ATTEMPTED REPATRIATION OF THREE AMPHIBIAN SPECIES INTO THE SHAKER TRACE WETLANDS AT MIAMI WHITEWATER FOREST, HAMILTON COUNTY PARK DISTRICT

by

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INTRODUCTION

Arguments for and against the repatriation of amphibian species has intensified during the recent years (Dodd and Seigel 1991; Burke 1991; Reinert 1991). Defining "success", creating a population with a sufficiently diverse gene pool, and providing good intention for creating or recreating a population have been among the more contested topics. Repatriation is defined as, "the release of individuals of a species into an area formally or currently occupied by that species" (Dodd and Seigel 1991).

Miami Whitewater Forest (MWF) is located in extreme southwest Ohio in Crosby Township, Hamilton County (Figure 1). A project is underway at a section of MWF involving the renaturalization, in part, of an area that had been under intense cultivation since at least the early 1900's. This area, north of New Haven Road, had been settled by a colony of Shakers. The buildings still stand, but when the Hamilton County Park District purchased the land, plans were made to restore these agricultural fields back to the wet meadows and marshes that were there originally.

An intense herpetological survey was conducted to establish base line data on amphibian and reptile species that had either already returned to the area, or had remained in spite of the alteration of the wetland ecosystem (Davis, Krusling, and Wauligman 1992). A few vernal ponds existed in woodlots on Baughman Road, and a permanent pond continued to hold water on one of the original Shaker farms near the northwestern corner of the parcel. Two other ponds associated with the latter no longer hold water but stayed wet throughout the summer. Irises grow in profusion in one of them and two locally rare rodents were observed there. One, the [redacted] was observed by Paul J. Krusling on one occasion and twice in one day I saw one near the iris stand. I also observed what I appeared to be a southern bog lemming (*Synaptomys cooperi*) under a log in the iris stand. The soil there is too moist for other vole-like rodents, and the habitat is optimal for the bog lemming. Bog lemmings have a tail that is significantly shorter than that of voles, but I was unable to see it for a positive identification.

In addition to the previously mentioned ponds, an oxbow-like pond remains behind the Knollman Farm on Oxford Road. This pond held water through mid summer in both 1992 and 1993. It is an old channel of Howard's Creek, which was straightened as it flows through the area, presumably to prevent erosion to a tilled field just east of the stream. At the northern extreme of the STW, approximately 200 meters west of Oxford Road, a small pond was dug during the summer of 1992, just inside of the bike trail loop. Another pond was dug during the winter of 1992 -93 in an oak hickory forest remnant near the bike trail shelter house. Just north of Baughman Road near the Cincinnati Gas and Electric transformer station, a pond was created during the summer of 1992. This pond seemed to be used less than the others by local wildlife, and a good growth of algae was never observed in the pond. I learned that it had been made deeper than originally planned and that it would be adjusted accordingly. The heart of the wetland is a series of large ponds made during 1991. These lie west of the Knollman Farm. A dirt road used as access to the fields for farm machinery borders these ponds to the south. The westernmost ponds dried during the summer drought of 1993. The largest pond, however, retained water all year.

John Klein, land manager for the Hamilton County Park District, discussed with me the possibility of reintroducing three local amphibian populations back into the STW area. He also requested that water samples from source ponds and introduction ponds be compared for several parameters.

Leopard Frog *(Rana pipiens)*

Davis et al.(1992) found that all of the ponds were being utilized as breeding sites by several species of frogs from three families (Table 1). The only Hamilton County species that could not be found in the ponds during the 1992 breeding season, were leopard frogs (*Rana pipiens*). Paul Krusling has been actively monitoring leopard frog populations in southwest Ohio for a number of years (personal communication), and had not seen one since the late 1970's. A large female was collected in Colerain Township during the spring of 1993 near Newberry Wildlife Sanctuary, and was accessioned into the Cincinnati Museum of Natural History. I know of no others in Hamilton County since Krusling's 1970's sightings.

"Leopard frogs were once "one of the most abundant frogs in Ohio" (Walker 1967). A great deal of concern has been shared among herpetologists nationwide over the apparent decline in amphibian populations (Phillips 1990; Baringa 1990). At the Declining Amphibian Population Task Force (DAPTF) Meeting in St. Louis, Michael J. Lanoo from Ball State University reported on an Iowa county where 20,000,000 leopard frogs were harvested annually for many years early in the century. A major frog leg industry there was able to continue taking this number until the frog leg industry died in that county, not because of a lack of frogs, but because of intensified competition elsewhere. Leopard frogs continued to be abundant there for years after the frog collectors had left. However, in a 1990 survey for leopard frogs in the same county, Lanoo was able to find only two leopard frogs (Michael J. Lanoo, personal communication, 1993).

Paul M. Daniel, curator of the Hefner Zoology Museum at Miami University in Oxford, Ohio, reported a noticeable decline in leopard frogs in Butler County, Ohio over the past few years (Paul M. Daniel, personal communication, 1992). Leopard frogs were still common and reproducing at Gilmore Ponds in 1992, a wetland preserve in Butler County (Davis, 1992). However, noticeably fewer leopard frogs were observed there during 1993 than in the recent past. Gilmore Ponds is approximately 2 km north of the Hamilton County border. The species continues to be found periodically throughout Butler County, and at Governor Bebb Park in Morgan Township, individuals have been heard chorusing during recent years, however I have never found any tadpoles or recent metamorphs there. Governor Bebb Park is approximately 4 to 5 km north of the Shaker Trace Wetlands (STW).

Krusling and Ferner (1993) reported leopard frogs from Boone, Kenton, and Campbell Counties in northern Kentucky, but found none during their 1993 survey. The most recent northern Kentucky records were from 1977 in Campbell County. Although Minton (1972) did not report leopard frogs from neighboring Franklin and Dearborn Counties, Indiana, his distribution map indicates that they were widespread and common through out the state. Daryl Karns of Hanover College in Hanover, Indiana, reported that leopard frogs have been placed on the state's list of species of special concern (Daryl Karns,

personal communication, 1993). Walker (1967) documented leopard frogs from Crosby Township, Newtown, Reading, and the Whitewater River in Hamilton County. Obviously, this species has historically been abundant throughout the Cincinnati Tri-state region.

Numerous ideas have been suggested to explain the decline of amphibian species. Acid precipitation, increased ultraviolet radiation due to decreasing ozone levels, genetic bottlenecking, and increased levels of environmental toxins from agriculture are among the more commonly discussed. The DAPTF has been established to begin looking for details on the decline of amphibians worldwide. During my discussions with other herpetologists at the October, 1993 meeting, many wondered if attempts for repatriation at the STW would be successful, citing that whatever caused them to decrease in the first place may prevent them from becoming re-established.

The leopard frog is defined as a species that inhabits fields, agricultural areas, and wet meadows during the late spring, summer, and fall (Smith 1961; Minton 1972; Walker 1967; Conant and Collins 1991). It requires ponds for breeding and as hibernacula. The STW provide optimal habitat for leopard frogs. Unfortunately they were the only local frog not using any of the ponds at the STW as breeding sites.

Spotted Salamander *(Ambystoma maculatum)*

Plans for the introduction of the spotted salamander into the STW were made based on the findings of the STW herpetological survey (Davis et al., 1992). Spotted salamanders were not found within the study area, but a breeding population was found approximately two km east of the park along Paddys Run Road, 300 to 400 meters south of the Butler County border. Several remnant oak hickory forests remain between the STW and the Paddys Run Road population. At the Paddys Run Road site, the breeding pond is in an old pasture, but the adjoining woods are dominated by oaks and hickories. At one time, the forest probably extended west to the STW. Topographic maps for the region (Shandon Quadrangle) show few changes in elevation, so the entire area may have once been a series of swamp forests.

Some of the ponds at the STW are perfectly suitable for spotted salamander reproduction. However, the lack of large woodlots limits the necessary habitat for non-breeding adults. At Indian Creek Park, a Butler Metro Park in Reily Township, Butler County, Ohio, an enormous spotted salamander population inhabits a moderately immature deciduous woodlot. On March 6, 1992, I counted over 1,000 breeding adults in an old cattle pond there. There are two mature woodlots at Indian Creek Park, however, my observations are that most adults are entering the breeding ponds from the secondary growth woods. Therefore it is quite possible that spotted salamanders introduced to the STW may naturalize and inhabit the shrubby woodlots, especially those along Baughman Road. However, the secondary growth woodlots at Indian Creek Park are much larger than those at the STW, and the relief is steep, whereas at the STW, the entire area is flat.

Marbled Salamander *(Ambystoma opacum)*

Southwest Ohio has been intensively surveyed for reptiles and amphibians for decades. Joseph T. Collins, among the country's leading herpetologists, is from Cincinnati, and during the 1960's he had "The Southern Ohio Herpetological Laboratory" (an old garage that he and his friends rented) on Day Road in Colerain Township, Hamilton County. Collin's collecting efforts were intense and specimens collected during that time often show up in literature. Roger Conant also spent time collecting in southwest Ohio, as did Charles Walker, and the herpetologists who conducted field studies to collect data for *The Salamanders of Ohio* (Pfingsten and Downs, 1989). Zoology students from Miami University have accumulated many southwest Ohio amphibian and reptile records as well. Hundreds of specimens have been cataloged into the Cincinnati Museum of Natural History's herpetological collections.

Despite the years of field efforts on the part of local herpetologists, marbled salamanders had gone unnoticed in Hamilton County until 1992 (Davis and McCarty, 1993). A population was located and identified in Crosby Township, Hamilton County along Paddys Run Road, at the same site where spotted salamanders, Jefferson salamanders (*Ambystoma jeffersonianum*), and streamside salamanders (*Ambystoma barbouri*) were found.

The decision was made to introduce marbled salamanders into the STW area from the Paddys Run Road population, assuming that the swamp forests were at one time, continuous between the two sites. The preferred habitat for marbled salamanders is oak hickory forest. In captivity, Paul Krusling (personal communication, 1992) found that they thrived only if kept in soil covered by oak leaves. The tannic acid from the oak leaves probably effected soil pH to their favor. Outside of pin oak swamp forests they are occasionally found in wet silver maple forests (King, 1935). The marshy areas along Baughman Road are dominated by silver maple trees and a very small pond was dug in the midst of a small oak hickory woodlot near the bike trail shelter house at the STW. Both of these areas may prove sufficiently suitable to sustain populations.

Jefferson Salamander *(Ambystoma jeffersonianum)* and Streamside Salamander *(Ambystoma barbouri)*

Although both of these species were found at the Paddys Run Road site, I chose not to repatriate them to the STW. The streamside salamander is the most abundant Ambystomatid salamander in southwest Ohio. It was reported from some of the hillsides that border the southern edge of the STW area (Davis et al., 1992) and Miami Whitewater Forest (Rubin 1992). If it breeds in Howard's Creek, it was overlooked during the 1992 STW survey. Howard's Creek, as it flows through the STW area, has many species of predatory fishes. Green sunfish (*Lepomis cyanellus*), longear sunfish (*Lepomis megalotus*), bluegill (*Lepomis macrochirus*), creek chubs (*Semotilus atromaculatus*), and yellow bullheads (*Ameiurus natalis*) would all be considered threats to developing salamander larvae. Kraus and Petranka (1989) found that streamside salamanders do not

breed in streams where fish pose a threat to their reproductive success. The species reproduces in all but the most polluted small streams, and will probably turn up in the STW area at some time.

I chose not to introduce Jefferson salamanders even though they were also reported by Davis et al. (1992). Jefferson salamanders form a complex series of genotypes consisting of diploid male and female populations, and triploid all female populations that reproduce parthenogenetically. Until 1991, the triploid females were considered a different species, the silvery salamander (Ambystoma platinium). Currently they are considered morphological and genetic variants of the Jefferson salamander. Many prominent herpetologists have lumped them into a group know as the "Jeffersonianum Complex" and have dealt with them only to that degree. Conant and Collins (1991) explain triploids as all female hybrids of the Jeffersonianum Complex. Electrophoretic analysis will probably solve the entire problem at some point in time. They are known to exist at MWF (Rubin, 1992), but the population has not been electrophoretically identified as diploid or triploid. No males were found in the Paddys Run Road population, but the females found there were not identified electrophoretically. Triploid females, do not use the genetic information from males, but they do need the sperm cells as a stimulus for parthenogenetic development of their ova. If each population (Miami Whitewater Forest and Paddys Run Road) was diploid (males and females) and Paddys Run Road specimens were introduced into the STW, there might be mixing of the two gene pools that would not have occurred under natural circumstances. Should herpetologists choose to collect Jefferson salamanders from Miami Whitewater Forest to help understand the genetics of the species, the gene pools need to remain unmixed and natural. It is unlikely, however, that Miami Whitewater Forest Jefferson salamanders would reach the STW area. The breeding pond for MWF is on Harrison Avenue near Blue Jay. Another potential pond is along the boardwalk of the Prairie Trail at the south end of the park (Davis et al., 1992).

CONDITIONS

Because marbled salamanders breed in the fall, it is necessary to look at the weather conditions from September 1992, when the first marbled salamander eggs were found through July 1993, when the last spotted salamander larvae and leopard frog tadpoles were moved to the STW.

On September 20, 1992 at the Paddys Run Road site, Paul Krusling, Wayne Wauligman, and I found 21 adult marbled salamanders, 12 were females, but none had eggs. The weather conditions were sunny and 45^{o}F. On October 4, 1992, Dave Wheat (a colleague of mine at Northwest High School) and I visited the same site and found that the females had laid their eggs. The weather conditions were sunny and 55^{o}F. By November, 1992 the ponds had filled with water and eggs had hatched. On March 26, 1993 I returned to the site with Dr. Paul Daniel to find the ponds still filled with water. The air temperature was 60^{o}F, the water temperature was 48^{o}F, and the skies were clear. This visit was made at 8:45 PM to optimize our efforts. Ambystomatid larvae stratify by species in ponds at night, allowing them to fill various feeding niches. Marbled

salamander larvae spend the daylight hours hidden in submerged vegetation, but at night move into open water to feed (Hassinger et al., 1970).

The spring of 1993 was cool and wet. Water persisted in vernal ponds into early summer. However, following the wet spring, came a severe drought, second only to the drought of 1988. Most of the ponds into which amphibian eggs and larvae were liberated stayed wet, but the dry conditions may have had deleterious effects on the metamorphosing larvae and post-metamorphic juveniles.

MATERIALS AND METHODS

In order to coordinate collection and release times, it was necessary to visit the ponds at the STW where larvae would be liberated before visiting the source ponds. At Indian Creek Park, breeding activity began on March 21, and by March 24 there were several hundred egg masses in the pond. As of March 28, I had located and marked only eleven spotted salamander egg masses at the Paddys Run Road breeding pond. If this were an off year for the Paddys Run Road pond, then it may have been unwise to collect egg masses or larvae there. John Klein had requested that I get written approval before taking specimens, of any developmental stage, from any locality to introduce into the STW. Although it was promised twice by the residents of the Paddys Run Road locality, I never received written permission. The residents insisted that verbal permission was adequate, but they were tenants, not the land owner.

Michael Muska, Executive Director of the Butler Metro Parks District, gave signed written approval for the collection of spotted salamander larvae and leopard frogs from Indian Creek Park and Gilmore Ponds respectively. Preferably, the spotted salamander larvae would have come from Paddys Run Road, but for the previously mentioned reasons, Indian Creek specimens were chosen.

The marbled salamander ponds are on property owned by The Chesapeake and Ohio Railroad. I did not obtain written permission to collect salamanders from those ponds.

During the leopard frog breeding season, mid-March to late April in Ohio (Walker 1967), several trips were made to the ponds at the Shaker Trace Wetlands to listen for leopard frogs chorusing. None were heard

Leopard frogs can be found in numbers in only a few southwest Ohio localities. As previously mentioned, Gilmore Ponds in Fairfield Township which is approximately 20 km east of the STW, is the best source of local specimens. My own field notes indicate that I have collected leopard frogs in Oxford, Reily, Morgan, Ross, Hanover, Milford, Wayne, and Fairfield Townships in Butler County within the past eight years. However, the only breeding site that I am certain of is at Gilmore Ponds. In northeastern Warren County, an enormous population still exists at the Spring Valley Wildlife Preserve. Although at one time, I had considered this a source, I elected not to introduce specimens from so far away. The mobility of frogs might allow animals introduced at the STW to move into surrounding areas and disrupt long standing gene pools. Gilmore Ponds was the sole source of leopard frog tadpoles that were introduced in the STW. If adequate leopard frogs cannot be collected at Gilmore Ponds, then Spring Valley may be used as an alternative source with some careful consideration.

Water in source ponds and release ponds was tested for similarities and differences. Because amphibians absorb dissolved molecules through their skin so readily, rapid immersion into a new pond could shock them or even create concentration gradients capable of causing superficial cellular damage. If larvae were released into a pond with significantly different standards, they were acclimated by slowly introducing water from the release pond into the container of water from the source pond with the larvae. Water samples were tested for dissolved oxygen, hardness (KH), pH, and temperature. The only significant differences observed between ponds during releases were in temperature and dissolved oxygen.

Temperature was measured with a standard swimming pool thermometer in a plastic sleeve, sealed at the bottom and with a perforated cap. When thrown into a pond, the tube fills with water, allowing the temperature to be read while the thermometer is still bathed in the water without influence from air temperature. Dissolved oxygen was measured with a CHEMetrics Inc. Dissolved Oxygen Self-Filling Ampule Kit, purchased from Ward's Biological Supply Company. pH and KH were measured with reagent kits manufactured by Aquarium Pharmaceuticals Inc. Water quality data were recorded and compared for each pond (Table 2).

Marbled salamander larvae were collected in open water at night in the beam of flashlights using eight inch nylon aquarium dip nets. Spotted salamander larvae were collected with 16 inch D - nets during the daylight hours from among submerged vegetation near the shore of the Indian Creek Park breeding pond. Spotted salamander egg masses were collected with the stick around which they were deposited. Egg masses were not removed from the source pond until they had developed a noticeable colony of the green algae, *Chlamydomonas*, in the eggs. Several species of this algae interact mutualistically with the developing larva in each egg. The algae metabolize the nitrogenous wastes of the larva and may proved nourishment to the larva by way of excess photosynthate. The egg masses were transported in five gallon buckets and were aerated with battery operated bait bucket pumps. In the release ponds, twenty egg masses were placed in shallow water in open sunlight, by pushing the stick with the egg mass into the mud. Eggs were placed in the oxbow pond, the recently dug pond in the oak hickory woodlot, and in the ponds along the north and south side of Baughman Road, excluding the larger pond that was dug during the summer of 1992. Larvae of both species were released into the same ponds. [redacted] The latter individuals were very near metamorphosis. Marbled salamanders were released on March 10 and at that time I notice that hundreds of others released previously by Wayne Wauligman were thriving and were quite large. On my later returns, I was unable to find the smaller specimens that I had released, but always found the earlier releases. Apparently the smaller individuals were consumed by the larger.

Early in April, 1993 leopard frogs began to chorus at Gilmore Ponds. [redacted] Any females collected would have been treated the same. All would have been injected with chorionic gonadotropins. Unfortunately no females were collected. [redacted] During the remainder of the spring, after the first leopard frogs were collected, I continued

to hear choruses for several weeks. Leopard frogs lay their eggs among aquatic vegetation and finding the egg masses is very difficult. I was unable to find any egg masses and would resort to collecting tadpoles. In Ohio, leopard frogs metamorphose during July (Walker, 1946). In south pond at Gilmore Ponds where I heard chorusing leopard frogs, I was unable to seine any larvae. In early July, a severe drought had caused the ponds and the Miami Erie Canal to dry at Gilmore Ponds. There were several small pools remaining in the canal and *Rana* tadpoles were abundant in them. On July 18, in three hours, over 3,200 tadpoles were seined from these pools. Most were so covered with mud, that they hardly recognizable. They were transported in five gallon buckets, aerated with battery operated bait bucket pumps to my classroom at Northwest High School. All were placed in two 55 gallon aquarium and were aerated with a Gast blower. The Gast blower created such a turbulence in the aquariums that the mud was rinsed from them. Each tadpole was identified, and all leopard frogs were separated from the others. Bullfrogs (*Rana catesbeiana*) and green frogs (*Rana clamitans*) are easily identified. The intestines of tadpoles are tightly coiled and in some species the coil shows through the abdominal wall. It does not show through the abdominal wall bullfrogs or green frogs, but shows through clearly in leopard frogs. Of the 3,200 tadpoles identified, only 53 were leopard frogs. All were released into the main pond at the SFW. The bullfrog and green frog tadpoles were returned to remaining pools of the Miami Erie Canal at Gilmore Ponds. No other leopard frog tadpoles were collected.

DISCUSSION

Paul Krusling and Wayne Wauligman have been successful in introducing Ambystomatid salamanders into newly created ponds at Embshoff Woods. My experience during the 1993 season certainly indicated that attempting to repatriate marbled and spotted salamanders is easier to accomplish than repatriating leopard frogs.

King (1935) discussed that an ecological advantage to the early (late?) reproduction of marbled salamanders may give them the opportunity to forage on other Ambystomatids in the same pond by spring.. The marbled salamander larvae are perhaps three to four cm long when the larvae of spring breeding species are beginning to escape from their eggs at less than two cm. Marbled salamanders have even been observed entering the gelatinous egg masses of other *Ambystoma* species to get unhatched larvae. The marbled salamander larvae that had been liberated by Paul Krusling and Wayne Wauligman were very large by March. Each time I returned to the ponds, I could find nothing but very large marbled salamander larvae. Because they are so highly predatory, I am not convinced that the repatriation of spotted salamanders will be successful. I will return during the spring of 1994 to stock more spotted salamander larvae. Marbled salamander larvae do not return to breeding sites until at least their second fall and often not until their third fall. By stocking the ponds with spotted salamander larvae during the spring of 1994, and if necessary 1995, they will be able to develop without the competitive pressures of marbled salamanders.

The pools from which the leopard frog tadpoles were taken were as much as 400 to 500 meters apart. Therefore the few that were taken are probably from a variety of egg

masses and will result in a diverse gene pool. I would have hoped to have collected and liberated about 1,000 tadpoles. But there are arguments for and against introducing a small number. If a few individuals are introduced, and there is a niche to be filled by them, their population will grow to fill it (Samson 1983). However I am disappointed with the number of leopard frog tadpoles collected, and will collect next year and release them at the STW.

Measuring success will not be possible until three years have passed and these amphibians return to their ponds to reproduce. The success of the salamanders will be largely a factor of the STW providing suitable habitat for the adults. The habitat is not optimal, but I have seen spotted salamanders thrive under habitat conditions much less than optimal. The small pockets of habitat for the marbled salamanders may suffice for some of them. I am most skeptical about the habitat in the vicinity of the oxbow pond.

The success of leopard frogs will be effected by the limited number that was released. There have been well documented attempts to repatriate other Anuran species that have met with no success. Ten sites at the Attwater Prairie Chicken National Wildlife Refuge in Texas were chosen for the reintroduction of Houston toads (*Bufo houstonensis*). A total of 500,000 adults, recent metamorphs, and tadpoles were released there, but no new populations were established (Dodd and Seigel 1991). Whatever has been responsible for the loss of leopard frogs in Hamilton County may not allow them to become established again.

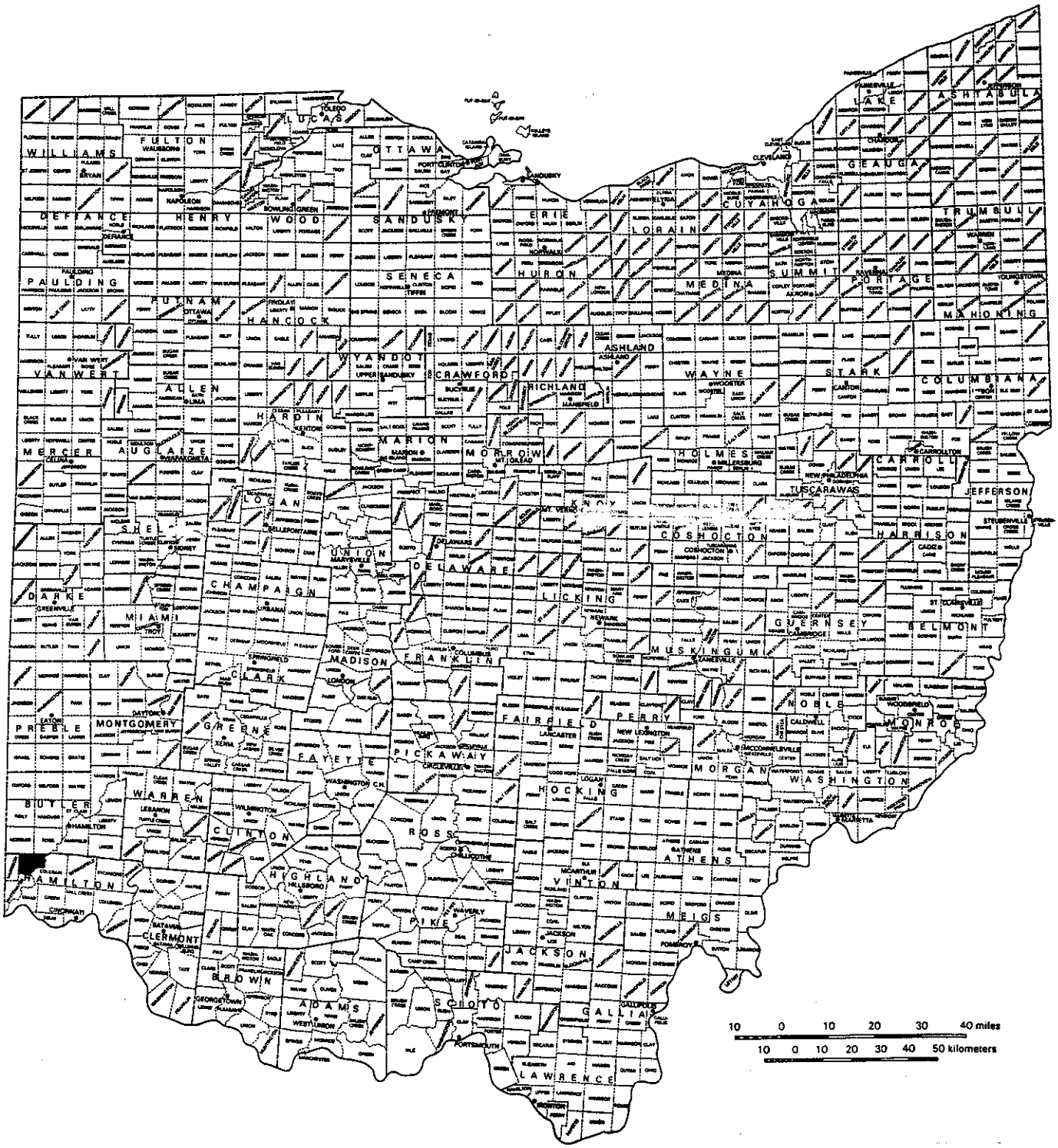
Stock populations of spotted salamanders and marbled salamander for further introductions are not a problem. I am concerned however, that moving leopard frogs from Gilmore Ponds in the future may not be possible if they are on the decline there. If this turns out to be the case, serious consideration needs to be given to obtaining specimens from the Spring Valley Wildlife Area in Warren County.

Water quality in the stock ponds and source ponds was not consistent, but was comparable. The dissolved oxygen levels in the oxbow ponds were always low, but insect larvae and other arthropods, and marble salamander larvae did quite well there. Spring peepers and both toad species use the pond for breeding as well. I saw nothing to indicate that any of the ponds would be unsuitable for amphibian reproduction.

APPENDIX A

Figures

Figure 1. The Shaker Trace Wetlands are located at The Miami Whitewater Forest in Crosby Township, Hamilton County, Ohio.



APPENDIX B

Tables

Table 1. Frog species using the STW as breeding sites.

Family Hylidae

Acris crepitans	Cricket Frog
Hyla chrysoscelis	Gray Treefrog
Pseudacris crucifer	Spring Peeper

Family Bufonidae

Bufo americanus	American Toad
Bufo woodhousei	Fowler's Toad

Family Ranidae

Rana catesbeiana	Bullfrog
Rana clamitans	Green Frog

Table 2. Water quality comparison for source and stock ponds.

Indian Creek Park Pond

March 22, 1993
Indian Creek Park Pond
Water Temperature - 47oF
pH - 7.6
KH - 150 to 300 PPM

Paddys Run Road Railroad Track Pond (east)

March 26, 1993
Water Temperature - 53oF
pH - 7.2
KH - 150

Paddys Run Road Railroad Track Pond (west)

March 26, 1993
Water Temperature - 57oF
pH - 6.6
KH - 200 PPM

Paddys Run Road Cattle Pond

March 28, 1993
Water Temperature - 49oF
pH - 8.0
KH - 300^{+} PPM

Shaker Trace Wetlands - Oxbow Pond

March 28, 1993
Water Temperature 50oF
PH - 6.2
KH - 300 PPM

May 28, 1993
Water Temperature - 64oF
pH - 6.0
KH - 150 to 300 PPM
Dissolved Oxygen - 2 PPM

Gilmore Ponds (South Pond)

April 7, 1993
Water Temperature - 48oF
pH - 7.0
KH - 150 PPM
Dissolved Oxygen - 6 PPM

Shaker Trace Wetlands (Main Pond)

May 1, 1993
Water Temperature - 64oF
pH - 6.8
KH - 150 to 300 PPM
Dissolved Oxygen - 6 PPM

July 19, 1993
Water Temperature - 81oF
pH - 6.4
KH - 150 to 300 PPM
Dissolved Oxygen - 56 PPM

Shaker Trace Wetlands (Baughman Rd. (north pond))

May 1, 1993
Water Temperature - 60oF
pH - 6.6
KH - 150 to 300 PPM
Dissolved Oxygen - 4 PPM

Shaker Trace Wetlands (Baughman Rd. (south pond))

May 1, 1993
Water Temperature - 63oF
pH - 6.8
KH - 150 to 300 PPM
Dissolved Oxygen - 4 PPM

Gilmore Ponds (Miami Erie Canal)
July 18, 1993

Water Temperature - 84oF
pH - 5.8
KH - 150 PPM
Dissolved Oxygen - 2 PPM

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