

ALL REPTILES IN ALL HABITATS NARRATIVE

Problems affecting species and habitats

Species threats

Respondents ranked the following threats to all reptiles in all habitats in Indiana:

Rank	Threats to all reptiles in all habitats
1	Unintentional take/ direct mortality (e.g., vehicle collisions, power line collisions, by-catch, harvesting equipment, land preparation machinery)
2 (tie)	Habitat loss (breeding range)
2 (tie)	Habitat loss (feeding/foraging areas)
3	Viable reproductive population size or availability
4	Specialized reproductive behavior or low reproductive rates
5	Degradation of movement/migration routes (overwintering habitats, nesting and staging sites)
6	Predators (native or domesticated)
7	Large home range requirements
8	Unregulated collection pressure
9	Near limits of natural geographic range
10	Bioaccumulation of contaminants
11	Dependence on irregular resources (cyclical annual variations) (e.g., food, water, habitat limited due to annual variations in availability)
12	Diseases/parasites (of the species itself)
13	Invasive/non-native species
14	Small native range (high endemism)
15	High sensitivity to pollution
16	Regulated hunting/fishing pressure (too much)
17	Dependence on other species (mutualism, pollinators)
18	Genetic pollution (hybridization)
19	Species overpopulation

Respondents offered additional threats to all reptiles in all habitats in Indiana (not ranked):

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- Artificial manipulation of water levels in wetlands seems likely to increase mortality of overwintering snakes. Snakes hibernate underground at the groundwater interface. Raising water levels in the winter could drown snakes and lowering water table could expose them to extreme cold temperatures. Both activities are likely to kill overwintering snakes
- Kirtland's snakes
 - Abrupt changes in drainage patterns due to development. Kirtland's snakes prefer moist soils that support earthworms.
 - Mowing, or moving or clearing of debris (cover items) on the ground. Kirtland's snakes are found in moist open environments, but often are found under natural and man-made debris

Respondents listed top threats to all reptiles in all habitats in Indiana (not ranked):

- Commercial fishing devices: Trot lines, branch lines, big nets, other passive fishing
- Predators
 - Extreme depredation by overabundant raccoons (on adults and eggs)
 - Nest depredation mainly by raccoons equals very low recruitment
 - Coyote predation
 - Suboptimal size nesting areas focuses nest depredation
- Road mortality
 - For eastern box turtles and other species
- Habitat loss, degradation, manipulation, inappropriate management and fragmentation; loss of connectivity
 - Affects reproduction
 - Loss of permanent wetland areas that include huge open/prairie buffer zones for nesting
 - Overland movement for nesting invites road kill of otherwise long-lived adults
 - Inappropriate management of nesting areas: Sandy fire breaks in managed areas are disked at inappropriate times, or are managed in inappropriate cover types
 - Fragmentation of populations due to habitat loss. Wetlands are managed as landscape scale systems relative to the Blanding's turtle, resulting in metapopulation disruption and potential metapopulation decline
 - Artificial manipulation of water levels in wetlands seems likely to increase mortality of overwintering snakes. Snakes hibernate underground at the groundwater interface. Raising water levels in the winter could drown snakes and lowering water table could expose them to extreme cold temperatures. Both activities are likely to kill overwintering snake
 - Massasauga rattlesnakes: Inappropriate management of sandy fire breaks in managed areas that are disked at inappropriate times, or are managed in inappropriate cover types. I have seen dead massasauga that have been disked on DNR lands
 - Populations seem to be in steep decline due to habitat fragmentation (from land use change and inappropriate management, e.g., fire suppression)
 - Habitat loss affect timber rattlesnakes
 - Habitat loss affects eastern box turtles
 - Habitat loss affects black king snake
 - Habitat destruction and fragmentation affects crowned snake
 - Development of drainage areas and flood plains, including development of park-like areas in which natural or man-made cover is removed
 - Habitat fragmentation that disrupts gene flow and re-colonization

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- Reproduction and low population issues
 - Nest/embryo/hatchling loss associated with attraction to row crop land for nesting
 - Extant population (if any) far below level for unassisted recovery
 - Because of low densities and small population sizes, populations that have become isolated due to habitat fragmentation are likely not viable
 - Most known populations seem to occur at such low densities that mating seems a remote possibility. All the problems associated with small population size and low reproductive rate seem likely to plague the Ornate box turtle. Most populations seem likely to be in a slow-motion death spiral at the moment
 - Timber rattlesnake's low reproductive rates are a serious threat when coupled with other threats
 - Habitat fragmentation that disrupts gene flow and recolonization
- Timber rattlesnake
 - Habitat loss
 - Human persecution and illegal take
 - Timber rattlesnakes are often killed because they are large venomous snakes
 - There is also a market for some reptiles in illegal trade.
 - Individual take coupled with low reproductive rates pose a serious threat for some reptiles
- Human collection
 - Threat for timber rattlesnake
 - Threat for eastern box turtle (human collection and road mortality)
 - Threat for black kingsnake
- Accidental take, road mortality
 - Affects eastern box turtle
 - Affects crowned snake
- Eastern box turtle
 - Habitat loss
 - Road mortality
 - Human collection
- Black kingsnake
 - Human collection
 - Habitat loss
- Crowned snake
 - Habitat destruction and fragmentation
 - Accidental take

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the threats to all reptiles in all habitats. Their responses included:

- Although it is clear that some respondents had particular species in mind, I find this to be a reasonable representation of threats to reptiles in Indiana. I would, however, rank habitat loss above take.

Habitat threats

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Respondents ranked threats to all reptile habitats in Indiana:

Rank	Threats to all reptile habitats
1	Habitat fragmentation
2	Habitat degradation
3	Agricultural/forestry practices
4	Successional change
5	Commercial or residential development (sprawl)
6	Stream channelization
7	Impoundment of water/flow regulation
8	Counterproductive financial incentives or regulations
9	Point source pollution (continuing)
10	Invasive/non-native species
11	Nonpoint source pollution (sedimentation and nutrients)
12	Residual contamination (persistent toxins)
13	Mining/acidification
14	Diseases (of plants that create habitat)
15	Drainage practices (stormwater runoff)
16	Climate change

Respondents noted additional threats to all reptile habitats in Indiana (not ranked):

- The impact of non-native earthworms should be closely monitored, as the Kirtland's snake's natural diet is believed to be comprised predominately of earthworms and slugs. The ecological impact of some non-native invertebrates has not been adequately studied
- Although the Southeastern crowned snake is found in conjunction with upland forested habitats in Indiana, this species prefers sand and siltstone glades

Respondents listed top threats to all reptile habitats in Indiana (not ranked):

- Habitat loss, degradation, manipulation, fragmentation
 - Channelization
 - Drain/cut off oxbow ponds
 - Eliminate flows that create point bars on rivers
 - Trample sandbars or remove other nesting areas along banks
 - Row crop practices: /crushing nests during ground insect/weed control; crushing overwinter hatchlings during harvest and early spring plowing
 - Habitat loss through wetland drainage/ tiny stream ditching
 - Fragmentation: Most habitats are now old dunes with overgrown savanna. Flat ground that was habitat is largely under row crop agriculture. Populations seem highly fragmented, and while population size estimates are tough to come by,

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populations seem small. Small isolated populations are likely to be subject to inbreeding and are at increased risk for local extinction

- Blanding's turtles
 - Manipulation of natural wetlands for management of other species has a disruptive impact on natural wetland dynamics. This may include reduced survival of Blanding's or reduced productivity of the habitat
 - Loss of adjacent uplands or inappropriate cover/management. Blanding's requires nesting habitats that are secure from disturbance and that are within a reasonable distance to wetland habitats. Loss of appropriate habitat (either due to tradition conversion to agriculture or to conversion of inappropriate conservation cover types) is negatively impacting reproductive success in this species. Long-distance movements
 - Fragmentation and small habitat size: most habitats are small remnants of native grassland, surrounded by either agriculture or fire-suppressed oak savanna. Habitat size needs to be expanded at sites that support seemingly salvageable populations of the Ornate box turtle
 - Much potentially suitable habitat has been lost through succession to exotic species and oak woodland. This turtle requires expansive open grassland. Lack of habitat management, or in the case of invasive species, because of the purposeful introduction of invasive shrubs, has resulted in open native grassland being lost to shrub land and oak woodland
 - Due to development: agriculture, coal mining
 - Timber rattlesnake habitat
 - Forest fragmentation and habitat loss are biggest threats. Timber rattlesnakes need large continuous blocks of forest habitat. When these areas are lost rattlesnakes become susceptible to human and predator encounters
 - Eastern box turtle habitat
 - Fragmentation and urbanization are biggest threats
 - Development of drainage areas and flood plains, including development of park-like areas in which natural or man-made cover is removed.
 - Habitat fragmentation that disrupts gene flow and re-colonization
 - Invasive species encroachment
- Fire suppression
 - Fire suppression in graminoid wetland habitat creates late successional wetlands that are not appropriate habitat. Conversely, late spring fire in these habitats is likely to cause direct adult mortality
 - Conversion of sand prairie nesting habitat to cropland or something else (e.g., forestation via fire prevention)
 - From personal experience, on edges on old dunes or in high-quality oak savanna habitats. Fire suppression has changed the nature of these plant communities on private and public lands (with the exception of nature preserves). It seems likely that continued fire suppression will degrade additional habitat as time passes.
 - Artificial manipulation of water levels
 - Artificial manipulation of water levels in wetlands seems likely to increase mortality of overwintering snakes. Snakes hibernate underground at the groundwater interface. Raising water levels in the winter could drown snakes and lowering water table could expose them to extreme cold temperatures. Both activities are likely to kill overwintering snakes. In addition, herbaceous wetlands are lost under this management regime, replaced by open water wetlands

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Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the threats to all reptile habitats. Their responses included:

- Looks good.

Additional research and survey efforts

Current body of research

Species research

Fifteen percent of respondents stated that the current body of science is adequate for all reptiles in all habitats in Indiana; seventy-seven percent state that it is inadequate.

Respondents identified the following citations (title, author, date, publisher) that would give the best overview of reptiles in all habitats in Indiana.

Author = minton;
Date = 2001

Author = reviewed in Minton;
Date = 2001

Author = review Minton's guide;
Date = 2001;
Publisher = Get BioBlitz & IUPFW reports from DNR

Title = ongoing background work in NE & MN

Title = various theses;
Author = Bruce Kingsbury et al

Title = Status and Distribution of candidate endangered herpetofauna in the Fish Creek watershed;
Author = Bruce Kingsbury, Spencer Cortwright;
Date = 1994;
Publisher = IDNR Division of Fish and Wildlife

Title = Spatial Ecology of the Timber Rattlesnake in south central Indiana;
Author = Walker and Kingsbury;
Date = 2000;
Publisher = Masters Thesis, IPFW

Author = Gibson and Kingsbury;
Date = 2003;
Publisher = Masters Thesis, IPFW

Title = A long term study of a box turtle (*Terrapene carolina*) population at Allee Memorial Woods, Indiana, with emphasis on survivorship;
Author = Williams and Parker;
Date = 1987; Publisher = Herpetologica

Title = North American Box Turtles;
Author = Dodd;
Date = 2001;
Publisher = University of Oklahoma Press

Title = Conservation Assessment for Kirtland's Snake (*Clonophis kirtlandii*);
Author = Jonanna Gibson and Bruce Kingsbury;
Date = 2004;
Publisher = USDA Forest Service, Eastern Region

Title = Kirtland's Snake;
Author = www.natureserve.org

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Title = Amphibians and Reptiles of Indiana;
Author = Minton;
Date = 2001;
Publisher = Indiana Academy of Sciences.

Title = Snakes of the United States and Canada;
Author = Ernst and Ernst;
Date = 2003;
Publisher = Smithsonian Institution

Title = Amphibians and Reptiles of Indiana;
Author = Minton;
Date = 2001;
Publisher = Indiana Academy of Science

Title = Snakes of the United States and Canada;
Author = Ernst and Ernst;
Date = 2003;
Publisher = Smithsonian Institute

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the current body of science for all reptiles in all habitats. Their responses included:

- While we have baseline information about many species, whenever we look at these animals in more detail, we discover much more about them. I think it is important to realize we know few species well.

Habitat research

Twenty-three percent of respondents stated that the current body of science is adequate for all reptile habitats in Indiana; forty-six percent of respondents stated that it is inadequate.

Respondents identified the following citations (title, author, date, publisher) that would give the best overview of reptile habitats in Indiana.

Title = ??? Sugar Creek???
Author = ?;
Date = late 1970s/early 1980s;
Publisher = PhD thesis IU Bloomington

Title = Not my expertise. Looks for historical;
Author = accounts of river geography &;
Date = physiography + hydrology

Title = Not my expertise;
Author = contact JW Lang for NE & MN

Title = Amphibians and Reptiles of Indiana;
Author = Sherman A. Minton, Jr.;
Date = 2001;
Publisher = Indiana Academy of Science

Title = Indiana Heritage Database;

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Author = Indiana Division of Nature Preserves

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the current body of science for all reptile habitats. Their responses included:

- It should be clear from the paucity of references that we still have a lot to learn about habitat/reptile interactions. we often know the "big picture," but still lack the details.

Research needs

Species research

Respondents ranked research needs for all reptiles in all habitats in Indiana:

Rank	Research needs for all reptiles in all habitats
1	Limiting factors (food, shelter, water, breeding sites)
2	Population health (genetic and physical)
3	Threats (predators/competition, contamination)
4	Distribution and abundance
5	Relationship/dependence on specific habitats
6	Life cycle

Respondents noted other research needs for all reptiles in all habitats in Indiana (not ranked):

- Cost effectiveness and periodic effective duration of local raccoon elimination
- Socioeconomic impacts of terminating commercial fishing use of commercial equipment in the lower West Fork and Middle East Fork White River
- Whether genetic stock from northern Arkansas will suffice for reintroduction, or will farmed stock from Arkansas or Louisiana will suffice
- Long-term fidelity to specific sites
- Limits to sand prairie needs for nesting
- Limits to recruitment when forced to nest in row crop areas
- I believe more information is needed for all topics concerning the black kingsnake in Indiana. However, this species is not currently endangered and this information is not urgently needed
- General life history information is needed for the Southeastern crowned snake in Indiana. Due to this species secretive nature, little is known about Indiana's populations

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research for all reptiles in all habitats. Their responses included:

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- This is not a reasonable representation of research needs. The ranking is fine, but the comments are not. They seem to be derived from comments based on one or two species.

Habitat research

Respondents ranked research needs for all reptile habitats in Indiana:

Rank	Research needs for habitat
1	Relationship/dependence on specific site conditions
2	Distribution and abundance (fragmentation)
3	Successional changes
4	Threats (land use change/competition, contamination/global warming)
5	Growth and development of individual components of the habitat

Respondents noted additional research needs for all reptile habitats in Indiana (not ranked):

- Cost effectiveness and periodic effective duration of local raccoon elimination
- Socioeconomic impacts of terminating commercial fishing use of commercial equipment in the lower West Fork and Middle East Fork White River
- Whether genetic stock from northern Arkansas will suffice for reintroduction, or will farmed stock from Arkansas or Louisiana will suffice Prairie restoration & fire management to perpetuate small sand blowouts
- The relationship between upland nesting habitat, dispersal distance, barriers to dispersal (etc.) may be critical information for the conservation of this turtle
- Spatial relationships between occupied wetlands relative to population dynamics
- Physical characteristics of overwintering sites
- Understanding successional dynamics of sand systems relative to the habitat requirements of some reptiles
- The highest priority should be to understand why Kirtland's snakes occur where we are currently finding them. With that information, we can maintain current populations before we determine the feasibility of increasing their numbers and distribution

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research for all reptile habitats. Their responses included:

- This is much better.

Conservation actions necessary

Species actions

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Respondents ranked conservation efforts by how well they address threats to all reptiles in all habitats in Indiana:

Rank	Conservation efforts for all reptiles in all habitats
1 (tie)	Population enhancement (captive breeding and release)
1 (tie)	Reintroduction (restoration)
1 (tie)	Native predator control
1 (tie)	Translocation to new geographic range
1 (tie)	Limiting contact with pollutants/contaminants
1 (tie)	Stocking
2	Exotic/invasive species control
3	Threats reduction
4	Habitat protection
5	Public education to reduce human disturbance
6	Regulation of collecting
7 (tie)	Population management (hunting, trapping)
7 (tie)	Disease/parasite management
7 (tie)	Protection of migration routes

Respondents noted other current conservation practices for all reptiles in all habitats in Indiana (not ranked):

- People need to be reminded that some reptiles are listed as endangered and illegal to take/collect
- Invasive species control (buckthorn, autumn olive, phargmites) to keep open herbaceous habitat suitable for massasauga rattlesnakes

Respondents recommended these practices for more effective conservation of all reptiles in all habitats in Indiana (not ranked):

- Restocking
 - Few if any turtles remain
 - Local restocking where raccoons reduced should hasten delisting criteria
- End use of commercial fishing equipment
- Predator management
 - Do periodic local removal of raccoons
 - Raccoon reduction near constrained (small) areas of occupied habitat in northeast Indiana

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- Expand and liberalize taking of raccoons to greatly reduce numbers associated with river cooter habitat. Raccoon reduction has been used regarding sea turtles in Florida and endangered Illinois mud turtle in Iowa, proposed for alligator snapping turtles in Louisiana

- Habitat restoration and management
 - Cease any future channelization plans and restore existing oxbow ponds
 - Design and manage conservation areas that specifically incorporate life history requirements of the Blanding's turtle across relatively large habitats (>1,000 acres). This species is too often subjected to management decisions that favor other species, and these often have a negative impact on available wetland and nesting habitat. In some cases, these management decisions seem likely to result in direct mortality of adults and eggs
 - Increasing habitat via restoration seems like a simple approach that would add sand prairie habitat to the fringes of savannah
 - Restore new, very large natural areas in northwest Indiana
 - Restore grassland habitats adjacent to known population sites would be a great start. Restoration could involve creation of native grassland system from adjacent agricultural fields, with the restoration designed to create habitat specifically for reptiles
 - Restore oak savannah at known sites would involve opening the canopy in oak woodlands to about 50 percent cover and control of invasive exotic shrubs. This would restore connectivity between potentially occupied habitat patches at larger public lands, and expand potential habitat.
 - Restore habitat and connectivity
 - I would recommend preserving large continuous blocks of forested habitat and prohibiting the collection of box turtles. If possible, I would attempt to lower meso predator numbers and protect nest cavities
 - When areas known or suspected to have Kirtland's snakes are threatened with development, seek to have the developer include shrubs and rock features near drainages to provide cover and to reduce mowing in areas Kirtland's snakes are likely to use

- Landowner incentives
 - Provide landowner financial incentive

- Research
 - Understanding the potential impacts of disked firebreaks on Slender glass lizard could be important. This practice seems likely to result in direct adult and juvenile mortality
 - Of general life history requirements

- Collection regulation

- Public education

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Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the conservation for all reptiles in all habitats. Their responses included:

- Fine for focal species discussed, but many species not discussed.

Habitat actions

Respondents ranked conservation efforts by how well they address threats to all reptile habitats in Indiana:

Rank	Conservation efforts for all reptile habitats
1	Habitat restoration on public lands
2	Habitat restoration incentives (financial)
3 (tie)	Succession control (fire, mowing)
3 (tie)	Protection of adjacent buffer zone
3 (tie)	Restrict public access and disturbance
4 (tie)	Cooperative land management agreements (conservation easements)
4 (tie)	Habitat protection incentives (financial)
4 (tie)	Habitat restoration through regulation
5	Habitat protection on public lands
6 (tie)	Corridor development/protection
6 (tie)	Land use planning
7	Habitat protection through regulation
8 (tie)	Artificial habitat creation (artificial reefs, nesting platforms)
8 (tie)	Managing water regimes
8 (tie)	Pollution reduction
8 (tie)	Technical assistance

Respondents listed no other current conservation practices for all reptile habitats in Indiana.

Respondents recommended the following practices for more effective conservation of all reptile habitats in Indiana (not ranked):

- Habitat restoration and management
 - Encourage return to natural meander channel (within flood control)
 - Let dead trees in river stay; perhaps add some

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- Enhance natural river channel evolution including point bar development and snags (downed trees in the water). This provides basking sites and nesting habitat away from row crop agriculture
- Use fire to maintain large sand prairies near appropriate wetlands
- Protection, restoration and appropriate management of adjacent uplands as nesting habitat around known populations
- Increasing habitat via restoration seems like a simple approach that would add sand prairie habitat to the fringes of savannah
- Restore habitat and connectivity, allow beaver activity
- Preserve large tracts of forested habitat
- Reduce development along the upper reaches of drainages
- Conservation easements
 - Rehabilitate drained oxbow ponds through conservation easements
 - Acquire/purchase easements on additional blocks of land that have permanent wetlands associated with large sandy uplands
- Research
 - Understanding the potential impacts of disked firebreaks on this species could be important. This practice seems likely to result in direct adult and juvenile mortality
- Develop mowing protocols relative to mowing schedules to reduce snake/mower encounters

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the conservation for all reptile habitats. Their responses included:

- Monitoring for the effectiveness of restoration efforts should be a part of plans so that we can learn how to do the right thing.

Proposed plans for monitoring

Current monitoring

Species monitoring

Respondents were aware of the following monitoring efforts by state agencies for all reptiles in all habitats in Indiana (not ranked):

- Statewide year-round monitoring
- Statewide once-a-year monitoring
- Occasional statewide (less than once a year and not regularly scheduled) monitoring
- Regional or local year-round monitoring
- Regional or local once-a-year monitoring
- Occasional regional or local (less than once a year and not regularly scheduled) monitoring

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Respondents were aware of the following monitoring efforts by other organizations for all reptiles in all habitats in Indiana (not ranked):

- Occasional statewide (less than once a year and not regularly scheduled) monitoring
- Occasional regional or local (less than once a year and not regularly scheduled) monitoring

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Respondents ranked monitoring efforts by state agencies based on their importance for conservation of all reptiles in all habitats in Indiana:

Rank	Monitoring efforts by state agencies for conservation of all reptiles in all habitats
1	Occasional regional or local (less than once a year and not regularly scheduled) monitoring
2 (tie)	Periodic statewide (less than once a year but still regularly scheduled) monitoring
2 (tie)	Occasional statewide (less than once a year and not regularly scheduled) monitoring
3	Periodic regional or local (less than once a year but still regularly scheduled) monitoring
4	Statewide once-a-year monitoring
5	Regional or local year-round monitoring
6	Regional or local once-a-year monitoring
7	Statewide year-round monitoring

Respondents ranked monitoring efforts by other organizations based on their importance for conservation of all reptiles in all habitats in Indiana:

Rank	Monitoring efforts by other organizations for conservation of all reptiles in all habitats
1	Occasional regional or local (less than once a year and not regularly scheduled) monitoring
2	Periodic regional or local (less than once a year but still regularly scheduled) monitoring
3 (tie)	Periodic statewide (less than once a year but still regularly scheduled) monitoring
3 (tie)	Occasional statewide (less than once a year and not regularly scheduled) monitoring
4	Regional or local year-round monitoring
5	Statewide once-a-year monitoring
6	Regional or local once-a-year monitoring
7	Statewide year-round monitoring

Respondents listed regional or local monitoring by state agencies for all reptiles in all habitats in Indiana (not ranked):

- DNR occasionally monitors some reptiles
- Agencies that issue drainage permits are relevant here

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- Fish Creek, Patoka River, Pigeon Creek IDNR has monitored timber rattlesnakes in Brown, Monroe and Morgan counties
- IDNR is monitoring box turtles in Martin, Brown and Morgan counties
- Citizens and scientists report Kirtland's snake encounters to the Indiana Natural Heritage Database on a sporadic basis. These reports are often sufficient to demonstrate persistent Kirtland's snake occupied sites. However, the environmental parameters of these sites have not been adequately studied or described to reveal important micro-habitat associations

Respondents listed regional or local monitoring by other organizations for all reptiles in all habitats in Indiana (not ranked):

- "BioBlitz" in Lake County
- Herp Center at IUPFW: I presume they've done something in Steuben and La Grange counties
- Fish Creek, Patoka River, Pigeon Creek, Muscatatuck River
- USDA Forest Service has contracted survey work in the southern portions of the Hoosier National Forest
- The Nature Conservancy occasionally monitors some reptiles

Respondents listed organizations that monitor all reptiles in all habitats in Indiana (not ranked):

- Herp Center at IUPFW: I presume they've done something in Steuben and La Grange counties
- TNC has funded some work at Cline Lake Fen to better understand population dynamics, habitat use, etc.
- Bruce Kingsbury, IUPU Fort Wayne
- USDA Forest Service
- Wildlife Diversity Section of Indiana Division of Fish and Wildlife accepts sighting information as does the Division of Nature Preserves for inclusion in the Heritage Database

Respondents considered monitoring techniques for all reptiles in all habitats in Indiana:

Monitoring techniques for all reptiles in all habitats	Used	Not used but possible with existing technology and data	Not economically feasible
Radio telemetry and tracking	X	X	--
Modeling	X	X	--

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Coverboard routes	--	X	--
Spot mapping	X	X	--
Driving a survey route	--	X	--
Reporting from harvest, depredation, or unintentional take (road kill, by-catch)	X	X	--
Mark and recapture	X	X	--
Professional survey/census	X	X	--
Volunteer survey/census	X	X	--
Trapping (by any technique)	X	X	--
Representative sites	X	X	--
Probabilistic sites	--	X	--

Respondents noted other monitoring techniques for all reptile habitats in Indiana:

- A standardized protocol could be developed as suggested by Gibson and Kingsbury 2004. However, a more difficult question might be where should the standardized protocol be implemented to provide an adequate picture of the status of the Kirtland's snake in Indiana

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for all reptiles in all habitats. Their responses included:

- Efforts to standardize monitoring approaches would be helpful for comparative purposes between sites and over time.

Habitat inventory and assessment

Respondents were aware of the following inventory and assessment efforts by state agencies for all reptile habitats in Indiana (not ranked):

- Statewide annual inventory and assessment
- Occasional statewide (less than once a year and not regularly scheduled) inventory and assessment
- Regional or local year-round inventory and assessment
- Regional or local once-a-year inventory and assessment
- Periodic regional or local (less than once a year but still regularly scheduled) inventory and assessment
- Occasional regional or local (less than once a year and not regularly scheduled) inventory and assessment

Respondents were aware of the following inventory and assessment efforts by other organizations for all reptile habitats in Indiana (not ranked):

- Periodic regional or local (less than once a year but still regularly scheduled) inventory and assessment
- Occasional regional or local (less than once a year and not regularly scheduled) inventory and assessment

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Respondents ranked inventory and assessment efforts by state agencies based on their importance for conservation of all reptile habitats in Indiana:

Rank	Inventory and assessment by state agencies for conservation of all reptile habitats
1	Occasional statewide (less than once a year and not regularly scheduled) inventory and assessment
2	Periodic regional or local (less than once a year but still regularly scheduled) inventory and assessment
3	Occasional regional or local (less than once a year and not regularly scheduled) inventory and assessment
4	Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
5 (tie)	Regional or local year-round inventory and assessment
5 (tie)	Regional or local once-a-year inventory and assessment
6	Statewide annual inventory and assessment
7	Statewide once-a-year inventory and assessment

Respondents ranked inventory and assessment efforts by other organizations based on their importance for conservation of all reptile habitats in Indiana:

Rank	Inventory and assessment by other organizations for conservation of all reptile habitats
1	Periodic regional or local (less than once a year but still regularly scheduled) inventory and assessment
2	Occasional regional or local (less than once a year and not regularly scheduled) inventory and assessment
3	Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
4	Occasional statewide (less than once a year and not regularly scheduled) inventory and assessment
5 (tie)	Regional or local year-round inventory and assessment

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- 5 (tie) Regional or local once-a-year inventory and assessment
- 6 (tie) Statewide annual inventory and assessment
- 7 (tie) Statewide once-a-year inventory and assessment

Respondents listed regional or local inventory and assessment by state agencies for all reptile habitats in Indiana (not ranked):

- If any inventory is occurring, it's for water quality or fish contamination
- I am assuming that the governmental division responsible for water pollution control conducts some sampling regarding organic and heavy metal toxins in the water
- These habitat assessments might occur in Indiana, but I am not positive how often these activities take place
- At this time, the habitat characteristics of Kirtland's snake are not sufficiently defined to be monitored by general habitat measures (such as habitat classification based on remote sensing). More information on Kirtland's snake habitat requirements is needed to define a reasonable habitat model for this species and to monitor the distribution and abundance of suitable habitat in the state
- I am not sure how often state agencies survey the crowned snakes habitat. The division of nature preserves monitors these habitats

Respondents listed regional or local inventory and assessment by other organizations agencies for all reptile habitats in Indiana (not ranked):

- Occasional grants to universities
- IUPUI-FW faculty and students work in wetlands with some reptile species in northeast Indiana
- TNC has focused on sand savannah and sand prairie conservation in the northwest for over a decade. These include some efforts to look for landscape scale opportunities for restoration and conservation of habitat for some reptiles

Respondents generally were not knowledgeable about organizations that monitor all reptile habitats in Indiana (not ranked). Respondents guessed or assumed that certain organizations might monitor habitats without being certain of their activities. Those that were certain listed the following organizations (not ranked):

- The Nature Conservancy
- Indiana DNR Division of Nature Preserves

Respondents considered inventory and assessment techniques for all reptile habitats in Indiana:

Inventory and assessment techniques for all reptile habitats	Used	Not used but possible with existing technology and data	Not economically feasible

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GIS mapping	X	X	--
Aerial photography and analysis	X	X	--
Systematic sampling	X	X	X
Regulatory information	X	--	--
Participation in land use programs	X	--	--
Modeling	--	X	--
Voluntary landowner reporting	X	--	--

Respondents listed additional inventory and assessment techniques for all reptile habitats in Indiana (not ranked):

- I believe this habitat "siltstone glade in upland forest" is monitored through surveys performed in this habitat

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the inventory and assessment techniques for all reptile habitats. Their responses included:

- Looks fine.

Recommended monitoring

Species monitoring

Respondents recommended the following monitoring techniques for effective conservation of all reptiles in all habitats in Indiana (not ranked):

- Occasional censusing with very large, heavily baited hoop nets left out overnight
 - Do not set during rising waters
 - Check within 12 hours
 - Search for nests in June (after determining any adults present at all); See methods used in Florida and Louisiana for nests, in Arkansas and Louisiana for capturing adults
- Looking for basking individuals with a spotting scope; use of fyke nets with big leads, or basking traps to estimate numbers after visual spotting determines presence
- Radio track females to nesting sites; Monitor nests for depredation. (Both are somewhat labor-intensive for at least one person.)
- Population recruitment needs to be assessed at sites that are likely to be identified for the conservation of the Blanding's turtle. Because of the long lifespan of this turtle, it is unclear if seemingly robust populations are in fact, recruiting new members or simply on a long slide towards population senescence
- I'm not sure if a salvageable population exists in the Indiana. It would be critical to survey known populations to determine population structure, density and potential for

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recruitment. This information could then be used to plan and implement a conservation effort geared towards this species

- Radio-telemetry, mark recapture techniques, and transect surveys. Due to the cryptic nature of these snakes, locating individuals without the help of telemetry is extremely difficult. Many studies conducted locally and nationally have included telemetry in their methods
- Eastern box turtle
 - Long-term surveys and radio-telemetry. Surveys would include mark recapture methods
- Black kingsnakes
 - Professional or volunteer survey would be the best. This could be done through representative sites or volunteer chosen routes.
 - Professional surveys and test the effectiveness of cover objects

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for all reptiles in all habitats. Their responses included:

- Good examples, but work needs to be done on many other species.

Habitat inventory and assessment

Respondents recommended the following inventory and assessment techniques for effective conservation of all reptile habitats in Indiana (not ranked):

- High-resolution aerial photography during low water, digitized for GIS. Goal is to locate:
 - Deep river holes with woody debris (favored by adults)
 - Health/permanence of oxbow ponds
 - Nesting habitat
- High resolution aerial photography during low water periods, digitize and use in GIS, regarding how lasting are oxbow ponds during droughts
- Occasional site visits to assess vegetation quality for this herbivorous turtle
- Blanding's turtle
 - High resolution aerial photography at normal marsh water levels, digitize for GIS
 - Monitor wetland vegetation: Blanding's prefer floating emergents (e.g. duck weed) and get crowded out by cattail expansion
- More data is needed on Kirtland's snake habitat

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the inventory and assessment techniques for all reptile habitats. Their responses included:

- Emphasis on GIS is on the right track.

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Technical experts and conservation organizations offered the following additional comments:

- Parts of this are painful to read, because I am concerned that they will lead to focusing on a few species. Concerns about Blanding's relate to Spotted Turtles, concerns about Kirtland's Snake relate to Butler's Garter Snake. These are just examples.