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AMPHIBIANS AND REPTILES OF THE GRAND CALUMET RIVER BASIN

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ABSTRACT. The Grand Calumet River and its associated dune and swale areas of northwest Indiana is a globally unique ecosystem. However, it has been nearly obliterated by industrial, commercial, and residential development. Remnant natural areas, some protected, some not, harbor an incredibly diverse array of amphibians and reptiles. This area features species whose ranges converge from all four compass directions, hence generating the impressive diversity. Clean up of the Grand Calumet River and improvement of riparian areas should help maintain this diversity. In addition, preservation of unprotected sites and well-planned habitat linkages will further enhance preservation of this diversity for generations to come.

Keywords: Grand Calumet River, Indiana, amphibians, reptiles, habitat quality, habitat protection, dune and swale

The ridge and swale area (Fig. 1) surrounding the Grand Calumet River is home to one of the more diverse assemblages of amphibians and reptiles in northwest Indiana. Each time Lake Michigan receded, a dune ridge formed trapping an elongate wetland behind it. Well over 100 ridges originally existed in what is now Gary, East Chicago, and Hammond, Indiana. Here, as a result of recent geologic and climatic events, species more typical of areas to the north, south, east, and west come together and occur in close proximity. Surprisingly, despite the long and intensive industrial history of the region, several relatively pristine natural areas have survived along with most of their salamander, frog, turtle, lizard, and snake species. The survival of these natural areas and their associated faunas provides unique opportunities for preservation and restoration.

In addition to the immediate riparian area, the contiguous ridge and swale sites were included in the study. Since amphibians and reptiles are less mobile than many other vertebrates and less likely to colonize remote or isolated habitats, existing centers of biodiversity must be inventoried, and the data factored into management decisions. Information available from recent inventories and older museum specimens and publications supplemented our own field experience in the area. Nomenclature follows Collins (1990), except the for the more recent elevation of *Bufo fowleri* to specific status (Sullivan et al. 1996).

PRE-SETTLEMENT CONDITIONS

Origin of the herpetofaunal assemblage.—Presumably, amphibians and reptiles entered what is now the Grand Calumet River area shortly after the end of the Wisconsinan glaciation. Remains of the cold-tolerant tur-

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tles, *Chelydra serpentina* and *Chrysemys picta*, have been found in association with mastodon bones in southeastern Michigan and east-central Indiana (Holman & Andrews 1994) at sites dated to 13,000–11,000 years before present (ybp). Other species that today have northern distributions also must have been present in the boreal forest that covered northwest Indiana at that time. However, the present-day site of the Grand Calumet River was still covered by the waters of post-glacial Lake Chicago. Subsequent fluctuation of lake levels (Chrzastowski & Thompson 1992; Chrzastowski et al. 1991) and climate change (Ahearn & Kapp 1984; Ebbers 1984) profoundly influenced the sequence and location of later colonization events.

The diverse herpetofauna includes northern elements (e.g., the blue-spotted salamander, *Ambystoma laterale*, and Blanding's turtle, *Emydoidea blandingii*) and eastern species (e.g., the eastern newt, *Notophthalmus viridescens*, and the green frog, *Rana clamitans*). These species may have been present since not long after glacial retreat, and they persist today in moist woodland and wetland habitats. Species of western or southern origin and characteristic of warmer or drier conditions (e.g., Fowler's toad, *Bufo fowleri*, the six-lined racerunner, *Cnemidophorus sexlineatus*, and the western slender glass lizard, *Ophisaurus attenuatus*) presumably entered the Calumet region during a hypsithermal interval (Smith & Minton 1957) about 6200 to 5050 ybp (Ahearn & Kapp 1984). Today, these species inhabit xeric dunes or open grasslands.

The parallel sand ridges north of the Grand Calumet River did not form until about 2500–1000 ybp (Thompson 1992). This landscape is very young, even for our recently glaciated region. Amphibian and reptile populations inhabiting dune and swale habitat must have colonized new wetlands and ridges as they formed.

In the 1830's, the Grand Calumet River was a shallow, sluggish body of water bordered by emergent marshes. Nearby upland ridges were usually open sand savanna interspersed with areas of dry-mesic to wet sand prairie. Adjacent swales also were diverse, with open water, marsh, and shrub swamp communities. Because of the diversity of available habitat and the unusual history of the areas, a unique assemblage of amphibians and reptiles was present at the time of settlement.

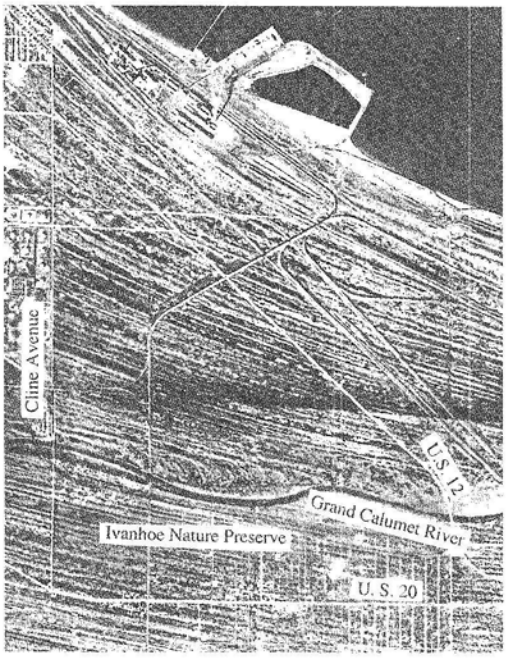

Figure 1.—A 1939 aerial photo of a section of the Grand Calumet River in west Gary and east Hammond (westernmost north-south road is Cline Avenue, the border between the two cities). The numerous rows of dune and swale are evident. U.S. 20 is the southernmost east-west roadway, and U.S. 12 angles from the southeast corner of the photo to the northwest corner. The Grand Calumet River (dark curved line) snakes through the bottom third of the photo. Ivanhoe Nature Preserve is the second and third "blocks" of swales northeast from the intersection of Cline Avenue and U.S. 20. The "hooked" dune ridges to the north of the Grand Calumet River mark successive mouths of the river as the mouth migrated eastward with the development of each new ridge. Photo and description courtesy of Steve Brown, Indiana Geological Survey.

Sources of information.—Any reconstruction of the pre-settlement herpetofauna must rely in part on somewhat later sources. The first museum specimens form the area were collected in 1902, but no records of amphibians or reptiles in the Grand Calumet River area were published prior to Shelford (1913), who listed species at a few localities west of Gary.

Combining early published sources, specimens in area museum collections, and knowledge based on the best remaining natural areas

and examples of particular habitat types, a potential total of 34 species of pre-settlement amphibians and reptiles has been compiled (Table 1). The sluggish open-water channel of the Grand Calumet River must have been inhabited by a variety of fully aquatic species. Snapping turtles (*Chelydra s. serpentina*), musk turtles (*Sternotherus odoratus*), and painted turtles (*Chrysemys picta marginata*) were certainly present in the lagoons by Miller, now in northeast Gary, in the early part of this century, because they are documented by museum specimens. Shelford (1913) reported the three species listed above, as well as map turtles (*Graptemys geographica*), in ponds north of the river at Clark Street (Sites 11 and 12 in Fig. 2), and these species may have been present in the channel as well. Mudpuppies (*Necturus maculosus*) still occur in Wolf Lake (straddles the Indiana/Illinois state line in northwest Hammond) and in Lake Michigan; they may have entered the river before severe water degradation.

Riparian wetlands probably provided foraging areas for all of the above species, as well as semi-aquatic species such as bullfrogs (*Rana catesbeiana*), green frogs (*Rana clamitans melanota*), Blanding's turtles (*Emydoidea blandingii*), and common water snakes (*Nerodia sipedon*). Terrestrial species may have entered riparian areas on occasion, but did not permanently reside there.

Swales adjacent to the river provided habitat for a rich array of species. Salamanders and frogs used these wetlands for breeding, and several species of turtles and snakes probably reached maximum abundance there. Shelford (1913) listed tiger salamanders (*Ambystoma t. tigrinum*), red-spotted newts (*Notophthalmus viridescens*), northern leopard frogs (*Rana pipiens*), snapping turtles (*Chelydra s. serpentina*), musk turtles (*Sternotherus odoratus*), painted turtles (*Chrysemys picta marginata*), map turtles (*Graptemys geographica*), and garter snakes (*Thamnophis s. sirtalis*) from swales near Clark Street (Sites 11 and 12 in Fig. 2). Various terrestrial species occupied the intervening sand prairie and savanna.

CURRENT STATUS

Grand Calumet River channel.—Because of severe water quality degradation, only a few tolerant reptiles presently inhabit the

Table 1.—Potential amphibian and reptile species during presettlement times in the Grand Calumet River basin. All authors of species are as in Minton (2001).

Frogs and toads
- *Acris crepitans blanchardi* (Northern cricket frog)
- *Bufo americanus* (American toad)
- *Bufo fowleri* (Fowler's toad)
- *Hyla versicolor* (Gray tree frog)
- *Pseudacris crucifer crucifer* (Spring peeper)
- *Pseudacris triseriata triseriata* (Western chorus frog)
- *Rana catesbeiana* (Bullfrog)
- *Rana clamitans melanota* (Green frog)
- *Rana pipiens* (Northern leopard frog)

Salamanders
- *Ambystoma laterale* (Blue-spotted salamander)
- *Ambystoma tigrinum tigrinum* (Eastern tiger salamander)
- *Necturus maculosus* (Mudpuppy)
- *Notophthalmus viridescens* (Eastern red-spotted newt)
- *Plethodon cinereus* (Redback salamander)

Snakes
- *Coluber constrictor* (Blue racer)
- *Elaphe vulpina vulpina* (Western fox snake)
- *Heterodon platirhinos* (Eastern hognose snake)
- *Lampropeltis triangulum* (Milk snake)
- *Nerodia sipedon* (Common water snake)
- *Opheodrys vernalis* (Smooth green snake)
- *Regina septemvittata* (Queen snake)
- *Storeria dekayi wrightorum* (Midland brown snake)
- *Thamnophis proximus proximus* (Western ribbon snake)
- *Thamnophis radix radix* (Plains garter snake)
- *Thamnophis sirtalis sirtalis* (Eastern garter snake)

Turtles
- *Chelydra serpentina serpentina* (Common snapping turtle)
- *Chrysemys picta marginata* (Midland painted turtle)
- *Clemmys guttata* (Spotted turtle)
- *Emydoidea blandingii* (Blanding's turtle)
- *Graptemys geographica* (Common map turtle)
- *Sternotherus odoratus* (Common musk turtle)

Lizards
- *Cnemidophorus sexlineatus* (Six-lined racerunner)
- *Eumeces fasciatus* (Five-lined skink)
- *Ophisaurus attenuatus attenuatus* (Western slender glass lizard)

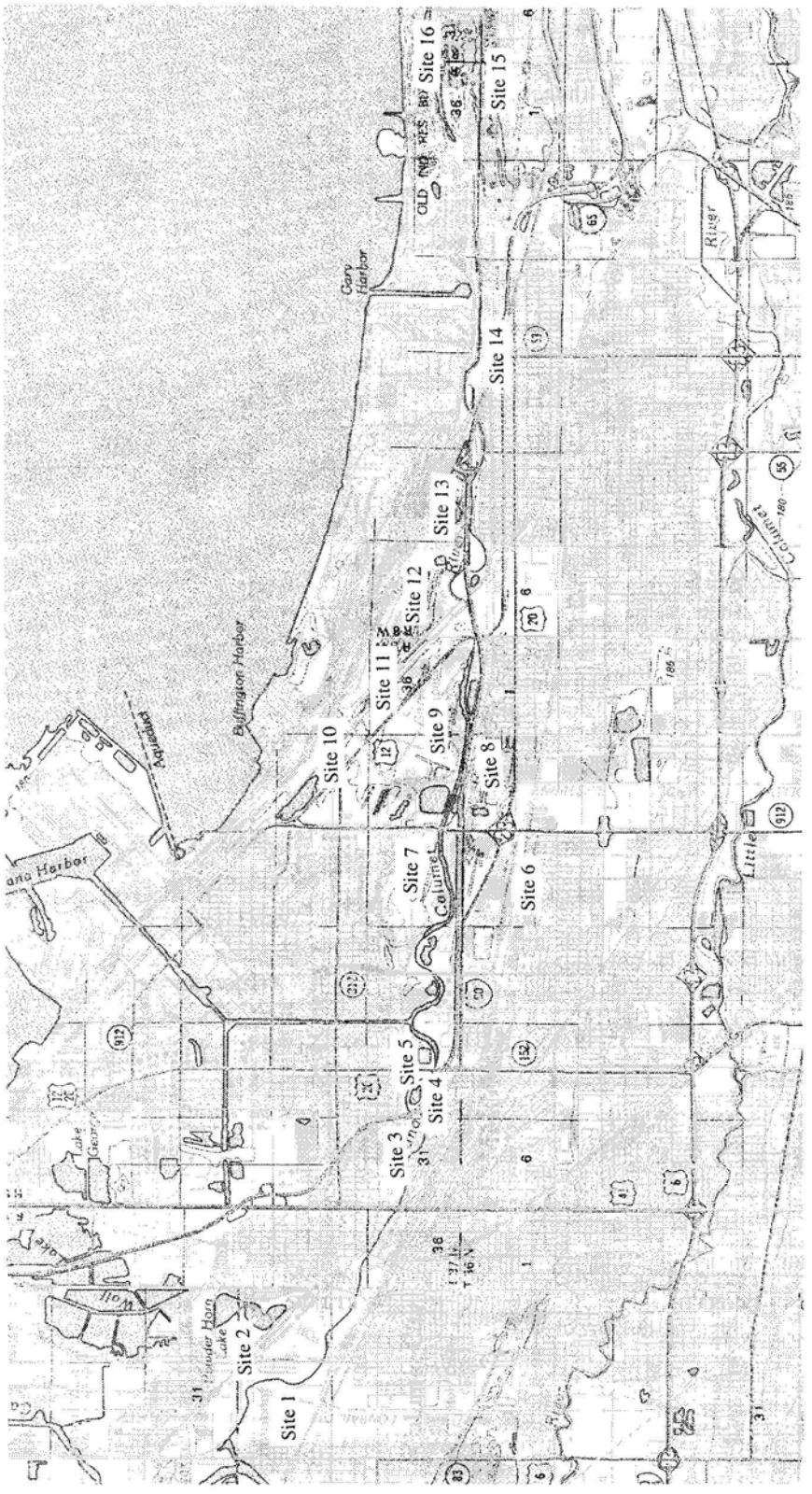

Figure 2.—Recent map of the Grand Calumet River, with the numbered sampling sites located along the north and south sides of the river. Each numbered reference site is named in the text.

channel of the Grand Calumet River. Snapping turtles and painted turtles have been reported from the eastern reaches of the river (Sobiech et al. 1994), and the authors observed both species at several locations from the Hammond Sanitary District (Site 3 in Fig. 2) to United States Steel Corporation (Site 14 in Fig. 2). Both species are relatively tolerant of poor water quality. At present, no amphibians are permanent residents of the open channel, although individual animals may enter the area from time to time.

Riparian areas.—Recent searches of riparian marshes have not revealed any amphibians or reptiles. Monospecific stands of common reed (*Phragmites australis*), which now dominates many, if not most, wetlands in the Calumet region (Choi 2002, this volume), may not provide useful habitat for most species. Areas densely dominated by cattails (*Typha latifolia*), which also are very common, provide marginally better habitat structure. Here, however, poor water quality and dense layers of cattail thatch are the limiting factors preventing amphibian and reptile colonization. Some common species, such as garter snakes, may enter the riparian wetlands on occasion.

Stands of young floodplain forest, characterized by pioneer species such as cottonwood and usually by a dense understory, are present at several locations along the river margin. These habitats are largely impenetrable. If wetlands isolated from the river exist in the cottonwood thickets, they could be used by some common amphibian species for breeding, but the sites are probably too heavily overgrown and shaded for most reptiles.

ADJACENT SITES

While the Grand Calumet River and bordering riparian wetlands support a depauperate herpetofauna, several natural areas near the river are noted for their species richness. Some parcels of lesser quality also support amphibians or reptiles tolerant of habitat modification. These sites are described below on a reach-by-reach basis from east to west.

Grand Calumet Lagoons reach.—The lagoons at the easternmost end of the Grand Calumet River (site 16 in Fig. 2) are partially bordered on the north and south by Miller Woods, which is part of Indiana Dunes National Lakeshore. Areas immediately south of the lagoons consist largely of dry-mesic sand savanna with interspersed marsh and pond communities in swales. The area to the north is a diverse dune complex in immediate proximity to Lake Michigan and includes unusual communities such as pannes (Wilhelm 1990). The Miller area is located in a transition from the more mesic, sheltered areas (which become increasingly more common) to the east, and the more open and increasingly prairie and savanna dominated sites to the west.

Specimens of amphibians and reptiles collected from the Miller area are available from as early as 1902. Several prominent scientists, including Carl Hubbs, Karl P. Schmidt, and Walter Stille, visited the area during the first half of the 20th century. However, locality data for these early specimens are usually vague and many of them may have been collected outside of the current boundaries of the National Lakeshore. More recent data (Table 2), gathered in the mid-1980's, is available from Resetar (1988) and Werth (1990). The study site (Site 15 in Fig. 2) of Werth (1990) was located a little more than 1 km south of the Lagoons, but the site included habitat representative of the general area.

Resetar (1988) listed 18 species of amphibians and reptiles occurring within Miller Woods (area around Site 15 in Fig. 2) at the time of his study. One of these, Fowler's toad, is characteristic of the pannes and blowouts north of the Grand Calumet Lagoons, though the other 17 species are more general in occurrence. All 18 species could occur in the immediate proximity of the lagoons. Only two other sections of the National Lakeshore, the Cowles Bog Unit and the Eastern Unit (both well east of the Grand Calumet River), support greater herpetofaunal species richness (Resetar 1988).

Additional species have been reported historically from Miller Woods (Site 15 in Fig. 2) and surrounding areas (now largely converted to industrial, commercial, and residential development), but are not documented from Miller Woods within Indiana Dunes National Lakeshore (*Acris crepitans blanchardi*, *Coluber constrictor*, *Elaphe v. vulpina*, *Eumeces fasciatus*, *Nerodia sipedon*, *Plethodon cinereus*, *Rana pipiens*, and *Thamnophis r. radix*). In Miller Woods, these species may be present but as yet undocumented, locally extirpated, or still present in habitat remnants outside of Miller Woods *per se*. *Acris crepi-*

Table 2.—Species of amphibians and reptiles from Miller Woods (Site 15) recorded by Resetar (1988) and Werth (1990).

Frogs and toads
Bufo fowleri (Fowler's toad)
Hyla versicolor (Gray tree toad)
Pseudacris c. crucifer (Spring peeper)
Pseudacris t. triseriata (Western chorus frog)
Rana catesbeiana (Bullfrog)
Rana clamitans melanota (Green frog)
Salamanders and newts
Ambystoma laterale (Blue-spotted salamander)
Ambystoma tigrinum tigrinum (Eastern tiger salamander)
Notophthalmus viridescens (Eastern red-spotted newt)
Snakes
Heterodon platirhinos (Eastern hognose snake)
Storeria dekayi wrightorum (Midland brown snake)
Thamnophis proximus proximus (Western ribbon snake)
Thamnophis sirtalis sirtalis (Eastern garter snake)
Turtles
Chelydra s. serpentina (Common snapping turtle)
Chrysemys picta marginata (Midland painted turtle)
Emydoidea blandingii (Blanding's turtle)
Sternotherus odoratus (Common musk turtle)
Lizards
Cnemidophorus sexlineatus (Six-lined racerunner)

tans blanchardi and *Rana pipiens* have disappeared from many historical localities in northwestern Indiana. Wilhelm (1990) noted that many of the locales in the general Miller area that were visited by early botanists have been destroyed. The existence of *Plethodon cinereus* labeled "Miller" in a museum collection implies that (as Wilhelm (1990) suggests) mesic forest pockets once existed near Miller Woods. This species is still common near Dune Acres (15 km east of Miller Woods) where the required habitat is present.

USX reach.—The USX (United States Steel Corporation) reach (Site 14 in Fig. 2) of the Grand Calumet River corridor includes some remnant ridge areas with black oak as well as successional species such as cottonwood. A botanical survey would help determine the extent of potential reptile habitat. If this site is used to bury contaminated sediments or materials, more research, including flora and fauna, would be useful. An effort to relocate animals prior to construction could be considered.

Gary Sanitary District reach.—The Clark and Pine complex (Sites 10–12 in Fig. 2) of seven sites is located north of the Grand Calumet River at the eastern end of the Gary Sanitary District reach and extends slightly into the adjacent USX reach. The seven natural areas may include perhaps the highest concentration of rare and endangered plant and animal species remaining in Indiana (Bowles 1989). Although only Clark and Pine East directly borders the Grand Calumet River, several of the areas are divided from each other only by railroad tracks or roads, and to some extent, they probably still function as a unit. Several of the ponds studied by Shelford (1913) were within or near the Clark and Pine complex. Other collectors, such as Hubbs and Mecks, also collected in the general area; and specimens are available from as early as 1902.

Clark and Pine East (site 12 in Fig. 2—area east of Clark Street), sometimes referred to as the Bongi site, borders the Grand Calumet River just east of the U.S. Route 12 bridge and extends to the north. The approximately 102 ha site was acquired by the Division of Nature Preserves, Indiana Department of Natural Resources, in 1993. The area was originally a classic example of ridge and swale habitat. At various times in the past, several of the ridges were mined for sand. The resulting low, wet, flat areas subsequently revegetated mostly with native species, including an unusual panne-like assemblage. Relatively undisturbed-but-overgrown sand savanna alternates with swales in the east-central part of the site. Management of Clark and Pine East continues and consists largely of brush clearing and controlled burning. Amphibians and reptiles were inventoried during 1990 and 1991 by Mierzwa et al. (1991) as part of the Illinois-Indiana Regional Airport Study. The most intensive inventory effort, including quantitative drift fence sampling using pitfall and funnel traps (see Heyer et al. 1994 for a detailed discussion of drift fence techniques), was focused within a complex of dry-mesic sand savanna, mesic to wet sand prairie,

marsh, and shrub swamp in the least disturbed portion of the site. During each visit to the site, visual sweep searches were also carried out in other parts of the site.

The 17 ha Clark and Pine Nature Preserve (Site 11 in Fig. 2) is located just northwest of Clark and Pine East. The two sites are separated by Clark Street. The Nature Preserve has been under state ownership for some time and has been intensively managed. The nature preserve is generally wetter and more open than Clark and Pine East with extensive areas of pond, marsh, sand prairie, and open sand savanna. The sand savanna includes both black oak (*Quercus velutina*) and jack pine (*Pinus banksiana*); the plant communities were described in detail by Bowles (1989). Clark and Pine Nature Preserve was sampled for amphibians and reptiles by Resetar (1988), using a combination of drift fence and visual sweep searches.

Other sites within the complex are privately owned. Lakeshore Railroad Prairie, a small site located just to the north of Clark and Pine East, has pond, marsh, panne, sand prairie, and sand savanna communities, the latter dominated by jack pine. Clarke Junction East and Clarke Junction West (Site 10 in Fig. 2) are located northwest of Clark and Pine Nature Preserve. These sites also include pond, marsh, panne, and sand prairie communities but suffer from shrub encroachment. Limited information on the herpetofauna of these sites, based on only a few visits, is included in Mierzwa et al. (1991). Morgan & Burling (1979) visited several Clark and Pine complex sites and reported the presence of some amphibians and reptiles, but their lists include at least one apparent misidentification and will not be included here. The list of amphibians and reptiles observed by Mierzwa et al. (1991) and Resetar (1988) within the Clark and Pine complex is presented in Table 3. Eighteen species occur within the complex at present, an unusually high number for a relatively small site. Unusual species include *Acris crepitans blanchardi* (a once common species that has nearly disappeared from northern Indiana) and the state-endangered *Clemmys guttata*.

A few additional species have been reported from the general vicinity of Clark and Pine, but their presence is based either on old museum specimens or on more recent anecdotal reports without specimen documentation. These species are: *Ambystoma laterale* (1978), *Bufo fowleri* (1917), *Heterodon platirhinos* (1902), *Hyla versicolor* (1904), and *Regina septemvittata* (1990). If any of these species are documented, that would only enhance the notable diversity of the site.

Table 3.—The amphibians and reptiles observed by Mierzwa et al. (1991) and Resetar (1998) within the Clark and Pine complex (Sites 10-12).

Frogs and toads
Acris crepitans blanchardi (Northern cricket frog)
Bufo americanus (American toad)
Pseudacris t. triseriata (Western chorus frog)
Rana catesbeiana (Bullfrog)
Rana clamitans melanota (Green frog)
Salamanders and newts
Ambystoma t. tigrinum (Eastern tiger salamander)
Notophthalmus viridescens (Eastern red-spotted newt)
Snakes
Lampropeltis triangulum (Milk snake)
Nerodia sipedon (Common water snake)
Storeria dekayi wrightorum (Midland brown snake)
Thamnophis p. proximus (Western ribbon snake)
Thamnophis s. sirtalis (Eastern garter snake)
Turtles
Chelydra s. serpentina (Common snapping turtle)
Chrysemys picta marginata (Midland painted turtle)
Clemmys guttata (Spotted turtle)
Emydoidea blandingii (Blanding's turtle)
Lizards
Cnemidophorus sexlineatus (Six-lined racerunner)
Ophisaurus a. attenuatus (Western slender glass lizard)

Little is known of the herpetofauna along other portions of the Gary Sanitary District reach. Some degraded habitat is present on the Gary Airport property (Site 9 in Fig. 2), and the authors have collected *Thamnophis s. sirtalis* and *Ophisaurus a. attenuatus* there. Mierzwa et al. (1991) reported on the herpetofauna of Ivanhoe Dune and Swale (Site 8 in Fig. 2), a site owned by The Nature Conser-

Table 4.—Species reported (Mierzwa et al. 1991) for the DuPont site (Site 7 in Figure 2).

Frogs and toads
Bufo americanus (American toad)
Pseudacris triseriata triseriata (Western chorus frog)
Rana clamitans melanota (Green frog)
Salamanders and newts
Ambystoma t. tigrinum (Eastern tiger salamander)
Snakes
Storeria dekayi wrightorum (Midland brown snake)
Thamnophis s. sirtalis (Eastern garter snake)
Turtles
Chelydra s. serpentina (Common snapping turtle)
Chrysemys picta marginata (Midland painted turtle)
Emydoidea blandingii (Blanding's turtle)
Lizards:
none

vancy. Since this site is south of the Indiana Toll Road and effectively isolated from the Grand Calumet River, the Ivanhoe Dune and Swale is not addressed here.

DuPont reach.—The privately owned DuPont site (Site 7 in Fig. 2) extends along the northern bank of the Grand Calumet River between Cline and Kennedy Avenues. In addition to marsh and floodplain forest along the river, the site includes extensive areas of dry-mesic to wet sand prairie, dry-mesic sand savanna, and swales with sedge meadow and marsh. No historical information is available on the herpetofauna. The site was sampled in 1990 and 1991 for amphibians and reptiles by Mierzwa et al. (1991) using a drift fence and occasional visual sweep searches. Although the DuPont site is not as species rich as the preserves described above, a minimum of nine species lives there (Table 4). Since not all habitat types were intensively sampled, additional species may be present at the site.

An area of open marsh is located south of the Grand Calumet River, between the DuPont site and the confluence with the Indiana Harbor Canal. The marsh is directly across the river from a J-shaped channel. River water swirls through this site, which can be characterized as a partially open marsh habitat located in a river bend. The area is inhabited by *Chelydra s. serpentina* and *Chrysemys picta marginata*, which benefit from the interspersion of open water and emergent marsh.

Two high-quality natural areas, Gibson Woods Nature Preserve (Site 6 in Fig. 2) and Toleston Ridges Nature Preserve (just north of Site 6 in Fig. 2) (also known as the Shell Oil Tract) are located south of this reach. Bacone (1979) included a list of amphibians and reptiles for Toleston Ridges. However, these sites are effectively isolated by the Indiana Toll Road, so they are not presented here.

East Chicago Sanitary District reach.—An area of upland meadow (Site 5 in Fig. 2) is located south of the river between the confluence of the Indiana Harbor Canal and a substation just southeast of the East Chicago Sanitary District Plant. The meadow is dominated by a variety of herbaceous plant species, but is susceptible to overgrowth by woody species. No amphibians or reptiles were noted during a site visit, but suitable habitat is present for several upland species.

Roxanna Marsh reach.—Little information is available on amphibian and reptile populations for Roxanna Marsh (Site 4 in Fig. 2). The northern leopard frog, *Rana pipiens*, was reported at the site in 1984 (Indiana Department of Natural Resources 1992). This report represents the most recent record of the species from the Indiana portion of the Grand Calumet River watershed. The same survey recorded *Chelydra s. serpentina* and *Chrysemys picta marginata* as common in open water areas. The marsh habitat is of relatively low quality and probably supports few species of amphibians and reptiles.

Hammond Sanitary District reach.—Land south of the treatment plant (Site 3 in Fig. 2) is separated from the river by a dike. Much of the area is overgrown with herbaceous vegetation. Water is ponded in some areas and supports a breeding population of toads. The site has been severely altered, but it could support additional species and might benefit from restoration or management.

Culverts reach.—This segment (area west of Site 3 in Fig. 2) has very little remaining natural area. No information is available for this segment of the Grand Calumet River and it is unlikely that any significant diversity of species remains there.

Burnham Prairie reach.—Burnham Prairie (Site 1 in Fig. 2) is located along the Grand Calumet River approximately 2.0 km to the west of the Illinois-Indiana state line. Although outside of the primary study areas, Burnham Prairie is discussed here as an example of the very different Chicago lake plain ecosystem. While the Indiana sites discussed above are on beach or near-shore sand deposits, Burnham Prairie is on silt-loam soils deposited in somewhat deeper water. This prairie is one of the last remaining examples of the black soil prairies once widespread in the Lake Calumet region and discussed at length by Cowles (1901). The site includes marsh, wet, wet-mesic, and dry-mesic prairie, and a small dry-mesic savanna grove with bur oak, *Quercus macrocarpa*. Two species that are common on the black soil site, *Rana pipiens* and *Thamnophis r. radix*, are rare a few kilometers east in northwest Indiana. Species richness is relatively low, possibly because the site is small; however, all six species found at Burnham Prairie are relatively abundant there (Mierzwa et al. 1991): *Bufo americanus*, *Pseudacris t. triseriata*, *Rana pipiens*, *Storeria dekayi wrightorum*, *Thamnophis r. radix*, and *Thamnophis s. sirtalis*.

EXTANT SPECIES

A total of 33 species of amphibians and reptiles has been recorded within the watershed of the Grand Calumet River. Seven of these were recorded historically but have not been reported recently. At least 26 species are still present. The habitat, distribution, and status of each species are briefly summarized below.

Acris crepitans blanchardi.—(Northern cricket frog). Cricket frogs are associated with the margins of permanent ponds and streams, and they must have been common at one time along the banks of the Grand Calumet River. Sometime in the late 1970's or early 1980's, this once abundant frog disappeared from most locales in the northern part of its range. A population at the Clark and Pine complex (Mierzwa et al. 1991) is the only known to persist in Lake County. Cricket frogs are quite common at both Clark and Pine Nature Preserve and Clark and Pine East, and they are frequently seen along swale edges during the summer months.

Ambystoma laterale.—(Blue-spotted salamander). This species inhabits wooded communities including relatively open savanna, woodland, mesic forest, and swamp forest. Breeding likely takes place in the swales. Blue-spotted salamanders are uncommon in the study area. Werth (1990) found one specimen at Miller Woods (Site 15 in Fig. 2). Mierzwa et al. (1991) collected two in the western part of Ivanhoe Dune and Swale (Site 8 in Fig. 2). Morgan & Burling (1979) reported one from the Clark and Pine areas (Site 10 in Fig. 2). The blue-spotted salamander is a northern species, which is near the southern limit of its range in northwest Indiana.

Ambystoma t. tigrinum.—(Tiger salamander). Although seldom seen because of burrowing habits, the tiger salamander is not uncommon in the vicinity of the Grand Calumet River. The species breeds in marsh or shrub swamp within swales and resides for the remainder of the year in dry-mesic sand savanna on the dune ridges. Individual salamanders are often found in surprisingly open locations. One Illinois population of tiger salamanders increased dramatically as savannas were opened up with brush clearing and prescribed burns (Mierzwa pers. obs.). Adult tiger salamanders usually do not travel far from breeding sites; recent studies in areas of sandy soil in New York have indicated that up to 80% of the population remains within 100 m of the breeding wetland with only a few individuals moving as far as 300 m. It is not known if these dispersal distances are to be expected in the midwestern U.S. Tiger salamanders that spend most of their time in burrows created by shrews or other other small mammals (Madison 1993) with limited surface activity on rainy nights.

Bufo americanus.—(American toad). American toads are common in the western part of the study area; and they occur at Clark and Pine, DuPont, Ivanhoe Dune and Swale, near the Hammond Sanitary District treatment plant, and at Burnham Prairie (Mierzwa et al. 1991). They have not been reported at Miller Woods. Elsewhere in northwest Indiana, populations frequently are found in river floodplains. Water quality may constrain the toads' use of Grand Calumet riparian areas, but some have been observed in swales adjacent to the river at DuPont (Site 7 in Fig. 2).

Bufo fowleri.—(Fowler's toad). This species, more characteristic of areas well to the

south, is restricted to sandy soil in northwest Indiana. In the dunes area, the toad typically breeds in blowout ponds and pannes in the immediate vicinity of Lake Michigan (Breden 1988). A population at Miller Woods (Site 15 in Fig. 2), north of the Grand Calumet Lagoons, may be the westernmost extant in the dunes area. Historically, the species occurred at Clark and Pine (Site 11 in Fig. 2), where in 1917 a specimen was collected at the pond closest to Lake Michigan.

Chelydra s. serpentina—(Snapping turtle). Snapping turtles are tolerant of pollution, and they are still present in the Grand Calumet River, in riparian marshes, and in most of the nearby wetlands. Because this species is fully aquatic and seldom basks in the sun, the snapping turtle is usually more common than the available records indicate. This species has been reported from the Grand Calumet lagoons (Site 16 in Fig. 2), Miller Woods (Site 12), DuPont (Site 7), and the Clark and Pine complex (Sites 10–12). The snapping turtle is a habitat generalist that can be found in most permanent water bodies.

Chrysemis picta marginata.—(Painted turtle). Numerous records of this species exist for the study area from as early as 1909 to as recently as 1996. The painted turtle is one of the few species still found in the main channel. At times, permanent swales close to the river support dense populations, especially at Miller Woods (Site 15 in Fig. 2), DuPont (Site 7), and the Clark and Pine complex (Sites 10–12). Painted turtles inhabit both ponds and rivers, and they are easily observed because of their proclivity to bask on logs or other floating objects.

Clemmys guttata.—(Spotted turtle). This small, attractive turtle is endangered in Indiana and in Illinois. The spotted turtle is characteristic of shallow, sedge-dominated wetlands and adjacent marsh borders. The Clark and Pine complex (Sites 10–12 in Fig. 2) supports one of the largest spotted turtle populations in northwest Indiana, but the species is suffering from illegal collecting. Suitable habitat is present in swales very close to the Grand Calumet River at Clark and Pine East (Site 12). This locale is nearly at the western distributional limit of the species.

Cnemidophorus sexlineatus.—(Six-lined racerunner). This lizard inhabits xeric, sparsely vegetated dunes. Populations in northwest Indiana are widely disjunct from the main body of the range, located well to the south, and presumably represent a relict population from a time of warmer or drier climate. Although the racerunner is strictly an upland species, this lizard is found in close proximity to the river at several locations where sand prairie or open sand savanna communities persist. Recent records are available from Clark and Pine (Site 11), Brunswick Center Savanna ("Brunswick Park" south of Site 12 in Fig. 2) (Mierzwa et al. 1991; Resetar 1988), and Miller Woods (Site 15) (Werth 1990).

Emydoidea blandingii.—(Blanding's turtle). This is a federal "species at risk" (formerly "Category 2"), and Blanding's turtle is included on special concern or watch lists in most states in which it is found. Recent attention has focused on the long life span (>60 years) and late age of maturity (14–20 years) of this species (Congdon et al. 1993). Because of these life-history characteristics, loss of reproductive females via highway mortality, over-collecting, or other causes may have significant long-term effects on population viability. Blanding's turtles live at points throughout the study area; recent reports are available from Miller Woods (Site 15), Clark and Pine East (Site 12), Clark and Pine Nature Preserve (Site 11), Lakeshore Railroad Prairie (just to the north of Site 12), Ivanhoe Dune and Swale (Site 8), and DuPont (Site 7). Populations appear to be at low density at most sites. Blanding's turtles are most common in swales that include pond and marsh communities and particularly those with considerable submerged vegetation. Individuals are occasionally encountered on land. Short-term movements in excess of 800 m have been observed (Mierzwa unpubl. data), suggesting that relatively large sites may be needed to support a viable population in the long-term. Blanding's turtles have been observed in sluggish, well-vegetated rivers such as Dead River at Illinois Beach State Park and may have once inhabited the Grand Calumet River; however, early observers apparently overlooked this species. The range of the Blanding's turtle is mostly to the north of the Grand Calumet River area.

Heterodon platirhinos.—(Eastern hognose snake). The only recent report of hognose snakes has been from Miller Woods (Site 15) (Werth 1990). This species historically was

found at Clark and Pine (Site 11). This upland species is found in sand prairie and sand savanna; it may occasionally forage for toads near wetland margins.

***Hyla versicolor* complex.**—Gray treefrogs are common at Miller Woods (Site 15), but the only record of their presence elsewhere in the study area is based on a 1904 specimen. A variety of semi-permanent wetlands is used for breeding; the adults spend the rest of the year in nearby trees and shrubs. Populations in northwest Indiana are thought to be *Hyla versicolor*, and the nearest report of the cryptic sibling species, *Hyla chrysoscelis*, was in Berrien County, Michigan (Bogart & Jaslow 1979).

***Lampropeltis triangulum*.**—(Milk snake). Milk snakes are uncommon in the study area. Resetar (1988) reported the species from Clark and Pine Nature Preserve (Site 11), and Mierzwa et al. (1991) collected two specimens at Clark and Pine East (Site 12) over two field seasons. One of these was caught in a drift fence in dry-mesic sand savanna and the other was found under roadside debris along Clark Street. Elsewhere in the region, milk snakes are characteristic of upland savannas; but they are occasionally collected in sedge meadows (Mierzwa 1993).

***Nerodia sipedon*.**—(Northern water snake). This semi-aquatic snake may have once inhabited the margins of the Grand Calumet River, but recent observations have been limited to swales in the Clark and Pine complex (Sites 10–12) (Resetar 1988; Mierzwa et al. 1991). Historically, the species was found in the Miller area, where two specimens were collected in 1902. Northern water snakes are thought to be relatively uncommon in the study area today.

***Notophthalmus viridescens*.**—(Eastern newt). Newts are aquatic as adults, but they are capable of terrestrial movements if ponds dry. The adult phase may be preceded by a terrestrial eft stage lasting up to several years. Newts are common at Miller Woods (Site 15) (Werth 1990) and uncommon but present in the Clark and Pine area (Sites 10–12), where they were reported by Shelford (1913) and Mierzwa et al. (1991). In both areas, newts inhabit pond and marsh communities in permanent and semipermanent swales.

***Ophisaurus a. attenuatus*.**—(Western slender glass lizard). This legless lizard is common in the more open western part of the study area. Recent observations have been mostly in xeric to dry-mesic sand prairie openings on ridges, but one specimen attempted to escape by swimming along the margin of a swale (Mierzwa unpubl. data). Extant populations are known from the Clark and Pine complex (Sites 10–12), Ivanhoe Dune and Swale (Site 8), and from disturbed areas at the Gary Airport (Site 9) (Mierzwa et al. 1991). Additional populations are probably present. Populations in the study area are disjunct and near the northern limit of the species' distribution; they may represent remnants from warmer or drier times.

***Pseudacris c. crucifer*.**—(Spring peeper). Spring peepers are common at Miller Woods (Site 15) and in the eastern part of the dunes region where woodland and forest are widespread. In the western part of our study areas, spring peepers have been reported only from Tolleston Ridges Nature Preserve (just north of Site 6). They breed in shrub swamps, marshes, and vernal ponds; and adults summer in shrubs and trees.

***Pseudacris t. triseriata*.**—(Western chorus frog). This species is characteristic of grassland and savanna areas. The western chorus frog is abundant in the western part of the study area, but is less common and more sporadically distributed in the eastern part. They breed in marshes; and during the summer months, adults forage in herbaceous vegetation.

***Rana catesbeiana*.**—(Bullfrog). Bullfrogs are semiaquatic, and they are usually observed at the margins of permanent ponds or rivers. Recent records are available from Miller woods (Site 15) and Clark and Pine East (Site 12); bullfrogs are probably widespread in the area but relatively uncommon.

***Rana clamitans melanota*.**—(Green frog). Green frogs have been observed at all Grand Calumet sites sampled in recent years, and they are relatively common at the larger natural areas. They are semiaquatic, inhabiting permanent marshes, ponds, and streams.

***Rana pipiens*.**—(Northern leopard frog). This species is usually associated with herbaceous vegetation, including sedge meadow, wet prairie, wet savanna, and marsh. Leopard frogs were recorded in Miller Woods (Site 15) in 1922 and 1935, and from Hessville in 1923 (area south and southwest of Gibson Woods

Nature Preserve, Site 6); but the only recent report from the Indiana portion of the study area is from Roxanna Marsh (Site 4) from 1984 (Indiana Department of Natural Resources 1992). Leopard frog populations were notably absent at the Indiana sites sampled in recent years (Mierzwa et al. 1991; Werth 1990). Leopard frog populations have reportedly declined in parts of the Midwest recently (Harding & Holman 1992). At nearby Illinois sites, including Burnham Prairie (Site 1) and Powderhorn Lake (Site 2 in Fig. 2), northern leopard frogs are still common (Mierzwa et al. 1991).

Sternotherus odoratus.—(Musk turtle). Several records of this aquatic turtle exist from the Grand Calumet area. In 1918, Carl Hubbs collected a specimen that is now in the Field Museum collection from the Grand Calumet River near Miller Woods (Site 15). Other specimens are available from the Grand Calumet Lagoons (Site 16) and Buffington (by Lake Michigan in northwest Gary). Shelford (1913) listed musk turtles as characteristic of the more open swales close to Lake Michigan. The species probably still occurs in some wetlands near the river, but its benthic preference makes it hard to document. Werth (1990) found musk turtles at Miller Woods (Site 15), and a single specimen seen crossing a road in Hammond in 1996 was turned in at Gibson Woods Nature Preserve.

Storeria dekayi.—(Brown snake). This small, secretive species is the second most common snake at most locations within the study area. Most individuals were caught in drift fences or found under boards or other debris. Dry-mesic sand savanna is probably the preferred habitat of the brown snake; but some individuals have been found in sedge meadows, wet prairies, or along the margins of marshes at Clark and Pine (Site 11) (Mierzwa et al. 1991).

Thamnophis p. proximus.—(Western ribbon snake). This semi-aquatic species is characteristic of shrubby wetland margins (Rossman et al. 1996), but is uncommon in the study area. So far, the species has been reported only at Miller Woods (Site 15) and Clark and Pine Nature Preserve (Site 11) (Resetar 1988). A specimen collected near Miller Woods in 1919 was found within the "pine-oak association."

Thamnophis r. radix.—(Plains garter snake). This species is characteristic of black-soil mesic prairie. The plains garter snake is abundant west of the Illinois state line, but is extremely rare in northwest Indiana. This snake is a western species and, except for disjunct Ohio populations, is near the eastern limit of its range here. The only Indiana records from the vicinity of the study areas are from the area in or around Miller Woods (Site 15) (1902) and Hessville (south and southwest of Gibson Woods Nature Preserve, Site 6) (1923, 1935). In contrast, during a 1991 effort, 38 plains garter snakes were caught in drift fences at Burnham Prairie (Site 1); and several more were found under boards just west of Wolf Lake and just north of Powderhorn Lake (Site 2) (Mierzwa et al. 1991). Seibert (1950) studied this species in the Lake Calumet area and reported a density of 840 plains garter snakes per ha in a vacant lot near 103rd and Stony Island Avenue in Chicago (northwest of the map in Fig. 2).

Thamnophis s. sirtalis.—(Common garter snake). This snake is the most widespread and abundant snake in the Grand Calumet River Area. The species has been reported, usually in substantial numbers, from every site studied to date. In the study area, common garter snakes are abundant in dry-mesic sand savanna and in successional fields. They are easily collected from under debris in vacant lots. Common garter snakes do not hesitate to enter marshes and ponds to forage for frogs and fish. This species has been found within meters from the Grand Calumet River; and in 1996 a specimen was observed along a railroad right-of-way 50 m north of the river at Clark and Pine East (Site 12).

SPECIES NOW LIKELY EXTIRPATED

Coluber constrictor.—(Blue racer). Two old specimens from "Miller" are available (Schmidt & Necker 1935), and one of them was collected by Meek in 1908. Morgan & Burling (1979) reported a blue racer from a site southeast of, but apparently isolated from, Miller Woods (Site 15).

Elaphe vulpina.—(Fox snake). A single, undated but old specimen (Field Museum of Natural History 2864) was collected at "Miller." Given significant field effort in Miller Woods in the past 15 years without new captures, then fox snakes are either very rare or extirpated.

Eumeces fasciatus.—(Five-lined skink). This lizard is known from a single old specimen collected at "Miller" (Schmidt & Necker 1935). The same consideration about rarity or extirpation for *Elaphe vulpina* applies to this skink.

Graptemys geographica.—(Map turtle). Shelford (1913) mentioned map turtles from swales near Lake Michigan, and museum specimens are available from Deep River in Lake County. Although the map turtle is not documented in the immediate vicinity of the Grand Calumet River, the species may once have lived there, and this turtle certainly was present within a few kilometers of the study area.

Necturus maculosus.—(Mudpuppy). Minton (2001) gives historical records of this species from Wolf Lake and Cortwright and Beamer have observed the species in Wolf Lake as recently as 2002. The mudpuppy still lives in Lake Michigan and probably entered the Grand Calumet River before the mouth closed. Poor water quality and contaminated sediments may preclude the presence of this bottom-dwelling aquatic species at present.

Opheodrys vernalis.—(Smooth green snake). A single specimen (Field Museum of Natural History 2110) was collected at "Miller" in 1902. Green snakes were once common on the black soil prairies just to the west of the Illinois state line (Seibert 1950). The nearest known extant population is at Van Vlissengen Prairie, which is located just northeast of Lake Calumet (northwest of the study area, not in Fig. 2).

Plethodon cinereus.—(Redback salamander). Carl Hubbs collected a redback salamander "near Miller" in 1917. This species is characteristic of mesic forest and common east of the study area in the National Lakeshore. A small area of suitable habitat was presumably present somewhere near Miller Woods at one time, but may have since been destroyed.

PROBLEMATIC SPECIES

A few additional species have been reported anecdotally; they could occur in the study area, but have not been reported or have been reported based on probable misidentifications. The spiny softshell, *Abalone spinifera*, inhabits Lake Michigan in Illinois. This turtle is not known from the study area, but could have been present historically. The queen snake, *Regina septemvittata*, was reported from Clark and Pine Nature Preserve in 1990, but the specimen was not collected (Griggs & Balzano pers. commun.). The observers were from the east coast and were not familiar with the local fauna, so the record is considered questionable; however, queen snakes are found in the headwaters of the little Calumet River in Porter County, so they could be present elsewhere in the drainage system. The pickerel frog, *Rana palustris*, was reported from the Clark and Pine complex (Sites 10–12) by Morgan & Burling (1979), but not by later investigators who spent much more time at the sites. The cool fen and wooded stream habitats frequented by this species are not present at Clark and Pine, and no other lake County records exist. Because the nearest known extant populations are several counties away, the report is problematic. Finally, a report of the massasauga rattlesnake, *Sistrurus catenatus*, from Clark and Pine East (Lake Michigan Federation 1984) must be rejected. Extensive sampling there by several people, including two with considerable massasauga experience, failed to confirm the record (Mierzwa et al. 1991). The habitat at Clark and Pine is also quite different from that typically used by the species. The report may be based on a sighting of the superficially-similar northern water snake.

POTENTIAL IMPACTS OF DREDGING

Dredging of the Grand Calumet River will have little direct impact on the amphibians and reptiles. Only two species (snapping turtle and painted turtle) are known to inhabit the channel at present. Some direct injury or mortality could result from dredging operations, but because both species are common in nearby wetlands, the river population would probably soon be supplemented from those sources. A few other species may occasionally enter the river, but these transient individuals represent a small fraction of the population primarily residing elsewhere.

Terrestrial or wetland habitat adjacent to the river could be impacted by sloughing of the banks, soil compaction by heavy machinery, or hydrological alteration related to sediment disposal. Much of the area along the river is highly degraded, e.g., with overly dense cattails and common reed, so modification of

these plant communities by dredging activities is not a significant degradation of amphibian and reptile habitat. In fact, areas dense with these plant species could be improved by dredging activities if average water level were to be increased to around one meter.

The primary concern is to protect wetland and terrestrial habitat contiguous to the river at the higher quality natural areas, such as, but not limited to, Miller Woods (Site 15), Clark and Pine Nature Preserve complex (Sites 10–12), and DuPont (Site 7). These sites include rare communities used by relatively high densities of amphibians and reptiles. Several rare or uncommon species, including the state-endangered spotted turtle, *Clemmys guttata*, and state-endangered Blanding's turtle, *Emydoidea blandingii*, could occur very near the river at some of these sites.

HABITAT ENHANCEMENT AND MANAGEMENT

Considering the long history of industrial use along the Grand Calumet River, it is perhaps amazing that so many amphibians and reptiles, some of them rare, persist in the area. However, because of the presence of several high quality natural areas contiguous to the river, unique restoration opportunities are available. Appropriate management of some of the sites described above could enhance the viability of amphibian and reptile populations.

Water quality in the Grand Calumet River has improved considerably since point source pollution has been reduced; however, most of the water in the system still originates as industrial discharge or treatment plant effluent. With the removal of contaminated sediments, the Grand Calumet or riparian wetlands in direct contact with the river might eventually be able to support a herpetofaunal assemblage of at least tolerant species. Clean-up of the river will provide an opportunity to speed or expand restoration of the better quality core areas already in public ownership, to lobby for acquisition of or negotiation of management agreements for other remnants of natural land, and ultimately to take advantage of the river corridor to once again link up some of the core areas.

Several sites identified by the Indiana Natural Areas Inventory, including parts of the Clark and Pine complex, remain in private ownership and are at risk of degradation. Site 13, for example, is being obliterated by construction activities in 2002. Acquisition of these sites would help to preserve a number of rare species. Acquisition of land contiguous to core natural areas, in conjunction with restoration activities discussed below, could greatly improve the long-term viability of sites that currently support high levels of biodiversity. The best quality sites are in need of woody vegetation management, including manual removal of exotic shrubs and the regular use of controlled fire. Enforcement activities to discourage illegal dumping and poaching also would be helpful.

Because most of the landscape around the Grand Calumet River once consisted of alternating ridges and swales, some of the amphibians and reptiles in the area are capable of utilizing both upland and wetland habitat. Restoration efforts that address both habitat components are likely to support the greatest diversity of wildlife, especially if restoration areas are adjacent to the existing core natural areas. Early efforts can serve to create buffer areas for existing preserves. Over time these buffers could be extended to serve as connections between preserves. The challenges to this process will be many in this complex urban landscape, but opportunities should be pursued as they present themselves.

Wetlands with a direct river connection could contribute to enhancement of water quality and potentially provide habitat for some semi-aquatic amphibians and reptiles, such as mudpuppies, bullfrogs, green frogs, snapping turtles, painted turtles, and northern water snakes. Turtles could benefit from opening the existing dense cattail and common reed marshes in riparian areas. For this, deepening of selected areas in conjunction with dredging operations could improve interspersion of marsh and open water habitats. Restocking or natural immigration of muskrats also can thin dense stands of cattails.

Many amphibians do not breed in riparian wetlands, even if cattails and common reeds are thinned, because of fish predation on eggs and larvae. Creation of a few palustrine emergent wetlands isolated from direct contact with the river could provide habitat for these species, including tiger salamanders, American toads, western chorus frogs, and northern leopard frogs. Because groundwater generally flows toward lower and larger bodies such as

the Grand Calumet River (Watson et al. 1989), wetlands of excellent quality have persisted at DuPont, Clark and Pine complex, Miller woods, and other sites, sometimes only meters from the main channel. Restored or created wetlands separated from the channel by narrow areas of upland may have a reasonable chance of maintaining good water quality and supporting a variety of plants and animals.

In addition to traditional enhancement and restoration techniques such as woody vegetation control or wetland excavation, complex but innovative opportunities are possible near the Grand Calumet River. Some areas of degraded habitat are presently of minimal value to amphibians and reptiles, but they are immediately adjacent to high quality natural areas. Areas impacted by heavy machinery movement or other dredging activity could be excavated to below the water table and then covered with clean sand, mimcking the ridge and swale topography once seen in early aerial photographs (see Fig. 1). If native vegetation can be established on both wetlands and intervening uplands, buffer or corridor areas could be established in this way. The technical feasibility of such an effort should first be carefully reviewed by appropriate specialists. Potentially suitable locations are present within the Gary Sanitary District and DuPont (Site 7) reaches, and others may be located through additional field efforts.

In Illinois, particularly near Burnham Prairie (Site 1), potential buffer restoration opportunities exist. Fill material between the river and the natural area could be excavated, assuming that it can be disposed of safely and economically; and wetlands could be established in the excavated areas. Similarly, any landfill site created for river sediments could be restored with the addition of native soil and vegetation on top of any cap material. Natural dispersal or reintroduction of animal species might then be feasible. This could be a fine opportunity to address an environmental problem and establish a semi-natural ecological system at the same time.

The Grand Calumet lagoons within and near Miller Woods may be better able to support aquatic life than more contaminated reaches to the west. After dredging operations are completed, any measures to control water movement between this and other reaches could help in maintaining suitable habitat conditions.

Corridor linkages.—Enhancement of existing riparian wetlands or restoration of wetlands in areas filled in the past could help to establish corridors linking some of the core natural areas. Such corridors would be especially useful if they included, in addition to riparian wetlands, at least a narrow upland border seeded with native grassland vegetation and scattered depressions with seasonal wetlands.

The Gary Regional Airport (Site 9), in particular, could be investigated for restoration feasibility along the river. Bordering the airport are marshes and degraded remnants of ridge and swale topography and at least one interesting and infrequently seen species, the western slender glass lizard. However, political and security considerations might constrain restoration efforts at this location. Wetlands near runways might increase the risk of bird strikes unless designed appropriately. The control tower is located near the river, and visibility during controlled burns could be an issue.

Areas adjacent to the Grand Calumet River today support a surprisingly diverse herpetofauna, although the remaining habitat is fragmented by past industrial land uses. Management and enhancement of remnant natural areas, restoration of wetlands and adjacent upland at more degraded sites, and a long-term strategy for linking or buffering core areas of open space could help maintain biodiversity well into the future.

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