Investigating Viability of Wild Rice Beds at Varying Water Depths

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ABSTRACT

Wild rice or Manoomin is an important cultural resource and food source for Ojibwe people. Increasing water levels due to climate change are a major threat to wild rice in the Great Lakes region. An area that has seen significant water level increase is Allouez Bay in Northern Wisconsin. In efforts to expand historical wild rice beds, the Lake Superior Research Institute (LSRI) seeds the bay, but the change in water level has caused them to have to re-seed in new areas, requiring additional time and resources. This study seeks to understand whether the original seed bed planted by the LSRI prior to the water level increase still remains now that the water level is too high for the rice to grow. I predicted that the original seed bed planted by the LSRI remains in Allouez Bay but has decreased in size and that the seed remains viable. Unfortunately, no seed was found in this study due to three potential factors: sample size, location accuracy and time of study.

Introduction

Manoomin, the word for Northern Wild Rice (Zizania palustris) in the Ojibwe language (Meeker et al., 1993) has been a staple food in the diet of Indigenous Peoples in the Upper Midwest since pre-colonization and continues to be to this day. The cultural importance of Manoomin to Ojibwe people can be traced as far back as the migration story. In this story, a prophet told the Ojibwe people to move west from their east coast territories to the place “where
the food grows on water” or they would be destroyed (Nam, 2016). So, the Ojibwe traveled west, settling at many different places along the way as they found Manoomin at each location (Benton-Banni, 1988).

Not only is Manoomin an important food source for Ojibwe people, but it is also vital for spiritual practices as well. Manoomin is often used in offerings to the spirits and is eaten during ceremonies, such as naming ceremonies when a child is born (Vennum, 1988). It is highly regarded as a sacred food.

Manoomin plants are highly susceptible to effects of changing water levels (Pip & Stepaniuk, 1988). The ideal depth for optimal Manoomin growth is between 1-2 feet, however, the plant can grow in a range of 0.5-3 feet of water (GLIFWC, nd). According to predictions of how climate change will affect the midwest region of North America, warmer air temperatures could cause higher rates of evaporation, thus decreasing water levels (Easterling & Karl, nd). However, current data from the Great Lakes region seems to show the opposite. Water level data from the National Oceanic and Atmospheric Administration’s (NOAA) Great Lakes Dashboard Project (2019) reveals an above average increase (approximately 400 cm) in water level for Lake Superior and predicts a continued increase into the year 2020.

The change in water level of Lake Superior over the last decade has greatly impacted the Manoomin restoration efforts in Allouez Bay by the Lake Superior Research Institute (LSRI). Located in Superior, Wisconsin (Douglas County), Allouez Bay is a coastal wetland extension of Lake Superior in the St. Louis Estuary. Remnants of the historic rice bed still exist in Allouez Bay in small, scattered clusters (Wild Rice Restoration, n.d.). The LSRI has recently started seeding the bay in an effort to maintain the growth of Manoomin. In 2010, 302 lbs of rice were initially seeded into Allouez Bay by the LSRI under the direction of Amy Eliot (David, 2013).
However, LSRI scientists have observed that the seed bed planted in 2010 (and subsequently in 2015 and 2016) no longer grows and produces rice, likely due to rising water levels. Therefore, LSRI now seeds further into shallow water. The main objective of this study is to evaluate if the rice bed planted by the LSRI in the last nine years remains in Allouez Bay now that the water level has risen. Should seed be found, a secondary objective would be to determine if the seed is still viable.

I predict that the original seed bed planted by the LSRI remains in Allouez Bay but has decreased in size. Support for this hypothesis comes from a study performed by Stevenson and Lee (1986) in Back Lake in Thunder Bay, Ontario, Canada. This study showed that when wild rice plants in the submerged-leaf, first floating-leaf, second floating-leaf, and the first aerial-leaf stages were subjected to increases in water depth of 45 cm, 60 cm, 75 cm, and 95 cm, there was a decrease in reproductive productivity (Stevenson & Lee 1986). Decreases in reproductive productivity were observed by the decline in the number of inflorescences, inflorescences that reached maturity, and the number of potential seeds. It is worth noting, however, that all plants in their treatments survived regardless of water depth. As water levels on Lake Superior have risen almost four times those tested in this study, this could account for the observation that wild rice plants are no longer observed in areas of Allouez Bay previously seeded by the LSRI.

I also predict that, should seed be found in the testing area, it will be viable. According to Kovach and Bradford (1991), *Z. palustris* seeds kept at a moisture content of at least 30% and even at a temperature below 20°C for one year, can remain viable. Further, naturally growing wild rice plants found in this region can withstand local water and temperature conditions for one year. Here, the unknown is whether the wild rice seeds remain viable beyond one year. This
study will allow us to gain insight into whether wild rice can withstand rising water levels and remain viable multiple years, so that it can grow if the water levels decrease again.

**Materials and Methods**

*Cultural Considerations*

As stated above in the introduction to this paper, wild rice is an extremely important plant to Ojibwe people. There were certain cultural and spiritual guidelines that the researchers in this study followed in order to pay respect to Ojibwe beliefs and traditions. Before research was conducted, researchers said a prayer of thanks for being able to conduct this research and proclaimed good intentions. Once the prayer was said, the researchers placed tobacco, a sacred medicine to Ojibwe people, in the water.

*Collection*

*Manoomin* seed bed samples were taken using a gravity coring device with a diameter of 2 ¾ inches at each sample location. Each sample location in Allouez Bay was chosen for meeting one of three requirements. Negative controls areas (yellow) are defined as never seeded by LSRI and noted by LSRI to never have had wild rice growing there (Figure 1). Positive control areas (red) are defined as seeded by the LSRI and are areas of known rice growth (Figure 1). Experimental (test) areas (blue) are defined as the areas where LSRI has recently seeded but have not observed growth in the last year (Figure 1). The experimental site was significantly deeper than positive and negative control areas, which is consistent with the prediction that water levels over the ideal depth of 1-2 feet may be preventing *Manoomin* (Table 1). Two negative control sites and two positive control sites were sampled, with two replicates taken at each
location. Due to weather concerns on the day of sampling, instead of testing two experimental areas, four replicates were taken at one location (point 149 in Figure 1). In total, 12 samples were collected. The location of each sampling site is shown on the map in Figure 1 and data for each sample can be shown in Table 1.

**Sample Storage**

Once samples were taken each sample was stored in a sealed plastic container and labeled with the date and GPS number where the sample was taken. Other measurements taken at each sample site were recorded in a waterproof notebook. Samples were either processed the same day as collection or stored overnight at 4°C and processed the next day. It is important to process samples within a timely manner for two reasons. The first being that some samples may begin to smell if left too long, especially if the samples are left unrefrigerated. The second and most important reason being that the viability test should be done shortly after collection, should seed be found, in order to obtain accurate results.

**Results**

**Determining appropriate sampling method**

Upon beginning this research, it became clear that there was no standard operating procedure for how to sample the seed bed. It was unclear what equipment would be best for obtaining seed until each method was tested as there was no prior research found on the depth of wild rice seeds in sediment.

Three sampling methods were tested. The first method was using the piston corer (Figure 2). This type of corer works by inserting and twisting the tube as far into the sediments as
possible. Once the tube is inserted, one person pulls up on the tube while the other pulls up on the plunger at the same rate. Unfortunately, the first round of testing on June 5th, 2019, revealed several challenges to using this corer. Specifically, this corer was difficult to insert through the vegetation mat at the water/sediment boundary, and therefore there were concerns whether it could sample deep enough into the sediment for seed collection. This corer also would not make a tight enough seal to suction the sediment into the tube; therefore, each time the corer was removed from the water, the sample was lost. Although the samples were lost, there was seed floating in the positive control area (point 147) after sampling. In total 16 seeds were counted. The seeds were placed back into the water after counting.

After consultation with coring expert, Dr. Kurt Schmude and some mechanical adjustments, a second round of practice in the Barker’s Island inlet on June 7th, 2019 was completed. This second round of practice allowed us to determine that this corer would work. In order to obtain a sample, someone would have to place a hand under the corer before pulling it out of the water. Even with a hand capping the bottom, small amounts of sample were lost, however, each sample had relatively the same amount of loss across groups.

On June 5th, 2019 the PONAR grab (Figure 2) was tested. This equipment was tested in an area with no wild rice so as not to disturb any rice beds. To use this device, someone needs to set the pinch-pin and then lower the device into the water until it reaches the bottom. Upon reaching the bottom, the pin will pop out and trip the dredge to shut and grab the sediment sample. The PONAR was ruled out as a sampling method because it would only pick up the upper sediment layer, above the vegetation mat, which is not deep enough to collect the seeds of interest.
The final and most effective method tested was the gravity corer. This method accounted for ten out of twelve samples collected (all except two replicates at one negative control site) on June 25th, 2019, (Figure 2). This corer works by inserting the corer into the sediment as far as it can be pushed down. If the device is not able to be pushed down, it can be driven down further into the sediments by dropping weights on the top. When the tube is pulled up, it creates a suction that extracts the sediment up with it.

**Germination and Viability Tests**

Should seed have been found, viability would have been tested using a tetrazolium (TZ) test. Seeds from the positive control samples and the test samples would have been sorted into petri dishes and moistened on a wet paper towel for one hour prior to testing. Each seed then would have been cut longitudinally with a single edge razor blade to expose the embryo and then subjected to a solution of 0.5% triphenyl tetrazolium chloride (Patil & Dadlani, n.d.). Seeds would have soaked for 24 hours in tetrazolium solution and then rinsed two times in de-ionized water. Once rinsed, each seed would be examined under a microscope and sorted into two groups: viable and non-viable based on the staining pattern left by the TZ.

**Sample analysis**

At the time of sampling, several measurements and observations were recorded (Table 1). Following collection, samples were processed to determine whether wild rice seeds were present. Unfortunately, no seeds were found in any of the samples, including positive controls. Although no seeds were found in the experimental area replicates, we cannot conclusively say that the rice bed no longer exists, as there was no seed found in the positive controls either. Positive control samples did contain wild rice seedlings or leaves, though, in three out of the four replicates; however, no traces of wild rice plants were found in the experimental samples. The data
collected in this study was insufficient in its ability to answer the research question due to multiple factors, as discussed later.

Other conclusions can however be extrapolated from the samples collected. There is a correlation between sediment type and wild rice growth. In positive controls areas with visible wild rice plants present, the sediments were composed of organic muck. In comparison, in negative control and experimental areas, both of which lacked wild rice plants, sediments were composed of either fine detritus or sand and gravel.

**Discussion**

**Water depth analysis of sample sites**

Sample sites were marked according to GPS location in Allouez Bay using Google Earth Pro software (points 144-149 in Figure 1). Using Historical Imagery from 2010 and 2015, two of the years that the LSRI seeded Allouez Bay, maps were created to show the change in water level (Figures 3-4). A substantial change in topography can be observed from the year 2010 to the present by looking at these maps. In 2010, when the water level was much lower, all areas (points 144-149) that were sampled would have been on land. It is clear that no rice would have been growing in the sample areas at this time. When comparing the 2010 map to the 2015 map, it shows that the water level has increased in those 5 years. In 2015, points 144, 145, 146, and 147 still would have been on land. Points 148 and 149, however, looks like they are located right on the edge of the vegetation or slightly in the water. Therefore, this confirms that it is likely that point 149 was actually seeded in 2015 or 2016.
Limitations and Future Directions

Due to weather concerns during sampling as well as concerns of disturbing rice beds, the sample size for this study was insufficient and therefore unable to answer the research question. It is possible that, would more locations have been sampled, rice seeds would have been discovered.

For future research, it is recommended that more samples be taken and more sample sites chosen. Sample site selection is a critical component of this analysis. Specifically, site selection should occur before sampling, with sites chosen on a map, which allows for GPS coordinates to direct researchers to sample site locations on the day of collection. This should reduce ambiguity into which group a site would fall into: positive, negative or experimental. This way it increases the probability of finding rice seed in a sample and streamlines the schedule on day of sampling. Additionally, planning for a backup collection day would alleviate the time restraints imposed by weather or sampling difficulties. It is important to keep in mind, however, that the more samples taken, the higher the chance of disturbing the rice beds.

Additionally, having equipment that is better suited for deep water sampling is recommended. Once in the experimental sites, it became harder to maneuver the coring device. One researcher had to pull up on the handle of the corer while the other had to bend down into the water to pull up from the base. Due to the depth of the site, it is recommended to either use a lighter coring device to make it easier for one person to pull it out of the water, or for the researchers to wear dry suits. This eliminates the chance of the researchers filling their waders when bending down to pull up the corer from the base.

Another limitation were the constraints imposed due to the timing of the McNair Summer Program that funded this research project. This research would have been better suited for spring
or early summer before the rice has begun to germinate. Due to the timing of the program, this research was done in mid-summer, when the rice was in the floating leaf stage. This caused some of the positive control samples to contain seedlings rather than seed. Further, it took time away from equipment testing and fieldwork preparation to be writing preliminary results as an assignment before data could be collected. Writing this summary would have fit better for time management and idea flow if the deadline could have been flexed until after data was collected. Overall, I learned many important skills from this project, and it was an invaluable experience in my career journey.

Acknowledgements

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I am also extremely grateful to those that contributed their knowledge, expertise and guidance to me during this project. Thank you to Dr. Andrew Breckenridge, Dr. Kurt Schmude, Dr. Nicholas Danz, and Kelly Beaster for consulting with me on this project, supplying equipment, and/or helping with field work. Most importantly, I would like to thank Dr. Jenean O’Brien and Amy Eliot. I learned so much about the research process from them and I am so grateful to have had the opportunity to work closely with them on this project.
References


Brown

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Tables and Figures

Figure 1. Allouez Bay Sample Sites as Identified by GPS Location, 2019
**Figure 2. Sampling Devices**

A) **Piston Corer**

B) **PONAR**

C) **Gravity Corer**


A) Piston Corer borrowed to us by Dr. Kurt Schmude. B) PONAR grab. Image from Hoskin Scientific LLC. C) Gravity Corer borrowed to us by Dr. Andy Breckenridge.
### Table 1. Sample Site Data

<table>
<thead>
<tr>
<th>Sample #</th>
<th>GPS #</th>
<th>Date</th>
<th>Sample type</th>
<th>Water depth</th>
<th>Secchi depth</th>
<th>Physical description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>145</td>
<td>6/5/19</td>
<td>Negative Control</td>
<td>23 inches</td>
<td>10.2 cm</td>
<td>Black, organic muck, smelly.</td>
</tr>
<tr>
<td>2</td>
<td>145</td>
<td>6/5/19</td>
<td>Negative control</td>
<td>22 inches</td>
<td>10.2 cm</td>
<td>Black, organic muck, smelly, cattail mat debris.</td>
</tr>
<tr>
<td>3</td>
<td>146</td>
<td>6/25/19</td>
<td>Positive control</td>
<td>24.5 inches</td>
<td>24.5 cm</td>
<td>Brown, smelly, organic muck. ~9 wild rice leaves.</td>
</tr>
<tr>
<td>4</td>
<td>146</td>
<td>6/25/19</td>
<td>Positive control</td>
<td>24.5 inches</td>
<td>24.5 cm</td>
<td>Brown, smelly, organic muck. 3 wild rice seedlings and some leaves.</td>
</tr>
<tr>
<td>5</td>
<td>147</td>
<td>6/25/19</td>
<td>Positive control</td>
<td>20 inches</td>
<td>15.7 cm</td>
<td>Brown, smelly, organic muck. 2 wild rice seedlings.</td>
</tr>
<tr>
<td>6</td>
<td>147</td>
<td>6/25/19</td>
<td>Positive control</td>
<td>20 inches</td>
<td>15.7 cm</td>
<td>Brown, smelly, organic muck. no wild rice.</td>
</tr>
<tr>
<td>7</td>
<td>148</td>
<td>6/25/19</td>
<td>Negative control</td>
<td>18 inches</td>
<td>9.1 cm</td>
<td>Fine detritus, no smell.</td>
</tr>
<tr>
<td>8</td>
<td>148</td>
<td>6/25/19</td>
<td>Negative control</td>
<td>18 inches</td>
<td>9.1 cm</td>
<td>Fine detritus on top of the core, brown muddy soil on bottom. Slight smell.</td>
</tr>
<tr>
<td>9</td>
<td>149</td>
<td>6/25/19</td>
<td>Test</td>
<td>33 inches</td>
<td>13.2 cm</td>
<td>Sandy</td>
</tr>
<tr>
<td>10</td>
<td>149</td>
<td>6/25/19</td>
<td>Test</td>
<td>33 inches</td>
<td>13.2 cm</td>
<td>Sandy and rocky</td>
</tr>
<tr>
<td>11</td>
<td>149</td>
<td>6/25/19</td>
<td>Test</td>
<td>33 inches</td>
<td>13.2 cm</td>
<td>Fine detritus and muck.</td>
</tr>
<tr>
<td>12</td>
<td>149</td>
<td>6/25/19</td>
<td>Test</td>
<td>33 inches</td>
<td>13.2 cm</td>
<td>Organic muck</td>
</tr>
</tbody>
</table>
Figure 3. Allouez Bay 2019 sample sites on Historical Imagery from 2010.
Figure 4. Allouez Bay 2019 sample sites on Historical Imagery from 2015