5.9 Challenges and Data Gaps

The availability of indicators across ecosystem types is summarized in Exhibit 5-44. Indicators that currently can provide national information on ecological condition are available for only 14 of the possible 126 indicator categories in the framework. More than half of the Category 1 indicators provide information only on ecosystem extent and landscape composition, with a few exceptions:

- The Forest Inventory and Analysis (FIA) and Forest Health Monitoring (FHM) programs together have achieved representative national coverage for both the present status and historical trends in the occurrence of fire, insect damage, and disease for forests.
- Satellite data provide continent-wide status and trends in the Normalized Difference Vegetation Index (NDVI), which serves as a surrogate for primary productivity, or the amount of energy available at the base of the ecosystems.[17]
- Historical hydrology data were analyzed for The Heinz Center report to determine trends in high and low-flows for more than 800 streams with no specified land cover and more than 500 forest streams across the U.S., and the number and duration of dry periods were calculated for 152 streams in grasslands, shrublands, and dry areas. These analyses could presumably have been performed for urban/suburban, agricultural, and very large watersheds, but they have not been performed to date.
- The current status and historical trends in the potential for sediment transport from farmland can be calculated from existing data (though not the amount of sediment actually lost).

For the rest of the essential ecological attributes, only partial data exist, at best (e.g., regional data or data for only part of the resource), for one or more indicators. For more than one-half of the major indicator categories in the seven ecosystem types, not even one indicator was identified for this report. For many more, only one existed, though several would be necessary. This situation will improve slightly in the next year or two. A number of active research programs are collecting and analyzing relevant ecological condition data at the national or regional level, but the results had not yet met the criterion for peer review at the time this report was finalized. Two years from now, research on indicators from the FIA program, FHM program, the National Water Quality Assessment (NAWQA) program, and the Environmental Monitoring and Assessment Program (EMAP) Western Streams Pilot should provide new Category 2, and a few Category 1 indicators, primarily biotic condition and ecological process indicators. As of now, the gaps are substantial.

[17]There is some debate as to whether standing crop chlorophyll can really be a surrogate for primary productivity, so this might be more appropriate as an ecosystem condition indicator.

What the Available Indicators Reveal about Some Ecological Issues of Recent Concern to EPA

The introduction to this chapter identified three reasons to monitor ecological condition:

- To establish baselines against which to assess the current and future condition of ecosystems.
- To provide a warning that action may be required.
- To track the outcomes of policies and programs, and adapt them as necessary.

This section addresses the question of how well the available indicators of ecological condition, notwithstanding the gaps evident in Exhibit 5-44, serve these purposes for some ecological issues that have been of concern to EPA over the past decade. These do not reflect all such issues, or signify EPA's priorities, but simply typify a diverse set of challenges for national ecological monitoring:

- Forest dieback
- Vertebrate deformities
- Harmful algal blooms
- Eutrophication
- Loss of biodiversity
- Non-target organism effects from pesticides and herbicides
- Issues related to ozone, UV-B, mercury, acidic deposition, and persistent bioaccumulative toxics (PBTs)

For the first five issues listed above, biota were harmed before the cause was known. For the other two, a perceived risk exists, but the extent of actual harm or exposure is unknown. In either case, data on the extent or trends in ecological condition is needed to inform how research is targeted or regulatory programs adjusted. Identifying indicators of the appropriate essential ecological attribute also should help to identify some of the factors that might be contributing to the extent of and trends in harm to biota and ecosystem function (EPA, SAB, 2002).

Forest dieback

Forest dieback can be exacerbated, if not caused, by some combination of acid deposition, air pollution, UV-B radiation, disease, insects, and unusual climate events (USDA, FS, 2002). Currently, the forest indicators provide a baseline for the extent of poor tree condition in 37 states; soon, these indicators will provide a baseline and future trends for the conterminous U.S. NDVI data are available as a surrogate for primary productivity in forests. FIA program plots are being examined for indications of harm to ozone-sensitive species. Relevant soil data (exchangeable base cations) are being measured, even

though that indicator cannot yet be reported. A UV-B monitoring network has been collecting data for less than 2 years, and the data are currently being evaluated. Data for ozone and acid deposition in high elevation forests remain poor, as do climate data. Most of these indicators are being monitored using a probability design, so continued FIA monitoring can provide a national baseline for assessing the extent and trends in forest dieback, and some of the EEAs that may contribute to it.

Vertebrate deformities

The ability of exogenous chemicals to interfere with normal endocrine functioning and related processes of an organism has raised increasing concerns for human health and the environment. Studies have reported that both synthetic and naturally occurring compounds interfere with normal endocrine function of invertebrates, fish, amphibians, reptiles, birds, and mammals causing effects such as birth defects, impaired fertility, masculinization of female organisms, feminization of male organisms, or organisms with both male and female reproductive organs. Two recent reports summarize available data from field and laboratory studies and provide an assessment of the state of the science (EPA, RAF, 1997; IPCS, 2002). The existing challenge is to further elucidate the cause-and-effect relationships for the observed adverse effects, determine which chemicals are of greatest concern, and the extent to which these chemicals negatively impact populations of fish and/or wildlife.

The only indicator identified in this chapter that tracks the extent or trends in animal deformities (irrespective of the cause) is a Category 2 indicator, Fish Deformities, collected by EMAP in coast and ocean ecosystems. Data are being collected on amphibian deformities by the USGS, using reports from a wide array of sources. A new national survey, the Amphibian Research and Monitoring Initiative, was established by USGS in 2000. However, it may be several years before USGS and EPA can detect national and/or regional trends from this initiative. Until there is a better understanding of which chemicals are of greatest concern, there is also some question about which chemi-

Exhibit 5-44: Distribution of available ecological condition indicators across the ecosystem types

Essential Ecological Attribute	Forests	Farmlands	Grasslands/ Shrublands	Urban/ Suburban	Fresh Waters	Coasts and Oceans	The Nation
Landscape Condition							
Extent of Ecological System/Habitat Types	1 1	1	1	1	1 1	1	1
Landscape Composition	2	1		2	2	2 2	
Landscape Pattern/Structure	2						
Biotic Condition							
Ecosystems and Communities	2		1 2		2 2 2 2 2	2 2 2	2
Species and Populations	2				2	2	2
Organism Condition	1 2 2				2	2 2	
Ecological processes							
Energy Flow							1
Material Flow	2						1
Chemical & Physical Characteristics							
Nutrient Concentrations	2	2 2		2 2	2 2	2 2	
Other Chemical Parameters	2 2				2	2 2	
Trace Organic /Inorganic Chemicals		2 2 2 2		1 2	2	2 2	2
Physical Parameters	2					2	
Hydrology and Geomorphology							
Surface and Ground Water Flows	1		1		1		
Dynamic Structural Conditions							
Sediment and Material Transport	2	2 2			2		
Natural Disturbance Regimes							
Frequency	2						
Extent							
Duration							

Note: Numbers correspond to indicator categories presented in this report.

cals to monitor in the fish and wildlife habitat. Additional information on chemicals will become available once EPA has fully implemented an Endocrine Disruptor Screening Program to test a chemical for its potential endocrine disruption activity.

Harmful algal blooms

Scientists have also been concerned about the condition of the nation's estuaries and in particular, about a perceived increase in harmful algal blooms (HABs); loss of submerged aquatic vegetation (SAV), which serves as habitat for fish; and sediment toxicity, which might limit the productivity of an important component of the estuarine food chain (Anderson and Garrison, 2000; Gallagher and Keay, 1998). EMAP, working with the states, has collected data on the condition of SAV, estuarine fish communities, estuarine benthic communities, sediment toxicity, and nutrient concentrations that should provide representative status and trends data for these indicators. The sampling design does not allow tracking of the frequency and extent of HABs or nutrient levels in estuaries, but USGS does monitor nutrient loads to coastal systems from four of the largest U.S. rivers. Continued monitoring of the estuaries is subject to state-by-state availability of funding.

Eutrophication

EPA has recently focused substantial attention on the listing by the states of their waters that do not meet their designated uses (usually expressed in terms of their ability to support aquatic life), and developing total maximum daily loads of pollutants that would allow the designated use to be achieved. Concern over eutrophication of lakes and reservoirs has prompted EPA to begin developing regional standards for the nutrients nitrogen and phosphorus. At present, there is no indicator monitoring suitable to track progress in reducing the number of eutrophic lakes and streams or the condition of the biotic communities in rivers and streams at the national or even regional level. Indicators monitored by the states are not comparable, the same waters are not necessarily sampled over time, and their representativeness is unknown and questionable. NAWQA uses comparable methods and intends to monitor the same streams over time, but the number of such streams in the various ecosystem types is too small to adequately represent all the factors that contribute to water quality at the national level. While the data are likely to be broadly representative of certain types of streams, they cannot be expanded to all streams with known statistical reliability. This fact is particularly important if the combination of factors affecting water quality in the study units (which depend on a variety of factors, including water quality management by the states, national patterns of air pollution and acid rain, geology and land use, and climate) is not statistically representative of these factors nationally. EMAP has demonstrated regional approaches to statistically representative sampling that include both biology and chemistry, but has not yet reported on relationships between them, nor is there any long-term commitment to repeating the pilot studies or expanding them to other regions. EPA is currently working with the states to rectify this situation, and some progress is reported in Chapter 2, Purer Water.

Loss of biodiversity

EPA is concerned generally about biodiversity, and this is one of the primary areas on which EPA comments in Environmental Impact Statements for significant projects involving federal funding under NEPA. The NatureServe indicator reported for many of the ecosystems is invaluable in indicating species at risk in the vicinity of such projects. Because the database is not based on a systematic survey of plots over time, however, it is not clear how to interpret data that are not reported. For example, the current data cannot distinguish naturally rare species from species whose numbers have been reduced. It is not clear how to determine whether future trends are the result of better (or less) field work or the actual status of the species in question. The answer likely depends on the species, but at this point the data seem less than ideal for national reporting.

Non-target organism effects from pesticides and herbicides

EPA is concerned about non-target organism effects from pesticides and herbicides. Pesticides and herbicides (including those incorporated into the genomes of crops) are registered for use by EPA such that their use in accordance with the registration is not expected to pose unnecessary risks to non-target organisms. Nonetheless, neither the models nor the compliance are likely to be perfect, so tracking any residues of such pesticides in non-target organisms would be useful, as would identifying any harm or mortality of organisms that might be caused by improper use of pesticides. There are Category 2 indicators for pesticide application and leaching pesticides in stream biota, and pesticides in sediment and fish tissue for fresh waters. There are no indicators in The Heinz Center report for pesticides in terrestrial organisms. Another indicator that might provide presumptive evidence of harm—animal die-off in fresh waters—is adequate for national reporting only for waterfowl.

Issues related to ozone, UV-B, mercury, acidic deposition, and persistent bioaccumulative toxics (PBTs)

In air, a number of pollutants travel regionally or even globally (e.g., ozone, acid deposition, PBTs [including mercury], ozone-depleting substances, greenhouse gases). What do the indicators reveal about baselines and trends in the levels of these pollutants in various ecosystems, or possible harm to biota as a result of exposure to these pollutants or their secondary effects? The chemical and physical characteristic EEA in Exhibit 5-44 contains many Category 2 indicators, but no indicators are available that provide a representative baseline for the nation.

For water, the NAWQA program samples sediment chemistry in more than 500 streams for many PBTs. Repeated sampling should provide an invaluable picture of trends, unless the variability is too high or there are important local sources that make these streams non-representative of streams in general. A smaller number of streams have been sampled for contaminants in fish tissue. A national monitoring network for mercury currently exists, with sampling sites primarily on the East coast and in the upper Midwest (see Chapter 2, Purer Water), but it is not adequate for establishing a national baseline for mercury or other PBTs. Monitoring for UV-B exposure is under development by USDA. EMAP has collected fish tissue residues for many of the PBTs, but there is no commitment to re-sample in the future.

To the extent that these factors affect tree growth, FHM will provide national trends information in the future, but at this point, there is no prospect for establishing trends in either exposure or effects for most of these chemicals.

Future Challenges

When the indicators available for this report are arrayed against the essential attributes in Exhibit 5-44, it is clear that indicators and adequate data are available to address only a portion of the information needed to describe ecological condition for the nation. Data for a few more indicators have been collected once, or for limited geographic regions, but the clear message is that more data are needed to describe and track ecological condition. This situation will improve over the next few years, but most of the gaps in Exhibit 5-44 are likely to remain for some time to come.

There are several challenges to developing adequate indicators of ecological condition for the nation:

- Indicators must be tied to conceptual models that capture how ecosystems respond to single and multiple stressors at various scales.
- Federal, state, and local monitoring organizations must find a way to coordinate and integrate their activities to meet multiple, potentially conflicting, data needs.
- Mechanisms must be found to ensure long-term commitments to measuring selected indicators over long periods and in standardized ways, to establish comparable baselines and trends.
- Indicators must simplify complex data in ways that make them meaningful and useful to decision-makers and the public.

None of these challenges appear insurmountable, but the gaps in Exhibit 5-44 indicate the work that remains to allow measurement of ecological condition at the national scale.