

A New Core Sampler for Estimating Biomass of Submersed Aquatic Macrophytes

JOHN D. MADSEN^{1,2}, RYAN M. WERSAL¹ AND THOMAS E. WOOLF³

ABSTRACT

We constructed a new core sampler of light-weight PVC pipe to sample above and below ground biomass of submersed macrophytes. The core sampler can be easily constructed, modified, or repaired in the field, as there are no valves or moving pieces. It can be constructed to sample in shallow or deep water. Comparisons were made between above-ground biomass samples collected from the core sampler and samples collected from a 0.10 m² quadrat from lakes in Minnesota and New York. There is a significant relationship between macrophyte biomass collected using both sampling methods, indicating that similar above ground biomass data can be collected using a core or a quadrat. The core sampler was more effective at sampling below-ground biomass and propagules, both beneath the sediment and those lying on the sediment surface.

Key words: turion, submersed plants, above ground biomass, below ground biomass.

INTRODUCTION

A significant problem in aquatic plant ecology is finding methods to effectively and efficiently collect and quantify submersed macrophyte biomass, because most sampling devices cannot effectively collect below-ground biomass. Standard benthos sediment samplers do not work well in macrophyte beds because they do not cut through shoots and roots, and plant material may clog valves or impair moving parts (Fornwall and Hough 1990). A core sampler for aquatic use has been effective in cutting through plant material, and is more practical for use in sampling submersed macrophyte beds (Fornwall and Hough 1990).

Fornwall and Hough (1990) have identified two competing needs of a coring device for sampling submersed macrophytes; a minimum diameter for sediment retention and a maximum diameter for retaining an adequate sample size. A number of core samplers have been constructed and used over the years to collect submersed macrophyte biomass. Rich et al. (1971) used a small-diameter coring device in lakes in Michigan, however the small diameter likely under-sampled plant biomass. Haller and Sutton (1975) and Bowes et al. (1979) constructed and used a polyvinyl-chloride (PVC) coring device to sample hydrilla (*Hydrilla verticillata* (L.F.) Royle) in Florida. The sampler worked well in shallow water but divers were needed to operate the device in deeper water (Sutton 1982). Sutton (1982) modified the previous

¹GeoResources Institute, Mississippi State University, Box 9652 Mississippi State, MS 39762-9652.

²Corresponding author, e-mail: jmadson@gri.msstate.edu.

³USDA-ARS, Northwest Watershed Research Center, Boise, ID 83712. Received for publication March 15, 2006 and in revised form June 23, 2006.

core sampler (Haller and Sutton 1975, Bowes et al. 1979) by adding galvanized pipe in order to eliminate the use of divers in deeper water. The use of galvanized pipe likely made the coring device substantially heavier, and it could only be turned into bottom sediments in a clockwise direction to avoid unscrewing the galvanized pipe from the sampler head (Sutton 1982). Pneumatic devices have also been deployed to sample aquatic macrophytes, but these samplers often have many moving parts, are complicated to operate, and are expensive to purchase and repair (Thayer et al. 1975, Schubauer and Hopkinson 1984). Finally, box corers are effective at sampling both above and below ground biomass, but require a large boat and specialized equipment to operate (Madsen et al. 2004).

Past core samplers were unable to operate in fluctuating water depths, heavy, had too many moving parts, valves that became clogged, or were complicated and expensive. We present here a new design of a PVC core sampler and data comparing its use to that of a traditional quadrat (Madsen 1993). This design for a core sampler is an effective and accurate alternative to using quadrats for sampling submersed macrophytes, and is particularly suited for estimating the density and biomass of tubers, turions, and seeds.

MATERIALS AND METHODS

Design and Use of the Sampler

Our core sampler is constructed entirely of standard polyvinyl-chloride (PVC) pipe with an inside diameter of 6 in. (0.194 ft²) (0.018 m²) (Figure 1). The use of PVC instead of galvanized pipe allows for a lighter, more manageable sam-

pler. Also, this sampler can be constructed or repaired in the field with relative ease. All parts of the core sampler were glued together using standard PVC cement. The handle is constructed using 5.0 cm (2.0 in) diameter pipe and is permanently capped on one end with a rubber quick cap used on the other. The main pipe is 2.0 in. in diameter and is connected to the handle by a 2.0 in. Tee. The length of the main pipe can vary depending on water depth; pipe lengths of 3.0 to 4.0 ft. works well in most instances. Core samplers to 10.0 ft. in length have been used. The main pipe is connected to a 4.0 in. to 2.0 in. reducing bushing that is then connected to a 6.0 in. to 4.0 in. reducing bushing. The actual corer tip is constructed of 6.0 in. PVC cut to a length of 12.0-15.0 in. and connected to the 6.0 in. by 4.0 in. reducing bushing. The bottom edge of the corer tip can be filed to a cutting edge if sampling in dense vegetation.

The sampler can be easily deployed from the side of a boat by pushing the corer into bottom sediments with the rubber quick cap removed. After the sampler is in the sediment, the rubber quick cap is placed on the open end of the handle to create a vacuum that holds the sediment core and plant biomass in the sampler. The sampler is removed from the sediment and out of the water until the end of the sampler can be placed into a pail. Once the sampler has been retrieved, the rubber quick cap is removed, and the sediment core and plant biomass are released into the pail for sorting. We typically use a benthic sample sorting pail or bucket with a mesh bottom to allow water to pass through, and then remove the excess sediment by dipping the bottom of the bucket into the water. This sampler can be used safely from a standard boat, or by wading.

Field Evaluation of Sampler

We collected above and belowground biomass samples of curlyleaf pondweed (*Potamogeton crispus* L.) in July of 2001 from three Minnesota Lakes; Leiberg Lake (44.15507°N, 94.31216°W) in Blue Earth County, West Jefferson Lake (44.25833°N, 93.77306°W), and Lake Washington (44.14445°N, 93.52192°W) in LeSueur County, using our core sampler and a 0.10 m² quadrat for comparison. Similar data were collected from six sites within Onondaga Lake (43.90000°N, 76.21000°W), Onondaga County, New York in July of 2002 and 2004. The quadrat samples from Onondaga Lake consisted of only above-ground biomass. Sampling was expanded on Onondaga Lake to include all aquatic macrophytes. All core and quadrat samples were taken as pairs next to one another at the respective sites. Thirty core samples and quadrat samples were collected from Leiberg Lake and again at Jefferson Lake. Ten core and quadrat samples were taken from Lake Washington and also the six sites within Onondaga Lake. Overall, there were 180 core samples and 180 quadrat samples. Core sampling consisted of placing the sampler at least 20 centimeters into the lake sediment following methods outlined by Madsen (1993). Core samples were rinsed through a 19 L pail with a 0.25 cm² wire mesh bottom to separate plants from sediment. Biomass samples obtained from the pail were then placed into 3.79-liter Ziploc bags and stored in a cooler for transport to the laboratory. Quadrat samples were obtained by hand pulling plants within the

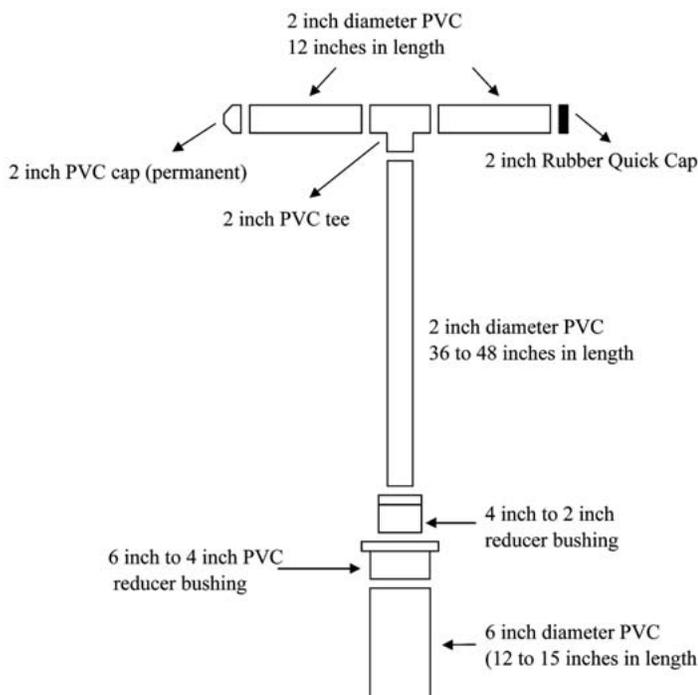


Figure 1. A schematic of a core sampler for collecting submersed aquatic macrophytes.

quadrat to obtain both above-ground and below-ground biomass. The samples collected from the quadrats were stored in similar fashion as the core samples.

In the laboratory, plant biomass was separated into above-ground (shoots) and below-ground (roots and rhizomes), washed, and dried at 55°C to a constant mass and then weighed. Curlyleaf pondweed turions were separated from all sample locations to assess the more accurate method (core or quadrat) for turion collection. Mass data were used to estimate total above-ground macrophyte biomass and turion biomass. Only above-ground biomass was used in our analyses due the lack of below-ground samples from the Onondaga Lake quadrats. Regression analysis was used to evaluate relationships between above-ground biomass collected from the core sampler and above-ground biomass collected from quadrats. We used an $\alpha = 0.05$ to determine statistical significance.

RESULTS AND DISCUSSION

A positive relationship ($F = 59.11$, $df = 179$, $p = 0.001$, $R^2 = 0.25$) was found between data collected using our core sampler and the use of a quadrat for sampling submersed macrophytes, indicating that comparable above-ground biomass can be collected using both methods (Figure 2). The poor correlation between the two sampling methods is due to over sampling of biomass using the quadrat and under sampling the canopy using the core sampler. In dense beds of submersed macrophytes shoots and leaves in the canopy may not be in the quadrat when the sample is taken, thus artificially inflating the biomass for that sample (Madsen 1993). In contrast, the core sampler is cylindrical in design which reduces the amount of edge to area sampled, eliminating the error in determining which plants are in or out of the sample, the plant matter cut off inside of the sampler is part of the sample (Madsen 1993). Likewise, the core sampler is

more precise and can more efficiently harvest below ground biomass (Sutton 1982, Madsen 1993). For these reasons, we re-analyzed both sampling methods excluding biomass values that were greater than 160 gDW m², values we felt were luxuriant growth of invasive species that normally do not occur on a large scale within a given lake or area. Again, a positive relationship ($F = 105.99$, $df = 171$, $p = 0.001$) was found between using our core sampler and the quadrat; the correlation between the two methods was strengthened ($R^2 = 0.38$) (Figure 2).

We did not find a significant linear relationship ($F = 1.27$, $df = 61$, $p = 0.26$) between the use of the core sampler and the quadrat in sampling curlyleaf pondweed turions. The regression analysis indicates that the core sampler was the more effective method for the collection of turions (Figure 3). Sutton (1982) indicated that the use of a core sampler in Florida efficiently sampled hydrilla propagules. Similarly, Woolf and Madsen (2003) found the core sampler to effectively collect above- and belowground biomass of curlyleaf pondweed in Minnesota. Case and Madsen (2004) and Wersal et al. (2006) used the same core sampler to sample sago pondweed (*Stuckenia pectinata* Börner) shoots, roots, and tubers in three Minnesota lakes. The core sampler was designed primarily to collect accurate turion samples for life history studies, and is particularly suited to monitor below-ground tubers and turions, as well as seeds or axillary turions and winter buds that have been released from the plant. Quadrat samples are inadequate for quantifying these propagules, yet the sampling of propagules is critical for understanding long-term control of most invasive submersed plants (e.g., hydrilla, curlyleaf pondweed, and waterchestnut (*Trapa natans* L.)).

The small diameter of the core design relative to the quadrat requires that more biomass samples be taken to accurately estimate biomass or propagule density (Downing and Anderson 1985, Madsen 1993). Despite this require-

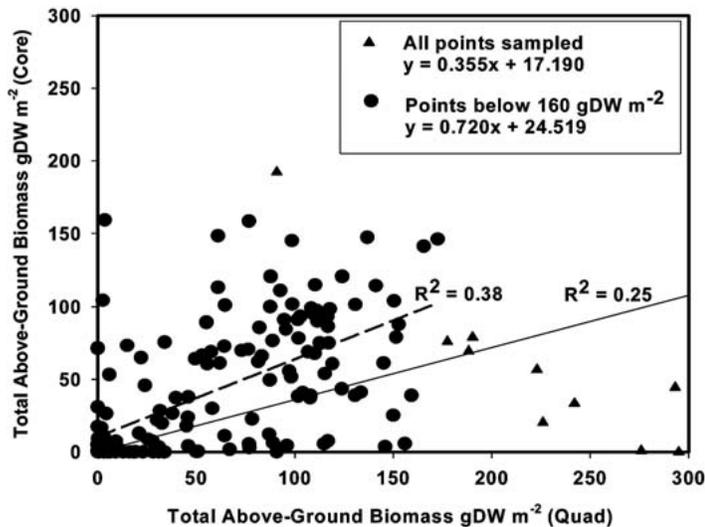


Figure 2. Comparison of total above-ground macrophyte biomass collected with the core sampler (0.018 m²) and quadrat (0.10 m²) from Minnesota and New York, $p \leq 0.001$ (solid line), $n = 179$. A comparison of above-ground biomass excluding samples greater than 160 gDW m² $p \leq 0.001$ (dashed line), $n = 171$.

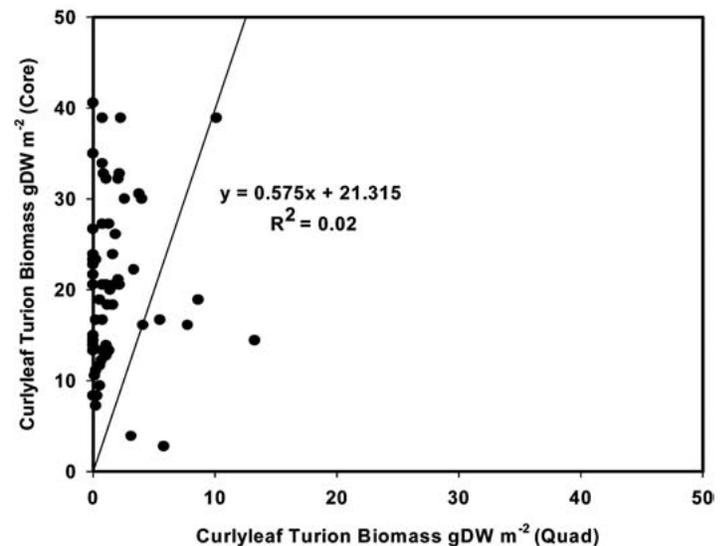


Figure 3. Comparison of turion biomass of curlyleaf pondweed collected with the core sampler and quadrat from Minnesota and New York, $p = 0.26$ and $R^2 = 0.02$, $n = 61$.

ment, the smaller samples sort quickly which reduces sample handling time (Downing and Anderson 1985). In addition, operating this sampler from a boat is much more rapid than deploying divers to collect biomass, therefore adequate samples across an entire lake or area can be collected quickly.

Sediments as well as aquatic macrophytes can be collected using this core sampler. Madsen et al. (1996) collected and characterized sediments (sediment type and particle size) from Onondaga Lake, New York using the core sampler. Also, Case and Madsen (2004) surveyed the Heron Lake System, Minnesota, using the core sampler to describe the sediment composition and particle size. The core sampler worked well in silt and clay sediments but had difficulties retaining sediment cores composed largely of sand. Reliability of sample retention is generally good with this sampler; though failures did occur. Failures (loss of sediment core) occurred largely due to high percentages of sand in the sediment or improperly sealing the rubber quick cap. An improper seal fails to create vacuum suction, thus preventing retention of the sample in the corer.

Our core sampler has worked well in many situations to collect both above and below-ground biomass. We conclude that the core sampler is an effective alternative to sampling with quadrats and is more effective at sampling turions and tubers of submersed macrophytes. The sampler's lighter weight and lack of valves and moving parts make it easier to handle and use. This design also allows surveys to be conducted in a more time efficient manner, permitting the collection and quantification of large amounts of data.

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