Technical Notes

Core National Indicators

Ecosystem Extent

Note: Several other indicators refer to this technical note for the discussion of remote-sensing data (National Land Cover Dataset) included at the end of this note.

The Indicator

"Coasts and oceans" are indicated by the area of brackish water off U.S. coasts. Brackish water is defined as all waters that have a salinity greater than about 1 part per thousand (ppt) and less than about 30 ppt (measurements are actually made in units called practical salinity units, which are quite close to parts per thousand).

Brackish water systems, including estuaries, are among the most productive ecosystems in the world—before 1985, estuarine-dependent fish species accounted for more than 50% of U.S. fish landings. Brackish water is a mixture of fresh water and seawater, and its distribution is a fundamental parameter of the distribution, abundance, and productivity of estuarine-dependent organisms and of essential fish habitats such as tidal wetlands (mangrove swamps, salt and brackish marshes, and intertidal flats), submerged attached vegetation (macroalgae and vascular plants), and oyster reefs.

Most variability in the salinity of coastal ecosystems is related to freshwater runoff and groundwater discharge. Thus, the areal extent of brackish water is an index of the amount of freshwater that flows from the continent to coastal waters and can be used as a surrogate for nutrient enrichment, sediment loading, and contaminant inputs.

"Croplands" includes the following U.S. Department of Agriculture (USDA) Economic Research Service (ERS) categories: cropland harvested, crop failure, cultivated summer fallow, cropland used only for pasture, and idle cropland; Conservation Reserve Program lands are included. Note: In the Farmlands chapter of this report (see Total Cropland, p. 91), we present multiple estimates of the area of croplands; the ERS was selected for use in this national indicator as illustrative of long-term trends.

"Forests" is defined by the USDA Forest Service as areas of at least one acre with a certain density of trees (at least 10% cover). See also the forest area indicator (p. 117) and its associated technical note (p. 239).

"Fresh waters" includes lakes and streams, as well as wetlands; however, only wetland acreage is reported in this indicator. Wetlands are defined according to the U.S. Fish and Wildlife Service's wetland classification system, which is the national standard, and include the following types of freshwater wetlands: principally palustrine forested wetlands, palustrine scrub-shrub wetlands, and palustrine emergent wetlands.

"Grassland/shrubland areas" for the lower 48 states are defined according to the National Land Cover Dataset (NLCD; see below) and include several land cover categories. Definitions of land cover in Alaska are from a separate study (see below).

"Urban/suburban areas" is generally defined here as land that is substantially covered by one of the following land cover types: low-intensity residential, high-intensity residential, commercial or industrial or transportation lands, and urban and recreational grasses. These categories are based on remote-sensing classification of land cover (see NLCD description below). A series of steps were taken to limit these areas to those thought to be most representative of urban and suburban issues (see the urban/suburban extent technical note for a thorough description, p. 264). There are several other ways that urban areas have been defined by various programs (again, see urban/suburban technical note, p. 264). The approach adopted by the ERS that relies on U.S. Census Bureau data for urban areas is a consistent dataset, however, it is based on different assumptions than the definition of urban/suburban areas in this report. The ERS time series is shown to give a sense of the relative change in urban/suburban areas over the past 50 years.

The land cover and ocean depth (bathymetry) map displays the geographic location of the various ecosystems. Data for forests, grass/shrublands, croplands, and urban/suburban were derived from the definitions in the NLCD. Only those rivers with flow rates exceeding 1000 cubic feet per second (cfs) are shown. Bathymetry data in coastal waters show the depth to the ocean floor in several ranges.

The Data

Coasts and Oceans: Data are not adequate for national reporting. Some data for the salinity of open waters of the U.S. Exclusive Economic Zone are available from the National Oceanographic Data Center (see http://www.nodc.noaa.gov/General/salinity.html). Local and regional data for semi-enclosed bodies of water are collected by a variety of federal and state agencies, but these data have not been compiled into a single source.

Cropland: Data on cropland extent come from the USDA ERS, and are available at http://www.ers.usda.gov/Emphases/Harmony/issues/arei2000/. ERS relies on data provided by the National Agricultural Statistics Service, as well as a variety of other sources. The ERS estimate for croplands is a reasonable estimate; however, it is not the only credible estimate. Specifically, the croplands extent measure (see p. 91) provides estimates of the extent of cropland from other agencies and programs; these estimates of mid-1990s cropland extent range from a low of 431 million acres (USDA Census of Agriculture) to a high of 510 million acres (USDA National Resources Inventory and NLCD). Data from ERS (455 million acres) are used here, but without additional research into which data source is more accurate, it would be equally fair to use any of the other estimates.

Forests: Data on forest extent are from the USDA Forest Service Forest Inventory and Analysis (FIA) program (see http://fia.fs.fed.us). FIA is a survey-based program that has operated since the late 1940s, collecting information on a variety of forest characteristics. See the technical note for the forest area indicator (p. 239) for additional details.

Fresh Waters: Data on freshwater wetlands are from the U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI). See Dahl (2000); data also available at ftp://wetlands.fws.gov/status-trends/SandT2000Report_lowres.pdf. The NWI produces periodic reports on the extent of wetlands in the United States. See also the technical note on freshwater extent (p. 246). River data are from the U.S. EPA River Reach File (see http://www.epa.gov/waterscience/BASINS/metadata/rf3a.htm), which was constrained so that only those rivers with flow rates of at least 1000 cfs were used. Procter & Gamble's Miami Valley Laboratory conducted this analysis for The Heinz Center.

Grasslands and Shrublands: Data on the extent of grasslands and shrublands (lower 48 states) are from the NLCD—see the detailed description below.

Grassland/shrubland data for Alaska are from a vegetation map of Alaska, based on Advanced Very High Resolution Radiometer (AVHRR) remote-sensing images with an approximate resolution of 1 kilometer on a side (see complete description below). The following groupings of classes were used (see http://agdc.usgs.gov/data/projects/fhm/#G, Statewide Vegetation/Land Cover; other classifications listed below): alpine tundra & barrens (#3); dwarf shrub tundra (#4); tussock sedge/dwarf shrub tundra (#5); moist herbaceous/shrub tundra (#6); wet sedge tundra (#7); low shrub/lichen tundra (#8); low & dwarf shrub (#9); tall shrub (#10); and tall & low shrub (#23).

See the Area of Grasslands and Shrublands technical note (p. 256) for information on the pre-settlement estimates of these lands from Klopatek et al. (1979).

Urban and Suburban Areas: Grassland and shrubland data are a relatively straightforward presentation of NLCD vegetation classes, but urban and suburban area data required additional processing. Basically, this involved identification of areas with urban/suburban land cover (using the NLCD classes; see below), then making adjustments to account for the intermixed land use at the edges of urban areas. For example, undeveloped parcels or large parks located within developed areas were included as "urban/suburban" even though they might have been classified as forest or grass/shrub according to the satellite data. See the technical notes on urban/suburban extent (p. 264) for additional information.

The Land Cover and Ocean Bathymetry Map: The map shown in this indicator was constructed from several datasets by USGS's Earth Resources Observations Systems Data Center. These datasets are described below.

Data Quality/Caveats

Because these data are from multiple sources, some caution is appropriate. Different programs use different definitions and may be conducted in different years. Every effort has been made here to identify consistent land cover categories and time periods.

Given the diversity of programs, definitions, techniques, and time periods, there are inevitable conflicts between these various estimates. For example, satellite data (described below) indicate that there are about 690 million acres of forest in the United States (all 50 states), while the USDA Forest Service's FIA program estimates that there are about 747 million acres of forest. Satellite remote sensing, which can provide data on the entire U.S. land surface, may serve as a common reference point, against which other programs that count only forest, for example, or only private lands, or only cropland, may be compared.

The National Land Cover Dataset (NLCD): In the 1990s, a federal interagency consortium was created to coordinate access to and use of land cover data from the Landsat 5 Thematic Mapper. Using Landsat data and a variety of ancillary data, the consortium processed data from a series of 1992 Landsat images, to create the NLCD on a square grid covering the lower 48 states. Each square in the grid, or "pixel," is approximately 100 ft on a side.

Each pixel was assigned one of 21 land cover classes, which are described at http://www.epa.gov/mrlc/classes.html and http://landcover.usgs.gov/classes.html. The steps of this classification process, which can be found in detail elsewhere (see Vogelmann et al. 2001 and Vogelmann et al. 1998), are summarized here. First, an automated process is used to create clusters of pixels for a given regional area. Second, these clusters were interpreted and labeled with the help of aerial photographs. Third, in cases where clusters of pixels included multiple land cover types (i.e., "confused clusters"), models that utilize ancillary data, such as elevation or population density, were used to help assign land cover classes. Finally, lands that are bare—especially clear cuts and quarries—and many grass areas, such as parks, golf courses, and large lawn, are not easily distinguished from other land cover classes during the automated process, so a process of on-screen verifications was used as clarification. These four steps were the general process, and additional steps were taken in certain regions in order to further improve the accuracy of classifications (see http://landcover.usgs.gov/accuracy/ for a discussion of NLCD error analysis).

Note that classification of pixels was based in part on the character of surrounding squares in the grid; thus, a pixel of grass-like land cover surrounded by residential pixels would probably be classified as "urban and recreational grasses" rather than as "pastureland." Where appropriate, the agencies also made use of data from both the Census Bureau and the U.S. Fish and Wildlife Service's National Wetlands Inventory data to help make such distinctions. Satellite data offer an unprecedented opportunity to classify land cover on a consistent basis over very large areas (i.e., the entire country). However, the accuracy of any classification is not perfect. The accuracy of satellite-derived classifications is related to many factors: amount of data available (i.e., many dates of imagery rather than just one), the detail of the required land cover information (i.e., forest vs. deciduous forest vs. sugar maple/beech/yellow birch), classification methods, computing power, and, of course, time and money. Assessments of the NLCD for the eastern United States indicate an accuracy of approximately 80% or higher for general land cover categories (e.g., forest, agriculture, developed). Accuracy assessments for the western United States are currently under way. Improving technology and techniques offer the potential to increase accuracy of the next NLCD (2000) currently being assembled by the Multi-Resolution Land Characterization Consortium. The land cover classes associated with the 30-m (100-foot) square pixels were grouped for the different ecosystems as follows (the number in parenthesis is the NLDC land cover class reference):

- *Forests:* deciduous (#41); evergreen (#42); mixed forest (#43)
- *Croplands:* pasture/hay (#81); rowcrops (#82); small grains (#83); fallow (#84); orchards/vineyards/other (#61)
- *Grass/Shrub:* shrubland (#51); grasslands/herbaceous (#71); bare rock/sand/clay (#31)
- *Water:* open water (#11); wetlands (#91 & #92)
- *Developed:* low-intensity residential (#21); high-intensity residential (#22); commercial/industrial/transportation (#23); urban/recreational grasses (#85)
- *Other:* quarries/strip mines/gravel pits (#32); transitional (#33); perennial ice/snow (#12)

Data Quality/Caveats: The power of satellite-derived classifications is that satellite data can easily cover the entire country and the classification process can be automated (though not completely). This makes it possible to compile a nationally consistent land cover dataset; however, any land cover classification is subject to error. The NLCD for the eastern United States has an accuracy of approximately 80% or higher for the general land cover categories used for our study (see http://landcover.usgs.gov/accuracy). Some of the known misclassifications that occur in the dataset include suburban areas or tree farms classified as forest; grasslands classified as agriculture, or vice versa; and fallow agricultural fields classified as barren lands.

Data Access: NLCD data are available at http://landcover.usgs.gov/mrlcreg.html. Further detail is also available from Vogelmann et al. (2001). Other data can be obtained from the sources cited in this note.

Coastal Bathymetry Data: These data come from the National Geophysical Data Center, and are known as ETOPO5 data. They were generated from a digital database of land and sea-floor elevations on a 5-minute latitude/longitude grid. The resolution of the gridded data varies from true 5-minute for the ocean floors, the United States, Europe, Japan, and Australia to 1 degree in data-deficient parts of Asia, South America, northern Canada, and Africa. Data sources are as follows: Ocean Areas: U.S. Naval Oceanographic Office; United States, W. Europe, Japan/Korea: U.S. Defense Mapping Agency; Australia: Bureau of Mineral Resources, Australia; New Zealand: Department of Industrial and Scientific Research, New Zealand; balance of world land masses: U.S. Navy Fleet Numerical Oceanographic Center. These various databases were originally assembled in 1988 into the worldwide 5-minute grid by Margo Edwards, then at Washington University, St. Louis, Missouri. Data have been described in NOAA (1988). The version of the data making up ETOPO5 is from May 1988, with the exception of a small area in Canada (120-130° W, 65-70° N), which was regridded in 1990; the data are available at: http://www.ngdc.noaa.gov/mgg/global/seltopo.html.

Alaskan Land Cover Data: Data for Alaska are from a vegetation map of Alaska by Flemming (1996), based on AVHRR remote-sensing images with an approximate resolution of 1 kilometer on a side. The following groupings of classes were used (see http://agdc.usgs.gov/data/projects/fhm/#G [Statewide Vegetation/Land Cover]):

- *Freshwater:* water (#1); glaciers and snow (#2)
- *Grass/Shrub:* alpine tundra & barrens (#3); dwarf shrub tundra (#4); tussock sedge/dwarf shrub tundra (#5); moist herbaceous/shrub tundra (#6); wet sedge tundra (#7); low shrub/lichen tundra (#8); low & dwarf shrub (#9); tall shrub (#10); tall & low shrub (#23)
- *Forest:* closed broadleaf & closed mixed forest (#11); closed mixed forest (#12); closed spruce forest (#13); spruce woodland/shrub (#14); open spruce forest/shrub/bog mosaic (#15); spruce & broadleaf forest (#16); open & closed spruce forest (#17); open spruce & closed mixed forest mosaic (#18); closed spruce & hemlock forest (#19)
- *Other:* 1991 fires (#21); 1990 fires & gravel bars (#22)

Hawaiian Land Cover Data: These data came from the National Oceanographic and Atmospheric Administration's (NOAA) Coastal Change and Analysis Program (C-CAP), which is a national effort to develop and distribute regional land cover and change analysis data for the coastal zone by using remote-sensing technology. The data used in this program are created from a combination of satellites and fieldwork. C-CAP classifies land cover types into 22 standardized classes that include forested areas, urban areas, and wetlands. C-CAP land cover data are derived from Landsat Thematic Mapper satellite imagery and are available at http://www.csc.noaa.gov/crs/lca/m_eight.html.

References

Dahl, T.E. 2000. Status and trends of wetlands in the conterminous United States 1986 to 1997. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service.

Flemming, M.D. 1996. A statewide vegetation map of Alaska using a phenological classification of AVHRR data. 1996 Alaska Surveying and Mapping Conference, Anchorage, Alaska.

Klopatek, J.M., R.J. Olson, C.J. Emerson, and J.L. Joness. 1979. Land-use conflicts with natural vegetation in the United States. Environmental Conservation 6:191–199.

NOAA. 1988. Data announcement 88-MGG-02. Digital relief of the surface of the earth. National Geophysical Data Center, Boulder, Colorado.

Vogelmann, J.E., S.M. Howard, L. Yang, C.R. Larson, B.K. Wylie, and N. van Driel. 2001. Completion of the 1990s national land cover data set for the conterminous United States from Landsat Thematic Mapper data and ancillary data sources. Photogrammetric Engineering & Remote Sensing 67:650–662.

Vogelmann, J.E., T.L. Sohl, P.V. Campbell, and D.M. Shaw. 1998. Regional land cover characterization using LANDSAT Thematic Mapper data and ancillary data sources. Environmental Monitoring and Assessments 51: 415–428.

Fragmentation and Landscape Patterns

There is no technical note for this indicator.

The Movement of Nitrogen

The Indicator

This indicator reports both the yield and load of nitrogen from major rivers to the U.S. coastal ocean. The *yield* of nitrogen from major watersheds is defined as the pounds of nitrogen per square mile of watershed area that enters rivers and streams through discharges, runoff, and other sources. The *load* of nitrate, a common form of nitrogen, from major rivers is defined as the tons of nitrate carried to the ocean each year by the four largest U.S. rivers.

Nitrogen can cause significant water-quality problems by stimulating the growth of algae. Two key references provide additional information about how excess nutrients can cause problems in coastal waters. The National Research Council published a study on nutrient pollution in the coastal ocean (NRC 2000) and the National Oceanographic and Atmospheric Administration (NOAA) did a one-time study of actual conditions in the nation's estuaries (National Estuarine Eutrophication Assessment, http://spo.nos.noaa.gov/projects/cads/nees/Eutro_Report.pdf).

The Data

Data Source: Riverine loads of total nitrogen were estimated using streamflow and water-quality data collected by the U.S. Geological Survey (USGS) as part of its National Stream Water Quality Accounting Network (NASQAN), its 1996–1999 National Water Quality Assessment (NAWQA), and its Federal–State Cooperative Program. A few of the stream gauges, most notably those at the mouth of the Mississippi River, are operated by the U.S. Army Corps of Engineers rather than the USGS.

Data Collection Methodology: Stream discharge is estimated by frequent measurement of water depth (stage), which is converted to discharge by use of a rating curve. Data are reported as daily averages. All water-quality samples are representative of the entire river cross-section (depth- and width-integrated) at the time of collection.

At the sites for which data are included in this report, samples were collected at least quarterly over the 4-year period 1996–1999; at most sites, approximately 15 samples were collected each year. A regression model relating concentration to discharge, day-of-year (to capture seasonal effects), and time (to capture any trend over the period) was developed using robust statistical techniques that made no assumption about the underlying statistical distribution of the data. One model was developed for nitrate plus nitrite concentrations (note that nitrite is usually much less abundant than nitrate, so it is normal to discuss the sum of nitrate plus nitrite simply as nitrate); a second model was developed for whole-water organic nitrogen plus ammonia for each station. These models were then used to make daily estimates of concentration, which were multiplied by the daily average discharge to yield the daily load. The daily load of total nitrogen was the sum of predictions of the two models.

Data Manipulation: For the maps, these daily loads were summed over the 4-year period to estimate the load for the entire period and divided by 4 to obtain the average annual load. The coefficient of variation of the average annual load is generally between 20 and 30%. The incremental load was then calculated as the difference between the output load that flowed from the watershed and the input(s) to the watershed. Outputs include the load at the downstream stations and, in the arid western areas, any decrease in runoff, because it was assumed that solutes accompanied any water that was lost to irrigation or transfers to other watersheds (i.e., piping water across watershed boundaries). The incremental yield (shown in the maps) is defined as the incremental load divided by the watershed area. The white areas of the map are areas for which insufficient USGS data exist to calculate loads.

For the time series plots, the daily loads were summed to determine the annual loads shown in the figure. Note that most of the year-to-year variation in the loads is due to differences in runoff, with wet years having higher loads and dry years having lower loads.

Data Access: All USGS data are available at http://water.usgs.gov/nwis. This site includes the discharge and nutrient concentration data used in developing the models that produced the load calculations presented here, but the models themselves are not available. Further information on the NASQAN and NAWQA programs can be found at http:/water.usgs.gov/nasqan and http://water.usgs.gov/nawqa. The NASQAN Web site contains stream discharge data collected by the U.S. Army Corps of Engineers.

References

National Research Council. 2000. Clean coastal waters: Understanding and reducing the effects of nutrient pollution. Washington, DC: National Academy Press.

Chemical Contamination

This technical note also applies to:

- Coasts and Oceans: Contamination in Bottom Sediments
- Farmlands: Pesticides in Streams and Groundwater
- Urban/Suburban: Chemical Contamination

This technical note applies to the core national indicator for chemical contamination, the coastal indicator for sediment contaminants, the farmlands indicator for pesticide, and the urban/suburban indicator for chemical contamination. One technical note applies to these three indicators because they are designed in a very similar fashion. In addition, most of the data (i.e., all freshwater data) for these three indicators are from the same program.

The Indicator—General

In the core national indicator, as well as the indicators for farmlands and urban/suburban areas, a dual approach is used: how frequently compounds are detected, and how often such "occurrences" are at concentrations that are above established human health standards and guidelines and aquatic life guidelines—"exceedances." The coastal sediment contamination indicator presents only data on exceedances of relevant guidelines.

Compounds reported here include many pesticides, polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), other compounds on the Environmental Protection Agency (EPA) priority pollutant list, potentially toxic trace elements, and a number of pesticide degradation products. The suite of compounds that were measured in different media varied depending on the use of the compounds in a particular area and the chemistry of the compounds. For example, many VOCs (e.g., solvents and fuel

additives) are more heavily used in urban than agricultural settings. Further, because of their volatility, VOCs would be expected to be of greater concern in groundwater than in streams or sediments. In general, the suite of compounds was designed to include compounds that occur frequently in ecosystems and/or have a high potential for adverse effects on people or ecosystems.

In order to understand how frequently compounds from a particular suite of contaminants occur in the environment, the U.S. Geological Survey's National Water Quality Assessment (NAWQA) program analyzes groundwater and water, sediments, and fish tissue from streams. EPA's Environmental Monitoring and Assessment Program (EMAP) analyzes sediments and fish tissue from estuaries. It is important to note that all chemical analyses have "detection limits," meaning that even if a compound is present at a concentration lower than the detection limit, the sample cannot be differentiated from one that completely lacks the compound. Analytical methods used for different environmental media are different (e.g., measurements of contaminant concentrations in stream water and groundwater use different techniques than are used in stream sediment analyses, and techniques used in fresh water differ from those used in salt water). However, within an environmental media (sediment, stream water, etc.), consistent analytical methods were used throughout the program. In addition, as data for this indicator are gathered over time, it will be important to consider the effect of improved detection methods (i.e., allowing contaminants to be detected at lower concentrations) on occurrence data.

The second component of the indicators provides a measure of the frequency (e.g., percentage of stream sites) of contaminants that exceeded established reference criteria for the protection of human health or aquatic life. These two types of reference criteria were established for different purposes and thus are based on different assumptions. Specifically, human health standards and guidelines assume that the water will be consumed daily over a person's lifetime, and that the effects of the contaminant would be cumulative (often referred to as "chronic" exposure). Human health standards and guidelines are not currently applied to stream or estuary sediments.

In comparison, guidelines that are designed for the protection of aquatic life are based on shorter-term (about 4 days) exposure. (This refers to U.S. EPA guidelines; Canadian guidelines are different (see references)). This is because aquatic organisms are generally smaller and they are exposed to contaminants in water in a different way than humans are. Also, in general, different species have different sensitivities to specific contaminants.

Standards and guidelines for the protection of wildlife are used to evaluate whether contaminant levels in prey species (fish, in this case) are sufficiently high to cause adverse effects in predator species (often fish-eating birds such as eagles).

Specific standards and guidelines used in this indicator are listed under the appropriate media description below.

Data Sources—General

The data for freshwater streams and groundwater were collected and analyzed by NAWQA (http://water.usgs.gov/nawqa/) in 36 major river basins and aquifers across the United States during 1992–1998.

The data for sediments and fish contamination in coastal waters were collected and analyzed by EPA's EMAP (http://www.epa.gov/emap/) from 1990 to 1997. The data were collected in a manner that allows conclusions to be drawn concerning the majority (approximately 76%) of the area of estuaries in the United States.

Data on sediment contamination in the Great Lakes are collected by a number of agencies. However, these monitoring programs generally focus on areas with highly polluted sediments. As such, these data are not comparable to the data presented here, in that they do not assess the occurrence of sediment contamination across the range of possible locations in the Great Lakes. The EPA Great Lakes National Program Office provided the Great Lakes fish contamination data that are noted in the text.

Freshwater Data: National Water Quality Assessment Program

Methods: The suite of compounds included in the Core National Indicator account for 75% of currently used agricultural pesticide applications (by amounts used), 90% of the nation's historical use of organochlorine pesticide (most of these compounds are no longer permitted for use in agriculture in the United States), plus PCBs and other industrial compounds, VOCs that are currently or soon may become regulated, and other compounds on the EPA priority pollutant list. A number of pesticide degradation products were also included. Nitrate and ammonium were measured in streams and groundwater. Trace elements were measured in stream sediments and groundwater. Radionuclides were measured only in groundwater. All of these contaminants occur naturally in the environment. Thus, they are included in graphics showing exceedances of human health and/or aquatic life benchmarks, but not in graphics showing the occurrence of contaminants. Human health benchmarks apply to those contaminants listed above that were measured in streams and groundwater. Aquatic life benchmarks apply to the contaminants listed above that were measured in streams and stream sediments.

Additional information about the USGS data used in the Heinz Center report can be found at: http://water.usgs.gov/nawqa/heinz_ctr/

The watersheds studied were selected to be generally representative of conditions in agricultural, urban, and mixed land uses. The national contaminants data are based on water samples collected from 109 stream sites and 3,549 wells, stream sediment from 558 stream sites, and composite whole-fish samples collected from 223 stream sites. The sites sampled are representative of a wide range of stream sizes, types, and agricultural, urban/suburban, and mixed land uses, but the sites were not selected to be a statistically representative sample of the nation's streams.

Data for the urban/suburban indicator come from surface water sites on streams that drain 21 urban/suburban watersheds located across the nation. Note that the sites used in this analysis probably are included with "urban and suburban areas" as defined in this report (see p. 181); however, the selection of the sites for sampling was not based on the definition used in this report.

Data for the farmlands indicator are based on water samples from 50 streams and 1084 monitoring wells.

Benchmarks for protection of human health, wildlife, and aquatic life: A variety of U.S., Canadian, and bi-national (International Joint Commission) standards and guidelines were used to evaluate the significance of the detected contaminants in surface water, groundwater, stream sediment, and whole fish.

In conformance with the way the guidelines are written, a concentration exceeding the aquatic-life guidelines in any single surface water sample was counted as an exceedance of the guide-

line. For human health standards or guidelines, exceedances were identified when a yearly time-weighted mean concentration exceeded the relevant standard or guideline at a surface water site.

For human health, three types of U.S. EPA standards and guidelines were used to evaluate NAWQA data: (1) Maximum Contaminant Level (MCL), (2) Risk-Specific Dose (RSD), and (3) Lifetime Health Advisory (HA-L). Values for these criteria were obtained by the U.S. Geological Survey (USGS) from U.S. EPA (2000, 2001). In all three cases, the standard and guideline levels are concentrations pertaining to lifetime exposure through drinking water.

The MCL is the maximum permissible annual average concentration of a contaminant in water that is delivered to any user of a public water system. The RSD is a guideline for potential carcinogens based on drinking-water exposure over a 70-year lifetime; an RSD value is always associated with a specified cancer risk. The RSDs presented are associated with a cancer risk of 1 in 100,000. The HA-L is an advisory guideline for drinking-water exposure over a 70-year lifetime, considering noncarcinogenic adverse health effects. More detail on these types of benchmarks, their derivation, and their underlying assumptions is provided in Nowell and Resek (1994). For some constituents, more than one of these three types of benchmarks are available. For these constituents, the MCL was used if available; otherwise, the lowest of the RSD (at 1 in 100,000 cancer risk) and HA-L values selected.

Note that the data on freshwater fish tissue do not include information relative to any human health standards because such standards apply to edible fish tissue (e.g., fillets), whereas entire fish were analyzed for the data reported here.

The three types of aquatic-life guidelines used are U.S. EPA chronic water-quality criteria for protection of aquatic organisms (U.S. Environmental Protection Agency 1999), Canadian water-quality guidelines (Canadian Council of Ministers of the Environment 2001a), and Great Lakes water-quality objectives (International Joint Commission [IJC] 1978). All guideline values used in this report are for freshwater aquatic life. The U.S. EPA chronic water-quality criterion for protection of aquatic organisms is the estimated highest concentration of a constituent that aquatic organisms can be exposed to for a 4-day period, once every 3 years, without deleterious effects. If no U.S. EPA chronic water-quality criterion for protection of aquatic organisms exists for a given constituent, then Canadian water-quality guidelines are used, if available. The older Great Lakes water-quality objectives are used only if neither U.S. EPA chronic water-quality criteria for protection of aquatic organisms nor Canadian water-quality guidelines are available for that constituent. The IJC water-quality objectives and Canadian water-quality guidelines are intended to specify maximum concentrations that should not be exceeded at any time.

For contaminants in sediment, the aquatic-life guideline used was the "probable effect level" from the Canadian Council of Ministers of the Environment (2001b). These guidelines are empirically based; they were derived by compiling data from multiple types of studies in the literature that measured both toxicity and contaminant concentrations in sediment. The Canadian probable effect level defines a concentration above which toxicity to aquatic organisms is likely.

For contaminants in whole fish, the New York fish-flesh criteria for protection of piscivorous (fish-eating) wildlife (Newell et al. 1987) were used. These guidelines are intended to protect target wildlife species from adverse effects other than cancer, such as mortality, reproductive impairment, and organ damage. Wildlife guidelines from the state of New York were used because no comparable national guidelines are available for a large number of contaminants.

Additional information on the standards and guidelines used in this report for pesticides is provided at http://ca.water.usgs.gov/pnsp/source/. Information on the numerical values for the standards and guidelines applied to herbicide, insecticide, and volatile organic compounds can be found at

http://oregon.usgs.gov/sumrpt/Benchmrk.1.html,
http://oregon.usgs.gov/sumrpt/Benchmrk.2.html, and
http://oregon.usgs.gov/sumrpt/Benchmrk.3.html.

Estuarine Data: USEPA Environmental Monitoring and Assessment Program (EMAP)

EMAP conducts annual surveys to measure indicators of the health of plants and animals, the quality of their surroundings, and the presence of pollutants (see http://www.epa.gov/emap/). The program, at present, is developing appropriate designs and sets of indicator requirements to characterize the condition of the nation's aquatic resources. Once these developmental issues are addressed, the goal of the program is long-term monitoring that will provide information on the overall health of the environment and the effectiveness of pollution prevention and control strategies.

EMAP-Estuaries (EMAP-E), implemented through partnerships between EPA, the National Oceanographic and Atmospheric Administration (NOAA), USGS, coastal states, and academia, will provide information on the ecological condition of the nation's estuaries as part of the larger program. The data from the EMAP-E program provided in this report spans the period from 1990 through 1997. Beginning in 2000, the EMAP-E effort expanded into a series of annual national surveys (National Coastal Assessment, or NCA) including all coastal states and Puerto Rico. Ecological health is being assessed by investigating the state, regional, and national distributions of fish and bottom-dwelling organisms (benthos). NCA is determining what portions of estuaries can support these plants and animals and finding out why certain areas do not support them. Data from NCA will be available for the next iteration of this report (1999–2005).

For this report, EMAP-E provided information assessing the contaminant levels in estuarine sediments and the condition of benthic organisms in those sediments. These data were collected from over 2000 sites from Cape Cod, Massachusetts, to Brownsville, Texas, and represent over 70% of the total estuarine acreage of the United States (excluding Alaska).

Data Collection Methodology: Evaluation of the potential effects of contaminated sediments on estuarine organisms is difficult because few applicable state or federal regulatory criteria exist for determining acceptable sediment concentrations of all substances. However, contaminated sediments and their potential toxicity to aquatic life are viewed by the public as a major threat to estuarine ecosystems. All site selections were based on probabilistic designs which permit the extrapolation of the data to the entire area. Using a Young-modified Van Veen grab, 5–10 grabs were collected from each site and homogenized. Separate 100-milliliter samples for organics and metals were retrieved from the homogenate and forwarded for quantification of about 125 different compounds (as outlined below). For this report, information assessing the portion of estuarine area with contaminants

above ERL or ERM guidelines (see definitions below; Long et al. 1995; Long et al. 1998a,b) is reported.

Data Access: The data presented here were obtained directly from EPA.

List of Contaminants Targeted in Sediments by EMAP

- Pesticides. Pesticides were chosen because of their current and historic prevalent use in society. Sediments were tested for concentrations of 14 pesticides plus six different forms of DDT, which has been banned in the United States since 1972. These pesticides included Aldrin, Alpha-Chlordane, Dieldrin, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Heptachlor, Heptachlor epoxide, hexachlorobenzene, Lindane (gamma-BHC), Mirex, Toxaphene, Trans-Nonachlor, 2,4'-DDD, 4,4'-DDD 2,4'-DDE, 4,4'-DDE, 2,4'-DDT, and 4,4'-DDT.
- Polychlorinated biphenyls (PCBs). EPA began to phase out the use and manufacturing of PCBs in the United States in 1976, but they are still found in the environment. Human health effects that have been associated with exposure to PCBs include acne-like skin conditions in adults and neurobehavioral and immunological changes in children. PCBs are known to cause cancer in animals. EMAP targeted 21 different PCB congeners.
- Polycyclic aromatic hydrocarbons (PAHs). A group of over 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, and other organic substances like tobacco or charbroiled meat, PAHs are usually found as a mixture containing two or more of these compounds, such as soot. Some PAHs are manufactured—they are found in coal tar, crude oil, creosote, and roofing tar, and a few are used in medicines or to make dyes, plastics, and pesticides. PAHs are included because of their role as a suspected carcinogen. The following compounds were targeted (plus several isomers of the listed PAHs): Acenaphthene, Anthracene, Benz(a)anthracene, Benzo(a)pyrene, Biphenyl, Chrysene, Dibenz(a,h)anthracene, Dibenzothiophene, 2,6-dimethylnaphthalene, Fluoranthene, Fluorene, 2-methylnaphthalene, 1-methylnaphthalene, 1-methylphenanthrene, 2,6-dimethylnaphtalene, Naphthalene, Pyrene, Benzo(b)fluoranthene, Acenaphthylene, Benzo(k)fluoranthene, Benzo(g,h,i)perylene, Ideno(1,2,3-c,d)pyrene, and 2,3,5-trimethylnaphthalene.
- Heavy metals. Heavy metals occur naturally in the marine environment; however, their concentrations can be increased by human activities such as discharges from industrial processes, burning of fossil fuels, and runoff from roadways that have had an accumulation of particulates from brake drums, for example. Sediments were tested for a total of 15 trace elements: aluminum, antimony, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, tin, and zinc. Metal concentrations were normalized using metal:aluminum ratios (see Windom et al. 1989).

Benchmarks for sediment quality: The sediment quality guidelines used in this indicator were developed by NOAA through its National Status and Trends Program (see http://response.restoration.noaa.gov/cpr/sediment/SPQ.pdf). Before these guidelines, there were no national criteria or other widely applicable numerical guidelines for sediment quality. These quality guidelines were developed as informal, interpretive tools to estimate the possible toxicological significance of chemical concentrations in sediments. The guidelines have not been promulgated as regulatory criteria or standards, cleanup or remediation targets, discharge attainment targets, or pass–fail criteria for dredged material disposal decisions, or for any other regulatory purpose. (See http://response.restoration.noaa.gov/cpr/sediment/SQGs.html.)

These guidelines were derived from examination of a large number of individual contamination studies, all in salt water. Data from each study were arranged in order of ascending concentrations. Study endpoints in which adverse effects were reported were identified. From the ascending data tables, the 10th percentile and the 50th percentile (median) of the effects database were identified for each substance. The 10th-percentile values were named the "Effects Range-Low" (ERL), indicative of concentrations below which adverse effects rarely occur. The 50th percentiles were designated the "Effects Range-Median" (ERM) values, representative of concentrations above which effects frequently occur. In this report, the ERL is referred to as the "possible effects" guideline and the ERM as the "probable effects" guideline.

The Data Gap

There are large amounts of data on contaminated sediments in the Great Lakes, but these data have for the most part been collected at sites known or suspected of being contaminated, rather than as part of efforts to determine the extent and severity of contamination. Sediments in the defined Areas of Concern (http://www.epa.gov/glnpo/aoc) are generally the most contaminated. Sediments in the open waters tend to have much lower concentrations, and they tend to migrate to sediment depositional areas. See the following for information on surveys that can identify "toxic substances in toxic amounts," which are found in the tributary mouths and embayments of the Areas of Concern: http://www.epa.gov/glnpo/glindicators/sedqual/sedqualitya.html.

Data are not presently available to compare fish tissue contamination to human health standards and guidelines in a consistent way across the country. See the technical note for Selected Contaminants in Fish and Shellfish (p. 228) for additional discussion.

Data are not presently collected in a consistent manner to allow reporting on soil contamination in urban and suburban areas. Individual studies (see Pouyat et al. 1991) have been conducted to determine the extent and nature of such contamination.

References

Canadian Council of Ministers of the Environment. 2001a. Canadian water quality guidelines for the protection of aquatic life: Summary table. In Canadian environmental quality guidelines, 1999. Winnipeg: Canadian Council of Ministers of the Environment. http://www.ec.gc.ca/ceqg-rcqe/English/Pdf/water_summary_table-aquatic_life.htm. Accessed July 24, 2001.

Canadian Council of Ministers of the Environment. 2001b. Canadian sediment quality guidelines for the protection of aquatic life: Summary tables. Updated. In Canadian environmental quality guidelines, 1999. Winnipeg: Canadian Council of Ministers of the Environment. http://www.ec.gc.ca/ceqg-rcqe/English/Pdf/sediment_summary_table.htm. Accessed July 24, 2001.

International Joint Commission. 1978. Great Lakes Water Quality Agreement of 1978, as amended by Protocol signed November 18, 1987, Annex I—Specific objectives.

International Joint Commission http://www.ijc.org/agree/quality.html#ann1. Accessed July 24, 2001.

Long, E.R., L.J. Field, and D.D. McDonald. 1998a. Predicting toxicity in marine sediments with numerical sediment quality guidelines. Environmental Toxicology and Chemistry 17(4):714–727.

Long, E.R., D.D. McDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management 19(1):81–87.

Long, E.R., G.I. Scott, J. Kucklick, M. Fulton, B. Thompson, R.S. Carr, K.J. Scott, G.T. Chandler, J.W. Anderson, and G.M. Sloane. 1998b. Magnitude and extent of sediment toxicity in selected estuaries of South Carolina and Georgia. NOAA Tech. Memo. NOS ORCA 128. Silver Spring, MD.

Newell, A.J., D.W. Johnson, and L.K. Allen. 1987. Niagara River Biota Contamination Project: Fish flesh criteria for piscivorous wildlife. New York State Department of Environmental Conservation, Division of Fish and Wildlife, Bureau of Environmental Protection, Technical Report 87-3.

Nowell, L.H., and E.A. Resek. 1994, National standards and guidelines for pesticides in water, sediment, and aquatic organisms: Application to water-quality assessments: Rev. Environ. Contam. Toxicol. v. 140, pp. 1–164.

Pouyat, R.V., and M.J. McDonnell. 1991. Heavy metal accumulation in forest soils along an urban-rural gradient in southeastern New York, USA. Water, Air, and Soil Pollution 57–58:797–807.

U.S. Environmental Protection Agency. April 1999. National recommended water quality criteria—Correction. U.S. Environmental Protection Agency, Office of Water, EPA-822-Z-99-001. http://www.epa.gov/ost/pc/revcom.pdf. Accessed July 24, 2001.

U.S. Environmental Protection Agency. Summer 2000. Drinking water standards and health advisories: U.S. Environmental Protection Agency, Office of Water, EPA-822-B-00-001. http://www.epa.gov/ost/drinking/standards/. Accessed July 24, 2001.

U.S. Environmental Protection Agency. 2001. Integrated Risk Information System (IRIS) database: U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment. http://www.epa.gov/iris. Accessed July 24, 2001.

Windom, H.L., S.J. Scropp, F.D. Calder, J.D. Ryan, R.G. Smith, I.C. Burney, F.G. Lewis, and C.H. Rawlinson. 1989. Neutral trace metal concentrations in estuarine and marine sediments of the southeastern United States. Environmental Science and Technology 3: 314–327.

At-Risk Native Species

This indicator also applies to

- At-Risk Native Forest Species
- At-Risk Native Freshwater Species
- At-Risk Native Grasslands and Shrublands Species

The Indicator

The species reported here are those in groups (such as mammals, birds, and fish) that are considered sufficiently well known that the conservation status, habitat, and location (by state) can be assigned with some degree of confidence for all members of the group. The conservation status assessment for each species is an attempt to determine the relative susceptibility of a species to extinction. The assessment process is based on consideration of up to 12 factors that relate to a species' degree of imperilment or risk of extinction throughout its range. Rare species are particularly vulnerable to extinction and so several aspects of rarity are characterized in the assessment process including population size and number of populations, and range extent and area of occupancy. However, trends in population and range size as well as magnitude and immediacy of threats are also important considerations in assessing a species' overall vulnerability or risk of extinction. Additional information on this ranking process can be found at http://www.natureserve.org/explorer/ranking.htm and in Master (1991).

There is general recognition among experts that both status information (as presented here) and trend information (whether a species is increasing, decreasing, or stable) are critical to understanding the condition of species. If and when trend information for large numbers of species becomes widely available, revising the current measure by incorporating trend information or substituting trend information for status should be considered.

The Data

Data Source: NatureServe (www.natureserve.org) and its member programs in the network of Natural Heritage programs develop and maintain information on each of the species reported here.

Data Collection Methodology: On an ongoing basis, NatureServe research biologists gather, review, integrate, and record available information about species taxonomy, status, and use of different habitats or ecological system types. They are assisted in this work by scientists in the network of Natural Heritage programs as well as by contracted experts for different invertebrate taxa. NatureServe staff and collaborators assign a conservation status by using standard Heritage ranking criteria (see http://www.natureserve.org/explorer/ranking.htm) and by using the best information available to them.

The Heritage ranking process considers five major status ranks: critically imperiled (G1), imperiled (G2), vulnerable (G3), apparently secure (G4), and demonstrably widespread, abundant, and secure (G5). In addition, separate ranks are assigned for species regarded as presumed extinct (GX) or possibly extinct (GH).

Critically imperiled species are often found in five or fewer locations, imperiled species are often found in 20 or fewer locations, and vulnerable species are often found in 80 or fewer locations. Apparently secure species are uncommon but not rare, and secure species are common—meaning they are both abundant and widespread. Presumed extinct species have not been located despite intensive searches, and possibly extinct species are missing and are known only from historic records, although there is some hope of their rediscovery. See Stein (2002) for further details on ranks.

These data are not from a site-based monitoring program, but rather from a census approach that focuses on the location and distribution of at-risk species. For other species, the dataset incorporates information from a wide variety of observations and sources.

Data Manipulation: NatureServe has summarized the actual global ranks into "rounded ranks" for the purposes of presentation and analysis. For example, an actual rank may express the bounds of uncertainty, noting for instance that a given species

falls somewhere in the range of "critically imperiled" to "imperiled." In such cases, the rounded rank reflects the *more* imperiled designation, in this instance, critically imperiled. Such rank rounding applies to between 10-20% of species included here. The analysis of the percent of at-risk species by region is based on all species that are known to occur within one or more states in each region.

For the core national indicator, only species groups for which sufficient information is available on the entire group are reported. Thus, mammal status is reported because data are available on the status of all mammals, but the status of mayflies and stoneflies is not included because data on all species in these two groups are not available. Groups reported for the national measure are mammals; birds; reptiles; amphibians; freshwater fishes; freshwater mussels; freshwater snails; crayfishes; fairy, clam, and tadpole shrimp; butterflies and skippers; giant silkworm and royal moths; sphinx moths; underwing moths; papaipema moths; tiger beetles; stoneflies; grasshoppers; mayflies; dragonflies and damselflies; ferns/fern allies; gymnosperms; and flowering plants.

For the forest, freshwater, and grassland/shrubland indicators, species were first identified as "forest species" or "freshwater species" or "grassland/shrubland species." In this process, species were assigned to an ecosystem if they live in that ecosystem during at least part of their life cycle and depend on access to that ecosystem type for their survival. This was a generally conservative approach; in preparing these lists, only species that are strongly associated with a habitat type were included. This means that some species that make frequent use of forest, or grasslands/shrublands, or fresh water may be excluded, butalso that the group of species reported for each of these systems here is quite representative of species that are dependent upon those habitats for their survival. Groups reported for the forest and grassland indicator are mammals, birds, reptiles, amphibians, grasshoppers, and butterflies and skippers. Groups reported for the freshwater indicator are freshwater and anadromous fishes; amphibians; reptiles; butterflies and skippers; freshwater mussels; freshwater snails; crayfishes; fairy, clam, and tadpole shrimp; dragonflies and damselflies; mayflies; stoneflies; and caddis flies.

At present, it is not possible to use the data presented here to distinguish naturally rare species from those that have been depleted in number. Increases in the number of at-risk species over time, however, would generally be interpreted as an increase in the number of depleted species after accounting for changes due to changes in taxonomy or to discovery of new species.

Data Quality/Caveats: Heritage conservation status ranks are updated on an ongoing basis through literature review and feedback from users of the network's databases, and also through periodic review of all statuses. Uncertainty about conservation status of a species is captured in part through the use of range ranks (see "Data Manipulation" above). A species' status may change over time due to several reasons, and not solely due to a species becoming more or less at risk of extinction. For example, more populations may be found than were known to exist, or a species may be split taxonomically into two species, such that the two new species may individually be at greater risk of extinction than their single parent species. Because status may change for reasons other than an actual change in condition, and because a species may experience a significant increase or decrease in population size without an incremental change in status, trend is itself a particularly useful measure to use in addition to conservation status and may be reported in future editions of this report if and when data on trends become available.

These data are not from a site-based monitoring program, but rather from a census approach that focuses on at-risk species; for more common species knowledge has been incorporated from a wide variety of observations and sources.

Data Access: Updated and more detailed information on all species is available at http://www.natureserve.org/explorer. For more customized data requests, contact jason_mcnees@natureserve.org.

The Data Gap

Data are not currently available on the status of most coastal and marine species. However, NatureServe will be incorporating status assessments for marine fishes into their databases. NatureServe already reports the status of nearly 150 coral species found off the coast of southern Florida. NatureServe expects to broaden its coverage of marine species to include many more invertebrates and, hopefully, Hawaiian fishes, which is a large challenge given that these are largely different varieties than those found in coastal regions of the mainland United States.

Data on the status of vascular plants exist (and are reported here), but for the most part, these plants have not been classified according to their habitat associations, in the manner that the animals reported here have been (i.e., animals that are dependent upon forests, or grasslands/shrublands, or fresh water). This is primarily a resource issue—there are far more vascular plants than vertebrate animals, and the size of the workload involved in categorizing them has prevented this work from taking place.

See the indicator for Status of Animal Species in Farmland Areas (page 103) for further discussion of the data gap with respect to species in agricultural landscapes.

See the indicator and technical note for urban/suburban Species Status (pp. 191 and 269) for discussion of the data gap with respect to species in urban/suburban areas.

References

Master, L.L. 1991. Assessing threats and setting priorities for conservation. Conservation Biology 5(4):559–563.

Stein, B.A. 2002. States of the Union: Ranking America's biodiversity. NatureServe, Arlington, VA. 25 p.

Condition of Plant and Animal Communities

The Indicator

The indicator would report separately on the biological community condition of (1) the combined area of land, lakes, and coastal waters and (2) linear features (streams and coastlines). Community condition would first be broken into two major categories: lands and waters under intensive human use and those that are left in semi-natural-to-natural condition. Intensive human use would be divided further into two categories: physically altered and highly managed. Semi-natural-to-natural lands and waters would be divided further into three categories: disturbed, less disturbed, and undisturbed.

Examples of system-specific components and indications of the possible data sources that might be used for reporting on each category follow.

Physically Altered Communities

- Areas covered by 30% or more constructed materials (e.g., asphalt, concrete, buildings), as measured from satellites. Data are available from the National Land Cover Dataset (NLCD; 30-m resolution. These data are derived from the Multi-Resolution Land Characterization Consortium, which is a partnership between the U.S. Geological Survey, the USDA Forest Service, the National Oceanographic and Atmospheric Administration (NOAA), and the Environmental Protection Agency (see the technical note for the national extent indicator, p. 207, for more details).
- Open mines, quarries, and gravel pits, measured from satellite. Data also available from the NLCD.
- Area of road surface (including unpaved roads). Data from the Federal Highway Administration, U.S. Department of Transportation, Highway Statistics 1999, http://www.fhwa.dot.gov/ohim/hs99/.
- Lined and culverted streams. Data not available.
- Hardened coastline miles. Partial data available from NOAA's Environmental Sensitivity Index atlases. (See Shoreline Types, p. 70.)

Highly Managed Communities

- Cropped land (not including interspersed natural area), as measured from satellites. Data from the NLCD.
- Forests planted with nursery stock. Data from Forest Service; see the forest management categories, page 119.
- Intensively grazed grassland. Data not available; also, no specific threshold has been identified that would be used to define which lands are intensively grazed.
- Stream miles impounded into lakes. Data not available.
- Drained or impounded wetlands (areas that remain wetlands but have been highly altered). Data not available.

Disturbed Semi-Natural Communities

- Forests heavily affected by invasive species. Data not available.
- Grasslands and shrublands heavily affected by invasives. Data not available.
- Coastal area heavily affected by invasive species. Data available only for selected estuaries (see p. 222).
- Freshwater rivers and streams with low IBI (Index of Biological Integrity, a species-based measure of disturbance). Data not available. See p. 253.
- Lands and waters with highly altered species mix, such as would be characteristic of altered fire or hydrologic regimes. Neither data nor methods are currently available.

Less Disturbed

- Semi-natural lands and waters that are neither clearly disturbed nor identified as undisturbed.

Undisturbed

- Biological communities with species mix essentially the same as would occur without man's influence. There is no generally accepted method to identify such lands and waters.

Plant Growth Index

The Indicator

The plant growth index is based on data collected by the Advanced Very High Radiation Radiometer (AVHRR) aboard the National Oceanographic and Atmospheric Administration's (NOAA) polar-orbiting satellites. Each 1.1 km^2 mapping area (pixel) has been measured twice a day. Daytime measurements in the visible wavelengths (0.58–0.68 m) and near-infrared wavelengths (0.725–1.1 m) are transformed into a Normalized Difference Vegetation Index (NDVI), which has a near-linear relationship to absorbed photosynthetically active radiation for a given land cover type. NDVI also correlates well with net uptake of carbon dioxide and plant biomass production.

For this indicator, NDVI is calculated at 2-week intervals and summed throughout the growing season; only values that exceed non-growing-season, background NDVI are included. Growing season start dates, end dates, and background NDVI were calculated for each land cover type and region. (For a detailed explanation of calculating growing-season accumulated NDVI, see Reed and Yang 1997).

Because the relationship between NDVI and absorbed photosynthetically active radiation varies by cover type, the growing-season accumulated NDVI was calculated separately for the forest, farmland, and grassland/shrubland areas in each county of the conterminous 48 states, for each year between 1989 and 2000 (except for 1994, when the satellite failed). The 11-year average growing-season accumulated NDVI was also calculated for each of the three land cover types in each county. The values in each county segment for each year were then normalized by using the corresponding 11-year average for that county segment to produce a plant growth index where a value of 1.0 equals the long-term average. Areas with plant growth indices greater than 1.0 have higher-than-average accumulated NDVI; within the same cover type and in an area as small as a county, this implies higher-than-average plant growth for that year. The regional and system-specific plant growth indices are the area-weighted averages of the segments contained within the region and system.

Land cover for each 1.1 km^2 pixel for the growing season was identified from the National Land Cover Dataset. These data are derived from the Multi-Resolution Land Characteristization Consortium, which is a partnership between the U.S. Geological Survey, the U.S. Forest Service, NOAA, and the Environmental Protection Agency. (See the national extent indicator's technical note on p. 207 for more details.)

The Data

Data Sources: Data on accumulated NDVI and analysis of those data are from the USGS's Earth Resources Observations Systems (EROS) Data Center, Sioux Falls, South Dakota (see http://edcwww.cr.usgs.gov/).

Data Quality/Caveats: In 2000, the NOAA-14 orbit drifted to a late afternoon overpass time. The effects of this on the plant growth index have yet to be fully understood. However, because the index is accumulated from the beginning of the growing season—a point that is identified each year from the inherent seasonal patterns in the NDVI data—scientists at the EROS Data Center believe the 2000 estimates are comparable to those of previous years.

The Data Gaps

Data for 1994 are unavailable because of satellite failure. Data are available only for the land area of the conterminous 48 states. The Coasts and Oceans chapter of this report includes an indicator of chlorophyll concentrations in coastal waters, a measure related to algal growth. That measure is based on maximum rather than accumulated concentrations, and thus is not directly comparable.

References

B.C. Reed and L. Yang. 1997. Seasonal vegetation characteristics of the United States. Geocarto International 12(2):65–71.)

Production of Food and Fiber and Use of Water

The Data

Forest Products: Data were obtained directly from the USDA Forest Service. The data used in the graph for the entire United States are the same as those used in the timber harvest indicator (see p. 130). Because no data were available for 1980, the data were divided by the interpolated value for 1980. The same data are not available on a regional basis, so "removals of growing stock" was used instead. This statistic is defined as the net volume of growing-stock trees removed from the inventory during a specified year by harvesting, cultural operations such as timber stand improvement, or land clearing. "Growing stock" is a classification of timber inventory that includes live trees of commercial species meeting specified standards of quality or vigor. Cull trees are excluded. When associated with volume, it includes only trees measuring 5.0 inches (12.7 cm) in diameter or greater at breast height. In general, the trends in "total timber harvest" and "removals of growing stock" are similar. Again, these data were divided by the interpolated value for 1980 in each of the six regions. Data are included from all 50 states.

Marine Fish Landings: Data were obtained directly from the National Oceanographic and Atmospheric Administration (NOAA) and are described in the fish and shellfish landings indicator (see p. 81). Data for Hawaiian waters were included in the Pacific Coast region and those for the Gulf of Mexico were reported in the Southeast region, even though a portion of these off the coast of Texas should be included in the Southwest region. Prior to 1976, much of what is now the Alaskan fishery—as well as portions of the other regional fisheries—was in international waters. These waters came under the control of the United States with the establishment of the U.S. Fishery Conservation Zone in 1976. Thus, the large rise in fish landings visible after 1976 (see the commercial fish and shellfish landings indicator, p. 81) resulted from the acquisition of new territory rather than a jump in the productivity of a given area of ocean. It was possible to include this situation in the indicator in the Coasts and Oceans chapter (p. 81); however, a similar approach was not possible for this indicator. For this reason, data prior to 1978 were not included. Landings were divided by the 1980 value, either nationally or regionally.

Freshwater Withdrawals: Data were derived from the U.S. Geological Survey Circular series "Estimated Use of Water in the United States," which has been published every 5 years since 1950 (note: consistency issues prevented the use of data prior to 1960). More recent compilations (1985–1995) are available electronically at http://water.usgs.gov/public/watuse/ (see the technical note for Water Withdrawals, p. 254). Withdrawals for any given year (and region) were divided by the 1980 value.

Agricultural Products: Data are available online from the U.S. Department of Agriculture's Economic Research Service (ERS). State-by-state data are from Table 7 of *U.S. Agriculture, 1960–96: A Multilateral Comparison of Total Factor Productivity* (Technical Bulletin 1895, available at http://www.ers.usda.gov/data/stateproductivity/). State data were summed for the entire U.S. graph. The data in Table 7 are normalized such that the output for Alabama in 1996 equals 1. These normalized data were summed, either for the nation as a whole or for each region, and then divided by the 1980 value to produce the index values for all other years.

Human Population: Data are available online from the U.S. Census Bureau via the "national" and "state" links at http://eire.census.gov/popest/estimates.php. U.S. or summed regional data were divided by the value for 1980 to produce the index values for all other years.

Outdoor Recreation

The Data

Data Source: Data come from a national survey conducted by phone (National Survey on Recreation and the Environment [NSRE] 1994–95; see http://www.fs.fed.us/research/rvur/recreation/publications/outdoor_recreation/title.htm), in which questions were asked about participation in 68 specific outdoor recreation activities. Similar surveys have been conducted since 1965; however, comparable data on recreation days are not available from them. NSRE 2000, whose data are of the same format as those shown here, is currently under way and will be released soon after this report is scheduled to go to press (see http://www.srs.fs.fed.us/trends/nsre.html).

Data from a total of 17,216 interviews were collected from January 1994 through May 1995. The NSRE survey was composed of two random-digit-dialing (RDD) telephone surveys. During the interviews, which averaged 20 minutes in length, Americans above the age of 15 were asked, among other questions, about participation in activities and the number of days and trips spent in recreation activities.

The NSRE data were grouped into several major activity groups, and the only manipulation of the data here was to re-bundle these groups slightly, as can be seen by comparing Table 4.2 in the NSRE report to the listing below. Note that these categories are compatible with those used in the NSRE 2000.

- *Walking and Biking:* biking, bike touring, walking
- *Viewing Activities:* bird-watching, wildlife viewing, fish viewing, sightseeing, studying nature near water
- *Picnics, Family Activities:* picnicking, family gathering
- *Motor Sports:* off-road driving, snowmobiling
- *Snow Skiing:* downhill skiing, cross-country skiing
- *Hiking, Climbing, Etc.:* hiking, orienteering, backpacking, mountain climbing, rock climbing, caving, horseback riding
- *Camping:* developed area, primitive area
- *Hunting:* big game, small game, migratory bird

- *Fishing:* freshwater, saltwater
- *Swimming and Beachgoing:* surfing, swimming/non-pool, snorkeling/scuba, visiting a beach or waterside
- *Motor Boating and Water Skiing:* motor boating, water skiing, jet skiing
- *Sailing, Floating, Rowing, Etc.:* sailing, canoeing, kayaking, rowing, floating, rafting, sailboarding/windsurfing

Data Limitations/Caveats: The RDD survey approach reaches a random sample of telephone numbers rather than of people. A substantial portion of non-representativeness of some groups is attributable to inability to reach selected households and absence of some households from telephone listings. Affluent families are virtually certain to have telephone numbers and many have more than one. However, many low-income households may not have a telephone. As a result, affluent people may have been over-represented somewhat in the survey sample. On the basis of Census data, differences in age, race, and gender were adjusted for over- or under-representation during data analysis.

Data Availability: Data for the 1994–95 NSRE are freely available on the Internet (see http://www.fs.fed.us/research/rvur/recreation/publications/outdoor_recreation/title.htm) and data for NSRE 2000 will eventually be available at no cost.

The Data Gap

As mentioned in the text, the list of activities for which recreation days are available is not exhaustive, and further distinctions for some activities (e.g., swimming, hunting, viewing) on whether they were conducted in a saltwater or freshwater setting are desirable.

Natural Ecosystem Services

There is no technical note for this indicator.