ILLINOIS NATURAL HISTORY SURVEY
PRAIRIE RESEARCH INSTITUTE

Monitoring Translocated Northern Riffleshell and Clubshell in Illinois

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Executive Summary

The recovery plan for the federally-endangered Northern Riffleshell (*Epioblasma rangiana*) and Clubshell (*Pleurobema clava*) listed an objective of establishing viable populations of the species in ten separate river drainages throughout their respective ranges. The recovery plan stated that population augmentations and reintroductions would be needed to achieve this objective, and the Vermilion River (Wabash River drainage) in Illinois was agreed upon as a potential location for reintroduction. Beginning in 2005, Illinois partnered with the U.S. Fish and Wildlife Service and state agencies in Ohio and Pennsylvania and began planning the release of these species into the Vermilion River. The goal was to re-establish self-sustaining Northern Riffleshell and Clubshell populations to their historical ranges in Illinois. A bridge construction project has provided an opportunity for the translocation of both species from Allegheny River, Forest County, Pennsylvania, to the Vermilion River basin, Champaign and Vermilion counties, Illinois. Animals were moved in 2010, 2012, and 2013, and all animals were affixed with passive integrated transponder tags, which have allowed researchers to monitor the animals. To date, 1,349 Northern Riffleshell and 958 Clubshell have been translocated to eight sites in the Vermilion River basin (five in the Middle Fork and three in the Salt Fork). Since the inception of the monitoring program, the detection rate per survey per site has varied from 18% to 100% for the Northern Riffleshell and from 37% to 100% for the Clubshell. Of the individuals encountered and inspected during the duration of the project, 56% of the Northern Riffleshell and 78% of the Clubshell have been alive. This relocation project is being funded, in part, by a natural resource damage assessment settlement (Hegeler Zinc—Lyondell Basell Companies) to the U.S. Fish and Wildlife Service and to the State of Illinois.

Project History

The Northern Riffleshell (*Epioblasma rangiana* – Figure 1) and Clubshell (*Pleurobema clava* – Figure 2) are two federally endangered freshwater mussels. Both were once widespread in the Ohio River and Great Lakes basins but both have experienced significant range reductions during the last century (figures 3 and 4). These range-wide declines are not attributed to one factor, but rather a combination of issues that reduced habitat and water quality, including impoundments, siltation, pollution, stream dredging, in-stream sand and gravel mining, and introduction of exotic species.

The U.S. Fish and Wildlife Service's (USFWS) Northern Riffleshell and Clubshell recovery plan, approved in 1994, identified a recovery objective of establishing viable populations in ten separate river drainages via augmentations and reintroductions (USFWS 1994). Beginning in 2005, natural resource agencies in Illinois partnered with the USFWS and natural resource agencies in Ohio, Pennsylvania, and West Virginia, and began planning the release of Northern Riffleshell and Clubshell into the Vermilion River (Wabash River drainage). Soon thereafter, the USFWS published the Augmentation and Reintroduction Plan for the Clubshell and Northern Riffleshell in Illinois (USFWS 2008). The plan discussed the recovery actions to be implemented for these two listed mussel species with the goal of re-establishing self-sustaining Northern Riffleshell and Clubshell populations to their historical range in Illinois.

A salvage project in Pennsylvania in the Allegheny River has provided an opportunity for the translocation of both species. Tens of thousands of freshwater mussels are being relocated from a section of Pennsylvania's Allegheny River beneath the U.S. Highway 62 (=Hunter Station) Bridge[1] to suitable habitat in Pennsylvania, Illinois, Ohio, and West Virginia. For Illinois, the pilot project began in 2010 when 150 Northern Riffleshell were collected at the Hunter Station Bridge in August by USFWS and Pennsylvania Fish and Boat Commission (PFBC) personnel, quarantined for a month at the Freshwater Mussel Conservation and Research Center at the Columbus Zoo and Aquarium in Ohio, and then translocated to Illinois. Each individual was affixed with a PIT (passive integrated transponder) and plastic shellfish tag (Figure 6). About half of the surviving animals were placed in a gravel riffle in the Salt Fork at the "Richter Tract," which is owned by the University of Illinois (U of I; Table 1; Figure 7). The other portion was moved to a gravel riffle in the Middle Fork River at the Middle Fork River County Forest Preserve ("MFNP"), which is owned by the Champaign County Forest Preserve District (CCFPD; Table 1; Figure 8). These two streams currently support diverse and highly-valued freshwater mussel assemblages, populations of known fish hosts for both species, and have multiple areas in conservation ownership (e.g., Cummings and Mayer 1997; Tiemann et al. 2007; Tiemann 2008).

[1] The U.S. Highway 62 (=Hunter Station) Bridge, which is scheduled for replacement by 2018, is located in Tionesta Township, Forest County, Pennsylvania, about 3 river miles downstream of the town of Tionesta (approximate coordinates of bridge 41.47235°N, 79.49992°W).

An attempt was made to monitor animals seasonally after a PIT tag reader was secured; however, conditions (e.g., weather and water levels) have not always been favorable to allow seasonal monitoring. When surveying for PIT-tagged freshwater mussels, a person carrying a PIT tag receiver wand slowly swept the streambed while walking the stream in a systematic manner (Figure 9). Detected tags are stored in the PIT reader, and data are later downloaded into a database after the sampling period ends. At least one additional sampler snorkeled (or used view buckets) if conditions were favorable[2] and visually examined the streambed for tagged mussels. If an animal was seen, a note was made whether it was alive or dead, and these data were stored in the database after the sampling period concluded. The area sampled includes the area stocked plus a 20-meter buffer, because individuals move or might have been washed downstream. After two years of monitoring the 2010 translocated animals, results (46% detection [Table 1] and 82% "survivorship"[3] [Table 2]) were presented to the USFWS, PFBC, and Illinois Department of Natural Resources (IDNR), and all parties agreed to continued relocation.

During August 2012, about 1,000 Northern Riffleshell and 200 Clubshell were collected from the same site in the Allegheny River (Figure 5) by USFWS, PFBC, IDNR, and Illinois Natural History Survey (INHS) staff. The animals were brought to Illinois and quarantined for two weeks at the INHS Aquatic Research Pond Facilities in Champaign-Urbana (Figure 10). As with the 2010 animals, all individuals were dual tagged, and the surviving animals were divided and placed at two sites in the Salt Fork (tables 1 and 3; figures 6 and 7): the Richter Tract and the Edgewood Farm Land and Water Reserve (= "Smith Property"), which is a private property site enrolled in a IDNR conservation program (Figure 11). Based on the record drought conditions of 2012, it was determined by USFWS, IDNR, and INHS staff that additional translocations should not occur at the MFNP site. Two monitoring events at the Richter Tract and Smith Property and one monitoring ever at the MFNP site occurred after the 2012 released and before

[2] Stream discharge and water temperature has hindered the effectiveness of snorkelers (e.g., Autumn 2013), and we followed the guidelines published by Dunn and Sietman (1997) to not handle (e.g., excavate) freshwater mussels during cold temperatures.

[3] To determine survivability, <10 individuals per site (as encouraged by USFWS) were excavated and examined (live or dead). Some individuals were seen alive at the surface siphoning, whereas other individuals were seen dead at the surface; these animals did not count toward the excavation numbers. Live were returned to point of capture and dead shells were deposited in the Illinois Natural History Survey (INHS) Mollusk Collection Champaign.

the 2013 release (Table 1). Results (45% detection [Table 1] and 71% "survivorship" [Table 2] for Northern Riffleshell and 57% detection [Table 3] and 100% "survivorship" [Table 4] for Clubshell) were again favorable, thus allowing the project to continue with another round of translocations in 2013.

Five additional sites (four in the Middle Fork in the Middle Fork State Fish and Wildlife Area [figures 12-15] and one in the Salt Fork in Kickapoo State Park [Figure 16]) were established in 2013, bringing the total number of sites to eight. During August 2013, 250 Northern Riffleshell and 750 Clubshell were collected from the same site in the Allegheny River (Figure 5) by USFWS, PFBC, IDNR, and INHS staff. The 2013 animals were brought to Illinois and quarantined for five days at the INHS Aquatic Research Pond Facilities (Figure 10), and all individuals were affixed with a PIT tag and a plastic shellfish tag. Each of the new 2013 sites received 50 Northern Riffleshell and 50 Clubshell (tables 1 and 3; figures 12-16). The Richter Tract and Smith Property also received about 250 Clubshell (tables 1 and 3; figures 6 and 7). The new 2013 sites, plus the Richter Tract and Smith Property sites, all have been monitored once since the 2013 release (tables 1-4).

Not only have detection rates been highly variable by site, season, and species (tables 1 and 3), but they also have fluctuated by tag-type and user. Due to budget constraints, our 2010 animals (all Northern Riffleshell) were affixed with leftover 125 kHz tags from an IDNR project (versus the 134 kHz tags purchased from BioMark, Inc., in 2012 and 2013). The 125 kHz tags have a detectability range of ~5 inches, which is significantly less than the ~12 inches of the 134 kHz tags. The Northern Riffleshell is known to burrow into the streambed and vertically migrate throughout the year; therefore, it is likely that some tags were not detectable during certain times. Also, during the course of the project, we have noticed that the relocation bed at both the Richter Tract and the Smith Property had migrated downstream (e.g., the boundaries of both sites had moved ~15 yards downstream), and that there are user differences when surveying (e.g., the speed of person sweeping or the angle at which he/she holds the wand). Tag interference (e.g., tags too close together) can alter the detectability (BioMark, Inc., Sam Breidenbach, personal communication), or some individuals could have been eaten, washed downstream outside of the project area, or had their tag fall off, thus making these animals nearly impossible to detect and further altering our results.

It should be noted that we have seen an increase in the number of dead shells for Northern Riffleshell at the surface during the autumn periods (Table 2) but not many live individuals. Both Northern Riffleshell and Clubshell are known to vertically migrate (Watters et al. 2009), which not only makes excavating difficult, but also can skew "survivorship" (e.g., the number of individuals seen alive versus dead). Most of the dead individuals encountered were older adults (e.g., larger size and more external "growth rings"), and we believe these deaths are due to natural mortality events.

In summary, we have established eight relocation sites in the Vermilion River basin in Champaign and Vermilion counties (Figure 17). A total of 1,349 Northern Riffleshell and 958 Clubshell have been translocated since 2010. Since the inception of the monitoring program, the detection rate per survey per site has varied from 18% to 100% for the Northern Riffleshell and from 37% to 100% for the Clubshell. Of the individuals encountered during the duration of the project, 56% of the Northern Riffleshell and 78% of the Clubshell have been alive. The detection and "survivorship" results from Illinois are similar to those from projects occurring in Ohio (Tom Watters, the Ohio State University, personal communication) and West Virginia (Janet Clayton, West Virginia Department of Natural Resources, personal communication).

Future Plans

This project will be monitored to assess performance of translocations, and is expected to provide benefits identified in the USFWS' recovery plan including establishing viable populations, maintaining genetic variability and potentially reclassifying the species from endangered to threatened. Future plans include regular monitoring of sites several times for the next 2-5 years. Animals will be documented via PIT tag readers and a small percentage will be excavated to assess survival. Depending upon success of the 2013 translocation, USFWS, IDNR, and INHS staff hope to collect more Northern Riffleshell and Clubshell in 2014 to augment the new sites established in 2013, and augment all the sites shortly before in-stream work begins on the Hunter's Station Bridge. Also, a study is set to begin to determine if e-DNA is a viable monitoring tool. Lastly, discussions are still occurring about establishing sites in the North Fork and releasing propagated Northern Riffleshell juveniles or infesting fishes with Northern Riffleshell glochidia.

Acknowledgements

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Appendix 1 – Tables and Figures

Table 1. Detection rates for Northern Riffleshell by site (with stream name) per sampling period. Data are "number detected / maximum number of individuals in the stream at a site at that period." Site information can be found in figures 6-7 and 11-17. "NS" = not sampled, and "-" = sites were not yet established.

	Richter (Salt)	*Smith (Salt)*	*Donut (Salt)*	*MFNP (Middle)*	*Ford (Middle)*	*Horse (Middle)*	*Kennekuk (Middle)*	*Beaver (Middle)*	*Mean*
Summer 2011	39/69	-	-	31/67	-	-	-	-	51%
Autumn 2011	12/66	-	-	28/67	-	-	-	-	30%
Spring 2012	38/66	-	-	NS	-	-	-	-	58%
Summer 2012	35/66	-	-	30/63	-	-	-	-	50%
Autumn 2012	321/555	302/471	-	NS	-	-	-	-	61%
Summer 2013	98/555	222/464	-	13/61	-	-	-	-	29%
Autumn 2013	37/550	235/463	50/50	NS	48/50	50/50	45/50	44/50	76%
Mean	38%	54%	100%	39%	96%	100%	90%	88%	

Table 2. Survival of known fate individuals for Northern Riffleshell by site (with stream name) per sampling period. Data are "number alive / (number alive + number dead)." Site information can be found in figures 6-7 and 11-17. "NS" = not sampled, and "-" = sites were not yet established. *No individuals were excavated during Autumn 2013; all individuals encountered during this time period were at the surface.

	Richter (Salt)	*Smith (Salt)*	*Donut (Salt)*	*MFNP (Middle)*	*Ford (Middle)*	*Horse (Middle)*	*Kennekuk (Middle)*	*Beaver (Middle)*	*Total*
Summer 2011	5/8	-	-	9/9	-	-	-	-	14/17
Autumn 2011	6/6	-	-	15/19	-	-	-	-	21/25
Spring 2012	2/2	-	-	-	-	-	-	-	2/2
Summer 2012	0/0	-	-	4/6	-	-	-	-	4/6
Autumn 2012	3/3	0/7	-	-	-	-	-	-	3/10
Summer 2013	17/22	8/9	-	6/7	-	-	-	-	31/38
Autumn 2013*	0/3	3/21	1/1	-	0/7	2/2	0/3	1/11	7/48
Total	33/44	11/37	1/1	34/41	0/7	2/2	0/3	1/11	82/186

Table 3. Detection rates for Clubshell by site (with stream name) per sampling period. Data are "number detected / maximum number of individuals in the stream at a site at that period." Site information can be found in figures 6-7 and 11-17. "-" = sites were not yet established (e.g., no Clubshell place at MFNP).

	Richter (Salt)	*Smith (Salt)*	*Donut (Salt)*	*MFNP (Middle)*	*Ford (Middle)*	*Horse (Middle)*	*Kennekuk (Middle)*	*Beaver (Middle)*	*Mean*
Summer 2011	-	-	-	-	-	-	-	-	-
Autumn 2011	-	-	-	-	-	-	-	-	-
Spring 2012	-	-	-	-	-	-	-	-	-
Summer 2012	-	-	-	-	-	-	-	-	-
Autumn 2012	73/110	51/91	-	-	-	-	-	-	61%
Summer 2013	41/110	64/91	-	-	-	-	-	-	54%
Autumn 2013	301/368	271/340	50/50	-	46/50	50/50	48/50	49/50	92%
Mean %	62%	69%	100%	-	92%	100%	96%	98%	

Table 4. Survival of known fate individuals for Clubshell by site (with stream name) per sampling period. Data are "number alive / (number alive + number dead)." Site information can be found in figures 6-7 and 11-17. "-" = sites were not yet established (e.g., no Clubshell place at MFNP). *No individuals were excavated during Autumn 2013; all individuals encountered during this time period were at the surface.

	Richter (Salt)	*Smith (Salt)*	*Donut (Salt)*	*MFNP (Middle)*	*Ford (Middle)*	*Horse (Middle)*	*Kennekuk (Middle)*	*Beaver (Middle)*	*Total*
Summer 2011	-	-	-	-	-	-	-	-	-
Autumn 2011	-	-	-	-	-	-	-	-	-
Spring 2012	-	-	-	-	-	-	-	-	-
Summer 2012	-	-	-	-	-	-	-	-	-
Autumn 2012	0/0	0/0	-	-	-	-	-	-	0/0
Summer 2013	5/5	2/2	-	-	-	-	-	-	7/7
Autumn 2013	0/0	0/2	0/0	-	0/0	0/0	0/0	0/0	0/2
Mean %	5/5	2/5	0/0	-	0/0	0/0	0/0	0/0	7/9

Figure 1. Prior to the 2010 release, the Northern Riffleshell (*Epioblasma rangiana*) had not been seen alive in Illinois in approximately 100 years and was considered extirpated from the state (Cummings and Mayer 1997)[4]. Within Illinois, the species was historically known from the Wabash and Vermilion River drainages. The Northern Riffleshell is typically found in medium to large rivers in clean, stable sand, gravel, and cobble riffles, where it can live several inches beneath the streambed surface (Cummings and Mayer 1992; Watters et al. 2009). The species is sexually dimorphic with males (top) more posteriorly pointed compared to females (bottom), which are more oval in profile (Watters et al. 2009). Potential hosts in the Vermilion River basin include Bluebreast Darter (*Etheostoma camurum*), Rainbow Darter (*Etheostoma caeruleum*), and Banded Darter (*Etheostoma zonale*) (Tiemann 2008; Watters et al. 2009; OSUM 2013). Photo courtesy of Kevin Cummings (INHS).

[4] Prior to the time of the 2010 release, Northern Riffleshell was not on Illinois' endangered and threatened species list. Upon the 2010 reintroduction, the species was added to the Illinois List of Endangered and Threatened Species because all federally listed species that occur in the state are automatically listed as Illinois endangered or threatened and added to the Illinois list without notice or public hearing (Illinois Compiled Statutes - 520 ILCS 10/7).

Figure 2. The Clubshell (*Pleurobema clava*) was believed to have been extirpated from Illinois until a single individual was found in the Middle Branch of the North Fork in Vermilion County (Cummings et al. 1998; Szafoni et al. 2000). Within Illinois, the species was historically known from the Wabash and Vermilion River drainages (Cummings and Mayer 1997; Tiemann et al. 2007). The Clubshell is typically found in medium to large rivers in clean, stable sand, gravel, and cobble riffles, where it can live several inches beneath the streambed surface (Cummings and Mayer 1992; Watters et al. 2009). Potential hosts in the Vermilion River basin include Central Stoneroller (*Campostoma anomalum*), Striped Shiner (*Luxilus chrysocephalus*), Blacknose Dace (*Rhinichthys atratulus*), Creek Chub (*Semotilus atromaculatus*), Northern Hogsucker (*Hypentelium nigricans*), Logperch (*Percina caprodes*), and Blackside Darter (*Percina maculata*) (Tiemann 2008; Watters et al. 2009; OSUM 2013). Photo courtesy of Kevin Cummings (INHS).

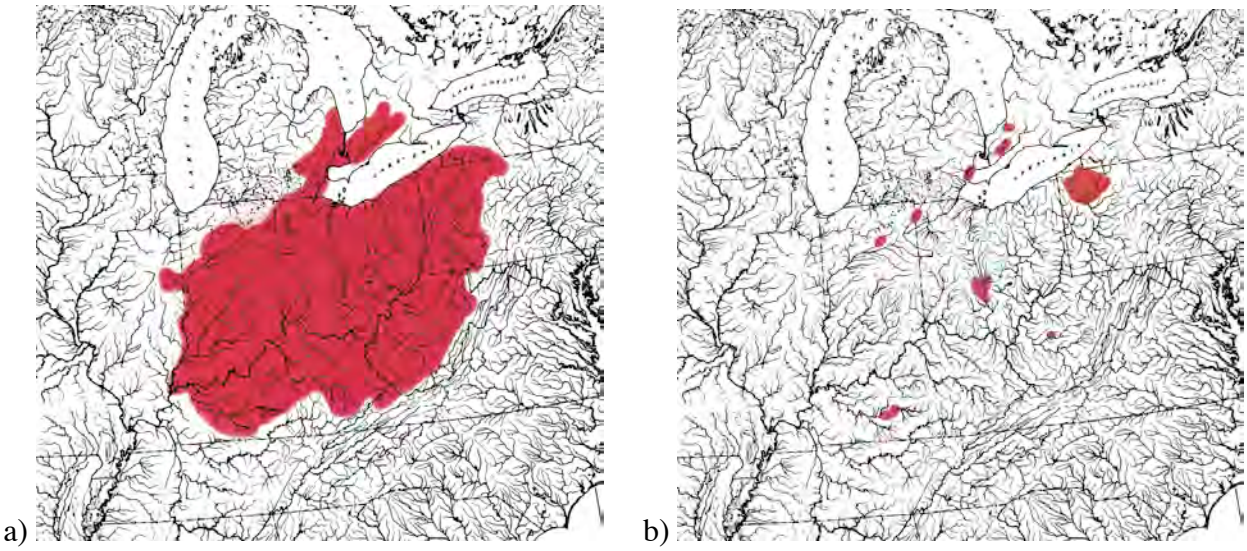

Figure 3. The approximate historic (a) versus current (b) distribution map for the Northern Riffleshell. Data were taken from literature and museum records. Some populations in (b) are functionally extirpated, as not all populations are reproducing.

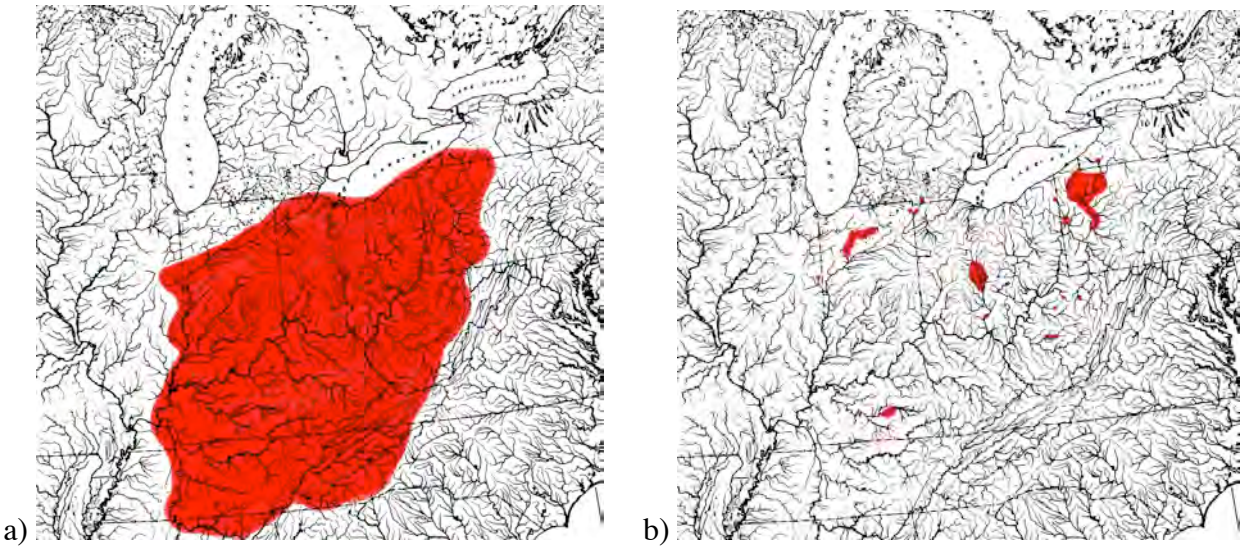

Figure 4. The approximate historic (a) versus current (b) distribution map for the Clubshell. Data were taken from literature and museum records. Some populations in (b) are functionally extirpated, as not all populations are reproducing.

Figure 5. Allegheny River at the U.S. Highway 62 (=Hunter Station) Bridge, Forest County, Pennsylvania, about 3 river miles downstream of the town of Tionesta (approximate coordinates of bridge 41.47235°N, 79.49992°W). Photo courtesy of Kevin Cummings (INHS).

Figure 6. Northern Riffleshell with encased PIT tags (top two mussels) and plastic shellfish tags (bottom three mussels). Both tags were affixed with a "super glue" product and the PIT tags were later covered with marine grade epoxy. Each freshwater mussel had a PIT tag transponder on the right valve and a plastic shellfish tag on the left valve. Each PIT tag has a unique alphanumeric code (up to 13 digits), whereas each shellfish tag is unique when factoring in shape, color, and numeric code (up to four digits). All tags have been databased and contain the following information: PIT tag number and type, plastic shellfish tag number and type, species, sex, length at capture, collection year, origin of mussel, quarantine information, release date and site information, and detection history. Photo courtesy of Robert Szafoni (IDNR).

Figure 7. The Salt Fork re-introduction site at the "Richter Tract." This site is owned by the University of Illinois as a Research Natural Area and is managed by the U of I Committee on Natural Areas (CNA). U of I staff of the CNA and U of I Legal reviewed and approved the action. This portion of the Salt Fork River is also an Illinois Natural Areas Inventory site. This site has the following stocking history: 2010 = 69 Northern Riffleshell; 2012 = 489 Northern Riffleshell and 110 Clubshell; 2013 = 258 Clubshell. Photo courtesy of Steve Buck (U of I).

Figure 8. The Middle Fork re-introduction site at "MFNP" (=Middle Fork River County Forest Preserve) within the Champaign County Forest Preserve District's (CCFPD). CCFPD staff and board approved the project. This portion of the Middle Fork River is also an Illinois Natural Areas Inventory site. The only stocking occurred in 2010, when 67 Northern Riffleshell were translocated. Photo courtesy of Robert Szafoni (IDNR).

Figure 9. INHS technician A.C. Haskett utilizing a PIT tag receiver while INHS biologist J.S. Tiemann snorkels looking for tagged freshwater mussels. INHS personnel R. Vinsel is in background recording data. Photo courtesy of Rob Kanter (U of I).

Figure 10. Quarantining of mussels in 2012 and 2013 took place at the Illinois Natural History Survey Aquatic Research Facility in Champaign-Urbana, Illinois. Four circular tanks were set over a gravel bed. The tanks were provided with continuous ground water (temperature ranged from 68°F – 72°F throughout the day), and were aerated using air pumps. Effluent water drained over the gravel bed and soaked into the ground. In 2012, the tanks had ~1" of gravel placed in the bottom, and the animals were daily fed a commercial grade shellfish diet. The quarantine period lasted two weeks based on data from Starliper (e.g., Starliper 2005; Starliper 2008; Starliper et al. 2008). In 2013, new data suggested quarantine period could be as little as five days (Tom Watters, the Ohio State University, personal communication); therefore, no gravel was placed in the tank and the animals were not fed. Photo courtesy of Mike Coffey (USFWS).

Figure 11. The Salt Fork re-introduction site at the "Smith Property." This site is owned by the Smith family and is enrolled as an IDNR's Nature Preserve program (Edgewood Farm Land and Water Reserve). IDNR, including the Illinois Nature Preserves Commission, reviewed and approved the action. This portion of the Salt Fork River is also an Illinois Natural Areas Inventory site. This site has the following stocking history: 2012 = 471 Northern Riffleshell and 91 Clubshell; 2013 = 249 Clubshell. Photo courtesy of Kevin Cummings (INHS).

Figure 12. The Middle Fork re-introduction site "Ford" within Middle Fork State Fish and Wildlife Area. IDNR reviewed and approved the action. This site has the following stocking history: 2013 = 50 Northern Riffleshell and 50 Clubshell. Photo courtesy of Alison Stodola (INHS).

Figure 13. The Middle Fork re-introduction site "Horse" within Middle Fork State Fish and Wildlife Area. IDNR reviewed and approved the action. This site has the following stocking history: 2013 = 50 Northern Riffleshell and 50 Clubshell. Photo courtesy of Alison Stodola (INHS).

Figure 14. The Middle Fork re-introduction site "Kennekuk" within Middle Fork State Fish and Wildlife Area. IDNR reviewed and approved the action. This site has the following stocking history: 2013 = 50 Northern Riffleshell and 50 Clubshell. Photo courtesy of Alison Stodola (INHS).

Figure 15. The Middle Fork re-introduction site "Beaver" within Middle Fork State Fish and Wildlife Area. IDNR reviewed and approved the action. This site has the following stocking history: 2013 = 50 Northern Riffleshell and 50 Clubshell. Photo courtesy of Alison Stodola (INHS).

Figure 16. The Salt Fork re-introduction site "Donut" within Kickapoo State Park. IDNR reviewed and approved the action. This site has the following stocking history: 2013 = 50 Northern Riffleshell and 50 Clubshell. Photo courtesy of Alison Stodola (INHS).

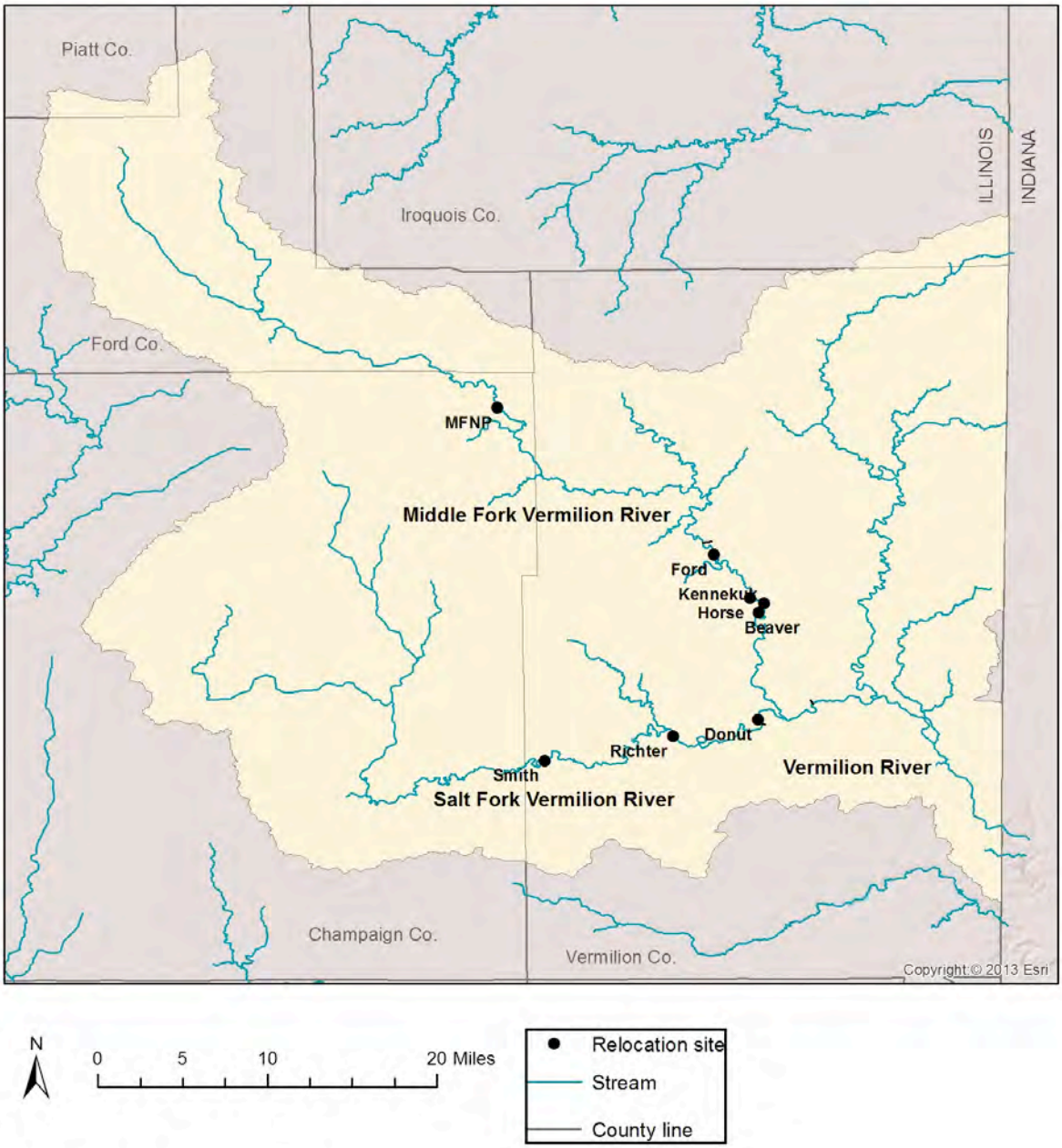

Figure 17. Vermilion River basin (Wabash River drainage) location and translocation sites from 2010-2013 for Northern Riffleshell and Clubshell. Map created by Alison Stodola (INHS).