Aquatic Invasive Plant Survey of the Missouri River Headwaters Area, Montana

A Final Report Submitted to the Montana Department of Natural Resources and Conservation

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Preface

This report presents data collected by Mississippi State University and Weed Management Services in 2011 in reservoirs and rivers that comprise the Missouri Headwaters area of Montana. Funding was provided by the Montana Department of Natural Resources and Conservation. We thank Alicia Stickney, Alice Stanley, and Ray Beck for assistance with planning and on the ground logistics. Field assistance was provided by Gray Turnage and Scott Watson, Mississippi State University; and Nathan Korb and Brad Bauer, The Nature Conservancy. Historical plant survey data from Lower Red Rock Lake was provided by Jeff Warren, US Fish and Wildlife Service. We thank Dr. Christopher Mudge, Dr. Wilfredo Robles, and Amanda Fernandez for reviewing an earlier version of this report. Any errors in presentation or fact, however, are the responsibility of the authors.

Executive Summary

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Myriophyllum spicatum and *Potamogeton crispus* are two non-native, Montana-listed noxious aquatic plants that are increasingly spreading in Montana and the Pacific Northwest. *Myriophyllum spicatum* was identified in Toston Reservoir and the Jefferson River system in 2010; however, the source of the infestation was not determined. *Potamogeton crispus* was known to occur in the upper Missouri, Madison, East Gallatin, and Jefferson river systems, but limited data existed quantifying its actual distribution in the Missouri River watershed.

The Geosystems Research Institute and Weed Management Services conducted aquatic invasive plant surveys on 13 reservoirs and 4 rivers within the Missouri headwaters area of Montana. Surveys were conducted from August to September 2011 with more than 1120 individual points sampled for aquatic plant species. Additional data from the US Fish and Wildlife Service are included in this report for Lower Red Rock Lake which represents data collected from an additional 87 locations within the lake from 2005 to 2009.

Within the assigned survey area, *Myriophyllum spicatum* was only observed in Toston Reservoir where it was found at 14% of sampled points. *Potamogeton crispus* was also observed growing in Toston Reservoir where it occurred at 20% of sample points. Other reservoirs in the Missouri Headwaters area where curlyleaf pondweed was observed include, Hebgen Reservoir and Ennis Reservoir. *Potamogeton crispus* was also found in the Madison River and the Gallatin River. This region of Montana has a number of natural lakes, man-made impoundments, and rivers with varying degrees of access which will influence the invasion potential for a given water body. Generally, the waters surveyed during this inventory supported a species rich community of native aquatic plants and all had areas that could be susceptible to non-native invasions.

Multiple water bodies also had several native milfoils (*Myriophyllum* spp.) which may be problematic with respect to accurate identification and potential management of Eurasian watermilfoil. Future surveys should continue to monitor existing Eurasian watermilfoil populations and new surveys directed towards high risk water bodies in Montana. These include aquatic sites directly associated with infested waters and water bodies that have access points that support motorized boat traffic.

Project Introduction

Understanding the dynamics driving macrophyte populations in a given water body has become increasingly important due to the introduction and spread of numerous non-native plant species. Non-native plants affect aesthetics, drainage, fishing, water quality, fish and wildlife habitat, flood control, human and animal health, hydropower generation, irrigation, navigation, recreation, and ultimately land values (Pimental et al. 2000, Rockwell 2003). The spread of non-native aquatic plants also impacts native plant communities and primary production in littoral zone areas of waterbodies. Littoral areas in freshwater lakes are the most productive regions within a body of water, and an important component of high productivity is a diverse native aquatic plant community (Wetzel 2001). The importance of plants in these areas are paramount as they contribute to the structure, function, and diversity of aquatic ecosystems, aid in nutrient cycling, produce food for aquatic organisms, and provide habitat for invertebrates and fish (Carpenter and Lodge 1986, Ozimek et al. 1990, Madsen et al. 2001). Littoral areas, are however, more prone to invasion by non-native plants as they experience more disturbance than other parts of a water body.

Two non-native aquatic plants that are becoming problematic in Montana and the Pacific Northwest are Eurasian watermilfoil (*Myriophyllum spicatum*) and curlyleaf pondweed *Potamogeton crispus*). *Myriophyllum spicatum* is an invasive vascular plant that has invaded freshwater lakes across the United States. The introduction of this species has likely resulted in the alteration of the complex interactions occurring in littoral habitats (Madsen 1997). *Myriophyllum spicatum* has been associated with declines in native plant species richness and diversity (Madsen et al. 1991a,b, Madsen et al. 2008), reductions in habitat complexity resulting in reduced macroinvertebrate abundance (Krull 1970, Keast 1984), and reductions in fish growth (Lillie and Budd 1992). *Myriophyllum spicatum* poses nuisance problems to humans by impeding navigation, limiting recreation opportunities, and increasing flood frequency and intensity (Madsen et al. 1991a). It is primarily spread by fragmentation and can be easily transported between water bodies by many vectors. Once established, it is very difficult to control. *Potamogeton crispus* also causes significant nuisance problems where it has become established (Bolduan et al. 1994, Catling and Dobson 1985, Woolf and Madsen 2003). It is widely considered to be an ecosystem transformer, like *Myriophyllum spicatum*, but this species tends to accelerate internal nutrient loading and eutrophication (James et al. 2002). Management of this species is often more difficult due to its life history strategy (turion production) and the limited availability of effective management options.

Both species are listed on Montana’s noxious weed list and are spreading throughout the state. *Myriophyllum spicatum* was identified in Toston Reservoir and the Jefferson River system in 2010. *Potamogeton crispus* was known to occur in the upper Missouri, Madison, East Gallatin, and Jefferson river systems, but little data existed regarding its actual distribution in Missouri River headwaters area. Pursuant to this, a systematic survey is needed to develop baseline information on the aquatic plant community. The survey would quantify the location and extent *Myriophyllum spicatum* and *Potamogeton crispus* within lakes/reservoirs in the upper Missouri River watershed and determine the presence of other non-native aquatic plants such as flowering rush (*Butomus umbellatus*). Data such as these are necessary to guide future management decisions, determine funding needs, and coordinate control efforts. Preliminary inventories have identified other submersed aquatic plants in these water bodies, which will also be a factor in developing management protocol.

Objectives

1. Conduct aquatic plant surveys within the Missouri headwaters are on Hebgen Reservoir, Cliff Lake, Wade Lake, Elk Lake, Ennis Reservoir, Ruby River Reservoir, Cataract Reservoir, Willow Creek Reservoir, Clark Canyon Reservoir, Toston Reservoir, Lima Reservoir, Upper Red Rock Lake, and Lower Red Rock Lake.

2. Conduct surveys of select river sections on the Madison River, Ruby River, Red Rock River, and the West Gallatin River for aquatic plants.

3. Conduct surveys at access points along river stretches for aquatic plants.

1. Reservoir Materials and Methods

Littoral zone point intercept surveys were conducted in the Missouri headwaters area on Hebgen Reservoir, Cliff Lake, Wade Lake, Elk Lake, Ennis Reservoir, Willow Creek Reservoir, Clark Canyon Reservoir, and Toston Reservoir (Figure 1.1). Ruby River Reservoir and Cataract Reservoir were not surveyed by boat as the water level in both reservoirs and lack of improved access prevented a formal survey, though a visual survey was conducted as access permitted. Surveys were designed and conducted using bathymetric data obtained by the Montana Department of Natural Resources and Conservation. Survey points were established in the littoral zone for each water body, which we designated as the 30-50 ft. depth contours and were based on other surveys conducted in Montana. Survey methods followed those outlined by Madsen (1999), Madsen and Wersal (2009), Wersal et al. (2009), and Wersal et al. 2010), where a pre-determined grid of points at set distances from one another were surveyed in each water body. The grid spacing was dependent upon the total size of the reservoir. A systematic or random-systematic survey method is a better survey design when initially surveying a water body as it is more apt to find rare species, in contrast with a random design which will likely under-sample rare but ecologically important species such as Eurasian watermilfoil (Barbour 1999). A systematic survey design also maximizes survey efficiency.

Surveys were conducted by boat using GPS (Global Positioning System) technology to navigate to each point. A Trimble YUMA® computer with integrated GPS receiver was used to conduct and store survey data. At each survey point, a weighted plant rake was deployed to determine the presence of all plant species. Spatial survey data were recorded electronically using FarmWorks Site Mate® software. Site Mate® allowed for the navigation to specific survey points, as well as, the displaying and collecting of geographic and attribute data while in the field. Collecting data in this fashion reduces data entry errors and reduces post survey data processing time. Collected data were recorded in database templates using specific pick lists constructed exclusively for this project. Voucher specimens were collected if a species was found for the first time and were dried and pressed.

In addition to plant presence/absence data, the depth at each point was recorded using a boat mounted depth finder or with a sounding rod in water depths of less than 10 ft. Water transparency was estimated using a sechhi disk at one to four locations throughout a given reservoir, depending on total size, between 1100 and 1300 hours. Mussel veliger samples were collected as well and samples were delivered to the Montana Department of Fish, Wildlife, and Parks for analysis.

Frequency of occurrence for each species in a water body was calculated by dividing the number of survey points that species was observed by the total number of points surveyed for a given water body, then multiplied by 100 to achieve a percent. Average species richness was estimated by calculating the sum of all species at a given survey point, and then calculating the mean across all survey points for a given water body. Species distributions are reported visually in a series of maps created for each water body surveyed.

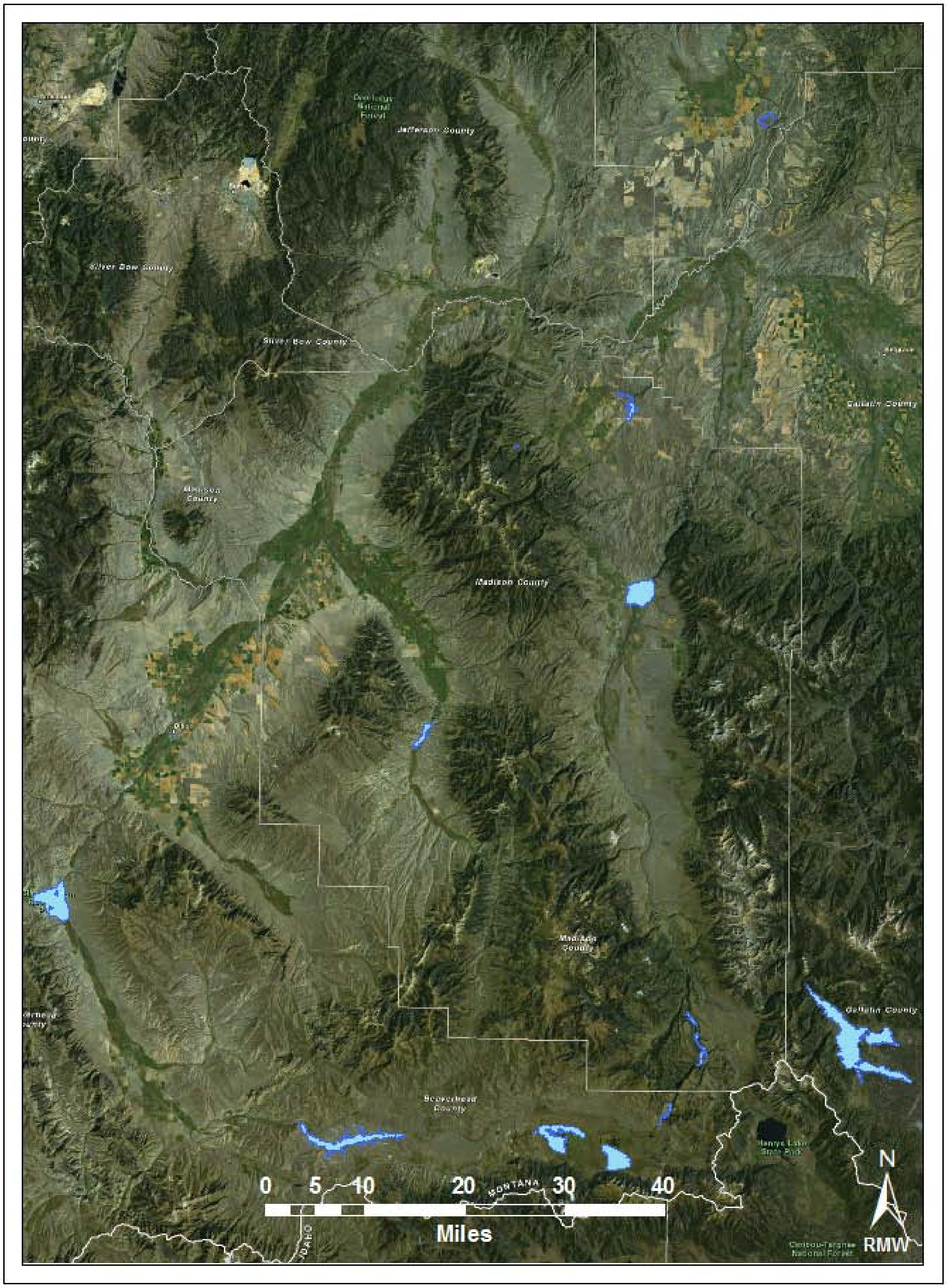

Figure 1.1. The survey area for 2011 encompassing 13 reservoirs in the Missouri headwaters, MT. Surveys were conducted in August and September 2011.

1. Reservoir Results and Discussion

Lake Name: Hebgen Reservoir

Dates Surveyed: August 26-29, 2011

Secchi: 17.3 ft. (8/26, Madison Arm), 10.9 ft. (8/27, North Arm)

Points Surveyed: 236

Eurasian watermilfoil = Negative

Hebgen Reservoir, with the exception of the Madison Arm and North Arm, is very deep > 75 ft. in most areas. Focus for this reservoir were the two shallow arms on the eastern side of the reservoir as these areas were also where the majority of the survey points were located (Figure 1.2). Additional points were surveyed in the littoral shoreline throughout much of the reservoir in areas that provided suitable habitat for plant growth. A visual plant survey was also conducted on the western shoreline. Points were surveyed to a water depth of 40 ft. with the maximum observed depth of plant growth being 17.8 ft. Of the 236 points sampled, 56% of these points were vegetated by some species of aquatic plant (Figure 1.3). *Elodea canadensis* was observed most often (41%) followed by *Potamogeton folisus* (25%) and Nitella sp. (19%) (Table 1.1). *Elodea canadensis* and *P. foliosus* were observed in both arms and along the western shoreline of the reservoir (Figures 1.4 and 1.5). *Myriophyllum sibiricum* was observed primarily in the north arm and along the western shoreline (Figure 1.6).

Potamogeton crispus was the only non-native species observed in Hebgen Reservoir. It was observed growing in the North Arm at three survey points and in the littoral zone along the western shoreline (Figure 1.7), though present, it was not wide spread. If this species is left unmanaged, it could result in significant ecological impacts. *Potamogeton crispus* is widely considered to be an ecosystem transformer as the presence of this species tends to accelerate internal nutrient loading and eutrophication (James et al. 2002). Increases in nutrient loading may further exacerbate the nuisance growth of this species and potentially other non-native species. The distribution of *P. crispus* in Hebgen Reservoir is still fairly localized and directed management would eliminate or contain the current population.

Table 1.1. Plant species list and percent occurrences for Hebgen Reservoir, MT, August 2011.

Species	Common Name	Frequency of Occurrence (%)
***Ceratophyllum demersum* L.**	Coontail	1
***Chara* sp.**	Muskgrass	10
***Elatine minima* (Nutt.) Fisch. & Mey.**	Waterwort	1
***Elodea canadensis* Michx.**	Elodea	41
***Myriophyllum sibiricum* Komarov**	Northern watermilfoil	6
***Nitella* sp.**	Brittlewort	19
***Potamogeton crispus* L.**	Curlyleaf pondweed	4
***Potamogeton foliosus* L.**	Leafy pondweed	25
***Potamogeton gramineus* L.**	Variableleaf pondweed	1
***Potamogeton illinoensis* Morong**	Illinois pondweed	0.4
***Potamogeton richardsonii* (Ar. Benn.) Rydb.**	Clasping-leaved pondweed	5
***Potamogeton zosteriformis* Fern.**	Flat-stemmed pondweed	0.4
***Ranunculus aquatilis* L.**	White water-buttercup	3
***Stuckenia pectinata* (L.) Börner**	Sago pondweed	8
***Typha latifolia* L.**	Common cattail	1
***Utricularia vulgaris* L.**	Common bladderwort	0.4
Average Survey Depth (ft)		13.4
Species Richness (avg. number per point)		1.3

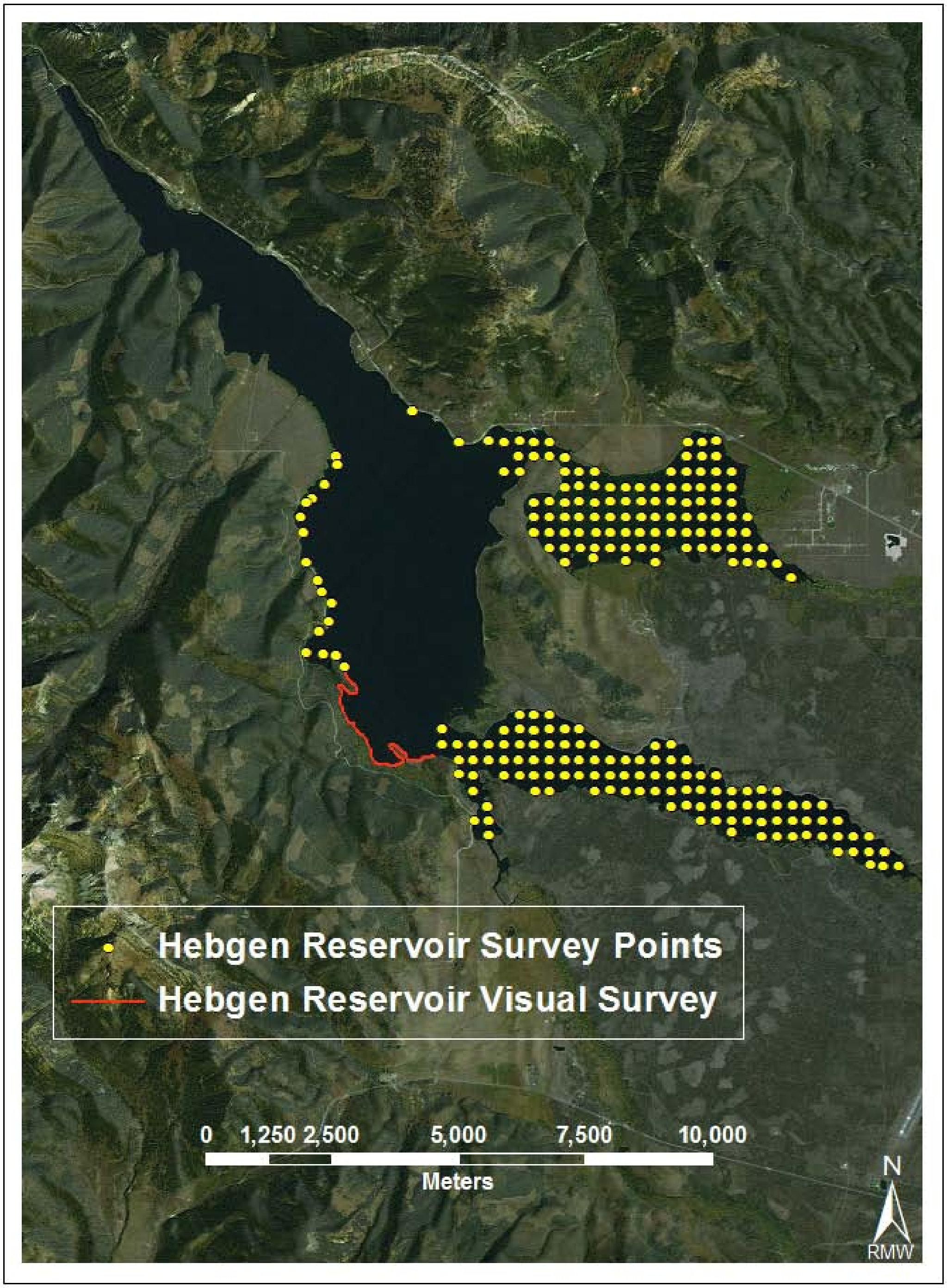

Figure 1.2. Survey points sampled during the littoral zone survey of Hebgen Reservoir conducted in August 2011.

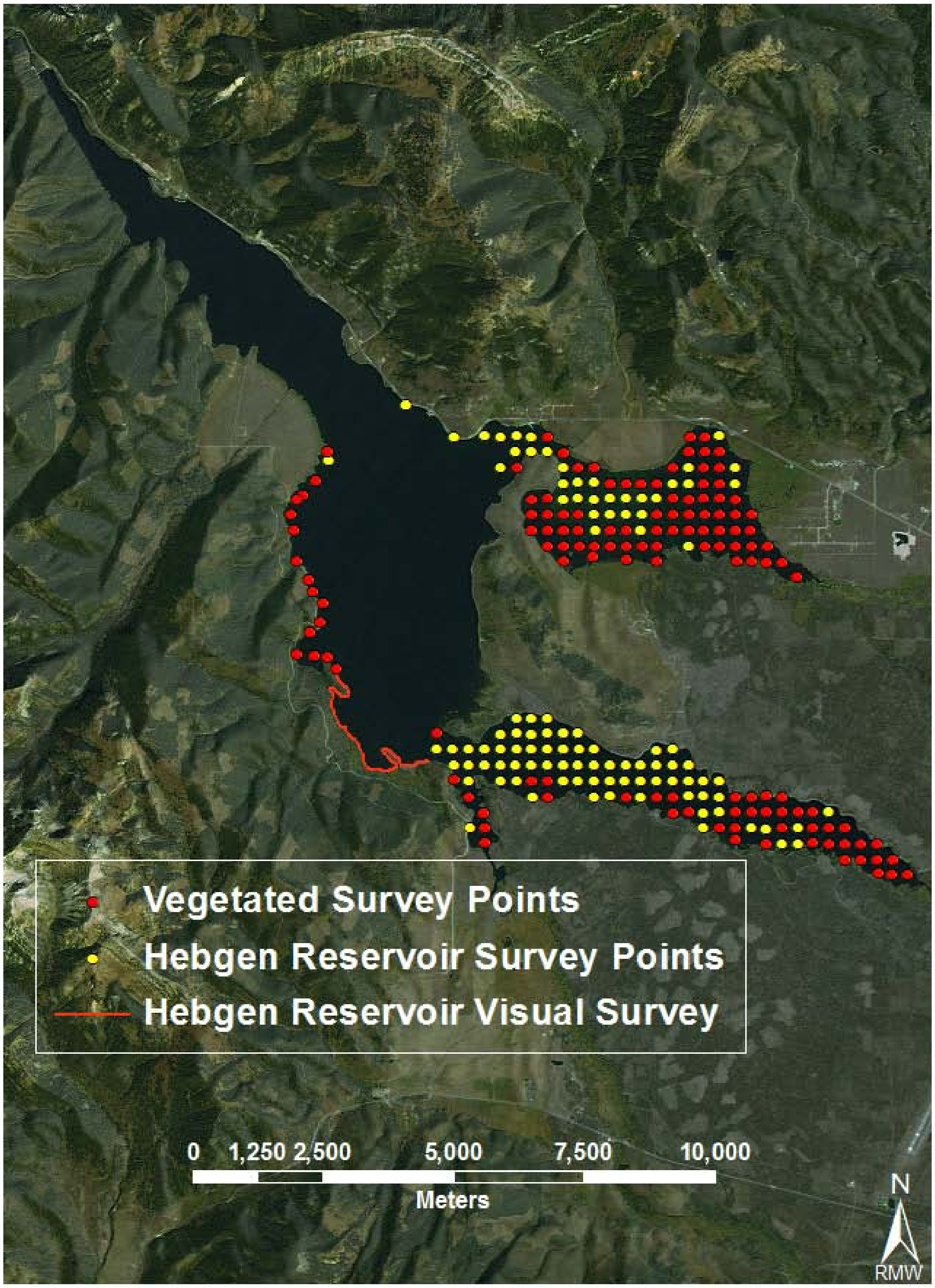

Figure 1.3. Survey points where aquatic plant species were observed during the littoral zone survey of Hebgen Reservoir conducted in August 2011.

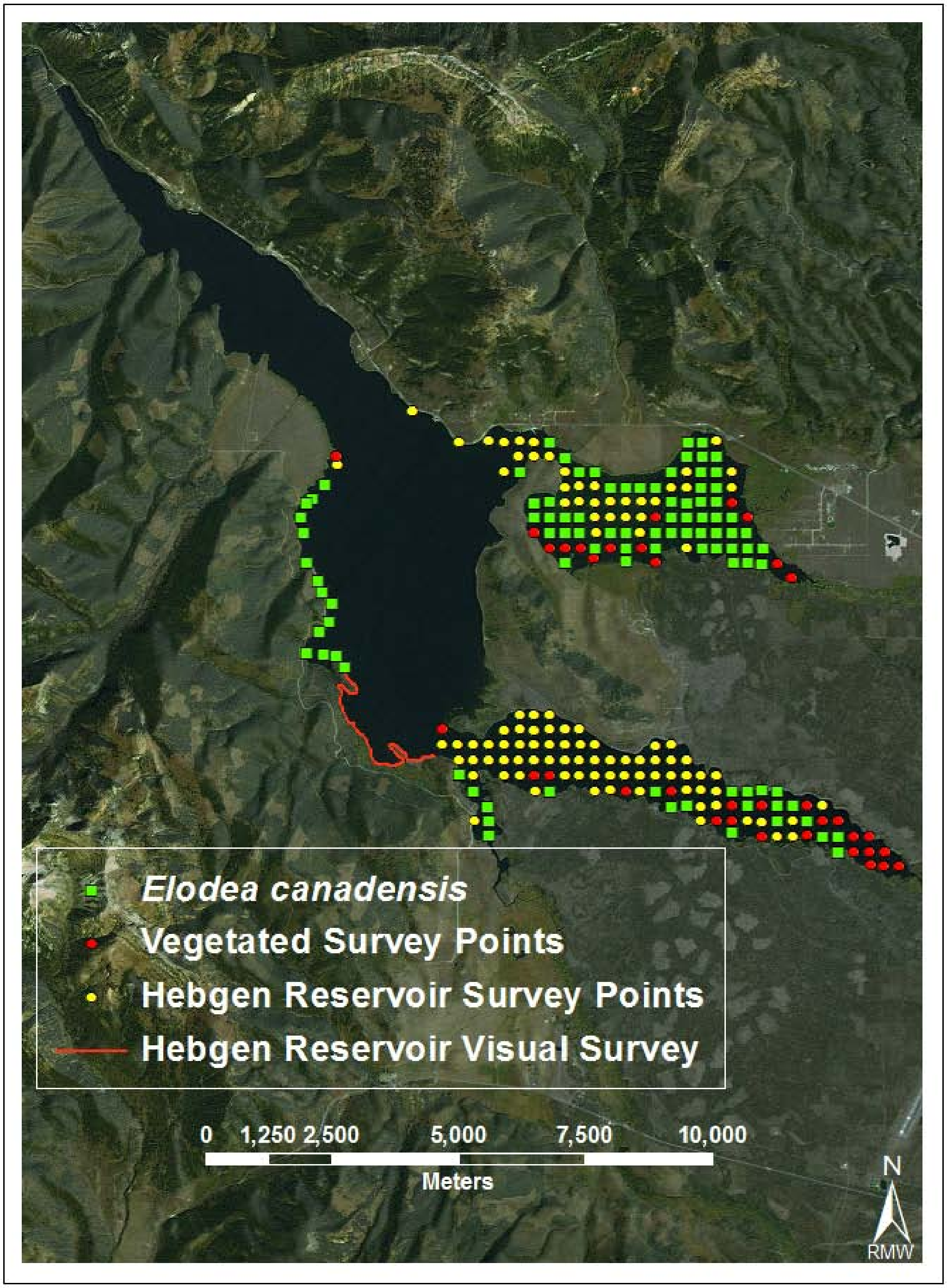

Figure 1.4. The distribution of *Elodea canadensis* in Hebgen Reservoir during the littoral zone survey conducted in August 2011.

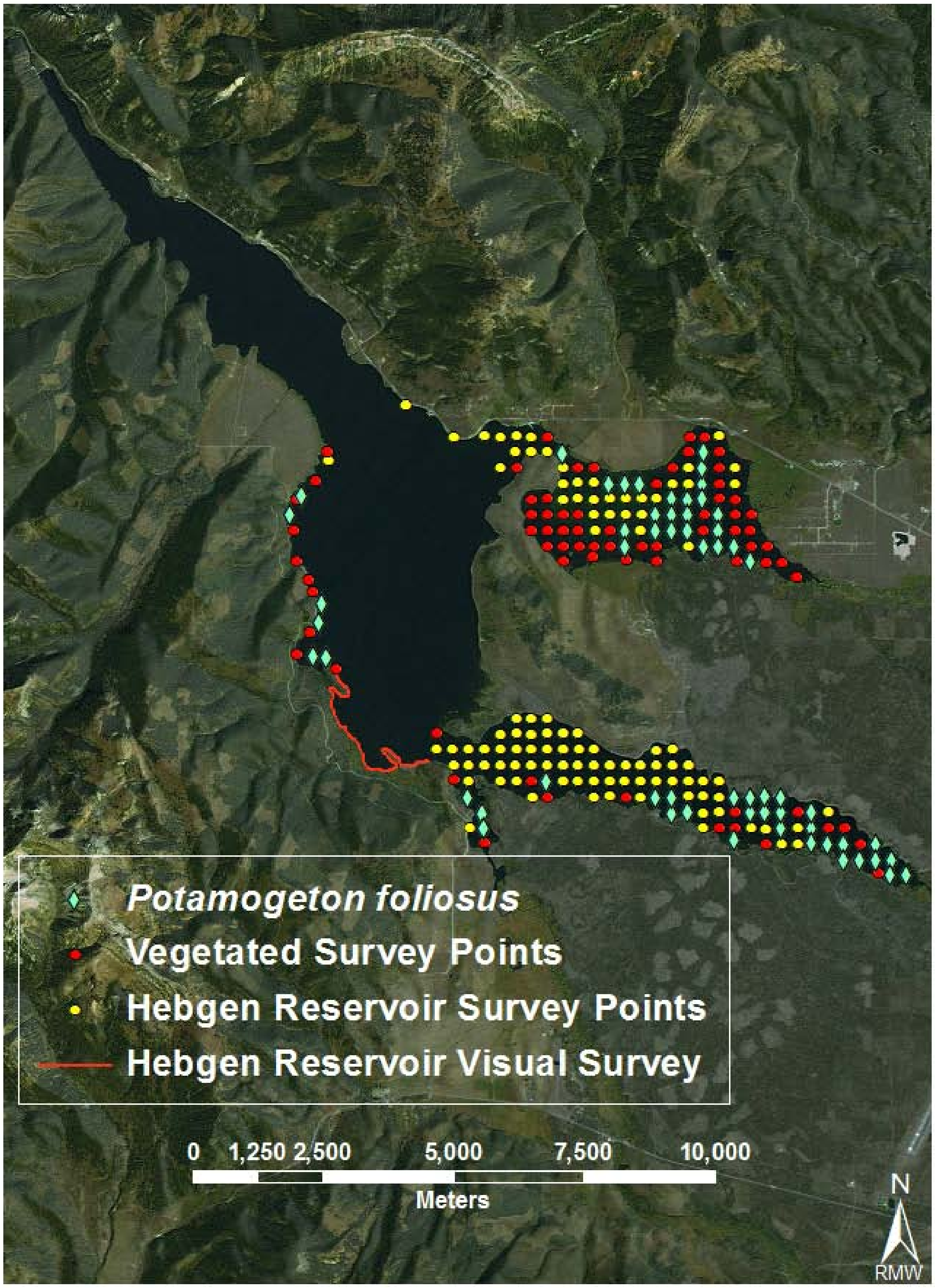

Figure 1.5. The distribution of *Potamogeton foliosus* in Hebgen Reservoir during the littoral zone survey conducted in August 2011.

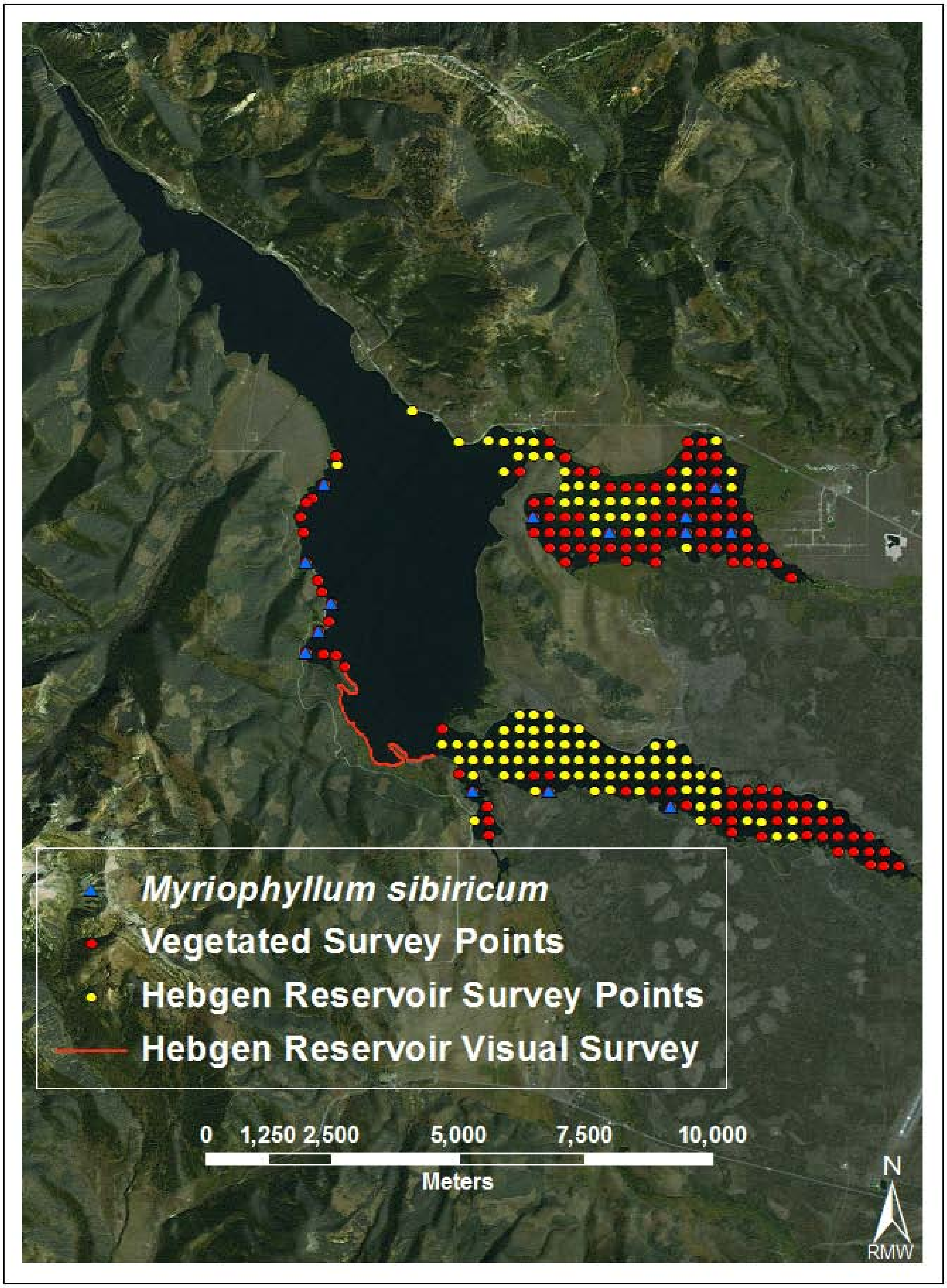

Figure 1.6. The distribution of *Myriophyllum sibiricum* in Hebgen Reservoir during the littoral zone survey conducted in August 2011.

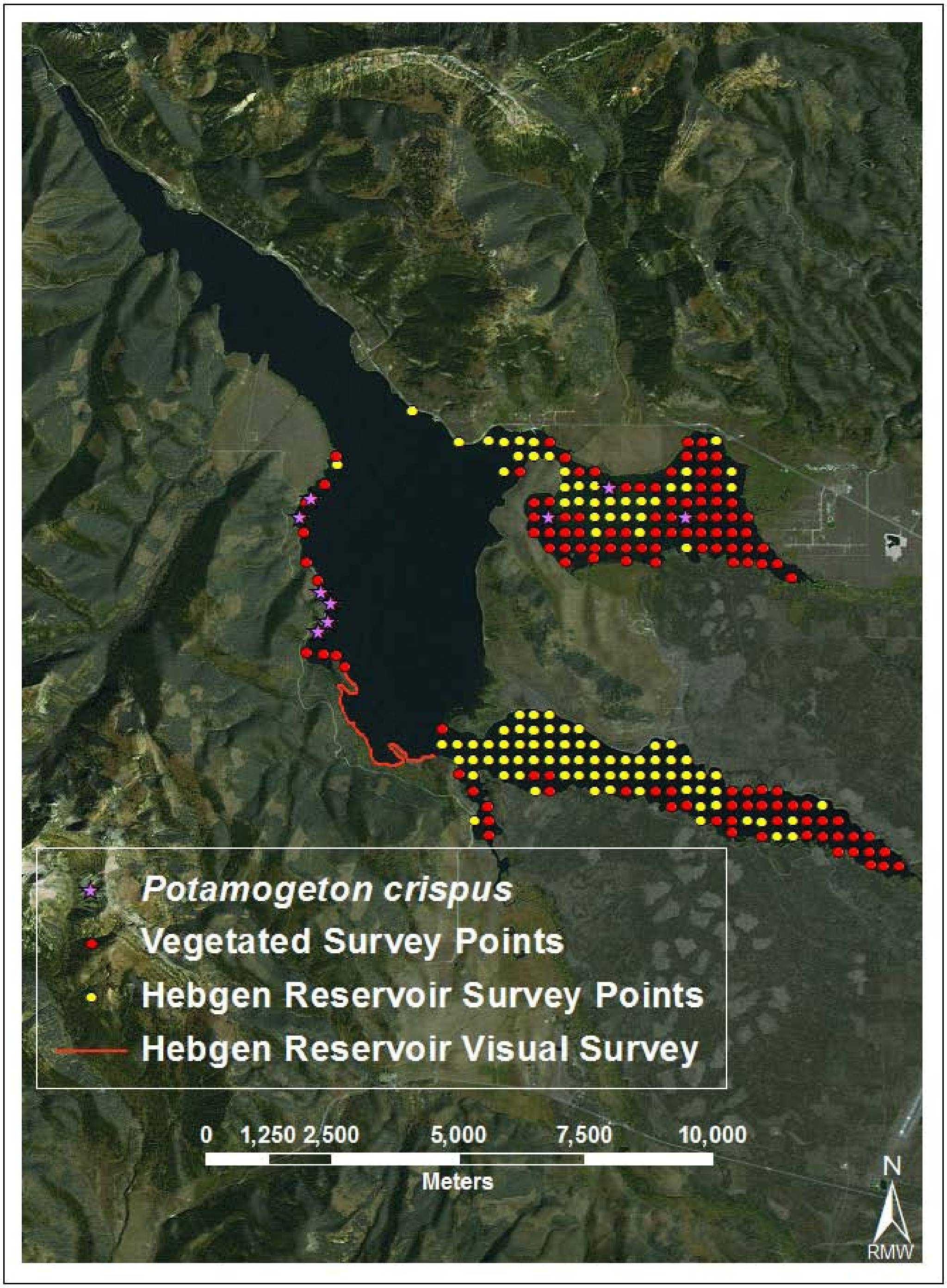

Figure 1.7. The distribution of *Potamogeton crispus* in Hebgen Reservoir during the littoral zone survey conducted in August 2011.

Lake Name: Cliff Lake

Date Surveyed: August 28, 2011

Secchi: 22.2 ft.

Points Surveyed: 152

Eurasian watermilfoil = Negative

Cliff Lake has an upper and lower section that is separated by a narrowing of the lake. The substrate is almost entirely sand or rock (typically these substrates do not support plant growth). The center areas in the upper and lower portions of Cliff Lake are very deep and shoreline habitat was often a sheer cliff that dropped off into deep water. The majority of the survey points were moved to the perimeter of the lake in order to intensively survey the littoral zone (Figure 1.8). Points were surveyed to a water depth of 96 ft. with the maximum observed depth of plant growth being 14 ft. Of the 152 points surveyed, 36% of these points were vegetated by some species of aquatic plant (Figure 1.9). The shallow area between the northern and southern portions of the lake was an area where plant growth occurred. *Myriophyllum pinnatum* was the most common species found in Cliff Lake, followed by *Myriophyllum sibiricum* and *Potamogeton praelongus* (Table 1.2).

Myriophyllum pinnatum has not previously been reported in the state of Montana as indicated by online plant databases, though it was found in several areas in the northern portion of the lake (Figure 1.10). *Myriophyllum sibiricum*, another native milfoil, was also found in Cliff Lake though its distribution was primarily in the southern portion of the lake (Figure 1.11). *Myriophyllum pinnatum* can be distinguished from *Myriophyllum sibiricum* by its smaller size, it generally has less leaflets, and it has more pronounced tapering at the leaf tip. *Myriophyllum pinnatum* also has a distinctive emergent form, though this was not observed in any of the areas in Montana. *Myriophyllum* species, both native and non-native, are difficult to distinguish in the field when plants are not in flower and the emergent bracts are absent, therefore, training in plant identification is essential when conducting field surveys. Additionally, with the development of genetic markers, milfoil species can be identified genetically if there are uncertainties regarding field identifications. Currently, there are laboratories at Grand Valley State University in Michigan, and Bowling Green State University in Kentucky that have extensive experience in genetically identifying milfoil species. Mississippi State University has also conducted genetic assays of milfoil species.

The pondweeds *Potamogeton praelongus* and *Stuckenia pectinata* were observed growing in both the northern and southern portions of the lake (Figures 1.12 and 1.13). *Polygonum amphibium*, a moist soil smartweed, was observed growing along the shoreline around the southern portion of the lake.

Table 1.2. Plant species list and percent occurrences for Cliff Lake, MT, August 2011.

Species	Common Name	Frequency of Occurrence (%)
***Ceratophyllum demersum* L.**	Coontail	2
***Chara* sp.**	Muskgrass	3
***Elodea canadensis* Michx.**	Elodea	3
***Myriophyllum pinnatum* Britton, Sterns & Poggenb.**	Cutleaf watermilfoil	13
***Myriophyllum sibiricum* Komarov**	Northern watermilfoil	11
***Potamogeton foliosus* L.**	Leafy pondweed	1
***Potamogeton praelongus* Wulf.**	Whitestem pondweed	10
***Potamogeton richardsonii* (Ar. Benn.) Rydb.**	Clasping-leaved pondweed	7
***Stuckenia pectinata* (L.) Börner**	Sago pondweed	9
Average Survey Depth (ft)		16.2
Species Richness (avg. number per point)		0.5

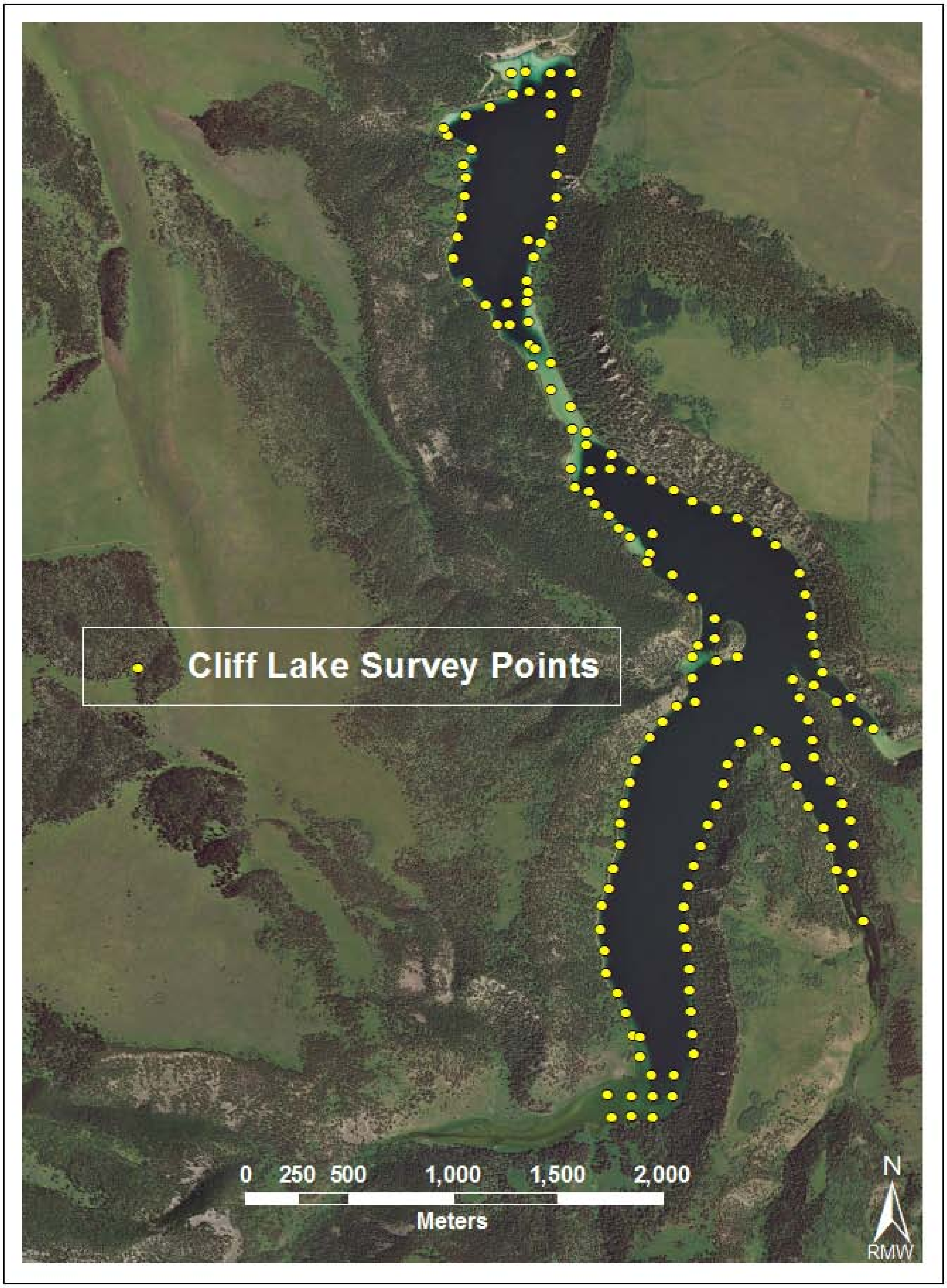

Figure 1.8. Survey points sampled on Cliff Lake during the littoral zone survey conducted in August 2011.

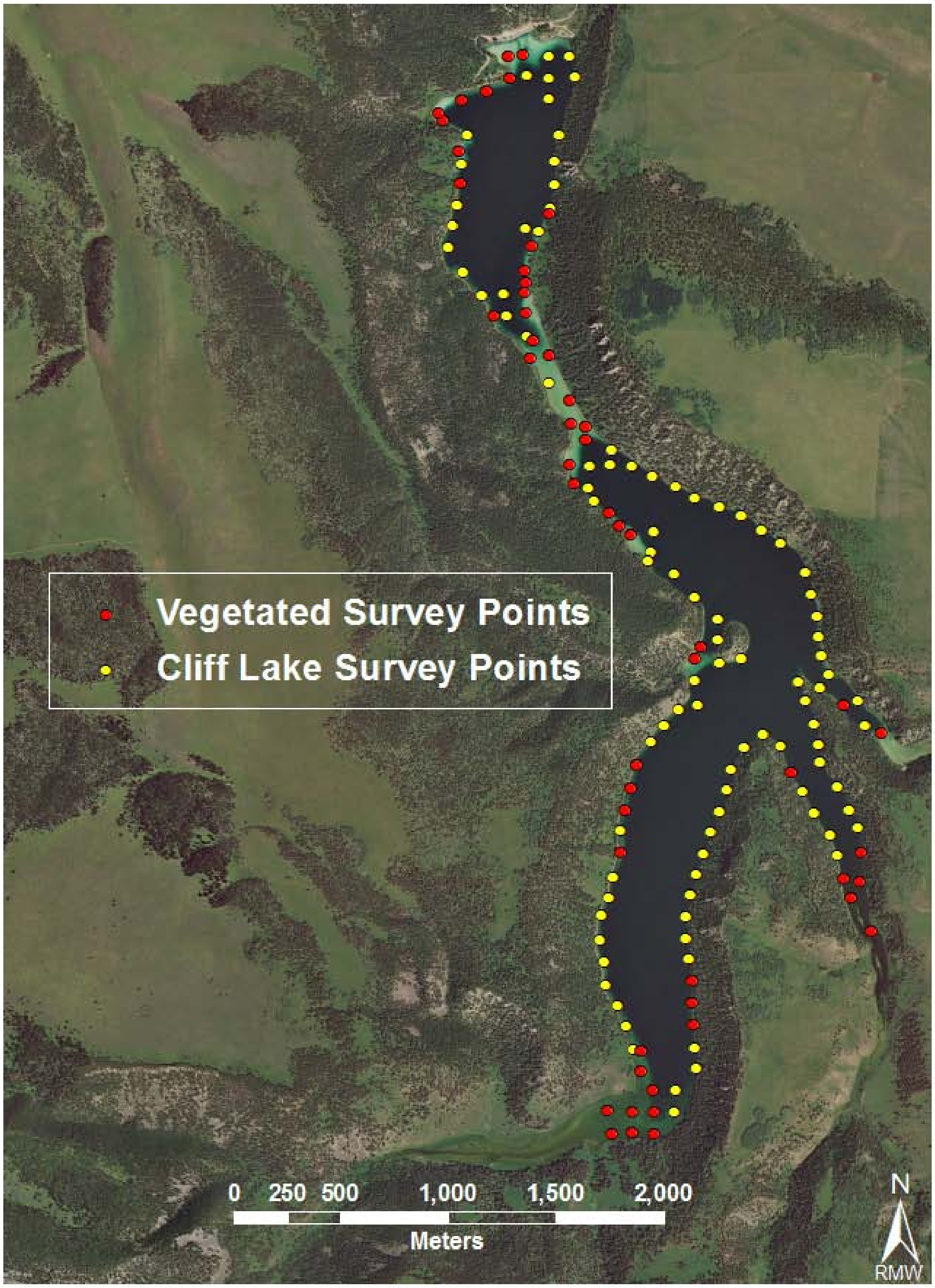

Figure 1.9. Survey points where aquatic plant species were observed during the littoral zone survey of Cliff Lake conducted in August 2011.

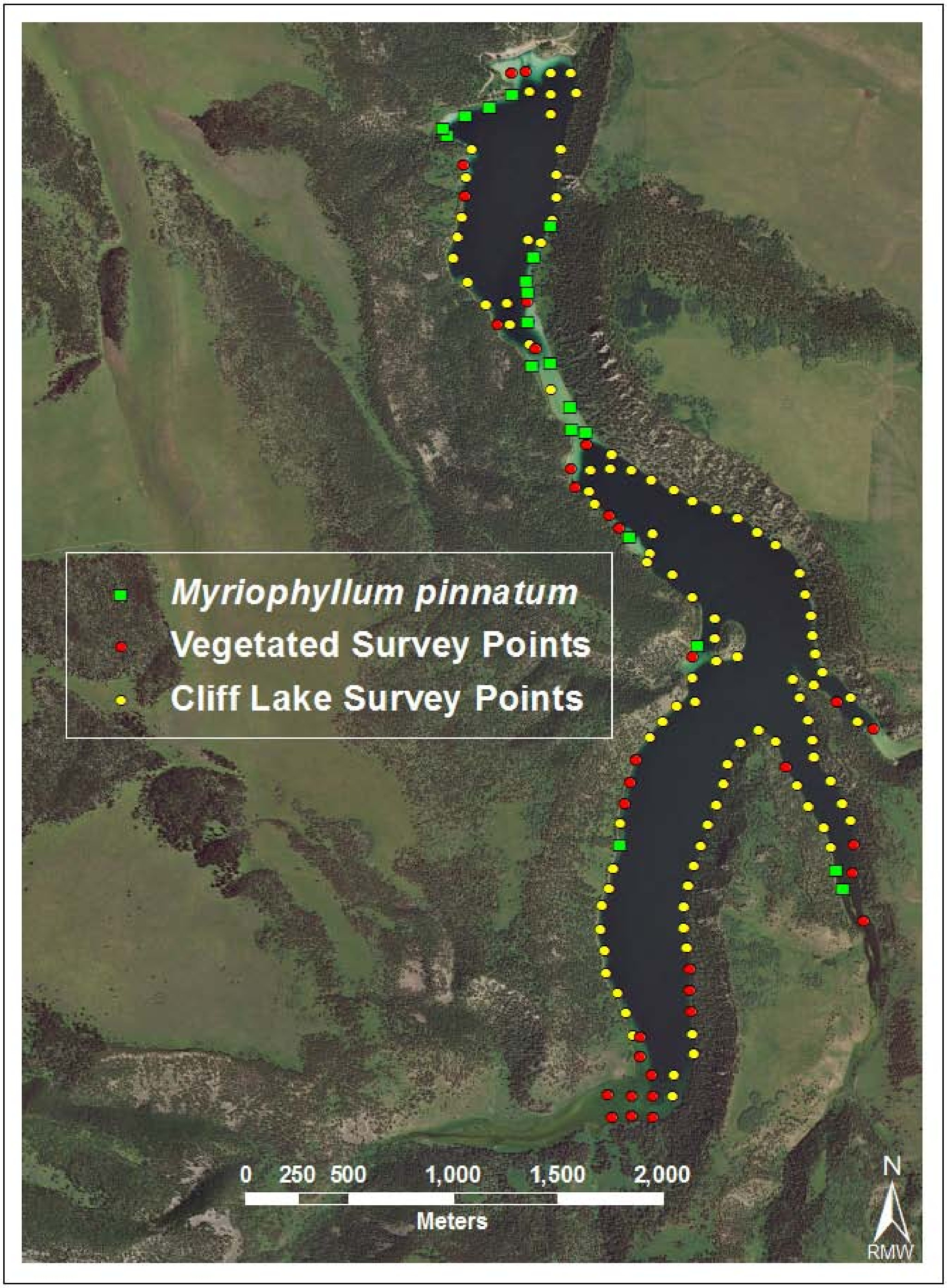

Figure 1.10. The distribution of *Myriophyllum pinnatum* in Cliff Lake during the littoral zone survey conducted in August 2011.

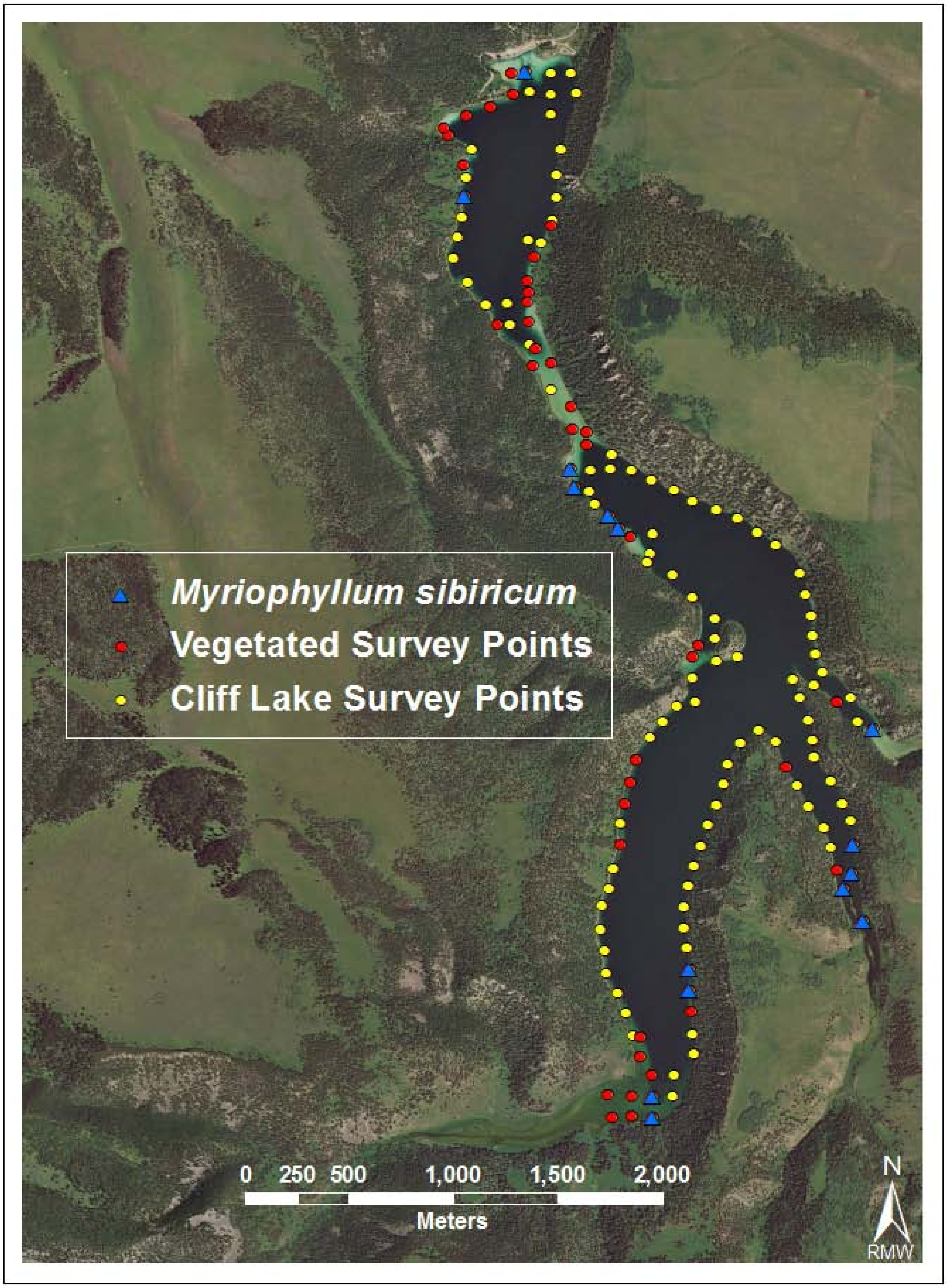

Figure 1.11. The distribution of *Myriophyllum sibiricum* in Cliff Lake during the littoral zone survey conducted in August 2011.

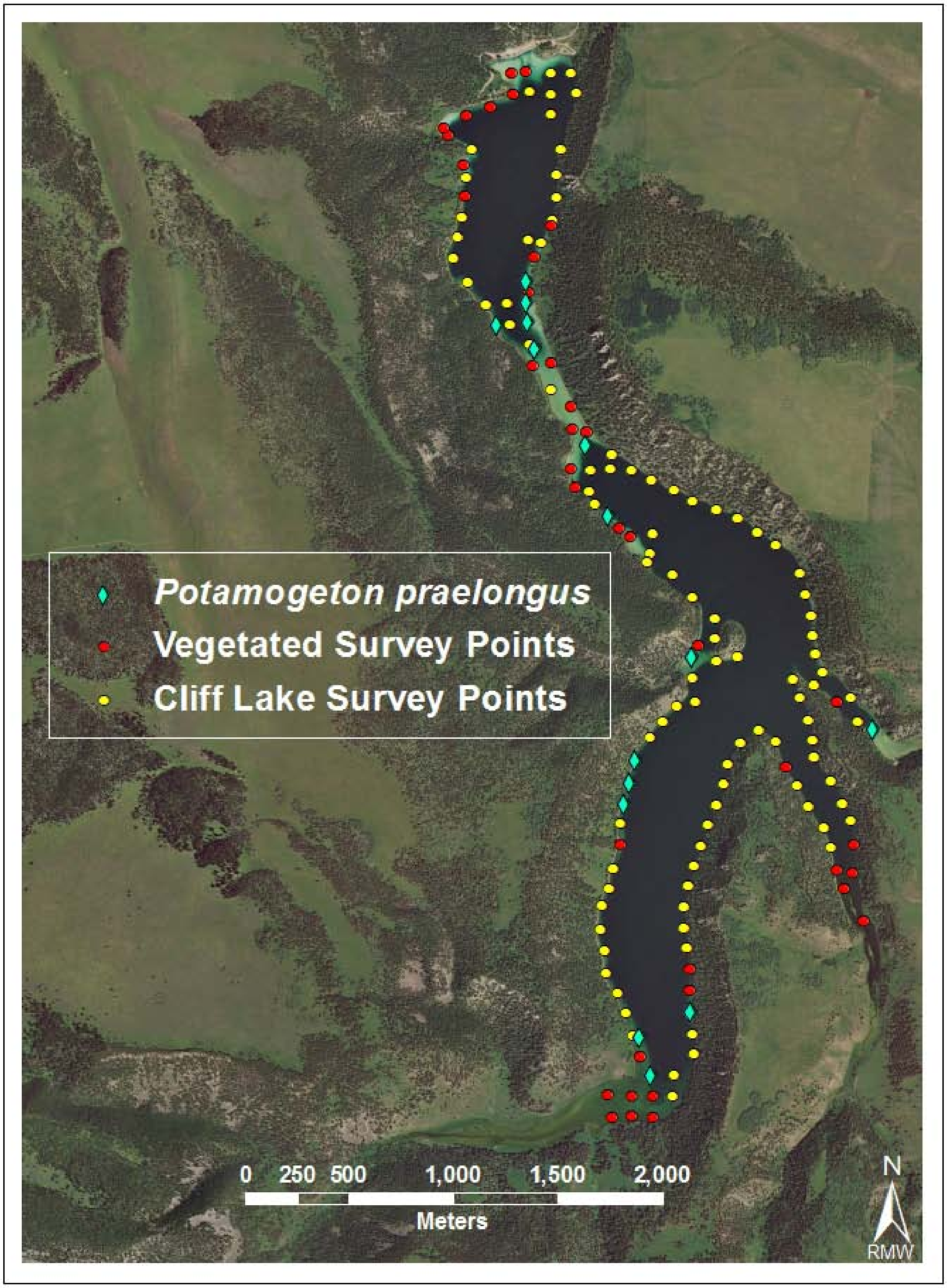

Figure 1.12. The distribution of *Potamogeton praelongus* in Cliff Lake during the littoral zone survey conducted in August 2011.

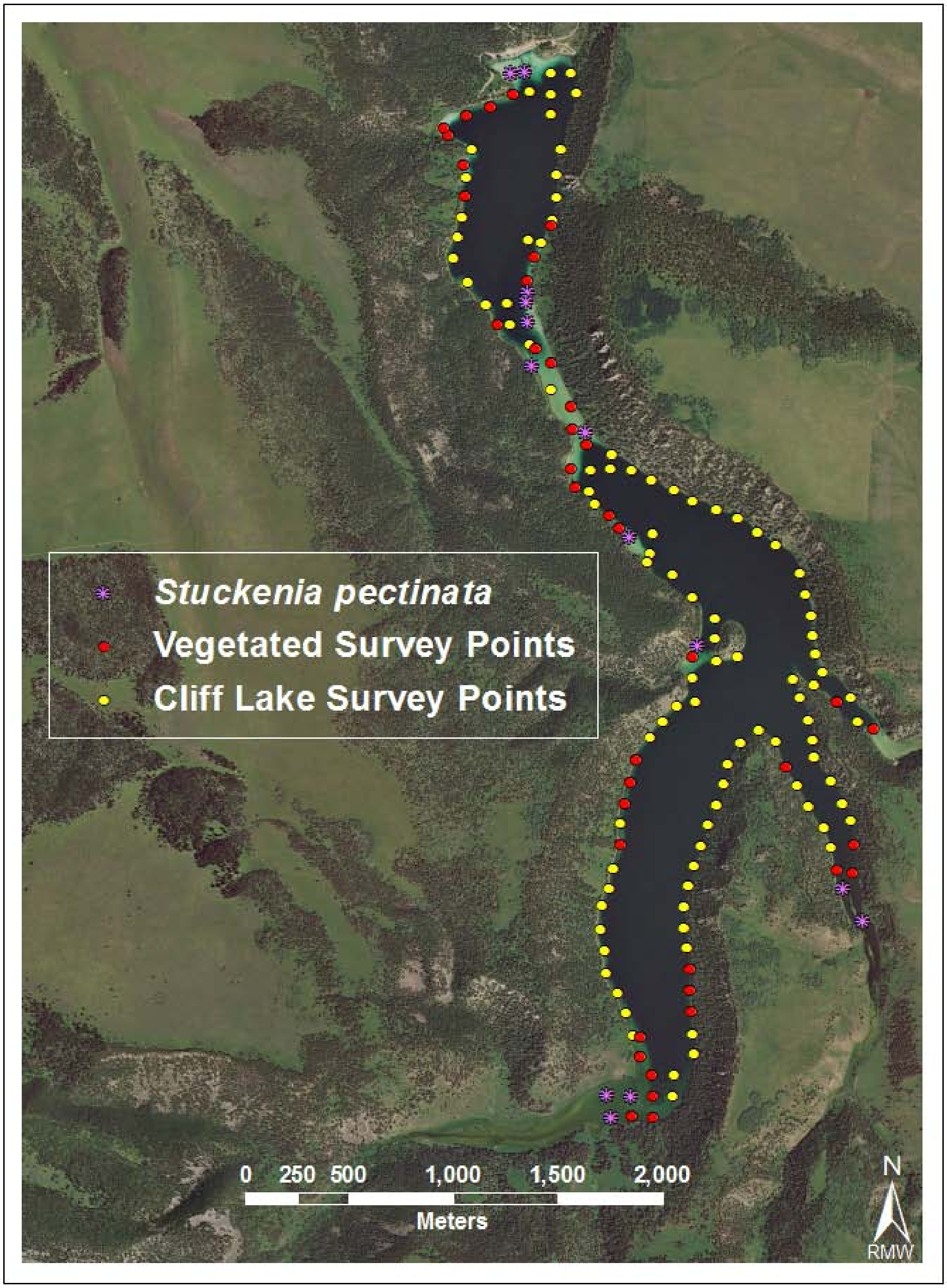

Figure 1.13. The distribution of *Stuckenia pectinata* in Cliff Lake during the littoral zone survey conducted in August 2011.

Lake Name: Wade Lake
Date Surveyed: August 29, 2011

Secchi: 27.5 ft.

Points Surveyed: 51

Eurasian watermilfoil = Negative

Wade Lake is also very deep, similar to the other lakes in the area. A point intercept survey was conducted around the perimeter of the lake to focus survey effort in the littoral zone where plants were most likely to occur (Figure 1.14). Points were surveyed to a water depth of 59 ft. with the maximum observed depth of plant growth being 15 ft.

Of the 51 points surveyed, 55% of these points were vegetated by some species of aquatic plant (Figure 1.15). *Chara* sp. and *Myriophyllum sibiricum* were the most common plant species found during the survey, with each species being present at 25% of the sample points (Table 1.3).

Myriophyllum sibiricum was observed in the southern portion of the lake and along the eastern shoreline (Figure 1.16). *Myriophyllum pinnatum* was also observed in Wade Lake in several locations along the southwestern shoreline of the lake in areas not inhabited by *M. sibiricum* (Figure 1.17). *Stuckenia pectinata* was primarily observed in the arm located along the western portion of the lake (1.18).

Table 1.3. Plant species list and percent occurrences for Wade Lake, MT, August 2011.

Species	Common Name	Frequency of Occurrence (%)
***Chara* sp.**	Muskgrass	25
***Myriophyllum pinnatum* Britton, Sterns & Poggenb.**	Cutleaf watermilfoil	12
***Myriophyllum sibiricum* Komarov**	Northern watermilfoil	25
***Nitella* sp.**	Brittlewort	6
***Potamogeton richardsonii* (Ar. Benn.) Rydb.**	Clasping-leaved pondweed	6
***Stuckenia pectinata* (L.) Börner**	Sago pondweed	10
Average Survey Depth (ft)		18.6
Species Richness (avg. number per point)		0.8

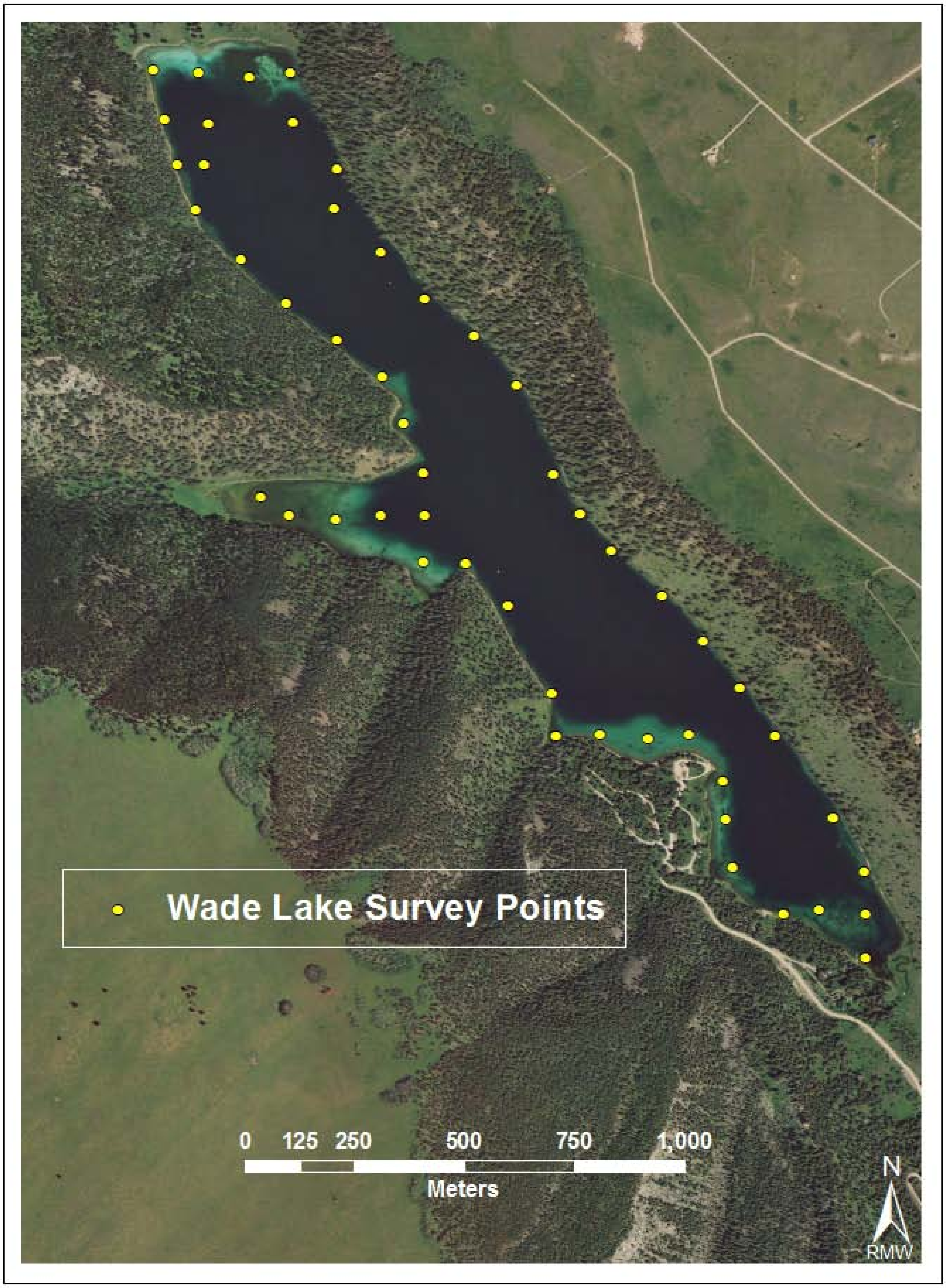

Figure 1.14. Survey points sampled on Wade Lake during the littoral zone survey conducted in August 2011.

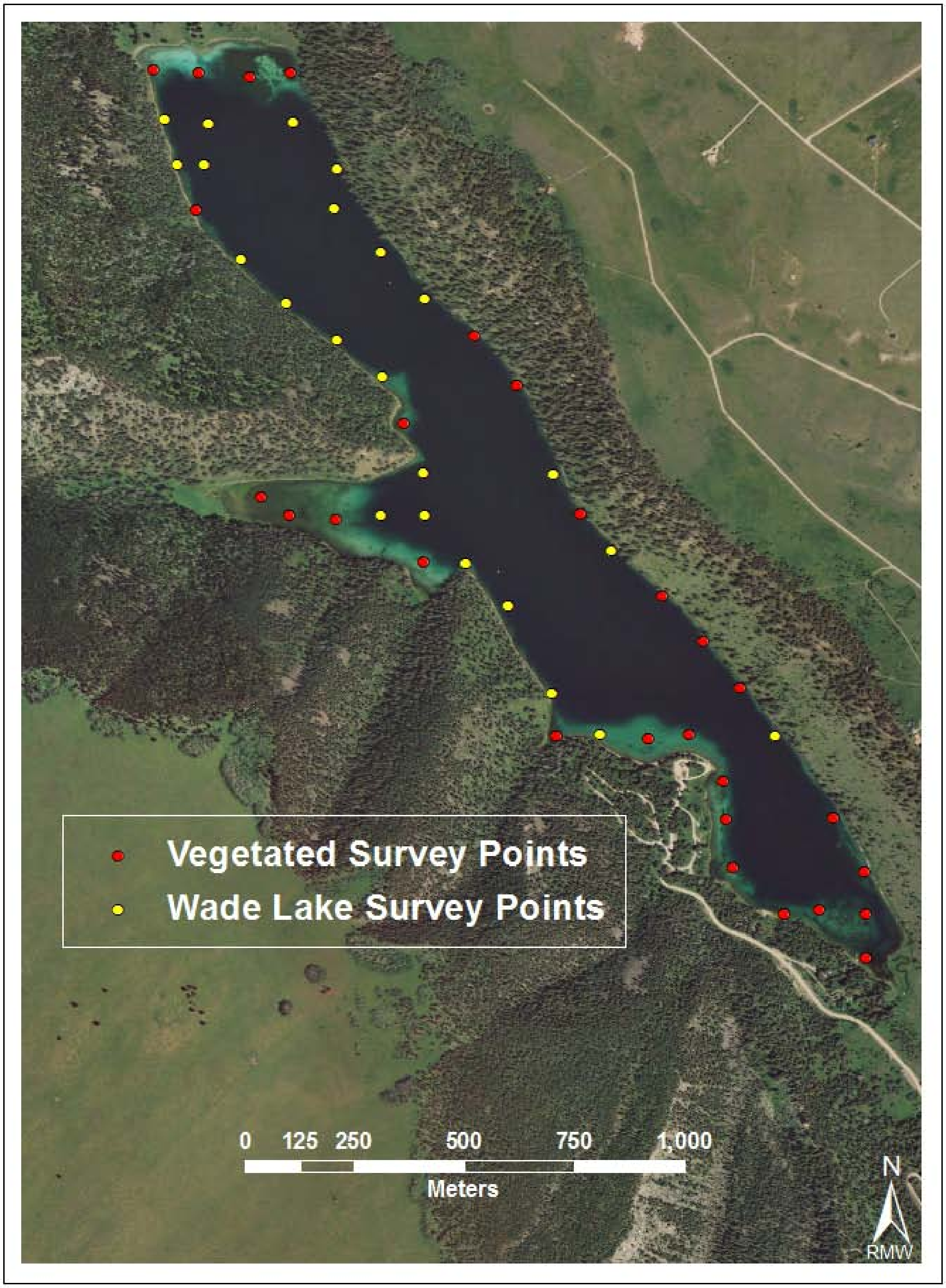

Figure 1.15. Survey points where aquatic plant species were observed during the littoral zone survey of Wade Lake conducted in August 2011.

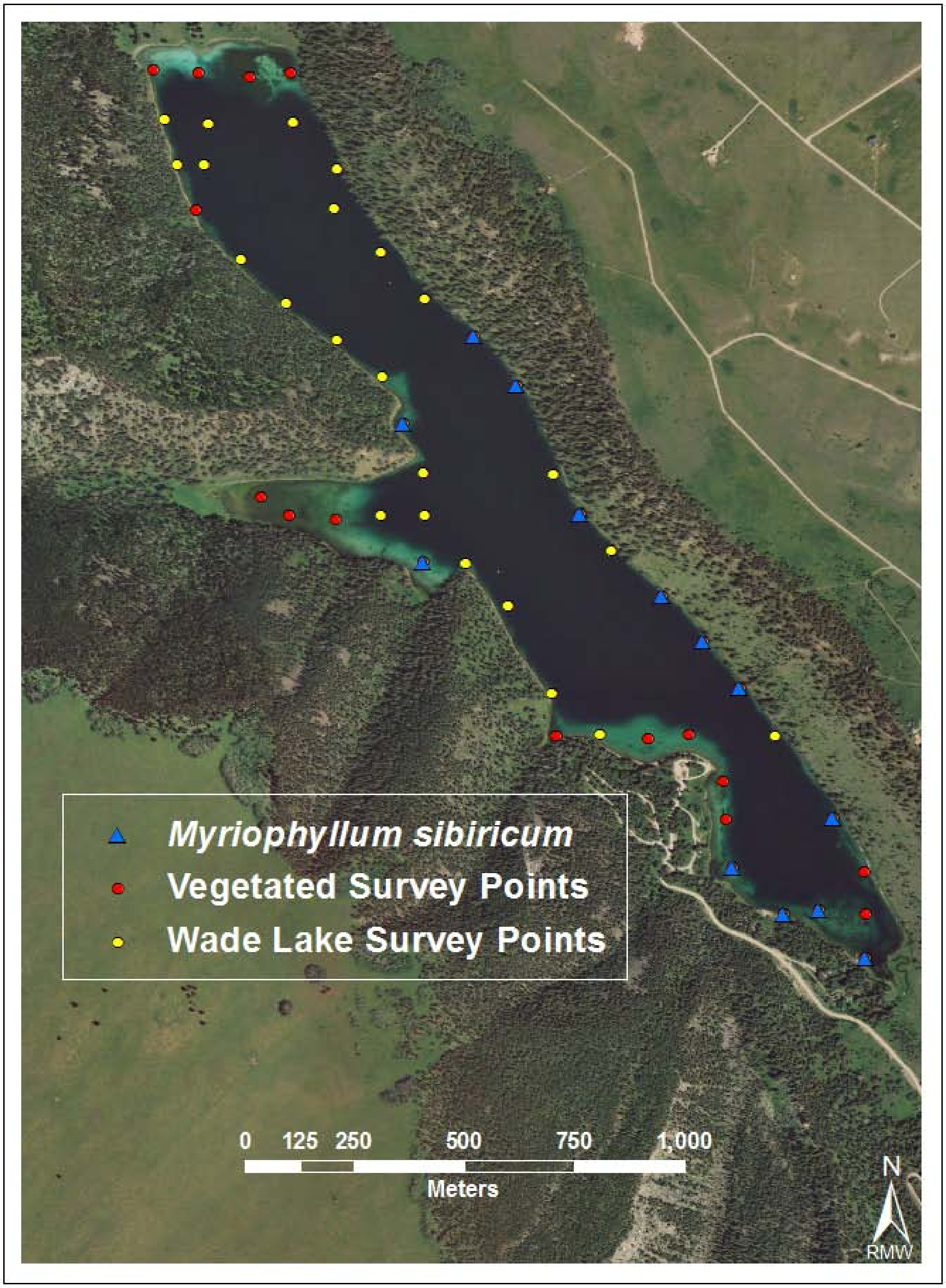

Figure 1.16. The distribution of *Myriophyllum sibiricum* in Wade Lake during the littoral zone survey conducted in August 2011.

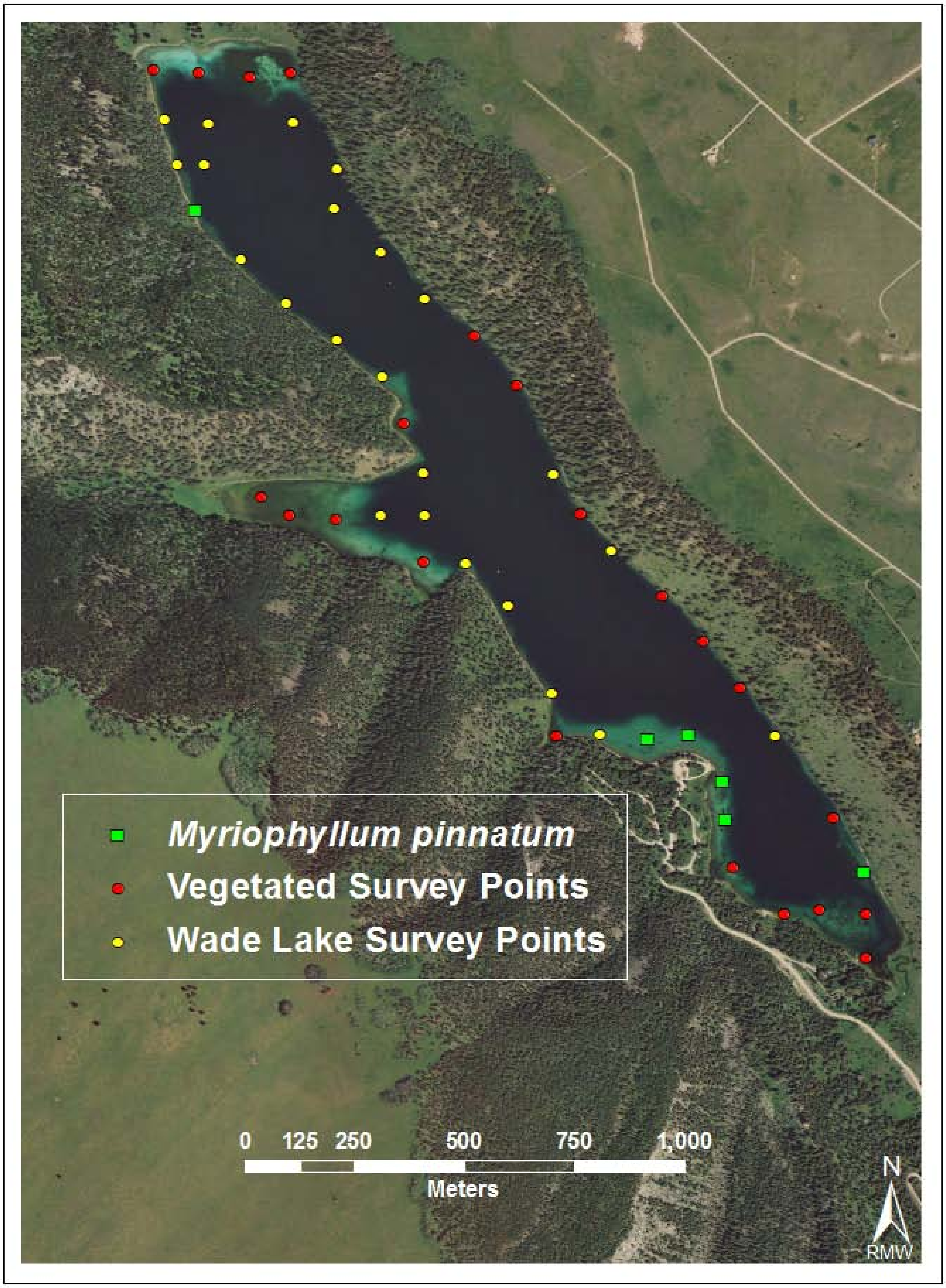

Figure 1.17. The distribution of *Myriophyllum pinnatum* in Wade Lake during the littoral zone survey conducted in August 2011.

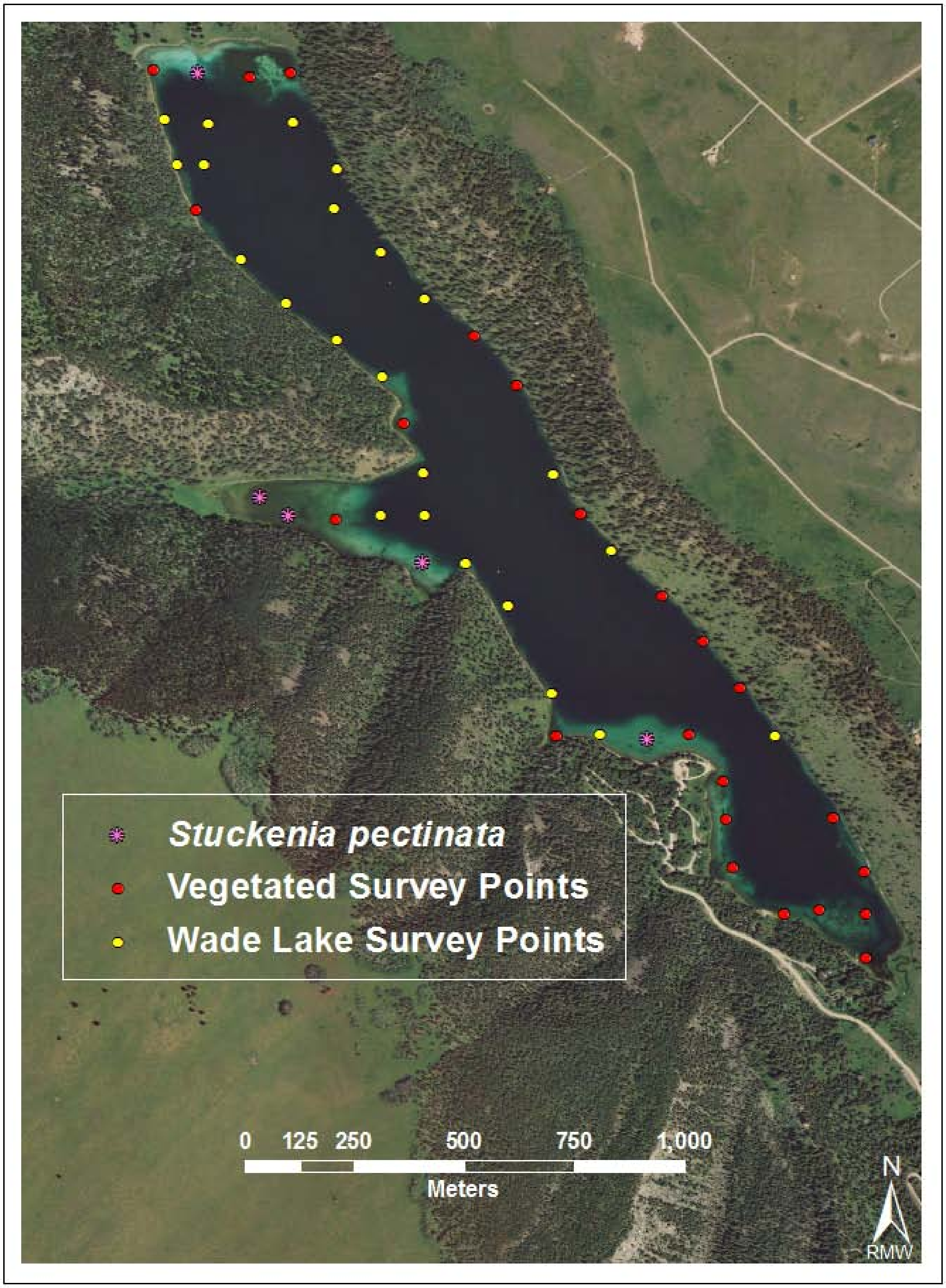

Figure 1.18. The distribution of *Stuckenia pectinata* in Wade Lake during the littoral zone survey conducted in August 2011.

Lake Name: Elk Lake

Date Surveyed: August 30, 2011

Secchi: 16.8 ft.

Points Surveyed: 88

Eurasian watermilfoil = Negative

Elk Lake is separated into two sections as the lake narrows and becomes shallow towards the southern portion of the lake. The middle of the lake was deep, and therefore, the point intercept survey was confined to the narrow littoral zone that occupied the perimeter of the lake (Figure 1.19). Points were surveyed to a water depth 40 ft. with the maximum observed depth of plant growth being 16 ft. Of the 88 points surveyed, 76% of these points had an aquatic plants species present (Figure 1.20).

Chara sp. was observed most often followed by *Potamogeton praelongus* (43%) and *Potamogeton richardsonii* (26%) (Table 1.4). In general, pondweeds were found most often in Elk Lake and their distributions are depicted in Figures 1.21-1.23. *Myriophyllum sibiricum* was observed growing throughout the lake (Figure 1.24). *Elodea canadensis* was also observed primarily in the northern and southern portions of the lake (Figure 1.25). *Nuphar luteum* was found growing in large beds in the northern most portion of the lake.

Table 1.4. Plant species list and percent occurrences for Elk Lake, MT, August 2011.

Species	Common Name	Frequency of Occurrence (%)
***Ceratophyllum demersum* L.**	Coontail	3
***Chara* sp.**	Muskgrass	53
***Elodea canadensis* Michx.**	Elodea	16
Schoenoplectus acutus* (Muhl. ex Bigelow) A. Löve & D. Löve var. *acutus	Hardstem bulush	1
***Lemna trisulca* L.**	Star duckweed	5
***Myriophyllum sibiricum* Komarov**	Northern watermilfoil	15
***Nitella* sp.**	Brittlewort	1
***Nuphar luteum* (Willd.) Pers.**	Yellow pondlily	1
***Potamogeton foliosus* L.**	Leafy pondweed	2
***Potamogeton praelongus* Wulf.**	Whitestem pondweed	43
***Potamogeton richardsonii* (Ar. Benn.) Rydb.**	Clasping-leaved pondweed	26
***Potamogeton zosteriformis* Fern.**	Flat-stemmed pondweed	17
***Ranunculus aquatilis* L.**	White water-buttercup	2
***Stuckenia pectinata* (L.) Börner**	Sago pondweed	8
Average Survey Depth (ft)		10.0
Species Richness (avg. number per point)		1.9

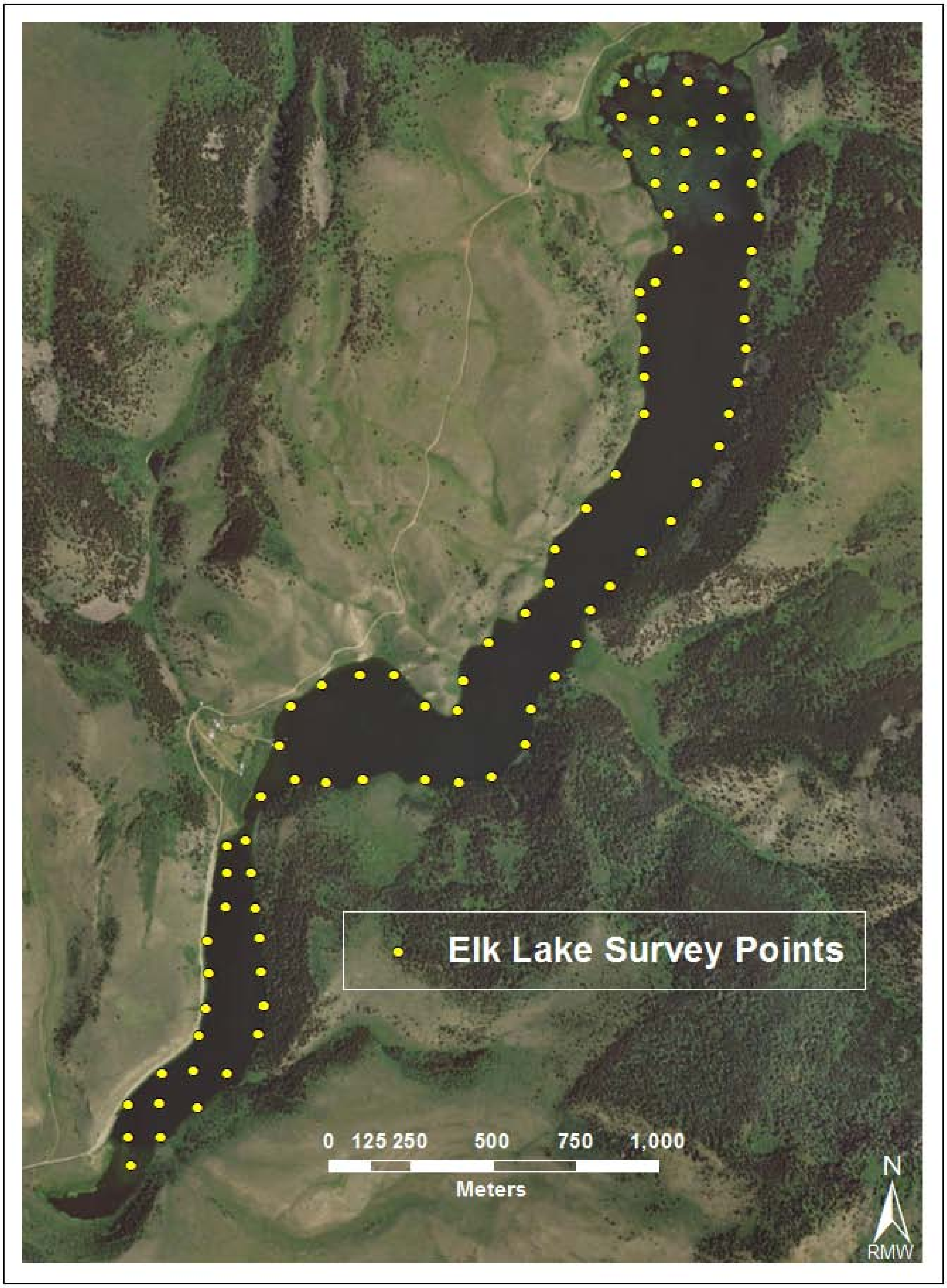

Figure 1.19. Survey points sampled on Elk Lake during the littoral zone survey conducted in August 2011.

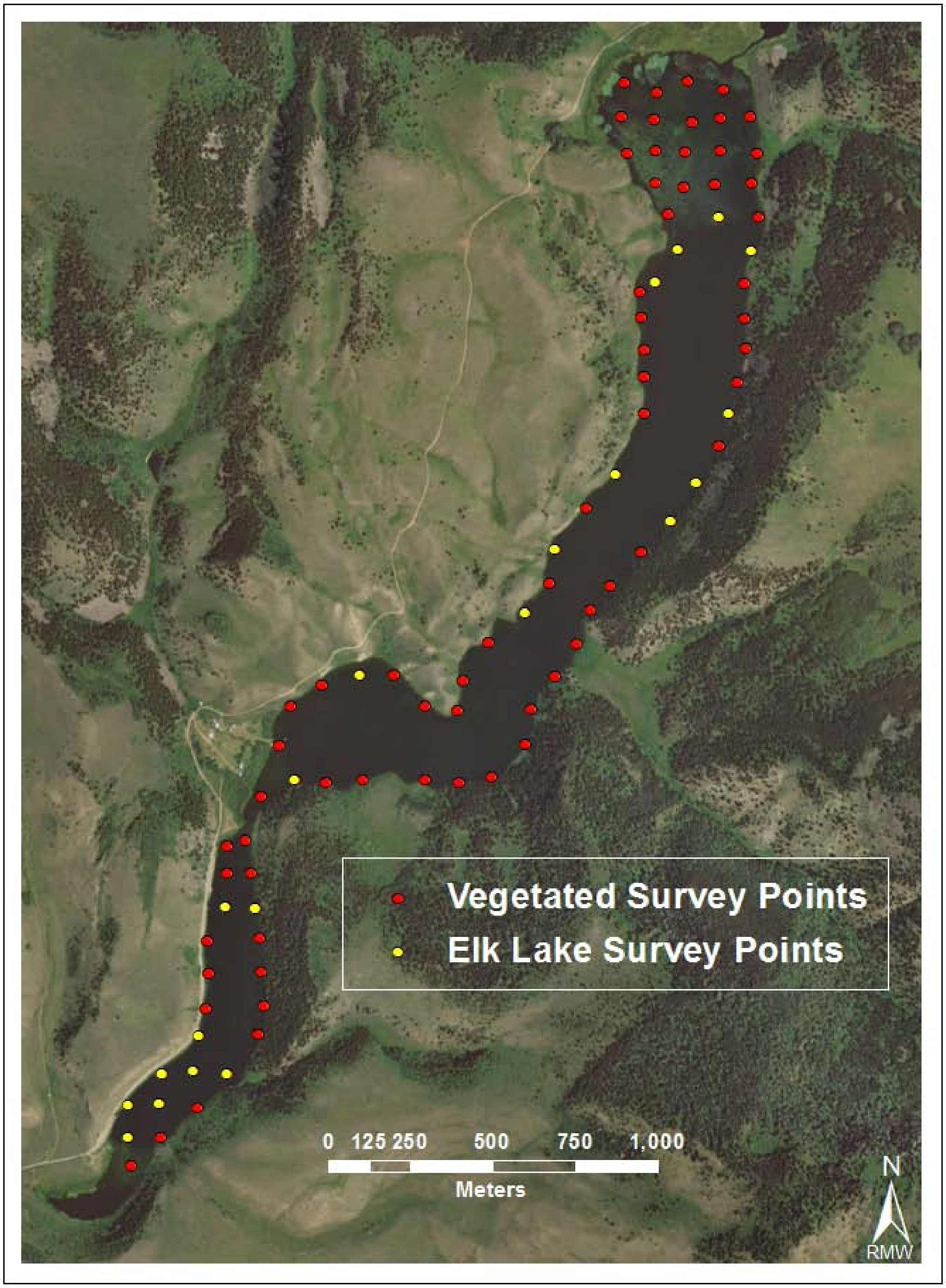

Figure 1.20. Survey points where aquatic plant species were observed during the littoral zone survey of Elk Lake conducted in August 2011.

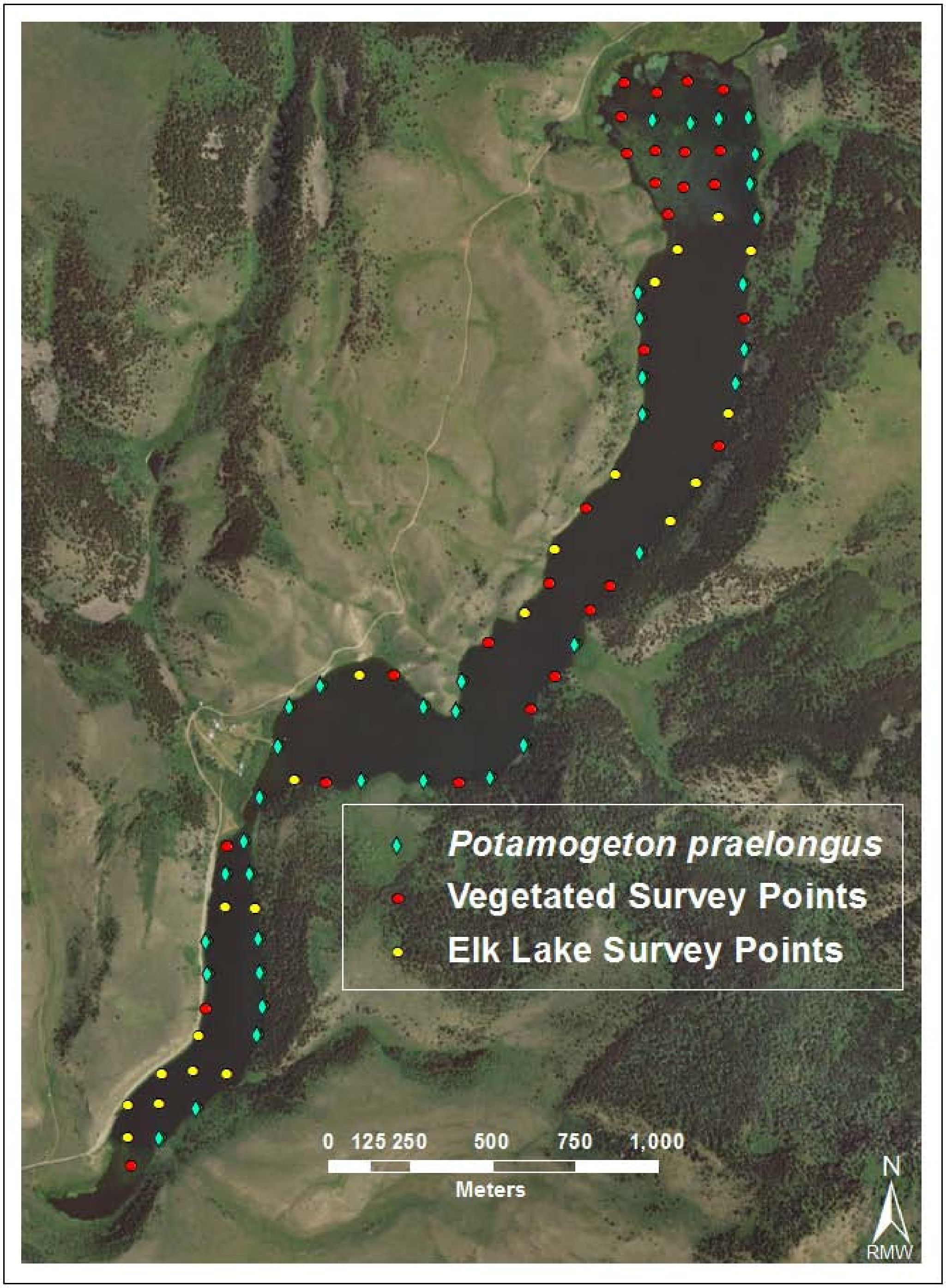

Figure 1.21. The distribution of *Potamogeton praelongus* in Elk Lake during the littoral zone survey conducted in August 2011.

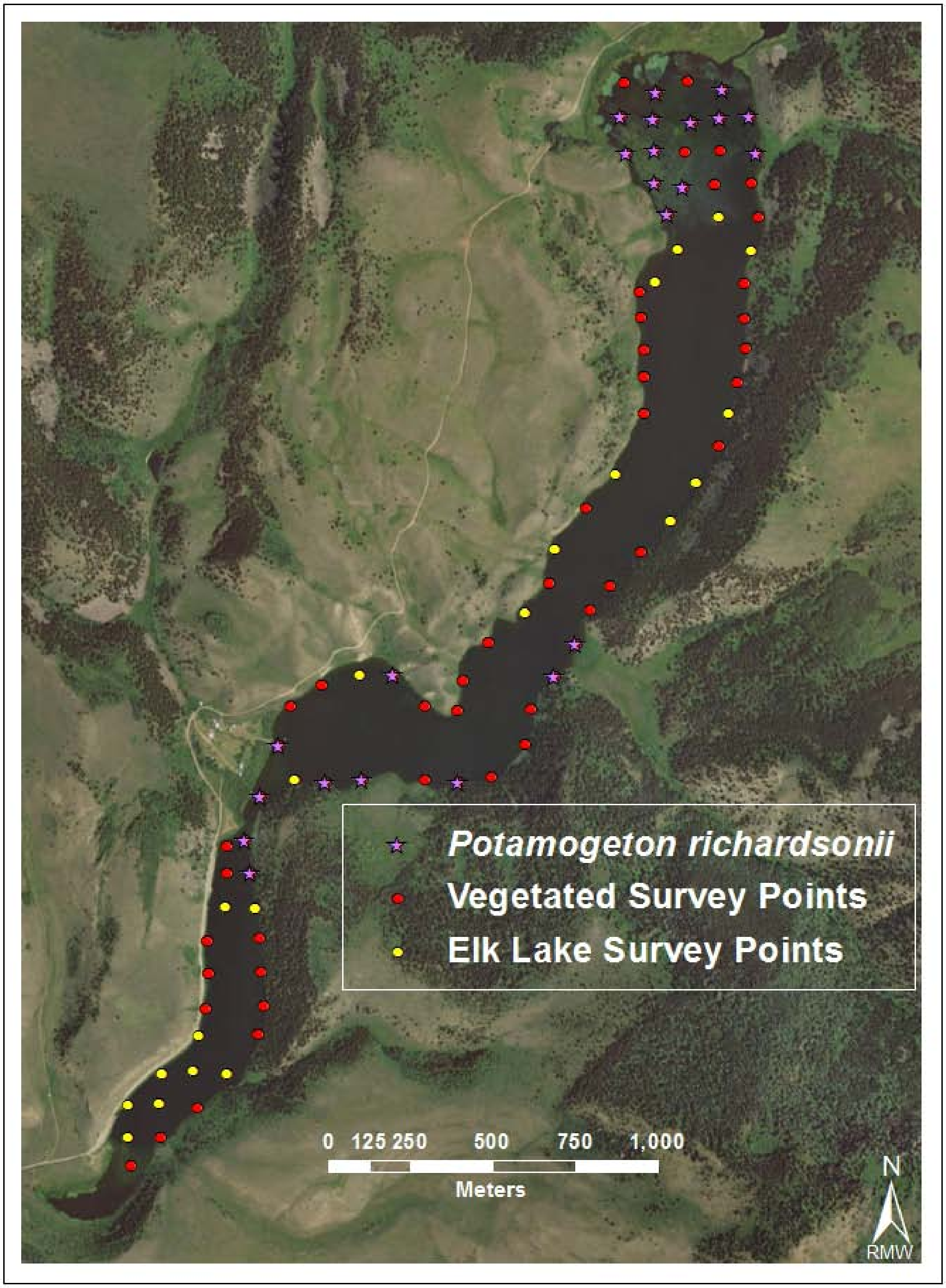

Figure 1.22. The distribution of *Potamogeton richardsonii* in Elk Lake during the littoral zone survey conducted in August 2011.

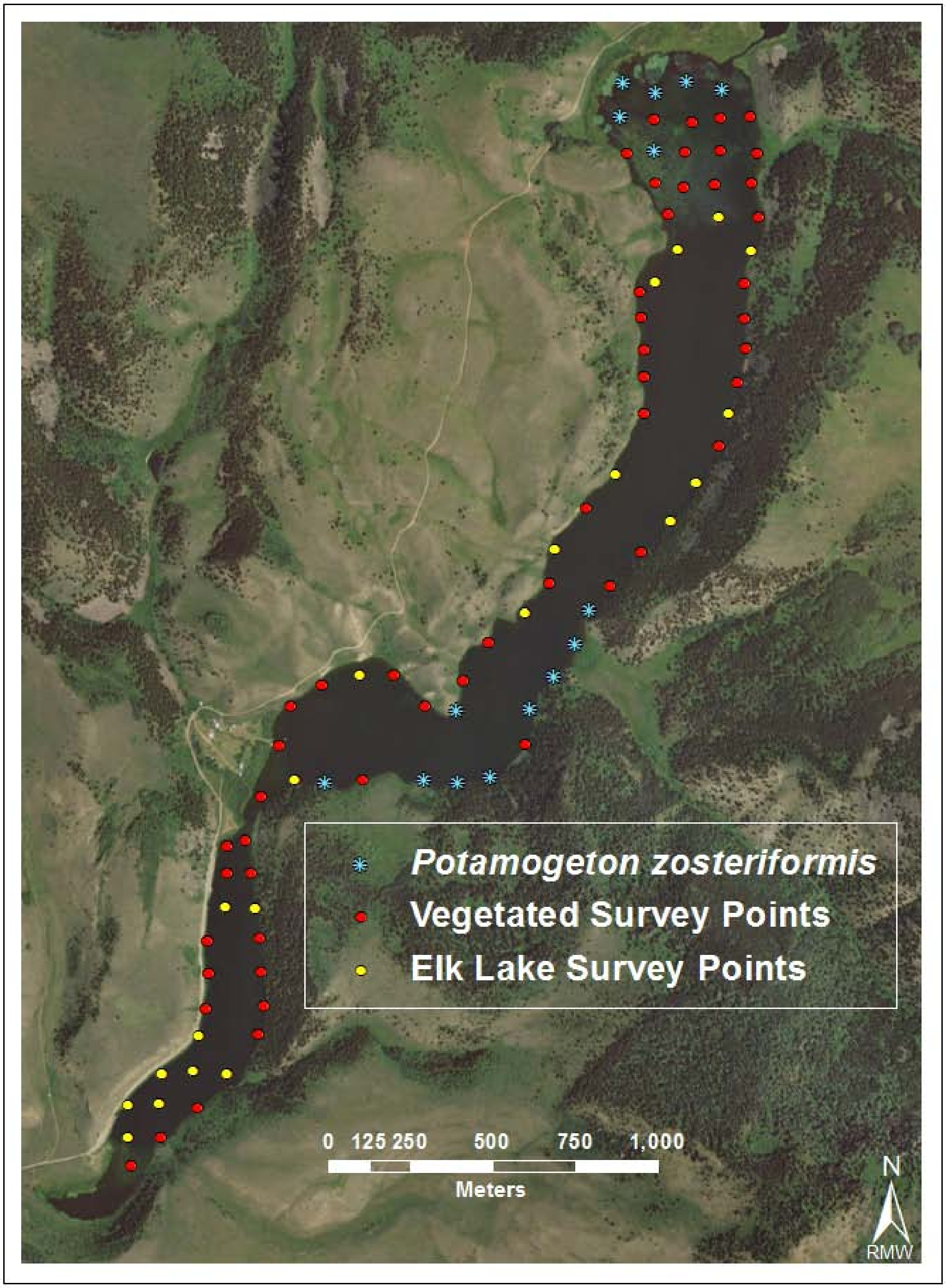

Figure 1.23. The distribution of *Potamogeton zosteriformis* in Elk Lake during the littoral zone survey conducted in August 2011.

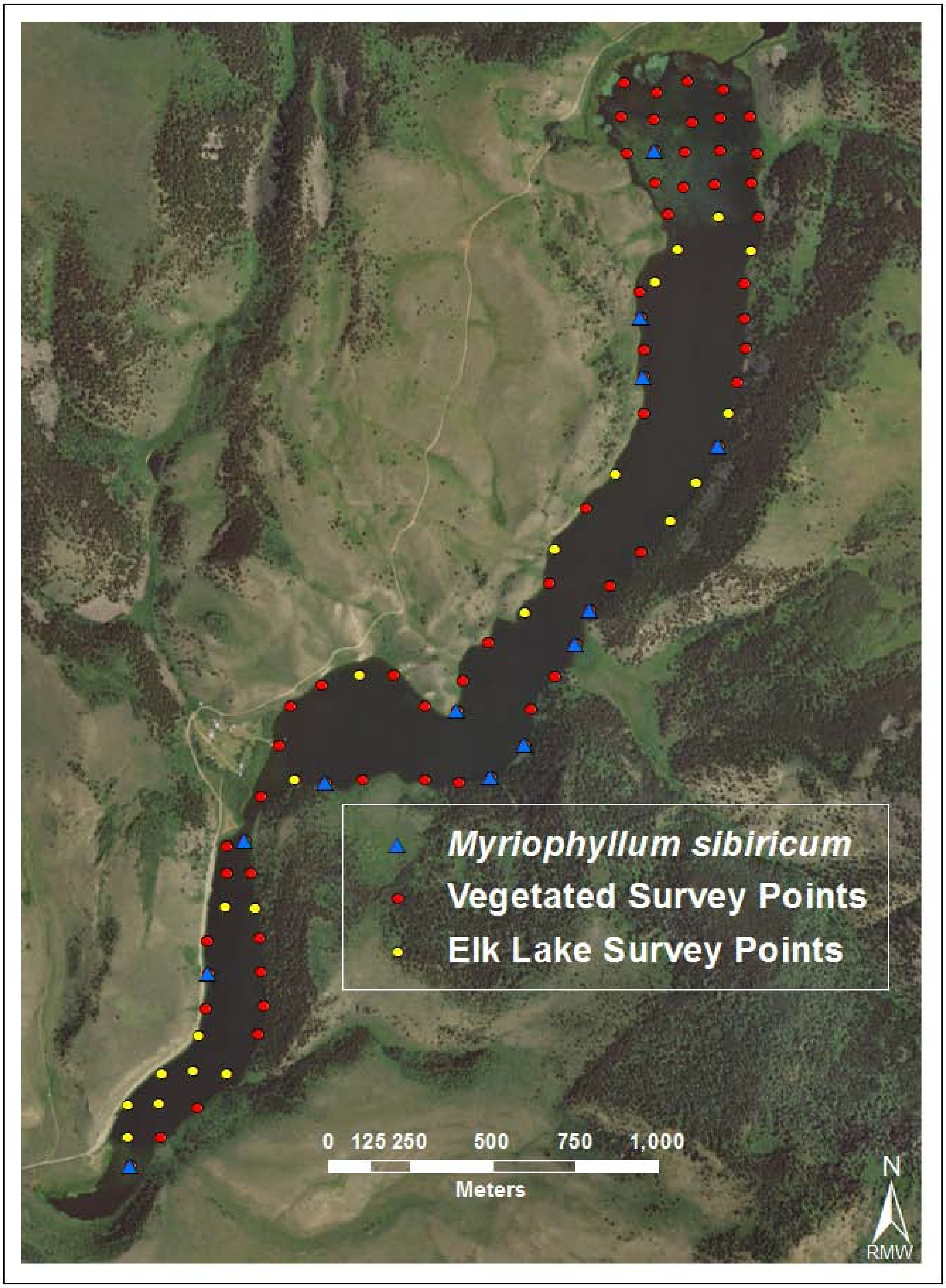

Figure 1.24. The distribution of *Myriophyllum sibiricum* in Elk Lake during the littoral zone survey conducted in August 2011.

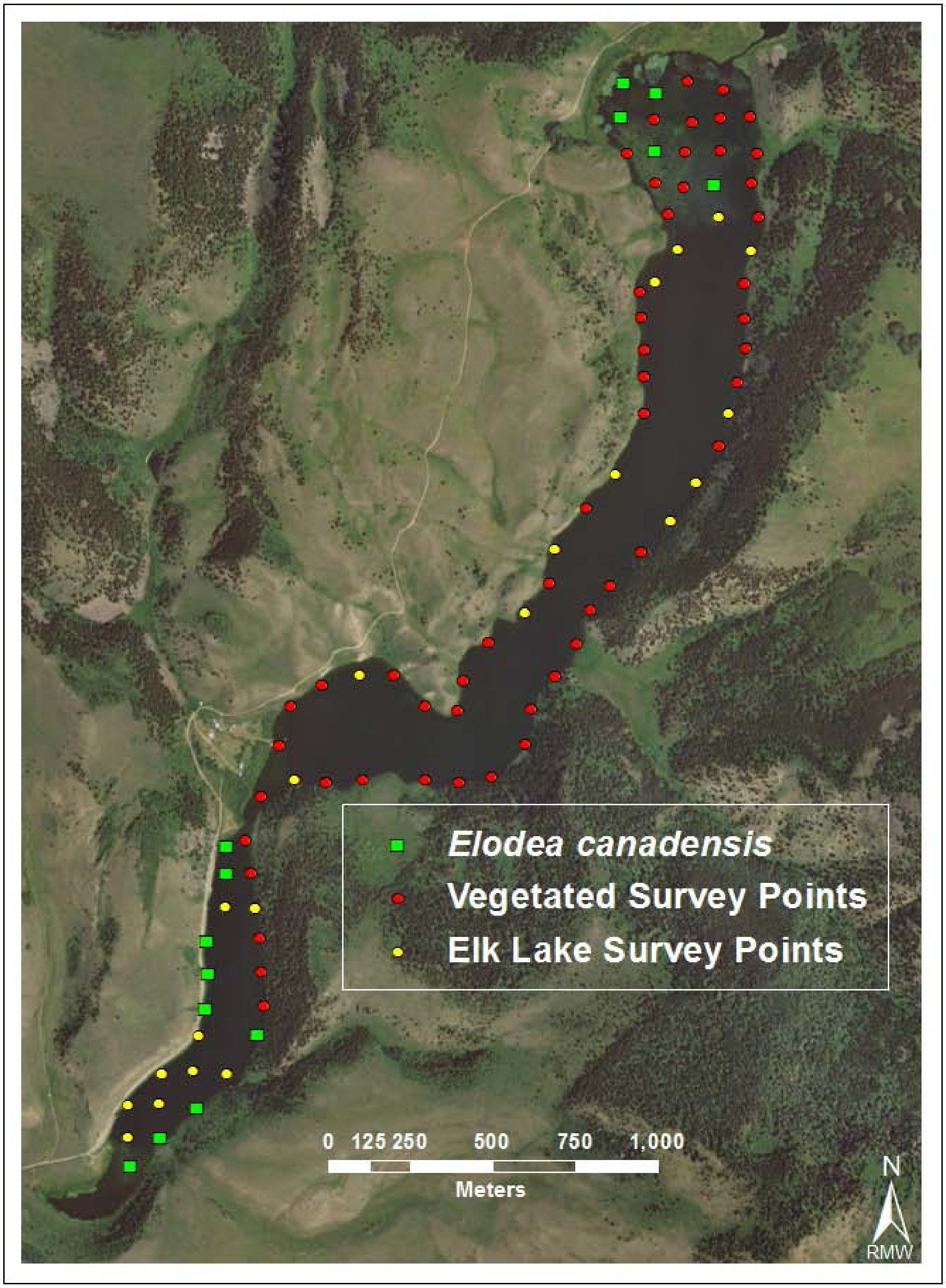

Figure 1.25. The distribution of *Elodea canadensis* in Elk Lake during the littoral zone survey conducted in August 2011.

Lake Name: Ennis Reservoir

Dates Surveyed: August 31-September 1, 2011

Secchi: 7.5 ft.

Points Surveyed: 100

Eurasian watermilfoil = Negative

Ennis Reservoir is a large shallow lake that can support plant growth throughout much of its area; therefore, the whole reservoir was surveyed (Figure 1.26). The points at the southern end of the lake were inaccessible by boat, though this area of the lake was surveyed by kayak when the river section from Ennis Fishing Access Point to the Ennis Lake was surveyed. Points were surveyed to a water depth of 13 ft. with the maximum observed depth of plant growth being 7.5 ft. Of the 100 points surveyed, 62% of these points had an aquatic plant species present (Figure 1.27).

Elodea canadensis and *Ceratophyllum demersum* were the most common plants observed in Ennis Reservoir, where they were observed at 38% and 25% of the sample points respectively (Table 1.5). Both species were widely distributed in the reservoir (Figures 1.28-1.29). Potamogeton foliosus was present in much of the shallower areas of the reservoir (Figure 1.30). *Sagittaria cuneata*, a shallow water plant that has submersed, floating, or emergent leaves, was found in the shallow areas of the southern portion of the reservoir (Figure 1.31). This species is highly variable, and in flowing water, often grows the flat, linear leaves.

Unlike other reservoirs surveyed during this study, aquatic plants have the potential to colonize the entire reservoir. The deepest water depth measured during this survey was 13.2 ft. with 52% water depth measurements below 10 ft. The shallow depths coupled with good water clarity (secchi of 7.5 ft.) result in great aquatic plant habitat. This should be of concern as *Potamogeton crispus* was observed at 4 locations during the current survey (Figure 1.32). The majority of *P. crispus* was found at the southern end of the lake where the Madison River enters. The other location was in the center of the lake, a likely result of turions moved by wave action.

Growth of *P. crispus* was not dense where it occurred, which suggest the population may not have been there very long. Therefore, management efforts should be initiated soon to prevent turion production, and the spread of this species within Ennis Reservoir or to other water bodies in the area. If *P. crispus* is allowed to grow, it will cover the 3760 acres that is Ennis Reservoir. Priority should be given to this reservoir with respect to future surveys and aquatic invasive species monitoring.

Table 1.5. Plant species list and percent occurrences for Ennis Reservoir, MT, August 2011.

Species	Common Name	Frequency of Occurrence (%)
***Ceratophyllum demersum* L.**	Coontail	21
***Chara* sp.**	Muskgrass	15
***Elodea canadensis* Michx.**	Elodea	38
***Myriophyllum sibiricum* Komarov**	Northern watermilfoil	1
***Nitella* sp.**	Brittlewort	4
***Potamogeton crispus* L.**	Curlyleaf pondweed	4
***Potamogeton foliosus* L.**	Leafy pondweed	19
***Ranunculus aquatilis* L.**	White water-buttercup	3
***Sagittaria cuneata* Sheldon**	Arumleaf arrowhead	10
***Stuckenia pectinata* (L.) Börner**	Sago pondweed	3
Average Survey Depth (ft)		8.5
Species Richness (avg. number per point)		1.1

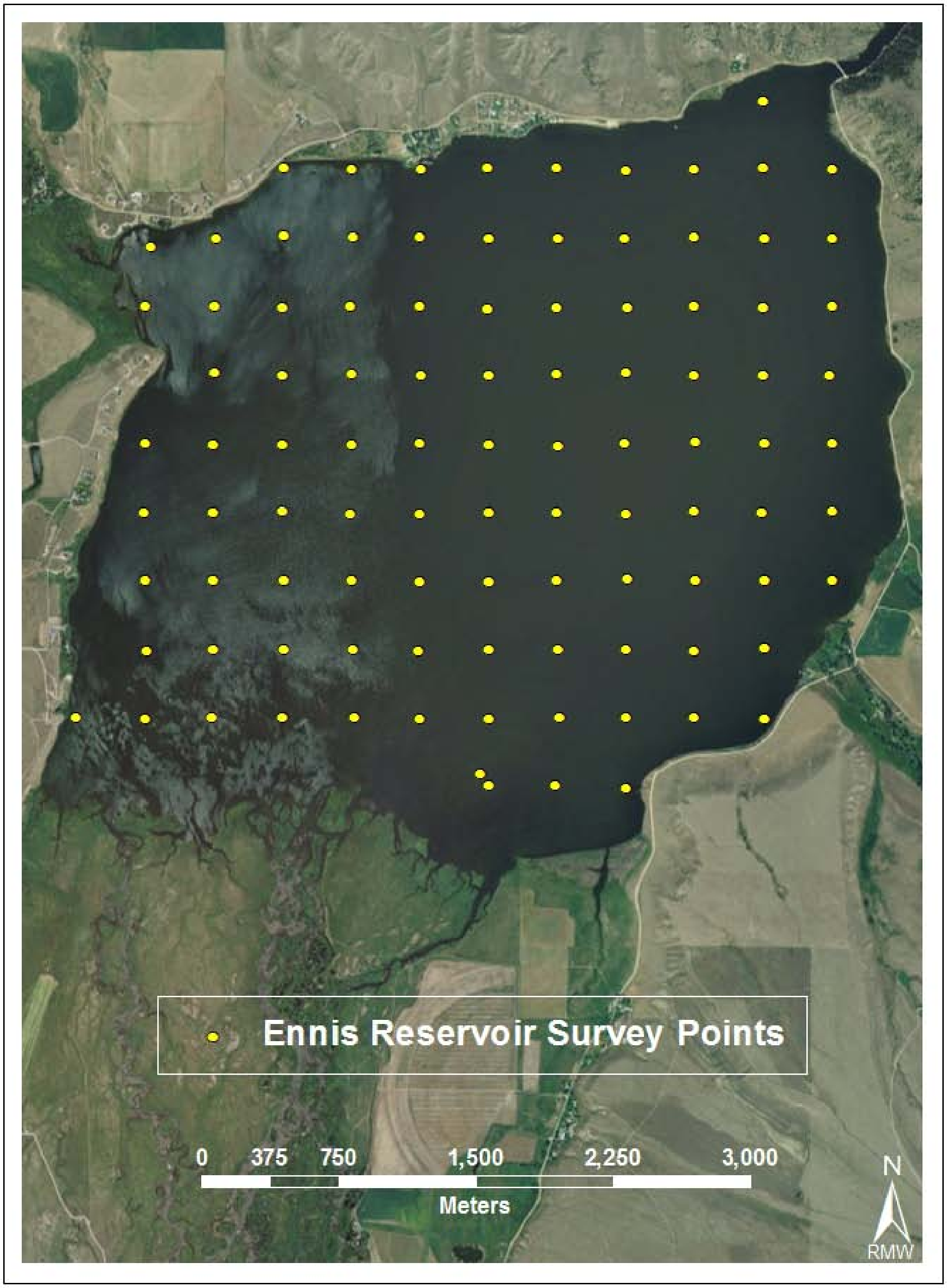

Figure 1.26. Survey points sampled on Ennis Reservoir during the littoral zone survey conducted in August-September 2011.

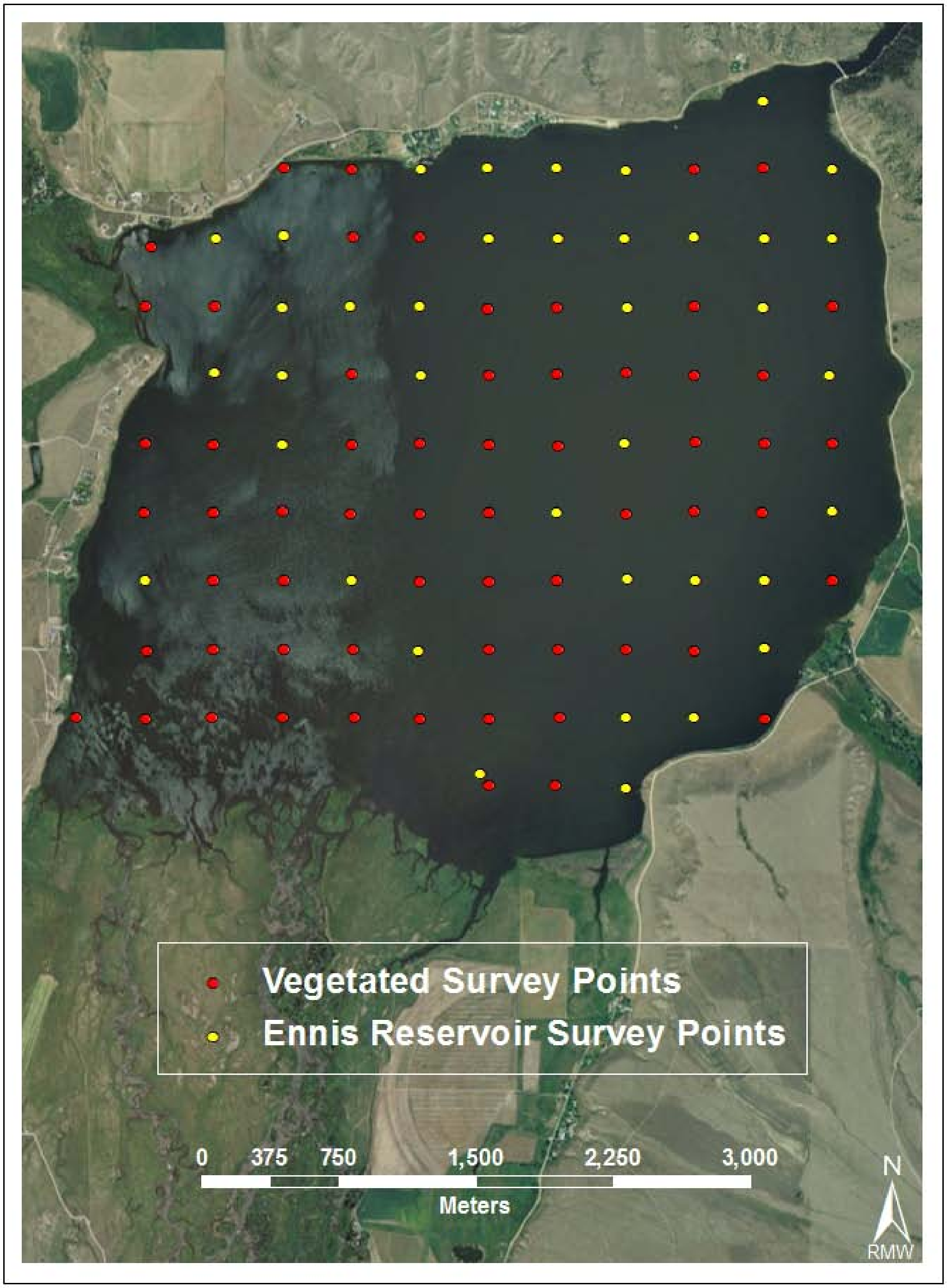

Figure 1.27. Survey points where aquatic plant species were observed during the littoral zone survey of Ennis Reservoir conducted in August-September 2011.

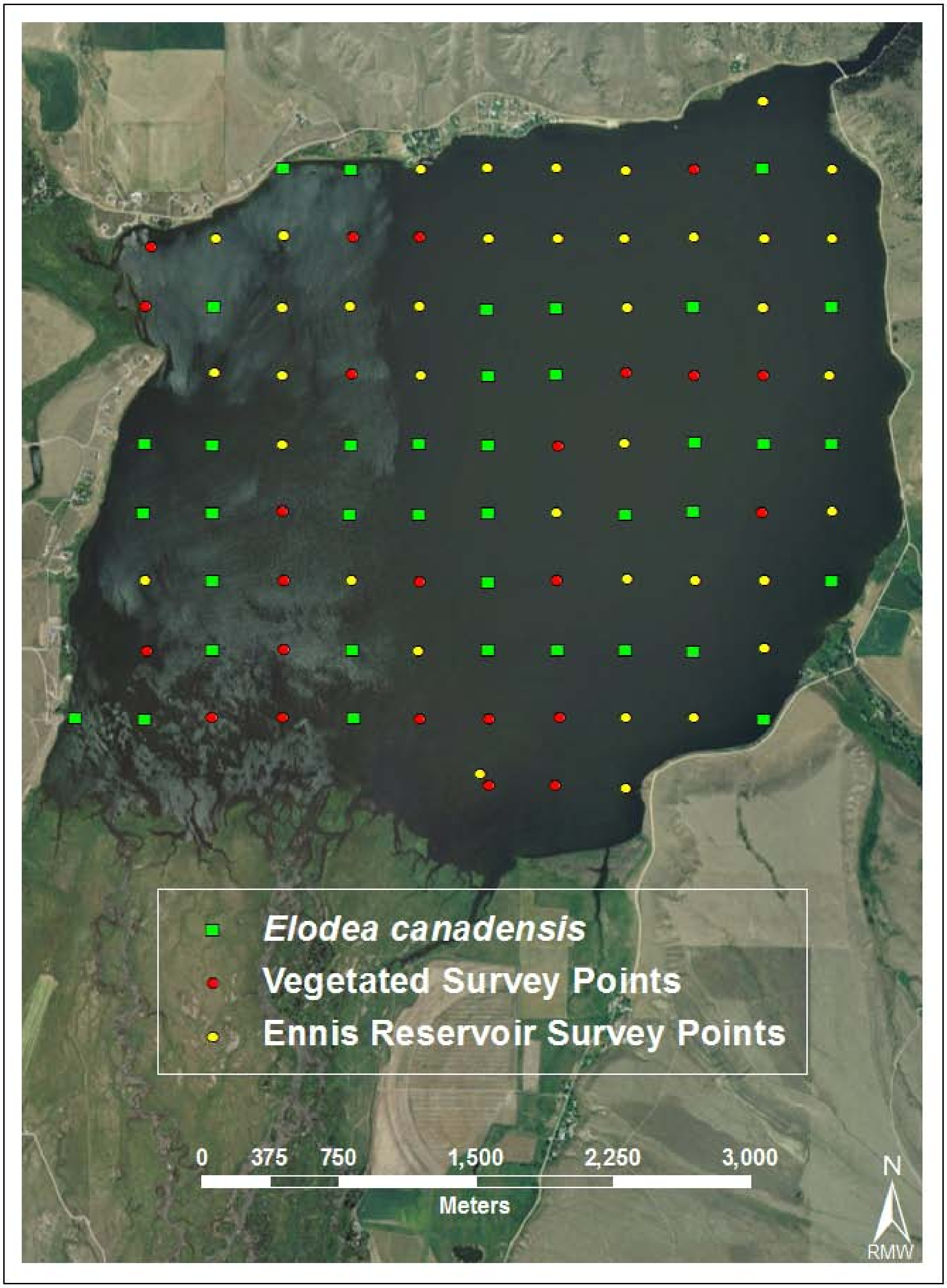

Figure 1.28. The distribution of *Elodea canadensis* in Ennis Reservoir during the littoral zone survey conducted in August-September 2011.

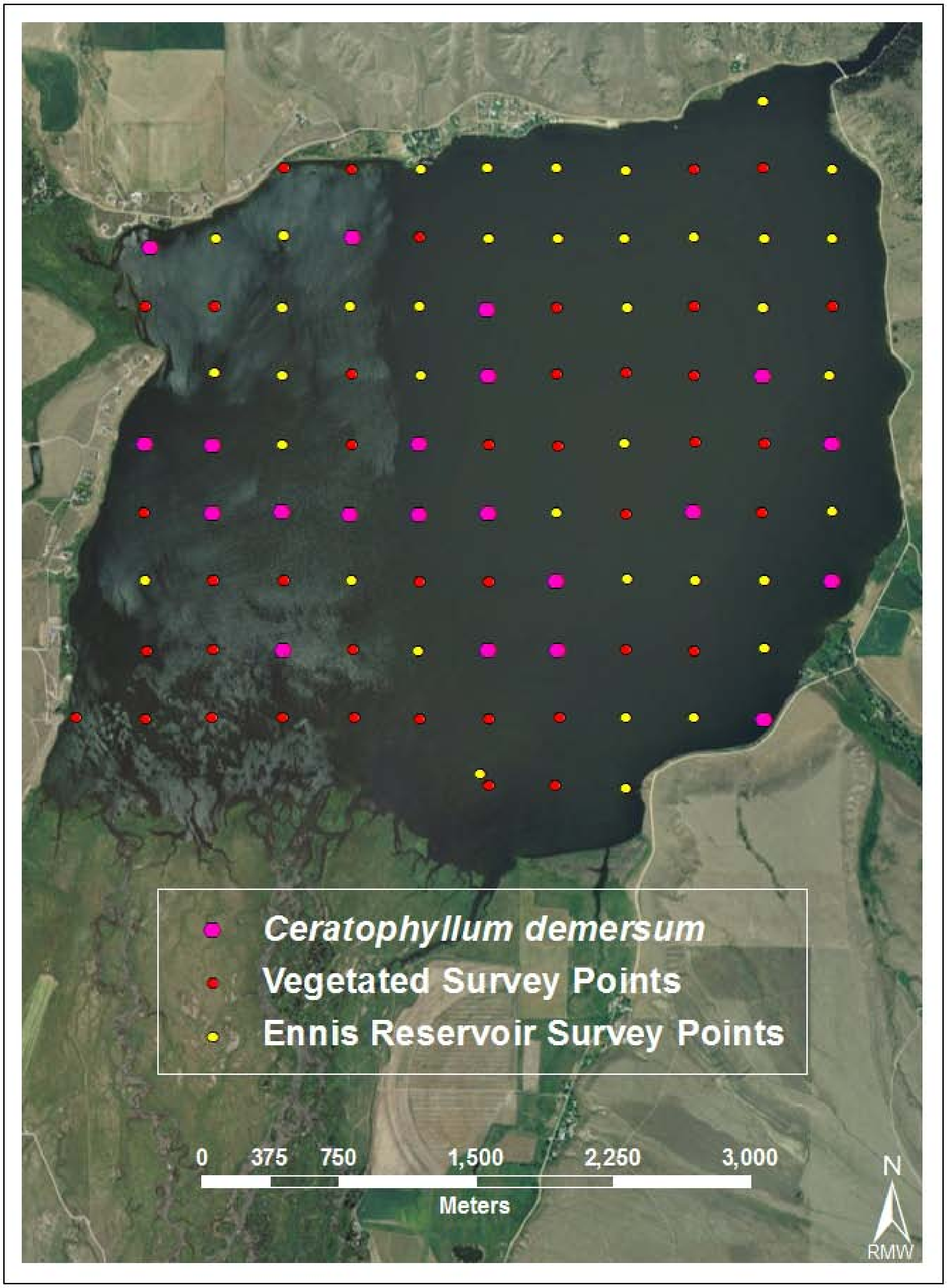

Figure 1.29. The distribution of *Ceratophyllum demersum* in Ennis Reservoir during the littoral zone survey conducted in August-September 2011.

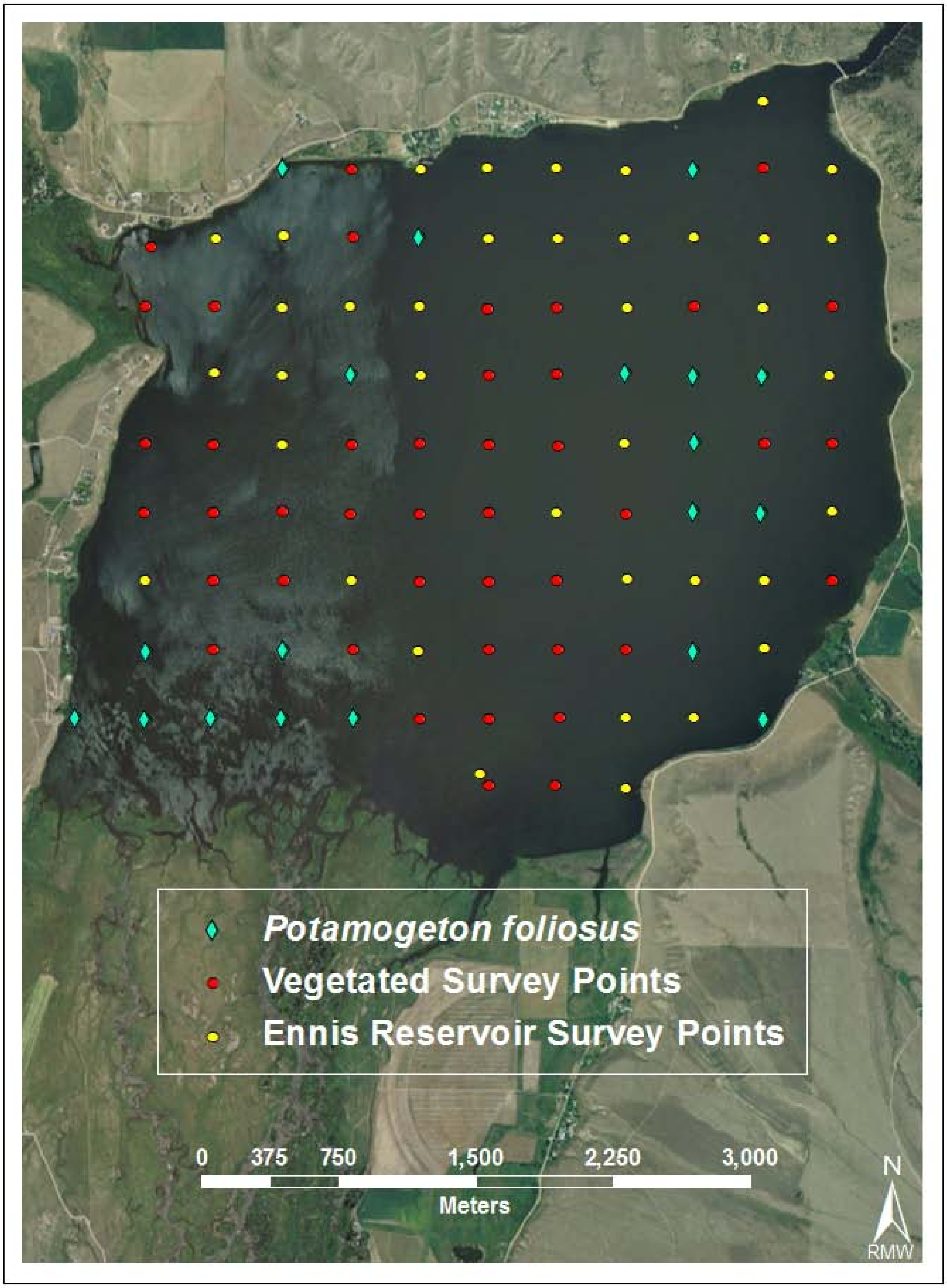

Figure 1.30. The distribution of *Potamogeton foliosus* in Ennis Reservoir during the littoral zone survey conducted in August-Septebmer 2011.

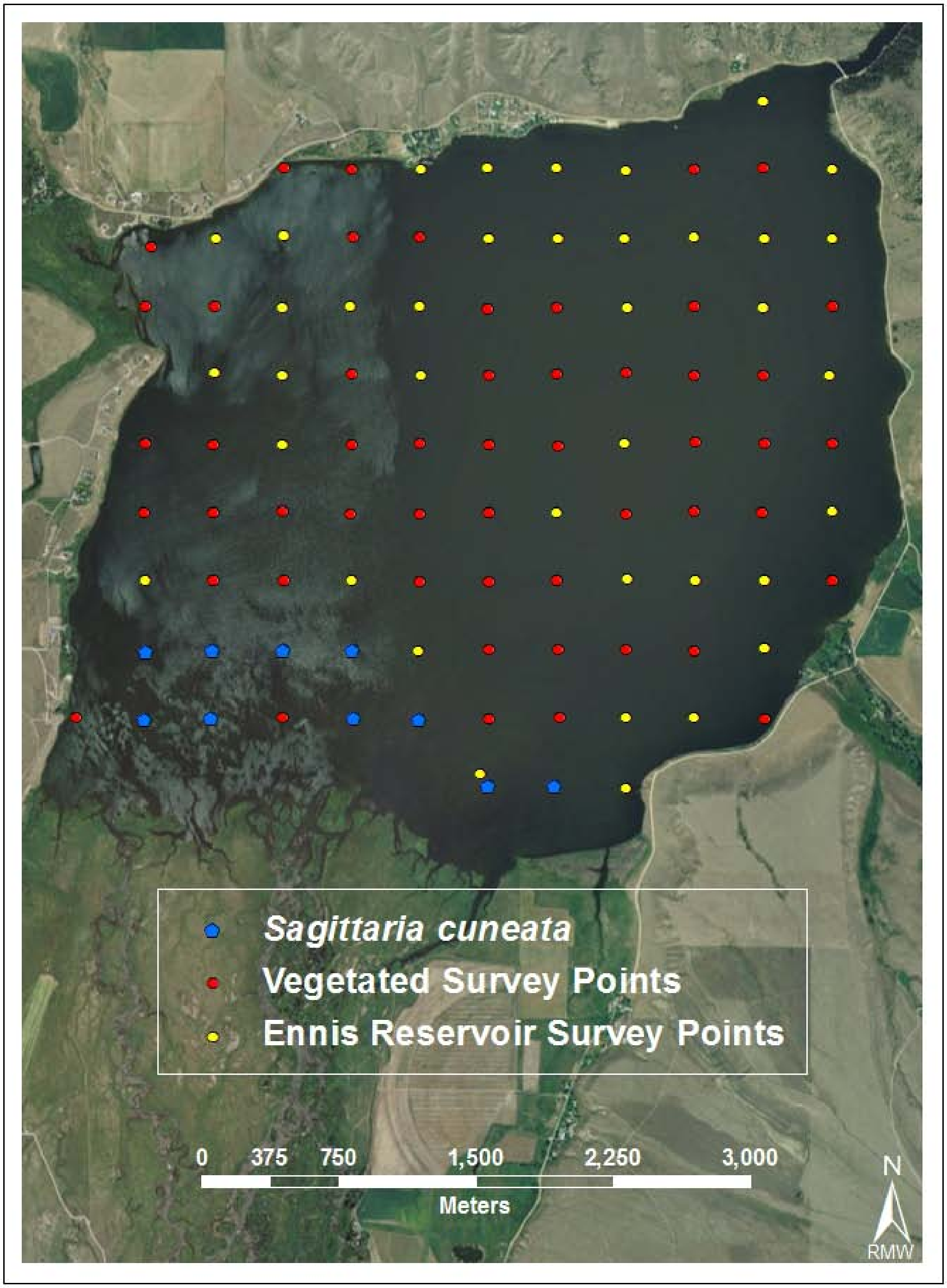

Figure 1.31. The distribution of *Sagittaria cuneata* in Ennis Reservoir during the littoral zone survey conducted in August-Septebmer 2011.

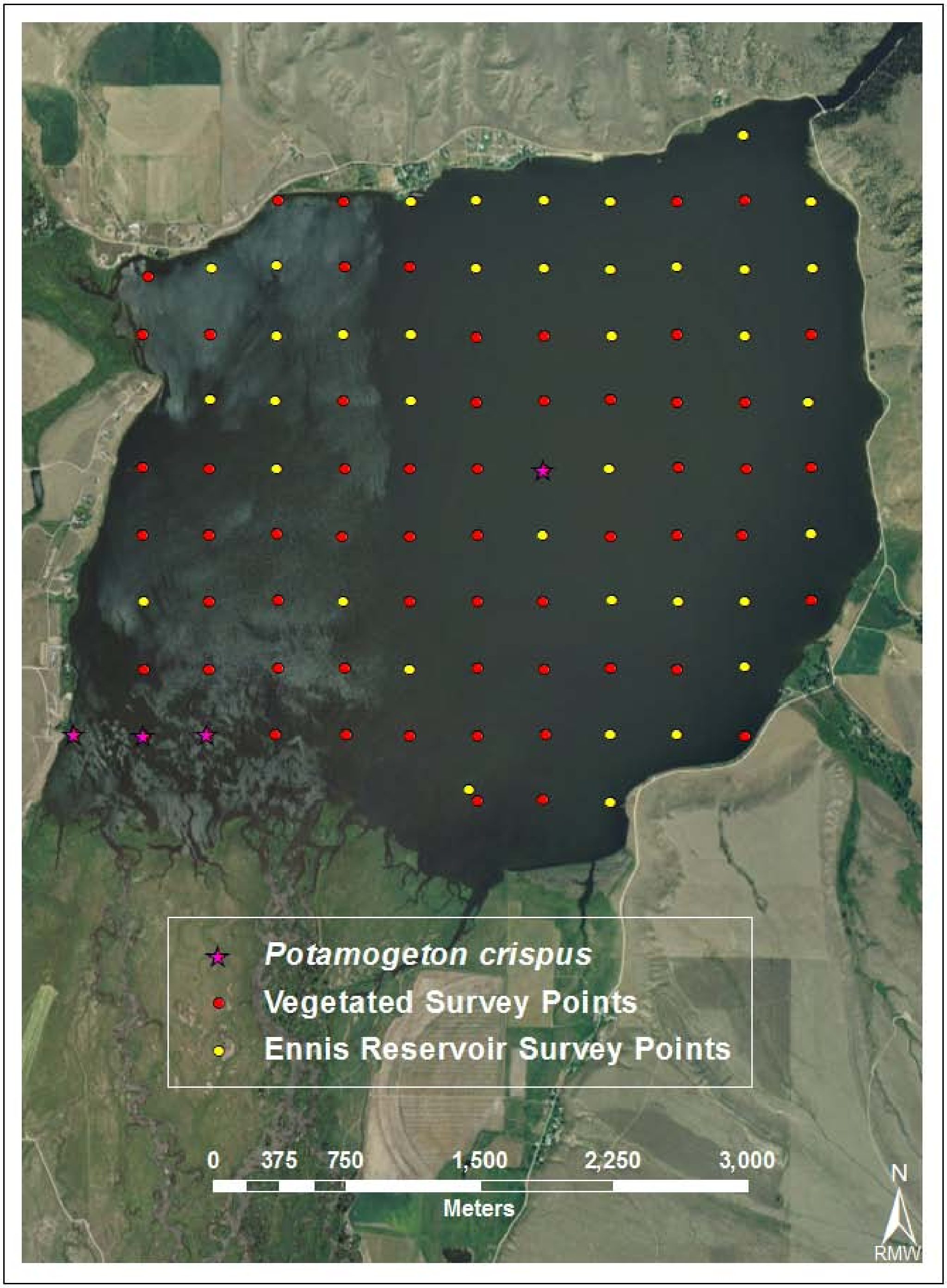

Figure 1.32. The distribution of *Potamogeton crispus* in Ennis Reservoir during the littoral zone survey conducted in August-Septebmer 2011.

Lake Name: Ruby River Reservoir

Date Surveyed: September 1, 2011

Points Surveyed: None

Eurasian watermilfoil = Negative

A systematic littoral survey of Ruby River Reservoir was not conducted as the dam was undergoing maintenance and the water level was down 30 to 50 ft (Figure 1.33). A visual survey was conducted by walking the exposed shoreline in several areas (Figure 1.34). Kayaks were also used in a few areas during the survey of the Ruby River. It is unlikely that there were plants in the reservoir where the water level was during the time of the survey, as it would have been too deep under normal reservoir conditions. Small seeded annual species such as some pondweeds may be present in the sediment and could germinate when the water level returns if desiccation of the seeds has not already occurred. However, there was no indication of aquatic plant species present.

Figure 1.33. The Ruby River flowing into a drawndown Ruby River Reservoir. The water level was estimated to be down approximately 30 to 50 ft. as indicated by the high water mark.


Figure 1.34. Surveying the shoreline for aquatic plants in Ruby River Reservoir, September 2011.

Lake Name: Cataract Reservoir

Date Surveyed: September 2, 2011

Points Surveyed: None

Eurasian watermilfoil = Negative

Cataract Reservoir is inaccessible by boat, and the access road to the primitive boat ramp was blocked by a large boulder that had fallen down from the cliffs above the road. The reservoir is approximately 30 to 40 acres in size, and the water level also appeared to be low (Figure 1.35). The entire perimeter of the reservoir was surveyed by walking and conducting rake tosses from the shoreline (Figure 1.36). There were no aquatic plants observed, and no signs of waterfowl or other wildlife that would utilize aquatic plants, which was a common occurrence at other reservoirs where aquatic plants were present.

Figure 1.35. The shoreline along Cataract Reservoir. The waterlevel appeared to be below the normal high water mark.


Figure 1.36. Surveying Cataract Reservoir from the shoreline during September 2011.

Lake Name: Willow Creek Reservoir (Harrison Lake)

Date Surveyed: September 2, 2011

Secchi: 8.2 ft.

Points Surveyed: 71

Eurasian watermilfoil = Negative

The water level appeared to be low, especially in the southern portion of the reservoir and some of the arms adjacent to the main reservoir which inhibited boat access. The majority of the perimeter of the reservoir consisted of rock cliffs that extend into the water column, which were unsuitable for plant growth. The area around the dam and spillway were surveyed to see if plants were escaping the reservoir, though no signs of vegetation were observed. Areas of the reservoir that contained navigable water and mud flats were included in the formal survey (Figure 1.37). Points were surveyed to a water depth of 36 ft. with the maximum observed depth of plant growth being 5.5 ft. Of the 71 points surveyed, 28% of these points had an aquatic plant species present (Figure 1.38).

Potamogeton foliosus was found most often followed by *Elodea canadensis* at 24% and 21%, respectively (Table 1.6). Both species were found in the same areas of the reservoir, which likely represent the most favorable habitats for plant growth (Figures 1.39-1.40). Other species observed during the survey included *Stuckenia pectinata*, *Ranunculus aquatilis*, and *Chara* sp. Though plants were present and identifiable, it appeared that most plants had begun senescence.

Table 1.6. Plant species list and percent occurrences for Willow Creek Reservoir, MT, September 2011.

Species	Common Name	Frequency of Occurrence (%)
***Chara* sp.**	Muskgrass	3
***Elodea canadensis* Michx.**	Elodea	21
***Potamogeton foliosus* L.**	Leafy pondweed	24
***Ranunculus aquatilis* L.**	White water-buttercup	3
***Stuckenia pectinata* (L.) Börner**	Sago pondweed	6
Average Survey Depth (ft)		11.2
Species Richness (avg. number per point)		0.6

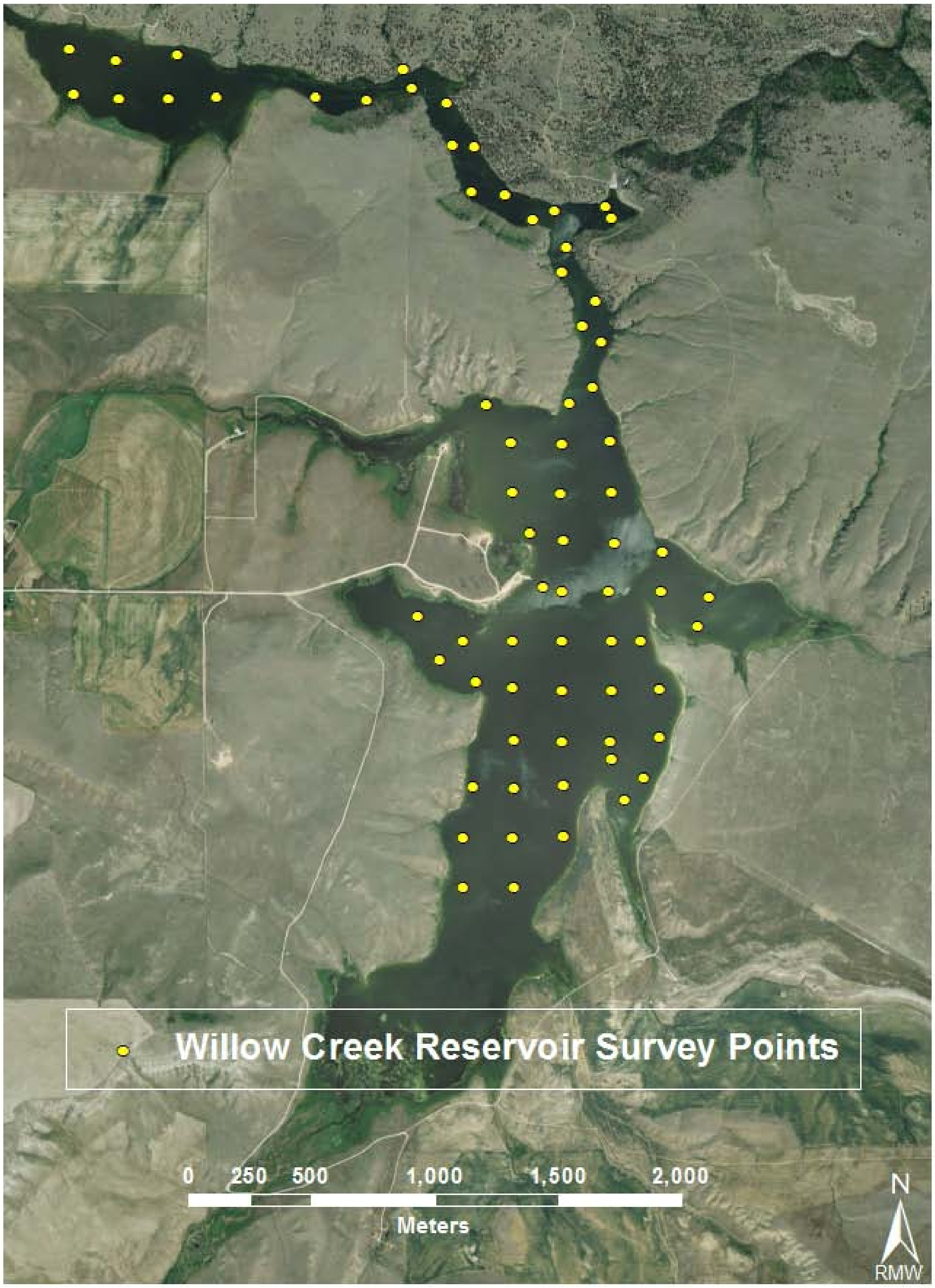

Figure 1.37. Survey points sampled on Willow Creek Reservoir during the littoral zone survey conducted in September 2011.

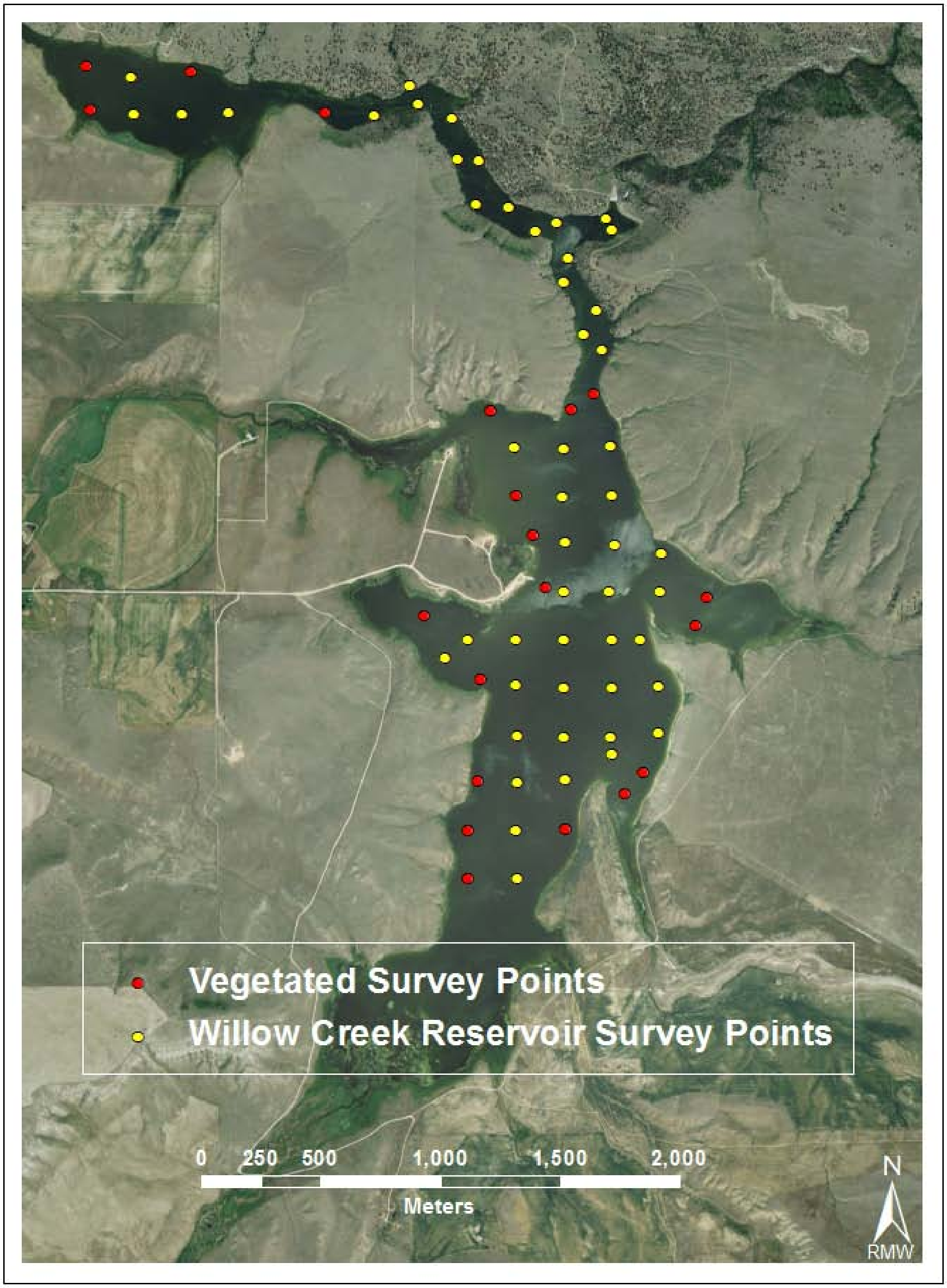

Figure 1.38. Survey points where aquatic plant species were observed during the littoral zone survey of Willow Creek Reservoir conducted in September 2011.

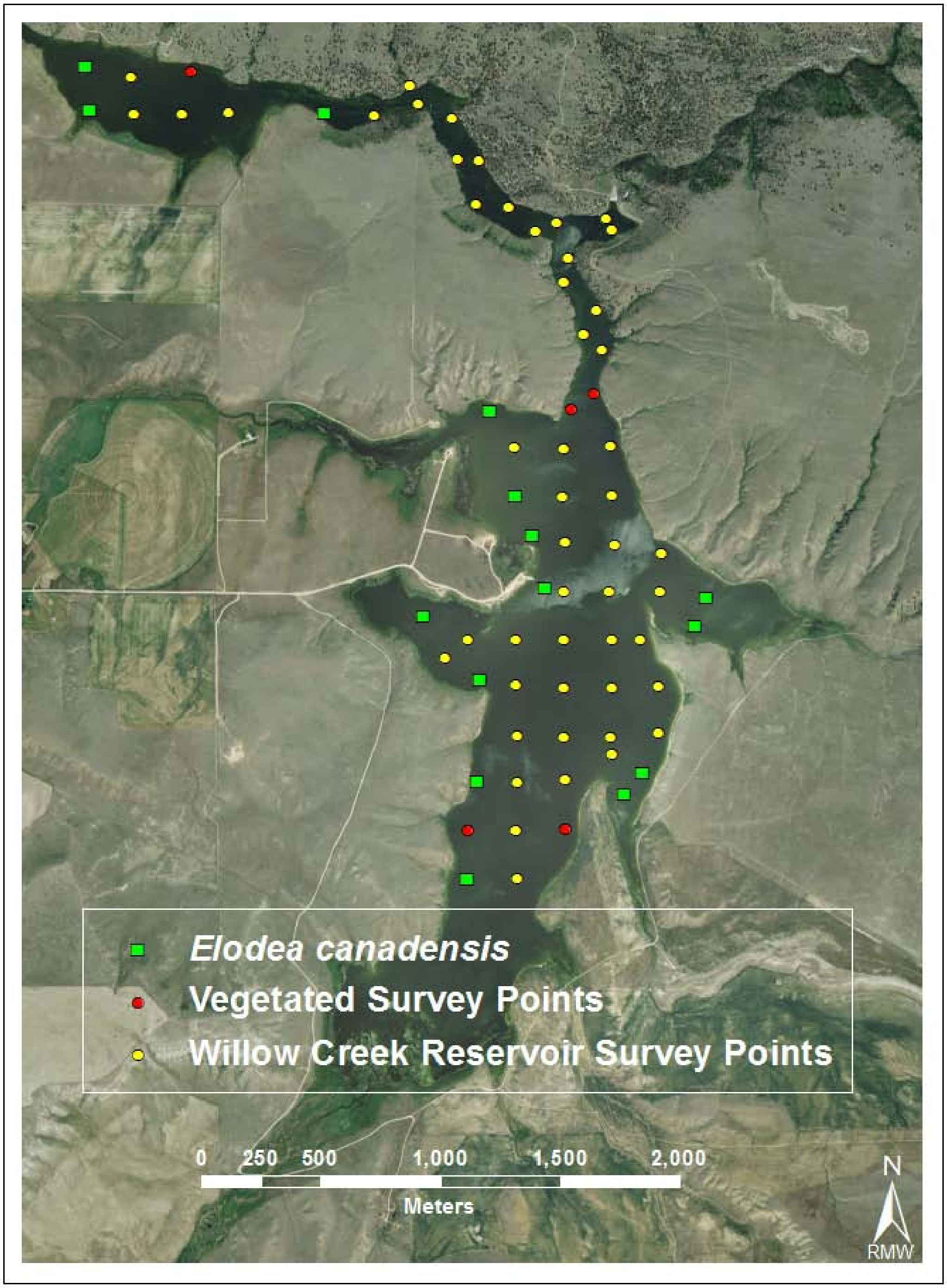

Figure 1.39. The distribution of *Elodea canadensis* in Willow Creek Reservoir during the littoral zone survey conducted in September 2011.

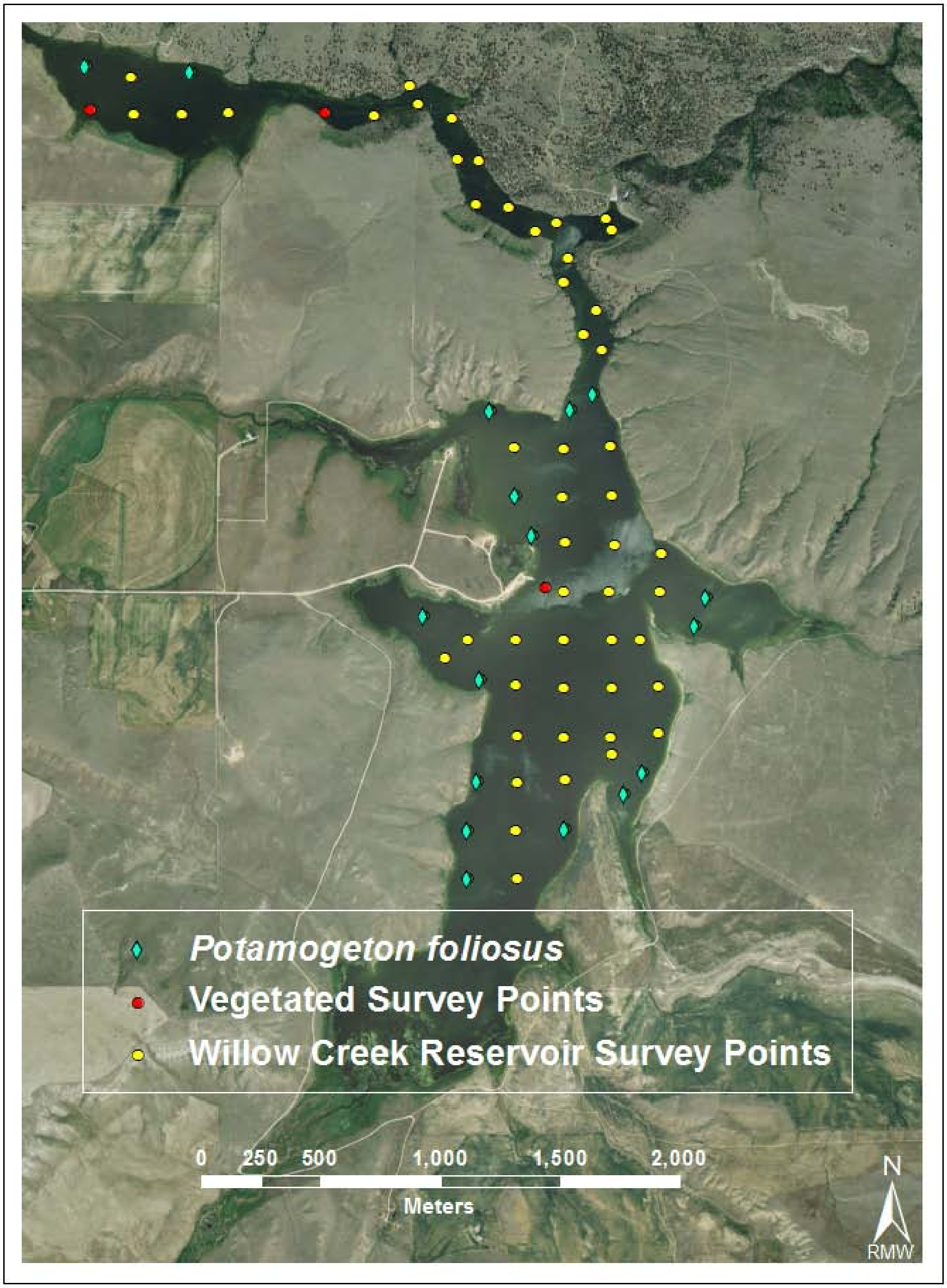

Figure 1.40. The distribution of *Potamogeton foliosus* in Willow Creek Reservoir during the littoral zone survey conducted in September 2011.

Lake Name: Clark Canyon Reservoir

Date Surveyed: September 3, 2011

Secchi: 10.5 ft.

Points Surveyed: 130

Eurasian watermilfoil = Negative

Clark Canyon Reservoir is deep throughout most of the central portion of the reservoir. The majority of the survey points were in the western portion of the reservoir (Figure 1.41). The littoral zone survey included some points to a depth of 94 ft. with a maximum depth of plant growth of 7 ft. Of the 130 points surveyed, 3% of these points had an aquatic plant species present (Figure 1.42). Few plant species were observed in this reservoir, and most species had begun to senesce (Table 1.7). *Potamogeton foliosus* and *Stuckenia pectinata* were observed at 2% of the sample points and their distributions are depicted in Figures 1.43 and 1.44. The distribution of *Ranunculus aquatilis* is depicted in Figure 1.45. Unlike in other reservoirs surveyed, a dense algae bloom was occurring during the time of the survey. The cause of the algal bloom in this reservoir is unknown.

Table 1.7. Plant species list and percent occurrences for Clark Canyon Reservoir, MT, September 2011.

Species	Common Name	Frequency of Occurrence (%)
***Potamogeton foliosus* L.**	Leafy pondweed	2
***Ranunculus aquatilis* L.**	White water-buttercup	1
***Stuckenia pectinata* (L.) Börner**	Sago pondweed	2
Average Survey Depth (ft)		21.8
Species Richness (avg. number per point)		0.1

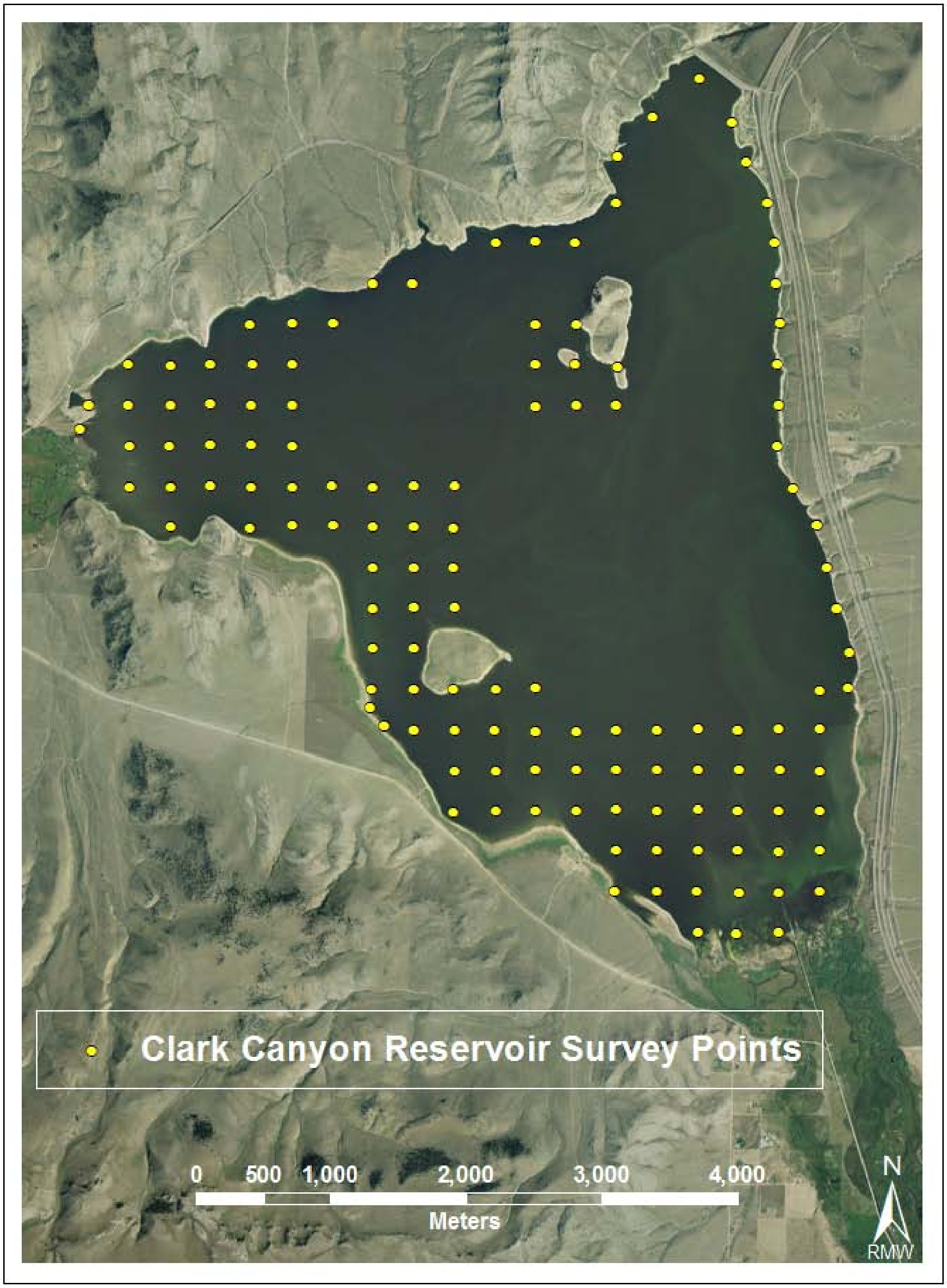

Figure 1.41. Survey points sampled on Clark Canyon Reservoir during the littoral zone survey conducted in September 2011.

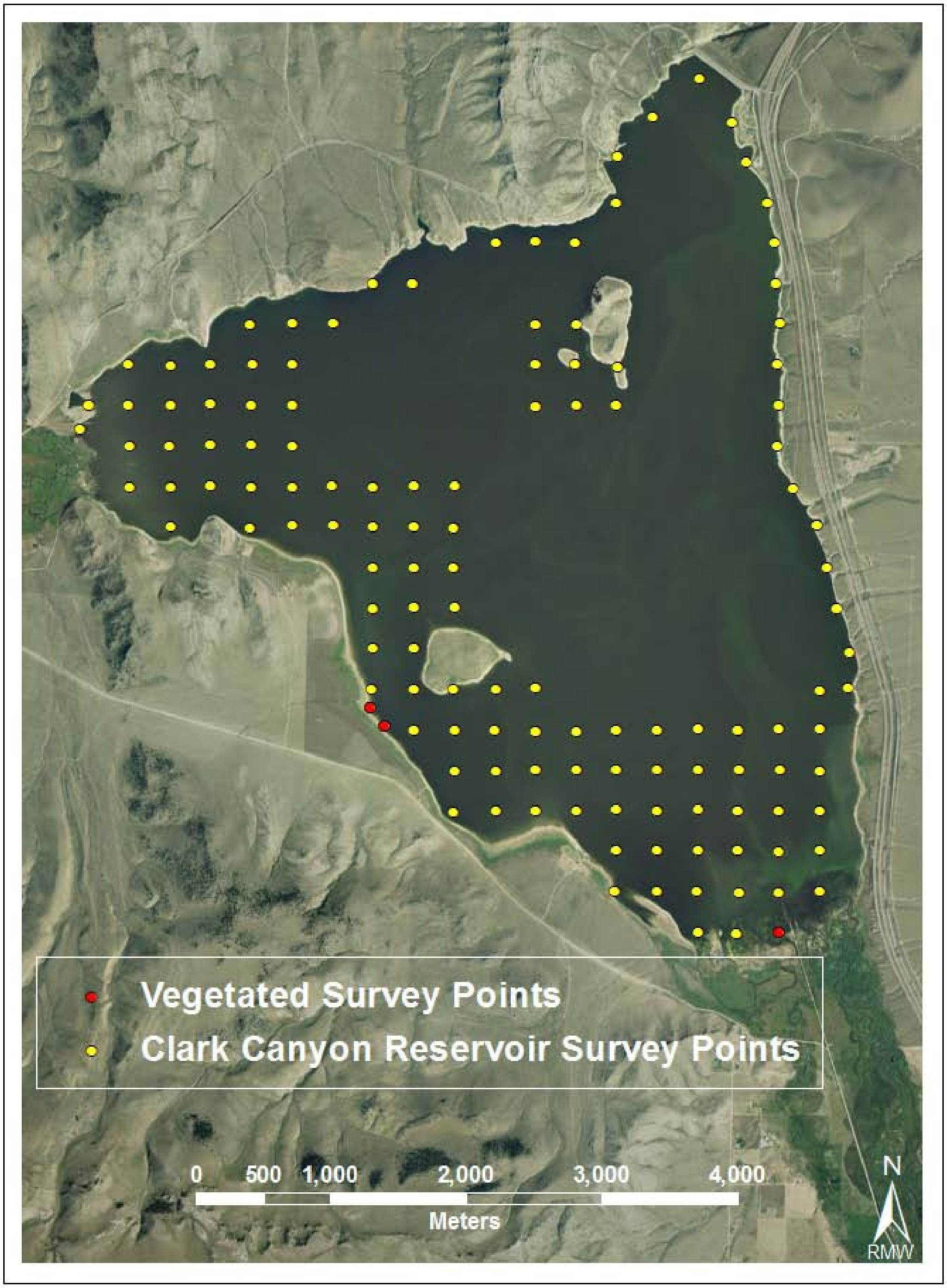

Figure 1.42. Survey points where aquatic plant species were observed during the littoral zone survey of Clark Canyon Reservoir conducted in September 2011.

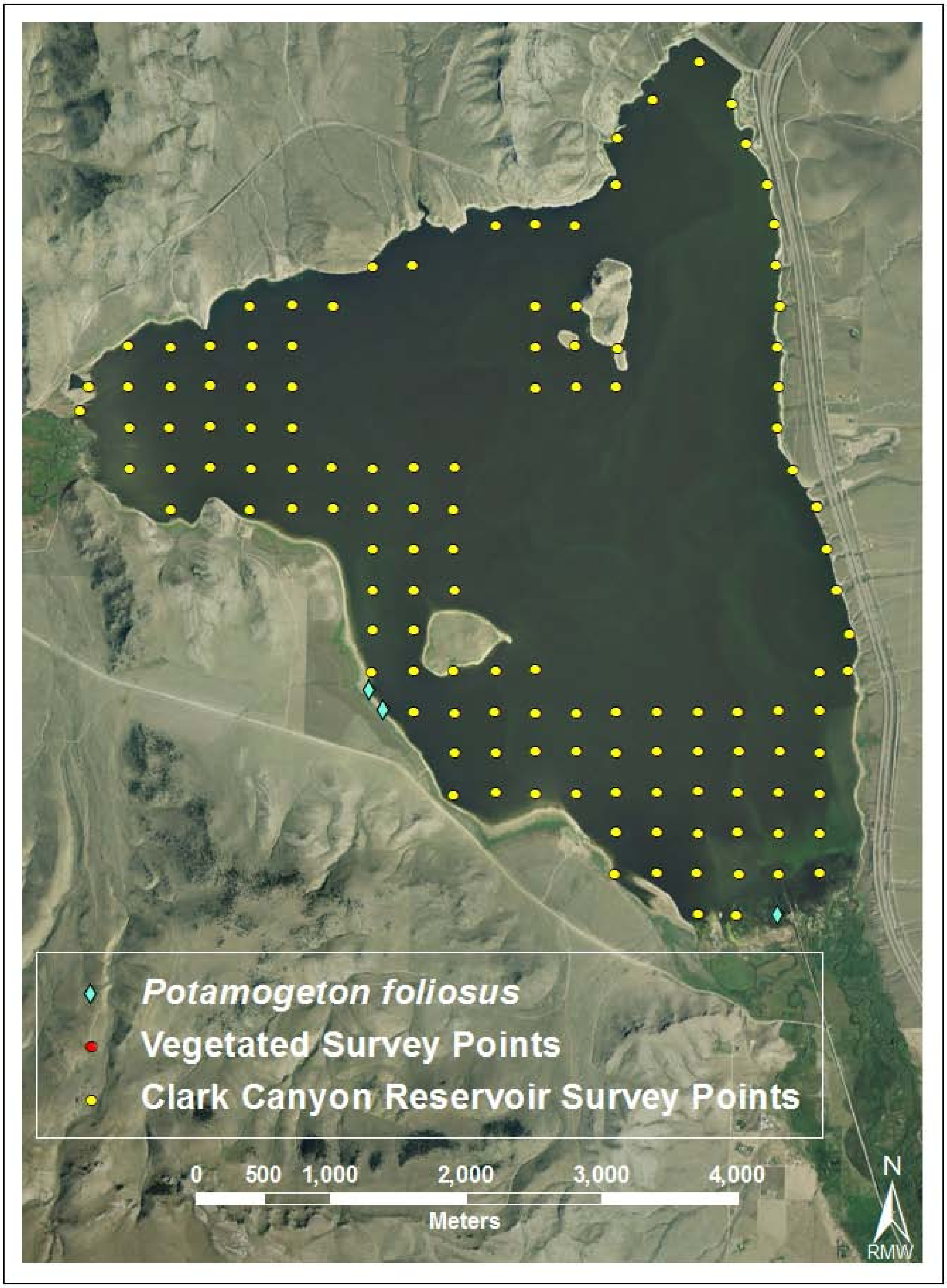

Figure 1.43. The distribution of *Potamogeton foliosus* in Clark Canyon Reservoir during the littoral zone survey conducted in September 2011.

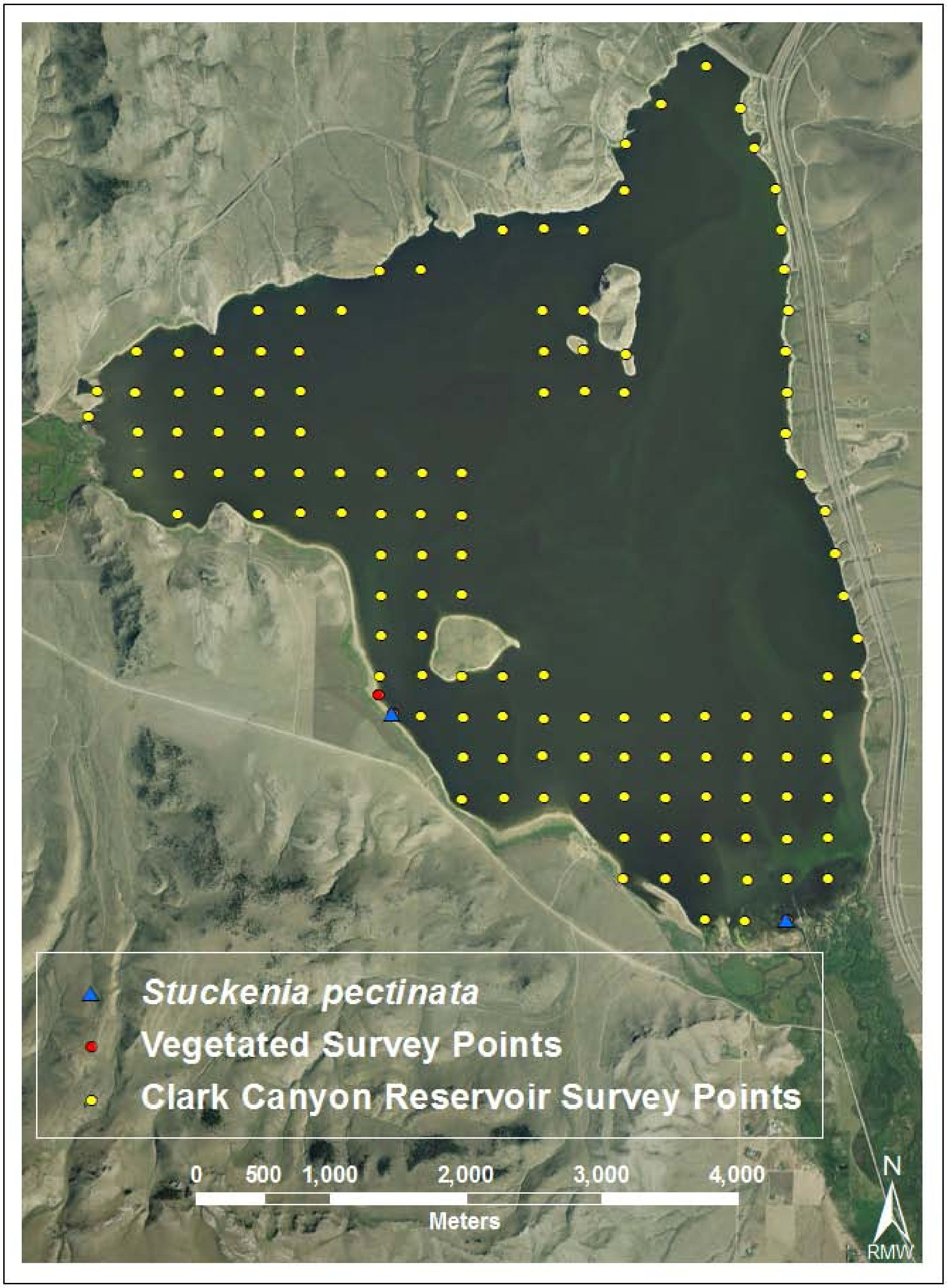

Figure 1.44. The distribution of *Stuckenia pectinata* in Clark Canyon Reservoir during the littoral zone survey conducted in September 2011.

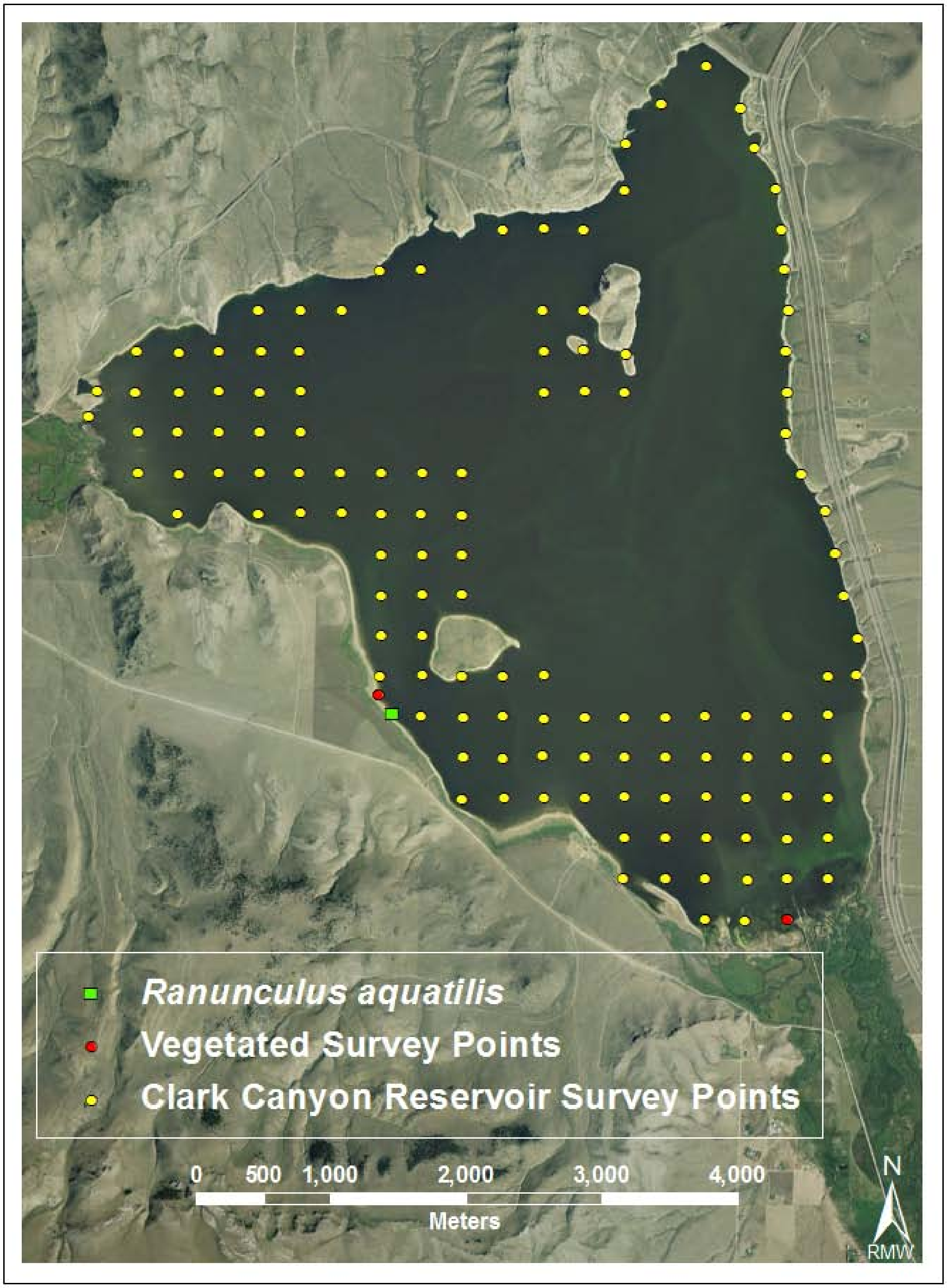

Figure 1.45. The distribution of *Ranunculus aquatilis* in Clark Canyon Reservoir during the littoral zone survey conducted in September 2011.

Lake Name: Toston Reservoir

Date Surveyed: September 9, 2011

Secchi: < 4 ft.

Points Surveyed: 103

Eurasian watermilfoil = Positive

Toston reservoir is a small, shallow, run of the river reservoir where water depths were generally shallow (< 20 ft.). Similar to Ennis Reservoir, much of this reservoir could become inhabited by aquatic vegetation due to the shallow nature of Toston. Points were surveyed to a water depth of 29 ft. (the maximum depth observed during the survey near the dam) with the maximum observed depth of plant growth being 7.5 ft (Figure 1.46). Of the 103 points surveyed, 35% of these points had an aquatic plant species present (Figure 1.47). Currently, plant growth is on shallow mud flats, along the shoreline, and around the numerous islands in the center of the reservoir. Species included *Stuckenia pectinata*, *Elodea canadensis*, *Myriophyllum sibiricum*, and *Myriophyllum quitense* (Table 1.8). Limitations to plant establishment currently include light availability due to turbidity, and the scouring action of water flow in deeper areas.

Myriophyllum spicatum and *Potamogeton crispus* were the dominant plant species in the reservoir, though *P. crispus* occurred most frequently and in greater densities. Both *M. spicatum* and *P. crispus* were found throughout the reservoir, and are well established (Figures 1.48-1.49). Currently, diver operated suction dredging is being conducted to control *M. spicatum*, though there have been no control measures undertaken for *P. crispus*. Removing only *M. spicatum* will likely result in a species shift towards a *P. crispus* dominated community, which with the management methods currently available and the life history of *P. crispus*, will be more difficult to control and contain then *M. spicatum*. *Potamogeton crispus* turions can likely remain viable longer than *M. spicatum* fragments and can be transported longer distances within a given water body. Diver operated suction dredging will be sufficient to manage *M. spicatum* in small areas of the reservoir, but dredging is generally slow and will likely not keep up with the eventual spread of *M. spicatum* throughout the reservoir. Additional management techniques, such as herbicide applications or drawdowns, can be effective on a larger scale and need to be implemented to control *M. spicatum* throughout the reservoir and not just in small beds.

In addition to *M. spicatum*, there were two other milfoil species observed during the survey. *Myriophyllum sibiricum* and an unknown milfoil species were found as the river opens into Toston Reservoir (Figures 1.50-1.51). The smaller unknown milfoil had characteristics that appeared to be intermediate between both *M. spicatum* and *M.* sibiricum. Therefore, seven samples were collected and shipped to Dr. Ryan Thum at the Annis Water Resources Institute at Grand Valley State for genetic verifications of milfoil identifications and to rule out the possibility of a hybrid milfoil. Dr. Thum has developed a rapid assay to determine an *M. spicatum* x *M. sibiricum* hybrid, and has tested milfoil species from around the country. The results of the genetic testing are summarized in Table 1.9. The samples that were identified as either *M. sibiricum* or *M. spicatum* in the field were in fact genetically verified as those species.

The unknown milfoil species was genetically identified as *Myriophyllum quitense*, and according to the USDA Plants Database has not previously been reported in Montana and could be in other water bodies in the state.

Having three species of milfoil in Toston Reservoir will present challenges with not only identification, but management of *M. spicatum* as well. All three species were found growing in close proximity to one another and if management personnel, such as dredging crews, are unable to correctly identify the rare native milfoils from *M. spicatum*, native species may be removed by mistake. It would be beneficial to establish a plant screening program with a nationally recognized laboratory such as Dr. Thum's to genetically verify field identifications prior to implementing management techniques.

Table 1.8. Plant species list and percent occurrences for Toston Reservoir, MT, September 2011.

Species	Common Name	Frequency of Occurrence (%)
***Elodea canadensis* Michx.**	Elodea	5
***Myriophyllum quitense* Kunth**	Andean watermilfoil	3
***Myriophyllum sibiricum* Komarov**	Northern watermilfoil	9
***Myriophyllum spicatum* L.**	Eurasian watermilfoil	14
***Lemna minor* L.**	Common duckweed	1
***Phragmites australis* (Cav.) Trin. Ex Steud.**	Common reed	1
***Potamogeton crispus* L.**	Curlyleaf pondweed	20
***Stuckenia pectinata* (L.) Börner**	Sago pondweed	6
***Typha latifolia* L.**	Common cattail	1
Average Survey Depth (ft)		7.6
Species Richness (avg. number per point)		0.6

Table 1.9. Results of the genetic verification of milfoil species in Toston Reservoir, MT, September 2011. Genetic verifications were performed by Dr. Ryan Thum at the Annis Water Resources Institute, Grand Valley State University, Michigan.

Sample	Field Identification	Genetic Verification
1	*Myriophyllum sibiricum*	*Myriophyllum sibiricum*
2	*Myriophyllum spicatum*	*Myriophyllum spicatum*
3	*Myriophyllum spicatum*	*Myriophyllum spicatum*
4	*Myriophyllum spicatum*	*Myriophyllum spicatum*
5	*Myriophyllum spicatum*	*Myriophyllum spicatum*
6	Test Milfoil 1-1	*Myriophyllum spicatum*
	Test Milfoil 1-2	*Myriophyllum quitense*
7	Test Milfoil 2-1	*Myriophyllum quitense*
	Test Milfoil 2-2	*Myriophyllum quitense*

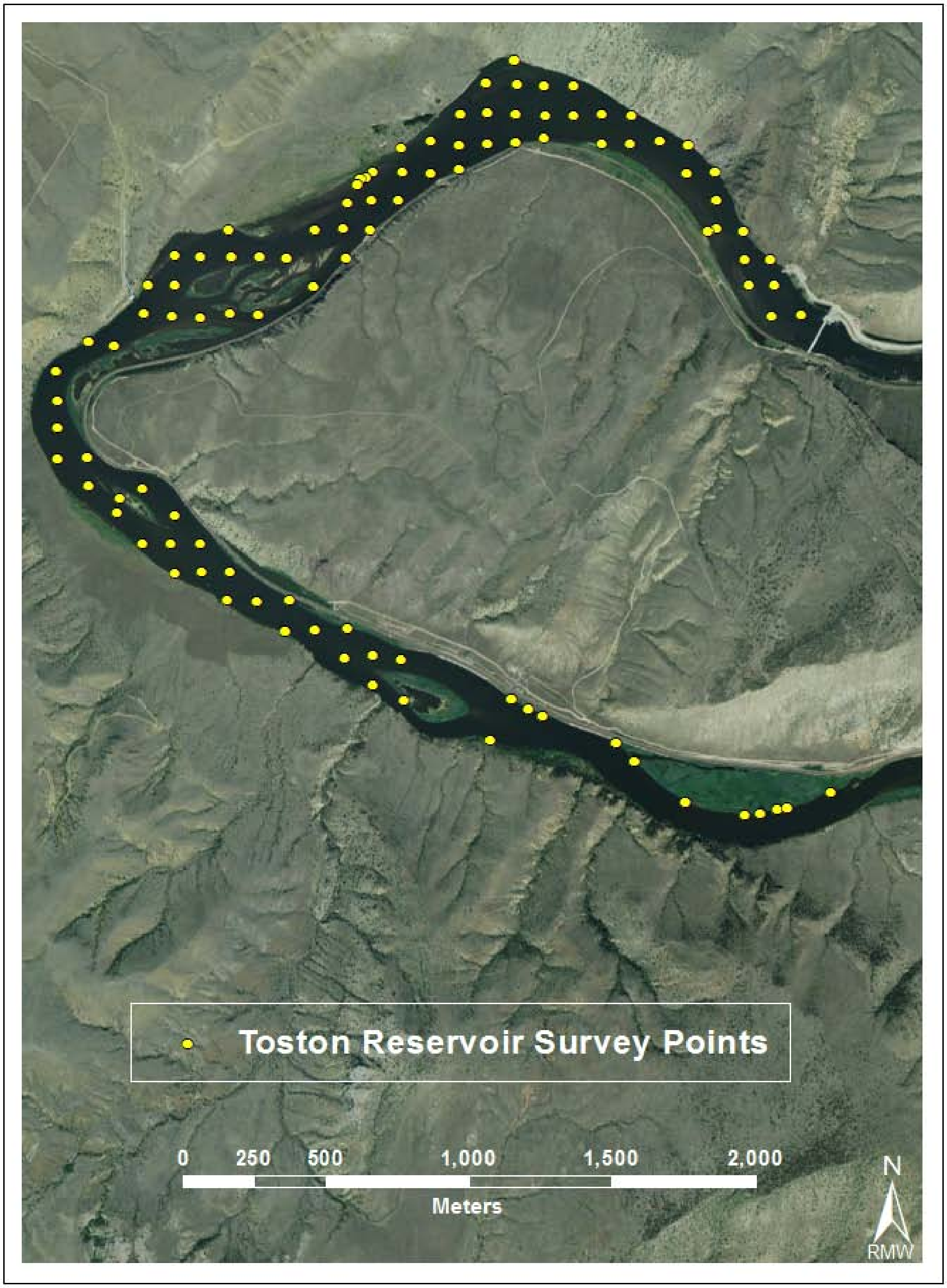

Figure 1.46. Survey points sampled on Toston Reservoir during the littoral zone survey conducted in September 2011.

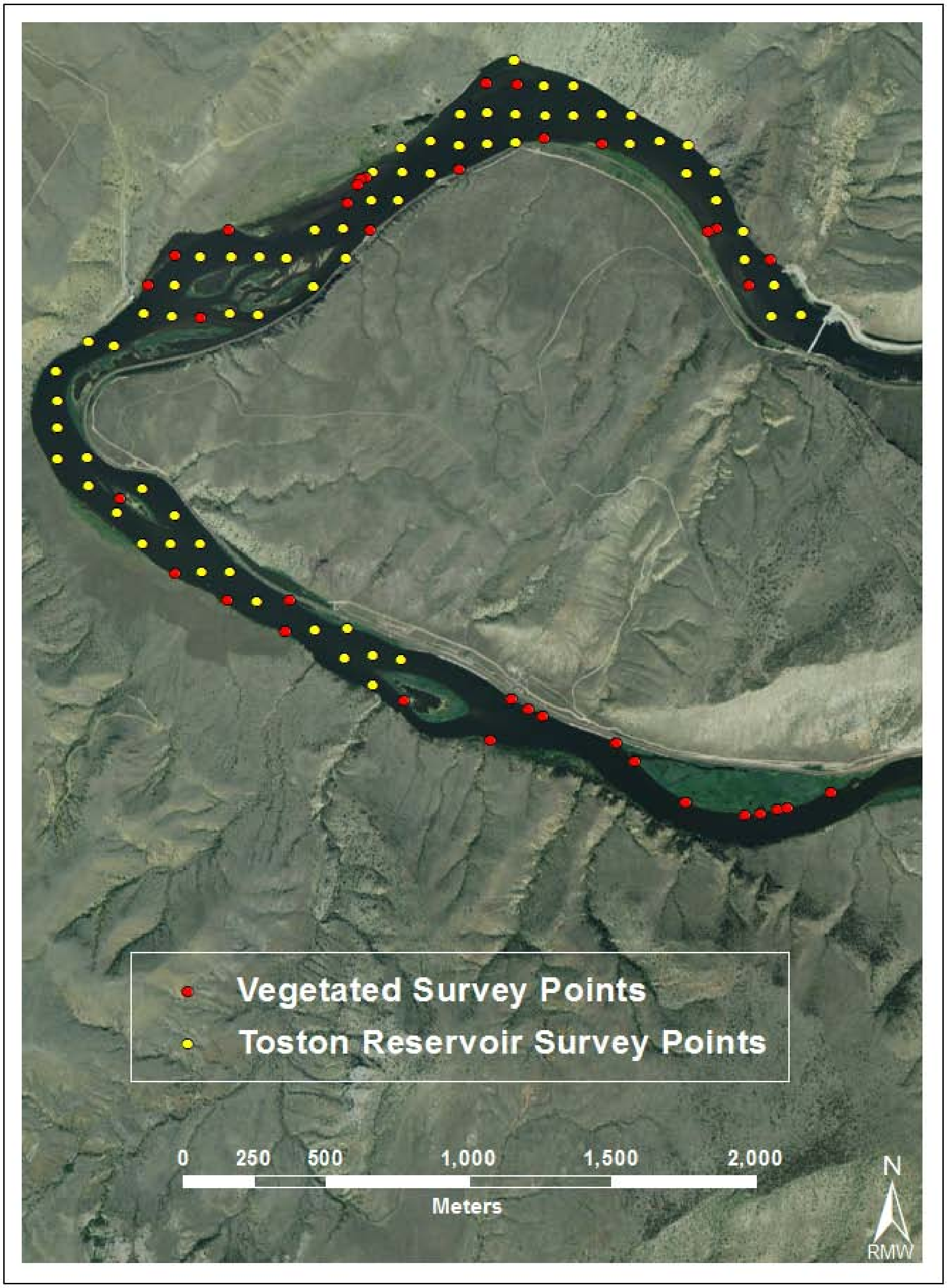

Figure 1.47. Survey points where aquatic plant species were observed during the littoral zone survey of Toston Reservoir conducted in September 2011.

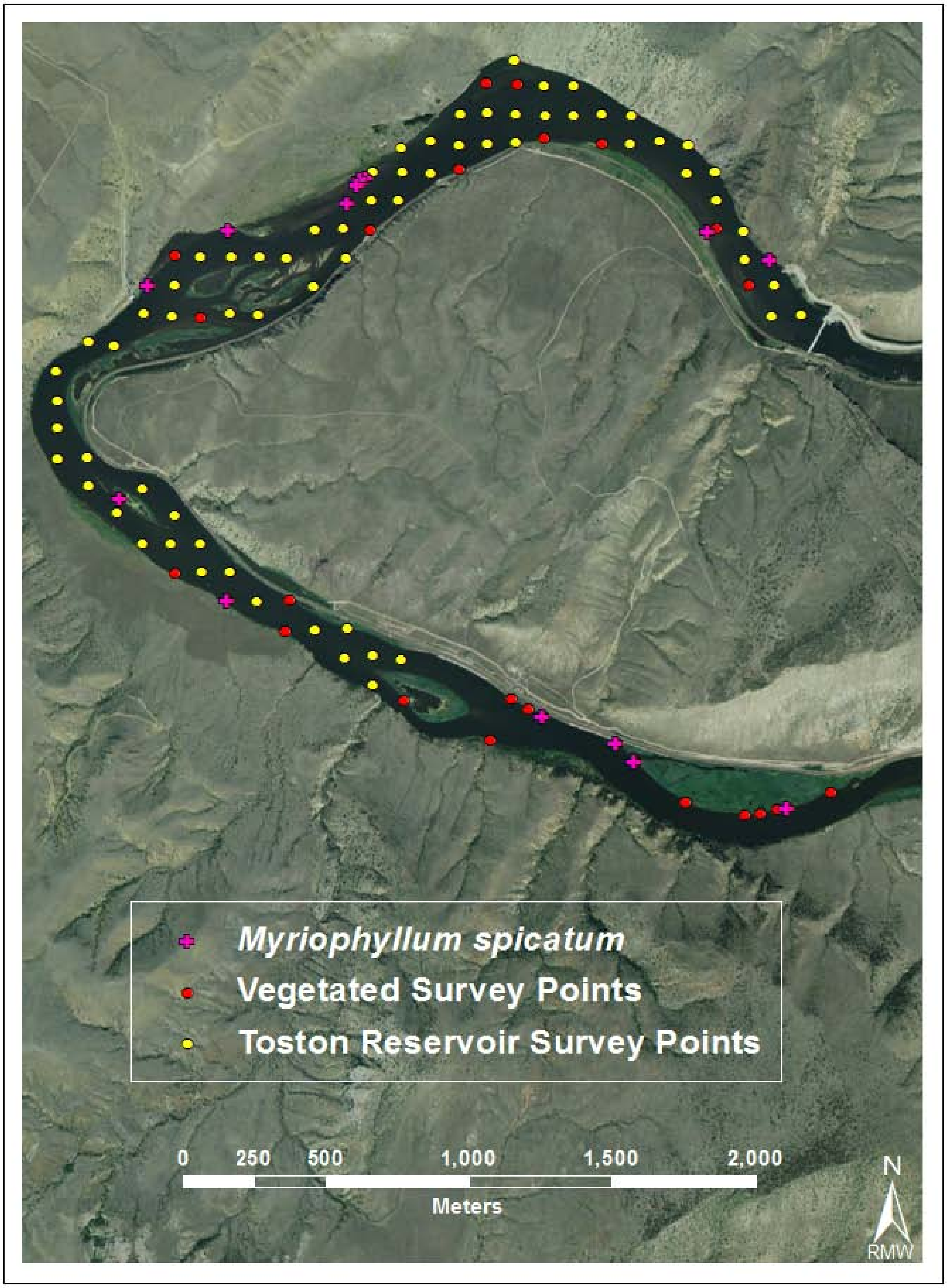

Figure 1.48. The distribution of *Myriophyllum spicatum* in Toston Reservoir during the littoral zone survey conducted in September 2011.

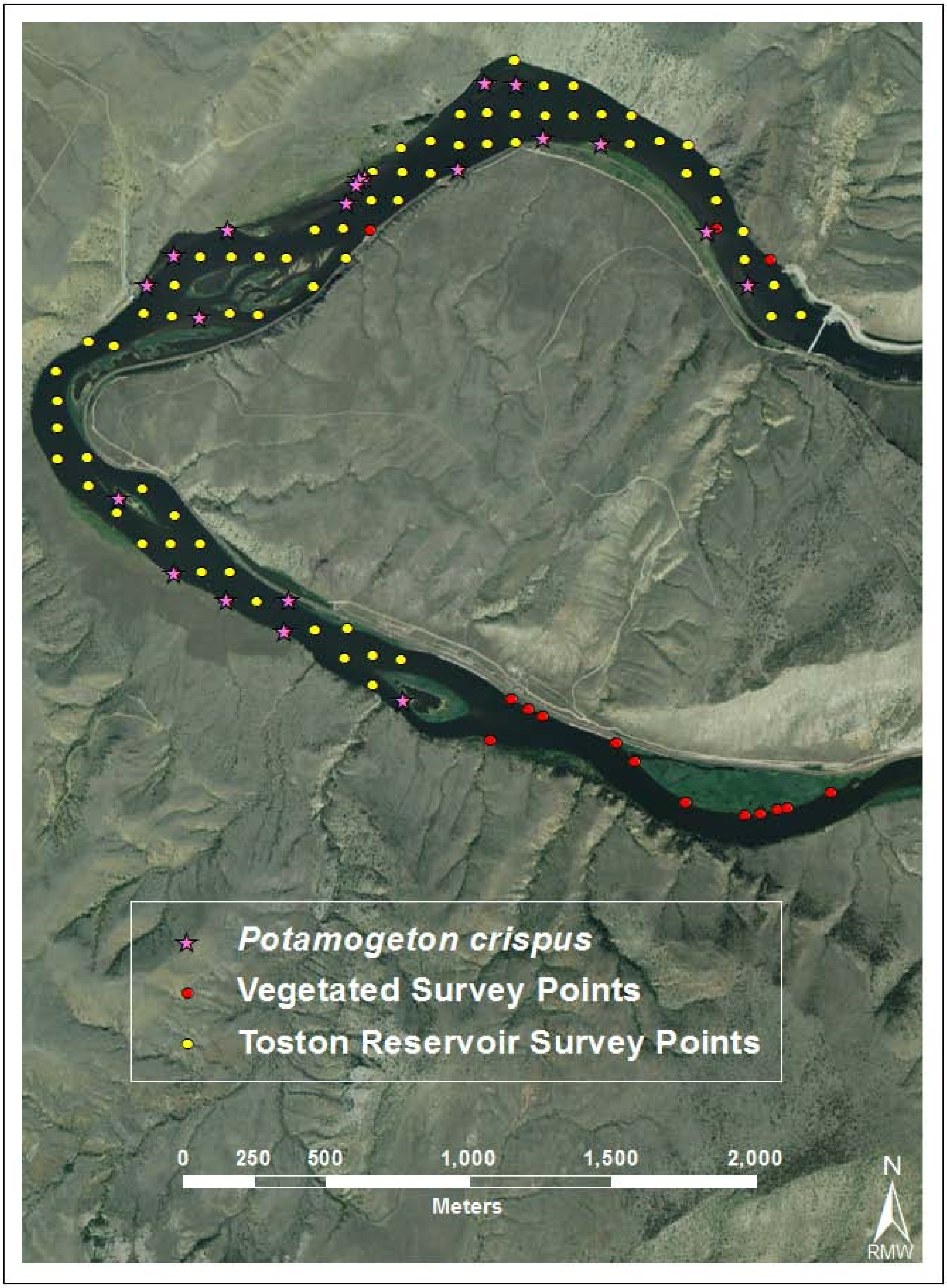

Figure 1.49. The distribution of *Potamogeton crispus* in Toston Reservoir during the littoral zone survey conducted in September 2011.

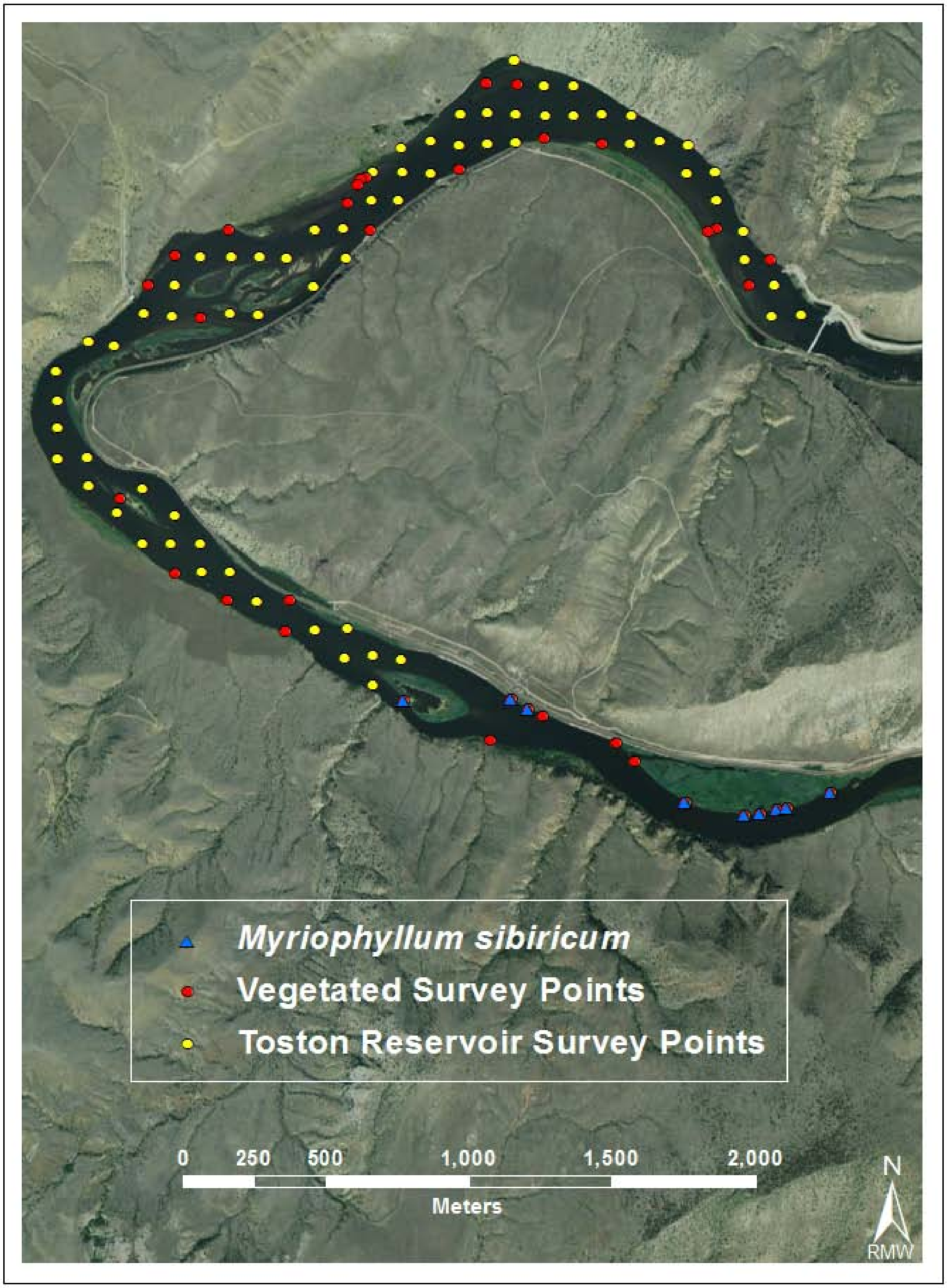

Figure 1.50. The distribution of *Myriophyllum sibiricum* in Toston Reservoir during the littoral zone survey conducted in September 2011.

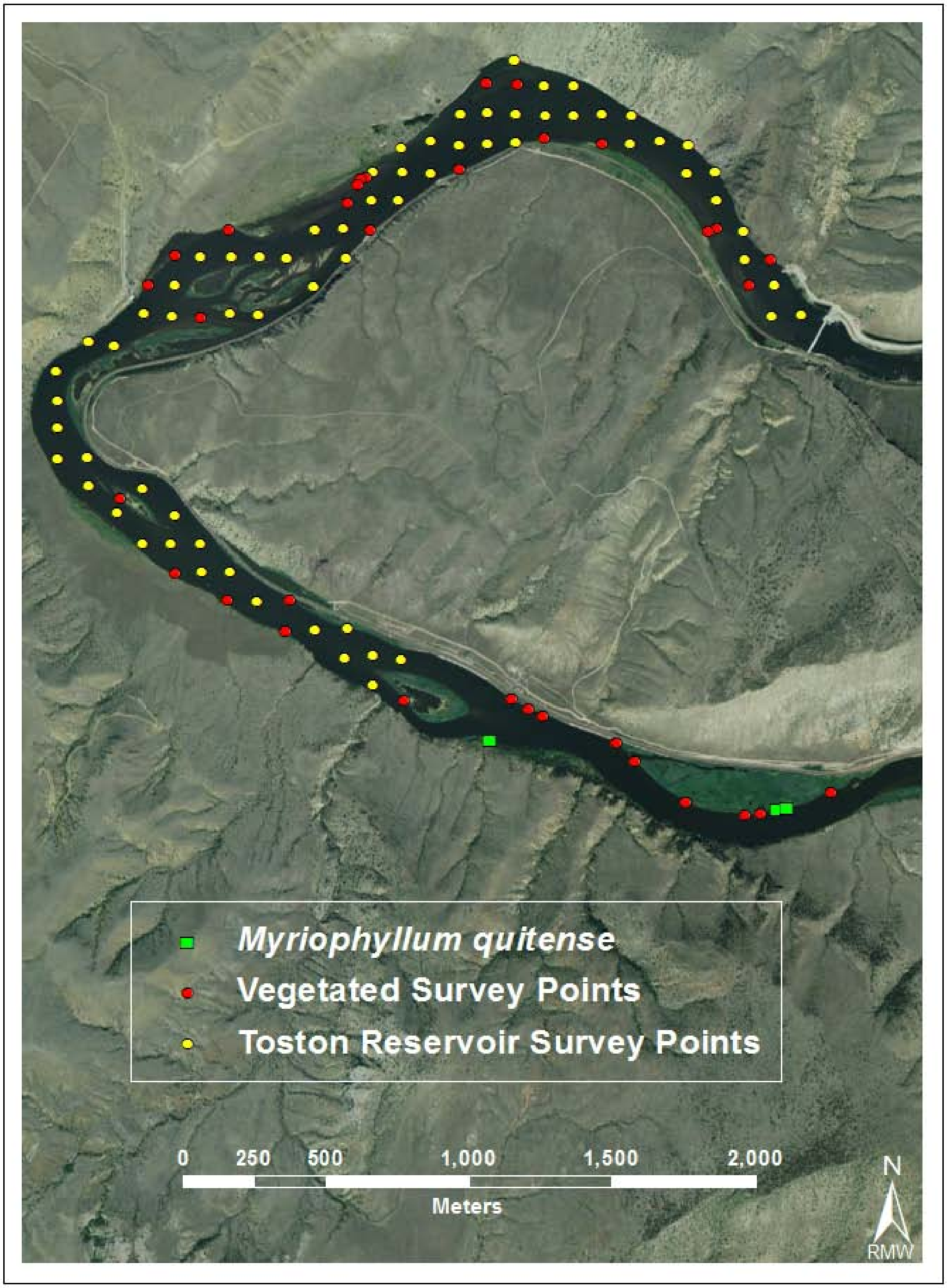

Figure 1.51. The distribution of *Myriophyllum quitense* in Toston Reservoir during the littoral zone survey conducted in September 2011.

Lake Name: Lima Reservoir

Date Surveyed: September 2, 2011 (Celestine Duncan, Consultant)

Secchi: not taken

Points Surveyed: 10

Eurasian watermilfoil = Negative

Red Rock River flows westward from Lower Red Rock Lake for approximately 17 miles before entering Lima Reservoir. The irrigation storage reservoir built in 1902 significantly alters the natural flow regime of the river. Lima Reservoir does not have a developed boat ramp which restricts public use of the water body limiting the potential for introduction and spread of non-native aquatic plants. Biologists with Red Rock Lakes National Wildlife Refuge infrequently use the reservoir for banding migratory birds, and no other watercraft are routinely observed (Jeffery Warren, pers. comm.). Due to restricted public use and annual drawdown, the potential for introduction and establishment of aquatic invasive species is low.

Submersed aquatic plant samples were collected along a 0.6 mile segment of the lower reservoir and inside the dam face (Figure 1.52). The sample area was the only location where an access road was near the reservoir and presented a potential site where watercraft could be launched. There was minimal submersed aquatic vegetation present, and some of those plants were senescing. *Elodea canadensis* and *Hippuris vulgaris* were observed most often at 40% of the sampled points (Table 1.10).

Table 1.10. Plant species list and percent occurrences for Lima Reservoir, MT, September 2011.

Species	Common Name	Frequency of Occurrence (%)
***Elodea canadensis* Michx.**	Elodea	40
Hippuris vulgaris	Common marestail	40
***Ranunculus aquatilis* L.**	White water-buttercup	20
***Stuckenia pectinata* (L.) Börner**	Sago pondweed	20
		3
Average Survey Depth (ft)		1.1
Species Richness (avg. number per point)		40

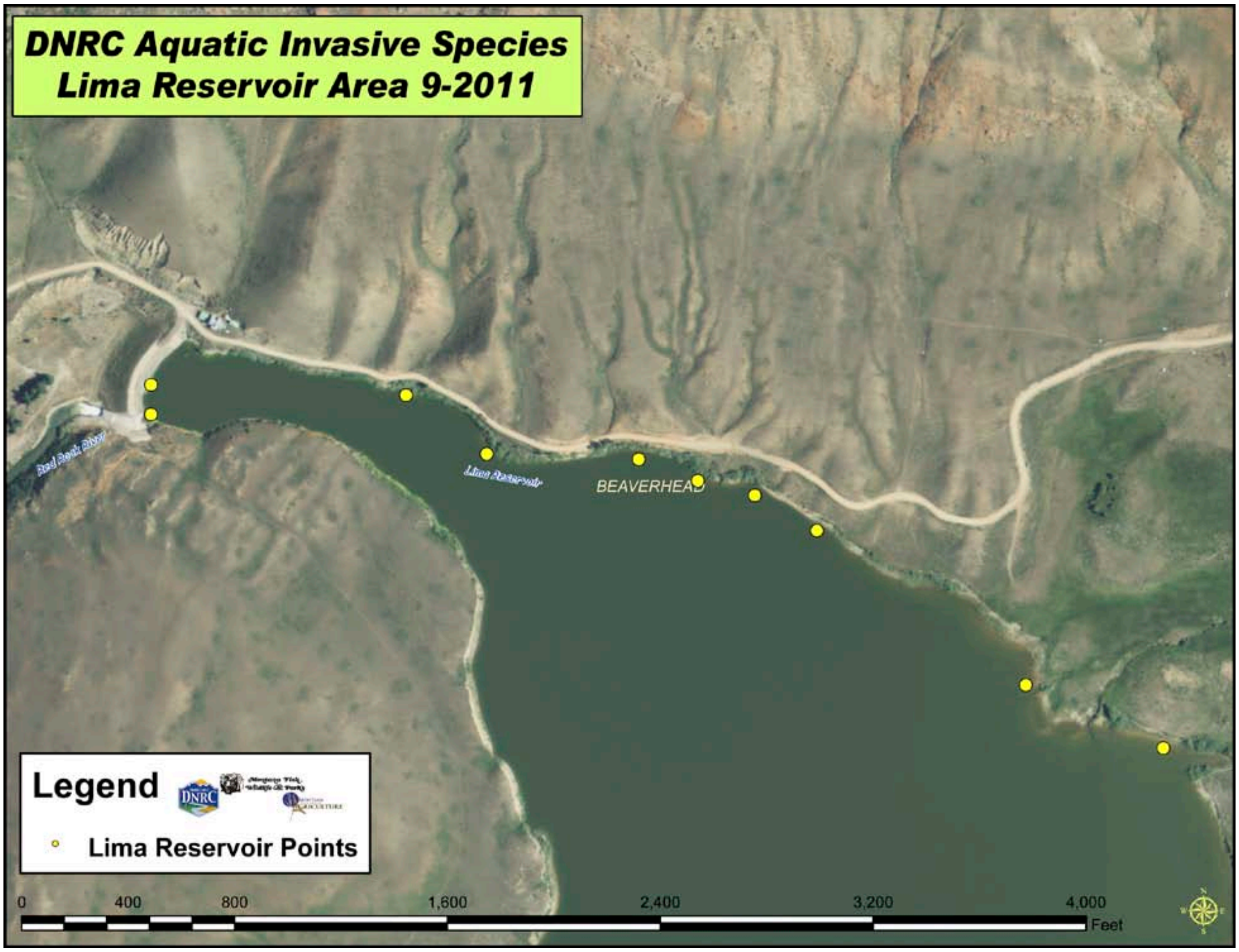

Figure 1.52. Points sampled on Lima Reservoir during the survey conducted in September 2011.

Lake Name: Red Rock Lakes and Red Rock Creek

Date Surveyed: September 3, 2011 (Celestine Duncan, Consultant)
September 7, 2011 (Red Rock Creek above Upper Red Rock Lake, survey by Nathan Korb and Brad Bauer, The Nature Conservancy)
2005-2009 (Lower Red Rock Lake, survey by Jeff Warren, US Fish and Wildlife Service)

Secchi: not taken

Points Surveyed: Red Rock Creek (above Upper Red Rock Lake) = 3
Upper Red Rock Lake = 33
Lower Red Rock Lake = 16, 50 by 50m plots (2005-2007); 71, 5 by 5m plots (2007-2009)

Eurasian watermilfoil = Negative

Red Rock Lakes National Wildlife Refuge (NWR) is managed by the U.S. Fish and Wildlife Service (USFWS). The refuge lies in the high-elevation Centennial Valley and contains primarily wetland and riparian habitats. Red Rock Creek flows through the upper end of the Centennial valley, creating Upper Red Rock Lake, River Marsh, and Lower Red Rock Lake marshlands. Water is managed to provide nesting habitat for swans and other waterfowl, with a secondary benefit for fisheries. Boating restrictions apply on both lakes with motorized watercraft prohibited (with exception of USFWS boats for management activities), and non-motorized boat use in Upper and Lower Red Rock Lake allowed only during certain times of the year to protect waterfowl nesting. There is one non-developed access point (dirt trail leading to the water) for non-motorized watercraft access to Upper Red Rock Lake. There is also limited non-motorized recreational watercraft use between Upper and Lower Red Rock Lake downstream to Lima reservoir.

Based on limited recreational use and prohibition on motorized boat use, the potential for introduction of aquatic invasive species in either Upper or Lower Red Rock Lake is relatively low. However, there is a robust native aquatic plant community in the littoral zone along the south and southwest portion of Upper Red Rock Lake, and presence of native milfoils and pondweeds indicate that habitat would be suitable for invasive aquatic plants such as Eurasian watermilfoil and curlyleaf pondweed.

Upper Red Rock Lake: Thirty-three random sample points were concentrated near the public access point within the shallow littoral zone (Figure 1.53). Non-native aquatic plants were not observed at any of the sample points or traversing between sample locations. Depth of littoral zone where samples were collected ranged from 1.5 to 4 ft. with dense cover of native aquatic vegetation present at most sample points. *Potamogeton richardsonii* was observed most often followed by *Nitella* sp., and *Myriophyllum sibiricum* (Table 1.11).

Table 1.11. Plant species list and percent occurrences for Upper Red Rock Lake, MT, September 2011.

Species	**Common Name**	**Frequency of Occurrence (%)**
Chara sp.	Muskgrass	3
Elodea canadensis Michx.	Elodea	24
Myriophyllum sibiricum Komarov	Northern watermilfoil	43
Nitella sp.	Brittlewort	54
Potamogeton foliosus L.	Leafy pondweed	15
Potamogeton nodosus	American pondweed	3
Potamogeton richardsonii (Ar. Benn.) Rydb.	Clasping-leaved pondweed	60
Ranunculus aquatilis L.	White water-buttercup	24
Sagittaria cuneata Sheld.	Arrowhead	36
Stuckenia pectinata (L.) Börner	Sago pondweed	24
Stuckenia vaginatus	Sheathing pondweed	21
Average Survey Depth (ft)		3
Species Richness (avg. number per point)		3.1

Lower Red Rock Lake: Surveys for submersed aquatic vegetation have been conducted annually in Lower Red Rock Lake by the USFWS since 2003, and historic data is available to 1922. The following information summarizes aquatic plant sampling conducted from 2005 through 2009 as supplied by the USFWS. A detailed report regarding submersed aquatic vegetation (SAV) and hydrologic data for Lower Red Rock Lake is on file with USFWS at Red Rock Lakes NWR (Jeffery Warren, pers. comm.)

Aquatic plant sampling from 2005 to 2007 consisted of 16, 50 by 50 m plots divided into smaller sub-sample quadrats that were surveyed for the presence of submersed aquatic plants. In 2007, an additional set of 5 by 5 m quadrats (n = 71) were generated within the open water areas of the lake and sampled for submersed aquatic plants. The most common submersed aquatic plant species *Myriophyllum sibiricum* ranging from 44.5% canopy cover in 2005 to 29.5% in 2006 (Table 1.12). *Myriophyllum sibiricum* cover was 33.3% in 2007. Other common species observed during 2007, in descending order of canopy cover, were *Ceratophyllum demersum, Potamogeton richardsonii, Lemna trisulca,* and *Stuckenia pectinata*.

Table 1.12. Plant species list and percent canopy cover in Lower Red Rock Lake, Red Rock Lakes NWR, MT, 2005, 2007, and 2009. Summaries from 16, 50 by 50 m plots for 2005 to 2007 are provided, as well as a summary of 71, 5 by 5 m plots completed 2007to 2009. Data provided from the US Fish and Wildlife Service.

Species	Common name	2005	2007	2007[a]	2009[a]
Bare soil				47.9	33.4
Ceratophyllum demersum	Coontail	2.3	7.6	6.7	2.9
Chara vulgaris	Common stonewort	0.8	0.0	0.2	12.3
Elodea canadensis	Common waterweed	0.0	0.0	0.0	0.0
Elodea nuttallii	Nuttals waterweed	0.7	0.0	0.0	0.0
Hippuris vulgaris	Common marestail	0.0	0.0	1.4	2.1
Lemna trisulca	Star duckweed	8.0	6.1	3.2	3.5
Myriophyllum sibiricum	Northern milfoil	44.5	42.8	33.3	19.6
Najas flexilis	Nodding waternymph	0.0	0.0	0.0	0.2
Najas sp.	Naiads	0.0	0.0	0.0	0.5
Potamogeton foliosus L.	Leafy pondweed	0.0	0.0	1.3	8.3
Potomogeton friesii	Flat-stalked pondweed	4.9	3.2	1.4	0.0
Potamogeton praelongus	Whitestem pondweed	2.1	0.8	0.4	0.4
***Potamogeton richardsonii* (Ar. Benn.) Rydb.**	Clasping-leaf pondweed	9.5	14.7	6.2	2.3
Potamogeton zosteriformis	Flat-stem pondweed	0.6	0.6	0.4	0.1
Ranunculus longirostris	Longbeak buttercup	6.2	0.0	0.1	0.0
***Sagittaria cuneata* Sheld.**	Arrowhead	0.0	0.0	0.1	0.2
Stuckenia filiformis	Slender-leaved pondweed	0.2	0.0	0.0	1.0
***Stuckenia pectinata* (L.) Börner**	Sago pondweed	1.0	1.2	1.6	2.7
Stuckenia vaginatus	Sheathing pondweed	0.3	0.3	0.3	1.1

[a]Data are from 5 by 5 m quadrat surveys

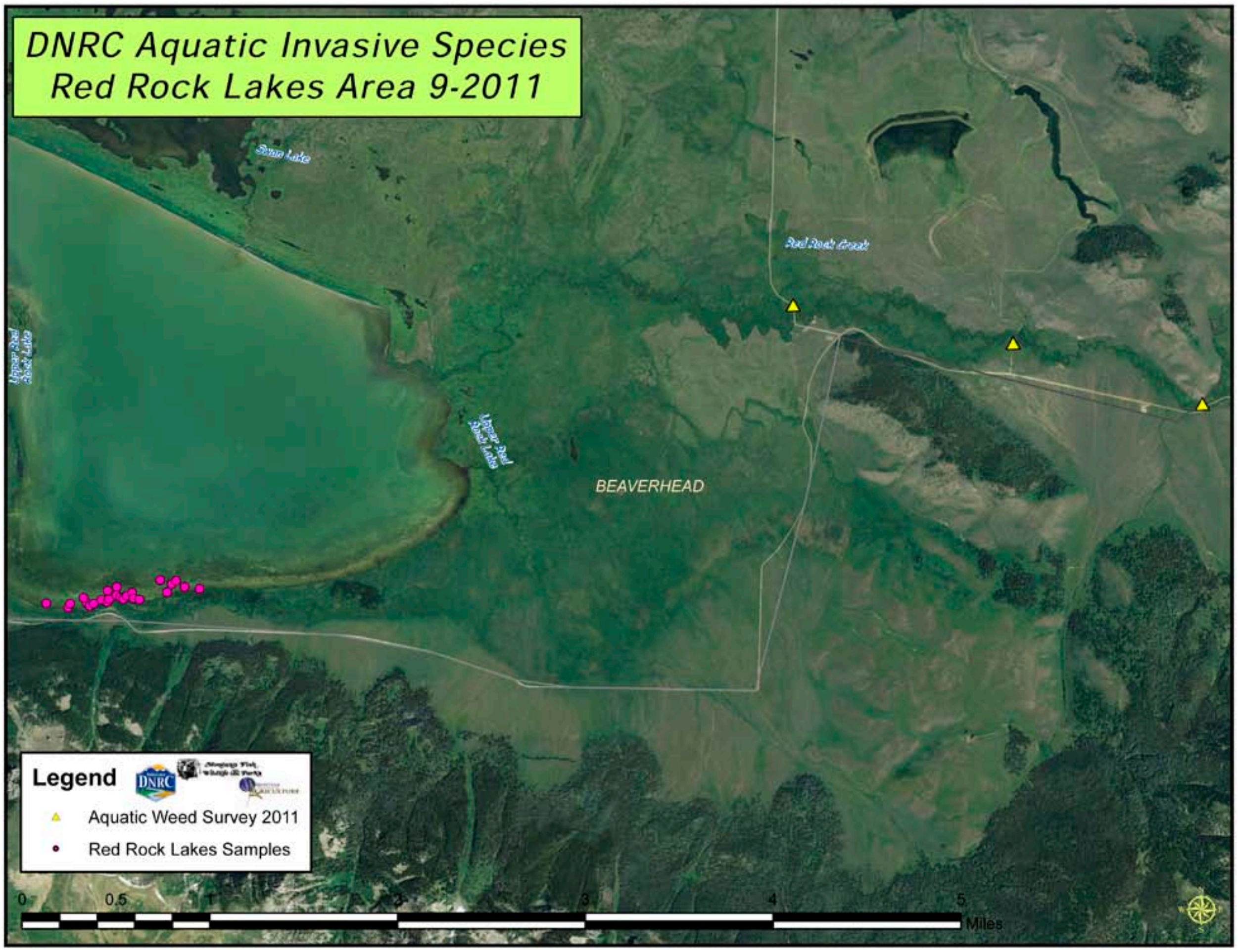

Figure 1.53. Points sampled in the Red Rock Lake area during surveys conducted in September 2011.

Conclusions from Reservoir Surveys: The lakes and reservoirs surveyed, with the exception of Wade Lake, Willow Creek Reservoir, and Clark Canyon Reservoir, had a relatively species rich aquatic plant community. Ruby River Reservoir and Cataract Lake did not appear to have aquatic plants, though a quantitative survey was not possible. Toston Reservoir was the only water body where *Myriophyllum spicatum* was found, though *Potamogeton crispus* was found in Hebgen Reservoir, Ennis Reservoir, and Toston Reservoir and should be of equal concern. Utilizing the point intercept survey method to survey the littoral zone of each reservoir allowed for a more direct, quantitative approach in areas more likely to support aquatic plant growth. Furthermore, the probability of observing a non-native aquatic plant in these reservoirs was > 80% based on the number of points that were surveyed in the littoral zone for a given water body.

Given the remoteness of the majority of these water bodies and the lack of access points, the probability of invasion by *Myriophyllum spicatum* is low. The primary means of spreading *Myriophyllum spicatum* between water bodies is by motorized watercraft. Therefore, priority should be given to lakes and reservoirs that have improved access for motorized watercraft and are important recreation areas. Of the current reservoirs surveyed, priority should be given to Hebgen Reservoir, Ennis Reservoir, and Toston Reservoir; as these reservoirs already have non-native aquatic plant species present, and use patterns and/or suitable habitat increases invasion potential. Continued surveys and monitoring should be conducted on these three reservoirs.

Management techniques should be identified and implemented in these reservoirs to control both *Myriophyllum spicatum* and *Potamogeton crispus* while populations are small. In considering 76propriate management techniques, it is recommended that only methods that have been shown to be effective via peer-reviewed literature and under similar use patterns should be evaluated. If data do not exist it may be necessary to conduct the necessary research to develop use patterns for a specific management technique in a given water body. It is much more cost efficient to manage a non-native species when the population is small.

2. River Materials and Methods

Surveys of select sections (sections most apt to support the growth aquatic plants) of the Madison River, Ruby River, Red Rock River, and West Gallatin River were conducted using kayaks (Figure 2.1). These river sections included approximately 11 miles on the Madison River from Varney Bridge Fishing Access Point (FAS) to Ennis Reservoir, approximately 12 miles on the Ruby River from Sweet Water Bridge to the Ruby Dam, approximately 11 miles on Red Rock River from Bridge 47 to Bridge 36, and approximately 12 miles on the Gallatin River from Gallatin Forks FAS to Headwaters State Park.

All river sections were surveyed with a three crew member team. Two kayaks (one on each side of the river) were used to increase the probability of observing a non-native species if in fact one was present. The other crew member drove to the access points along the entire stretch of river and surveyed the fishing access points 300-500 ft. above and below each access point.

Points were logged using a GPS device directly in plant beds or in areas that would be suitable for plant colonization and growth. The number of points to be surveyed in each river varied because of variability in river channels and location of aquatic plants. Every attempt was made to record the presence of large plant beds, areas where new species were observed, and areas that would support plant growth.

Due to the subjective manner in surveying river sections and FAS, no statistics could be computed and therefore a species list was generated and reported for each river section and for all FAS. Visual representations of the distributions of important plant species are display in a series of maps for each river survey (Figures 2.2 to 2.10).

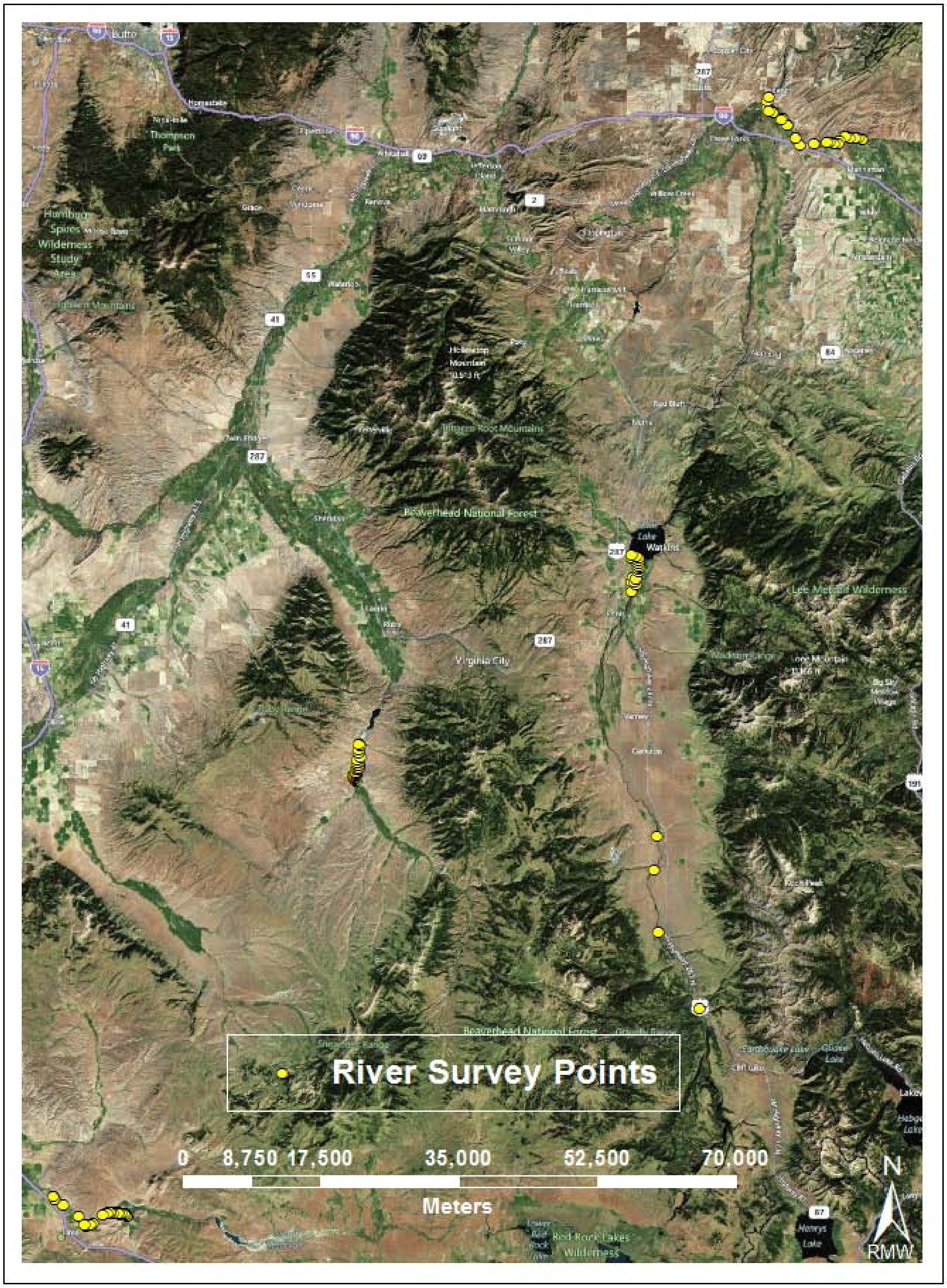

Figure 2.1. Survey locations on four rivers in the Missouri headwaters area of Montana, September 2011.

2. River Results and Discussion

River: Madison River

Date Surveyed: September 12, 2011

Eurasian watermilfoil = Negative

Whole River Survey: Varney Bridge FAS to Ennis Reservoir

Plant species observed while surveying the river section included *Schoenoplectus acutus* (hardstem bulrush), *Elodea canadensis*, *Stuckenia pectinata*, *Ranunculus aquatilis*, *Potamogeton foliosus, Myriophyllum sibiricum, Potamogeton richardsonii, Typha latifolia*, *Phalaris arundinacea* (reed canary grass), *Sagittaria cuneata*, and *Sparganium* sp. The locations of the dominant species and species of concern are depicted in Figures 2.2 and 2.3.

One *Potamogeton crispus* turion was found floating in the river just before the river emptied into Ennis Reservoir (Figure 2.2). This section of river slows considerably as it enters into Ennis Reservoir, which creates suitable habitat for plant establishment and growth. As with Ennis Reservoir, much of this river section could be colonized by a submersed aquatic plant such as *Myriophyllum spicatum* or *Potamogeton crispus*. Furthermore, given the braided nature of the Madison River as it enters Ennis Reservoir, it will be difficult to routinely survey this area and detect a potential non-native species.

Access Points: A total of 251 minutes were spent surveying access points alone.

Valley Garden: *Stuckenia pectinata*, *Ranunculus aquatilis*, *Myriophyllum sibiricum*, *Chara* sp., and *Elodea canadensis*

Ennis: No aquatic plants observed, water flow was rapid at this site.

Burnt Tree Hole: *Stuckenia pectinata, Ranunculus aquatilis, and Chara* sp.

Eight Mile Ford: *Stuckenia pectinata*, *Ranunculus aquatilis*, and *Elodea canadensis*

Varney Bridge: *Stuckenia pectinata* and *Ranunculus aquatilis*

Storey Ditch: *Stuckenia pectinata* and *Ranunculus aquatilis*

McAtee: *Stuckenia pectinata* and *Ranunculus aquatilis*

Ruby Creek: *Stuckenia pectinata*

Palisades: *Stuckenia pectinata* and *Ranunculus aquatilis*

Lyons Bridge: *Stuckenia pectinata* and *Ranunculus aquatilis*

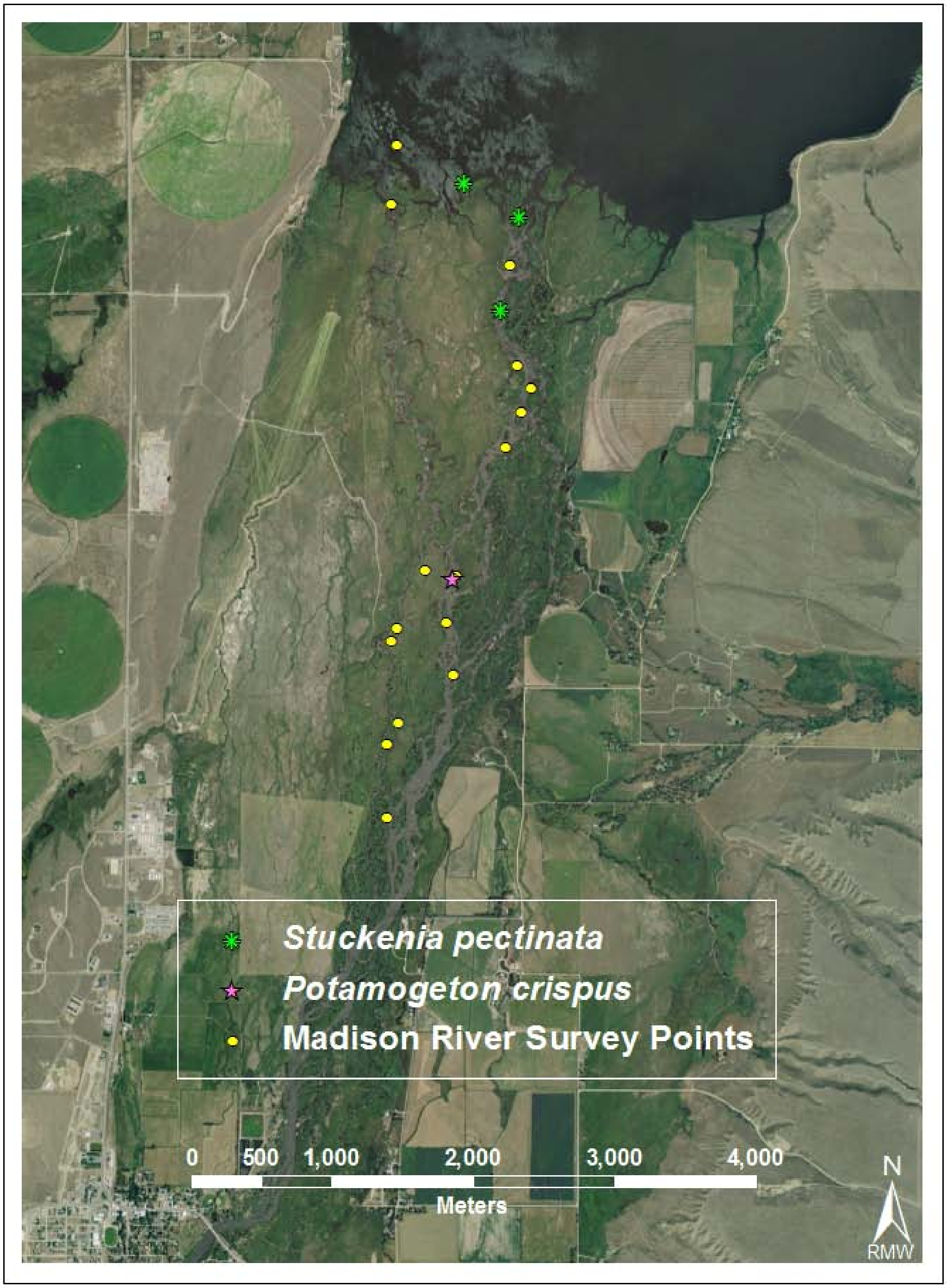

Figure 2.2. Locations of pondweeds in the section of the Madison River as it enters Ennis Reservoir, September 2011.

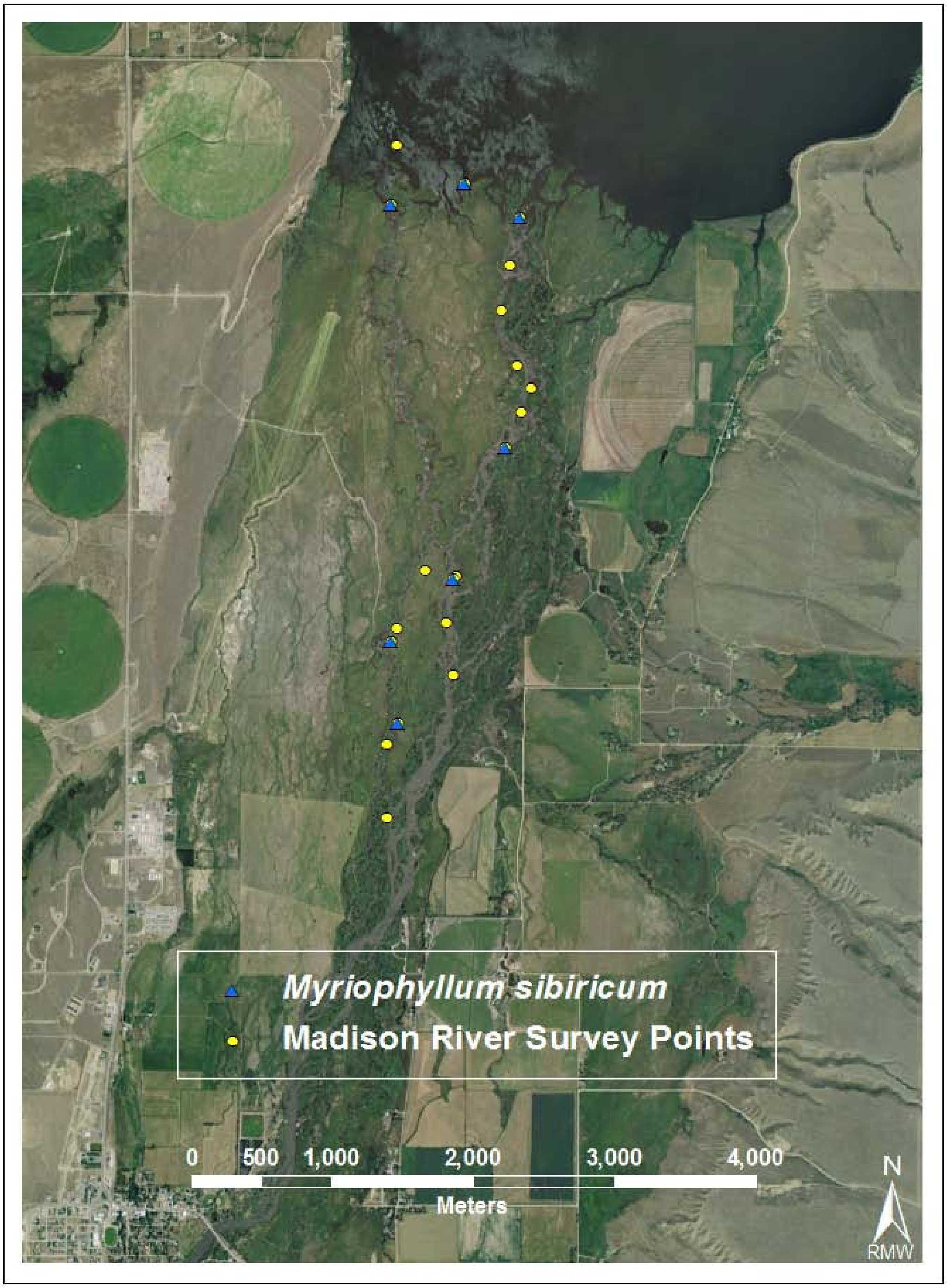

Figure 2.3. Locations of *Myriophyllum sibiricum* in the section of the Madison River as it enters Ennis Reservoir, September 2011.

River: Ruby River

Date Surveyed: September 13, 2011

Eurasian watermilfoil = Negative

Whole River Survey: Sweetwater Creek Bridge to Ruby Dam

Aquatic invasive species were not found in the Ruby River during this survey. The only submersed plant species observed was *Stuckenia pectinata*, which was observed along most of the river (Figure 2.4). *Myriophyllum sibiricum* was observed at one location during the survey (Figure 2.5).

Shoreline emergent species included *Equisetum* sp., *Phalaris arundinacea* (reed canary grass), and *Eleocharis* sp.. *Polygonum amphibium* was common along the shoreline of the river. The water in the Ruby Reservoir was down approximately 30 to 50 ft. judging by the high water line and willows along the shoreline. There were no aquatic plants observed in Ruby Reservoir as the crew kayaked to the take out point. However, it would not be inconceivable that *Stuckenia pectinata* could be present when normal water levels return given the many locations in the river where it was found.

Access Points: A total 125 minutes were spent surveying access points alone.

Cow Camp: *Stuckenia pectinata* and *Equisetum* sp.

Cottonwood Creek: *Equisetum* sp.

Vigilante Station: *Equisetum* sp.

Bridge 80: *Stuckenia pectinata*, *Typha latifolia*, and *Equisetum* sp.

Ledford Creek: *Stuckenia pectinata*, *Eleocharis* sp., and *Equisetum* sp.

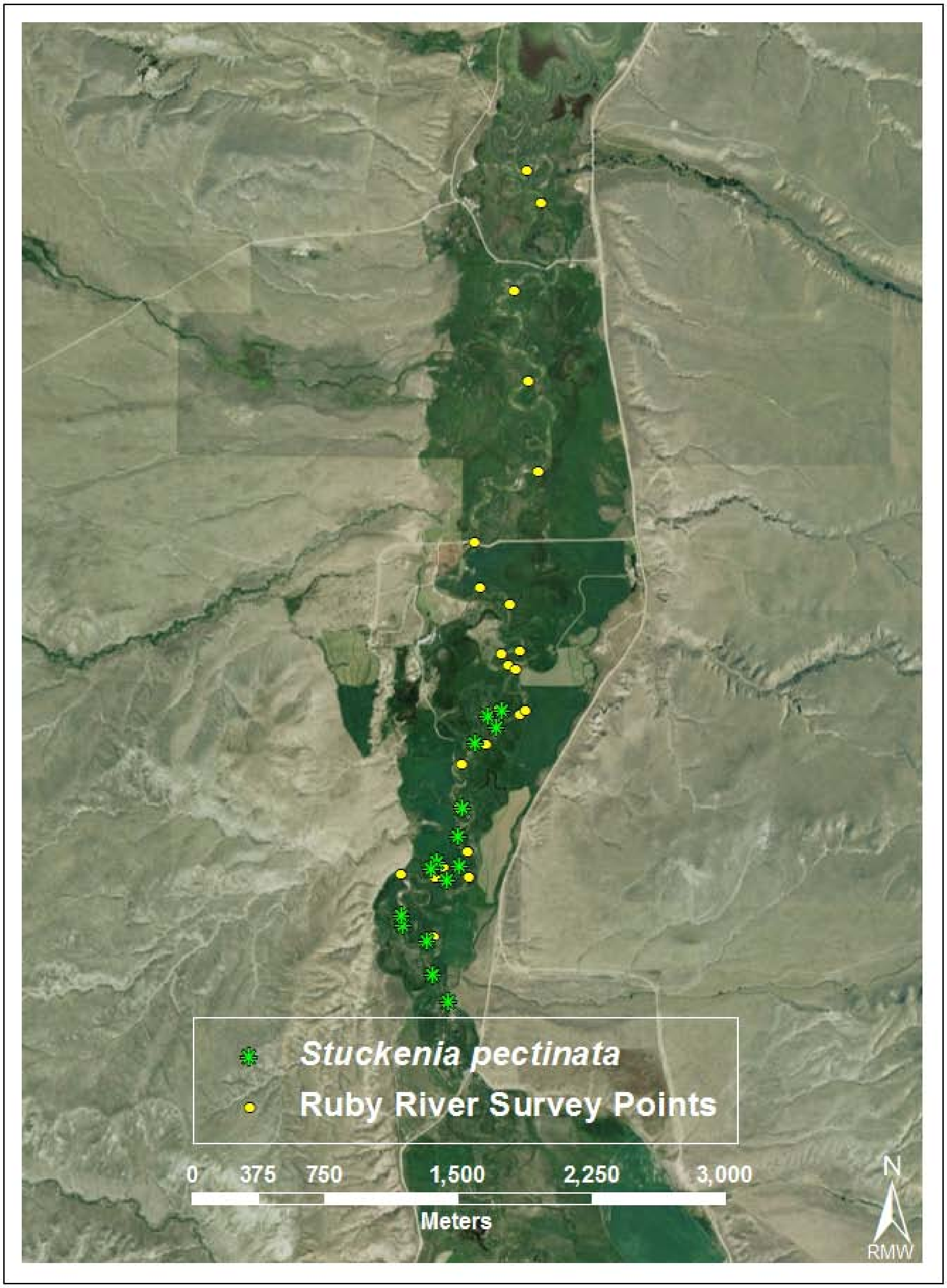

Figure 2.4. Locations of *Stuckenia pectinata* in the section of the Ruby River that was surveyed in September 2011.

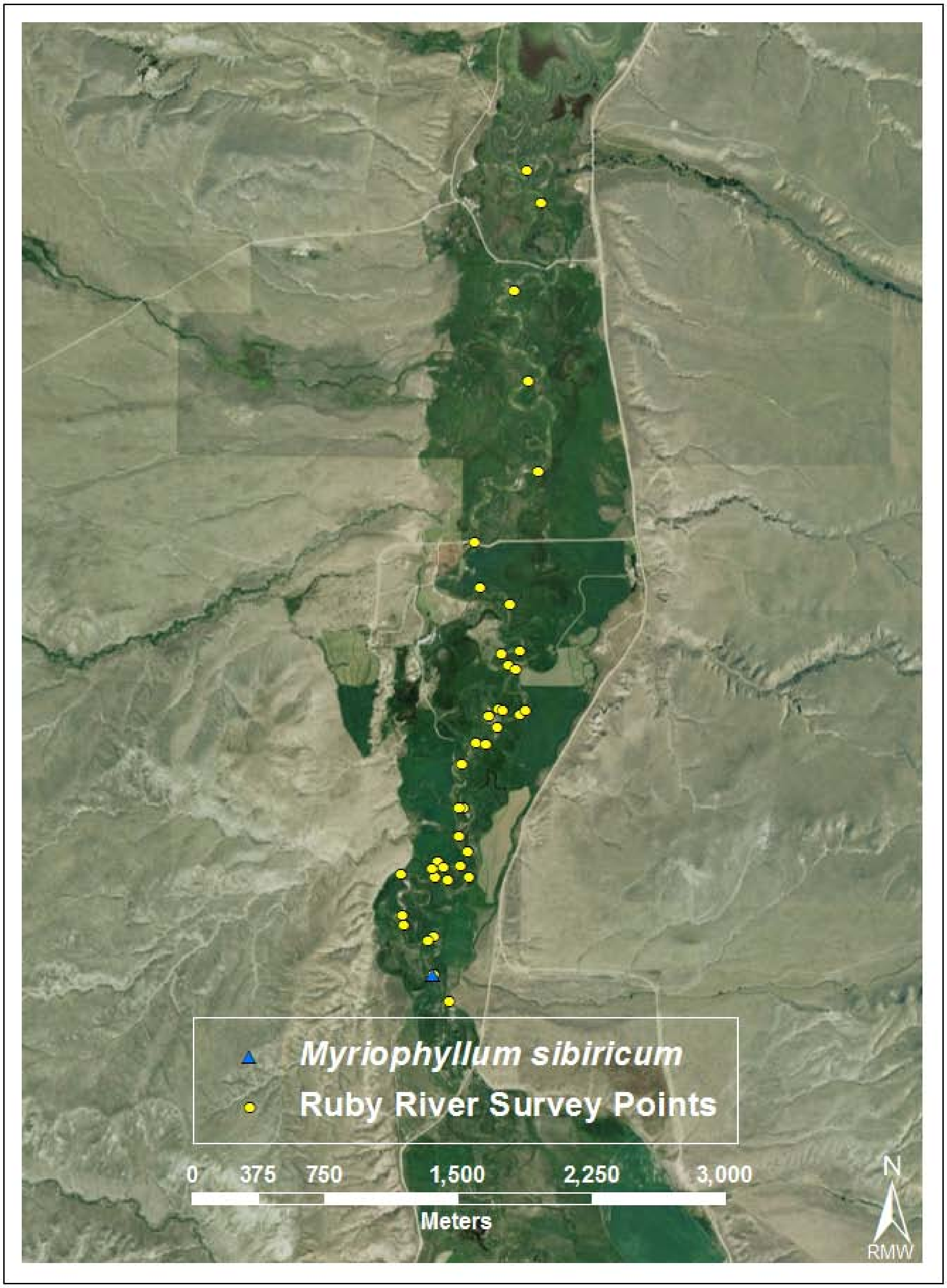

Figure 2.5. Locations of *Myriophyllum sibiricum* in the section of the Ruby River that was surveyed in September 2011.

River: Red Rock River

Date Surveyed: September 14, 2011

Eurasian watermilfoil = Negative

Whole River Survey: Bridge 47 to Bridge 36

Aquatic invasive species were not found in the Red Rock River. Plant species observed included *Stuckenia pectinata*, *Myriophyllum pinnatum*, *Myriophyllum sibiricum*, *Ranunculus aquatilis*, *Chara* sp., and *Elodea canadensis*. *Stuckenia pectinata* and *M. pinnatum* were the most common species and occurred in large beds throughout the upper portion of the river. The locations of *Stuckenia pectinata*, *Myriophyllum pinnatum*, and *Myriophyllum sibiricum* locations are depicted in Figures 2.6-2.8. The downstream portion of the river section had high water flows and few plant species, with the exception of *S. pectinata* which was observed at some of the access points. *Polygonum amphibium* was also common along the shoreline.

The two milfoil species identified during this survey were distinctly different in appearance. *Myriophyllum sibiricum* was larger and had different leaf morphology than the species identified as *Myriophyllum pinnatum*. The plant identified as *Myriophyllum pinnatum* had originally been identified as *Myriophyllum hippuroides* (western watermilfoil). After consulting with other experts and looking at pressed specimens and photos, the plant characteristics more closely match those of *M. pinnatum*. The current problem is that there are no previous reports of native milfoil species in Montana (as indicated by the find of *M. quitense* in Toston Reservoir by MSU researchers). The USDA Plants Database is also lacking in milfoil data for Montana so it is often unclear as to the distribution of a given species in the state. Additionally, as stated earlier, when identifying most milfoil species, taxonomic keys require plants to be in flower or have the emergent bracts present above the water. Therefore, it is recommended to verify the identification of these species genetically by a recognized laboratory.

The Nature Conservancy used the Montana stream monitoring protocol for aquatic plant survey at three fishing access points on Red Rock Creek above Upper Red Rock Lake (Figure 1.52). Aquatic vegetation was limited to white water-buttercup (*Ranunculus aquatilis L.*). No invasive non-native aquatic plants were observed at these access points.

Access Points: A total 90 minutes were spent surveying access points alone.

Lima Dam: No aquatic plants observed. High water release was observed from the dam.

Kidd Bridge: *Stuckenia pectinata*

Wolfe Bridge: *Stuckenia pectinata*

Bimat Bridge: No aquatic plants observed, water flow was rapid at this site.

Sage Creek: *Stuckenia pectinata*

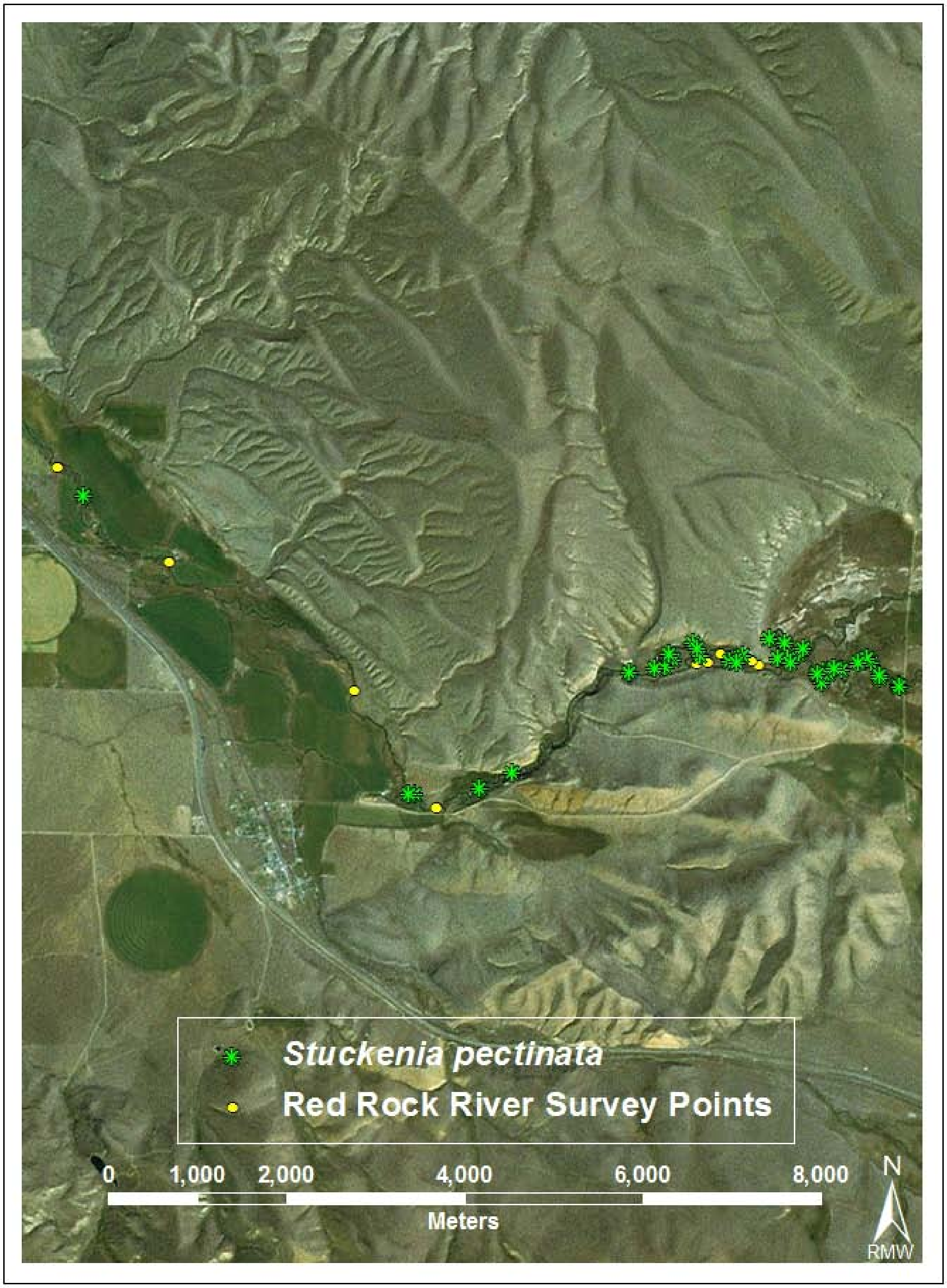

Figure 2.6. Locations of *Stuckenia pectinata* in the section of the Red Rock River that was surveyed in September 2011.

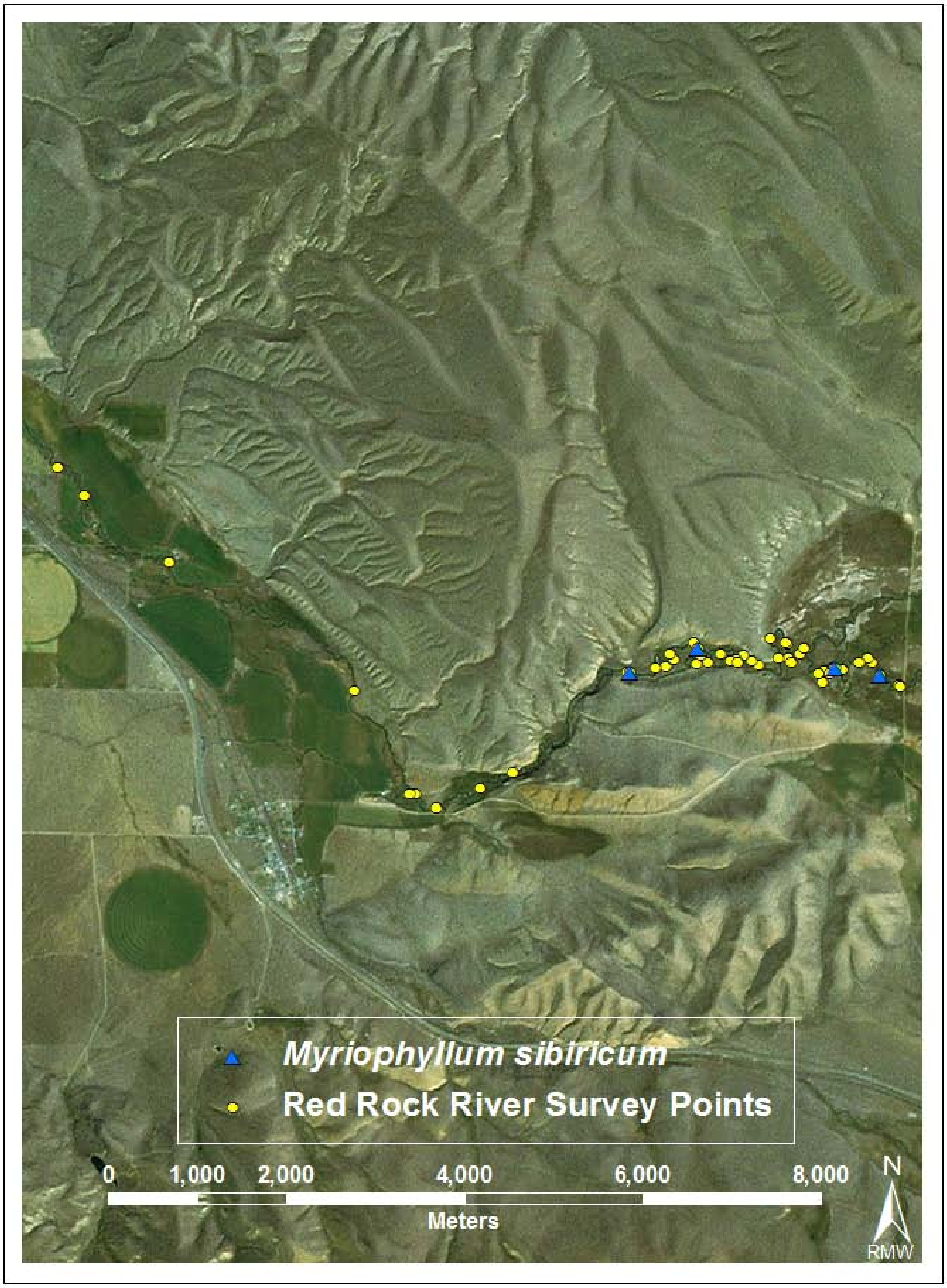

Figure 2.7. Locations of *Myriophyllum sibiricum* in the section of the Red Rock River that was surveyed in September 2011.

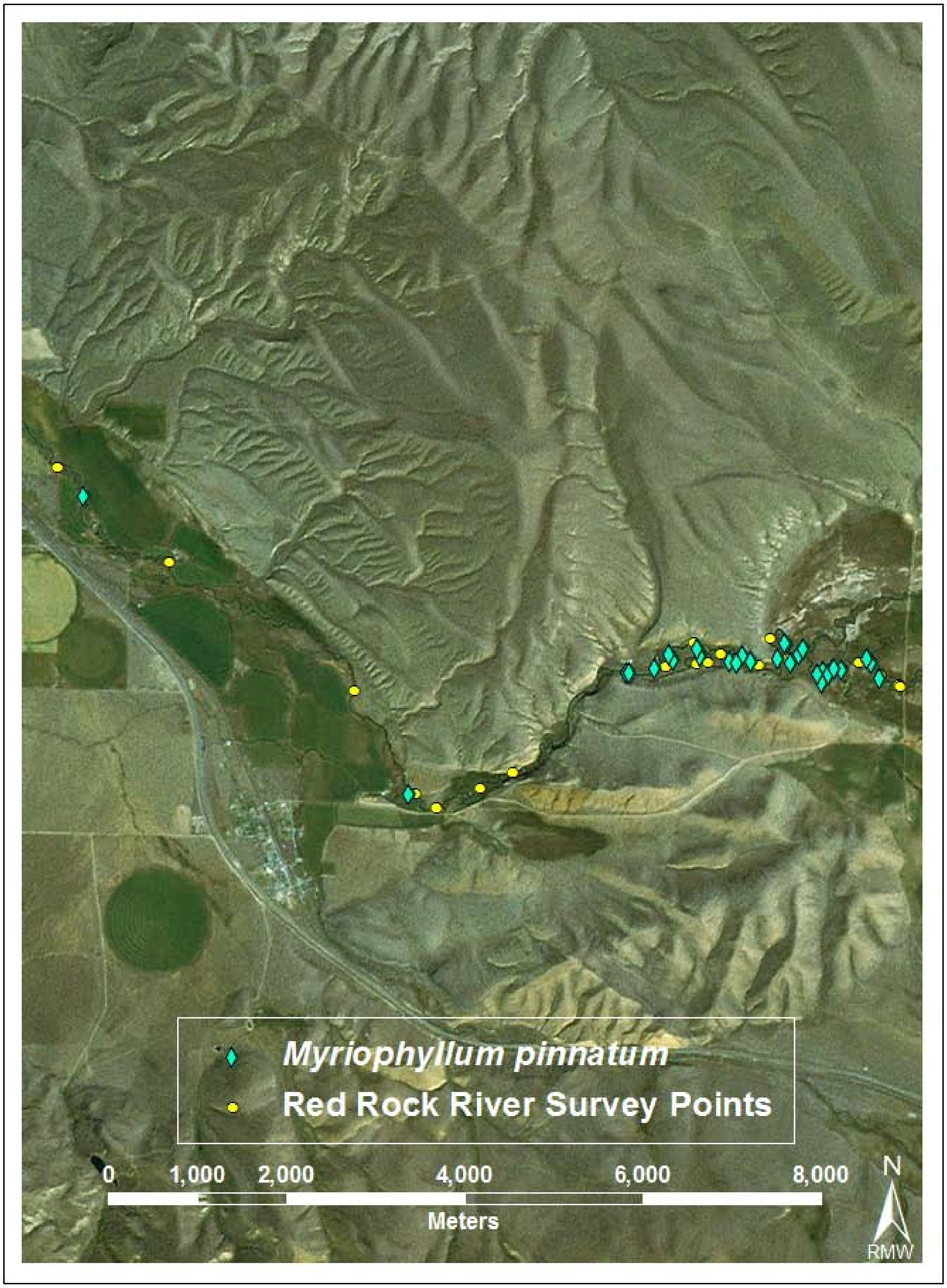

Figure 2.8. Locations of *Myriophyllum pinnatum* in the section of the Red Rock River that was surveyed in September 2011.

River: Gallatin River

Date Surveyed: September 15, 2011

Eurasian watermilfoil = Negative

Whole River Survey: Gallatin Forks FAS to Headwaters State Park

Potamogeton crispus was observed in several areas during this survey (Figure 2.9), and other than *Stuckenia pectinata* (Figure 2.10), it occurred most often. Other species included *Equisetum* sp., *Lemna minor*, *Potamogeton foliosus*, *Elodea canadensis*, and *Chara* sp., *Polygonum amphibium* was common along the shoreline.

Access Points: A total 135 minutes were spent surveying access points alone.

Sheds Bridge: No aquatic plants observed.

Cameron Bridge: No aquatic plants observed.

Erwin Bridge: No aquatic plants observed.

4 Corners: *Elodea canadensis*, *Ranunculus aquatilis*, *Lemna minor*, and *Polygonum amphibium*. Plants were observed growing in small pools left by the river receding. There were not plants observed growing in the main river channel.

Gallatin Forks: *Polygonum amphibium*

Centennial Park: No aquatic plants observed in main channel or the small pools off from the main channel.

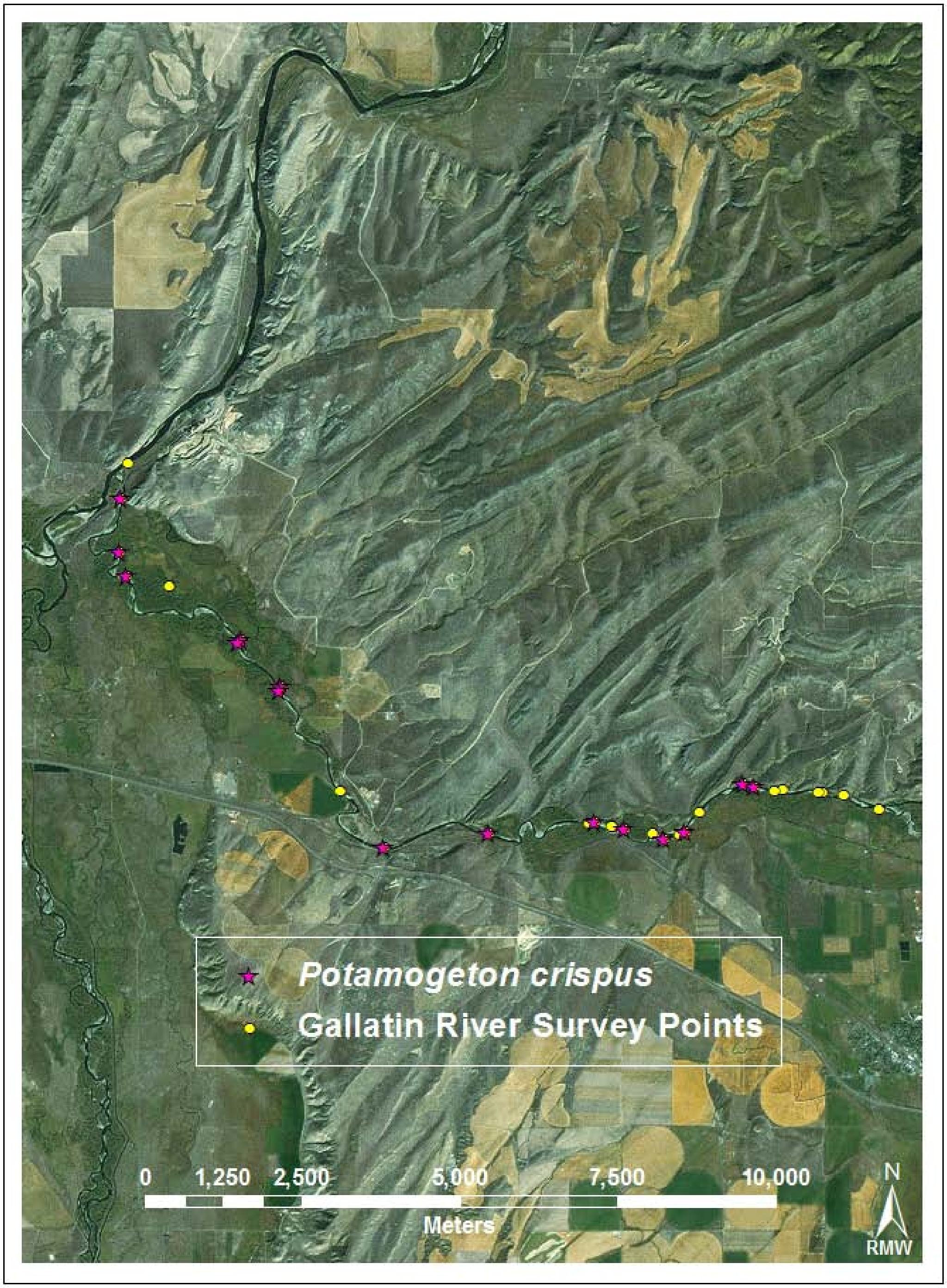

Figure 2.9. Locations of *Potamogeton crispus* in the section of the Gallatin River that was surveyed in September 2011.

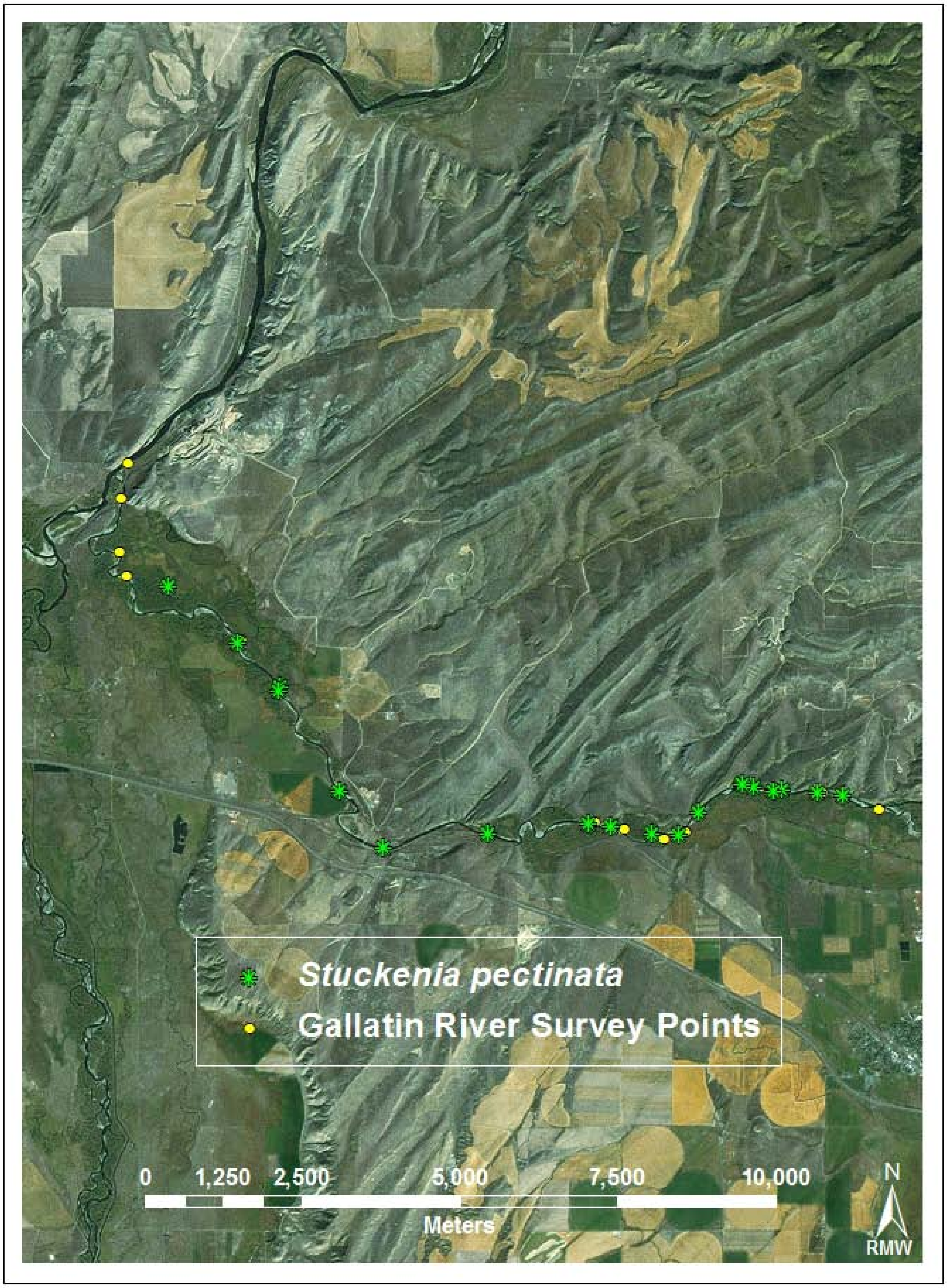

Figure 2.10. Locations of *Stuckenia pectinata* in the section of the Gallatin River that was surveyed in September 2011.

Conclusions from River Surveys: *Potamogeton crispus* was the only non-native aquatic plant observed during the surveys of the rivers and FAS points. A turion was found in the Madison River as it entered into Ennis Reservoir, which was not too surprising as *Potamogeton crispus* was found both upstream in Hebgen Reservoir and downstream in Ennis Reservoir. Management efforts should be initiated to slow or eliminate the spread of this species to other portions of the Madison River or to other water bodies in the area. *Potamogeton crispus* was also found in several areas in the Gallatin River, which was not surprising as the East Gallatin River also has *P. crispus* present.

Of the rivers surveyed, the Gallatin River and the lower Madison would have been the most likely place to find *Myriophllum spicatum* due to its closer proximity to the Jefferson River, which has several areas infested with this species, and the increased level of recreation on the Madison River. The other rivers are much further away from a source population and do not have *Myriophyllum spicatum* in upstream reservoirs. The probability of *Myriophyllum spicatum* being in the rivers surveyed, other than the Gallatin River, is low.

3. Conclusions and Recommendations

- Develop a statewide survey protocol, similar to Idaho, to direct state agency personnel, contractors, or volunteers on a standardized survey method that is easily repeatable and quantifiable.

- Continued monitoring will assist in determining the spread of Eurasian watermilfoil, likely habitats for its infestation, and locations for active management.

- It is recommended that all aquatic plant management personnel, including divers, dive supervisors, herbicide applicators, and site scouts be required to undergo periodic aquatic plant identification training, specifically to differentiate between Eurasian watermilfoil and northern watermilfoil. As part of this training, it must be reinforced that no one can differentiate between northern watermilfoil and Eurasian watermilfoil from a boat unless the plants are topped out; proper identification requires a sample in the hand for analysis.

- An agreement should be established with a nationally recognized laboratory to verify milfoil identifications. This is important given the number of people that have been involved with surveys in Montana waters. The lab should have expertise in genetic assays of milfoil species and the ability to offer rapid identification.

- The US Fish and Wildlife Service should establish permanent monitoring points in Upper Red Rock Lake concentrated along the southern littoral zone both east and west of the recreationist/watercraft access point. Monitoring for aquatic invasive species should be conducted at these points on a yearly schedule. Signage on the importance of "inspect, clean, and dry" and information on aquatic invasive species should be placed in the kiosk at Upper Red Rock Lake campground.

- Appropriate research and demonstration projects should be identified that will improve the management of Eurasian watermilfoil in flowing water systems and other waters of Montana. Suitable funding internal or external to the program can then be sought for research support. Other state programs have found that appropriate applied research is critical to management.

- Assessment is critical in identifying which management techniques are effective in controlling Eurasian watermilfoil, and which techniques are not effective. This determination should be done objectively, quantitatively, and using statistical analysis.

- A regular assessment program will, over time, assist in selecting herbicides or other management techniques that are both effective in controlling aquatic plants, and cost-effective.

- We recommend that the State of Montana develop a decision matrix or decision tree that gives guidance on control techniques that are appropriate for a given set of site characteristics, size of plant infestation, and use restrictions. An example is shown in Table 3.1. While this may not be required in all situations, it will assist in developing management plans.

Table 3.1. Example of a decision matrix for management of Eurasian watermilfoil. Be advised that this is an example only, to demonstrate the concept (Madsen and Wersal 2008). A working decision matrix or decision tree should be developed by Montana agencies in cooperation with external expertise.

Site water exchange characteristics	**Target plant (Eurasian watermilfoil) colony characteristic**				
	Scattered individual plants	**Small dense beds less than 2 acres**	**Dense beds from 2-5 acres**	**Dense beds from 5 to 25 acres**	**Dense beds over 25 acres**
Very Short exposure time (<12 h)	Hand pulling Diver dredge	Diver dredge Benthic barrier Diquat Endothall	Diquat Endothall	Diquat Endothall	Drawdown 2,4-D Triclopyr
Short exposure time (12 – 24 h)	Hand pulling Diver dredge	Diver dredge Benthic barrier Diquat Endothall 2,4-D Triclopyr	Diquat Endothall 2,4-D Triclopyr	2,4-D Triclopyr	Drawdown 2,4-D Triclopyr
Moderate exposure time (24-72 h)	Hand pulling Diver dredge	Diver dredge Benthic barrier Diquat Endothall 2,4-D Triclopyr	Diquat Endothall 2,4-D Triclopyr	Diquat Endothall 2,4-D Triclopyr	Drawdown Diquat Endothall 2,4-D Triclopyr
Long exposure time (> 72 h)	Hand pulling Diver dredge 2,4-D Triclopyr	Diver dredge Benthic barrier Diquat Endothall 2,4-D Triclopyr	Diquat Endothall 2,4-D Triclopyr	Diquat Endothall 2,4-D Triclopyr	Drawdown Diquat Endothall 2,4-D Triclopyr Fluridone

Literature Cited

Barbour, M.G., J.H. Burk, W.D. Pitts, F.S. Gilliam, and M.W. Schwartz. 1999. Terrestrial Plant Ecology. Addison Wesley Longman, Inc. Menlo Park, CA. 649p.

Bolduan, B.R., G.C. Van Eeckhout, H.W. Quade, and J.E. Gannon. 1994. *Potamogeton crispus* – the other invader. Lake and Reservoir Management 10:113-125.

Catling, P.M. and I. Dobson. 1985. The biology of Canadian weeds. 69. *Potamogeton crispus* L. Canadian Journal of Plant Science 65:655-668.

Carpenter, S.R. and D.M. Lodge. 1986. Effects of submersed macrophytes on ecosystem processes. Aquatic Botany 26:341-370.

James, W.F., J.W. Barko, H.L. Eakin, P.W. Sorge. 2002. Phosphorus budget and management strategies for an urban Wisconsin lake. Lake and Reservoir Management 18:149-163.

Keast, A. 1984. The introduced macrophyte, *Myriophyllum spicatum*, as a habitat for fish and their invertebrate prey. Canadian Journal of Zoology 62:1289-1303.

Krull, J.N. 1970. Aquatic plant-invertebrate associations and waterfowl. Journal of Wildlife Management 34:707-718.

Lillie, R.A., and J. Budd. 1992. Habitat architecture of *Myriophyllum spicatum* as an index to habitat quality for fish and macroinvertebrates. Journal of Freshwater Ecology 7:113-125.

Madsen, J.D. 1997. Ch. 12. Methods for management of nonindigenous aquatic plants. pp. 145-171. In: J.O. Luken and J.W. Thieret, (eds.). Assessment and Management of Plant Invasions Springer, New York. 324pp.

Madsen, J.D. 1999. Point and line intercept methods for aquatic plant management. APCRP Technical Notes Collection (TN APCRP-M1-02), U.S. Army Engineer Research and Development Center, Vicksburg, MS. 16 pp.

Madsen, J.D., C.F. Hartleb and C.W. Boylen. 1991a. Photosynthetic characteristics of *Myriophyllum spicatum* and six submersed macrophyte species native to Lake George, New York. Freshwater Biology 26:233-240.

Madsen, J.D., J.W. Sutherland, J.A. Bloomfield, L.W. Eichler, and C.W. Boylen. 1991b. The decline of native vegetation under dense Eurasian watermilfoil canopies. Journal of Aquatic Plant Management 29:94-99.

Madsen, J.D., P.A. Chambers, W.F. James, E.W. Koch, and D.F. Westlake. 2001. The interactions between water movement, sediment dynamics and submersed macrophytes. Hydrobiologia 444:71-84.

Madsen, J. D. and R. M. Wersal. 2008. Assessment of Eurasian watermilfoil (*Myriophyllum spicatum* L.) populations in Lake Pend Oreille, Idaho for 2007. GeoResources Institute Report 5028, 116p.

Madsen, J.D., R.M. Stewart, K.D. Getsinger, R.L. Johnson and R.M. Wersal. 2008. Aquatic plant communities in Waneta Lake and Lamoka Lake, New York. Northeastern Naturalist 15:97-110.

Madsen, J. D. and R. M. Wersal. 2009. Aquatic plant community and Eurasian watermilfoil (*Myriophyllum spicatum* L.) management assessment in Lake Pend Oreille, Idaho for 2008. Geosystems Research Institute Report 5032, 65p.

Pimentel, D., L. Lack, R. Zuniga and D. Morrison. 2000. Environmental and economic costs of nonindigenous species in the United States. BioScience 50:53-65.

Ozimek, T., R.D. Gulati, and E. van Donk. 1990. Can macrophytes be useful in biomanipulation of lakes? The Lake Zwemlust example. Hydrobiologia 200/201:399-407.

Rockwell, W.H. 2003. Summary of a survey of the literature on the economic impact of aquatic weeds. Report to the Aquatic Ecosystem Restoration Foundation. http://www.aquatics.org/pubs/economic_impact.pdf. 18 pp.

Wersal, R.M., J.D. Madsen and J.C. Cheshier. 2009. Eurasian watermilfoil monitoring and mapping in Noxon Rapids Reservoir for 2009. Geosystems Research Institute Report 5041, 11p.

Wersal, R.M., J.D. Madsen, and J. Cheshier. 2010. Aquatic plant monitoring in Noxon Rapids Reservoir and Cabinet Gorge Reservoir for 2010. Geosystems Research Institute Report 5042, 18p.

Wetzel, R.G. 2001. Limnology: Lake and River Ecosystems, Third Edition. Academic Press, San Diego, CA, USA. 1006 pp.

Woolf, T.E. and J.D. Madsen. 2003. Seasonal biomass and carbohydrate allocation patterns in southern Minnesota curlyleaf pondweed populations. Journal of Aquatic Plant Management 41:113-118.