DARRIN
Fresh Water Institute

Lake George, New York
Adirondack Field Station at Bolton Landing

Saratoga Lake Aquatic Plant Survey – 2009

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Background

Quantitative aquatic plant surveys were undertaken in 2009 for Saratoga Lake, New York as part of a cooperative effort between Aquatic Control Technologies (ACT) and the Darrin Fresh Water Institute, and supported by the Saratoga Lake Protection and Improvement District (SLPID). The aquatic plant survey was designed to be comparable to pre-treatment and post-treatment data collected by the author in 2004, 2007 and 2008 (Eichler & Boylen 2004; 2007; 2008a: 2008b) to evaluate a treatment program based on application of the herbicide fluridone (SONAR^{TM}) in 2007 and the herbicide triclopyr (Renovate) in 2008 and 2009 to control Eurasian watermilfoil (*Myriophyllum spicatum*). The Point-Intercept Rake Toss method presently required by NYS DEC for Tier III Lakes was employed.

The survey area encompassed the entire littoral zone of Saratoga Lake, including the 2009 Renovate treated areas along the western shore of the lake, an expanded southern treatment area (2007 Sonar treatment area plus 20-25%) and an expanded northern treatment area (2008 Renovate treatment area plus 20-25%). The assessment was designed to generate the information necessary to review effectiveness of aquatic plant management efforts, meet all permit requirements and provide data for comparison of post-treatment conditions to prior survey information. The project consisted of three components: 1) collection of herbarium specimens throughout the lake for compilation of a species list, 2) point-intercept frequency and depth data for points distributed within the treatment area, and 3) point-intercept frequency and depth data for points distributed within an untreated (control) area of the lake.

Introduction

Survey Site

Saratoga Lake is located in Saratoga County, New York in the towns of Saratoga, Stillwater, Round Lake, and Malta. The lake has a surface area of approximately 3765 acres and a surface elevation of 203 ft amsl. Saratoga Lake has a single outlet, Fish Creek, draining to the Hudson River. Average water depth is reported to be 25 ft, with a maximum depth of 95 ft (Mikol and Polsinelli 1985). Hydraulic retention time is reported to be 0.4 years and lake volume is 381,000,000 m^3. Transparency via secchi disk in 2003 was reported to be 4.1 m (SLPID 2003).

An aquatic plant survey of Saratoga Lake in 1932 (NYS DEC 1932) indicated that the lake was quite free of "weeds" except in a few protected bays, primarily along the south and west shores. Common species included *Ceratophyllum demersum, Elodea canadensis, Vallisneria americana* and the pondweeds; *Potamogeton amplifolius, P. praelongus, P. nodosus*, and *P. compressus*. One exotic species, *Potamogeton crispus* was reported. In 1969, the NYS DEC pesticides unit did a more extensive mapping of aquatic plants in Saratoga Lake. They reported a healthy native plant community with 13 submersed species, 2 native rooted floating-leaf species, 3 native emergent species and 3 free floating species (Dean 1969). *Myriophyllum spicatum* populations

were first confirmed in the mid-1970's and reported to be the dominant aquatic plant species in the lake by the early-1980's (Hardt et al. 1983). Additional data collections by the US EPA Clean Lakes Program reported 14 submersed species, 2 floating-leaved species, 2 emergent species and 3 free floating species in 1981-82 (Hardt et al. 1983). Both *Myriophyllum spicatum* and *Potamogeton crispus* were reported as occurring as dense growth. By 1994, the Saratoga Lake aquatic plant community included 23 submersed species, 3 native rooted floating-leaf species, 2 native emergent species and 1 free floating species (Eichler and Boylen 1995). *Myriophyllum spicatum* was the most common plant species, present in 68 percent of survey points. Two other exotic aquatic plant species were reported, *Potamogeton crispus* and *Trapa natans*.

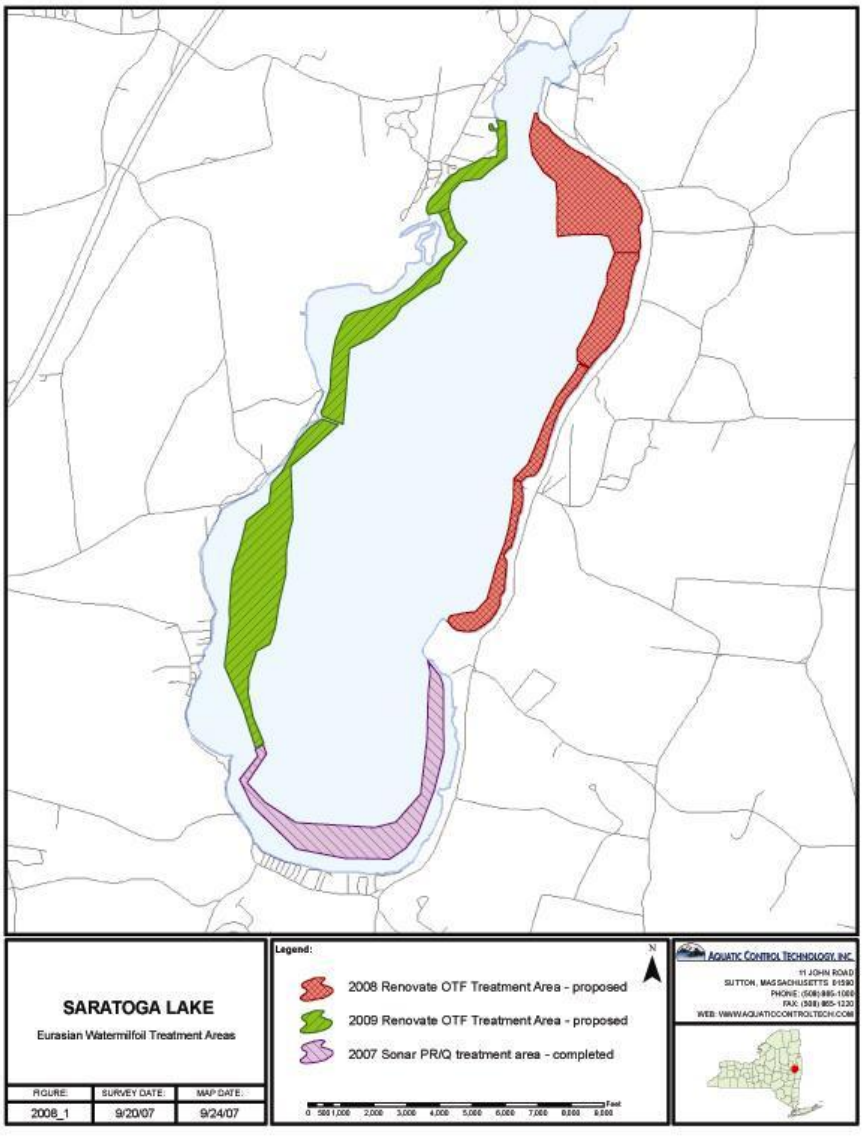
Nuisance aquatic plant growth has posed problems for Saratoga Lake for the past two decades. Excessive aquatic plant growth is reported to impact water-based recreation, aesthetic quality, environmental issues related to loss of habitat diversity, exclusion of native plant and animal species, and hydrodynamics. Nuisance growth of aquatic plants in Saratoga Lake is mainly attributable to three non-native species: Eurasian watermilfoil (*Myriophyllum spicatum),* Curly-leaf Pondweed (*Potamogeton crispus),* and Waterchestnut (*Trapa natans),* with the majority of effort devoted to the management of Eurasian watermilfoil.

In 1994, an aquatic plant survey of Saratoga Lake was conducted by the Darrin Fresh Water Institute to evaluate ongoing aquatic plant harvesting and lake level drawdown programs for the control of *Myriophyllum spicatum* and *Potamogeton crispus*. Volunteer efforts were also employed to hand harvest scattered growth of *Trapa natans*. These aquatic plant management efforts were instituted in 1984 and continue on an annual basis. Results of the 1994 survey indicated a diverse population of native aquatic plants dominated by the exotic invasive *Myriophyllum spicatum*. While mechanical harvesting provided access to the open waters of the lake for recreational use, this technology was not having an appreciable long-term effect on the density of growth of *Myriophyllum spicatum*. Winter draw-down and the resultant ice scour in shallow waters (depth less than 1 meter) was determined to be negatively effecting the growth of *Myriophyllum spicatum*. In 2000 and 2003, two additional aquatic plant management tools were evaluated on an experimental basis, biological control agents (weevils) and herbicide (SONAR) application. Biocontrol agents, while promising, continue to be experimental. Surveys conducted in 2004 (Eichler and Boylen 2004) indicated that native species richness in the herbicide treated areas had increased, however Eurasian watermilfoil was still the dominant species. A three year herbicide treatment effort was initiated in 2007 with fluridone (Sonar) treatment of the southern margin of the lake in the area of Browns Beach. Triclopyr (Renovate) herbicide was applied in 2008 and 2009 on the eastern and western margins of the lake, respectively.

Methods

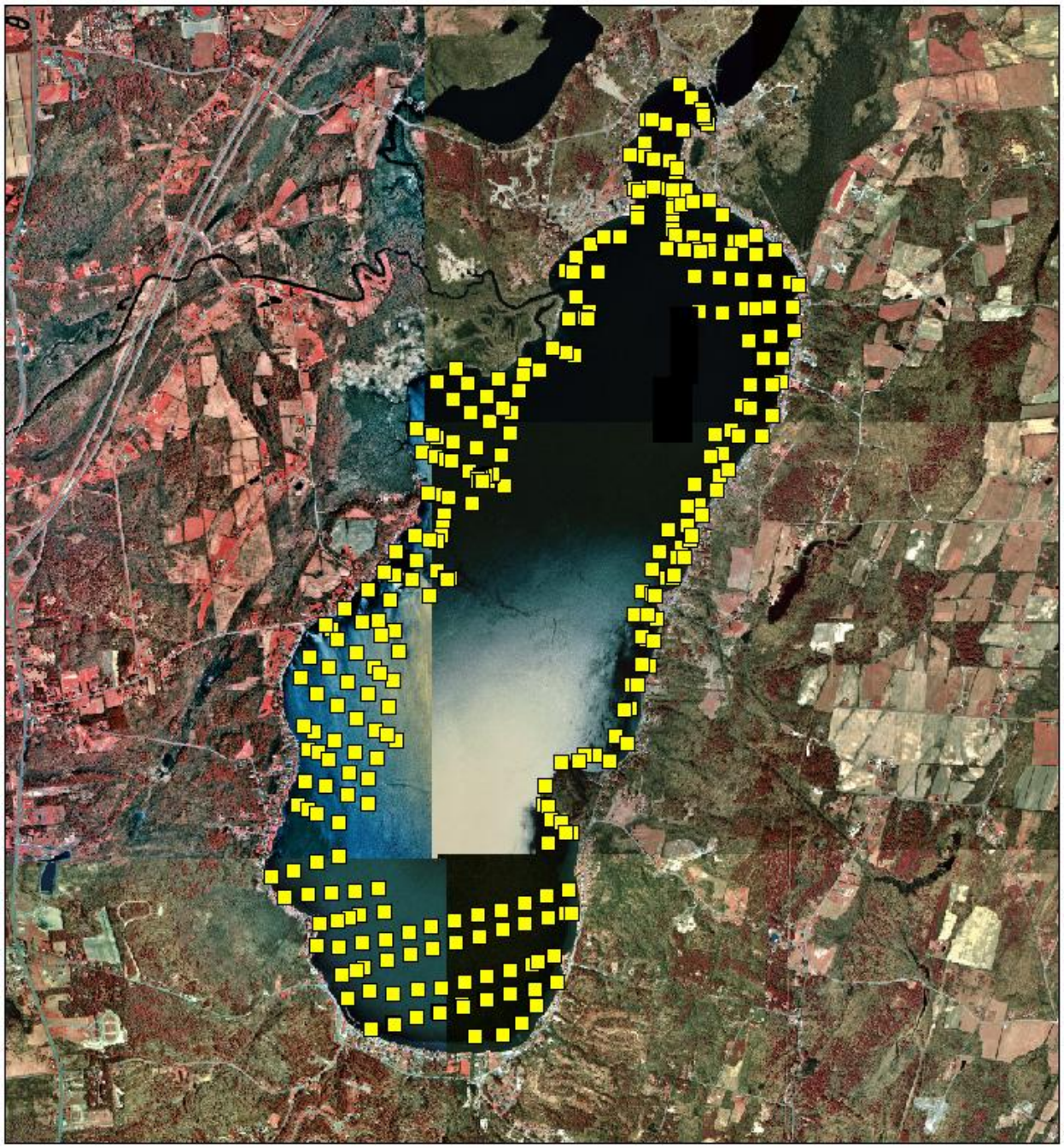
Species List and Herbarium Specimens. As the lake was surveyed, the occurrence of each aquatic plant species observed was recorded and adequate herbarium specimens collected. The herbarium specimens were pressed, dried, and mounted (Hellquist 1993) at the Darrin Fresh Water Institute Laboratory in Bolton Landing, NY, where they became part of the permanent collection.

Point Intercept Survey. The frequency and diversity of aquatic plant species were evaluated using a point intercept method (Madsen 1999). At each grid point intersection, all species located at that point were recorded, as well as water depth. Species were located by a visual inspection of the point and by deploying a rake to the bottom, and examining the plants retrieved. A differential global positioning system (Garmin GPSmap 168) was used to navigate to each point for the survey observation. Point intercept plant frequencies were surveyed in August of 2007, 2008 and 2009 at the time of maximum aquatic plant abundance. Based on an 80 m grid and excluding the majority of points outside the littoral zone, we surveyed a total of 324 points on Saratoga Lake. The point



intercept method allows a large number of discrete observations in a short period of time facilitating statistical analysis and comparisons. Point intercept methods also allow for production of distribution maps for all species listed (Figure 1).

Figure 1. Distribution of point intercept survey points for Saratoga Lake aquatic plant survey.



Results and Discussion

In August of 2009, the aquatic plant community of Saratoga Lake included 20 submersed species, 2 floating-leaved species, 2 floating species and 2 emergent species for a total of 26 species. A total of 24 species were collected in the point intercept portion of the 2009 survey which is comparable to the 25 species reported for previous surveys in 2007 and 2008. Three exotic species, *Myriophyllum spicatum, Potamogeton crispus* and *Trapa natans* have been reported; however, *Trapa natans* was absent in the last two surveys and *Potamogeton crispus* was reported in moderate numbers. *Myriophyllum spicatum* remains a common member of the aquatic plant community, but at greatly reduced numbers when compared to previous surveys. Species richness was quite high, with a large number of species occurring in more than 10% of survey points (Table 2). Eurasian watermilfoil declined to the tenth most abundant species by frequency of occurrence (7% of survey points). A list of species observed for Saratoga Lake is provided in Table 1.

Table 1. Aquatic plant species present in Saratoga Lake in recent surveys.

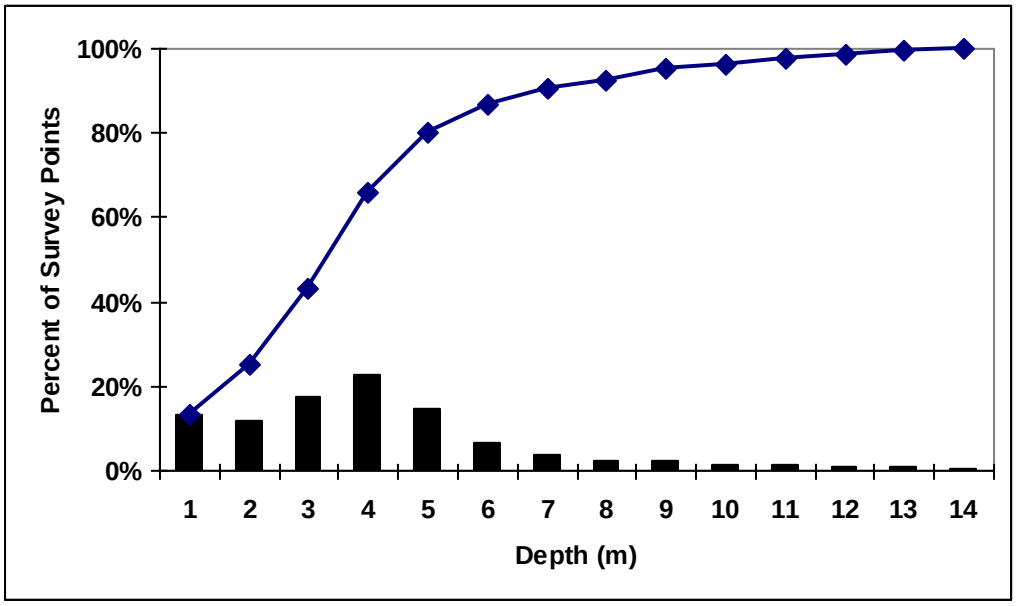
Species	Common Name	1932	1969	1982	1994	2004	2007	2008	2009
Ceratophyllum demersum L.	coontail	x	x	x	x	x	x	x	x
Chara/Nitella sp.	muskgrass, chara		x	x	x	x	x	x	x
Eleocharis acicularis (L.) Roemer & Schultes	needle spike-rush	x		x	x	x			
Elodea canadensis Michx.	elodea	x	x	x	x	x	x	x	x
Eriocaulon septangulare With.	pipewort				x				
Lemna minor L.	duckweed	x	x	x	x	x	x	x	x
Lemna trisulca	duckweed					x	x	x	x
Megalodonta beckii Torr.	water marigold				x	x	x	x	x
Myriophyllum sibiricum	northern watermilfoil		x						
Myriophyllum spicatum L.	Eurasian watermilfoil			x	x	x	x	x	x
Najas flexilis (Willd.) Rostk. & Schmidt.	bushy pondweed		x		x	x	x	x	x
Najas minor				x					
Najas guadalupensis (Spreng.) Magnus	Southern naiad			x	x	x	x	x	x
Nuphar variegata Engelm. ex Durand	bullhead lily		x	x	x	x	x	x	x
Nymphaea odorata	white pondlily		x	x		x	x	x	x
Pontederia cordata	pickerelweed	x	x			x	x	x	x
Potamogeton amplifolius Tuckerm.	largeleaf pondweed	x	x	x	x	x	x	x	x
Potamogeton crispus L.	curlyleaf pondweed	x	x	x	x	x	x	x	x
Potamogeton epihydrus Raf.	ribbon-leaf pondweed				x				
Potamogeton gramineus L.	variable-leaf pondweed				x	x	x	x	x

Species	Common Name	1932	1969	1982	1994	2004	2007	2008	2009
Potamogeton illinoensis L.	Illinois pondweed					x	x	x	x
Potamogeton natans	pondweed	x	x						
Potamogeton perfoliatus L	Clasping-leaved Pondweed				x	x	x	x	x
Potamogeton praelongus Wulfen	white-stem pondweed	x			x	x	x	x	x
Potamogeton pusillus L.	small pondweed		x		x	x	x	x	x
Potamogeton richardsonii (Ar. Benn.) Rydb.	Richardsons' pondweed		x	x		x			
Potamogeton robbinsii Oakes	Robbins' pondweed		x	x	x			x	x
Potamogeton zosteriformis Fern.	flat-stem pondweed				x	x	x	x	x
Ranunculus longirostris Godron	white watercrowfoot				x	x			x
Sagittaria graminea Michx.	arrowhead	x	x	x	x	x			
Scirpus	rush	x	x						x
Sparganium sp.	burreed	x			x				x
Spirodela polyrhiza (L.) Schlieden	great duckweed			x	x				
Stuckenia pectinata L.	sago pondweed			x	x	x	x	x	x
Trapa natans L.	waterchestnut				x	x	x		
Typha	cattail	x	x	x	x	x	x	x	x
Utricularia vulgaris L.	great bladderwort				x				x
Vallisneria americana L.	wild celery	x	x	x	x	x	x	x	x
Wolffia	watermeal		x	x					
Zosterella dubia Jacq.	water stargrass			x	x	x	x	x	x

Maximum Depth of Colonization

Maximum depth of colonization by rooted aquatic plant growth extended to a depth of 6 meters. Calculated maximum depth of colonization (MDOC) by macrophytes ranged from 4.3 to 4.9 meters in 2004 (Eichler and Boylen 2004), and was comparable to 1994 records (Eichler and Boylen 1995). Specimens of *Ceratophyllum demersum, Najas guadalupensis* and *Myriophyllum spicatum* were found between 5 and 6 meters depth in 2008. Thus, 6 meters is the maximum extent of the littoral zone, representing an increase of approximately 1 meter in depth from 1994 estimates (Eichler and Boylen 1995) and comparable to depth records for 2004 (Eichler and Boylen 2004) and 2007 (Eichler and Boylen 2008). Depth distribution of sampling points (Figure 2) was equitable throughout the littoral zone in 2007, 2008 and 2009.

Figure 2. Depth Distribution of Saratoga Lake sampling points in 1 meter depth classes.



Species Richness and Distribution

A total of 24 species were observed in open lake surveys of Saratoga Lake in 2009 (Table 1). Twenty-two species were found in samples from the treated area and 20 species were reported in samples from untreated areas. These results are comparable to previous surveys in 2007 and 2008 (25 species, Eichler and Boylen 2008a; 2008b), 2004 (21 species, Eichler and Boylen 2004), 1994 (22 species, Eichler and Boylen 1995), 1982 (21 species, Hardt et al. 1983) and 1969 (20 species, Dean 1969). The limited occurrence of *Potamogeton crispus* can be attributed to the timing of the current survey (August), rather than an actual decline in the abundance of this species. *Potamogeton crispus* generally reaches peak abundance in June and July, and then undergoes senescence. Species absent from the 2009 survey but present in prior surveys were generally either present in only a single survey year or relatively uncommon in prior surveys (<1% of survey points).

Maps of the distribution of aquatic plant species and groups of species (i.e. Broad-leaf Pondweeds) for Saratoga Lake are included in Appendix A. Eurasian watermilfoil continued to decline in frequency of occurrence (7% of survey points in 2009, down from 13% of survey points in 2008, 48% of survey points in 2007 and 54% in 2004). *Ceratophyllum demersum* remains the most widespread native plant, present in 61% of survey points. A number of other native species were also commonly observed. A list of frequency of occurrence for all species observed is provided in Table 2. While the frequency of occurrence of most native species has remained stable since the pre-treatment survey of 2004, there were some exceptions. Two exceptions were *Najas guadalupensis* and *Elodea canadensis*, species present in limited numbers

in 2004 prior to treatment but much more abundant in post-treatment surveys in 2007, 2008 and 2009. A related species, *Najas flexilis*, declined in 2007 but returned to pre-treatment levels in 2008 and increased in abundance in 2009. Getsinger et al. (2002) reported declines in *Najas flexilis* and *Elodea canadensis* in the year following fluridone treatment of two Vermont lakes, however these species returned to levels comparable to pretreatment in the following year. Eichler and Boylen (2008) reported similar increases in frequency of occurrence of *Najas flexilis* and *Elodea canadensis* in two Vermont lakes following triclopyr treatments. *Potamogeton crispus* increased in abundance between the pre-treatment survey in 2004 and subsequent post-treatment surveys in 2007 and 2008, but still remained a minor component of the overall population. All other differences were in the less common species.

Table 2. Percent frequency of occurrence of aquatic plant species in Saratoga Lake.

Species	Common Name	2004	2007	2008	2009
Ceratophyllum demersum	coontail	38.2%	52.1%	59.0%	61.4%
Chara/Nitella	muskgrass, chara	6.8%	9.8%	6.8%	10.5%
Elodea canadensis	elodea	7.4%	10.4%	25.3%	40.7%
Lemna trisulca	duckweed	2.5%	0.0%	2.2%	2.5%
Megalodonta beckii	water marigold	1.8%	0.6%	0.9%	0.9%
Myriophyllum spicatum	Eurasian watermilfoil	54.2%	49.7%	13.0%	6.8%
Najas flexilis	bushy pondweed	5.5%	1.8%	8.6%	13.6%
Najas guadalupensis	Southern naiad	11.4%	13.5%	30.9%	38.3%
Nuphar luteum	yellow pondlily	0.3%	0.0%	0.6%	0.3%
Nymphaea odorata	white pondlily	0.0%	0.0%	0.6%	0.3%
Potamogeton amplifolius	largeleaf pondweed	0.3%	0.0%	1.2%	1.2%
Potamogeton crispus	curlyleaf pondweed	1.2%	6.1%	5.6%	**3.1%**
Potamogeton gramineus	variable-leaf pondweed	0.3%	0.0%	0.3%	1.9%
Potamogeton illinoensis	Illinois pondweed	1.8%	1.2%	4.0%	4.6%
Potamogeton perfoliatus	Clasping-leaved Pondweed	2.8%	8.0%	5.9%	8.0%
Potamogeton praelongus	white-stem pondweed	1.5%	1.8%	2.8%	3.1%
Potamogeton pusillus	small pondweed	0.6%	4.9%	8.6%	6.5%
Potamogeton robbinsii	Robbins' pondweed	0.0%	0.0%	0.3%	0.9%
Potamogeton zosteriformes	flat-stem pondweed	6.2%	11.7%	14.5%	17.3%
Ranunculuslongorostris	white watercrowfoot		0.0%	0.0%	0.3%
Stuckenia pectinata	sago pondweed	0.3%	0.0%	2.5%	0.3%
Trapa natans	waterchestnut	0.3%	0.6%	0.0%	0.3%
Vallisneria americana	wild celery	23.4%	23.9%	30.6%	31.2%
Zosterella dubia	water stargrass	28.6%	34.4%	23.1%	20.4%

In 2009, *Myriophyllum spicatum* was the tenth most abundant species, present in 5% of all

samples collected in the untreated (control) area and 9% of all samples collected in the treated area (Table 3, Figure 3). In the control portion of the survey, Eurasian watermilfoil was the thirteenth most widely distributed plant. Common native species included *Ceratophyllum demersum* (62%), *Elodea canadensis* (42%), *Najas guadalupensis* (36%), *Vallisneria americana* (31%), *Zosterella dubia* (22%), *Potamogeton zosteriformes* (17%), *Najas flexilis* (17%), *Chara/Nitella* (12%), *Potamogeton perfoliatus* (11%), *Potamogeton pusillus* (7%) and *Potamogeton illinoensis* (5%). In the treated portion of the survey, Eurasian watermilfoil remained a dominant plant (9% of survey points, Figure 4). A number of native species were commonly observed, including *Ceratophyllum demersum* (61%), *Najas guadalupensis* (41%), *Elodea canadensis* (40%), *Vallisneria americana* (31%), *Zosterella dubia* (18%), *Potamogeton zosteriformes* (18%), *Najas flexilis* (9%), *Chara* sp. (8%), *Potamogeton pusillus* (7%) and *Lemna trisulca* (5%). With this diversity and distribution of native species, the test for selectivity should be sensitive to a number of species, and the probability of native plant restoration in areas formerly inhabited by Eurasian watermilfoil should be high following management efforts.

Table 3. Percent frequency of occurrence of aquatic plant species in Saratoga Lake.

Species	**All**	**Control**	**Treated**
Myriophyllum spicatum	6.8%	4.9%	9.4%
Ceratophyllum demersum	61.4%	61.6%	61.2%
Elodea canadensis	40.7%	41.6%	39.6%
Najas guadalupensis	38.3%	36.2%	41.0%
Vallisneria americana	31.2%	31.4%	30.9%
Zosterella dubia	20.4%	22.2%	18.0%
Potamogeton zosteriformes	17.3%	16.8%	18.0%
Najas flexilis	13.6%	16.8%	9.4%
Chara/Nitella	10.5%	12.4%	7.9%
Potamogeton perfoliatus	8.0%	11.4%	3.6%
Potamogeton pusillus	6.5%	6.5%	6.5%
Potamogeton illinoensis	4.6%	5.4%	3.6%
Potamogeton praelongus	3.1%	4.3%	1.4%
Potamogeton crispus	3.1%	5.4%	0.0%
Lemna trisulca	2.5%	0.5%	5.0%
Potamogeton gramineus	1.9%	2.7%	0.7%
Potamogeton amplifolius	1.2%	0.5%	2.2%
Megalodonta beckii	0.9%	0.5%	1.4%
Potamogeton robbinsii	0.9%	0.5%	1.4%
Nuphar variegata	0.3%	0.0%	0.7%
Stuckenia pectinata	0.3%	0.0%	0.7%
Nymphaea odorata	0.3%	0.0%	0.7%
Ranunculus longirostris	0.3%	0.5%	0.0%
Utricularia vulgaris	0.3%	0.0%	0.7%

Figure 3. Distribution of Eurasian watermilfoil (*Myriophyllum spicatum*) in surveyed areas of Saratoga Lake in 2009.

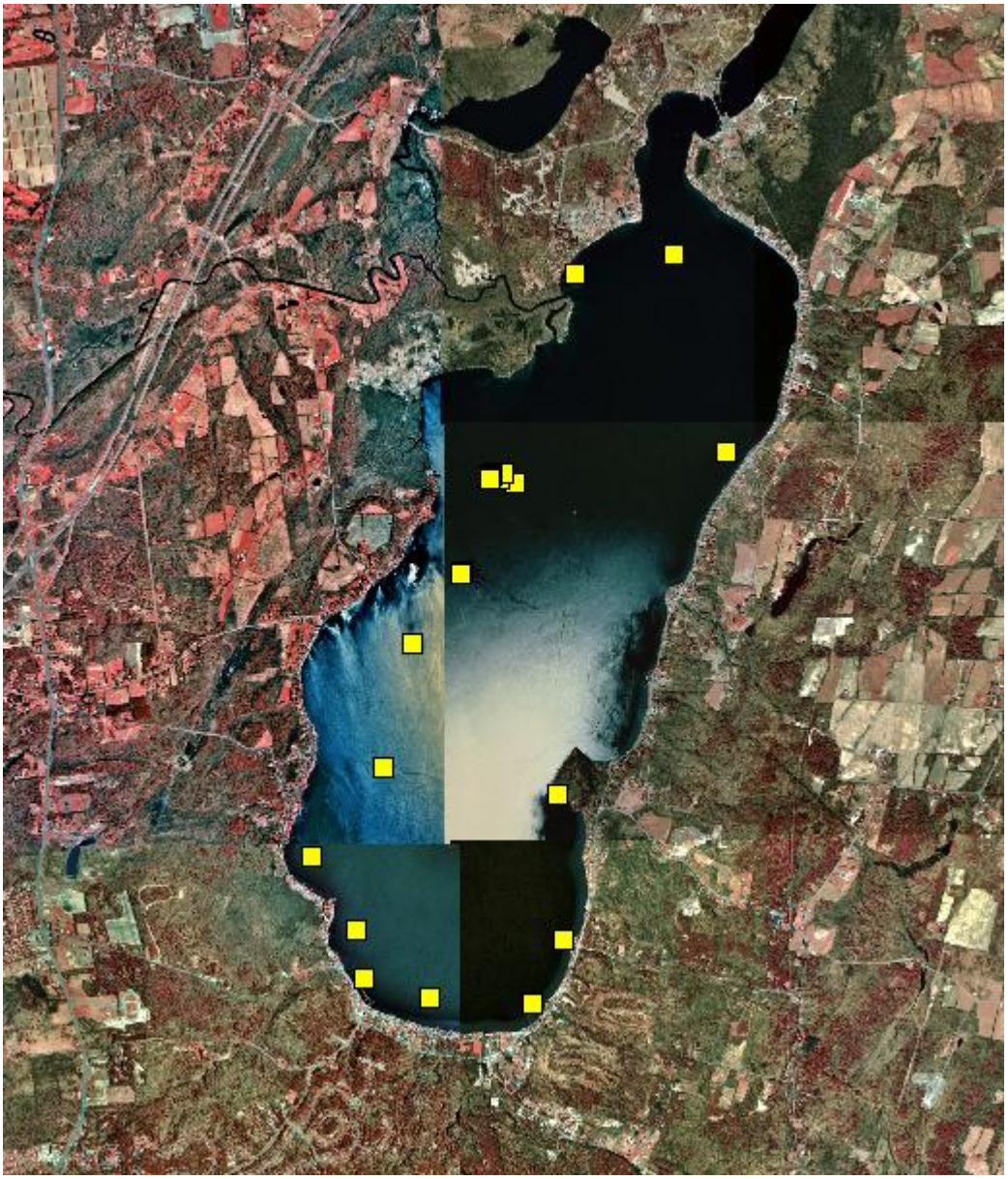
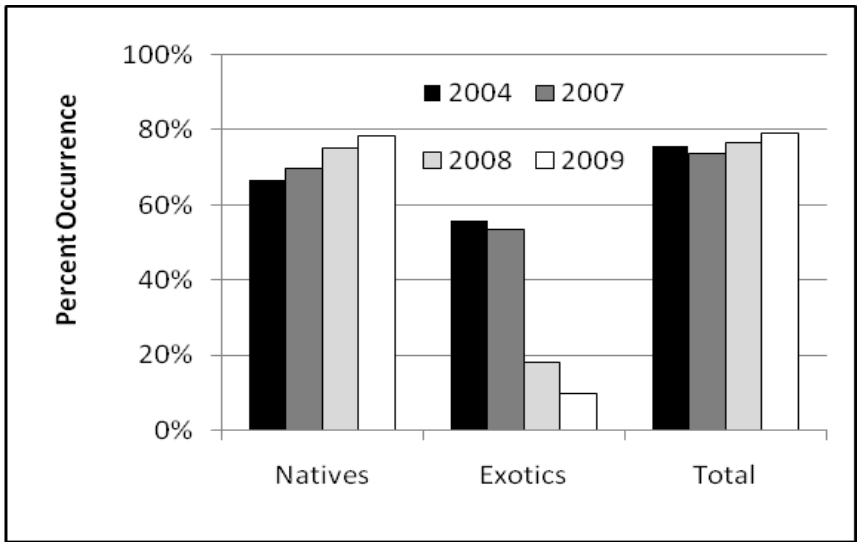


Figure 4. Saratoga Lake frequency of occurrence summaries for all sampling points.



In 2009, 81% of survey points in the control area and 75% in the treated area supported native species. Sixty-seven percent of whole lake points were vegetated by native plant species in 2004, 70% in 2007, 75% in 2008 and 78% in 2009 (Figure 4). In depths less than 6 m, representing the littoral zone, 90% of survey points contained native species and 88% of survey points less than 2 meters depth yielded native aquatic plants in 2009. Eurasian watermilfoil was present in 7% of whole lake survey points, and 12% of survey points within the littoral zone or zone of aquatic plant growth. It is apparent that exotic species, dominated by Eurasian watermilfoil, were clearly more abundant lakewide in 2004, 2007 & 2008 (56%, 53% and 18% of survey points, respectively) than in 2009 (10% of survey points).

For survey points within the littoral zone, water depth less than 6 m (Figure 5), results similar to whole lake surveys are reported. The impact of the herbicide treatment for 2009 is less apparent on the relative abundance of exotic species when comparing treated (11% of survey points) and control sites (12%), most likely due to the fact 2009 is the final year of a 3 year program to treat the whole lake. Eurasian watermilfoil declined from 31% of littoral zone survey points within the treatment area in 2008 to 11% of comparable survey points post-treatment in 2009. The expected relationship of greater frequency of occurrence of aquatic plants with shallower water depth is consistent with that reported by Eichler and Boylen (1995) where frequency of occurrence values in the littoral zone ranged from 78 to 87% of survey points.

Species richness results for the point intercept survey are presented in Table 4 and Figure 6. In 2004 whole lake species richness was 2.00 ± 0.10 species per survey point. Whole lake species richness increased to 2.31 ± 0.17 in 2007, 2.47 ± 0.12 by 2008 and 2.74 ± 0.12 by 2009. For

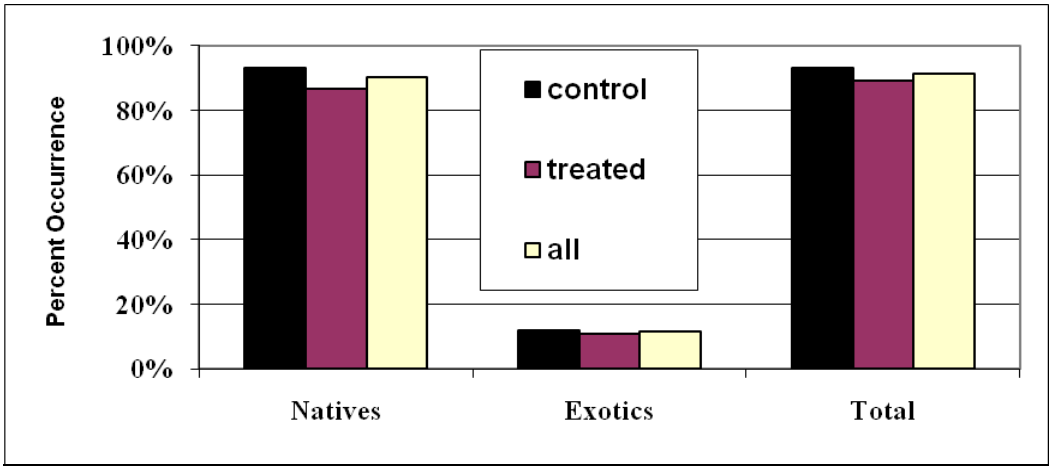


Figure 5. Saratoga Lake frequency of occurrence summaries for sampling points less than 6 meters water depth.

less than 2 meters) yielded 3.04 ± 0.21 species per sample point. In comparison, littoral (<6m depth) species richness in 2007, 2008 and 2009 were 2.74 ± 0.20, 2.88 ± 0.13 and 3.17 ± 0.12 species per sample point. The shallow fringe (<2m depth) species richness in 2007, 2008 and 2009 was 4.31 ± 0.30, 3.99 ± 0.22 and 4.25 ± 0.23, respectively.

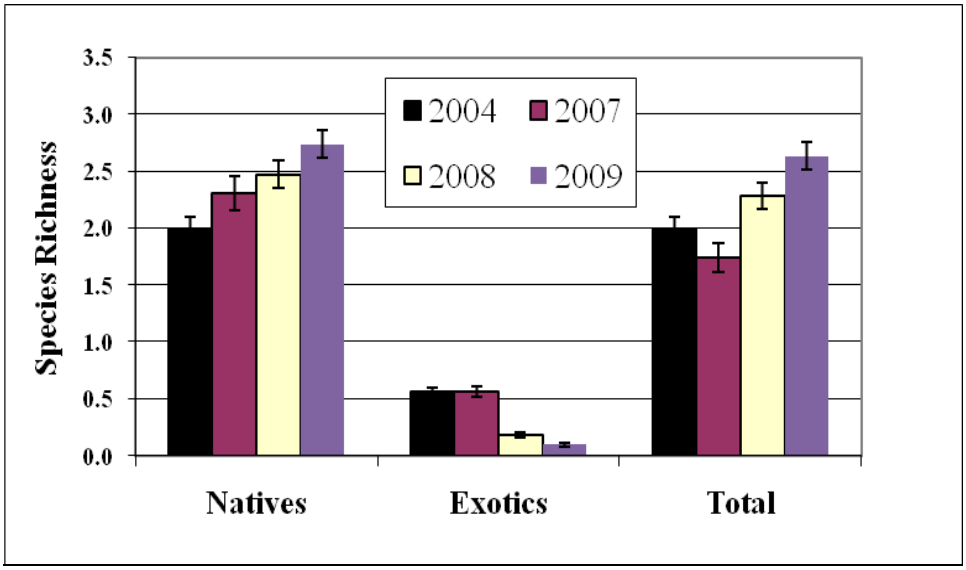
Native species richness was 2.07 ± 0.18 species per survey point in 2007 for the entire littoral zone (depths less than 6 meters), exceeding the 2004 littoral, native species richness of 1.65 ± 0.09 species per survey point, but still less than the 2.66 ± 0.12 species per survey point in 2008 and 3.05 ± 0.12 species per survey point in 2009.

Whole lake native species richness was 1.43 ± 0.08 species per sample in 2004, 1.74 ± 0.19 species per sample in 2007, 2.29 ± 0.11 species per sample in 2008 and 2.64 ± 0.12 species per sample in 2009. In the shallow portion of the littoral zone, depths less than 2 meters, species richness was 2.47 ± 0.18 native species per sample in 2004, 3.54 ± 0.44 in 2007, 3.84 ± 0.22 in 2008 and 4.22 ± 0.24 native species per sample in 2009. As expected, species richness in the littoral zone and its shallow fringe was higher than whole lake species richness. Lack of a Eurasian watermilfoil canopy in water depths less than 2 meters may also allow for greater species richness. The negative impact of a canopy of Eurasian watermilfoil on species richness of native plants has been well documented (Madsen et al. 1989; 1991). Conversely, species richness increases in areas where Eurasian watermilfoil growth is reduced (Boylen et al. 1996). Species richness in the control area exceeded that in the treated area, but generally by less than 1 species per survey point. The elimination of Eurasian watermilfoil from many of the survey points in the treated area accounts for the majority of the difference. A sharp decline in exotic species richness was observed following herbicide treatments in 2007, 2008 and 2009 while total and native species richness increased.

Table 4. Saratoga Lake species richness for the point intercept survey.

Plant Grouping	Water Depth Class	Statistic	2004	2007	2008	2009
Native plant species	Whole Lake (all depths)	Mean	1.43	1.74	2.29	2.64
		N	325	163	324	324
		Std. Error	0.08	0.19	0.11	0.12
	Points with depths <6m	Mean	1.65	2.07	2.66	3.05
		N	274	137	278	278
		Std. Error	0.09	0.18	0.12	0.12
	Points with depths <2m	Mean	2.47	3.54	3.84	4.22
		N	80	39	76	76
		Std. Error	0.18	0.44	0.22	0.24
All plant Species	Whole Lake (all depths)	Mean	2.00	2.31	2.47	2.74
		N	325	163	324	324
		Std. Error	0.10	0.17	0.12	0.12
	Points with depths <6m	Mean	2.31	2.74	2.88	3.17
		N	274	137	278	278
		Std. Error	0.10	0.20	0.13	0.12
	Points with depths <2m	Mean	3.04	4.31	3.99	4.25
		N	80	39	76	76
		Std. Error	0.21	0.50	0.22	0.23

Figure 6. Saratoga Lake species richness.
Error bars are standard error of the mean.



Summary

Quantitative aquatic plant surveys were undertaken in 2009 for Saratoga Lake, New York as part of a cooperative effort between Aquatic Control Technologies (ACT) and the Darrin Fresh Water Institute, and supported by the Saratoga Lake Protection and Improvement District (SLPID). The project was designed to obtain data to evaluate aquatic plant management efforts and review potential new strategies. The project included three components: 1) collection of specimens for compilation of a species list, 2) point-intercept frequency and depth data for points distributed in previously treated areas (South End and Franklins Beach), and 3) point-intercept frequency and depth data for points distributed in herbicide treated areas (Mannings Cove and the west shoreline).

In Saratoga Lake, Eurasian watermilfoil (*Myriophyllum spicatum*) expanded rapidly after an initial invasion in the 1970's. *Myriophyllum spicatum* populations were first confirmed in the mid-1970's and reported to be the dominant aquatic plant species in the lake by the early-1980's (Hardt et al. 1983). In 1994, the Saratoga Lake aquatic plant community contained 23 submersed species, 3 native rooted floating-leaf species, 2 native emergent species and 1 free floating species (Eichler and Boylen 1995). *Myriophyllum spicatum* was the most common plant species, present in 68 percent of survey points. Two other exotic aquatic plant species were reported, *Potamogeton crispus* and *Trapa natans*. *Potamogeton crispus* is seasonally abundant, forming a dense band at the deep margins of Eurasian watermilfoil growth in the spring and early summer. *Trapa natans* has been reported as scattered individuals on the delta of Kayadeross Creek and in Mannings Cove, however it was absent from the 2008 and 2009 surveys. Herbicide treatments were incorporated into the aquatic plant management program in 2007 to supplement previously employed lake level drawdown and mechanical harvesting. A three year herbicide treatment effort was initiated with fluridone (Sonar) treatment of the southern margin of the lake in the area of Browns Beach in 2007. Triclopyr (Renovate) herbicide was applied in 2008 and 2009 on the eastern and western margins of the lake, respectively. In August of 2009, the aquatic plant community of Saratoga Lake included 20 submersed species, 2 floating-leaved species, 2 floating species and 2 emergent species for a total of 26 species, 24 of which were collected in the point intercept portion of the survey. These results are comparable to previous surveys in 2007 and 2008 (25 species, Eichler and Boylen 2007), 2004 (21 species, Eichler and Boylen 2004), 1994 (22 species, Eichler and Boylen 1994), 1982 (21 species, Hardt et al. 1983) and 1969 (20 species, Dean 1969). Twenty-two species were found in samples from the treated area and 20 species were reported in the control samples in 2009.

Exotic species, dominated by Eurasian watermilfoil, were clearly more abundant lake-wide in 2004, 2007 and 2008 (56%, 53% and 18% of survey points, respectively) than in 2009 (10% of survey points). Eurasian watermilfoil remains a common member of the aquatic plant community, 7% of all survey points in 2009, but at greatly reduced numbers when compared to previous surveys. Eurasian watermilfoil declined from first to tenth most abundant species by

frequency of occurrence between 2007 and 2009.

Native species were dominant in 2009. Common native species in the untreated control areas included *Ceratophyllum demersum* (62%), *Elodea canadensis* (42%), *Najas guadalupensis* (36%), *Vallisneria americana* (31%), *Zosterella dubia* (22%), *Potamogeton zosteriformes* (17%), *Najas flexilis* (17%), *Chara/Nitella* (12%), *Potamogeton perfoliatus* (11%), *Potamogeton pusillus* (7%) and *Potamogeton illinoensis* (5%). Eurasian watermilfoil was uncommon in the previously treated portion of the survey, reported for less than 5% of survey points. In the treated areas of Saratoga Lake, Eurasian watermilfoil was present in 9% of survey points in 2009. A number of native species were commonly observed, including *Ceratophyllum demersum* (61%), *Najas guadalupensis* (41%), *Elodea canadensis* (40%), *Vallisneria americana* (31%), *Zosterella dubia* (18%), *Potamogeton zosteriformes* (18%), *Najas flexilis* (9%), *Chara* sp. (8%), *Potamogeton pusillus* (7%) and *Lemna trisulca* (5%). With this diversity and distribution of native species, the test for selectivity should be sensitive to a number of species, and native plant restoration in areas formerly inhabited by Eurasian watermilfoil appears to be rapid following management efforts.

In 2004 whole lake species richness was 2.00 ± 0.10 species per survey point. Whole lake species richness increased to 2.31 ± 0.17 in 2007, 2.47 ± 0.12 in 2008 and 2.74 ± 0.12 by 2009. For survey points exclusively within the littoral zone (depths less than 6 meters) species richness in 2004 was 2.31 ± 0.10 species per sample and the shallow end of the littoral zone (depths less than 2 meters) yielded 3.04 ± 0.21 species per sample point. In comparison, littoral (<6m depth) species richness in 2007, 2008 and 2009 were 2.74 ± 0.20, 2.88 ± 0.13 and 3.17 ± 0.12 species per sample point. The shallow fringe (<2m depth) species richness in 2007, 2008 and 2009 was 4.31 ± 0.30, 3.99 ± 0.22 and 4.25 ± 0.23, respectively. Native species richness lake-wide and in the treatment zone was higher post-treatment in 2007, 2008 and 2009 than during 2004 (pre-treatment).

Principal areas of Eurasian watermilfoil expansion in 2004 were reported in the northeast at Franklins Beach and the southwest in the area of Rileys Cove. Franklins Beach was selected as the control (untreated) area for 2007 while the south end of the lake and Browns Beach area were treated with herbicide (Figure 6). In 2008, the Franklins Beach area was selected for treatment, the west shore including Mannings Cove served as the control, and Browns Beach west across the south end of the lake was assessed 1 year post-treatment. In 2009, the west shore and Mannings Cove areas were treated, the Franklins Beach area was assessed 1 year post-treatment and Browns Beach west across the south end of the lake was assessed 2 years post-treatment. Substantial reduction in Eurasian watermilfoil frequency of occurrence was observed in the treated area between 2008 (pre-treatment) and 2009 (post-treatment) while the previously treated control areas increased from 2% to 5%. Eurasian watermilfoil declined from 26% of littoral zone survey points within the treatment area in 2008 to 9% of comparable survey points post-treatment in 2009.

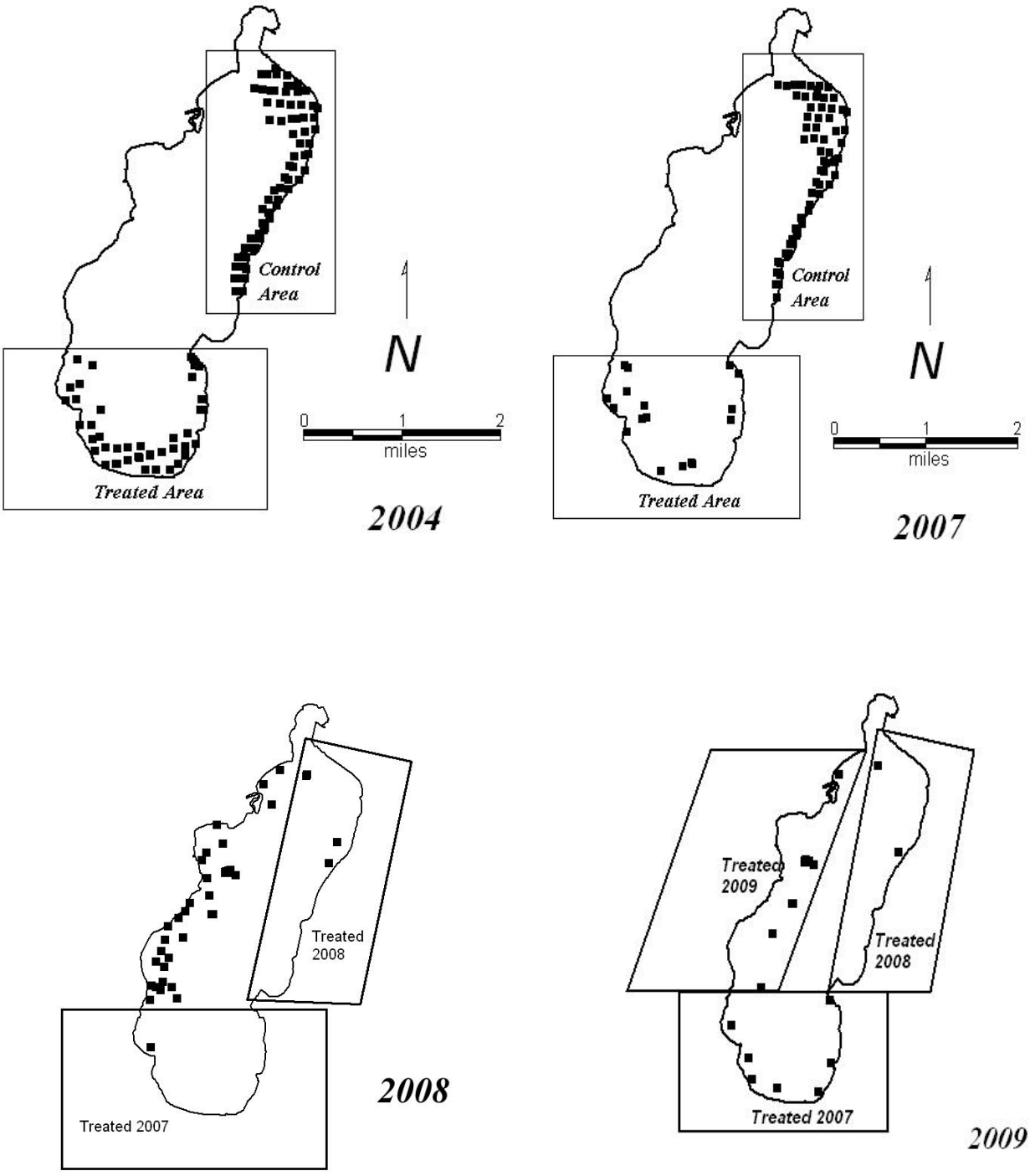


Figure 7. A comparison of the distribution of Eurasian watermilfoil (*Myriophyllum spicatum*) growth in selected areas of Saratoga Lake in 2004, 2007, 2008 and 2009.

Lakewide aquatic plants were found to occur in 91% of survey points in the littoral zone, comparable to 2004, 2007 and 2008 (89%, 88% and 89%, respectively), and not indicative of any major change in the aquatic plant population. Eurasian watermilfoil abundance declined from 66% of littoral zone survey points in 2004 to 59% of survey points in 2007, 21% in 2008 and 8% in 2009. In the 2009 survey, Eurasian watermilfoil was present in 7% of whole lake survey points, and 8% of survey points less than 6 m water depth, representing the littoral zone or zone of aquatic plant growth. Exotic species, dominated by Eurasian watermilfoil, were equitably distributed in the previously treated areas (10% of survey points) than the treated area (9%), suggesting durability of treatment regimes from 2007 and 2008.

Eurasian watermilfoil abundance declined from 58% of littoral zone survey points within the treatment area in 2004 to 25% of comparable survey points post-treatment in 2007. In 2008, Eurasian watermilfoil abundance continued to decline to 3% of littoral zone survey points within the treatment area. In the control area, Eurasian watermilfoil abundance increased from 74% of survey points in 2004 to 80% of comparable survey points in 2007. In 2008, Eurasian watermilfoil abundance declined to 26% of survey points in untreated areas. In 2009, the decline in Eurasian watermilfoil abundance continued, with lake-wide frequency of occurrence at 7% of survey points. This decline coupled with what appeared to be sub-lethal effects of the herbicide in the untreated areas, suggest efficacy of the herbicide over a much greater area than anticipated.

The littoral zone or maximum depth of colonization (MDOC) by aquatic plants was calculated to extend to a depth of 4.9 meters based on transparency data. *Ceratophyllum demersum* and *Najas guadalupensis*, however were commonly found between 5 and 6 meters depth, with occasional *Myriophyllum spicatum* specimens also encountered, suggesting a littoral zone maximum depth of approximately 6 meters, 1.0 meter greater than reported in 1994. Suppression of canopy formation through mechanical harvesting may allow for light penetration and thus the survival of native plant species in areas of dense Eurasian watermilfoil growth. Changing water clarity may also be a by-product of the invasion of Saratoga Lake by zebra mussels (*Dreissena polymorpha*) in the mid-1990's. Improved water clarity is frequently reported following zebra mussel invasions due to their ability to filter large volumes of phytoplankton from the water column. Reduced Eurasian watermilfoil density in shallow waters as a result of winter draw-down and ice scouring has also provided areas for colonization of native species resistant to winter draw-down.

Evidence continues to suggest that a native species, Water Stargrass (*Zosterella dubia*) is replacing Eurasian watermilfoil at the shallow end of its range. The frequency of occurrence of *Zosterella dubia* has increased substantially, reported in 19% of samples in 1994, 47% of samples in 2004 and 44% of samples in 2007 in the control area. In 2008 and 2009, while still quite abundant, the frequency of occurrence of this species declined to 23% and 20% of survey points lakewide. The operators of the mechanical harvesters continue to report that *Zosterella dubia* has become a prevalent species in their harvested materials. Survey results indicate that

this species is found growing densely in waters of 1 to 1.5 meters depth at the inner margins of dense Eurasian watermilfoil growth. The growth habit of this species may be a consideration in future management efforts.

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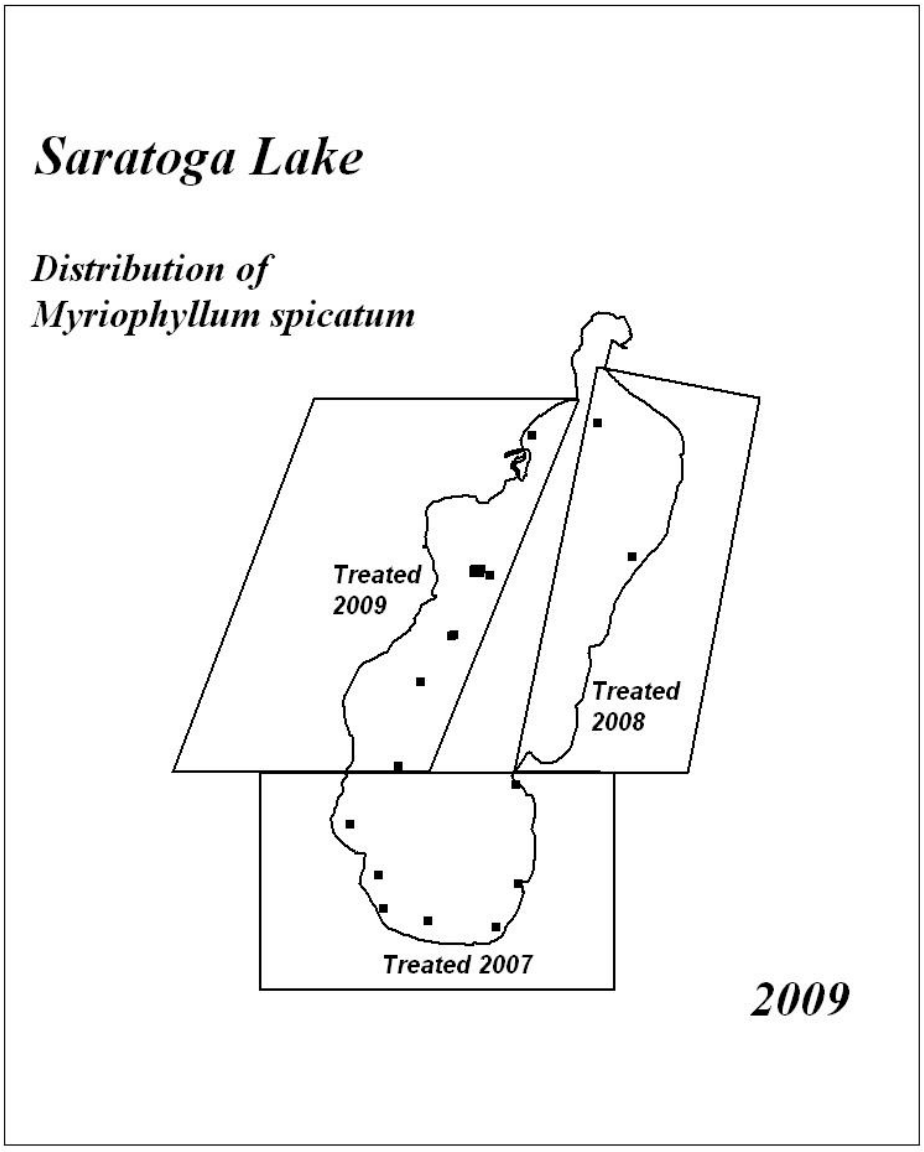
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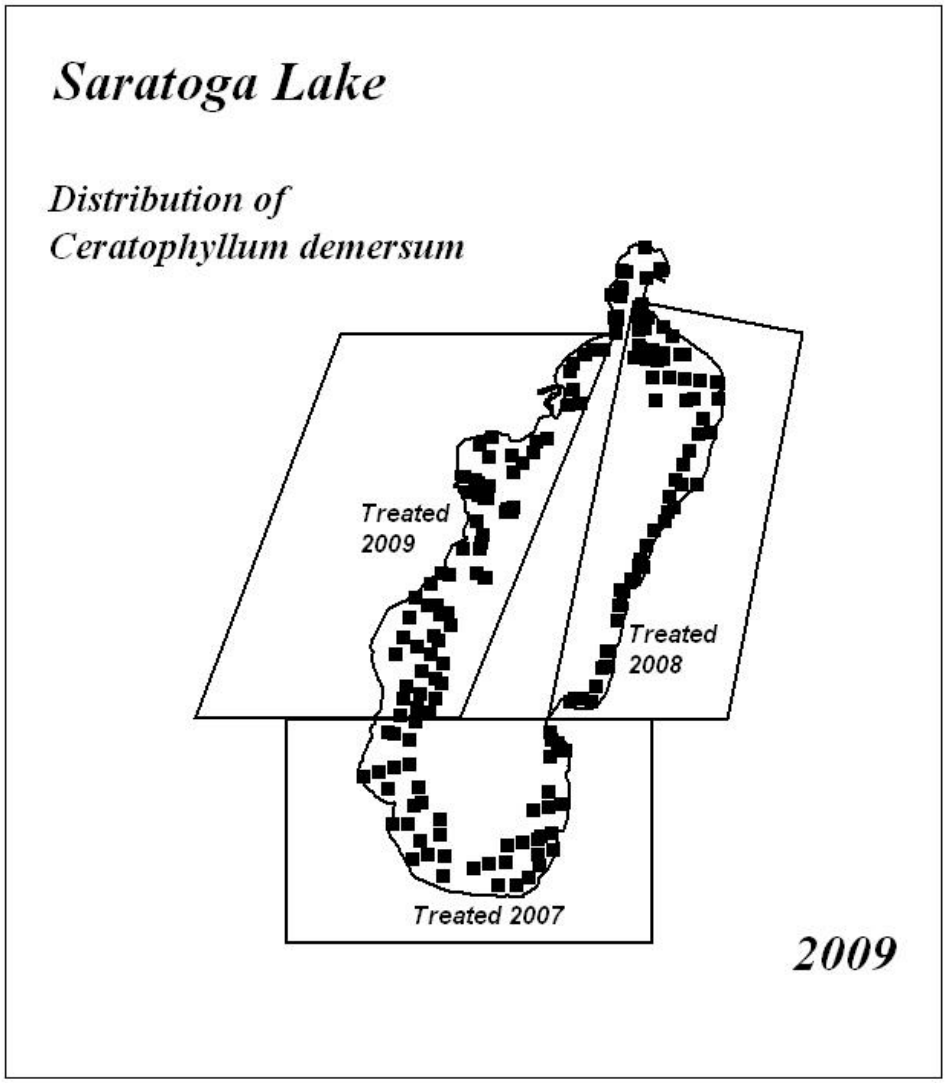
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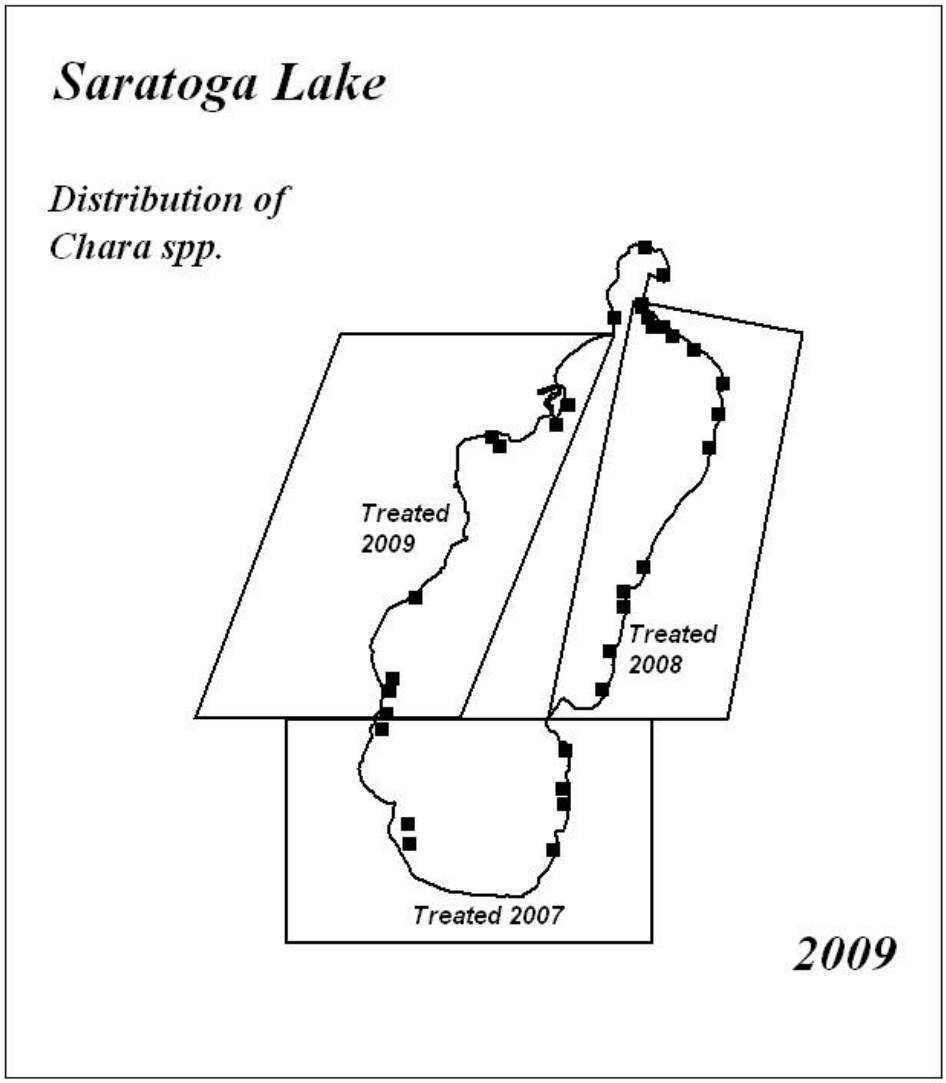
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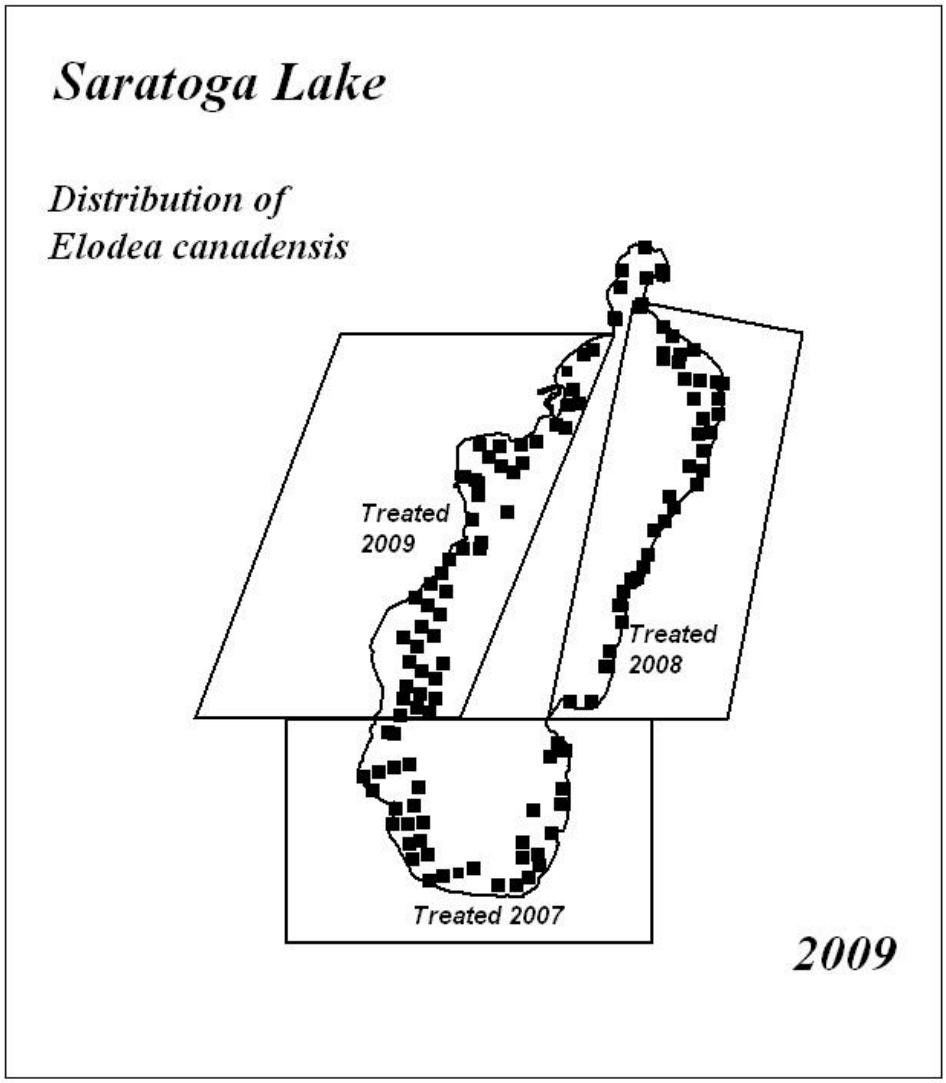
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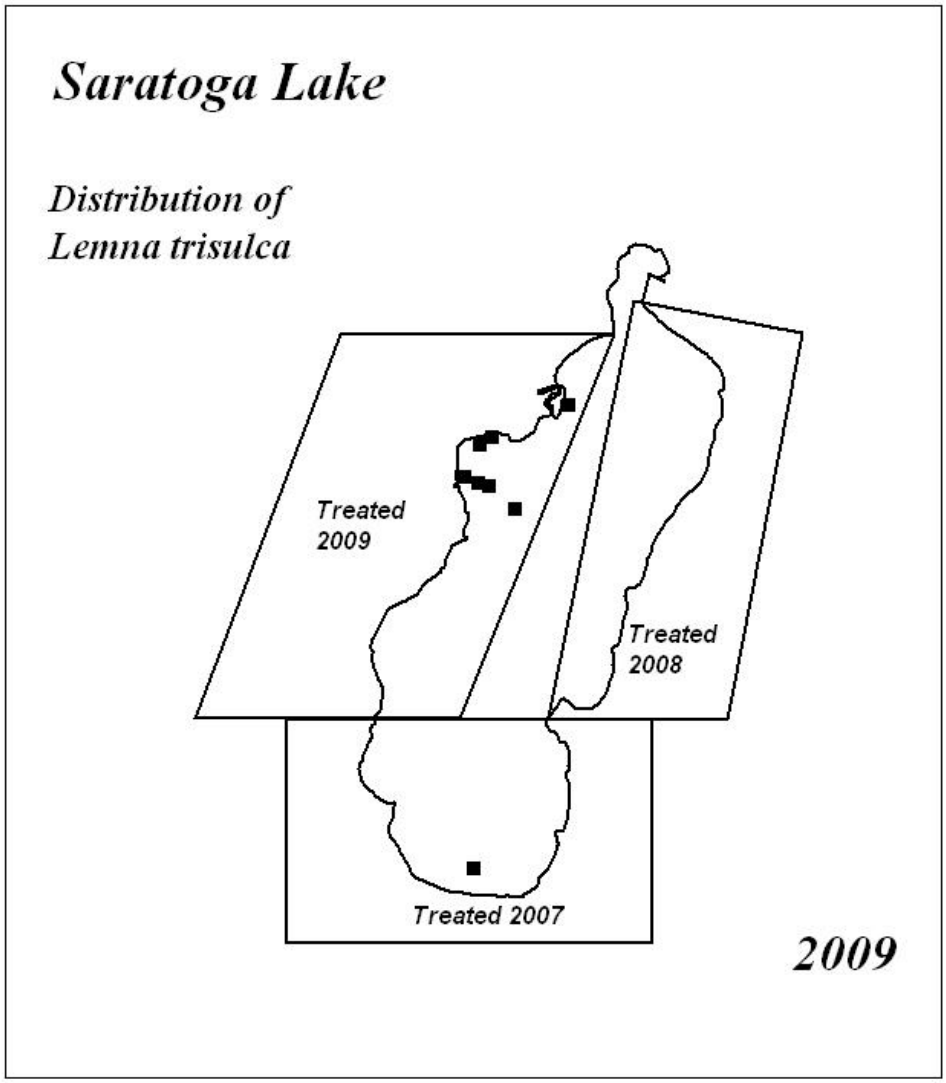
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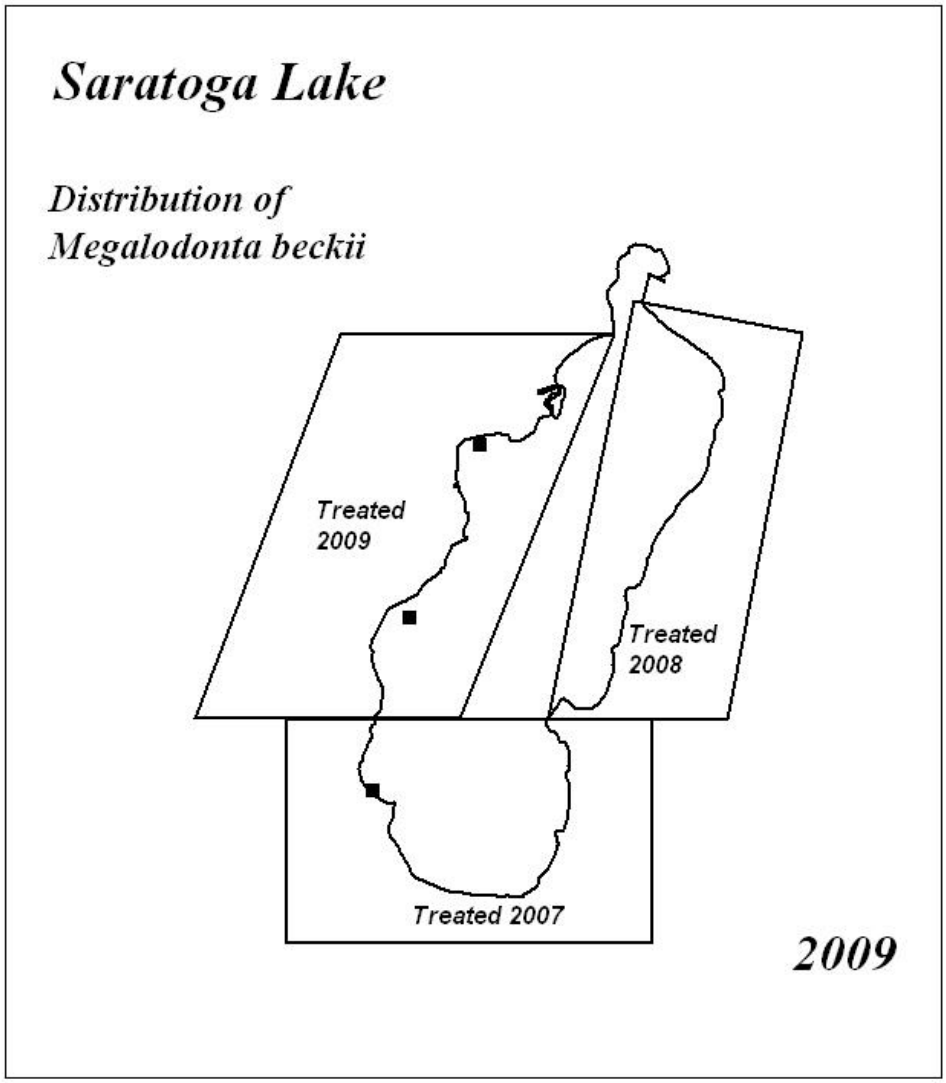
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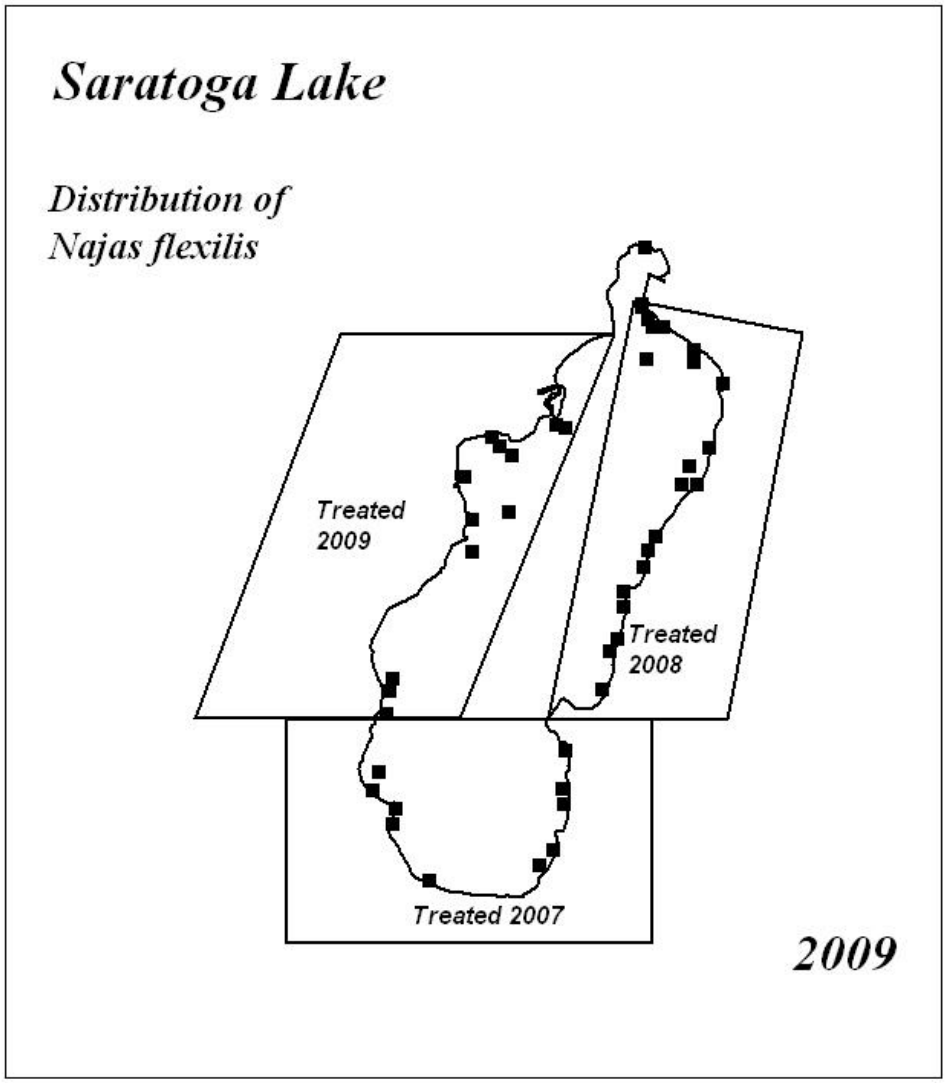
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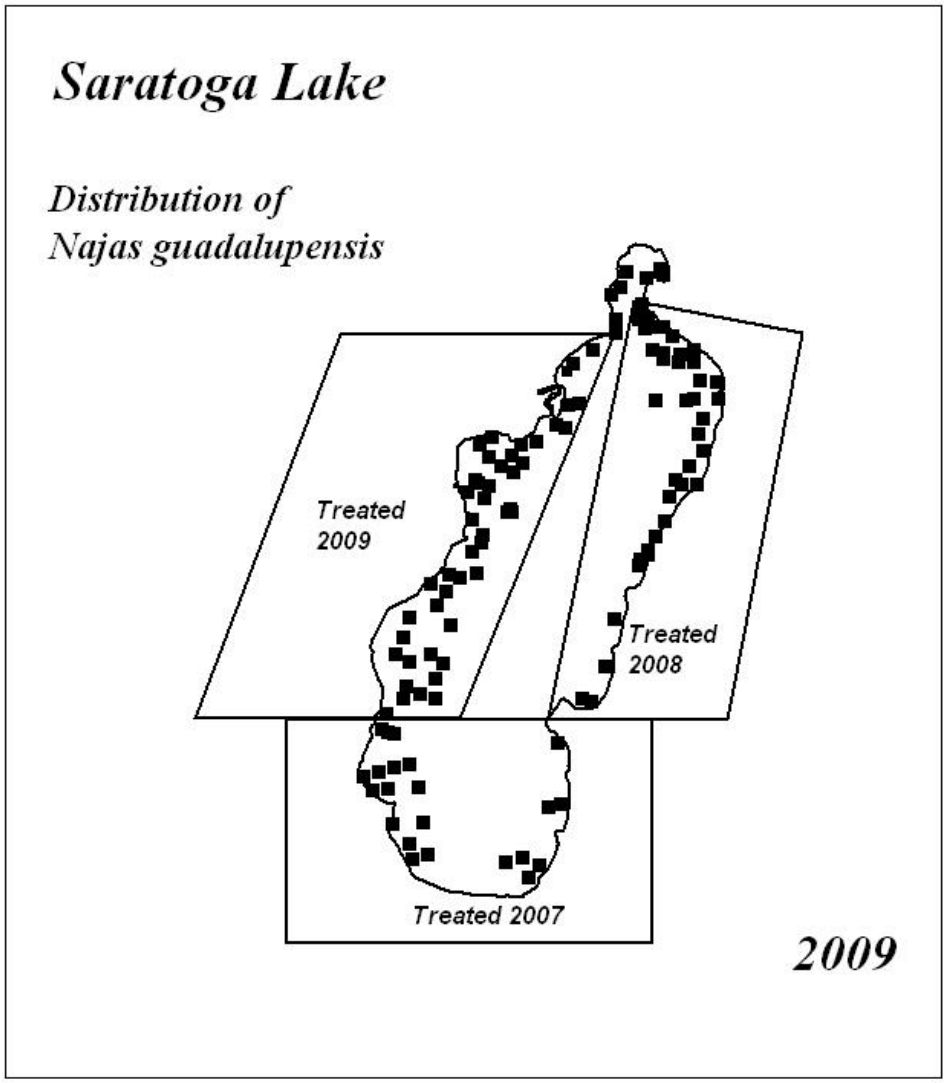
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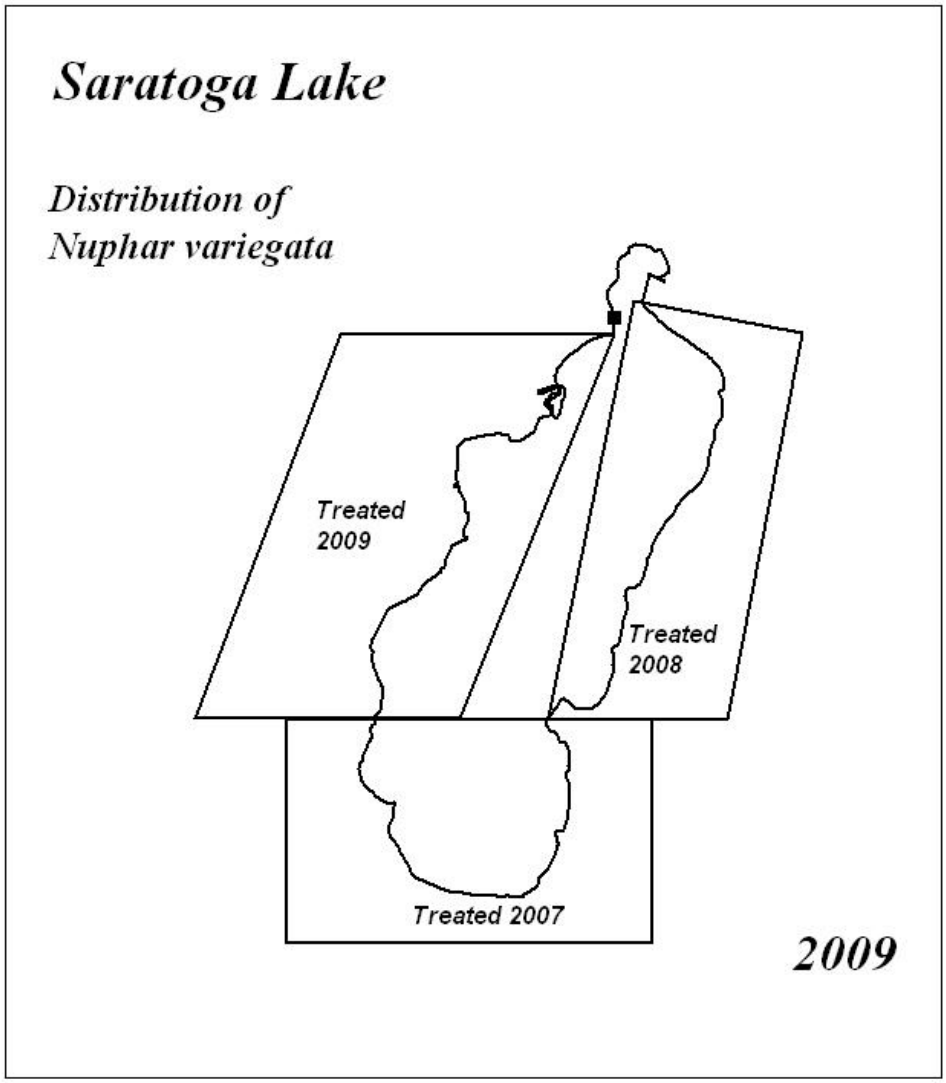
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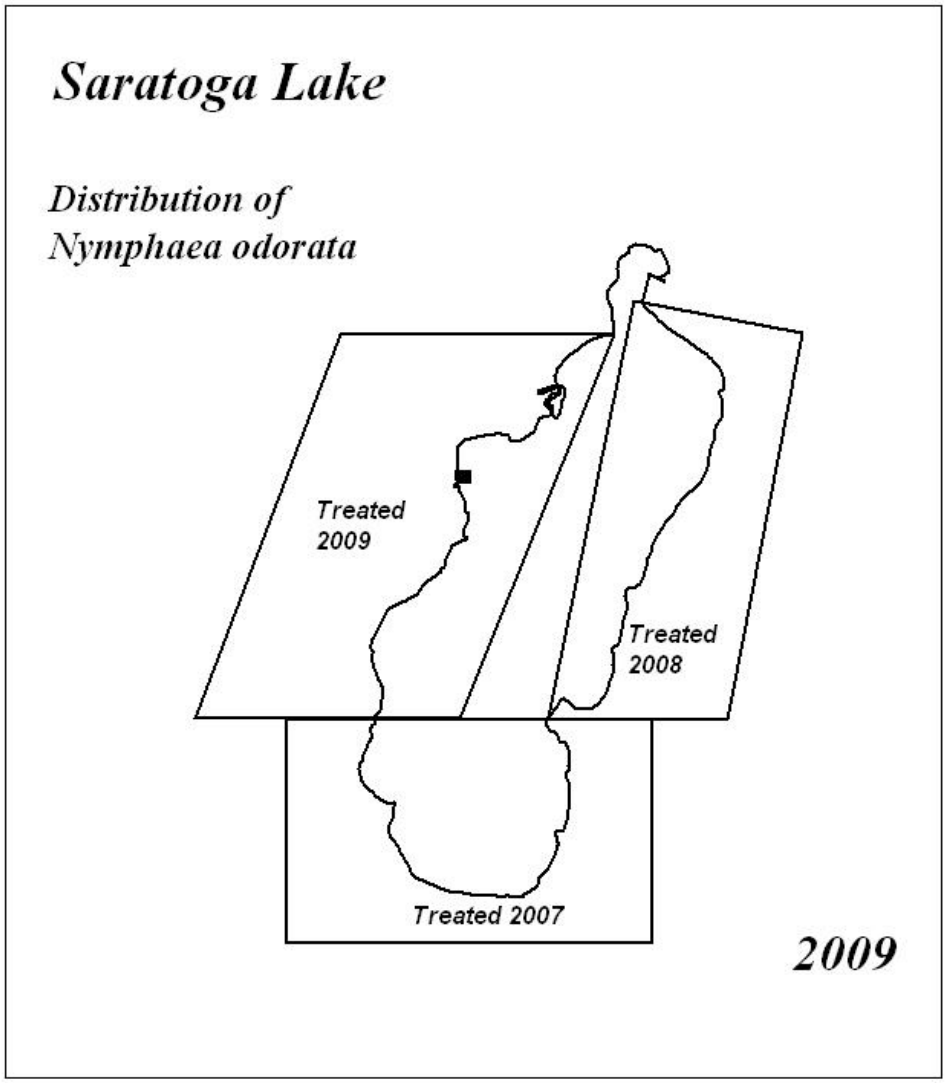
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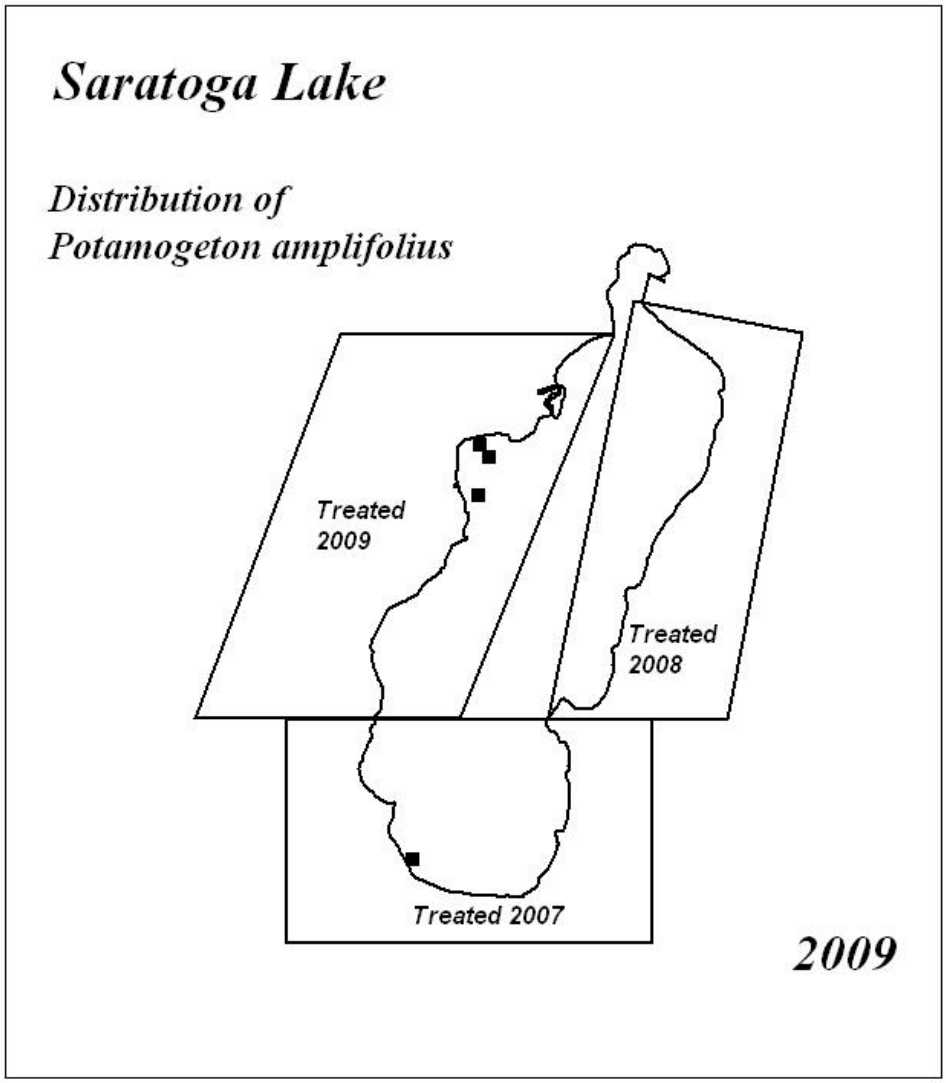
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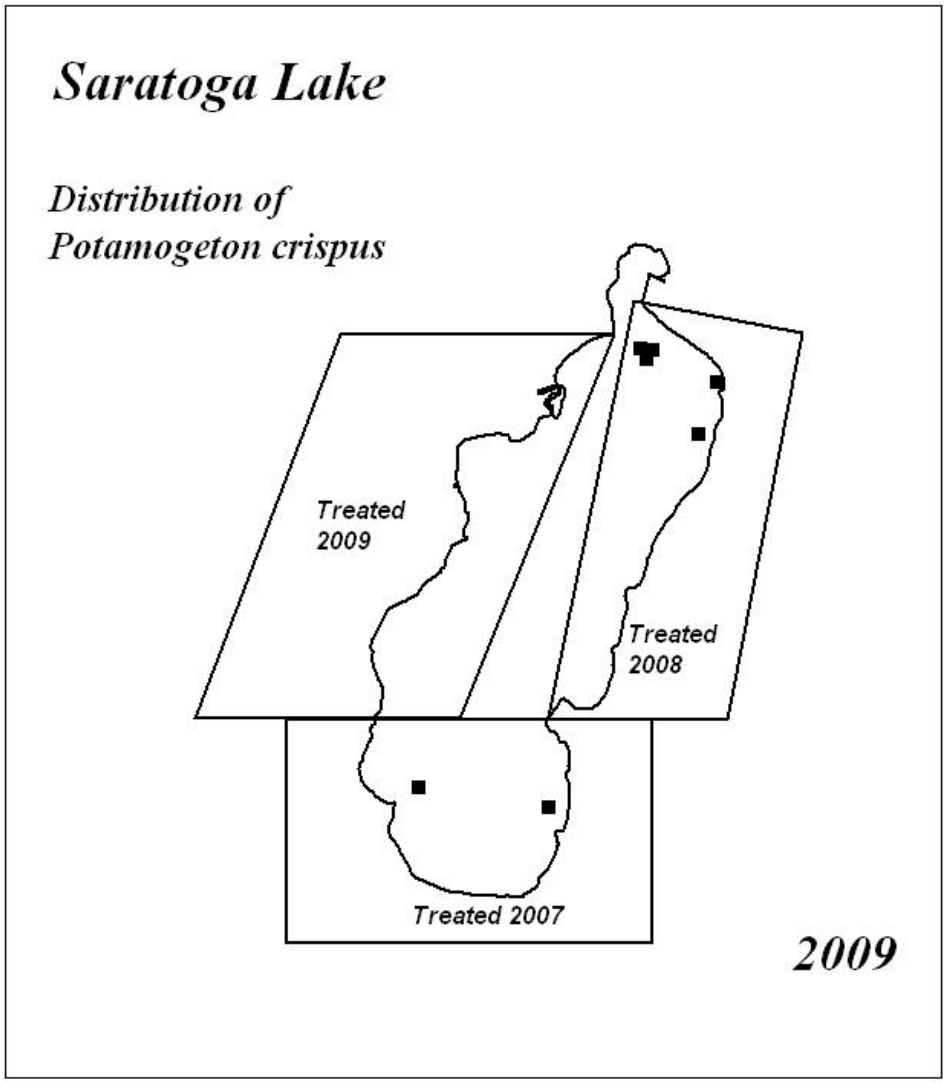
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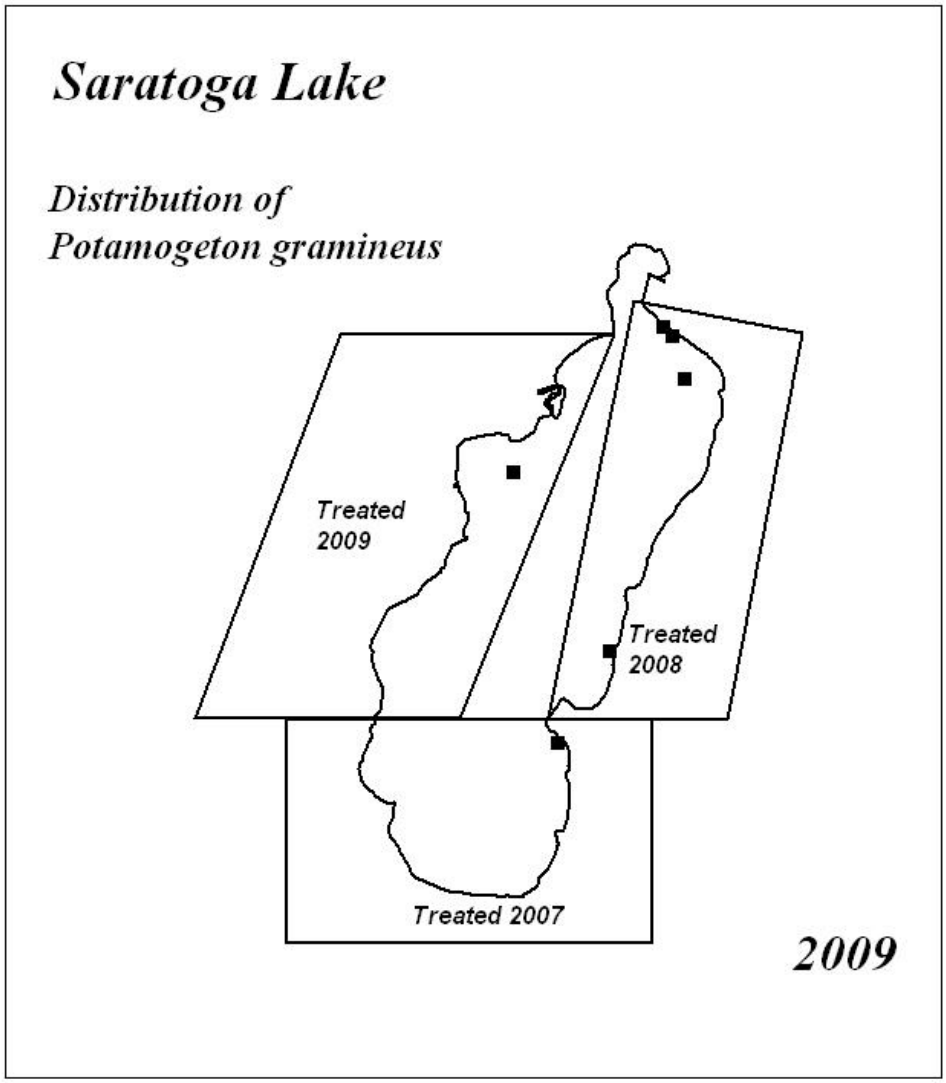
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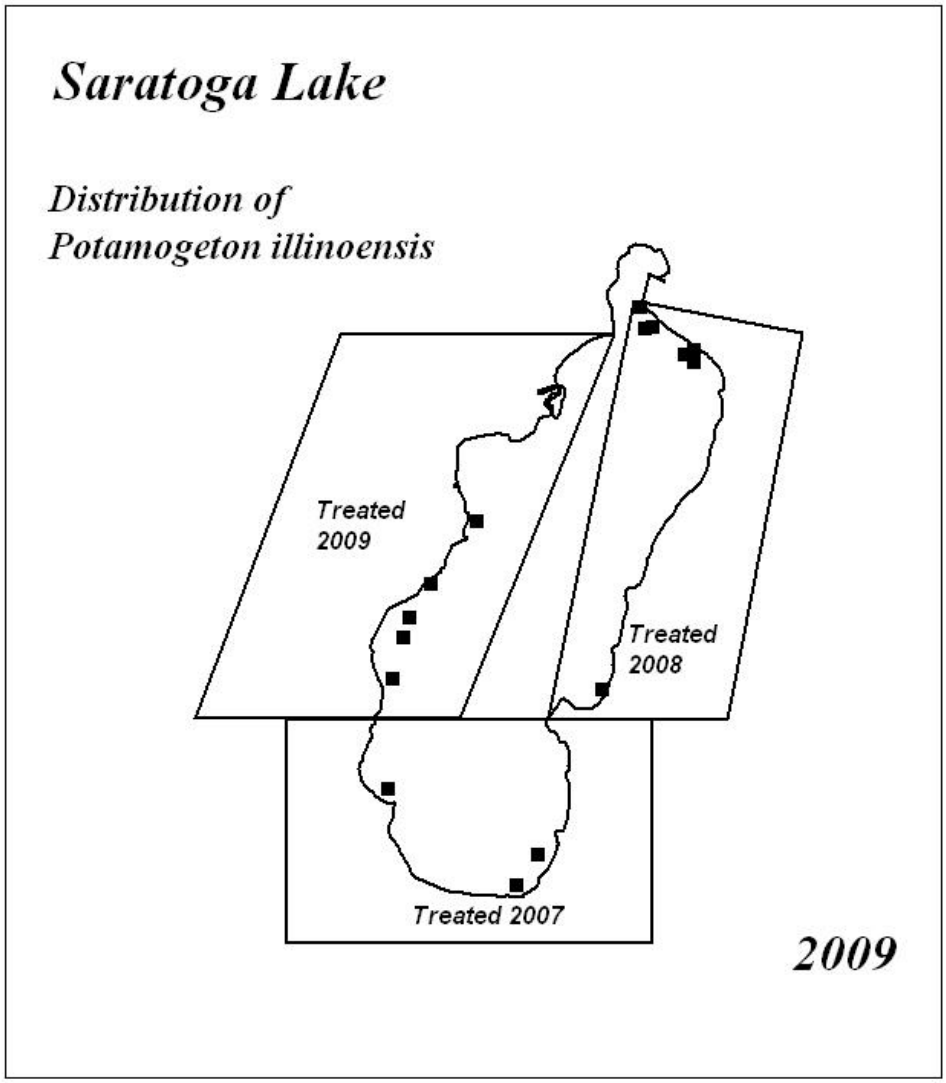
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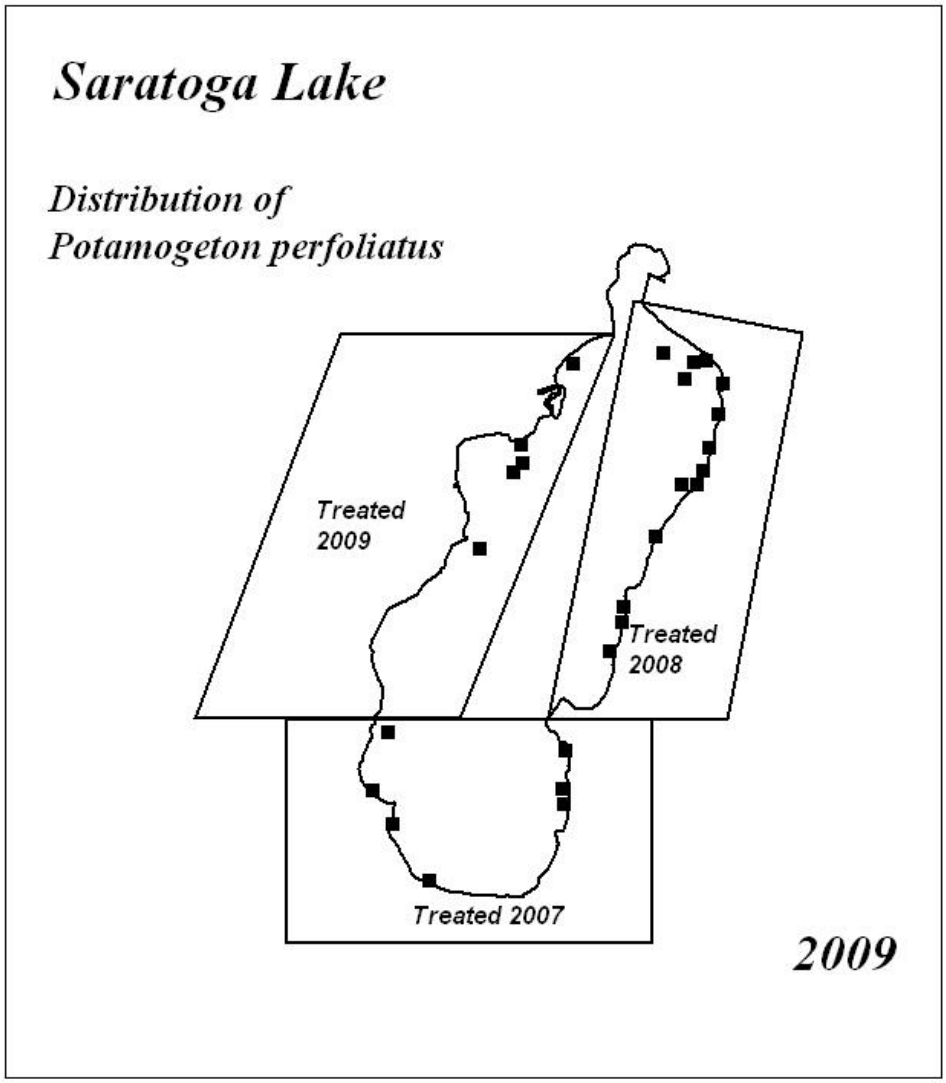
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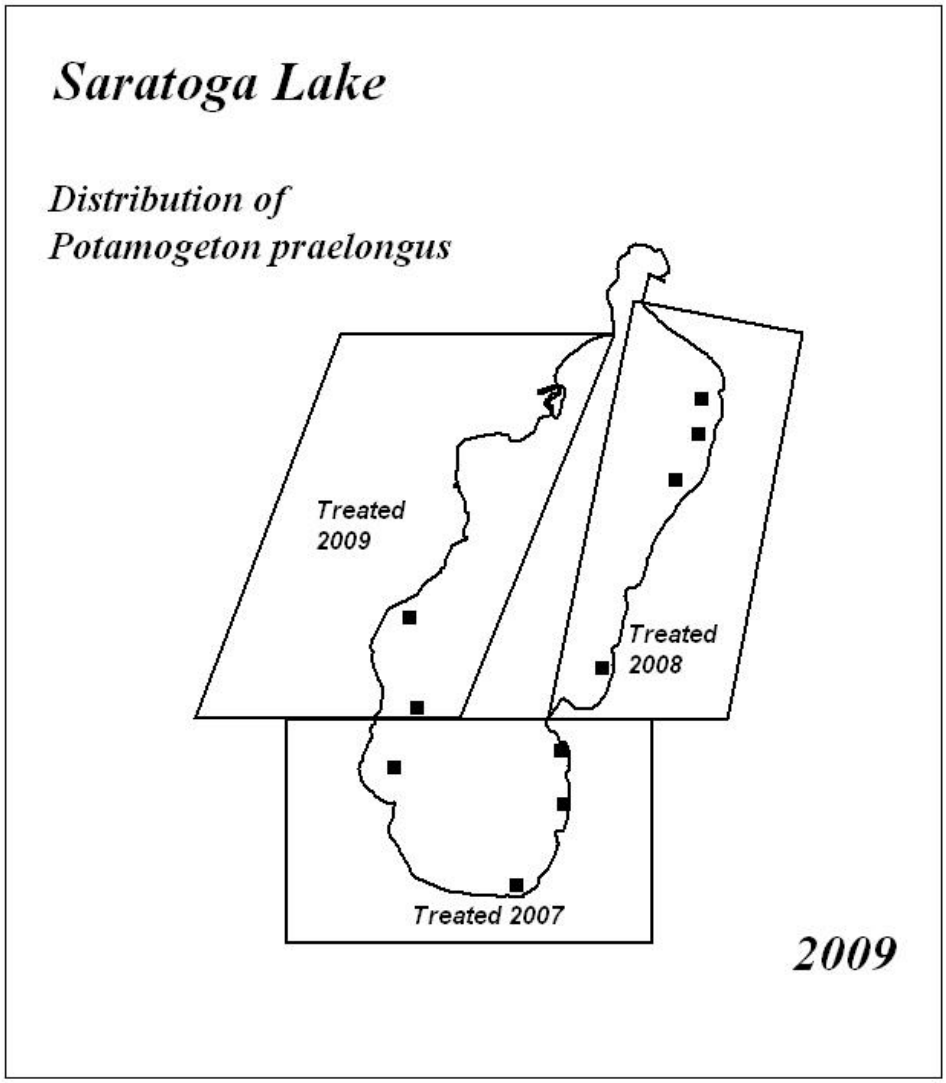
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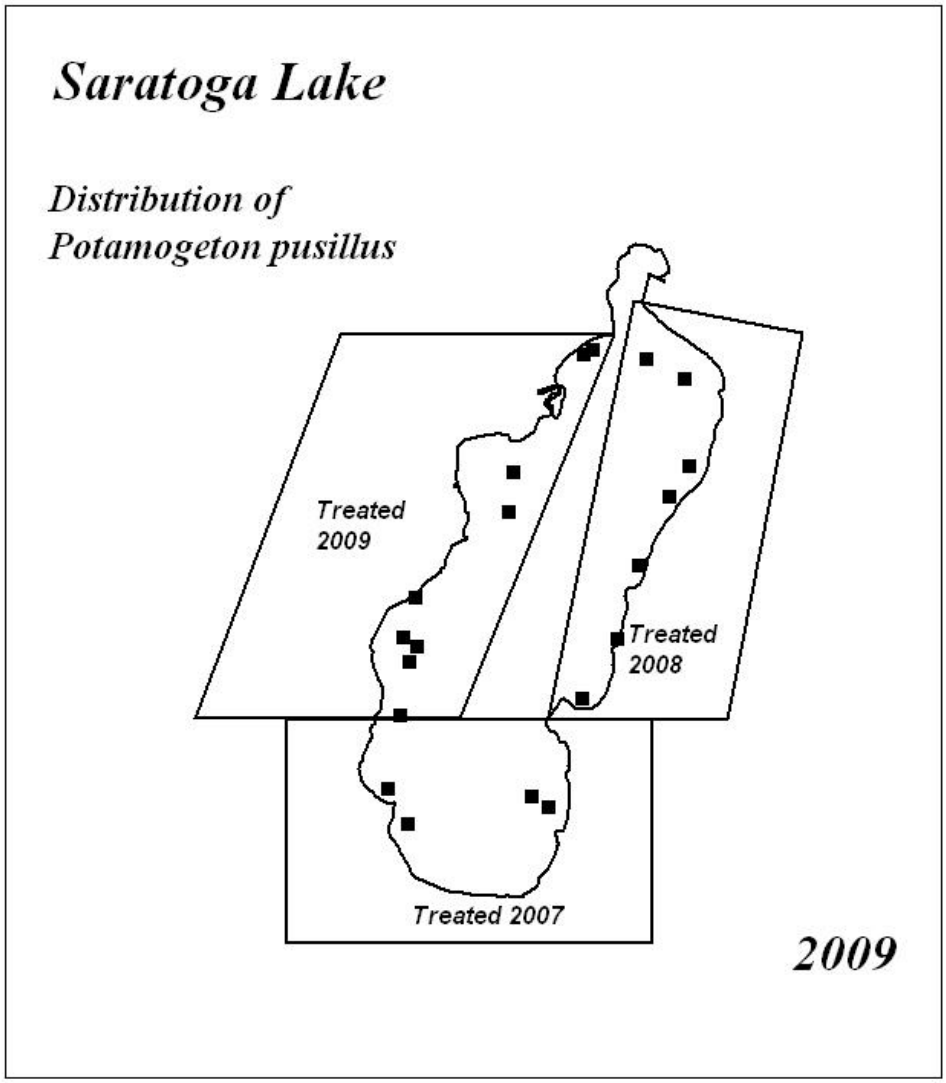
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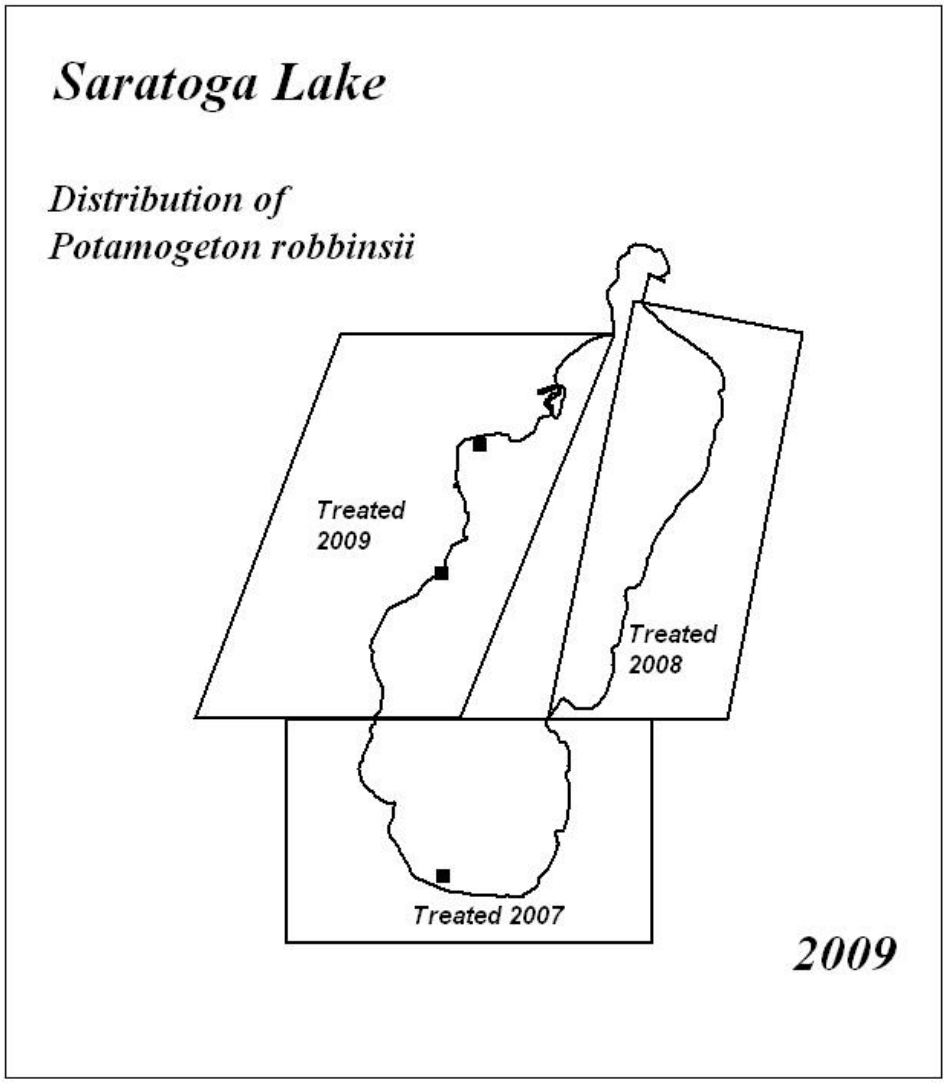
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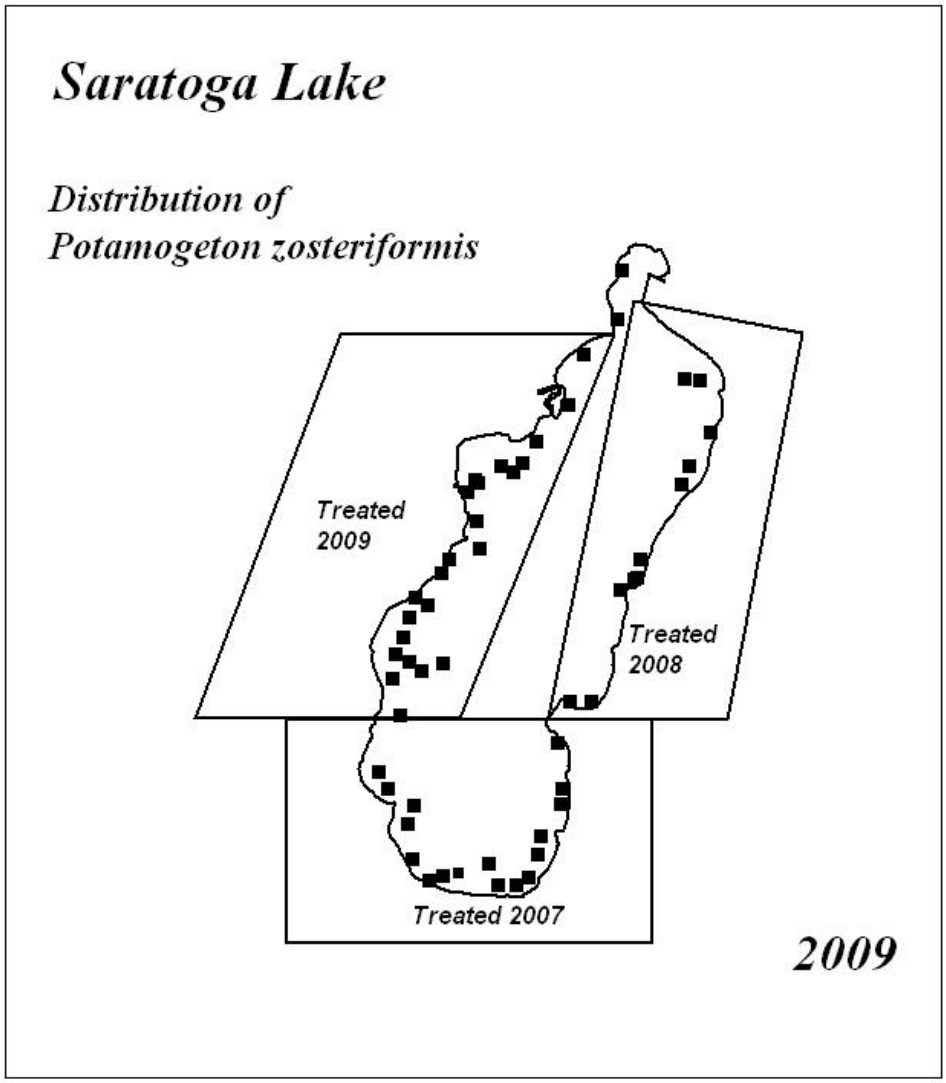
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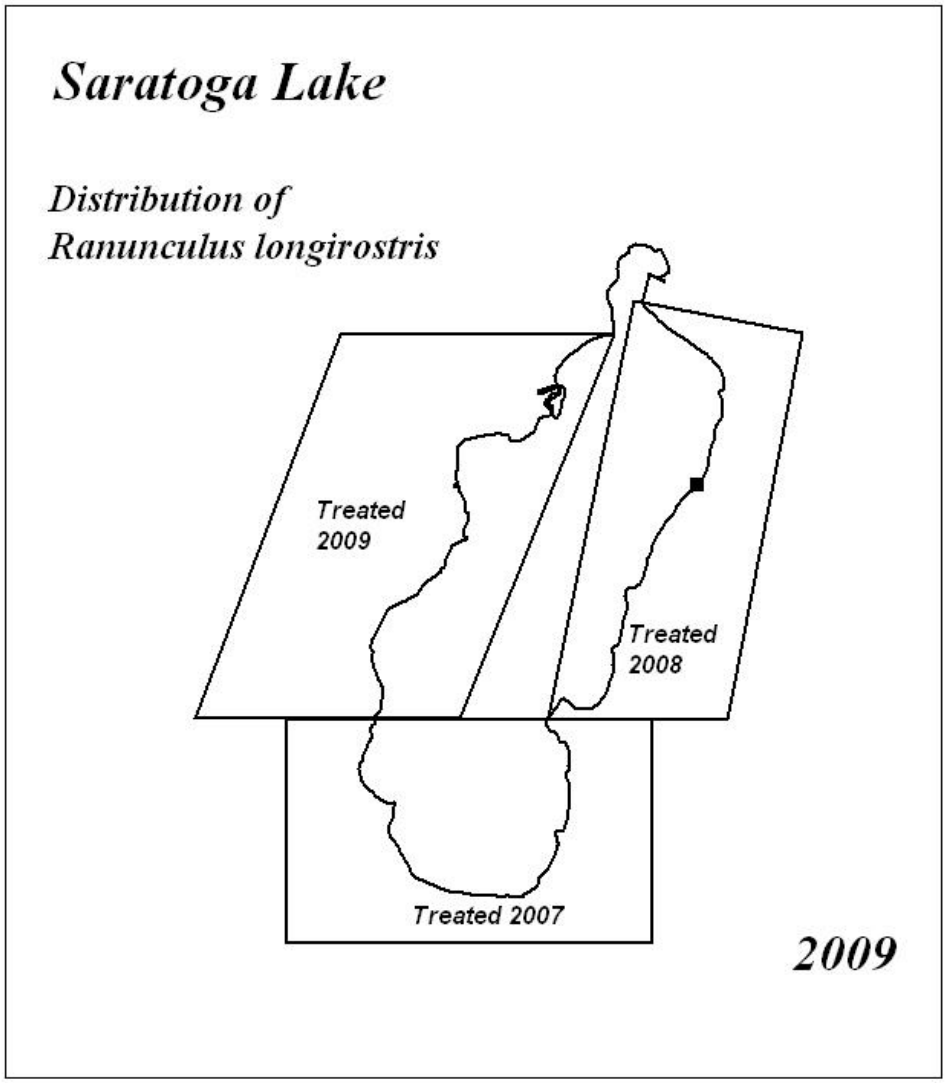
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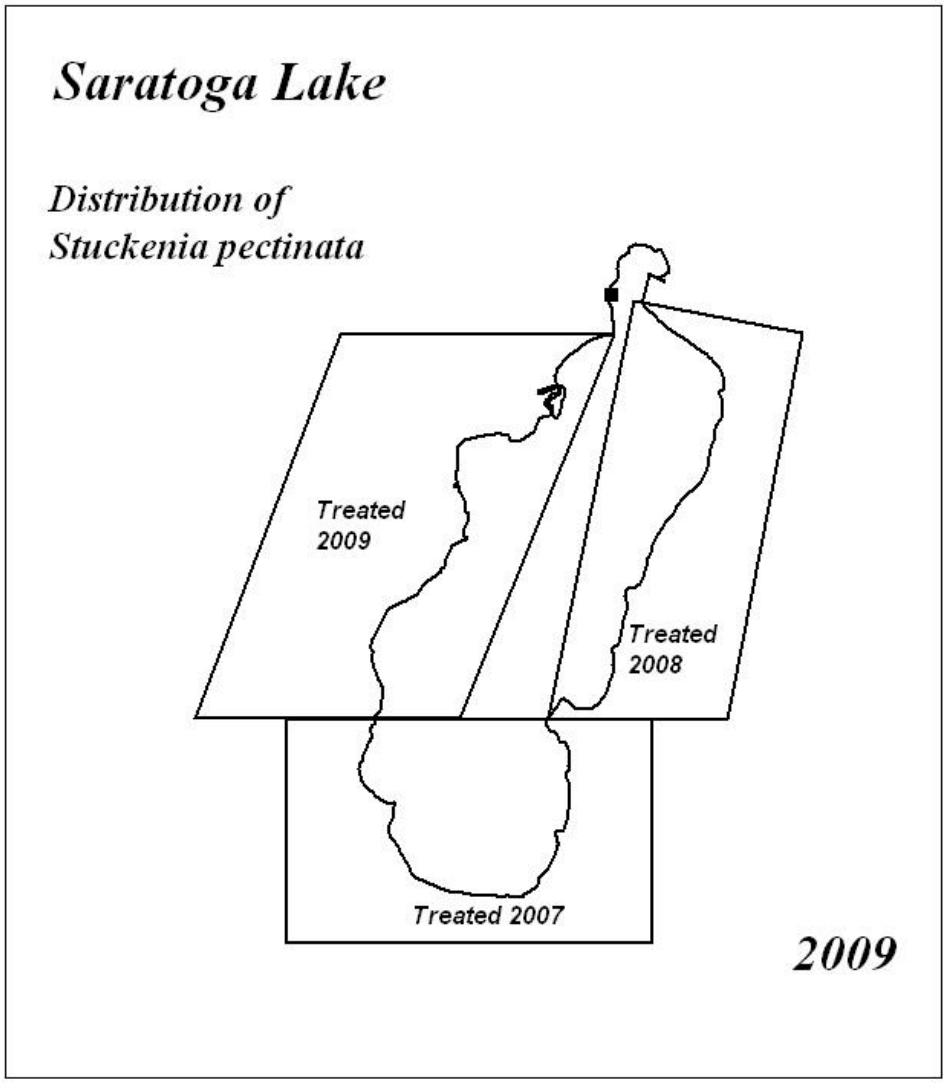
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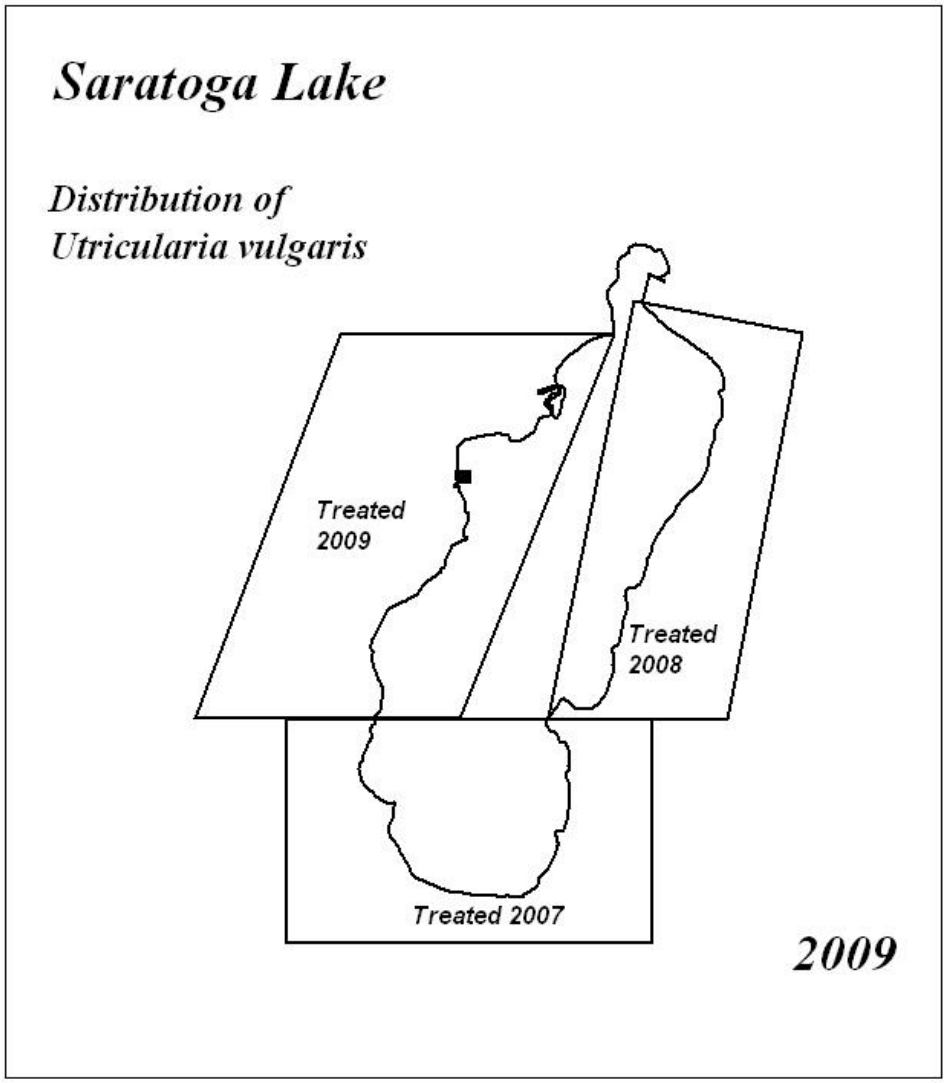
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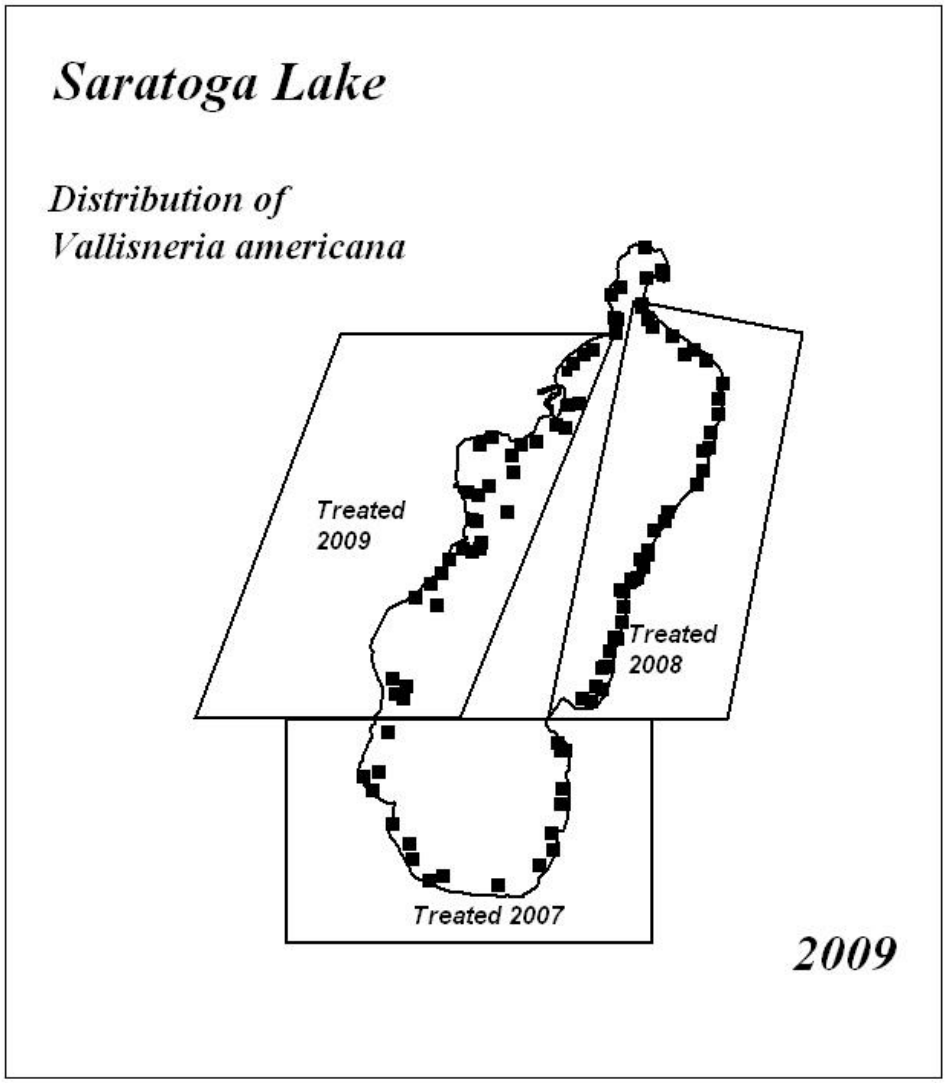
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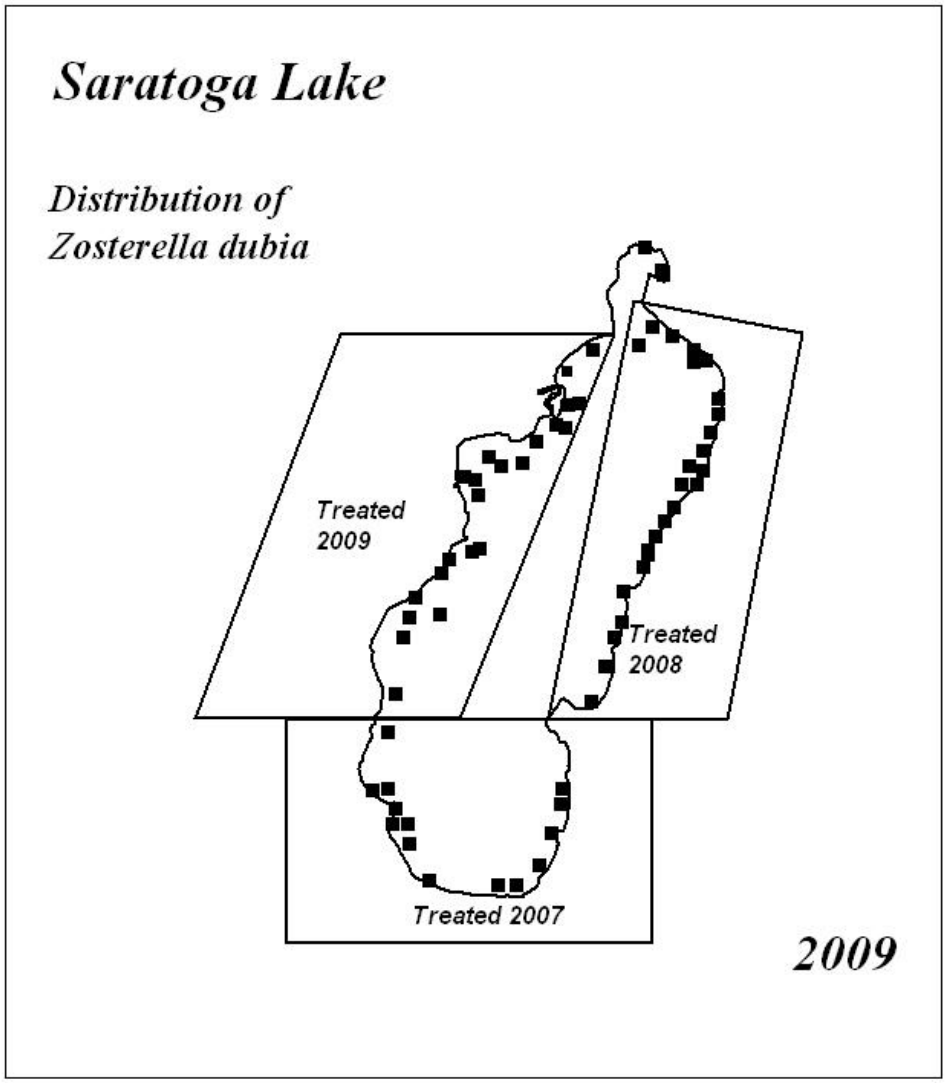
Saratoga Lake
Distribution of
Zosterella dubia
Treated
2009
Treated
2008
Treated 2007
2009