

NORTH DAKOTA and Landsat

The State of North Dakota once did not figure prominently in the Nation's economy. The sparsely populated State supported food production, and hunters and anglers were drawn to its lakes, rivers, and wide-open spaces, but its economy was overshadowed by that of other States. However, the State and its prairie expanses recently rocketed from an economic afterthought to a national energy leader with the soaring production of oil and natural gas in the Bakken oil patch.

The Bakken development has been transformative for North Dakota's landscapes in myriad ways. It has boosted economic output, drawn thousands of new residents to cities like Williston and Watford City, and led to a proliferation of oil and gas pads.

In the past two decades, North Dakota experienced other major changes, such as the expansion of the depressional wetlands of the Prairie Pothole Region on the eastern side of the State. These critical breeding areas for waterfowl, which stretch across Minnesota, South Dakota, North Dakota, and Canada, are home to more than 50 percent of North America's migratory birds (U.S. Environmental Protection Agency, 2021).

Changes from oil and gas production, urban development, and wetland resurgence can all be tracked over time using the unparalleled Earth observation record of the USGS Landsat data archive. Its 50-year record of repeat imagery also aids in the monitoring, cataloging, and management of cropland, invasive insect species, and natural or human-made disaster recovery. Here are just a few examples of the benefits offered to North Dakota by the Landsat Program.

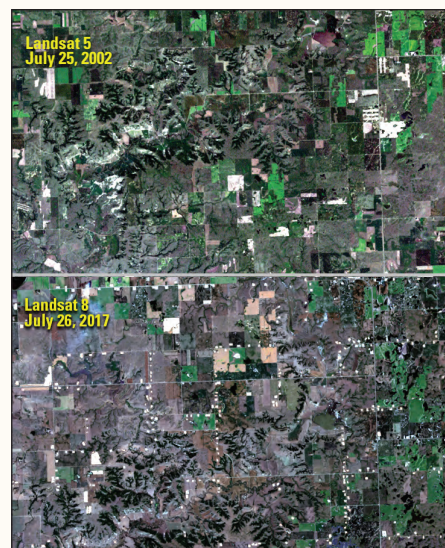
Tracking Changes from Energy Development

The Landsat archive can be used to compare how a changing area's landscapes appeared 50 years ago to how they look today, but the depth of the satellite record offers value beyond illustrative comparisons. The National Land Cover Database (NLCD) sorts each 30-meter plot of land in the United States into land cover classes, such as wetlands or cultivated crops, and releases coast-to-coast updates every 2–3 years. The NLCD also includes secondary data layers of surface features such as impervious urban surfaces and tree canopy cover. The two most recent NLCD releases include a layer that maps oil and gas pads across the United States (Dewitz and U.S. Geological Survey, 2021). Powered by Landsat, researchers can track the extensive landscape changes and urban growth that have accompanied the surge in energy development across North Dakota. Such efforts, in turn, can inform urban planning and land management at the State and local levels.

Landsat images from (top) July 25, 2002, and (bottom) July 26, 2017, show the emergence of well pads in North Dakota's Bakken oil patch. Image credits: U.S. Geological Survey.

National Land Imaging Program Benefits—North Dakota

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.



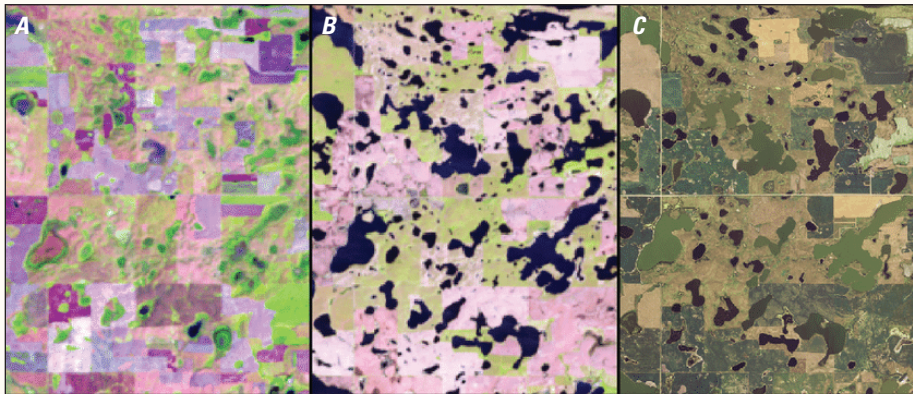
The Landsat series is a joint effort of the USGS and NASA. NASA develops and launches the spacecraft; the USGS manages satellite operations, ground reception, data archiving, product generation, and data distribution. Funding for the National Land Imaging Program's Landsat operations and data management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

Monitoring Crops from Above

North Dakota maintains a strong agricultural heritage, and agricultural production accounted for more than \$7.3 billion in revenue in 2020, which, along with agricultural processing, amounted to 7.6 percent of the State's total gross domestic product (University of Arkansas, 2022). North Dakota's agricultural output features a diverse group of crops. In 2020, North Dakota led the Nation in the production of all dry edible beans, pinto beans, canola, flaxseed, honey, rye, all sunflower, and all wheat (U.S. Department of Agriculture, 2021). Landsat data are a key input for the U.S. Department of Agriculture's Cropland Data Layer, which maps crop types year by year across the lower 48 States; however, Landsat's value to agriculture goes beyond crop type mapping. The data can be used to monitor crop health at broad scales because they go beyond visible light and record infrared and near-infrared energy. Landsat thermal sensors also can be used to calculate water use efficiency through estimates of evapotranspiration, which is the combined rate of evaporation from the Earth's surface and transpiration from plant leaves.

Watching Over Wetlands

North Dakota's wetlands serve as critical habitat for migratory birds and double as a draw for recreation. These dynamic areas undergo frequent change, shrinking in some areas as seasonal wetlands are drained for crop production and growing in others. High-resolution aerial surveys can be used to map wetland extent, but these surveys are too costly to repeat frequently. Landsat's long-term repeat observations of North Dakota's wetlands enable researchers to not only map changes to wetland extent year by year but also to monitor trends within each year, track trends over time, delineate ephemeral lakes from permanent ones, and model future changes (Rover and others, 2011; Vanderhoof and others, 2017).



Landsat imagery and a National Agriculture Imagery Program (NAIP) aerial photograph of the same area in Stutsman County, North Dakota, show the dynamic nature of prairie pothole wetlands in (A) dry and (B and C) wet conditions. The satellite data were acquired on September 2, 1992, and May 23, 2013. The (C) NAIP data were collected in 2012. Image credits: (left and center) U.S. Geological Survey and (right) NAIP.

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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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