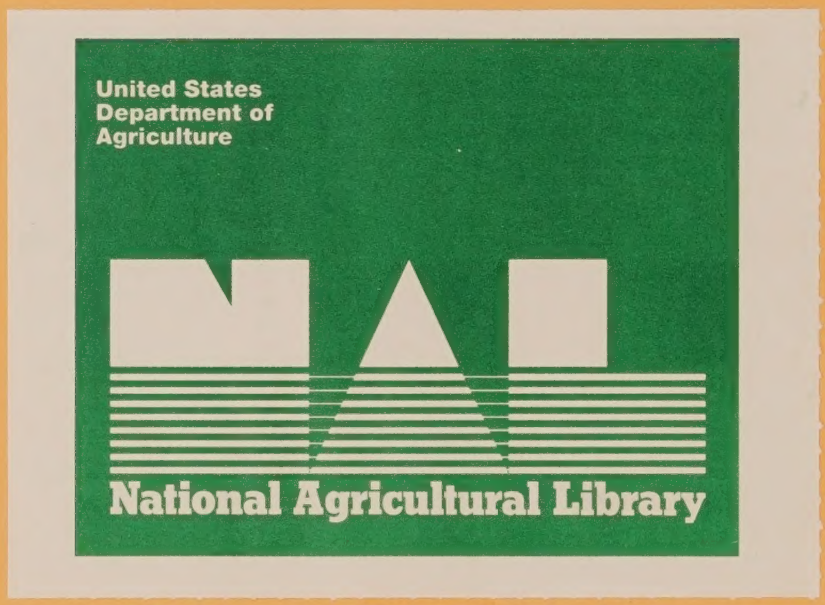
United States Department of Agriculture
Natural Resources Conservation Service

Ecosystem Indicators

A Process To Assist With Planning and Monitoring Activities

Developed By The
NRCS Indicators Action Team

April 1996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ECOSYSTEM INDICATORS

ACTION TEAM FINAL REPORT

Prepared by the

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EXECUTIVE SUMMARY

The Natural Resources Conservation Service (NRCS) assigned an "Action Team" the task of facilitating the use of indicators for planning and implementation activities within the agency. While the state-of-the-art in the use of indicators to assess ecosystem processes is not well advanced there are some indicators that can be useful today. The Team developed a model to direct the selection of indicators for use in evaluations of ecosystem condition. The Team also developed a preliminary set of indicators and recommendations for their further development and use. Additional analysis of indicators is needed by the NRCS Science and Technology Consortium.

Evaluations of ecosystem condition require responses to specific questions regarding the interrelationships and integrity of the system's soil, water, air, plant, animal, and human resources through the functioning of ecological processes within the system. Design of the Indicator Selection Model was directed by these concerns: What are the questions that need to be answered in evaluations of ecosystem condition? What are the attributes to measure that provide answers to these questions? How are the attributes measured (what indicator to use)?

The Indicator Selection Model is comprised of seven elements or levels: 1) **Ecosystem Aspect** - a broad grouping of environmental, ecological, and human community considerations that are common to all natural ecosystems; 2) **Framing Questions** - the minimum set of diagnostic questions that need to be answered in comprehensive evaluations of ecosystem condition; 3) **Ecosystem Components** - a listing of related environmental, ecological, socioeconomic, cultural or political factors considered to be important elements of an ecosystem; 4) **Assessment Questions** - those questions that are formulated in reference to the Framing Questions and their constituent Ecosystem Components; 5) **Indicators** - the quantitative or qualitative assessments of ecosystem components that are needed in order to answer the Assessment Questions; 6) **Measurement** - the approach used to measure the variable(s) to be assessed by the Indicator(s); and, 7) **Interpretation** - the process used to interpret the measured values collected using the Indicator and the Measurement. Initial use of the model is made by entering the system at the first element and proceeding through the remaining levels in a step-wise fashion. Continued application of the model to select additional indicators can be an iterative process, with re-entry at the appropriate level.

The Indicator Selection Model presented in this report is designed to guide stakeholders and resource planners to think beyond single resource issues and consider the condition of the larger ecosystem including human dimensions of the system.

The report concludes with ten (10) recommendations for action by NRCS.

INTRODUCTION

In June, 1994 the Natural Resources Conservation Service (NRCS) issued policy on providing Ecosystem-Based Assistance (130-GM, Part 406). A month later the agency released its Action Plan on Providing Ecosystem-Based Assistance for the Management of Natural Resources. Both documents identify the need for "indicators that can be used to measure the results of conservation systems and programs in terms of ecosystem health." An "Action Team" was assigned the task of facilitating the use of indicators for planning and implementation activities within the agency. Members of the Indicators Action Team are listed in Appendix D.

The Indicators Action Team (Team) saw its charge as:

- developing a model for identifying and using indicators to assess ecosystem conditions (ecologic, economic, and social);
- developing a preliminary set of indicators; and,
- making recommendations for the use of indicators at multiple scales, e.g., field, regional and national.

While indicators can be used for a wide variety of purposes, the action team focused its efforts primarily on the use of indicators within the conservation planning and natural resource assessments as conducted by the NRCS. Other uses for indicators would entail different considerations. The team did not examine the use of indicators to comply with the Government Performance Results Act of 1993 (GPRA). The requirements for GPRA reporting in terms of scope of issues and national uniformity would likely be different than those for conservation planning and natural resource assessment.

Much remains to be learned about indicators of ecosystem condition. The state-of-the-art is generally not well advanced. Some attributes of ecosystem condition can be **directly measured** (i.e., soil organic matter, soil temperature, crop yield, deer density, etc.) **statistically estimated** (i.e., national crop yields, timber volume, deer populations, conversion of wetlands, etc.) or **predicted by models** (i.e., soil erosion rates, rate of change in timber volume, global warming, watershed runoff, etc.). However many attributes of ecosystem condition, and indeed most ecosystem processes, are more difficult to describe (i.e., carrying capacity, energy transport and balance, habitat quality, niche breadth, population recruitment, biodiversity, watershed viability, soil quality etc.) leading us to search for **surrogate** or **indirect measures** of ecosystem condition. The team did not distinguish between indicators that are measured, modeled, or estimated directly from those that are indirectly assessed with surrogates, but included them all under the category of indicators.

In addressing ecosystem indicators the team accepted the definition of *ecological system* as found in the glossary of the National Planning Procedures Handbook: "the organization and interactions of communities of living things, including humans, together with the chemical and physical factors in their environment." Note that while NRCS plans conservation treatment by land use the assessment of ecosystems may often include the analysis and integration of multiple resource conditions across all land uses in the unit being assessed.

INDICATORS

The Team defined an indicator as something that measures or describes a current condition in relation to a predetermined reference or set of references and, when observed over time, demonstrates trends. Purposes for using indicators are to:

- enable land managers to make personal assessments of the impacts of their land management decisions on ecosystem condition;
- enable planners to assess ecosystem conditions including ecological, social, and economic elements at multiple scales;
- quantify objectives, enable the use of quantitative analysis tools, and facilitate the integration of multiple objectives within the planning process;
- evaluate status, condition and trends of ecological, economic and social resources;
- enable planners, advisors, researchers as well as land managers to evaluate the effects of management actions in order to; 1) make corrections in implementation plans or goals, and 2) to increase the knowledge of how systems respond to management changes; and,
- enable various publics, interest groups, and technical professionals to evaluate ecosystem conditions using a common set of terms and methods.

There are many indicators that can be used. The challenge is to narrow the list of potential indicators to those that fit within the constraints of cost, equipment, expertise, staff and training budget and still obtain meaningful information. In general, indicators should be:

- meaningful to the problem at hand;

- easy to measure and practical to use;
- capable of being repeatedly measured without introducing bias;
- socially acceptable and easily understood;
- relatively inexpensive to measure; and,
- suitable for use in status and trend reports, both statistical and non-statistical.

A potential indicator is evaluated in terms of the uses to which the information will be applied. Potential indicators are evaluated according to their attributes as listed below.

- Precision (or reproducibility) - if the measurement is made repeatedly, would the results be consistent?
- Accuracy - how closely does the measurement reflect the actual resource condition?
- Integration over Time - does the measurement reflect just this instant or does it reflect several hours, days, weeks, or years?
- Integration over Space - does the measurement reflect just this spot or does it reflect a larger area?
- Sensitivity - how much change in the actual resource condition is necessary to see change in what is measured?
- Limits of Detection - is there a threshold below which or above which the measurement doesn't work?

One should be aware of the limitations in the use of indicators. Ecosystems often exhibit similar responses to various stresses. Indicators of system-level (large scale) stress are largely nonspecific with respect to causal agents. Therefore changes in energetics, nutrient cycling, community structure and function, etc., may result from one to many stressors acting independently or in combination.

Ecosystem processes are often variable over time (e.g., they exhibit "noise") the short-term analysis of which may lead to incorrect conclusions about long-term trends. Natural fluxes or pulses often occur at irregular intervals from frequent disturbances such as storm events, and seasonal, annual, or less frequent but perhaps catastrophic events such as flooding, fires, earthquakes, etc.

INDICATOR SELECTION MODEL

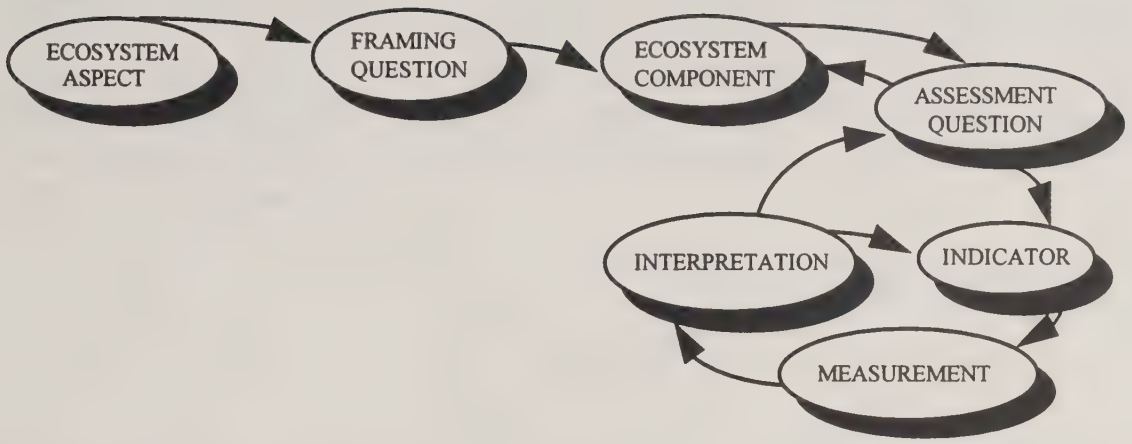
The Team recognized the need to develop a system or model to direct the selection of indicators for use in evaluations of ecosystem condition. The National Research Council's Rangeland Classification Committee proposed such a system for use in evaluating the condition of rangeland ecosystems. This system is presented in the publication, Rangeland Health: New Methods to Classify, Inventory and Monitor Rangelands (NRC, National Academy Press, Wash. D.C., 1994). The Team relied on this earlier work for guidance in constructing the Indicator Selection Model.

Fundamental to the development of the Indicator Selection Model is the notion that evaluations of ecosystem condition require responses to specific questions regarding the interrelationships and integrity of the system's soil, water, air, plant, animal, and human resources through the functioning of ecological processes within the system. The choice of criteria to use as a basis for evaluating ecosystem condition and, therefore, the selection of indicators used to measure these criteria, will depend on the questions to be answered.

Design of the Indicator Selection Model was directed by these concerns: What are the questions that need to be answered in evaluations of ecosystem condition? What are the attributes to measure that provide answers to these questions? How are the attributes measured (what indicator to use)?

The Indicator Selection Model provides a framework in which to organize thinking and provide rationale for the choice of indicators used in evaluating ecosystem condition. The model is suited for use in selecting indicators for generalized, comprehensive, evaluations of ecosystem condition, status, and quality. The model is also useful as a tool for identifying resource concerns during conservation planning activities and in the selection of appropriate criteria and indicators for monitoring the effects of management decisions.

The Indicator Selection Model is comprised of seven elements or levels: Ecosystem Aspect, Framing Questions, Ecosystem Components, Assessment Questions, Indicators, Measurement, and Interpretation. Initial use of the model is made by entering the system at the first element and proceeding through the remaining levels in a step-wise fashion. Continued application of the model to select additional indicators can be an iterative process, with re-entry at the appropriate level.



The first element of the model is **ECOSYSTEM ASPECT**. An Ecosystem Aspect represents a broad grouping of environmental, ecological, and human community considerations that are common to all natural ecosystems. Four Ecosystem Aspects are proposed; Ecosystem Processes, Recovery Processes, Landscape and Community Structure, and Abiotic Features. Ecosystem Aspect groupings serve to help describe and set boundaries for ecosystems structures and functions. Ecosystem Aspects are described in Table 1.

TABLE 1

ECOSYSTEM ASPECT	
SYSTEM PROCESSES	The functioning of internal, system-sustaining, ecological processes (flows or cycles). The cultural, social, political, and economic systems of human communities are addressed. The capacity of systems to produce commodities and satisfy values.
RECOVERY PROCESSES	Considers ecosystem structure and the functioning of ecological and human community processes that determine system resistance and resilience to disturbance or stress. Processes and mechanisms that provide for long term sustainability.
LANDSCAPE AND COMMUNITY STRUCTURE	Plant and animal species composition, the spatial and temporal distribution of species, the hierarchical assemblage of species (i.e. at different trophic levels). Human community cultural, social and economic diversity and distribution are considered. Addresses landscape patterns, their configuration and connectivity and the integrity of natural communities (including human communities).
ABIOTIC FEATURES	Considers the abiotic or physical characteristics of the ecosystem.

For each Ecosystem Aspect, one or more **FRAMING QUESTIONS** are presented as the second element of the model. Framing Questions are the minimum set of diagnostic questions that need to be answered in comprehensive evaluations of ecosystem condition. These Framing Questions are asked at all scales of ecosystem evaluation. Framing Questions are listed in Table 2. Additional framing questions should be developed to address other applications.

TABLE 2

ECOSYSTEM ASPECT	MINIMUM FRAMING QUESTIONS
SYSTEM PROCESSES	1. Are precipitation and ground water resources captured, stored, used and released in a safe and stable manner? 2. Are kinds and flows of chemicals (minerals, nutrients, other) and energy in balance and optimized for plant and animal communities and biomass production requirements? 3. Are annual cash flows, technical assistance and conservation incentives timely and adequate for desired community and landuser incomes?
RECOVERY PROCESSES	4. Are soil, water, air, plant and animal resources and biophysical processes in place and in a condition to allow timely and full recovery from stresses and disturbances and to meet management objectives? 5. Are social and economic systems available to allow landusers and communities and the resources they manage to recover from environmental and socioeconomic stresses? 6. Are there human and animal resource health concerns associated with the management of present or planned enterprises?
LANDSCAPE AND COMMUNITY STRUCTURE	7. Do landscape features and patterns facilitate use, protection and optimization of ecosystem processes? 8. Do commodity markets, investment capital and public programs encourage landuses, enterprises and resource management that are compatible with ecosystem processes? 9. Are decision-making processes available to communities and individuals to resolve conflicts regarding current and desired uses, management and protection of natural resources? 10. Does the social infrastructure (health care, education, multi-culture recognition, etc.) support and promote the desired quality of life for the communities and individuals?
ABIOTIC FEATURES	11. Are current and planned landuses and desired future conditions suited to the abiotic conditions (e.g., stream temperature, flow velocities, riffle/pool ratios, riparian shading, climate, topography, soils and geology)?

These first two elements of the model, Ecosystem Aspect and Framing Questions are proposed for use as a standard for all ecosystem evaluations, applicable at all scales or organizational levels (field, farm, watershed, state, region, etc.).

The third element of the model, **ECOSYSTEM COMPONENTS**, is a listing of related environmental, ecological, socioeconomic, cultural or political factors considered to be important elements of an ecosystem. The list of Ecosystem Components (factors, elements, attributes, characteristics) is made with reference to a specific Framing Question. Ecosystem Components identified represent potential attributes to assess that may provide answers to a Framing Question.

When the Indicator Selection Model is applied to the selection of indicators for comprehensive inventories of ecosystem condition, such factors as nutrient and energy cycles, disturbance regimes, and institutional incentives may be identified as Ecosystem Components. When the Indicator Selection Model is used during the planning process, Ecosystem Components can additionally be identified by listing resource concerns. Ecosystem Components and resource concerns are expected to vary with different kinds of ecosystems and as the scale of system evaluation changes. Examples of Ecosystem Components are shown in Table 3.

TABLE 3

ECOSYSTEM ASPECT	FRAMING QUESTIONS	EXAMPLE ECOSYSTEM COMPONENTS
SYSTEM PROCESSES	1.	Hydrologic cycle; Soil Stability; Soil infiltration rates; Vegetative cover;
	2.	Nutrient cycling; Crop/Biomass production/Decomposition rates; Atmospheric transport; Energy flow; Trophic accumulation
	3.	Financial viability; Government/Industry programs
RECOVERY PROCESSES	4.	Trophic diversity; Niche diversity; Soil potential/resiliency; Disturbance regime; Competition; Gene pool quality/quantity Contaminant buffering; Predator-prey relationships
	5.	Social safety nets
	6.	Health problems and treatment
LANDSCAPE AND COMMUNITY STRUCTURE	7.	Diversity; Connectivity; Land cover; Community dynamics; Patterns;
	8.	Economic diversity;
	9.	Institutional incentives/Constraints; Ownership;
	10.	Infrastructure; Cultural diversity; Demographics;
ABIOTIC FEATURES	11.	Topography; Soil types/potentials; Geology; Land uses; Water quality/quantity; Physical habitat; Channel morphology

ASSESSMENT QUESTIONS, the fourth element of the model, are those questions that are formulated in reference to the Framing Questions and their constituent Ecosystem Components (or resource concerns). Assessment Questions identify the topic and need for an indicator and criterion. These questions are based on the environmental features and socioeconomic conditions, the interrelationships, the processes and structure of a given ecosystem.

During the planning process Assessment Questions are typically founded on issues identified by stakeholders. Issues are revealed through an iterative process that solicits stakeholders' responses to Framing Questions. The output is an identification of ecosystem components reflecting the resource concerns within the area. If soil erosion has been raised as an issue, the stability of soils within the ecosystem becomes an assessment criterion, and the assessment question, Are the soils stable? is asked. This process is iterative because responses and the issues they lead to are not all discovered immediately. Definitive assessment questions should be tailored to specific resource concerns. Assessment Questions are developed with reference to the organization level (scale) for which the ecosystem evaluation is to be made. Examples of Assessment Questions are presented in Table 4. Additional examples of Assessment Questions are provided in Appendix A.

The fifth element of the model, **INDICATORS**, are the quantitative or qualitative assessments of ecosystem components that are needed in order to answer the Assessment Questions. Indicators are the measuring tools used to assess the status, condition, or trend of a given ecosystem attribute (ecosystem component). Ecosystem condition is not a physical characteristic that can be measured directly. The basis for the use of indicators is that relationships can be inferred between a relatively easily measured ecosystem attribute (i.e. litter distribution and amount) and more difficult to measure ecosystem components or processes (i.e. energy flow and nutrient cycling).

Application of the Indicator Selection Model requires the assessment of multiple ecosystem attributes. There is no single measure or index to ecosystem condition that provides the comprehensive evaluations necessary to respond to the Framing Questions of the model. Indicators selected will often vary by geographic scale and location, the kinds and nature of stakeholders involved in a planning effort, and the availability of resource specialists, inventory techniques and resource and socioeconomic data. Single indicators that can be used to infer multiple ecosystem attributes or that can be referenced at various scales need to be identified and used where appropriate.

During the planning process, issues must be definitive and refined sufficiently to select suited indicators. Resource specialists play an important role in validating and refining initial issues and can often provide immediate feedback on possible indicators as issues are discussed. A matrix that depicts example indicators that may be used to answer assessment questions can be found in Appendix B. The indicators in Appendix B are grouped according to the six resource considerations (Soil, Water, Air, Plants, Animals and Human) (SWAPA+H) and subheadings used in the Field Office Technical Guide

TABLE 4- Examples of Assessment Questions

Ecosystem Aspects	Framing Questions	Ecosystem Components	Example Assessment Questions
System Processes	1.	Hydrologic cycle	Are water losses to runoff and evaporation in balance with soil and plant resources?
	2.	Nutrient cycle Energy flow Decomposition	What is the spatial distribution of nutrients and energy? Are nutrients and/or minerals being lost from the system?
	3.	Financial viability Education/training knowledge	Are production efficiencies (inputs vs. outputs) sufficient to sustain system enterprises?
Recovery Process and Conditions	4.	Niche diversity Tropic diversity Soil potential	Is there evidence of recovery with human intervention? Are soil parameters within ranges sufficient to allow recovery from stresses? Is recovery impaired due to species competition?
	5.	Social safety nets	Does the community have a diverse revenue base? Does producer have discretionary income?
	6.	Health problems/treatment	Are there risks from the types and methods of application of agrichemicals?
Landscape and Community Structure	7.	Land use Ownership Connectivity	What are trends in ownership patterns? What are the patterns of land cover? To what extent is the natural vegetation fragmented?
	8.	Economic diversity	What markets are in place? What commodity programs are in place?
	9.	Incentives/constraints	What is the community dynamics? What types of partnerships exist? What is the kind and nature of community governments?
	10.	Infrasctructure	What are the health, education, and banking facilities? What is the incidence of illness that might be related to agricultural practices in the area?
Abiotic Features	11.	Topography Soil association Geology Climate Water quantity Physical habitat channel morphology	What is the landuse(s) of the resource? What are the water sources and quality of water source for desired use? What is the general texture of the surface soil horizon? Is the texture likely to make soils unstable if vegetative cover is removed? What are the key limitations of physical habitat?

(FOTG) Conservation Practice Physical Effects (CPPE) Worksheet. Additional indicators have been listed where appropriate to reflect the broader issues involved in ecosystem assessment.

The sixth element of the model, **MEASUREMENT**, is the approach used to measure the variable(s) to be assessed by the Indicator(s) selected in level five of the model. Measurement determines the units of measure to record when using a given indicator. It is important to collect indicator information using tested and generally accepted methods and procedures.

Evaluation of ecosystem condition is a judgment, not a measurement. The seventh element in the model, **INTERPRETATION**, is the process used to interpret the measured values collected using the Indicator selected in level five and the Measurement identified in level six of the model. In order to interpret the measured values, it will often be necessary to establish a target value.

"Target value" is the term used to identify the measured value (rate, amount, extent) for an indicator that is considered desirable. A target value can be the same value as a science-based criterion such as a state water quality standard for nitrate concentration in drinking water. If there is a quality criterion in the FOTG for an indicator, this quality criterion can be used as the target value. A target value may differ from the FOTG quality criterion if necessary for site-specific conditions. In the planning process, target values, or quality criteria, for indicators may initially be formulated by stakeholders and resource specialists and later refined during the inventory and analysis stages of the planning process. Target values help quantify a desired future condition.

Essential to the concept of a criterion is the notion of a **"threshold"**. A threshold separates an acceptable condition from an unacceptable condition. To set a target value, a threshold is determined or predicted. Often this work has already been done and a target value is available, or one can easily be set from published information, or by consulting with others.

If an existing quality criterion for an indicator is not available, a target value can be determined using other approaches. Ecological reference sites are commonly used to set target values. Interpretations must be able to distinguish changes that result in the crossing of a threshold from those that are only temporary because of normal fluctuations. The use of appropriate reference sites helps to filter out normal fluctuations of indicator variables. Other methods for determining target values include: experimentation; predictive models; historical records; and, in the absence of data or a reference site, best professional judgment.

USE OF INDICATORS

NRCS involvement in selection and use of ecosystem indicators should assist stakeholders to evaluate the consequences of past and proposed management actions. The Indicator Selection Model presented in this report is designed to guide stakeholders and resource planners to think beyond single resource issues and consider the condition of the larger ecosystem including human dimensions of the system. Actual monitoring of the indicators can be performed by NRCS and Conservation District personnel, the land user, local volunteers, or public agencies but the goal is for local decision-makers to become more aware of the current quality of their ecosystem, begin identifying desired future conditions, and evaluate progress towards these objectives.

Field Office Use

Following are two examples that depict the relationship of indicators to the FOTG, and the INDICATOR SELECTION MODEL described previously. Additional examples are presented in Appendix C.

Framing Question No. 1. - Are precipitation and ground water resources captured, stored, used and released in a safe and stable manner?

Ecosystem Component - Soil Stability

Assessment Question - Are the soils stable?

RESOURCE: SOIL	FOTG - Section V (CPPE)
CONSIDERATION: SOIL EROSION	FOTG - Section V (CPPE)
INDICATOR: Sheet and Rill Erosion	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: Soil loss less than "T"	FOTG - Section III (Quality Criteria)

Framing Question No. 2. - Are kinds and flows of nutrients, minerals and energy in balance and optimized with ecosystem production requirements?

Assessment Question - What is the spatial distribution of nutrients and energy?

RESOURCE: SOIL	FOTG - Section V (CPPE)
CONSIDERATION: SOIL CONDITION	FOTG - Section V (CPPE)
INDICATOR: Soil Organic Matter Content	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: 90% of reference soil(s).	FOTG - Section III (Quality Criteria)

Regional and National Use

The following examples are presented to illustrate the use of indicators for regional and national level assessments. Some indicators may be found to be robust and nationally consistent, but because natural systems are extraordinarily complex and variable other indicators may require regional interpretation.

1. Soil Leaching Class - This is an indicator of the intrinsic potential for leaching. The soil leaching class was determined at each NRI sample point in an analytical framework using site specific data for a few basic soil properties. When combined with a complex algorithm that estimates pesticide leaching classes the resulting 4X4 matrix can be used to evaluate the potential for pesticide flow from a field by leaching. The result was a procedure (Soil-Pesticide Interaction Screening Procedure) where analysts can have a high degree of confidence in estimating soil-pesticide interactions that will not leach. This index is easy to interpret and has national application.

2. Vertical Habitat Structure Index (VHSI) - This index is based on ecological theory and the hypothesis that vertically complex habitats support a richer fauna than do more simple habitats. This index was developed for use in evaluating USDA programs. NRI data were used to construct the index for each Major Land Resource Area (MLRA). When tested against geographically extensive bird data the model was validated as bird species richness and other measures of diversity were significantly ($p < 0.02$) correlated with the VHSI. However interpretation of the model is not nationally consistent as bird species richness was positively correlated with the index in MLRAs where forest cover was the natural vegetation, but was negatively correlated with the index in MLRAs in the plains regions where the natural vegetation was prairie plants or native rangeland communities, not forest land.

RECOMMENDATIONS

Recommendation:

- **Clarify agency policy to reflect a greater emphasis on using ecosystem condition indicators in planning and evaluating the results of conservation activities.**

The mission of the NRCS is to 'provide leadership and administration of programs to help people conserve, improve, and sustain our natural resources and environment.' The implementation of agency programs to achieve 'a productive nation in harmony with a quality environment' rests on our ability to objectively assess ecosystem conditions and evaluate the results of our conservation planning efforts.

A clear policy statement would define the NRCS commitment to gathering, interpreting, and analyzing information on ecosystem conditions through the use of indicators. Effective conservation planning is an evolutionary process, based on what is learned through measurement and evaluation of impacts on resource conditions. Because of the diversity of resource issues across the nation, policy should encourage the selection of indicators specific to local concerns as well as indicators reflecting national concerns.

The use of ecosystem indicators should focus on coordination with partners in the identification, collection, analysis, and use of the data. In the 'Blue Ribbon Panel report' to the Chief, questions are raised about a balance between the NRCS role of protecting natural resources while a client is interested in managing a farm or ranch for profit. If policy allows for the formulation of objectives that include a broader community view, then any accomplishments from the process will be of greater value to that community. Policy should encourage using indicators that measure both conditions that are important to the landowner and conditions that are important to the larger community.

Initially multiple kinds of indicators may need to be considered. They *may be used by customers* to evaluate the effects of changes on an individual basis, *may be used by NRCS planning personnel* in the conservation planning process or may be used to represent *Performance indicators* by management for evaluation of NRCS activities at state, regional, or national levels. The indicators for these different applications may be the same or different, it will depend on the resource issue and scale of the planning unit.

The policy statement should include specific guidance for the selection and application of indicators and incorporation into the FOTG. Under the current structure of the FOTG, information on indicators could be included in section 5. One very important application of indicators is in the measuring of conservation effects.

Recommendation:

- **A field test of the indicator selection model should be conducted at field and national levels. Coordination from the Programs and Soil Science and Resource Assessment areas will be essential in conducting this test. The initial test at the field level should begin with field offices in each of the existing ecosystem pilot sites (formally EBA) across the nation.**

The workgroup recognized that the indicator selection model described in this report needs to be refined based on a field evaluation. The current ecosystem pilot sites provide a good opportunity to conduct this test. Along with testing the model we should test how information from new indicators is incorporated into the Field Office Computing System (FOCS) and the reporting process, and the relationship to the strategic planning.

Any test of the process will depend on the resource issues identified at the field office level. Strategic 'performance' indicators should be based on a broad view of resource issues tempered with the identified concerns at the field office level. Based on the assumptions presented in this document, NRCS is in a position to collect indicator 'type' data as it is reported by field office staffs, on a wide variety of natural resource indicators - via FOCS using the National Information Management System (NIMS). A test of this process should include the following:

Identify Benchmark conditions. By definition, indicators can show trends or changes which implies a comparison against some existing or current condition. Test how best to incorporate the benchmark condition into FOCS in order to establish trends over time.

Evaluate how indicator data links to strategic planning. If current output (NIMS reports) from selected sites are to be used then strategic plans may need revision in order to relate to the resource issues and indicators that are used at lower levels of the organization.

Identify training needs for selecting and using indicators. Part of this test should be to determine the training needed to allow field office staffs to effectively use of indicators in both planning and evaluating the results of conservation activities.

Recommendation:

- **Recognize that resource knowledge can be evaluated along a continuum ranging from professional judgment to rigorous assessment methodologies.**

Indicators should be considered from both a quantitative and qualitative perspective in light of resource issues, scale of planning unit, staff available to collect data, and objectives. Quantitative measurements currently imply a value based on models,

monitoring, or extensive inventories. Qualitative indicators based on best professional judgment should contribute to a decision that "this is the right direction" or "this is not the right direction."

The perceived "value" of indicators and target values (relative to a specific resource issue) may vary with different levels of the organization. Some data could be based on local, on the land experience, some by models, and some by monitoring. This report proposes several methods for determining target values, including 'best professional judgment'. An openness to all of these approaches is important, given the nature of the approach, experience of the field office staffs, and availability of other sources of formal monitoring or expertise. Without the option of using best professional judgment, field office staffs would be limited to use of predictive models, or other assessment approaches that require extensive data, training, and or labor inputs. These more formal options must be considered for use in light of the resource problems being monitored, and other inputs needed to produce results. Data from all levels should generally describe a current (or desired future) condition. The methodology for linking the various levels of data may be difficult to establish. It will require the coordination of discipline specialists, management specialists, and strategic planning specialists and an openness to change.

Recommendation:

- **Use a common framework for selecting and evaluating ecosystem indicators to meet management expectations for all levels of the Agency.**

The selection of indicators must be coordinated so that the information generated will be useful to the field level and potentially for state, regional, and national aggregation. The local concerns identified by conservation districts and other partners should be given comparable importance as national performance indicators. In the Blue Ribbon Panel report, a statement was made that "Government Performance and Results Act of 1993...will promote accomplishments through measurable results - not processes (like meetings held), or activities (like acres mapped, plans written,...)." The report also made a recommendation relative to resource assessment to "Articulate clearly natural resource assessment needs at the local, state, regional, and national levels, in each case recognizing the specific role of NRCS."

There MUST be a common framework in which Field Office, State, Regional, and National Office resource objectives can be measured and evaluated. The indicators selection model is flexible enough to be used at all levels of the agency to assist in evaluation of ecosystem conditions. The single element that can begin to bring these various views together is the indicators selection process used within the context of the natural resource and human considerations identified in Section V of the Field Office Technical Guide (FOTG) as modified locally to meet community expectations. The resource and human considerations currently identified in the FOTG parallel more than 70% of the human and resource issues in this document (appendix D, Indicators Matrix).

The Field Office Computing System (FOCS) currently has the capability of capturing effects (quantitative or qualitative) on most of the natural resource considerations identified in the Indicators Matrix in this report. However, many of the human considerations identified in this report are not currently in FOCS.

Recommendation:

- **Interpretation of data must be a process that uses the best available knowledge recognizing the need to be flexible as new knowledge is obtained.**

Data reported from any particular field office may be quantitative or qualitative making aggregation of different elements difficult to combine. As this occurs, management needs to work with appropriate partners or discipline experts to interpret the data and pass it on to the next higher level of aggregation. Quality is best measured by the outcomes or impact on the resources (measured by site investigation, monitoring, inventory, use of models, etc.) and not by forcing a unit of measurement that is inappropriate for a particular resource issue or where the expertise is not available to measure. Conservation plans are the delivery vehicle for NRCS technical assistance and if considered as the sole measure of meeting specific resource concerns by management, will likely not be as successful from a customers point of view.

Recommendation:

- **Training on the integration of indicators into our planning process should be on a scale that is consistent with our current levels of technology, the understanding of the process by state discipline specialists and expectations from management.**

- **Once this process has been tested, reviewed, and revised the National Planning Procedures Handbook should be updated to include the process.**

As policy is implemented, training and incorporation on a new paradigm of doing business is extremely important. The agency is already in a position to take the first step forward in this process by fully implementing the revisions to the FOTG and then utilizing the functionality in FOCS to extract data as it is documented. Training will become more critical as the review and analysis of that data at state and regional levels supports the process. This could include items like development of quality criteria, clarification of resource concerns, establishment of target values, etc..

Recommendation:

- **Refinement of indicator methodology is a high priority for NRCS. The proposed set of Ecosystem Aspects and 11 Framing Questions will be used as the starting point for further development.**

- **Make assignments to NRCS Institutes, Centers, and Cooperating Scientists to fill gaps in our knowledge of ecosystem and resource quality and the indicators of that quality. This should include development of tools that can be used in the field to measure/assess resource/ecosystem status (with standardization of measurement) and a process to integrate/coordinate data with other national inventories (NRI, partner agency inventories).**

Clarification of indicators, their development, use and interpretation is a high priority for NRCS and refinements in their use should be conducted in the context of the organizational level using indicator data and how it could fit into the next layer. Another specific recommendation of the Blue Ribbon report is the "development of assessment tools and environmental indicators that quantify changes in range health, forest health, soil quality, wetlands, wildlife habitat, ...keeping in mind linkages to air and water quality". It is strongly encouraged that as indicators are developed and refined, that a multi-disciplinary approach be used as much as possible to provide a broad view of the issues.

Recommendation:

- **The National Science and Technology Consortium should be assigned the development of a document that identifies tools, processes, and other guidance that would be beneficial to field and state office staffs in development and use of indicators for all SWAPAH resource considerations.**

Guidance is needed on available indicators. The *Water Quality and Quantity Tools for Use in Planning Water Resources* was revised in 1995 to provide this type of guidance identified in this recommendation. This document could be used either as a prototype for development of a larger document or just for the water resource data in a new document. An expanded document would provide guidance to state and field office level staffs on tools or processes that are currently available and how they might be used in the process.

Recommendation:

- **The National Science and Technology Consortium should be assigned to review and comment on the current (and future) listing of effects categories that are used in FOCS.**

This review should include an evaluation of data elements including: current units, precision, min/max values, and recommendations for evaluation tools. Other recommendations might include the use of information at various levels of the agency and as new technology is accepted, recommendations for other changes within FOCS.

Recommendation:

- **A working group made up of representatives from the Programs and Soil Science and Resource Assessment areas should be established to coordinate the implementation of these recommendations.**

General acceptance by NRCS on the use of indicators is a fundamental requirement if the agency wants to 'provide leadership and administration of programs to help people conserve, improve, and sustain our natural resource and environment.' The potential impact of the use of indicators on state and field offices is such that a coordinated effort will be needed by both national program and technology staffs to support the effort. Greater use of indicators is a natural evolution of our conservation planning process. We need to invest in long term efforts to refine the indicator selection model, guidance available to support the field, and the use of information in our evaluation, progress reporting, and strategic planning.

Appendix A. Examples of Assessment Questions.

Assessment questions are presented by framing question. These questions are not intended to be an all inclusive list. Additional questions can be added by the stakeholders as needed.

Framing Question 1: Are precipitation and ground water resources captured, stored, used and released in a safe and stable manner?

Are water losses to runoff and evaporation in balance with soil and plant resources?

Are irrigation waters efficiently and timely used?

Are perennial stream flows, and ground water aquifers and water storage reservoir volumes, stable (within natural or acceptable range of variability)?

Framing Question 2: Are kinds and flows of chemicals (minerals, nutrients, other) and energy in balance and optimized for plant and animal communities and biomass production requirements?

What is the spatial distribution of nutrients and energy?

What is the temporal distribution of nutrients and energy?

Are nutrients and/or minerals being lost from the system?

Are nutrients and/or minerals accumulating in the system?

Framing Question 3: Are annual cash flows, technical assistance and conservation incentives timely and adequate for desired community and landuser incomes?

Are financial conditions or incentives sufficient to sustain system enterprises?

Are levels of landowner participation in government sponsored resource conservation programs consistent with production potentials/limitations of the system?

Framing Question 4: Are soil, water, air, plant and animal resources and biophysical processes in place and in a condition to allow timely and full recovery from stresses and disturbances and to meet management objectives?

Are pest populations being held in check by predators?

Are desired species being damaged by predators?

Has human intervention substituted for natural predation in pest control?

Are crop losses above economic thresholds?

Appendix A.

Is the system affected by periodic natural disturbance?

Is the system affected by periodic management disturbance?

Is there evidence of recovery without human intervention?

Is there evidence of recovery with human intervention?

Are soil parameters within ranges sufficient to allow recovery from stresses?

Do soils have capacity to buffer toxic effects from contaminants?

Are all levels of the food web in place and functioning?

Is recovery impaired due to species competition?

Are managed species varied spatially and temporally in order to minimize risk of catastrophic loss?

Is there sufficient genetic variation in the managed species to minimize risk of catastrophic loss?

Is there a sufficient soil seed bank to revegetate disturbed areas?

Framing Question 5: Are social and economic systems available to allow landusers and communities and the resources they manage to recover from environmental and socioeconomic stresses?

Does grower's enterprise contain diverse sources of income?

Does the community have a diverse revenue base?

Does current management system allow enterprise to remain competitive within local, national and international economies?

Does the producer have latitude to make decisions about management or do others control those choices?

Can producer pay debts/taxes?

Can producer incur new debt in response to changes in commodity and financial markets, natural conditions, or public regulations?

Does producer have discretionary income?

Does grower have access to personal, community, or public forms of financial, material, or technical assistance?

Framing Question 6: Are there human and animal resource health concerns associated with the management of present or planned enterprises?

Are there documented harmful health effects of current management methods for animals or humans?

Appendix A.

Are there risks from the types and methods of application of agrichemicals?

Are current practices safe?

Are there broader community health risks from local enterprise management?

Framing Question 7: Do landscape features and patterns facilitate use, protection and optimization of ecosystem processes?

What are the trends in ownership patterns?

What are the trends in development patterns (acreage's, ranchettes)?

What is the compatibility of developing uses?

What are the patterns of land cover?

What are the major land uses (homogeneity)?

Are there zoning restrictions?

What is the distribution of vegetation/use types?

To what extent is the natural vegetation fragmented?

What is the size class distribution and diversity of landscape patches?

Do the political borders correspond with ecological, economic, social and institutional boundaries and/or functions of interest?

What is the relationship between ecological and economic processes?

Is the ecosystem/watershed/area sufficiently uniform to produce predictable responses to changes suggested by planners, especially with respect to the ecological, economic and social considerations?

What is the spatial pattern and diversity of native flora and fauna?

What are the kinds, amounts and connectedness of habitats along water courses and water bodies?

Framing Question 8: Do commodity markets, investment capital and public programs encourage landuses, enterprises and resource management that are compatible with ecosystem processes?

What is the size class distribution and diversity of landscape patches?

What markets are in place (grain elevators, saw mill, stock yards, tourism)?

What products are supported?

What commodity programs are in place?

Appendix A.

Is there a presence of program provisions allowing land set-asides?

Framing Question 9: Are decision-making processes available to communities and individuals to resolve conflicts regarding current and desired uses, management and protection of natural resources?

What is the community dynamics?

What is the cultural diversity?

Are there subgroups or subcultures in the population?

Are there institutional constraints?

What types of partnerships exist?

What is the number of civic and community groups?

What percent of the community participates in elections, meetings and/or hearings?

What data and information processes are available?

Is there a process in place for selecting the best indicators for measuring the impact of land use decisions on ecological, economic and social conditions?

What is the kind and nature of community governments?

Is there a presence of land and water growth management plans?

What are the comparative statistics and trends on literacy and education accomplishments?

What are the kinds, frequency and ethnic attendance of cultural celebrations?

What is the history of successful citizen/community initiatives?

Framing Question 10: Does the social infrastructure (health care, education, multi-culture recognition, etc.) support and promote the desired quality of life for the communities and individuals?

How effective and efficient are the modes of transportation and communication?

Are the health, education, and banking facilities distributed for universal use?

What structure is in place to promote a healthy food supply?

What is the incidence of illness that might be related to agricultural practices in the area?

Appendix A.

Framing Question 11: Are current and planned landuses and desired future conditions suited to the abiotic conditions (e.g., stream temperature, flow velocities, riffle/pool ratios, riparian shading, climate, topography, soils and geology)?

What is the landuse (s) of the resource?

What are the major soil types and what kinds of soil properties can potentially limit the intended landuse?

What are the water sources and quality of water source for desired use?

What is the general texture of the surface soil horizon? Is the texture likely to make soils unstable if vegetative cover is removed?

Is the land surface of sufficient steepness to limit machine-intensive management options? Does the steepness contribute to slope instability?

Does the land have a general aspect toward a specific compass point?

Does the potential evapotranspiration of the site equal or exceed the average precipitation?

What are key limitations of physical habitat?

Appendix B: Ecosystem Indicators Matrix

Ecosystem Aspect:	System Processes			Recovery Processes and Conditions			Landscape and Community Structure				Abiotic Features
Framing Questions and associated Assessment Questions: / **Indicators**	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	Question 9	Question 10	Question 11
Soil											
Erosion											
Sheet and rill	X	X		X							X
Wind erosion	X	X		X							X
Concentrated flow	X	X		X							X
Classic gully		X		X							X
Streambank	X	X									X
Irrigation induced	X	X									X
Soil mass movement	X	X									X
Roads, scour areas		X									X
Soil Condition											
Tilth, crusting,	X	X		X							X
Infiltration	X										X
Compaction	X	X									X
Excess chemicals				X							X
Excess organic waste		X									X
Excess fertilizer				X							X
Excess pesticides				X							X
Soil micro/macro fauna				X							
Organic matter content				X							
Cation-exchange capacity				X							
Depth to pans/water table											X
Permeability rate											X
Shrink-swell potential											X
pH				X							X
Soil Deposition											
Onsite damage	X	X									X

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Ecosystem Aspect:	System Processes			Recovery Processes and Conditions			Landscape and Community Structure				Abiotic Features
Framing Questions and associated Assessment Questions:	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	Question 9	Question 10	Question 11
Indicators											
Offsite damage	X	X									X
Onsite safety	X					X					
Offsite safety	X					X					
Water											
Water Quantity											
Seeps	X										
Ponding/flooding	X	X		X							X
Soil subsurface saturation	X	X		X							X
Inadequate outlets	X										X
Irrig. water mgmt.	X			X							X
Nonirrigated water mgmt.	X			X							X
Onsite conveyance capacity	X										
Offsite conveyance capacity	X										
Lake/streams capacity	X										
Groundwater overdraft	X			X							X
Water Quality: groundwater											
Pesticides						X					
Nutrients/organics		X				X					
Salinity		X									X
Heavy metals						X					
Pathogens						X					
Water Quality: surface water											
Pesticides						X					
Nutrients/organics		X				X					
Turbidity	X	X									X

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Ecosystem Aspect:	System Processes			Recovery Processes and Conditions			Landscape and Community Structure				Abiotic Features
Framing Questions and associated Assessment Questions:	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	Question 9	Question 10	Question 11
Indicators											
Low dissolved oxygen		X									
Salinity		X									X
Heavy metals						X					
Temperature	X	X									X
Pathogens						X					
Aquatic habitat suitability	X	X									X
Trophic state	X	X		X		X					X
Fish community assemblage	X	X		X							X
Macroinvertebrate assemblage	X	X		X							X
Air											
Air Quality											
Airborne sediment/smoke											
Safety	X										X
Property damage	X										X
Health	X					X					X
Conveyance											X
Airborne chemical drift		X				X					X
Airborne odors											X
Fungi, molds, pollen											
Air Condition											
Air temperature		X		X							X
Air Movement											X
Humidity		X									X
Plants											
Suitability of plants											
Not well adapted to site	X	X									X
Unsuitable for intended use	X	X									X
Condition of plants											
Productivity	X	X	X	X							X

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Ecosystem Aspect:	System Processes			Recovery Processes and Conditions			Landscape and Community Structure				Abiotic Features
Framing Questions and associated Assessment Questions:	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	Question 9	Question 10	Question 11
Indicators											
Health and vigor	X	X		X							X
Damage from wind											X
Plant management											
Establishment, growth, harvest	X	X	X								
Nutrient management		X		X							
Pest management		X		X							
Crop rotations				X							
Crop genetic variability				X			X				
Non-crop genetic variability				X			X				
Percent natural vegetation							X				
Riparian zone condition							X				X
Fragmentation/connectedness of landscape patches							X				X
Natural plant communities											
Biodiversity				X			X				
Abundance of multiple seral stages				X			X				
Threatened/endangered				X							
Animals											
Habitat for Domestic and wildlife											
Food requirements		X		X							
Cover/shelter				X			X				X
Water quantity and quality	X			X		X					X
Threatened/endangered				X			X				
Wildlife habitat quality				X			X				X
Wildlife habitat quantity				X			X				X
Spatial configuration/availability				X			X				X
Fragmentation/landscape connectivity				X			X				X
Biodiversity				X			X				
Management											

Appendix B: Ecosystem Indicators Matrix

Ecosystem Aspect:	System Processes			Recovery Processes and Conditions			Landscape and Community Structure				Abiotic Features
Framing Questions and associated Assessment Questions: / **Indicators**	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	Question 9	Question 10	Question 11
Population/resource balance		X		X							
Animal health		X		X							
Human											
Economics											
Finanical viability											
Production costs											
Enterprise production costs			X		X			X			
Mortgage/rent			X								
Tax Payments			X					X		X	
Debt payments			X		X						
Commodity prices			X		X			X			
Access to production credit			X		X			X		X	
Access to technical assistance			X	X	X			X		X	
Access to production inputs					X		X	X		X	
Access to markets											
Government incentives											
Conservation financial assistance			X					X		X	
Tax incentives			X					X		X	
Crop subsidy payments			X		X			X		X	
Competitiveness in market			X		X			X			
Diversification of farm enterprises				X	X		X				
Off-farm income			X		X						
Family net income			X		X						
Discretionary income			X		X						
Infrastructure availability											
Transportation					X		X	X		X	
Communication					X		X			X	
Energy sources					X		X			X	
Social											
Mgmt. experience/knowledge					X						

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Ecosystem Aspect:	System Processes			Recovery Processes and Conditions			Landscape and Community Structure				Abiotic Features
Framing Questions and associated Assessment Questions: / **Indicators**	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	Question 9	Question 10	Question 11
Cultural values and social norms								X	X		
Personal networks: family/friends					X				X		
Community support organizations					X				X	X	
Land ownership patterns							X				
Land development patterns							X				
Participation in public decisions									X	X	
Institutional											
Public social support programs			X		X			X		X	
Insurance					X			X			
Regulatory constraints			X		X			X			
Educational systems					X					X	
Health care systems					X	X				X	
Major health problems						X				X	
Agrichemical handling						X					
Animal waste handling						X					
Farm safety procedures						X					

Appendix C. Example Uses of the Indicator Selection Model in Relationship to the FOTG.

Framing Question No. 1. - Are precipitation and ground water resources captured, stored, used and released in a safe and stable manner?

Ecosystem Component - Soil Stability

Assessment Question - Are the soils stable?

RESOURCE: SOIL	FOTG - Section V (CPPE)
CONSIDERATION: SOIL EROSION	FOTG - Section V (CPPE)
INDICATOR: Sheet and Rill Erosion	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: Soil loss less than "T"	FOTG - Section III (Quality Criteria)
INDICATOR: Wind Erosion	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: Soil loss less than "T"	FOTG - Section III (Quality Criteria)

Assessment Question - Are water losses to runoff and evaporation in balance with soil and plant resources?

RESOURCE: SOIL	FOTG - Section V (CPPE)
CONSIDERATION: SOIL EROSION	FOTG - Section V (CPPE)
INDICATOR: Concentrated Flow Erosion	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: Less than 125% of incised flow channels in relation to reference site(s)	FOTG - Section III (Quality Criteria)
CONSIDERATION: SOIL CONDITION	FOTG - Section V (CPPE)
INDICATOR: Infiltration	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: 75% of reference site(s) infiltration rate	FOTG - Section III (Quality Criteria)
RESOURCE: WATER	
CONSIDERATION: WATER QUANTITY	FOTG - Section V (CPPE)
INDICATOR: Vegetative Cover	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: 75% or more cover in relation to reference site	FOTG - Section III (Quality Criteria)

Framing Question No. 1 and Assessment Question Continued:

LAND USE*: CROPLAND	
RESOURCE: PLANTS	
CONSIDERATION: PLANT CONDITION	FOTG - Section V (CPPE)
INDICATOR: Plant productivity	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: 90% of crop production in relation to reference levels	FOTG - Section III (Quality Criteria)

Assessment Question - Are irrigation waters efficiently and timely applied?

RESOURCE: SOIL	FOTG - Section V (CPPE)
CONSIDERATION: SOIL EROSION	FOTG - Section V (CPPE)
INDICATOR: Irrigation Induced Erosion	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: Soil loss less than "T"	FOTG - Section III (Quality Criteria)

RESOURCE: WATER	
CONSIDERATION: WATER QUANTITY	FOTG - Section V (CPPE)
INDICATOR: Irrigation Efficiency	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: Irrigation efficiency of 90% of system capability	FOTG - Section III (Quality Criteria)

Assessment Question - Are perennial stream base flows, and ground water aquifer and water storage reservoir volumes, stable (within the natural or acceptable range of variability)?

RESOURCE: SOIL	FOTG - Section V (CPPE)
CONSIDERATION: SOIL EROSION	FOTG - Section V (CPPE)
INDICATOR: Amount of Eroded Streambank	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: 90% of streambank with suitable cover	FOTG - Section III (Quality Criteria)

RESOURCE: WATER	
CONSIDERATION: WATER QUANTITY	FOTG - Section V (CPPE)
INDICATOR: Damage to land, crops, or or structures resulting from overland flow	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: No damage within normal range of climatic varibility	FOTG - Section III (Quality Criteria)

* Indicators may change with differing land uses.

Framing Question No. 1 and Assessment Question Continued:

INDICATOR: Available storage capacity in relation to potential storage capacity	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: 75% of potential (within the range of climatic variability)	FOTG - Section III (Quality Criteria)

INDICATOR: Water Table Level	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: 90% of reference levels	FOTG - Section III (Quality Criteria)

RESOURCE: PLANTS	
CONSIDERATION: PLANT SUITABILITY	FOTG - Section V (CPPE)
INDICATOR: Species Composition of Streambank Vegetation	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: 80% similiarity of vegetation in relation to reference stream(s)	FOTG - Section III (Quality Criteria)

Framing Question No. 2. - Are kinds and flows of nutrients, minerals and energy in balance and optimized with ecosystem production requirements?

Assessment Question - What is the spatial distribution of nutrients and energy?

RESOURCE: SOIL	FOTG - Section V (CPPE)
CONSIDERATION: SOIL CONDITION	FOTG - Section V (CPPE)
INDICATOR: Soil Organic Matter content	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: 90% or more of reference soil(s).	FOTG - Section III (Quality Criteria)

INDICATOR: Soil Chemical/Nutrient Content	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: Within 10% of reference soil(s).	FOTG - Section III (Quality Criteria)

LAND USE*: RANGE	
RESOURCE: PLANTS	
CONSIDERATION: PLANT CONDITION	FOTG - Section V (CPPE)
INDICATOR: Ecological Condition	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: 60% of species composition and productivity relative to reference conditions	FOTG - Section III (Quality Criteria)

* Indicators may change with differing land uses.

Framing Question No. 2 and Assessment Question Continued:

LAND USE*: CROPLAND	
INDICATOR: Plant Productivity	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: 90% of crop production relative to reference level(s)	FOTG - Section III (Quality Criteria)

LAND USE*: CROPLAND	
RESOURCE: PLANTS	
CONSIDERATION: PLANT CONDITION	FOTG - Section V (CPPE)
INDICATOR: Cropping System - Crops, Cropping Sequence, and Crop Residue Use	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: Soil condition rating less than or greater than 1	FOTG - Section III (Quality Criteria)

LAND USE*: RANGE	
RESOURCE: ANIMALS	
CONSIDERATION: MANAGEMENT	FOTG - Section V (CPPE)
INDICATOR: Utilization of Key Forage Species	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: 50% use of current seasons growth	FOTG - Section III (Quality Criteria)

Assessment Question - What is the temporal distribution of nutrients and energy?

LAND USE*: CROPLAND	
RESOURCE: PLANTS	
CONSIDERATION: PLANT CONDITION	FOTG - Section V (CPPE)
INDICATOR: Cropping System - annual vs. perennial crops/crop sequence (crop growth period relative to growing season length)	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: % of reference level(s)	FOTG - Section III (Quality Criteria)

LAND USE*: RANGE	
INDICATOR: Species Compostion (active growth period for present vegetation relative to growing season length)	FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: 100% of growing season	FOTG - Section III (Quality Criteria)

* Indicators may change with differing land uses.

Framing Question No. 2 Continued:

Assessment Question - Are nutrients and/or minerals being lost from the system?

RESOURCE: WATER
CONSIDERATION: WATER QUANTITY — FOTG - Section V (CPPE)
INDICATOR: Vegetative Cover — FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: 90% of reference site(s) — FOTG - Section III (Quality Criteria)

LAND USE*: CROPLAND
CONSIDERATION: WATER QUALITY — FOTG - Section V (CPPE)
INDICATOR: Amount of Nutrient Organic Materials in runoff water — FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: Meet Water Quality Standard — FOTG - Section III (Quality Criteria)

OR

INDICATOR: Rates and timing of nutrient applications — FOTG - Section III (Quality Criteria)
EXAMPLE TARGET VALUE: Amount and timing withing range of reference site(s)

LAND USE*: CROPLAND (Irrigated)
INDICATOR: Depth of Percolation — FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: 90% of reference site(s) — FOTG -Section III (Quality Criteria)

Assessment Question - Are nutrients and/or minerals accumulating in the system?

RESOURCE: SOIL — FOTG - Section V (CPPE)
CONSIDERATION: SOIL CONDITION — FOTG - Section V (CPPE)
INDICATOR: Organic Waste Content on/in soil — FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: Less than 110% of reference site(s). — FOTG - Section III (Quality Criteria)

OR

INDICATOR: Rates and Timing of organic waste applications on/in soil relative to reference site(s). — FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: Amount and Timing within range that is appropriate for reference site(s) — FOTG - Section III (Quality Criteria)

* Indicators may change with differing land uses.

Framing Question No. 2. and Assessment Question Continued:

INDICATOR: Soil Chemical/Nutrient Content — FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: Within 10% of reference soil(s) — FOTG - Section III (Quality Criteria)

Framing Question No. 3. - Are annual cash flows and conservation incentives timely and optimized for desired community(ies) and landuser incomes?

Assessment Question - Are production efficiencies (inputs vs. outputs) sufficient to sustain system enterprises?

LAND USE*: RANGE
RESOURCE: PLANTS
CONSIDERATION: PLANT CONDITION — FOTG - Section V (CPPE)
INDICATOR: Plant species composition and productivity — FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: 90% of reference conditions — FOTG - Section III (Quality Criteria)

LAND USE*: RANGE
RESOURCE: ANIMAL — FOTG - Section V (CPPE)
CONSIDERATION: MANAGEMENT — FOTG - Section V (CPPE)
INDICATOR: Calving Percentage and calf weaning weights — FOTG - Section V (CPPE)
EXAMPLE TARGET VALUE: 90% of reference herds

LAND USE*: RANGE
RESOURCE: HUMAN
CONSIDERATION: STANDARD OF LIVING
INDICATOR: Beef Cattle Prices
EXAMPLE TARGET VALUE: 90% of local prices

LAND USE*: RANGE
INDICATOR: Production Costs (fixed plus variable) per pound of beef produced
EXAMPLE TARGET VALUE: 90% of reference costs/production ratio

* Indicators may change with differing land uses.

Framing Question No. 3 Continued:

Assessment Question - Are levels of landowner participation in government sponsored resource conservation programs consistent with production potentials/limitations of system?

RESOURCE: HUMAN
CONSIDERATION: CONSERVATION PROGRAMS
INDICATOR: Number of Conservation District Cooperators
EXAMPLE TARGET VALUE: 75% of total operating units

Appendix D. NRCS Indicators Action Team Members.

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