Figure 1. Percentage of streamgages (out of approximately 220) in the Mid-Atlantic Water Resources Region recording normal to above-normal streamflow for each day from June 22–October 30, 1999. The dashed line represents the percentage of streamgages expected to record normal to above-normal flows on any given date.

Because no single definition or index of drought works in all circumstances, other agencies—the National Oceanic and Atmospheric Administration, U.S. Department of Agriculture, and the National Drought Mitigation Center in conjunction with USGS, U.S. Bureau of Reclamation, and others—have recently developed a new information product called the "Drought Monitor." Designed to assist resource managers, this product is a weekly synthesis of multiple indices, outlooks, and news accounts and represents a consensus of federal and academic scientists on the current status of drought in the United States. It is available online at http://enso.unl.edu/monitor/monitor.html.

Robert M. Hirsch and Harry F. Lins are Chief Hydrologist and Hydrologist, respectively, at the U.S. Geological Survey, Reston, VA.

NEW REPORTS

New York City's Watershed Management Strategy

by Laura Ehlers

January 21, 1997 marked an important event in the history of American water management, namely the signing of the mammoth New York City Watershed Memorandum of Agreement (MOA) as a legal framework to protect the drinking water supply of nine million people. The culmination of years of negotiation between upstate and downstate interests, the MOA commits New York City to a long-term watershed management program that combines land acquisition, new watershed rules and regulations, and financial assistance to watershed communities to promote environmental quality and their local economies. Most important for New York City, the agreement currently satisfies provisions of the EPA's Surface Water Treatment Rule that will allow the City to avoid filtering its upstate Catskill/Delaware water supply until at least 2002.

Immediately following the signing of the MOA, the National Research Council's Water Science and Technology Board was asked by the New York City Comptroller's Office to provide a scientific evaluation of the watershed management program. The goal of the NRC study was to determine whether the MOA is based on sound science and to recommend improvements to strengthen watershed management for this large unfiltered supply. A new WSTB report, *Watershed Management for Potable Water Supply: Assessing New York City's Approach,* is the culmination of this two-year study.

The NRC committee was asked to address many provisions of the MOA including (1) the use of setback distances to protect bodies of water from nonpoint source pollution; (2) the Total Maximum Daily Load (TMDL) program; (3) siting and technology requirements for wastewater treatment plants and septic systems; (4) the phosphorus offset pilot program; (5) the enhanced monitoring program; and (6) antidegradation policy. The role of active disease surveillance in watershed management was explored and a microbial risk assessment was conducted. Finally, the committee considered the potential impact of future changes in federal regulations regarding safe drinking water.

The NRC committee found the MOA to be a good template for proactive watershed management that, if properly implemented, will maintain high water quality in the Catskill/Delaware system. However, it warned that the MOA is not a guarantee of permanent filtration avoidance because of changing regulations, uncertainties regarding sources of pollution, advances in science that may improve treatment technologies, and natural variations in climate, streamflow, and watershed conditions. The committee recommended that New York City place the highest priority on pathogenic microorganisms in the watershed and direct its resources towards (1) improved methods for detecting pathogens, (2) identifying the sources of pathogens, (3) understanding pathogen transport and fate, and (4) demonstrating the ability of best management practices (BMPs) to reduce pathogens in stormwater. Currently, the main focus of New York City's watershed management strategy is phosphorus because of its role in eutrophication and its contribution to the creation of disinfection byproducts. Considerably less effort has been expended developing monitoring and modeling tools for microbial pathogens, which pose a more significant and direct threat to public health.

The report states that the concept of balancing

watershed rules and regulations with targeted financial support of watershed community development is a reasonable strategy for New York City and possibly other water supplies. The report acknowledges that resulting economic development in the watershed region may affect water quality. However, existing information convinced the committee that population growth in the Catskill/Delaware watershed is very limited and that increased economic activity can be offset by careful planning, directed development, more extensive environmental regulation, and improved wastewater management, as provided in the MOA. Such measures should maintain high water quality in the reservoirs over the next several years, assuming growth rates do not increase substantially. Highlights from some of the other conclusions and recommendations found in the report are presented below.

- Monitoring of all parameters in streams, subsurface flow, and wastewater treatment plant effluent should be based primarily on flow proportional sampling rather than on fixed-frequency sampling.
- The MOA requires setbacks or "buffer zones" between some polluting activities and waterbodies to help protect the water supply. The report states that setbacks in the watershed must be actively managed in order to achieve the pollutant removals ascribed to buffer zones and gives suggestions for such management. The City is urged to not rely upon setbacks as the sole protection from nonpoint source pollution.
- Stormwater BMPs are limited in their ability to remove pollutants from runoff. Performance monitoring of these BMPs will be critical to the success of many MOA programs including the TMDL program, the phosphorus offset pilot program, the Watershed Agricultural Program, and Stormwater Pollution Prevention Plans.
- Planned upgrades to wastewater treatment plants will be sufficient to counter pollutant increases with population growth for 40 to 100 years. However, failing and new septic systems should be upgraded/constructed using best available control technology—aerobic treatment units coupled with a rigorous inspection and maintenance program.

The committee was chaired by Charles R. O'Melia of the Johns Hopkins University. Funding was provided by the New York City Comptroller's Office. To order a prepublication copy of the report, contact the National Academy Press at 800-624-6242 or *http://www.nap.edu*.

Ecological Indicators for the Nation
by Jeffrey Jacobs

In the realm of environmental sciences and policymaking, indicators are useful in monitoring conditions and changes in the nation's ecosystems and in measuring the effects of environmental policies. There have been multiple efforts to developing ecological indicators for the United States. However, the complexities and uncertainties of ecosystems and their behavior present significant challenges in developing a concise and comprehensive set of national-level indicators. Although no current indicators of environmental conditions or trends have the stature of influential economic indicators, the environmental indicators of global mean atmospheric temperature, sea surface temperatures, and atmospheric carbon dioxide concentrations are attracting considerable attention. The development of indicators of comparable power for ecological processes will help focus attention on ecosystem conditions, providing clues that could help guide and improve environmental policy decisions. The recently released report from the WSTB and BEST, *Ecological Indicators for the Nation*, represents an important step forward in the country's development of ecological indicators.

To avoid some of the pitfalls common to ecological indicator development (e.g., lack of clear linkages between an indicator and underlying ecological processes), the report recommends use of the following criteria to evaluate potential indicators:

General importance*:* Does the indicator provide information about changes in important ecological and biogeochemical cycles?

Conceptual basis: Is the indicator based on a well understood and generally accepted conceptual model of the system to which it is applied?

Reliability: Has the indicator proven reliable?

Temporal and spatial scales: Does the indicator provide information about local, regional, or national processes? Are the changes measured by the indicator likely to be short- or long-term?

Statistical properties: Is the indicator sensitive enough to detect important changes, but not so sensitive that signals are masked by natural variability?

Data requirements: How much and what kinds of information are necessary to permit reliable estimates of the indicator to be calculated?

Skills required: What technical and conceptual skills must the collectors of data for an indicator possess?

Data quality: Are the data reasonably accurate?

Robustness: Is the indicator likely to be relatively insensitive to expected sources of interference or changes in measurement technologies?

International compatibility: Is the indicator compatible with indicators being developed outside the Unites States?

Costs, Benefits, and Cost-Effectiveness: How do the indicator costs compare to its benefits? Is there a less

costly way to obtain information from this indicator?

According to the report, national-level indicators should be developed for three major categories: (1) land cover and land use, (2) ecological capital, and (3) ecosystem functioning. It was recommended that these indicators be implemented sequentially, with the land cover indicator implemented first. The land cover indicator includes aquatic and dryland ecosystems and records the percentage of land in each of many land cover categories. A similar land use indicator should be developed when sufficient information is available.

Ecological capital refers to physical components, such as soil, and to the species that drive and maintain ecosystem processes. As an indicator of soil condition, the NRC committee recommended that *soil organic matter* be used. It was also recommended that *nutrient runoff* be used to indicate the loss of essential nutrients from the soil. As indicators of biotic capital, two indicators were recommended: *total species diversity* and *native species diversity*.

Regarding ecosystem functioning, the report describes three indicators of terrestrial productivity and two indicators of aquatic productivity. The recommended indicators of terrestrial productivity are *production capacity*, measured by total chlorophyll per unit area, *net primary production*, a direct measure of the amount of energy and carbon that has been brought into an ecosystem, and *carbon storage* of ecosystems, a direct measure of the amount of carbon sequestered or released by ecosystems. The two indicators recommended for aquatic ecosystems are *stream oxygen* and the *trophic status of lakes* (the latter can be developed from a few key characteristics that determine lakes' functional properties and their ability to provide ecosystem services).

Because agriculture represents a large and important percentage of the nation's overall land use, it merits additional indicators, according to the report. *Nutrient use efficiency* and *nutrient balance*, for both nitrogen and phosphorus, are described as important indicators in agricultural settings. Similarly, the report provides indicators of forested ecosystems and notes that similar indicators can and should be developed for other vegetation types. Indicators to evaluate the "diversity status" of a local area are described: *independence of an area*, *species diversity*, and *deficiency of natural diversity*, all of which provide unique information on various aspects of diversity.

The NRC committee was chaired by Gordon Orians of the University of Washington. The report was prepared in response to a request from the U.S. Environmental Protection Agency. To obtain a prepublication copy of the report, contact the National Academy Press at 800-624-6242 or *http://www.nap.edu*.

Hydrologic Science Priorities for the U.S. Global Change Research Program: An Initial Assessment

By Stephen D. Parker

During the past decade, an in-depth understanding of the water cycle, especially at regional scales, has emerged as a major scientific challenge within the U.S. Global Change Research Program (USGCRP), a federal effort to enhance understanding of the global environment and assess its possible evolution. As water is a critical component of other systems and critical to humankind, it has emerged as a cross-cutting theme in the USGCRP. The global water cycle, now one of USGCRP's six fundamental program elements, offers two primary research challenges: (1) land-surface interactions and (2) atmospheric processes. Research in hydrologic science is primarily in the first area, an area that includes land surface–atmospheric coupling over a range of spatial and temporal scales and includes the role of the land surface state in climate variability and change. According to the new WSTB/BASC report *Hydrologic Science Priorities for the U.S. Global Change Research Program: An Initial Assessment,* these challenges are important but limited. Broader challenges for hydrologic sciences that address cross-disciplinary research and recognize the integrative nature of terrestrial hydrology could strengthen the USGCRP.

This first report by the Committee on Hydrologic Science states that terrestrial hydrologic processes, specifically the storage and movement of water on land and within the terrestrial biosphere, are important across all of the USGCRP elements and should serve as a unifying physical process within the USGCRP. To meet these additional challenges, this report identifies two broad science areas that augment the current hydrologic sciences content of the USGCRP: (1) predictability and variability of regional and global water cycles and (2) coupling of hydrologic systems and ecosystems through biogeochemical cycles.

Predictability directly addresses the USGCRP priority of identifying possible future environmental change. The report recognizes current plans within the climate variability element but recommends additional research topics that can strengthen the long-term research goals of USGCRP. These additional topics include enhanced understanding of linkages in variability of global and regional hydrologic systems as the basis for producing improved predictions. The emphasis on variability and predictability, particularly in regional hydrologic systems, is designed to link the understanding of the global water cycle with emerging regional and local water resources issues.

According to the report, cross-disciplinary research involving hydrologic science is key to addressing challenges identified under both the USGCRP global carbon cycle and global water cycle elements. For example, terrestrial ecosystems exert a strong influence

on the global water cycle through evaporation processes. Also, ecosystem disturbances are likely to be a major pathway for any changes and shifts in water and chemical cycles resulting from human activity. The foundation for this research must be a better understanding of the water and chemical pathways and of hydrologic–ecosystem linkages and a new means of achieving this understanding. It is then possible to address the combined influences of climate change and land use change, which occur in the context of natural variability, on hydrologic systems and ecosystems.

The USGCRP should give high priority to developing effective measurement and data strategies specifically for the terrestrial component of the global water cycle. The strategies should address multiple needs, ranging from the detection of change to process studies to operational applications. Future planning for remote sensing and ground-based measurement networks should be integrated to give measurement strategies that are responsive to the priorities discussed above. This will require a high degree of interagency and international collaboration, and it will require new approaches to planning hydrologic measurements. Considerable attention also needs to be given to recovering and archiving hydrologic data and making the data available through effective data and information systems. These strategies need to integrate remote sensing and ground-based data, and they must be sustained over the long term.

Water issues are central to the USGCRP emphasis on global change and its impacts. Therefore water issues can help guide the evolution of new initiatives within the USGCRP. To yield effective results, concerted efforts need to be made to improve connections between hydrologic research and its applications.

As noted on page 9, this report was released in early September. Copies can be obtained at no charge by sending an e-mail request to *sdparker@nas.edu.*

UPDATE: CURRENT PROJECTS

Restoration of the Greater Everglades

The Committee on the Restoration of the Greater Everglades Ecosystem, approved in late September, will function as an independent scientific review panel to give advice on the implementation of the Central and Southern Florida Comprehensive Review Study (Restudy) and the restoration of the South Florida Ecosystem. This committee was formed at the request of the Secretary of the Interior, Bruce Babbit.

The Florida Everglades is the largest single wetland in the contiguous United States. Since the mid-1880s, the historical Everglades has been drained and half of the area devoted to agriculture and other development. The remaining wetland areas have been altered by human disturbances, chiefly by diverting water for human uses, lowering water flows to protect against floods, and greatly increasing the nutrient supply to the wetlands by runoff from agricultural fields and urban areas. The present management system of canals, pumps, and levees will not be able to provide adequate water supplies to agricultural and urban areas, or sufficient flood protection, let alone to support the natural ecosystems remaining as wetlands.

The committee will provide a scientific overview and technical assessment of the many complicated, interrelated activities that are occurring at the federal, state, local, and non-governmental levels. In addition to strategic assessments and guidance, the committee will provide more focused advice on technical topics of importance to the restoration efforts.

Members of the new committee are James M. Davidson, *Chair*, University of Florida (Ret.); Jean M. Bahr, University of Wisconsin; Linda K. Blum, University of Virginia; Patrick L. Brezonik, University of Minnesota; Robert W. Burchell, Rutgers University; Frank W. Davis, University of California, Santa Barbara; Wayne C. Huber, Oregon State University; Stephen R. Humphrey, University of Florida; Daniel P. Loucks, Cornell University; Scott W. Nixon, University of Rhode Island; Gordon H. Orians, University of Washington; Kenneth W. Potter, University of Wisconsin; Larry Robinson, Florida Agricultural and Mechanical University; Steven E. Sanderson, Emory University; Rebecca R. Sharitz, Savannah River Ecology Laboratory; and John Vecchioli, U.S. Geological Survey (Ret.). The committee's first meeting will be December 2-4 in Ft. Lauderdale, FL. Meeting schedules and agendas will be posted on the National Academies website (http://www.national-academies.org). For more information contact Stephen Parker at 202-334-3422 or *sdparker@nas.edu* or Tricia Jones at *pjones@nas.edu.*

Privatization of Water Services in the United States

Private development of water services was the initial approach taken by many U.S. cities for drinking water supply and wastewater services. With the growth of large cities and strong governments, however, local government took over most of the private water supply and sewerage companies. During the past 15–20 years, there has been a renewed interest in privatizing water services, with many cities leasing various parts of water supply and treatment systems to private operators. While the privatization of water services holds much promise, the long-term consequences of privatization are not clear.

A newly appointed WSTB committee will provide a comprehensive review of water service privatization in the United States and its economic and fiscal, regulatory,