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MICHIGAN and Landsat

Water means a lot to Michigan, often called the Great Lakes State. The name "Michigan" comes from an Ojibwe word meaning large, or great, water or lake. As the only State touching four of the five Great Lakes—Michigan, Superior, Huron, and Erie—it claims the longest freshwater coastline in the United States.

Yet Michigan is not just about water—forests, agriculture, mines, cities, and even sand dunes stretch across the State's landscape. Much of what happens on the land does connect in some way with Michigan's inland and coastal waters. Michigan relies on a healthy environment to support its residents, abundant tourists, and diverse species of wildlife that call the State and its surrounding waters home. From hundreds of miles above, Landsat satellites provide a clearer picture of the connections among land, water, and the people and wildlife that inhabit the State.

Here are several examples of how Landsat benefits Michigan, especially as it relates to the Great Lakes Restoration Initiative (GLRI). The GLRI is a collaborative effort among Federal agencies and their partners, including adjacent States, that aims to protect and restore the Great Lakes.

Helping Control an Invasive Species

The control and prevention of invasive species—plants, fish, and mussels—is one focus area for the GLRI. For example, Landsat images have helped map the distribution of the dense and towering invasive *Phragmites australis* (Cav.; Trin. ex Steud.), or common reed, in coastal areas such as southeastern Michigan along Saginaw Bay, Lake St. Clair, and Lake Erie. Left unchecked, the wetland plant reduces habitat for fish, plants, and wildlife; interferes with recreation; and can even be a fire hazard. Mapping stands of common reed aids in their management and environmental remediation by State and local authorities (Naranjo, 2017).

Showing Coastal Land Cover Changes

Landsat data form the foundation of the National Oceanic and Atmospheric Administration's (NOAA) Coastal Change Analysis Program, which maps coastal land cover and land change. The Michigan Coastal Management Program partners with NOAA to help protect and restore the State's coastline and coastal communities. Aided by the longtime series of Landsat data, the Coastal Change Analysis Program in the Great Lakes Region, with GLRI support, analyzes decades of coastal land-cover change, such as new development, that spurs losses or gains of wetlands, tree and forest cover, grasses, and pavement. Information gained through these analyses is crucial to wetland restoration and other environmental management decisions (NOAA, 2014).

National Land Imaging Program Benefits—Michigan

The U.S. Geological Survey (USGS) National Land Imaging Program provides a wide range of satellite imagery and other remotely sensed and geospatial data to Government, commercial, academic, and public users. Those users can get worldwide access to Landsat satellite data through the National Land Imaging Program-funded USGS Earth Resources Observation and Science (EROS) Center.

Invasive common reed is a wetland reed that can fill coastal areas with dense, tall stands and cause problems for fish, people, and other plants. Photograph credit: Michigan Department of Environment, Great Lakes, and Energy; used with permission.

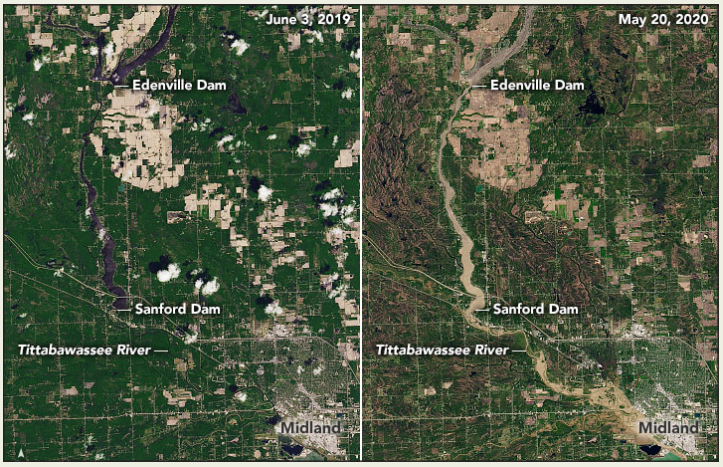
The Landsat series is a joint effort of the USGS and NASA. NASA develops and launches the spacecraft; the USGS manages satellite operations, ground reception, data archiving, product generation, and data distribution. Funding for the National Land Imaging Program's Landsat operations and data management is provided through the USGS.

Monitoring Algae Issues

Another major focus in the GLRI action plan is "reducing nutrient runoff that contributes to harmful/nuisance algal blooms" (GLRI, 2021). Landsat images have helped identify algae issues in Michigan's inland lakes and adjacent Great Lakes via mapping of toxic algal blooms and the nuisance *Cladophora* spp. (Kützing, 1843) algae, which can detach from underwater rocks or invasive mussels and wash ashore as a mass of green muck (Ramsayer, 2014; Brooks and others, 2015). Landsat data showing forest canopy change also helped U.S. Department of Agriculture (USDA) Forest Service scientists examine the watershed of Lakes Superior and Michigan. Their studies enabled them to predict rising levels of total phosphorus, which feed algae and enter streams draining into those two Great Lakes. Armed with this information, the Forest Service was able to direct resources more efficiently to help improve near-shore water quality (USDA Forest Service—Northern Research Center, 2014).

Informing the Public About a Catastrophe

Landsat satellite images help to visualize the effects of natural or anthropogenic flooding as well. For example, when the Edenville and Sanford Dams failed May 19, 2020, amid floodwaters on the Tittabawassee River in central Michigan, Landsat 8 captured the aftermath the following day (Patel, 2020). In their reporting, media outlets juxtaposed that satellite image with a prior year's Landsat image to help illustrate the flood's devastating effects on surrounding land and neighborhoods. A feature called Image of the Week from USGS EROS spotlights other stories of certain events captured by Landsat images.



Natural-color Landsat 8 images captured June 3, 2019, and May 20, 2020, show the area around Midland, Michigan, and the upstream Edenville and Sanford Dams before and after the dams were breached following heavy rains May 19, 2020. Image credit: Joshua Stevens of NASA Earth Observatory; and the USGS.

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Landsat—Critical Information Infrastructure for the Nation

Landsat is the most widely used land remote sensing data source within Federal civilian agencies. Local, State, Tribal, and Federal agencies use Landsat to monitor and forecast a wide range of land surface phenomena. Information from Landsat contributes to day-to-day decisions on land, water, and resource use that protect life and property; safeguard the environment; advance science, technology, and education; support climate change resiliency; and grow the U.S. economy. Landsat's imagery provides a landscape-level view of land surface, inland lake, and coastal processes, both natural and human-induced. Landsat enables us to better understand the scope, nature, and speed of change to the natural and built environment.

Businesses draw upon Landsat data to provide customer-specific applications to improve logistics, resource allocation, and investment decisions. Commercial space imaging firms leverage Landsat data to refine product offerings and support new information services. A 2017 USGS study determined the total annual economic benefit of Landsat data in the United States to be $2.06 billion, far surpassing its development and operating costs (Straub and others, 2019).

Landsat 8 and Landsat 9 provide 8-day repeat coverage of the Earth's land surfaces. The National Aeronautics and Space Administration (NASA) and the USGS are currently reviewing the findings from a joint Architecture Study Team, which will inform the design and implementation approach for Landsat Next, the follow-on mission to Landsat 9. Landsat 9 and its successors are planned to provide a sustainable, space-based system to extend the 50-year Landsat series of high-quality global land imaging measurements—the world's longest time series of the Earth's land surface.

The long-term availability of consistent and accurate Landsat data, combined with a no-cost data policy, allows users to analyze extensive geographic areas and to better understand and manage long-term trends in land surface change. New cloud computing and data analytics technologies use Landsat data in a wide range of decision-support tools for Government and industry. Much like global positioning system and weather data, Landsat data are used every day to help us better understand our dynamic planet.

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ISSN 2327-6916 (print)
ISSN 2327-6932 (online)
https://doi.org/10.3133/fs20213047