantify into a single statistic. In addition to the weaknesses in quantifying success for each particular practice, the ability to address every farm in a particular community would increase the level of difficulty in assessment. Much information, however, can be gained about the

practices used within an area by survey. By gaining an understanding of the overall use of sustainable agriculture practices one can make an assessment of the motivations and degree to which an area is a local food or ecoagriculture system. There are 5 key steps to measuring indictors: 1) utilization of Agricultural Census information, 2) creating a sample of farms to survey, devising a survey, surveying farms, and assessing results.

The US Census of Agriculture (Ag Census)

The Ag Census is a government assessment of agriculture within the agricultural districts in the US, conducted every 5 years. An Ag District is an area of land set by the government that tends to cross town and county lines, although many counties in and of themselves are agricultural districts. The census provides the simple framework to which we may organize our study, providing both the timeframe (5 years) and fixed areas to examine (Ag Districts). This resource also provides essential background information on agricultural areas that will be utilized by our assessment. Each Ag District contains its own statistics on various aspects of production, the economy, and land use that are readily available to the public on the Internet. This information will be the first figures to be used in each study, as well as the initial baseline to which data can be compared.

Although the information provided by the Ag Census does not provide all the detail required for our assessment, it does provide some indicators of ecological, cultural, and economic ecoagriculture motivations for each district. These are discussed below.

The first motivation "reduction of inputs and outputs" can be partially addressed by the Ag census, which provides the acreage of agricultural land where commercial fertilizers, herbicides, pesticides and growth controlling chemicals are used and can be traced throughout time. However, alternative nutrient building or degrading components such as compost and animal manures are not measured and will require further research.

The acreage of irrigation can also be accessed through the Ag Census, but the duration of water use and types of irrigation are not covered. Information about water contamination from agricultural runoff would also require further research, and may be found through the monitoring of phosphorous levels in water bodies (*see* watershed indicators).

Questions concerning soil health may also be answered by the Ag census, which provides information about acreage of land that is covered in cover crops, legumes, soil improving grasses, and land left fallow (not harvest/ not pasture). Soil erosion and compaction issues can often be linked with these practices, but research would be required to address the particular extent of soil comparability from agriculture (see soil organic matter).

The acreage of farmland out of agricultural use is also briefly addressed, with statistics provided on the area of woodlot, pasture, and unharvested (fallow) land. These

practices may be indicators of the community's potential motivation to rebuild soil for future generations and to provide habitat for local species, further questioning would need to be done to reassure these assumptions. Leaving land out of production may also be done for a variety of reasons including contamination and lack of labor. Farmers are also capable of providing many other habitats within a farm that are not measured within the Ag Census, including the preservation of ponds, streams, and hedgerow areas.

In sum, an ecoagriculture approach entails innovative practices, thus a conventionally geared measurement tool such as the Ag Census will not provide the appropriate information to complete the assessment of a community. The Ag Census does, however, provide some information on a few key indicators, particularly regarding the extent (acerage) of particular practices, and how these measures were derived. This provides useful background information for designing a survey of farmers.

Choosing Farms to Survey

From an ecological perspective the measurement of farming practices on each individual farm would be critical to assessing the impacts of agriculture within a community. Provided the difficulty of merely mapping the location of each farm in a community it would be impractical to attempt surveying each farmer, especially under time and budget constraints. A random sample of the farms within an area would be an ideal method of assessment. However this sample must account for the variation in farms within an area. For example, it would be impossible to make generalizations about the sustainability of an agricultural community based on the evaluation of practices within a single small-scale organic vegetable farm when only minutes away exists a larger conventional poultry farm, that would pose a far greater threat to the local habitat. A survey must adequately represent the scale and types of farms within a community, thus stratified sampling would be most appropriate measuring technique.

In order to adhere to the Ag Census measurement would be conducted every 5 years, to the agricultural districts designated by the federal government. General information provided by each census includes; the percentage of farmland within an area, the number of farms, the number of farms producing various products (dairy, fruit and berries, cattle and calves, sheep and goats, nursery and greenhouse), and the market value of all the agricultural products sold in a an area. For the purpose of creating a stratified sample the percentage of products being produced within an area can help determine the number of each type of farm to survey. From this percentage one may deduce what types of farms dominate the agricultural community, and reduce some of the inaccuracy of a completely random sample. The stratified sample would thus represent the appropriate district percentage of farm type. For example if 30% of all farms within a district were dairy farms, and the sample size were 100, a random sample of 30 dairy farms would be surveyed. With the help of local extension officers, a list of farms within the area would then be composed and the random sample for each group of production would be composed.

Devising a Survey

The questions provided within the LMRC under the title "Twenty Questions for Assessing the Performance of an Ecogriculture Landscape" provide a basic model for an ecoagriculture assessment. However, it does not cater to specific agricultural areas and to those outside of academia. In order for researchers to answer the broad questions within the LMRC they must be able to interpret and explicate what is being asked into that which farmers can understand. This inductive leap that each individual researcher must make in order to follow LMRC guidelines will lead to inaccuracy, thus a new survey must be designed to relate to farmers. The new survey must also address the regional changes ecologically and culturally, to which agricultural practices are most yield-effective and sustainable within an area. A researcher must take note of the common practices used in an area, and the purposes behind the use of each practice whether cultural, social, ecological, or economically driven. Ideally, we would find proof of a local food and ecoagriculture system by identifying indicators that demonstrate the sustainable ethic of farmers, the utilization and protection of local habitat, and the understanding of socio-economic constraints.

An additional survey must be done of the agricultural community, with assistance from those within the agricultural community. This entails many obstacles, including the identification and mapping of each farm in a local community. Even fairly organized communities have had a great deal of difficulty in this task. In Chatham, NY a local organization called "Chatham Keep Farming" comprised of cooperative extension researchers, farmers, food distributors, and local volunteers spent three years working on merely mapping the locations of each individual farm in the town. In addition to mapping each of the farms, the organization was able to find much information about the agricultural use and practices occurring within their rural community.

Chatham Keep Farming was originally created in order to educate the community about the local food economy, specifically the interrelationships between consumers, producers, wholesalers/retailers, and food servers. In addition to locating the vast number of farms in the community, the organization also surveyed farmers and community members in order to learn more about the specific elements of their local food system. Keep Farming was able to find the percentage use of tillage, the use of each variety of cover crop, number and types of animals designated to an area of land, land used for conservation purposes both legally and unofficially, and various other specifics about the agricultural practices of a community. This study demonstrates the potential to measure practices on a large scale and gain community support; however, to create a survey that focuses on an ecoagriculture system, additional information must be obtained.

Questions from the Chatham Keep Farming study (listed below) cover a great range of agricultural topics that can be utilized in an ecoagriculture assessment. The survey has a number of relevant questions including; a) the economic costs and profits of each operation, b) farmland use, the acreage in production, the acreage out of production, the types of crops produced, the number of animals being supported on each piece of land, and the season extension techniques providing food for long periods of time. The survey also

asked about the practices and operations exploited to generate community involvement and outreach like U-pick productions, roadside stands, and various other tourist like attractions. Although economic aspects of agriculture within the area often extended beyond the needs of our assessment some questions were designed to help demonstrate how the two subjects integrate. For example, a question asked the amount of land that was owned by each farmer versus leased or lent by neighbors. Questions like these touched upon commonly recognized practices within the area, and demonstrate the communities reverence towards agriculture.

In the Chatham survey, questions were composed by community members who had a firm understanding of the dynamics of the local area, and the common agricultural practices utilized by farmers. Unlike the LMRC's 20 questions, the survey was designed to appeal and relate to farmers, and other farmers were an active part in the organization. This aspect of the Chatham survey must be incorporated into each ecoagriculture assessment, involving the cooperation of community members and researchers to formulate questions that properly reflect the local area. The Chatham survey also provided much helpful information to the community, helping to facilitate local trade between each of the various parties within the local food system. An ecoagriculture assessment may also provide positive contribution such as these to the communities involved.

The Chatham survey covered a number of topics that could potentially be of importance to an ecoagriculture assessment of a community. The survey could be improved by providing adequate space for subjects to provide their own personal responses. A space under each question for farmers to add thoughts would be needed for analyzing the data provided, not only to better understand the specific factors that have caused them to select an answer but to potentially explain their motivations for a specific practice. Additional questions could also be asked on the history of farmland use to gain a better understanding of the past cultural connections to practice use, such as family tradition. This may also help to shed light on the past ecological concerns of the area, such as contamination or poor soil. Water use and distribution was not covered in the Chatham survey and would require additional question on where water sources come from, the duration of irrigation (if used), and other questions pertaining to the effects of local ecological conditions. Habitat building techniques and awareness of local native species issues must also be questioned. A single survey that touches on a great range of topics, like Chatham, could help to account for diversified farms and provide a larger representation of the elements that compose the local food system.

Following are two different survey sections; one is of the Chatham Keep Farming Survey from 2003, and the other an example section of ecoagriculture survey:

a. Keep Farming Survey

The town of Chatham is doing a comprehensive plan. "Keep Farming" is a local effort aimed at collecting information about farming in hopes of influencing the comprehensive plan to benefit farmers. You are being asked to a) complete this survey, and b) participate in a follow-up interview.

Please complete as much of the survey as you can. Skip the questions that don't pertain to your farming operation. Some of the information involved can be found on your 1997 and 2003 federal agriculture census. We are asking about 1997 in order to look at trends in farming. If you aren't sure how to answer a question, you can talk about it in the interview instead.

We are asking for this information to a) get an accurate profile of farming in Chatham; b) get an accurate sense of the economic impact that farming has on the town; and c) get a better understanding of what you think the town can do to help support agricultural operations.

Privacy: The following information will not be shared with any agency. We will only use this information to get a sense of general trends and data in Chatham. When we use the information it will be used in general graphs and charts and not be connected to your name or farm.

Part 3: Farm Production

Section A: Crops

How many acres are in production for each of the following crops?

Corn (field) for grain or seed 2003: _____ 1997: _____

Corn (field) for silage or green chop 2003: _____ 1997: _____

Soybeans for beans 2003: _____ 1997: _____

Dry edible beans 2003: _____ 1997: _____

Wheat for grain 2003: _____ 1997: _____

Oats for grain 2003: _____ 1997: _____

Barley for grain 2003: _____ 1997: _____

Rye for grain 2003: _____ 1997: _____

Sorghum for grain 2003: _____ 1997: _____

Sorghum for silage or green chop 2003: _____ 1997: _____

How many acres are in production for the following?

Alfalfa 2003: _____ 1997: _____

Grass or mixed hay 2003: _____ 1997: _____

Crops	**How many <u>acres</u> are in production for each of the following crops?**	**Are these products used as <u>covercrops</u>? If so why?**	**If <u>not</u> used as <u>covercrop</u> for what purpose?**
Corn			
Soybeans			
Sweet Peas			
Wheat			
Oats			
Barley			
Rye			
Sorghum			
Alfalfa			
Hay			
Clover			

Grass silage, haylage, and green chop 2003: _____ 1997: _____

Straw (oats, wheat, barley, and small grains) 2003: _____ 1997: _____

b. Ecoagriculture Farm Practice Survey

Part 3: Farm Production

Question 1: Covercrops

Are there any other crops you are growing as a covercrop?

1. Acreage =
2. Why?

What other items are being produced on your farm to increase organic matter?

Analyzing Data

An ecoagriculture assessment focuses on the development of a rural community to a more sustainable and community oriented system. This progression measured by the practice assessment will focus on the **adoption of effective and innovative practices** and the **growth of motivations** that address these factors. The product of the ecoagriculture practice assessment will include two parts; an analysis of the change in practices and **a grade** of the overall ecoagriculture motivations that are established within the survey.

The presence of common practice indicators is the first most clear-cut aspect of the analysis. Not all practices can be measured and the initial assessment would be geared to identify the most common practices. The survey measures practices in terms of acreage. Each practice should be quantified in terms of the extent of land devoted to them.. For example if the amount of fallow land were to expand throughout the 5 years between each measurement it would indicate a positive growth within the district towards an ecoagriculture system. The indicator will reveal expansion or reduction of this practice. Here new and innovative practices being used throughout the community that either address issues of environmental concern or rural development will also be recorded. As mentioned earlier, the practice indicator is only the first sign of ecoagriculture within a community, the motivations that justify their use is the primary measurement and concluding factor of the assessment.

Questions about agricultural practices within the study will reflect the motivations mentioned earlier, and will provide a space for personal reflection. The survey will be graded much like a test. Each question regarding an ecoagriculture practice within the survey will represent the various motivations discussed earlier, and will be worth a certain number of points. The points for each question will be uniform. Points will be granted based on the number of questions demonstrating practices being utilized that represent motivations or justification provided by the farmer that the practices used on a farm represent these motivations. For example, if a farmer covers all of his 10 acres of field of drip irrigation and articulates that he had invested in this technology to conserve water and

to become more efficient, then he would be provided a mark . A grade will then be assigned out of 100 depending on the percentage of questions answered that demonstrate motivations, ecoagriculture practices, or both.

The assessment on each community or agricultural district will be much like the Chatham report written following the survey. First statistics will be provided on the sustainable practices used throughout the area, each measurement will be in terms of acreage. Innovative practices discovered may also be noted in this portion of the report. Then the ecoagriculture practice grade of the community will be provided with an explanation of what motivations were most consistent and which were absent. The final element of the report would be the comparison of past assessments and the overall growth of the community toward an ecoagriculture system.

Conclusion

Farmers understand their systems and communities on a different level than that of their extension and government counterparts which is vital to evaluating a local food system. It's from this final connection with the motivations of a farmer to which we can assess larger trends within a community. Although the actions of one farmer may only be a piece of the complex interworking of the food system, it is a key bridge to understanding his vision and his local community.

5. Community Supported Agriculture, Natalie Thomson

Introduction

This portion of the project focuses on the institutional indicators of ecoagriculture and local food systems; it is based on the Landscape Measures Resource Center (LMRC) approach to assessing landscape performance. The LMRC approach offers four broad goals to consider when assessing landscape performance; these are conservation; production; livelihood; and institutions. Here we focus on Ithaca, New York and Tompkins County to look at how three specific indicators influence landscape performance toward the goal of social organization and institutional support. Ithaca and Tompkins County have been chosen as the model for this project because a large number of small-scale farms operate within a narrow radius of Ithaca and are supported by community members and institutions, thereby allowing them to be financially and ecologically successful. This section will explore how Community Supported Agriculture (CSA) in Ithaca, New York can be used as a case study of institutional landscape performance indicators.

Selecting Indicators

The three indicators chosen for this case study are: marketscape, specifically CSA; CSA-based income; and on-farm practices, which in this report will be referred to as agro-environmental farm practices (AEFP). Selection of these indicators was based on the LMRC framework regarding the goal of institutional performance. The LMRC provides a set of criteria for determining institutions indicators; these are: knowledge norms and values; public policy; producers and community members' capacity to learn and innovate; and markets. With these in mind, we can define each of our chosen indicators in terms of the criteria set forth by the LMRC.

a. Marketscape is a borrowed term from Duncan Hilchey and Joanna Green's *Growing Home: A Guide to Reconnecting Agriculture, Food and Communities*. They define marketscape according to Lyson and Green's definition from 1999: consisting of "all the real or potential opportunities for farmers ina given area to sell their products". The idea that many different marketscapes exist in a given area to provide opportunities for farmers to sell their products is indicative of a supportive institutional framework. In this case study, we focus on CSA as one specific marketscape. Community Supported Agriculture is a mutually supportive and cooperative relationship between producer and consumer in which the consumer pays for a crop "share" in advance of the growing season; in return the producer commits to supplying fresh, quality produce to shareholders on a weekly basis throughout the growing season. The number of CSAs that exist in an area is indicative of community participation in, and public support for, more sustainable agriculture and local foods. In general, a larger number of CSA opportunities in an area would suggest greater public support for sustainable agriculture and local foods.

b. CSA-based income is a measure of the net gains that a farmer earns from products sold through CSA alone. This indicator is representative of the successfulness and profitability of a CSA opportunity. Over time we would expect to see an increase in CSA-based income, suggesting greater participation in CSA opportunities and increasing profitability of CSA operations.

c. An Agro-environmental farm practice is a new term, meant to categorize any method of agriculture that promotes sustainability (agricultural, environmental, ecological, social, etc.). The list of agricultural methods is long and growing, but includes (although is not limited by) practices such as organic, carbon sequestration, composting, crop rotation, on-farm energy production etc. The purpose of this indicator is to begin to measure sustainability of farm methodology. We would expect to see a correlation between the number of AEFPs employed by a farmer and the sustainability of his/her farm; such that the more sustainable a farm is, the more AEFPs are used on that farm, and vice versa.

Measurement Plan for the Indicators Selected

1) Marketscape

   i) Unit of Measure and Analysis: The unit of measure for marketscape will be the number of CSAs per unit area. In this case we will define our area as Ithaca, New York (an alternative could be to use Tompkins County as the unit area). We would expect that as community support and influence for local sustainable agriculture increases, the number of CSAs per unit area will increase.

   ii) Sampling Strategy: For this indicator, we will use purposive sampling – we want to focus on only the farms that are participating in the CSA marketscape.

   iii) Tool and Instruments used to sample, acquire and analyze data: We will use a variety of resources for this indicator. The most useful will be online resources, including farm websites or localharvest.org. The USDA Ag Census from 2007 also provides some pertinent information on CSA involvement per county. A combination of these resources will allow us to determine a baseline number of CSAs in Ithaca, NY, as well as enable us to keep track of this number over time. A secondary resource will be the Cornell Cooperative Extension (CCE) of Tompkins County; they keep their own personal record of farms participating in CSA. Ultimately we will use some form of map-builder to create a map of Ithaca that shows the location of each farm participating in CSA. (For internet users, this is a tentative example of how the final map will look: http://www.mapbuilder.net/users/CasalP/73287)

b) CSA-based Income

i) Unit of Measure and Analysis: The unit of measure for CSA-based income will be net income from goods sold through CSA per growing season. An increase in CSA-based income over time would be indicative of greater participation in CSA opportunities by both growers and consumers, and would reflect the increasing profitability of the CSA operations.

ii) Sampling Strategy: To measure this indicator, we will again use purposive sampling; we are interested in the income generated by all farms in the unit area that are participating in CSA.

iii) Tools and Instruments used to sample, acquire and analyze data: To start, we will use the USDA Ag Census data on farm income (the USDA records direct-to-consumer sales per county; this information is not ideal for the purposes of this project, but will at least provide a baseline measure of CSA-based income). Beyond that, we will need to conduct a survey of all farms involved in CSA in the unit area in an attempt to acquire first hand data on their CSA sales. (There is one caveat with this indictor: simply knowing the dollar value of CSA sales will not allow us to know net income from CSA. In order to know this number exactly, we would have to know the dollar value of the resources that went into producing only CSA products; few, if any, farms produce solely for CSA. In the future, we could change this indicator to net farm income for farms participating in CSA. In this sense we would determine net income on a per farm basis of all farms involved whatsoever in CSA; we would then compare this net income value to farms that do not participate in CSA. We would expect net income of farms involved in CSA opportunities to be greater than net income of farms operating without CSA participation, thus reflecting the economic performance of CSA-involved farms.

c) Agro-environmental Farm Practices (AEFP)

i) Unit of Measure and Analysis: The unit of measure will be the number of AEFP utilized per farm. A greater the number of AEFP employed on a per-farm basis will indicate greater concern for agricultural land and its long-term sustainability, both on the part of the farmer and the consumer.

ii) Sampling Strategy: To measure this indicator, we will use purposive sampling to again focus on only the farms involved in CSA. We want to know how CSA farmers are contributing to sustainability in general.

iii) Tools and Instruments used to sample, acquire and analyze data: To acquire data, we will have to conduct a survey, or hold interviews, with all farmers involved in CSA in Ithaca. The USDA Ag Census from 2007 provides limited information on specific farm practices employed per county; this information will be useful in determining a baseline status. Additional

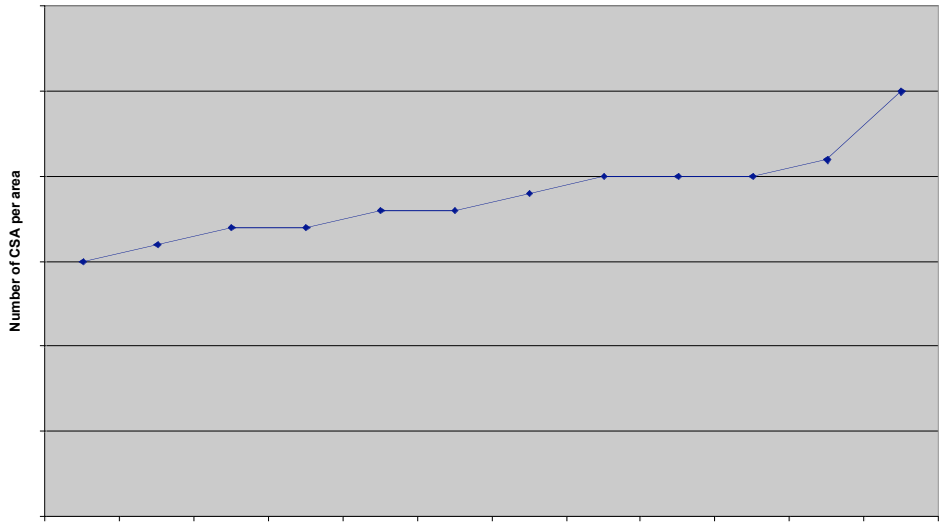
resources might include farm websites and localharvest.org. Conducting key informant interviews would allow us to document which farms are employing which AEFPs as well as any change in this indicator over time. This information will be displayed using on the proposed map, and will be represented per farm (refer to previous sample map, if possible). We will compare the number of AEFPs employed per farm per year to find an increasing trend over the years.

Results

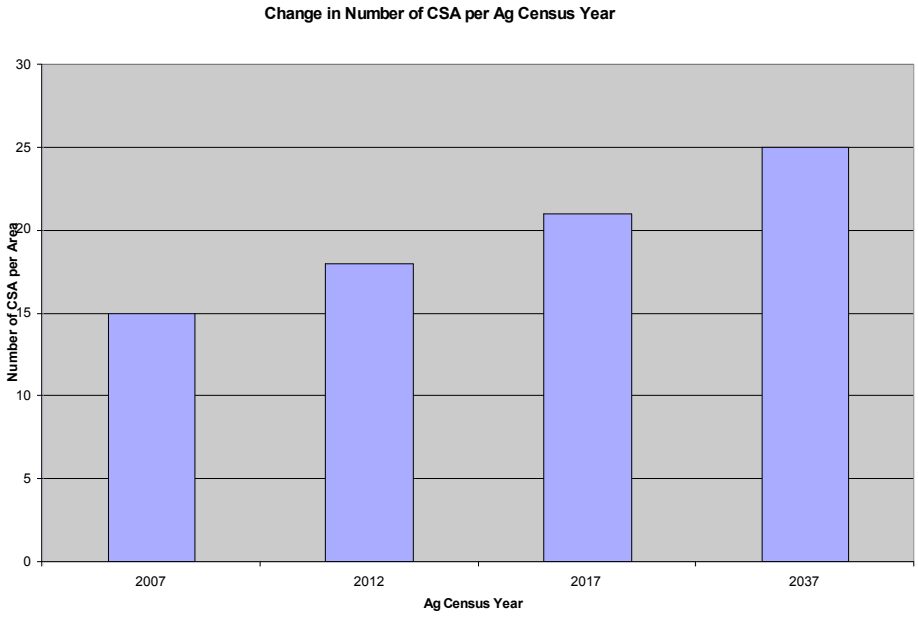
Through analysis of these three indicators, we will be able to show a progression and development of sustainable agriculture and supportive community involvement. Ideally, all three indicators will continue to increase over time until they have reached a level of maximal functionality. As the number of CSAs per area, the income generated from those operations, and the number of AEFPs employed per farm all increase, we would expect to find that farmers and community members had grown in conjunction with one another to better the performance of the landscape and of the institutional support system in that area.

For the purposes of this project, we have chosen the year 2007 as the baseline year. The USDA Ag Census from 2007 provides relative (though not specific enough) information for each of our three institutional indicators. We can use these data to establish a preliminary base year status for each indicator. Following are examples using hypothetical data that show the expected trends in these three indicators over time. There are two graphs for each indicator, the first showing general change over time, and the second comparing data from four specific Ag Census years.

These first two graphs show change in the number of CSAs that exist per unit area (in this case study Ithaca, NY is the unit area). We would expect to see an increase in this number over the years; but of course this number cannot increase forever. Eventually we would expect the number of CSAs per area to stop increasing; currently we have not made any estimations as to when that will occur. Graph 2 compares hypothetical data from Ag Census years 2007, 2012, 2017 and 2037.

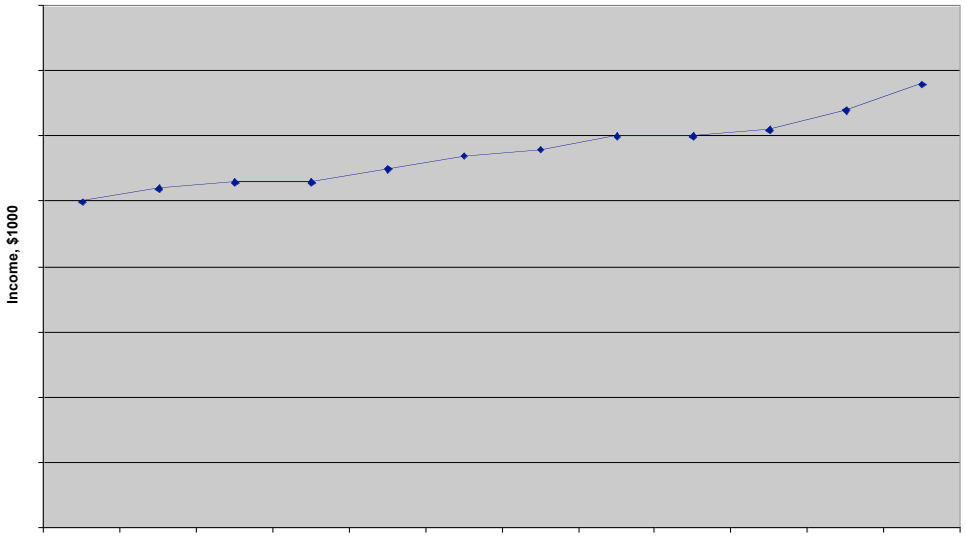


Graph 1. Trend in Number of CSA per Area



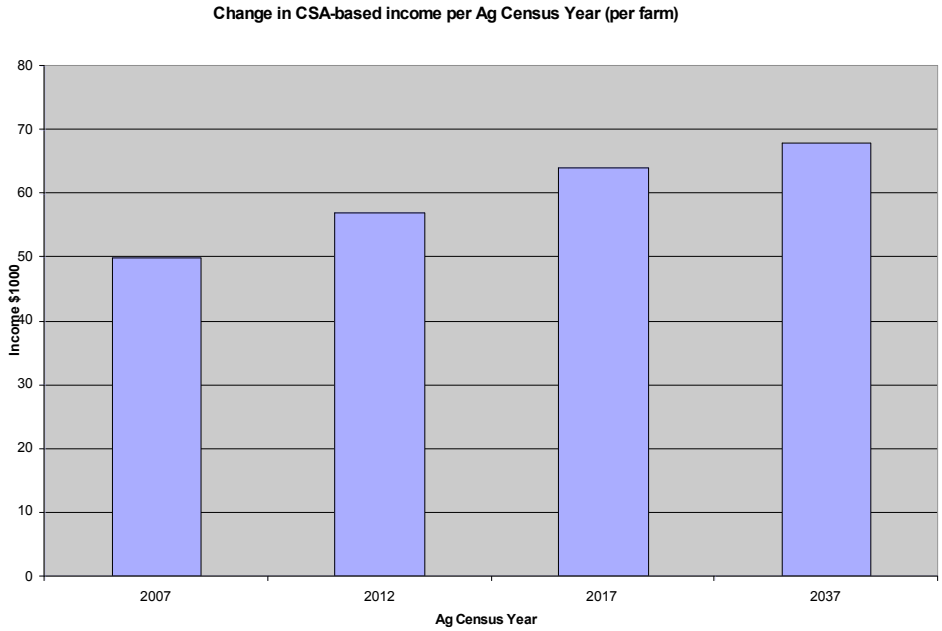
Graph 2. Comparison of CSA per Ag Census Year

The following two graphs display hypothetical data for CSA-based income. Again we expect to see an increasing trend in these numbers, but as with our first indicator, farm income likely will only increase so far and eventually we would see a plateau in Graph 3 below.



Graph 3. Trend in CSA-based Income

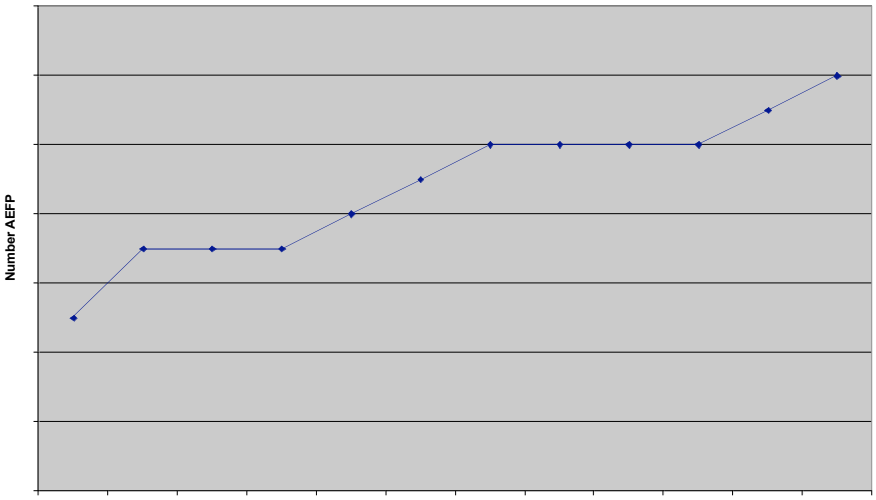
Graphs 3 and 4 show income earned per farm. We expect these numbers to increase because we expect to see increasing participation in CSA. The greater the number of consumers involved in CSA, the greater the income of farmers participating in CSA will be. Graph 4 below compares per farm income between four Ag Census years.



Graph 4. Comparison of per Farm Income per Ag Census Year

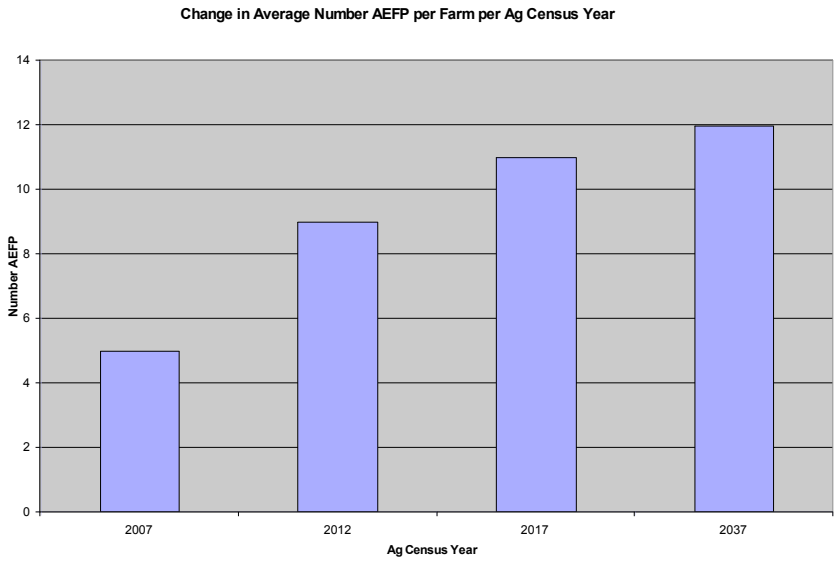
The data used for the second indicator is a hypothetical average income earned per farm per year. To display each individual farm's income changes over the years would be a messy endeavor at this point and would not efficiently aid in the purposes of this report.

The final two graphs show expected trends in the number of agro-environmental farm practices employed per farm. Again we are suggesting that the greater the number of AEFPs employed by a farmer, the greater the farmer's concern for the welfare and sustainability of his/her agricultural land. Graph 5 below exemplifies an expected trend in the use of AEFPs per farm.



Graph 5. Trend in Number of AEFP Employed per Farm

Lastly, we compare the number of AEFPs employed per farm in the next four Ag Census years; again these data are hypothetical.



Graph 6. Comparison of Number of AEFP per Farm per Ag Census Year

To graphically represent this final indicator, we will use the average number of AEFP employed per farm per year. In collecting the data we will gather separate information for each individual farm; but to display the trend in this indicator over time we will use an average of all the farms surveyed.

For each of these three indicators, we chose the year 2007 as the base year. While there does exist some information prior to 2007 for one or two of the indicators, there is not substantial information for all three of them that existed before 2007. As previously mentioned, the Ag Census from 2007 has relevant information, although not entirely comparable to the intentions of this report, which can be used to supply information for a base year of 2007. All three of these indicators can be tracked on a per-year basis. Year-to-year comparison will be useful to show initial changes in these indicators. After several decades we will be able to see trends in how these indicators change over time.

Conclusions

Collectively, these three indicators show how Community Supported Agriculture might increase the sustainability of farmland as well as the institutional support system of a community. At present there already exist several CSA opportunities in Ithaca, NY. It is not certain what the average farm income is for those farms participating in CSA. However, comparing Ag Census data prior to the year 2007, one can see an increase in the net farm income in Tompkins County (although these data may include large-scale farm operations, which is not what we are interested in for this report). While much of the information necessary to complete this report does exist, it may be difficult to collect. We cannot be certain that all, if any, farmers will be willing or able to participate in our survey. This could be extremely detrimental to the success of this report as much of the data

collection will come from first-hand surveys and interviews with farmers. Should be we successful in compiling all of the information required for this report, the results should prove useful in expressing the benefits to sustainability that CSA can have on a community.

We do not expect data collection to be financially costly; rather they will be more time-intensive. Similarly, once we have sufficient data to begin analysis, we do not expect much of a financial burden in these efforts. It is likely that local and academic organizations would be interested in supporting this research, as the findings profess to be useful in analyzing the successfulness of a form of institutional support system (CSA). The two main obstacles we expect in pursuing this project are willingness of farmers to participate, and having enough time to collect and analyze the data in its entirety.

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