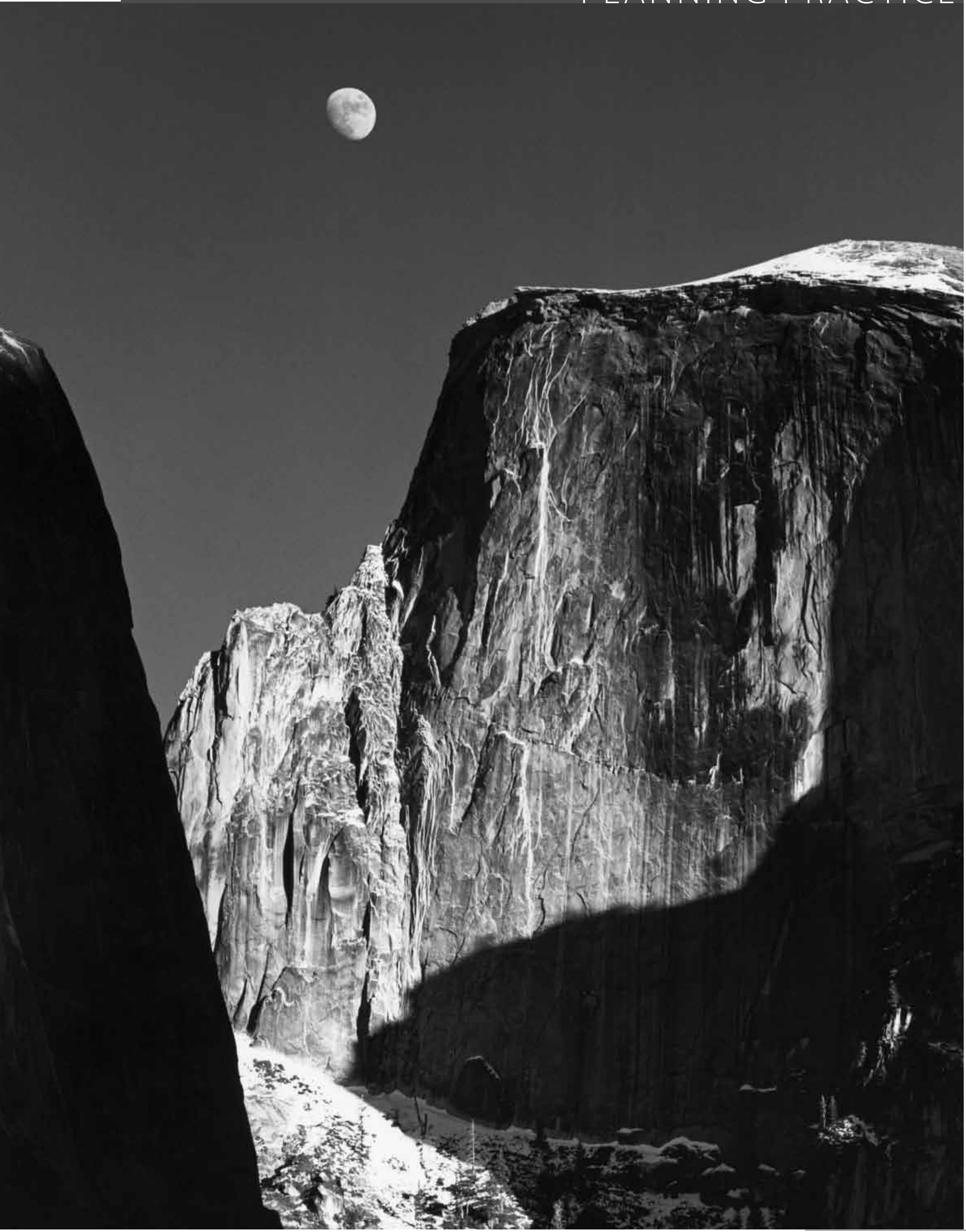
Mapping the Land to Protect It

By Peter Gisolfi and Christopher Tramutola

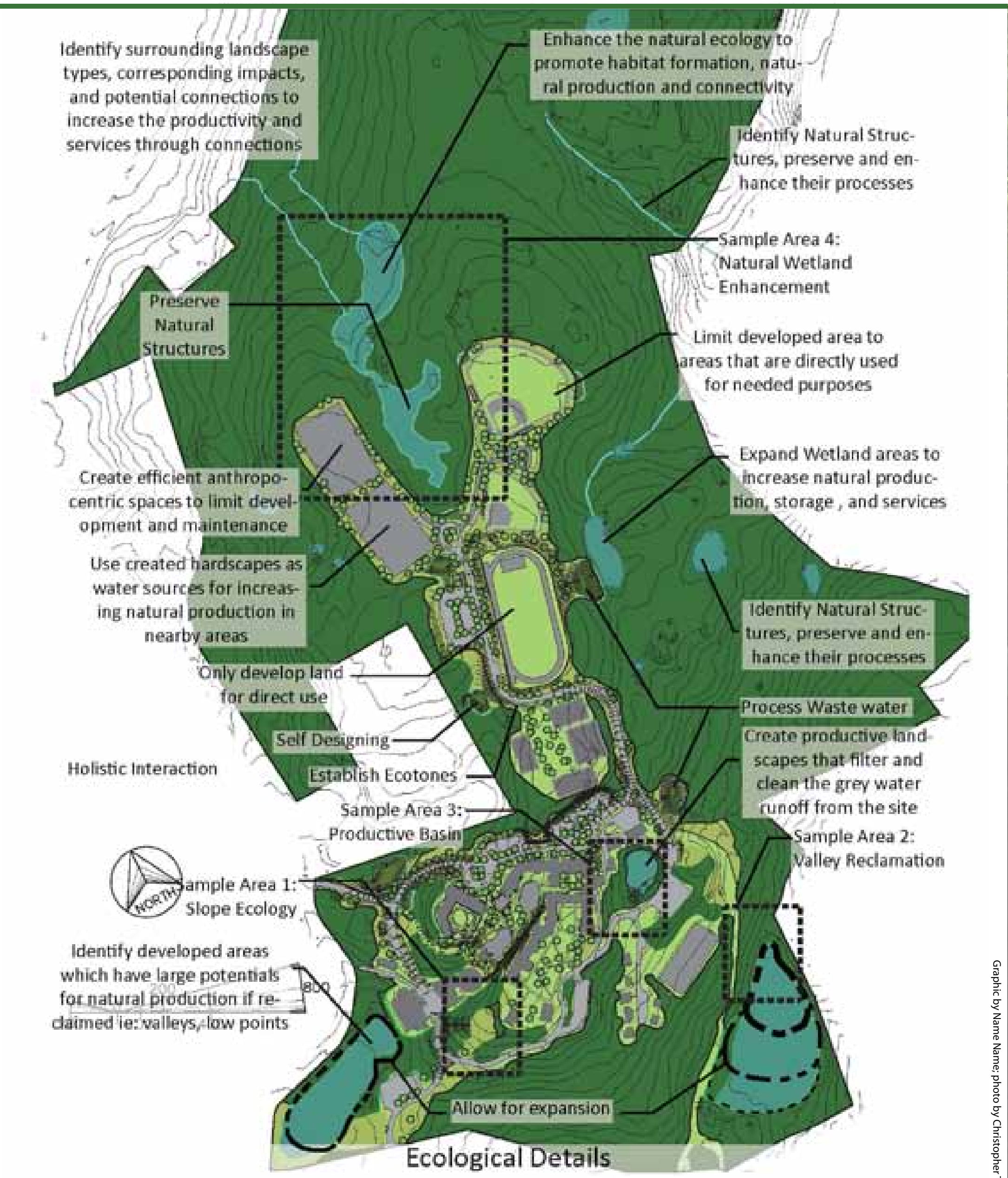
THE FIRST EUROPEANS TO ENCOUNTER THE NEW WORLD THOUGHT THEY had arrived at the Garden of Eden—a place of inexhaustible natural resources. But by the second half of the 19th century, many resources that had been thought of as unlimited had been diminished. It became apparent that if the country's inhabitants continued on this path of destruction, places of extraordinary natural beauty might disappear forever.

Natural preservation was first attempted in the U.S. at California's Yosemite Valley. American landscape architect Frederick Law Olmsted participated in the planning that preserved Yosemite as a state park in 1864. Part of Yosemite became a national park in 1890 and the remainder in 1906. Natural preservation persisted for several decades, but was focused solely on extraordinary natural places.

Conservation came next, and with it the impulse to save state and national forests throughout the country. Only later, in the 1930s, did the idea of stewardship emerge, when the Dust Bowl struck the Great Plains. Careless farming and grazing on the land enabled wind-borne soil erosion that devastated the agricultural community. It was during this event that the federal government invested in land mapping and



Moon and Half Dome, Yosemite National Park, California, 1960 by Ansel Adams © Ansel Adams Publishing Rights Trust/CORBIS



Graphic by Name Name; photo by Christopher Tramutola

Design using ecological tools

Using the tools and concepts established by ecological research, the master plan for this school campus anticipated changes in buildings and the landscape over time. While some areas were disturbed and hardscape constructed, other areas were created as enhanced natural landscapes. The photos on the following pages show the results.

documentation as a means of inventorying and managing agricultural soils. Since that time, federal data combined with evolving mapping and modeling technology has had a tremendous impact on planning and landscape architecture.

From Dust Bowl to data

In April 1935, in response to the Dust Bowl, Congress passed a law establishing the Soil Conservation Service. Public Law 74-46 recognized that " . . . the wastage of soil and moisture resources on farm, grazing, and forest lands . . . is a menace to the national welfare." The law, which required soil erosion prevention measures, had unexpected but positive consequences in planning and design. In the subsequent decades of the 20th century, soil mapping, based on SCS data, became the basis for natural resources inventories.

Another critical source of information about the land comes from the U.S. Geological Survey, founded in 1879. This agency has been mapping geological formations for more than 130 years. Together, USGS and SCS information provide an invaluable, three-dimensional view of the land.

With this information available, the academic world began using the data for landscape analysis. Philip Lewis started to use SCS and USGS maps in the landscape architecture program at the University of Wisconsin in the late 1950s and later documented that early work in his 1996 book, *Tomorrow by Design.* And, in a parallel

One of the enhanced landscapes on the school property six years after implementation. Because the disturbance created by a track and athletic field lowered the net primary productivity of the overall campus, this wetland was expanded so that the additional stormwater could equalize the negative impact.

development, Ian McHarg used the same information for landscape mapping starting in the 1960s at the University of Pennsylvania. In 1969, he self-published *Design With Nature*, a revolutionary volume for landscape architecture, regional planning, and the whole environmental movement. In that book, McHarg explains how to use the information to analyze the land and, in a series of eloquent diatribes, expresses passionately why it is essential to do so.

As new federal organizations arose, additional data became available. For example, the U.S. Fish and Wildlife Service, established in 1940, provides data on wetlands and sensitive waterways. The Department of Transportation, organized in 1966, in conjunction with the U.S. Army Corps of Engineers (originally founded in 1802) provides data on roadways. Finally, the National Oceanic and Atmospheric Administration, formed in 1970, measures and produces data related to coastal shorelines and large bodies of water.

The data produced by these and other similarly focused organizations is used by planners and landscape architects in site assessments, analysis, and design. As the information becomes more complex and our tools of research reveal more intricate data, our synthesis of analysis can direct our designs more accurately—whether for sustainability, suitability, or conservation.

Planners and landscape architects use the available data in numerous ways. Wetland data in particular are used by both


Photo by Christopher Tramutola

Reestablished native landscape with a meadow and wildflowers. The school's adjacent athletic fields and access ways are the only maintained areas of the site.

professions to delineate sensitive landscapes and ecosystems that should be protected. Landscape architects may use the information to design intricate hydrologic systems to enhance the landscape; planners may use the information to outline zoning. An additional layer of analysis was added with the Federal Emergency Management Agency floodplain maps, which have had a significant impact on zoning and urban design. Agencies like the Environmental Protection Agency and the Department of Environmental Protection provide more precise information regarding sensitive landscapes, species, and toxins.

Digital process eases accessibility

As a direct result of the increased amount of data and its accessibility, landscape analysis has become much more sophisticated over the past 40 years. Certainly, the use of geographic information systems has made data more widely available, and the use of digital technology has changed the way we work. Instead of tracing information from printed reports by hand, landscape architects and planners can obtain all pertinent information digitally, layer the data, and then produce the relevant maps. GIS provides a means of seeing "relationships, patterns, and trends" that was not available before, as is noted on www.gis.com, the website operated by ESRI, the GIS pioneer based in Redlands, California.

Most land-planning exercises are based on a straightforward question: What is the best use of the land or where is the best place for this use to be located? Suitability maps help to answer this question by allowing multiple factors to be considered at once. For example, a soils map might indicate suitability for cropland, suitability for preservation as forest lands, or suitability for construction. When suitability maps are produced for each category, they can be overlaid and an overall synthesis of suitability ascertained.

For example, soil horizon data has been combined with topographic information to give a more complete view of a site's suitability. The slope percentage, aspect, hydrology, vegetation, bedrock strata, and soil structure provide the needed information to judge what use the site can accommodate.

This McHargian method shows that more sensitive or highly productive landscapes have a combination of key factors that are easily seen when overlaid. Wetlands, for instance, generally have poorly drained soils or high bedrock strata, submergible vegetation, larger carbon sequestration rates, a higher level of biodiversity and, typically, are located in the valley of a watershed. While any of these factors individually do not necessarily indicate a sensitive landscape, the combination of factors provides a better understanding of the land and how it can be protected, enhanced, or used.

Since the early 1970s, specific conventions have developed to protect certain landscapes. The land types usually under consideration include wetlands, floodplains, steep slopes, aquifer recharge areas, prime agricultural land, key wildlife habitat, prime pasture and rangeland, and forest and woodland.

The evolving theory is that if we protect the more important and fragile landscape resources, we will actually preserve the environmental sustainability of the ecosystem. To take an obvious example, for many years suburban development all over U.S. occurred on our most valuable agricultural soils. The conventional wisdom is that the King of Prussia shopping mall and the surrounding suburbs in Montgomery County, Pennsylvania, are located on some of the best agricultural land in the Northeast: flat land in a limestone valley—with fertile, well-drained, and neutral soil that is ideal for the crops that human beings consume.

However, many types of land that were open to development 50 years ago have been protected by a profusion of local, state, and national laws, including Pennsylvania's ambitious farmland preservation program. In some jurisdictions, it is no longer permissible to build on floodplains, wetlands, steep slopes, or aquifer recharge areas. In other places, floodplain development may occur, but it must meet certain requirements. Still, simply prohibiting or limiting development in the more fragile areas does not necessarily lead to the best plan or to a self-sustaining ecosystem. Those are more subtle and elusive goals.

In the present . . .

What is the current situation? The Soil Conservation Service, now renamed the National Resources Conservation Service, is still the authoritative source for soil survey information, but now its scope of activities has widened. Data are now available online for more than 95 percent of the nation's counties, and that number is expected to increase to 100 percent in the future. Once the data meet two criteria (frequent updates and parcel-by-parcel recording), it will be easier to predict and substantiate the benefits of planning with natural systems. NRCS, USGS, NOAA, and other organizations are adjusting procedures so that their research can be updated more quickly and be available at smaller scales.

Not only is NRCS data more accessible now, but GIS has revolutionized our ability to use the information effectively. GIS offers a more complex "real-time" view of existing sites as well as how the sites might be altered by development. A digital GIS is generally the most efficient way to store, compute, and analyze the data collected.

GIS is superior to other program types, like CAD and 3-D modeling, because its software allows information and calculations to be stored within "objects" identified on the plan (buildings, open space, etc.). In this way, data can be recalled when modifications are needed. A number of different GIS programs offer this type of digital software, ArcGIS being the most widely used.

With the aid of digital software, hypothetical designs can be seen and analyzed virtually at once. These GIS-based digital ecosystem models are capable of measuring large amounts of raw data, which can then be applied and adjusted as plans are developed. Examples of ecosystem GIS models are the National Aeronautics and Space Administration's MODIS (Moderate Resolution Imaging Spectroradiometer); the USGS's NLCD (National Land Cover Dataset) and its MRLC (Multi-Resolution Land Characteristics) Consortium; and Ecological Zone maps generated by state department of environmental conservation agencies. These models are now capable of aiding design decisions as precise as urban planning scales, but are not yet at the scale of a typical landscape architectural project. Once predictions and substantiations become more precise, there will be a strong need to further enhance the expectations for site analysis at all scales.

Our current planning process still includes variables that need to be measured more accurately. This precision will allow communities to gauge their success in meeting their established goals, especially in the areas of sustainability, green infrastructure, and suitability, where clear quantitative data are not always available.

In the future . . .

What does the future hold? As more raw data become available, natural processes and natural services—the resources natural areas provide for human needs—will be more accurately projected. New tools of analysis are currently in the testing stages. Using information programs like GIS, which provides almost instantaneous feedback, designs can be evaluated according to how different schemes affect natural services such as sequestration of carbon and release of oxygen (photosynthesis), food and fuel production, water filtration, and open space. The evaluations can be enhanced by using plug-ins that enable users to provide more targeted information about topics.

Plug-ins are currently available from organizations such as the Natural Capital Project, Intergovernmental Panel on Climate Change, and Fluxnet (a global network that measures the exchanges of carbon dioxide, water vapor, and energy between land ecosystems and the atmosphere.) The use of these enhancements in conjunction with data gathered from GIS sources allows the information to serve as a tool for design as well as analysis.

These evaluations can clearly show how different developments and design ideas affect natural services, such as net primary production, stormwater filtration, and biodiversity. The projections can also establish new principles to support natural processes, such as the creation of ecotones (transitional zones between ecosystems), ecological buffers, and open, evolving (unmaintained) landscapes. Having this information readily available will produce a better-informed designer, provide greater clarity to the public, and result in more ecologically sophisticated plans. Moreover, the process could possibly result in lower construction costs and far less maintenance of the land.

Since the 1930s, detailed information about natural processes has been systematically gathered by publicly funded agencies. This information can now be accessed more easily than ever before. The future for planning and design will be determined by how effectively we use these data—along with other data—to get a complete picture of the landscape. We can now use data along with modeling and mapping to quantify impacts and easily compare multiple future scenarios—so we can know the cost of our decisions before they are final. In other words, we can anticipate the expected outcomes.

We all applaud highway and bridge design responsive to seismic mapping, which identifies potentially dangerous areas. In the future, will we proceed recklessly, or—using the data and mapping tools now available—will we consider the costs before deciding on a course of action? ■

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RESOURCES

ONLINE

Natural Capital Project: www.naturalcapitalproject.org.
Intergovernmental Panel on Climate Change: www.ipcc.ch.
Fluxnet: www.fluxdata.org.
National Resources Conservation Service: www.nrcs.usda.gov.
United States Geological Survey: www.usgs.com.
U.S. Fish and Wildlife Service: www.fws.gov.
National Oceanic and Atmospheric Administration: www.noaa.gov.
ESRI: www.gis.com; MODIS: modis.gsfc.nasa.gov; NLCD: landcover.usgs.gov.
MRLC: www.mrlc.gov; U.S. Army Corps of Engineers: www.usace.army.mil.