

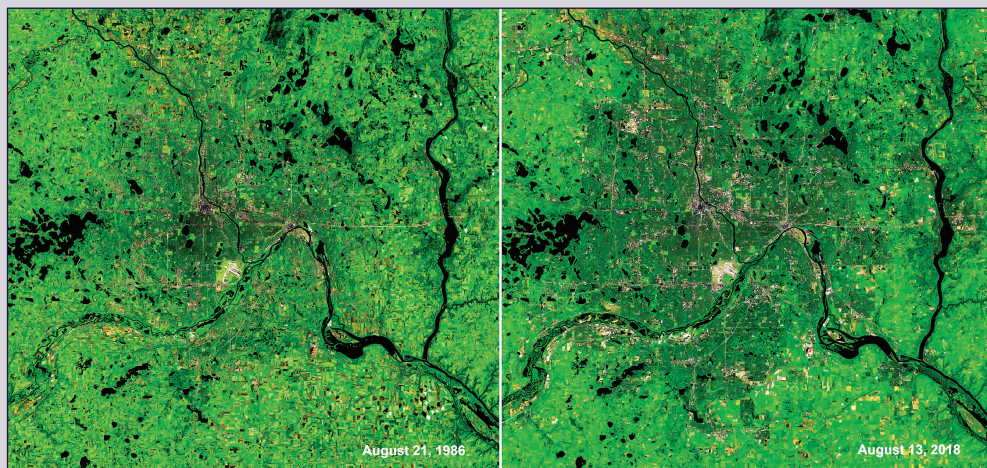
MINNESOTA and Landsat

Minnesota, the “Land of 10,000 Lakes,” treasures the beauty of its natural environment. The State is also home to a wide range of agriculture, manufacturing, tourism, and natural resource industries. Minnesotans understand the need to grow their economy and manage their resources in an environmentally sustainable manner.

Landsat land-imaging satellites underpin public and private sector decisions in the State and across the Nation for effective adaptation to changing landscapes. Those decisions often lead to enhanced agricultural productivity, smart urban development, and sustainable forest management. Landsat also enables more accurate inland lake water-quality monitoring, increased aster resilience and risk assessment, effective water use, more-informed climate research, and other applications. Here are several examples for the State of Minnesota.

Smart Urban Development

The Twin Cities of Minneapolis and St. Paul are home to about 54 percent of Minnesota’s population. Municipal authorities must balance continued economic development and the resulting urban growth to maintain harmony with the surrounding environment. Landsat sensors are ideally suited for detecting the effect people have on the surrounding landscape. For cities, that translates into the monitoring of urban sprawl and land-use efficiency, measuring impervious surface area (for example, buildings, roads, and parking lots), observing heat island effects, and linking urban growth and rainfall pattern change.



Urban and suburban growth in the Twin Cities area over the past 32 years. The image on the left is from August 1986, and the image on the right is from August 2018. Image credits: U.S. Geological Survey.

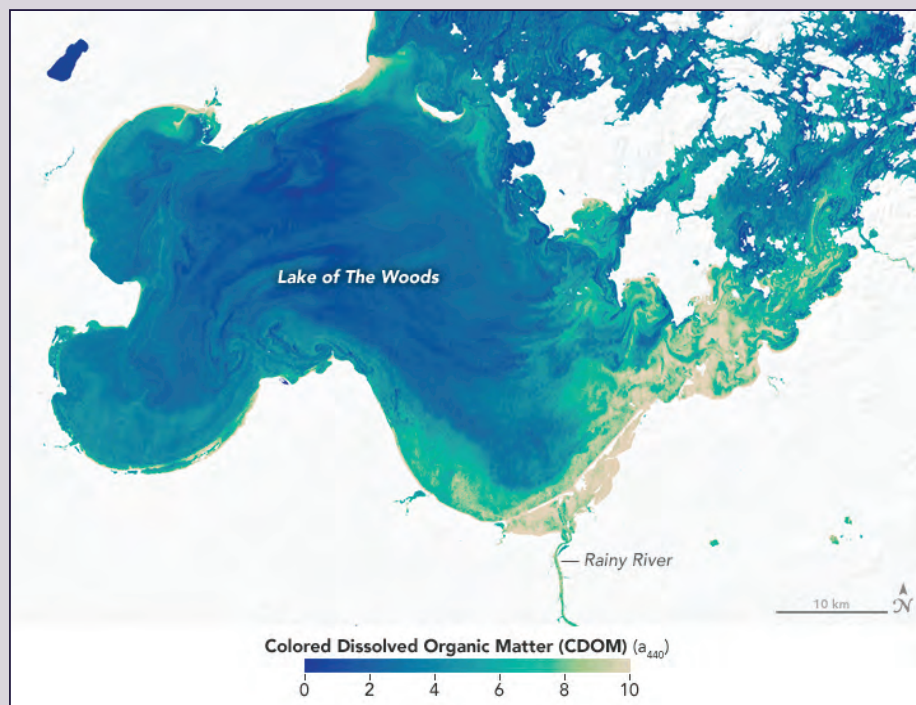
National Land Imaging Program Benefits—Minnesota

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.

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.

Water-Quality Monitoring

Minnesota's numerous inland lakes are sources of pride, respite, and recreation for its citizens. State and local authorities need to protect lakes' water quality for recreational, consumptive, and environmental purposes. With so many lakes across so broad an area, it has proven impossible to assess even a small fraction of them through conventional field methods. The use of Landsat is a cost-effective way to gather the information needed for regional water-quality assessments. Using Landsat, researchers at the University of Minnesota were able to classify the water clarity of more than 10,000 lakes in the State. Knowledge gained from this work can inform local authorities' water management and remediation efforts (University of Minnesota, 2022).



Colored dissolved organic matter in Minnesota's Lake of the Woods. Image credit: NASA.

Precision Agriculture

Landsat data help farmers to make decisions on optimal livestock rotation, understand current crop conditions, and vary their application of fertilizer and seed. AWG Farms in Minnesota has used Landsat imagery to monitor its fields' variable nitrogen content in beet leaves and soil tillage since 1997. With this knowledge, using global positioning system-enabled variable fertilizer application, AWG Farms can save 60–70 pounds of nitrogen per acre and reduce effects on the environment from nutrient runoff and leaching caused by over-application of fertilizer (Anjozian, 2012).



Landsat 5 imagery of a sugar beet field collected July 13, 2005, shows a true color composite (left), color infrared (center), and near-infrared band (right) processed to show vegetation status related to nitrogen. Photograph credit: Gary Wagner, AWG Farms; used with permission.

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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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