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Experimental Return of Wood Frogs to West-Central Illinois

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ABSTRACT

Habitat and climatic changes suggest a continued shrinking of the southern margin of the range of *Rana sylvatica* in many states of the USA. Reintroduction and habitat improvement were studied as methods to resist local and regional extirpation. Eggs from Indiana were translocated to a west-central Illinois county (McDonough) where this frog has been absent in historic times. Data over a 12 year period confirm the development of a breeding population, whose size and local distribution are increasing despite frequent drought conditions. These first seven known years of breeding in McDonough County will hopefully lead to a long surviving study colony, and observations of the methods and results should help others trying to preserve this frog locally. Some general reintroduction and habitat improvement methods are briefly discussed.

INTRODUCTION

Rana sylvatica has a large boreal range across Alaska and Canada, including open arctic tundra. But south of Canada it tends to be found in cooler mesic forests, and has the common name "wood frog". Its range is now quite restricted in 12 states of the USA, and less so in North Carolina and Tennessee. Ashton (1976) lists the species as peripheral, rare, threatened, or extirpated in seven of these states. The present distribution indicates that former populations almost certainly occurred in Iowa and Nebraska. Peripheral relict populations indicate this in Conant and Collins (1991), map 333. It appears incontestable that the range of this species was displaced southward by the glaciers and has since shifted northward (see Porter, 1972, p. 258). An 1892 relict Peoria population (Garman, 1892) confirms the earlier presence of wood frogs in west-central Illinois. The present range reduction presumably followed climatic changes and a reduction of Illinois forests described by King (1981). These frogs were certainly more widespread in Illinois during the cooler, moister postglacial period indicated by more spruce and fir pollen (Dyson, 1962, p. 208; King, 1981).

Translocation and habitat improvement studies reported here provide methods to retard local disappearance of this species, or to reestablish it where extirpated. McDonough County was chosen for the introduction site, because (1) 27 years of field work in the area confirm that *R. sylvatica* was not already present, and (2) the author's residence near the study area allowed more frequent monitoring of the population. Such closer proximity to a study population aids in gaining new information about the species, and some is reported here.

MATERIALS AND METHODS

Donor Area

The *R. sylvatica* source was Brown County in south-central Indiana. Wood frogs occur nearer to McDonough County to the north, near Rock Island County, Illinois. However, the geographic differences indicated by proposed subspecies, such as relative leg length, may reflect latitudinal trends (in this case a version of Allen's rule), so it seemed better to deviate less from the natural pattern of genetic polymorphism by using more southern donor material (see map in H. Smith, 1978, p. 64). The northern subspecies assignment to the former Peoria locality is probably a guess, since P. Smith (1961) said he saw no specimens.

Eggs were usually taken from one 200 m^2 pond, but once came from a bay of a larger nearby lake. Only a small fraction of the eggs present were taken. Thirty-two advanced larvae were taken in 1989; 16 adults in 1988; and three adults from Parke County, Indiana, in 1985 (Table 3). Eggs were more practical to find and transport (in 3.8 liter, or one gallon jars) and were usually released one mass at a time near the edges of ponds. Too little air space (water above the jar shoulders) or eggs occupying more than about 2/3 of the water volume can result in some mortality, so this was avoided. Eggs were kept cold (about 5-10^{o} C), and released as soon as possible (in about 6-18 hr.).

Translocation Area

The introduction area in McDonough County is about 8 km ENE of Macomb. Fig. 1 shows the topographic relief is greater than usual locally. The bluff slopes have allowed a better survival of earlier lumbered or pastured forest. Much of the forest is redeveloping oak-hickory protected for over 20 years. Locations of most of the relevant ponds or clusters of ponds are shown by circled numbers in Fig. 1. Individual ponds are referred to in the text by adding letters (1A, 1 1/2A, etc.). The pond numbers were assigned partly in chronological order of wood frog activity. As Table 1 mostly shows, the first releases were made at the pond 1 group in 1982; wood frogs then bred in the 2 group in 1987; eggs were released into pond group 3 in 1987; one frog called from pond 4 in 1988; larval transfers to pond 5 were attempted later in 1988; and wood frogs oviposited in pond group 6 in 1989. Pond groups 1 1/2 and 2 1/2 were enlarged and used for wood frog transfers still later (1991 and 1992) but these additional ponds were assigned numbers based on their position relative to pond groups 1 and 2. Pond 4 is not included in Tables 1-3 because wood frog eggs were never found or placed in pond 4.

Most ponds are surrounded by forest, but a more savannah-like environment exists near some on the mitten shaped "plateau" of upland in the lower right corner of Fig. 1 by area 2, at pond 4, and by the number 1 series of ponds. However, the steep NE facing bluff by the easternmost 1 pond (pond 1A) is forested, and cooler and more mesic conditions are indicated by the presence of basswood trees (*Tilia americana*) and wild ginger plants (*Asarum canadense* var. *reflexum*). All numbered ponds (Fig. 1 and Table 1) were hand dug by the author between 1984 and the present, except for the 1 oxbow series and a cluster at 6 which were dug about 100 years earlier.

<u>Habitat Improvements</u>

The most important habitat improvement favoring *R. sylvatica* was the creation (digging) of many breeding ponds in forested areas. Algae and other pond organisms (some named below) were added to hasten the development of adequate pond habitat. Some trees were removed or girdled to admit sunlight for more algal growth. One to three six-channel chimney flue tiles of 91 1/2 x 32 x 22 cm were sometimes placed on pond bottoms for added refuge from predators and from dessication as the pond dried. Often one to three dead branches (about 2-3 m long) were placed in the centers of ponds in spring to provide floating oviposition sites which move up and down with changing water levels. These were utilized by the frogs.

Adjacent disturbed oak-hickory forest habitat was improved by adding leaf duff, logs, tree plantings (mostly hard maples), and underground rock-pile retreats. These changes do favor *R. sylvatica*. Mulching conserves soil moisture and reduces soil temperature fluctuations. Shelford (1937) showed that a thicker forest floor leaf layer and more mature hard maple forest favored *R. sylvatica* in northern Illinois and Indiana. *R. sylvatica* and other amphibians were observed using the rock piles for shelter from dryness and temperature extremes.

Figures 2-4 show pond 2C at an earlier digging stage and in its final form in 1991, with *R. sylvatica* eggs. The basin is about 12 by 15 m, with deepest spots to about 2 m. All other dug ponds were smaller (to a minimum size of about 2 x 1 x 1 m) and the amount of water varied with the weather.

<u>Monitoring Methods</u>

Mark-recapture methods and traps or drift fences were not used to monitor the frog populations because they can increase mortality. An encircling fence around a pond of metamorphosing tadpoles may sound effective, but could result in major slaughter by the frequently patrolling raccoons (*Procyon lotor*) in the area.

The methods that evolved included conservative estimates of the number of eggs in released or oviposited egg masses. The egg number per mass varies and can be much less than some estimates given in the literature. It was impossible to accurately count eggs in a large three-dimensional egg mass without damaging them. When larvae of wood frogs alone were transferred between ponds, these were counted. The relative numbers of larvae were followed by estimates or minimum counts of animals seen at the surface on clear sunny days. Less than two weeks from the start of metamorphosis, all or nearly all larvae were usually dipnetted from the ponds and counted as they were placed in pails and soon returned to their ponds. In the two largest ponds (1A and to a lesser extent 2C) netting was not effective in catching most of the tadpoles, and more general estimates were made based partly on data for other populations, partly reviewed in Duellman and Trueb (1986). With the exception of pond 1A, however, tadpoles were monitored throughout each season and estimates modified by events and conditions at each pond. A permanent record was recopied from field notes each year. This semi-quantitative data is accurate enough to show trends and make comparisons.

RESULTS

General History of Releases and Breeding

Estimated numbers or counts of ovipositions, releases, transfers, and metamorphoses are given for individual ponds in Table 1. Table 2 shows summed values for the three main areas: I--the main river valley (pond series 1) and adjacent lower eastern tributary valley; II--the upper eastern tributary valley and slopes (pond series 1 1/2, 2, and 2 1/2, and 4); and III--the western tributary area and westward (pond 5 and pond groups 3 and 6). Finally the grand totals per year are summarized in Table 3.

As shown in Table 1, no eggs developed to metamorphosis the first year (1982). This was because they were placed in small streamlet pools in forested area X, and all these bodies of water dried up before metamorphosis, and were not used subsequently. No translocations were made in 1983, 1986, 1990, or after 1991. But in 1984 and five later years (Table 1) most releases were made at the easternmost main valley pond 1A. This was the best group 1 pond in that it lasted the longest most seasons and had the best quality adjacent forest (at X). Eggs were only found once in any other main valley pond (adjacent 1B), and that pond dried before they could metamorphose. There are actually about five oxbow ponds between the two southern tributaries in Fig. 1, and these were all examined in most years.

There are habitat trends at pond 1A, whose quality has gradually diminished because it has been silting in. Twenty years ago it supported a colony of beavers. Later it supported muskrats and turtles. Now this roughly 15 by 105 m curved pond rarely gets much more than 1 m deep and is more subject to outside influences. The effects of the "50-year" 1988 drought were not strongly felt until 1989, when 1A was essentially dry except for a 3 x 2 x 1 m pit that had been dug in the bottom (in 1988). Thirty-two nearly metamorphosed Indiana *R. sylvatica* larvae were placed in this pit and hopped out soon afterwards. The next year pond 1A was refilling, and most of the wood frog eggs were suffocated when the water level rose about 1/3 m above the oviposition level and the eggs fell into 1 m deep water. An extra translocation was made in 1991 to aid recovery from the bad years. The number of successfuly metamorphosing animals, both total and at 1A, appeared to be the largest ever but was exceeded in 1993.

However, in 1992 there were unusual cold snaps. Although breeding started earlier than most years (first calls on March 3rd, first eggs on the 5th, and eggs confirmed at 1A by the 8th), the air temperature dropped from above 10^{o} C to below -10 1/2^{o} C on March 11th. It must have been still colder during the night, and the shallow weed bed where the eggs were laid was exposed to a wind chill from NW winds. The eggs looked dead later, and no eggs hatched when one mass was transferred and observed in a smaller pond (3A). Dan Wise of the Western Illinois University Geography Department confirmed that 1992 was the coldest summer in local weather recording history (since 1950). He and other meteorologists attribute this in part to dust thrown up by volcanoes in recent years (pers. comm.)

Tables 1 and 2 also show trends for areas II and III. The first confirmed *R. sylvatica* breeding in McDonough County since at least 100 years (and probably many more) took place in II when some (more than 3) apparently two and three-year-old wood frogs arrived in 1987. They called in nine ponds in the southernmost part of Group 2, and one egg mass was oviposited in 2A. Both area II and III populations were satellites of 1A at first but are increasing, with oviposition at an increasing number of ponds (Table 1). In addition, eggs were first laid at 2 1/2B and 3B in 1993.

Table 3 shows the establishment of a breeding colony from releases in 1984-85 and 1987-88, and an apparent recovery from the effects subsequent to the 1988 drought. Oviposition levels gradually increased again, to the highest level ever. The second greatest number of successful metamorphoses occurred in 1992, even though there was only one more supplementary egg translocation in 1991, plus 32 larvae in 1989. Still greater estimates were made for 1993 after this manuscript was submitted; about 16,000 eggs laid and over 2,500 of these metamorphosed. The percent metamorphosis in Tables 2 and 3 is the number estimated to metamorphose, divided by the sum of the estimated numbers of releases and ovipositions.

Estimates of the metamorphosed population are difficult to make because the animals are so secretive. Twenty-two egg masses were found in 1992, indicating at least this many adult females. More than 28 calling males were heard in 1992, some at ponds where no oviposition occurred. If you assume that sexually immature frogs make up about 50% of the population as in *R. pretiosa* (Turner, 1960), there would be at least 50 immatures. This total of 100 is too small, since almost 2,000 frogs were estimated to have metamorphosed in 1991 (Table 3). An estimated 943 more metamorphosed in 1992, though only one of these was seen later, in early August of 1992. From the above, the total metamorphosed population of wood frogs in McDonough County probably reached about 1,000 or more in 1992. Of course there was winter mortality, but 1993 breeding data just obtained confirms that the population is established and growing. At least 43 egg masses were found; about the same number as in 1992 for area I (but this year none died from freezing), more in area II, and much more (19 instead of 1) in area III.

Egg Mortality Factors

The main egg mortality factor observed during this study was water level change. Egg masses dessicated if the water level dropped, or suffocated when the water level rose. This could be compensated for to some degree if the egg mass was deposited either on a flexible weed stem that hung down into the water or on floating sticks which were usually present. Sometimes relocated egg masses were moved in time to reduce losses. Egg masses could also suffocate if they slid down the slanting bottom to deeper water or broke loose from an attachment (perhaps after wave action, or in two cases from being examined too often). Some eggs hatched anyway after getting into deeper water. In the worst case two egg masses fell into water about 1 m deep for two days. They were fished out with a net, and roughly one half hatched after a delayed development.

Cold shock can kill *R. sylvatica* eggs. However, egg masses were found with the upper part encased in ice yet there was little subsequent damage after warmer temperatures returned. The loss of about 6,000 eggs to cold at 1A in 1992 was unusual.

Predation of wood frog eggs by either vertebrates or invertebrates was not observed.

Larval Mortality Factors

Premature pond drying and predators were the two major causes of larval mortality. Food shortage also contributed. The wood frog does not need permanent ponds to breed in, but requires only vernal pools that last until about June 15th in this area. However, newly dug ponds were small (a "D" in Table 1 indicates the year digging started) and were more subject to drying before silt sealed the bottom of the clay basins. In some cases pond drying was circumvented by adding water or by transferring larvae to other ponds. Newer ponds 2 1/2A and B (west of "(2)" in Fig. 1) are droughtproof, because they can be refilled through garden hoses from a house. New ponds are oligotrophic, and insufficient plant food causes stunting and presumably increased mortality. When stunting became obvious, the populations were sometimes thinned by transfer to other ponds, but more often algae were added (frequently *Spirogyra*). As the ponds become older and sometimes larger, some eventually can last until the time of metamorphosis and have the nutritive resources to support more than one egg clutch. Asterisks in Table 1 mark the years in which some of the ponds reached this partial independence from food and water additions. Older ponds 1A and group 6 did not get any aid, except for some pond deepening and shade reduction. Some of the ponds will not be used for future larval transfers, and to some degree the *R. sylvatica* appear to pick the better available ponds for oviposition.

Metamorphosing froglets probably leave the ponds at night during a rain, although some were seen leaving drying ponds in daytime without rain. In the 1988 major drought, the forest duff became dry, and some late metamorphosing froglets stayed by the moisture of a small pond basin (2A), whose drying was delayed until July 8 by adding buckets of water. The froglets took refuge from dessication within sunbaked cracks in the clay bank. After the first good rain (on July 17) they all disappeared, presumably dispersing into the forest floor duff.

Predators were the most dramatic larval mortality factor, and there were many predators of varying importance over the years. Their effects were less in the small ponds deeper in the woods and worse in more open valley areas, most notably at 2C, 2B, and probably 1A. Raccoons were serious predators only partly kept in check by coyotes, dogs, and hunters. A few breeding *R. sylvatica* were found partly eaten, and raccoon tracks increased as the ponds dried. A few mink (*Mustela vison*) were present but no predation of wood frogs was confirmed. Birds were not major predators either as occasional visits by great blue herons (*Ardea herodias*), green-backed herons (*Butorides striatus*), or kingfishers (*Megaceryle alcyon*) to ponds 1A and 2C appeared to have little effect on *R. sylvatica* larvae numbers. Among reptiles, immature northern water snakes (*Nerodia sipedon*) contributed to noticeable losses at 2C (and nearby 2B, 2D, and 2E) in some years. Turtles (mostly *Chrysemys picta*) probably caused some losses in 1A. Bullfrogs (*Rana catesbeiana*) probably caused some losses at 1A, 2C and 2B. Smallmouth salamander larvae (*Ambystoma texanum*) were numerous in most ponds but were not large enough to prey on wood frog tadpoles. Some tiger salamander (*Ambystoma tigrinum*) larvae introduced from local sources largely eliminated the *R. sylvatica* tadpoles in 2C and adjacent 2B in 1988. *Ambystoma tigrinum* have not reproduced or caused predation since. Fish were usually kept out of the ponds, but in 1990 tiny green sunfish (*Lepomis cyanellus*) were accidentally introduced into 2B, 2C, and 2D with aquatic vegetation, along with four small goldfish (*Carassius auratus*) in 2B. The fish grew larger and decimated the tadpoles in 1991 before being recognized. Subsequently, fish were almost completely removed by draining and seining the ponds, apparently caused no problem in 1992, and will be monitored in future years.

The usual invertebrate predators of tadpoles are also present. Water spiders, *Notonecta sp.*, and some of the larger water beetles presumably took some smaller tadpoles. The more dangerous predators of larger tadpoles are dragonfly and water tiger (*Dytiscidae*) larvae. The latter increased in some of the smaller ponds in 1991. A leech was once observed feeding on an apparently injured wood frog tadpole, and another leech did so when accidentally confined with four tadpoles in an aquarium.

Competition

There are six common and three uncommon species of frogs in the study area, eight of which have ranges that broadly overlap that of *R. sylvatica* but also occupy large areas outside its range. These eight species have prospered in both areas, and to my knowledge no published reports show a marked negative effect by *R. sylvatica* on these widespread forms. At least seven have used the new breeding ponds. If tadpoles of other species share the same pond with *R. sylvatica* tadpoles, there is some possiblity of competition for resources, particularly for the numerous *Pseudacris triseriata* and *Bufo americanus* tadpoles. But both species are smaller and feed differently. Four other species breed later in the year, including bullfrogs which find all the ponds but 1A and 2C too small to breed in. If some of these other resident frog populations decrease in the future, it will probably be from continued environmental deterioration and not from the presence of *R. sylvatica*.

The one local frog species whose range does not overlap the wood frog range widely is *Rana blairi*. This medium sized *Rana* is dominant among similar sized members of the same genus in much of Transeau's Prairie Peninsula and the plains for which the frog is named. It is certainly the dominant medium sized *Rana* in McDonough County and can be found in or near most ponds, including *R. sylvatica* breeding ponds. However, *R. blairi* generally does not feed from or shelter in the forest floor like the wood frog. And *R. blairi* mostly breeds in ponds surrounded by open land and not utilized for *R. sylvatica* breeding. However, some intermediate type ponds can be used by both species. Both have bred in 1A, the *R. blairi* choruses calling a little later (but overlapping *R. sylvatica*) and mainly from the opposite end of the elongated pond. The *R. blairi* eggs were in deeper water out of the wind and partly survived the 1992 cold shock. *Rana blairi* has sometimes called from 2B, 2C and 2D in recent years, and laid a few eggs in 2C and 2B. Tadpoles of the two species are more similar in size and feeding habits, eating algae near the surface away from the shallows. Their food use appears to overlap more. However, most *Rana* habitat in McDonough County is favorable for the fairly abundant *R. blairi* but not for *R. sylvatica*.

In 1993 ecological and temporal isolating mechanisms were clearly evident. The wood frogs mainly bred on March 30 or 31st (41 of 43 egg masses). They abandoned ponds 1A and 2C in more open areas, and utilized other ponds in more wooded areas nearby. Calls from *Rana blairi* were not heard until the next rain, on April 7th. Three egg masses from *Rana blairi* were found in 1A on April 9th and no *R. sylvatica* eggs (the pond was waded and carefully examined on April 3rd and 9th). One *R. blairi* egg mass may have been oviposited a few days earlier in a pond not used by *R. sylvatica*. Only pond 2B contained eggs from both species, and there was no time overlap. Long after their breeding season was over (by July) *Rana blairi* still have not ovoposited in any other pond with *R. sylvatica* eggs.

DISCUSSION

Most vertebrate and invertebrate animal introductions have not been monitored or studied carefully, other than some birds and mammals in more recent years. *Rana sylvatica* can be introduced (or reintroduced) into areas of locally mesic wooded habitat and even disturbed woodland in drier areas like west-central Illinois if certain habitat improvements are made. The scarcity of both forests and suitable forest ponds in today's cornfield-modified Illinois Prairie Peninsula makes it obvious why *Rana sylvatica* is mostly absent. However, there are still bits of habitat that could support the wood frog if it could reach them.

One other successful translocation of *R. sylvatica* eggs has been made by Sexton and Philips (1986) in St. Louis County, Missouri, presumably using local donor populations. If one is conveniently near a donor pond, a higher survival rate can be obtained by dipping up recently hatched larvae before they have dispersed from the egg mass.

Survival rates vary per pond and year. One of Sexton and Philips' introductions succeeded and one did not. In the present study, the largest breeding choruses in areas I, II and III could shift from a local pond used in a previous year and form at a nearby pond that was currently larger or more suitable. This tended to increase the number of successful metamorphoses. Estimated survival rates from eggs to metamorphosis (Table 1) varied from 0-87% in different ponds for different years. These values would be still lower if egg number estimates are too conservative. Many survival rates may seem excessively low in these oligotrophic and short lasting new ponds. However, in Alaska, Herreid and Kinney (1966) estimated the average egg fertilization success in nature as 86.7% and that only 3.7% of these zygotes survived to metamorphosis. Duellman and Trueb (1986) show 4.8% and 5.2% for two other *Rana* (Table 11-3). In my study tadpoles in smaller ponds farther from streams appeared to suffer less predation but were more vulnerable to food (algae) shortage or premature pond drying.

Rana sylvatica can be translocated successfully for conservation or study purposes, but translocations should not be attempted without a reason. One should keep and publish records, and should not (1) overcollect donor populations, (2) place donors far outside the general region or biome that they come from, nor (3) greatly alter the pattern of genetic polymorphism in a continuous population.

The *R. sylvatica* population formed here has other usefulness besides contributing information about survival factors. Like the former Peoria population, this is a disjunct or "outpost" colony, near the range border, in a generally unfavorable macroclimate. If there are long term unfavorable climate trends, these *R. sylvatica* could serve as an indicator population to show how much these conditions can be offset by a redeveloping favorable habitat and microclimate.

The future of this population involves survival and possible spread. Protection of forest and breeding ponds are necessary for survival. As Fig. 1 shows, the area is encircled by a road so further possible local spread can easily be monitored from a car by listening for calling in March. The habitat gets worse in all directions, so successful dispersal is not too likely. It is possible but not likely that tadpoles could be washed downriver in a flood and survive to reach and populate suitable habitat.

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Table 1. *Rana sylvatica* use of numbered study area ponds, 1982-1992.

Pond	Eggs	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1A	RL	1000*	0	1000	3000	0	2350	7800	32	0	6700	0
	OV						?	5600		3000	2800	6000
	MT	0		100	300		200	500	30	30	900	0
1B	OV							1200				
	MT							0				
1 1/2A	RL						D				154	
	MT										2	
1 1/2B	RL					D					500	
	OV										0	1000
	MT										300	300
1 1/2C	RL						D				446	*
	OV											400
	MT										40	200
1 1/2D	RL						D				300	
	MT										0	
2A	RL			D							800	
	TR								200	50		200
	OV						200	400				
	MT						100	150	60	0	200	7
2B	RL	D									1000*	
	TR									100		
	OV							200			400	800
	MT							20		5	5	110
2C	RL					D					900*	
	OV							200	400	350	800	1500
	MT							30	60	20	0	50
2D	RL					D					300	
	TR											150
	OV										900	
	MT										0	1
2E	RL	D									500	
	TR											100
	OV										150	
	MT										15	5
2 1/2A	TR										D	100
	MT											13
2 1/2B	TR					D					150	150
	MT										50	15
6	OV								200*			
	MT								20			
3A	RL					D	250	50			400	
	TR							57	12	40		330
	OV										200	
	MT						3	40	10	0	400	2
3B	RL						D				100	*
	TR								23	40		75
	MT								20	5	50	20
3C	RL						D				100	
	TR									20		75
	MT									3	15	20
5	TR					D		?				*
	OV											300
	MT							10				200

Abbreviations: RL = estimated number of Indiana eggs released; TR = estimated number of eggs or larvae transferred to the pond from another local pond; OV = estimated number of eggs oviposited; MT = estimated number of frogs metamorphosing from the pond; D = the year digging started for the pond; * = approximate year the pond no longer required additions of water or food.

Table 2. Summed *Rana sylvatica* use for three area subdivisions, 1982-1992.

	Area I (pond 1 series)					Area II (pond series 1 1/2, 2, 2 1/2)					Area III (pond series 3, 5, 6)				
1982	1000	RL	0	MT	0%										
1983															
1984	1000	RL	100	MT	10%										
1985	3000	RL	300	MT	10%										
1986															
1987	2350	RL	200	MT	9%						250	RL	3	MT	1%
	?	OV				200	OV	100	MT	50%					
1988	7800	RL				800	OV	200	MT	27%	50	RL			
	6800	OV	500	MT	3%	(-57)					57	TR	50	MT	48%
1989	32	RL	30	MT	"94%"	400	OV	120	MT	33%	200	OV			
(larvae)						(-35)					35	TR	50	MT	21%
1990	3000	OV	30	MT	1%	350	OV	25	MT	10%					
						(-100)					100	TR	8	MT	8%
1991	6700	RL				4900	RL				600	RL			
	2800	OV	900	MT	9%	2250	OV				200	OV	465	MT	58%
	(-150)					150	TR	612	MT	8%					
1992	6000	OV	0	MT	0%	3700	OV	701	MT	20%	300	OV			
	(-300)					(-180)					480	TR	242	MT	31%
Sum	40482		2060	MT	5%	12378		1758	MT	14%	2272		818	MT	36%
Average of annual %					15%					25%					28%

Abbreviations: Same as in Table 1, but here TR is only from outside the subdivision.

Table 3. Total *Rana sylvatica* study area use, 1982-1992.

	RL	OV	MT	%		Average Subdivision % (from Table 2)		Ind. adult release (1A)
1982	1000	0	0	0%		0%		
1983	0	0	0					
1984	1000	0	100	10%		10%		
1985	3000	0	300	10%		10%		3
1986	0	0?	0?					
1987	2600	200	303	11%		20%		
		(more in 1A?)						
1988	7850	7600	750	5%		26%		16
1989	32	600	200	32%		49%		
	(larvae)			33%	eggs only	27%	eggs only	
1990	0	3350	63	2%		6%		
1991	12200	5250	1977	11%		25%		
1992	0	10000	943	9%		17%		
Sum	27332	27000	4636	9%				19
Average of 9 annual %				10%		16%	(eggs only)	

Figure 1. McDonough County, Illinois, wood frog translocation area (USGS Topographic Maps). The circled numbers indicate ponds or pond groups. The "X" marks the location of the most favorable local habitat, mature white oak forest.

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Figure 2. Pond 2C during its excavation (1987). The scale is shown by the shovel.

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Figure 3. Pond 2C in March 1991. The scale is shown by the wheelbarrow.

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Figure 4. Wood frog eggs oviposited in Pond 2C, March 1991.

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