METHODOLOGICAL CHALLENGES FOR DEFINING AND MEASURING AGRICULTURAL LANDSCAPE INDICATORS

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The decision of the Organization for Economic Co-operation and Development (OECD) to investigate landscape indicators creates many opportunities and ground-breaking challenges. The explicit opportunity is to develop a means to monitor intrinsic landscape quality across political boundaries. Implicit opportunities may prove to be equally important. They include:

- *The opportunity for policy-makers to monitor and manage the aspect of environment that is experienced most broadly and directly by local people and the body politic, that is, the landscape.*
- *The opportunity for policy-makers to anticipate public response to future landscapes.*
- *The opportunity to link landscape indicators with related biogeochemical functions, population and economic phenomena.*
- *The opportunity to examine cross-scale effects between fine-scale landscape phenomena and global and regional phenomena, data, and indicators.*

Challenges are also abundant, and will require policy-makers, planners, and scholars to be inventive. Among the challenges:

- *Defining landscape indicators adequately: in a way that accurately conveys the experience of landscape and that also is amenable to monitoring across political boundaries and ecological regions.*
- *Determining what information constitutes an adequate baseline for monitoring agricultural landscape change.*
- *Determining what data are available, or practically could be gathered, to build that baseline and maintain a monitoring system.*
- *Articulating the value of landscape meaningfully in the context of other agricultural indicators that are more widely understood and valued in the scientific and policy communities.*

This paper describes and details these opportunities and challenges, and relates them to some ongoing work in the USA.

Introduction

Because the agricultural landscapes of the OECD nations are increasingly a product of policy, an indicator approach to monitoring and directing landscape change is particularly appropriate and likely to be productive. Agricultural *means* human management of fields, and agricultural landscapes – even those that are perceived as "natural" – are inherently the result of human choices. In addition, agricultural landscape indicators are likely to be practical for policy because of the relatively large extent of agricultural land management units compared with urban land uses– whether the unit we consider is a field (a homogenous area of a particular management regime) or a farm (an area of multiple fields which is managed by a single entity, e.g., a farm family and/or a corporation.) Finally, changing international trade, environmental, and agricultural policy, diffusion of new agricultural technologies and practices across the globe, and global ecological and climate change are creating new agricultural landscapes at a rate that is noticeable, and jarring, to local farmers and the broader public in many locales. Surprising landscape effects of climate change, habitat loss, and unintended effects of policy and technology make it difficult to predict the appearance of future landscapes. In the face of such difficulty, there is a widely felt need to establish baseline data with which to anticipate the future. An indicators approach to agricultural landscapes is not only needed but can be practically and productively applied to guide agricultural, environmental, and trade policy to produce future landscapes of value.

I have been asked to identify methodological challenges for developing agricultural indicators. In describing these challenges, I often will refer to my own work with others over the past 25 years, in which we have measured and mapped agricultural landscape perceptions and developed prospective future scenarios for agricultural landscapes. References within the papers to which I refer here describe a much larger, and very rich set of literatures in landscape perception, farmer perception and behavior, landscape assessment, landscape ecology, geographic information systems, and future landscape scenario design. My intent here is to refer to works in which my co-authors and I have drawn on and summarized those literatures in the context of agricultural landscape measurement.

Landscapes can influence public perceptions to achieve valued landscape functions

As defined by the European Landscape Convention of the Council of Europe (2000), "landscape means an area as perceived by people…" (Chpt.1, Art. 1). Further, member nations of the Council have agreed to establish procedures for the public to participate in defining and implementing landscape policies (Chpt.2, Art. 5). These two articles clarify that public perception is of the essence to landscape quality. In the United States, public perception of landscapes has been recognized somewhat less broadly, as essential to management decisions for projects on federally-owned land and for federally-funded projects on private land (Nassauer 1989, Nassauer 1992). Numerous state, and some local laws, have emulated federal landscape quality protection procedures, e.g. (USDA 1995). As defined in Volume 3 of the OECD Environmental Indicators for Agriculture (2001), agricultural landscapes are the "*visible* outcomes resulting from the interaction between agricultural commodity production, natural resources and the environment…" (p. 368) (emphasis mine).

I have argued elsewhere that this defining characteristic, visibility, or appearance, is both an opportunity to strategically manage agricultural landscapes to achieve public support for *invisible or sometimes unattractive beneficial ecological functions*, and a pitfall for environmental policy when the visible characteristics of landscape are managed in a way that obscures hidden ecological costs (Nassauer 1989, Nassauer 1992, Nassauer 1997). This argument depends on understanding that the appearance of landscape is separable from its function; any given commodity can be produced in many different landscape patterns. The pattern of agricultural landscapes is a matter of policy and farmer choice, constrained by ecological characteristics of the place, technological choices, and broader cultural values and patterns, like land division and ownership patterns (Nassauer, Corry, and Cruse 2002).

Understanding that appearance is separable from these other variables points to strategic opportunities for policy to intentionally link public perceptions with distinct, but valuable, ecological and production functions. Without this intentional link, agricultural policy runs the risk of producing landscapes that may be "good" ecologically or for production, but not be seen as "good". Alternatively, without this link, agricultural landscape indicators could suggest the protection or creation of landscapes that look "good" but are not "good" ecologically or for production. This disjunction between what is visible and landscape functions must be recognized from the outset if we wish to propose intellectually defensible and strategically effective agricultural landscape indicators.

Indicators will track selected aspects of landscape, and much of what we will discuss during this workshop will be *what to select*. Our recommendations must pragmatically consider data availability and data management, but they should first consider which potential landscape indicators can join valued visible landscape characteristics with function. We should set our sights on enabling policy to strategically link the realm of appearance with the realm of function.

Present and past landscapes have only sometimes been valued for their appearance, as well as ecologically healthy, and agriculturally productive. To guide future landscape change, indicators should be sufficiently conceptually broad to measure the value of innovative landscape patterns that may not exist (Nassauer, Corry, and Cruse 2002). Some innovations may be beneficial and some may be destructive of some values. Adequate indicators may not forecast the particular patterns, but they should be able to measure their value.

How the public perceives value in future agricultural landscapes will depend in part on whether they contain patterns that are familiar and valued in present landscapes. This doesn't necessarily mean that future landscapes must look the same as present landscapes. It does mean that selected presently valued pattern characteristics might be employed in future appearances to maintain landscape value even as landscapes change. For example, in our survey of perceptions of alternative future scenarios for Cornbelt USA agriculture, the future landscape pattern that Iowa, USA, farmers valued most highly was purely our digital invention (Nassauer and Corry 1999). It had never been seen before. However, it included a vivid, familiar contour strip pattern that farmers recognized from the strip-cropping practices that were introduced in the Cornbelt in the 1930's, and that farmers find very attractive.

These ideas present the following questions for this workshop: How can we construct indicators that validly convey what is perceived as valuable in agricultural landscapes? How can we select indicators and monitor agricultural landscapes to help policy makers "take the pulse" of public opinion of landscape appearance? How can we develop indicators that will measure future, novel landscape appearances as well as past and present landscape characteristics?

Cross-scale effects between fine-scale landscape phenomena and global and regional phenomena should influence the selection of landscape indicators.

While landscapes are experienced at a very fine grain (people notice and value landscape characteristics smaller than a weed in a field or a dying tree), agricultural landscape indicators may be assumed to demand coarse-grained data in order to monitor extensive areas. This scale disjunction could lead us to monitor broad-scale phenomena that do not validly reflect landscape perception. At the same time, fine-scale landscape changes can have surprising cumulative broad-scale effects. In everyday life, people often literally "can't see the forest for the trees". For example, while people may notice the loss of certain types of valued agricultural landcover locally (e.g., grazed meadows), they may not be concerned about that loss until they know that the landcover type is becoming relatively rare across their entire region or begin to notice it's ecological effects. In these cases, it is important to link fine-scale perceptual phenomena with broader landscape changes as well as biogeochemical, population, and economic phenomena that constrain fine-scale landscape patterns. Finally, some fine-scale local landscape changes may be the unintended, displaced consequences of policies, international business decisions, or technologies in other parts of the world. For example, changes in US agricultural and trade policy may promote unintended changes in agricultural practices and landscape quality in other regions – including developing countries. If we define and measure agricultural landscape indicators across scales and link them to global or regional indicators of other phenomena, we can avoid methodological problems of:

- Invalid measures at the wrong scale
- Failure to notice cumulative effects of local landscape changes
- Displaced local landscape effects of national, multi-national, or technological change in other parts of the world.

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These ideas present the following questions for this workshop: What data are relevant for monitoring the fine-scale phenomenon of landscape perception? How might data be efficiently collected to describe this phenomenon? What coarse-scale data describing broad scale phenomena should be linked to fine-scale landscape indices?

Landscape indicators should allow policy-makers to anticipate interactions between visible landscape change and biogeochemical, production, population, and economic phenomena.

Economic indicators have long been accepted as a tool for policy-formation. In the United States, agricultural and demographic/housing indicators also are widely available. The federal Census of Agriculture provides data for tracking selected production, economic, and demographic characteristics at 5-year intervals, and the Census of Population provides data for tracking housing, economic, and demographic characteristics at 10-year intervals. A recently completed system of ecosystem indicators for the United States by the Heinz Center (2002) responded to a lack of similar indicators for the nation's ecosystems. It identifies a wide array of indicators by landcover and land use types and establishes a baseline from which to monitor change. Data availability was a fundamental limitation for selection of US ecosystem indicators. Production of food and fiber in agricultural landscapes are indexed by drawing on data from the US Department of Agriculture. However, the report offers no indicators for landscape quality in any ecosystem type – including farmlands or grasslands. Outdoor recreation indicators, including "viewing activities" are called out for several ecosystem types, but such viewing activities are limited to immediately quantifiable characteristics like "hours spent watching wildlife." The Heinz Center Report notes that data for tracking so-called intangible values are dramatically lacking, and very much needed. However, "landscape quality" is NOT explicitly included among the intangible ecosystem services for which indicators are needed – despite the powerful federal mandate to measure "presently unquantified aesthetic qualities" that has been in place since 1969. Despite the thousands of environmental impact statements and assessments that have been filed in response to the US National Environmental Policy Act, federal agency organic acts, and analogous state acts, and the well-articulated policies and hundreds of plans of the federal land holding and advisory agencies (e.g., USDA 1995), no single, consistent data base for landscape quality exists for the United States.

Quantified landscape indicators would allow scientists, planners, and policy-makers to look for the following types of potential relationships:

- Landscape indicators may sometimes be surrogates for potential ecological indicators, predicting landcover or land use change that has implicit ecological implications.
- Landscape indicators may sometimes act as independent variables, predicting ecological indicators.
- Landscape indicators will sometimes be illuminating intervening variables – explaining landscape patterns that are initiated by demographic or socio/economic changes.
- Landscape indicators may sometimes be dependent variables, predicted by ecological change.

These ideas present the following questions for this workshop: What other agricultural indicators will be recommended by the OECD? What potential relationships can be identified between these other indicators and landscape indicators? How can the measurement of landscape qualities be calibrated to illuminate these relationships? What strategic relationships should be constructed among indicators to enhance their effectiveness?

Summary of opportunities for agricultural landscape indicators

Overall, developing agricultural landscape indicators presents several opportunities to monitor and manage landscape quality:

- Because of its inherent value as an "essential component of people's surroundings" (Chapt. 2, Art. 5, Council of Europe, 2000).
- Because of its power to influence public perception of and support for ecological quality and agricultural production and related policies.
- To guide and demonstrate the potential for innovative, new landscape patterns to be valued by the public.
- To directly affect landscape quality phenomena that are apparent at broad scales, but may not be immediately apparent at fine scales
- To directly affect or respond to biogeochemical, production, population, and economic phenomena that are may be monitored at broader scales.

Responding to the scope of these opportunties raises formidable methodological challenges – most of which relate to data classification, cost, and management.

Define landscape indicators adequately: in a way that accurately conveys the experience of landscape and that also is amenable to establishing a shared baseline for monitoring across political boundaries and ecological regions.

An adequate definition of landscape indicators first depends upon validly reflecting the phenomenon of landscape perception, answering the question, "What do people notice and value?" To validly measure what people notice, we should present people with visible landscapes (*in situ* or in images, like photographs or simulations) to measure their response. Presenting respondents with words that describe or point to landscapes is not adequate for measuring landscape quality, and especially, for anticipating response to change. To anticipate change, we should pay attention to characteristics that could be visible in future landscapes, not only what people notice now. To measure change , we must consider the spectrum of value: What people perceive as being undesirable, as well as what they regard as desirable. And we must assume that different communities may have different values. For example, professional design and planning communities have consistently been shown to value landscape differently from the general public (e.g., Zube, et al. 1974) In Environmental group members value the landscape differently from the general public (Nassauer 1993). Farmers may value agricultural landscapes differently from the general public (Nassauer 1988). Local people may have different values than tourists. Different national or ethnic values for landscape may amplify these differences (Kaplan 1989).

Amidst what could be a bewildering array of differences, there are unifying concepts. The evolutionary and information-processing theorists of landscape perception would suggest that savannah like landscapes will be broadly valued (Nassauer 1995). Landscapes that exhibit recognizable signs of human care will be broadly valued, but the particular signs may vary across cultures and regions (Nassauer 1988, Nassauer 1995, Nassauer 1997, Beedell and Rehman 1999, Cary 1999, Gobster 1999, Menzies 2000). Furthermore, different policy or activity contexts may provoke different perceptions – increasing similarity among groups. For example, Cornbelt USA farmers have told me that this landscape wouldn't be attractive to farm, but it would be a place they would go to enjoy the view on a Sunday drive (Nassauer 1989). In a more recent interview survey, a young farmer told me that he would have to choose a monoculture corn landscape alternative for it's production value, but he found an alternative of native perennial grass strip intercropping more attractive and would choose it if he could make money doing it (Nassauer and Corry 1999).

Whatever landscape characteristics people notice and value, data classification must be sufficiently rich to include or at least imply those characteristics. To pursue linkages with ecological and production indicators, it also must include classes that are relevant for those linkages. A hierarchical data classification can link coarse-grained data, describing conceptually-broad landscape quality classes across a continent, with relatively few classes extending over a large region, to fine-grained data with more classes, describing much smaller areas (Allen and Hoekstra 1987). Such small areas might be conceived as sample points or even limited to "hot spots" of landscape change. This structure could allow monitoring of many data classes to capture fine-scale characteristics and to allow for fine-scale variation in data classes among regions and communities at levels in the hierarchy where cross-boundary comparisons are not needed.

Very fine scale perception data might be measured as nominal scales, including many landcovers and landscape features. Coarser scales in the hierarchy should allow for interval scale data and could employ unifying conceptual constructs, like desirability, attractiveness, or care. Anchoring interval measurement scales for landscape perception data requires scale end-points that are shared by all respondents. Cross-boundary comparisons might usefully focus on establishing perception scales with enpoints defined by anchor reference landscape that are recognized by all cultures and population groups for cross-boundary comparisons. Using multiple scales for these coarse-scale comparisons will help to validate ratings and to allow for multiple dimensions of landscape value to be measured.

Since data classification and resolution limit what is "conceivable" for any data set, fine-grain data needs should inductively determine coarse-scale data classes within a hierarchical data structure. Hierarchical data structures, sampling of fine-grain phenomena, and novel data gathering techniques should all be considered to both practically and validly measure landscape quality across the OECD nations.

Addressing the dilemma of spatial and classification scales can help to identify baseline data for landscape indicators. Following from a hierarchical concept of landscape classification, baseline data might incorporate existing local data sets of many classes at a fine scale, and these local data sets need not be uniform across regions. Comparisons across regions might occur with interval scale data of measures like desirability, scenic beauty, attractiveness, care, apparent ecological quality, naturalness, etc., which can be compared across regions. A local, fine-scale spatial data baseline for a sample landscape in Cornbelt USA might include nominal landcover classes like strip-cropping, corn/soybean rotation, or herbaceous riparian buffer strip, nominal landcover classes for a sample agricultural landscape. Across regions, these landscapes might be described by their interval scale ratings as: highly attractive, or moderately unattractive. The montado landscape in the Alentejo region of Portugal might include very different nominal landcover classes like, cork oak with cereal understory, or holm oak with grazed pasture understory. However, these landscapes, too, might be described by their interval scale ratings as: highly attractive, or moderately attractive. These are very different landcovers and agricultural systems could be compared on regional residents' ratings of conceptual dimensions of landscape perception. To allow for international and regional comparisons, baseline data sets could focus on experiential concepts rather than only particular landcovers.

Determine what data are available, or practically could be gathered, to build a baseline and maintain a monitoring system.

Costs of data-gathering and management are formidable barriers to applying indicators across wide areas. For this reason, the Heinz Center (2002) built indicators for farmland ecosystems for the United States solely with currently available data. However, there are not currently available data for directly monitoring landscape quality across the United States, or across the OECD nations. Resolving the tension between using available landcover/land use data interpreted from satellite images and representing perceived fine-scale and regional variation in landscapes is a key methological challenge for agricultural landscape indicators. Building interval scale, quantitative indicators that can encompass a variety of local nominal landcover/land use scales should be considered. Certain adjectival scales (operationalized as bi-polar adjective scales, Likert scales, or emerging from Q-sort analyses) have repeatedly proven their validity in landscape perception studies over the past thirty years (e.g., Zube , et al. 1974, Fairweather and Swaffield 2000). Employing these scales redundantly, as multiple measures, will be useful to establishing a landscape indicator baseline. As landscape indicators are constructed from responses to enormously varied local landscapes, as they are applied to spatial data sets that are limited in resolution and classes, and as they are strategically linked with other indicators – certain scales may prove to be more pragmatically useful than others. A baseline landscape indicator set should offer alternative interval scale measures that will allow opportunistic trials for their fit with other data and indicators.

New technologies, like web-based landscape perception surveys can dramatically increase the efficiency with which such interval scale measurement can be applied to a wide variety of landcover/land use combinations in local landscapes (e.g., Wherrett 2000, Bishop 1999). With an adequate respondent sample size, a relatively large number of landcover/land use landscape combinations can be measured. With an adequate repeat measures respondent sampling strategy, such an approach also lends itself to monitoring over time. Where web-based surveys cannot reach all people who should be sampled, traditional landscape perception survey techniques can augment web-based data gathering.

Articulate the value of landscape meaningfully in the context of other agricultural indicators that are more widely understood and valued in the scientific and policy communities.

While landscape indicators must necessarily begin with nominal data representing a large number of classes or types, interval scale quantitative data may be more useful for making comparisons across political boundaries and regions, across changing landscapes over time, and in relationship to other quantified indicators for biogeochemical, population, and economic phenomena. Agricultural landscape indicators that nest measurement of fine-scale local landscapes within broader conceptual categories of perception and within broader spatial classes at lower resolutions will not only ameliorate methodological problems. Such an approach also will “speak the language” of science and policy. Interval scale data on landscape perception will allow for quantitative comparisons and speak the language of science and policy. These conceptual data should be constructed to allow them to be linked to spatial data in geographic information systems (GIS). Ultimately, indicators should be mapped to allow comparisons across regions and nations, and over time.

Too often in the past, managing landscape value has been misunderstood as hopelessly intractable, subject to the arbitrary whims of individual taste. Results of empirical landscape perception research and recent thought in environmental aesthetics correspond in their conclusions: *community* values underpin landscape values, and are subject to measurement and mapping (e.g.,Eaton 1990, USDA 1995, Eaton 1997, Nassauer 1997). High level generalizations are not only possible but “natural” to the experience of landscape. Explaining what makes for landscape value is challenging, and it is our challenge in this workshop, but experiencing landscape value is a commonplace of everyday life across cultures. Our work in recommending agricultural landscape indicators is to go the next step: to show how indicators can be selected and developed so that they will be widely understood tools for affecting the future of landscapes

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Recommendations

In summary, agricultural landscape indicators should be developed to be cognizant of their capacity to:

1. Monitor and protect landscape quality.
2. Anticipate innovation and novel future landscape characteristics.
3. Anticipate how changing landscape quality may effect and be affected by changing ecological, production, population, and economic phenomena.
4. Anticipate cumulative effects of fine-scale local landscape changes.
5. Anticipate displaced landscape effects beyond the boundaries of OECD member nations.
6. Strategically anticipate how public perception of landscapes may affect opinions of policy and ecological, population, and agricultural change.

Landscape indicator data structures should grow from considering the following recommendations:

1. Establish baseline data in a nested hierarchy of scales – validly reflecting the fine scale of landscape perception and pragmatically setting up links to coarser, more extensive spatial data.
2. Establish a system for regularly monitoring the indicators selected.
3. Employ regional representational cluster sampling or “hot spot” samples to assure that fine-scale perception data are linked to broad scale spatial and conceptual data.
4. Base fine-scale indicators on responses to landscape images – direct representations of visible characteristics.
5. Use available technologies (e.g., web-based surveys) to set up cost-efficient systems for regularly gathering perception data.
6. Facilitate comparisons across regions, nations, and over time by gathering interval scale data that measures experiential concepts.
7. Link landscape indicator data with biogeochemical, population, and economic data.
8. Look for and model relationships between landscape indicators and other agricultural indicators.
9. Link perception data (describing response to small spatial extents at fine scales) to GIS spatial data (describing broad spatial extents at coarser scales).
10. Link interval scale conceptual data with nominal scale landcover/land use and landscape type data.
11. Map landscape indicators at broad spatial extents, and possibly, at small extents.

My recommendations are not comprehensive. They are offered as a part of our discussion at this workshop, where our many experiences and perspectives will allow us to think together about recommendations to the OECD. Our opportunity is to assure consideration of landscape, the essential fabric by which we understand what is happening in our worlds and in which we seek invaluable lifetime satisfactions.

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