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Effectiveness of Temporary Carp Barriers for Promoting Wild Rice Growth in a Southern Bay of Upper Clam Lake

Prepared for St. Croix Tribal Environmental Services – Natural Resources Department, September 2011
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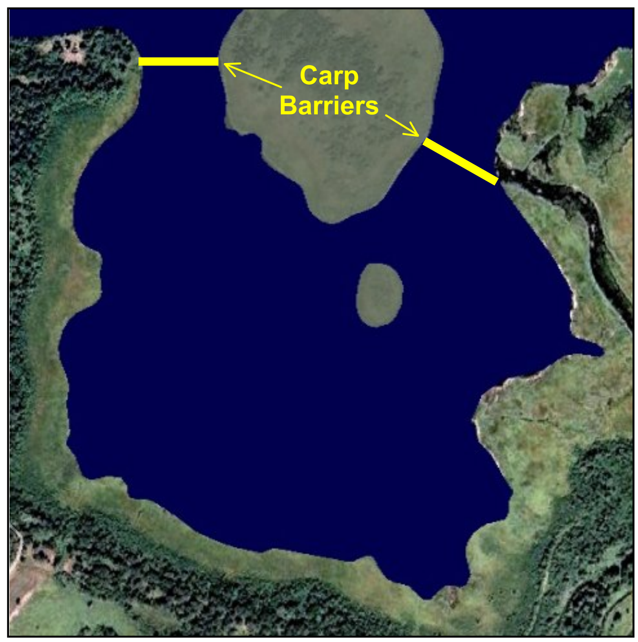
Project Context

Over the past 10 years, stands of northern wild rice (*Zizania palustris*) in Upper Clam Lake (Burnett Co., WI) have decreased dramatically. Previous studies have identified carp as the primary cause of this severe decline in rice (Johnson and Havranek 2010). In recent years, St. Croix Tribal Environmental Services has been actively monitoring and managing wild rice in the lake. As a part of these ongoing monitoring and management activities, in the spring of 2011 their staff installed nets to exclude carp from the large, shallow bay (80 acres, <1 m deep) on the southern end of Upper Clam Lake (Fig. 1). In 2010, prior to installation of the carp barrier, this southern bay supported the most substantial stands of wild rice in the entire lake. However, even these stands were generally sparse and confined to very shallow areas near shore. Freshwater Scientific Services, LLC was contracted to assess the late-summer distribution and density of rice growth in this southern bay in both 2010 and 2011. This brief report summarizes our monitoring methodology and findings from these surveys.

Figure 1. Maps of Upper Clam Lake showing the location of the enclosed southern bay (left) and a detailed view (below) showing the location of the installed carp barriers.



Methods

Installation of Carp Barriers

Staff from St. Croix Tribal Environmental Services installed the carp barriers on April 10, 2011. These barriers consisted of two nets with surface floats and bottom weights (height = 2 × water depth, 3/8–inch mesh) stretched across the two narrow channels that connected the southern bay to the main lake basin. After installing the net, fence-posts were pushed into the sediment along each side of the net (roughly every 10 m) to provide additional support and prevent the net from shifting position or sagging. These barriers were in place before carp moved into shallow areas to spawn, but carp were not removed from behind the barrier.

Field Surveys

We conducted the first of two wild rice surveys in the southern bay of Upper Clam Lake on September 9, 2010. For this survey, we assessed rice stem density (stems/m^2) at regular distance intervals along 10 transects that were oriented roughly perpendicular to the southern shoreline of the bay (Fig. 2). Along each transect, we began assessing rice stem density just outside of the edge of observed rice growth. Subsequent sample points along each transect were determined by moving the sample boat (12-ft, flat-bottom jon-boat) toward the southern shore with 10 pushes of the rice-pole (10-ft long pole with a hinged foot for pushing off of soft sediments).

At each 10-push distance interval, we recorded the GPS location using a handheld Garmin GPS-76, measured water depth, visually rated the density of rice growth in the immediate vicinity as *sparse*, *moderate*, *dense*, or *very dense*, and counted rice stems emerging from within delineated sample areas (quadrats). For these stem counts, we only counted stems with seed heads. The quadrat size for each location was selected based upon the qualitative rice density ratings (Table 1). We chose to use larger quadrats (12.3 m^2 and 3.1 m^2) in *sparse* and *moderate* stands of rice to increase detection of rice stems, as these areas generally had very low stem density with widely-spaced clusters of stems. These large quadrat areas were delineated using a PVC pole (cut to the appropriate length (3.5 m or 1.75 m) and held parallel to and then perpendicular to the side of the boat. When using these large quadrats, we collected one sample from each side of the boat (2 samples per location). Alternatively, we used smaller quadrat frames (0.10 m^2 and 0.05 m^2) to assess a relatively small number of near-shore sites with *dense* or *very dense* rice (4 sites). Using these smaller frames greatly reduced the amount of time needed to count stems in areas with denser rice growth. When using these smaller quadrats, we collected 2 samples from each side of the boat (4 samples per location).

Table 1. Quadrat frame size selection criteria used during the Sept. 2010 survey (based upon subjective rice density ratings).

Rice Density Rating	Quadrat Dimensions	Quadrat Area	Samples per Location
Sparse	3.5 x 3.5 m	12.3 m^2	2
Moderate	1.75 x 1.75 m	3.1 m^2	2
Dense	0.32 x 0.32 m	0.10 m^2	4
Very Dense	0.22 x 0.22 m	0.05 m^2	4

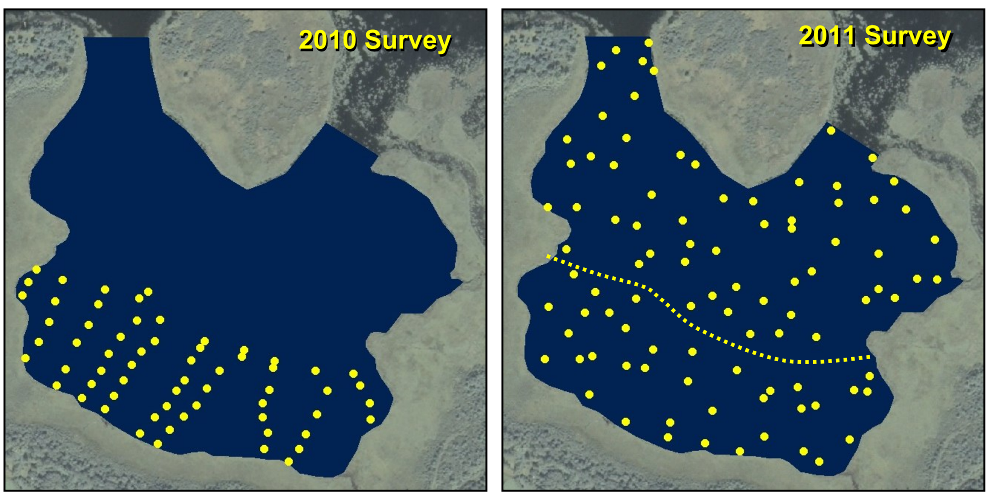
We conducted a second survey on Aug 30 2011 to assess rice growth after the carp barriers were in place. We modified the survey methods used for this second survey to allow for more rapid sampling, reduce damage to rice stands, standardize data collection, and simplify statistical analyses for future comparisons. These modifications included (1) using a kayak instead of a jon-boat to minimize destruction of rice plants, (2) using only one quadrat frame size (1.5 x 1.5 m), and (3) establishing random sample points across the entire bay (Fig. 3). At each sampled location we recorded water depth, noted the presence of additional plant taxa, and counted rice stems emerging from within the delineated quadrat areas. We collected 2 quadrat samples from each side of the kayak at all locations (4 samples per location). For each sample, we delineated the quadrat area using a 1.5-m long PVC pole held parallel to and then perpendicular to the side of the kayak.

Data Analysis

For each survey, we calculated the wild rice stem density (stems/m^2) for each collected sample by dividing the total stem count by the quadrat area. We then calculated the average stem density and standard error (1) for each sampled location and (2) for the entire sampled area of interest (Table 2). Plotted histograms of stem density data clearly indicated that the data were not normally distributed (heavily skewed to the right). Accordingly, we compared the 2010 and 2011 results using a nonparametric Mann-Whitney test (Zar 2010) to determine if the density of rice growth in the bay changed significantly between the sampled years. The 2010 survey did not include samples from the entire bay, as we only sampled in the southern one-third of the bay where rice was observed to be growing. Consequently, we were not able to make bay-wide comparisons of rice density from the two surveys. Instead, we limited our statistical comparison to include only the data that were collected from the same area during both surveys. This included data from points that covered roughly the southern one-third of the bay (Fig 2).

We also compared the results of the two surveys visually by creating wild rice stem density maps using GIS software (ArcView 3.3 with Spatial Analyst extension). Mapped stem densities were estimated by interpolating between sample points (IDW interpolation).

Figure 2. Maps showing the locations that were sampled during the 2010 and 2011 wild rice stem count surveys in the southern bay of Upper Clam Lake. The portion of the bay from which carp were excluded in 2011 is shaded. All data from locations north of the dashed line in the 2011 map were excluded from the between-year comparisons.



Results & Discussion

The stem density maps indicated that that in both years the densest rice stands occurred in near-shore areas, with very sparse rice in the central portion of the bay (Fig. 3). Additionally, rice stem densities in some near-shore areas appeared to be higher in 2010 than in 2011. Similarly, statistical analyses showed that average wild rice stem density in the southern portion of the bay decreased from ~10 stems/m^2 in 2010 to ~2 stems/m^2 in 2011 ($P = 0.03$, Mann-Whitney test). However, much of this decrease appeared to be the result of more intensive sampling immediately next to shore in 2010. Four of these shoreline samples supported very dense rice in 2010 (50-150 stems/m^2). These high densities were 10 to 30 times greater than seen at any of the other 53 sampled locations and heavily influenced the calculated statistics (Table 2) and the interpolated stem density maps (Fig. 3). When these four outliers were excluded from the calculations, the average stem density in 2010 dropped from ~10 to ~4 stems/m^2, and was more comparable to the average stem density we observed in 2011 ($P = 0.10$).

Unlike the 2010 survey, the 2011 survey sampled rice growth over the entire bay. This survey showed that he densest rice stands (Fig. 4) grew along the southeast shoreline in a band roughly 100 to 150 m wide, with additional moderately dense stands along portions of the northeast and northwest shorelines. Rice plants were widespread throughout the bay, but the majority of the bay supported only sparse rice growth, consisting of small patches of rice (5-10 stems) with 20 to 50 m distance between patches (Fig. 5). In particular, the central portion of the bay only supported sparse, patchy rice growth.

Table 2. Comparison of 2010 and 2011 average wild rice stem density and standard error (SE).

Data Set	Samples	Average (stems/m^2 ±1SE)
2010 *(all points)*	57	9.9 ±3.4
2010 *(4 outliers excluded)*	53	3.6 ±0.6
2011 *(all points)*	93	1.2 ±0.2
2011 *(southern points only)*	36	2.3 ±0.4

Figure 3. Maps of wild rice stem density from the 2010 and 2011 surveys. Maps produced by interpolation between sampled points (inverse distance weighting; IDW method).

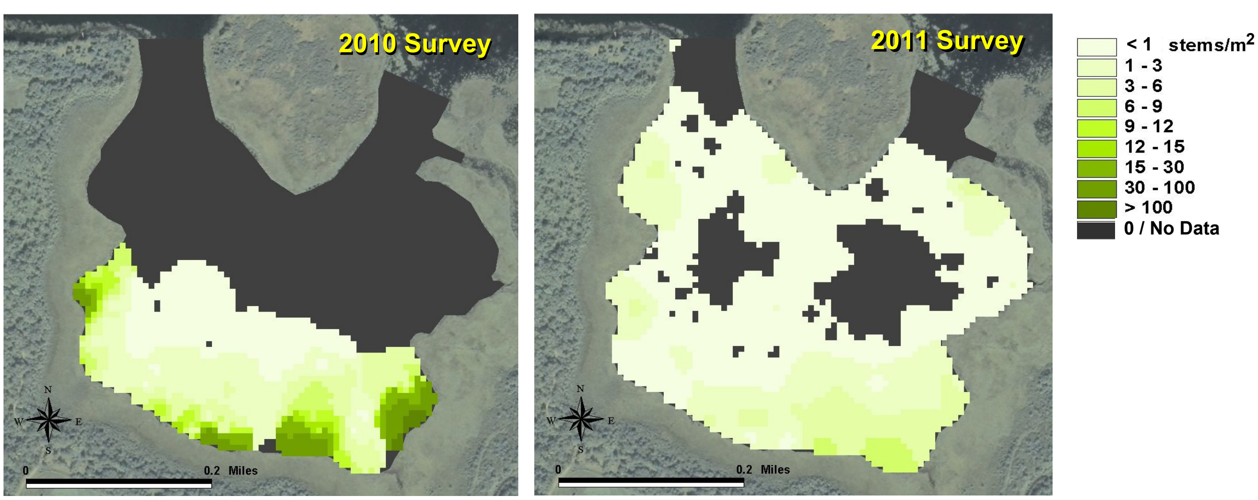


Figure 4. Denser rice growth (~20 stem/m^2) along the southeast shoreline of the bay. This rice density was typical of this area in both 2010 and 2011.

Figure 5. Sparse, patchy rice growth (<1 stem/m^2) as found over much of the surveyed area in both 2010 and 2011, particularly in the central portion of the bay.

Evidence of Reduced Carp Activity

Although the density of wild rice in the southern bay did not increase in 2011 after the carp barriers were installed, increased native aquatic plant growth in the bay suggested that the nets successfully reduced carp activity in the bay in 2011. The abundance and diversity of aquatic plants generally appeared to be greater than in previous years, and were dramatically greater in the enclosed bay than in the areas immediately outside of the carp barrier. In 2011, we observed dense growth of native aquatic plants over roughly 80% of the bay, with many areas supporting a fairly diverse assemblage of plant species (Table 3). These dramatic differences were very similar to what we observed during the carp exclosure plot experiment conducted in 2010 (Johnson and Havranek 2010). In that study, we observed much denser and more diverse growth of native aquatic plants inside our carp exclosures (no carp), with substantially lower plant abundance and diversity immediately outside of the exclosures where carp were present (Fig. 6).

Table 3. List of aquatic plant taxa observed growing in the southern bay of Upper Clam Lake in Aug 2011 after carp were excluded.

Common Name	Taxonomic Name	Frequency
Bushy Pondweed	*Najas flexilis*	Common
Canadian Waterweed	*Elodea canadensis*	Common
Coontail	*Ceratophyllum demersum*	Common
Narrowleaf Pondweed	*Potamogeton* spp.	Common
Common Bladderwort	*Utricularia vulgaris*	Occasional
Flat-stem Pondweed	*Potamogeton zosteriformis*	Occasional
Floating-leaf Pondweed	*Potamogeton natans*	Occasional
Illinois Pondweed	*Potamogeton illinoensis*	Occasional
Muskgrass	*Chara* spp.	Occasional
Northern Watermilfoil	*Myriophyllum sibiricum*	Occasional
River Bulrush	*Schoenoplectus fluviatilis*	Occasional
Spatterdock	*Nuphar variegata*	Occasional
Water Marigold	*Bidens beckii*	Occasional
White Watercrowfoot	*Ranunculus longirostris*	Occasional
White Waterlily	*Nymphaea odorata*	Occasional
Arrowhead	*Sagittaria* spp.	Rare

Evidence of Need for Wild Rice Seeding

The 2010 carp exclosure plot experiment clearly indicated that exclusion of carp alone did not result in rice growth; seeding of rice was also necessary (Johnson and Havranek 2010). In that study, it appeared that the wild rice seed bank in lake sediments had been severely depleted by carp. This suggests that similar seed depletion may have occurred in the southern bay over the past 10 years, and may explain why we did not see increased rice growth in the bay after installation of the carp barriers. Although we observed substantial wild rice seed production in the bay in 2011, seed dispersal of rice is fairly limited. To enhance the expansion of wild rice stands in the southern bay, managers should strongly consider seeding the bay in addition to keeping the carp barriers in place. This would likely lead much more widespread and dense rice growth in future years. Given the current carp control strategies being implemented on Upper Clam Lake by the St. Croix Tribal Environmental Services (mass carp removal), there may soon be a need for locally produced seed stock to reestablish rice stands in the rest of the lake. Dense rice growth in the southern bay would provide a perfect source of locally-adapted seed for this purpose.

Figure 6. Images showing the dramatic difference in the abundance and diversity of native aquatic plants inside and immediately outside plots where carp had been excluded for one full summer (Johnson and Havranek 2010).

References

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