AREA 3

Biodiversity indicators must be matched to land-use objectives.

Finding 3A
Biodiversity is too broad a concept and too variable across forest types to be represented by a universal set of indicators.

No matter how far science advances understanding of sustainable forestry, the only way to monitor the status of biodiversity is through indicators—a relatively few measures that provide information about the status of as many unmeasured biodiversity elements as possible. We will never have the ability to track "life in all its forms."

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NCSSF Results: Forest stakeholders and decision makers need to partition biodiversity into discrete components, such as aquatic/riparian values, late-successional values, early-successional values, game species values, snag and down wood values, or other specific components that are to be sustained. Only when this level of specificity is reached about values to be sustained by a specific forest or landscape can informative indicators be selected (NCSSF A8: *Identification of Biodiversity Indicators to Apply to Sustainable Forestry*).

In any forest type, at any scale, indicators are tools for assessing success or failure at maintaining biodiversity. Therefore, indicators must be chosen carefully. This hasn't always happened in sustainable forestry. But through the first and second phases of the A8 project, NCSSF has fostered the development and refinement of a tool to help select biodiversity indicators. ■

Finding 3B
Clear objectives and processes are crucial to selecting appropriate sets of indicators.

Various policy initiatives have developed biodiversity indicator systems, beginning with the 1992 Montreal Process Criteria and Indicators. Since then, sustainable forest management certification systems such as—the Forest Stewardship Council, Sustainable Forestry Initiative, Canadian Standards Association, American Tree Farm System, Green Tag—have emerged with their own sets of biodiversity performance measures and indicators. In 2002, the Heinz Center for Science, Economics, and the Environment released the *State of the Nation's Ecosystems* report with a peer-reviewed, agreed upon small set of national-scale indicators that is updated periodically. NCSSF A8 identified more than 2,000 biodiversity indicators currently in use or proposed by scientists.

NCSSF Results: The bottleneck in effective selection and use of indicators is not a lack of good indicators or good science, but rather the lack of (1) clearly articulated management objectives for the values to be sustained and (2) a clear process for selecting indicators to reflect specific values and objectives. Therefore, although stakeholders may repeatedly select certain indicators for different situations (e.g., forest types, scales of application), a universal "core set" isn't useful (NCSSF A8).

NCSSF A8 research suggests that any tendency within laws, regulations, or certification systems to rely on only a few "core" indicators across large forests or landscapes can produce significant distortions or unintended consequences—the indicators may not be efficient or reflect the values or conditions to be sustained. Other NCSSF research shows that no single measure is adequate to measure biodiversity in sustainable forestry; multiple measures will be necessary (NCSSF A5W, A5E). ■

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Finding 3C
A logically structured process is needed for selecting indicators.

Based on NCSSF survey research, decision makers said they were constrained in using indicators due to a lack of:

- existing data to calculate indicators
- information about how to select indicators
- information about how to use indicators
- credible indicators
- money (cost was listed first as the most constraining factor).

NCSSF Results: The reliability of identified measures is frequently questioned, at least in part because selection of indicators often has lacked transparency, social inclusiveness, and/or a logical structured process for selecting indicators that are locally appropriate and reflect values to be sustained (NCSSF A8).

Many forest managers and policy makers have been frustrated by the lack of a logical, stepwise, transparent process for selecting indicators. This frustration can be addressed by:

- subdividing biodiversity into more separate, workable units
- selecting indicators with a structured process so that their meaning can be interpreted by stakeholders and used by managers in forest decision making.

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Forest stakeholders must participate in the early stages of indicator selection to identify biodiversity values that interest and concern them. Scientists and forest managers can then help select indicators that track the societal values most cost-effectively. A follow-up project sponsored by NCSSF is developing and testing a new indicator selection process that meets these needs. Some key science priorities for biodiversity indicators are:

- testing the effectiveness of policy response indicators that measure the level of policy response being taken to reduce pressure on a biodiversity value
- improving species-habitat associations for "coarse-filter" indicators that measure broad indicators of ecosystem health
- extracting useful indicators from existing state, regional, and national databases
- conducting critical analysis to determine the most at-risk species, structures, and processes in individual forest systems
- identifying indicator thresholds (i.e., critical levels below which a biodiversity value is compromised).

A large gap remains between researchers who study forest biodiversity indicators and decision makers and users. This gap results from a lack of communication and information flow. Most decision makers face substantial information barriers in using biodiversity indicators. Researchers often are only weakly influenced by decision makers and are not meeting their information or applications needs (NCSSF A8). Most decision makers do not use peer-reviewed science journals as a primary source of information. Although researchers were key sources of forest biodiversity information for some decision makers, decision makers did not influence most researchers' selection of research topics. Conversely, researchers often feel their work is not understood and used effectively by decision makers. ■

Finding 3D

An effective set of indicators includes three different types that cover five separate functions.

Based on a new framework of evaluation criteria, NCSSF-funded research identified many good biodiversity indicators for sustainable forestry—and many poor ones.

NCSSF Results: Informative biodiversity indicators for any single biodiversity value should measure (NCSSF A8):

- **current condition of the biodiversity value (a condition indicator)**
- **the level of one or more pressures affecting the value (a pressure indicator)**
- **the level of policy response being taken to reduce pressure (a policy response indicator).**

Each candidate indicator should be evaluated for:

- ecological breadth—number of other ecosystem components correlated to the indicator
- practicality—feasibility of measuring the indicator, including cost, time, and skill
- relevance—degree to which the indicator responds to the stress from a particular influence; e.g., timber harvesting as opposed to air pollution, or vice versa
- scientific merit—extent to which science supports the indicator
- usability— the ability of stakeholders to use the indicator to make decisions.

Table 2 lists indicators that exemplify these five characteristics. They can be used to thoroughly evaluate effective and informative indicators for use. Indicators of habitat quality are often surrogates for direct measures of biodiversity. Some indicators will be more generally applicable and will have direct links to biodiversity. Others will be less direct. For example, ongoing NCSSF research shows great promise for new, widely applicable indicators based on soil biology and chemistry.

In NCSSF's review of existing indicators, 47 received high scores for scientific merit, ecological breadth, and practicality. These included some commonly used indicators such as:

- the percent of forest in different forest types
- the percent of forest in different age classes (including late-successional and old-growth classes where they would naturally occur).
- various measures of standing and fallen dead wood, amount of forest, and age classes
- tree size
- harvest rate in managed forest settings.

These are predominantly condition indicators. Pressure and policy indicators would also be required to create an effective mix for even the broadest set of biodiversity objectives. ■

Table 2

Examples of Effective Indicators Identified by Functional Category (NCSSF A8)

Top-Ranked Indicators for Scientific Merit (*Scientific basis and support for an indicator*)		**Top-Ranked Indicators for Utility** (*An indicator's level of usefulness for decision makers*)		**Top-Ranked Indicators for Practicality** (*Ease of measuring an indicator*)		**Top-Ranked Indicators for Relevance** (*Responsiveness to stressors in a decision making or policy area*)		**Top-Ranked Indicators for Ecological Breadth** (*Degree with which an indicator indicates something about the entire ecological system*)	
Water cycle	3	Forest age	2.4	Soil layers	2.67	Aquatic and riparian water quality forestry BMPs	3	Aquatic fine woody debris	3
Tree harvesting levels	2.87	Forest type composition	2.36	Epiphytes	2.6	Biodiversity terrestrial forestry BMPs	3	Aquatic logs LWD	3
Hydrology	2.75	Aquatic and riparian water quality forestry BMPs	2.18	Late-successional species dominance	2.6	Canopy structure	3	Disturbance regimes indices	3
Logging road coverage	2.75	Biodiversity terrestrial forestry BMPs	2.18	Bird indicator species	2.5	Cavity nesting bird species	3	Ecosystem biomass	3
Disturbance-related bird species	2.62	Habitat supply	2.18	Bird indices of biotic integrity	2.5	Disturbance regimes indices	3	Habitat supply	3
Habitat supply	2.62	Snags	2.18	Cavity nesting bird species	2.5	Ecosystem biomass	3	Logging road coverage	3
Stand age distribution	2.62	Stand age distribution	2.18	Disturbance-related bird species	2.5	Ecosystem respiration	3	Stream canopy cover	3
Forest age	2.57	Tree size/density	2.18	Exotic plant species	2.5	Exotic plant species	3	Tree harvesting levels	3
Aquatic and riparian water quality forestry BMPs	2.5	Ecosystem biomass	2.09	Forest bird species	2.5	Foliage height diversity	3	Aquatic macro-invertebrates	2.75
Disturbance regimes indices	2.5	Forest soil BMPs	2.09	Lichen indices of biotic integrity	2.5	Forest age	3	Cold-water Fish	2.75

1 = poor; 2 = fair; 3 = good

Implications of Area 3 Findings for Sustainable Forestry

Policy indicators establish overall directions and objectives. Condition and pressure indicators are expressed with units of measure (e.g., snags/acre, rotation length, etc.) and provide information on current conditions and trends. As a result, policy, condition, and pressure indicators all would be useful in making management decisions and in achieving biodiversity objectives in sustainable forestry (Table 3).

As forest certification systems and regulatory programs address the need to manage and protect certain aspects of biodiversity, policies and plans must address biodiversity indicators. Major certification systems and regulatory programs tend to emphasize *policy response* indicators, e.g., land area in reserves or the existence of a snag policy and management plan. Some use *condition* indicators such as criteria for wildlife habitat to be retained, e.g., percent of land area in early successional vegetation, to a limited degree.

What is generally lacking is system flexibility and a process that forest managers can use to select condition and pressure indicators tailored to specific biodiversity values to be sustained in a specific forest or landscape. These indicators must be easy to measure and audit. This suggests the need to reassess the role of indicators and how they are selected and used in certification systems or regulatory programs.

For example, large-diameter snags are known to be important for biodiversity in many forest types. A sample condition indicator for large snags might be the density of large snags in the landscape. This metric tells us about the status, or condition, of the resource at present, and has units of measure (snags/acre). Research continues to improve understanding of relationships between condition indicators and biodiversity, such as that between snag density and the diversity and abundance of woodpecker species, or whether snags should be distributed evenly across the property or clustered in streamside zones and other small reserves.

A pressure indicator would tell something about where a resource is headed. A good pressure indicator might be harvest rotation length. If the present-day rotation length is too short to allow large diameter snags to develop, there will be fewer large-diameter snags in the future, regardless of the current density as indicated by the condition indicator.

In this respect, condition indicators alone can be misleading—evidence of change in a condition indicator may come too late, whereas pressure indicators can provide an early warning to future change in condition. Finally, a policy response indicator might be the presence of an internal policy for snag management. One of the easiest ways to identify policy response indicators is when there are no units of measure for the indicator (NCSSF A8).

Good indicators will have high scientific merit; i.e., a well-established scientific relationship between the indicator and the value(s) of concern. An indicator has good ecological breadth when it is correlated to a large number of other values that are not being measured. For example, large living-tree density, e.g., density of trees greater than 18 inches in diameter, can be a good indicator of mature forest epiphytes such as sensitive mosses and lichens, nesting habitat for raptors, and future large-diameter snag density.

Table 3
Types of Biodiversity Indicators (NCSSF A8)

Different types of indicators are designed to provide decision makers with different kinds of information. If indicators are chosen from each the three types listed, decision makers will be much better able to track performance for sustainability.

Type	Purpose
Condition	To indicate the level, or **condition**, of a specific value to be sustained (e.g., indicator: density of large-diameter snags).
Pressure	To indicate the **level of a stressor** affecting the **condition** of a value of interest (e.g., indicator: rotation length [a pressure that affects density of large-diameter snags]).
Policy Response	To indicate the level of **policy action** taken to maintain the **condition** or reduce the **pressure** (e.g., indicator: existence of a management strategy for maintaining large-diameter snags).

Practicality and utility are important to forest managers. Indicators are practical if they are not expensive to measure, do not require special skills (e.g., a plant taxonomist) to measure, and do not require complicated analysis. Utility refers to the forest manager's ability to use the indicator to make a decision. If the measured indicator metric does not guide the manager in making decisions, the indicator has low utility (Table 4). If indicators have been evaluated and have the above characteristics, they probably will be useful. They will inform decision makers and help them develop policies and objectives related to sustainable forestry. They will also be useful to independent auditors in assessing conformance with forest certification programs.

Using indicators to monitor results is an important way to determine if desired goals are being met. Effective monitoring can be based on a formal census of target species, or it may use informal tracking and recording of individual species or indicator occurrences encountered through other activities.

The Forest Biodiversity Indicators Selection Web Tool (NCSSF A8) helps forest managers, stakeholders, and policy makers to navigate the complex process of measuring biodiversity for sustainable forestry and provides users with a list of relevant indicators. NCSSF is now funding a set of pilot activities (NCSSF A8 II) focused on refining its utility and effectiveness by field testing the indicator selection process with stakeholder groups in various regions. The project includes "train the trainers" workshops to create a nationwide pool of people who can help others use the web-based selection tool and conduct the workshop-based selection process.

Table 4

Biodiversity Indicator Evaluation Criteria (NCSSF A8)

Before specific indicators are selected for use in any sustainable forestry situation, each should be evaluated for each of 5 categories of evaluation criteria. Indicators that are not evaluated for these criteria are unlikely to serve decision makers or stakeholders well.

Evaluation Category	Description
Relevance	The degree to which the indicator responds to the stressor of concern; e.g. timber harvesting as opposed to air pollution.
Scientific merit	Extent to which the indicator is supported by science.
Ecological breadth	The number of other ecosystem components (species, structures, and/or processes that the indicator indicates.)
Practicality	The feasibility, including cost, time, and skill required, of measuring the indicator.
Utility	Ability of decision makers to make decisions with the indicator.