

# Minnesota Lakes

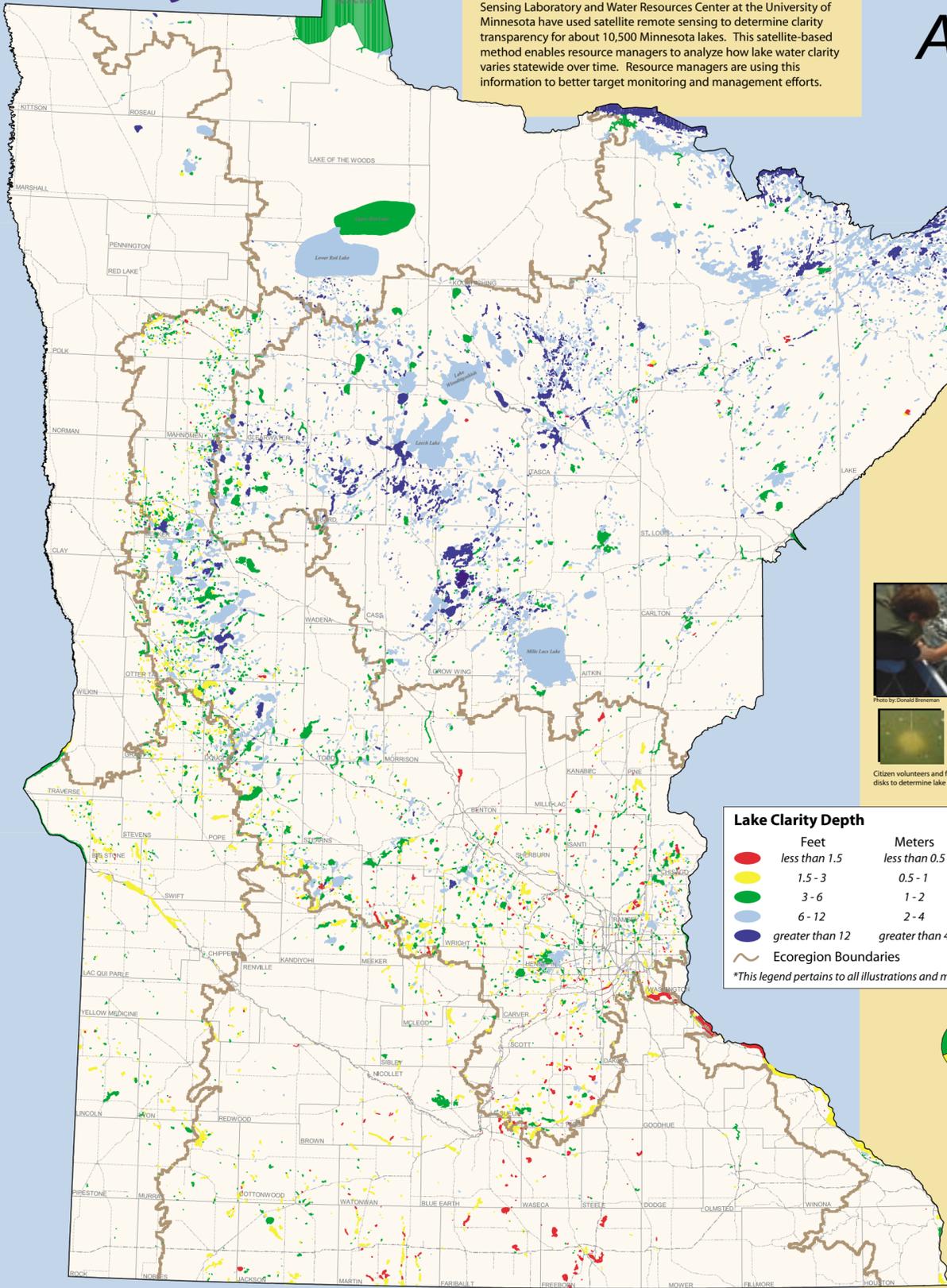


Using satellite images taken from space, a statewide census of water clarity – a key indicator of lake water quality – has been created for the first time.

Employing state of the art image analysis technology, the Remote Sensing Laboratory and Water Resources Center at the University of Minnesota have used satellite remote sensing to determine clarity transparency for about 10,500 Minnesota lakes. This satellite-based method enables resource managers to analyze how lake water clarity varies statewide over time. Resource managers are using this information to better target monitoring and management efforts.

## A View from Space

### "Census of Water Clarity"



Lake Clarity Depth	
Feet	Meters
less than 1.5	less than 0.5
1.5 - 3	0.5 - 1
3 - 6	1 - 2
6 - 12	2 - 4
greater than 12	greater than 4

~ Ecoregion Boundaries  
\*This legend pertains to all illustrations and maps.



#### Measuring Lake Clarity

The clarity of lakes usually is measured in terms of the depth to which one can see an object below the water surface. The standard device used to do this is a Secchi disk, a white disk, eight inches (20 centimeters) in diameter attached to a rope that is lowered through the water column until the disk disappears from sight. That depth is called the Secchi disk transparency. The clearer the lake is, the deeper the measurement.

The Minnesota Pollution Control Agency (MPCA) coordinates the collection of Secchi disk readings by staff and citizen volunteers on about 850 lakes annually. These measurements are essential to the satellite data analysis, but they include only a small percentage of the state's lakes. Satellite data enable monitoring of nearly all the 10,000+ lakes in the state.

#### Monitoring Lakes from Space

The Landsat satellite orbits the Earth 438 miles above the surface. Its sensor, called a multispectral scanner, records images of the same 115-mile wide path every 16 days. Nineteen images from five orbits are needed to cover Minnesota. The smallest area recorded is 30 x 30 meters (about 1/4 acre). The scanner records digital images of the surface reflectance in visible and infrared wavelengths of the electromagnetic spectrum. The infrared spectral bands are especially useful for mapping vegetation, and the visible blue and red bands are sensitive to physical properties of water, including its clarity or transparency.

The first step in mapping lake clarity is to separate water from land features. Next the analyst determines the relationship between the intensity of reflected blue and red wavelengths and the Secchi disk transparency for a set of 25-50 "calibration" lakes. The relationship then is applied to all the lakes in the image, providing a census of lake clarity.

Satellite remote sensing provides a cost-effective way to gather the information for water quality assessments in lake-rich areas like Minnesota. This has been done statewide for ~1990 and ~2000 time periods and is available at <http://water.umn.edu>. New dates, as well as earlier dates (~1975, ~1985 and ~1995), will be added as completed and will enable analysis of changes in lake clarity over time. This map was created using ~2000 satellite data and Secchi disk readings.

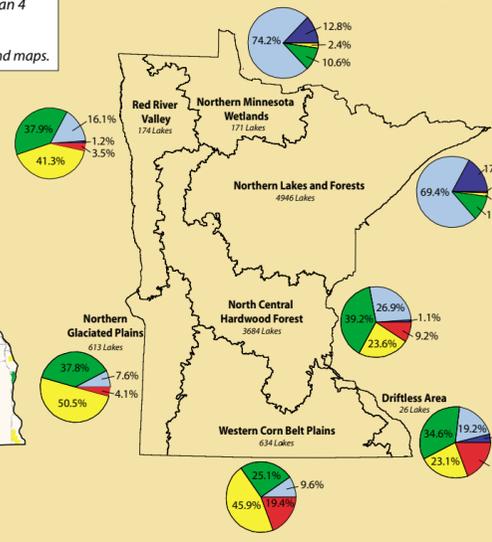
#### Factors that Affect Clarity

Lake clarity is affected primarily by three different constituents found in water: (1) microscopic plants called algae suspended in the water, (2) suspended sediment – clay and silt – primarily from soil erosion, and (3) dissolved natural organic matter, called humic material, that is derived from the partial decay of terrestrial plants. Algae and decomposition products of algae are the primary factors controlling light penetration in most Minnesota lakes. For such lakes, water clarity is closely related to nutrient status.

Lakes with high clarity have low levels of algae and nutrients. Most lakes with low water clarity have high concentrations of algae (measured in terms of chlorophyll) and high concentrations of the primary nutrients, phosphorus and nitrogen. Sediment tends to be important in some lakes of southern Minnesota where soil erosion is a problem. Humic color affects some lakes in northern Minnesota, especially in forested watersheds with wetlands.

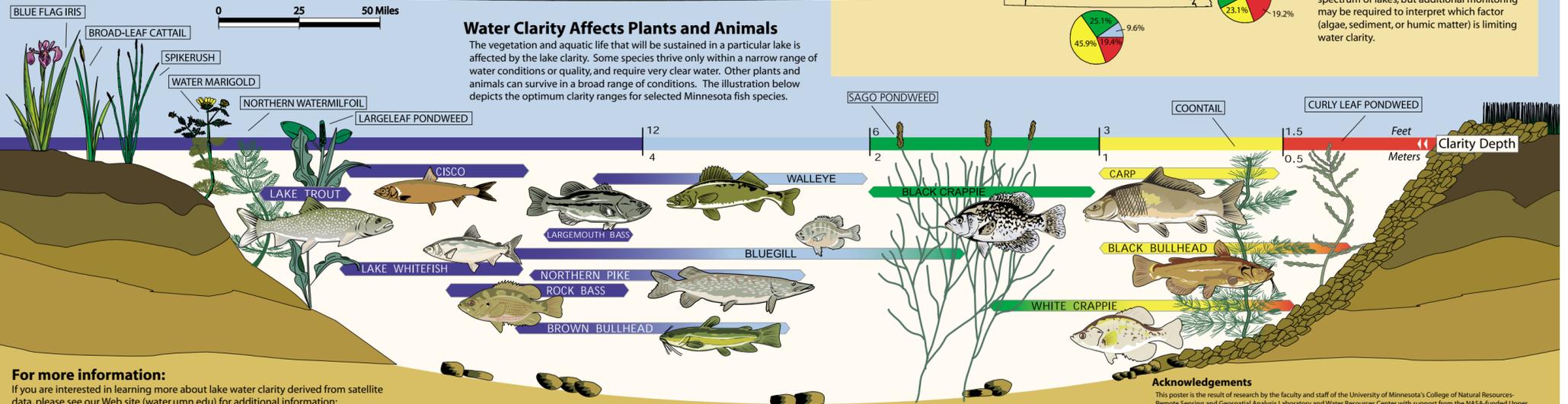
Satellite imagery provides an accurate measure of water clarity across a broad spectrum of lakes, but additional monitoring may be required to interpret which factor (algae, sediment, or humic matter) is limiting water clarity.

#### Minnesota Lake Clarity by Ecoregion



#### Water Clarity Affects Plants and Animals

The vegetation and aquatic life that will be sustained in a particular lake is affected by the lake clarity. Some species thrive only within a narrow range of water conditions or quality, and require very clear water. Other plants and animals can survive in a broad range of conditions. The illustration below depicts the optimum clarity ranges for selected Minnesota fish species.



#### For more information:

- If you are interested in learning more about lake water clarity derived from satellite data, please see our Web site ([water.umn.edu](http://water.umn.edu)) for additional information:
- Search for the lake of your choice
- Download classroom activities
- Learn about other ways satellite imagery is being used to help monitor Minnesota's land and water resources

[water.umn.edu](http://water.umn.edu)

#### Acknowledgements

This poster is the result of research by the faculty and staff of the University of Minnesota's College of Natural Resources-Remote Sensing and Geospatial Analysis Laboratory and Water Resources Center with support from the NASA-funded Upper Great Lakes Regional Earth Science Applications Center, Minnesota Department of Natural Resources and Minnesota Pollution Control Agency. Volunteers and field scientists with MPCA's Citizen Lake Monitoring Program acquired field data. The poster was developed in cooperation with the Science Museum of Minnesota.

