Upper Manistee Riparian Corridor Restoration Project
Amphibians, Reptiles and Macroinvertebrates
Inventory Final Report

September 17, 2012

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Acknowledgement: Funding for this project was provided by a Sustain our Great Lakes program grant managed by the National Fish and Wildlife Federation.


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Executive Summary

In May 2010, Herpetological Resource and Management, LLC (HRM) was contracted by Conservation Resource Alliance (CRA) to assess a portion of the Upper Manistee River watershed to: 1) document the presence and distribution of amphibians, reptiles and aquatic macroinvertebrates associated with a proposed stream restoration project, 2) establish sample points and transects for future monitoring following the restoration to assess changes in species composition, and 3) establish baseline data for future comparison to post-restoration wildlife species richness and distribution.

The study was conducted to document species richness, abundance, and distribution. Weather conditions in all years were atypical, with unusually hot, dry weather in spring 2010 and summer 2012 and cold weather in spring 2011 with snow persisting into mid-April. Several impoundments were drawn down between 2010 and 2011 sampling periods, which likely impacted herpetofauna abundance, the number of species present, and habitat use. Despite these challenges, relatively high numbers of herpetofauna species were documented over the three-year assessment. Restoration efforts by CRA were made to maintain and create structure to support herpetofauna post-restoration. After sampling in 2011, the local hydrology was restored to fast-moving gravel-bottom streams with associated floodplain wetlands. By 2012, several of the inundated wetland areas previously sampled were dry, had substantially lower water levels, or had been converted to part of the stream morphology. The following summarizes the findings of this survey:

- Post-restoration, the assessment area has fast-moving streams, seasonally inundated flood plains, backwater ponds, and uplands that support a diverse assemblage of amphibians and reptiles and may serve as an important wildlife corridor.
- Results for both aquatic macroinvertebrate and herpetofauna demonstrate shifts from wetland to riparian communities for the sampled portions of the Flowing Wells River and Upper Manistee River.
- A total of 23 species of amphibians and reptiles were observed during pre-restoration sampling in 2010 and 2011, and 17 species of amphibians and reptiles were observed during post-restoration sampling in 2012.
- The distribution of herpetofaunal activity changed as water levels changed the location of the shoreline. Higher water levels in 2010 and 2011 corresponded to observations further from the centerline of the stream than in 2012 when water levels were lower.
- Northern Leopard Frog (*Rana pipiens*), Green Frog (*Rana clamitans*), and Midland Painted Turtle (*Chrysemys picta marginata*) were observed during pre- and post-restoration surveys in relatively high numbers within the assessment area.
- Rare species including the Blanding’s Turtle (*Emydoidea blandingii*) and Wood Turtle (*Glyptemys insculpta*) were observed during pre- and post-restoration surveys.
- Aquatic macroinvertebrate community composition demonstrated general shifts from taxa that are tolerant of wetland (low dissolved oxygen) and disturbed conditions to those taxa are that may be indicative of high water quality and riverine conditions. Aquatic macroinvertebrates in the Flowing Wells River pre-restoration were represented by 21 families in 10 orders, and post-restoration were represented...
by 12 families in eight orders. In the Upper Manistee River there were 28 families in 12 orders during pre-restoration surveys, and 28 families in 11 orders during post-restoration surveys.

- Both sensitive and tolerant taxa of aquatic macroinvertebrates were documented.

These findings are the result of surveys conducted over three field seasons with atypical weather conditions. While HRM provided a comprehensive assessment of the survey area property, the weather conditions may have influenced the results. The observed species likely do not fully represent the true species composition at the site, which is likely higher than observed. Restoration measures implemented will likely continue to improve overall habitat for herpetofauna and aquatic macroinvertebrate communities that require high quality riverine conditions and maintain habitat for those communities that require marsh and pond conditions. This variety of environments will continue to increase species richness and diversity of communities at the study site. Additional species and trends in habitat use and biodiversity can become apparent through future surveys and monitoring.

This report provides detailed, comprehensive inventories of taxonomic diversity and distribution of the amphibians, reptiles, and aquatic macroinvertebrates that occur within the study area. These results provide a baseline for the assessment of changes in species richness, number of families, distribution, and relative abundance following habitat restoration measures that occurred in spring of 2011. Results of surveys before and after restoration allow for a meaningful comparison of species distribution and species richness to show the efficacy of the project. Surveys included techniques aimed at documenting both common and uncommon species. The results of this survey will provide a point of comparison for future studies and help guide restoration and management decisions.
Introduction

Amphibians, reptiles, and macroinvertebrates are recognized as key bioindicators—gauges of environmental health. These animal groups are highly sensitive to environmental pollutants and habitat disturbances. Their presence, distribution, and relative abundance can be important tools in identifying the need for and success of habitat restoration projects.

The Upper Manistee River is a designated Natural River; however, it has been degraded by decades of trout farming, intensive recreation, and other human activities. Between summer 2011 and spring 2012, restoration efforts included the removal of seven small dams and the implementation of conservation practices, such as the creation of snake hibernacula, placement of basking logs, and the preservation of a lagoon area. The restoration of the natural flow and function of the river and enhancement of adjacent riparian and upland areas was conducted to improve habitat quality. The objectives of restoration efforts were to 1) restore fish passage 2), encourage herpetofauna, macroinvertebrates, and other organisms to utilize the restored habitats, and 3) improve degraded riparian habitat and enhance adjacent uplands.

In May 2010, Herpetological Resource and Management, LLC (HRM) was contracted by Conservation Resource Alliance (CRA) to assess a portion of the Upper Manistee River watershed to document the presence, relative abundance, and distribution of amphibians, reptiles and aquatic macroinvertebrates associated with a stream restoration project. The funding for this project was provided by a Sustain our Great Lakes program grant managed by the National Fish and Wildlife Federation. As part of this assessment, sample points and transects were established that can be used for future monitoring to assess long-term changes in species composition. Monitoring for these groups of organisms was conducted in spring and summer of 2010, 2011, and 2012 to help assess the overall condition prior to and following the habitat restoration. Surveys conducted in 2010 and 2011 provided baseline data on herpetofauna species and invertebrate families present, as well as relative abundance and distribution. These data were compared with data collected in 2012 to demonstrate potential shifts in pre- and post-restoration wildlife communities.
Site Description

The project area is located on the Upper Manistee River watershed located ten miles east of the city of Kalkaska in Kalkaska County, Michigan. The study area included portions of the Upper Manistee River and Flowing Wells River where restoration practices were conducted (Map 1). In 2010 and 2011, the site consisted of a mosaic of wetland and upland habitats including emergent marsh, northern coniferous bottomland forest, inundated shrub swamp, shrub-carr, watercourse, open water, pine plantation, and old field habitat. Following restoration activities, previously inundated wetlands and slow-moving waterways at the study site shifted to fast-moving streams, upland areas, and seasonal wetlands with saturated conditions.

Methodology - Herpetofauna

Herpetofaunal surveys were conducted from May 18 to May 20, 2010; April 29 to April 30, 2011, April 4 to April 6, and June 25 to June 27, 2012. Intensive visual, aural, and capture surveys were conducted along two one-mile line transects with an associated 300-foot buffer (Map 2-3). Transect locations were based on the meander of the rivers: in most places each transect aligned with the centerline of its respective river. Teams of two to six surveyors used a variety of sampling techniques in terrestrial and aquatic habitats.

Each type of aquatic habitat was searched for adult, juvenile, and larval or hatching amphibians and reptiles. Survey techniques included the use of watercraft (Photo 1-2) and traps (baited and unbaited; Photo 3-4). Sampling for aquatic species involved capturing individuals by hand or dip net, observation through binoculars and aural identification of calling frogs.

Time-constrained ground searches were used to inventory terrestrial habitats for evidence of reptiles and amphibians. Techniques used included visual investigation of potential nesting and basking sites, dip-netting, turning over cover materials (logs, boards, debris), visual observations (Photo 5-6), and anuran (frog and toad) calling surveys to assess the species richness, relative abundance, and distribution of resident herpetofauna. Amphibians and reptiles discovered during ground searches were identified by visual characteristics. No voucher samples were collected, but photographs were taken when possible. All survey activities were in accordance with HRM's Scientific Collector’s and Threatened and Endangered Species permits issued by the State of Michigan.

Each positively identified amphibian or reptile was documented. The following data were collected for each record: (1) species; (2) gender (when possible); (3) behavior; and (4) reproductive condition of each individual (if it can be determined). Observation locations were recorded using Trimble® Geo XT GPS Unit and Juno SB units (1-3m accuracy), and mapped using ArcMap 9.3.1®.
Methodology – Aquatic Macroinvertebrates

Macroinvertebrate sampling was conducted on May 20, 2010, April 30, 2011, June 26, 2012, and June 27, 2012. In 2010, three sample points were established along each of the two transects (Map 2-3). In 2011 and 2012, collection of macroinvertebrates was conducted from the sampling locations that were established in 2010. When possible, shallow areas with a gravel or cobble bottom and fairly fast current were selected for sampling. Sampling was conducted from downstream to upstream using D-frame nets (Photo 7). Submerged wood, leaf litter, cobble, and rocks were also sampled because macroinvertebrates often use these structures for foraging and cover. Upon completion of sampling at each location, collected specimens were stored in 95% ethanol for later identification using a microscope. All equipment was cleaned between sites to avoid contamination. The methods used to collect and identify macroinvertebrates were consistent between years.
Results

Herpetofauna

A total of 23 species of amphibians and reptiles were observed during pre-restoration sampling in 2010 and 2011, with 15 in Transect A and 16 in Transect B. Pre-and post-restoration conditions provided wetland conditions suitable for a variety of species of herpetofauna (Photo 8-115). Seventeen species of amphibians and reptiles were observed during post-restoration sampling in 2012, with 13 in Transect A and 12 in Transect B (Table 1-2; Figure 1-3). One additional species of herpetofauna (Wood Turtle, *Glyptemys insculpta*) was documented in 2012 post-restoration that were not observed prior to restoration.

HRM observed the following reptiles and amphibians in 2010 (Tables 1-2): Eastern Garter Snake (*Thamnophis sirtalis sirtalis*) (Photo 116), Northern Water Snake (*Nerodia sipedon sipedon*) (Photo 117), Blue Racer (*Coluber constrictor fuscitinctus*), Eastern Snapping Turtle (*Chelydra serpentina serpentina*) (Photo 118), Midland Painted Turtle (*Chrysemys picta marginata*) (Photo 119), Five-lined Skink (*Plestiodon fasciatus*), Eastern American Toad (*Bufo americanus americanus*), Gray Treefrog (*Hyla versicolor/H. chrysoscelis*), Wood Frog (*Rana sylvatica*), Green Frog (*Rana clamitans melanota*), Northern Leopard Frog (*Rana pipiens*; Photo 120), and Bullfrog (*Rana catesbeiana*). Additional species detected in 2011 include Northern Brown Snake (*Storeria dekayi dekayi*) (Photo 121), Northern Red-bellied Snake (*Storeria occipitomaculata occipitomaculata*) (Photo 121), Northern Ribbon Snake (*Thamnophis sauritus septentrionalis*), Eastern Hog-nosed Snake (*Heterodon platirhinos*) (Photo 122), Red-backed Salamander (*Plethodon cinereus*) (Photo 123), Spotted Salamander (*Ambystoma maculatum*), Blue-spotted Salamanders (*Ambystoma laterale*), Northern Spring Peeper (*Pseudacris crucifer crucifer*), Eastern Spiny Soft-shell Turtle (*Apalone spinifera spinifera*), and Blanding’s Turtle (*Emydoidea blandingii*). Calling surveys also documented breeding activity of Wood Frogs, Northern Spring Peepers, and strong choruses of Leopard Frogs in 2011.

In 2012, during post-restoration surveys the following reptiles and amphibians were observed: Eastern American Toad, Northern Spring Peeper, Wood Frog, Northern Leopard Frog, Green Frog (Photo 124), Spotted Salamander (*Ambystoma maculatum*), Blue spotted Salamander, Red-backed Salamander, Eastern Newt (*Notophthalmus viridescens*), Northern Brown Snake (Photo 125), Northern Red-bellied Snake (Photo 126), Northern Water Snake, Eastern Garter Snake, Five-lined Skink (Photo 127), Wood Turtle (Photo 127-128), Eastern Snapping Turtle, Midland Painted Turtle (Photo 129-131). Species not previously observed were Wood Turtle and Eastern Newt. Observations were made for predated Eastern Snapping Turtle nests (Photo 132), juvenile Midland Painted Turtles, and Green Frog egg masses (Photo 133). Herpetofaunal species not observed post-restoration were Blanding’s Turtle, Eastern Spiny Softshell Turtle, Bullfrog, Eastern Hog-nosed Snake, Blue Racer, Northern Ribbon Snake, and Gray Treefrog.

Based on restored habitat conditions, known species distribution, historic data and species natural history, Eastern Massasauga Rattlesnake (*Sistrurus catenatus*; a species of special concern in Michigan) and the State Threatened Spotted Turtle (*Clemmys guttata*) may occur within the assessment area (Table 1-2). In addition, Ring-necked Snake (*Diadophis punctatus*
edwardsii), and Eastern Smooth Green Snake (Opheodrys vernalis) are likely to occur within the assessment area and are listed as species of greatest conservation need.

Shifts in herpetofaunal species presence and abundance were not dramatic, though distribution changed between pre- and post-restoration activities (Figure 1-3, Map 4-5). The distribution of herpetofauna observations changed with changes in water level (Map 6). Higher water levels in 2010 and 2011 corresponded to observations further from the centerline of the stream than in 2012 when water levels were lower. During post-restoration surveys, pond areas, the canal to the east of Transect A, and the lagoon to the west of Transect B had an influx of observations compared to pre-restoration surveys, whereas fewer observations were made in the southern third of Transect A and the northern third of Transect B during post-restoration sampling than pre-restoration sampling.

Notable changes in distribution and/or abundance were observed for some frog species including Northern Leopard Frog, Green Frog, and Gray Treefrog. Based on visual analysis, Northern Leopard Frogs changed in distribution from an even distribution over the southern end of Transect A and the northern end of transect B, to a group of observations near an impounded pond area east of the middle of Transect A and a few observations along a slow-flowing stream in the northern half of Transect A (Map 7). Transects A and B had decreases in relative abundance of Northern Leopard Frog. Green Frog distribution changed as water levels changed the location of the shoreline (Map 8). Higher water levels in 2010 and 2011 corresponded to Green Frog observations further from the centerline of the stream than in 2012 when water levels were lower. Pre-restoration, observations were concentrated in the southern half of Transect A and the northern half of Transect B, and post-restoration a greater proportion of observations were made in Transect A along wide shallow portions of the stream (Map 6). Transects A and B had decreases in relative abundance of Northern Leopard Frog. Pre-restoration, in May 2010, several Gray Treefrog observations were made in the northern third of Transect B; however, no other Gray Treefrog observations were made in 2011. Thus the lack of observations post-restoration does not necessarily indicate a shift in Gray Treefrog population due to restoration.

Notable changes in distribution and abundance were observed for some turtle species including Midland Painted Turtle and Eastern Snapping Turtle (Map 4, 5, and 9). Midland Painted Turtle observations pre-restoration were distributed relatively evenly over the northern two-thirds of Transect A (Map 9). Post-restoration, Midland Painted Turtle observations shifted to a pond area to the east of the middle of Transect A and to a preserved lagoon area west Transect B. Pre- and post-restoration, Midland Painted Turtle observations were made near to the centerline of Transect A and in inundated wetland areas in Transect B. Post-restoration, several observations were also concentrated in a preserved backwater area in Transect B. Transect B had an increase in relative abundance of Midland Painted Turtles (Figure 2). Eastern Snapping Turtles were observed post-restoration in the same vicinities as they were observed pre-restoration, and increased in relative abundance in post-restoration surveys (Figure 1-3).
Aquatic Macroinvertebrates

During pre-restoration aquatic macroinvertebrate surveys, HRM documented 21 families of aquatic macroinvertebrate within ten orders along Transect A (Photo 136-141; Table 3-4; Figure 4-9). We also encountered 28 families of macroinvertebrate within 11 orders along Transect B. A total of 37 families were recorded between both transects. The orders documented include beetles, caddisflies, clams and mussels, crustaceans, dobsonflies and fishflies, dragonflies and damselflies, flies, leeches, mayflies, snails, stoneflies, and true bugs.

During post-restoration aquatic macroinvertebrate surveys, HRM documented 12 families within 6 orders along Transect A (Table 3, Figure 4-6), and 28 families within 10 orders along Transect B (Table 4, Figure 7-9). A total of 30 families were recorded between both transects. The orders documented include beetles, caddisflies, clams and mussels, crustaceans, dobsonflies and fishflies, dragonflies and damselflies, flies, leeches, mayflies, snails, and true bugs.

At Transect A at sample point 1 (north), pre-restoration surveys detected high relative abundances of Planorbidae (ramshorn snail) and Gyrinidae (whirligig beetle) (Figure 4). Dragon and damselflies (Calopterygidae, broad-winged damselfly; Coenagrionidae, narrow-winged damselfly; Libellulidae, skimmer dragonfly), true bugs (Corixidae, water boatman; Gerridae, water strider; Notonectidae, backswimmer) were also present. During post-restoration surveys, the highest relative abundances were of Amphipoda (scud) and Isopoda (sow bugs), and Physidae (bladder snail) and Sphaeriidae (fingernail clam) were present.

On Transect A, sample point 2 (middle) there were high relative abundances of Hirudinea (leech), Planorbidae (ramshorn snail), and Libellulidae (skimmer dragonfly) detected during pre-restoration surveys (Figure 5). In addition, Chironomidae (non-biting midge), Dixidae (meniscus midge), and Psychodidae (moth fly) were present pre-restoration. A shift in community composition was observed as four of 17 total detected families were identified during pre- and post-restoration surveys. During post-restoration surveys, the highest relative abundances were of Amphipoda (scud) and Isopoda (sow bugs), followed by Amphipoda (scud). Additional families detected during post-restoration surveys were Heptageniidae (mayfly) and Baetidae (mayfly).

On Transect A, sample point 3 (south) there were high relative abundances of Chironomidae (non-biting midge) and Psychodidae (moth fly) detected during pre-restoration sampling (Figure 6). Some families such as Lymnaeidae (pond snail) were detected during pre-restoration conditions but not during post-restoration surveys. This sampling point demonstrated a shift in community as only two of 12 total detected families were identified during pre-restoration surveys.

At Transect B sample point 1 (north), pre-restoration surveys detected several taxa of aquatic macroinvertebrates (Figure 7). A shift in community composition was observed with only eight families observed during pre-restoration surveys and 13 families only detected during post-restoration surveys. During post-restoration surveys, Baetidae (small
minnow mayfly), Brachycentridae (humpless casemaker), Glossosomatidae (rock casemaker), Rhyacophilidae (free-living caddisflies), and Leptoceridae (long-horned casemaker) were observed.

At Transect B sample point 2 (middle), a shift in community composition was observed with four out of 18 total detected families present during pre- and post-restoration surveys (Figure 8). Macroinvertebrate communities present during pre-restoration surveys included Physidae (bladder snail) and Limnephilidae (northern casemaker). Macroinvertebrate communities present during post-restoration surveys included Caenidae (squaregill mayfly), Leptophlebiidae (prong-filled mayfly), and Chironomidae (non-biting midge).

At Transect B sample point 3 (south), during pre-restoration surveys, Ephemeroptera (mayfly) taxa were present (Figure 9). A shift in community composition was observed with four out of 24 total detected families present during pre- and post-restoration surveys. Tricoptera (caddisfly) communities shifted from Hydropsychidae (net spinner caddisfly) and Limnephilidae (northern casemaker) during pre-restoration surveys, to Leptoceridae (long-horn casemaker) and Brachycentridae (humpless casemaker) during post-restoration surveys.
Discussion

Our results demonstrated detectable shifts from wetland to riparian communities for the sampled portions of the Flowing Wells River and Upper Manistee River. Observed amphibian and reptile communities demonstrated high quality water conditions both pre- and post-restoration. Changes in abundance and distribution characterized a shift of the study site from slow-flowing wetland conditions to fast-flowing riverine conditions. Post-restoration conditions provided pond, wet meadow, floodplain, and riverine conditions suitable for a variety of species of herpetofauna (Photo 8-115). A total of 23 species of amphibians and reptiles were observed during pre-restoration sampling in 2010 and 2011, and 17 species of amphibians and reptiles were observed during post-restoration sampling in 2012 (Table 1-2). Seventy percent of potentially occurring species were observed during post-restoration surveys. Post-restoration conditions demonstrated potential for species of special concern such as Eastern Massasauga Rattlesnake and threatened species such as Spotted Turtle to be present. Aquatic macroinvertebrate community composition demonstrated general shifts from taxa that are tolerant of wetland (low dissolved oxygen) and disturbed conditions to those taxa are that may be indicative of clean, flowing stream and riverine conditions (Table 3-4).

These findings are the result of surveys conducted over three field seasons often with atypical weather conditions. While HRM provided a comprehensive assessment of the property, the weather conditions may have influenced the findings, so the observed species likely do not fully represent the true species composition for the assessment area. Although surveys included techniques aimed at documenting both common and uncommon species, several species were only observed one year. It is possible that species that were observed only one year during pre-restoration surveys were not present during post-restoration surveys; however, it is more likely that these species were simply not detected due to low abundance, cryptic habits, or atypical weather conditions. Additional post-restoration surveys would likely glean a better understanding of the true number and relative abundance of amphibian and reptile species and macroinvertebrate families present.

Herpetofauna

Weather conditions in all years were atypical, with unusually hot, dry weather in spring 2010 and summer 2012 and cold weather in spring 2011 with snow persisting into mid-April. Several impoundments were drawn down between 2010 and 2011 sampling periods, which may have negatively impacted herpetofauna abundance and number of species detected in those areas.

Weather conditions in 2010 and 2012 were warmer than typical for mid-May in Northern Michigan, which made surveying for herpetofauna challenging. In 2011, the start of a late spring created favorable conditions for documenting amphibians and some reptiles. In 2010, a total of 13 species of amphibian and reptile were documented, while in 2011, 15 species were documented, and in 2012, a total of 17 species of amphibian and reptile were documented (Table 1-2). Pre-restoration, the site was assessed to potentially support at least 30 species of amphibians and reptiles.
Restoration activities conducted by CRA increased the diversity of habitats at the study site to include riverine and floodplain areas as well as maintain open water and marshes communities. Post-restoration, marsh and open water areas (the lagoon) of the site were determined to support similar species as pre-restoration surveys, such as Blanding’s Turtle and other pond associated species. Riverine and floodplain areas were assessed to support additional species, such as Eastern Massasauga Rattlesnake and Wood Turtle. Detected species richness and distribution and evidence of reproduction (i.e., nests, eggs, young of year) demonstrated the potential of this area to provide critical habitat for foraging, breeding, and development for a number amphibians and reptiles. Since a healthy reptile and amphibian community can indicate high quality ecosystems and high water quality, the post–restoration study site should also provide important habitat for a variety of wildlife.

Observed amphibian distribution during pre-restoration surveys was centered on beaver impoundments, and fewer observations were associated with riparian forested habitats (Map 4). During post-restoration surveys, amphibian observations were centered on pond and slow-flowing areas (Map 5). These observations are consistent with the habitat requirements of most Michigan amphibians. Most species of amphibians in Michigan are associated with ponds, lake edges and wetlands, not the open, flowing water of rivers and streams. The slow-moving water, thick vegetation and food-rich ponds provide foraging grounds and ample cover from predators (Harding 1997). During pre-restoration surveys it was noted that the bottomland forest associated with Flowing Wells River was an impressive, high-quality, relatively undisturbed ecosystem that provided habitat for a number of amphibian species. Restoration activities maintained areas of slow moving open water habitat to provide conditions that support a rich assemblage of amphibians. Even though the observed relative abundance of Green Frog and Northern Leopard Frog at Transect B decreased between pre-and post-restoration, this decrease may not be indicative of the effects of restoration activities. Frogs are known to have extreme changes in abundance from year to year, thus long-term monitoring is necessary to view population trends (Wake 1991). However, these two species are relatively common throughout Michigan, and are likely to remain at the study site for years to come.

Observed reptile species richness in 2010 and 2012 was somewhat low, but this could be attributed in part to very warm conditions during our surveys (Table 1-2, Figure 1-3). Typically, snakes are encountered basking to warm their bodies in May and June. The hot temperatures made basking unnecessary, and reduced the likelihood of visual encounters. In 2011, observed species richness increased likely due to better weather for surveying, and the actual number of species present is likely higher than what has been indicated from limited site visits (Table 1-2).

Five species documented during pre-restoration sampling, Blanding’s Turtle, Northern Leopard Frog, Blue Racer, Eastern Hog-nosed Snake, and Blue-spotted Salamander, are listed as Species of Greatest Conservation Need (SGCN) by the State of Michigan Wildlife Action Plan (Eagle, Hay-Chmielewski et al. 2005) (Table 1-2). The detection of Wood Turtle (listed as a Species of Special Concern and Species of Greatest Conservation Need) during post-restoration sampling indicated possible increased opportunities of habitat utilization for this species. Since shifts in species richness and relative abundance were not dramatic, the lack of detection of other SGCN species during
Post-restoration sampling does not necessarily indicate the absence of these species. Suitable habitats are present for multiple SGCN species not detected in 2012 such as Blue Racer, Eastern Massasauga Rattlesnake and Spotted Turtle, and these habitats will likely continue to increase in quality. Post-restoration conditions should not have reduced the habitat suitability for Eastern Hog-nosed Snake, as this species prefers upland areas. Populations of such species may still be stable, but too little is known about their current status in the State and they may be at risk of becoming threatened. This lack of information may be in part to the cryptic nature of Eastern Hog-nosed Snake.

Post-restoration conditions provide highly suitable habitat for Eastern Massasauga Rattlesnake. The increased area of wet meadow and stands of seasonally inundated speckled alder increase the suitability of the study area to fulfill life requisites for Eastern Massasauga Rattlesnakes. Since there is a nearby known population of Eastern Massasauga Rattlesnake, there is great potential for individuals of this species to colonize the restored site. Continued effort should be made to improve habitat for this Federal Candidate species and targeted monitoring is recommended. In addition, the potential for repatriation of this species to the area could be considered.

**Herpetofauna Species Abstracts**

**Blanding’s Turtle**

In Michigan, Blanding’s Turtle is listed as a Species of Special Concern. While these turtles are considered threatened and even endangered in the more southern portions of their range, they are still locally common in some parts of Michigan. This species requires a mosaic of wetland habitats for their survival. For much of the year, they prefer open water areas with structures such as logs or stumps to bask. Females require well drained soils, usually with southern exposure, for nesting and will travel long distances to locate a suitable nesting location. Hibernation occurs within ponds where the animals burrow into the mud below the frost line. The Blanding’s Turtle has a life span of approximately 80 years, and does not reach sexual maturity until around 20 years of age. Adults have no natural predators, but hatchling and juvenile turtles suffer very high mortality rates. Annual nest predation by predators, especially raccoons, is often 100%. For this reason, it may take one adult female decades to produce enough turtles to replace herself and her mate and thus maintain a stable population. (Harding 1997; Carl H. Ernst 2009).

**Wood Turtle**

Wood Turtle is listed as a Species of Special Concern in Michigan, is protected throughout its range, and is currently being considered for federal protection. It is typically found in association with moving water (streams, creeks, or rivers), although individuals in some populations may wander considerable distances away from water, especially in the warmer months. Wood turtles do best in a mosaic habitat of riparian woods, shrub or berry thickets, swamps and open, grassy areas. This species displays a number of life history traits that make it especially vulnerable to exploitation and habitat alteration by humans. This species is characterized by having a low reproductive rate (low clutch size and/or high nest and hatchling mortality) and delayed sexual maturity, and a long adult reproductive lifespan.
It has been demonstrated that such species have virtually no harvestable surplus in their populations, and any factor (natural or anthropogenic) which reduces the normally high survivorship of older juveniles and mature adults will result in a declining or even extirpated population. Restoration efforts will likely improve habitat for this riverine species. (Harding 1997; Carl H. Ernst 2009).

**Eastern Massasauga Rattlesnake**

Eastern Massasauga Rattlesnake currently faces a population decline because of road mortality resulting from habitat fragmentation as well as direct human persecution. In Michigan, the Massasauga is listed as a Species of Special Concern; however, throughout the remainder of its range it is endangered. It is currently a candidate for Federal protection under the Endangered Species Act. The snake requires fen or marsh type habitat with abundant sedge and grass cover and plenty of sun exposed areas. Additionally, many snakes migrate to upland fields during the reproductive season in order to regulate body temperature and incubate eggs internally. They hibernate underground, typically in crayfish or mammal burrows near the edges of the fen or marsh, where they spend the winter submerged in the groundwater. Other species of herpetofauna are often found sharing the hibernaculum. This snake is extremely shy and secretive, making accurate inventory exceptionally difficult. Appropriate habitat for this species is abundant through the region and known populations are very close to the assessment area (Harding 1997; Holman 2012).

**Spotted Turtle**

This species inhabits shallow ponds, wet meadows, tamarack swamps, bogs, fens, marsh channels, sphagnum seepages, and slow streams. Spotted Turtle are most likely to be found in clear, shallow water with mud or muck bottom and ample aquatic and emergent vegetation. These turtles will travel over land, and can move long distances during mating season. These turtles are relatively small, with adults ranging 3-6” in carapace length, and are patterned by small yellow spots on a smooth black shell. Spotted Turtle populations have suffered from loss of critical habitats, raccoon predation, and collection for the pet trade. In mid-June nesting occurs in well-drained soil or grassy areas, and eggs hatch 2-3 months later (Harding 1997; Holman 2012).

**Blue Racer**

Blue Racer prefer areas that are dry and sunny with access to cover, including shrubby fence lines, old fields, hedgerows, thickets, open forest, and woodland edges. This species also inhabits moist areas, including grassy lake edges and marshes. Coloration of Blue Racer varies between individuals from gray to blue to brown above, and light blue or cream on the belly. Hatchlings are 7-14”, and adults can reach over 6’ in length. These snakes eat a varied diet, including insects, spiders, frogs, salamanders, small turtles, lizards, snakes, birds, bird eggs, mice and other small rodents. Blue Racers are non-venomous, and will often escape when danger is detected. However, if cornered these snakes will coil and strike as well as release a foul-smelling musk. Females nest in June and July, and eggs hatch in August or early September (Harding 1997; Holman 2012).
Aquatic macroinvertebrate community composition was likely affected by pre- and post-restoration conditions. The sampling points along Transect A and B during pre-restoration surveys were all located where standing water was present and little to no water flow was apparent (Map 2). This lack of water movement likely created conditions with low concentrations of dissolved oxygen in the water. During post-restoration surveys the water level at aquatic macroinvertebrate sampling points was lower, and the exact location of some sampling points (i.e., Flowing Wells sample point 1, north; Upper Manistee sample point 1, north) had no standing water. The samples associated with each sampling point were collected at the nearest location towards the center-lines of both transects (no more than 15 feet from the original sampling point) where water was present during post-restoration.

The observed shifts in families and detected relative abundance at Transect A and B may represent a shift from a pond to riverine community. Pre-restoration aquatic macroinvertebrate communities sampled along Transect A (Flowing Wells River) and Transect B (Upper Manistee River) included high relative abundances of several taxa that are tolerant of low concentrations of dissolved oxygen common to still waters. Groups that are indicators of high dissolved oxygen levels and good water quality (i.e., stoneflies, Plecoptera; mayflies, Ephemeroptera; scuds, Amphipoda) were also observed during pre-restoration surveys. During post-restoration surveys a greater number and abundance of groups that are indicators of high water quality and high dissolved oxygen concentration (i.e., Ephemeroptera, mayflies; Plecoptera, stoneflies; Trichoptera, caddisflies) and a lower abundance of groups tolerant of low-quality and low dissolved oxygen conditions (i.e., Gastropoda, snails; Rhynchobdellida, leeches) were observed. Even though some macroinvertebrate families indicative of high dissolved oxygen concentrations and high water quality (such as Ephemeroptera; mayfly) were observed only during pre-restoration surveys, these families may have been present during post-restoration surveys, though simply undetected. Variations in weather patterns between years and time of day of sampling may account for changes in detectability of various macroinvertebrate families. The results from post-restoration aquatic macroinvertebrate community surveys indicate that within one year of restoration activities water quality increased and ecological function was moving towards that of a riverine system. Summaries for some of the important orders detected are provided below.

*Aquatic Macroinvertebrate Abstracts*

**Order Plecoptera: Stoneflies**

Stoneflies are among the most sensitive groups of insects to water quality, requiring high levels of dissolved oxygen. The greatest diversity of species occurs in fairly fast-flowing streams where the larvae are scavengers or active predators. Larvae are also food for many birds, game and nongame fish and other animals. Adults are fairly short-lived, generally do not feed, and are comparatively weak fliers, not forming aerial mating swarms like many other aquatic insects. Larvae are generally recognizable by their flattened form, paired cerci, widely spreading legs and armored appearance (Merritt, Cummins et al. 2008).
Order Ephemeroptera: Mayflies

The presence of mayfly larvae is also an extremely important indicator of water quality. The larvae of all species of mayflies are aquatic and are generally very sensitive to water pollution. Since nearly all mayflies are herbivores and/or detritivores, they help to keep the plant life under control as well as contribute to the decomposition of organic matter. They also serve as a valuable food source for birds, fish, and other insects. The short-lived adults do not feed and devote all of their time to swarming, mating, and in some species short upstream migrations. The adult mayflies are easily distinguished from other insects by primitive traits such as their inability to fold their wings flat over their bodies. Larva are often confused with those of damselflies and stoneflies, however they are distinct in that they have single claws, rows of abdominal gills, and in some cases, three cerci (Voshell 2003; Merritt, Cummins et al. 2008).

Order Amphipoda: Scuds

Amphipods are an extremely important benthic organism in a pond community. Not only are they good indicators of water quality, they also play a valuable role in the food chain. Scuds, also called sideswimmers, are able to live in a variety of aquatic environments, including lakes, ponds, streams, brooks and springs. However they require high concentrations of dissolved oxygen as well as unpolluted water. Many species are sensitive to pesticides and heavy metals. While many species of scuds are detritivores, helping to decompose plant and animal matter, some live on aquatic vegetation eating the film of algae, fungi, and bacteria that coats the plant. Aside from preventing detritus from accumulating, amphipods serve as a food source for other invertebrates, amphibians, water birds and fish (Voshell 2003; Merritt, Cummins et al. 2008).

Order Decapoda: Crayfish

Crayfish are another extremely important benthic organism. They are identified by their five pairs of legs and their overall lobster-like appearance. As a species crayfish play an important role in the ecological make up of a freshwater habitat. Crayfish are capable of living in a wide variety of habitats and conditions and because of this occur in a multitude of places. As omnivores crayfish control populations of species such as snails and plant populations found within the river. Crayfish also provide food for several other species including smallmouth bass and water snakes. But besides playing an important role in the habitat, the crayfish can also be used as an indicator species. While tolerant of variable habitat conditions, crayfish are sensitive to many different kinds of pollutants, such as metals, herbicides, and pesticides (Voshell 2003; Merritt, Cummins et al. 2008).

Order Trichoptera: Caddisflies

There are more species of Trichoptera than is in any other aquatic order (Voshell 2003). These insects span a large range of water conditions; however, as most species of Trichoptera live in clean freshwater streams and are sensitive to pollution. High species richness and relative abundance of Trichoptera communities compared to other aquatic macroinvertebrate communities can indicate high quality stream systems. Trichoptera may
fulfill important ecological roles as they facilitate the creation of detritus from vegetation that falls into streams, and are a food source for fish and birds (Voshell 2003; Merritt, Cummins et al. 2008).
Conclusion

The survey conducted by HRM on behalf of CRA within a portion of the Upper Manistee Watershed revealed a shift from wetland to riparian communities. The change in distribution of herpetofaunal activity also corresponded to changes in water levels associated with shifts from inundated wetland to riparian and upland communities. Seventeen amphibian and reptile species, including some rare species, were observed post-restoration. Thirty families of aquatic macroinvertebrates were observed during post-restoration surveys. Aquatic macroinvertebrate community composition demonstrated general shifts from taxa that are tolerant of wetland (low dissolved oxygen) and disturbed conditions to those taxa that are often associated with clean, flowing stream and riverine conditions. Comparisons of amphibian, reptile and aquatic macroinvertebrate communities before and after restoration activities and characteristics of these communities indicate the post-restoration conditions to be high-quality wildlife habitat that can support a variety of sensitive organisms and other wildlife.
Recommendations

Because habitat loss and fragmentation are likely the main factors that contribute to amphibian and reptile population declines in Michigan. Current efforts by CRA to preserve intact and restored habitat is quite possibly the most effective and efficient means of conserving reptile and amphibian communities within this region. To compliment recent restoration efforts, the following recommendations could further reduce impacts to herpetofauna and their habitats and increase habitat suitability for herpetofauna.

1. Create turtle nesting areas at sandy sites on southern-facing stream bank areas. This will help all turtles, but specifically Wood Turtle and Blanding’s Turtle will likely benefit significantly from these sites.

2. Increase basking and cover opportunities by opening portions of the river canopy and placing dead logs and woody debris in the water. Some debris consisting of floating mats of layered leaves and branches can provide additional protection for juvenile turtles, including Wood Turtles and Blanding’s Turtles as well as aquatic snakes such as Northern Water Snakes.

3. Aggressively control exotic and invasive plant species colonization with amphibian and reptile friendly techniques. The risks and benefits and timing of control measures should be thoroughly considered before selecting a control regime. HRM recommends consulting a qualified herpetologist in assisting with developing a management strategy to minimize negative effects on herpetofauna.

4. When possible, avoid the use of fertilizers, pesticides, and herbicides, as these chemical can affect the habitat and the reptile and amphibian species living there.

5. Manage subsidized mesopredator numbers and/or artificially incubate eggs to allow successful recruitment of turtles and snakes.

6. Maintain and enhance wildlife corridors and restore/create new ones at critical locations. This can include placement of or oversizing existing culverts, removal of dams, restoring riparian habitats.

7. Minimize mowed areas to allow herpetofauna safe havens in old field and grassland habitats. If necessary timing mowing for late fall when most herpetofauna are inactive and underground.

8. Provide educational interpretive signage to inform site users about environmentally important areas and about amphibians and reptiles.

9. Continue research of amphibian and reptile communities to document long term trends in population fluctuation and species distribution within restoration area.
Table 1. Amphibian and reptile species observed during surveys in 2010, 2011, and 2012 at the Flowing Wells River (Transect A). Species undetected during post-restoration surveys and are likely to occur under post-restoration conditions are indicated.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Pre-restoration</th>
<th>Post-restoration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2010 Observed</td>
<td>2011 Observed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turtles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blanding's Turtle*</td>
<td><em>Emydoidea blandingii</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eastern Snapping Turtle</td>
<td><em>Chelydra s. serpentina</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midland Painted Turtle</td>
<td><em>Chrysemys picta marginata</em></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Spotted Turtle*</td>
<td><em>Clemmys guttata</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Turtle*</td>
<td><em>Glyptemys insculpta</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snakes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue Racer*</td>
<td><em>Coluber constrictor foxii</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eastern Garter Snake</td>
<td><em>Thamnophis s. sirtalis</em></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Eastern Massasauga Rattlesnake*</td>
<td><em>Sistrurus c. catesicus</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northern Brown Snake</td>
<td><em>Storeria d. dekayi</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northern Ribbon Snake</td>
<td><em>Thamnophis sauritus septentrionalis</em></td>
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</tr>
<tr>
<td>Northern Water Snake</td>
<td><em>Nerodia s. sipedon</em></td>
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<td>X</td>
</tr>
<tr>
<td>Lizards</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Five-lined Skink</td>
<td><em>Plestiodon fasciatus</em></td>
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<td></td>
</tr>
<tr>
<td>Salamanders</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue-spotted Salamander*</td>
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<tr>
<td>Eastern Newt</td>
<td><em>Notobothalamus viridescens</em></td>
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<tr>
<td>Eastern Red-backed Salamander*</td>
<td><em>Plethodon cinereus</em></td>
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</tr>
<tr>
<td>Spotted Salamander*</td>
<td><em>Ambystoma maculatum</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frogs</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Bullfrog</td>
<td><em>Rana catesbeiana</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eastern American Toad</td>
<td><em>Bufo americanus</em></td>
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<td></td>
</tr>
<tr>
<td>Green Frog</td>
<td><em>Rana catesbeiana</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northern Leopard Frog*</td>
<td><em>Rana pipiens</em></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Northern Spring Peeper</td>
<td><em>Pseudacris crucifer</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Frog</td>
<td><em>Rana sylvatica</em></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Table 2. Amphibian and reptile species observed during surveys in 2010, 2011, and 2012 at the Upper Manistee River (Transect B). Species that were undetected during post-restoration surveys and are likely to occur under post-restoration conditions are indicated.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Pre-restoration</th>
<th>Post-restoration</th>
<th>Likely to Occur:</th>
<th>Unobserved</th>
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<tr>
<td></td>
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<td>2011 Observed</td>
<td>2012 Observed</td>
<td></td>
</tr>
<tr>
<td><strong>Turtles</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Eastern Snapping Turtle</td>
<td>Chelydra s. serpentina</td>
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<td>X</td>
<td>X</td>
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<td>Eastern Spiny Softshell Turtle</td>
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<td>Midland Painted Turtle</td>
<td>Chrysemys picta marginata</td>
<td>X</td>
<td>X</td>
<td>X</td>
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</tr>
<tr>
<td>Spotted Turtle*</td>
<td>Clemmys guttata</td>
<td></td>
<td></td>
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<tr>
<td>Wood Turtle*</td>
<td>Glyptemys insculpta</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Snakes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue Racer*</td>
<td>Coluber constrictor foxii</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Eastern Garter Snake</td>
<td>Thamnophis s. sirtalis</td>
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<td>Sistrurus c. catenatus</td>
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<tr>
<td>Northern Brown Snake</td>
<td>Storeria d. dekayi</td>
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<tr>
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<td>Storeria o. occipitomaculata</td>
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<td>Northern Water Snake</td>
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<td>Five-lined Skink</td>
<td>Plestiodon fasciatus</td>
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<td><strong>Frogs</strong></td>
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<td>Eastern American Toad</td>
<td>Bufo americanus</td>
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<td>Rana clamitans</td>
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<td>X</td>
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<tr>
<td>Northern Leopard Frog*</td>
<td>Rana pipiens</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Northern Spring Peeper</td>
<td>Pseudacris crucifer</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Wood Frog</td>
<td>Rana sylvatica</td>
<td>X</td>
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</tbody>
</table>

Table 3. Aquatic macroinvertebrate relative abundance within Flowing Wells River (Transect A). Pre-restoration surveys were conducted in 2010 and 2011, and post-restoration surveys were conducted in 2012.

<table>
<thead>
<tr>
<th>Group</th>
<th>Order*</th>
<th>Family</th>
<th>Common Name</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
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</thead>
<tbody>
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<tr>
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<td>Brachycentridae</td>
<td>Humless Casemaker</td>
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<td>Sphaeriidae</td>
<td>Fingernail Clam</td>
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<td>Unionidae</td>
<td>Eastern Elliptio (Elliptio\ complanata)</td>
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<td>Cambaridae</td>
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<td>Odonata</td>
<td>Calopterygidae</td>
<td>Broad-winged Damselfly</td>
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<td>Goenagrionidae</td>
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<td>Libellulidae</td>
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<td>Flies</td>
<td>Diptera</td>
<td>Chironomidae</td>
<td>Non-biting Midge</td>
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<td>Dixidae</td>
<td>Meniscus Midge</td>
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<td>Psychodidae</td>
<td>Moth Fly</td>
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<td>Glossiphoniida</td>
<td>Leech</td>
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<td>Hirudinea</td>
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<td>Snails</td>
<td>Gastropoda*</td>
<td>Lymnaeidae</td>
<td>Pond Snail</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Snails</td>
<td>Gastropoda*</td>
<td>Physidae</td>
<td>Bladder Snail</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Snails</td>
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<td>Planorbidae</td>
<td>Ramshorn Snail</td>
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<tr>
<td>True Bugs</td>
<td>Hemiptera</td>
<td>Corixidae</td>
<td>Water Boatman</td>
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<td>True Bugs</td>
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<td>Gerridae</td>
<td>Water Strider</td>
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<tr>
<td>True Bugs</td>
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<td>Notonectidae</td>
<td>Backswimmer</td>
<td></td>
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</tbody>
</table>

*Identified to Class because of taxonomic uncertainties as to the Order of these organisms.
Table 4. Aquatic macroinvertebrate relative abundance within Upper Manistee River (Transect B). Pre-restoration surveys were conducted in 2010 and 2011, and post-restoration surveys were conducted in 2012.

<table>
<thead>
<tr>
<th>Group</th>
<th>Order</th>
<th>Family</th>
<th>Common Name</th>
<th>Year</th>
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<td>Dytiscidae</td>
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<td>Elmidae</td>
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<td>Gyrinidae</td>
<td>Whirligig Beetles</td>
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<td>Coleoptera</td>
<td>Haliplidae</td>
<td>Crawling Water Beetles</td>
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<tr>
<td>Caddisflies</td>
<td>Trichoptera</td>
<td>Brachycentridae</td>
<td>Humpless Casemaker</td>
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</tr>
<tr>
<td>Caddisflies</td>
<td>Trichoptera</td>
<td>Glossosomatidae</td>
<td>Rock Casemaker</td>
<td>X</td>
</tr>
<tr>
<td>Caddisflies</td>
<td>Trichoptera</td>
<td>Hydropsychidae</td>
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<td>Leptoterae</td>
<td>Long-Horned Cassmaker</td>
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<td>Limnephilidae</td>
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<tr>
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<td>Free -Living Caddisflies</td>
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<td>Veneroida</td>
<td>Sphaeriidae</td>
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<td>Corydalidae</td>
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<tr>
<td>Dragonflies &amp; Damselflies</td>
<td>Odonata</td>
<td>Aeshnidae</td>
<td>Damer Dragonfly</td>
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</tr>
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<td>Odonata</td>
<td>Calopterygidae</td>
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<td>Odonata</td>
<td>Conenagionidae</td>
<td>Damselfly</td>
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<td>Odonata</td>
<td>Cordulegasteridae</td>
<td>Spiketail Dragonfly</td>
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<tr>
<td>Dragonflies &amp; Damselflies</td>
<td>Odonata</td>
<td>Libellulidae</td>
<td>Skimmer Dragonfly</td>
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<td>Tabanidae</td>
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**Table 4. (Cont.)**

<table>
<thead>
<tr>
<th>Group</th>
<th>Order</th>
<th>Family</th>
<th>Common Name</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
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<td>Lymnaeidae</td>
<td>Pond Snail</td>
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<tr>
<td>Snails</td>
<td>Basommatophora</td>
<td>Physidae</td>
<td>Bladder Snail</td>
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<tr>
<td>Snails</td>
<td>Basommatophora</td>
<td>Planorbidae</td>
<td>Ramshorn Snail</td>
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<td>True Bugs</td>
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<tr>
<td>True Bugs</td>
<td>Hemiptera</td>
<td>Notonectidae</td>
<td>Backswimmers</td>
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</tr>
</tbody>
</table>

*Identified to Class because of taxonomic uncertainties as to the Order of these organisms.*
Figure 1. Amphibian and reptile observed relative abundance pre-restoration in 2010 and 2011 compared with post-restoration in 2012 for Transect A.
Figure 2. Amphibian and reptile observed relative abundance pre-restoration in 2010 and 2011 compared with post-restoration in 2012 for Transect B.
Figure 3. Amphibian and reptile observed relative abundance during pre-restoration surveys in 2010 and 2011 and post-restoration surveys in 2012 for Transect A and B combined.
Figure 4. Observed relative abundance of aquatic macroinvertebrates during pre-restoration surveys in 2010 and 2011 and post-restoration surveys in 2012 at Flowing Wells (Transect A) sample point 1 (north).
Figure 5. Observed relative abundance of aquatic macroinvertebrates during pre-restoration surveys in 2010 and 2011 and post-restoration surveys in 2012 at Flowing Wells (Transect A) sample point 2 (middle).
Figure 6. Observed relative abundance of aquatic macroinvertebrates during pre-restoration surveys in 2010 and 2011 and post-restoration surveys in 2012 at Flowing Wells (Transect A) sample point 3 (south).
Figure 7. Observed relative abundance of aquatic macroinvertebrates during pre-restoration surveys in 2010 and 2011 and post-restoration surveys in 2012 at Upper Manistee (Transect B) sample point 1 (north).
Figure 8. Observed relative abundance of aquatic macroinvertebrates during pre-restoration surveys in 2010 and 2011 and post-restoration surveys in 2012 at Upper Manistee (Transect B) sample point 2 (middle).
Figure 9. Observed relative abundance of aquatic macroinvertebrates during pre-restoration surveys in 2010 and 2011 and post-restoration surveys in 2012 at Upper Manistee (Transect B) sample point 3 (south).
Maps

Map Text

Map 1. Monitoring areas and restoration sites within the Upper Manistee River Watershed survey area in 2012.

Map 2. Sampling points within the Upper Manistee River Watershed survey area in 2010 and 2011.

Map 3. Sampling points within the Upper Manistee River Watershed survey area in 2012.

Map 4. Detected amphibian and reptile species richness and distribution within the survey area in 2010 and 2011.

Map 5. Detected amphibian and reptile species richness and distribution within the survey area in 2012.

Map 6. Detected amphibian and reptile distribution within the survey area during pre-restoration surveys in 2010 and 2011 and during post-restoration surveys in 2012.

Map 7. Detected distribution of Midland Painted Turtle (Chrysemys picta marginata) within the survey area during pre-restoration surveys in 2010 and 2011 and post-restoration surveys in 2012.

Map 8. Detected distribution of Green Frog (Rana clamitans) within the survey area during pre-restoration surveys in 2010 and 2011 and post-restoration surveys in 2012.

Map 9. Detected distribution of Northern Leopard Frog (Rana pipiens) within the survey area during pre-restoration surveys in 2010 and 2011 and post-restoration surveys in 2012.
UMRCRA Study

Map 4 - Detected Amphibian and Reptile Species Richness and Distribution within the Survey Area in 2010 and 2011

Legend
- Blanding's Turtle
- Blue Racer
- Blue-spotted Salamander
- Bullfrog
- Eastern American Toad
- Eastern Garter Snake
- Eastern Hog-nosed Snake
- Eastern Newt
- Eastern Snapping Turtle
- Eastern Spiny Softshell Turtle
- Five-lined Skink
- Gray Treefrog
- Green Frog
- Hybrid Salamander
- Midland Painted Turtle
- Northern Brown Snake
- Northern Leopard Frog
- Northern Red-bellied Snake
- Northern Ribbon Snake
- Northern Spring Peeper
- Northern Water Snake
- Red-backed Salamander
- Spotted Salamander
- Wood Frog

Note: This information is illustrated for general reference purposes only.

Data Source:
Michigan Center for Geographic Information Conservation Resource Alliance
Huron Natural Resources Management GIS Data Library
UMRCRA Study
Map 5 - Detected Amphibian and Reptile Species Richness and Distribution within the Survey Area in 2012

Legend
- Blue-spotted Salamander
- Eastern American Toad
- Eastern Garter Snake
- Eastern Newt
- Eastern Snapping Turtle
- Five-lined Skink
- Green Frog
- Hybrid Salamander
- Midland Painted Turtle
- Northern Brown Snake
- Northern Leopard Frog
- Northern Red-bellied Snake
- Northern Spring Peeper
- Northern Water Snake
- Red-backed Salamander
- Spotted Salamander
- Wood Frog
- Wood Turtle

Note: This information is illustrated for general reference purposes only.

Data Source:
Michigan Center for Geographic Information Conservation Resource Alliance HRM GIS Data Library

[Map showing the distribution of detected amphibian and reptile species with corresponding legend and data source information]
UMRCRA Study
Map 6 - Detected Amphibian and Reptile Distribution within the Survey Area During Pre-restoration Surveys in 2010 and 2011 and During Post-Restoration Surveys in 2012.

Legend
Herpetofauna Observations
- 2010
- 2011
- 2012

Note: This information is illustrated for general reference purposes only.

Data Source:
Michigan Center for Geographic Information
Conservation Resource Alliance
HRM GIS Data Library
UMRCRA Study

Locator Map

Legend
Observations
- 2010
- 2011
- 2012

Note: This information is illustrated for general reference purposes only.

Data Source:
Michigan Center for Geographic Information Conservation Resource Alliance
HRM GIS Data Library
UMRCRA Study

Locator Map

Assessment Site

Legend
Observations
- 2010
- 2011
- 2012

Note: This information is illustrated for general reference purposes only.

Data Source:
Michigan Center for Geographic Information Conservation Resource Alliance HRM GIS Data Library
Photos

Photo 1. HRM team members assessing Flowing Wells stream conditions in the northern portion of Transect A during summer post-restoration surveys.

Photo 2. HRM team member accessing the east branch of the Flowing Wells River on the northern portion of Transect A during summer post-restoration surveys.
Photo 3. HRM team prepping traps to collect turtles during pre-restoration surveys.

Photo 4. Baited funnel trap placed along wetland edge observed during pre-restoration surveys.
Photo 5. Documenting amphibian observation with use of GPS unit during pre-restoration surveys.
Photo 6. Surveying in vegetation for herpetofauna along Upper Manistee riparian habitat during pre-restoration surveys.
Photo 7. HRM team member using a dip net and collection tray to collect aquatic macroinvertebrate samples at a sampling location along Flowing Wells River.

Photo 8. Upper Manistee along assessment area looking north observed during pre-restoration surveys.
Photo 9. Upper Manistee along assessment with sandy bed and abundant available cover observed during pre-restoration surveys.

Photo 10. Wetland seep with iron deposits flowing to river observed during pre-restoration surveys.
Photo 11. Northern bottomland forest with bed of sphagnum moss and sedges observed during pre-restoration surveys.

Photo 12. Northern bottomland forest with bed of sphagnum moss and sedges observed during pre-restoration surveys.
Photo 13. Flooded tussock sedge meadow along Upper Manistee during pre-restoration surveys.

Photo 14. Former beaver pond on Upper Manistee during restoration.
Photo 15. Stream conditions of the middle third of Transect B during post-restoration surveys in early spring 2012. Sandy and silty substrate is present.

Photo 16. Field conditions present at the middle third of Transect B during post-restoration surveys. This area contained fish rearing facility prior to restoration.
Photo 17. Stream conditions at a dam removal site on the portion of the Upper Manistee east of Transect A during post-restoration surveys.

Photo 18. Created snake hibernacula structure created to the northwest of the middle third of Transect B during post-restoration surveys. This series of cavities and tunnels extends approximately eight foot below the surface.
Photo 19. HRM team member using a video-scope to detect snakes in the crevices and tunnels of this created snake hibernacula structure during post-restoration surveys.

Photo 20. Brush pile approximately 200 foot northwest of the middle third of Transect B observed during post-restoration surveys. These piles were created from cleared vegetation as part of restoration efforts and may provide cover for herpetofauna.
Photo 21. Upland conditions of the middle third of Transect B during post-restoration surveys.

Photo 22. Seasonal wetland conditions in the middle third of Transect B during post-restoration surveys.
Photo 23. Stream conditions at the middle third of Transect B after dam removal during post-restoration surveys.

Photo 24. Low water levels at former beaver pond on northern portion of Transect B during post-restoration surveys.
Photo 25. Restored river conditions on Transect B during post-restoration surveys.

Photo 26. A dam/weir structure and sandy area that also provides turtle nesting habitat created on Transect B as part of restoration efforts.
Photo 27. Stream conditions on Transect A during early spring post-restoration surveys.

Photo 28. Stream conditions in the north third of Transect A during early spring post-restoration surveys.
Photo 29. Stream conditions in the north third of Transect A during early spring post-restoration surveys.

Photo 30. Stream conditions at the northern third Transect A during early spring post-restoration surveys.
Photo 31. Stream conditions at the northern third of Transect A during early spring post-restoration surveys.

Photo 32. Stream conditions at the northern third of Transect A during early spring post-restoration surveys.
Photo 33. Stream conditions at the northern third of Transect A during early spring post-restoration surveys.

Photo 34. Stream conditions at the northern third of Transect A during early spring post-restoration surveys.
Photo 35. Stream conditions at the northern third of Transect A during early spring post-restoration surveys.

Photo 36. Stream conditions at the northern third of Transect A during early spring post-restoration surveys.
Photo 37. Stream conditions at the northern third of Transect A during early spring post-restoration surveys.

Photo 38. Stream conditions at the northern third of Transect A during early spring post-restoration surveys.
Photo 39. Stream conditions at the northern third of Transect A during early spring post-restoration surveys.

Photo 40. Stream conditions at the northern third of Transect A during early spring post-restoration surveys.
Photo 41. Stream conditions at the northern third of Transect A during early spring post-restoration surveys.

Photo 42. Created snake hibernacula structure created to the northwest of the middle portion of Transect B during summer post-restoration surveys.
Photo 43. Summer, post-restoration conditions at upland area west of Transect B where there were fish hatchery pools prior to restoration.

Photo 44. Old stumps where Northern Brown Snake (*Storeria d. dekayi*) was observed. These logs were at the north end of the field to the northwest of the middle third of Transect B during post-restoration surveys.
Photo 45. Stream conditions at the middle third of Transect B during summer post-restoration surveys.

Photo 46. Predated Eastern Snapping Turtle (*Chelydra serpentina serpentina*) nests at the middle third of Transect B during summer post-restoration surveys.
Photo 47. Predated Eastern Snapping Turtle (*Chelydra serpentina serpentina*) nests at the middle third of Transect B during summer post-restoration surveys.

Photo 48. Stream conditions at the middle third of Transect B during summer post-restoration surveys.
Photo 49. Stream conditions at the middle third of Transect B during summer post-restoration surveys.

Photo 50. Stream conditions at the middle third of Transect B during summer post-restoration surveys.
Photo 51. Stream conditions at the middle third of Transect B during summer post-restoration surveys.

Photo 52. Stream conditions at the middle third of Transect B during summer post-restoration surveys.
Photo 53. Raccoon tracks on the stream bank at the middle third of Transect B during summer post-restoration surveys.

Photo 54. Flood plain areas along the Upper Manistee River Stream in the lower half of Transect B during summer post-restoration surveys.
Photo 55. Flood plain areas along the Upper Manistee River in the lower half of Transect B during summer post-restoration surveys.

Photo 56. Stream conditions in the southern third of Transect B during summer post-restoration surveys.
Photo 57. Stream conditions in the southern third of Transect B during summer post-restoration surveys.

Photo 58. Stream conditions in the southern third of Transect B during summer post-restoration surveys.
Photo 59. Stream conditions in the southern third of Transect B during summer post-restoration surveys.

Photo 60. Stream conditions in the southern third of Transect B during summer post-restoration surveys.
Photo 61. Stream conditions in the southern third of Transect B during summer post-restoration surveys.

Photo 62. Stream conditions in the southern third of Transect B during summer post-restoration surveys.
Photo 63. Stream conditions in the southern third of Transect B during summer post-restoration surveys.

Photo 64. Stream conditions in the southern third of Transect B during summer post-restoration surveys.
Photo 65. Stream conditions in the southern third of Transect B during summer post-restoration surveys.

Photo 66. Wetland conditions in the northern third of Transect B during summer post-restoration surveys with reduced open water.
Photo 67. Wetland conditions in the northern third of Transect B during summer post-restoration surveys with more channelized flow and ponding.

Photo 68. Wetland conditions in the northern third of Transect B during summer post-restoration surveys showing lower water levels.
Photo 69. Drained wetland conditions in the northern third of Transect B during summer post-restoration surveys.

Photo 70. Wetland conditions in the northern third of Transect B during summer post-restoration surveys with exposed logs and emergent vegetation establishing.
Photo 71. Drained wetland conditions in the northern third of Transect B during summer post-restoration surveys.

Photo 72. Drained wetland conditions in the northern third of Transect B during summer post-restoration surveys.
Photo 73. Flood plain and upland area in the northern third of Transect B during summer post-restoration surveys.

Photo 74. Upland area in the northern third of Transect B during summer post-restoration surveys.
Photo 75. Stream conditions in the middle third of Transect B during post-restoration surveys.

Photo 76. Stream conditions in the middle third of Transect B during post-restoration surveys.
Photo 77. Post-restoration summer conditions at a drained wetland/floodplain area between in the middle third of Transect B. At time of summer surveys this area had fen conditions.

Photo 78. Post-restoration summer conditions at a drained wetland/floodplain area in the middle third of Transect B. At time of summer surveys this area had fen conditions.
Photo 79. Upland conditions west of the middle third of Transect B during post-restoration surveys.

Photo 80. Old wood cover west of the middle third of Transect B where Five-lined Skink (*Plestiodon fasciatus*) during post-restoration surveys.
Photo 81. Five-lined Skink (*Plestiodon fasciatus*) observed west of the middle third of Transect B during post-restoration surveys.

Photo 82. Old wood cover west of the middle third of Transect B where Five-lined Skink (*Plestiodon fasciatus*) during post-restoration surveys.
Photo 83. Conditions in the preserved lagoon/old ox-bow area in the middle third of Transect B during post-restoration surveys.

Photo 84. Wetland conditions in the preserved lagoon/old ox-bow area in the middle third of on Transect B during summer post-restoration surveys.
Photo 85. Upland conditions between the preserved lagoon/old ox-bow area in the middle third of Transect B during post-restoration surveys.

Photo 86. Upland conditions between the preserved lagoon/old ox-bow area in the middle third of Transect B during post-restoration surveys.
Photo 87. Flowing Wells stream conditions in the middle third of Transect A during summer post-restoration surveys.

Photo 88. Flowing Wells stream conditions in the middle third of Transect A during summer post-restoration surveys.
Photo 89. Flowing Wells stream conditions in the middle third of Transect A during summer post-restoration surveys.

Photo 90. Flowing Wells stream conditions in the northern third of Transect A during summer post-restoration surveys.
Photo 91. Flowing Wells stream conditions in the northern third of Transect A during summer post-restoration surveys.

Photo 92. Flowing Wells stream conditions in the northern third of Transect A during summer post-restoration surveys.
Photo 93. Flowing Wells stream conditions in the northern third of Transect A during summer post-restoration surveys.

Photo 94. Flowing Wells stream conditions in the northern third of Transect A during summer post-restoration surveys.
Photo 95. Flowing Wells stream conditions in the northern third of Transect A during summer post-restoration surveys.

Photo 96. Flowing Wells stream conditions in the northern third of Transect A during summer post-restoration surveys.
Photo 97. Flowing Wells stream conditions in the northern third of Transect A during summer post-restoration surveys.

Photo 98. Flowing Wells stream conditions in the northern third of Transect A during summer post-restoration surveys.
Photo 99. Flowing Wells stream conditions in the northern third of Transect A during summer post-restoration surveys.

Photo 100. Flowing Wells stream conditions in the northern third of Transect A during summer post-restoration surveys.
Photo 101. Flowing Wells stream conditions in the northern third of Transect A during summer post-restoration surveys.

Photo 102. Flowing Wells stream conditions in the northern third of Transect A during summer post-restoration surveys.
Photo 103. Flowing Wells stream conditions in the northern third of Transect A during summer post-restoration surveys.

Photo 104. Flowing Wells stream conditions in the northern third of Transect A during summer post-restoration surveys.
Photo 105. Flowing Wells stream conditions in the northern third of Transect A during summer post-restoration surveys.

Photo 106. Flowing Wells conditions in the middle third of Transect A during post-restoration surveys.
Photo 107. Flowing Wells conditions in the middle third of Transect A during summer post-restoration surveys.

Photo 108. Flowing Wells conditions in the middle third of Transect A during summer post-restoration surveys.
Photo 109. Flowing Wells conditions in the middle third of Transect A during summer post-restoration surveys.

Photo 110. Flowing Wells conditions in the middle third of Transect A during summer post-restoration surveys.
Photo 111. Flowing Wells stream conditions in the northern third of Transect A during summer post-restoration surveys.

Photo 112. Wetland and flood plain conditions near Flowing Wells River in the middle third of A during summer post-restoration surveys.
Photo 113. Flowing Wells River bank conditions in the middle third of Transect A during summer post-restoration surveys. Erosion fence provided stability at toe of slope.

Photo 114. Bottomland forest conditions east of Transect A and the east branch of the Upper Manistee River Stream during post-restoration surveys.
Photo 115. Dead cover suitable for snake and skink habitat in an old field area east of Transect A during post-restoration surveys.

Photo 116. Eastern Garter Snake observed basking within assessment area observed during pre-restoration surveys.
Photo 117. Northern Water Snake basking along Upper Manistee during pre-restoration surveys.

Photo 118. Eastern Snapping Turtle found by CRA staff during pre-restoration surveys.
Photo 119. Female Midland Painted Turtle collected in trap during pre-restoration surveys.

Photo 120. Northern Leopard Frog, observed during pre-restoration surveys.
Photo 121. Juvenile Northern Red-bellied Snake and Northern Brown Snake found under log near Upper Manistee during pre-restoration surveys.

Photo 122. Eastern Hog-nosed Snake found by CRA staff during pre-restoration surveys.
Photo 123. Red-backed Salamander (*Plethodon cinereus*) was observed during pre- and post-restoration surveys.

Photo 124. Green Frog (*Rana clamitans*) was observed during summer post-restoration surveys.
Photo 125. Northern Brown Snake (*Storeria d. dekayi*) was observed during summer post-restoration surveys.

Photo 126. Northern Red-bellied Snake (*Storeria o. occipitomaculata*) observed at the north end of the field to the west of Transect B during post-restoration surveys.
Photo 127. Five-lined Skink (*Plestiodon fasciatus*) observed west of Transect B during post-restoration surveys.

Photo 127. Wood Turtle (*Glyptemys insculpta*) observed on southern third Transect B during post-restoration surveys
Photo 128. CRA team member holding the male Wood Turtle (*Glyptemys insculpta*) observed in the southern third of Transect B during post-restoration surveys.
Photo 129. Midland Painted Turtle (*Chrysemys picta marginata*) were observed on Transect A during post-restoration surveys.

Photo 130. Midland Painted Turtles (*Chrysemys picta marginata*) basking on a created log structure in the Flowing Wells River during summer post-restoration surveys.
Photo 131. Over 15 Midland Painted Turtles (*Chrysemys picta marginata*) with their heads just above the water’s surface in the preserved lagoon/old ox-bow area to the southern west of Transect B during post-restoration surveys. Arrows indicate individual turtles.

Photo 132. Predated Eastern Snapping Turtle (*Chelydra s. serpentina*) nest observed on the bank of the restored pond area of Transect A during summer post-restoration surveys.
Photo 133. Green Frog (*Rana clamitans*) egg masses in the preserved lagoon/old ox-bow area of Transect B during post-restoration surveys.

Photo 134. A dragonfly (Order Odonata) observed during summer post-restoration surveys.
Photo 135. An Adult in order Hemiptera in the family Notonectidae. This family of aquatic macroinvertebrate was sampled in Flowing Wells River and the Upper Manistee River during 2012 in post-restoration conditions.

Photo 136. An Adult in order Hemiptera in the family Gerridae. This family of aquatic macroinvertebrate was sampled in Flowing Wells River and the Upper Manistee River during 2012 in post-restoration conditions.
Photo 137. A nymph in order Odonata in the family Coenagrionidae. Adult in order Hemiptera in the family Gerridae. This family of aquatic macroinvertebrate was sampled in Flowing Wells River and the Upper Manistee River during 2012 in post-restoration conditions.

Photo 138. Giant Water Bug collected along Upper Manistee River and released after identification during pre-restoration surveys.
Photo 139. A nymph in order Odonata in the family Libellulidae. Adult in order Hemiptera in the family Gerridae. This family of aquatic macroinvertebrate was sampled in Flowing Wells River and the Upper Manistee River during 2012 in post-restoration conditions.
References