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Comparison of Three Biomass Sampling Techniques on Submersed Aquatic Plants in a Northern Tier Lake

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PURPOSE: Quantifying biomass to measure aquatic plant abundance can be costly and labor intensive. This technical note compares several alternate, less exhaustive techniques for biomass sampling in the field.

INTRODUCTION: Quantifying biomass in the field is necessary for monitoring the effectiveness of nuisance aquatic plant management strategies. However, measuring relative plant abundance can be costly and labor intensive, typically involving a boat with dredging capabilities or divers using quadrats. Because resources required to assess plant communities are usually limited, simpler but effective and scientifically acceptable sampling techniques should help ensure that valid plant monitoring is included in management plans. To that end, this technical note compares several alternate, less exhaustive techniques (rake, PVC-core sampler) for biomass sampling to the standard boat operated box-core sampler. These techniques include a common garden rake, which can be easily handled from a boat, can be purchased locally, and allows for collected data to be compared year to year. Madsen et al. (2007) found that the PVC core sampler had a positive relationship with divers using quadrats, especially for sampling underground biomass.

Although it supports a diverse native plant community, Shawano Lake, WI has a history of invasive aquatic plant problems, specifically curlyleaf pondweed (*Potamogeton crispus* L.) and Eurasian watermilfoil (*Myriophyllum spicatum* L.). Located in east-central Wisconsin, this 2,454-ha lake has been infested with Eurasian watermilfoil since 1991 (*www.dnr.state.wi*) and, more recently, curlyleaf pondweed. Both exotic plants are problematic in the northern tier states, and large infestations can alter water quality, recreational activities, fisheries habitat, native plant populations, and waterfowl usage (Madsen et al. 1991; Aiken et al. 1979).

METHODS: During the week of June 1 through 6, 2006, plant aboveground biomass and curlyleaf pondweed turions were collected from Shawano Lake, WI. Three biomass sampling methods (box-

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core sampler, rake, and PVC-core sampler) were compared at 50 randomly selected sites chosen from the 2005 point-intercept survey (Owens et al. 2007) (Figure 1).

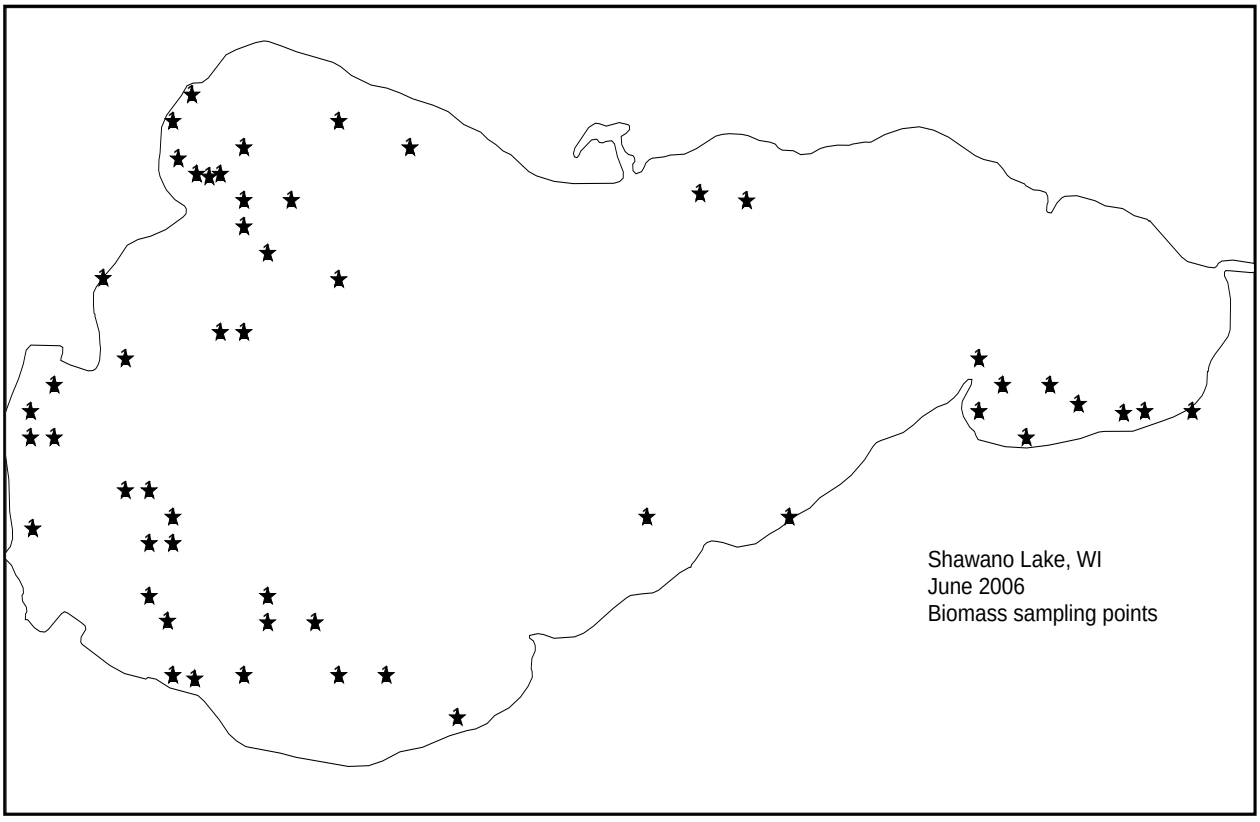

Figure 1. Sites for biomass collection sampled in June 2006.

Box-core sampler: The box-core sampler (Figure 2) was designed to sample 0.1 m^2 and has been employed to quantify plant abundance in previous studies (Madsen et al. 2004; Stewart et al. 2005). The box-core sampler was raised above the boat deck to a height of 165 cm using a battery-powered winch and dropped into the lake, where the sampler snapped closed upon contact with the bottom, cutting through plants to retrieve the biomass sample. The sampler was raised back to the boat and emptied into a sieve for washing and collecting plant biomass and turions.

Rake: The rake method has been previously employed to quantify plant biomass (Skogerboe et al. 2004; Skogerboe and Getsinger 2006). In this study, the rake (33 cm length (0.086 m^2)) was lowered from the side of the boat through the water column until hitting the bottom. The rake was rotated one complete 360° turn to harvest plant materials and then slowly brought to the surface, where aboveground biomass and turions were collected and bagged.

Figure 2. 0.1-m^2 box-core sampler deployed by person in boat.

PVC-core sampler: The PVC-core sampler (Figure 3) was deployed following methods described by Madsen et al. (2007). The sampler (0.018 m^2) was lowered from the side of the boat (front of boat, same location) through the water column until hitting bottom. The sampler was pushed into the sediment, triggered, and then slowly raised. Aboveground biomass and turions harvested were collected and bagged.

Plant material was shipped overnight to the Lewisville Aquatic Ecosystem Research Facility (LAERF), where it was sorted to species, dried, and weighed (g/DW). Biomass samples were adjusted to standard units of 1.0 m^2 for comparisons. Statistical differences between treatment dry weights were calculated using a Kruskal-Wallis test. Significant differences between means were determined using Mann-Whitney U at $p = 0.05$ level of significance. Statistics were performed using Statistica 7.1 (StatSoft, Inc., Tulsa, OK).

For all percentages calculated within this study, statistical differences were determined using a Chi-square Pearson index for 2 x 2 contingency table comparisons of the number of species for all sites (Statistix, Version 1, Tallahassee, FL).

Figure 3. PVC-core sampler being deployed.

RESULTS AND DISCUSSION: Owens et al. (2007) reported the presence of 31 species of aquatic and wetland plants in Shawano Lake in 2005. Of these, three were introduced exotic plants, including two submersed plant species: Eurasian watermilfoil and curlyleaf pondweed. Of the 28 native plant species identified, 19 were submersed, six were emergent, and three were floating-leaved.

Fourteen aquatic and wetland plant species were collected (2006) with the box-core sampler (the study's standard method), including the two introduced submersed plant species: Eurasian water-milfoil and curlyleaf pondweed. The rake method harvested 19 species, including Eurasian water-milfoil and curlyleaf pondweed. The PVC-core sampler harvested nine species, including curlyleaf pondweed but not Eurasian watermilfoil. No emergent plants were collected with any sampling method, probably due to depths sampled.

Significant differences were found for biomass distribution in 3 out of 14 species when comparing the box-core sampler and the rake method. These included forked duckweed (*Lemna trisulca* L, p=0.0609), Eurasian watermilfoil (p=0.0435), and wild celery (*Vallisneria americana* L., p=0.015). The remaining 11 species collected by the two methods did not exhibit significant differences. These

included coontail (*Ceratophyllum demersum* L.,p=0.1479), muskgrass (*Chara* spp.,p=0.6122), American elodea (*Elodea canadensis* Michx., p=0.9535), alternate milfoil (*Myriophyllum alterniflorum* DC, p=0.2934), northern milfoil (*M. sibiricum* Komarov, p= 0.8393), najas (*Najas* spp.,p=0.1068), broadleaf pondweed (*Potamogeton amplifolius* Tuck, p=0.8779), curlyleaf pondweed (p=0.1991), whitestem pondweed (*P. praelongus* Wulfen, p=0.7563), Robbin's pondweed (*P. robbinsii* Oakes, p=0.4460), and flatstem pondweed (*P. zosterformis* Fern., p= 0.2795) (Figure 4).

Figure 5 shows that overall the rake and box-core sampler found no differences in percentage for each species for all sites except for two species: alternate milfoil (p=0.0262) and wild celery (p=0.0045). The remaining 12 species collected by the two methods for each site did not exhibit differences. These included coontail (p=0.2949), muskgrass (p=0.2746), American elodea (p=0.7622), forked duckweed (p=0.6490), Eurasian milfoil (p=0.1462), northern milfoil (p= 0.6053), najas (p=0.4793), broadleaf pondweed (p=0.6053), curlyleaf pondweed (p=0.0732), whitestem pondweed (p=0.4403), Robbin's pondweed (p=0.7223), and flatstem pondweed (p= 0.8812) (Figure 2).

Significant differences were found for all species when comparing the box-core sampler and the PVC-core sampler. Only nine of the 14 species collected by the box-core sampler were likewise collected by the PVC-core sampler. These included coontail (p=0.000), chara (p=0.0219), American elodea (p=0.0061), forked duckweed (p=0.0000), najas (p=0.0000), curlyleaf pondweed (p= 0.059), Robbin's pondweed (0.0006), flatstem pondweed (0.0001), and wild celery (0.0125) (Figure 4).

Figure 5 shows significant percentage differences for plant species collected between the PVC sampler and box-core sampler for all sites. The nine species collected included coontail (p=0.0000), muskgrass (p=0.0006), American elodea (p=0.0000), forked duckweed (p=0.0000), najas (p=0.0000), curlyleaf pondweed (p=0.0021), Robbin's pondweed (p=0.0000), flatstem pondweed (p= 0.0000) and wild celery (p=0.0001) (Figure 5).

The box-core sampler (study standard) collected 14 plant species. The rake has a larger sampling area, collecting more species, thus suggesting the rake method, of the two alternative, low cost sampling techniques, appears to be a more valid collecting tool for quantifying biomass of aquatic plants. The relative ease of use and low requirements for expensive equipment and labor make the rake technique a viable alternative to the box-core sampler. Between the rake and box-core sampler, only three of the 14 plants collected between the two methods had significant differences in biomass. A possible reason for these differences could be attributed to plant growth form. Wild celery has a basal growth form, whereas Eurasian watermilfoil has fine leaves and slender stems that could slide easily through rake tines, and forked duckweed is a small (2-5 mm in length) floating plant not easily captured with a rake.

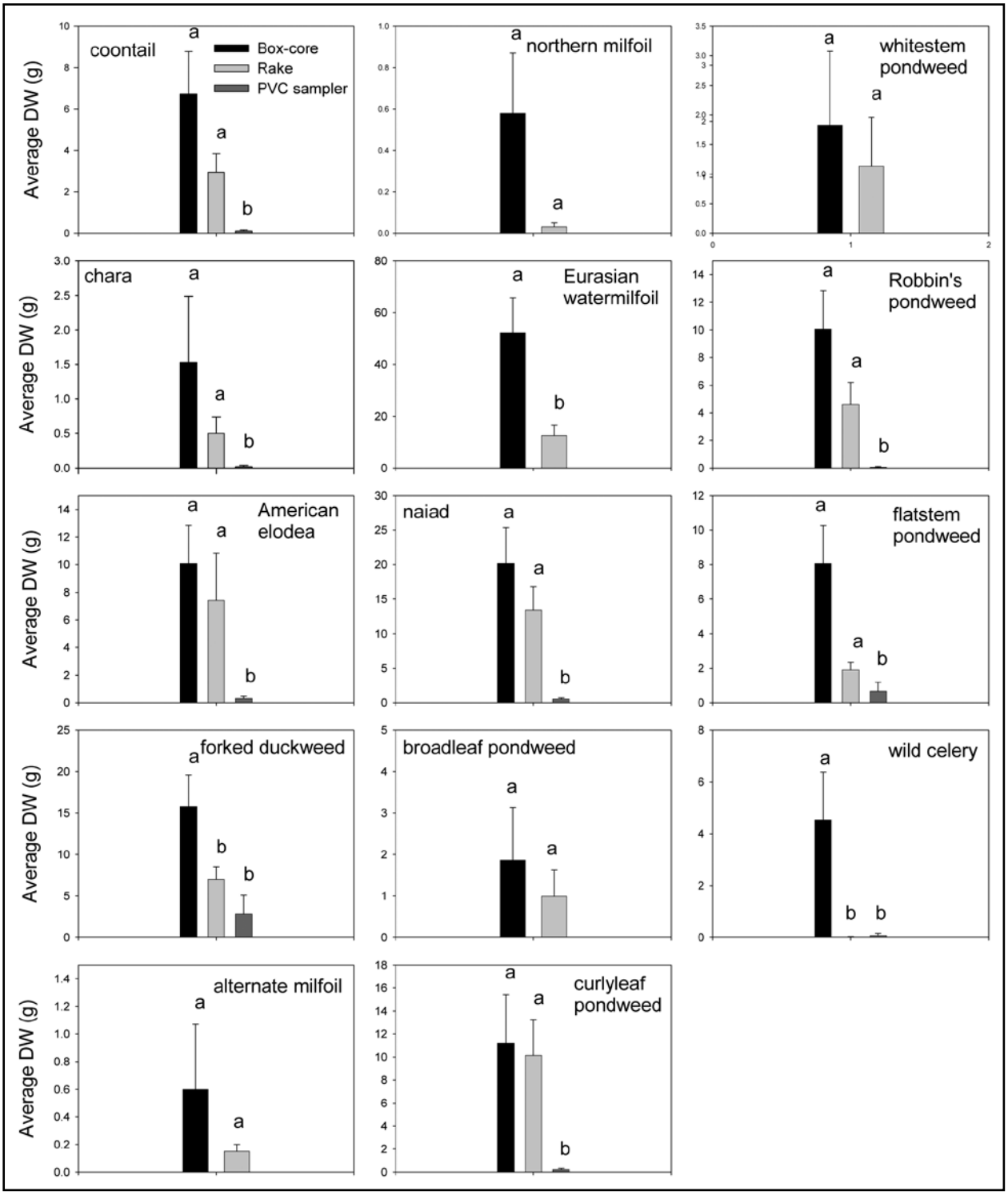

Figure 4. Average biomass for each plant species found in Shawano Lake, WI for each sampling method. Bars represent average biomass (DW (g). Letters indicate significant difference (Mann-Whitney U test (p=0.05).

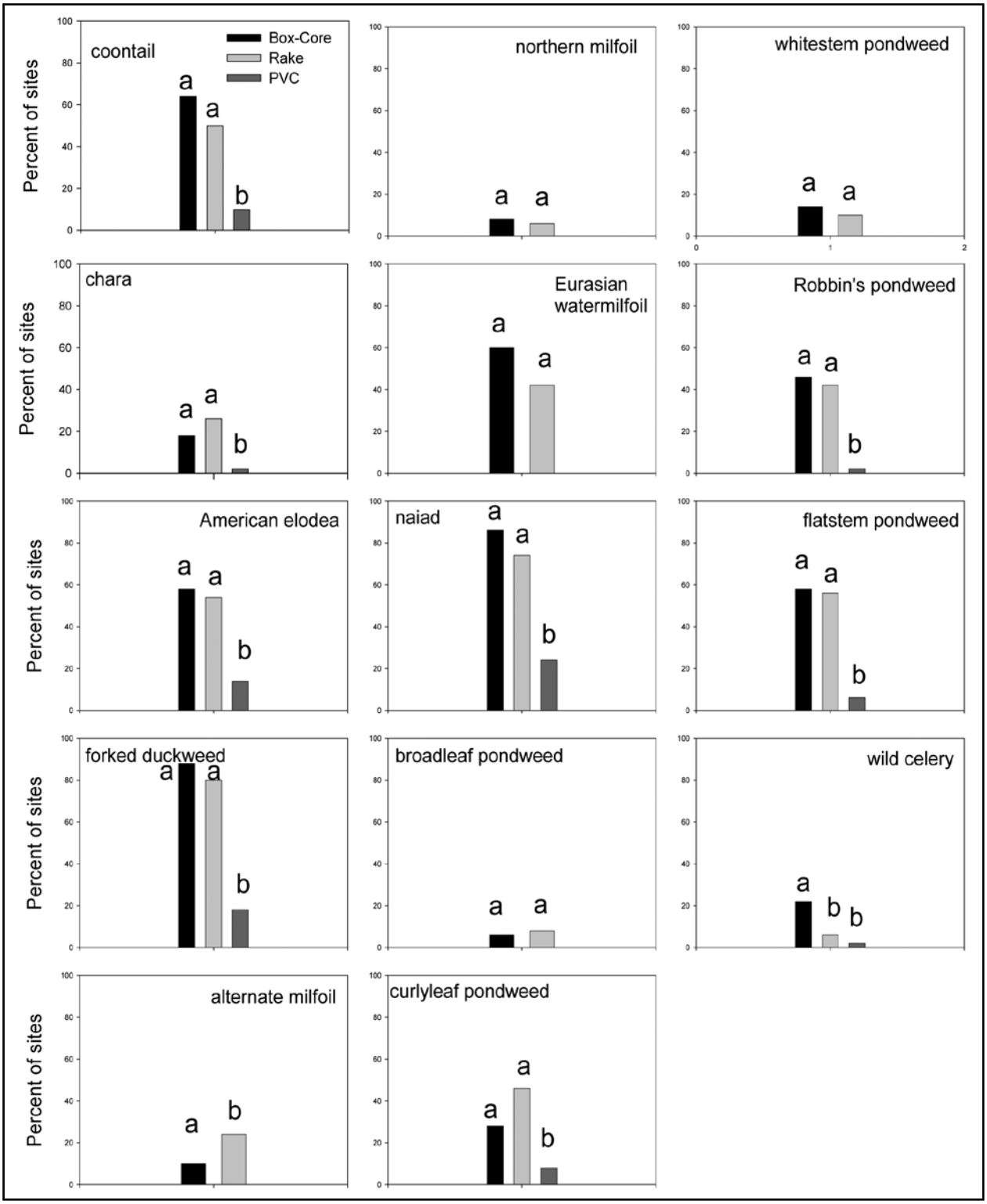

Figure 5. Percent of specific plant species found at the 50 sites in Shawano Lake, WI for each sampling method. Bars represent percent of sites where a specific plant was collected. Letters indicate significant differences (Chi-square Pearson index 2 x 2 contingency table).

Biomass and species differences preclude the PVC-core sampler as a substitute for more complex sampling and quantification methods, such as the box-core sampler. While the PVC-core sampler has proven effective for sampling underground biomass (Madsen et al. 2007), the area sampled is apparently inadequate to produce comparable sampling results for aboveground biomass. Deploying the PVC-core sampler multiple times per site might help correct this problem.

Both the rake and PVC-core sampler were less effective sampling curlyleaf pondweed turions than the box-core sampler (study standard). The box-core sampler averaged 35.9 turions, the rake 8.84 turions, and the PVC sampler 5.96 turions. This may be misleading, however. Turions may be attached to plants and/or have dropped to substrates, dependent upon season and other conditions. The box-core sampler would potentially collect turions in either case, whereas the rake methods would most likely only collect turions that remained attached to plants. Due to a smaller-sized capture area, the PVC sampler may require increased samples be collected to obtain sufficient data.

In conclusion, of the two alternative biomass sampling techniques tested, the rake showed the greatest potential for sampling aboveground biomass when compared to the standard method (boat operated box-core sampler). The rake was easily handled from a boat, could be purchased (inexpensively) from any garden store, and provided consistent data from year to year. Although not well addressed in this paper, the rake has proven to be less effective for collecting plants with basal growth forms (i.e. wild celery).[1] The rake would not be useful for sampling underground propagules, such as tubers. Madsen et al. (2007) found the PVC core sampler had a significant positive relationship with divers using quadrats, especially for sampling underground biomass. This study found the PVC core sampler and rake method were less effective samplers for curlyleaf pondweed turions when compared to the box-core sampler.

Further research is being conducted comparing standard methods (box-core sampler, or diver-operated quadrat) with less expensive and less labor-intensive methods such as the rake.

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