Surveys and Monitoring for the Hiawatha National Forest: FY 2013 Progress Report

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Michigan Natural Features Inventory
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Cover photograph: Eckerman Fen, Hiawatha National Forest, Chippewa County, MI, 21 August 2013. Inset photo: Incurvate dragonfly (*Somatochlora incurvata*), from Hickey Creek Truck Trail Fen, Schoolcraft County, 28 August 2013. Photos by David L. Cuthrell

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Niagara Habitat Monitoring – for rare snails and ferns and placement of data loggers (East Unit)

Vegetation monitoring, as outlined in Alternative 2 of the Niagara EIS, was initiated to develop the methodology needed to understand the changes that may occur in karst feature habitat due to vegetation management. Specifically, this monitoring was designed to address microhabitat conditions within karst feature habitat and how those conditions may be affected by vegetation management with respect to changes in light intensity, ground temperature, relative humidity, and moss cover between treated and untreated sites.

After reviewing the monitoring plan and the prescribed timber sales, sites were selected for sampling with the assistance of HNF staff. Sampling plots were circular and 1/10 of an acre (11.3m radius) (James and Shugart 1970). Sampling included the collection of overall plot level and three $1m^2$ plots along the cliff/boulder face where rare ferns typically would be growing or rare landsnails were likely to occur (Figure 1). Overall plot level data, measurements focused on forest structure and species composition. Canopy heights for five canopy dominants were measured. Tree density and composition was measured in two categories tree (dbh ≥ 3.5 inches) and subcanopy (dbh < 3.5 inches). Other overall plot level measurements included percent canopy closure, plant species lists and coarse woody debris (CWD). Percent canopy closure was estimated along the cardinal directions from the plot center. Ocular tube readings of canopy conditions were taken at paced intervals five times in each cardinal direction. The ratio of hits to misses in the ocular tube gave the percentage canopy cover for that plot. No analyses have been completed at this time but data has been summarized

To address the differences that may occur after the different treatments, we sampled at a total of 14 sites (8 Option 2, 6 Control sites). In conjunction with the sampling we placed data loggers at a total of 30 sites (8 reference sites, 8 Option 2, 8 Option 3, and 6 Control sites). Two data loggers were placed at each site at the plot center. One data logger placed at the top of the cliff or boulder recorded temperature and light intensity while a second data logger placed at the base recorded both temperature and relative humidity. All data loggers were placed in the field during July (16-18) and all were collected on August 9, 2013. Data has been offloaded from the devices and is currently being summarized and preliminary analysis will occur shortly.

Figure 1. Vegetation and plot sampling as part of the Niagara Monitoring Project, July 2013, Mackinac Co., MI.

Pitcher's Thistle and Weevil Inventory (East Unit)

Monitoring Pitcher's thistle (*Cirsium pitcheri*) for two invasive weevil species was initially conducted in 2011, both to begin the development of a sampling protocol as well as to initiate periodic assessments of Pitcher's thistle populations for possible infestations. During 2013 we re-visited the largest Pitcher's Thistle site and monitored for the presence of the weevils. This is now particularly important given the discovery of *Larinus planus* (Figure 2) in a Wisconsin Pitcher's thistle population, and several locations in Lower Michigan, as far north as Wilderness State Park in Emmet County. Monitoring was initiated by surveying Pitcher's thistle occurrences known in the Hiawatha Forest eastern unit as identified by polygons supplied by HNF staff. Sampling was conducted by accessing these occurrences and selecting and examining a minimum of 35 flowering plants per sampling site. For each individual selected any observations related to plant damage, herbivory, insect/invertebrate presence or sign, and general vitality. Each flowering head was briefly inspected for weevil presence or damage (e.g. head mining) from weevils or other invertebrates. During 2013 we chose to sample not only on the dunes and associated Pitcher's thistle, we also drove the FS Roads to the north and searched for weevils associated with Canada thistle (*Cirsium arvense*). We inspected over 100 Pitcher's thistle plants and several patches of Canada thistle. In addition, whenever thistles were encountered during all HNF field work activities during 2103 (including marsh thistles, *Cirsium palustre*, bull thistle, *Cirsium vulgare*, and swamp thistle (*Cirsium muticum*) we inspected them for weevils. No target weevils were seen during the 2013 field season in the Upper Peninsula, however we did locate several *Larinus planus* in the Northern Lower Peninsula. Continued monitoring in the HNF is warranted.

Figure 2. *Larinus planus* on Pitcher's thistle, 8 August 2013, Charlevoix State Park, Michigan.

Raptor Nest Checks and Productivity Surveys (East and West Units)

Both the Red-shouldered Hawk (*Buteo lineatus*, state threatened) and Northern Goshawk (*Accipiter gentilis*, special concern) are Regional Forester Sensitive Species (RFSS) with known nesting occurrences within the east and west units of the Hiawatha National Forest (HNF). During the 2013 surveys a total of 116 nests or old nesting territories (62 East, 54 West) were checked for breeding use with a subset of those (active or possibly active nests) visited a second time for nest productivity. Initial nesting surveys (conspecific call playbacks) were conducted during early May 2013 (1st-9th) with productivity surveys (using telescoping fiberglass pole and video camera to inspect nests) during mid June 2013 (9th – 13th). All nesting information was provided to HNF at the completion of the surveys. During the initial survey a total of 30 active RSHA nests were located 9 West, 21 East) and 4 NOGO (0 West, 4 East). The total number of RSHA chicks produced during 2013 was 61 and 80% of the active nests were successful. One reason for the higher than normal nest success rate and increased productivity could be due to the very late Spring which delayed nesting season. Because of this delay, we counted more chicks in the nests but they were younger, which could have over-estimated nest success rates. Nest success is summarized below in table 1.

Table 1. 2013 Season Summary of nesting raptors in the Hiawatha National Forest.

RSHA	Active Nests	Successful Nests	Number of young	young/active	young/ successful	
	30	24	61	2.03	2.54	80 % of nests successful
NOGO	4	2	5	1.25	2.50	50 % of nests successful

Assessment of Proposed Sites for Lakeside Daisy Reintroduction (East Unit)

No activities conducted to date, we need to re-evaluate this project and see how we can be of assistance to the HNF. The activity was identified as one that could take place any time during the project period.

Dwarf Lake Iris Monitoring in Wedens Bay Candidate RNA (West Unit)

In early June 2013, MNFI staff joined Hiawatha NF staff to continue mapping and monitoring populations of the federally threatened dwarf lake iris (*Iris lacustris*) at Wedens Bay Candidate Research Natural Area in Stonington Peninsula, Delta County. GPS points of dwarf lake iris colonies and lists of associated vascular plant species and non-native invasive species (NNIP) were taken during field surveys. MNFI later visited and surveyed a known colony of the state special concern and Regional Forester's Sensitive Species (RFSS) Cooper's milk vetch (*Astragalus neglectus*) near Peninsula Point Lighthouse, resulting in a significant expansion of its mapped occupied habitat and element occurrence (EO) rank.

Groundwater-dependent Ecosystems (GDE) Level I Inventory

In spring 2013, MNFI staff identified approximately 35 peatlands on Hiawatha National Forest lands for potential surveys using high resolution areal imagery and other resources. In August 2013, we performed Level I field inventories of 10 of these peatland sites, including five sites in the eastern unit of the HNF, and five sites in the western unit (Table 2). For each site, we completed a Forest Service GDE Level I Inventory field form. In addition to ecological assessments and vegetation inventories, we conducted meander surveys for T, E, and SC vascular plants and dragonflies.

Surveys resulted in five new element occurrences (EOs) of poor fen, two new EOs of northern fen, and updates of two previously documented patterned fens and one previously documented northern fen (Table 2). We also documented a new population of the state endangered dwarf raspberry (*Rubus acaulis*) in the vicinity of a population first documented in 2010, and collected information to update a previously documented record of the state special concern English sundew (*Drosera anglica*) (Table 2). Surveys failed to detect previously documented occurrences of the state threatened moor rush (*Juncus stygius*), but considerable suitable habitat persists.

Dragonfly surveys at these 10 sites resulted in four new EOs and one EO update (Table 2) for the Incurvate emerald (*Somatochlora incurvata*). In addition, it appears that all 10 sites sampled have good to excellent potential for the dragonfly to occur, and it is very likely with more survey effort all 10 sites will support populations for the Incurvate emerald. Some of the surveys were conducted under less

than optimal conditions for dragonflies and this is one plausible reason why we failed to locate the Incurvate emerald at additional sites.

Following completion of peatland surveys, MNFI staff will complete and distribute Forest Service GDE Level I Inventory field forms, vascular plant species lists, and rare species data to Hiawatha NF staff. After a sufficient number of GDE sites have been surveyed, we plan to work with Hiawatha NF staff to implement Level II monitoring protocols at selected sites representative of a diversity of GDE types.

Table 2. List of GDE Field Survey Sites and Associated Element Occurrences.

Site	Unit	County	Central TRS	EOs
Pointe aux Chenes Patterned Peatland	E	Mackinac	T41N R04W S33	Patterned fen (update); Northern fen (new); Poor fen (new)
St. Ignace – Trout Lake Rail Trail	E	Mackinac	T41N R04W S34	Northern fen (new)
Castle Rock Road	E	Mackinac	T41N R04W S27	Poor fen (new); Incurvate emerald (update)
Eckerman Fens	E	Chippewa	T46N R06W S15	Northern fen (update); Poor fen (new); *Rubus acaulis* (update); Incurvate emerald (new)
Eighteen Mile Lake	W	Delta	T43N R20W S17	Northern fen (new); Incurvate emerald (new)
Hickey Creek Truck Trail	W	Schoolcraft	T45N R17W S10, 11	Poor fen (2; new); Incurvate emerald (new)
Old Plank Road	W	Alger	T44N R19W S20	Poor fen (new); Incurvate emerald (new)
Shingleton Fen	W	Schoolcraft	T45N R17W S5	Patterned fen (update); *Drosera anglica* (update)

Wetland snail habitat and population inventory (East and West Units)

As part of the GDSE project one of the groups we sampled for were land snails that are found in wetland habitats. We sampled snails at all 8 sites visited as part of this project and we recorded very few snails and no listed species as part of GDSE sampling. In addition, we sampled for land snails along East Lake Road in the East Unit of the HNF. The primary goal of these snail surveys was to document the presence/absence of TES land snail species within the proposed East Lake Road Improvement Project area. MNFI targeted species known to occur in the area, including the state endangered land snail (*Vallonia gracilicosta albula*) and the state-threatened land snail (*Euconulus alderi*).

Targeted microhabitats included moss, organic litter, and woody debris on and at the base of limestone boulders, outcrops, cliffs and over shallow limestone bedrock. Samples of organic material were collected by hand, placed in paper bags to facilitate drying, and labeled with date, collectors, latitude and longitude, collection number, bag number, and microhabitat type. Paired samples were collected where necessary, representing both sides of the road. For boulder or cliff habitat types, one sample was taken from the top of the boulder or side of cliff, and one sample was taken at the base of the boulder or cliff. In cases where no boulders or cliffs were present, one sample was taken from the top or side of

a stump or downed log, and one sample was taken at the base. Latitude and longitude of each sample collection site was recorded with handheld GPS units. Photographs of most collection sites were taken.

Samples taken from the tops of boulders, cliffs, stumps, and logs generally consisted of moss with some leaves and coarse organic debris. Samples taken from the bases of these features consisted primarily of leaves and coarse organic debris. Approximately 600-800 ml of organic material was collected with each sample. We collected 12 samples from along this stretch of road. Processing of samples began by drying for approximately 72hrs at 100-110ºF. Samples were then gently sieved through standard wire mesh sieves, sized 8mm, 2mm, 1mm, and 0.25mm. Gastropod shells were picked from each fraction of sieved organic material with the aid of a stereo microscope at 10x power, and a high intensity fiber optic light source. Shells were identified to species using a stereo microscope and light source at 10x-50x power. Numbers of individuals of each species in each sample were recorded. Samples were placed in vials, labeled, and are stored at MNFI.

All 12 samples along East Lake Road contained at least one species of gastropod. The number of each species found in each sample is given in Appendix 1. Rare/listed species found include the state special concern eastern flat-whorl (*Planogyra asteriscus*), special concern honey vertigo (*Vertigo tridentata*), and special concern median striate (*Striatura meridionalis*). Each snail was found at its own unique site, resulting in a total of three rare snail sites along this approximately 14 mile stretch. For a list of all 26 land snail species recorded during 2013 surveys, refer to Appendix 1.

Hine's Emerald Dragonfly Site Visit/Habitat Evaluation (East Unit)

It was discussed at a HED conference call last year that we would be working with Dr. Dan Soluk, professor at South Dakota State University, to test his model of potential HED occupied patches. We offered to help out with the field work, however we never heard back from Dr. Soluk and so this task will have to be re-evaluated. For this reason, limited Hine's emerald dragonfly work was conducted on the forest this past field season.

We visited three known sites including Horseshoe Bay, Martineau Creek SW, and Summerby Swamp. We did not locate any HEDs at the Horseshoe Bay site (small wetland swale immediately along the shoreline) but did locate a new site within this large wetland compex where I observed one male HED. This site is approximately 0.47 miles ESE from where I observed two males hover guarding pools during August of 2012.

Work at Summerby Swamp focused on mapping the cattail patches and establishing a baseline which can be used to periodically assess how quickly cattails are encroaching on northern fen and HED habitat. The mapping has been completed along the roadside north of M-123. I walked the outer edge of the cattails at the site and took GPS points and recorded three categories. Zero was given to a spot where no cattails were present, 1 equaled locations where there were sparse plants, and a number 2 was recorded at points where there were dense cattails. This process can be repeated at other HED sites if this proves useful to site managers.

Mussel Surveys (West Unit)

Eighteen of the 45 unionid mussel species native to Michigan have been documented in the Upper Peninsula (Appendix 2). Data on the current status and distribution of these species is far from

complete. Most surveys for mussels in Michigan have focused on the Lower Peninsula. Though fewer mussel species are found in the Upper Peninsula than the Lower, mussels play an integral role in stream and lake ecosystems, and there is potential for discovering previously undocumented populations of rare species. The ongoing spread of zebra mussels (*Dreissena polymorpha*) through Michigan's lakes and streams has had a dramatic negative effect on native mussels. Results from these surveys provide baseline mussel occurrence data while the Upper Peninsula is still relatively unaffected by zebra mussels. The goal of this survey was to begin to document the current status and distribution of unionid mussel species within the western portion of the Hiawatha National Forest, an area where very little recent or historical information on mussels was available. MNFI surveyed a number of sites in the eastern Upper Peninsula including portions of Hiawatha NF in 2007 (Badra 2010).

Unionid mussel surveys were performed to determine the presence/absence and abundance of each species at each site. A measured search area was used to standardize sampling effort among sites and allow unionid density estimates to be made. Typically 128m2 provides a good compromise between amount of search effort per site and the number of sites to be completed within the timeline of the project. In most cases the search area extends from bank to bank in order to include the widest range of microhabitats. Handheld GPS units were used to document the position of survey sites. Latitude and longitude of each site was recorded.

Live unionids and shells were located with a combination of visual and tactile means. Glass bottom buckets were used to facilitate visual searches. Occasional tactile searches through the substrate were made at sites where primarily visual detection was used to help ensure that buried unionids were not being overlooked. Live individuals were identified to species and planted back into the substrate anterior end down (siphon end up) in the immediate vicinity of where they were found. Shells were also identified to species. Presence/absence was recorded for the invasive exotic zebra mussel (*Dreissena polymorpha*) and Asian clam (*Corbicula fluminea*). When zebra mussels were found attached to live native unionid mussels, the number attached to each was counted. Zebra mussels attached to live unionid mussels were removed by hand before the unionid was placed back in the substrate.

Habitat data were taken to describe and document stream conditions at the time of the surveys. The substrate within each transect was characterized by estimating percent composition of each of the following six particle size classes (diameter); boulder (>256mm), cobble (256-64mm), pebble (64-16mm), gravel (16-2mm), sand (2-0.0625mm), silt/clay (<0.0625) (Hynes 1970). Woody debris, aquatic vegetation, exposed solid clay substrate, and eroded banks were noted when observed. The percentage of the search area with pool, riffle, and run habitat, and a rough assessment of current speed were estimated visually. Conductivity and pH were recorded with an Oakton handheld meter. Alkalinity was measured with a LaMotte kit (model DR-A) and hardness was measured with a Hach kit.

A total of eight native mussel species were found at the 25 sites surveyed. Locations of sites are given in Appendix 3. Shells of the state threatened slippershell (*Alasmidonta viridis*) were found at Site 1 in Big Murphy Creek (Figure 3). Numbers of individuals of each species found are given in Appendix 4.

Physical and chemical habitat measures are provided in Appendix 5. Substrate at Sites 8 and 9 in the Sturgeon River, and Site 11 in the East Branch of the Whitefish River consisted of varying amounts of bedrock slab. At Site 8 the stream bottom was a continuous unbroken bedrock slab that extended the full width of the River. Freshwater sponge with symbiotic algae was common on the bedrock slab. No unionid mussels were found at this site. The substrate at Sites 9 and 11 consisted of broken slabs of

bedrock with pebble, gravel, sand, and silt in the cracks between slabs. Live mussels were found within these sand and gravel filled spaces at Site 9.

Au Train Lake had the highest density of native mussels at 3.84 individuals per m2. It was also the only site with zebra mussels, which had attached to just over 50% of the live unionid mussels found (Figure 4). Infestation rate and intensity for each species are given in Appendix 6. There is now the opportunity to survey native mussel communities within Hiawatha NF lakes and streams before they are impacted by zebra mussel invasion. The native mussel communities in many of these lakes and streams have never been documented.

Without management action, zebra mussels are likely to spread throughout many lakes and some streams in Hiawatha National Forest over the next several years. The primary mode of dispersal for invading zebra mussels is being inadvertently transported on boats, trailers, kayaks, personal water craft, bait buckets, and other gear. The occurrence of zebra mussels in Au Train Lake in 2013 may be one of the first in Hiawatha NF. With the ease and quickness that boats/trailers/gear can be transported from one waterbody to another, zebra mussels are very likely to spread from Au Train Lake to surrounding lakes and streams, unless action is taken. A focused effort to clean watercraft and gear before they are transported from Au Train Lake to other waterbodies could help reduce the spread. Zebra mussels are undoubtedly being transported from areas where they are common (e.g. the Lower Peninsula and Wisconsin) into to the Upper Peninsula and Hiawatha NF.

Figure 3. Cylindrical papershell (*Anodontoides ferussacianus*, upper left), spike (*Elliptio dilatata*), and the state threatened slippershell (*Alasmidonta viridis*, lower right) from Big Murphy Creek (Site 1). photo by Pete Badra

Figure 4. (left) Native unionid mussels from Au Train Lake (Site 20) with zebra mussels attached. Eastern elliptio (*Elliptio crassidens*) top left; fatmucket (*Lampsilis siliquoidea*) middle left; giant floater (*Pyganodon grandis*) bottom left; (Right) Close-up of zebra mussels attached to a native mussel (giant floater, *Pyganodon grandis*) from Au Train Lake (Site 20). photos by Becky Norris

Minimizing the accidental transportation of zebra mussels and their larvae into lakes and streams is crucial. Zebra mussels have free swimming larvae which drift with the current when they are released from the adult. Unlike native unionid mussels which have larvae that are carried upstream to new habitats by fish hosts, zebra mussels have not adapted to invading flowing water/river habitats. Being transported upstream on boats, trailers, bait buckets, etc. is the primary way zebra mussels become, and remain established in river systems. Rivers in Michigan with impoundments and recreational boating are much more prone to being colonized with zebra mussels, while those without boating tend to be zebra mussel free. Education and outreach on reducing the spread of zebra mussels and other aquatic exotic species, such as Michigan Sea Grant's Clean Boats Clean Waters program, may be effective. The posting of educational material at boat ramps and canoe/kayak access points could help spread awareness and contribute to the control of zebra mussels. Use of power washers at high traffic boat access points is another option.

Recommendations for minimizing the spread of zebra mussels and other aquatic exotic species:

1. Inspect and remove any visible mud, plants, fish, or other animals before transporting boats, trailors, canoes, kayaks, fishing tackle, and any other gear.
2. Drain water from boats, motors, trailers, live wells, etc. before transporting them
3. Dry watercraft and equipment for at least five days before using them in a new lake/stream

The ongoing spread of zebra mussels through Michigan has had dramatic negative effects on lake and stream ecosystems including native mussels. Water bodies like the Detroit River and Lake St. Clair in the southern Lower Peninsula, once supported some of the most diverse mussel communities in the state, and have now been largely extirpated by the impact of zebra mussels over the past 25 years.

Bumble Bee Survey protocol/pilot study (East and West Units)

This field season was a pilot study to determine the best method of conducting surveys for bumble bees on the HNF. After collecting bumble bees incidentally while doing other surveys (i.e., GDSE, raptor productivity checks, Pitcher's thistle weevil surveys) we decided to research other ideas for monitoring. In early August we conducted a one day pilot following a protocol that has been established in Maryland and modeled after the North American Breeding Bird Survey. A total of 13 stops yielded bumble bees, which are still being processed and identified. The survey is essentially a road-side survey with stops every ½ mile. See website below for more information:

http://www.slideshare.net/sdroege/bumblebee-roadside-surveys-a-pilot-survey-and-recommendations

We feel this will be a good method to help start to understand the diversity and relative abundance of bumble bees and other pollinators on the HNF, and if enough sampling stations (~ 100-200 stations) are used we will be able to detect changes in the number of bumble bee species and detect declines of a little as 1% to 2%.

Reconcile databases – MNFI/NRIS

MNFI continues to update the Biotics Database after every field season and we have been making changes to web-based subscription access. We are currently reviewing access requirements/rates with several agencies and groups of data users and will be providing the Hiawatha National Forest access to the full shape file level in the very near future. This access is being provided as a direct result of our great working relationship we have established over the past three years and we look forward to continued collaboration on this and future projects!

Literature Cited

Badra, P.J. 2010. Assessment of the status and distribution of native mussels (Unionidae) in Michigan, and results of unionid surveys in the Eastern Upper Peninsula and Huron-Clinton Metroparks. Report number MNFI 2010-11. Report to Michigan Department of Natural Resources and Environment, Water Bureau. Lansing, MI. 71pp.

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Appendix 1. Land snail sampling locations and results from the HNF 2013.

Appendix 1. List of land snails collected as part of surveys, by location, and number per sampling site.

		East Lake Road Waypoints												Pt. Aux Chenes Fen West	Pt. Aux Chenes Fen Middle	Pt. Aux Chenes Fen East	Pt. Aux Chenes Fen Near Trail Road	Trout Lake Rail Trail West	Trout Lake Rail Trail East	Eckerman S. Fens	Hickey Creek Truck Trail South	Hickey Creek Truck Trail South	Eighteen Mile Lake Fen	Hickey Creek Truck Trail North	Old Plank Road
Species		44	45	46	47	48	49	177	178	179	180	183	185	145	148	150	151	153	154	159	227	236	239	290	328
Anguispira alternata		1																							
Carychium exiguum			2																						
Cochlicopa lubrica		12	3	36	112	6	1																		
Cochlicopa morseana		1	4	2																					
Cochlicopa sp. (young)			2																						
Columella edentula		5	1																						
Discus catskillensis		24	29	3	9	2	4			2															
Euconulus chersinus						1	1																		
Euconulus fulvus		2	3*	1	1		1			1															
Euconulus sp. (young)		1				2																			
Glyphyalinia indentata					2	1	1																		
Glyphyalinia sp. (broken shells)		2					4																		
Glyphyalinia wheatleyi			1			9				1													1		
Helicodiscus parallelus		7	2	4	3	13			1																
Helicodiscus sp. (young)		6	2				5	1																	
Nesovitrea binneyana (=Glyphyalinia)		4	2		1	5	1	4				1													
Paravitrea multidentata		7	5		5																				
Planogyra asteriscus	SC								1																
Punctum minutissimum			2																						
Pupillidae young (possibliy *Vertigo*)								3		2	2		5												

		East Lake Road Waypoints												Pt. Aux Chenes Fen West	Pt. Aux Chenes Fen Middle	Pt. Aux Chenes Fen East	Pt. Aux Chenes Fen Near Trail Road	Trout Lake Rail Trail West	Trout Lake Rail Trail East	Eckerman S. Fens	Hickey Creek Truck Trail South	Hickey Creek Truck Trail South	Eighteen Mile Lake Fen	Hickey Creek Truck Trail North	Old Plank Road
Striatura exigua		7	1	1	12	2		12					3	3	1	1	2								
Striatura ferrea		3	2											2	4	1			1						
Striatura meridionalis	SC		4																						
Striatura milium		1	2			6	1	1				1													
Strobilops labyrinthicus		5	8	1	13	37	17	6	9	22	12		5												
Strobilops sp. (broken shells)											4														
Vertigo gouldi		12	8	2	1	50	2						3												
Vertigo gouldi paradoxa												1													
Vertigo tridentata	SC												1												
young *Vertigo* or *Columella edentula*		10	5						1							1									
Vitrina angelicae		2		2				2		1															
Zoogenetes harpa		2	2		13																				

Appendix 2. Native freshwater mussels (Unionidae) found in Michigan. Species found in the western portion of Hiawatha NF during this study, and species known to occur in the Upper Peninsula are noted.

Species	Common name	Found in this study	Known to occur in the UP	State status	Federal status
Actinonaias ligamentina	Mucket		x		
Alasmidonta marginata	Elktoe		x	SC	
Alasmidonta viridis	Slippershell	x	x	T	
Amblema plicata	Threeridge		x		
Anodontoides ferussacianus	Cylindrical papershell	x	x		
Cyclonaias tuberculata	Purple wartyback		x	T	
Elliptio complanata	Eastern elliptio	x	x		
Elliptio crassidens	Elephant-ear				
Elliptio dilatata	Spike	x	x		
Epioblasma obliquata perobliqua	White catspaw			E	E
Epioblasma torulosa rangiana	Northern riffleshell			E	E
Epioblasma triquetra	Snuffbox			E	E
Fusconaia flava	Wabash pigtoe		x		
Lampsilis fasciola	Wavy-rayed lampmussel			T	
Lampsilis siliquoidea	Fatmucket	x	x		
Lampsilis ventricosa	Pocketbook		x		
Lasmigona complanata	White heelsplitter				
Lasmigona compressa	Creek heelsplitter	x	x		
Lasmigona costata	Fluted-shell		x		
Leptodea fragilis	Fragile papershell				
Leptodea leptodon	Scaleshell			SC	E
Ligumia nasuta	Eastern pondmussel			E	
Ligumia recta	Black sandshell		x	E	
Obliquaria reflexa	Three-horned wartyback			E	
Obovaria olivaria	Hickorynut		x	E	
Obovaria subrotunda	Round hickorynut			E	
Pleurobema clava	Clubshell			E	E
Pleurobema sintoxia	Round pigtoe		x	SC	
Potamilus alatus	Pink heelsplitter				
Potamilus ohiensis	Pink papershell			T	
Ptychobranchus fasciolaris	Kidney-shell			SC	
Pyganodon grandis	Giant floater	x	x		
Pyganodon lacustris	Lake floater			SC	
Pyganodon subgibbosa	Lake floater			T	
Quadrula pustulosa	Pimpleback				
Quadrula quadrula	Mapleleaf				
Simpsonaias ambigua	Salamander mussel			E	
Strophitus undulatus	Strange floater	x	x		
Toxolasma lividus	Purple lilliput			E	
Toxolasma parvus	Lilliput			E	
Truncilla donaciformis	Fawnsfoot			T	
Truncilla truncata	Deertoe			SC	
Utterbackia imbecillis	Paper pondshell			SC	
Venustaconcha ellipsiformis	Ellipse			SC	
Villosa fabalis	Rayed bean			E	E
Villosa iris	Rainbow			SC	

Appendix 3. Locations of sites surveyed in Hiawatha National Forest (Summer 2013).

Site #	Waterbody	Access	Latitude (N)	Longitude (W)
1	Big Murphy Creek	FH43	46.07275	-86.46681
2	Big Murphy Creek	449/snowmobile trail	46.06719	-86.43358
3	Indian River	449	46.09152	-86.40982
4	Indian River	Little Indian Rd.	46.18497	-86.49165
5	Little Indian River	Little Indian Rd.	46.19668	-86.52842
6	Sturgeon River	497	45.86770	-86.67968
7	Sturgeon River	2231	45.94270	-86.70630
8	Sturgeon River	H-13	45.98939	-86.68088
9	Sturgeon River	442	46.03882	-86.75334
10	Black Creek	2235	46.06611	-86.74487
11	Whitefish River, E. Branch	2236	46.09180	-86.84832
12	Chicago Lake	Boat access	46.04130	-86.60297
13	Rapid River	US-41	46.02361	-86.97397
14	Chippeny Creek	2428	46.03639	-86.92556
15	Trout Lake (impoundment)	OO-3	46.23780	-86.85793
16	Tributary to Rock River	H-01	46.43509	-86.91906
17	Rock River	H-01	46.42569	-86.91239
18	Rock River	H-01/2276	46.38991	-86.91461
19	Au Train River	2276	46.37663	-86.84343
20	Au Train Lake	2596/Boat access	46.39570	-86.83686
21	Stutts Creek, N. Branch	2251	46.32254	-86.51046
22	Colwell Lake	M-94/western boat access	46.22435	-86.43653
23	Beaton Lake	2246	46.23737	-86.41864
24	Clear Lake	2246/Boat access	46.24436	-86.41501
25	Steuben Lake	Boat access	46.20227	-86.42722

Appendix 3. Locations of sites surveyed in Hiawatha National Forest (Summer 2013).

Appendix 4. Numbers of unionid mussels, relative abundance, and density recorded at each survey site (Summer 2013).

		Big Murphy Creek						Indian River				Little Indian R.		
		1			2			3	4			5		
Common Name	Species	#	RA	D	#	RA	D	#	#	RA	D	#	RA	D
Slippershell	*Alasmidonta viridis* (T)	S(5)										S(1)		
Cylindrical papershell	*Anodontoides ferussacianus*	2	0.50	0.02	1	0.50	0.01							
Eastern elliptio	*Elliptio complanata*													
Spike	*Elliptio dilatata*	2	0.50	0.02								2	1.00	0.02
Fatmucket	*Lampsilis siliquoidea*	S(3)			1	0.50	0.01		S(1)			S(9)		
Creek heelsplitter	*Lasmigona compressa*													
Giant floater	*Pyganodon grandis*				S(1)									
Strange floater	*Strophitus undulatus*													
	Total # individuals and density	4		0.03	2		0.02	0	0		0.00	2		0.02
	# species live	2			2			0	0			1		
	# species live or shell	4			3			0	1			3		
	Area searched (m^2)	128			128			128	128			128		
Asian clam	*Corbicula fluminea*													
Zebra mussel	*Dreissena polymorpha*													

Appendix 4. Numbers of unionid mussels (#), relative abundance (RA), and density (D, indvs./m^2) recorded at each survey site (Summer 2013). Numbers of unionid shells found are given in parentheses(S(#)). Presence/absence of non-native bivalves are noted. (T= State threatened)

	Sturgeon River								Black Creek			Whitefish R., E.Br.	Chicago Lake		
	6	7			8	9			10			11	12		
	#	#	RA	D	#	#	RA	D	#	RA	D	#	#	RA	D
Alasmidonta viridis (T)															
Anodontoides ferussacianus															
Elliptio complanata															
Elliptio dilatata															
Lampsilis siliquoidea		7	1.00	0.05		14	1.00	0.11	2	1.00	0.02				
Lasmigona compressa															
Pyganodon grandis													4	1.00	0.03
Strophitus undulatus															
Total # individuals and density	0	7		0.05	0	14		0.11	2		0.02	0	4		0.03
# species live	0	1			0	1			1			0	1		
# species live or shell	0	1			0	1			1			0*	1		
Area searched (m^2)	128	128			128	128			128			128	128		
Corbicula fluminea															
Dreissena polymorpha															

* One shell fragment was found outside transect.

	Rapid River			Chippeny Creek			Trout Lake	Trib. to Rock R.	Rock River			
	13			14			15	16	17			18
	#	RA	D	#	RA	D	#	#	#	RA	D	#
Alasmidonta viridis (T)												
Anodontoides ferussacianus									1	1.00	0.01	
Elliptio complanata												
Elliptio dilatata												
Lampsilis siliquoidea												
Lasmigona compressa				1	0.50	0.01						
Pyganodon grandis				1	0.50	0.01						
Strophitus undulatus	S*											
Total # individuals and density	0		0.00	2		0.02	0	0	1		0.01	0
# species live	0			2			0	0	1			0
# species live or shell	0			2			0	0	1			0
Area searched (m^2)	206			128			108	128	128			128
Corbicula fluminea												
Dreissena polymorpha												

	Au Train River			Au Train Lake			Stutts Crk., N.Br.	Colwell Lake			Beaton Lake		
	19			20			21	22			23		
	#	RA	D	#	RA	D	#	#	RA	D	#	RA	D
Alasmidonta viridis (T)													
Anodontoides ferussacianus													
Elliptio complanata				62	0.50	1.94							
Elliptio dilatata													
Lampsilis siliquoidea				21	0.17	0.66					3	0.21	0.02
Lasmigona compressa													
Pyganodon grandis	1	1.00	0.01	40	0.33	1.25		10	1.00	0.05	11	0.79	0.06
Strophitus undulatus													
Total # individuals and density	1		0.01	123		3.84	0	10		0.05	14		0.08
# species live	1			3			0	1			2		
# species live or shell	1			3			0	1			2		
Area searched (m^2)	128			32			128	192			172		
Corbicula fluminea													
Dreissena polymorpha				X									

	Clear Lake			Steuben Lake		
	24			25		
	#	RA	D	#	RA	D
Alasmidonta viridis (T)						
Anodontoides ferussacianus						
Elliptio complanata						
Elliptio dilatata						
Lampsilis siliquoidea						
Lasmigona compressa						
Pyganodon grandis	1	1.00	0.01	S(1)		
Strophitus undulatus						
Total # individuals and density	1		0.01	0		0.00
# species live	1			0		
# species live or shell	1			1		
Area searched (m^2)	128			128		
Corbicula fluminea						
Dreissena polymorpha						

Appendix 5. Physical and chemical habitat measures taken at mussel survey sites, including percent pool/riffle/run habitat and percent composition of each substrate size class.

Site #	Waterbody	Approx. Current speed (m/s)	Pool	Riffle	Run	Boulder	Cobble	Pebble	Gravel	Sand	Silt	pH	Conductivity (µS)	Alkalinity (mg/l CaCO3)	Hardness (mg/l)	Water temp. (C)
1	Big Murphy Creek	0.5			100				5	60	35	8.50	193.0	90	140	20.5
2	Big Murphy Creek	0.7			100					75	25	7.98	205.0	92	160	18.9
3	Indian River	0.7			100					100		7.93	199.7	98	120	18.7
4	Indian River	0.7			100		5	30	25	30	10	8.07	188.5	88	120	21.7
	tiny tributary at Site 4											7.90	38.0	184		9.4
5	Little Indian River	0.7			100			15	15	60	10	8.22	184.1	98	120	23.2
6	Sturgeon River	0.5			100					100		7.67	218.0	108	160	20.3
7	Sturgeon River	0.7	10		100	5	15	25	25	25	5	7.88	217.0	104	160	20.9
8	Sturgeon River	0.5		50	50	*				1	1	8.12	196.0	110	120	22.5
9	Sturgeon River	0.7			100	10**	5	1	2	5	2	8.13	182.0	110	140	24.6
10	Black Creek	0.5	30	10	60		15	25	20	30	10	7.47	173.4	80	100	18.5
11	Whitefish River, E. Branch	1		33	67	***	2	20	10	5	3	7.75	291.0	154	200	20.2
12	Chicago Lake	0	100							80	20	7.75	19.7	8	40	22.5
13	Rapid River	0 - 1	90	10		20	40	20	10	10		7.70	393.0	219	240	19.5
14	Chippeny Creek	near 0			100	20	30	7	7	6	30	7.73	361.0	188	300	23.6
15	Trout Lake (impoundment)	0 - 0.66	60	40		10	20	20	20	10	20	7.62	247.0	140	180	19.5
16	Tributary to Rock River	0.2		10	90		20	30	20	20	10	7.75	184.0	100	140	17.7
17	Rock River	0.3			100	20	20	10	10	20	20	7.68	285.0	128	200	17.1
18	Rock River	0.5	5	5	90	10	20	20	10	20	20	8.06	280.0	172	200	17.4
19	Au Train River	0.3			100				5	90	5	8.31	279.0	152	200	18.7
20	Au Train Lake	0	100						10	50	40	8.14	261.0	152	180	23.1
21	Stutts Creek, N. Branch	1		20	80	10	20	30	20	30	10	8.01	216.0	128	120	16.3
22	Colwell Lake	0	100							80	20	8.79	156.2	60	80	21.6
23	Beaton Lake	0	100							70	30	8.44	164.9	84	100	21.4
24	Clear Lake	0	100							80	20	8.54	64.8	35	60	21.0
25	Steuben Lake	0	100							60	40	8.19	161.5	80	100	19.8

* 98% bedrock slab
** 75% bedrock slab
*** 60% bedrock slab

Appendix 5. Physical and chemical habitat measures taken at mussel survey sites, including percent pool/riffle/run habitat and percent composition of each substrate class.

Appendix 6. Zebra mussel (*Dreissena polymorpha*) colonization intensity (zm/u) and frequency (%cu) on native unionid mussels in Au Train Lake (Site 20).

		Au Train Lake		
Species		ucz	zm/u	%cu
Lampsilis siliquoidea	Fatmucket	6	1.40	29
Pyganodon grandis	Giant floater	24	1.90	60
Elliptio complanata	Eastern elliptio	36	1.72	58
	Total	66	1.75	54

Appendix 6. Zebra mussel (*Dreissena polymorpha*) colonization intensity (zm/u) and frequency (%cu) on native unionid mussels in Au Train Lake (Site 20). (ucz = number of unionid mussels colonized by zebra mussels; zm/u = mean number of zebra mussels per colonized unionid mussel; %cu = percentage of unionids colonized by zebra mussels)