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Aquatic Vegetation Inventory and Mapping at Promised Land State Park

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Prepared for Western Pennsylvania Conservancy and Pennsylvania Bureau of State Parks

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Aquatic Vegetation Inventory and Mapping at Promised Land State Park

Abstract

This project was undertaken, primarily, to improve our understanding of the aquatic vegetation of the lakes at Promised Land State Park. Both Promised Land Lake and Lower Lake are home to substantial diversity of aquatic plant species, but vary in physical structure, species assemblages, and specific plant community composition.

Multiple methodologies were used to survey for species presence and attempt to characterize communities.

It is well understood that the Bureau of State Parks is under pressure from competing interests to manage its aquatic resources for purposes ranging from biological conservation to various forms of active recreation. These interests are often at odds and irreconcilable, particularly in the context of aquatic ecosystems.

In both cases, Promised Land Lake and Lower Lake, we advise that no effort be undertaken to actively manage aquatic vegetation, in spite of the presence of large populations of *Myriophyllum heterophyllum*, an aggressive weed, in both lakes.

We further suggest that additional resources be dedicated to continuing examination of aquatic resources at Promised Land State Park. This baseline study represents an opportunity to build a thorough scientific study over time.

Disciplines

Botany

Comments

Prepared for Western Pennsylvania Conservancy and Pennsylvania Bureau of State Parks

Final Report
Aquatic Vegetation Inventory and Mapping at
Promised Land State Park



Callitriche heterophylla – Promised Land Lake, August 2014

June 18, 2015

Botany Department
Morris Arboretum of the University of Pennsylvania

Prepared for Western Pennsylvania Conservancy
and
Pennsylvania Bureau of State Parks

Summary:

This project was undertaken, primarily, to improve our understanding of the aquatic vegetation of the lakes at Promised Land State Park. Both Promised Land Lake and Lower Lake are home to substantial diversity of aquatic plant species, but vary in physical structure, species assemblages, and specific plant community composition.

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We further suggest that additional resources be dedicated to continuing examination of aquatic resources at Promised Land State Park. This baseline study represents an opportunity to build a thorough scientific study over time.

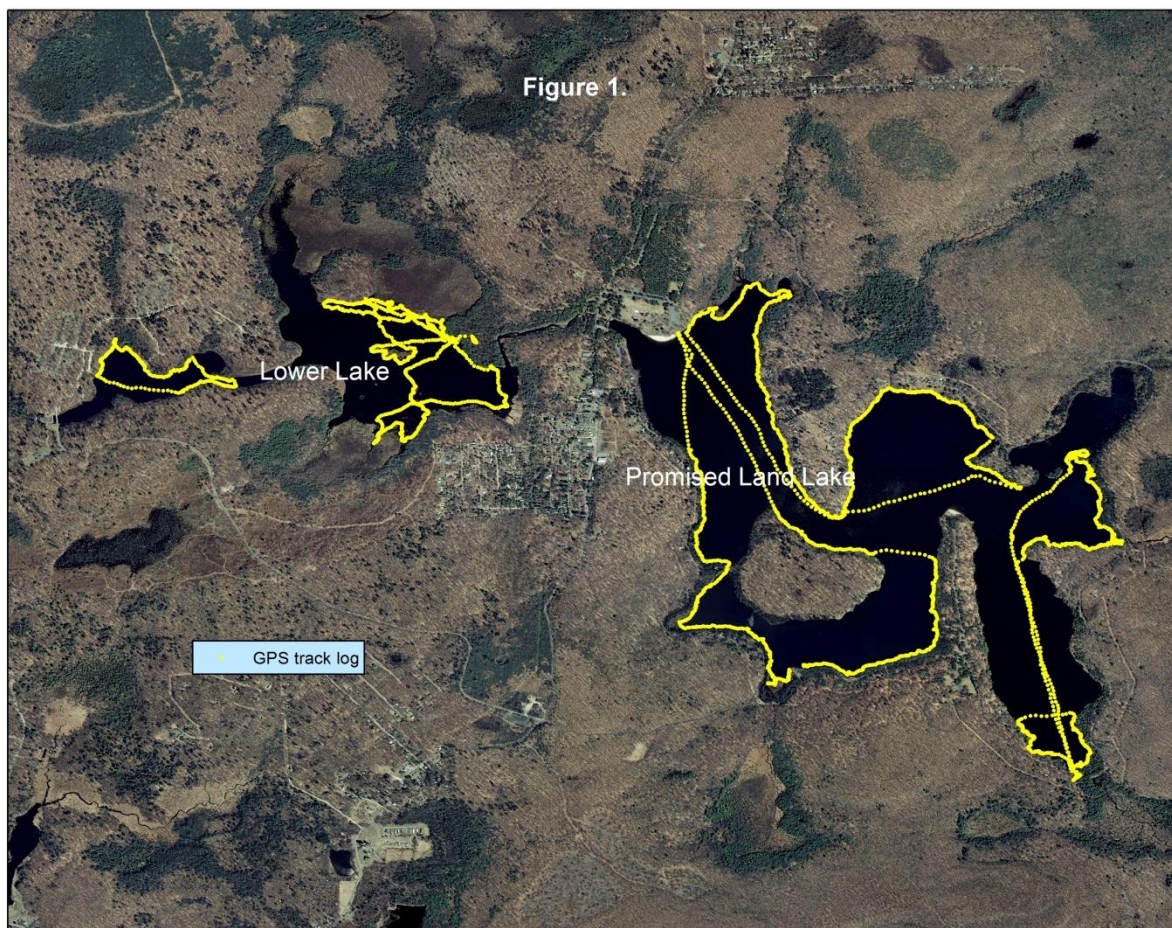
Purpose of the Project:

This project was undertaken for the general purposes of 1) adding to our knowledge of aquatic plant distributions in Pennsylvania; 2) assisting the Bureau of State Parks in making appropriate management decisions in balancing the needs of living organisms with recreational demands; 3) to add data to the Pennsylvania Natural Heritage Program and the Department of Environmental Protection's Clean Lakes Program; and 4) to enhance our understanding of the relationships between water quality and specific aquatic plant assemblages.

General Methodologies:

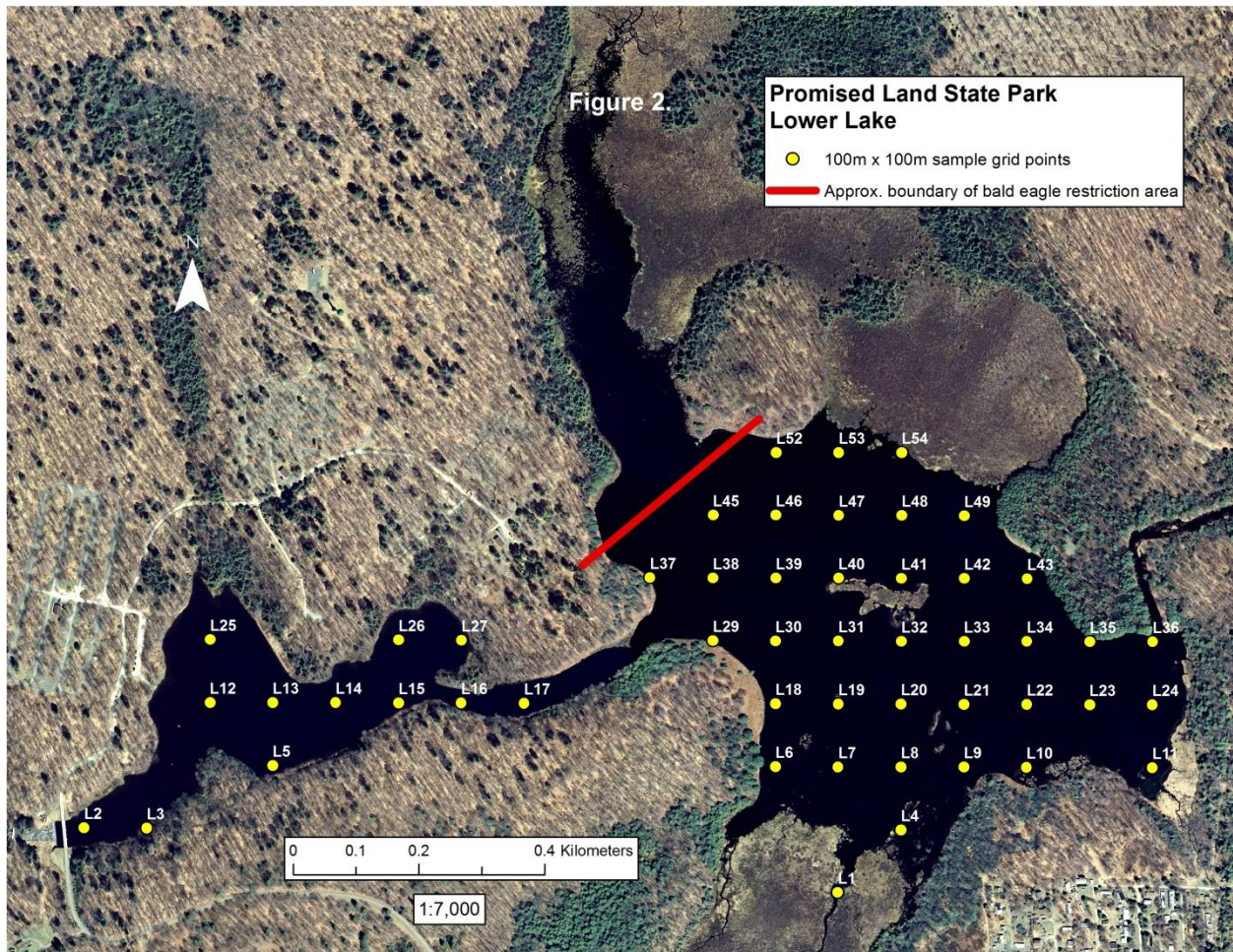
Field work on this project took place from June 19 to June 25, 2014 and from August 20 to August 25, 2014 for a total of 13 days. A typical field day consisted of both point-based sampling and a comprehensive inventory of part of a lake.

Both Promised Land Lake (Upper Lake) and Lower Lake at Promised Land State Park were surveyed for aquatic plant species by examining the littoral zones by boat and/or on foot where appropriate. All species of aquatic plants encountered were collected, identified (on site, if possible, or later in the lab), pressed and dried, and prepared for deposition in the herbarium at the Morris Arboretum (MOAR). Figure 1 shows the GPS track logs of these survey meanders.



Additionally, a more intensive survey method was applied to Lower Lake. Prior to visiting Lower Lake, a regular grid of points 100 meters equidistant was overlaid on the surface of the lake in GIS. Once in the field, each point was navigated to and all species observed within approximately 5 meters of each point recorded. Figure 2 shows the layout of the grid system described. Note that the northern arm of Lower Lake was off limits due to the presence of nesting Bald Eagles.

This purpose of this point-based sampling methodology was to provide a basis for repeatability should further aquatic vegetation studies be undertaken at Promised Land State Park in the future. Unfortunately, there was not enough time in this project to apply this more quantitative methodology to Promised Land Lake (Upper Lake).

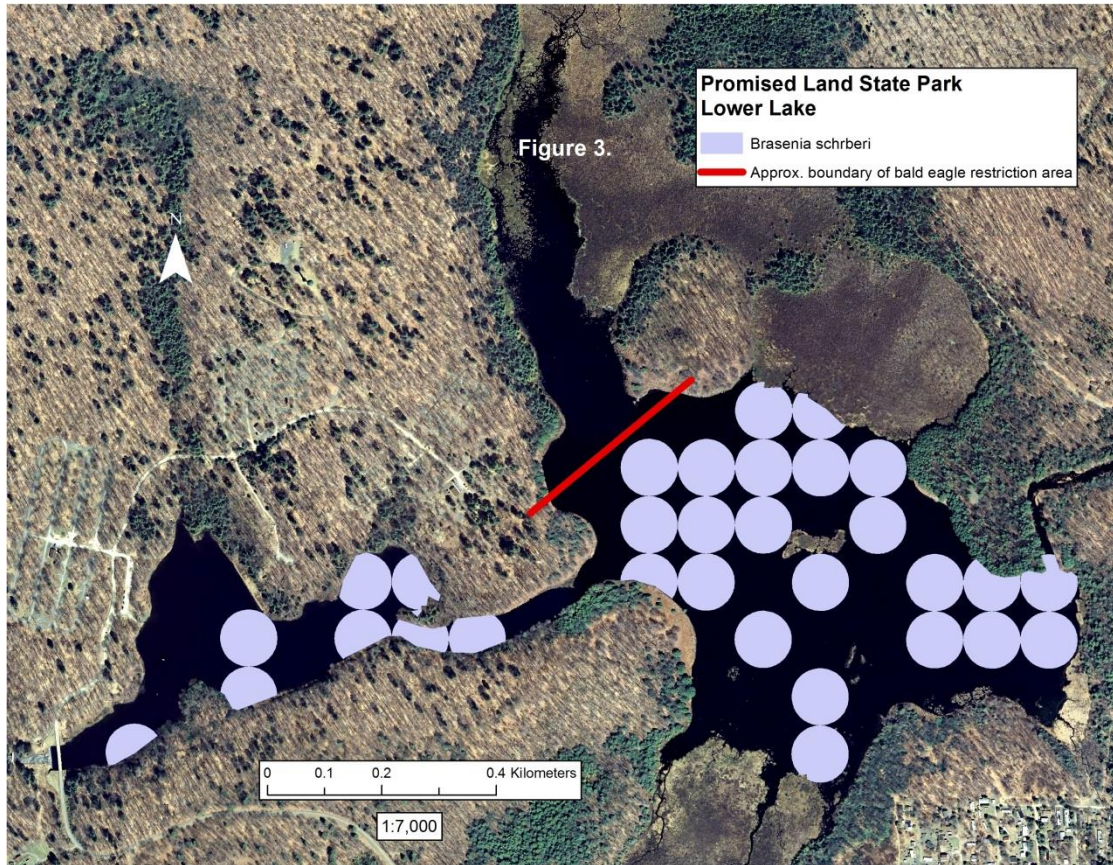


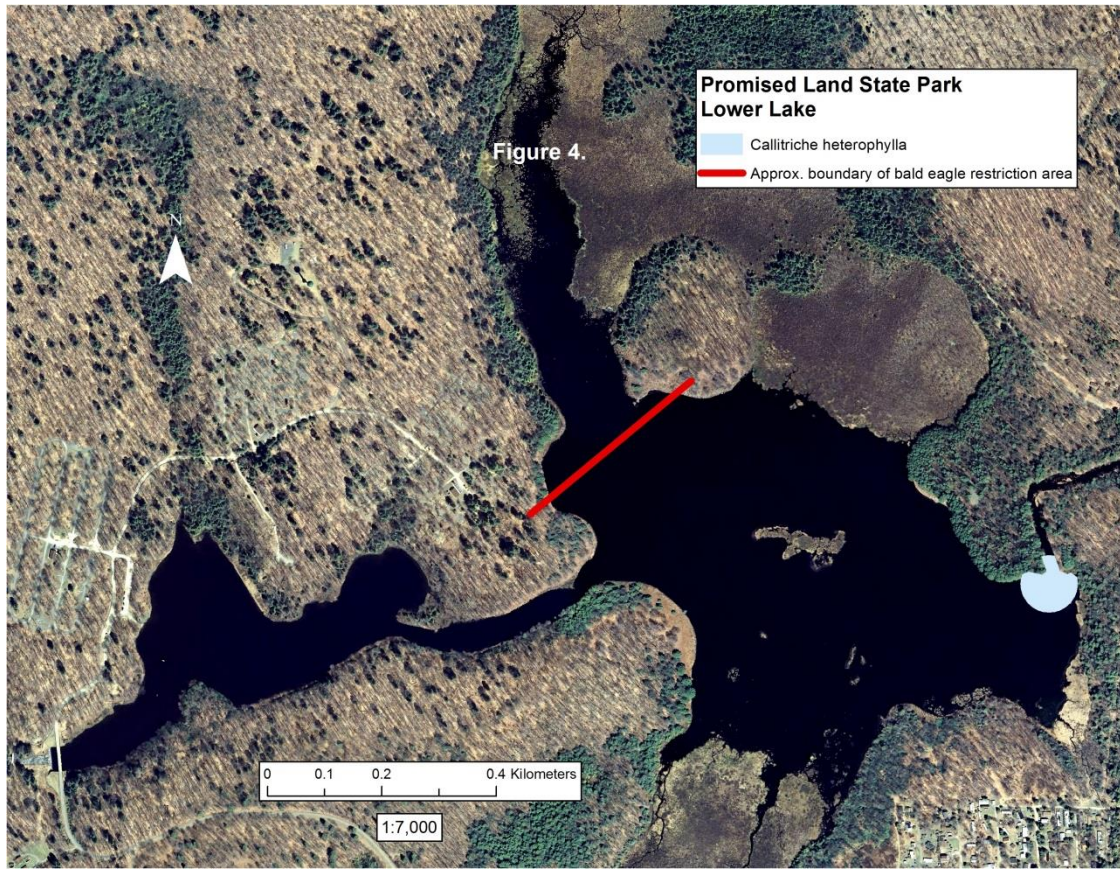
Using plant distribution and water quality data compiled over a number of years and from a number of lakes, an analysis of species actually present vs. species predicted to be present, given existing water quality parameters, was conducted. The specific statistical procedures in the analysis included binary regression analysis for comparison of presence/absence data with numerical water quality data, and utilization of Beal's Smoothing, a technique for predicting the probability of a species' presence based on that species' association with other species in other lakes.

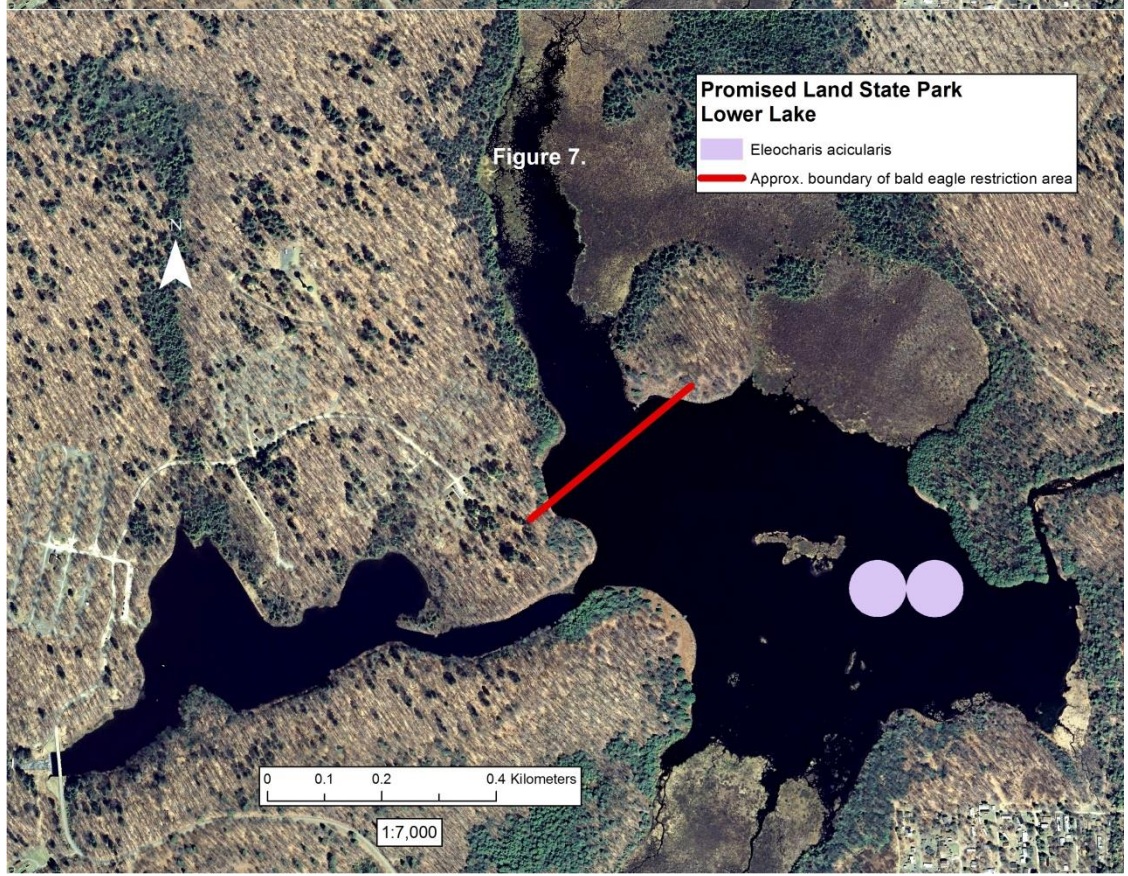
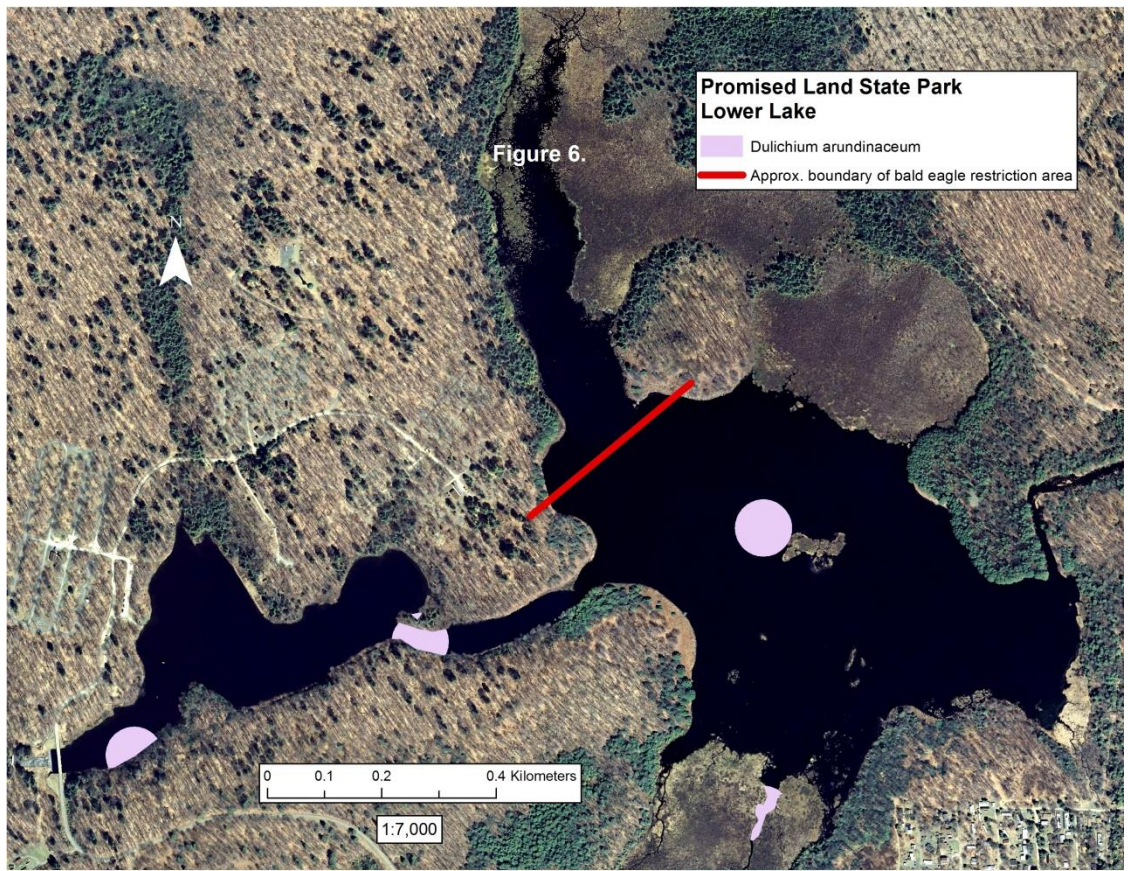
A comprehensive list of species observed and individual species maps were prepared. Areas of the lakes that represent especially critical or sensitive resources were noted. Specific recommendations for management of these areas were prepared.

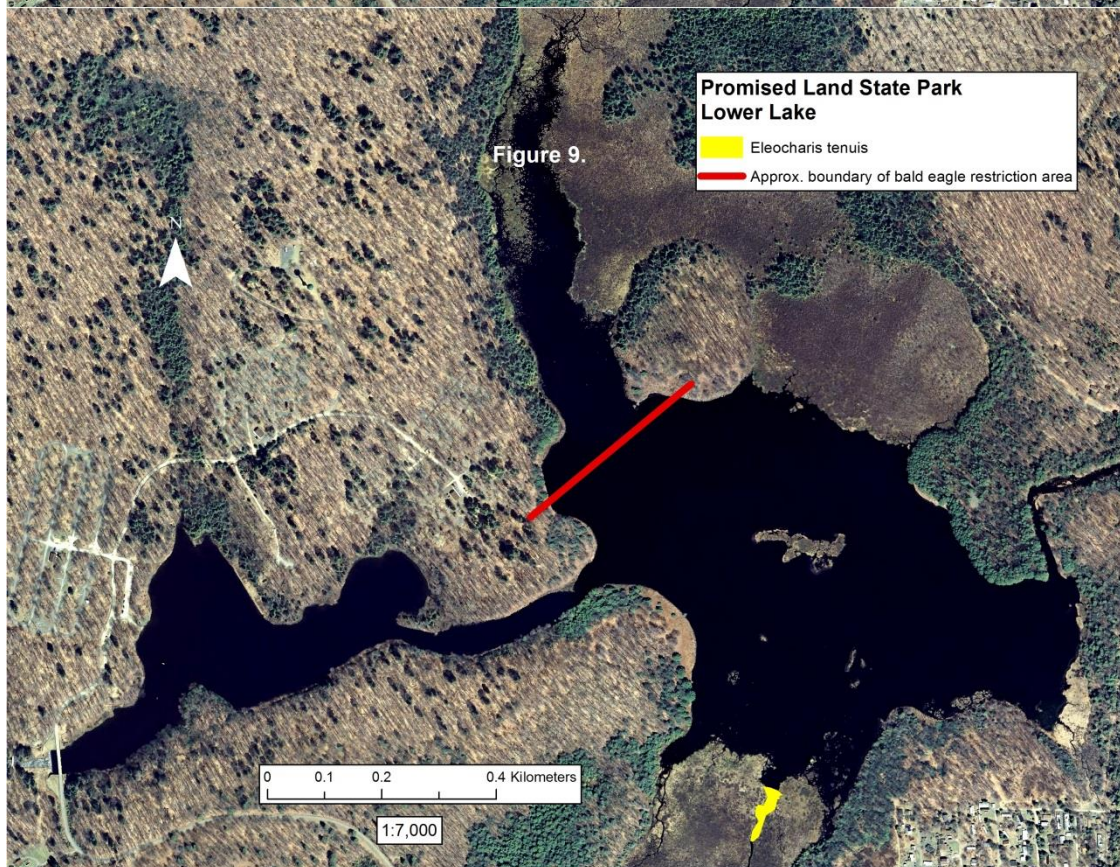
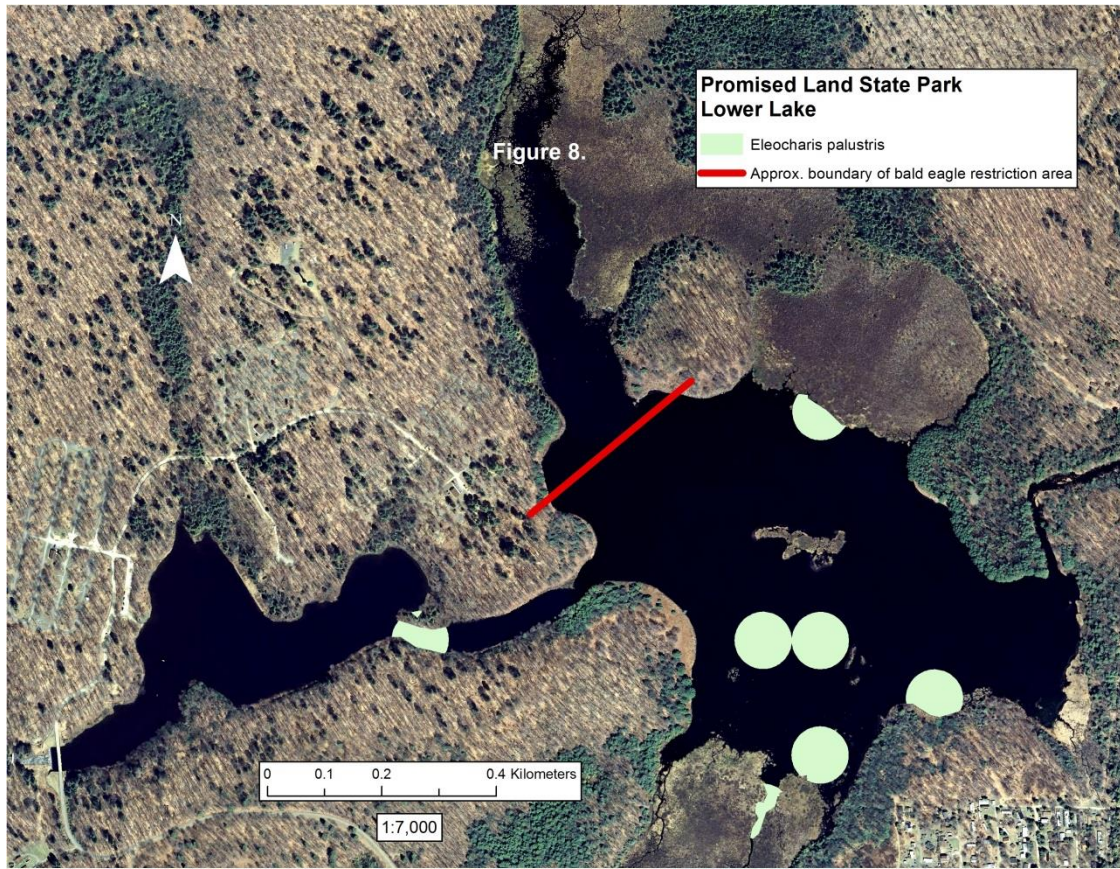
Results:

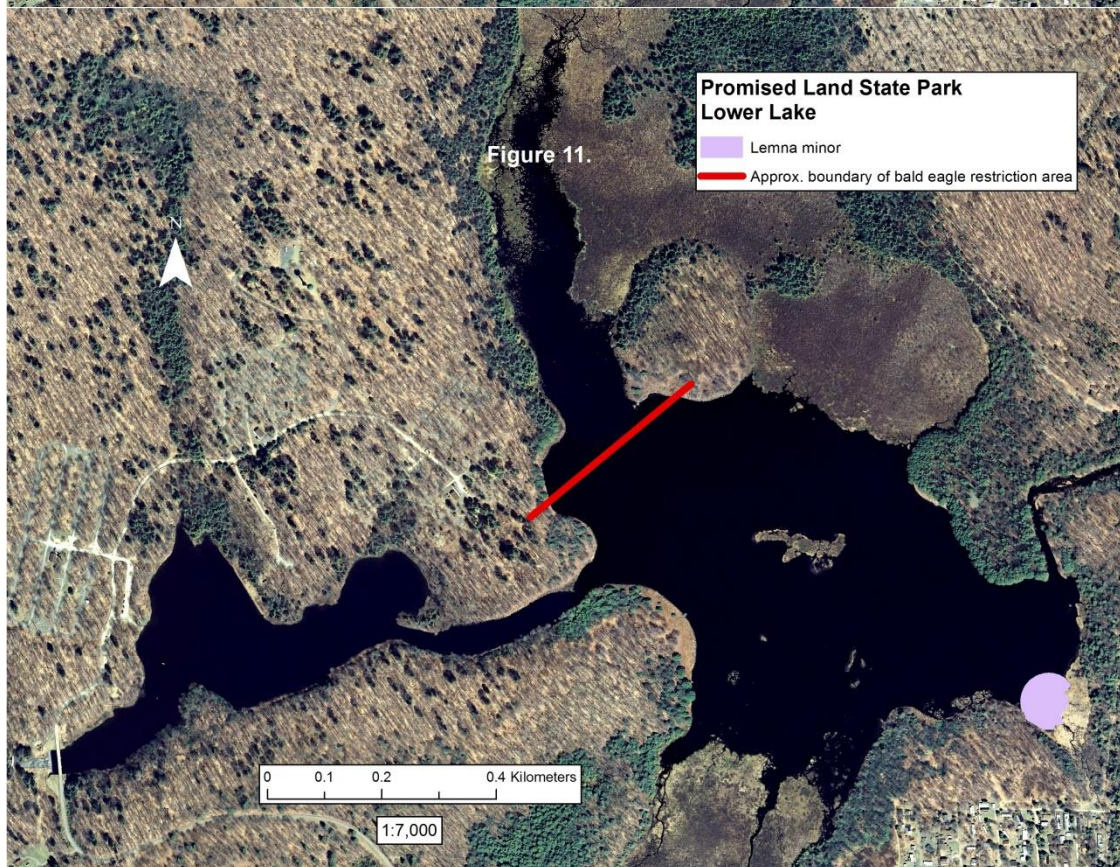
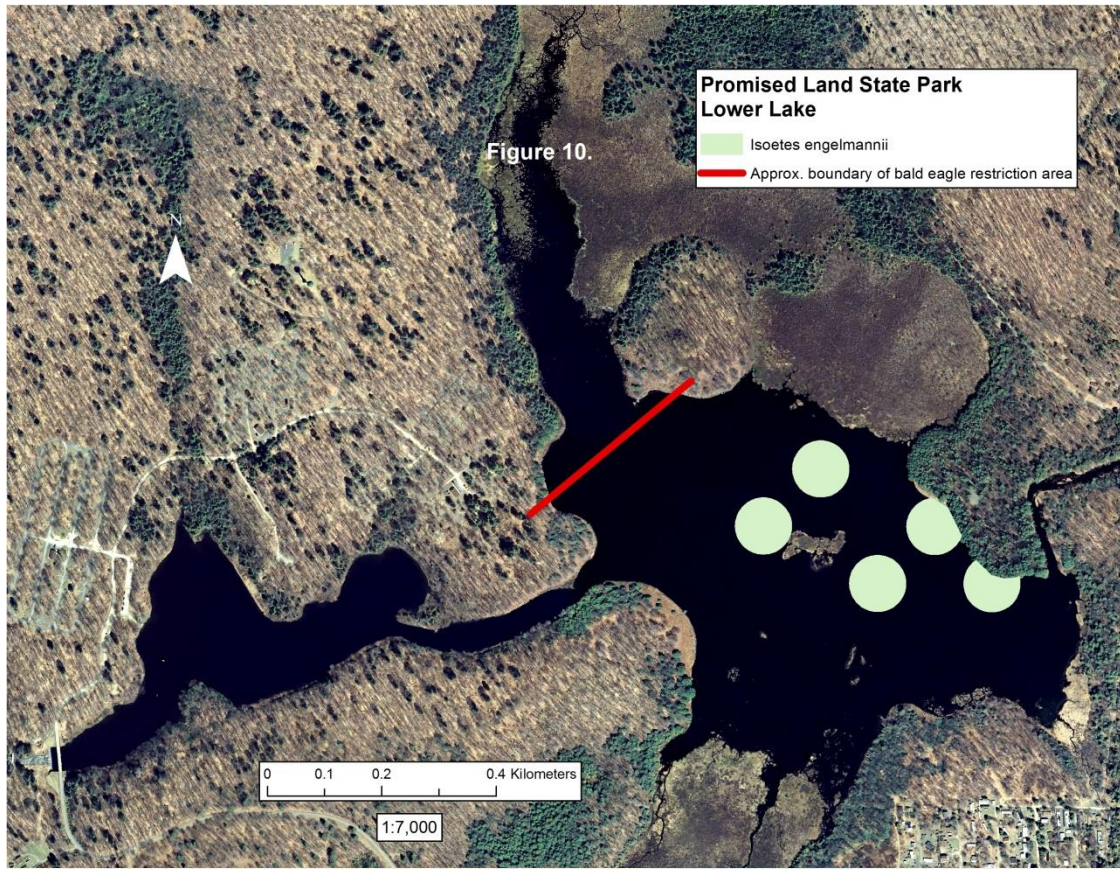
Figures 3 through 23 show the distributions of the various aquatic plant species observed in the Lower Lake in the 2014 field season.

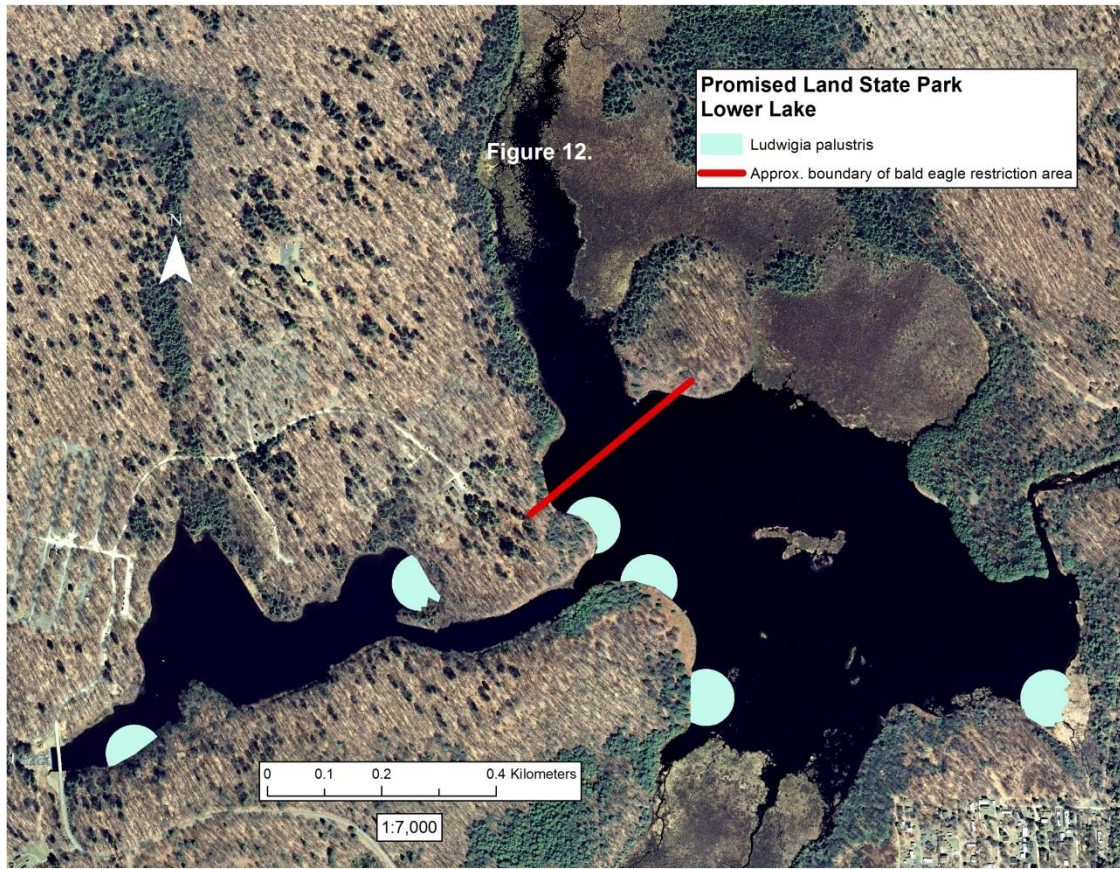


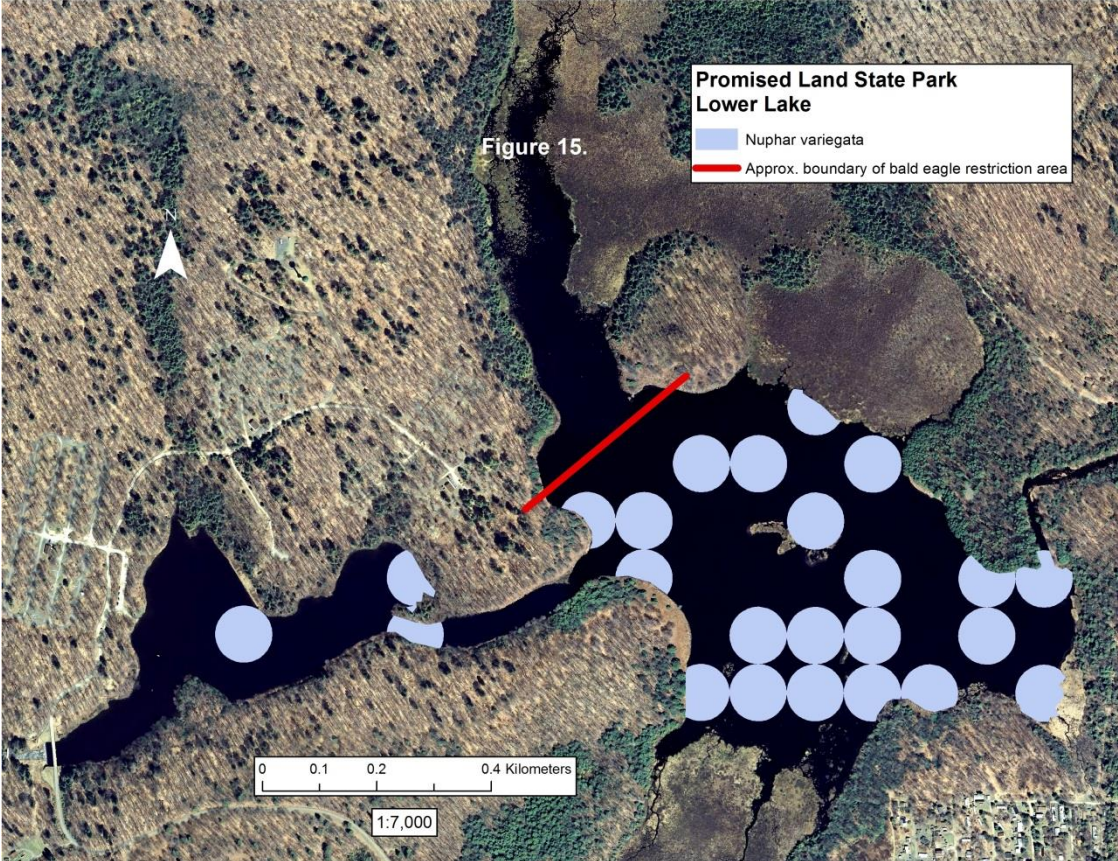
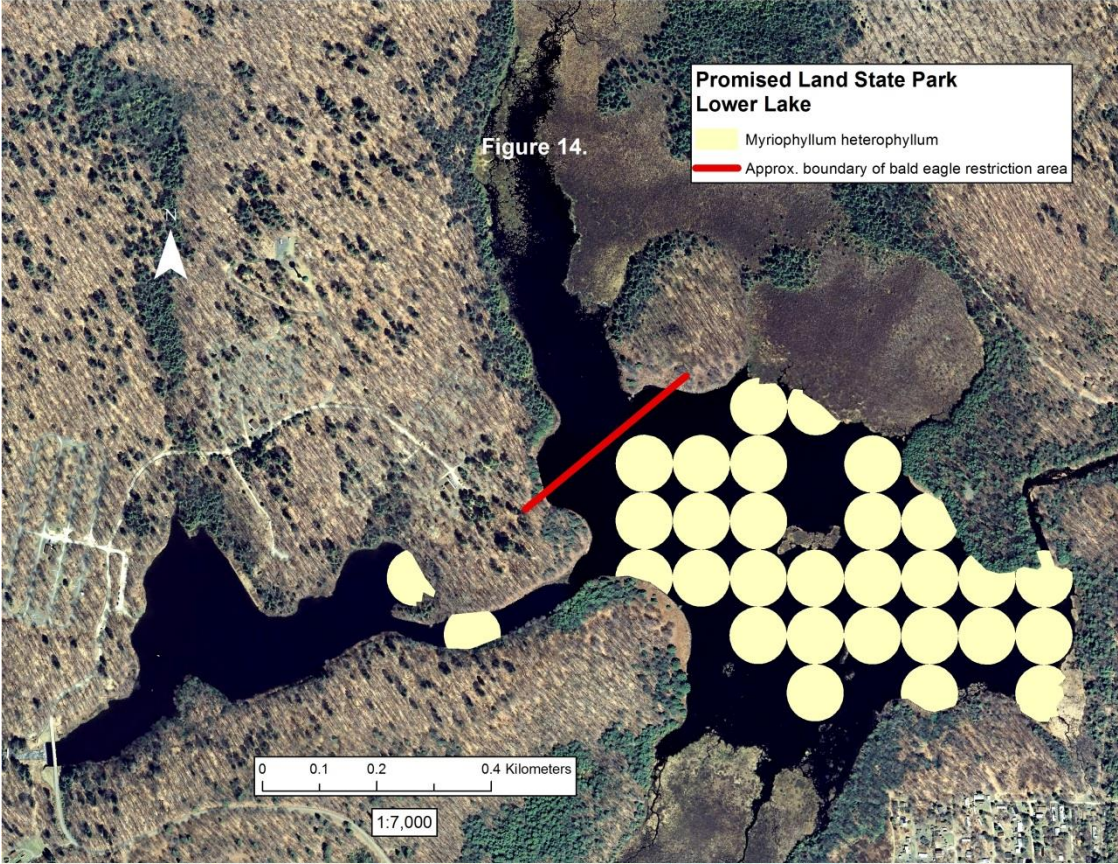


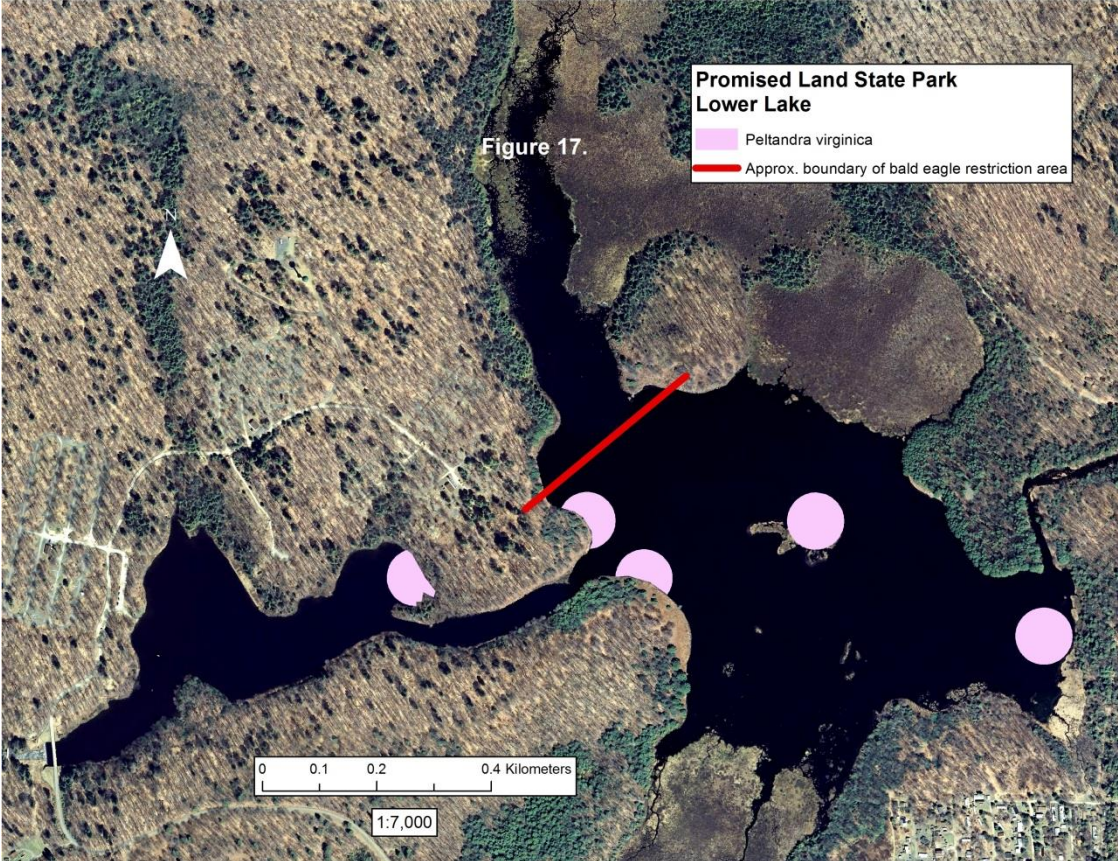
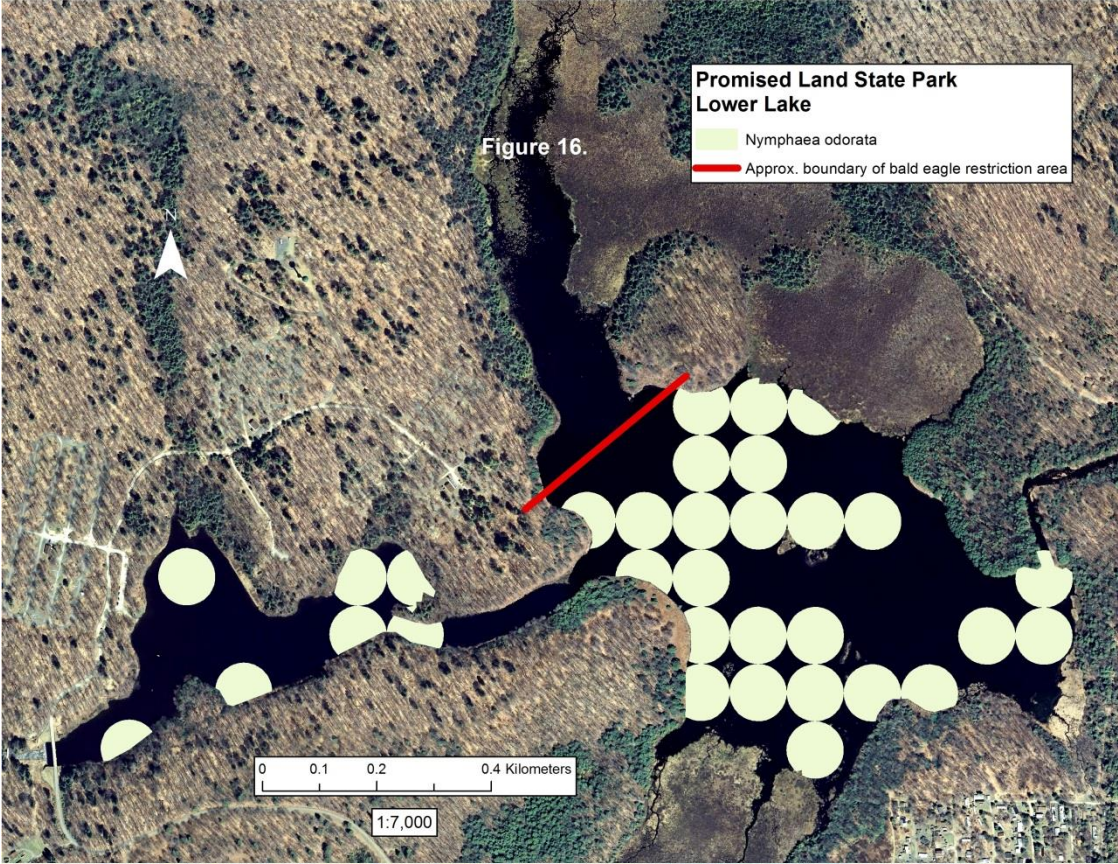


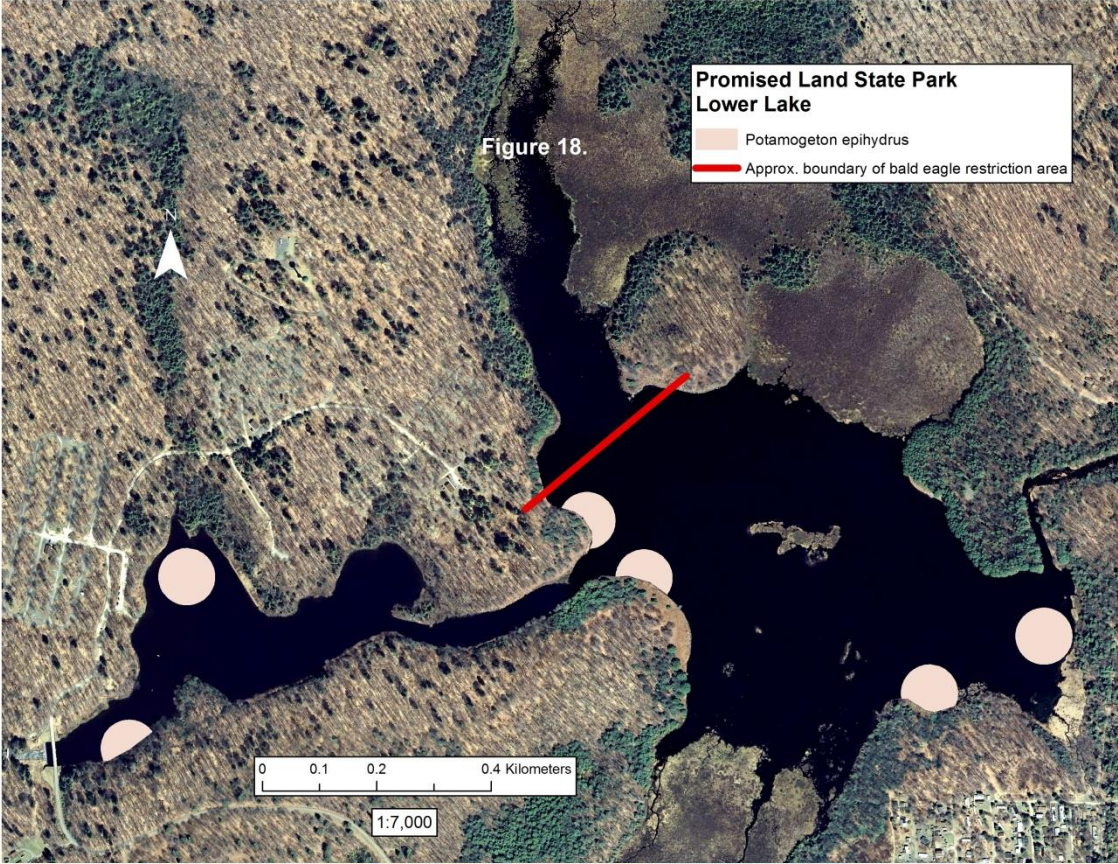


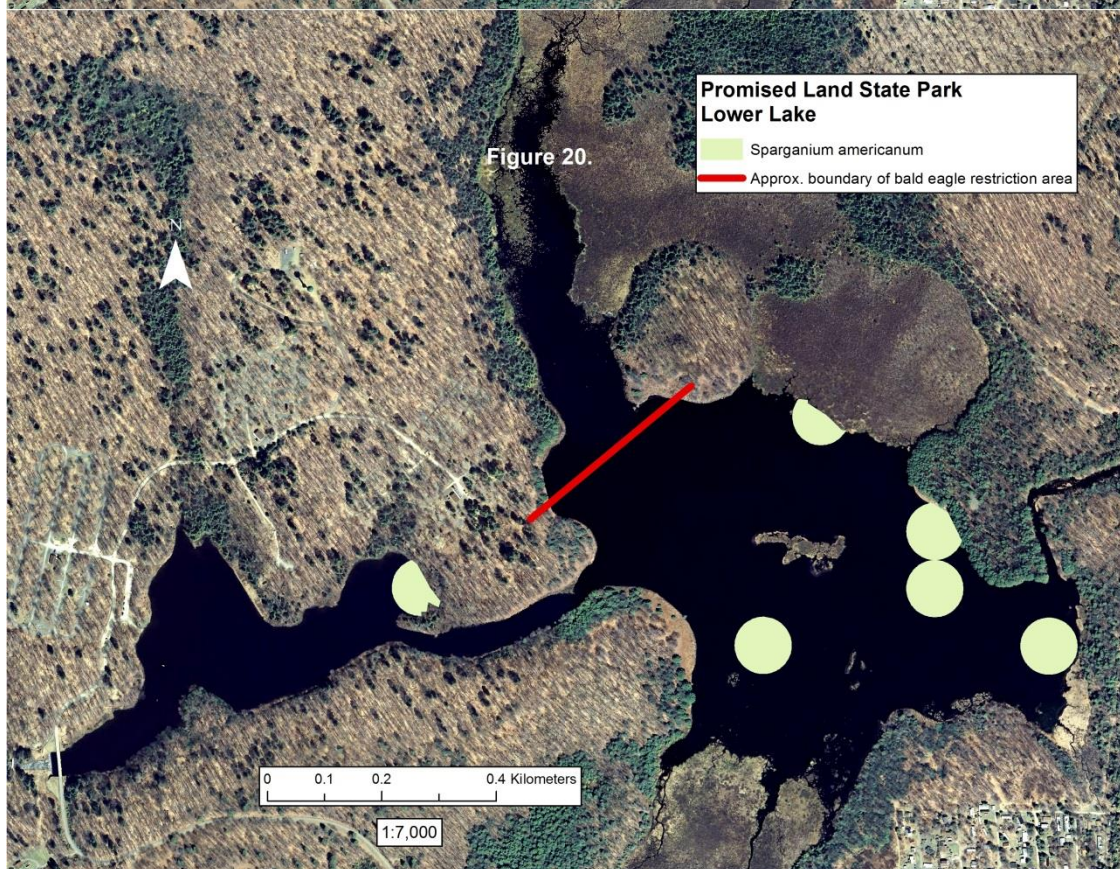
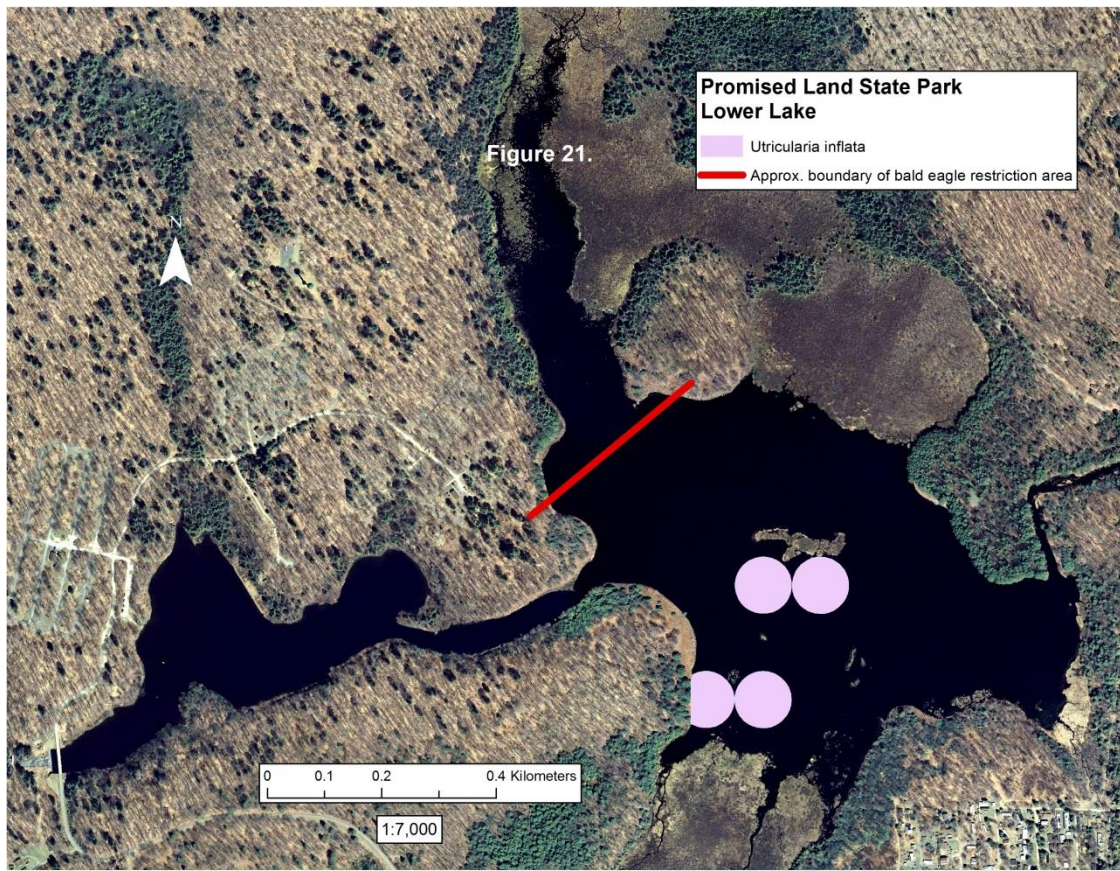












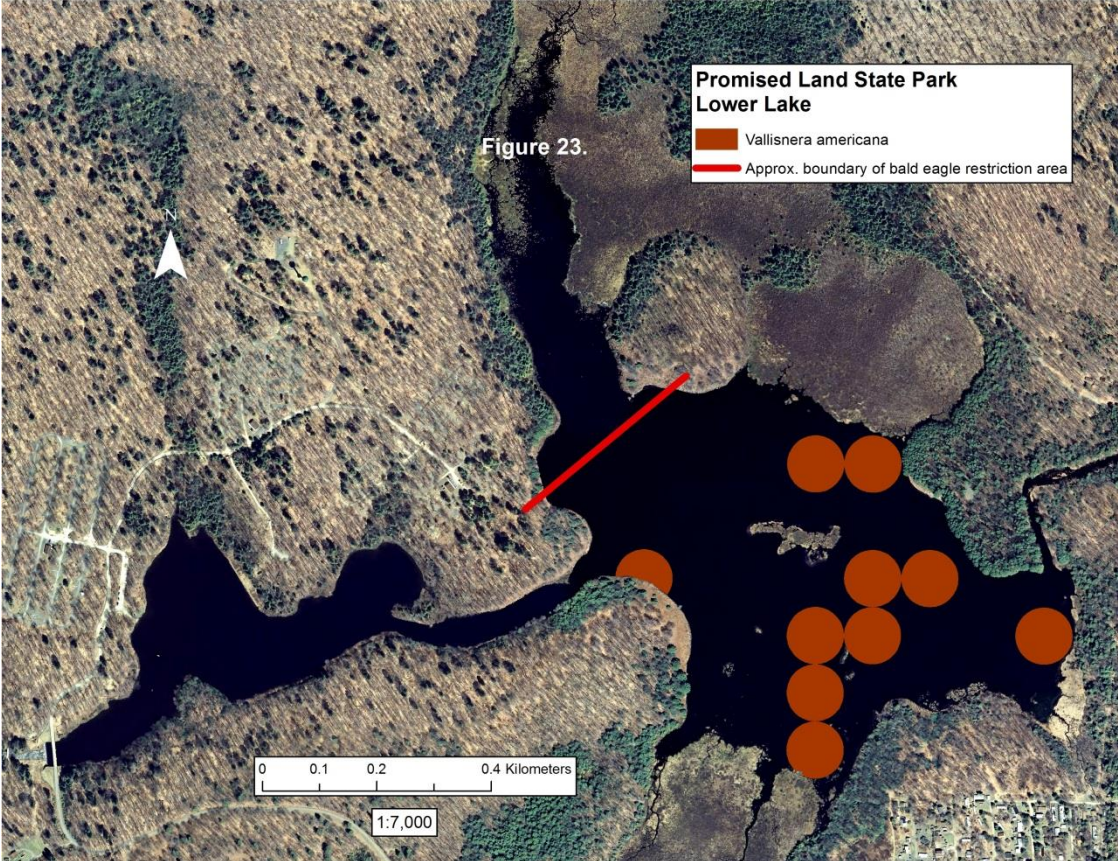
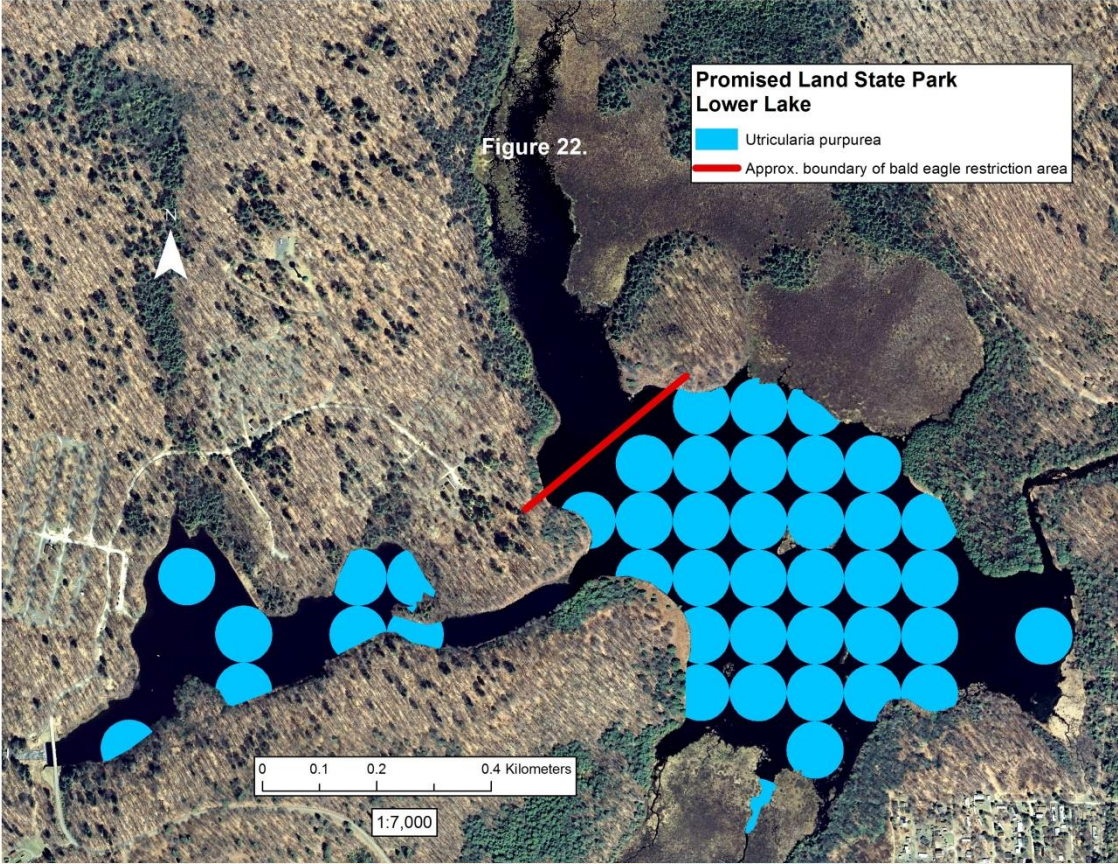


Table 1 is a listing of the aquatic plant species observed in this study compared with the species observed in our 2005 inventory of the lakes at Promised Land State Park. Note that there are more species on the overall diversity list than are accounted for in the point-based sampling. This is a result of the fact that not all species present were observed at a sampling point.

Table 1.			
LOWER LAKE AQUATIC SPECIES 2014	LOWER LAKE AQUATIC SPECIES 2005	UPPER LAKE AQUATIC SPECIES 2014	UPPER LAKE AQUATIC SPECIES 2005
Brasenia schreberi	Brasenia schreberi	Brasenia scheberi	Brasenia schreberi
Callitriche heterophylla	Decodon verticillata	Callitriche heterophylla	Callitriche heterophylla
Decodon verticillatus	Dulichium arundinaceum	Elodea nuttallii	Ceratophyllum echinatum
Dulichium arundinaceum	Elatine triandra	Fontinalis sulivantii	Chara sp.
Elatine minima	Eleocharis acicularis	Iris versicolor	Decodon verticillata
Elatine triandra	Eleocharis olivacea	Isoetes sp.	Dulichium arundinaceum
Eleocharis acicularis	Eleocharis palustris	Ludwigia palustris	Elatine minima
Eleocharis olivacea	Fontanalis sullivantii	Myriophyllum heterophyllum	Elatine triandra
Eleocharis palustris	Glyceria borealis	Nuphar variegata	Eleocharis acicularis
Eleocharis tenuis	Isoetes engelmannii	Potamogeton amplifolius	Eleocharis palustris
Fontanalis sullivantii	Lemna minor	Potamogeton crispus	Elodea nuttallii
Glyceria borealis	Ludwigia palustris	Potamogeton sp.	Fontanalis sullivantii
Isoetes engelmannii	Lysimachia terrestris	Sagittaria latifolia	Isoetes echinospora
Lemna minor	Myriophyllum farwellii	Sparganium americanum	Isoetes engelmannii
Ludwigia palustris	Myriophyllum heterophyllum	Utricularia inflata	Lemna minor
Lysimachia terrestris	Myriophyllum humile	Utricularia purpurea	Lysimachia terrestris
Myriophyllum heterophyllum	Najas flexilis	Vallisneria americana	Myriophyllum farwellii
Myriophyllum humile	Najas gracillima		Myriophyllum heterophyllum
Najas flexilis	Nuphar variegata		Najas flexilis
Najas gracillima	Nymphaea odorata		Nuphar variegata
Nuphar variegata	Pontederia cordata		Nymphaea odorata
Nymphaea odorata	Potamogeton bicupulatus		Pontederia cordata
Peltandra virginica	Potamogeton epihydrus		Potamogeton amplifolius
Pontederia cordata	Potamogeton pusillus		Potamogeton epihydrus
Potamogeton crispus	Potamogeton spirillus		Potamogeton pusillus
Potamogeton epihydrus	Sagittaria graminea var. graminea		Potamogeton spirillus
Potamogeton obtusifolius	Sagittaria latifolia		Sagittaria graminea var. graminea
Sagittaria graminea var. graminea	Sparganium americanum		Sagittaria latifolia
Sagittaria latifolia	Triadenum virginicum		Sparganium americanum
Sparganium americanum	Typha latifolia		Spirodella polyrhiza
Triadenum virginicum	Utricularia inflata		Typha latifolia
Typha latifolia	Utricularia macrorrhiza		Utricularia gibba
Utricularia geminiscapa	Utricularia purpurea		Utricularia macrorrhiza
Utricularia gibba	Vallisneria americana var. americana		Utricularia minor
Utricularia inflata			Utricularia purpurea
Utricularia macrorrhiza			Vallisneria americana var. americana
Utricularia purpurea			
Vallisneria americana			

Table 2 was extracted from a much broader analysis of aquatic species in Pennsylvania. In a Beals' Analysis, the output values represent comparative probabilities of any species occurring in the presence of a larger set of species actually present at a given site. Note that some species actually present may have lower values in the table than other species not actually observed. In spite of the somewhat counterintuitive nature this phenomenon, this analysis has value for future research in that it indicates species that may have been overlooked, or species that would seem to have potential for occurrence in these lakes at a later point in time.

Table 2. Output of Beals' Smoothing Analysis

Values in table represent comparative likelihood of species occurrence given existing species assemblage

	Lower Lake	Promised Land Lake
<i>Brasenia schreberi</i>	0.659917653	0.652082086
<i>Callitriche heterophylla</i>	0.362386942	0.365707099
<i>Ceratophyllum demersum</i>	0.044224843	0.051415302
<i>Ceratophyllum echinatum</i>	0.322842598	0.380373865
<i>Cladium mariscoides</i>	0.040037956	0.034819324
<i>Decodon verticillatus</i>	0.557935596	0.540365756
<i>Dulichium arundinaceum</i>	0.564432979	0.560356081
<i>Elatine minima</i>	0.498007774	0.514750004
<i>Elatine triandra</i>	0.425098836	0.406932771
<i>Eleocharis acicularis</i>	0.71202904	0.704949975
<i>Eleocharis obtusa</i>	0.124767445	0.114015818
<i>Eleocharis olivacea</i>	0.258583546	0.214580789
<i>Eleocharis palustris</i>	0.548648179	0.555991769
<i>Eleocharis robbinsii</i>	0.051685903	0.064370282
<i>Elodea nuttallii</i>	0.402014494	0.467421144
<i>Equisetum fluviatile</i>	0.120339125	0.116175704
<i>Eriocaulon aquaticum</i>	0.421958983	0.417673081
<i>Fontanalis sullivantii</i>	0.486617595	0.492359608
<i>Glyceria borealis</i>	0.172352314	0.119506784
<i>Iris pseudacorus</i>	0.074924834	0.070243694
<i>Iris versicolor</i>	0.18602331	0.199670926
<i>Isoetes echinata</i>	0.488177806	0.50461179
<i>Isoetes engelmannii</i>	0.282596737	0.266462237
<i>Juncus militaris</i>	0.157771513	0.16470173
<i>Lemna minor</i>	0.361533165	0.365554571
<i>Lobelia dortmanna</i>	0.089560568	0.092288986
<i>Ludwigia palustris</i>	0.40465045	0.36242801
<i>Lysimachia terrestris</i>	0.63567245	0.61136508
<i>Myriophyllum farwellii</i>	0.148442864	0.136936918
<i>Myriophyllum heterophyllum</i>	0.193814516	0.179240897
<i>Myriophyllum humile</i>	0.387193531	0.330385208
<i>Myriophyllum spicatum</i>	0.057296522	0.075406648

Myriophyllum tenellum	0.099279098	0.094595611
Najas flexilis	0.685947835	0.717788041
Najas gracillima	0.259164274	0.299420506
Nuphar variegata	0.857694685	0.860395432
Nymphaea odorata	0.789477348	0.788124859
Nymphoides cordata	0.194269359	0.193166316
Orontium aquaticum	0.175392658	0.166218713
Peltandra virginica	0.134790406	0.160084128
Pontederia cordata	0.662004292	0.66531992
Potamogeton amplifolius	0.29100123	0.316895008
Potamogeton bicupulatus	0.395729691	0.335606694
Potamogeton crispus	0.070737854	0.079219468
Potamogeton diversifolius	0.194628835	0.20521304
Potamogeton epihydrus	0.778926492	0.766127527
Potamogeton foliosus	0.078623854	0.091380253
Potamogeton natans	0.100176439	0.122117594
Potamogeton pusillus	0.390782923	0.404406875
Potamogeton robbinsii	0.266518027	0.279860735
Potamogeton spirillus	0.560669303	0.557250202
Sagittaria gramineus	0.316578805	0.298717886
Sagittaria latifolia	0.545015395	0.531543255
Sagittaria rigida	0.093645364	0.102197789
Schoenoplectus purshii	0.0387148	0.029415639
Schoenoplectus subterminalis	0.159604684	0.167360067
Schoenoplectus torreyi	0.061735924	0.063090332
Sparganium americanum	0.77007699	0.772858441
Sparganium angustifolium	0.03962782	0.042761147
Sparganium chorocarpum	0.134283215	0.111788698
Sparganium eurycarpum	0.038623255	0.040196221
Sparganium fluctuans	0.026238995	0.022202525
Sprirodela polyrhiza	0.25477466	0.310198307
Utricularia cornuta	0.092830032	0.081930935
Utricularia geminiscapa	0.051061802	0.036978476
Utricularia gibba	0.352302283	0.388565302
Utricularia inflata	0.263987303	0.200984031
Utricularia intermedia	0.042257931	0.045408856
Utricularia macrorhiza	0.555295885	0.582030118
Utricularia minor	0.207381845	0.231902078
Utricularia purpurea	0.511683166	0.473356813
Vallisneria americana	0.475247383	0.486959964
Wolffia borealis	0.043739703	0.043219734
Wolffia columbiana	0.031220272	0.02884968

Discussion and Recommendations:

Lower Lake

It seems noteworthy that several species observed in the 2005 survey 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 lack 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.



Figure 24. Surface inflorescences of *Myriophyllum heterophyllum*

The values for total nitrogen (TN), total phosphorus (TP), and alkalinity recorded at the Promised Land lakes places them at about average to slightly above average for nutrients and alkalinity among a sample of 60 lakes in eastern Pennsylvania. The averages as noted are TN=0.541381, TP=0.032988, and Alk=15.22846.

Table 3. Generalized Summer Water Quality Values

	pH	TN (mg/L)	TP (mg/L)	Alk (CaCO ₃ - mg/L)
Lower Lake	6.677778	0.5675	0.01425	11.81
Promised Land Lake	6.19	0.685	0.0155	11.81

Given the relatively high nutrient values and pH values of greater than 6, both lakes at Promised Land State Park are vulnerable to invasion by additional non-native species and/or expansion of the non-natives already present if significant disturbance or removal of plants is undertaken.

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.

Promised Land Lake

The discrepancy between the number of species seen in 2014 and the greater number observed in 2005 is a result of the lack of time to complete a thorough inventory of the larger lake.

It's interesting, however, 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.

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.

As noted in Figure 25 (areas of special interest), these two small coves are areas of high species diversity. There is little, if any, *Myriophyllum heterophyllum* here and these areas are somewhat sheltered from wind and therefore less disturbed. These also are areas where the shoreline is less steep and small streams feed into the lake.

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.

As noted earlier, 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.

