

Abstract

Studies of aquatic plants of eastern Pennsylvania lakes were continued with quantitative inventories of 6 lakes and qualitative surveys of 6 additional lakes. The surveys resulted in 14 new records of PNHP-listed species and updates of 6 previously known occurrences. Accumulated information on species abundance resulted in one recommendation to delist and 2 recommendations for changes in status at the annual Rare Plant Forum. A study of 8 Pennsylvania populations of *Myriophyllum heterophyllum*, carried out by our intern, failed to find any evidence of hybridization that might help to explain the aggressive growth of this species in northeastern counties.

Analysis of occurrence patterns of non-native aquatic species revealed differences between low alkalinity, mesotrophic lakes and highly eutrophic lakes. Although curly pondweed (*Potamogeton crispus*) is present in both types of lakes, only in highly eutrophic situations (high alkalinity, phosphorus and nitrogen) is it abundant. On the other hand, long-leaved waterwort (*Elatine triandra*), shows the opposite pattern; it is abundant in low phosphorus, low alkalinity lakes. Additional lake quality data are needed to allow for further analyses of the influence of water chemistry on plant occurrence.

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Cover photo: Goose Pond in Wayne County, PA

Objectives

1. Conduct quantitative surveys of aquatic vegetation of six natural glacial lakes in northeastern Pennsylvania. Specific deliverables: a) GIS-based vegetation maps of submergent and emergent vegetation for each lake, and b) PNHP field survey reports to be submitted for data entry as appropriate.
2. Preparation of a report based on our six years of work on aquatic vegetation of northeastern Pennsylvania. Specific deliverables: report(s) suitable for publication focusing on a) plant communities and habitats of natural glacial lakes in northeastern PA, and b) correlation of aquatic plant occurrence with physical and chemical characteristics of the lakes.
3. Strengthen the scientific basis for classification of aquatic vascular plants as endangered, threatened or rare by the Pennsylvania Natural Heritage Program (PNHP). Recommend changes in the status of plant species of special concern as appropriate. Specific deliverables: recommendations submitted to the annual Rare Plant Forum for modifications of the Plants of Special Concern lists.
4. Continue to increase the coverage of the PNHP database by actively gathering new and updated distribution and abundance data for listed species. Deliverables: field reports submitted to PNHP for all listed species encountered.
5. Provide services to project review staff at Pennsylvania Natural Heritage Program to assist in evaluating the potential impact of proposed development on occurrences of listed species. This phase of the work may include telephone and/or email consultation and field visits.

Justification

The aquatic vegetation of northeastern Pennsylvania has traditionally been under-studied. We began our intensive study of aquatic flora in 2000; we have conducted qualitative inventories of species presence in 113 lakes, and have developed a database of 2,540 occurrences of 277 vascular plant species by lake and date.

Findings from the six years of our work on lakes have given us a much better understanding of the aquatic flora on northeastern Pennsylvania. The data we collected have led to many new records of PNHP-listed species and resulted in 17 recommendations for changes in the PNHP listings of endangered, threatened, rare, and undetermined species; 15 of which were recommendations to delist. It is extremely important to the credibility of the heritage program overall to provide a strong scientific basis for listing species and to remove from the lists those that do not need protection.

Table 1. Lakes surveyed by year.

| year | number of lakes surveyed* | total PNHP records | new PNHP records | status changes recommended** |
|------|---------------------------|--------------------|------------------|------------------------------|
| 2000 | 15 | 44 | 33 | 4 |
| 2001 | 22 | 85 | 63 | 4 |
| 2002 | 30 | 38 | 31 | 9 |
| 2003 | 40 | 41 | 30 | 0 |
| 2004 | 13 | 27 | 23 | 0 |
| 2005 | 13 | 20 | 14 | 4 |

*some lakes were visited in more than one year.

** The following species have been deleted from the species of special concern list on the basis of our field work in northeastern PA lakes: *Elatine minima*, *Eleocharis olivacea*, *Glyceria borealis*, *Gentiana linearis*, *Najas gracillima*, *Orontium aquaticum*, *Polygonum aquaticum* var. *stipulaceum*, *Potamogeton bicupulatus*, *Potamogeton robbinsii*, *Utricularia geminiscapa*, *Utricularia inflata*, *Utricularia purpurea*, *Utricularia minor*, *Wolffia borealis*, *Xyris montana*.

Materials and Methods

Lake surveys were carried out between July 5 and August 22, 2005 at a total of 13 sites. A rowboat was used to make a circuit of each lake for the purpose of observing and sampling the aquatic flora. At 6 lakes a GPS receiver (Garmin GPSmap 60, Garmin International, Inc. Olathe, KS) was used to define sampling sites located about 20 m apart in the littoral zone following a method described by Grund (undated) for western Pennsylvania lakes. All plant species within a 3 m radius were sampled using a grappling tool constructed from 2 garden rakes bolted together back to back that was dragged across the lake bottom. Samples were identified immediately or later in the laboratory, and herbarium specimens prepared for each species found at each lake. A depth gauge (Garmin Fishfinder 100, Garmin International, Inc., Olathe, KS) was used to record water depth at each sampling point.

Products Delivered

- PNHP field surveys for 20 occurrences of listed species.
- Analysis of aquatic plant occurrence.
- Detailed mapping of aquatic plant occurrence for six lakes.
- List of herbarium specimens deposited in the Herbarium of the Morris Arboretum (MOAR) see Appendix A.
- Research on genetic structure of *Myriophyllum heterophyllum* populations in Pennsylvania.
- Recommendations to Autumn Sabo regarding project review site visits.

Results and Conclusions

2005 Lake Surveys

In 2005 12 lakes were surveyed for aquatic plants, six of those involved detailed mapping of occurrence, the other six were presence/absence surveys.

- *Dunn Pond, Susquehanna County
- *Goose Pond, Wayne County
- *Hickory Lake, Wayne County
- *Lake Lacawac, Wayne County
- *Lake Lodore, Wayne County
- Mud Pond at Newton Lake, Lackawanna County
- Newton Lake, Lackawanna County
- Pickereel Lake, Pike County
- *Porter's Lake, Pike County
- Promised Land State Park, Lower Lake, Pike County
- Promised Land State Park, Upper Lake, Pike County
- Pond at Varden Conservation Area, Wayne County

*sites where detailed mapping was carried out

PNHP-listed Plants

Twenty occurrences of PNHP-listed species of aquatic plants were documented, field reports were submitted to the Middletown PNHP office in December 2005. Fourteen were new occurrences and six were updates of previously known species occurrences. Species documented included: *Lobelia dortmanna* - 2 sites, *Juncus militaris* - 2 sites, *Utricularia cornuta* - 2 sites, *Schoenoplectus subterminalis* - 2 sites, *Sparganium angustifolium* - 2 sites, *Carex lasiocarpa* - 1 site, *Eleocharis robbinsii* - 2 sites, *Nymphoides cordata* - 1 site, *Myriophyllum farwellii* - 2 sites, *Bidens discoidea* - 1 site, *Myriophyllum heterophyllum* - 2 sites, *Utricularia inflata* - 1 site.

Possible candidates for status revision -

Our data suggest that the status of several species should be revised. We are particularly concerned about *Utricularia inflata*, *Myriophyllum heterophyllum*, *Myriophyllum farwellii*, and *Schoenoplectus subterminalis*. Additional large populations of all four species were documented this year.

We have commented in previous years about *Myriophyllum heterophyllum*. We have now documented six populations in northeastern Pennsylvania. In most cases this species dominates the lakes where it is present. Amanda Treher, the Pennsylvania Flora Intern for 2005-06, working in the



Myriophyllum heterophyllum

molecular laboratory at the Academy of Natural Sciences of Philadelphia, carried out a study of the genetic structure of *M. heterophyllum* populations in Pennsylvania to try to understand why this species is so vigorous in the northeastern part of the state. Her morphological and molecular studies of 8 populations of *M. heterophyllum* in Pennsylvania, 1 in Delaware, and 2 in Connecticut indicate that all Pennsylvania plants are genetically similar and there is no evidence of hybridization (Treher et al. 2006). Hybridization has been reported in Connecticut populations (Moody and Les 2002). The complete report on Amanda Treher's intern project (Treher 2006) is included in Appendix B.

Another continuing paradox concerns the status of *Utricularia inflata*. We continue to find new populations of this plant, which was first collected in the state in the early 1990s. Coincidentally, a recent inquiry from a New York botanist revealed that *U. inflata* has recently appeared in lakes in the Adirondacks (John Titus, personal communication). It seems more and more apparent that this plant, which was formerly confined to the southeastern coastal plain, is spreading rapidly northward and does not need protection. Published reports confirm its presence in Orange County, New York (Mitchell et al. 1994) and in eastern Massachusetts (Sorrie 1992).

A recommendation to remove *U. inflata* from the PHNP list was submitted to the annual Rare Plant Forum in March 2006 and approved.

Two other species that we have been watching are *Myriophyllum farwellii* and *Schoenoplectus subterminalis*. We found two very large populations of *Myriophyllum farwellii* in 2005. Similarly, the discovery of two new large populations of *Schoenoplectus subterminalis*, suggests that this species may be abundant enough to consider downgrading its listing. Recommendations to the Rare Plant Forum in March 2006 to change the status of *M. farwellii* from PE to PR and *S. subterminalis* from PT to PR were both approved.

New Invasive Aquatic?

In August 2005 we discovered a population of parrot-feather (*Myriophyllum aquaticum*) in the Delaware Canal in Bristol, Bucks County. Although there were previous reports of this species in Pennsylvania, we were unaware of any extant populations. This potentially invasive species is native to South America and has become a serious aquatic weed in California, Washington State, and many other parts of the world. We will monitor this site in the coming year to determine the viability and full extent of the population.



Parrot-feather (*Myriophyllum aquaticum*)

Analysis of Aquatic Plant Occurrence

When we began our work on aquatic plants in 2000, our initial goal was to learn more about the abundance of aquatic species and arrive at more accurate species designations under the Pennsylvania Natural Heritage Program. The data we have gathered over 6 years of fieldwork has led us to recommend the delisting of 15 species and changes in the status of 6 others.

A year or so after we began our aquatic plant survey we became aware of DEP's lake water quality project. After discussions with Barbara Lathrop, we decided to try to coordinate our inventory work with DEP's sampling schedule in the hope that we could learn more about aquatic plant occurrence through correlations between water quality data and vascular plant occurrence.

At the conclusion of the 2005 field season we had surveyed 110 lakes of which DEP had water quality for 47. We used Canoco to analyze data for the 47 sites for which we had both water quality and plant data. Overall, alkalinity, total phosphorus, and total nitrogen and to a lesser extent pH were found to be most important water quality parameters in determining plant distribution.

Species that occur in 50 or more of the 110 sites are listed in Table 2. These species occur in a wide range of water quality conditions.

Table 2. The most common aquatic plants in 112 lakes in eastern Pennsylvania.

| | # of lakes |
|--------------------------------|------------|
| <i>Nuphar variegata</i> | 80 |
| <i>Potamogeton epiphydrus</i> | 72 |
| <i>Sparganium americanum</i> | 70 |
| <i>Nymphaea odorata</i> | 64 |
| <i>Dulichium arundinaceum</i> | 58 |
| <i>Eleocharis acicularis</i> | 57 |
| <i>Triadenum virginicum</i> | 55 |
| <i>Brasenia schreberi</i> | 53 |
| <i>Eleocharis palustris</i> | 53 |
| <i>Pontederia cordata</i> | 53 |
| <i>Sagittaria latifolia</i> | 50 |
| <i>Utricularia macrorrhiza</i> | 50 |

Canonical correspondence analysis (fig. 1) in CANOCO (ter Braak and Smilauer, 2002) reveals a continuum of species arrayed along the alkalinity, total nitrogen, and total phosphorus vectors. For those endangered, threatened or rare species for which we have both plant occurrence and water quality for at least 3 sites, occurrence tends to be clustered at the low end of the

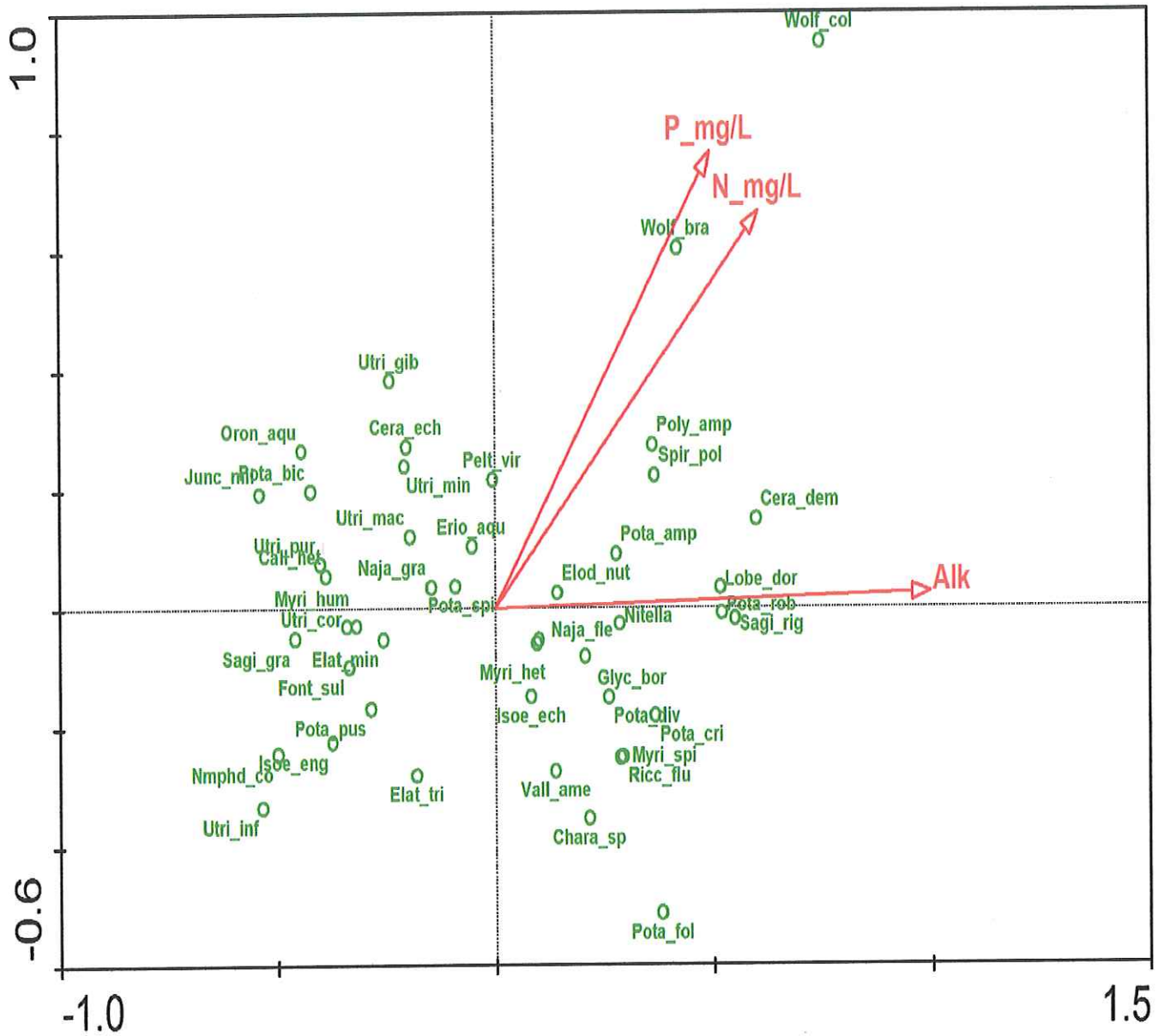


Figure 1. Canonical correspondence analysis of aquatic plant species with environmental factors.

spectrum for all 3 parameters; however resolution is poor and reliability is questionable due to low sample size, especially for PHNP-listed plants.

Non-native exotics are generally not a severe problem in lakes in northeastern Pennsylvania.

Occurrence of *Potamogeton crispus*, the most common invasive species in our surveys correlates with increasing alkalinity and total phosphorus (figs. 2 and 3).

Elatine triandra, another non-native plant that is spreading into Pennsylvania, is more likely to be found in lakes of low alkalinity and low phosphorus (figs. 4 and 5).

We need more sites for which we have both vegetation data and water quality data in order to do more meaningful analyses.

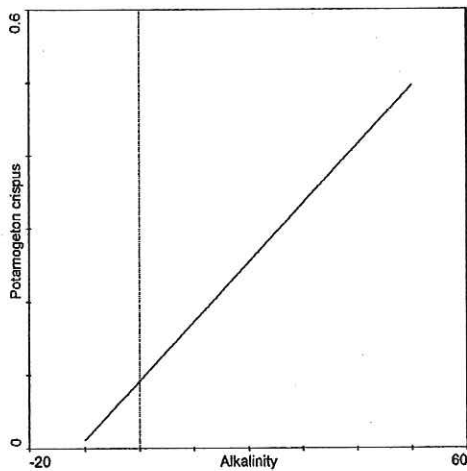


Figure 2.

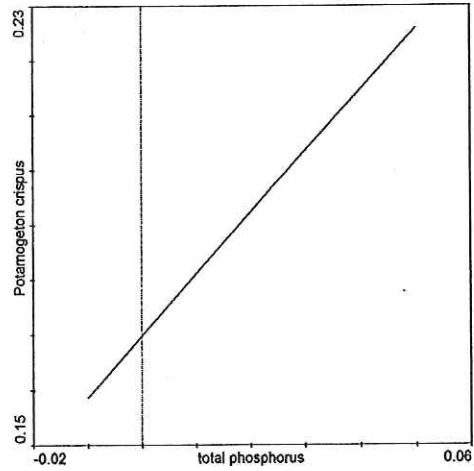


Figure 3.

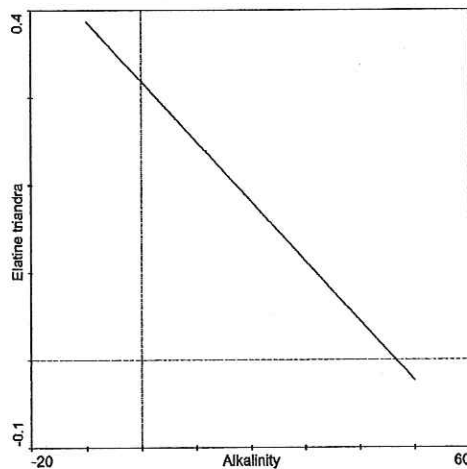


Figure 4.

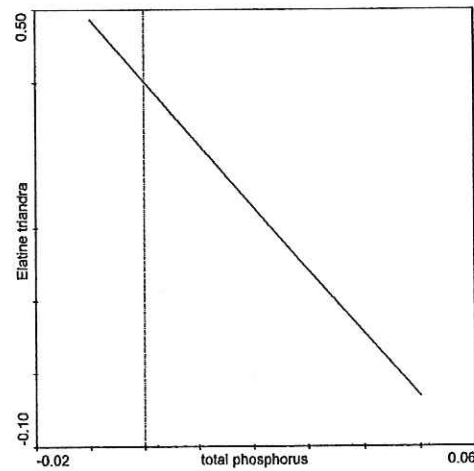


Figure 5.

Aquatic Plant Presentations

In an ongoing effort to increase knowledge about aquatic plant diversity and awareness of the ecological roles of aquatic plants we have participated in workshops and symposia throughout the state.

Ann Rhoads presented a program on aquatic plants as part of a one-day workshop on Pond and Lake Management held at the PP&L Environmental Center at Lake Wallenpaupack on June 18, 2005. The Pike County Cooperative Extension Service sponsored the program

On July 16 Ann Rhoads led a canoe trip on the Delaware River in Wayne County for the Delaware Highlands Conservancy to acquaint participants with rare plants of the river and river shore.

Ann Rhoads presented a two-day workshop on aquatic plants at Nescopeck State Park in Luzerne County on July 20-21, 2005 for the Ecological Services Section of the Pennsylvania Bureau of Forestry. Attendees were BOF field staff members. The workshop included an indoor session with live specimens and an outdoor field trip.

Tim Block presented a talk on aquatic plants for the Pennsylvania Lake Management Society annual meeting in State College in October 2005.

Tim Block gave a presentation on invasive aquatic plants at the Kings Gap Biodiversity Symposium to be held at Shippensburg University on March 15, 2006.

Environmental Reviews

Two days were spent conducting site visits for the purpose of environmental reviews at the request of Autumn Sabo. All three sites that we visited were located in the Atlantic Coastal Plain Physiographic Province in southern Bucks County. Four field reports were submitted to PNHP as a result of these field visits.

June 1, 2005 – Sterling Helicopter site State Road, Croydon, PA. A field survey by Dr. Timothy Block confirmed the presence of native populations of *Ilex opaca* and *Quercus phellos*.

August 25, 2005 – 6.7 acre site at the intersection of State Road and Street Road in Bensalem Township. A field visit by Drs. Ann Rhoads and Timothy Block confirmed the presence of single specimens of *Ilex opaca* and *Quercus phellos*.

August 25, 2005 – Lumber company proposed expansion site between the Delaware Canal and the railroad, Bristol, PA. A field visit by Drs. Ann Rhoads and Timothy Block confirmed the presence of a small population of *Quercus phellos*.

May 3, 2006 – Field visit by Drs. Ann Rhoads and Timothy Block to Dixon Road Woods coastal plain forest in Bucks County to evaluate the extent of the *Leucothoe racemosa* and *Quercus phellos* populations in view of development plans for the site.

In addition we reviewed a survey for *Ilex opaca* done on the Gaster-Robinson Tract in Marple Township, Delaware County.

Discussion of Management Recommendations

Our work on aquatic plants during the 2005 field season resulted in 3 recommendations for status change under the Pennsylvania Natural Heritage Program; all were approved by the Rare Plant Forum at a meeting on March 25, 2006.

Myriophyllum farwellii changed from PE to PR

Schoenoplectus subterminalis changed from PT to PR

Utricularia inflata removed from the PNHP list

Observations on the correlation between lake nutrient levels and the abundance of various invasive species suggest that adding nutrients to lakes or increasing the pH could shift the balance between species leading to greater abundance of invasives such as *Potamogeton crispus* or *Cabomba caroliniana*. This finding has implications for the liming of lakes and streams.

Our interactions with lake community residents reveal an ongoing need for better sources of information and education about how lake ecosystems function and the diversity of species which comprise them. We are currently working on a manual of aquatic plants to help meet this need.

Literature Cited

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Appendix A
Detailed Lake Surveys

Data from the 7 lakes at which detailed, GPS-based surveys were conducted follow. Only true aquatic species were mapped, although species lists for most sites contain bog and shoreline species also.

Dunn Pond

Orson, PA

Susquehanna County, Pennsylvania

Ownership: Dunn Lake LLC c/o Daniel Maisano, 103 Indian Springs Road, Kennett square, PA

Contact: Richard Pais, Pais Ecological Services, Wilkes-Barre, PA

Latitude: 41.82306N

Longitude: 75.48222W

Quad: Orson

Elevation: 1974 feet above mean sea level

Natural glacial lake

Date visited: July 11, 2005

Number of sampling points: 37

Number of aquatic macrophytes plants recorded: 38, number mapped: 35

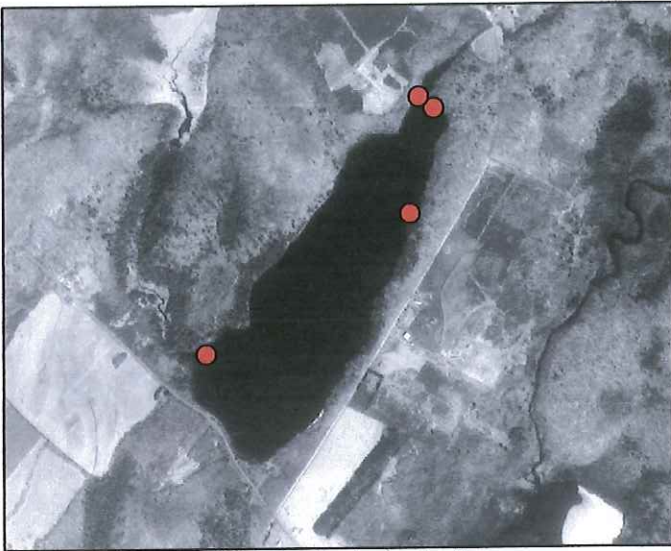
PNHP-listed species present: *Lobelia dortmanna*, *Juncus militaris*, *Utricularia cornuta*

Comments: This lake is an oligotrophic natural lake with a natural forested shoreline and no structures currently in the vicinity. However, a development plan has been prepared for 17 homes and an inn and restaurant to be located around the lake.



Lobelia dortmanna flowering at Dunn Pond July 11, 2005

Dunn Pond



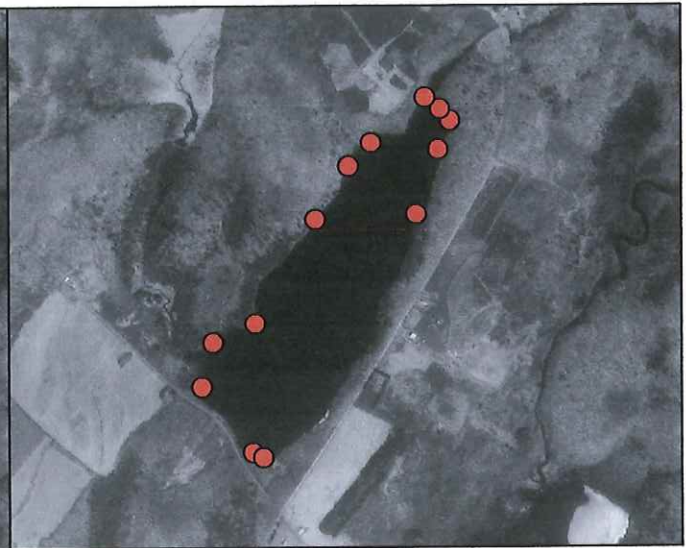
Callitriche heterophylla



Carex utriculata



Ceratophyllum sp.



Dulichium arundinaceum

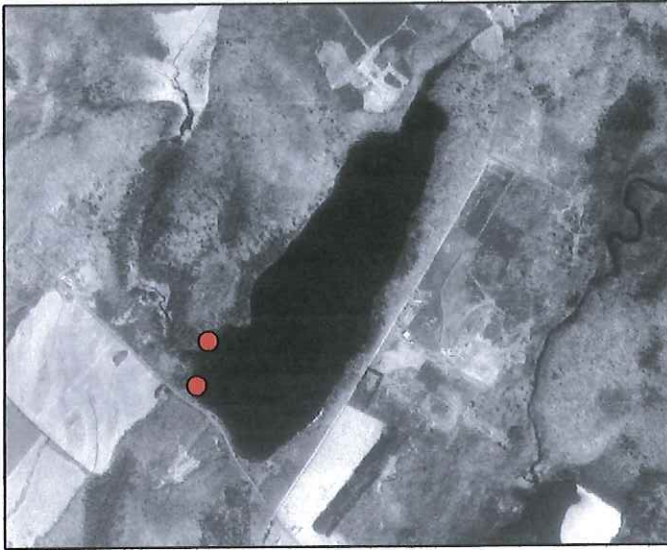


Eleocharis acicularis



Elodea nuttallii

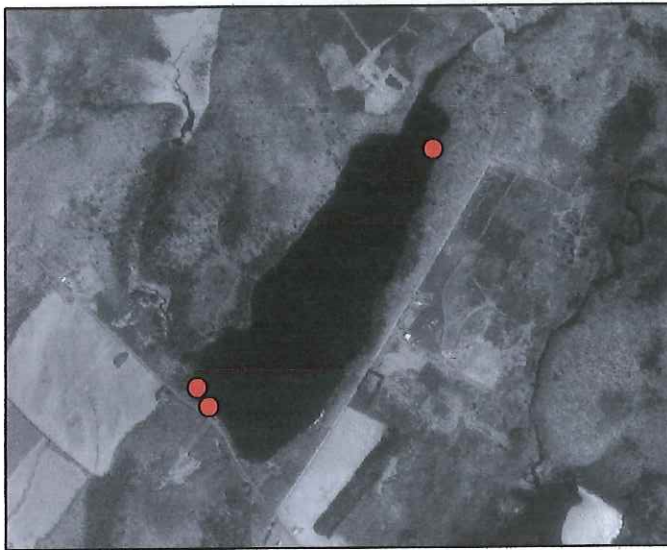
Dunn Pond



Equisetum fluviatile



Eriocaulon aquaticum



Fontanalis sullivantii



Glyceria borealis



Glyceria canadensis



Isoetes echinospora

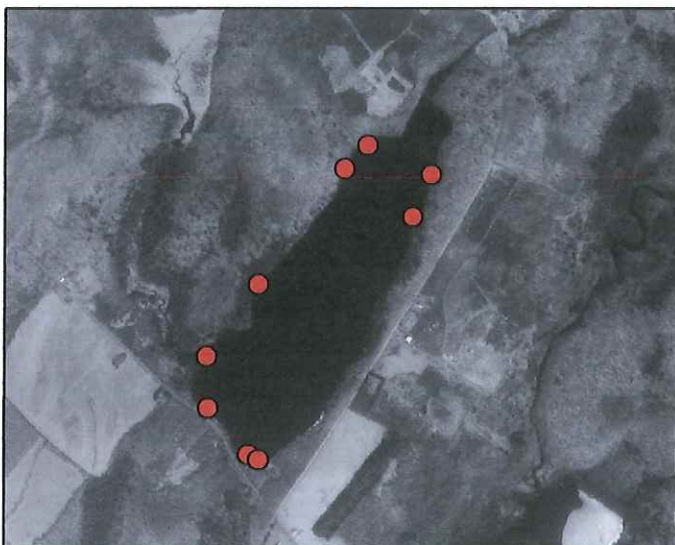
Dunn Pond



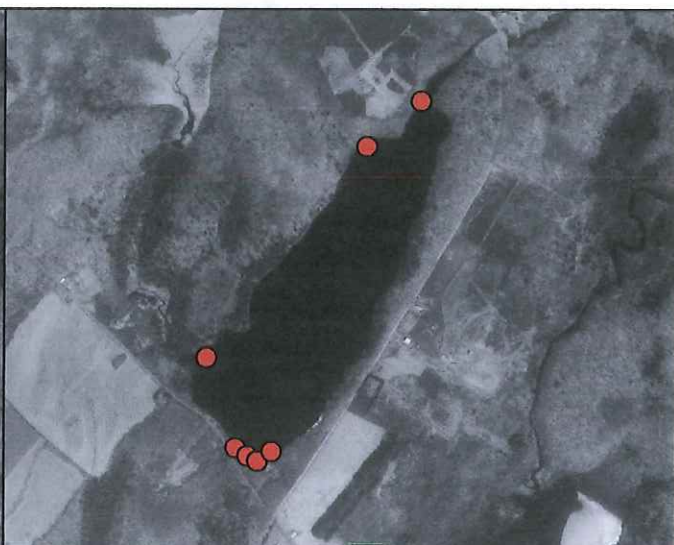
Juncus militaris



Lobelia dortmanna



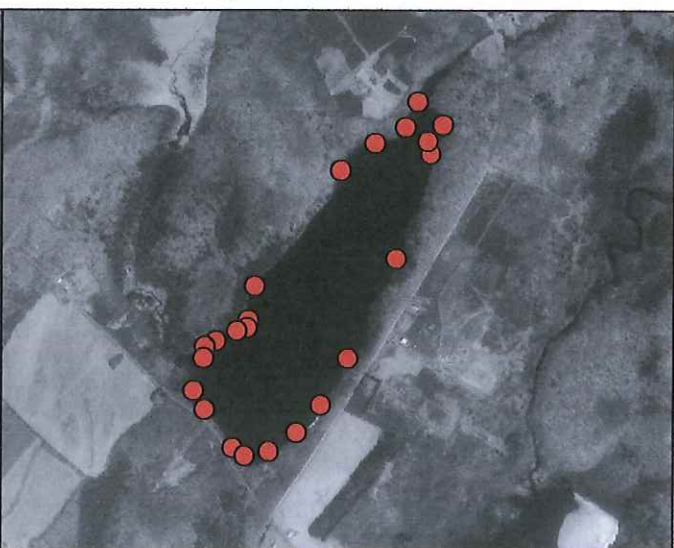
Lysimachia terrestris



Najas flexilis

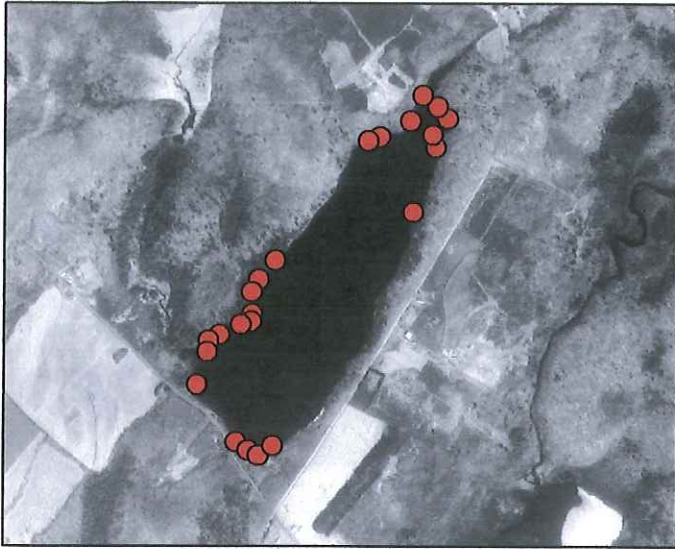


Nitella sp.



Nuphar variegata

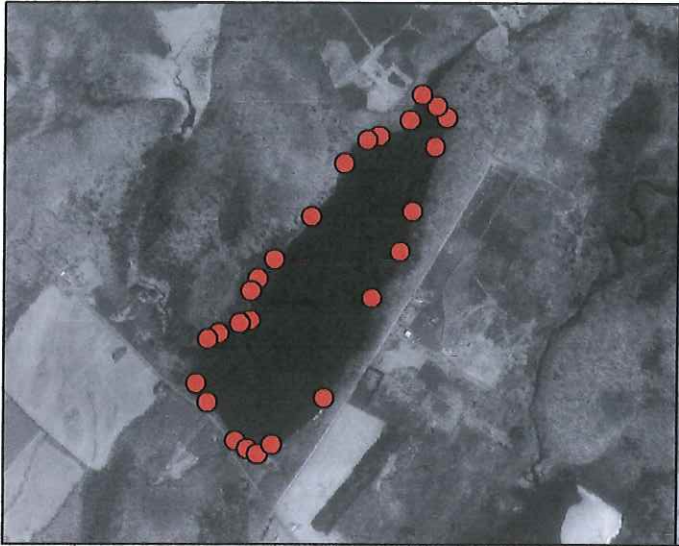
Dunn Pond



Nymphaea odorata



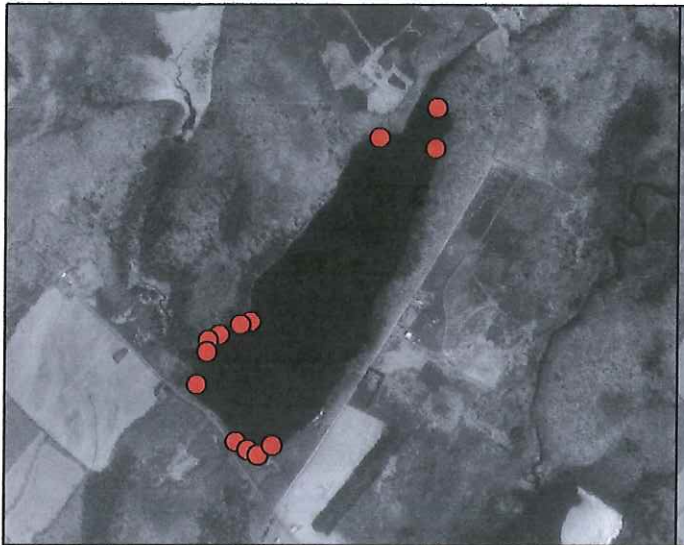
Polygonum sp.



Pontederia cordata



Potamogeton epihydrus

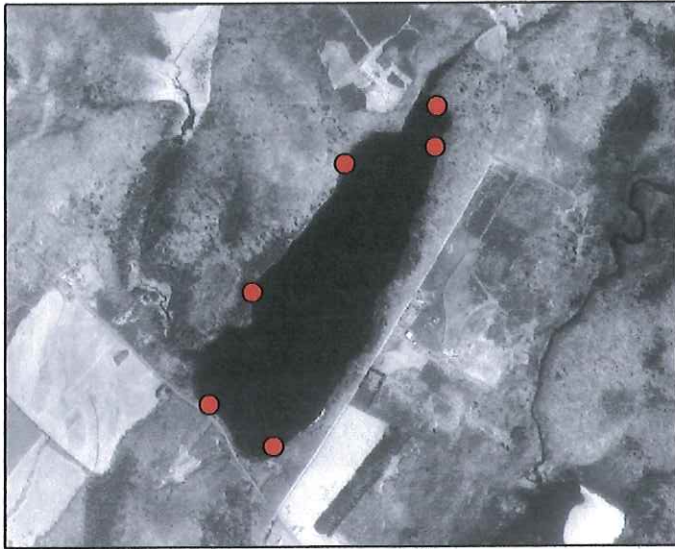


Potamogeton natans



Potamogeton robbinsii

Dunn Pond



Potamogeton spirillus



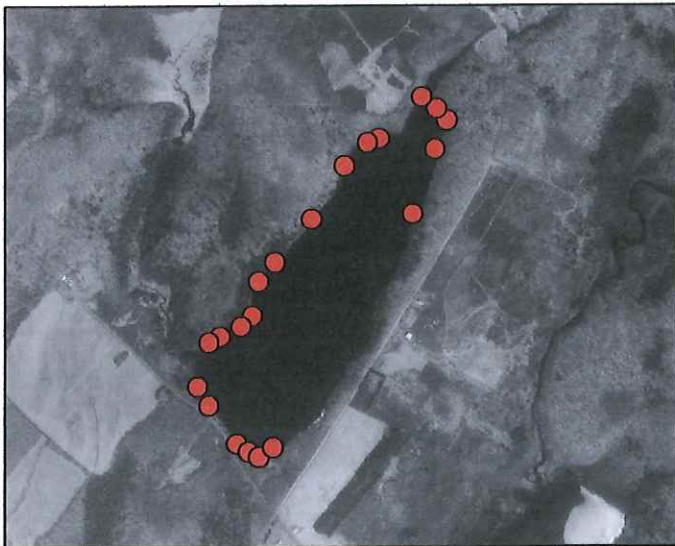
Ranunculus aquatilis



Sagittaria rigida



Schoenoplectus tabernaemontani



Sparganium americanum



Torreyochloa pallida

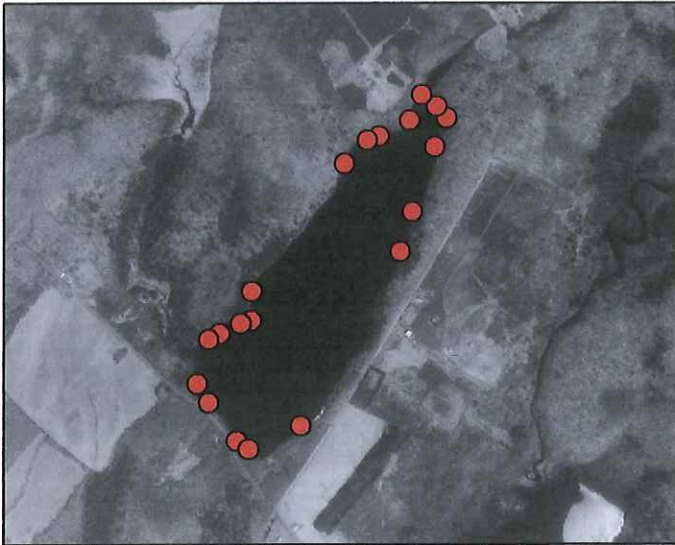
Dunn Pond



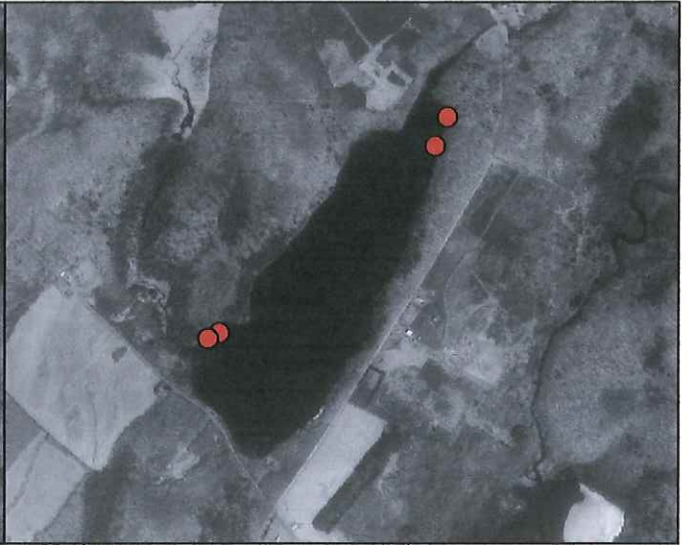
Typha latifolia



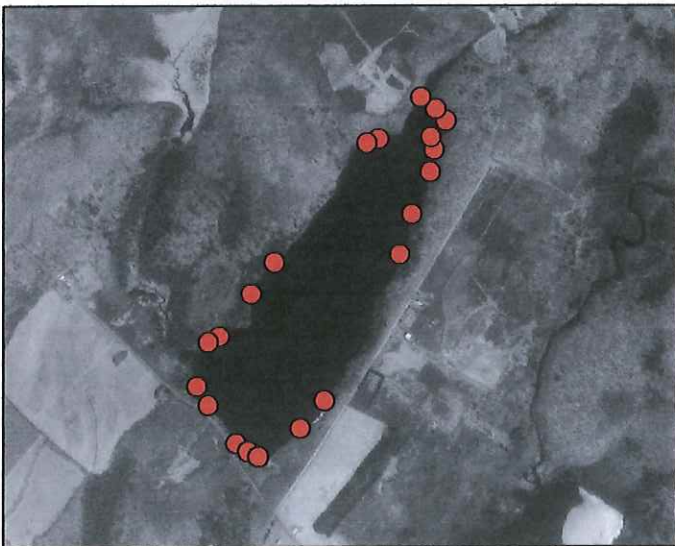
Utricularia cornuta



Utricularia gibba



Utricularia macrorhiza



Utricularia purpurea