2003. Proceedings of the Indiana Academy of Science 112(1):43–54

AMPHIBIANS AND REPTILES FROM TWENTY-THREE COUNTIES OF INDIANA

Robert Brodman: Biology Department, Saint Joseph's College, Rensselaer, Indiana 47978 USA

ABSTRACT. Amphibians and reptiles from 23 counties, 13 in northern Indiana and 10 in southwestern Indiana, were surveyed from 1998–2001 using standardized call-survey, terrestrial and aquatic search-and-seize, and trapping methods. A total of 3514 populations of amphibians representing 33 of the 39 species known from Indiana was found at 1539 sites. The most common species, western chorus frogs (*Pseudacris triseriata*, spring peepers (*P. crucifer*), American toads (*Bufo americanus*), and green frogs (*Rana clamitans*), comprised 74% of the frog populations encountered, while smallmouth salamanders (*Ambystoma texanum*), tiger salamanders (*A. tigrinum*), unisexual salamanders of the *A. laterale*-complex, and red-backed salamanders (*Plethodon cinereus*) made up 67% of the salamander populations. Five species of amphibians with distributions within the areas that I surveyed, plains leopard frog (*R. blairi*), hellbender (*Cryptobranchus alleganiensis*), red salamander (*Pseudotriton ruber*), green salamander (*Aneides aeneus*), and northern dusky salamander (*Desmognathus fuscus*), were not found. I maximized observations of amphibian species richness by using combinations of techniques rather than a single method. All amphibian species were more abundant in wildlife preserves than along randomly chosen routes. Reptiles were encountered much less frequently than were amphibians; however, most of the methods were targeted towards detecting amphibian communities. I observed 286 reptiles representing 27 species at 129 sites.

Keywords: Amphibians, reptiles, survey, Indiana

Amphibian declines throughout the world (Barinaga 1990; Houlahan et al. 2000; Lannoo et al. 1994; Wake 1991) have emphasized the need for an inventory of species to determine how widespread declines have been and to serve as baseline data for long-term monitoring and future surveys to assess changes in the status of the herpetofauna. The US Central Division of the Declining Amphibian Population Task Force recommended atlas projects in each state.

The checklist is the fundamental record of an atlas project. From these checklists, atlas maps can be produced; however, for data to be compared among locations or time, effort must also be recorded. Measures of species seen per unit effort can be calculated and used to investigate regional relative abundance patterns, changes over time, and changes among species (Cyr & Larivee 1993). The lack of this information limits the usefulness of historical data on amphibians and reptiles in Indiana (Grant 1936; Minton 2001; Mittleman 1947; Simon et al. 2002; Swanson 1939).

The Indiana Declining Amphibian Population Task Force and the Indiana Department of Natural Resource Technical Advisory Committee on amphibians and reptiles initiated an Indiana Herpetofauna Atlas with the goal to conduct surveys throughout the state over a four-year period of time (1998–2001) to produce data on the presence and abundance of amphibians and reptiles with quantified effort. Here I report on my surveys of 23 counties in Indiana. My objectives are to: 1) determine the status of the herpetofauna and species status state-wide during a four year period; 2) determine past trends of the herpetofauna at certain sites with rich herpetological records; 3) provide baseline data on species richness, relative abundance and species status of amphibians and reptiles that can be used to determine population trends and begin long-term monitoring of certain populations; and, 4) analyze amphibian presence and abundance patterns among randomly chosen sites and non-randomly chosen preserves.

METHODS

Preserve sites were chosen non-randomly in representative regions and habitats of the state targeting those properties with historical records, high species diversity, rare or endangered species and prospects for long-term protection of

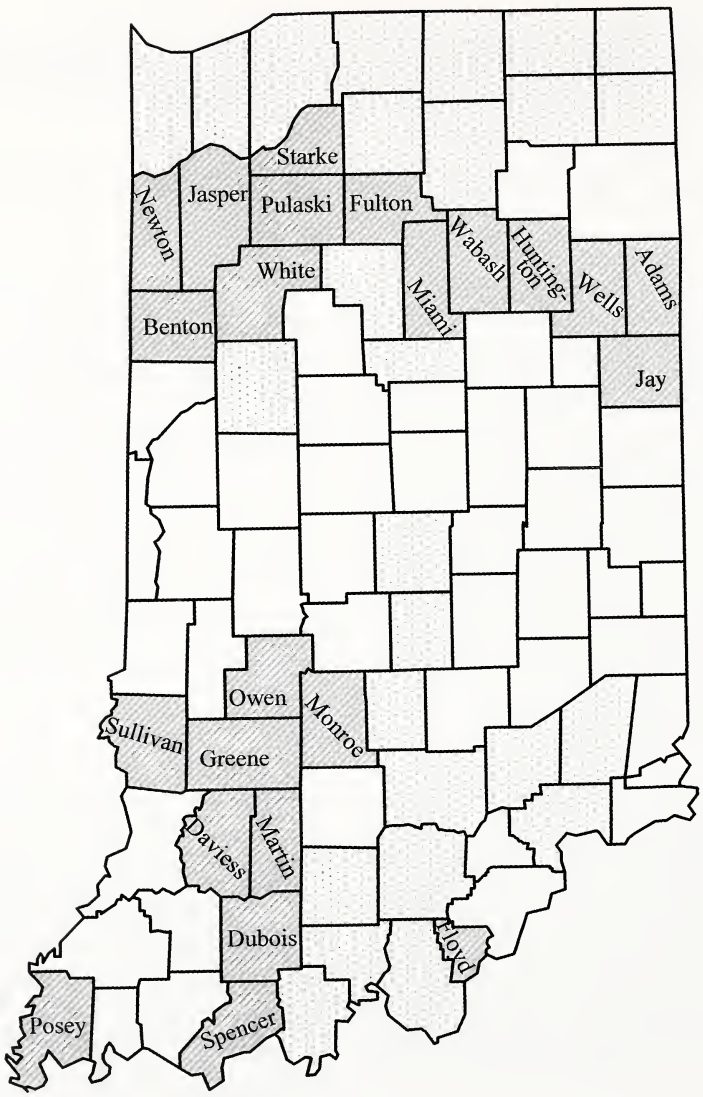

Figure 1.—Map of survey locations by county. Counties surveyed for amphibians and reptiles are labeled and shaded with diagonal lines. Small dots indicate counties with additional information on the abundance of amphibians from surveys conducted in the 1990s in the recent literature and from Indiana Department of Natural Resources.

habitat. I also surveyed random samples of sites in blocks representing each major region of the state's herpetofauna (Brodman 1998; Minton 2001; Smith & Minton 1957). Effort was equalized among visits to a given site and among blocks, but not among counties. From 1998–2001 I surveyed 56 preserve sites in 23 counties. Random samples of survey sites were selected from a random set of 50 national wetland inventory topographic maps 1:24,000 scale (NWI) from northern Indiana and 15 NWI maps from southwestern Indiana. I targeted wetlands that were within 200 m of secondary roads. Most were in agricultural fields and residential properties. I surveyed sites in Jasper, Benton, White, Pulaski, Newton, Huntington and Wabash Counties in 1998; Wabash, Miami, Huntington, Adams and Jay Counties in 1999; Sullivan, Greene, Owen, Monroe, Martin, Daviess, Dubois, Spencer, Floyd and Posey Counties

in 2000; and Newton, Pulaski, Starke, Fulton and Wells Counties in 2001 (Fig. 1). Of the 39 species of amphibian known from Indiana, my survey sites were within the range of every species except the ravine salamander-complex (*Plethodon richmondi/electromorphus*) (Highton 1999; Minton 2001). To simplify the situation of unisexual populations of salamanders with various hybrid chromosome combinations from *Ambystoma laterale*, *A. jeffersonianum*, or *A. texanum*, I will consider these as a single taxon and refer to them as unisexual salamanders.

I considered amphibian breeding-ponds within 0.5 km of each other to be a single population site. All sites were surveyed using standard methods of amphibian population monitoring (Heyer et al. 1994; Karns 1986). Estimates of population abundance were quantified by a combination of anuran call indices, density estimates and per effort catch. I conducted anuran call surveys on at least three occasions (late March–mid April, late April–late May, early June–early July) at wetlands throughout the study areas targeted each year. Relative abundance was estimated on an ordinal scale while effort was measured as the number of km surveyed. I used time constrained search-and-seize using seines and dip nets for aquatic species, terrestrial/cover object searches, minnow traps for aquatic species, and visual sweeps of appropriate habitat for basking animals, eggs and larvae. Effort was measured as the number of person-hours spent using each method. Minnow traps were used to determine relative abundance by recording the number of animals caught per trap-day.

The primary methods employed in this survey were intensive directed sampling and opportunistic sampling. Directed sampling is sampling in areas that clearly should contain amphibians. Opportunistic sampling includes night-time road cruising with periodic (every 0.5 km) auditory sampling, visual sweeps through candidate areas searching for terrestrial animals, and overturning logs near wetland habitats. Small wetlands were dip-netted and seined thoroughly and systematically; but for larger wetlands, shallow edges were randomly sampled at several locations. Egg-mass densities were determined by quadrat sampling (see Brodman 1995). Terrestrial salamanders were monitored by numbers caught or seen per person-hours of hand search-and-seize methods. Numbers of egg masses, larva and adult animals caught or seen per person-hours of dip netting, seine sampling and opportunistic sampling give an indication of density and survey effort.

Table 1.—Effort by method in each county surveyed. Data are km of call route (CR), terrestrial survey person-hours (TS), aquatic survey person-hours (AS), the number of minnow trap-days (MT) and total effort (TE) for each county.

County	CR	TS	AS	MT	TE
Southern Indiana					
Floyd	45	15	14	0	74
Greene	50	13	14	15	92
Sullivan	71	18	18	15	122
Daviess	55	15	15	15	100
Owen	39	55	55	0	149
Monroe	42	60	65	5	172
Spencer	42	16	13	0	71
Martin	39	14	12	0	65
Posey	56	21	25	30	132
Dubois	97	14	15	5	131
Northern Indiana					
Wells	39	12	13	12	76
Adams	82	13	13	0	108
Jay	103	15	16	0	134
Huntington	122	14	15	0	151
Wabash	166	22	40	0	228
Miami	108	20	20	0	148
Benton	333	18	18	0	369
White	50	12	12	0	74
Pulaski	69	42	42	38	191
Newton	150	43	48	20	261
Starke	24	35	35	14	108
Jasper	830	60	60	108	1058
Fulton	21	18	18	34	91
Total	2631	565	596	311	4103

I used auditory frog call surveys for the assessment of amphibian breeding intensity. Relative population abundance was categorized using the Karns (1986) ordinal index of breeding chorus intensity on a scale of 0–5. Salamander and reptile relative abundance were also categorized on an ordinal scale from 0–5 using the following formulas:

Aquatic survey
= Ln (5 × captures/person-hour)

Minnow traps
= Ln (35 × captures/trap-day)

Terrestrial survey

Table 2.—Summary of amphibian abundance. Data are overall abundance (AB), number of sites present (SP), the percentage of counties (%C) or preserves (%P) present, and the ratio of new county records to absences from historic counties (CR). Data are presented from random sites, non-randomly chosen preserves and totals for the state.

	Random		Preserves			Total			
Species	AB	SP	AB	SP	%P	AB	SP	%C	CR
Frogs									
Chorus	1916	650	577	219	86	2493	869	100	3:0
Spring peeper	1656	506	574	200	68	2230	706	87	7:0
Eastern gray	663	246	205	76	32	868	322	48	3:1
American toad	616	252	199	87	34	814	339	83	6:3
Cricket	242	92	236	85	30	478	177	74	3:7
Green	221	123	201	97	64	422	220	100	11:0
Cope's gray	208	96	182	86	34	390	182	52	5:0
Fowler's toad	241	102	132	69	39	373	171	74	4:3
Bullfrog	114	64	125	73	48	239	137	100	11:0
Northern leopard	106	64	94	45	36	200	109	57	2:2
Southern leopard	12	8	120	42	29	132	50	43	0:1
Wood	13	8	42	15	20	55	23	35	5:2
Crawfish	0	0	3	3	2	3	3	13	1:5
Spadefoot	2	1	1	1	2	3	2	9	1:1
Pickerel	0	0	2	1	2	2	1	4	0:3
Salamanders									
Smallmouth	15	6	110	39	39	125	45	74	8:3
Tiger	38	15	41	18	23	79	33	43	7:5
Unisexual	9	5	52	19	28	61	24	48	8:0
Red-backed	0	0	37	17	16	37	17	43	0:5
Blue-spotted	0	0	27	18	7	27	18	13	2:1
Spotted	0	0	23	13	13	23	13	22	1:4
Two-lined	1	1	16	6	11	17	7	26	1:5
Marbled	0	0	13	7	9	13	7	26	1:3
Jefferson	2	1	11	4	5	13	5	22	1:0
Lesser siren	0	0	11	8	7	11	8	17	0:2
Zigzag	0	0	10	6	9	10	6	17	0:2
Slimy	0	0	10	4	5	10	4	13	1:6
Eastern newt	0	0	8	6	5	8	6	13	2:2
Streamside	0	0	8	2	4	8	2	4	0:0
Cave	0	0	4	1	2	4	1	4	0:4
Four-toed	0	0	3	2	2	3	2	9	1:1
Longtail	0	0	3	2	2	3	2	4	0:6
Mudpuppy	0	0	2	2	4	2	2	4	0:2
Total	6075	2240	3082	1273	—	9157	3514	—	96:86

$$= \text{Ln}\ (450 \times \text{captures/person-hour})$$

All calculated values below 1 were rounded up to 1 if at least one animal was encountered and all values greater than 5 were rounded down to 5. A total effort of 2631 km of call survey routes, 565 person-hours of terrestrial surveys, 596 person-hours of aquatic surveys and 311 minnow trap-days was conducted in this study (Table 1).

RESULTS

Amphibians.—I detected a total of 3514 populations at 1539 sites in the 23 counties that I surveyed. Data for each species are summarized in Table 2. There was a significant and strongly positive correlation between the relative abundance of species and the number of sites that each species was present (Pearson correlation, $r = 0.994$; $p < 0.001$).

I found 15 of the 16 species of frogs known from Indiana. The only species absent was the plains leopard frog (*Rana blairi*). I found 18 of Indiana's 23 salamander species. I did not encounter the hellbender (*Cryptobranchus alleganiensis*), red salamander (*Pseudotriton ruber*), green salamander (*Aneides aeneus*), northern dusky salamander (*Desmognathus fuscus*) and the ravine salamander-complex. I found 96 new county records, and there were 86 instances of a species absent from a county with a historical record (Table 2). The species with the most new county records were the bullfrog (*Rana catesbeiana*), green frog (*R. clamitans*), spring peeper (*Pseudacris crucifer*), smallmouth salamander (*Ambystoma texanum*), tiger salamander (*A. tigrinum*), and unisexual salamander. The species with the most absences from counties with historical records were the crawfish frog (*R. areolata*), cricket frog (*Acris crepitans*), longtail salamander (*Eurycea longicauda*), and northern slimy salamander (*Plethodon glutinosus*).

The most abundant species of frogs were the western chorus frog (*P. triseriata*), spring peeper, eastern gray treefrog (*Hyla versicolor*) and American toad (*Bufo americanus*). When combined, these four species accounted for two-thirds of all frog populations encountered. The western chorus frog, green frog and bullfrog were the only species found in all 23 counties. The most abundant salamanders were the smallmouth salamander, tiger salamander, red-backed salamander (*Plethodon cinereus*), and unisexual salamander. These species represent two-thirds of the total salamander abundance that I detected.

Amphibians were relatively more abundant and had greater species richness at the non-randomly chosen preserves compared to sites from random blocks (Table 2). All 33 species of amphibians encountered in this survey were found at the preserves, but two species of frog, the pickerel frog (*R. palustris*) and crawfish frog, and most of the salamander species (78%) were not found at the random sites. After weighing the abundance and number of sites by effort, amphibians were found to be about three times more common and abundant at the preserves than at random sites. If I exclude the four most abundant frog species, then the other species were about seven times as likely to be found or heard in preserves than along a random route. The greatest differences for species encountered at least 20 times were for the southern leopard frog (*R. sphenocephala*) and wood frog (*R. sylvatica*).

The number of sites that each species was found in each county is summarized in Table 3. Floyd and Owen Counties had the most amphibian species of any county, while Benton County had the fewest. The counties with the greatest number of new county records were Huntington, Miami, Pulaski and Sullivan, while Martin, Dubois, Greene, and Monroe Counties had the most species with past records absent (Table 3). Counties with the greatest number of sites with amphibians present were Fulton, Posey, Daviess and Floyd, whereas Adams, Dubois, Huntington, and Benton had the fewest (Table 3).

I compared the field methods to determine if any were more efficient or effective. During aquatic surveys seines yielded a mean of 3.7 species per site and 45.0 animals per person-hour, dip-nets yielded a mean of 4.9 species per site and 17.4 animals per person-hour, and minnow traps yielded a mean of 3.0 species per site and 2.4 animals per trap-day. Terrestrial and aquatic search-and-seize and visual sweeps yielded a mean of 4 species per site and 0.2 animals per person-hour. Although seining collected the greatest number of amphibians per person-hour and aquatic dip-nets produced the greatest species richness per person-hour, the combination of all four techniques was necessary to maximize species richness. For example, I encountered the lesser siren (*Siren intermedia*) and mudpuppy (*Necturus maculosus*) only in minnow traps, whereas the eastern spadefoot toad (*Scaphiopus holbrooki*) and crawfish frog were encountered only during night-time call surveys.

Reptiles.—I found reptiles at 129 sites in 19 of the 23 counties (Table 4). Just three species, painted turtle (*Chrysemys picta*), common garter snake (*Thamnophis sirtalis*) and eastern box turtle (*Terrapene carolina*)) made up more than half (53%) of the 286 reptiles found in this survey and accounted for 9 of the 13 new county records. The six-lined racerunner (*Cnemidophorus sexlineatus*), bullsnake (*Pituophis melanoleucus*), and eastern hognose snake (*Heterodon platirhinus*) were also relatively common; however, I observed each in only two counties in northwest Indiana. I found turtles in 65% of the counties, snakes in 61% of the counties and lizards in

Table 3.—Summary of the presence and abundance of amphibians in each county surveyed. Data are the number of sites for each species in each county, new county records (+) and absences (−) from counties with prior records. Counties are coded as follows: Floyd = fd, Posey = po, Dubois = du, Martin = ma, Spencer = sp, Monroe = mo, Owen = ow, Daviess = da, Sullivan = su, Greene = gr, Adams = ad, Jay = jy, Wells = we, Huntington = hu, Wabash = wa, Miami = mi, Fulton = fu, Benton = be, White = wh, Starke = st, Pulaski = pu, Newton = ne, and Jasper = ja.

	Counties								
Species	fl	po	du	ma	sp	mo	ow	da	su
Frogs									
Spring peeper	30	0	20+	8	5+	16	18	15	48
Chorus	26	43	38	25	4	8	14	28	34
Northern leopard	0−	0	0	0	0	0−	0	0	0
Pickerel	1	0	0	0−	0	0−	0	0	0
Southern leopard	5	18	4	4	5	2	1+	2	7
Crawfish	0	0	0−	0−	1	1	0	0−	1+
Eastern gray	0	0	0	0	0	0	0	0	0
Cope's gray	31	30+	2	21	9	3	11	20+	9
American toad	5	3	0−	14	0−	7	3	1	0
Fowler's toad	5	12	5+	3	10	1	6	14	7
Spadefoot	1	0	0	0−	0	0	1+	0	0
Cricket	19	20	3	2	15	3	0−	34	31
Green	8	9	2	4	4+	4	5	14+	6+
Bullfrog	8	10	1	2	3	3+	1	24+	7+
Wood	1+	1+	0	0−	0	4	3	1+	0
Salamanders									
Tiger	0−	0	0	0	0	0−	0−	2	1+
Smallmouth	1	16	1	1	1+	0−	1	4	3+
Streamside	2	0	0	0	0	0	0	0	0
Jefferson	0	0	0	1	0	1	1	0	1
Unisexual	1+	1+	0	0	0	1	2+	0	0
Blue-spotted	0	0	0	0	0	0	0	0	0
Spotted	2	7	0	0−	1	0−	0−	0	0
Marbled	1	2	0−	0−	0−	1	1+	1	1
Eastern newt	1+	0	0	0	0	1	0−	0	0
Lesser siren	0	3	0−	0	0	0	0	0−	1+
Mudpuppy	0	2	0	0	0	0	0	0	0
Red-backed	1	1	0−	0−	0−	3	4	0−	1
Zigzag	1	1	0	0−	0	1	3	0	0
Slimy	0−	1	0−	0−	0−	0−	1	0	0
Four-toed	0	0	0	0	0	1	0	0	0
Two-lined	2	0	0−	1	0−	1	1	0	0
Longtail	0−	0	0−	0	0−	2	0−	0	0
Cave	0−	0	0	0−	0−	0−	1	0	0

30% of the counties surveyed. I observed about 10% of the reptiles while driving. Fifteen of the specimens encountered were road-killed and another 13 were live animals seen along roadsides.

Reptiles were encountered much less frequently than were amphibians, and all but 10 of the reptiles observed were in preserves. Because several of the methods targeted amphibians, and most of the terrestrial searches were in preserves, no direct comparisons can be made between amphibians and reptiles or reptiles in preserves and those in random sites.

DISCUSSION

Amphibians.—The strong correlation between the abundance and number of sites present among species confirms that the trend first observed in Jasper County (Brodman & Killmurry 1998) is a state-wide phenomenon.

Table 3.—Extended.

Counties													
gr	ad	jy	we	hu	wa	mi	fu	be	wh	st	pu	ne	ja
14+	2+	0−	0	4+	65	35+	48	17+	36	10	38	66	211
8	12	41	6+	13+	67	33	23	88	35	13	36	63	171+
0	2	8	1+	4	15	12+	18	3	2	6	8	12	18
0	0	0	0	0	0	0−	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
0−	0	0	0	0	0	0	0	0−	0	0	0	0	0
0	0−	7	0	1+	21	43	31	28+	27	5+	30	29	100
10	0−	0−	0	0−	0−	0−	0−	0−	0−	0−	10	5+	21
0−	1	4	3	4+	19	22+	7	77	16+	2+	21+	48	82+
0−	0	0−	0	1+	2	11+	8	0	6	1	12	16	53
0	0	0	0	0	0	0	0	0	0	0	0	0	0
23+	1+	8	2	0−	2	2+	0−	0−	4	0−	7	0−	1
4+	2+	4	2+	6+	15	8+	24	10+	9+	3	26+	6	46
4+	4	6	2	3+	3+	5+	17+	2+	2	2	7+	6+	19
0	0	0	0	0	0−	0	3+	0	0	3	7+	0	0
2+	3	1+	1+	1+	2	0−	1	0	1	0−	1+	2+	21
2+	3	2	1	1+	4	0−	0	0	1+	1+	3+	0	0−
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1+	0	0	0	0	0	0	0	0	0	0
0	2+	3+	1+	2+	5+	0	0	0	0	3	3+	0	0
0	0	1+	0	0	0	0	0−	0	0	0	8+	0	9
0	0	0	0	0	1	1	0	0	0	0	1+	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0−	0	0	0	0	0	4+
0−	0	0	0	0	0	0	0	0	0	0−	1+	0	3
0	0	0	0	0	0	0	0−	0	0−	0	0	0	0
1	0	0	0−	0	2	2	0	0	0	2	0	0	0
0−	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	2+	0	0	0−
0	0	0	0	0	0−	0	0	0	0	2+	0	0	0
0−	0	0	0	0−	1	1+	0	0	0−	0	0	0	0
0−	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0

This suggests that presence-absence data are sufficient in determining relative abundance of amphibians on a county or state regional-level. Statewide monitoring programs need not use abundance indices that are more prone to human error and observer bias (Mossman et al. 1998). In studies using large numbers of people to conduct call surveys, observers agreed on presence or absence of species much more often than when they agreed on index values (Bishop et al. 1997; Hemesath 1998; Kline 1998; Shirose et al. 1997). This study also supports the finding that combining call surveys with time-constrained search-and-seize methods increases the accuracy of determining the relative abundance of frogs and toads (Kline 1998).

My finding that amphibians are disproportionately more abundant in preserves than along random routes brings into question

Table 4.—Summary of the presence and abundance of reptiles in each county surveyed. Data are the total number of animals seen or captured for each species in each county, and number of sites present (SP) for each species. An asterisk indicates a new county record. Counties are coded as follows: Floyd = fd, Posey = po, Dubois = du, Martin = ma, Spencer = sp, Monroe = mo, Owen = ow, Daviess = da, Sullivan = su, Greene = gr, Adams = ad, Jay = jy, Wells = we, Huntington = hu, Wabash = wa, Miami = mi, Fulton = fu, Benton = be, White = wh, Starke = st, Pulaski = pu, Newton = ne, and Jasper = ja.

	Counties																				
Species	fl	po	du	ma	sp	mo	ow	da	su	gr	ad	jy	wa	fu	be	wh	st	pu	ne	ja	SP
Turtles																					
Snapping	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	3	4	8
Painted	0	12	2	5	1	0	0	1+	1+	1+	0	0	3	14	0	2	2	0	15	38	26
Blanding's	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4	2
Map	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Red-eared slider	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
Eastern box	8	3	3+	0	1+	0	0	2+	1+	0	0	0	0	0	0	0	0	3+	0	1	4
Ornate box	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	4
Spiny softshell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	4
Lizards																					
Slender glass	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
Six-lined racerunner	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	2	8
Five-lined skink	0	1+	1	0	1+	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Broad-headed skink	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Snakes																					
Racer	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	2	1	7
Northern ringneck	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1+	0	0	0	2
Black rat	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Western fox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	2	0	4
Eastern hognose	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	2	8
Prairie king	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	1
Northern copperbelly	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Northern water	3	1	2	0	0	1	1	0	1+	0	0	0	1	0	0	0	0	0	1	2	11
Rough green	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Bull	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	4	12
Brown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	4	4
Plains garter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	1	4
Eastern ribbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4	3
Common garter	0	0	3+	1	0	0	1	1	0	0	1	1	3	0	0	4	0	0	8	6	18
Cottonmouth	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Table 5.—Amphibian relative abundance from recent surveys in 49 counties of Indiana. Data include the number of sites with populations present (SP) and percentage of counties present (%C) from my study, recent DNR reports and published papers.

Species	SP	%C
Frogs	4241	
Chorus	1004	92
Spring peeper	829	84
American toad	447	88
Eastern gray	418	43
Green	357	96
Bullfrog	225	94
Cricket	209	59
Fowler's toad	205	65
Cope's gray	204	49
Northern leopard	170	53
Wood	75	39
Southern leopard	63	39
Pickerel	28	22
Spadefoot	4	8
Crawfish	3	6
Plains leopard	0	0
Salamanders	623	
Smallmouth	114	53
Tiger	72	39
Red-backed	64	51
Blue-spotted	63	20
Cave	54	9
Unisexual	38	29
Spotted	34	47
Two-lined	29	29
Eastern newt	25	31
Zigzag	22	22
Northern slimy	19	27
Longtail	17	20
Hellbender	15	6
Marbled	14	24
Jefferson	13	24
Streamside	8	12
Lesser siren	8	8
Four-toed	6	6
Mudpuppy	4	6
Northern dusky	2	2
Ravine-complex	1	1
Green	1	1
Red	0	0

whether random routes give an accurate depiction of amphibian distribution and abundance. Coupled with the negative effects of roadway traffic (Ashley & Robinson 1996; Fahrig et al. 1995) and road salt on amphibian mortality (Turtle 2000), surveying wetlands that are only within 200 m of roads may be biased towards underestimating amphibian abundance and overestimating declines.

Regardless of these concerns, I have provided a baseline data set on amphibian relative abundance that can be repeated. Future studies should involve long-term monitoring of some of the preserves and random routes surveyed herein.

Reptiles.—With the exception of painted turtles observed basking in numerous habitats, reptiles were infrequently encountered during this survey. Although 286 reptiles were observed in 23 counties, I do not feel that this sample size is robust enough for the same analysis that was done on the amphibian data. This is primarily because my methods were targeted for amphibians and reptiles that use wetlands. However, after spending over 1000 person-hours in the field and finding so few reptiles, the apparent rarity of reptiles may be real.

Historical trends.—Population trends observed by comparing my results to those from previous surveys can be made within limitations (Lannoo et al. 1994). Although past methods were not standardized or effort quantified, ranked relative abundance of species can be compared. Several of my survey areas had been surveyed in past decades. Minton (1998) surveyed sites in Jasper, Pulaski, Benton and Floyd Counties from 1948–1993. Grant (1936) reported amphibians and reptiles observed at Jasper-Pulaski Fish and Wildlife Area and Starke County from 1931–1934. Swanson (1939) collected amphibians and reptiles from Jasper, Pulaski, Martin, Monroe, Posey, Greene, Daveiss, and Dubois Counties. Mittleman (1947) reported notes on amphibians and reptiles collected from 1945–1946 in Monroe, Owen, and Martin Counties.

Grant (1936) reported the racer (*Coluber constrictor*), eastern ribbon snake (*Thamnophis sauritus*), common garter snake, six-lined racerunner and eastern hognose snake as common in Jasper-Pulaski Fish and Wildlife Area; and he reported the painted turtle, spotted turtle (*Clemmys guttata*), ornate box turtle (*Terrapene ornata*) and Blanding's turtle (*Emydoidea blandingii*) as common in Jasper-Pulaski Fish and Wildlife Area and in Starke County. Swanson (1939) considered the slender glass lizard (*Ophisauris ventralis*), six-lined racerunner, Blanding's turtle, spotted tur-

tle, ornate box turtle, and fox snake (*Elaphe vulpina*) to be common at Jasper-Pulaski Fish and Wildlife Area. I do not consider any of these species to be common in these areas today.

Swanson (1939) listed the smallmouth salamander, red-backed salamander, longtail salamander, Fowler's toad (*Bufo fowleri*), chorus frog, crawfish frog, eastern fence lizard (*Sceloporus undulatus*), five-lined skink (*Eumeces fasciatus*), worm snake (*Carphophis amoena*), northern ringneck snake (*Diadophis punctatus*), racer, eastern hognose snake, common kingsnake (*Lampropeltis getulus*), northern water snake (*Nerodia sipedon*), copperbelly water snake (*Nerodia erythrogaster*), red-bellied snake (*Storeria occipitomaculata*), rough green snake (*Opheodrys aestivus*), copperhead (*Agkistrodon mokasen*) and timber rattlesnake (*Crotalus horridus*) to be common in southern Indiana. Among these species I would only consider the chorus frog, Fowler's toad, and smallmouth salamander as currently common species in southwestern Indiana.

Mittleman (1947) considered the zigzag salamander (*Plethodon dorsalis*), two-lined salamander (*Eurycea cirrigera*), cricket frog, gray treefrog (*Hyla versicolor* and *H. chrysoscelis*), bullfrog, green frog, and queen snake (*Regina septemvittata*) to be "exceedingly common" in Indiana. Today only green frogs, the two gray treefrog species, and cricket frogs are common, and the later is common only in the southern part of its range.

Minton (1998) reported several species that declined during his lifetime. The cave salamander (*Eurycea lucifuga*), longtail salamanders, and zigzag salamander were plentiful in Floyd County but declined in the 1970s. The plains leopard frog, crawfish frog, and Blanding's turtle were common in Benton County in the early 1950s but did not occur in 1993. The cricket frog and blue-spotted salamander were common at Jasper-Pulaski Fish and Wildlife Area in the 1940s and 1950s but declined in the 1970s. My findings support Minton's observations that these species are no longer common in those counties.

Species status.—I consider species of amphibians that were encountered in fewer than 5% of the sites that had the presence of at least one species, and species found in fewer than 10% of the counties, to be rare. By these criteria five species of frog and 12 species of salamander are considered rare. These species include the wood frog, eastern spadefoot toad, crawfish frog, pickerel frog, plains leopard frog, Jefferson salamander (*A. jeffersonianum*), northern slimy salamander, four-toed salamander (*Hemidactylium scutatum*), streamside salamander (*A. barbouri*), mudpuppy, longtail salamander, cave salamander, hellbender, red salamander, green salamander, ravine salamander, and northern dusky salamander.

I found additional information on the abundance of amphibians from surveys conducted in the 1990s and reported in the recent literature (Kolozsvary & Swihart 1999) and Indiana Department of Natural Resources reports. I combined additional amphibian survey data from 26 additional counties (Brown, Cass, Crawford, Dekalb, Elkhart, Harrison, Howard, Jackson, Jefferson, Jennings, Johnson, Kosciusko, Lagrange, Lake, La Porte, Marion, Marshall, Noble, Orange, Perry, Porter, Ripley, Saint Joseph's, Steuben, Tippecanoe, and Washington Counties) with my data to assess the recent abundance of each species in Indiana (Fig. 1). Some of this additional coverage, such as surveys of subterranean and river fauna of Blue River Watershed and areas in central and southeastern Indiana, fills gaps in my surveys.

Based on the larger data set (Table 5), the southern leopard frog, wood frog, pickerel frog, eastern spadefoot, crawfish frog and plains leopard frog are rare. Also note that each of these species was encountered much less often than two species that are on the state special concern list, the cricket frog (*Acris crepitans*) and northern leopard frog (*Rana pipiens*). In the larger data set, rare salamanders include the western lesser siren, marbled salamander (*Ambystoma opacum*), Jefferson salamanders, four-toed salamander, streamside salamander, mudpuppy, longtail salamanders, red salamander, hellbender, green salamander, ravine salamander-complex, and northern dusky salamander.

I consider species of reptiles that made up less than 5% of the 286 animals seen or captured, and found in less than 5% of the 156 sites that had at least one species of reptile, to be rare. Based on this criterion all reptile species are considered rare in Indiana with the exception of the painted turtle, common snapping turtle (*Chelydra serpentina*), eastern box turtle, six-lined racerunner, bullsnake, eastern

hognose snake, northern water snake, and common garter snake. I am more concerned about the possible declines of reptiles in Indiana than amphibians. However, this conclusion should be considered with caution because upland and riverine habitats were not targeted as rigorously as wetland habitats. Survey methods targeted for reptiles, such as drift-fence arrays, turtle traps and mark-recapture, should be employed in future surveys to establish a more robust and unbiased baseline data set.

The first stage of conservation planning is to review data on biodiversity of the region (Margules & Pressey 2000). After compiling data, the next step is to collect more information on the localities of species considered to be rare in the region. We need to distinguish between species that are threatened with extinction from those that were missed or underrepresented on the basis of habitats surveyed and methods used (Margules & Pressey 2000). Once these species-specific surveys are completed, then conservation goals, planning, and implementation of conservation actions should occur (Margules & Pressey 2000).

ACKNOWLEDGMENTS

This study was funded by grants from the Indiana Department of Natural Resources Division of Fish and Wildlife and Division of Nature Preserves. I thank Lee Casebere and Katie Smith for permission to work on state properties and for providing DNR survey reports, including Indiana Department of Natural Resource Technical Advisory committee reports by Mary Linton, Jessica Marks, Michael Finkler, David Beamer, Bruce Kingsbury, Steve Perrill, Daryl Karns, Mike Lodata, Mike Ewert, Spencer Cortwright, John Iverson, and Alan Resetar. I also thank Brent Fisher of the DNR for sharing information from his hellbender survey. I am also grateful for field assistance provided by numerous students from Saint Joseph's College, most notably Jeanette Jaskula, Marissa Marlin, Michael Parrish, Heidi Krouse, Brandon Seifert and Sarah Martin. I give a special thanks to Jim Bogart for identifying blue-spotted salamander-complex larvae. I also thank the late Sherman Minton for providing distribution maps and site localities of each species.

LITERATURE CITED

Ashley, E.P. & J.T. Robinson. 1996. Road mortality of amphibians, reptiles, and other wildlife on the Long Point Causeway, Lake Erie, Ontario. Canadian Field-Naturalist 110:403–412.

Barinaga, M. 1990. Where have all the froggies gone? Science 247:1033–1034.

Bishop, C.A., K.E. Pettit, M.E. Gartshore & D.A. McLeod. 1997. Extensive monitoring of anuran populations using call counts and road transects in Ontario, Canada (1992–1993). Pp. 149–160, *In* Amphibians in Decline. (D.M. Green, ed.). Report from the Canadian Declining Amphibian Task Force, Herpetological Conservation Volume 1, Society for the Study of Amphibians and Reptiles, Canadian Association of Herpetologists, Montreal.

Brodman, R. 1995. Annual variation in breeding success of two syntopic species of *Ambystoma* salamanders. Journal of Herpetology 29:111–113.

Brodman, R. 1998. Biogeography of Midwest amphibians. Pp. 24–30, *In* Status and Conservation of Midwestern Amphibians. (M.J. Lannoo, ed.). University of Iowa Press, Iowa City, Iowa.

Brodman, R. & M. Killmurry. 1998. Status of amphibians in northwest Indiana. Pp. 125–136, *In* Status and Conservation of Midwestern Amphibians. (M.J. Lannoo, ed.). University of Iowa Press, Iowa City, Iowa.

Cyr, P.S. & J. Larivee'. 1993. A checklist approach for monitoring neotropical migrant birds: Twenty year trends in birds of Quebec using EPOQ. Pp. 229–236, *In* Status and Management of Neotropical Migratory Birds. (D.M. Finch & P.W. Stangel, eds.). U.S. Forest Service General Technical Report. RM-229, Fort Collins, Colorado.

Fahrig, J.J., J. Pedlar, S. Pope, P. Taylor & J. Wegner. 1995. Effect of road traffic on amphibian density. Biological Conservation 73:177–182.

Grant, C. 1936. Herpetological notes from northern Indiana. Proceedings of the Indiana Academy of Science 4:244–246. Hemesath, L.M. 1998. Iowa's frog and toad survey, 1991–1994. Pp. 206–216, *In* Status and Conservation of Midwestern Amphibians. (M.J. Lannoo, ed.). University of Iowa Press, Iowa City, Iowa.

Heyer, W.R., M.A. Donnelly, R.W. McDiarmid, L.A. Hayek & M.S. Foster. 1994. Measuring and Monitoring Biological Diversity. Standard Methods for Amphibians, Smithsonian Institution Press, Washington, D.C.

Highton, R. 1999. Geographic protein variation and speciation in the salamanders of the *Plethodon cinereus* group with the description of two new species. Herpetologica 55:43–90.

Houlahan, J.E., C.S. Findlay, B.R. Schmidt, A.H. Meyer & S.L. Kuzmin. 2000. Quantitative evi-

dence for global amphibian population declines. Nature 404:752–755.

Karns, D.R. 1986. Field Herpetology: Methods For the Study of Amphibians and Reptiles in Minnesota. James Ford Bell Museum of Natural History, Occasional Paper 18.

Kline, R. 1998. Monitoring amphibians in created and restored wetlands. Pp. 360–368, *In* Status and Conservation of Midwestern Amphibians. (M.J. Lannoo, ed.). University of Iowa Press, Iowa City, Iowa.

Kolozsvary, M.B. & R.K. Swihart. 1999. Habitat and the distribution of amphibians: patch and landscape correlates in farmland. Canadian Journal of Zoology 77:1288–1299.

Lannoo, M.J., K. Lang, T. Waltz & G.S. Phillips. 1994. An altered amphibian assemblage: Dickinson County, Iowa, 70 years after Frank Blanchard's survey. American Midland Naturalist 131:311–319.

Margules, C.R. & R.L. Pressey. 2000. Systematic conservation planning. Nature 405:243–253.

Minton, S.A. 1998. Observations on Indiana amphibians populations: A forty-five year overview. Pp. 217–220, *In* Status and Conservation of Midwestern Amphibians. (M.J. Lannoo, ed.). University of Iowa Press, Iowa City, Iowa.

Minton, S.A. 2001. Amphibians and Reptiles of Indiana. Indiana Academy of Science, Indianapolis.

Mittleman, M.B. 1947. Miscellaneous notes on Indiana amphibians and reptiles. American Midland Naturalist 38:466–484.

Mossman, M.J., L.M. Hartman, R. Hay, J.R. Sauer & B.J. Dhuey. 1998. Monitoring long-term trends in Wisconsin frog and toad populations. Pp. 169–198, *In* Status and Conservation of Midwestern Amphibians. (M.J. Lannoo, ed.). University of Iowa Press, Iowa City, Iowa.

Shirose, L.J., C.A. Bishop, D.M. Green, C.J. MacDonald, R.J. Brooks & N.J. Helferty. 1997. Validation tests of an amphibian call count survey technique in Ontario, Canada. Herpetologica 53: 312–320.

Simon, T.P., J.O. Whitaker, J.S. Castrale & S.A. Minton. 2002. Checklist of the vertebrates of Indiana. Proceedings of the Indiana Academy of Science 111:182–214.

Smith, P.W. & S.A. Minton. 1957. A distributional summary of the herpetofauna of Indiana and Illinois. American Midland Naturalist 58:341–351.

Swanson, P.L. 1939. Herpetological notes in Indiana. American Midland Naturalist 22:684–695.

Turtle, S.L. 2000. Embryonic survivorship of the spotted salamander (*Ambystoma maculatum*) in roadside and woodland vernal pools in southeastern New Hampshire. Journal of Herpetology 34:60–67.

Wake, D.B. 1991. Declining amphibian populations. Science 253:860.

Manuscript received 27 January 2003, revised 14 March 2003.