ReMetrix

Lake Gaston 2013 Submerged Vegetation Mapping Summary Report

Hydroacoustic Sampling with
Species Point Sampling

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Executive Summary
This report summarizes the methods and results for mapping submerged aquatic vegetation in Lake Gaston, with a particular focus on hydrilla. Hydroacoustic data were collected along the entire 5,344-acre littoral zone of the lake. In addition, 889 physical sampling points were collected by ReMetrix in the lake including Cotton Creek and the western river channel for species information. All of the data ReMetrix collected for this report were collected between October 16-24, 2013.

The results estimate a total of 759 acres of submerged vegetation (14% of the main lake littoral zone). Hydrilla was estimated as comprising 671 acres (88%) of the lake-wide submerged vegetation acres. Of the lake-wide hydrilla acreage, 417 acres (54%) were classified as hydrilla monocultures. Also, 241 acres (36%) of the lake-wide hydrilla acreage occurred in the Flats.

The lake-wide hydrilla acreage in 2013 is significantly lower than 2012 (a decrease of 56%). The "Estimated Change of SAV" map depicts some noticeable changes in the geographic distribution of hydrilla as well. The lake-wide acreage of submerged vegetation (all species inclusive) in 2013 is 56.7% lower than in 2012.

Physical sampling for species characteristics took place at 862 sites in the main lake, 287 of which had hydrilla presence (33%). This represents a statistically significant decrease of 41% in hydrilla frequency at permanent sampling sites compared to 2012. The 2013 frequency of hydrilla is outside the overall range established from this method since 2007, which is from 42% to 63%. This is most likely due to the unusual environmental conditions in 2013. No submerged plants were found at 490 sites in the main lake (57%).

Maps, tables, and statistics of these results and others are included within the summary report and the Appendix.

ReMetrix believes the results from this year's project are a reliable estimation of the lake-wide submerged vegetation community, cover, and biovolume within the October project window. Furthermore, ReMetrix intends to continue refinement of analytical techniques and the continued incorporation of third-party Volunteer data as the project progresses in future years. See more project data at http://gaston.remetrix.com.

Sincerely,

Doug Henderson
Commercial Manager, ReMetrix LLC

A. Project Goals

The Lake Gaston mapping project is designed to meet the following key goals:

(1) Determine the total amount of hydrilla and submerged aquatic vegetation (SAV) lake-wide, and monitor changes in total SAV and hydrilla annually;

(2) Inventory hydrilla and SAV species lake-wide, and monitor changes to species populations annually;

(3) Inventory hydrilla and SAV species in Cotton Creek and the river channel west of the lake;

(4) Provide the annual mapping results in a report and an on-line web atlas.

In addition, the project was designed to be consistent from year-to-year, quantitative, and third-party verifiable. Finally, results of the annual study are to be delivered to the LGWCC in a timeframe that is relevant for planning upcoming treatment programs.

B. Study Area Description

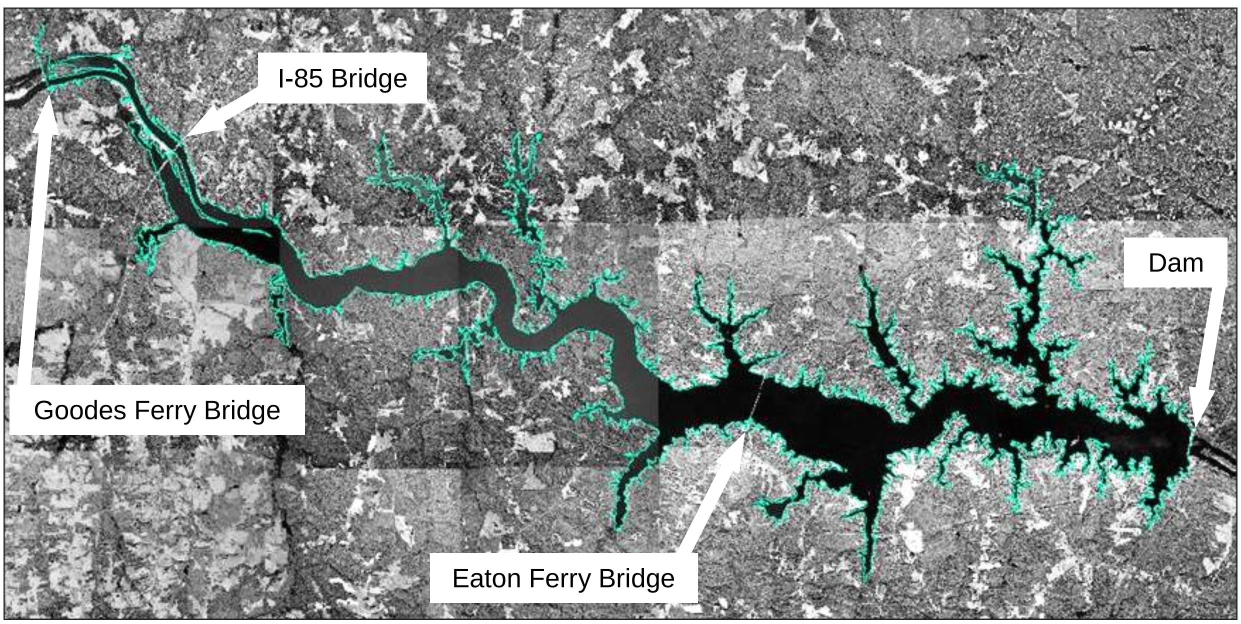

Figure 1. The teal outline of the lake shows the shoreline and the extent of the study area for this project.

The study area is the littoral zone of Lake Gaston extending from the dam at the eastern boundary of the lake, westward to the Goodes Ferry Bridge/Route 1 (Figure 1). The 5,253-acre littoral zone is spread along 312 miles of shoreline and is characterized by submerged aquatic vegetation ranging from dense beds to patchy growth.

A secondary study area extends along the river channel west of the I-85 bridge to near the base of Kerr Dam, and includes Cotton Creek.

The characteristics of the littoral zone are diverse. Some areas are only a few feet wide, where the water depth increases quickly from the shoreline, while other areas of the littoral zone extend far into the lake from the shoreline and are many hundreds of acres in size.

C. Hydroacoustic Methodology (Background)

Hydroacoustic data are a pivotal aspect of this project. Hydroacoustic data enable significantly improved estimates of submerged plant bottom coverage in comparison to physical sampling and visual estimation of submerged plant cover.

Hydroacoustic data collected by ReMetrix using a digital 420kH BioSonics transducer mounted on a boat and actively linked to DGPS. The boat operator drives transects across the study area while the transducer pings the water column approximately five-to-ten times per second. The data from each ping are linked to a geographic coordinate via the DGPS beacon. Figure 2 depicts this process.

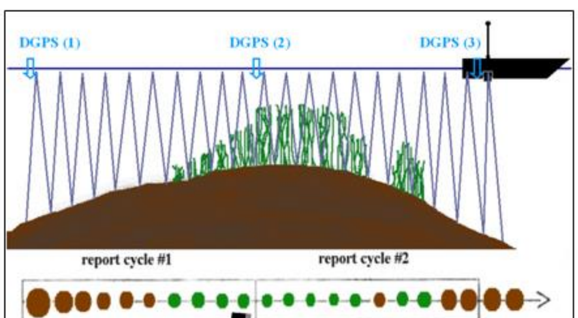

Figure 2 *(see text)*

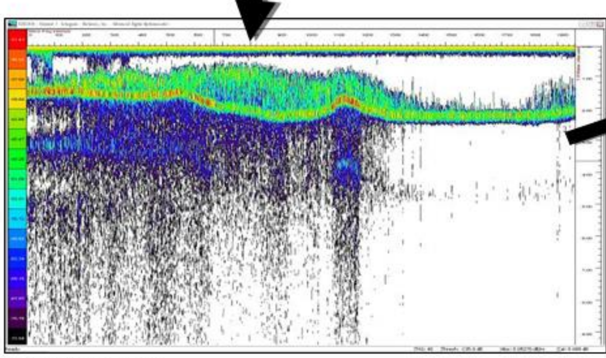

Figure 3 *(see text)*

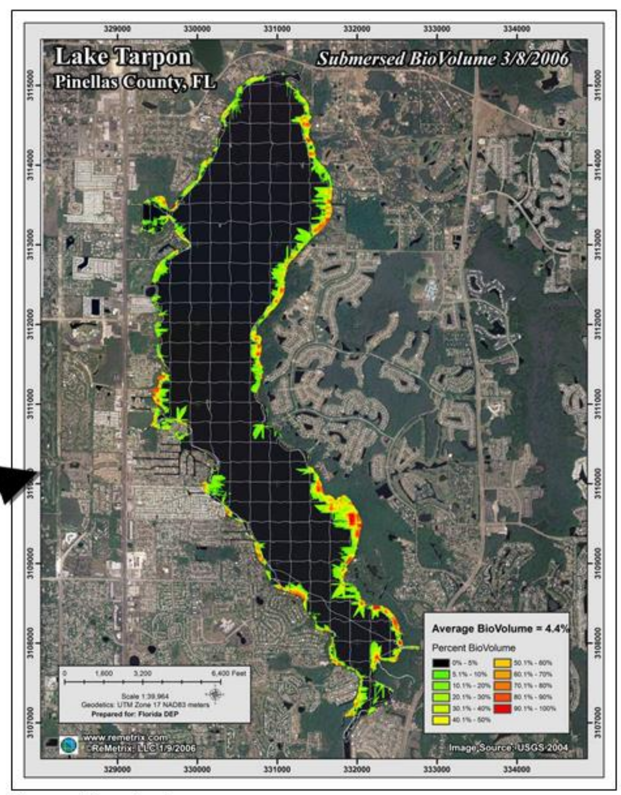

Figure 4 *(see text)*

The data from each ping contains submerged plant cover, plant height, and water depth. BioSonics, Inc. testing indicates that the hydroacoustic system returns digital samples with greater than 0.013% accuracy every 1.8 centimeters. Figure 3 (above) shows an example of the raw acoustic data collected along a transect.

The raw acoustic data are processed to filter out noise, calculate statistics, and export the data for viewing in a Geographic Information System. Data from all of the transects in the sampling program are combined and modeled using geostatistical software to produce vegetation coverage (biocover) and vegetation volume (biovolume) maps for the entire study area (Figure 4, above, shows a biovolume map).

Biocover and biovolume are estimates of the amount of vegetation in a water body. Biocover is an estimation of the percentage of the bottom covered with plants. Biovolume is an estimate of the percentage of the water column filled by the plant at any specific point. In the final maps created, statistics indicating total biocover and biovolume for an entire mapped area are calculated.

D. Hydroacoustic Sampling

ReMetrix collected linear hydroacoustic transects within the entire littoral zone of the lake, as shown in Figure 5.

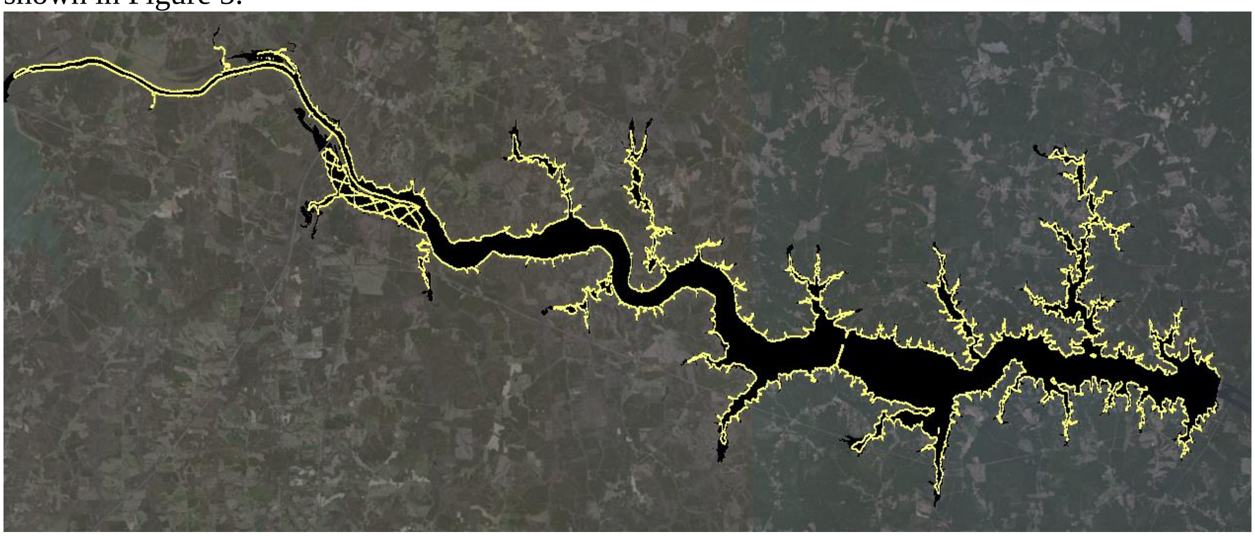

Figure 5. Lake-wide hydroacoustic transects.

ReMetrix also collected in the western river channel and Cotton Creek, as well as a more detailed survey of the Flats region (Figure 5). The transect plan for the Flats is shown in more detail in Figure 6.

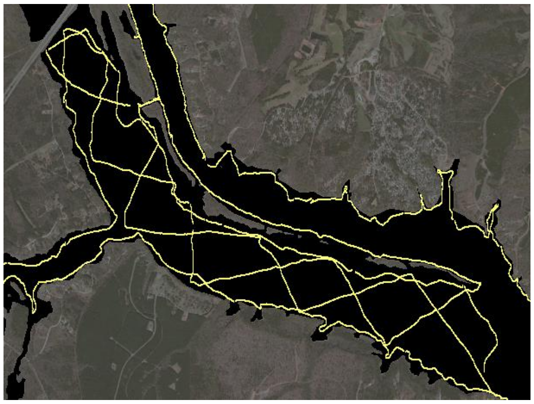
Figure 6. Transect grid plan used for hydroacoustic data collection within the Flats.

E. Physical Species Sampling Methodology and Plan

Systematically determining plant species from hydroacoustic signatures is not possible using current technology. For this reason, physical sampling (a.k.a., pole or rake sampling) must be used in order to determine plants species at a site. The plant species data from each site are then combined with the adjacent hydroacoustic plant bed data to determine acres of hydrilla and other species.

A total of 889 permanent sites were sampled for aquatic plants in 2013, 861 of which were in the main lake. Twenty-eight additional sites were sampled in Cotton Creek and the western river channel. Plant sample data were collected by using a vegetation sampling tool (Figure 7). The tool consisted of two 16” X 5/8” bolts inserted perpendicular to each other so they are centered approximately 1” from the threaded end of a 25’ extension pole. At each sample location, the threaded end of the vegetation sample tool was placed into the water until it touched bottom. The tool was then twisted several times and pulled from the water. ReMetrix has adopted this vegetation sample tool, opposed to a thatch rake, because it does a better job collecting short rooted plants, the user can ensure the tool is making sufficient contact with the bottom, and the samples taken from it are more representative of the vegetation at the exact coordinate being surveyed.

Two samples were collected per sample location. Data recorded about each sample were species name, injury, and cover rankings (Table 1), patchiness, and latitude and longitude. If no plant was found, then “no plant” was recorded as the species name. Photos were taken at the end of every sampling session.

Specific results from physical species sampling can be found in Table 6 of Section G in this report.

Table 1. Ranking systems for physical plant samples.

INJURY RANKINGS
1: Healthy
2: Slight Injury
3: Moderate Injury
4: Severe Injury
5: Dead Plant
6: Not Present

COVER RANKINGS
1: 80-100%
2: 60-79%
3: 40-59%
4: 20-39%
5: <19%
6: Not Present

Figure 7. Sampling tool photos.

F. Data Analysis

Step 1, Shoreline and Littoral Zone Creation
A shoreline polygon layer was created by tracing the water-land interface based on imagery obtained from ESRI's Bing Aerial Imagery service (info available here: http://www.esri.com/software/arcgis/arcgisonline/bing-maps.html). After the shoreline was created, a littoral zone polygon was drawn at the outer edge of where the hydroacoustic data detected plant.

Two data sources were used to develop the littoral zone polygon: hydroacoustic data collected by ReMetrix since 2007 and a digitized version of a USGS topographic map. The hydroacoustic data were collected when the lake level was approximately 200-feet in elevation. The acreage of the lake-wide littoral zone changes a few percent or less each year based on the latest updates to the littoral zone boundary from the most recent annual hydroacoustic data set.

Step 2, Hydroacoustic Modeling for Estimates of BioCover and BioVolume
After the shoreline and littoral zone were defined, the acoustic data were modeled for biocover and biovolume.

The first step in this process was selecting only the records falling within the littoral zone, preventing data from outside the littoral zone from influencing the models.

Secondly, areas where plant intersected with the hydroacoustic 'near-field' (the zone adjacent to the transducer face) were designated as 'topped-out' vegetation. Data points where the lake-bottom intersected with the near field were removed from the dataset (Figure 9).

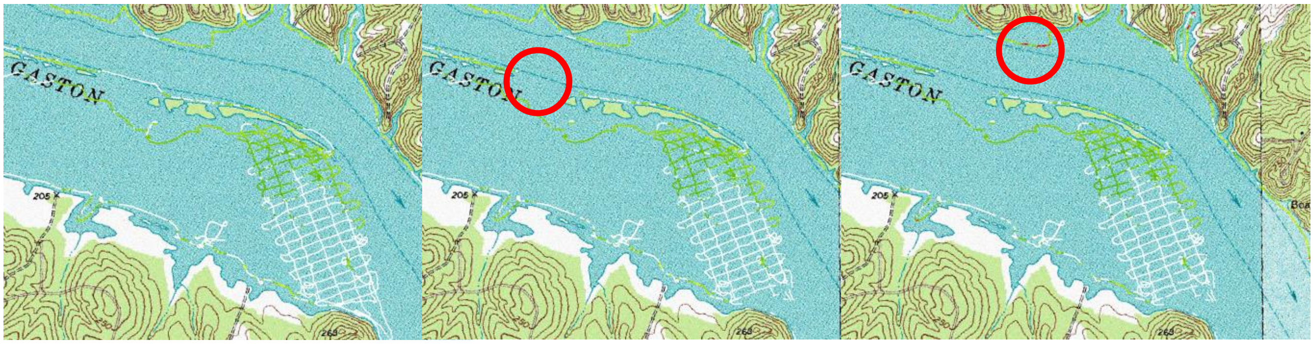

Fig 9: Original dataset *Remove > 10 feet* *Convert plant in near-field to 100% plant*

After preparing the data, two models were created for each vegetative estimate. The first, Model A, was used for littoral areas within 60-feet of the hydroacoustic collection track. The second model, Model B, was used for littoral areas beyond 60-feet of the collection track. Model A produced a grid of 5-foot resolution and Model B produced a grid of 60-foot resolution. The two models were then combined to provide a final estimation of plant biocover and biovolume within the littoral zone (Figure 10).

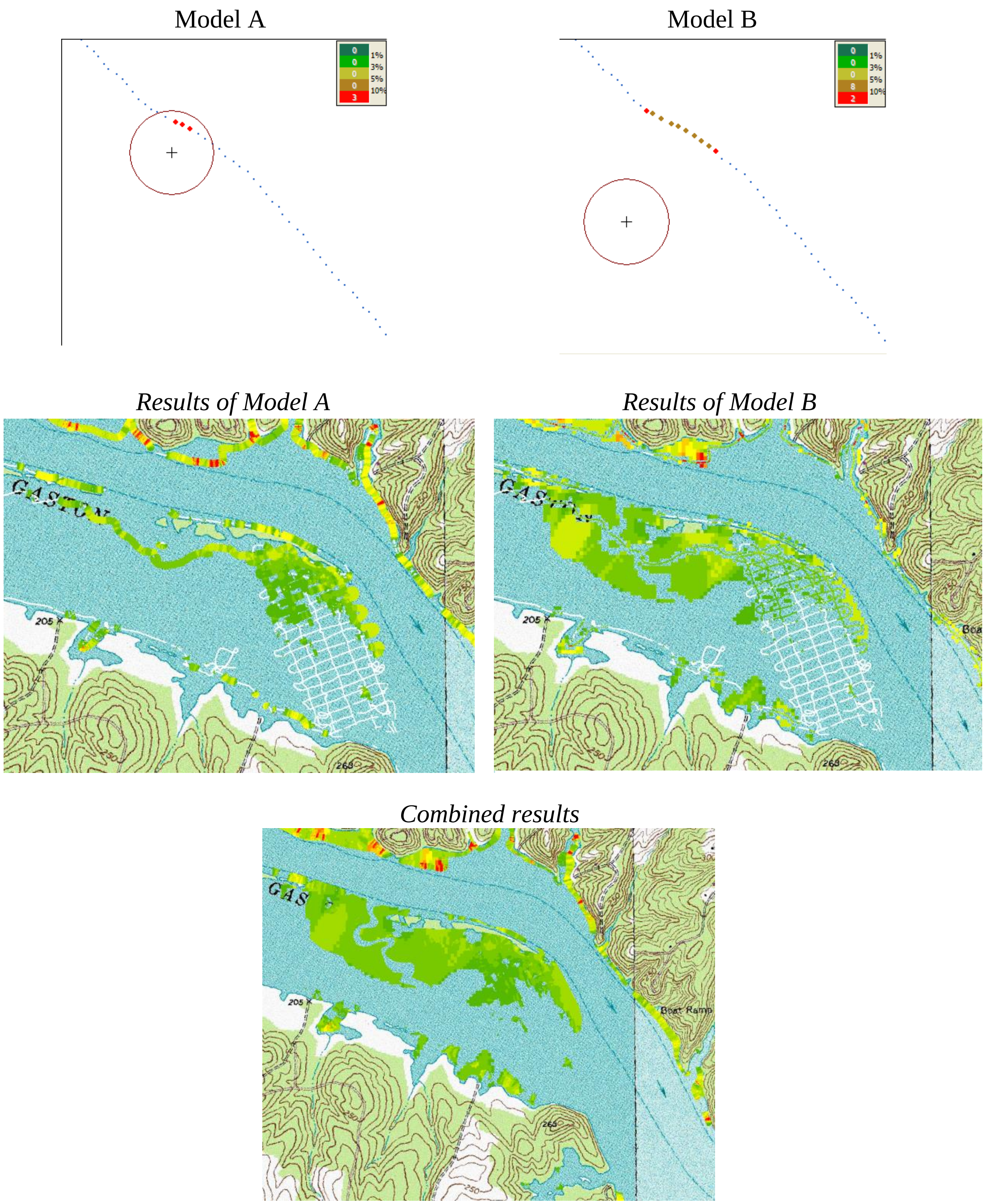

Figure 10. Examples showing the process of creating the models.

Step 3, Accuracy Assessment of the Models

Background
Typical measures of error in models are 'omission errors' and 'commission errors.' These measures are used to determine how well a model correlates with actual sample data at the same location. For this type of analysis, ReMetrix compared the pole sample results to the biocover model as a means for evaluating model results.

We used two 'classes' to develop the error estimates: '**plant**' (for where a pole sample or Biocover model indicated plant was present), or '**no plant**' (where a pole sample or Biocover model indicated no plants were present).

As a means for explaining a particularly difficult concept we will follow just one comparison through the description, however error was calculated for both 'classes' and both types of error. In the following example, we will use 'plant' pole samples and 'no plant' areas in the model.

> *Calculating omission error:* Of only the pole sample points where plant was found, what proportion of these points lie within a 'no plant' area in the model? In this scenario, a high omission error suggests that the model could be underestimating the amount of plant that is truly present at that location.
>
> *Calculating commission error:* Of all the pole sample points ('plant' or 'no plant') that lie within a 'no plant' area in the model, what proportion of those pole samples points are 'plant'? In this scenario, a high commission error suggests that the model could be overestimating the amount of 'no plant' that is truly present at that location.

Discussion
The pole samples were conducted from the bow of the boat and the hydroacoustic equipment and GPS antenna were located near the stern of the boat (approximately 15-feet of separation). Table 2 shows the accuracy when the model indicated there was plant within 15-feet of a physical plant sample.

Table 2. Lake-wide BioCover model accuracy assessment results after consideration of 15-foot positional difference due to hydroacoustic and GPS antenna distance to pole sample location.

			Raster Classification	
		Omission error ↓	plant	no plant
Pole Sample points	plant	17.7%	289	89
	No Plant	3.4%	13	490
		Commission error →	4.3%	15.4%

The greatest source of discrepancy in Table 2 is where the pole sample indicated 'plant' but the model indicated 'no plant,' resulting in a 17.7% omission error and a 15.4% commission error. ReMetrix investigated the 89 locations that represented this discrepancy. Of the 89 locations, 78 (87%) were either Lyngbya, dead plant, or had a cover rating equal to '5' from the pole sample (less than 20% plant cover). Figure 11 below shows a representative sample of Lake Gaston pole samples with a cover equal to '5.'

Figure 11. A representative example of pole samples where cover rating equals '5.'

As the photos indicate, sites ranked as '5' frequently had scant plant cover, sometimes as little as one or two stems of plant. So while plant was technically found at these sites, the cover is often sparse enough to be considered negligible. In the context of evaluating the contribution of such sites to the omission and commission error statistics, one is forced to weigh the statistical definition of a classification discrepancy against a practical definition. To gain a better understanding of how these samples affect the omission and commission errors, an analysis was generated to further investigate these points (Table 3).

Table 3. Same as Table 2 but with the '5' cover ratings, dead plant, and/or Lyngbya removed from the final column.

			Raster Classification	
		Omission Error ↓	plant	no plant
Pole sample points	plant	2.2%	289	11
	no plant	3.4%	13	490
		Commission error →	4.3%	2.2%

If pole samples ranked as a cover of '5' and/or Lyngbya are removed from the analysis, the omission error is reduced to 2.2% (from 17.7%) and the commission error is reduced to 2.2% (from 15.4%).

Another way to summarize the results in Tables 2 and 3 is that the model correctly predicted the presence or absence of plants about 88% of the time [(289 + 490)/889] when very sparsely vegetated areas are considered in the analysis, and about 96% of the time [(289 + 490)/811] when very sparsely vegetated areas are not considered in the analysis. Considering that the pole samples currently help evaluate the success of the model in predicting the presence or absence of plants, one can infer two conclusions:

(a) the model does an excellent job (96%) of predicting plant presence in areas where pole sample plant cover is either none or greater than 20%;

(b) the model still does a good job (88%) of predicting plant presence regardless of what pole plant cover rating is involved.

From the perspective of making vegetation management decisions, the classification of these 78 sparsely vegetated points as either ‘plant’ or ‘no plant’ probably has little practical impact. The marginal percent of sparse biocover in question, along with the even smaller percent of associated biovolume, is unlikely to have any significant effect on management planning or treatment strategies.

Most of the remaining error in Tables 2 and 3 can be explained by the patchiness or randomness of aquatic vegetation in some areas (see Figure 12 as an example), and the characteristics of the varied shoreline. A majority of the 11 areas where the model indicated there was plant but the pole sample indicated “no plant” also occurred in areas of very low-density vegetation, where the probability of the pole contacting vegetation was low. No adjustments were made to the models for these areas since the hydroacoustic samples indicating some plant presence vastly outnumber the pole samples. A review of the hydroacoustic data for many of these areas confirmed that these zones typically have low-density plant populations where a limited number of pole samples may have easily missed patchy plant beds.

Figure 12. Example of patchy hydrilla surrounded by bare substrate in Lake Gaston.

G. Results

Maps of the results for each region can be found in the Appendix.

All results can also be viewed and investigated in the Lake Gaston Web Atlas constructed for this project.

Table 4. Lake-wide results (does not include results from Cotton Creek or the western river channel, which are shown in Table 5).

Category	2007 Lake-wide	2008 Lake-wide	2009 Lake-wide	2010 Lake-wide	2011 Lake-wide	2012 Lake-wide	2013 Lake-wide	*Change from '11-'12*
Study area extent	18,340 ac	18,313 ac	18,320 ac	18,322 ac	18,324 ac	18,322 ac	18322	*0 ac*
Littoral zone size	4,960 ac	4,906 ac	5,061 ac	5,132 ac	5,228 ac	5,372 ac	5,344 ac	*-28 ac*
Lake-wide SAV	1,438 ac	1,504 ac	1,652 ac	1,752 ac	1,617 ac	1,753 ac	**759 ac**	***-994 ac***
Avg SAV Biocover within littoral zone	29%	31%	33%	35%	31%	33%	15%	*-18%*
Avg SAV Biovolume within littoral zone	11%	12%	16%	11%	7%	10%	5%	*-5%*
Lake-wide hydrilla	1,235 ac	1,244 ac	1,477 ac	1,665 ac	1,449 ac	1,541 ac	**671 ac**	***-870 ac***
Hydrilla as a monoculture	932 ac	950 ac	745 ac	1,320 ac	1,177 ac	843 ac	417 ac	*-426 ac*
Hydrilla within mixed stands	303 ac	294 ac	731 ac	345 ac	272 ac	698 ac	254 ac	*-444 ac*
Lake-wide hydrilla *not incl. Flats*	*n/c*	*n/c*	*n/c*	*n/c*	1,132 ac	1,340 ac	**443 ac**	***-897 ac***
Hydrilla as a monoculture					935 ac	807 ac	255 ac	*-582 ac*
Hydrilla within mixed stands					197 ac	533 ac	188 ac	*-345 ac*

n/c = not calculated this project year

Table 5. Aquatic plant species and occurrences found during the 2013 lake-wide physical sampling of ***862 total points****. (Points from Cotton Creek and the western river channel are not included to keep results comparable to historical data. They are shown in Tables 6a and 6b.)*

Common name	Scientific name	2013 Occurrence	% Occurrence
Submerged Plants			
Brazilian waterweed	*Egeria densa*	6	0.7%
brittle naiad	*Najas minor*	6	0.7%
coontail	*Ceratophyllum demersum*	4	0.5%
Eurasian watermilfoil	*Myriophyllum spicatum*	1	0.1%
hydrilla	*Hydrilla verticillata*	287	33.3%
naiad	*Najas* spp.	68	7.9%
Submerged Algae			
Compsopogon	*Compsopogon* spp.	22	2.6%
Lyngbya	*Lyngbya* spp.	35	4.1%
muskgrass	*Chara* spp.	39	4.5%
Emergent Plants			
arrowhead	*Sagittaria lancifolia*	7	0.8%
bulrush	*Scirpus* spp.	3	0.3%
cattail	*Typha* spp.	60	7.0%
grass	*grass spp.*	4	0.5%
lotus	*Nelumbo lutea*	11	1.3%
pickerelweed	*Pontederia cordata*	13	1.5%
rush	*taxonomy incomplete*	4	0.5%
wild taro	*Colocasia*	5	0.6%
water-willow	*Justicia* spp.	284	32.9%
Floating-Leaf Plants			
spatterdock	Nuphar lutea	9	1.0%
watershield	*Brasenia* spp.	7	0.8%
yellow water lily	Nymphaea mexicana	3	0.3%
Other			
no plant	*n/a*	490	56.8%

Emergent and floating-leaf species are not within the primary scope of the project, however ReMetrix still records their presence when observed at the permanent sample sites.

Two new species were identified at the permanent sample sites in 2013: emergent wild taro (*Colocasia*) at five sites, and floating yellow water lily (*Nymphaea mexicana*) at three sites.

The following submerged species categories exhibited significant change ($p < 0.01$) at permanent physical sample sites from 2012-2013 based on chi-square analysis:

Common name	Scientific name	2012 Observations	2013 Observations	*% Change '12-'13*
Submerged Plants				
hydrilla	*Hydrilla verticillata*	489	287	*-41%*
Algae				
Compsopogon	*Compsopogon* spp.	38	22	*-42%*
muskgrass	*Chara* spp.	62	39	*-37%*

($n = 860; p < 0.01$)

The "no plant" category also exhibited significant change among permanent physical sample sites from 2012-2013.

Common name	Scientific name	2012	2013	*% Change*

		Observations	Observations	*'12-'13*
no plant	*n/a*	296	490	*66%*

(*n = 860; p < 0.01*)

Finally, when the four categories of invasive species are summed, these also exhibit significant change among permanent physical sample sites from 2012-2013.

Common name	Scientific name	2012 Observations	2013 Observations	*% Change '12-'13*
Total invasive species*	*n/a*	530	329	*-38%*

**Sum of hydrilla, Brazilian waterweed, Eurasian watermilfoil, and Lyngbya observations in above table.*
(*n = 860; p < 0.01*)

Tables 6a and 6b. Aquatic plant species and occurrences found during the 2012 'special study areas' physical sampling.

6a. Cotton Creek (7 points)

Common name	Scientific name	2013 Occurrence	% Occurrence
Emergent Species			
cattail	*Typha* spp.	1	*14%*
Other			
no plant	*n/a*	7	*100%*

6b. Western river channel (20 points)

Common name	Scientific name	2013 Occurrence	% Occurrence
Submerged Species			
Brazilian waterweed	*Egeria densa*	16	*80%*
hydrilla	*Hydrilla verticillata*	2	*10%*
naiad	*Najas* spp.	1	*5%*
Other			
no plant	*n/a*	3	*15%*

Table 7. Percent occurrence of all aquatic plant species identified at all lake-wide permanent physical sampling sites from 2007-2012 (does not include points sampled in Cotton Creek or the western river channel).

Common name	Scientific name	2007 % Occurrence (n= 867)	2008 % Occurrence (n=856)	2009 % Occurrence (n=856)	2010 % Occurrence (n=852)	2011 % Occurrence (n=859)	2012 % Occurrence (n=860)	2013 % Occurrence (n=862)
Submerged Plants								
bladderwort	*Utricularia* spp.	0.20%	--	--	0.10%	--	--	--
Brazilian waterweed	*Egeria densa*	3.20%	3.20%	3.20%	2.50%	1.40%	1.20%	0.70%
brittle naiad	*Najas minor*	0.10%	1.30%	2.60%	3.80%	1.60%	1.00%	0.70%
coontail	*Ceratophyllum demersum*	4.60%	3.40%	2.90%	1.30%	0.60%	0.70%	0.46%
Eurasian watermilfoil	*Myriophyllum spicatum*	0.50%	0.10%	0.40%	0.10%	0.10%	0.10%	0.12%
hydrilla	*Hydrilla verticillata*	54.00%	62.90%	42.40%	62.40%	50.40%	56.90%	33.29%
naiad	*Najas* spp.	0.50%	3.20%	1.20%	1.10%	1.20%	6.70%	7.89%
pondweed spp.	*Potamogeton* spp.	0.10%	--	--	--	--	--	--
Submerged Algae								
algae spp.	taxonomy incomplete	0.10%	--	--	--	--	0.20%	--
Compsopogon	*Compsopogon* spp.	--	--	--	--	--	4.40%	2.55%
Lyngbya	*Lyngbya wollei*	4.30%	3.20%	4.60%	3.20%	3.40%	3.50%	4.06%
muskgrass	*Chara* spp.	13.80%	12.50%	3.60%	6.10%	4.30%	7.20%	4.52%
Emergent Plants								
arrow arum	*Peltandra* spp.	0.20%	--	--	--	--	--	--
arrowhead	*Sagittaria* spp.	0.50%	0.40%	0.50%	--	--	0.70%	0.81%
bulrush	*Scirpus spp.*	--	--	--	--	--	--	0.35%
cattail	*Typha latifolia*	1.20%	1.30%	1.60%	1.90%	9.70%	8.10%	6.96%
grass	*grass spp.*	--	--	--	--	--	--	0.46%
lotus	*Nelumbo lutea*	0.70%	0.50%	0.50%	0.50%	1.20%	1.40%	1.28%
pennywort	*Hydrocotyle* spp.	--	0.10%	--	--	--	0.10%	--
pickerelweed	*Pontederia cordata*	0.20%	--	--	--	--	2.30%	1.51%
rush	taxonomy incomplete	0.60%	0.80%	0.70%	--	--	2.90%	0.46%
wild taro	*Colocasia*	--	--	--	--	--	--	0.58%
water-willow	*Justicia* spp.	8.20%	11.00%	6.30%	14.00%	39.50%	31.20%	32.95%
Floating-Leaf Plants								
duckweed	*Lemna minor*	--	0.10%	--	--	--	0.10%	--
pond-lily	*Nuphar* spp.	0.10%	0.20%	0.50%	0.20%	1.70%	0.20%	1.04%
watershield	*Brasenia* spp.	0.20%	0.50%	0.60%	0.80%	0.80%	1.30%	0.81%
yellow water lily	Nymphaea mexicana	--	--	--	--	--	--	0.35%
Other								
no plant	*n/a*	26.50%	24.60%	46.30%	30.90%	30.40%	34.40%	56.84%

Emergent and floating-leaf species are not within the primary scope of the project, however ReMetrix still records their presence when observed at the permanent sample sites.

Appendix