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Factors Determining Richness of Reptile and Amphibian Species in a Riparian Wildlife Dispersal Corridor

by

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Final Report

Surveys of reptile and amphibian species were conducted along the Cache River corridor in southern Illinois to determine the effect of width of a riparian corridor on species richness. It is believed that for passage species, a wide corridor will allow more species to move between core areas. Species lists were produced for sites in a core area to determine the possible number of species that may occur within the corridor, as well as in 2 narrow sites and 2 wide sites within the corridor. Data from this research show that the richness of reptile and amphibian species (corridor dwellers) was lower in the wide sites than in the narrow sites. Because the first narrow site was located closer to the core area, it was decided that immigration from the core allowed a largernumber of species to be present nearer to the core area regardless of width. In addition, the narrow areas provided more habitat heterogeneity and thus supported a higher number of reptile and amphibian species. This suggests that width of a site may not be the most important factor in determining species richness. Instead, factors such as distance from the core area and habitat heterogeneity may be more important in determining the species richness of reptiles and amphibians. Also, it was determined that an effective faunal dispersal corridor will cater to the life cycle requirements of its potential tenants. Studies into the natural history of the reptile and amphibian species found in the core area, suggest that a lack of upland habitats and

fishless pools along with severe inundation of terrestrial habitat prevents many species of snake, lizard, and salamander from occurring in the corridor. However, the riparian habitat of the corridor meets the life cycle requirements of 10 species of anura and 4 reptile species, and will allow them to persist within the corridor and pass between core areas in generational time.

A faunal dispersal corridor may be defined as a linear habitat whose main function is to connect two or more significant habitats or core areas (Beier and Lowe, 1992). Corridors provide connections for fragmented habitats that were contiguous before the impact of urban, industrial, or agricultural development (Saunders and Hobbs, 1991). Fragmentation of habitats has been considered to be a serious threat to biological diversity and a main cause of the present extinction crises (Wilcox and Murphy, 1985). Connecting core areas with corridors may facilitate the movement of poulations between these habitats, thus allowing an escape from problems prevalent in isolated habitats. This linking of substantial habitats may provide small populations relief from inbreeding depression and demographic and ecological stochasticity, thus reducing the possibility of local extinction. In addition, the corridor may provide supplemental habitat (Simberloff and Cox, 1992).

Unfortunately, a corridor may also have negative impacts on core area populations. The risk of exposure to predators and the spread of fire and disease through the corridor must be considered when determining the usefulness of linking core habitats. This link between habitats may also act as a sink drawing animals from one core habitat only to expire in the corridor before arriving at the second, connected habitat (Simberloff et al., 1992). In addition, a corridor may also have negative impacts on core area populations. Regardless of the uncertain and negative effects a corridor may have upon the inhabitants of the core area, it is still considered to be a prudent conservation strategy in maintaining healthy animal populations (Noss, 1987). Moreover, several authors contend that corridors must be maintained in spite of a lack of ability to assess their true role in maintaining diversity rather than be

eliminated only to discover the critical benefits they provided for the conservation of plants and animals (Saunders and Hobbs, 1991; Harris and Scheck, 1991).

Of the physical characteristics of the corridor important to conservation, Harrison (1992) identified habitat, width, length, human activities, and location as being the most significant. Of these variables, corridor width has gained much attention. Soulé and Gilpin (1992) suggested that a wide corridor facilitates the movement of organisms better than a corridor of narrow width. A narrow corridor characteristically provides less habitat than a wide corridor. Further, greater exposure to edge in narrow corridors can increase the exposure of inhabitants to predators and human activites. Consequently, corridors of substantial width and quality should contain a higher diversity of organisms, particularly that of corridor dwellers, than narrow areas (Friend, 1991; Harris and Scheck, 1991; Saunders and de Rebeira, 1991; Saunders and Hobbs, 1991).

When estimating the value of a corridor one must take into account the type of fauna utilizing the corridor, as well as the physical qualities of the corridor. Animals utilizing corridors to move between habitats can be considered either passage species or corridor dwellers. Passage species, such as medium-to-large sized mammals and birds, briefly travel through the corridor and require only a limited number of their life-cycle requirements to be met within the corridor. Corridor dwellers, on the other hand, remain in the corridor for several generations. This subset of corridor users includes

many insects, amphibians, reptiles, small mammals, and non-migratory birds of limited dispersal ability. Corridor dwellers need most or all of their life-cycle requirements to be met in the corridor (Beier and Loe, 1992)

The objective of this study was to determine the effect of width of a riparian corridor on the species richness of reptile and amphibian inhabitants. Riparian corridors are considered to be some of the most diverse, dynamic, and complex habitats. These types of corridors are dependent upon natural disturbance (flood, fire, landslides, debris, and channel migration) to create and maintain habitat heterogeneity (Naiman et al., 1993). Dickson (1989) suggested that a greater number of species of reptiles and amphibians inhabit areas of greater width than smaller width. In light of this suggestion, I quantified species richness of reptiles and amphibians along sections of a riparian corridor of varying width. Only the species found in all sections, regardless of width, should be able to traverse the corridor from one end to another. Characteristics of the riparian corridor that affect its use by species of reptiles and amphibians are discussed in relation to the natural history and life-cycle requirements of the reptiles and amphibians inhabiting the corridor. Using these data, recommendations are proposed to help alleviate the physical problems attributed to the corridor that discourage the movement of the animals from one core area to another.

Materials and Methods

Description of the corridor

This study was conducted along the Cache River in the southern Illinois counties of Union, Johnson, Alexander, Pulaski, Massac, and Pope.

This river system occurs at the junction of 4 major physiological provinces: the Central Lowlands, the Interior Low Plateaus, the Coastal Plains, and the Ozark Plateau. In order to drain portions of the Cache River directly into the Mississippi and improve suitability of the surrounding floodplain for agriculture, the Post Creek Cutoff was constructed in 1915. This channel effectively divided the Cache River into the Upper Cache River and Lower Cache River. The Upper Cache River has a total drainage of 353 sq. km and ranges from 271 m to 103 m above sea level. The Lower Cache River has a total drainage of 927 sq. km and ranges from 102 m to 85 m above sea level. Rock outcroppings, cliffs, and sandstone overhangs with upland and lowland forests composed of oaks, hickories, maples, ashes, and cypresses make up the topography and vegetation of the Upper Cache River basin. In contrast, the Lower Cache River basin is primarily composed of flat bottomland swamps dominated by cypress and tupelo trees. Unlike the Upper Cache River, the Lower Cache River is subject to periodic flooding due to its low elevation, poor drainage, mismanaged placement of damms and levees, and channelization. This damaged floodplain is from 2 to 4 km wide. About 70% (145, 000 ha) of its wetland habitat has been converted to agriculture, which in effect separates the lowland floodplain from the adjacent upland forests and clouds the sluggish Cache River with silt (Hutchison, 1987; Demissie et al., 1990).

The Cache River connects the once contiguous large habitats of Wildcat Bluff/Heron Pond and Horseshoe Lake (Fig 1). Located in the Upper Cache River area, the Wildcat Bluff/Heron Pond Nature Preserve encompasses an area of 789 ha and is composed mostly of Cache River floodplain bounded by steep bluffs and mesic upland forests. The 200 ha of the Horseshoe Lake

Nature Preserve is an ancient oxbow of the Mississippi and is mainly comprised of lowland forest (McFall, 1991). Wildcat Bluff/Heron Pond is connected to Horseshoe Lake by an 80 km stretch of riparian forest of differing widths along the Cache River. The Cache River and its riparian zone may therefore serve as a dispersal corridor for animals moving between Wildcat Bluff/Heron Pond and Horseshoe Lake.

Data collection

Four sites along the Cache River corridor and 2 sites in the Wildcat Bluff/Heron Pond Nature Preserve were surveyed to determine species richness of reptiles and amphibians at each site. The Wildcat Bluff and Heron Pond sites were surveyed to produce a species list for what can be considered a core area in this system. This species list was used to determine the total number of reptiles and amphibians that potentially could occur in the corridor. An unpublished survey of the reptiles and amphibians of the Cache River basin was compared to our survey to determine the effectiveness of our survey methods (Phillipi et al., 1986). However, we modified the published survey to include only species currently occurring in the corridor. Sites along the riparian corridor included 2 with wide (>1000 m) riparian habitat and 2 with narrow (<100 m) riparian habitat. The wide and narrow sites alternated along the corridor, with the first being a narrow site (Fig. 1). A transect of 500 m in length was established at each site, and in the core area. Each transect was parallel to the river, included the entire width of the riparian habitat at that site, and encompassed as many types of habitat as possible (swamps, ponds, and lowland and upland forest).

Seacrh methods for reptiles and amphibians along each transect were similar to Campbell'sl and Christmans' (1982) time-constrained technique and Crump's and Scott's (1994) visual encounter survey (VES), with additional trapping effort for turtles and salamanders. Species were located within the 500-m transect by turning cover, inspecting retreats, watching for surface activity, listening for calls, and trapping. Floating metal screen funnel traps and seines were used in ponds, swamps, and streams to survey salamanders in the breeding season. Aquatic turtles were surveyed at each site using hoop traps with a funnel entrance made of corded fisherman's netting and baited with chicken liver. Visual enounter surveys were conducted several times from March through October of 1994 and then again in March through June of 1995. Breeding adult and larval salamanders were trapped during March of 1995, and turtles were trapped during May and June of 1995. A total of 22 person-hours was spent conducting surveys at each site.

Descriptions of the Research Sites

Core Area.- The two transects at Wildcat Bluff and Heron Pond in Johnson County were located at T13S, R3E, NW 1/4 of Sec 19 and T13S, R3E, NW 1/4 of Sec 30 (Karnak Quadrangle), respectively (Fig .1). Wildcat Bluff and Heron Pond are part of one large (785 ha) area of habitat found 2 km north of the town of Belknap in the Upper Cache River. The diverse habitat along the two 500-m transects includes a buttonbush-cypress swamp, a mesic bottomland and upland forest, shallow swamp ponds, rocky-bluff outcroppings, and a swift-moving section of the Cache River. Many of these areas become flooded in the early spring, but because of proper drainage are usually dried to their normal levels by late spring.

Site 1.-This site in the Upper Cache River was located 3 river-km from the core area in Massac County at T14S, R3E, NE 1/4 of Sec. 5 (Karnak Quadrangle), 1.5 km south of the town of Forman (Fig.1). This first narrow area followed a very sluggish and shallow section of the Cache River, and ran parallel to a railroad embankment and a large bluff (Indian Point). The transect here included dry riparian forest less than 80 m wide, marshy pools, a remnant cypress swamp, and 2 fishless ponds. This area is very dry, rarely flooded, and surrounded by large tracts of agriculture.

Site 2.- This was the first of two wide sites and was found 24 river-km from the core area. This site in the Lower Cache River is located in Pulaski County at T14S, R1E, NW 1/4 of Sec 14 (Cypress Quadrangle), 1.5 km south of the town of Perks (Fig. 1). The riparian habitat at these sites was 1200 m wide and tends to be flooded year-round. This low floodplain habitat was composed mostly of cypress trees and buttonbush shrubs that flanked a very deep and almost stationary stretch of the Cache River. The surrounding area connecting the uplands north and south of the riparian corridor was dominated by agriculture, old fields, and roads.

Site 3.- This site was the second of the 2 narrow sites and was found 31 river-km from the core area. It was located in the Lower Cache River in Pulaski County at T14S, R1E, NE 1/4 of Sec 20 (Cypress Quadrangle), 3.5 km southeast of the town of Perks. Riparian habitat around the Cache River was less than 80 m wide at this site (Fig. 1). The southeast end of this transect was composed of drier disturbed upland forest that bordered the steep bank of the dredged, sluggish, Cache River channel. In this area, two ephemeral ponds surrounded by willow and old-growth oak trees were located on the border of

the riparian and old-field upland habitat. To the west, however, the habitat became modified into a flooded cypress/buttonbush swamp flanked by agriculture.

Site 4.- This site is the second of the two wide corridor areas. It was located 56 river-km from the core area at the border of Alexander and Pulaski counties at T15S, R1W, NW1/4 of Sec 7 (Tamms Quadrangle), on the eastern edge of the town of Tamms (Fig. 1). The habitat at this site was 1500 m wide and composed mostly of heavily-logged cypress/buttonbush swamp bordering a very silty and sluggish stretch of the Cache River. The area was littered with dead secondary growth trees and urban trash and showed evidence of recent flooding. Only a few tracts of land in this site remain uninundated by standing water all year. The corridor at this site is closely bordered by urban sprawl.

Analysis of data

The hypothesis that species richness of amphibians and reptiles is dependent upon corridor width was tested by single-factor analysis of variance (ANOVA), with wide (sites 2 and 4) and narrow (sites 1 and 3) as the treatments. The significance level was set at alpha equals 0.05, and the probability of type I statistical error (failure to reject the null hypothesis when it is actually false) was evaluated by power analysis (Cohen, 1988). Statistical tests were conducted using SPSS for windows, ver. 6.0 (SPSS, 1993), and power analysis was conducted using SOLO Power Analysis (SOLO, 1992).

Results

Surveys of the core area detected 37 species, including 6 species of salamanders, 11 species of frog, 11 species of snakes, 5 species of lizards, and 4 species of turtles (Table 1). This represents 88% of the species previously reported as occurring in this area, and indicates that the survey methods used were effective at detecting a wide range of species.

Species richness of reptiles and amphibians was much lower at sites 2, 3, and 4 than that in the core area, but was only slightly lower at site 1. Thirty-four species were detected at site 1 (5 species of salamanders, 11 species of frog, 9 species of snakes, 5 species of lizards, and 4 species of turtles, 15 species at site 2 (0 species of salamander, 10 species of frogs, 1 species of snakes, 1 species of lizard, and 3 species of turtles), 19 species at site 3 (1 species of salamander, 10 species of frogs, 4 species of snakes, 2 species of lizards, and 2 species of turtles), and 15 species at site 4 (0 species of salamander, 10 species of frogs, 1 species of snakes, 1 species of lizard, and 3 species of turtles).

Only 14 species were encountered at every site (*Hyla avivoca, H. chrysoscelis, H. cinerea, Pseudacris crucifer, P. triseraita, B. woodhousii, Rana clamitans, R. sphenocephela, R. catesbeiana, Eumeces fasciatus, E. laticeps, Nerodia erythrogaster, Trachemys scripta,* and *Chelydra serpentina*). Six species of reptiles and amphibians were found only in the core area (*Eurycea lucifuga, Carphophis amoenus, Diadophis punctatus, Nerodia sipedon, N. rhombifer,* and *Virginia valeria*). In addition, 5 species that were not detected in the core area were encountered in the corridor; *Agkistrodon contortrix, Sternotherus odoratus,* and *Chrysemys picta* were detected at site 1 and 2 and *Thamnophis sirtalis* and *T. sauritus* were detected in sites 1 and 3 .

The species richness of amphibians and reptiles was not significantly affected by width of the riparian habitat at the site (F=2.35, df=1, P=0.26), but the power for the test was low (0.39). Similarly, the species richness of the five taxonomic groups (salamander, frogs, lizards, snakes and turtles) was not significantly affected by the width of the riparian habita (P>0.05 for each taxanomic group). For total species and the separate taxonomic groups, the trend was in a direction opposite to that expected; more species were detected in the narrow sites than in the wide sites.

The total number of species of reptiles and amphibians detected per site declined drastically with distance from the site (Fig. 2a). This pattern varied among taxanomic groups, however. The decline in species richness at sites 2, 3 and 4 was particularly striking for salamanders (Fig. 2c), snakes (Fig. 2d), and lizards (Fig. 2e), but weak or absent for frogs (Fig. 2b) and turtles (Fig. 2f).

Discussion

Species Richness and Its Relationship to Corridor Width, Distance from Core Area, and Habitat Heterogeneity

Width of the riparian habitat did not appear to be the main factor determining species richness of reptiles and amphibians at my study sites. An experiment modeling corridors by Soulé and Gilpin (1991) identified corridor width as a primary consideration when designing conservation plans that include wildlife movement corridors. In addition, several other authors have identified width as a factor that will determine the species richness of a corridor (Friend, 1991; Harris and Scheck, 1991; Saunders and de Rebeira, 1991; Saunders and Hobbs, 1991). In contrast to expectations, the total species

richness was higher in the narrow areas than in the wide areas. Width of a corridor may still be important for providing cover for passage species such as many birds and medium-to-large-sized mammals, but factors other than width appear to have a strong effect on local species richness of corridor dwellers such as most reptiles and amphibians. (Saunders and Hobbs, 1991).

Proximity to the core area may have been an important factor determining species richness at my sites (Fig. 2). Site 1 had the highest species richness in the corridor and was only 3 river-km from the core area. The high richness at this site may be ephemeral and depend solely on yearly recruitment from the core area. This is similar to the rescue effect as described by Brown and Kodric-Brown (1977), in which small, unstable populations are constantly being replenished by immigrants from permanent populations. At greater distances from the core area, the total number of reptile and amphibian species detected at each site dropped dramatically. This decrease in species richness within the corridor may be due to increased rates of predation, lack of abundant prey items or interspecific competition. Corridors have higher edge-to-habitat ratios than core areas. Predator activity can be high near edges (Soulé and Gilpin, 1991) . The high edge-to-habitat ratio may expose the corridor inhabitants to a higher degree of predation than that of inhabitants of the core area, increasing rates of local extinction and making the corridor population sink for these species (Simberloff et al., 1992). However, this pattern of species decline was only noticed for salamanders, lizards, and snakes during this study. The frog and turtle species did not decline in the corridor. It was not uncommon in my sites to find turtle nests ravaged by predators. Predation on corridor dwellers may come from fish, birds, or mammals, as well as other members in the herpetofaunal

community itself. Because of the lack of decline of certain species in the Lower Cache River, increased predation in the corridor is probably not a general explanation for the lower species richness within that corridor. The presence or absence of abundant food items may also play an important role determining richness of predatory species in a corridor. However, from observations made during this study, there was an abundance of prey items (insects, fish, frogs, birds, and small mammals) to sustain populations of predatory reptiles and amphibians. Fitch (1982), also suggested that snakes maintain stable populations in the face of drastic oscillations of prey abundance. Although unknown, interspecific competition for prey or habitat may also cause a decline in species richness in the corridor.

Habitat heterogeneity is an important factor in determining species richness within a corridor. Harrison (1992) suggested that the habitat within the corridor will influence which species utilize the corridor. In this study, the habitat types present at each site had an effect on which corridor dwellers were present. The wide sites in the corridor examined in this study contained only 1 type of natural habitat, lowland floodplain forest. This forest was typically surrounded by agriculture or old field habitat. Although the narrow sites had a smaller total area of riparian habitat, both contained several different habitat types. Site 1, the first narrow site, was composed of dry upland habitat, 2 fishless ponds, a small cypress swamp, a railroad track and was only 100 km from an adjacent bluff. The habitat heterogeneity at this site may account for the occurence of 19 more species than in the wide areas. Site 3, the second narrow site, was composed of a floodplain swamp but also included a small area of upland habitat with 2 ephemeral ponds surrounded by hardwood trees. The heterogeneity at this site may account for the

occurence of 4 more species than in the wide areas. Unfortunately, this study cannot separate the effects of habitat heterogeneity and the distance from the core area on the observed species richness because site 1 was closest to the core area and contained the greatest diversity of habitat types.

An investigation into the natural history and life-cycle requirements of the corridor dwellers potentially using a corridor will provide insight into the effectiveness a corridor will have in promoting dispersal from 1 habitat to another (Friend, 1991; Harris and Scheck, 1991; Soulé and Gilpin, 1991). Unlike passage species, corridor dwellers need to have all of their life-cycle requirements met in the immediate area of the corridor in order for that corridor to be used effectively in their conservation (Beier and Lowe, 1992) On the other hand, when a species is not found throughout the corridor it is suggestive that some aspect of its life-cycle requirement is not being met in the corridor. Unlike passage species, corridor dwellers need to have all of their life-cycle requirements met in the immediate area of the corridor in order for that corridor to be used effictively in their conservation (Beier and Lowe, 1992). Hibernacula, breeding sites, and habitats in which the species are otherwise active are requirements in the life history of reptiles and amphibians in temperate regions that should be considered in order to assess the suitability of a corridor. What follows is a summary of the life-cycle requirements for each of the species of reptile and amphibian inhabiting the Cache River basin. Because patterns of species richness between the groups of reptiles and amphibians differed in the corridor, each will be considered separately when evaluating their life-cycle requirements. Based on this information, the sites along the Cache River corridor will be scrutinized for

compliance to these life-cycle requirements in hopes of better explaining the presence or absence of these species in the Cache River corridor.

Life-cycle Requirements of the Amphibians and Reptiles in the Cache River Basin

Frogs - Of the 11 frogs found in the core area, 10 occur throughout the corridor. Both *Hyla cinerea* and *H. avivoca* require some type of cypress swamp, flood plain swamp, marsh, or slough (Johnson, 1992; Smith, 1961; Wright and Wright, 1948; Trauth, 1992). Sloughs, swamps and flood plain forests abound in both the core area and the corridor. *H. versicolor*, *Pseudacris triseriata* , *P. crucifer*, and *Acris crepitans* require woodland ponds, lowland marshes, swamps, streams, or ditches (Johnson, 1992; Smith, 1961; Wright and Wright, 1949). Other than woodland ponds, those unspecific aquatic habitat requirements appear to be met by all habitats in the corridor containing water. In fact, Smith (1961) states that in Illinois the only habitat requirement for *A. crepitans* is any wet place. Judging from the abundance of these species throughout the corridor, most wet places in the Cache River basin may serve as breeding habitats for these frogs. It appears that the habitat requirements for the ranid frogs are also met at all of the sites along the corridor. *Rana clamitans*, *R. catesbeiana*, and *R. sphenocephela* will inhabit swamps, marshes, streams, creeks, ponds or sloughs (Johnson, 1992; Smith, 1961; Wright and Wright, 1949). Swamps, sluggish streams, and sloughs are quite common throughout the corridor. Smith (1961) mentions that in Illinois *R. catesbeiana* will occur anywhere there is a permanent body of

water and *R. sphenocephela* may be found in fields well away from water. He also mentions that *R. clamitans* commonly occurs near clear waters. During this study however, *R. clamitans* was consistently found calling in or near the silty waters of the Cache River. Of the two bufonid ftoads in this area, *Bufo woodhousii* tends to have the least demanding habitat requirements. They may be found near cypress ponds, river bottoms, and open, dry areas adjacent to marshes (Cagle, 1942a; Johnson, 1992; Smith, 1961; Wright and Wright, 1949). During this study, these toads were discovered in many different terrestrial habitats adjacent to the corridor, including agricultural fields, old fields, and roads. The heavily-cultivated lands surrounding the Cache River may be used extensively by *B. woodhousii*. This bufonid is not restricted to the riparian habitat along the Cache River and may not require that habitat to disperse between core areas. The other bufonid toad, *B. americanus*, was only found in the well-drained areas of the Upper Cache River in the core area and site 1. In Illinois, this particular subspecies, *B.americanus charlesmithi*, inhabits forests with steep-sided excavations in the Mississippi flood plain (Smith, 1961). In Missouri, Johnson (1992) describes this species as preferring rocky, wooded areas along the edges of hardwood forests. It is possible that *B. americanus charlesmithi* cannot tolerate the constant, heavy flooding and the lack of well-drained soils associated with the riparian flood plain of the lower Cache River at sites 2, 3, and 4.

For many organisms the habitat used for hibernation is different from that habitat used in their active period. In temperate regions many amphibians supercool during a period of hibernation to escape the harsh conditions of winter. Probably most of the frogs inhabiting the Cache River basin hibernate in areas very near to where they are active in the spring,

summer, and fall. These frogs must be able to tolerate dampness during hibernation because of the severe inundation of the terrestrial habitat. The microhabitat for hibernation of *B. americanus* is 1 m under the surface of the soil, whereas *B. woodhousii, H. versicolor, P. crucifer, P. triseriata,* and *A. crepitans* hibernate under at the surface of the soil hidden under leaves, logs, rocks, and debris (Schmid, 1982; Storey and Storey, 1987). *H. cinerea* has been found to hibernate in the bark of rotting trees (Neill, 1948). *Rana catesbeiana* is known to hibernate in the aquatic area it uses in the active season, whereas *R. clamitans* have been found hibernating on land 100 feet from the nearest source of water (Bohnsack, 1951; Willis et al., 1956). In other situations *R. clamitans* and *R. sphenocephela* have been known to hibernate in stream banks and in logs (Neill, 1948). *Rana clamitans* has also been found to hibernate in aquatic situations (Wright and Wright, 1949). It is assumed that *H. avivoca* also hibernates terrestrially or aquatically near the habitat they use in the active season. Other than *B. americanus charlesmithi,* it is assumed that the flood plain riparian habitat of the Cache River corridor is sufficient for both breeding and hibernating of 10 species of frogs. As the life history of *B. americanus charlesmithi* reveals, they may be limited by drier habitats in the active and hibernating seasons and thus cannot maintain a healthy population in the lower Cache River.

Salamanders - No salamanders occur consistently throughout the corridor. For the ambystomatid salamanders, the overwhelming factor limiting their ability to reproduce in and maintain stable populations in the Lower Cache river is a lack of fishless ponds. Phillippi et al. (1986) mention the problem of flooding in the Cache River as a source for the introduction of

fish predators in the previously fishless pools. Breeding adults, larvae, and juveniles of *Ambystoma maculatum, A. opacum, A. talpoideum,* and *A. texanum* were found in the 2 ephemeral ponds at site 1. Because of suitable breeding habitat, these species may not have to rely solely on recruitment from the core area for their presence at site 1. Other than at site 1 and the core area, ephemeral fishless ponds were found only in the sparsely-wooded upland area of site 3. Larval *A. maculatum* were found in the northernmost pond of site 3 in the late spring. The preference of *A. maculatum* for upland ponds in well-drained forests has been documented and may account for the presence this species presence at site 3 (Downs, 1989). Cagle (1942a) comments on locating this species in southern Illinois in oak-hickory forests adjacent to swamps. It should be assumed that *A. maculatum* will not be using the corridor to move from one core area to another. Unlike *A. maculatum, A. talpoideum* courts terrestrially and lays its eggs in forested, low-lying bottomlands and swamps in the fall or winter. The fall and winter rains create ephemeral fishless ponds which initiates the hatching of the terrestrially-laid eggs (Petranka and Petranka, 1981; Johnson, 1992; Smith, 1961). Unfortunately, the lack of fishless ponds along most of the riparian area in the corridor limits successful establishment of these populations. *A. talpoideum* also breeds in the fall or winter. Courtship for this species occurs in ephemeral fishless ponds. In Illinois, they are found in the same lowland cypress habitats as *A. opacum* and presumably were not breeding in the Lower Cache River due to a lack of fishless pools (Johnson, 1992; Patterson, 1978; Semlitsch, 1985). *A. texanum* breeds in the spring and may be found in the fishless ponds of wooded prairies, river floodplains, swamps, and cultivated fields (Johnson, 1992; Smith, 1961.). Although the habitat breadth of *A. texanum* is wider than that of *A. opacum* and *A. talpoideum,* they still will

not breed in the upland ponds at site 3, nor will they tolerate the fish-filled waters of sites 2 and 4. However, because *A. texanum* is known to occur in very disturbed areas throughout the state, it has not been clearly determined why their presence was not detected in the Lower Cache. McWilliams and Bachman (1988) discuss the importance of life history to help conserve populations of *A. texanum*. They suggest excluding fish predators and maintaining ephemeral ponds for the successful survival the larvae. These suggestions equally apply to maintaining fishless upland and lowland ponds for the successful survival of populations of *A. maculatum, A. texanum, A. opacum,* and *A. talpoideum*. Also, the effects of clear cutting has been shown to drastically decrease populations of *A. talpoideum* (Raymond and Hardy, 1991). Clear cutting for agriculture is evident along both sides of the Cache River extending down the entire length of the corridor. This clear cutting will obviously inhibit use of these areas by all species of *Ambystomaa* as well as many other species of reptiles and amphibians.

Like the ambystomatid salamanders, the 2 species of plethodontid salamanders do not occur consistently throughout the corridor. *Plethodon glutinosus* is known to inhabit damp ravines or moist areas in the summer and wooded hillsides in the spring (Johnson, 1992; Smith 1961). These salamanders have only been found in the Upper Cache River at site 1 and the core area, where they were consistently located under railroad ties on the well-drained embankment of site 1 and in the mesic forests of the core area. As noted by Pfingsten (1989), *P. glutinosus* will never be found in river bottoms or areas subject to flooding. With this information, it is clear that these salamanders would not occur on the floodplain of the riparian forest of the Cache river at sites 2, 3, and 4. *Eurycea lucifuga* was only captured near

the swamps and bluffs of the core area. This amphibian has a marked affinity for limestone outcroppings or caves (Hutchison, 1958; Johnson, 1992; Guttman, 1989; Smith, 1961). Smith (1961) notes that in Illinois these salamanders are found in swamps bordered by rocky bluffs. Site 1 is adjacent to a nearby rocky bluff, but it is separated from this bluff by a 100-m strip of agricultural land. This tract of agricultural land may be a barrier restricting any potential immigration of these salamanders from the bluff. The plethodontid salamander *E. longicauda* was not detected in the core area or the corridor. It is known to exist near the core area and site 1 (Phillippi et al., 1986). In Illinois, this animal is usually found in or near forested, rocky streams with a swift current (Smith, 1961). This species will probably not be using the Cache River corridor to pass from Wildcat Bluff/Heron Pond to Horseshoe Lake because of the lack of swift, rocky streams and the prevalence of sluggish muddy streams and sloughs.

Although not detected in the corridor or core area, *Siren intemedia* is suspected to occur in the Cache River basin (Phillippi et al., 1986). According to Smith (1961) this animal is commonly found in swamps, ditches and sloughs. These situations are abundant throughout the Cache River basin. It is possible that sampling methods used in this study were inadequate to determine the presence of sirens.

All of the salamanders in the Cache River probably have a period of inactivity. Although these salamanders may take on a fossorial lifestyle when inactive, they probably exist near the same aquatic or terrestrial habitats as when they are active.

Lizards - Of the 5 species of lizards occurring in the core area, only *Eumeces fasciatus* was found consistently throughout the corridor. According to Conant (1954), *E. fasciatus* in Ohio prefers ravines and moist environments. Fitch (1954), however, finds them to be common on wooded hillsides or hardwood forests. It appears from this study, that *E. fasciatus* is quite tolerant of the flooding conditions of site 2 and 4. In fact, at site 3 they were found on logs in the middle of the swamp. The flooded region of the Cache River probably has detrimental effects on many of the species of animals that prefer dry environments to live and lay their eggs. It has been observed that *E. fasciatus* will move its eggs to higher areas, such as stumps, when floodwaters rise (Henry S. Fitch, pers. comm.). This species is readily found in many unnatural conditions along the corridor: roadsides, houses, bridges, and fences. Like *B. woodhousii, E. fasciatus* may also traverse habitats outside of the corridor. Unlike *E. fasciatus, E. laticeps* does not seem to tolerate the inundated areas of the Lower Cache very well. Along with *E. fasciatus,* they are found in the dry upland areas of site 3 and the railroad embankment of site 1. Netting (1939) reports that *E. laticeps* is found in drier areas than *E. fasciatus. E. Laticeps* is also considered to be more arboreal, living mainly on dry cliffs, sunny hillsides, and hilltops (Conant, 1954). Thus, *E, laticeps* would probably not fare well in the inundated forests of the Cache River at sites 2 and 4. The other 3 species of lizards, *Scincella lateralis, Cnemidophorus sexlineatus,* and *Sceloporus undulatus,* do not occur along the Cache River below site 1. *S. lateralis* is fond of leaf litter in woodlands, woodland edges, mesophytic forests, pine woods and wooded fields. This species burrows in loose soil and is found in dry and moist habitats (Brooks, Jr., 1967; Fitch and von Achen, 1977). Surprisingly, they are not found in the sparsely-wooded area's of the uplands at site 3. Their absence in the upland at

site 3 may be due to that areas lack of leaf litter and abundance of tall grasses. They are, however, found in the leaf litter between the base of the railroad embankment and the riparian forest at site 1. Although not explaining their absence at site 3, the constant inundation of the terrestrial habitat in the Lower Cache River potentially has negative effects on the life-cycle of this small burrowing reptile. *C. sexlineatus* may be affected in similar ways. This thermophillic lizard inhabits rocky or sandy soil with sparse vegetation (summarized in Fitch, 1958b). The only area along the Cache River where *C. sexlineatus* and rocky and sparsely-vegetated habitat occur is along the railroad embankment in the core area and at site 1. These well-drained areas exist in sharp contrast to the damp habitat found in the Lower Cache River. Although a small area of dry upland may be found at site 3, it is heavily vegetated with high grass, oak and willow trees and does not provide the strict habitat which *C. sexlineatus* requires. *S. undulatus* also requires dry areas. Unlike *C. sexlineatus*, *S. undulatus hyacinthinus* is found in open dry areas, such as wooded hillsides or woodlots (Smith, 1946; Smith, 1961). In the Cache River, this species was only located along the railroad embankment of site 1 and the mesic forest of the core area. Sites 2 and 4 provide no dry wooded habitat, whereas the dry habitat at site 3 is too sparsely wooded to support a sizeable population of *S. undulatus*.

These 5 lizards hibernate in various habitats near the area they inhabit in the active season. According to several authors, *E. fasciatus, E. laticeps, S. lateralis,* and *S. undulatus* are known to hibernate in logs, stumps, debris, or under rocks (Fitch, 1954; Hamilton, 1948; Neill, 1948). Those 3 species may also hibernate subterraneally. All of these microhabitats for hibernating appear in the Lower Cache River, but probably suffer from heavy flooding. In

sites 2 and 4, where flooding is the worst, *E. fasciatus* is readily found. *S. undulatus hyacinthinus* has been found to hibernate in burrows beneath the ground, and spaces between rocks and logs. Even with the apparent lack of habitat in the active season, this species would undoubtedly suffer great losses from constant inundation during terrestrial or subterranean hibernation. Lastly, it has been well-documented that *C. sexlineatus* will hibernate in deep burrows during the winter. They were also found to hibernate only in areas with well-drained soils (Etheridge et al., 1983; summarized in Fitch 1958b). This would presumably limit them from hibernating in the damp Lower Cache River. Regardless of the lack of quality hibernating areas in the Lower Cache River, sites 2, 3 and 4 provide no habitat for *C. sexlineatus* in the active season.

Snakes - A total of 14 snakes were detected in the Cache River basin during this study. For ease in discussing their habitat requirements, they have been divided into 3 functional groups: aquatic snakes (*Nerodia erythrogaster, N. sipedon, N. rhombifer,* and *A. piscivorous*), large terrestrial snakes (*Agkistrodon contortrix, Lampropeltis getula, Coluber constrictor, Elaphe obsoleta,* and *Heterodon platirhinos*), and medium or small terrestrial or subterranean snakes (*Thamnophis sirtalis, T. sauritus, Diadophis punctatus, Virginia valeria,* and *Carphophis amoenus*).

The only species of snakes occurring consistently at every site in the corridor is *N. erythrogaster*. In the core area, this species is found very near the other three species of aquatic snakes (*N. sipedon, N. rhombifer,* and *A. piscivorous*). On first impression, it would seem that if *N. erythrogaster* occurs throughout the corridor, then the other three species should occur

throughout the corridor. Unfortunately, the Lower Cache is tailored to meet only the habitat specificities of *N. erythrogaster*. Although they all frequent aquatic areas, only *N. erythrogaster* and *A. piscivorous* are found in muddy sloughs, drainage ditches, and swamps (Burkett, 1966; Cagle, 1942a; Diener, 1957; Smith 1961). It has been suggested that *N. sipedon* does not occur frequently in muddy waters, swamps, or heavily-shaded regions (Lagler and Salyer, 1945). This may be true for *N. rhombifer* as well. Both species' diet depends heavily on fish (98% by volume for *N. rhombifer* and nearly 80% by volume for *N. sipedon*) and it may be assumed that both species would have trouble obtaining such prey items in the muddy waters outside of the core area (Cagle, 1942a; Diener, 1957; Hess and Klimstra, 1975; Lagler and Salyer, 1945).

Published records for the hibernacula of these three natricines are lacking, however it has been noticed that *N. sipedon* hibernates beneath logs and stumps, in the banks of ponds, in mammal burrows, and in ant mounds (Carpenter, 1953; Ernst and Barbour, 1989; Neill, 1948). It is possible that all 3 of these natricines' hibernating sites are very close to the habitat they utilize while active. *A. piscivorous*, however, requires upland habitats to hibernate. This animal utilizes swamps, sloughs, and marshes in the summer, but is frequently encountered on hills, bluffs, and rock outcroppings before the season of inactivity (Burkett, 1966; Dundee and Burger, 1948; Smith, 1961; Weill, 1947). *A. piscivorous* is probably constrained from occurring at sites 2, 3 and 4 by intensive agriculture and roads separating the swamps from potential upland hibernacula. Although site 3 has a small area of upland habitat, it does not have cliffs or other suitable hibernacula. *A. piscivorous* does occur at site 1 due to the adjacent rocky bluffs and small swamp found

there. Unfortunately, the sites in the Lower Cache River fail to meet the habitat requirements for the periods of activity of *N. sipedon* and *N. rhombifer* and the periods of inactivity of *A. piscivorous*.

The Lower Cache River also fails to meet the habitat requirements for all of the large terrestrial snakes. *H. platirhinos* requires well-drained soils and is commonly found in deciduous forests and open woodlands. Like the lizard *C. sexlineatus*, it also does not occur in the Lower Cache River due to a lack of well-drained soils. This species may be found to hibernate in the same habitat it uses when active. *H. platirhinos* is known to burrow into sandy soil and probably could not tolerate the severe and extended inundation of terrestrial habitat in the Lower Cache River during hibernation (Platt, 1969). *A. contortrix, E. obsoleta, L. getula,* and *C. constrictor* all require wooded hillsides, although they all may be found in low-loying areas during the period of activity. During the period of inactivity, however, they retreat to forested hillsides, bluffs or rock outcroppings (Fitch, 1960, 1963[a], 1963[b]; Smith 1961).

A. contortrix, E. obsoleta, and *C. constrictor* have been known to hibernate communally in wooded hillsides (Ernst and Barbour, 1989). Although detailed natural history data on *L. getula* is lacking, they were located in the same habitats as *A. contortrix, E. obsoleta,* and *C. constrictor.* These 4 species were all found near the railroad embankment of site 1 and the core area. *E. obsoleta* has been found near the edge of the riparian forest and the small upland area of site 3. *E. obsoleta* and *C. constrictor* are commonly regarded as species occurring in wooded areas adjacent to fields (Mitchell, 1994; Weatherhead and Charland, 1985). The single *E. obsoleta* found at site 3 either hibernated in the marginal upland area there or traveled across roads,

through old fields and agricultural areas from the nearest upland hibernaculum to get to that site. It is unknown why the other edge species, *C. constrictor*, was not detected at this site. With suitable upland habitat, these 5 snakes may consistently occur in the floodplain area of the Cache River. Currently, they are now no longer common in the Lower Cache River due to a lack of suitable habitat for hibernating.

Of the medium-to small-sized snakes, only *T. sauritus* and *T. sirtalis* occur in the Lower Cache River. According to literature records, both species may be found in grassy areas near water. These species are also known to hibernate in well-drained situations. *T. sauritus*, however, is more commonly found in bushes near water than is *T. sirtalis* (Carpenter, 1952). Carpenter (1953) has found *T sirtalis* to be hibernating completely submerged in water. Fitch (1965) reports that *T. sirtalis* may occur in almost every major type of habitat (wooded hills, tall grass prairies, old fields, pond margins etc.). Grassy or old field habitats may be found on the margins of all sites, yet these species were only found at sites 1 and 3. *T. sirtalis* is known to occur in similar numbers in disturbed habitats as well as undisturbed habitats (Blaesing, 1979). Also, these animals were not found in the core area. At site 1 they were found under railroad ties on the railroad embankment. However, at site 3 they were located near the steep bank of the Cache River away from the upland area. It is possible that these two species do occur at every site along the corridor and in the core area, but remained undetected during this survey.

The smallest snakes, *C. amoenus*, *D. punctatus*, and *V. valeria*, were found only in the core area. Clark (1970) reports that *Carphophis vermis*

needs sloped areas with well-drained soil for hibernation. Fitch (1958a) finds *C. amoenus* common in rocky wooded areas. Simirlary, *D. punctatus* occurs in well-drained woodlands, and hilltop pastures with loose soil; they are found in moist soil, but probably do poorly in wet soil (Fitch, 1975). Because of the limited mobility of *C. amoenus* and assumed limited mobility of *D. punctatus*, these two species probably do not migrate to different habitats to hibernate (Barbour et al., 1969; Fitch, 1958a). It is thought that both *D. punctatus* and *C. amoenus* would not be able to tolerate flood conditions because of their fossorial lifestyle (Henry S. Fitch, pers. comm.). It is obvious that the lack of unflooded forests in sites 2 and 4 eliminate the chance for the survival of these two species in the wide areas of the Lower Cache River. In addition, the marginally wooded upland area of site 3 has a choked understory of large grasses, which may hinder the movements of such fossorial organisms. These two species were not located at site 1. It may be that the railroad embankment, which provided summer habitat for the transient larger snakes, cannot provide enough upland habitat to fullfill the entire life-cycle of such small snakes. Because of limited mobility of *D. punctatus* and *C. amoenus*, presumably site 1 would receive little recruitment from the core area. The semifossorial *V. valeria* is also of small size and found only in the core area. In, Illinois, this species commonly occurs in or near forested woodsides (Smith, 1961). Fitch (1958a) has found them in deciduous forests with rocks and brush. Also, this species has been found to hibernate in rock crevices (Collins, 1974). If these animals have to be associated with rocky wooded hillsides, then they should be expected not to be found anywhere along the Cache River corridor. The thin strip of agriculture separating the adjacent bluff from site 1 may prevent *V. valeria* from traveling to the railroad embankment or the riparian corridor of site 1.

Although not found anywhere in the Cache River basin during this study, *Farancia abacura* is suspected to occur in the core area. Ernst and Barbour (1989), found this animal to be abundant in swamps and to prey selectively on salamanders. This species is also known to hibernate in stumps or logs in hills overlooking the banks of the swamps they inhabit in the active season (Neill, 1948). This species would not fare well in the Lower Cache River where salamanders and wooded hillsides are rare or absent.

Turtles - A total of 6 turtle species were detected in the Cache River basin. Only *Trachemys scripta* and *Chelydra serpentina* were found in the core area and at every site along the corridor. The habitat requirements for both of these species are found in every site along the Cache River corridor. These species may be found in oxbows, sloughs, lakes, and creeks with soft bottoms. Both of these species hibernate underwater, while *C. serpentina* may also hibernate on land (Ernst et al., 1994). These animals are commonly seen crossing roads near the corridor. Cagle (1950) found that *T. scripta* is quite common in swamps and deep pools in southern Illinois. Unlike the aquatic *T. scripta* or *C. serpentina*, *Terrapene carolina* was found on the sloping mesic forest of the core area and on a dry hill at site 4. This species commonly occurs in well-drained bottomlands, floodplains, and hillsides with abundant leaf litter and logs (Carpenter, 1957; Ernst et al., 1994; Stickel, 1950). *T. carolina carolina* hibernates in well-drained soils, sand, vegetable debris, or mud in hillsides or stream bottoms (Congdon et al., 1989; Ernst et al., 1994; Schwartz and Schwartz, 1991). It is not clear why this animal was not found throughout the corridor. Numerous individuals were seen on the roads running parrallel to the Cache River, suggesting that this animal may

be using the uplands, roads, or agriculture to disperse from major habitats. *Chrysemys picta* and *Sternotherus oderatus* are known from this study to only occur at site 1. Although they have different life history requirements, both species should be expected to be found throughout the entire corridor. *C. picta* and *S. oderatus* occur in slow-moving, shallow water. They are usually seen in creeks, streams, sloughs, oxbows, and ponds with soft bottoms. Although they are more terrestrial and are found only in the core area and site 2, *K. subrubrum* also inhabits those same areas and are fond of silty water. Both *C. picta* and *S. oderatus* hibernate in the water, whereas *K. subrubrum* hibernates on land (Ernst et al., 1994; Gibbons, 1983; Mitchell, 1994; Smith, 1961). They presumably do not require a different habitat in which to hibernate. Clearly evident, with the skewed distribution along this corridor of these three species, was a lack of reliable sampling. Unfortunately, trapping for turtles was not intense. To the detriment of a good turtle survey, most searches for reptiles were conducted by hand rather than by trap. This may have been the reason why *Apalone spinifer* was not detected in the core area or the corridor. Presumably, *A. spinifer* occurs in the Cache River basin (Phillippi et al., 1986). *A. spinifer* has an affinity for rivers, marshy creeks, bayous, oxbows, lakes, and impoundments with soft bottoms and aquatic vegetation. This species, as well as *K. subrubrum*, *S. oderatus*, and *C. picta*, should be well accommodated by the river, swamp, and slough habitat found within the entire corridor.

Conclusion, Implications for Conservation Biology of Reptiles and Amphibians through the Use of Corridors

Corridor width is a readily quantifiable factor that should be considered when corridors are being designed or evaluated in terms of their role in the

conservation of organisms. As shown by this study, width per se may not be the most critical factor in determining species richness of corridor dwellers in an area, especially for species considered to be corridor dwellers. To maintain the full diversity of species in the corridor, a degree of habitat heterogeneity similar to that in the core area may be required. Without dry upland habitats flanking the riparian area, many species of large terrestrial snakes may not survive within that portion of the corridor. In the Cache River corridor, those uplands are separated from the natural riparian area by agriculture, roads, old fields, and human structures. Tinkle (1959) discussed the dual usage of cliffs and swamps in winter and summer by many of the same species of reptiles and amphibians found within the Cache River corridor. Ford et al. (1991) supplied information on the diversity of different species of snakes found in upland habitat and floodplain forest in different seasons. In addition, Fitch (1958a) provided data on the dual usage of upland and lowland habitat for many species of reptiles and amphibians in Kansas. In addition to a lack of snake richness, the Cache River corridor also has a deficit of lizard and salamander species. The absence of fishless pools due to periodic flooding of the Cache River does not permit successful breeding in the corridor by many species of salamanders. This flooding has also made the terrestrial environment unsuitable for most small snakes and lizards. In short, the lack of connected uplands and severe inundation of the riparian area has made much of the corridor inhospitable to all but 14 species of reptiles and amphibians. Apparently only those 14 species have all of their life requirements met by the riparian forest of the corridor. This result emphasizes that the natural histories and life-cycles of the potential inhabitants of the corridor must be studied in order to assess the suitability of the habitat heterogeneity within that corridor for those corridor dwellers.

In addition to width of and habitat heterogeneity in a corridor, length of a corridor may be an important determinant of its success. Species richness may be higher closer to the core area, even in areas of very small width, because reptile and amphibian recruitment from the core area may allow populations to persist through high immigration rates. However, the results of my study indicate that this rescue effect may diminish or disappear very rapidly as the distance from the core area increases.

Although beyond the scope of this study, movement of corridor dwellers from the core area into the corridor and then along the corridor is vital to demonstrating the effectiveness of a corridor. Reptiles and amphibians are generally not as vagile as birds or large mammals. Many authors have published works on movements of reptiles and amphibians (Bennett et al., 1970; Brown and Parker, 1976; Cagle, 1944; Dole, 1965; Fitch, 1958a; Fitch and Shirer, 1971; Fond et al., 1991; Fraker, 1970; Freedman and Catling, 1979; Gregory, 1982; Gregory and Stewart, 1975; MaCartney et al., 1988; Martof, 1953; Patterson, 1978; Petranka and Petranka, 1981; Semlitch, 1981; Semlitsch, 1985; Stone et al., 1993; Stickel and Cope, 1947; Whitford and Vinegar, 1966; Willis et al., 1956). Some of these studies discuss the movement of reptiles and amphibians into different environments at different times of the year. Long distance traveling for many of these animals appears to be associated with movement within home ranges and movement from summer habitats to winter hibernacula. However, some amphibians and reptiles may move substantial distances in a short time. For example, Keister et al. (1982) found that in just over a year *T. carolina* moved a straight line distance of approximately 10 km. Even at this rate it would take 8 years

for an animal to move from one core area to another through the Cache River corridor. Further, many of these movements may not be directed from one large habitat to another. It is possible that these animals move through corridors in an undirected fashion, with much backtracking. If this were the case, these corridor dwellers would take a very long time to move from one core area to another. Quick dispersal by rivers has been cited as a means for dispersal of lizards through a riparian area, and may be shown to move other corridor dwellers between habitats quite rapidly (Heger and Fox, 1992). However, if a corridor is too long to allow frequent recruitment from core areas, and the organism is of low vagility and is unaided in its movement by an external source, then the corridor must provide the habitat heterogeneity to fullfill the life-cycle requirements of that organism to allow it to persist within the corridor and pass between core areas over generational time.

The results of this research identified habitat heterogeneity and distance from the corridor as the 2 most important factors in determining the species richness of reptiles and amphibians in the Cache River riparian corridor in southern Illinois. This suggests that an effective corridor should contain a variety of habitats similar to that found in the core area. An effective faunal dispersal corridor will cater to all of the life-cycle requirements of its potential tenants.

Acknowledgements

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Table 1. Reptile and amphibian species of the Cache River corridor. X=presence observed during this study and 0=presence not observed during this study.

	Sites				
Species	Core	I	II	III	IV
Hyla avivoca	X	X	X	X	X
Hyla cinerea	X	X	X	X	X
Hyla versicolor	X	X	X	X	X
Pseudacris crucifer	X	X	X	X	X
Pseudacris triseriata	X	X	X	X	X
Acris crepitans	X	X	X	X	X
Rana clamitans	X	X	X	X	X
Rana catesbeiana	X	X	X	X	X
Rana sphenocephela	X	X	X	X	X
Bufo americanus	X	X	O[*,?]	O[?]	O[?]
Bufo woodhousii	X	X	X	X	X
Ambystoma opacum	X	X	O[2]	O[2]	O[2]
Ambystoma texanum	X	X	O[3]	O[3]	O[3]
Ambystoma maculatum	X	X	O[1]	X	O[1]
Ambystoma talpoideum	X	X	O[2]	O[2]	O[2]
Ambystoma tigrinum	O[*,?]	O[*,?]	O[1]	O[5]	O[5]
Eurycea lucifuga	X	O[6]	O[6]	O[6]	O[6]
Eurycea longicauda	O[*,?]	O[*,?]	O[8]	O[8]	O[8]
Plethodon glutinosus	X	X	O[4]	O[4]	O[4]
Siren intermedia	O[7]	O[7]	O[7]	O[*,?]	O[7]
Terrapene carolina	X	O[34]	O[4]	O[*,?]	X
Trachemys scripta	X	X	X	X	X
Chrysemys picta	O[?]	X	O[?]	O[?]	O[?]

Sternotherus odoratus	$0^{*,?}$	X	$0^?$	$0^{*,?}$	$0^?$
Kinosternon subrubrum	X	$0^?$	X	$0^?$	$0^?$
Chelydra serpentina	X	X	X	X	X
Apolone spinefera	$0^?$	$0^?$	$0^?$	$0^?$	$0^?$
Eumeces laticeps	X	X	0^5	X	0^5
Eumeces fasciatus	X	X	X	X	X
Scincella lateralis	X	X	0^5	0^5	0^5
Cnemidophorus sexlineatus	X	X	0^5	0^5	0^5
Sceloporus undulatus	X	X	0^5	0^5	0^5
Carphophis amoenus	X	$0^?$	0^5	0^5	0^5
Diadophis punctus	X	$0^?$	0^5	0^5	0^5
Heterodon platirhinos	X	X	0^5	0^5	0^5
Farancia abacura	$0^{*,?}$	$0^?$	$0^{4,9}$	$0^{4,9}$	$0^{4,9}$
Elaphe obsoleta	X	X	$0^{*,3}$	X	0^3
Coluber constrictor	X	X	0^4	0^4	0^4
Lampropeltis getula	X	X	0^4	0^4	0^4
Thamnophis sauritus	$0^?$	X	$0^?$	X	$0^?$
Thamnophis sirtalis	$0^?$	X	$0^?$	$0^?$	$0^?$
Virginia valeria	X	0^4	0^4	$0^{*,4}$	0^4
Nerodia erythrogaster	X	X	X	X	X
Nerodia sipedon	X	$0^{*,7}$	0^7	0^7	0^7
Nerodia rhombifer	X	$0^{*,7}$	0^7	0^7	0^7
Agkistrodon contortrix	$0^?$	X	0^4	0^4	0^4
Agkistrodon piscivorus	X	X	0^4	0^4	0^4

* Absent, but presence known in approximate area from literature records and subsequently not used in the analysis of these data (Phillippi et al., 1986).

? Absent for unknown reasons.

[1] Absent due to a lack of upland fishless ponds formed in the spring.

[2] Absent due to a lack of floodplain fishless ponds formed in the fall or winter.

[3] Absent due to a lack floodplain fishless ponds formed in the spring.

[4] Absent due to a lack of forested upland habitat.

[5] Absent due to a lack of uninundate soils.

[6] Absent due to a lack of rock outcrops.

[7] Absent due to a lack of clear, shallow, and unshaded water.

[8] Absent due to a lack of rocky, swift streams.

[9] Absent due to a lack of abundant prey items.

Fig. 1. Map of the Cache River corridor showing the location of the research sites.

Fig. 2a. Relation between the number of reptile and amphibian species and the distance from the core area.

Fig. 2b. Relation between the number of frog species and the distance from the core area.

Fig. 2c. Relation between the number of salamander species and the distance from the core area.

Fig. 2d. Relation between the number of snake species and the distance from the core area.

Fig. 2e. Relation between the number of lizard species and the distance from the core area.

Fig. 2f. Relation between the number of turtle species and the distance from the core area.

Uplands

Riparian Forest

Agriculture, Urban or Old Field

2 km

Cache River

Wildcat Bluff - Heron Pond

Site 2

Site 3

Post Creek cutoff

Site 1

Site 4

Horseshoe Lake

Illinois

River

Mississippi

river diversion

River

Ohio

Kentucky

Missouri

Enlarged Area