



FACING TOMORROW'S CHALLENGES: USGS SCIENCE IN THE DECADE 2007–2017

# Understanding Ecosystems and Predicting Ecosystem Change

*In 2007, the U.S. Geological Survey (USGS) developed a science strategy outlining the major natural science issues facing the Nation in the next decade. The science strategy consists of six science directions of critical importance, focusing on areas where natural science can make a substantial contribution to the well-being of the Nation and the world. This fact sheet focuses on understanding ecosystems and predicting ecosystem change, and how USGS research can strengthen the Nation with information needed to meet the challenges of the 21st century.*

## Importance of Ecosystems

Ecosystems constitute the Earth's biosphere and support human existence. Knowledge of ecosystems is critical to the well-being of the Nation because ecosystems supply the natural resources and other goods and services that humans require. Resilient, functioning ecosystems build soil, enhance pollination of crops, purify water, supply raw materials, regulate the atmosphere, cycle nutrients, and detoxify waste. These and other ecosystem processes collectively form the basis for all life on Earth.

For terrestrial, freshwater, and coastal/marine ecosystems to continue supplying these benefits, human interactions with ecosystems need to be well managed, especially in the face of increasing global pressures. A proactive approach to managing ecosystems will require an advanced understanding, gained through research, of ecosystem structure, function, condition, and distribution. The ability to project future ecosystem states in response to societal pressures is vital to ensuring that ecosystems continue as the essential life-support systems for the Earth.

Land change affects ecosystems in critical ways. It alters their structure and function; can limit the availability of goods and services that are essential for ecosystem health and societal well-being; directly impacts habitat quality and biodiversity; creates pathways for the spread of invasive species; and affects atmospheric chemistry, weather and climate, water quality and quantity, and other environmental systems. Because the

resilience of ecosystems varies geographically, understanding change in a geographical and ecosystems framework is essential for managing its consequences.

## Why Action is Needed Now

Large-scale, rapid change is now taking place in all natural systems throughout the world. Growing human populations and substantial alterations to landscapes, oceans, and the atmosphere have caused widespread changes in the global distribution and abundance of organisms. Changes in biodiversity alter ecosystem processes, productivity, and structure, and often reduce the resilience of ecosystems to future environmental change.

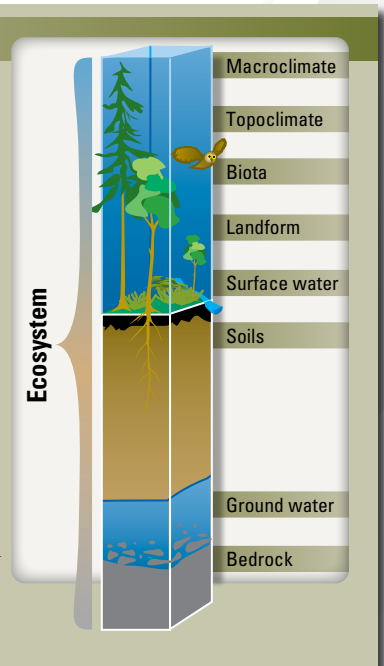
The state and fate of ecosystems and the materials they supply to human societies, previously of interest mainly to earth scientists and environmentalists, are rapidly emerging as a global concern of citizens, governments, and industry. There is a growing realization that it is impossible to separate economic development from the environment and that environmental degradation can undermine economic development.

Effective management of ecosystems and natural resources depends on a thorough knowledge of the types and distributions of ecosystems and their attributes, in concert with a comprehensive understanding of ecosystem processes and function. However, understanding of ecosystem condition, change, and causes of change is currently hampered by incomplete knowledge of the connections between and among species, including humans, and the environment. The United States currently lacks scientifically sound indicators of ecosystem condition, comprehensive maps of ecosystem distributions, and a rigorous ecosystem monitoring program. These deficiencies

## What is an Ecosystem?

An ecosystem is an integrated system of organisms interacting with their physical environment. Energy and materials cycle through these organisms and their environment, including soil, sediment, water, and the atmosphere. Ecosystems serve as a framework for understanding the diversity of the Earth's physical and biological processes. Because organisms interact with the physical environment at all scales—from microscopic to global—ecosystem boundaries are by definition a human construct. Nevertheless, defining discrete ecosystem units can be useful for management or conservation purposes.

**The vertical structure of an ecosystem**, showing the spatial integration of its biological and physical components. (Reproduced with permission from Bailey, R.G., 1996, *Ecosystem geography*: New York, Springer-Verlag.)



hamper the Nation's ability to understand, forecast, and mitigate ecosystem change, assess ecosystem vulnerability to human activities, and avoid damage to regional and global ecosystems.

## How the USGS Can Help

Ecosystem studies require the full power of an integrated systems approach and thus are a perfect fit with USGS capabilities and strengths. As the only Federal agency that combines scientific expertise in biology, hydrology, geology, and geography, the USGS is uniquely positioned to advance understanding of terrestrial, freshwater, and marine ecosystems and to predict ecosystem change.

During the next decade, the USGS will emphasize the fundamental research, mapping, and monitoring necessary to assess the Nation's ecosystem function, as well as begin to document and forecast change. Working with partners, the USGS will develop new products, including standardized national maps of ecosystems in the United States and regularly updated status and trends assessments, that will help communities and land and resource



**Land use** has dramatically altered the distribution and composition of forest lands in the Eastern United States, changing the structure and function of these ecosystems. The extensive loss of bottomland hardwood forests, for example, has affected water quality, increased the risk of floods, and altered the distribution and abundance of animals that depend on these forests, such as the ivory-billed woodpecker.

managers make informed decisions about sustainable resource use. In addition to forming an excellent science foundation for managing ecosystems across the Nation, the information, understanding, and tools and systems approach provided by this strategic direction will serve as

a critical underpinning for other USGS strategic focus areas, including climate variability and change, energy and minerals, natural hazards, the role of environment and wildlife in human health, and water.

## USGS Science Can Meet the Challenge

### The USGS is ready to take action by:

- Conducting basic, place-based research into ecosystem structure, function, and processes.
- Coordinating, developing, and regularly updating scientifically rigorous, standardized, geospatial classification models and maps of national ecosystems at scales appropriate to land-manager needs.
- Identifying ecosystems vulnerable to ongoing changes of climate, contamination, and land use, and quantifying the consequences of ecosystem and land-use change to water quality and quantity, health, hazard risk, biodiversity, and other ecosystem services to human society.
- Developing a multipartner, robust assessment of the status and trends of the Nation's ecosystems.
- Expanding and modernizing USGS observation networks by using new and emerging technologies for long-term observations of the physical and biological resources that are impacted by land-use/land-cover change, climate, contaminants, and other drivers of ecosystem structure and function.
- Developing credible forecasts of responses to ecosystem stressors, including land use, climate change, contaminants, invasive species, and other threats.
- Working with other Federal agencies to evaluate and test restoration or mitigation methods and technologies for increasing ecosystem resilience to disturbances.

## A Vision For the Future

The USGS is the Nation's premier source of information in support of science-based decisionmaking for ecosystem management. USGS scientists collaborate with others to document the nature and causes of ecological change across the Nation and to provide information on the consequences of change to human health and safety, ecosystem function and resilience, and the resources upon which human societies are built.

### For Additional Information

U.S. Geological Survey, 2007, Facing Tomorrow's Challenges—U.S. Geological Survey Science in the Decade 2007–2017: Available online at <http://pubs.er.usgs.gov/usgspubs/cir/cir1309>

Also, visit the USGS home page at <http://www.usgs.gov/>