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Sanford Lake – Initial Mussel Report for Four Lakes Task Force

D. Woolnough and D. Zanatta
Central Michigan University, Biology Department and Institute for Great Lakes Research

With the ever-increasing human impacts on biodiversity one group of organisms most impacted by human disturbances are native freshwater mussels (unionids, sometimes referred to as clams). When declines in native mussel populations are detected they are often considered 'canaries in the coalmine' for freshwater ecosystems, giving the advanced warning of other ecosystem concerns to follow. Currently, 72% of the approximately 300 species of freshwater mussels native to North America are considered endangered, threatened, or need protection predominately due to human actions (Downing et al. 2010). With over 300 species of freshwater mussels in North America and 43 species in Michigan, they are very diverse with variable host use, brood time and habitat use. Native mussels can be found in a variety of habitats from rivers, lakes, backwaters and wetlands. Of the 43 species of freshwater mussels in Michigan, 28 of these species are listed as species of conservation concern (endangered, threatened or special concern) and of those 28, five species are federally endangered (Mulcrone and Rathbun 2020). The threats that have imperiled mussels include habitat destruction, fragmentation, channel modification and introduction of non-endemic mollusks (Downing et al., 2010). In the Great Lakes watersheds, the non-native mollusks that are highlighted as causing extreme declines of native freshwater mussels are the dreissenids (Zebra and Quagga Mussels).

Freshwater mussels are important to aquatic ecosystems because they stabilize stream beds, oxygenate and mix the sediments through burrowing actions and filter large portions of the water column (Haag 2012). Often dominating the biomass of the benthic community, freshwater mussels can filter up to 100% of the water column per day with different species of unionids filtering at different rates and particles of varying type and size (Caldwell et al. 2016). The life cycle of a freshwater mussel involves a parasitic stage on fish which is highly susceptible to disturbances (McMahon 2002). Freshwater mussels require a host fish for development of their larval stage (glochidia), an obligate ectoparasitic relationship (Strayer, 2008) and are directly linked to the fish diversity in the region. Often, when there are more diverse fish communities in freshwater systems there are also correspondingly more diverse mussel communities (Watters 1992) and vice versa; therefore, native mussels provide a direct linkage from the benthic zone of freshwaters to the pelagic (i.e., open water) areas in diverse healthy ecosystems. It is important to note that individual native freshwater mussel do not use any fish as a host fish that swims by, but the relationship can be very specific to one (e.g., specialist mussels) to a few or many (e.g., generalist mussels) host species. With the complex life-cycle of the native mussels, that includes the requirement of using a host fish, it makes native freshwater mussels highly sensitive to rapid changes in their habitats and the environment.

Native freshwater mussels provide important ecological benefits to freshwater systems (Vaughn and Hakenkamp 2001; Vaughn 2010, 2018, Woolnough et al. 2020). These numerous benefits, as mentioned above, include their natural ability to efficiently filter water. Loss of native mussels can result in degradation of water quality leading to negative impacts on ecosystem health, human commercial and recreational uses. As a natural filter feeder, native mussels are known (in the Great Lakes region) to filter and remove many chemicals from the water column including personal care products, pharmaceuticals

and pesticides (Woolnough et al. 2020). Because some native freshwater mussels have lifespans exceeding 50 years (Haag 2012), these mussels have the ability to hold onto and bury these chemicals into the riverbeds naturally instead of releasing them into the water column; they are long-term water clarifiers. Juvenile mussels are important food sources for some fish (e.g., Freshwater Drum) and larger mussels are a food source for turtles, raccoons, muskrats and otters (Haag 2012) and contribute to the food chain. Mussel shells, both live and dead, serve as habitat for aquatic invertebrates that are food for fish as well as for terrestrial organisms (Allen et al. 2012). For centuries, human cultures have used native mussels for food, their shells for tools and ornamentation and buttons for clothing, and pearls have been gathered from wild mussels for jewelry (Haag 2012).

Mussel kills resulting from catastrophic events similar to the loss of habitat during the failure of Edenville and Sanford dams, can be severely detrimental to the ecosystem. Evidence after mussel kills has shown that there is a nutrient influx and increased productivity due to the nutrients in the water from decomposing mussel bodies. It is estimated that it may take decades to recover full ecosystem function after large mussel die-offs (DuBose et al. 2019).

Large densities of mussels can result in increased water clarity, affecting growth and community composition of plankton and macrophytes helping to provide a healthy aquatic ecosystem (Zieritz et al. 2019). Different species of native freshwater mussels are known to filter different food particles (e.g., algae, bacteria; Nichols and Garling 2000) at varied rates (Malish and Woolnough 2019). Therefore, a diverse native mussel community is thought of as a healthy mussel community that concurrently supports healthy waterways (FMCS 2016). Native freshwater mussels are documented to be one of the most sensitive group of organisms to nutrients and chemicals in aquatic ecosystems and the ‘canary in the coalmine’ moniker for native mussels and the roles they play in the lakes and river ecosystems of Michigan is apt (Vaughn 2018).

Historic data on native freshwater mussel distribution is often lacking in many parts of North America including in the Great Lakes region (FMCS 2016). However, in the Four lakes region there were semi-quantitative studies at 28 sites in the lakes, downstream of dams and in the nearby tributaries from 1979 through 1981 throughout the Upper Tittabawassee watershed (Hoeh and Trdan 1984) when 14 species were found. Up to 22 species of native freshwater mussels have been reported in the Tittabawassee watershed (Mulcrone and Rathbun 2020), however standardized survey protocols (Metcalfe-Smith et al. 2000, Strayer and Smith 2003, Chambers and Woolnough 2018) collecting quantitative data on diversity and density have not been performed in the Four Lakes area. Several of these species (described below) are considered at risk of extirpation from Michigan (special concern, threatened or endangered) and one is listed as endangered under the U.S. Endangered Species Act.

Epioblasma triquetra (Snuffbox) is a federally endangered native freshwater mussel endemic to the United States and Canada and considered globally rare by the International Union for Conservation of Nature Red List (USFWS 2012, COSEWIC 2011, IUCN 2017). Snuffbox have a unique adaptation for capturing and parasitizing its host with glochidia (Caldwell et al. 2016). Gravid Snuffbox females gape to attract and capture (i.e., trap) a host fish. Laboratory host fish tests have found a variety of potential hosts for Snuffbox; recent research at Central Michigan University (CMU) re-confirmed that *Percina caprodes* (Logperch) was a successful host for Snuffbox and for the first time *P. maculata* (Blackside

Darter) was also determined to be a successful host in the Great Lakes region (Caldwell et al. 2016). There are known populations of Snuffbox in Michigan however many populations have low densities and evidence of reproduction is unknown (USFWS 2012). Historical museum records (University of Michigan Museum of Zoology) indicate Snuffbox was also present in the lower Chippewa River and the Salt River, but these have likely been extirpated as recent surveys have failed to detect live Snuffbox and only found empty shells (Chambers et al. 2018). A population of Snuffbox in the Four Lakes would be one of only two that remain in the Lake Huron watershed, with the other in Ontario (Beaver et al. 2019).

General description of mussel community pre-disaster

Hoeh and Trdan (1984) documented 13 native freshwater mussel species alive and one species that was only found as a shell from 1979-1981 in the Upper Tittabawassee watershed. Michigan Natural Features Inventory (MNFI 2021) documents and stores a database of species of concern in the State of Michigan, including mussels by county. MNFI has documented five listed mussel species (four special concern and one threatened) in Gladwin County and 11 listed species in Midland County (four additional special concern, one state endangered species – Black Sandshell – and the Snuffbox mussel that is state and federally endangered). A total of 11 state or federally listed mussel species have been reported from the counties of the Four Lakes region. Michigan Mussels Web App (MMWA 2021) that is a collaboration between MNFI and US Fish and Wildlife Service highlights the regions of the Four Lakes mussel fauna including four species of concern in the Secord Lake headwaters of the Tittabawassee River as well as the same four species of concern in the Tobacco River/West Arm of Wixom Lake and three species of concern in the Smallwood, Wixom and Sanford lake portions of the Tittabawassee River.

Mulcrone and Rathbun (2020) gives an up-to-date account of mussel species distribution across Michigan and they document all species of native mussel present (common and rare) across the state by US Geological Survey Hydrologic Units (HUC Code 8). These HUCs are essentially watershed units that would encompass the entire Tittabawassee River watershed. In the HUC encompassing the Four Lakes region Mulcrone and Rathbun (2020) document the presence of 22 species including the state and federally endangered Snuffbox, state endangered Black Sandshell and Lilliput, state threatened Slippershell, as well as eight species of special concern. This suggests that 22 species is likely the maximum number of species of native freshwater mussels to be found in the Four Lakes region. Past data may not reflect true distribution of mussels since much of Michigan's lakes and rivers have not been thoroughly surveyed using standardized methods (Strayer and Smith 2003). Evidence has shown that in areas where species of mussels are thought to have been extirpated, with increased search effort rare species may still be found alive (Metcalfe-Smith et al. 2000).

There may be live Snuffbox present in the Four Lakes area in Gladwin and Midland Counties because many fresh shells were documented during recent drawdowns of Wixom Lake through the operations of Edenville Dam which would indicate a take (i.e., any act that kills or injures wildlife including habitat alteration or degradation) of Snuffbox under the U.S. Endangered Species Act regulatory definitions. Due to the presence of fresh Snuffbox shells the USFWS has requested evaluation of unionid habitat in the Four Lakes area to prevent future take and assess operational activities that may harm Snuffbox. Other unionids in the region, many of which are also listed as endangered, threatened, or special concern by the State of Michigan, have been similarly influenced by dam operations.

Pre-disaster mussel data, from a variety of sources, are summarized in Table 1 below.

Mussel communities post-dam failure

Rapid dewatering, whether due to natural fluctuations in waters, human-induced changes, or extreme events, is likely to lead to mortality of mollusks due to the water requirements of these organisms, as well as the inability for them to escape to an area that has not dewatered. Research on mussel mortality and survivorship in dewatered areas has often focused in the Southern US due to dewatering and high air and water temperatures causing many mollusk kills in that region (Howells et al. 2000; Randkelev et al. 2018), but is likely what occurred in Wixom and Sanford Lakes and adjacent tributaries as well. Although it should be noted that some studies suggest that changing water levels could aid in unionid survival in areas invaded by Zebra Mussels by allowing the native mussels the ability to burrow and escape, while killing some of the shallow water Zebra Mussels (Bowers and De Szalay 2004). Oxygen and depth can limit areas native freshwater mussels can survive in stagnant waters during times of dewatering or high temperatures (Burlakova and Karateyev 2007). Dewatering, in combination with the of rapid death of mussels, as was the case in Wixom and Sanford Lakes, has the potential to cause failure in ecosystem function and may take years to restore (DuBose et al. 2019).

Erosion and substrate scouring (especially in the former Wixom and Sanford lakes) during the dam failures, may have resulted in major alteration of the areas that mussels previously used as habitat. This unstable and potentially mobile riverbed now present in the historical natural river channels may have destroyed or modified what may have been high quality mussel habitat prior to the dam failures. Surveys during summer low water periods will be needed to investigate habitat use by mussels.

The presence of large numbers of fresh shells are likely the result of the dewatering of the lakes and rapid change from a lake-like impounded state to a free-flowing river. Many of the species inhabiting the former impounded lakes (e.g., genus *Pyganodon* and *Utterbackia*) are well adapted for living in lentic systems and can be found in high densities, but are not typically common in free-flowing systems. Furthermore, many mussel species are fairly plastic in their shell shapes allowing them to inhabit a variety of habitats (lakes, wetlands, rivers; soft or more coarse substrates), however rapid change like what has happened in the Four Lakes are too fast for them to adapt to the new, mostly lotic, system in the former Wixom and Sanford lakes. Surveys are needed to investigate survival in the natural river channels.

Natural channels in the deepest and flowing regions of the Four Lakes was likely potential habitat for the native freshwater mussels and the most diverse area for the mussel fauna prior to dam failures. The mussels that were previously inhabiting the impounded lakes were dominated by lake-specialized species. The natural river channels of Wixom and Sanford lakes may have acted as a refuge (i.e., protection from dewatering) for some of the mussel fauna during relatively slow drawdown or dewatering events of the littoral zones. However, the resulting riverine habitat post- dam failure may no longer be suitable as a temporary refuge during and after lake restoration especially for mussels that would normally inhabit the lake regions with less flow. Surveys are needed to determine what mussel community remains in the natural river channel of Secord, Smallwood, Wixom and Sanford lakes; although Secord and Smallwood lakes were not influenced as much by dewatering, their mussel assemblage could be a natural source for restoring the native mussels in Wixom and Sanford lakes.

Considerable erosion and scouring of the river bed throughout Wixom and Sanford lakes post dam failures likely had the most impact on mussel habitat immediately upstream and downstream of the

dams. These catastrophic events likely scoured, moved or killed all native freshwater mussels in those areas and these may be too logistically challenging and dangerous for future surveys. However, river reaches downstream of dams can be quite good habitat for native mussels regardless of type of dam (e.g., low-head or hydroelectric; Barnett and Woolnough 2021). Where lake habitat has been lost, mussels have died, but the thalweg (deepest portion of the historic river channel) may have maintained the pre-dam-failure diversity of the mussel community in Wixom and Sanford lakes. However, even the riverine portion of Wixom and Sanford lakes is likely impacted by sedimentation and mobile substrates from upstream regions during the dam failure events. Mobile sediments are known to kill native freshwater mussels via smothering. In Wixom and Sanford lakes, prior to the dam failures, there was much more lentic (lake-like) habitat compared to lotic (riverine-flowing) habitat. However, since late May 2020 the systems are essentially all lotic habitat, which has the potential to be good habitat for native freshwater mussels. Any wetted areas in Wixom and Sanford lakes that is logistically feasible to access that is <1 m deep can be surveyed using wading or snorkeling timed or quadrat search methods using (Strayer and Smith 2003) and areas >1 m in depth would require SCUBA for freshwater mussel surveys.

Central Michigan University (CMU) is under contract with the Four Lakes Task Force to design and perform standardized surveys of all four lakes and remaining mussel habitat and assess the status of mussels in the lakes. CMU will be designing studies to document mussel species and populations present post disaster, including the presence of any threatened or endangered species, and also work with the regulatory agencies to address impacts and, if necessary, mitigating factors. CMU will be using college students to aid in surveys by using standardized surveys (e.g., Strayer and Smith 2003) including timed search methodologies that are likely to incorporate SCUBA techniques at randomized locations throughout the lakes. Survey methods will be suitable to detect rare species (e.g., at least 4 person hours, Metcalfe-Smith et al. 2000 and possibly quadrat surveys). CMU has experience with detection and restoration of rare and common mussel species throughout the Great Lakes region and will apply their knowledge to determine the distribution of mussel species in the Four Lakes.

Dr. Daelyn Woolnough CMU website:
https://www.cmich.edu/colleges/se/biology/fac_staff/Pages/Daelyn-A.-Woolnough.aspx
Dr. David Zanatta CMU website:
https://www.cmich.edu/colleges/se/biology/fac_staff/Pages/David-T.-Zanatta.aspx

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Table 1. *Endangered, threatened, special concern, and unlisted native freshwater mussels in the Four Lakes region. (P = present, A = absent during study/documentation). Nomenclature from Mulcrone and Rathbun 2020.*

Scientific Name	Common Name	Listing	1984	2020	Smallwood, Wixom, Sanford Lakes	Tobacco R. Wixom Lake West Arm	Secord Lake	Gladwin Co	Midland Co
Actinonaias ligamentina	Mucket			P					
Alasmidona marginata	Elktoe	MI Special Concern	P	P	P	P	P	1981	2011
Alasmidonta viridis	Slippershell	MI Threatened	P	P	P	P	P	2015	2012
Amblema plicata	Threeridge			P					
Anodontoides ferussacianus	Cylindrical Papershell		P	P					
Cambrarunio (formally Villosa) iris	Rainbow	MI Special Concern		P				1926	2015
Eurynia dilatata	Spike		P	P					
Epioblasma triquetra	Snuffbox	Federally and MI Endangered		P					2009
Fusconaia flava	Wabash Pigtoe		P	P					
Lampsilis cardium	Plain Pocketbook		P	P					
Lampsilis siliquoidea	Fatmucket		P	P					
Lasmigona complanata	White Heelsplitter		P	P					
Lasmigona compressa	Creek Heelsplitter	MI Special Concern	P	P		P	P	1926	2011
Lasmigona costata	Flutedshell	MI Special Concern		P					2015
Leptodea fragilis	Fragile Papershell			P					
Ligumia recta	Black Sandshell	MI Endangered		A					2015
Pleurobema sintoxia	Round Pigtoe	MI Special Concern		P					2011
Ptychobranchus fasciolaris	Kidneyshell	MI Special Concern	P	P					2015
Pygandon grandis	Giant Floater		P	P					
Strophitus undulatus	Creeper		P	P					
Taxolasma parvum	Lilliput	MI Endangered		P					
Truncilla truncata	Deertoe	MI Special Concern		A					2015
Utterbackia imbecillis	Paper Pondshell	MI Special Concern	P	P					
Venustaconcha ellipsiformis	Ellipse	MI Special Concern	P	P	P	P	P	1981	2015
	TOTAL NUMBER OF SPECIES IN SUMMARY		14	22	3	4	4	5	11
		Reference	Hoeh and Trdan 1984	Mulcrone and Rathbun 2020	MMWA 2021	MMWA 2021	MMWA 2021	MNFI 2021	MNFI 2021
		Focus of Data	Entire Community (28 sites Four Lakes Watershed)	General Community in HUC8	Listed Species	Listed Species	Listed Species	Listed Species (year last detected)	Listed Species (year last detected)