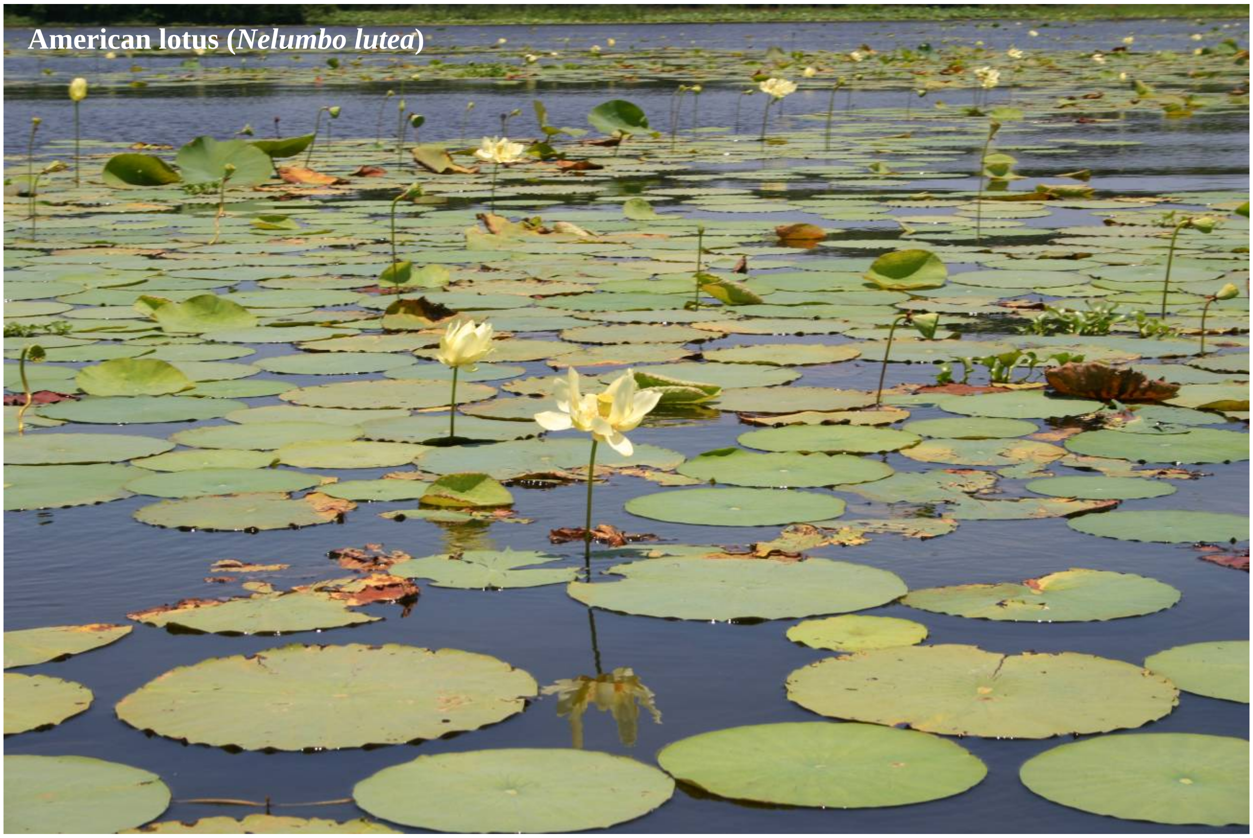
Aquatic Plant Community Assessment within the Littoral Zone of the Ross Barnett Reservoir, MS in 2009: A Five Year Evaluation



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 four 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) continue monitoring 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) continue to 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 300 meter grid point intercept survey was the method used in July 2009 to evaluate aquatic plant distribution in the Reservoir (Madsen 1999). Only points located in the littoral zone at locations previously selected from the past four years were surveyed or attempted to be surveyed (vegetation densities and water levels dictated access to some points). 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 2009 allows changes to be statistically quantified in the plant community over time (Figures 2 to 5). For better organization of gathering sampling data, the Reservoir was divided into seven sections: Upper Reservoir, Middle Reservoir 5, Middle Reservoir 4, Lower Reservoir 3, Lower Reservoir 2, Lower Reservoir 1, and Pelahatchie Bay.

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 695 points were surveyed in 2009. At each survey point, a weighted plant rake with an attached rope was deployed and reeled 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 indicated 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. 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. 2009).

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 on June 1, 2009 to assess the current density of hydrilla tubers in the Ross Barnett Reservoir. Tubers are normally produced in the fall and winter months after hydrilla plants have senesced. Sampling the sediment for tubers in areas of known hydrilla occurrence allows for estimation of future hydrilla populations. During this survey we sampled sites 1, 5, 7, 8, 10, and 11 (Figure 6). These sites were chosen for tuber sampling due to previous hydrilla occurrence and herbicide treatments. 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.

RESULTS AND DISCUSSION

Littoral Survey

The 2009 point survey of the Ross Barnett Reservoir yielded 23 aquatic or riparian plant species (Table 1). After 5 years of surveying, a total of 26 species have been observed. Additionally, the non-native invasive species water lettuce (*Pistia stratiotes* L.) and Cuban bulrush (*Oxycaryum cubense* (Poepp. & Kunth) Lye) were observed in Pelahatchie Bay after the survey was completed. Thus, they were not included in the survey analyses. Water lettuce and Cuban bulrush will be added to the species pick list for following surveys and vigorously monitored and treated due to their aggressive growth habit. Herbicides and rates applied to these two species in 2009 are shown in Table 3. The native plant American lotus (*Nelumbo lutea* (Willd.)) was the dominant species, which increased in occurrence from 17% in 2005 to 27% in 2009. White waterlily (*Nymphae odorata* Aiton) has remained constant over the last five years, while coontail (*Ceratophyllum demersum* L.) significantly decreased from 7.6% in 2008 to 3.6% in 2009. 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 cause problems in a water body similar to non-native plants. Species richness was significantly greater in 2009 at 1.08 (mean number of species per point) than in any other surveyed year at a 0.05 level of significance (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.

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 (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 12, waterhyacinth in figures 13 to 17, and hydrilla in figures 18 to 21. 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.

Invasive Species Management

Waterhyacinth and Alligatorweed Assessment: The frequency of occurrence for alligatorweed had decreased significantly ($p \leq 0.01$) from 2005 to 2008, but significantly increased to 14.9% in 2009. The frequency of occurrence for waterhyacinth increased significantly in the last two years, climbing from 1.2% in 2007 to 4% in 2008 and 8.6% in 2009. Estimated acreages of non-native plants are displayed in Table 2. The estimated acreage for alligatorweed has more than doubled from 2008 to 2009, according to the data collected in 2009. This tremendous increase in occurrence may be attributed to the increase in water level of the Reservoir over the last 2 years and the addition of approximately 25 locations of alligatorweed observed up the Pearl River that were not surveyed in 2008. The majority of the alligatorweed populations found along the river, however, were mostly free-floating plants trapped in brush along the river's edge and not rooted in the sediment. These small, river populations may be responsible for reinfestations of the Reservoir or aiding in the expansion of existing alligatorweed populations. 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. Fluctuating water levels and "hidden" plants among dense stands of other plant species also make treatment difficult at times. Herbicides and rates applied to alligatorweed and waterhyacinth in 2009 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 1, 5, 6, 12, and 13 during the littoral survey (Figure 22). Sites 12 and 13 were created as new hydrilla sites in 2009 after a few small populations were observed at these locations during the survey. Site 12 is located in Middle Reservoir 5 just on the southeastern side of the highway 43 bridge along the shoreline. Site 13 is located in a small pocket in Lower Lake 3. Site 1 has consistently produced hydrilla, despite previous fluridone treatments in 2006 and 2007 (Figure 23). This may be attributed to the high boat traffic in this area of the Reservoir or due to a small tuber bank still providing new plants each year. No hydrilla was found in Site 4 during the survey, indicating that previous fluridone treatments were successful. Site 11 was treated with fluridone in 2007 and 2008. Still, a few plants were found during the tuber survey in June 2009. In addition, no hydrilla was found in Site 11 during the point survey in July 2009 (Table 3). Fluridone application locations to hydrilla in 2009 are shown in Figure 24. The water level in Site 11 was slightly higher in July 2009 and may have hindered observation of these few plants if still present. Water movement in this site is also high and may require repeated contact herbicide treatments with endothall to control these populations more efficiently. Sites 1, 5, and 7 were also treated with fluridone in 2009. Site 5 has the highest density of hydrilla than all other hydrilla sites on the Reservoir. Very low water movement and boat disturbance in this location should allow fluridone treatments to be effective. Future research should be directed towards understanding the water exchange characteristics in the hydrilla populations that have proven difficult to control, namely sites 1, 5, and 11. 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 small population in the newly created Site 12 is a firm indication of how important vigorous 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.

Hydrilla Tuber Assessment: The tuber surveys from 2006 to 2009 have yielded very few hydrilla tubers. Tubers found in Site 4 in 2006 explained why new plants were discovered in 2008. However, no tubers or plants were found in Site 4 or any other hydrilla site in 2009. The absence of tubers in recently performed surveys indicates that the hydrilla may be overwintering as root crowns and growing the next year with very little or no tuber production. All plants found in the 2009 point survey had well developed root crowns and healthy shoots. Low tuber production may inhibit greater plant densities and the use for higher herbicide treatment, given that fragmentation of plants by boat traffic is limited. The decrease of tuber production and healthy biomass may be attributed to the active use of fluridone in these areas (MacDonald et al. 1993).

RECOMMENDATIONS

- Apply fluridone to Sites 1, 5, 6, 11, 12, and 13 in May 2010.
- Continue copper and diquat applications along with fluridone at Sites 1, 5, and 11.
- Continue treatments of alligatorweed and waterhyacinth in the Reservoir, as well as along the Pearl River to prevent further introduction and spread.
- Continue vigorous monitoring of hydrilla populations and ensure precise documentation of their locations.
- Begin herbicide applications on waterlettuce and Cuban bulrush to prevent further spread throughout Pelahatchie Bay and the Reservoir.
- Continue to monitor waterlettuce and Cuban bulrush distribution and assess herbicide treatment efficacy.

RECOMMENDED FUTURE WORK

- Continue monitoring plant distribution to assess spread in nuisance species populations.
- Assess techniques to control nuisance species and promote the growth of more desirable native plants.
- Determine water exchange characteristics at hydrilla sites.
- Accurately estimate coverage of nuisance aquatic plant species (particularly waterhyacinth and alligatorweed) using remote sensing (e.g., aerial or satellite imaging) technology.

ACKNOWLEDGEMENTS

We would like to thank the Pearl River Valley Water Supply District for funding this project. We also thank Jimmy Peeples and Amanda Fernandez for assisting in surveys and Joshua Cheshier for assistance with data organization. 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 2005-2009. 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)
Alternanthera philoxeroides	alligatorweed	E I	21.1	3.9	4.0	7.3	14.9a
Azolla caroliniana	mosquito fern	N	0.0	0.2	0.4	0.0	0.5
Cabomba caroliniana	fanwort	N	2.2	0.0	0.5	1.3a	0.6
Ceratophyllum demersum	coontail	N	4.4	4.9	3.5	7.6a	3.6a
Colocasia esculenta	wild taro	E I	0	0.9	0.7	2.4a	2.4
Eichhornia crassipes	waterhyacinth	E I	4.9	2.9	1.2	4.0a	8.6a
Hydrilla verticillata	hydrilla	E I	0.0	0.6a	1.2a	0.6a	0.8
Hydrocotyle ranunculoides	pennywort	N	6.4	0.5	1.4	2.8a	1.3a
Juncus effusus	common rush	N	0.0	0.0	0.0	0.2	1.7
Lemna minor	common duckweed	N	3.1	2.5	1.9	1.4a	1.3
Limnobium spongia	American frogbit	N	1.5	0.8	0.7	1.3	0.3
Ludwigia peploides	waterprimrose	N	4.9	7.4	4.3	10.2a	14.8a
Myriophyllum aquaticum	parrotfeather	E I	0.7	0.0	0.2	1.0a	0.4
Najas minor	brittle naiad	E I	0.0	0.0	1.9a	1.0a	0.3
Nelumbo lutea	American lotus	N	17.1	17.7	21.2	24.8a	26.9
Nitella sp.	stonewort	N	0.1	0.0	0.0	0.0	0.0
Nymphaea odorata	white waterlily	N	4.4	3.4	4.9	5.4	5.9
Potamogeton foliosus	leafy pondweed	N	0.0	0.0	0.0	0.6	0.0
Potamogeton nodosus	American pondweed	N	2.7	2.7	2.4	3.0	2.9
Sagittaria latifolia	broadleaf arrowhead	N	1.0	1.2	0.0a	0.5	1.3
Sagittaria platyphylla	delta arrowhead	N	0	1.8	0.8	0.3a	2.3a
Scirpus validus	softstem bulrush	N	1.2	0.2	0.0	0.0	0.0
Spirodella polyrhiza	giant duckweed	N	0.0	0.0	0.0	0.16	0.7
Typha sp.	cattail	N	1.3	2.4a	0.7	1.1	7.1a
Utricularia vulgaris	bladderwort	N	0.0	0.4	0.0	0.5	0.1
Zizaniopsis miliacea	giant cutgrass	N I	1.5	3.5	1.9a	4.1	10.4a

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 2008. 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]
Alligatorweed	3175	444	377	1021	339	2309	307
Brittle naiad	0	0	178	111		44	
Hydrilla	120	67	111	89	275	133	155
Parrotfeather	111	111	22	133		67	
Waterhyacinth	733	333	111	555	167	1332	561
Waterlettuce*							5*
Cuban bulrush*							51*

[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 2009.

Species	Acres Treated	Herbicide/Rate
Alligatorweed	307	glyphosate/1.5%**
Waterhyacinth	561	2,4-D/1.0%**
Cuban bulrush	51	2,4-D/1.5%, glyphosate/0.5%**
Waterlettuce	5	diquat/2.0%**
Hydrilla	155 surface acres (898 acre/ft)	fluridone (Sonar Q)/0.98 lb per acre/ft
		fluridone (Sonar PR)/1.0 lb per acre/ft

**** All foliar applications performed with 0.5% rate of surfactant.**

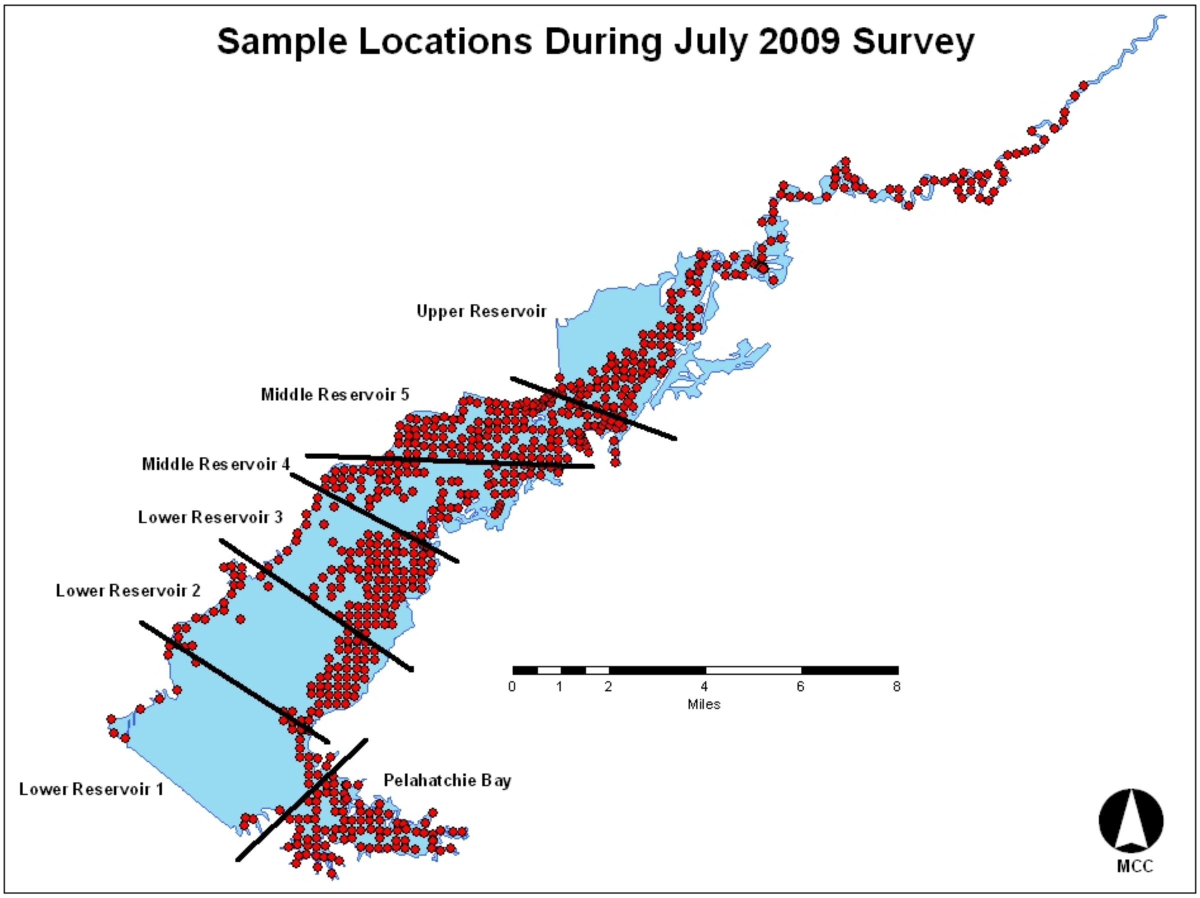

Figure 1. Sampling locations for the 2009 littoral zone survey of the Ross Barnett Reservoir.

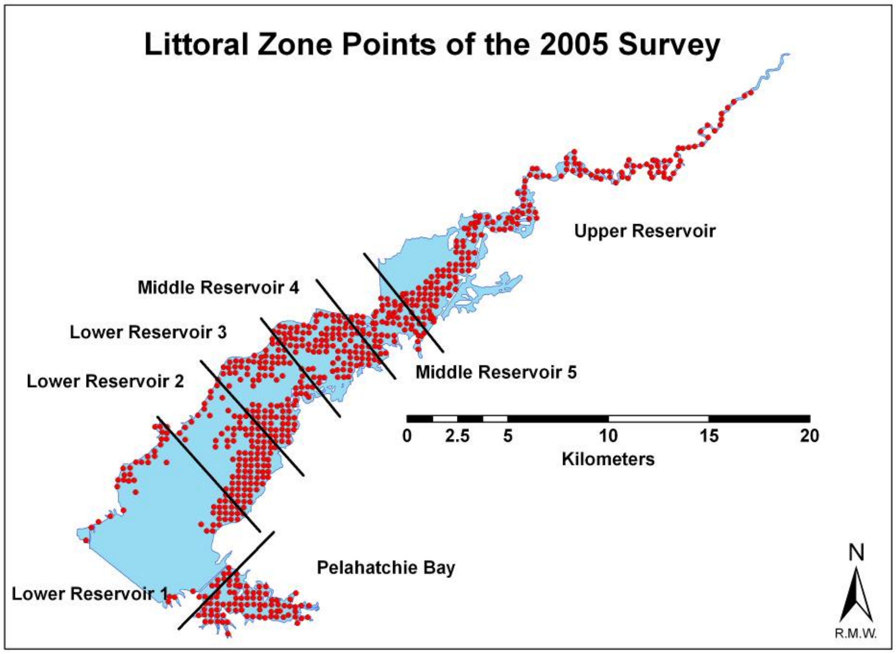

Figure 2. Sampling locations for the 2005 littoral zone survey of the Ross Barnett Reservoir (Wersal et al. 2006a).

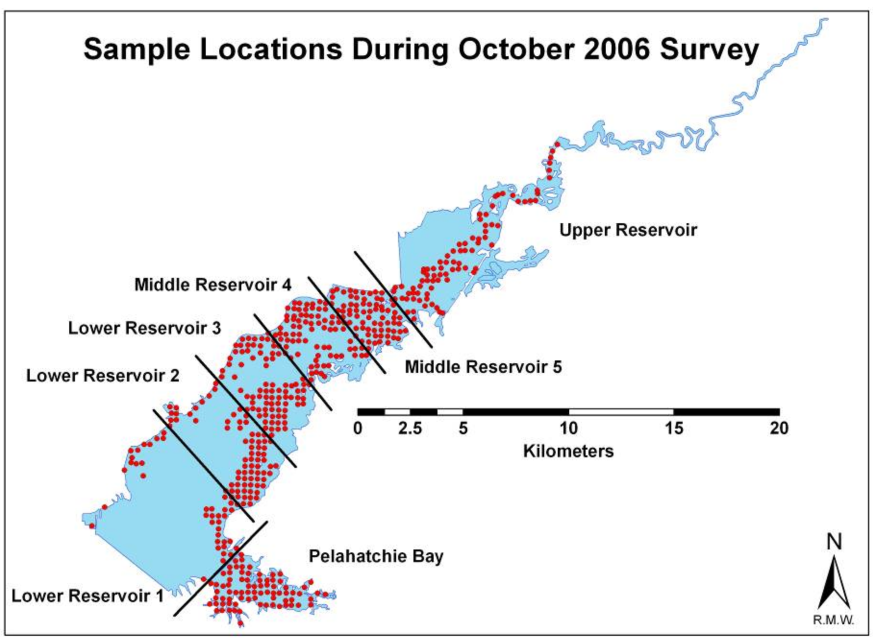

Figure 3. Sampling locations for the 2006 littoral zone survey of the Ross Barnett Reservoir (Wersal et al. 2007).

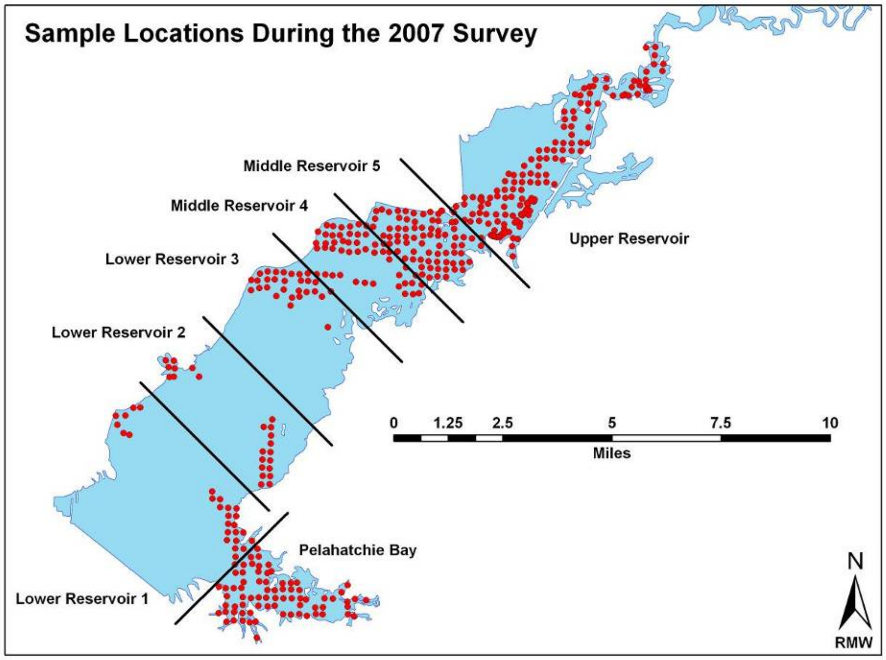

Figure 4. Sampling locations for the 2007 littoral zone survey of the Ross Barnett Reservoir. (Wersal et al. 2008).

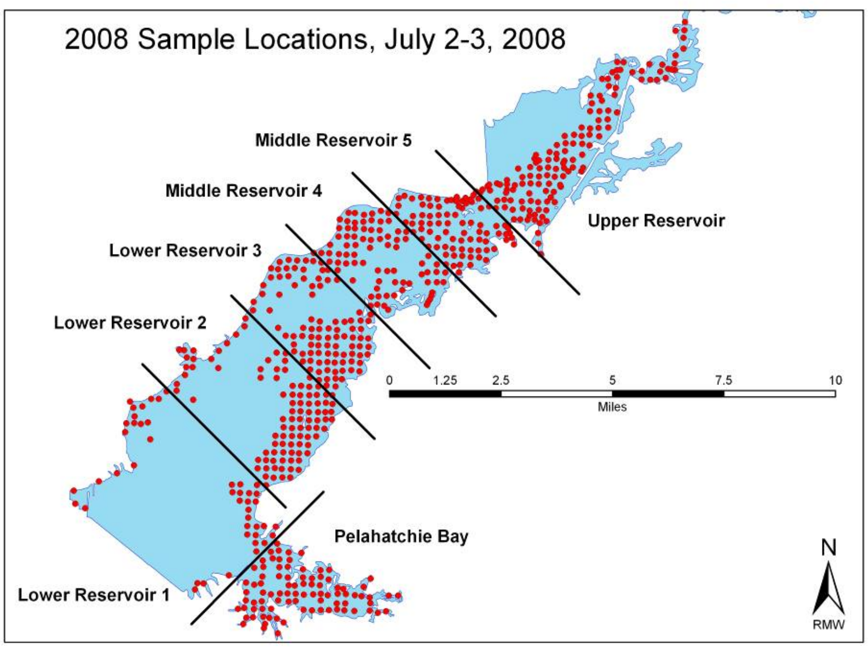

Figure 5. Sampling locations for the 2008 littoral zone survey of the Ross Barnett Reservoir (Wersal et al. 2009).

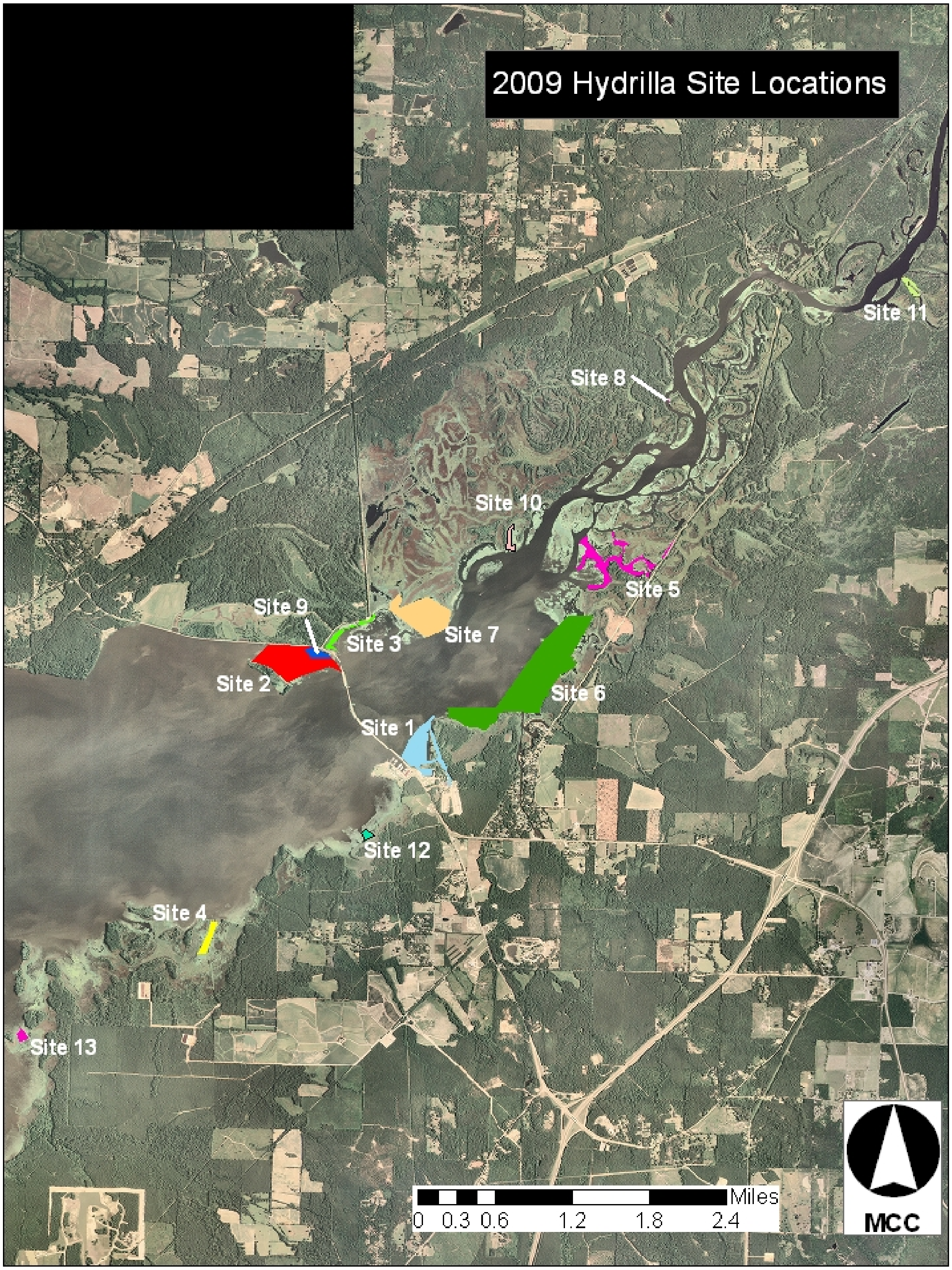

Figure 6. Hydrilla site locations on the Ross Barnett Reservoir as of 2009.

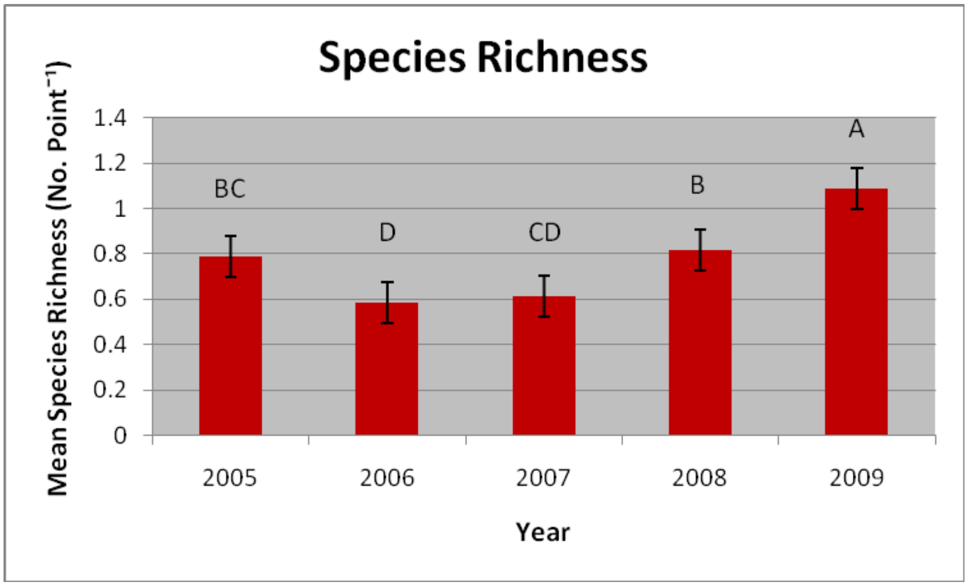

Figure 7. Mean (± 1 SE) species richness during surveys conducted between 2005 and 2009.

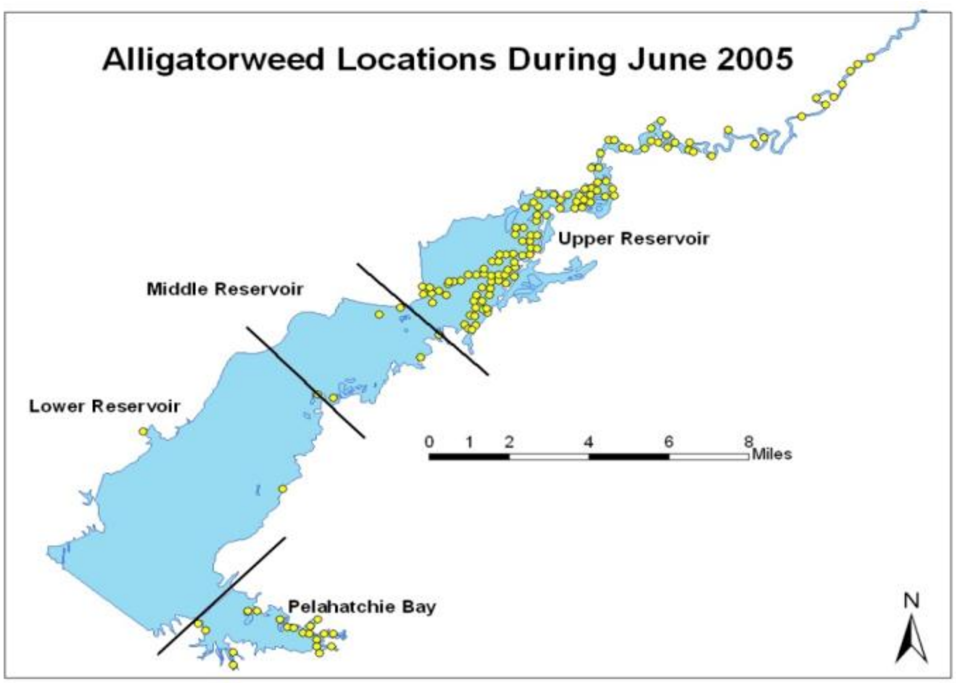

Figure 8. Alligatorweed occurrence locations in the Ross Barnett Reservoir in 2005 (Wersal et al. 2006a).

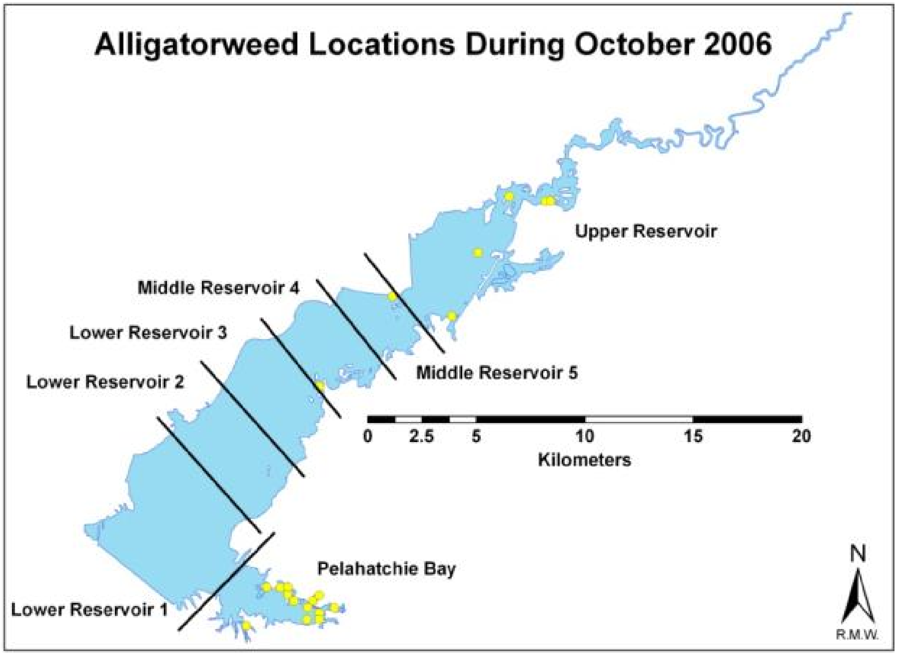

Figure 9. Alligatorweed occurrence locations in the Ross Barnett Reservoir in 2006 (Wersal et al. 2007).

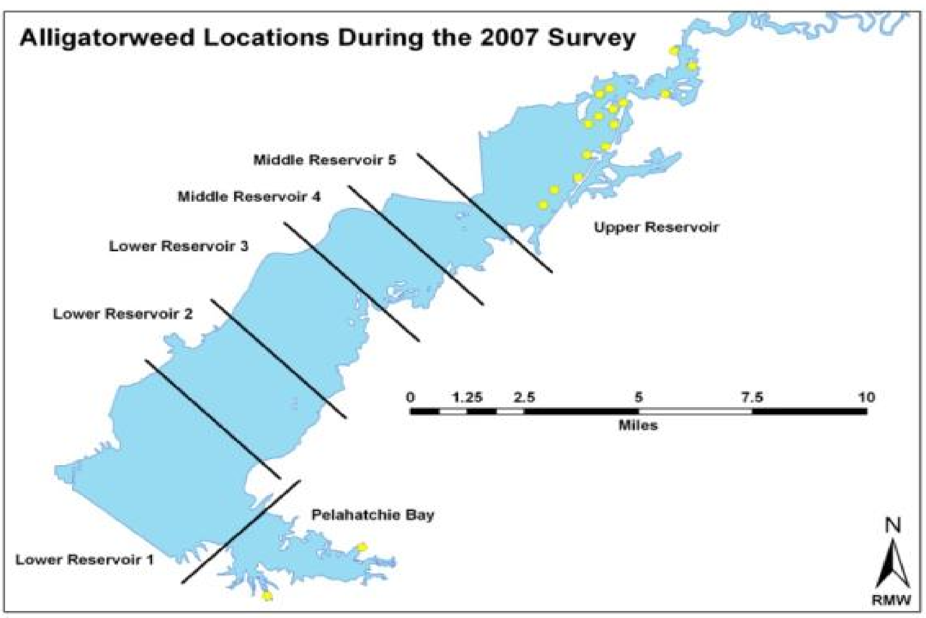

Figure 10. Alligatorweed occurrence locations in the Ross Barnett Reservoir in 2007 (Wersal et al. 2008).

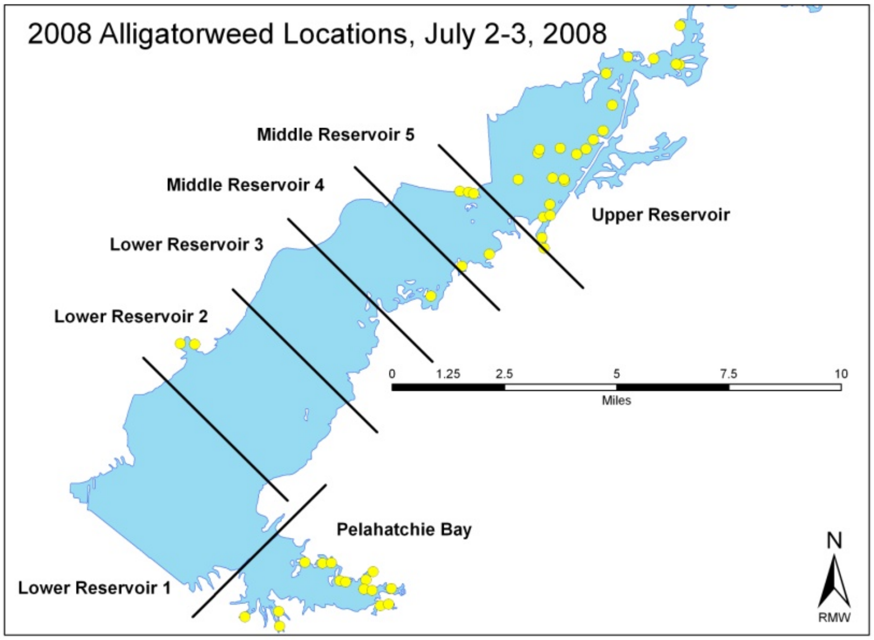

Figure 11. Alligatorweed occurrence locations in the Ross Barnett Reservoir in 2008 (Wersal et al. 2009).

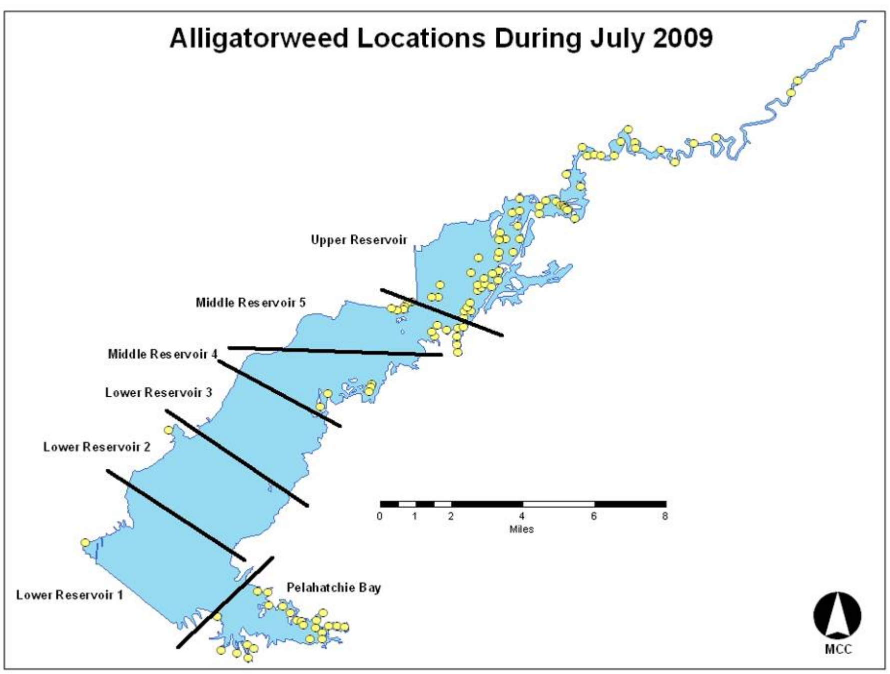

Figure 12. Alligatorweed occurrence locations in the Ross Barnett Reservoir in 2009.

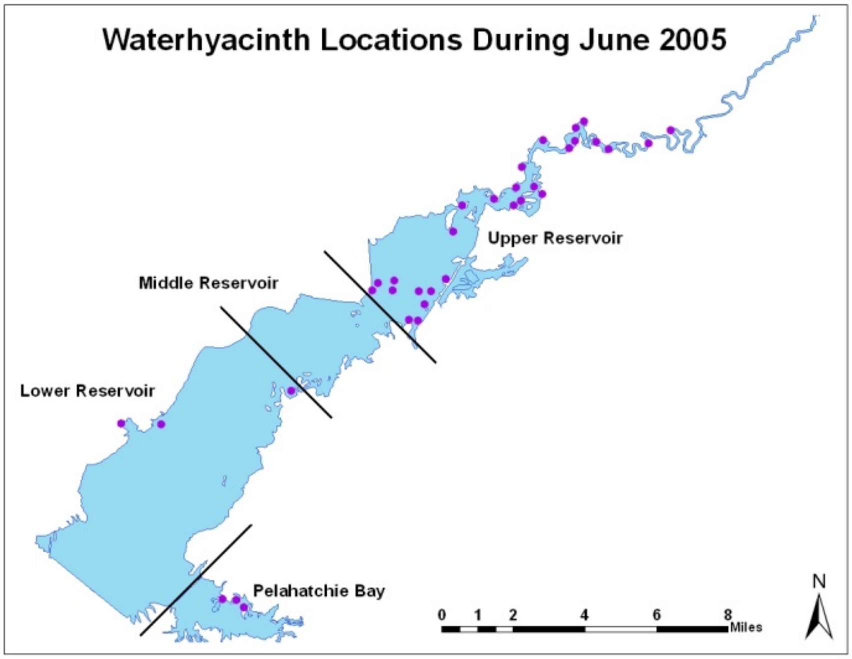

Figure 13. Waterhyacinth occurrence locations in the Ross Barnett Reservoir in 2005 (Wersal et al. 2006a).

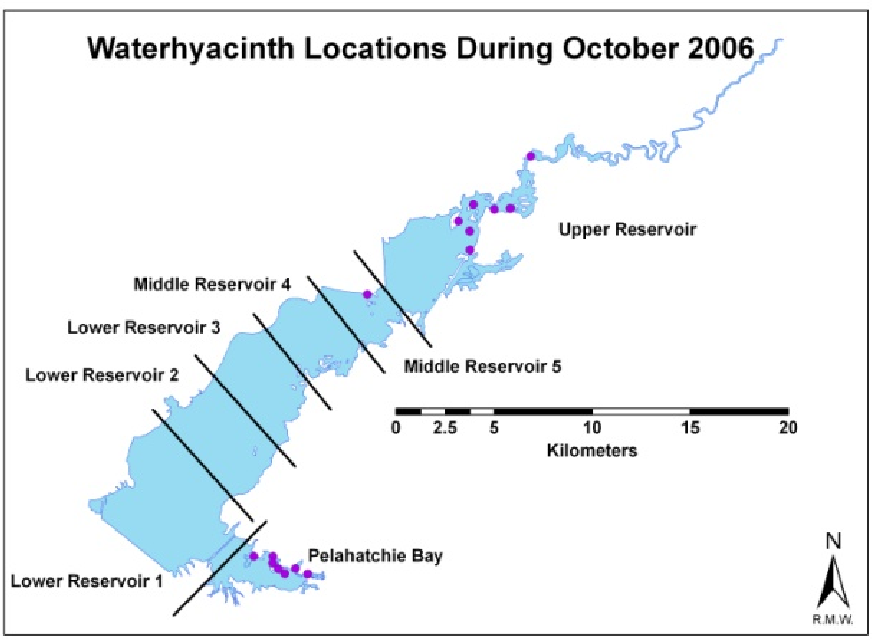

Figure 14. Waterhyacinth occurrence locations in the Ross Barnett Reservoir in 2006 (Wersal et al. 2007).

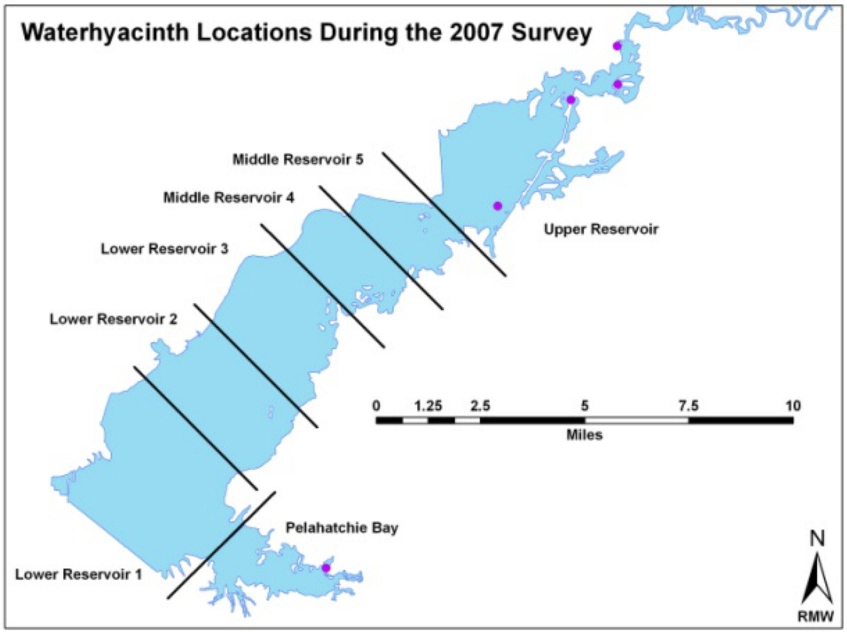

Figure 15. Waterhyacinth occurrence locations in the Ross Barnett Reservoir in 2007 (Wersal et al. 2008).

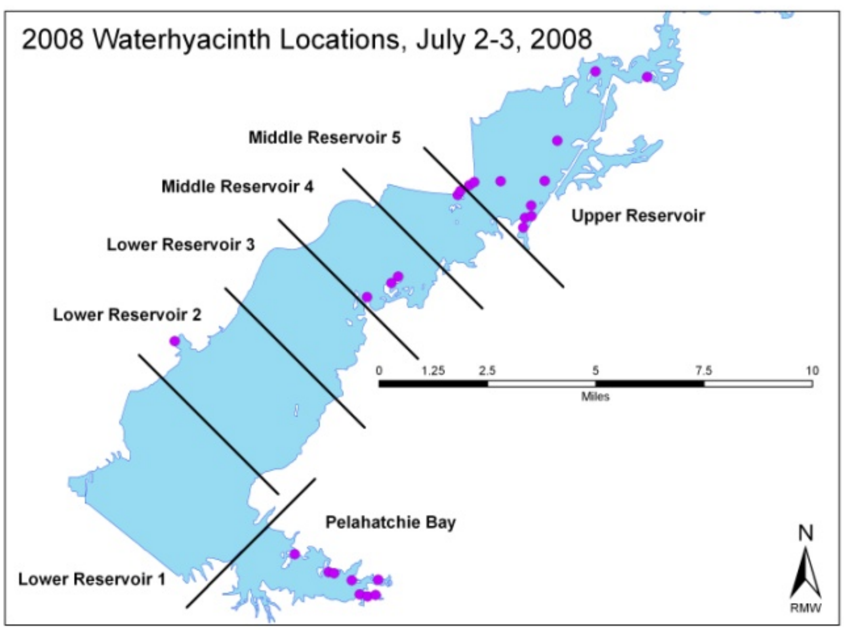

Figure 16. Waterhyacinth occurrence locations in the Ross Barnett Reservoir in 2008 (Wersal et al. 2009).

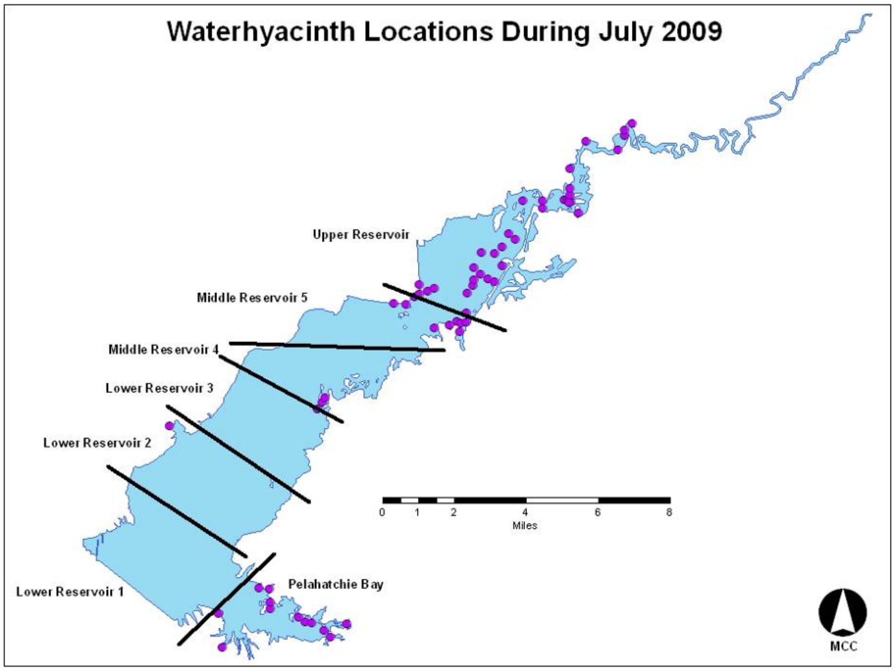

Figure 17. Waterhyacinth occurrence locations in the Ross Barnett Reservoir in 2009.

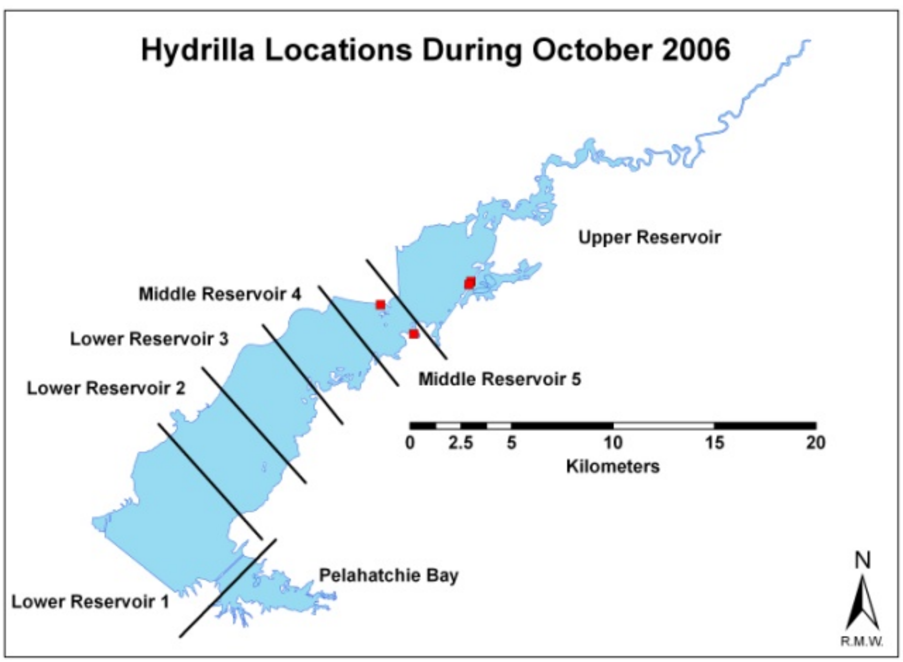

Figure 18. Hydrilla occurrence locations in the Ross Barnett Reservoir in 2006 (Wersal et al. 2007).

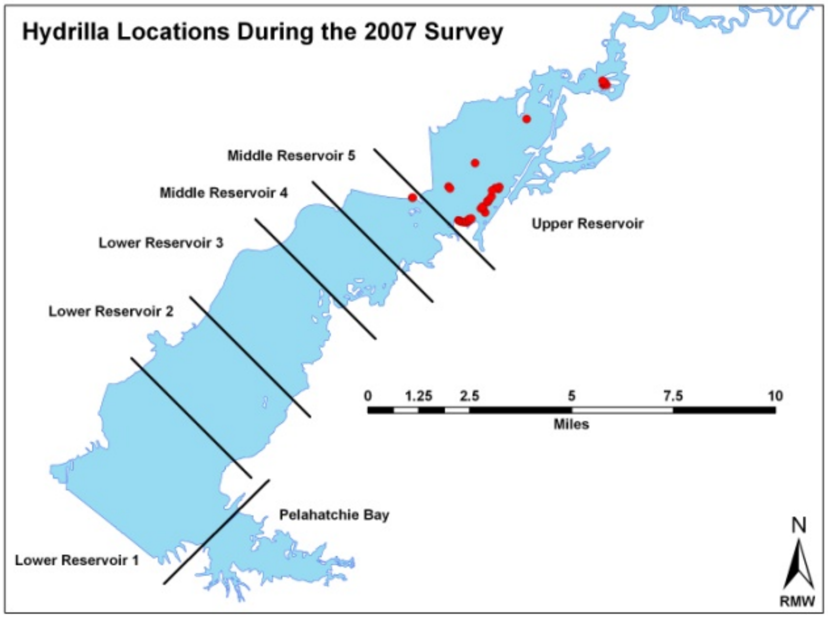

Figure 19. Hydrilla occurrence locations in the Ross Barnett Reservoir in 2007 (Wersal et al. 2008).

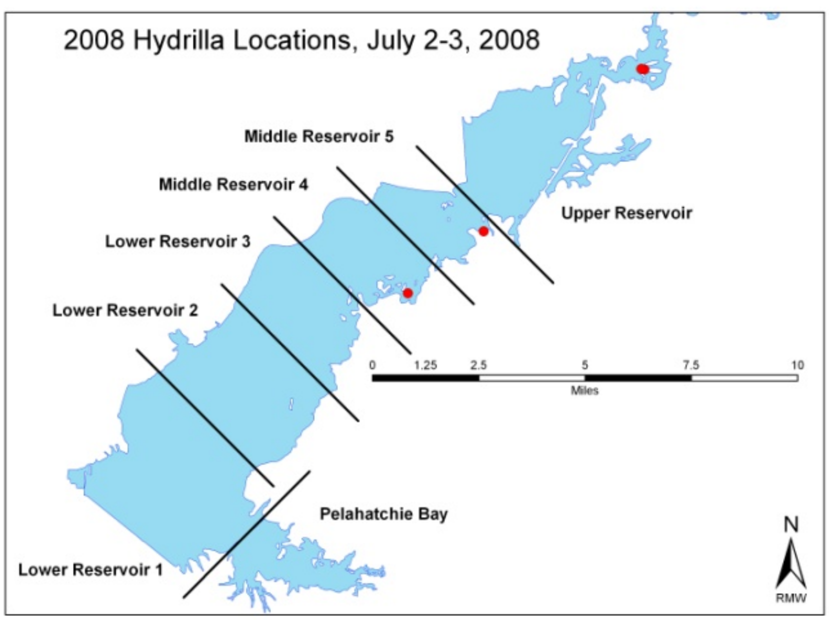

Figure 20. Hydrilla occurrence locations in the Ross Barnett Reservoir in 2008 (Wersal et al. 2009).

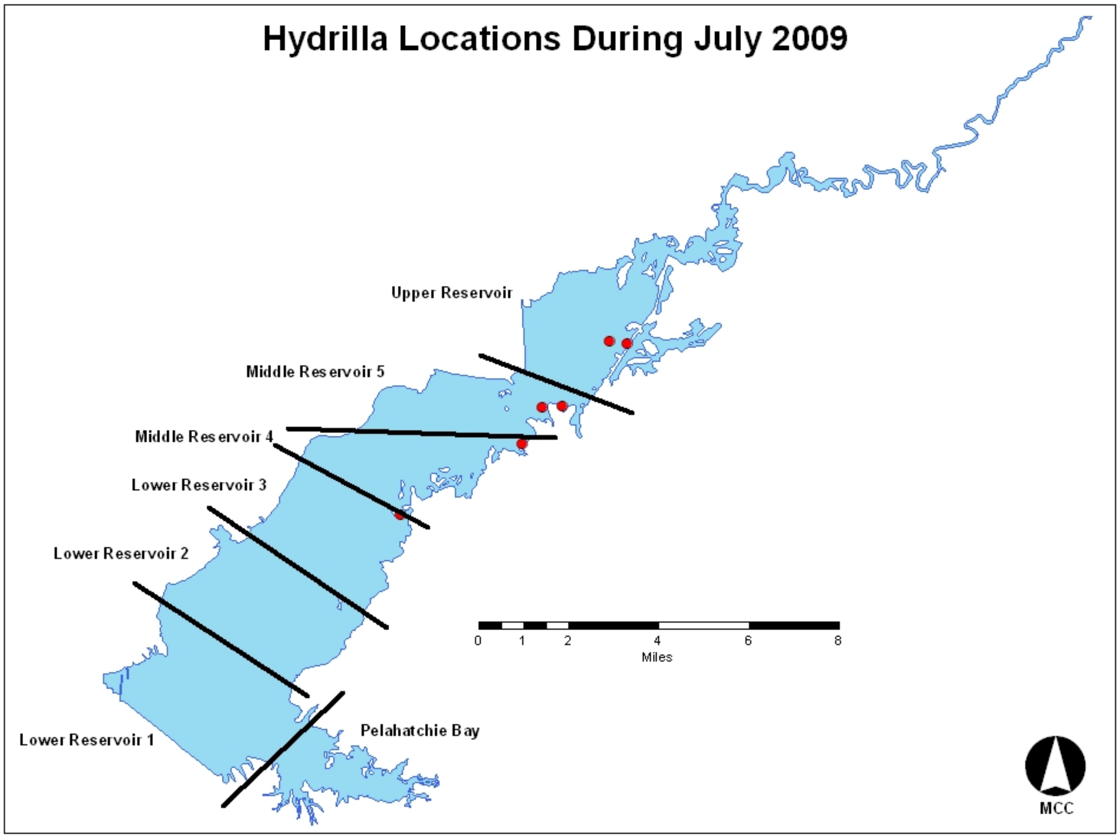

Figure 21. Hydrilla occurrence locations in the Ross Barnett Reservoir in 2009.

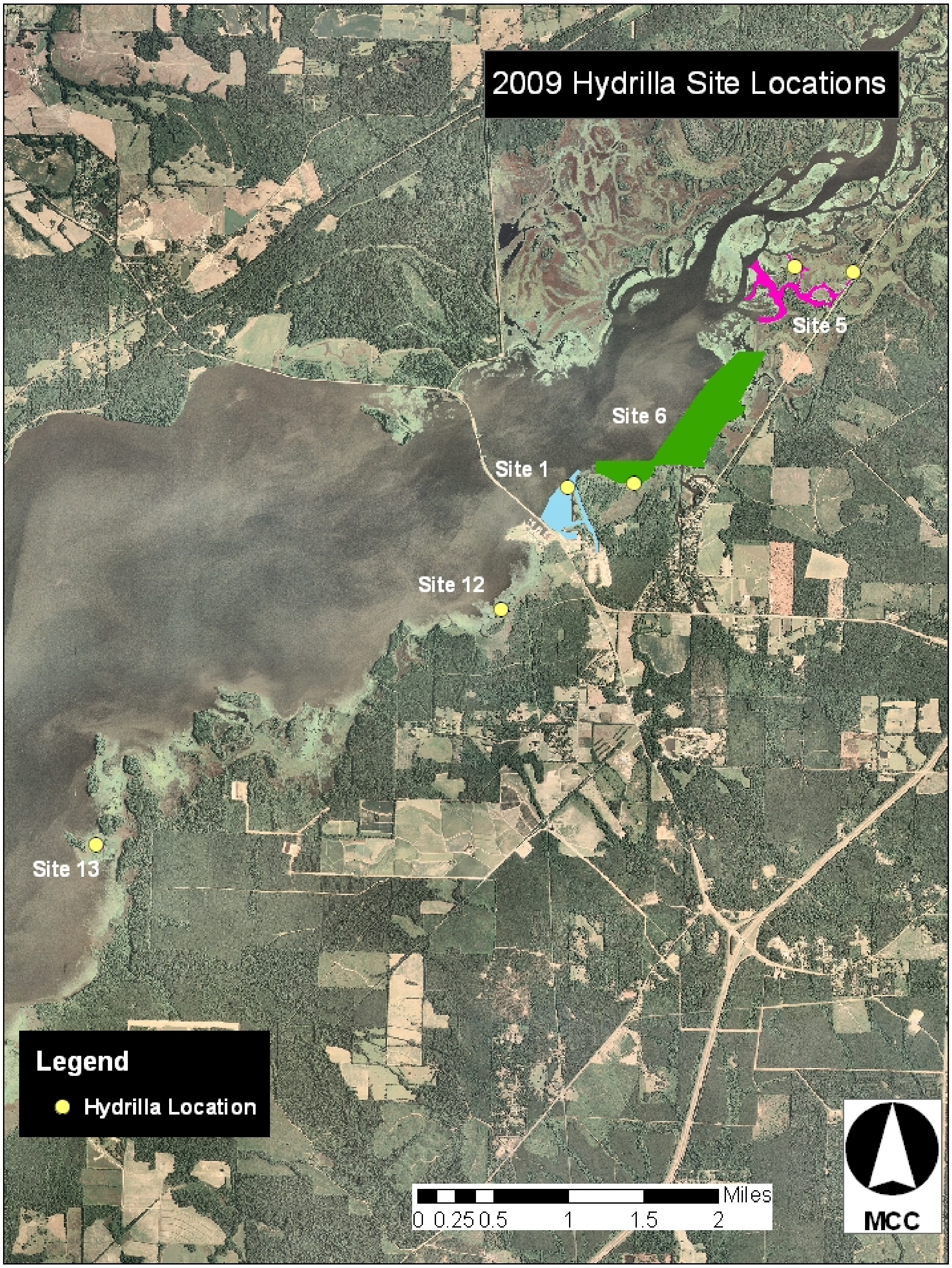

Figure 22. Hydrilla locations within designated sites in the Ross Barnett Reservoir in 2009.

Figure 23. Hydrilla growing in Site 1, July 2009.

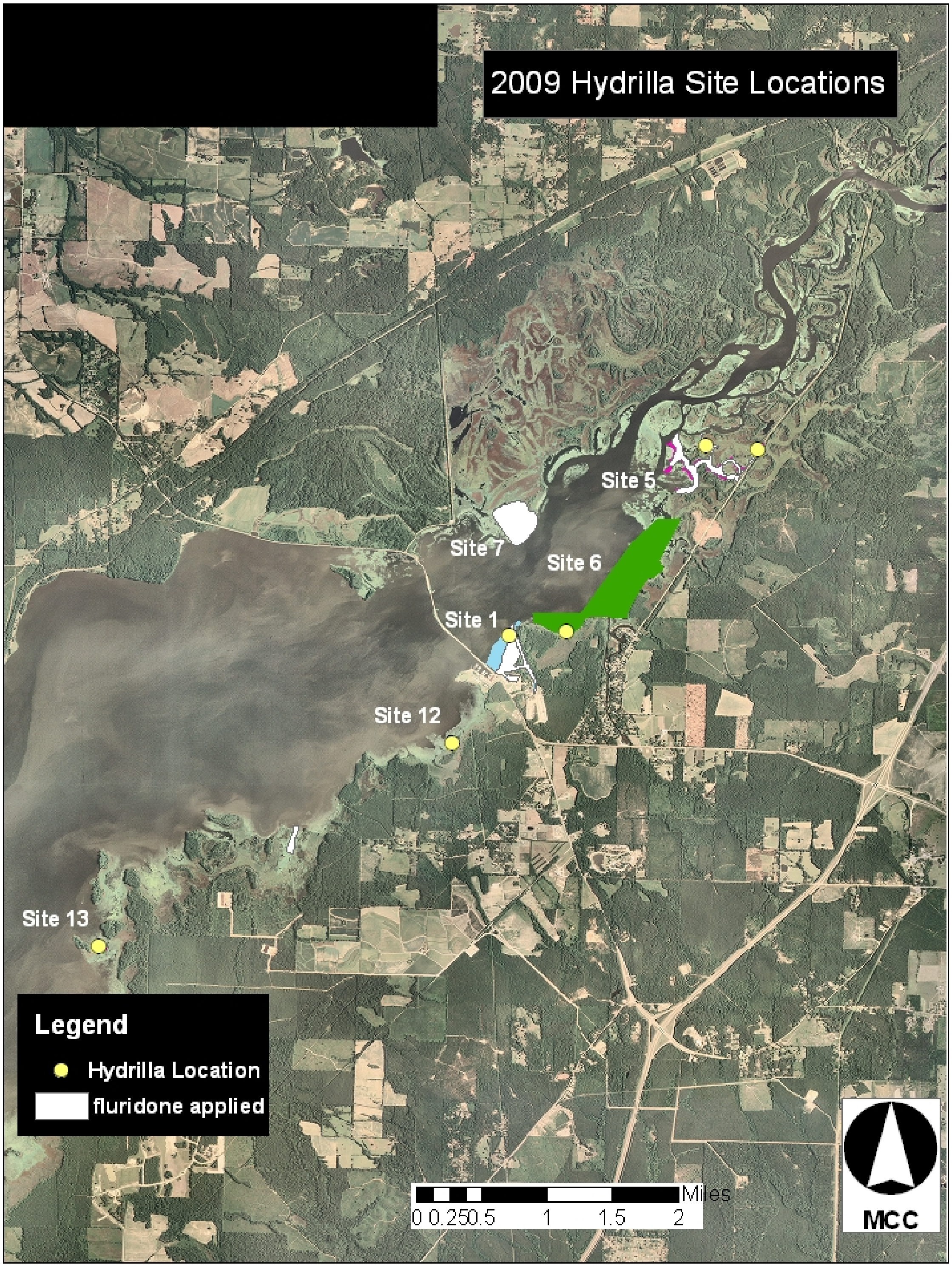

Figure 24. Locations of fluridone applications to hydrilla on the Ross Barnett Reservoir in July, 2009.