



2014

Baseline Studies of Aquatic Plants and Water Quality in Selected State Park Lakes

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Abstract

This project was undertaken as a baseline study of aquatic plant species and water quality in a set of six state parks lakes selected by the Pennsylvania Bureau of State Parks. Inventories were conducted at these lakes during the field season of 2014. Water quality parameters were measured in these lakes by staff from Pennsylvania Department of Environmental Protection's Clean Lakes Program between 2007 and 2015. Specimens of all species observed were collected and deposited in the herbarium at the Morris Arboretum of the University of Pennsylvania.

For various reasons cited in this report, the value of conducting detailed aquatic plant species/water quality analyses at these lakes was very limited. Nonetheless, this project accomplished its main goal of serving as a plant diversity baseline against which future studies can be compared.

Disciplines

Botany

Comments

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Baseline Studies of Aquatic Plants and Water Quality
in Selected State Park Lakes



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Cover image:

Great Blue Heron – Lake Nockamixon; Nockamixon State Park; July 23, 2014

Abstract

This project was undertaken as a baseline study of aquatic plant species and water quality in a set of six state parks lakes selected by the Pennsylvania Bureau of State Parks. Inventories were conducted at these lakes during the field season of 2014. Water quality parameters were measured in these lakes by staff from Pennsylvania Department of Environmental Protection's Clean Lakes Program between 2007 and 2015. Specimens of all species observed were collected and deposited in the herbarium at the Morris Arboretum of the University of Pennsylvania.

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Objective/Purpose

The objectives of this project are as follows:

- 1) To add to our knowledge of aquatic plant distributions in Pennsylvania
- 2) To assist the Pennsylvania Bureau of State Parks in making appropriate management decisions for the living inhabitants of their lakes in balance with recreational demands
- 3) To inform the Pennsylvania Natural Heritage Program of new listed species occurrences
- 4) To add data to the Pennsylvania Department of Environmental Protection's Clean Lakes Program
- 5) To add to our understanding of the relationships between water quality and specific aquatic plant assemblages

Justification

Historically, our knowledge of plant occurrences in terrestrial systems has dwarfed that for aquatic systems. Among the several reasons for this are the relative difficulty of collecting aquatic specimens, difficulty in identifying aquatic plants to species, and a general lack of understanding of the ecological importance of aquatic plants. In spite of recent efforts by the Morris Arboretum and other organizations to rectify this shortcoming, we still lack sufficient understanding of the overall distributions of aquatic plant species in Pennsylvania.

This project will help address the above gap in our scientific knowledge and lead to a better understanding of how various uses of lakes may lead to changes in our aquatic flora.

In two cases (Nockamixon State Park (partial inventory), 2003 and Promised Land State Park, 2005), plant inventories have been conducted by the Morris Arboretum. Updated plant inventories will be especially valuable in further understanding occurrence dynamics in water bodies in Pennsylvania. Although some aquatic plant collections exist, no systematic aquatic plant surveys have, to date, been conducted at Lyman Run, Cowan's Gap, or Frances Slocum State Parks. Among the known management/conservation issues that exist are the presence of *Hydrilla verticillata* and *Myriophyllum spicatum* at Lake Nockmixon and an expanding population of *Myriophyllum heterophyllum* in both the Upper and Lower Promised Land Lakes. This project will provide further monitoring of these situations.

Methods and Materials

Appropriate background and laboratory research was conducted at the Morris Arboretum of the University of Pennsylvania.

Due to the specific phenologies of many aquatic plant species, multiple visits were made to each of the selected lakes during the field season to assure observation of complete species diversity.

All species encountered in this study were collected and processed as permanent herbarium specimens. Herbarium specimens were deposited at the Herbarium of the Morris Arboretum of the University of Pennsylvania (MOAR).

The PA DEP Clean Lakes Program collected water quality data for the lakes at Frances Slocum, Lyman Run, Nockamixon, and Promised Land State Parks and was scheduled to collect data at Cowan's Gap State Park in 2014 (Barbara Lathrop, personal communication).

Field visits were made to each lake in this study as follows:

Cowan's Gap Lake	July 18 and August 18, 2014
Frances Slocum Lake	August 11 and September 9, 2014
Lyman Run Lake	July 21 and August 27, 2014
Lake Nockamixon	June 19, July 23, and August 8, 2014
Promised Land Lakes	June 25, July 20 – 24, 2014

Aquatic plant species surveys were conducted by meandering by boat along the littoral zone of each lake. All plant species encountered were recorded and collected. A GPS track log of each survey was recorded and those logs are illustrated in the results/discussion sections that follow for each lake.

Cowan's Gap Lake

Results

The table below lists all of the aquatic plant species found in Cowan's Gap Lake in 2014.

Species	Family	Common name	Nativity	PNHP Status	PABS Suggested Status
<i>Eleocharis tenuis</i> var. <i>tenuis</i>	Cyperaceae	Spike-rush	Native	Not listed	Not listed
<i>Elodea nuttallii</i>	Hydrocharitaceae	Waterweed	Native	Not listed	Not listed
<i>Isoetes engelmannii</i>	Isoetaceae	Appalachian quillwort	Native	Not listed	Not listed
<i>Justicia americana</i>	Acanthaceae	Water-willow	Native	Not listed	Not listed
<i>Lemna minor</i>	Araceae	Duckweed	Native	Not listed	Not listed
<i>Ludwigia alternifolia</i>	Onagraceae	False loosestrife	Native	Not listed	Not listed
<i>Lysimachia terrestris</i>	Myrsinaceae	Swamp-candles	Native	Not listed	Not listed
<i>Najas minor</i>	Hydrocharitaceae	Waternymph	Introduced	Not listed	Not listed
<i>Potamogeton diversifolius</i>	Potamogetonaceae	Snailseed pondweed	Native	Not listed	Not listed
<i>Potamogeton pusillus</i>	Potamogetonaceae	Pondweed	Native	Not listed	Not listed
<i>Sagittaria latifolia</i> var. <i>latifolia</i>	Alismataceae	Wapato	Native	Not listed	Not listed
<i>Sparganium americanum</i>	Sparganiaceae	Bur-reed	Native	Not listed	Not listed
<i>Vallisneria americana</i> var. <i>americana</i>	Hydrocharitaceae	Tape-grass	Native	Not listed	Not listed

Most recent water quality data for Cowan's Gap Lake; Summer 2014

	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Alkalinity (mg/L)
Cowan's Gap Lake	Not available	Not available	Not available
Median for 60 eastern PA lakes	0.42875	0.0155	11.81

Discussion/Management Recommendations

The lake at Cowan's Gap State Park was drawn down in 2002 and again in 2008, and is scheduled to be drawn down again in 2014 (fig. 2), in order to facilitate repairs and/or improvements to the dam and the beach area. This process has resulted in the presence in this lake of very limited aquatic plant diversity.



Figure 1 - Cowan's Gap Lake drawdown notification

Somewhat surprising is the fact that only one species, *Najas minor*, is not native to Pennsylvania.

It can take many years, even decades, to recover some semblance of the plant diversity once living there. Since we have no previous records, nor inventories for Cowan's Gap Lake, it's not possible to speculate on what species may have been present, but are now lost.

The number and frequency of drawdowns at Cowan's Gap Lake and the limited number of aquatic plant species present makes water quality/species assemblage analysis pointless.

As long as the priority for this lake is to maintain recreational opportunities, there will be limited chances for native plant diversity to increase. Day use of the beach and picnic areas appears to be fairly heavy in summer. This strategy which emphasizes beach maintenance may, in fact, be most appropriate for this shallow, artificial impoundment. It is not recommended that resources be expended to attempt to increase plant diversity at Cowan's Gap Lake.

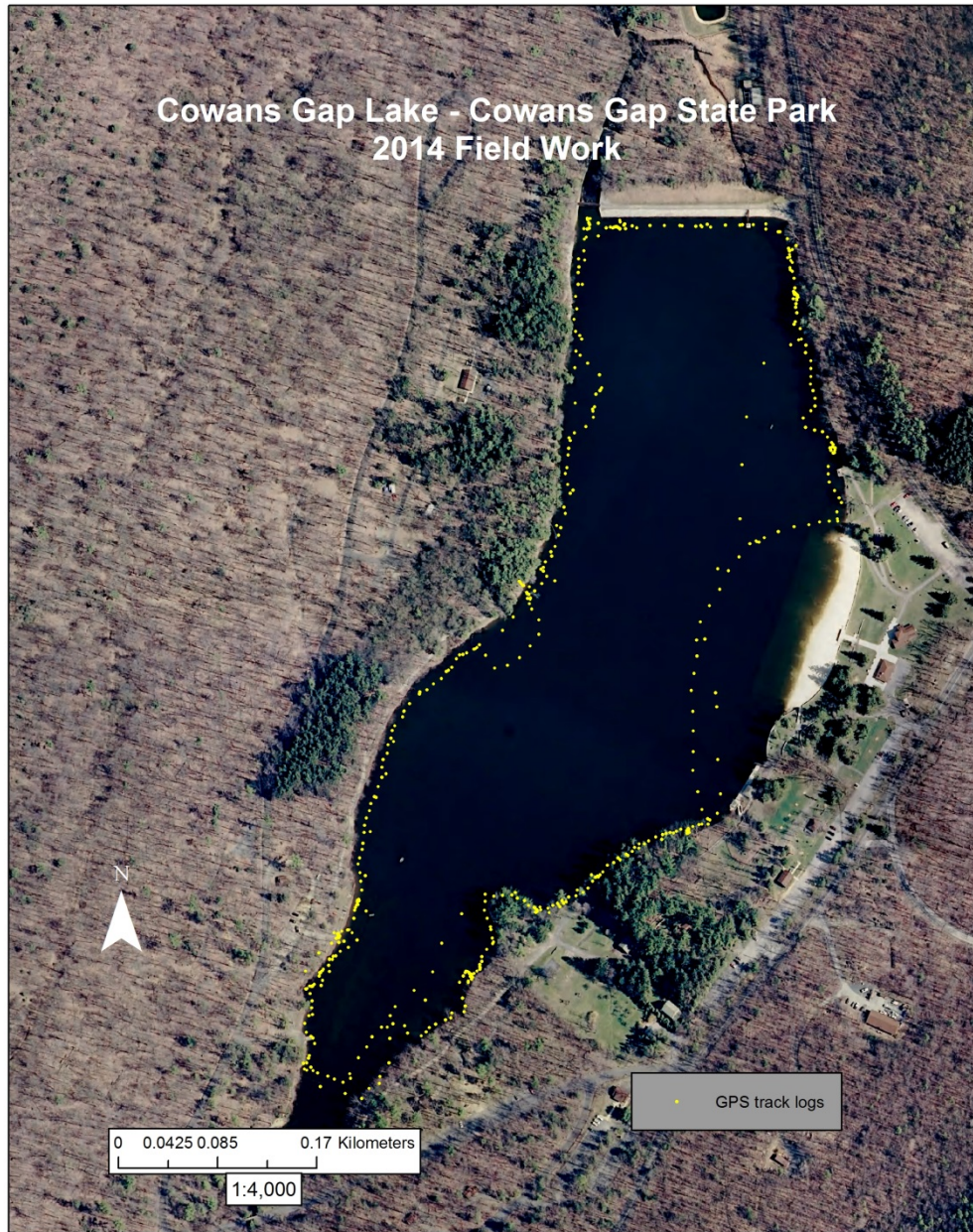


Figure 2 - GPS track logs; Cowan's Gap Lake

Frances Slocum Lake

Results

The table below lists all of the aquatic plant species found in Frances Slocum Lake in 2014.

Species	Family	Common name	Nativity	PNHP Status	PABS Suggested Status
<i>Ceratophyllum demersum</i>	Ceratophyllaceae	Coontail	Native	Not listed	Not listed
<i>Eleocharis palustris</i>	Cyperaceae	Creeping spike-rush	Native	Not listed	Not listed
<i>Elodea nuttallii</i>	Hydrocharitaceae	Waterweed	Native	Not listed	Not listed
<i>Iris pseudacorus</i>	Iridaceae	Water flag	Introduced	Not listed	Not listed
<i>Lemna minor</i>	Araceae	Duckweed	Native	Not listed	Not listed
<i>Nuphar variegata</i>	Nymphaeaceae	Spatterdock	Native	Not listed	Not listed
<i>Sagittaria latifolia</i> var. <i>latifolia</i>	Alismataceae	Wapato	Native	Not listed	Not listed
<i>Schoenoplectus tabernaemontani</i>	Cyperaceae	Great bulrush	Native	Not listed	Not listed
<i>Sparganium americanum</i>	Sparganiaceae	Bur-reed	Native	Not listed	Not listed
<i>Typha latifolia</i>	Typhaceae	Common cat-tail	Native	Not listed	Not listed
<i>Wolffia brasiliensis</i>	Araceae	Pointed water-meal	Native	Not listed	Not listed

Most recent water quality data Frances Slocum Lake; Summer 2007

	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Alkalinity (mg/L)
Frances Slocum Lake	1.17	0.04	18.9
Median for 60 eastern PA lakes	0.42875	0.0155	11.81

Discussion/Management Recommendations

The dam for Frances Slocum Lake was constructed in 1968. This lake was built primarily as a flood control mechanism. The low species diversity is typical of lakes of this age, not having existed long enough to have received plant propagules from other lakes.

Frances Slocum Lake is eutrophic or, perhaps, hypereutrophic (DEP, 2013; AquaLink, Inc., 2010), having high total nitrogen, total phosphorus, and total alkalinity values. Figure 4 shows the layer of algae that covers the quieter surface areas of the lake in summer as a result of high nutrient inputs.

Given that Frances Slocum Lake is unlikely to become a haven for plant species of special concern, or even a site of significant native aquatic plant diversity, its continued management as a recreational facility is entirely appropriate.

However, efforts to remediate nutrient inputs, which have been underway for some time, should be continued.



Figure 1 - Algal bloom at Frances Slocum Lake; August 2014

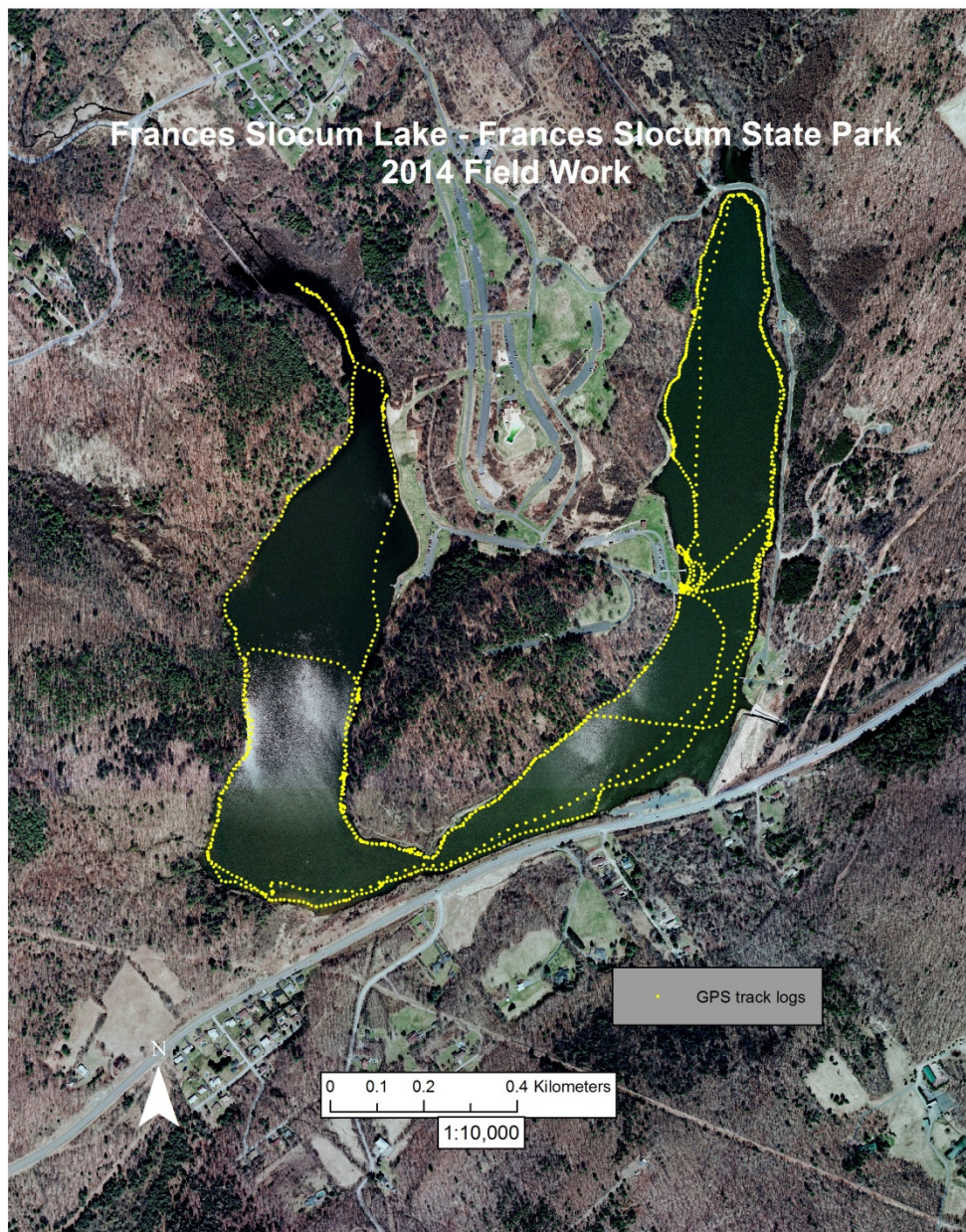


Figure 2 - GPS track logs; Frances Slocum Lake

Lyman Run Lake

Results

The table below lists all of the aquatic plant species found in Lyman Run Lake in 2014.

Species	Family	Common name	Nativity	PNHP Status	PABS Suggested Status
<i>Eleocharis palustris</i>	Cyperaceae	Creeping spike-rush	Native	Not listed	Not listed
<i>Eleocharis tenuis</i> var. <i>tenuis</i>	Cyperaceae	Spike-rush	Native	Not listed	Not listed
<i>Elodea nuttallii</i>	Hydrocharitaceae	Waterweed	Native	Not listed	Not listed
<i>Iris versicolor</i>	Iridaceae	Northern blue flag	Native	Not listed	Not listed
<i>Lemna minor</i>	Araceae	Duckweed	Native	Not listed	Not listed
<i>Peltandra virginica</i>	Araceae	Arrow-arum	Native	Not listed	Not listed
<i>Potamogeton bicupulatus</i>	Potamogetonaceae	Pondweed	Native	Not listed	Special populations
<i>Sparganium americanum</i>	Sparganiaceae	Bur-reed	Native	Not listed	Not listed
<i>Spirodela polyrhiza</i>	Araceae	Greater duckweed	Native	Not listed	Not listed
<i>Typha latifolia</i>	Typhaceae	Common cat-tail	Native	Not listed	Not listed
<i>Vallisneria americana</i> var. <i>americana</i>	Hydrocharitaceae	Tape-grass	Native	Not listed	Not listed

Most recent water quality data for Lyman Run Lake; Summer 2008

	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Alkalinity (mg/L)
Lyman Run Lake	0.68	0.029	11.4
Median for 60 eastern PA lakes	0.42875	0.0155	11.81

Discussion/Management Recommendations

Lyman Run Lake was drawn down in 2000 (fig. 5) and remained empty until 2007 to allow for complete replacement of the original dam which was constructed in 1949. This long period of drawdown clearly accounts for the very limited aquatic plant diversity observed at this lake in the summer of 2014.

The only species naturalized in the lake are *Eleocharis tenuis*, *Elodea nuttallii*, *Lemna minor*, *Potamogeton bicupulatus*, *Spirodela polyrhiza*, *Sparganium americanum*, and *Typha latifolia*. The other species listed in the table above were planted in the upper end of the lake in what appears to be a limited restoration attempt.

The short length of time since rebuilding of the dam and the limited number of species present make any water quality/species assemblage analysis pointless in this case. The nutrient values

for this lake are probably uninformative due to the short length of time the lake has been filled since dam reconstruction.

As there are a limited number of other lakes in this region, and therefore, limited opportunity for natural dispersal of native aquatic plant species, it would be worthwhile to expand species restoration efforts, especially along the north shore of the lake.

There is no reason to consider undertaking vegetation control as all species present at this time are native to Pennsylvania, and none inhabit particularly extensive areas of the lake.

Since no non-native plant species are present at this time, signage should be posted at the boat ramp reminding people putting boats in the lake to clean all plant material from their boats and trailers before launching.



Figure 3 - Lyman Run Lake dam under construction; 2006



Figure 4 - GPS track logs; Lyman Run Lake

Lake Nockamixon

Results

The table below lists all of the aquatic plant species found in Lake Nockamixon in 2014.

Species	Family	Common name	Nativity	PNHP Status	PABS Suggested Status
<i>Acorus calamus</i>	Acoraceae	Sweet flag	Introduced	Not listed	Not listed
<i>Ceratophyllum demersum</i>	Ceratophyllaceae	Coontail	Native	Not listed	Not listed
<i>Hydrilla verticillata</i>	Hydrocharitaceae	Hydrilla	Introduced	Not listed	Not listed
<i>Iris pseudacorus</i>	Iridaceae	Water flag	Introduced	Not listed	Not listed
<i>Myriophyllum spicatum</i>	Haloragaceae	Eurasian water-milfoil	Introduced	Not listed	Not listed
<i>Nymphaea odorata</i>	Nymphaeaceae	Fragrant water-lily	Native	Not listed	Not listed
<i>Peltandra virginica</i>	Araceae	Arrow-arum	Native	Not listed	Not listed
<i>Sagittaria latifolia</i> var. <i>latifolia</i>	Alismataceae	Wapato	Native	Not listed	Not listed
<i>Saururus cernuus</i>	Saururaceae	Lizard's-tail	Native	Not listed	Not listed
<i>Schoenoplectus tabernaemontani</i>	Cyperaceae	Great bulrush	Native	Not listed	Not listed
<i>Sparganium americanum</i>	Sparganiaceae	Bur-reed	Native	Not listed	Not listed
<i>Sparganium eurycarpum</i>	Sparganiaceae	Bur-reed	Native	Not listed	Not listed
<i>Typha latifolia</i>	Typhaceae	Common cat-tail	Native	Not listed	Not listed

Most recent water quality data for Cowan's Gap Lake; Summer 2010

	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Alkalinity (mg/L)
Lake Nockamixon	0.38	0.018	37.2
Median for 60 eastern PA lakes	0.42875	0.0155	11.81

Discussion/Management Recommendations

Although a large impoundment, the limited diversity of aquatic plants is not surprising given the relative youth of this lake. The dam at Lake Nockamixon was constructed in the early 1970s, primarily as a flood control measure.

Most noteworthy aquatic plant-wise is that the non-native species *Myriophyllum spicatum* and *Hydrilla verticillata* (a federal noxious weed) are widespread, indeed nearly throughout the lake. Most of the native species present are among the most common aquatic plant species in Pennsylvania.

Lake Nockamixon is far too large, and the infestation far too involved, to seriously entertain any control measures for either of the above-mentioned invasive species.

Lake Nockamixon is eutrophic (2003, Tetra Tech. Inc.), having high average total nitrogen, total phosphorus, and total alkalinity values. Nutrient inputs come from nearby agricultural activities as well as from sewage treatment plants, residential lawns, golf courses, and non-point sources upstream on the feeder streams. All of the aquatic plant species observed are tolerant of such conditions.

The limited number of species present, and their status as nutrient generalists makes an analysis of water quality/species assemblage uninformative.

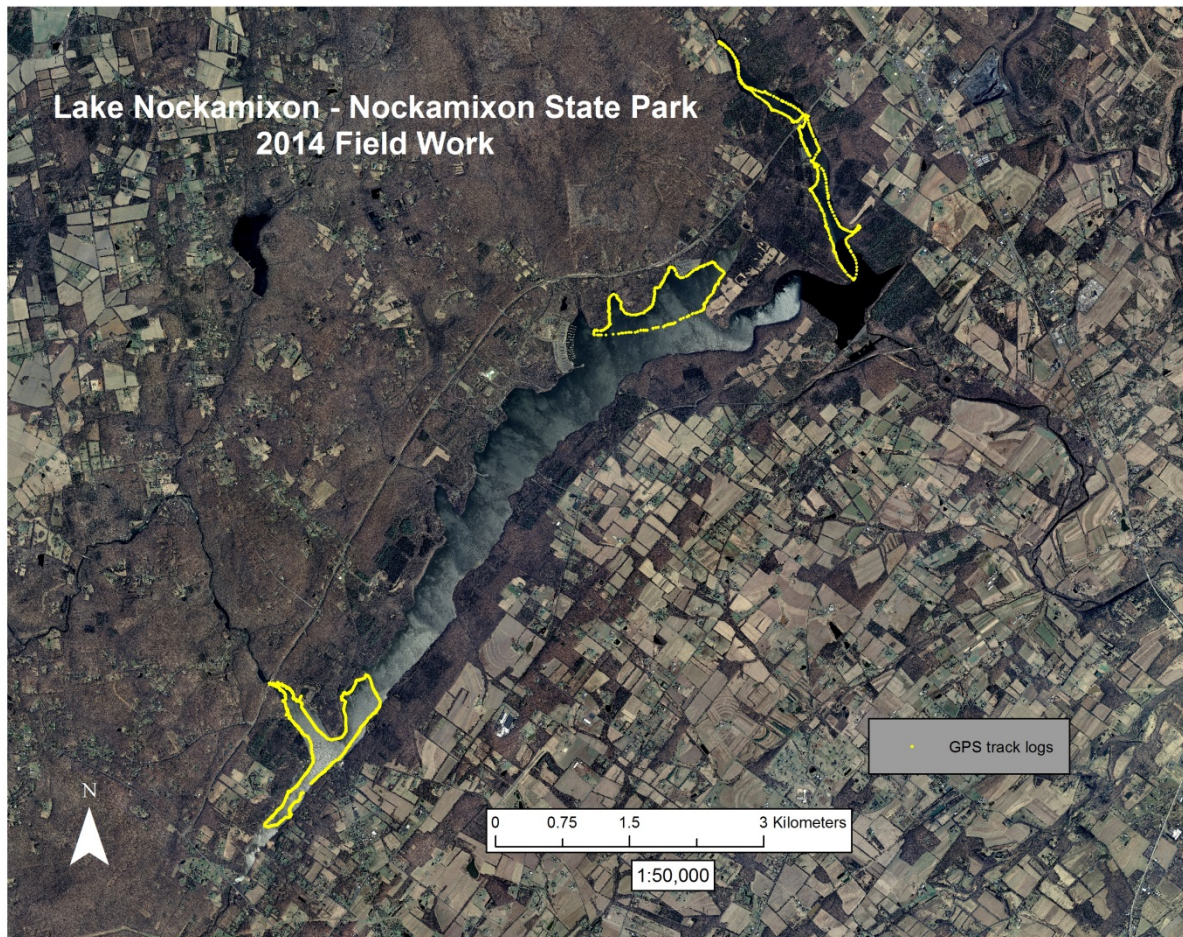


Figure 5 - GPS track logs; Lake Nockamixon

Promised Land Lake

Results

The table below lists all of the aquatic plant species found in Promised Lake in 2014.

Species	Family	Common name	Nativity	PNHP Status	PABS Suggested Status
<i>Bidens frondosa</i>	Asteraceae	Beggar-ticks	Native	Not listed	Not listed
<i>Brasenia schreberi</i>	Cabombaceae	Purple wen-dock	Native	Not listed	Not listed
<i>Callitriche heterophylla</i>	Plantaginaceae	Water-starwort	Native	Not listed	Not listed
<i>Ceratophyllum echinatum</i>	Ceratophyllaceae	Hornwort	Native	Not listed	Not listed
<i>Decodon verticillatus</i>	Lythraceae	Water-willow	Native	Not listed	Not listed
<i>Dulichium arundinaceum</i> var. <i>arundinaceum</i>	Cyperaceae	Three-way sedge	Native	Not listed	Not listed
<i>Elatine minima</i>	Elatinaceae	Small waterwort	Native	Tentatively undetermined	Special populations
<i>Elatine triandra</i>	Elatinaceae	Threestamen waterwort	Introduced	Not listed	Not listed
<i>Eleocharis palustris</i>	Cyperaceae	Creeping spike-rush	Native	Not listed	Not listed
<i>Elodea nuttallii</i>	Hydrocharitaceae	Waterweed	Native	Not listed	Not listed
<i>Iris versicolor</i>	Iridaceae	Northern blue flag	Native	Not listed	Not listed
<i>Isoetes engelmannii</i>	Isoetaceae	Appalachian quillwort	Native	Not listed	Not listed
<i>Ludwigia palustris</i>	Onagraceae	Marsh-purslane	Native	Not listed	Not listed
<i>Myriophyllum heterophyllum</i>	Haloragaceae	Broad-leaved water-milfoil	Native	Endangered	Special populations
<i>Najas flexilis</i>	Hydrocharitaceae	Northern waternymph	Native	Not listed	Not listed
<i>Najas gracillima</i>	Hydrocharitaceae	Slender waternymph	Native	Threatened	Special populations
<i>Nuphar variegata</i>	Nymphaeaceae	Spatterdock	Native	Not listed	Not listed
<i>Nymphaea odorata</i>	Nymphaeaceae	Fragrant water-lily	Native	Not listed	Not listed
<i>Pontederia cordata</i>	Pontederiaceae	Pickereel-weed	Native	Not listed	Not listed
<i>Potamogeton amplifolius</i>	Potamogetonaceae	Bigleaf pondweed	Native	Not listed	Not listed
<i>Potamogeton bicupulatus</i>	Potamogetonaceae	Pondweed	Native	Not listed	Special populations
<i>Potamogeton crispus</i>	Potamogetonaceae	Curly pondweed	Introduced	Not listed	Not listed
<i>Potamogeton diversifolius</i>	Potamogetonaceae	Snailseed pondweed	Native	Not listed	Not listed
<i>Potamogeton epihydrus</i>	Potamogetonaceae	Ribbonleaf pondweed	Native	Not listed	Not listed
<i>Potamogeton pectinatus</i>	Potamogetonaceae	Sago pondweed	Native	Not listed	Not listed
<i>Potamogeton pusillus</i>	Potamogetonaceae	Pondweed	Native	Not listed	Not listed
<i>Potamogeton spirillus</i>	Potamogetonaceae	Snailseed pondweed	Native	Not listed	Not listed
<i>Sagittaria latifolia</i> var. <i>latifolia</i>	Alismataceae	Wapato	Native	Not listed	Not listed
<i>Sparganium americanum</i>	Sparganiaceae	Bur-reed	Native	Not listed	Not listed
<i>Typha latifolia</i>	Typhaceae	Common cat-tail	Native	Not listed	Not listed

<i>Utricularia geminiscapa</i>	Lentibulariaceae	Bladderwort	Native	Not listed	Special populations
<i>Utricularia gibba</i>	Lentibulariaceae	Humped bladderwort	Native	Not listed	Not listed
<i>Utricularia inflata</i>	Lentibulariaceae	Inflated bladderwort	Native	Not listed	Special populations
<i>Utricularia purpurea</i>	Lentibulariaceae	Purple bladderwort	Native	Rare	Special populations
<i>Vallisneria americana</i> var. <i>americana</i>	Hydrocharitaceae	Tape-grass	Native	Not listed	Not listed

Most recent water quality data for Promised Land Lake; Summer 2009

	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Alkalinity (mg/L)
Promised Land Lake	0.29	0.018	5.6
Median for 60 eastern PA lakes	0.42875	0.0155	11.81

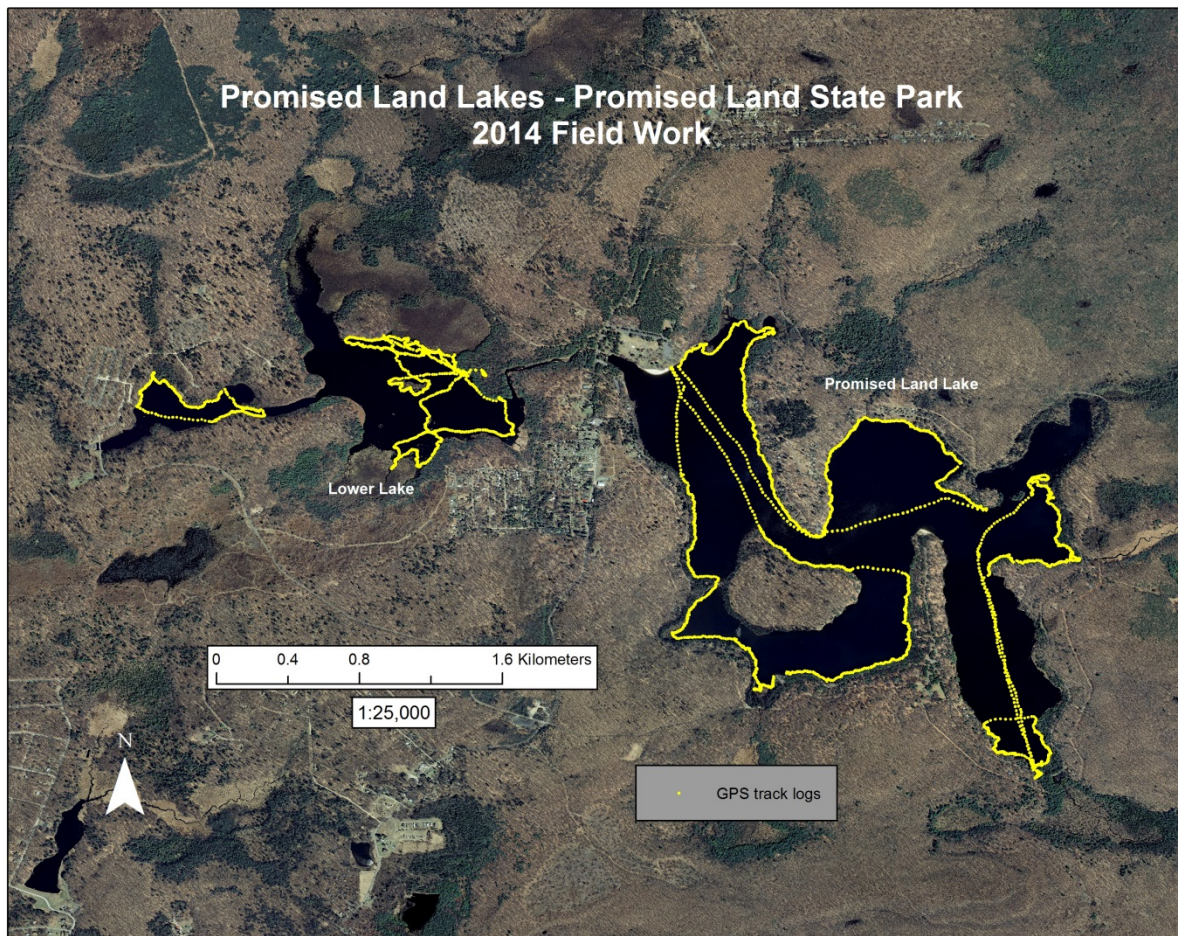


Figure 6 - GPS track logs; Promised Land Lake and Lower Lake

Discussion/Management Recommendations

It's interesting to note that Promised Land Lake has the largest population of *Elatine minima* we've seen among the more than 140 lakes we've inventoried since 2000. This plant is present on sandy to gravelly substrates, generally in water less than 1 meter deep in much of the littoral zone.

One of the most significant differences between Promised Land Lake and Lower Lake is that, while Lower Lake is largely a flooded bog accounting for its general shallowness, Promised Land Lake is a network of flooded shallow valleys. Much of Promised Land Lake is shallow also and therefore occupied by dense stands of aquatic vegetation.

The aquatic vegetation of Promised Land Lake is dominated by *Myriophyllum heterophyllum* throughout much of its area. As with Lower Lake, the population of this aggressive species seems to be spreading and becoming more dense. Again, as with the Lower Lake, *Myriophyllum farwellii* is among the species not observed in 2014 that was present in 2005.

As with the Lower Lake, in spite of the presence of large areas of *Myriophyllum heterophyllum*, no active management is advised. The size alone of Promised Land Lake precludes any reasonable strategy for aquatic plant management.

Nutrient values for Promised Land Lake are generally below the median values for a set of 60 lakes sampled in eastern Pennsylvania from 2000 to 2012. However, these values are not limiting to a large number of other aquatic plant species that could potentially grow here, including a number of non-native, invasives.

It's unfortunate that there was insufficient time in one field season to conduct an adequate baseline study of the entirety of Promised Land Lake. Continued intensive surveys should be conducted at Promised Land Lake.

Lower Lake (Promised Land State Park)

Results

The table below lists all of the aquatic plant species found in Lower Lake in 2014.

Species	Family	Common name	Nativity	PNHP Status	PABS Suggested Status
<i>Brasenia schreberi</i>	Cabombaceae	Purple wen-dock	Native	Not listed	Not listed
<i>Calamagrostis canadensis</i> var. <i>canadensis</i>	Poaceae	Canada bluejoint	Native	Not listed	Not listed
<i>Callitriche heterophylla</i>	Plantaginaceae	Water-starwort	Native	Not listed	Not listed
<i>Carex canescens</i> var. <i>canescens</i>	Cyperaceae	Sedge	Native	Not listed	Not listed
<i>Carex lurida</i>	Cyperaceae	Sedge	Native	Not listed	Not listed
<i>Carex radiata</i>	Cyperaceae	Sedge	Native	Not listed	Not listed
<i>Carex rosea</i>	Cyperaceae	Sedge	Native	Not listed	Not listed
<i>Ceratophyllum echinatum</i>	Ceratophyllaceae	Hornwort	Native	Not listed	Not listed
<i>Decodon verticillatus</i>	Lythraceae	Water-willow	Native	Not listed	Not listed
<i>Drosera rotundifolia</i>	Droseraceae	Round-leaved sundew	Native	Not listed	Not listed
<i>Dulichium arundinaceum</i> var. <i>arundinaceum</i>	Cyperaceae	Three-way sedge	Native	Not listed	Not listed
<i>Elatine minima</i>	Elatinaceae	Small waterwort	Native	Tentatively undetermined	Special populations
<i>Elatine triandra</i>	Elatinaceae	Threestamen waterwort	Introduced	Not listed	Not listed
<i>Eleocharis acicularis</i>	Cyperaceae	Needle spike-rush	Native	Not listed	Not listed
<i>Eleocharis olivacea</i>	Cyperaceae	Capitate spike-rush	Native	Rare	Special populations
<i>Eleocharis palustris</i>	Cyperaceae	Creeping spike-rush	Native	Not listed	Not listed
<i>Eleocharis tenuis</i> var. <i>tenuis</i>	Cyperaceae	Spike-rush	Native	Not listed	Not listed
<i>Galium trifidum</i>	Rubiaceae	Cleavers	Native	Not listed	Rare
<i>Glyceria borealis</i>	Poaceae	Northern mannagrass	Native	Endangered	Special populations
<i>Hypericum boreale</i>	Hypericaceae	Dwarf St. John's-wort	Native	Not listed	Not listed
<i>Hypericum mutilum</i>	Hypericaceae	Dwarf St. John's-wort	Native	Not listed	Not listed
<i>Hypericum punctatum</i>	Hypericaceae	Spotted St. John's-wort	Native	Not listed	Not listed
<i>Isoetes engelmannii</i>	Isoetaceae	Appalachian quillwort	Native	Not listed	Not listed
<i>Juncus effusus</i> var. <i>solutus</i>	Juncaceae	Soft rush	Native	Not listed	Not listed
<i>Juncus subcaudatus</i>	Juncaceae	Rush	Native	Not listed	Not listed
<i>Lemna minor</i>	Araceae	Duckweed	Native	Not listed	Not listed
<i>Ludwigia palustris</i>	Onagraceae	Marsh-purslane	Native	Not listed	Not listed
<i>Lysimachia terrestris</i>	Myrsinaceae	Swamp-candles	Native	Not listed	Not listed

<i>Myosotis scorpioides</i>	Boraginaceae	Forget-me-not	Introduced	Not listed	Not listed
<i>Myriophyllum heterophyllum</i>	Haloragaceae	Broad-leaved water-milfoil	Native	Endangered	Special populations
<i>Najas flexilis</i>	Hydrocharitaceae	Northern waternymph	Native	Not listed	Not listed
<i>Najas gracillima</i>	Hydrocharitaceae	Slender waternymph	Native	Threatened	Special populations
<i>Nuphar variegata</i>	Nymphaeaceae	Spatterdock	Native	Not listed	Not listed
<i>Nymphaea odorata</i>	Nymphaeaceae	Fragrant water-lily	Native	Not listed	Not listed
<i>Peltandra virginica</i>	Araceae	Arrow-arum	Native	Not listed	Not listed
<i>Pontederia cordata</i>	Pontederiaceae	Pickereel-weed	Native	Not listed	Not listed
<i>Potamogeton bicupulatus</i>	Potamogetonaceae	Pondweed	Native	Not listed	Special populations
<i>Potamogeton crispus</i>	Potamogetonaceae	Curly pondweed	Introduced	Not listed	Not listed
<i>Potamogeton diversifolius</i>	Potamogetonaceae	Snailseed pondweed	Native	Not listed	Not listed
<i>Potamogeton epihydrus</i>	Potamogetonaceae	Ribbonleaf pondweed	Native	Not listed	Not listed
<i>Potamogeton pusillus</i>	Potamogetonaceae	Pondweed	Native	Not listed	Not listed
<i>Potamogeton spirillus</i>	Potamogetonaceae	Snailseed pondweed	Native	Not listed	Not listed
<i>Rhynchospora alba</i>	Cyperaceae	White beak-rush	Native	Not listed	Not listed
<i>Sagittaria latifolia</i> var. <i>latifolia</i>	Alismataceae	Wapato	Native	Not listed	Not listed
<i>Schoenoplectus tabernaemontani</i>	Cyperaceae	Great bulrush	Native	Not listed	Not listed
<i>Scirpus cyperinus</i>	Cyperaceae	Wool-grass	Native	Not listed	Not listed
<i>Scirpus cyperinus</i>	Cyperaceae	Wool-grass	Native	Not listed	Not listed
<i>Sparganium americanum</i>	Sparganiaceae	Bur-reed	Native	Not listed	Not listed
<i>Spirodela polyrhiza</i>	Araceae	Greater duckweed	Native	Not listed	Not listed
<i>Triadenum virginicum</i>	Hypericaceae	Marsh St. John's-wort	Native	Not listed	Not listed
<i>Typha latifolia</i>	Typhaceae	Common cat-tail	Native	Not listed	Not listed
<i>Utricularia geminiscapa</i>	Lentibulariaceae	Bladderwort	Native	Not listed	Special populations
<i>Utricularia gibba</i>	Lentibulariaceae	Humped bladderwort	Native	Not listed	Not listed
<i>Utricularia inflata</i>	Lentibulariaceae	Inflated bladderwort	Native	Not listed	Special populations
<i>Utricularia purpurea</i>	Lentibulariaceae	Purple bladderwort	Native	Rare	Special populations
<i>Vallisneria americana</i> var. <i>americana</i>	Hydrocharitaceae	Tape-grass	Native	Not listed	Not listed

Most recent water quality data for Lower Lake; Summer 2009

	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Alkalinity (mg/L)
Lower Lake	0.5675	0.01425	11.81
Median for 60 eastern PA lakes	0.42875	0.0155	11.81

Discussion/Management Recommendations

Several species observed in our 2005 survey of Lower Lake were not seen in 2014. Of these *Myriophyllum farwellii* is perhaps most significant as its conservation status is Pennsylvania endangered. Two other species apparently now missing are *Potamogeton pusillus* and *P. spirillus*.

It's an anecdotal observation at this point, but it seems that the density of cover of both *Myriophyllum heterophyllum* and *Utricularia purpurea* has increased since the 2005 survey was conducted. This may explain the loss of the above mentioned species as well as a general decline in the frequency of most other submergent species.

In spite of the limited number of threatened or endangered aquatic plant species, all of the Lower Lake should be considered ecologically sensitive. The average water depth is about three feet, the only significantly deeper area being the outlet channel in the western arm of the lake. Due to its shallowness, virtually the entire lake is capable of supporting rooted aquatic plants.

In spite of the density and frequency of *Myriophyllum heterophyllum*, which should be considered a non-native invasive at Promised Land, no control measures are recommended at this time. Mechanical removal on such a large scale would be cost-prohibitive. Application of aquatic herbicides is species non-specific and would result in the loss of the less common species growing among the *Myriophyllum heterophyllum/Utricularia purpurea* mats. The pressure to reduce the density of aquatic vegetation in Lower Lake to accommodate boating and other recreational activities should be resisted.

The values for total nitrogen (TN), total phosphorus (TP), and alkalinity recorded at the Lower Lake places them at about average to slightly above median for nutrients and alkalinity among a sample of 60 lakes in eastern Pennsylvania. These values would not be limiting to the possible occurrences of many other aquatic plant species, including other non-native species.

Regular observations on changes in the vegetation in Lower Lake should be done. We do not anticipate that significant changes in species composition or water quality parameters will take place absent significant changes in management strategy.

Literature Cited

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