

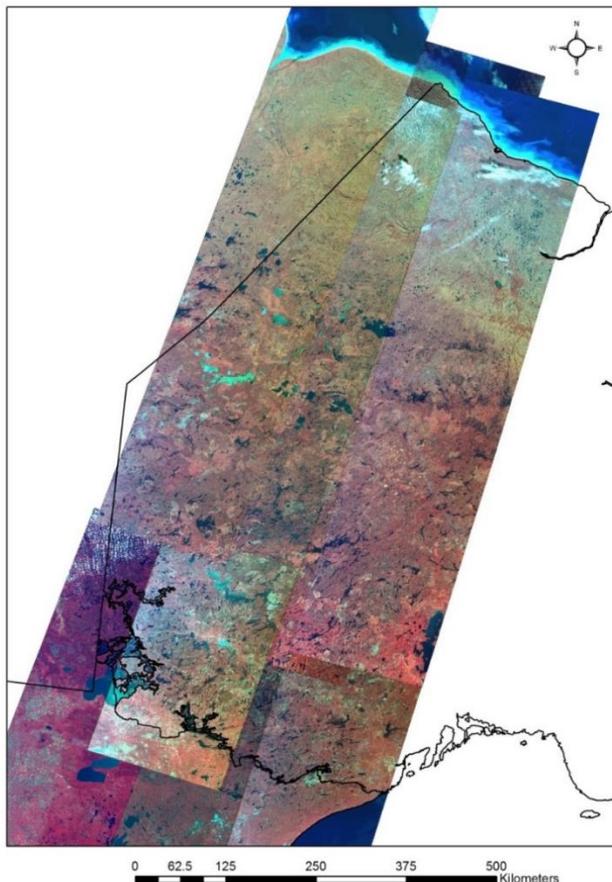
Water Clarity of Lakes in Western Ontario

Lake clarity and trophic status are important factors influencing waterfowl species occurrence and numbers. Northwestern Ontario has a very large number of lakes, but very few are road accessible. There thus is a scarcity of water quality data on the lakes. Consequently, we classified lake clarity using Landsat imagery and chlorophyll using MERIS imagery to support Boreal Forest waterfowl research for Environment Canada. We extended the methods and models developed for Minnesota lakes (Olmanson et al. 2011) and applied them to over 67,000 lakes (4 ha and larger) in northwestern Ontario.

Summary of Landsat image data and calibration statistics for Ontario water clarity classification

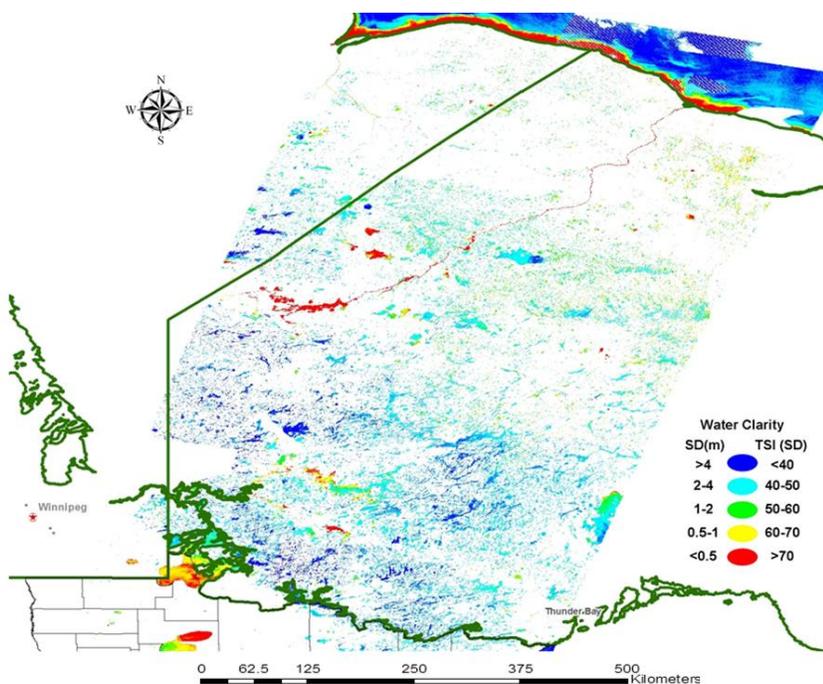
Image Date	Path	Rows	Number Images	Sensor	Landsat	Estimated % Clear	Model Statistics*			
							N	SD Range (m)	R ²	RMSE
8/24/2008	28	21-26	6	TM	5	90	248	0.1 - 9.8	0.82	0.335
8/25/2008	27	20-26	7	ETM+ slc off	7	95	277	0.1 - 9.8	0.85	0.327
8/26/2008**	26	21-26	6	TM	5	90	805	0.46 - 8.3	0.85	0.154
9/16/2008	29	25-26	2	TM	5	80	139	0.3 - 8.2	0.83	0.264
9/3/2009**	29	20-24	5	TM	5	95	99	0.1 - 7.7	0.87	0.357
* Model statistics from Minnesota lakes and Landsat imagery										
**Used calibration data from adjacent scene overlap										

The Landsat imagery (four paths with 26 images) and a classification map of lake water clarity are shown below.



The overall conclusions and recommendations from the study are:

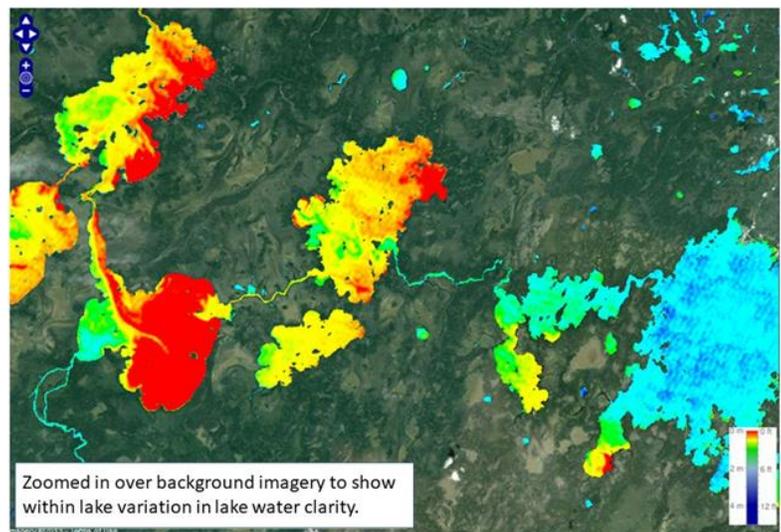
1. Satellite-based (Landsat) measurement of lake clarity, a key indicator of water quality, is an accurate and economical method to monitor conditions of over 10,500 lakes in Minnesota. Although the method could not be validated with independent field data, it appears to work equally well for more than 67,000 lakes in northwestern Ontario.
2. MERIS multispectral imagery was shown to be an accurate and economical method to estimate chlorophyll levels in Minnesota lakes (> 150 ha in size), and it also appears to work well in northwestern Ontario. Additional validation data are needed, however, to fully evaluate its accuracy.
3. With the large number and remoteness of lakes in northwestern Ontario, satellite remote sensing is virtually the only economical way to collect water quality information that should be useful for studies such as Boreal Forest waterfowl research.



4. The LakeBrowser, which has the capability to zoom into specific lakes with aerial photography in the background, greatly enhances the information that can be assembled. It is anticipated that an Ontario version of the LakeBrowser would also be useful for the agencies and the public.

5. In Minnesota, satellite-based water clarity maps have been used by state agencies to identify lakes for further field monitoring. In Ontario, satellite data could be used for a similar purpose to leverage funds available for field monitoring and the

capabilities of new imagery products that will become available in the near future. Systems such as Landsat 8, which was launched in February 2013, and Sentinel 2 and 3, scheduled for launch in 2014, will greatly increase the temporal, spatial and spectral resolution capabilities of satellite imagery for regional water quality assessments. Developing a field monitoring program for Ontario that could be used to calibrate and validate these remote sensing water quality products would dramatically improve the accuracy and usefulness of the data for future studies.



References

Olmanson, L. G. and M. E. Bauer. 2013. Satellite Remote Sensing and Monitoring of Ontario Lakes for Boreal Forest Waterbird Surveys. Final Report to Environment Canada, 867 Lakeshore Road, Burlington, Ontario L7R 4A6, Canada. 10 p.

Olmanson, L. G., P. L. Brezonik, & M. E. Bauer. 2011. Evaluation of medium to low resolution satellite imagery for regional lake water quality assessments. *Water Resources Res.*, 47, W09515, doi: [10.1029/2011WR011005](https://doi.org/10.1029/2011WR011005).