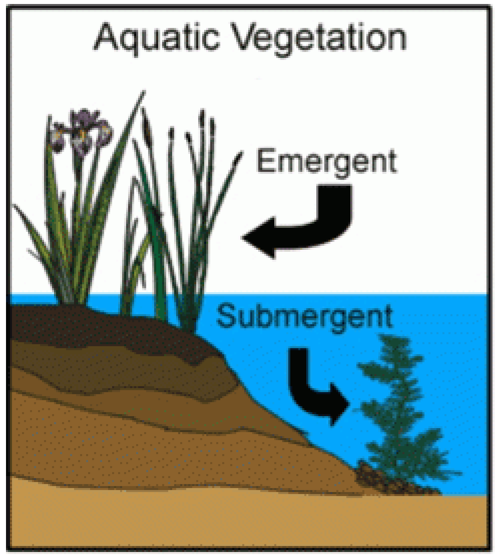
Mapping Aquatic Vegetation

Aquatic plants in lakes and wetlands are widely recognized as important ecosystem features. Native vegetation provides important ecosystem services, including habitat for fish and also can be an aesthetic asset. On the other hand, aquatic vegetation can cause impediments for boaters and swimmers; non-native (exotic) invasive species often are especially problematic in this regard and also crowd out of more desirable plant species.



Aquatic plant surveys and assessments have become common parts of monitoring efforts by federal, state and local natural resource agencies, shoreland owner groups, and environmental consultants. The diversity and abundance of aquatic plants are important indicators of lake or wetland health, but accurate maps are difficult to acquire because ground-based mapping requires much time and human effort. Consequently, only a small fraction of this resource has been mapped.

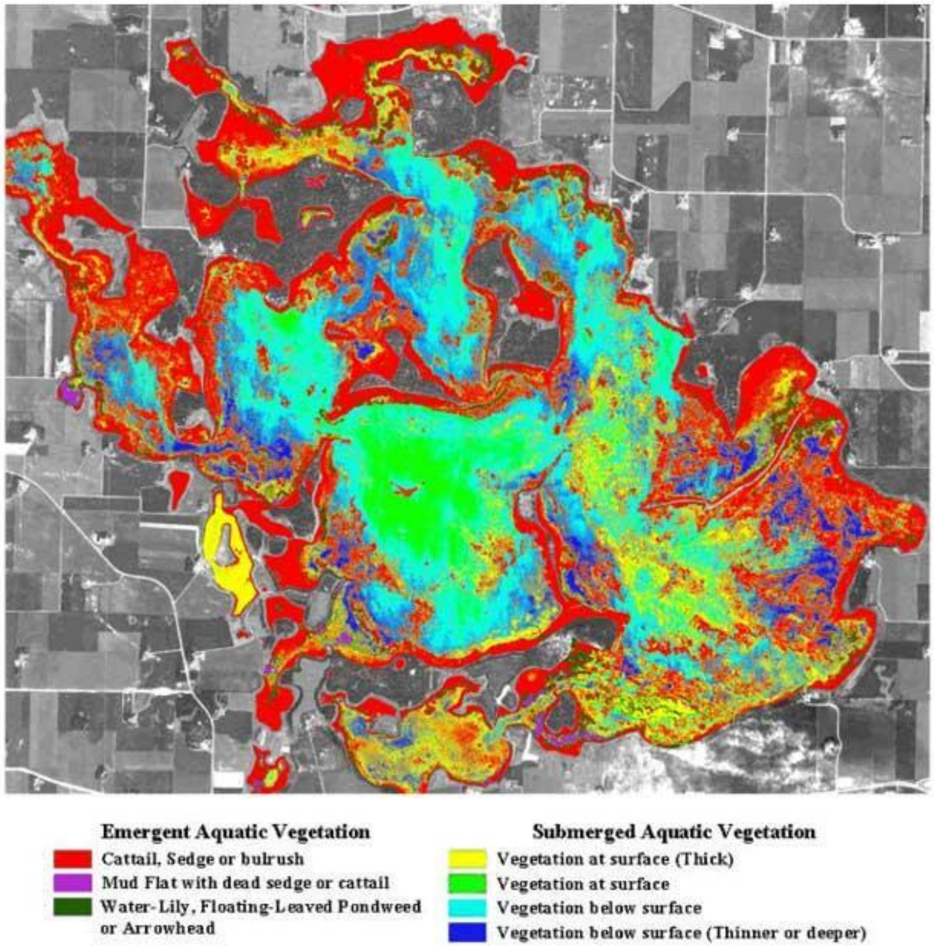
In past studies (Huser, 2008; Sawaya *et al*., 2003), we have evaluated the feasibility of using high-resolution satellite imagery to map and classify aquatic plants. We used two sources of commercially available high-resolution satellite data: IKONOS and QuickBird. Some results from these studies are described below.

Swan Lake

We used IKONOS imagery to map the distribution of aquatic plants in this large (~3600 ha) wetland in Nicollet County, Minnesota. Swan Lake is classified as a "Type 4 wetland," meaning it is a deep freshwater marsh with standing water and abundant emergent aquatic vegetation. The IKONOS image was acquired on September 1, 2001. Swan Lake has a maximum depth of 2 m (~7 feet), clear water throughout, and an abundance of aquatic vegetation. We thus assumed that aquatic vegetation was present throughout the wetland. A survey conducted by researchers at Minnesota State University at Mankato, in which the presence/absence of 27 aquatic plant species at 118 evenly distributed sample points on the lake was recorded, verified this assumption.

Vegetation sampling was aided by a GPS system and data recorder with digital IKONOS imagery.

Because of the lake's large size and abundance of aquatic plants, collection of ground-based reference data to interpret the image would have been difficult without modern technology. We used GPS technology and a tablet computer to display the satellite image. We identified different types of aquatic vegetation in the field and located them directly on the image using the computer. Being able to identify locations on the image while in the field was especially useful, and having the image available shortly after its acquisition was a significant benefit because we could identify image areas with different (unique) spectral-radiometric responses and target them for field identification. We targeted emergent vegetation for species identification and also noted the location of submerged vegetation topped out at the surface.

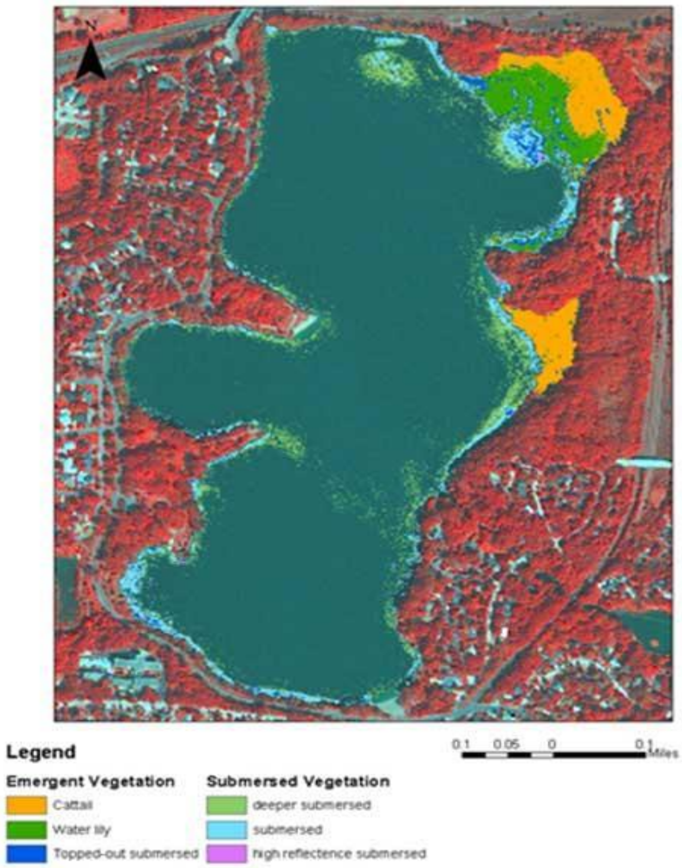


Emergent and submersed aquatic vegetation distribution in Swan Lake (Nicollet County, MN).

The first step in processing the IKONOS image was to separate wetland features from terrestrial features by digitizing the aquatic-terrestrial boundary around the wetland and all islands. We identified the boundary using spectral-radiometric differences and spatial patterns visible on the image. We then made a subset of the image with the wetland polygon to mask out terrestrial features and create a wetland-only image. We next stratified the wetland pixels into emergent and submersed vegetation by performing an unsupervised classification. Using the field reference data, we identified five classes of emergent vegetation in the image and recoded them to create an emergent vegetation map. We repeated this procedure for the thick submersed vegetation image parts and identified two submersed classes. Finally, we created an aquatic plant classification map by overlaying the submersed and emergent aquatic plant maps over the panchro-matic image. The results are shown in the image above.

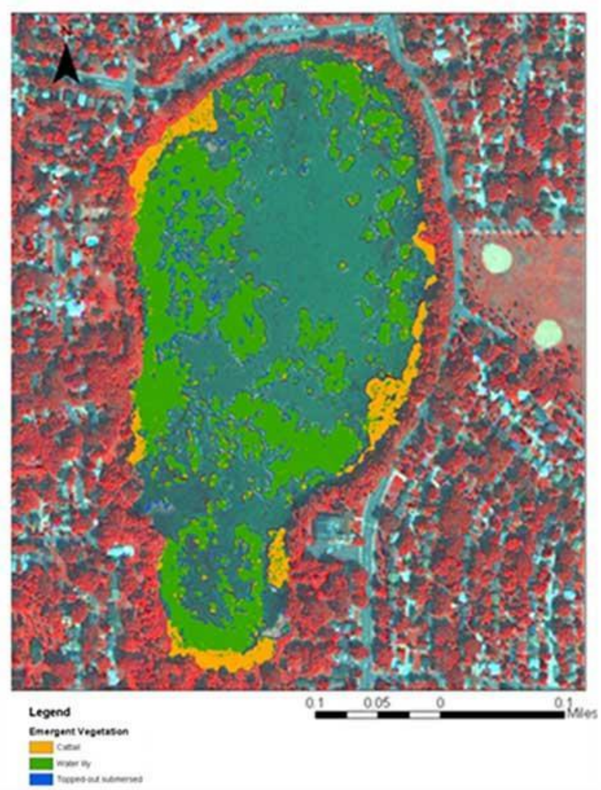
City of Minneapolis Lakes

We also used IKONOS imagery to characterize and map aquatic vegetation in several lakes in the City of Minneapolis. Image processing methods were similar to those described above; details are provided in Huser (2008). It is apparent from the processed imagery for Cedar Lake and Diamond Lake (see images to the left and below) that submersed vegetation can be delineated in satellite imagery if the water is relatively clear (e.g., SD > ~ 2 m); of course, if it were not (e.g., SD < 1 m), it is likely that low light penetration would limit the extent of submersed vegetation growing at the bottom, except in very shallow waters. Two species dominated the emergent vegetation of Cedar Lake: cattail and water lily. Submersed aquatic plant species were topped out (at the water surface) in small areas of Cedar Lake, but field work was not done to identify the species. Spectral signatures differed for completely submersed plants that were near the surface and those deeper in the water column, thus accounting for the two categories of submersed vegetation (light green and light blue) in the Cedar Lake map.



Emergent and submersed aquatic vegetation in Cedar Lake.

Diamond Lake is a small, shallow lake in south Minneapolis that has extensive coverage by emergent aquatic vegetation in summer. Two emergent species, cattail and water lily, dominated the plant composition in this lake.



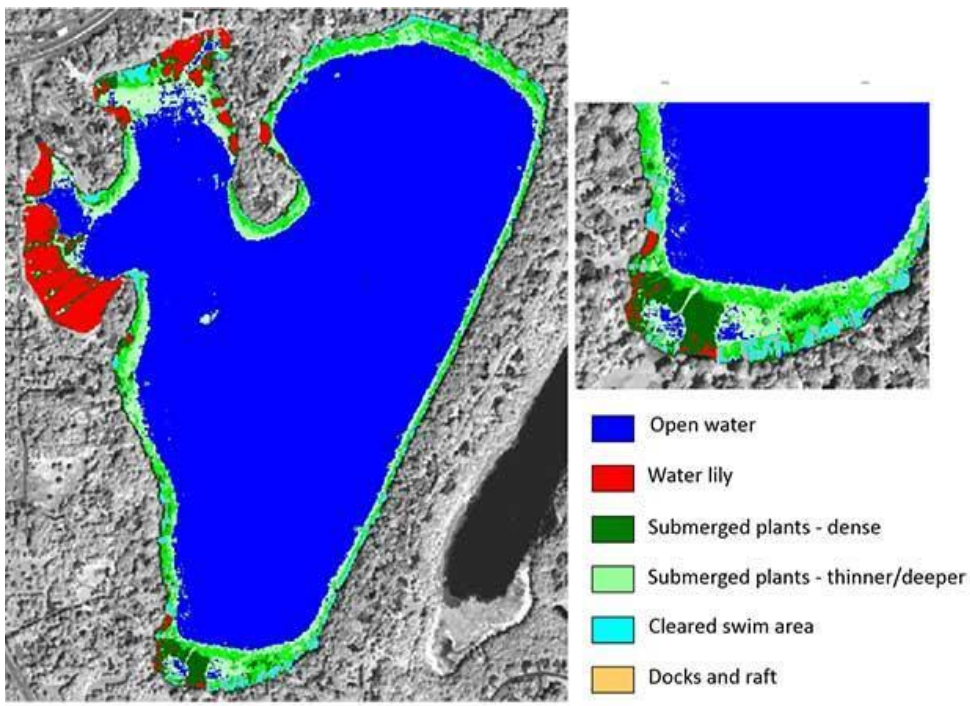
Emergent aquatic plant distribution in Diamond Lake

Lake Minnetonka Area, Hennepin County

To evaluate the use of QuickBird imagery, we acquired an image of the Lake Minnetonka area in the western Twin Cities area for July 28, 2002. The image also included Christmas Lake (655 ha) in Hennepin County, Minnesota. The Minnesota Department of Natural Resources collected the field data for the lakes.

We used similar imagery processing procedures for lakes in the QuickBird image as for Swan Lake mapping except that we also separated the open water areas before classification of the submerged and emergent/floating aquatic plants. A map of the vegetation in Christmas Lake is below.

The aquatic plant assessment of Christmas Lake indicates that submerged plants can be separated from open water areas and classified to a plant top depth of around 2 m. It also appears that submerged plants with denser growing characteristics like Eurasian watermilfoil, a non-native (invasive) species in Minnesota lakes, can be separated from other submerged plants that tend to have less dense characteristics.



Christmas Lake Aquatic Plant Map

References

Huser, K. S. 2008. Using high-resolution satellite imagery for aquatic vegetation surveys. M.S. thesis, Univ. of Minnesota, Minneapolis, MN.

Sawaya, K., L. G. Olmanson, N. Heinert, P. L. Brezonik, and M. E. Bauer. 2003. Extending satellite remote sensing to local scales: Land and water resource monitoring using high-resolution imagery. Remote Sens. Environ. 88: 144-156.