Aquatic Plant Distribution Assessment within the Littoral Zone of the Ross Barnett Reservoir, MS in 2010: A Six Year Evaluation

An Annual Report to the Pearl River Valley Water Supply District

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INTRODUCTION

The Ross Barnett Reservoir, located near Jackson, MS, is the state's largest surface water impoundment. This 33,000 acre water body provides the city of Jackson with potable water, fishing and recreational opportunities, essential wildlife habitat, and a beautiful amenity to its surrounding residential communities and commercial developments. The introduction of non-native plant species in the Reservoir has threatened its biodiversity and natural processes. Not only can multiple non-native plants do extreme harm to an area, but just one exotic species can alter an entire ecosystem if not controlled properly (Pimental et al. 2000). The exotic invasive plant hydrilla (*Hydrilla verticillata* (L.f.) Royle), was observed in the Reservoir in 2005 (Wersal et al. 2006a). This submersed aquatic plant is on the State and Federal Noxious Weed Lists and has been nicknamed "the perfect aquatic weed" due to its aggressive growth habit and adaptive morphological characteristics (Langeland 1996). Alligatorweed (*Alternanthera philoxeroides* (Mart.) Griseb.), and waterhyacinth (*Eichhornia crassipes* (Mart.) Solms) are also species of concern that have spread to a large degree and negatively impacted the Reservoir's services and available recreational opportunities. Impacts from these plant species, as well as other aquatic invasives, prompted the Pearl River Valley Water Supply District to create a long-term management plan to strategically monitor these plants and assess control methods to suppress their spread.

Systemic herbicide applications have primarily been the management technique used for alligatorweed and waterhyacinth over the last decade (Wersal et al. 2009). Hydrilla has been managed over the last five years by the contact herbicide endothall and the systemic herbicide fluridone. Applications of fluridone have proven successful, greatly reducing the concentrated populations of hydrilla on the Reservoir. However, fragmentation of hydrilla and water movement seems to keep scattered populations present, mainly in the northern portion of the Reservoir. To ensure that the current management techniques are effective, intensive surveying and regular assessments are imperative to the success of any long-term management maintenance program (Madsen 2007).

OBJECTIVES

Objectives were to 1) monitor the aquatic plant community in the Ross Barnett Reservoir by recording location and distribution of aquatic plants in the littoral zone (water depths ≤ 10 feet; 2) monitor and assess the current hydrilla populations as well as document the occurrence and establishment of new populations; and 3) assess the effectiveness of hydrilla management. The results of this assessment are included in this report.

MATERIALS AND METHODS

Vegetation Survey

A survey was conducted on a 300 meter grid (Madsen 1999, Wersal et al. 2009) in September 2010 to evaluate aquatic plant distribution in the Reservoir. Only points located in the littoral zone at locations previously selected from the past five years were surveyed. Points inaccessible by boat were not sampled, or a new point near the location was made. Sampling at depths of 10 feet or less allowed for a more rigorous survey on the Reservoir at locations most favorable for plant growth (Figure 1). Sampling of the same points from 2005 to 2010 allows changes in the plant community to be statistically quantified over time (Figures 1 to 6).

Survey accuracy of 3-10 feet (1-3 m) was achieved by using a Trimble AgGPS106™ (Sunnyvale, California) receiver coupled with a Panasonic C-29 Toughbook™ (Secaucus, New Jersey) computer. A total of 620 points were surveyed in 2010. At each survey point, a weighted plant rake with an attached rope was deployed and pulled in to determine the presence or absence of plant species. Depth was recorded at each point a Lowrance LCX-28C depth finder (Tulsa, Oklahoma) or with a sounding rod at depths less than 10 feet. Navigation to survey points, the display and collection of geographic and attribute data while afield, and spatial data were recorded electronically using FarmWorks Site Mate® software version 11.4 (Hamilton, Indiana). Utilization of this software decreases the likelihood of errors in data entry and post processing time. Database templates with pick lists created exclusively for this project were used in recording collected data.

Plant species presence was averaged over all points sampled and multiplied by 100 to obtain percent frequency. Total species richness was calculated and presented as the mean (± 1 SE) of all species observed at each point. Mean species richness was compared between years using a general linear model. Changes in the occurrence of plant species was determined using McNemar's Test for dichotomous response variables that assesses differences in the correlated proportions within a given data set between variables that are not independent (Stokes et al. 2000, Wersal et al. 2006a, Wersal et al. 2008). A pairwise comparison of species occurrences was made between years using the Cochran-Mantel-Haenszel statistic (Stokes et al. 2000, Wersal et al. 2006b, Wersal et al. 2007, Wersal et al. 2008, Wersal et al. 2009, Cox et al. 2010). All analyses were conducted at a $p < 0.05$ level of significance.

Invasive Species Management

Waterhyacinth and Alligatorweed Assessment: Data obtained from the point intercept surveys conducted on the Reservoir were used to assess management efficacy on these species. A quantitative comparison was then made by the analysis of changes in the frequency of occurrence of each species between years.

Hydrilla Assessment: Occurrence of hydrilla in the Reservoir was assessed and analyzed in a similar fashion to waterhyacinth and alligatorweed.

A tuber survey was conducted in June, 2010 to assess the current density of hydrilla tubers in the Ross Barnett Reservoir. Sampling the sediment for tubers in areas of known hydrilla occurrence allows for estimation of future hydrilla populations. A PVC coring device was used to collect 20 sediment samples at each site (Madsen et al. 2007). The sediment was sieved through a pail with a wire mesh bottom to separate the sediment from any plant material. Any tubers found were transported to Mississippi State University where they were sorted, dried, and weighed to calculate tuber biomass and density. Tuber surveys conducted since 2005 have yielded very few hydrilla tubers. The recovery of tubers in site 4 in 2006 is the only record of tuber occurrence since 2005 and explained the discovery of new hydrilla plants in 2008. Although no other tubers have been found, it is possible that hydrilla plants may be overwintering and re-growing from healthy root crowns with very little tuber production. Low tuber densities may decrease the year to year recruitment of hydrilla and possibly the number of herbicide treatments necessary for eradication. If herbicide treatments are reduced, minimizing fragmentation and transport of hydrilla within the Reservoir would become more critical. Fluridone treatments have been documented to inhibit tuber production as well as remove standing biomass (MacDonald et al. 1993).

RESULTS AND DISCUSSION

Littoral Survey

The 2010 point survey of the Ross Barnett Reservoir yielded a total of 21 aquatic or riparian plant species (Table 1). After 6 years of surveying, a total of 26 species have been observed. The native plant American lotus (*Nelumbo lutea* (Willd.)) was the dominant species, which increased in occurrence from 17% in 2005 to 27% in 2010 (Table 1). White waterlily (*Nymphae odorata* Aiton) has remained constant over the last six years, while coontail (*Ceratophyllum demersum* L.) significantly decreased from 7.6% in 2008 to 3.9% in 2010. Other native species that commonly occurred were waterprimrose (*Ludwigia peploides* (Kunth) P.H. Raven) and giant cutgrass (*Zizaniopsis miliacea* (Michx.) Doll & Asch.). Although native species, waterprimrose and giant cutgrass may form monotypic stands in waterbodies similar to non-native plants. Species richness was significantly greater in 2009 than in 2008 with 1.08 plant species observed per point, though there were no differences in species richness observed between 2009 and 2010 (Figure 7). Water depth was a key determinant in species richness at each point during the year of the survey. In the years 2008 (0.82 mean species richness) and 2009, higher water levels allowed for better accessibility to locations in the Reservoir with higher plant presence; thus, higher mean species richness per point (Figure 7). Water levels in 2010 were lower, thus, access to many survey points was limited.

Alligatorweed, waterhyacinth, hydrilla, parrotfeather (*Myriophyllum aquaticum* (Vell.) Verdc.), and brittle naiad (*Najas minor* All.), all had occurrences below 10% for all survey years, except for alligatorweed which increased to 14.9% in 2009 but decreased to 11.9% in 2010 (Table 1). Alligatorweed was the non-native species observed most often in all years, followed by waterhyacinth, hydrilla, brittle naiad, and parrotfeather. The distribution of alligatorweed is depicted in figures 8 to 13, waterhyacinth in figures 14 to 19, and hydrilla in figures 20 to 24. Generally, the occurrence of all aquatic plant species were in Pelahatchie Bay and the northern portion of the Reservoir where water levels and environmental conditions favor plant growth.

Waterlettuce (*Pistia stratiotes* L.) was not found during the 2010 survey after being observed in 2009 along a small channel in Pelahatchie Bay. It appears that the early detection and immediate combination applications of 2,4-D and diquat were successful at eradicating this species. Cuban bulrush (*Oxycaryum cubense* (Poepp. & Kunth) Lye) was also discovered in Pelahatchie Bay in 2009 and is still well established there. Combination applications of 2,4-D and diquat were made in 2009 and 2010, but efficacy of these treatments is currently not attainable because the extent of its establishment is still being determined. Nevertheless, herbicide treatments should persist to prevent further spread of Cuban bulrush throughout the Reservoir.

Invasive Species Management

Waterhyacinth and Alligatorweed Assessment: The frequency of occurrence for alligatorweed had decreased significantly ($p \leq 0.01$) from 2005 to 2008, increased to 14.9% in 2009, and decreased to 11.9% in 2010. The frequency of occurrence for waterhyacinth decreased significantly from 2009 (8.6%) to 2010 (5.2%). Estimated acreages of non-native plants are displayed in Table 2. The estimated acreage for alligatorweed had more than doubled from 2008 to 2009, according to survey data from 2009. This tremendous increase in occurrence may be attributed to the increase in water level of the Reservoir in 2009 and the addition of approximately 25 locations of alligatorweed observed up the Pearl River that were not surveyed in 2008. The estimated acreage of alligatorweed for 2010 decreased by approximately 700 acres; which is attributed to low water levels, rigorous herbicide applications, and a fluctuation in the number of surveyed locations between years. Small, existing alligatorweed populations along the river are likely responsible for supplying propagules and establishing new populations in the Reservoir. Dense pockets and pools of vegetation that are not accessible by boat may also provide plant propagules to the Reservoir. The increase in occurrence of waterhyacinth from 2008 to 2009 is most likely due to higher water levels and the ability to access more of the survey points to find these populations. The significant decrease in waterhyacinth from 2009 (8.6%) to 2010 (5.2%) is likely due to low water levels making many infested areas inaccessible to survey. “Hidden” plants among dense stands of other plant species also make surveying and treatment difficult at times. Herbicides and rates applied to alligatorweed and waterhyacinth in 2010 are shown in Table 3. Additional surveying methods such as remote sensing should be explored and incorporated into the surveying scheme of the Reservoir to determine the extent of these plant-inhabited areas and improve monitoring and distribution assessments.

Hydrilla Assessment: Hydrilla was observed in sites 5, 6, and 15 during the littoral survey (Figure 25). Although not surveyed in 2010, Site 14 was created as a new hydrilla site after a few small populations were observed at this location by Aquaservices, Inc. Site 14 is located in Upper Lake 6 just on the northern side of site 11 adjacent to the Pearl River (Figure 25). Site 15 was created as a new hydrilla site in 2010 after large populations were observed growing throughout this canal during the survey. Site 15 is located in the northeastern corner of Middle Reservoir 5, bearing east/northeast of Tommy’s Trading Post boat landing. It mainly comprises a narrow channel that provides a small lake house community access to and from the Upper Lake (Figure 25). No hydrilla was found in Sites 1, 4, 11, 12, or 13 during the 2010 survey. Sites 1 and 11 have consistently had hydrilla present, despite consecutive fluridone treatments in 2007, 2008 and 2009. Sites 1, 5, 6, and 11 were treated in June and August 2010 with combinations of copper and diquat. Sites 12 and 13 were treated in June 2010 with fluridone. Sites 14 and 15 were treated with copper and diquat in August 2010. Hydrilla treatment data from 2005 to 2010 is shown in Table 4. The survey data indicates that previous fluridone treatments in Sites 12, and 13 have been successful. Site 5 has the highest density of hydrilla than all other hydrilla sites on the Reservoir. However, the hydrilla population in Site 15 is also extensive and growing in a canal that receives moderate boat traffic to and from the upper lake (Figure 26). Intense management should begin immediately at this site to prevent fragmentation and further spread of these plants. In general, fluridone treatments have been successful in not allowing hydrilla to expand. However, continuous monitoring should be implemented to locate these small, hard-to-locate populations that will spread rapidly if ignored. The discovery of the population in the newly created Site 14 is a firm indication of how important monitoring is to a management strategy. Monitoring the distribution and treatment of hydrilla should be continued to prevent the further spread of this species in the Reservoir. Furthermore, education and outreach measures should be developed to instruct the public and Reservoir users on the proper identification of hydrilla and other invasive species; and the problems associated with these species being present.

Following the 2010 survey, a new hydrilla population was discovered by Aquaservices, Inc. on the upper lake portion of the Reservoir. This population is located directly east across the main channel from hydrilla Site 8 (Figure 27). We propose that this new location be named Site 16 and included in the current management strategies of hydrilla on the Reservoir. Combination applications of diquat and copper should begin immediately along with monitoring to assess treatment efficacy and prevent further spread of hydrilla in this site and throughout the reservoir.

RECOMMENDATIONS

- Apply fluridone to Sites 5, 15, and 16.
- Apply copper and diquat applications to Sites 1, 6, 11, and 14.
- Continue 2,4-D treatments of alligatorweed and waterhyacinth in the Reservoir, as well as along the Pearl River to prevent further introduction and spread.
- Continue monitoring of hydrilla populations and ensure precise documentation of their locations.
- Continue extensive herbicide applications on Cuban bulrush to prevent further spread throughout Pelahatchie Bay and the Reservoir.
- Continue to monitor Cuban bulrush distribution and assess herbicide treatment efficacy.

RECOMMENDED FUTURE WORK

- Determine water exchange characteristics at hydrilla sites.

ACKNOWLEDGEMENTS

We would like to thank the Pearl River Valley Water Supply District for funding this project. We also thank Dustin Forsythe and Eric Henderson for assisting in surveys. Special thanks also go to Josh Yerby and AquaServices, Inc. for providing us with detailed treatment data on the Reservoir and generously complying with our needs to make this information available.

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Table 1. Percent frequency of occurrence for aquatic plant species observed in the littoral zone during the Ross Barnett Reservoir Surveys 2005-2010. The letter 'n' refers to the total number of points sampled in a given year. Letters in a row for a given species denotes a significant difference among years at a p = 0.05 level of significance.

Species Name	Common Name	Native (N) or Exotic (E), Invasive (I)	2005 % Frequency (n=677)	2006 % Frequency (n=508)	2007 % Frequency (n=423)	2008 % Frequency (n=627)	2009 % Frequency (n=695)	2010 % Frequency (n=620)
Alternanthera philoxeroides	alligatorweed	E I	21.1	3.9	4.0	7.3	14.9a	11.9
Azolla caroliniana	mosquito fern	N	0.0	0.2	0.4	0.0	0.5	0.0
Cabomba caroliniana	fanwort	N	2.2	0.0	0.5	1.3a	0.6	0.0
Ceratophyllum demersum	coontail	N	4.4	4.9	3.5	7.6a	3.6a	3.9
Colocasia esculenta	wild taro	E I	0	0.9	0.7	2.4a	2.4	2.1
Eichhornia crassipes	waterhyacinth	E I	4.9	2.9	1.2	4.0a	8.6a	5.2a
Hydrilla verticillata	hydrilla	E I	0.0	0.6a	1.2a	0.6a	0.8	0.9
Hydrocotyle ranunculoides	pennywort	N	6.4	0.5	1.4	2.8a	1.3a	0.3
Juncus effusus	common rush	N	0.0	0.0	0.0	0.2	1.7	1.6
Lemna minor	common duckweed	N	3.1	2.5	1.9	1.4a	1.3	1.5
Limnobium spongia	American frogbit	N	1.5	0.8	0.7	1.3	0.3	0.3
Ludwigia peploides	waterprimrose	N	4.9	7.4	4.3	10.2a	14.8a	11.9
Myriophyllum aquaticum	parrotfeather	E I	0.7	0.0	0.2	1.0a	0.4	0.2
Najas minor	brittle naiad	E I	0.0	0.0	1.9a	1.0a	0.3	0.2
Nelumbo lutea	American lotus	N	17.1	17.7	21.2	24.8a	26.9	26.8
Nitella sp.	stonewort	N	0.1	0.0	0.0	0.0	0.0	0.0
Nymphaea odorata	white waterlily	N	4.4	3.4	4.9	5.4	5.9	5.3
Oxycaryum cubense	Cuban bulrush	E I						0.0
Pistia stratiotes	waterlettuce	E I						0.0
Potamogeton foliosus	leafy pondweed	N	0.0	0.0	0.0	0.6	0.0	0.3
Potamogeton nodosus	American pondweed	N	2.7	2.7	2.4	3.0	2.9	1.1
Sagittaria latifolia	broadleaf arrowhead	N	1.0	1.2	0.0a	0.5	1.3	1.0
Sagittaria platyphylla	delta arrowhead	N	0	1.8	0.8	0.3a	2.3a	1.1
Scirpus validus	softstem bulrush	N	1.2	0.2	0.0	0.0	0.0	0.0
Spirodella polyrhiza	giant duckweed	N	0.0	0.0	0.0	0.16	0.7	0.5
Typha sp.	cattail	N	1.3	2.4a	0.7	1.1	7.1a	5.5
Utricularia vulgaris	bladderwort	N	0.0	0.4	0.0	0.5	0.1	0.0
Zizaniopsis miliacea	giant cutgrass	N I	1.5	3.5	1.9a	4.1	10.4a	8.5

Note: An "a" indicates a statistically significant change in frequency of occurrence from the previous year for the indicated plant species.

Table 2. Estimated acreage of the non-native aquatic plant species occurring in the Ross Barnett Reservoir from 2005 to 2010. Acreage was calculated based on the total number of points for which a given species was observed. Each point of the survey represents approximately 22.2 acres.

Species	2005 Estimated Acreage	2006 Estimated Acreage	2007 Estimated Acreage	2008 Estimated Acreage	2008 Acreage Treated[1]	2009 Estimated Acreage	2009 Acreage Treated[1]	2010 Estimated Acreage	2010 Acreage Treated[1]
Alligatorweed	3175	444	377	1021	339	2309	307	1643	650
Brittle naiad	0	0	178	111		44		22	
Hydrilla	120	67	111	89	275	133	155	133	80
Parrotfeather	111	111	22	133		67		22	
Waterhyacinth	733	333	111	555	167	1332	561	710	410
Waterlettuce*							5*	0	0.5
Cuban bulrush*							51*	22	130

[1] Acreage treated refers to the total surface area of water treated, not necessarily to the extent of plant infestation.

* Denotes first observation in 2009 of indicated plant species.

Table 3. Herbicides and rates of application applied to non-native species in the Ross Barnett Reservoir in 2010.

Species	Acres Treated	Herbicide/Rate
Alligatorweed	650	glyphosate @ 2 qts/acre*
		2,4-D @ 2 qts/acre*
Waterhyacinth	410	2,4-D @ 2 qts/acre**
		diquat @ 1 qt/acre**
Cuban bulrush	127	2,4-D @ 2 qts/acre*
		diquat @ 1 qt/acre*
Waterlettuce	0.5	2,4-D @ 1 qt/acre*
		diquat @ 1 pt/acre*
Hydrilla	80	fluridone (Sonar Q)/0.98 lb per acre/ft
		fluridone (Sonar PR)/1.0 lb per acre/ft
		diquat @ 1.75 gal/acre
		copper @ 2.5 gal/acre

*** foliar applications applied with nonionic surfactant @ 1 pt/acre**

**** foliar applications applied with nonionic surfactant @ 1 qt/acre**

Table 4. Hydrilla treatment data from 2005 to 2010. Locations shown in Figure 25.

Treatment Records							
Hydrilla Site	**Year Discovered**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
1	2005	1	1-F (April)	1-F	1	1-FC	C (Jun, Aug, & Oct)
2	2005	1	1-F (April)	F			
3	2006		1-F (April)	F			
4	2006		1-F (April)	1-F	1	F	
5	2006		1-F (April)	F	?	1-FC	1-C (Jun, Aug, & Oct)
5b[1]	2009					1	
6	2007			1-F	?	1	1-C (Jun, Aug, &Oct)
7	2007			1	?	F	
8	2007			1	?		
9	2007			1	?		
10	2007			1	?		
11	2007			1-F	1-F	1-F	C (Jun, Aug, & Oct)
12	2009					1	F (June)
13	2009					1	F (June)
14	2010						1-C (Aug & Oct)
15	2010						1-C (August)
16	2010						1

"1" indicates observation of hydrilla

"F" indicates fluridone treatment

"C" indicates copper & diquat treatment

"?" indicates that treatment status is unknown

[1] Site 5b was discovered in 2009 and recently merged with Site 5

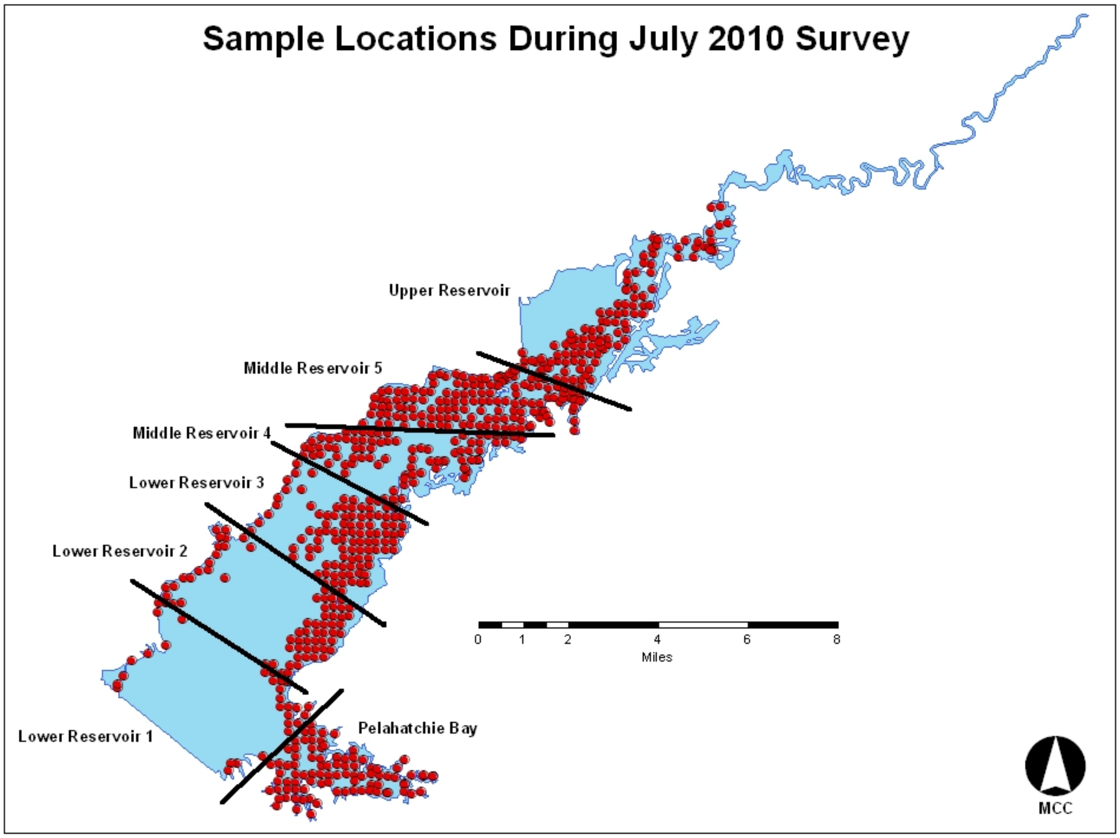

Figure 1. Sampling locations for the 2010 littoral zone survey of the Ross Barnett Reservoir.

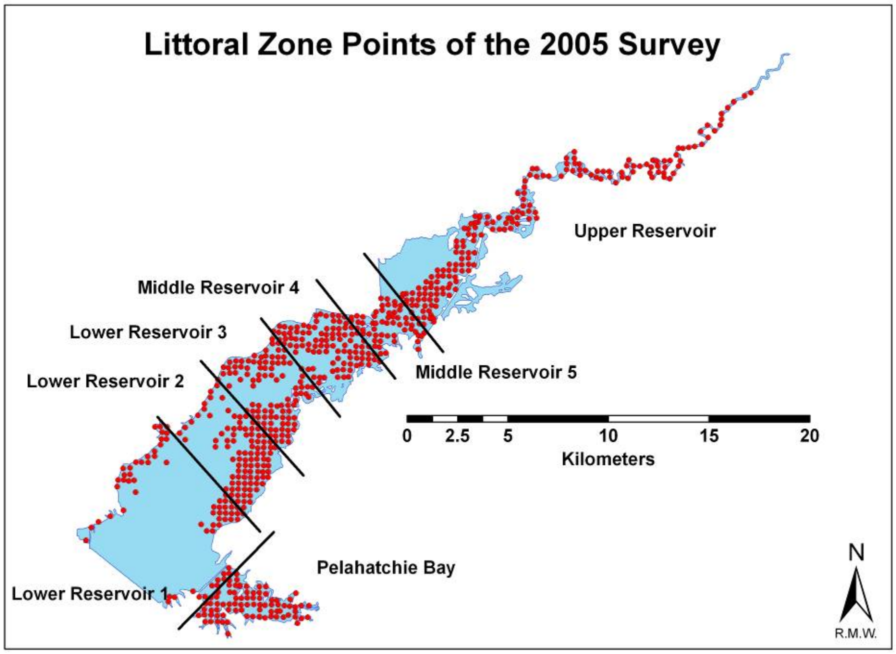

Figure 2. Sampling locations for the 2005 littoral zone survey of the Ross Barnett Reservoir (Wersal et al. 2006a).

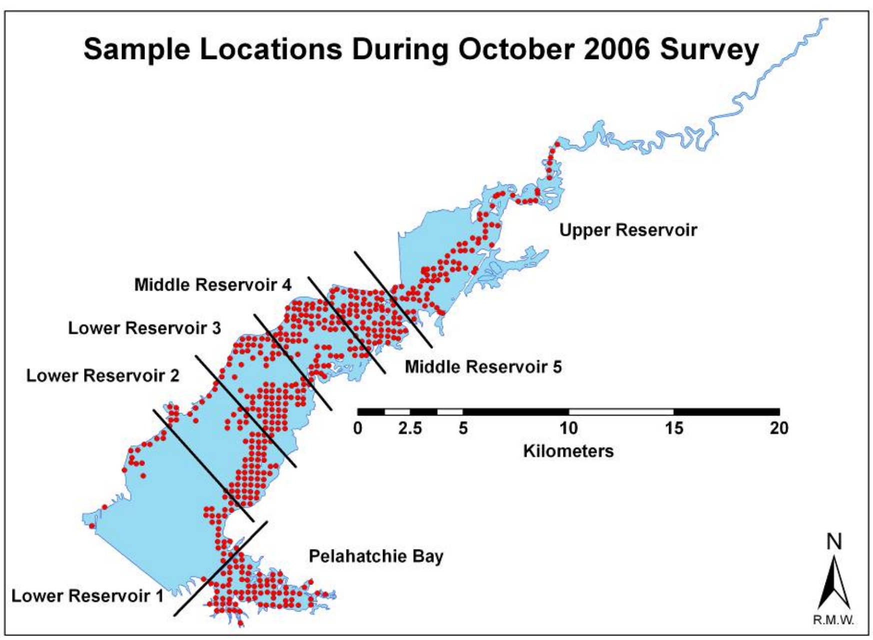

Figure 3. Sampling locations for the 2006 littoral zone survey of the Ross Barnett Reservoir (Wersal et al. 2007).

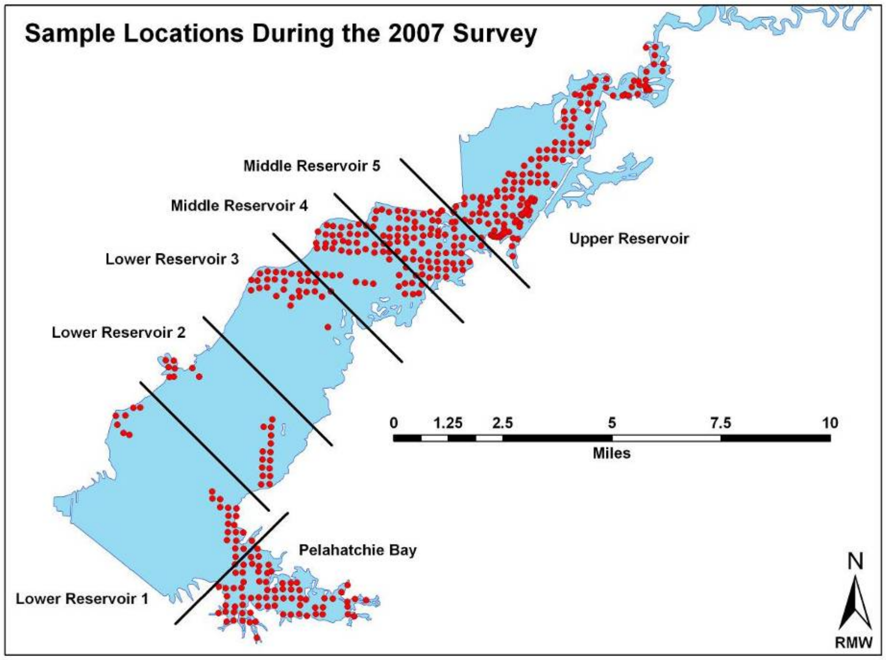

Figure 4. Sampling locations for the 2007 littoral zone survey of the Ross Barnett Reservoir. (Wersal et al. 2008).

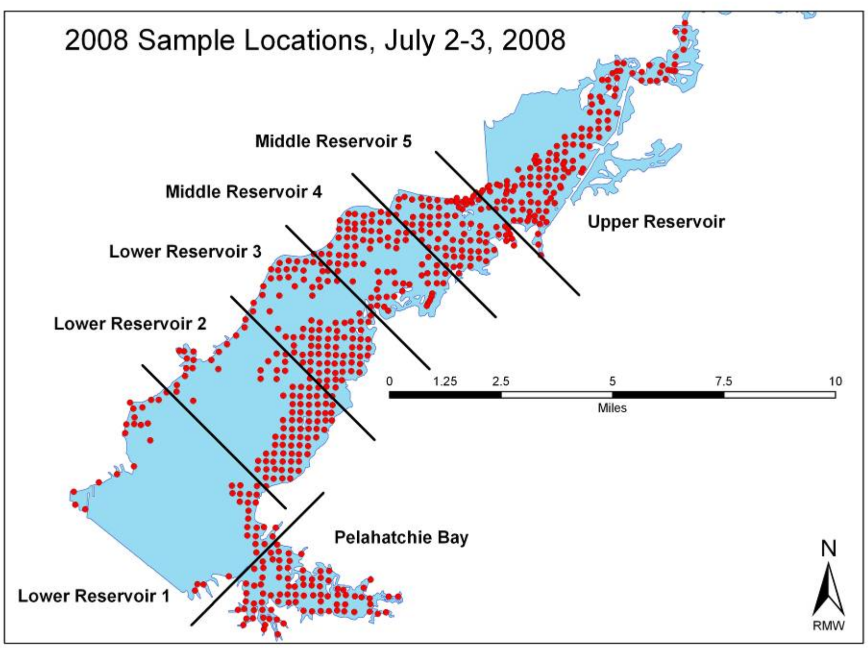

Figure 5. Sampling locations for the 2008 littoral zone survey of the Ross Barnett Reservoir (Wersal et al. 2009).

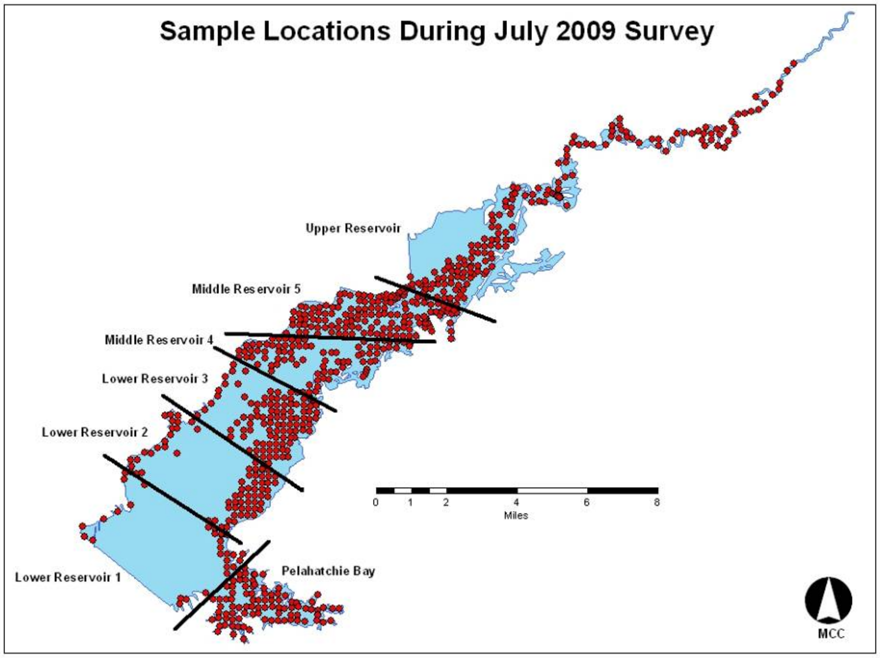

Figure 6. Sampling locations for the 2009 littoral zone survey of the Ross Barnett Reservoir (Cox et al. 2010).

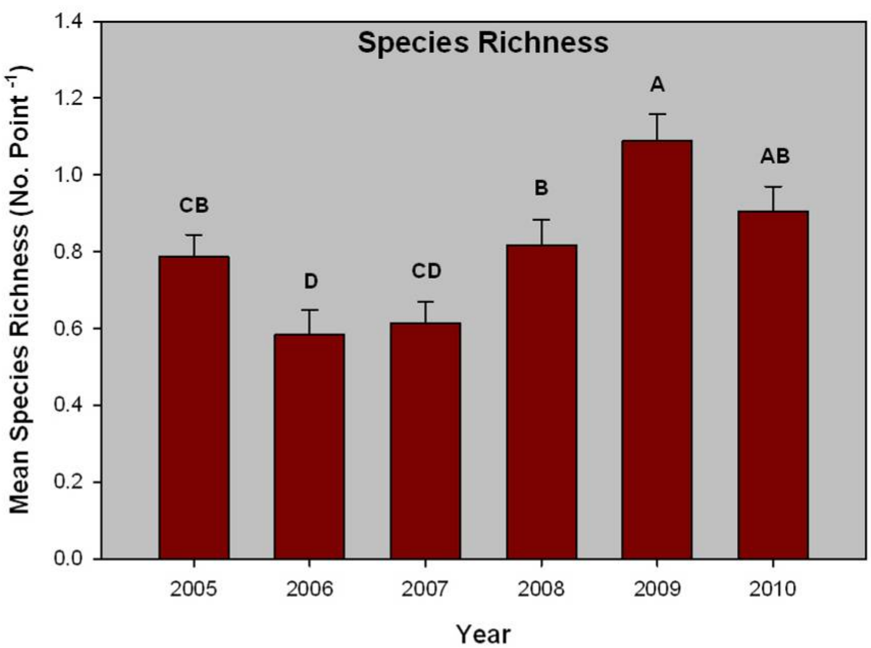

Figure 7. Mean (± 1 SE) species richness during surveys conducted between 2005 and 2010.

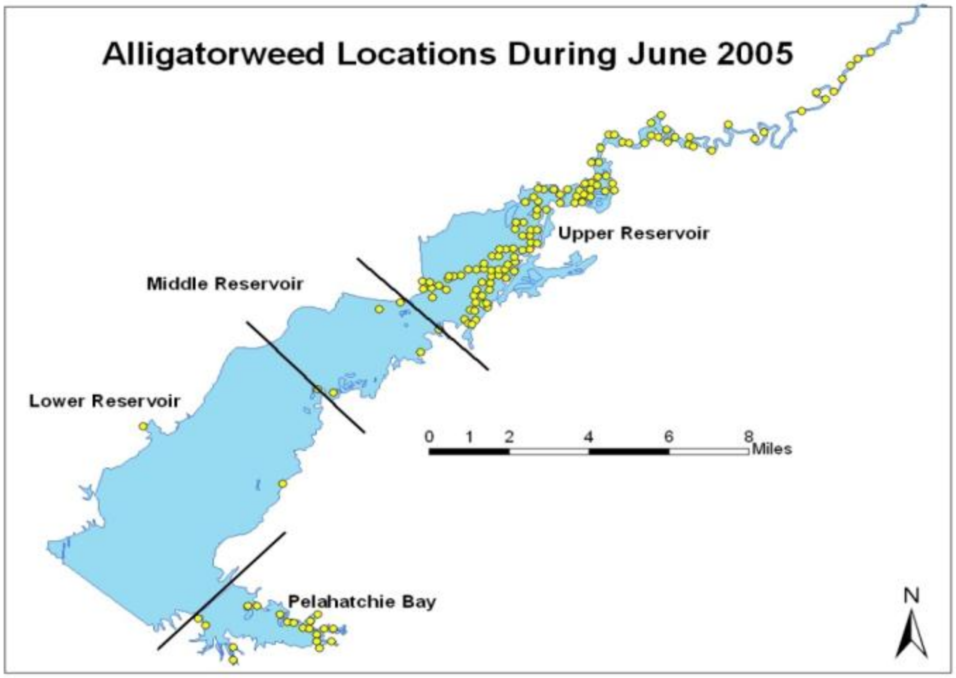

Figure 8. Alligatorweed occurrence locations in the Ross Barnett Reservoir in 2005 (Wersal et al. 2006a).

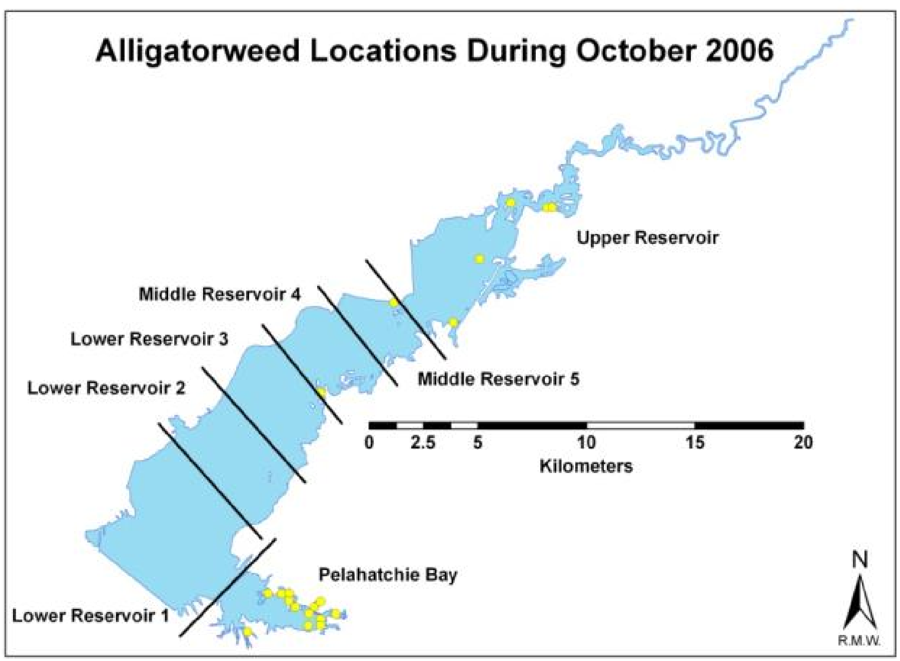

Figure 9. Alligatorweed occurrence locations in the Ross Barnett Reservoir in 2006 (Wersal et al. 2007).

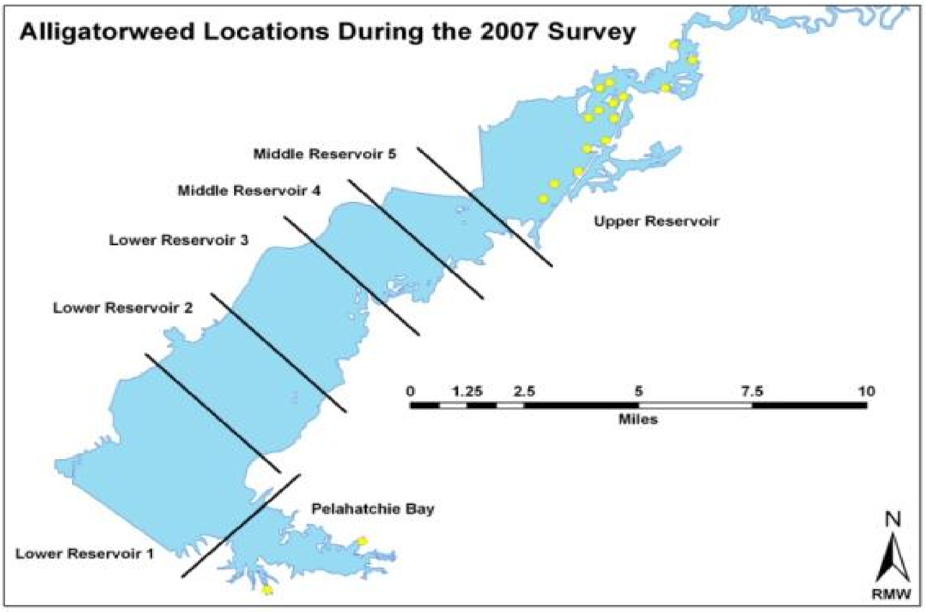

Figure 10. Alligatorweed occurrence locations in the Ross Barnett Reservoir in 2007 (Wersal et al. 2008).

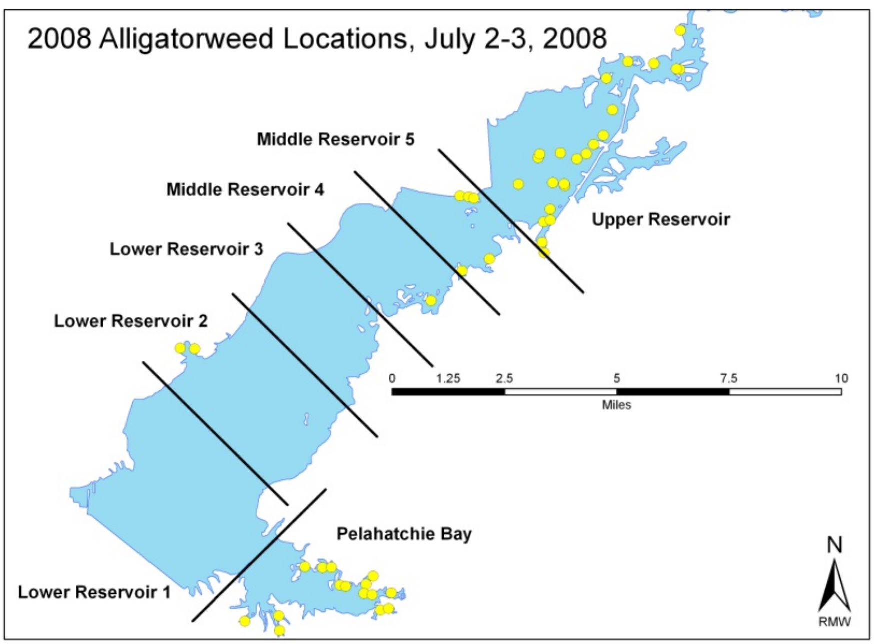

Figure 11. Alligatorweed occurrence locations in the Ross Barnett Reservoir in 2008 (Wersal et al. 2009).

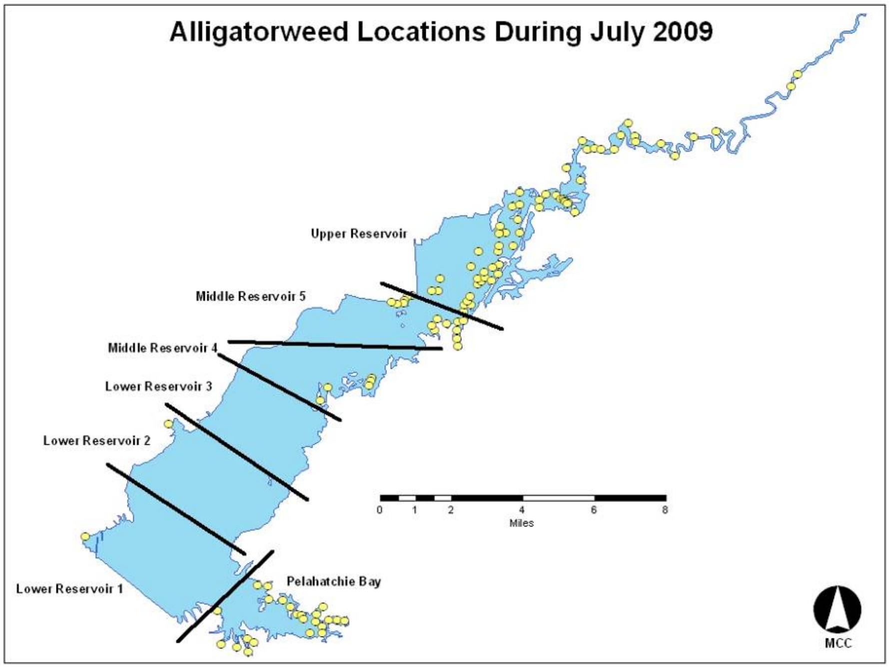

Figure 12. Alligatorweed occurrence locations in the Ross Barnett Reservoir in 2009 (Cox et al. 2010).

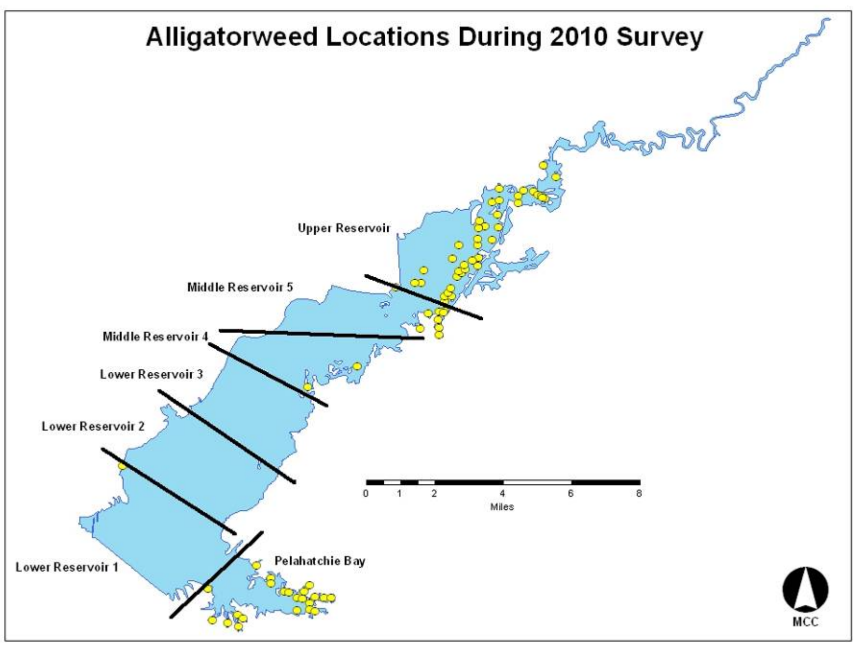

Figure 13. Alligatorweed occurrence locations in the Ross Barnett Reservoir in 2010.

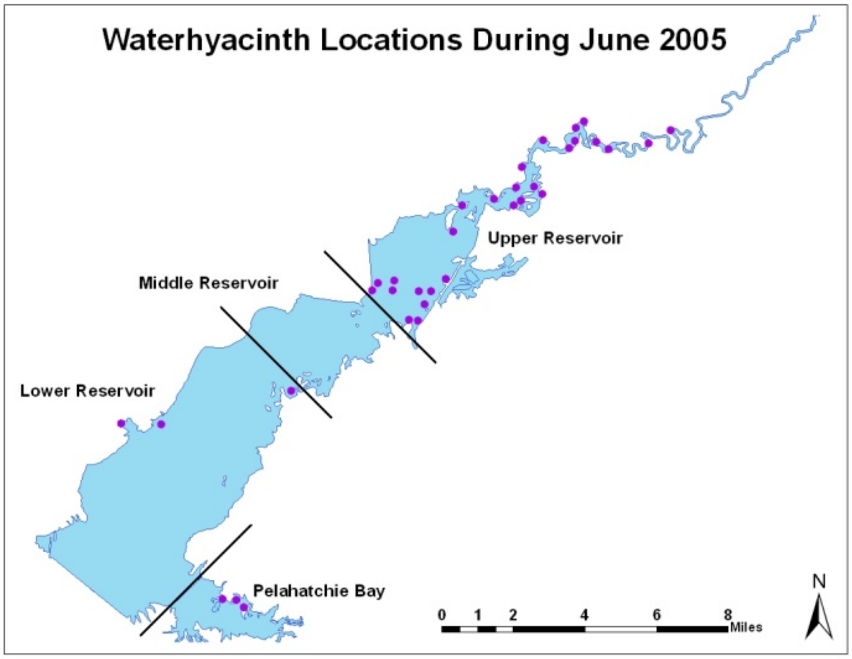

Figure 14. Waterhyacinth occurrence locations in the Ross Barnett Reservoir in 2005 (Wersal et al. 2006a).

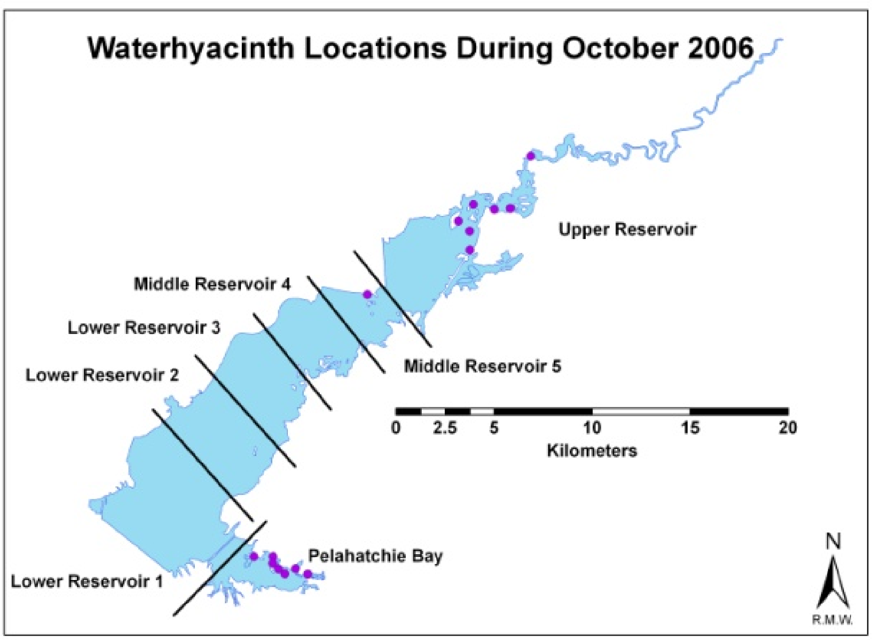

Figure 15. Waterhyacinth occurrence locations in the Ross Barnett Reservoir in 2006 (Wersal et al. 2007).

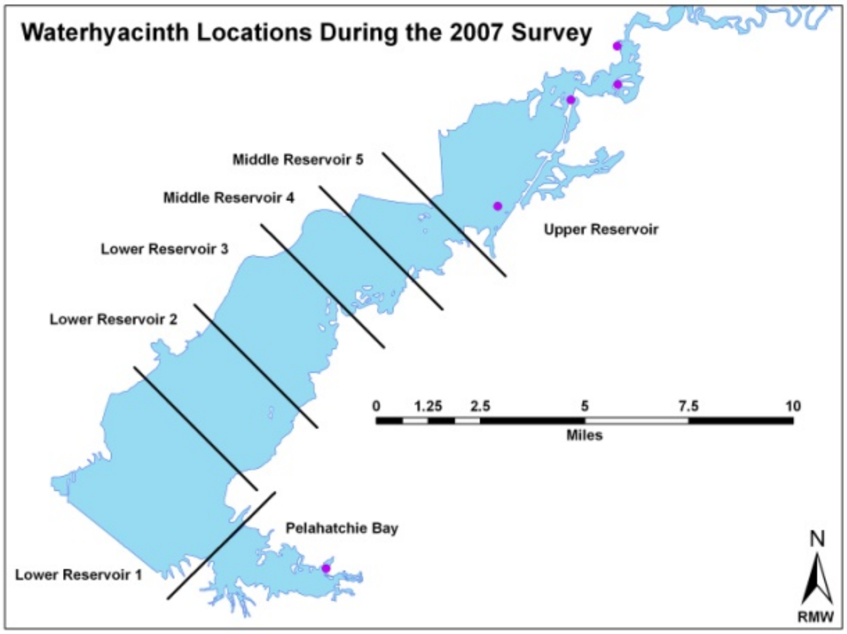

Figure 16. Waterhyacinth occurrence locations in the Ross Barnett Reservoir in 2007 (Wersal et al. 2008).

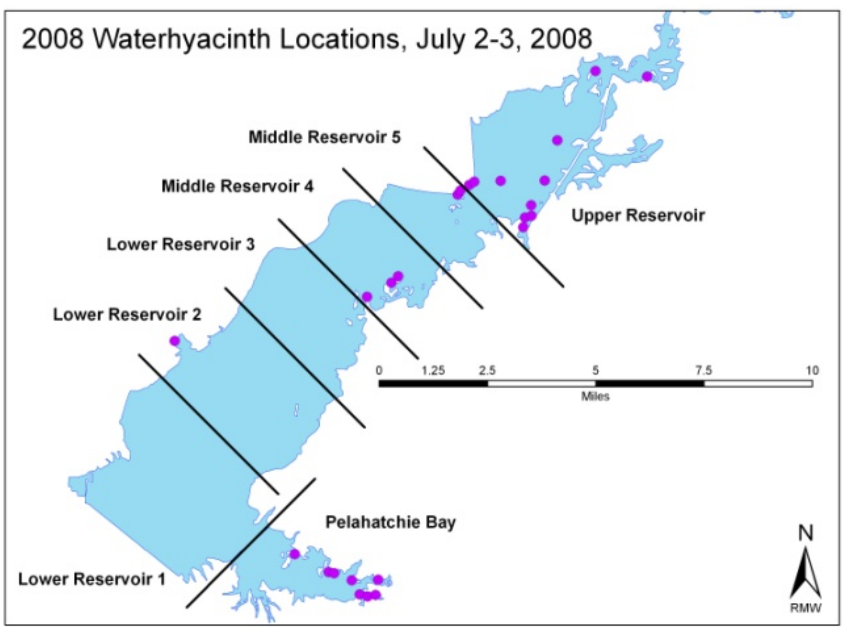

Figure 17. Waterhyacinth occurrence locations in the Ross Barnett Reservoir in 2008 (Wersal et al. 2009).

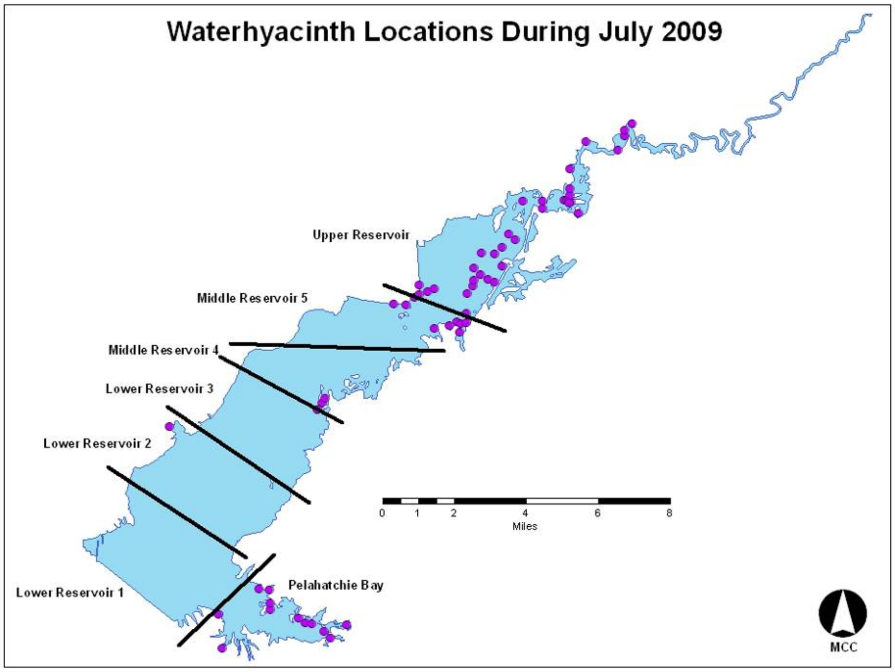

Figure 18. Waterhyacinth occurrence locations in the Ross Barnett Reservoir in 2009 (Cox et al. 2010).

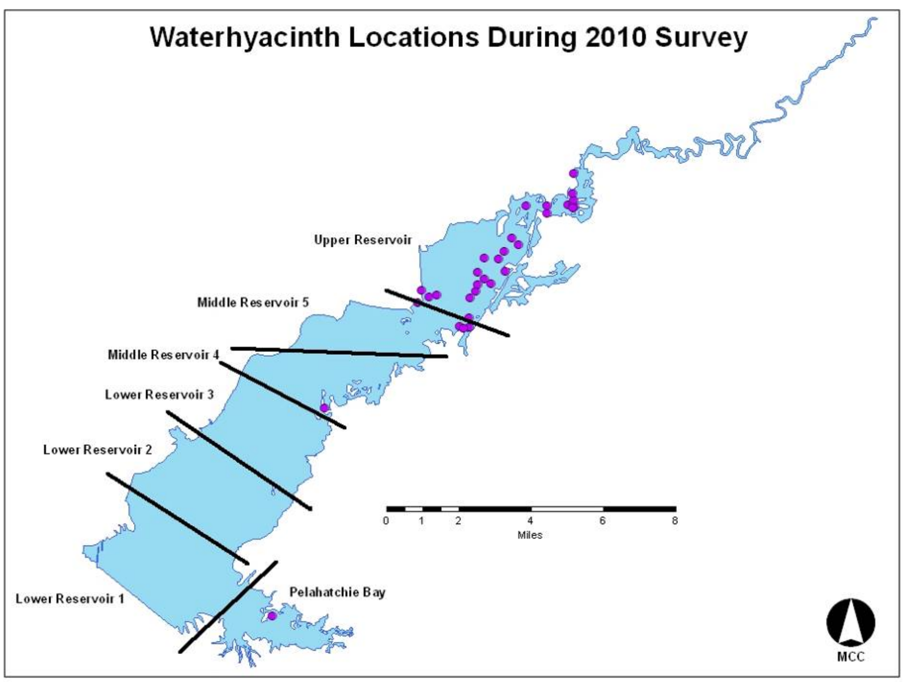

Figure 19. Waterhyacinth occurrence locations in the Ross Barnett Reservoir in 2010.

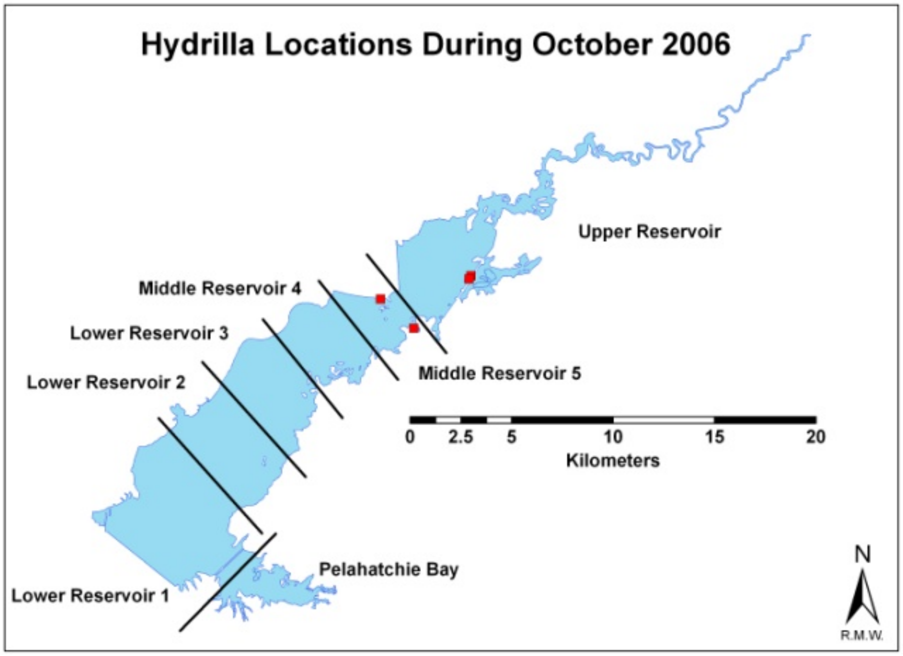

Figure 20. Hydrilla occurrence locations in the Ross Barnett Reservoir in 2006 (Wersal et al. 2007).

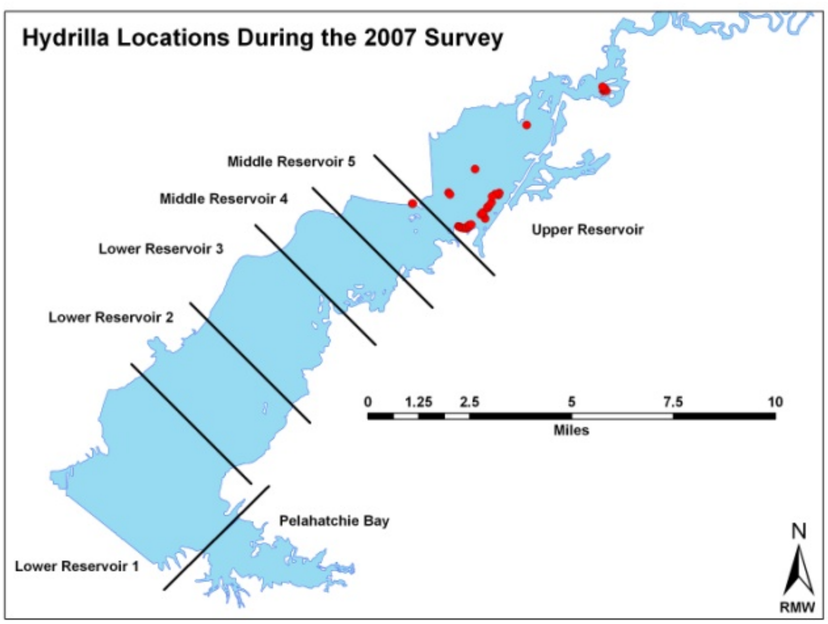

Figure 21. Hydrilla occurrence locations in the Ross Barnett Reservoir in 2007 (Wersal et al. 2008).

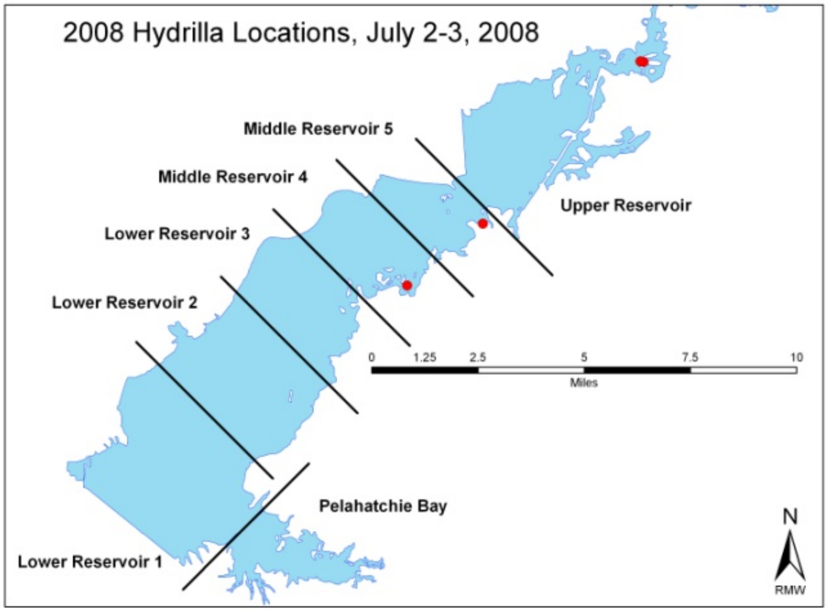

Figure 22. Hydrilla occurrence locations in the Ross Barnett Reservoir in 2008 (Wersal et al. 2009).

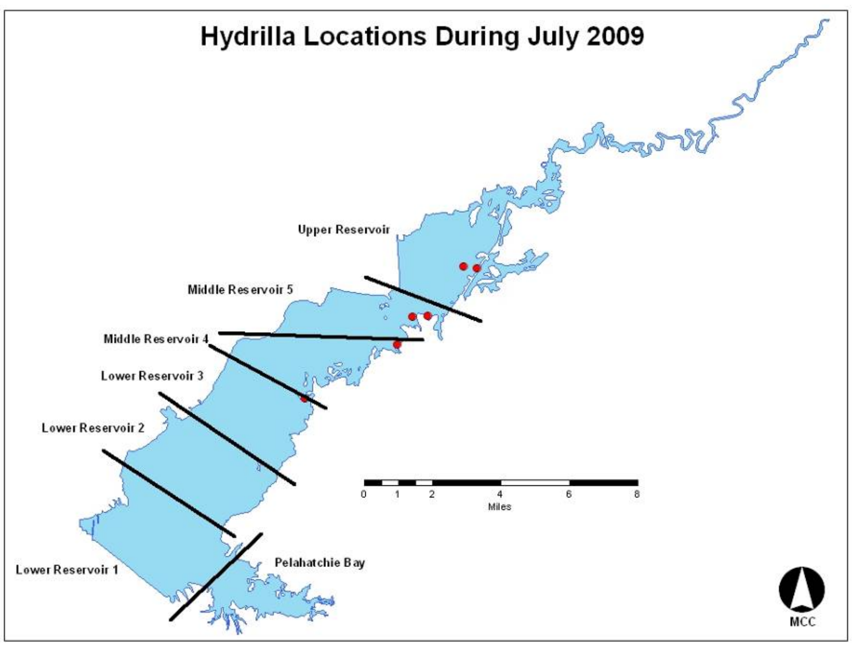

Figure 23. Hydrilla occurrence locations in the Ross Barnett Reservoir in 2009 (Cox et al. 2010).

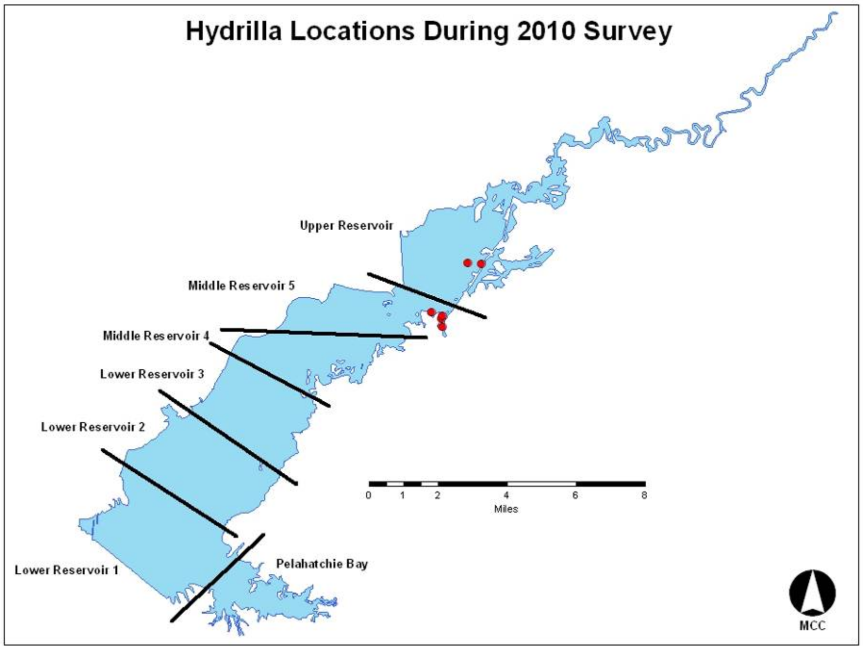

Figure 24. Hydrilla occurrence locations in the Ross Barnett Reservoir in 2010.

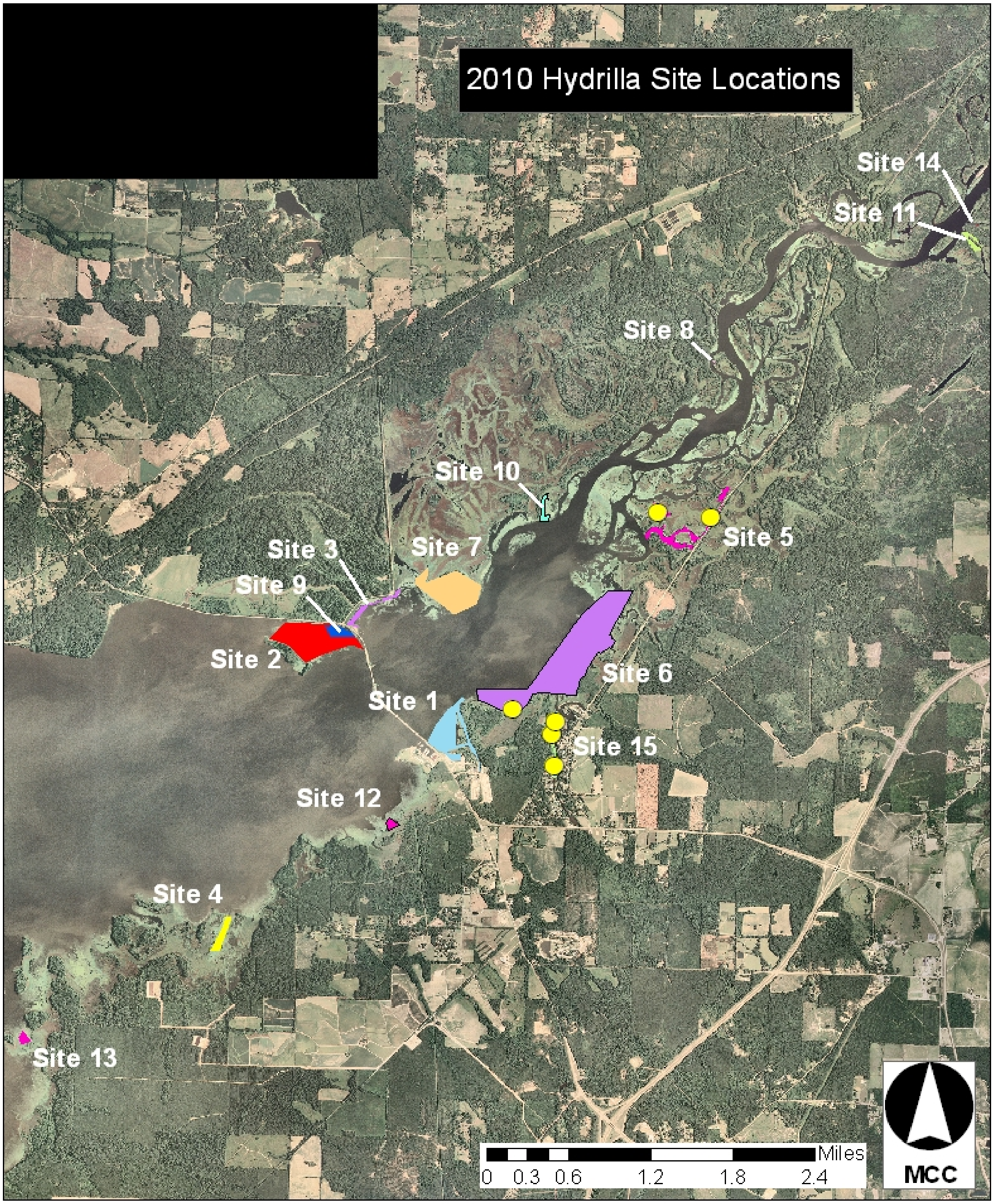

Figure 25. Hydrilla locations within designated sites in the Ross Barnett Reservoir in 2010.

Figure 26. Hydrilla growing in Site 15, September 2010.

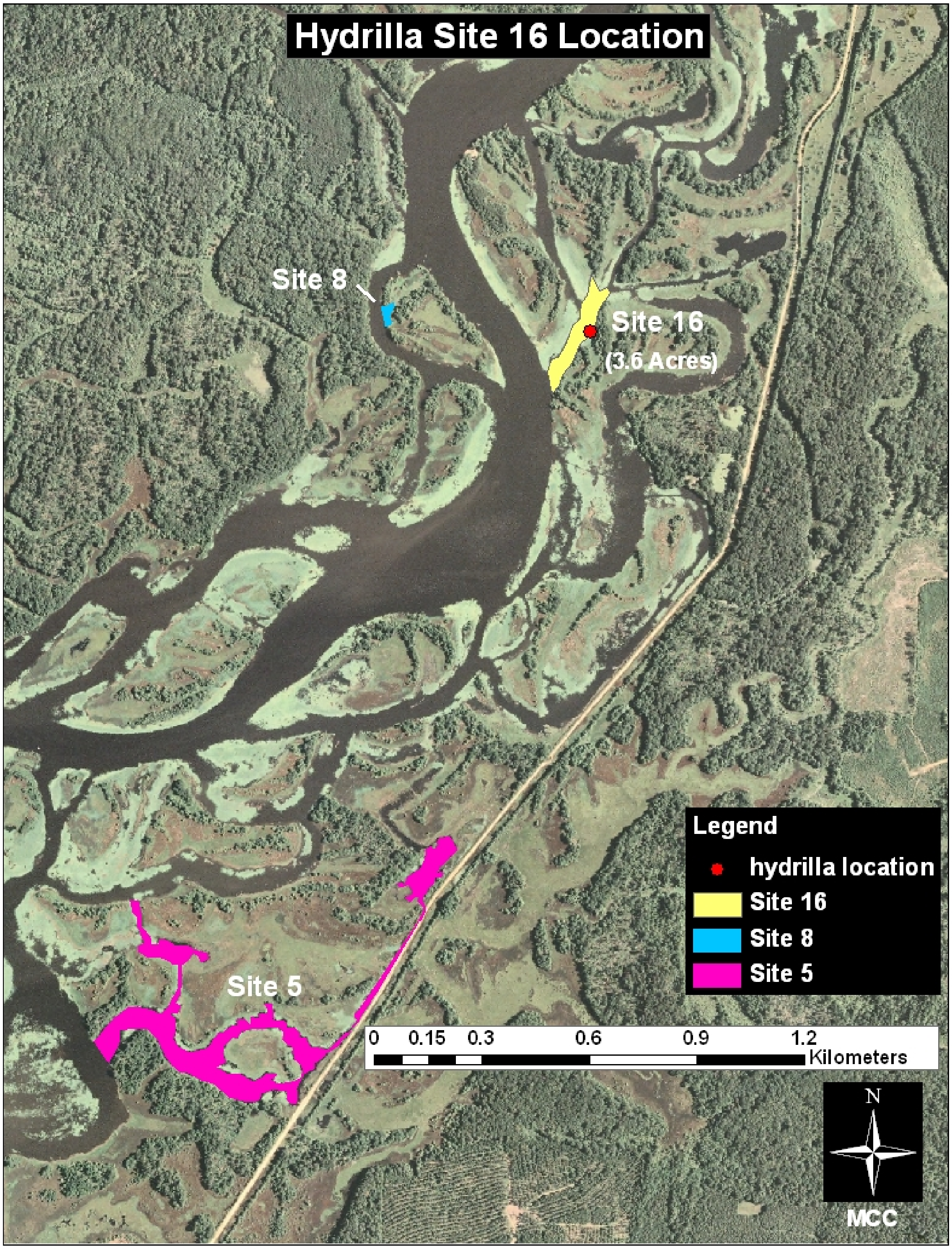

Figure 27. The location of a newly discovered hydrilla population on the Upper Lake, proposed to be named Site 16.