ALL SUBTERRANEAN SYSTEMS HABITAT NARRATIVE

Subterranean Systems include: Surface openings of subterranean features reaching as far as natural light can penetrate (i.e., twilight zone) and connected underground rooms and passages beyond natural light penetration.

Problems affecting species and habitats

Species Threats

Respondents ranked the following threats to wildlife in all subterranean systems habitat in Indiana:

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

Respondents offered additional threats to wildlife in all subterranean systems habitat in Indiana (not ranked):

- Loss of forest habitat surrounding winter hibernacula/caves
- Unregulated human activity in hibernacula

    - Disturbance related to research/monitoring
- Need caves or mines for hibernation within 60 miles of summering ground

Respondents listed top threats to wildlife in all subterranean systems habitat in Indiana (not ranked):

- Human disturbance of hibernating bats
    - Ray's Cave in Greene County
    - Education of cavers and continued improvements to cave gates are important to Indiana bat survival
    - Some traditional hibernacula have been rendered unsuitable or degraded due to cave development/commercialization, including disturbance of hibernating bats by human visitation

- Habitat loss, degradation and fragmentation
    - Loss of summer and winter (caves habitat)
    - Loss of typical maternal roosting structures (large snags with sloughing bark)
    - Some traditional hibernacula have been rendered unsuitable or degraded due to cave development/commercialization, modification of the cave environment, or alternation of surface features
    - Threats also occur on summer habitat (not addressed here because it is not captured within the "cave habitat" category)
    - Alterations to microclimate within hibernacula
    - Pollution
        - Nonpoint sources of pollution, especially sediments and pesticides
        - Point sources of pollution particularly sewage and spills of chemicals being transported along roads and railroads

- Invasive/non-native
    - *Oxidus gracilis* is a non-native carnivorous millipede invading caves in the east; it is now in several Indiana caves and preying on the food base for cave salamanders. Further east, reports of greatly decreased insect diversity in caves invaded by this millipede have been reported. Potential impact is unknown, but could be significant

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the threats to wildlife in all subterranean systems habitats. There were no responses.

Habitat threats

Respondents ranked threats to all subterranean systems habitat in Indiana:

Rank	Threats to all subterranean systems habitat
1	Habitat degradation
2	Commercial or residential development (sprawl)
3	Climate change
4	Agricultural/forestry practices
5 (tie)	Residual contamination (persistent toxins)
5 (tie)	Point source pollution (continuing)
6	Habitat fragmentation

7	Nonpoint source pollution (sedimentation and nutrients)
8	Mining/acidification
9	Drainage practices (stormwater runoff)
10 (tie)	Stream channelization
10 (tie)	Impoundment of water/flow regulation
11	Invasive/non-native
12	Successional change
13	Counterproductive financial incentives or regulations

Respondents noted other threats to all subterranean systems habitat in Indiana (not ranked):

- Pollution
  - Dumping refuse in sinkholes; these often contain persistent toxins associated with transformers, tires, appliances, pesticide containers and electronic devices
- Habitat loss
  - Need caves and mines for habitat

Respondents listed top threats to all subterranean systems habitat in Indiana (not ranked):

- Habitat loss, degradation and fragmentation
  - Adverse modifications to cave entrances (e.g., poorly designed bat gates), which cause a change in interior microclimates/temperatures
  - Of forested areas surrounding caves used by bats during the fall swarming period
  - Of breeding habitat (note that breeding habitat also occurs in areas of the state not associated with caves)
  - Loss of roost trees via a number of man-related activities (commercial, agricultural, etc.)
  - Pollution: Degradation of caves by potential migration of chemicals that alter the cave ecosystem
    - Both non-point and point sources of pollution associated with the increasing human population of Southern Indiana and development of the area

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the threats to all subterranean systems habitats. There were no responses.

Additional research and survey efforts

Current body of research

research

Fourteen percent of respondents stated that the current body of science is adequate, while 57 percent find it inadequate for wildlife in all subterranean systems habitat in Indiana.
A respondent noted, “There is lots of research but also great need due to endangered status.”

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

Title = Distribution and status of the northern cavefish;
Author = Pearson, W. D. and C. Boston;
Date = 1995;
Publisher = Final report to IN Department of Nat. Res.Div. of F&W

Title = Age, growth and fin erosion of the northern cavefish, Amblyopsis spelaea, in KY and IN;
Author = Louis, M.;
Date = 1999;
Publisher = Unpubl. M.S. Thesis, University of Louisville

Title = Wintering populations of bats in Indiana, with emphasis on the endangered Indiana Myotis, Myotis sodalis;
Author = Virgil Brack, Jr., Scott A. Johnson, and R. Keith Dunlap;
Date = 2003;
Publisher = Proceedings of the IN Academy of Science

Title = Management of hibernacula in the state of Indiana;
Author = Johnson, Brack, Dunlap;
Date = 2002;
Publisher = Bat Conservation International

Title = Biennial hibernacula survey reports;
Publisher = reports submitted to IDNR

Title = Home range near hibernacula in spring and autumn;
Author = Russell C. Romme, Amy B. Henry, R. Andrew King, T. Glueck, and K. Tyrell;
Date = 2002;
Publisher = The Indiana Bat: Biology and Management of an Endangered . Bat Conservation International

Title = The nonhibernating ecology of bats in Indiana with emphasis on the endangered Indiana bat, Myotis sodalis;
Author = Virgil Brack, Jr.;
Date = 1983;
Publisher = Purdue University

Title = Brack, Johnson and Dunlap, 2003.;
Publisher = Proc. Ind. Acad, Sci. 112:-61-74.

Title = Mumford and Whitaker 1982

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 wildlife in all subterranean systems habitats. There were no responses.

Habitat research

Fourteen percent of respondents stated that the current body of science is adequate, while 71 percent find it inadequate for all subterranean systems habitat in Indiana.

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

Title = Cave adaptation in Amblyopsid fishes;
Author = Poulson, T.;
Date = 1963;
Publisher = Amer. Midl. Nat. 70(2):257-290

Title = A faunal inventory of subterranean streams using a modified index of biotic integrity;
Author = Jones, T.G.;
Date = 1997;
Publisher = Unpubl. Ph.D. Disst. University of Louisville

Title = Hibernacula of the endangered Indiana bat in Indiana;
Author = Brack, Virgil Jr., A.M. Wilkenson, R.E. Mumford;
Date = 1984;
Publisher = Proceedings of the Indiana Academy of Science, vol. 93:463-468

Title = Distribution and ecology in Indiana. Pp 48-54 in Indiana Bat: Biology and Management of an Endangered (A. Kurta and J. Kennedy, Eds.); A
uthor = John Whitaker Jr. & Virgil Brack Jr.;
Date = 2002;
Publisher = Bat Conservation International

Title = Mumford and Whitaker 1982

Title = Veilleux et al. 2003.;
Publisher = J. Mamm, 841068-1075.

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 subterranean systems habitats. There were no responses.

Research needs

research

Respondents ranked research needs for wildlife in all subterranean systems habitat in Indiana:

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

Respondents noted other research needs for wildlife in all subterranean systems habitat in Indiana (not ranked):

- We need urgently need to determine the effects of the loss/fragmentation/timber management of summer habitat/forest on maternity colonies/reproductive success, not just caves/winter habitat
- More information is needed on autumn swarming and spring staging. Similarly new hibernacula need to be recorded
- Metapopulation dynamics
- Extent of populations in subterranean systems which cannot be entered by humans

- Need to know more about rabies in bats

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for wildlife in all subterranean systems habitats. There were no responses.

Habitat research

Respondents ranked research needs for all subterranean systems habitat in Indiana:

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

Respondents noted additional research needs for all subterranean systems habitat in Indiana (not ranked):

- Forest habitat research
  - How much forest habitat needs to remain around a hibernaculum to sustain a population of size x during the fall swarming period?
  - Recommend a detailed analysis of forest canopy to openness ratio and habitat intricacies that provide preferred home range requirements, e.g. primary roosts, secondary roosts, water, night roosts, food
- Indiana bats
  - How does cave environment, especially temperature and temperature stability, affect suitability and use of cave by Indiana bats
  - What components of the habitat immediately surrounding the cave are most important to Indiana bats during fall swarming and spring staging. How is this habitat used
- Cavefishes habitat research
  - Assessment of the physical dimensions of the phreatic environment available to cavefishes, and the connections between known windows into the system
  - Toxin concentrations in cave sediments and their recruitment rates into underground waters
- Need to know more of the relationship between winter and summer habitat, and also of migration

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for all subterranean systems habitats. There were no responses.

Conservation actions necessary

actions

Respondents ranked conservation efforts by how well they address threats to wildlife in all subterranean systems habitat in Indiana:

Rank	Conservation efforts for wildlife in all subterranean systems habitat
1 (tie)	Habitat protection
1 (tie)	Regulation of collecting
2	Threats reduction
3	Public education to reduce human disturbance
4	Limiting contact with pollutants/contaminants

Respondents noted other current conservation efforts for wildlife in all subterranean systems habitat in Indiana (not ranked):

- Controlling human disturbance
  - Posting signs at caves, installing-bat friendly gates, land acquisition, installing video cameras to deter cave visits, using light-sensitive "speloggers" to monitor levels of human visitation
  - Regulation of research and research-related disturbances
- Protect caves and mines in which bats occur

Respondents recommended these practices for more effective conservation of wildlife in all subterranean systems habitat in Indiana (not ranked):

- Habitat protection
  - Negotiating with the owner of Ray's Cave and other hibernacula to allow them to be gated or use other techniques to control human disturbance
  - Gating, securing conservation easements, or purchasing unprotected hibernacula (prioritizing based on current numbers or potential of hibernacula to harbor large numbers if disturbance is presently limiting numbers)
  - Protecting surface features and forest cover surrounding hibernacula and managing for high quality swarming habitat
  - Purchasing and protecting recorded Indiana bat hibernacula and summer habitat
  - Acquiring and protecting reserve at Blue Spring Caverns
  - Protecting caves and mines

- Control human disturbance/public education
  - Public education is needed on the importance of caves, snags and the importance of bats to man
  - Limit public access to population concentrations already under agency control at Harrison/Crawford State Forest and Spring Mill State Park
  - Protect cave entrances from inappropriate management activities

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the practices for more effective conservation of wildlife in all subterranean systems habitats. There were no responses.

Habitat actions

Appendix F-60: Aggregated Subterranean Systems

Respondents ranked conservation efforts by how well they address threats to all subterranean systems habitat in Indiana:

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

Respondents listed other current conservation practices for all subterranean systems habitat in Indiana (not ranked):

- Public education/restrict human disturbance
  - On retaining old, dead or dying trees that provide habitat for wildlife, including the Indiana bat
  - Close and/or year-round gating of caves with large populations of hibernating or reproducing bats will ensure normal trophic cascades for those systems
  - Restrict recreation caving in some caves might reduce periodic disturbances, increases in turbidity and remobilization of toxins and sediments

Respondents recommended the following practices for more effective conservation of all subterranean systems habitat in Indiana (not ranked):

- Conservation easements
  - O private property containing swarming habitat and connected karst features around key hibernacula
  - With selected cave owners in Orange, Washington, Lawrence and Harrison counties

- Habitat protection and acquisition
  - Protect cave entrances from disturbance
  - Establish reserve at Blue Spring Cavern
  - Restrict entry to selected caves at Harrison-Crawford State Forest

  - Gating, securing conservation easements, or purchasing unprotected hibernacula (prioritizing based on current numbers or potential of hibernacula to harbor large numbers if disturbance is presently limiting numbers)
  - Purchasing and protecting recorded Indiana bat hibernacula and summer habitat

- Public education about the importance of caves, snags and the importance of bats to man

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the practices for more effective conservation of all subterranean systems habitats. There were no responses.

Partner agencies/organizations

Organizations	% time spent in subterranean systems habitat
Division of Fish and Wildlife	0.5
Indiana Division of the Izaak Walton League of America	1
IDNR- Division of Forestry- Cooperative Forest Management Section (Private Lands)	2
Indiana Department of Natural Resources Division of Forestry, Properties Section (State Forests)	2
Robert Cooper Audubon Society	3
U.S. Department of Agriculture, Forest Service Hoosier National Forest	5
US Fish and Wildlife Service Ecological Services (does not include national wildlife refuges)	5
Veolia Water Indianapolis, LLC	5
Big Oaks National Wildlife Refuge, USFWS	10
Hoosier Environmental Council	10
Lincoln Hills RC&D	10
The Nature Conservancy	10
Lost River Conservation Association	40
Indiana Karst Conservancy	100
Federal Highway Administration (FHWA)	?
IN DNR, Division of State Parks & Reservoirs, Interpretive Services	~2-3
Fur Takers of America	
Law Enforcement Division, Indiana Department of Natural Resources	

Proposed plans for monitoring

Current monitoring

monitoring

Respondents were aware of the following monitoring efforts by state agencies for wildlife in all subterranean systems habitat in Indiana (not ranked):

- Periodic statewide (less than once a year but still regularly scheduled) monitoring

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

Respondents were aware of the following monitoring efforts by other organizations for wildlife in all subterranean systems habitat in Indiana (not ranked):

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

Respondents ranked monitoring efforts by state agencies based on their importance for conservation of wildlife in all subterranean systems habitat in Indiana:

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

Respondents ranked monitoring efforts by other organizations based on their importance for conservation of wildlife in all subterranean systems habitat in Indiana:

Rank	Monitoring efforts by other organizations for conservation of wildlife in all subterranean systems habitat
1	Periodic statewide (less than once a year but still regularly scheduled) monitoring
2	Periodic regional or local (less than once a year but still regularly scheduled) monitoring
3	Occasional regional or local (less than once a year and not regularly scheduled) monitoring
4 (tie)	Regional or local once-a-year monitoring
4 (tie)	Statewide once-a-year monitoring
4 (tie)	Occasional statewide (less than once a year and

not regularly scheduled) monitoring

Respondents listed regional or local monitoring by state agencies for wildlife in all subterranean systems habitat in Indiana (not ranked):

- Indiana bat
  - IDNR conducts biennial hibernacula surveys in all known Indiana bat hibernacula in the state (except Batwing and Twin Domes Caves, which are surveyed under a separate federal contract)
  - Occasional monitoring/research is conducted in cave habitats on a localized basis by state agencies for specific purposes (such as the swarming habitat study at Wyandotte Cave)
  - Monitoring is also occasionally conducted in summer habitat (not included in this survey)
  - Caves in southern Indiana are monitored. Currently there are 33 hibernacula reported for the Indiana bat in southern Indiana

Respondents listed regional or local monitoring by other organizations for wildlife in all subterranean systems habitat in Indiana (not ranked):

- Rick Clawson, Missouri DOC, conducts the biennial winter surveys at Twin Domes and Batwing caves. The Indiana Karst Conservancy (Keith Dunlap) also assists with monitoring efforts, especially at hibernacula that they own or oversee. I have monitored the Indiana bat population in Reeves Cave in Monroe County
- There are surveys conducted at localized locations throughout Indiana, primarily in summer habitat but also some cave habitat work, to address specific management or research needs. For example, surveys are conducted at all Department of Defense properties
- Caves in southern Indiana are monitored. Currently there are 33 hibernacula reported for the Indiana bat in southern Indiana
- University of Louisville has been monitoring the Northern Cavefish at irregular intervals and locations in southern Indiana since 1994
- Biyearly monitoring for cave bats in about 18 caves in which Indiana myotis is known to hibernate

Respondents listed organizations that monitor wildlife in all subterranean systems habitat in Indiana (not ranked):

- Indiana DNR (Keith Dunlap, Scott Johnson)
- Local NSS Grotto members
- U.S. Fish and Wildlife Service
- Federal agencies (e.g., Forest Service, DoD, COE)
- Educational institutions (federal permit holders)
  - Indiana State University
  - Purdue University
  - University of Louisville, Biology Department
- Local/County agencies
- Private Conservation Organizations (e.g., Indiana Karst Conservancy)
- Indiana Cave Survey
- Ecological consultants (federal permit holders)
  - Dr. Virgil Brack, ESI

Respondents considered monitoring techniques for wildlife in all subterranean systems habitat in Indiana:

Monitoring techniques for wildlife in all subterranean systems habitat	Used	Not used but possible with existing technology and data	Not economically feasible
Radio telemetry and tracking	X	--	--
Modeling	X	X	--
Spot mapping	--	X	--
Reporting from harvest, depredation, or unintentional take (road kill, by-catch)	X	--	--
Mark and recapture	X	X	--
Professional survey/census	X	--	--
Volunteer survey/census	X	--	--
Trapping (by any technique)	X	--	--
Representative sites	X	X	--
Probabilistic sites	X	--	--

Respondents noted other monitoring techniques for wildlife in all subterranean systems habitat in Indiana (not ranked):

- AnaBat/acoustic and/or video monitoring of cave entrances to assess bat presence/use
- Stable isotope analysis, genetic genotyping of individuals (through guano analysis), thermal imagery surveys, contaminant analysis/monitoring through guano and/or whole body analysis
- Delury or survey/removal techniques have been used at Donaldson Cave in the 1990's
- Mist-netting stream
- Cave counts
- Rabies lab bats
- Trapping cave and mine entrances

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for wildlife in all subterranean systems habitats. There were no responses.

Habitat inventory and assessment

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

- Statewide once-a-year inventory and assessment
- Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
- Occasional statewide (less than once a year and not regularly scheduled) 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 subterranean systems habitat in Indiana (not ranked):

- Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
- Occasional statewide (less than once a year and not regularly scheduled) 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 ranked inventory and assessment efforts by state agencies based on their importance for conservation of all subterranean systems habitat in Indiana:

Rank	Inventory and assessment by state agencies for conservation of all subterranean systems habitat
1	Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
2	Periodic regional or local (less than once a year but still regularly scheduled) inventory and assessment
3	Occasional statewide (less than once a year and not regularly scheduled) inventory and assessment
4	Statewide once-a-year inventory and assessment
5	Occasional regional or local (less than once a year and not regularly scheduled) inventory and assessment

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

Rank	Inventory and assessment by other organizations for conservation of all subterranean systems habitat

1 (tie)	Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
1 (tie)	Occasional statewide (less than once a year and not regularly scheduled) inventory and assessment
1 (tie)	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

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

- Cave habitat is assessed when the winter surveys of hibernacula are conducted statewide
- State conducted annual monitoring of the cave environment in most major hibernacula. Human disturbance in key hibernacula is also monitored
- **T**he contractor who conducts the biennial hibernacula surveys also documents information on cave "condition" (e.g., breakdown) and makes management recommendations
- Karst regions and summer habitat in Indiana
- South central part of state
- IDNR Division of Fish and Wildlife (nongame biologists)

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

- Completed by Rick Clawson, Missouri DOC, for Twin Domes and Batwing caves. USFWS-Reeves Cave and others
- Several organizations collect information on the location and condition of caves, as well as the presence of bats in caves, which provides useful information
- Karst regions and summer habitat in Indiana
- Hoosier National Forest
- Harrison/Crawford State Forest
- Spring Mill State Park
- Caves of south central Indiana
- Indiana Karst Conservancy and local grottos

Respondents listed organizations that monitor all subterranean systems habitat in Indiana (not ranked):

- Indiana Karst Conservancy
- NSS Grottos
- U.S. Fish and Wildlife Service
- I-69 bat consultants
- The Nature Conservancy
- Indiana Cave Survey
- USDA Forest Service
- Ecological consultants (federal permit holders)
  - Virgil Brack, ESI
- Universities (federal permit holders)

- University of Louisville
- Indiana State University
- Purdue University

Respondents considered inventory and assessment techniques for all subterranean systems habitat in Indiana:

Inventory and assessment techniques for all subterranean systems habitat	Used	Not used but possible with existing technology and data	Not economically feasible
GIS mapping	X	--	--
Aerial photography and analysis	X	--	--
Systematic sampling	X	X	--
Regulatory information	X	--	--
Participation in land use programs	--	X	--
Modeling	X	X	--
Voluntary landowner reporting	X	--	--

Respondents listed additional inventory and assessment techniques for all subterranean systems habitat in Indiana (not ranked):

- Temperature and relative humidity monitoring with remote data loggers
- Cave survey
- Visual estimation: Has the entrance been changed in any way from its historical configuration (forest canopy opened up, entrance enlarged or blocked, etc.)

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 subterranean systems habitats. There were no responses.

Recommended monitoring

monitoring

Respondents recommended the following monitoring techniques for effective conservation of wildlife in all subterranean systems habitat in Indiana (not ranked):

- Bats
  - Biennial hibernacula surveys (which I would classify as "professional survey/census") are the only means currently available to track Indiana bat population trends on a statewide or range-wide basis. These surveys are conducted range-wide

  - Survey and monitoring activities conducted in summer habitat are used to: 1) evaluate summer distribution in the state, and 2) evaluate roosting and foraging habitat use/needs. These surveys are conducted in Indiana as well as other states throughout the range of the
  - Intensive radio telemetry that tracks roost and foraging movements of specific colonies in representative areas across the state
  - Trapping for Indiana bat includes mist netting and harp trapping. Internal cave surveys are important and more emphasis should be placed on the use of AnaBat
  - Stable isotope analysis, genetic genotyping of individuals (through guano analysis), thermal imagery surveys, contaminant analysis/monitoring through guano and/or whole body analysis

- Cavefishes
  - Development of an index of biotic integrity (IBI) for vertebrate cave communities in southern Indiana
  - Selection of five to 10 locations for survey/counts every two to five years. A similar survey schedule has been established for cavefish populations in Mammoth Cave National Park and could be used as a model (both IBI and survey)

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for effective conservation of wildlife in all subterranean systems habitats. There were no responses.

Habitat inventory and assessment

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

- Bats
  - Cave microclimate monitoring with data loggers should continue. A range-wide protocol for monitoring cave temperature and humidity has been developed by Bat Conservation International and is being widely used (contact Jim Kennedy or Merlin Tuttle at BCI). I believe Scott Johnson has been following this protocol in Indiana
  - Techniques to link summer/winter populations (new genetic techniques such as stable isotope analysis; pit tagging)
  - Information on habitat use/needs in the vicinity of caves during swarming is a critical need. At present, radio telemetry represents the best potential to collect this information
  - Cave survey in winter, and net survey in summer

- Cavefishes
  - Population surveys every five years and development of an IBI to be applied at five to 10 critical locations. These to include Blue Spring Caverns, Spring Mill State Park and Harrison-Crawford State Forest

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 effective conservation of all subterranean systems habitats. There were no responses.

Appendix F-61: Subterranean Systems

Technical experts did not provide input on a representative species for this habitat.

There are no species of greatest conservation need in this guild.

SUBTERRANEAN SYSTEM CAVE ENTRANCE NARRATIVE

Habitat description

Subterranean Systems Cave Entrances: Surface openings of subterranean features reaching as far as natural light can penetrate (i.e., twilight zone).

Problems affecting species and habitats

Species threats

The respondent listed no "critical threat" to wildlife in cave entrances habitat in Indiana however, Invasive/non-native species was identified as a "serious threat". The respondent listed as "somewhat of a threat" (not ranked):

- High sensitivity to pollution
- Dependence on irregular resources (cyclical annual variations) (e.g., food, water, habitat limited due to annual variations in availability)
- Habitat loss (breeding range)
- Habitat loss (feeding/foraging areas)

The respondent listed "small native range (high endemism)" as "slight threat" for wildlife in cave entrances habitat in Indiana.

The respondent listed no additional threats to wildlife in cave entrances habitat in Indiana.

The respondent listed the top threat to wildlife in cave entrances habitat: "*Oxidus gracilis* is a non-native millipede that invades caves in the East. It is now in several Indiana caves and is preying on the food base for cave salamanders. Further east, reports of greatly decreased insect diversity in caves invaded by this millipede have been reported. Potential impact is unknown but could be significant."

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the threats to wildlife in cave entrances habitats. There were no responses.

Habitat threats

The respondent listed no "critical threat" or "serious threat" for cave entrances habitat in Indiana. The respondent listed as "somewhat of a threat" (not ranked):

- Commercial or residential development (sprawl)
- Invasive/non-native species
- Nonpoint source pollution (sedimentation and nutrients)
- Habitat degradation
- Agricultural/forestry practices
- Residual contamination (persistent toxins)
- Point source pollution (continuing)
- Mining acidification
- Drainage practices (stormwater runoff)

The respondent listed the following as "slight threat" for cave entrances habitat in Indiana (not ranked):

- Counterproductive financial incentives or regulations
- Habitat fragmentation

- Successional change

The respondent listed no additional threats to cave entrances habitat in Indiana.

The respondent listed as top threat to cave entrances habitat in Indiana: “Forestry practices that open the forest canopy around cave entrances can greatly impact the habitat for this species, drying out the entrance to the point that it is not usable habitat by the salamanders.”

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the threats to cave entrances habitats. There were no responses.

Additional research and survey efforts

Current body of research

Species research

The respondent stated that the current body of science for wildlife in cave entrances habitat in Indiana is inadequate.

The respondent did not identify citations (title, author, date, publisher) that would give the best overview of wildlife in cave entrances habitats in Indiana.

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 wildlife in cave entrances habitats. There were no responses.

Habitat research

The respondent stated that the current body of science for cave entrances habitat in Indiana is inadequate.

The respondent did not identify citations (title, author, date, publisher) that would give the best overview of cave entrances habitats in Indiana.

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 cave entrances habitats. There were no responses.

Research needs

Species research

The respondent listed no “urgently needed” or “greatly needed” research needs for wildlife in cave entrances habitat in Indiana. The respondent stated that the following research is “needed” on the following topics (not ranked):

- Limiting factors (food, shelter, water, breeding sites)
- Threats (predators/competition, contamination)

The respondent listed the following as “slightly needed” for wildlife in cave entrances habitat in Indiana (not ranked)”

- Life cycle
- Distribution and abundance
- Relationship/dependence on specific habitats

The respondent listed no other research needs for wildlife in cave entrances habitat in Indiana.

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for wildlife in cave entrances habitats. There were no responses.

Habitat research

The respondent listed no "urgently needed" or "greatly needed" research needs for cave entrances habitat in Indiana. The respondent stated that the following research is "needed" on the following topics:

- Successional changes
- Distribution and abundance (fragmentation)]
- Threats (land use change/competition, contamination/global warming)

The respondent listed no additional research needs for cave entrances habitat in Indiana.

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for cave entrances habitats. There were no responses.

Conservation actions necessary

Species actions

The respondent listed no conservation efforts that address threats "very well" to wildlife in cave entrances habitat in Indiana. Conservation efforts that address threats "somewhat" include (not ranked):

- Habitat protection
- Threats reduction
- Public education to reduce human disturbance

The respondent listed no other current conservation practices for wildlife in cave entrances habitat in Indiana.

The respondent recommended the following practice for more effective conservation of wildlife in cave entrances habitat in Indiana:

- Protect cave entrances from inappropriate management activities

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the practice for more effective conservation of wildlife in cave entrances habitats. There were no responses.

Habitat actions

The respondent listed "protection of adjacent buffer zone" as the best conservation effort to address threats to cave entrances habitat in Indiana. Conservation efforts that address threats "somewhat" include (not ranked):

- Habitat protection through regulation
- Habitat protection on public lands

- Restrict public access and disturbance
- Cooperative land management agreements (conservation easements)

The respondent listed no other current conservation practices for cave entrances habitat in Indiana.

The respondent listed the need to "protect cave entrances from disturbance" as a specific practice for more effective conservation of cave entrances habitat in Indiana.

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the conservation practices for cave entrances habitats. There were no responses.

Proposed plans for monitoring

Current monitoring

Species monitoring

The respondent was not aware of monitoring efforts by state agencies or other organizations for wildlife in cave entrances habitat in Indiana.

The respondent rated no monitoring efforts by state agencies or other organizations as "very crucial" or "somewhat crucial" for conservation of wildlife in cave entrances habitat in Indiana. Listed as "slightly crucial" is

- Periodic statewide (less than once a year but still regularly scheduled) monitoring by agencies and organizations

The respondent cited no regional or local monitoring by state agencies, or organizations that conduct such monitoring for wildlife, in cave entrances habitat in Indiana.

The respondent listed no monitoring techniques for wildlife in cave entrances habitat in Indiana, and cited no recommendations for conducting such monitoring.

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for wildlife in cave entrances habitats. There were no responses.

Habitat inventory and assessment

The respondent was not aware of inventory and assessment efforts by state agencies or other organizations for cave entrances habitat in Indiana.

The respondent listed no "very crucial" inventory and assessment efforts by state agencies or other organizations for conservation of entrances habitat in Indiana. Listed as "somewhat crucial" efforts by agencies and organizations include: "occasional regional or local (less than once a year and not regularly scheduled) inventory and assessment."

The respondent listed Indiana Davison of Fish and Wildlife, Nongame Section as the state agency that inventories and assesses cave entrances habitat in Indiana.

The respondent listed the following regional or local inventory or assessment efforts by other organizations for cave entrances habitat in Indiana:

- Indiana Karst Conservancy and local grottos

The respondent listed the following organization that monitors cave entrances habitat in Indiana:

- Indiana Karst Conservancy and local grottos

The respondent cited no current or possible inventory and assessment techniques for cave entrances habitat in Indiana.

The respondent listed the following inventory and assessment technique for cave entrances habitat in Indiana:

- Visual estimation – Has the entrance been changed in any way from its historic configuration (forest canopy opened up, entrance enlarged or blocked, etc.)

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 cave entrances habitats. There were no responses.

Recommended monitoring

Species monitoring

The respondent recommended no monitoring techniques for wildlife in cave entrances habitat 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 wildlife in cave entrances habitats. There were no responses.

Habitat inventory and assessment

The respondent listed no recommendations for inventory and assessment techniques for cave entrances habitat in Indiana.

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 cave entrances habitats. There were no responses.

CAVES HABITAT NARRATIVE

Habitat description

Subterranean Systems Caves: Connected underground rooms and passages beyond natural light penetration.

Problems affecting species and habitats

Species threats

Respondents ranked the following threats to wildlife in caves habitat in Indiana:

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

Respondents offered additional threats to wildlife in caves habitat in Indiana (not ranked):

- Loss of forest habitat surrounding winter hibernacula/caves
- Need caves or mines for hibernation within 60 miles of summering ground
- Unregulated collection pressure/unregulated human activity

  - Disturbance related to research/monitoring
  - In hibernacula

Respondents listed top threats to wildlife in caves habitat in Indiana (not ranked):

- Human disturbance of hibernating bats
  - E.g., Ray's Cave in Greene County
  - Development/commercialization that allows for human visitation
  - Lack of education for cavers; education is critical to Indiana bat survival
  - Lack of cave gates: Gates are critical to Indiana bat survival

- Habitat loss, degradation
  - Some traditional hibernacula have been rendered unsuitable or degraded due to development/commercialization
  - Threats also occur within summer habitat (not addressed here because it is not captured within "cave habitat" category)
  - Modification of cave environment
  - Alteration of surface features
  - Alterations to microclimate within hibernacula
  - Loss of winter caves habitat
  - Loss of traditional roosting structures (large snags with sloughing bark)

- Pollution
  - Nonpoint sources: sediments and pesticides
  - Point sources: sewage and spills of chemicals transported by roads and rail

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the top threats to wildlife in cave habitat. There were no responses.

Habitat threats

Respondents ranked threats to caves habitat in Indiana:

Rank	Threats to caves habitat
1	Habitat degradation
2	Commercial or residential development (sprawl)
3	Climate change
4 (tie)	Habitat fragmentation
4 (tie)	Agricultural/forestry practices
5 (tie)	Residual contamination (persistent toxins)
5 (tie)	Point source pollution (continuing)
6	Nonpoint source pollution (sedimentation and nutrients)
7 (tie)	Stream channelization
7 (tie)	Impoundment of water/flow regulation
8	Mining/acidification
9	Drainage practices (stormwater runoff)

10 (tie) Successional change

10 (tie) Invasive/non-native species

11 Diseases (of plants that create habitat)

Respondents noted other threats to caves habitat in Indiana (not ranked):

- Dumping refuse in sinkholes; refuse often contains persistent toxins associated with transformers, tires, appliances, pesticide containers and electronic devices
- Loss of habitat (caves and mines)

Respondents listed top threats to caves habitat in Indiana (not ranked):

- Habitat loss, degradation, fragmentation
  - Of forested areas surrounding caves used by bats during the fall swarming period
  - Of breeding habitat (note that breeding habitat also occurs in areas not associated with caves)
  - Of roost trees and other habitat via man-related activities (commercial, agricultural, etc.)
  - Of caves and mines needed for hibernation
  - By potential migration of chemicals that alter cave ecosystems
    - Point and nonpoint pollution associated with increasing human population in Southern Indiana

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the top threats to caves habitat. There were no responses.

Additional research and survey efforts

Current body of research

Species research

Seventeen percent of respondents stated that the current body of science for wildlife in caves habitat in Indiana is adequate; fifty percent stated that it is inadequate. A respondent also noted, “There is lots of research but also great need due to endangered status.”

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

Title = Distribution and status of the northern cavefish;
Author = Pearson, W. D. and C. Boston;
Date = 1995;
Publisher = Final report to IN Department of Nat. Res.Div. of F&W

Title = Age, growth and fin erosion of the northern cavefish, Amblyopsis spelaea, in KY and IN;
Author = Louis, M.;
Date = 1999;
Publisher = Unpubl. M.S. Thesis, University of Louisville

Title = Wintering populations of bats in Indiana, with emphasis on the endangered Indiana Myotis, Myotis sodalis;
Author = Virgil Brack, Jr., Scott A. Johnson, and R. Keith Dunlap;
Date = 2003;
Publisher = Proceedings of the IN Academy of Science

Title = Management of hibernacula in the state of Indiana;
Author = Johnson, Brack, Dunlap;
Date = 2002;
Publisher = Bat Conservation International

Title = Biennial hibernacula survey reports;
Publisher = reports submitted to IDNR

Title = Home range near hibernacula in spring and autumn;
Author = Russell C. Romme, Amy B. Henry, R. Andrew King, T. Glueck, and K. Tyrell;
Date = 2002;
Publisher = The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International

Title = The nonhibernating ecology of bats in Indiana with emphasis on the endangered Indiana bat, Myotis sodalis;
Author = Virgil Brack, Jr.;
Date = 1983;
Publisher = Purdue University

Title = Brack, Johnson and Dunlap, 2003.;
Publisher = Proc. Ind. Acad, Sci. 112:-61-74.

Title = Mumford and Whitaker 1982

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 wildlife in cave habitat. There were no responses.

Habitat research

Seventeen percent of respondents stated that the current body of science for caves habitat in Indiana is adequate; sixty-seven percent stated that it is inadequate.

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

Title = Cave adaptation in Amblyopsid fishes;
Author = Poulson, T.;
Date = 1963;
Publisher = Amer. Midl. Nat. 70(2):257-290

Title = A faunal inventory of subterranean streams using a modified index of biotic integrity;
Author = Jones, T.G.;
Date = 1997;
Publisher = Unpubl. Ph.D. Disst. University of Louisville

Title = Hibernacula of the endangered Indiana bat in Indiana;
Author = Brack, Virgil Jr., A.M. Wilkenson, R.E. Mumford;
Date = 1984;
Publisher = Proceedings of the Indiana Academy of Science, vol. 93:463-468

Title = Distribution and ecology in Indiana. Pp 48-54 in Indiana Bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, Eds.); A
uthor = John Whitaker Jr. & Virgil Brack Jr.;
Date = 2002;
Publisher = Bat Conservation International

Title = Mumford and Whitaker 1982

Title = Veilleux et al. 2003.;
Publisher = J. Mamm, 841068-1075.

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 cave habitat. There were no responses.

Research needs

Species research

Respondents ranked research needs for wildlife in caves habitat in Indiana:

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

Respondents noted additional research needed for wildlife in caves habitat in Indiana (not ranked):

- Urgent need to determine effects of loss/fragmentation/timber management on summer habitats and forests regarding maternity colonies and reproductive success
- More information needed on autumn swarming and spring staging. Similarly, new hibernacula need to be recorded
- Metapopulation dynamics
- Extent of populations in subterranean systems which cannot be entered by humans
- Need to know more about rabies in bats

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for wildlife in cave habitat. There were no responses.

Habitat research

Respondents ranked research needs for caves habitat in Indiana:

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

Respondents noted additional research needs for caves habitat in Indiana (not ranked):

- How much forest habitat needs to remain around a hibernaculum to sustain a population of "size X" during the fall swarming period?
- Indiana bats:
  - How does cave environment, especially temperature and temperature stability, affect suitability and use of cave by Indiana bats
  - What components of habitat immediately surrounding caves are most important to Indiana bats during fall swarming and spring staging? How is this habitat used
- Recommend a detailed analysis of forest canopy to openness ratio and habitat intricacies that provide preferred home range requirements, e.g. primary roosts, secondary roosts, water, night roosts, food
- Cave fishes:
  - Physical dimensions of the phreatic environment available to cavefishes
  - Connections between known windows into the system
  - Toxin concentrations in cave sediments and their recruitment rates into underground waters
- Need to know more of the relationship between winter and summer habitat, and migration

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for cave habitat. There were no responses.

Conservation actions necessary

Species actions

Respondents ranked conservation efforts by how well they address threats to wildlife in caves habitat in Indiana:

Rank	Conservation efforts for wildlife in caves habitat
1 (tie)	Habitat protection
1 (tie)	Regulation of collecting
2	Threats reduction
3	Public education to reduce human disturbance
4	Limiting contact with pollutants/contaminants

Respondents noted additional conservation efforts for wildlife in caves habitat in Indiana (not ranked):

- To control human disturbance
  - Posting signs at caves
  - Install bat-friendly gates
  - Install fake video cameras to deter cave visits
  - Use light-sensitive “speloggers” to monitor human visitation
  - Manage research-related disturbance

- Habitat acquisition and protection
  - Protect caves and mines in which bats occurs
  - Land acquisition

Respondents recommended these practices for more effective conservation of wildlife in caves habitat in Indiana (not ranked):

- Reduce human disturbance
  - Negotiate with owner of Ray’s Cave and other hibernacula to allow them to be gated or employ one or more techniques to control human disturbance (see Q44 above)
  - Gating
  - Limit public access to population concentrations already under agency control at Harrison/Crawford State Forest and Spring Mill State Park
  - Indiana bat/other bats: Public education is needed on importance of caves, snags and importance of bats to man

- Habitat protection, acquisition
  - Secure conservation easements
  - Purchase unprotected hibernacula (prioritizing on current numbers or potential of hibernacula to harbor large numbers if disturbance is presently limiting numbers)
  - Protect surface features and forest cover surrounding hibernacula and manage for high quality swarming habitat
  - Purchase and protect recorded Indiana bat hibernacula and summer habitat
  - Protect caves and mines
  - Acquire and protect a reserve at Blue Springs Caverns

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the effective conservation of wildlife in cave habitat. Their responses included:

- Regarding the bulleted item, "Install fake video cameras to deter cave visits" under the "To control human disturbance" heading above...

  PLEASE remove the word "fake" from this item ASAP!!! Especially if this website is accessible to the general public. Let's not let the www in on an effective means of detering would-be cavers and/or vandals at sensitive sites. Thanks.

Habitat actions

Respondents ranked conservation efforts by how well they address threats to caves habitat in Indiana:

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

Respondents listed additional conversation efforts for caves habitat in Indiana (not ranked):

- Public education
  - On retaining old, dead or dying trees that provide habitat for wildlife, including Indiana bat
- Restrict human access
  - Closing access or year-round gating of caves with large populations of hibernating or reproducing bats will ensure normal trophic cascades for those systems
  - Restrict recreational caving in some caves might reduce periodic disturbances, increases in turbidity and remobilization of toxins in sediments

Respondents recommended the following practices for more effective conservation of caves habitat in Indiana (not ranked):

- Conservation easements
  - On private property containing important swarming habitat and connected karst features around key hibernacula
  - With selected cave owners in Orange, Washington, Lawrence and Harrison counties

- Restrict human access
  - Establish reserve at Blue Springs Cavern
  - Restrict entry to caves at Harrison/Crawford State Forest

Respondents instructed readers to see answers to question 47 as well.

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the practices for effective conservation of cave habitat. There were no responses.

Proposed plans for monitoring

Current monitoring

Species monitoring

Respondents were aware of the following monitoring efforts by state agencies for wildlife in caves habitat in Indiana (not ranked):

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

Respondents were aware of the following monitoring efforts by other organizations for wildlife in caves habitat in Indiana (not ranked):

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

Respondents ranked monitoring efforts by state agencies based on their importance for conservation of wildlife in caves habitat in Indiana:

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

6 Regional or local year-round monitoring

Respondents ranked monitoring efforts by other organizations based on their importance for conservation of wildlife in caves habitat in Indiana:

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

Respondents listed regional or local monitoring by state agencies for wildlife in caves habitat in Indiana (not ranked):

- I-bat hibernacula
- Indiana bat monitoring
  - IDNR: Conducts biennial hibernacula surveys in all known Indiana bat hibernacula in the state (except Batwing and Twin Domes caves, which are surveyed under a separate federal contract)
  - State agencies occasionally monitor/research cave habitats on a local basis for specific purposes (such as the swarming bat habitat study at Wyandotte Cave
  - Monitoring is also occasionally conducted in summer habitat (not included in this survey)
  - Caves in Southern Indiana are monitored. Currently there are 33 hibernacula reported for Indiana bat here

Respondents listed regional or local monitoring by other organizations for wildlife in caves habitat in Indiana (not ranked):

- Indiana bat:
  - Rick Clawson, Missouri DOC, conducts biennial winter surveys at Twin Domes and Batwing caves
  - Indiana Karst Conservancy (Keith Dunlap) also assists with monitoring efforts, especially at hibernacula that they own or oversee.
  - I have monitored the I-bat population in Reeves Cave in Monroe County
- There are surveys conducted throughout Indiana, primarily in summer habitat; cave habitat work addresses specific management or research needs. For example, surveys are conducted at all Department of Defense properties

- University of Louisville has been monitoring the Northern Cavefish at irregular intervals and locations in southern Indiana since 1994

- Biyearly monitoring for cave bats in about 18 caves in which Indiana myotis is known to hibernate

Respondents listed organizations that monitor wildlife in caves habitat in Indiana (not ranked):

- Indiana DNR (Dr. Virgil Brack/ESI, Keith Dunlap, Scott Johnson)
- Indiana Karst Conservancy
- Local NSS Grotto members
- U.S. Fish and Wildlife Service
- USDA Forest Service
- Department of Defense
- U.S. Army Corps of Engineers
- Educational institutions with federal permits
  - Purdue University
  - Indiana State University
  - University of Louisville, Biology Department
- Ecological consultants with federal permits
- Local/county agencies
- Indiana Cave Survey
- Private conservation organizations

Respondents considered monitoring techniques for wildlife in caves habitat in Indiana:

Monitoring techniques for wildlife in caves habitat	Used	Not used but possible with existing technology and data	Not economically feasible
Radio telemetry and tracking	X	--	--
Modeling	X	X	--
Spot mapping	--	X	--
Reporting from harvest, depredation, or unintentional take (road kill, by-catch)	X	--	--
Mark and recapture	X	X	--
Professional survey/census	X	--	--
Volunteer survey/census	X	--	--
Trapping (by any technique)	X	--	--
Representative sites	X	X	--

Probabilistic sites	X	--	--

Respondents noted other monitoring techniques for wildlife in caves habitat in Indiana (not ranked):

- AnaBat/acoustic and/or video monitoring of cave entrances to assess bat presence/use
- Stable isotope analysis, genetic genotyping of individuals (through guano analysis), thermal imagery surveys, contaminant analysis/monitoring through guano and/or whole body analysis
- Delury or survey/removal techniques have been used at Donaldson Cave in the 1990's
- Mist-netting stream
- Cave counts
- Rabies lab bats
- Trapping cave and mine entrances

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for wildlife in cave habitat. There were no responses.

Habitat inventory and assessment

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

- Statewide once-a-year inventory and assessment
- Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
- Occasional statewide (less than once a year and not regularly scheduled) 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 caves habitat in Indiana (not ranked):

- Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
- Occasional statewide (less than once a year and not regularly scheduled) 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 ranked inventory and assessment efforts by state agencies based on their importance for conservation of caves habitat in Indiana:

Rank	Inventory and assessment by state agencies for conservation of caves habitat

1	Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
2	Periodic regional or local (less than once a year but still regularly scheduled)
3	Occasional statewide (less than once a year and not regularly scheduled) inventory and assessment
4	Occasional regional or local (less than once a year and not regularly scheduled) inventory and assessment
5	Statewide once-a-year inventory and assessment
6 (tie)	Statewide annual inventory and assessment
6 (tie)	Regional or local year-round inventory and assessment
6 (tie)	Regional or local once a year inventory and assessment

Respondents ranked inventory and assessment efforts by other organizations based on their importance for conservation of caves habitat in Indiana:

Rank	Inventory and assessment by other organizations for conservation of caves habitat
1	Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
2 (tie)	Occasional regional or local (less than once a year and not regularly scheduled) inventory and assessment
2 (tie)	Occasional statewide (less than once a year and not regularly scheduled) inventory and assessment
3	Periodic regional or local (less than once a year but still regularly scheduled) inventory and assessment

Respondents listed regional or local inventory and assessment by state agencies for caves habitat in Indiana (not ranked):

- Cave habitat is assessed when winter surveys of hibernacula are conducted statewide
- State conducted annual monitoring of the cave environment in most major hibernacula
- Human disturbance in key hibernacula is also monitored
- The contractor who conducts the biennial hibernacula surveys also documents information on cave condition (e.g., breakdown) and makes management recommendations
- Karst regions and summer habitat in Indiana
- South-central Indiana

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

- Completed by Rick Clawson, Missouri DOC, for Twin Domes and Batwing caves
- Completed by USFWS for Reeves Cave and others
- Several organizations collect information on the location and condition of caves, as well as the presence of bats in caves, which provides useful information
- Karst regions and summer habitat in Indiana
- Hoosier National Forest
- Harrison/Crawford State Forest
- Spring Mill State Park
- Caves of south-central Indiana

Respondents listed organizations that monitor caves habitat in Indiana (not ranked):

- Indiana Karst Conservancy
- NSS Grottos
- U.S. Fish and Wildlife Service
- I-69 bat consultants
- The Nature Conversancy
- U.S. Geological Survey
- Indiana Cave Survey
- USDA Forest Service
- Indiana Department of Natural Resources
- Indiana Cave Survey
- Ecological consultants (federal permit holders)
- Universities (federal permit holders)
  - Purdue University
  - Indiana State University
  - University of Louisville
- Virgil Brack and his company

Respondents considered inventory and assessment techniques for caves habitat in Indiana:

Inventory and assessment techniques for caves habitat	Used	Not used but possible with existing technology and data	Not economically feasible
GIS mapping	X	--	--
Aerial photography and analysis	X	--	--
Systematic sampling	X	X	--
Regulatory information	X	--	--
Participation in land use programs	--	X	--
Modeling	X	X	--
Voluntary landowner	X	--	--

reporting

Respondents listed additional inventory and assessment techniques for caves habitat in Indiana (not ranked):

- Temperature and relative humidity monitoring with remote dataloggers
- Cave survey

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 cave habitat. There were no responses.

Recommended monitoring

Species monitoring

Respondents recommended the following monitoring techniques for effective conservation of wildlife in caves habitat in Indiana (not ranked):

- Continue ongoing biennial winter surveys at all known hibernacula
- Indiana bats
  - Biennial hibernacula surveys (which I would classify as "professional survey/census") are the only means currently available to track Indiana bat population trends on a statewide or range-wide basis.
  - Survey and monitoring activities conducted in summer habitat to: 1) evaluate summer distribution in the state, and 2) evaluate roosting and foraging habitat use/needs. These surveys are conducted in Indiana as well as other states
  - Trapping for Indiana bat includes mist netting and harp trapping
- Hibernacula counts to track population levels (already being done)
- Intensive radio telemetry that tracks roost and foraging movements of specific colonies in representative areas across the state
- Internal cave surveys are important and more emphasis should be placed on the use of AnaBat
- Development of an index of biotic integrity (IBI) for vertebrate cave communities in southern Indiana
- Select 5 to 10 locations for survey/counts every two to five years. A similar survey schedule has been established for cavefish populations in Mammoth Cave National Park and could be used as a model (both IBI and survey)

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for effective conservation for wildlife in cave habitat. There were no responses.

Habitat inventory and assessment

Respondents recommended the following inventory and assessment techniques for effective conservation of caves habitat in Indiana (not ranked):

- Cave microclimate monitoring with dataloggers should continue. A range-wide protocol for monitoring cave temperature and humidity has been developed by Bat Conservation International and is being widely used (contact Jim Kennedy or Merlin Tuttle at BCI). I believe Scott Johnson has been following this protocol in Indiana
- Cave microclimate data used in conjunction with results of hibernacula surveys

    - Techniques to link summer/winter populations (new genetic techniques such as stable isotope analysis; pit tagging)
    - Information on habitat use/needs in the vicinity of caves during swarming is a critical need. At present, radio telemetry represents the best potential to collect this information
- Population surveys every five years and development of an IBI to be applied at five to 10 critical locations. These to include Blue Spring Caverns, Spring Mill State Park, and Harrison/Crawford State Forest
- Cave survey in winter, and net survey in summer

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 effective conservation of cave habitat. There were no responses.

ALL WETLANDS HABITAT NARRATIVE

The results below are the aggregated data from all wetland sub-habitat responses.

Habitat description

Wetlands include: Areas shallowly flooded temporarily or permanently to cover the base of plants but not prolonged inundation of the entire plant; Areas temporarily flooded often supporting aquatic plants and animals; Areas temporarily or permanently flooded with woody vegetation taller than 6 meters; Areas of usually shallow wetlands dominated by non-woody plants such as cattail, reeds or rushes; Areas with moist non-vegetated soil, often produced in shallow wetlands by advance and retreat of water levels; Areas permanently flooded and often supporting aquatic plants and animals; and Areas flooded temporarily or permanently with woody vegetation shorter than 6 meters.

Problems affecting species and habitats

Species threats

Respondents ranked the following threats to wildlife in all wetland habitats in Indiana:

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

17 Species overpopulation

18 Unregulated collection pressure

19 Dependence on other species (mutualism, pollinators)

20 Regulated hunting/fishing pressure (too much)

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

- Habitat loss, degradation, fragmentation
  - Continued loss and degradation of emergent wetland habitat in portions of the state due to development and poor agricultural practices
- Human interaction
  - With wildlife species trapping, relocation, scaring
  - Reproductive intervention by humans
- Devaluing of wildlife species due to overpopulation
- Restricted management options
  - Although not habitat specific, the inability to responsibly and proactively manage muskrats according to the wildlife conservation model, as opposed to reactive measures through nuisance practices, is a concern regarding conservation of muskrats. This concern applies across the landscape, not just in urban and suburban environments
- Artificial manipulation of water levels
  - In wetlands seems, this will likely increase mortality of over wintering 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 over wintering snakes

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

- Habitat loss, degradation, fragmentation
  - Loss of early successional habitat
  - Loss of shallow marshes due to drainage for development and poor agricultural practices
  - Habitat loss through annual cycle
  - Water quality
  - Loss due to urbanization
  - Continuing loss and/or degradation of emergent wetlands
  - Increase in migration distance to breeding sites as a result of habitat loss
  - Loss of ephemeral wetlands is the top threat; unfortunately, most existing ephemeral wetlands have been destroyed in Indiana. Even more unfortunately, many of them were destroyed with the misguided notion that deep water was better for wildlife; landowners were advised to dredge out the ephemeral wetlands to provide duck habitat. These fish-infested deep waters have no habitat for plains leopard frog
  - Loss and degradation of upland forested habitat
  - Loss of winter feed due to fall tillage
  - Loss of permanent wetland areas that include huge open/prairie buffer zones for nesting
  - Fragmentation of populations due to habitat loss. Wetlands are managed as landscape scale systems relative to Blanding's turtle, resulting in metapopulation

disruption and potential metapopulation decline. Because of low densities and small population sizes, populations that have become isolated are likely not viable

- Degradation of habitat by invasive plant species
  - Invasive species like reed canary grass are proliferating in the habitats that remain, decreasing plant diversity, cover, and the overall health of the wetland

- Increased migration distance; loss of connectivity
  - Increase in migration distance to breeding sites as a result of habitat loss are the biggest threats to birds
  - Overland movement for nesting invites road kill of otherwise long-lived adults

- Specialized habitat
  - Only a few locations are known to have green salamanders in Indiana and this is a habitat specialist needing rocky outcrops in forested areas

- Genetic pollution
  - Hybridization with blue-winged warbler

- Overpopulation
  - Possible disease outbreaks due to large concentrations of birds often in small areas

- Human intervention during nesting process

- Predation
  - Suboptimal size nesting areas focuses nest depredation

- Artificial manipulation of habitat/improper management
  - 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
  - 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 disced on DNR lands

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

- Yes.

Habitat threats

Respondents ranked threats to all wetland habitats in Indiana:

Rank	Threats to all wetland habitats in Indiana
1	Habitat degradation
2	Habitat fragmentation
3	Agricultural/forestry practices

4	Commercial or residential development (sprawl)
5	Nonpoint source pollution (sedimentation and nutrients)
6 (tie)	Point source pollution (continuing)
6 (tie)	Successional change
6 (tie)	Counterproductive financial incentives or regulations
7	Drainage practices (stormwater runoff)
8	Invasive/non-native species
9	Impoundment of water/flow regulation
10	Stream channelization
11	Mining/acidification
12	Residual contamination (persistent toxins)
13	Climate change
14	Diseases (of plants that create habitat)

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

- Drainage of wetland areas
- Legal jurisprudence issues unclear; draft of state isolated wetland law out for comment

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

- Habitat loss degradation, fragmentation
  - Loss of early successional woody habitat
  - Loss by filling or draining wetlands
  - Stream and lake "renovation" have degraded habitat back to where it was when the original habitat destruction occurred
  - Due to development
    - Agricultural practices
    - Drainage practices
    - Road construction
    - Urban sprawl
    - Coal mining
  - Loss due to deforestation
  - Development encroachment on some colonies
  - Destruction of nesting trees
  - Little or no protection of isolated wetlands
  - Loss through drainage/tiny stream ditching
  - Conversion of sand prairie nesting habitat to cropland or something else (e.g., forestation via fire prevention)
  - Pollution/increased sediment and nutrient loads
  - Blanding's turtles: 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 (ether due to tradition conversion to agriculture or to conversion of inappropriate conservation cover types) is negatively impacting reproductive success in this species

    - Loss that leads to loss of connectivity
        - Affects Blanding's turtles and other species

- Invasive species
    - Degradation of plant community by exotic plants invading wetland habitats
    - Loss of ephemeral wetland habitat, invasion of wetlands by species like reed canary grass, cattails, purple loosestrife or other invasives that create monocultures, agricultural practices that destroy ephemeral wetlands

- Overpopulation
    - Canada Geese are their own worst enemy. Their concentrations by large numbers of geese on small wetlands have the capacity to pollute the water and cause increased erosion due to their feeding habits

- Improper management practices
    - 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
    - Artificial manipulation of water levels in wetlands seems likely to increase mortality of over wintering 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 over wintering snakes. In addition, herbaceous wetlands are lost under this management regime, replaced by open water wetlands
    - 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

A respondent noted, "The participant has to speculate about the meaning of successional change. Is a 'change' an increase or decrease in early successional habitats? Climate change also is speculative. Agriculture/forestry practices have different effects. Grouping these practices into a single category does not appropriately represent each individual practice. Point and nonpoint pollution may have a positive or negative effect."

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

- I would emphasize that wetland conservation must not be limited to the wetland as a single entity. Wetlands must be managed in the context of the surrounding uplands. Wetlands should be managed as complexes rather than singly, strivng for numerous and hydrologically diverse wetlands in an area.

Additional research and survey efforts

Current body of research

<u>Species research</u>

Twenty-three percent respondents stated that the current body of science is complete, up-to-date and extensive or adequate for wildlife in all wetland habitats in Indiana; seventy-two percent stated that it is inadequate or nonexistent.

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

Title = Spring Breeding Duck Survey;
Author = Kristen Chodacheck;
Date = 2003;
Publisher = IDNR

Title = Waterfowl Ecology & Management;
Author = Compiled by: Ratti, Flake, Wentz;
Date = 1982;
Publisher = The Wildlife Society

Title = The Birds of Indiana;
Author = Russel E. Mumford, Charles E. Keller;
Date = 1984;
Publisher = Indiana University Press

Title = Atlas of Breeding Birds of Indiana;
Author = John S. Castrale, Edward M. Hopkins, Charles E. Keller;
Date = 1998;
Publisher = Indiana Department of Natural Resources

Title = Canada Goose Management;
Author = Clarence Schoenfield/Ruth L. Hine;
Date = 1977;
Publisher = University of Wisconsin, Stevens Point

Title = Managing Canada Geese in Urban Environments;
Author = Smith/Craven/Curtis;
Date = 1999;
Publisher = Jack Berryman Institute Publication #16/ Cornell University Cooperative Extension, Ithaca, NY

Title = Atlas of Breeding Bird of Indiana;
Author = Castrale, Hopkins & Keller;
Date = 1998;
Publisher = Indiana Dept. of Natural Resources

Title = Birds of Indiana;
Author = Mumford;
Date = ?;
Publisher = Indiana University Press?

Title = Amphibians and reptiles from 23 counties of Indiana.;
Author = Robert Brodman;
Date = 2003;
Publisher = Proceedings of the Indiana Academy of Science, 112: 43-54.

Title = various theses;
Author = Bruce Kingsbury et al

Author = Mumford and Whitaker 1982

Title = Fur animals of Indiana;
Author = David Brooks;
Date = 1959;
Publisher = IDF&W

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

Title = ongoing background work in NE & MN
Title = BNA Account - Golden-winged Warbler;
Author = JL Confer;
Date = 1992;
Publisher = American Ornithologists' Union

Title = Birds of Indiana;
Author = R Mumford and C. Keller;
Date = 1984;
Publisher = Indiana Univerisity Press

Title = Canada Goose Management;
Author = uk;
Date = uk;
Publisher = uk

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

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

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 wildlife for all wetland habitats. There were no responses.

Habitat research

Twenty-eight percent respondents stated that the current body of science is adequate for all wetland habitats in Indiana; sixty-seven percent stated that it is inadequate or nonexistent.

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

Title = Waterfowl & Wetlands- Integrated Review;
Author = Edited : Bookhout;
Date = 1979;
Publisher = The Wildlife Society

Title = Creating Freshwater Wetlands;
Author = Hammer;
Date = 1997;

Publisher = CRC Press

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 wetland habitats. Their responses included:

- Understanding the influences of management practices is still limited. Great emphasis must be placed on monitoring the effects of management to improve approach.

Research needs

Species research

Respondents ranked research needs for wildlife in all wetland habitats in Indiana:

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

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

- Research is needed to justify extending or modifying hunting seasons to eliminate the problem of the so-called nuisance goose in urban areas, around lakes and golf courses
- Food availability throughout annual cycle
- Ways to deter use
- Impact of high snow goose populations on Canada geese nesting sites
- Develop more effective dispersal, relocation or removal techniques for maxima geese
- Information on metapopulation dynamics and migration distances to and from ephemeral wetlands are needed. Information on how many ephemeral wetland habitats within the landscape are needed to maintain healthy populations of the Spotted salamander is also needed. Information on buffer size and vegetation composition around ephemeral wetlands is needed
- Quite little is known about much of the basic natural history or this species
- Research needs related to muskrats are not habitat specific
- Long-term fidelity to specific sites
- Limits to sand prairie needs for nesting.
- Limits to recruitment when forced to nest in row crop areas

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

- No. The rankings are fine, but the written responses are presented focusing on migratory waterfowl. Much emphasis should be given to nongame.

Habitat research

Respondents ranked research needs for all wetland habitats in Indiana:

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

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

- Habitat needs should be researched in an attempt to find and propagate habitats that are esthetically pleasing to humans for urban settings yet displeasing to geese
- Availability throughout annual cycle
- Information on metapopulation dynamics and migration distances to and from ephemeral wetlands are needed. Information on how many ephemeral wetland habitats within the landscape are needed to maintain healthy populations of the species is also needed. Information on buffer size and vegetation composition around ephemeral wetlands is needed
- Spatial relationships between occupied wetlands relative to population dynamics
- Physical characteristics of overwintering sites

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for all wetland habitats. There were no responses.

Conservation actions necessary

Species actions

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

Rank	Conservation efforts for wildlife in wetland habitats
1 (tie)	Reintroduction (restoration)
1 (tie)	Stocking
2 (tie)	Population management (hunting, trapping)
2 (tie)	Food plots

3 Protection of migration routes
4 Disease/parasite management
5 Habitat protection
6 Regulation of collecting
7 Exotic/invasive species control
8 Threats reduction
9 (tie) Native predator control
9 (tie) Translocation to new geographic range
9 (tie) Limiting contact with pollutants/contaminants
9 (tie) Public education to reduce human disturbance
9 (tie) Culling/selective removal

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

- Wetland restoration
- Invasive species control (buckthorn, autumn olive, phragmites) to keep open herbaceous habitat suitable for massasauga
- Preserve wetlands

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

- Habitat protection, manipulation, restoration
  - Provide quality upland nesting cover adjoining these wetlands.
  - Reduce fall tillage near wetlands
  - Habitat protection throughout annual cycle
  - Enhance migratory/staging habitat
  - Enhance breeding habitat where populations do not conflict with land use
  - Ephemeral wetland and forested upland habitat protection
  - 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 (water level manipulations, late spring prescribed fire), these management decisions seem likely to result in direct mortality of adults
  - Restoration in new, very large natural areas in northwest Indiana
  - Restore connectivity

- Surveys
  - Continue five-year surveys

- Hunting seasons
  - Modify hunting seasons and open urban areas to hunting to reduce numbers of so-called nuisance geese populations in lieu of nest destruction and egg shaking
  - Develop practices and procedures to increase harvest of local birds

- Public outreach

  - Outreach programs are needed to effectively and accurately educate citizens about wildlife (game and non-game), the wildlife conservation model (for game and non-game), and the need for effective muskrat management programs

- Predator management
  - Raccoon reduction near constrained (small) areas of occupied habitat in northeast Indiana

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the conservation needs for all wildlife in all wetland habitats. There were no responses.

Habitat actions

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

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

Respondents listed other current conservation practices for all wetland habitats in Indiana (not ranked):

- Many current conservation practices and incentives programs promoted by biologists seem to be aimed at ducks and actually manage against this species

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

- Retard succession to desired habitat stage; incentives to conserve shrubby habitats
- Regulations are needed to protect small wetlands and other habitat
- Habitat protection and restoration incentives for private landowners and for conservation easements
- Continue efforts to protect and enhance wetland and riparian habitats
- Control plant species that spread by vegetative means that from thick colonies such as cattail
- Food plots

- Refuge areas
- Protect forested ephemeral wetlands and forests

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the conservation of all wetland habitats. There were no responses.

Partner agencies/organizations

The following organizations indicated that they work in Wetland habitats.

Organization	Percent of time spent in Wetland habitats
Little River Wetlands Project, Inc.	90
Ducks Unlimited	85
Indiana Grand Kankakee Marsh Restoration Project	70
Wawasee Area Conservancy Foundation, Inc.	70
Ducks Unlimited, Inc.	65
U.S. Fish and Wildlife Service - Indiana Private Lands Office	60
Dunes-Calumet Audubon Chapter	50
Earth Source, Inc.	50
Valparasio Chain of Lakes Watershed Group, Inc.	50
Blue Heron Ministries, Inc.	40
Muscatatuck National Wildlife Refuge US FWS	40
Patoka River National Wildlife Refuge & Management Area	40
American Consulting, Inc.	35
Indiana state trappers assoc	35
Red-tail Conservancy, Inc.	33
ACRES, Inc.	30
Indiana Division of the Izaak Walton League of America	30
Indiana Dunes National Lakeshore	30
Indiana Native Plant and Wildflower Society	30
JFNew and Associates	30
Merry Lea Environmental Learning Center of Goshen College	30
Division of Fish and Wildlife	28
Robert Cooper Audubon Society	25
Sassafras Audubon Society	25
Save the Dunes Conservation Fund	25
The Nature Conservancy	25
Trillium Land Conservancy, Inc.	25
US Fish and Wildlife Service Ecological Services (does not include national wildlife refuges)	25
Big Oaks National Wildlife Refuge, USFWS	20

Appendix F-64: Aggregated Wetlands

EnviroScience Incorporated	20
Indiana Bass Chapter Federation	20
Lake Maxinkuckee Environmental Council (LMEC)	20
Lost River Conservation Association	20
MWH Americas, Inc.	20
NICHES Land Trust	20
Pheasants Forever Inc.	20
Sierra Club Hoosier Chapter	20
Wabash River Heritage Corridor Commission	20
Cinergy Corp.	15
IDNR- Division of Forestry- Cooperative Forest Management Section (Private Lands)	15
Arrow Head Country Resource Conservation & Development Area, Inc.	10
South Bend-Elkhart Audubon Society	10-20?
Clark's Valley Land Trust	10
Hoosier Environmental Council	10
Imdian Deer Hunters Association	10
Indiana Association of Soil and Water Conservation Districts	10
Indiana Chamber of Commerce	10
Indiana Environmental Institute	10
Lake Bruce Conservancy district	10
Lincoln Hills RC&D	10
Northern Indiana Public Service Company (NIPSCO) a Subsidiary of NiSource	10
Northwestern Indiana Regional Planning Commission (NIRPC)	10
Steelheaders of Northwest Indiana (Northwest Indiana Steelheaders)	10
Sycamore Land Trust	10
Whitewater Valley Land Trust, Inc.	10
St. Joseph River Watershed Initiative	7
Central Indiana Land Trust	5
fish lake conservancy district	5
Four Rivers Resource Conservation & Development Area	5
Indiana Association of Cities and Towns	5
Indiana Quail Unlimited	5
Indiana Smallmouth Club (ISC)	5
Mason & Hanger Corp. Newport Chemical Depot	5
Naval Support Activity Crane	5
St. Joseph County Soil & Water Conservation District (SWCD)	5
U.S. Department of Agriculture, Forest Service Hoosier National Forest	5
Valparaiso Lakes Area Conservancy District	5
Veolia Water Indianapolis, LLC	5
Bartholomew County Conservation Council, Inc.	2
Indiana Department of Natural Resources	1

Division of Forestry, Properties Section (State Forests)	
American Society of Landscape Architects, Indiana Chapter	
Amos W Butler Audubon Society	
Central Hardwoods Joint Venture/American Bird Conservancy	
DNR Division of Nature Preserves	
Fur Takers of America	
IN DNR, Division of State Parks & Reservoirs, Interpretive Services	
Indianapolis Flycasters	
Kankakee River Basin Commission	
Law Enforcement Division, Indiana Department of Natural Resources	
National Audubon Society - Indiana Important Bird Areas Program (IBA)	
U.S. Army Corps of Engineers Regulatory Branch, Louisville District (Please note this is only a part of the larger organization and while the greater organization may be involved in areas not noted below, our answers are specific to the Regulatory program.)	
USDA Natural Resources Conservation Service	
Great Lakes Commission	
Federal Highway Administration (FHWA)	
fur takers of america chapter 7-E north west in.	

Proposed plans for monitoring

Current monitoring

Species monitoring

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

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

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

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

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

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

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

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

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

- At present only when a permit for work in a wetland is applied for
- Smaller more numerous wetlands have little oversight
- Selected state fish and wildlife areas and reservoir properties operated by the Indiana Department of Natural Resources conduct counts during the fall migration period; same properties as part of the weekly Waterfowl survey from August to January

- Statewide for existing and new colonies every five years
- Waterfowl neck collar observations statewide as encountered
- IDNR nongame herpetologist incorporates this as part of the annual field season
- INDR runs NAAMP frog monitoring program
- IDNR - Division of Nature Preserves
- Agencies that issue drainage permits
- Fish Creek, Patoka River, Pigeon Creek

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

- Federal Breeding Bird Survey statewide; May Day Bird Count, Summer Bird Count
- Species is not monitored. Habitat changes requiring permits are checked by, IDNR, IDEM, USACOE (in some cases)
- Lake associations, businesses and anyone living around a emergent wetland with a yard with Canada goose complaints will monitor populations in order to prove they have a problem so they can destroy nests or eggs
- Christmas bird count
- Spencer Cortwright, IUN
- Robert Brodman, Saint Joseph's College
- University professors and members of the Herpetology Technical Advisory Committee for Indiana as part of their annual field seasons
- Northwest Indiana (Newton, Jasper, Pulaski, Lake, Porter counties)
- "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

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

- U.S. Geological Survey
- Birding groups
- Waterfowl USA
- Ducks Unlimited
- The Nature Conservancy
  - Funded research at Cline Lake Fen to better understand population dynamics, habitat use, etc.
- The Audubon Society
- Indiana Department of Natural Resources - Divisions of Fish and Wildlife
  - Population monitoring efforts at state, regional and local scales are to monitor annual trends. Monitoring programs used by IDFW are not habitat specific for muskrat
- IDNR – Division of Reservoirs
- U.S. Fish and Wildlife Service
- Spencer Cortwright, IUN
- Robert Brodman, Saint Joseph's College
- Ball State University; Tom Morrell.
- Bruce Kingsbury, IUPU Fort Wayne

Respondents considered monitoring techniques for wildlife in all wetland habitats in Indiana:

Monitoring techniques for wildlife in all	Used	Not used but	Not economically

wetland habitats		possible with existing technology and data	feasible
Radio telemetry and tracking	X	X	--
Modeling	X	X	--
Coverboard routes	X	X	--
Spot mapping	X	X	--
Driving a survey route	X	X	--
Reporting from harvest, depredation, or unintentional take (road kill, by-catch)	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	X	--

Respondents noted other monitoring techniques for wildlife in all wetland habitats in Indiana (not ranked):

- Aerial surveys
- Look for burrows in muck

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

- Monitoring yearly in most cases is unnecessary. However, routine monitoring would be very valuable. A more reasonable regime for many needs is every 5-10 years or after a major distrubance, but then for 2-3 consecutive seasons.

Habitat inventory and assessment

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

- Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment

- Occasional statewide (less than once a year and not 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 wetland habitats in Indiana (not ranked):

- Periodic statewide (less than once a year but still regularly scheduled) 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 ranked inventory and assessment efforts by state agencies based on their importance for conservation of all wetland habitats in Indiana:

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

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

Rank	Inventory and assessment by other

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

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

- On state land
- Isolated wetlands law
- Northeast Indiana

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

- Statewide aerial imagery
- Indiana wetland inventory maps
- County aerial photos for NRCS
- Soils mapping county maps
- Cortright monitors populations in Brown and Porter counties; Brodman monitors populations in Owens County
- Kankakee Sands and other TNC preserves: Staff evaluates restored/created habitat to judge its ability to support plains leopard frog and other species of concern
- Robert Brodman, Saint Joseph's College in Northwest Indiana
- Northwest Indiana (Newton, Jasper, Pulaski, Lake and Porter counties)
- IUPU-FW faculty and students work in wetlands with this species in NE Indiana

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

- USDA
- U.S. Fish Wildlife Service
- Natural Resource Conservation Service
- Indiana Department of Environmental Management

- IDNR, nongame herpetologist, university professors, members of the Herpetology TAC Committee for Indiana
- The Nature Conservancy
- Robert Brodman, Saint Joseph's College
- Ball State University, Northeast Indiana
- Indiana State University, Northwest Indiana

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

Inventory and assessment techniques for all wetland habitats	Used	Not used but possible with existing technology and data	Not economically feasible
GIS mapping	X	X	--
Aerial photography and analysis	X	X	--
Systematic sampling	X	X	--
Regulatory information	X	--	--
Participation in land use programs	X	X	--
Modeling	X	X	--
Voluntary landowner reporting	X	X	--

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

- Pit-fall trapping and cover board objects adjacent to ephemeral wetlands; mark and recapture
- Visual estimate of amount of appropriate habitat being provided in restored areas
- Look for runways in muck and trap for them

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 wetland habitats. There were no responses.

Recommended monitoring

Species monitoring

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

- Spot-mapping in appropriate habitats
- Nesting and brood counts statewide
- Aerial survey
- Banding and neck collaring

- Continue current state surveys every five years
- Mark and recapture: Means to track species movement and association with non-target species and times of interaction with non-target species
- Mark and harvest: Means to track species movement and association with non-target species and times of interaction with non-target species. Also eliminates and reduces concentrations in undesirable areas.
- Weekly waterfowl counts at selected sites. Samples most of the major concentration areas. Very good historical data for trend analysis
- Professional survey and either mark recapture or telemetry
- Pit-fall traps and coverboard objects near ephemeral wetland breeding sites
- Fall surveys at breeding sites
- Call surveys and systematic sampling
- Minnow trapping and possible either mark recapture or telemetry
- Look for burrows in muck connected with trapping
- IDNR – Division of Fish and Wildlife uses harvest reports and professional surveys. The assumption is that aquatic systems include all habitat types occupied by muskrats
- Radio track females to nesting sites and monitor nests for depredation (Both are somewhat labor-intensive for at least one person.)

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for effective conservation for wildlife in all wetland habitats. There were no responses.

Habitat inventory and assessment

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

- A variety of method centering on aerial surveys
  - Aerial/satellite imagery coupled with modeling
  - Wetlands should be monitored by overhead photo methods with ground truth checks. This should occur on a regular basis with aggressive enforcement against illegal wetlands destruction
  - Spring aerial surveys
  - Analysis of county aerial photos
  - Systematic surveys and GIS
  - High-resolution aerial photography at normal marsh water levels; digitize for GIS

- Canada geese
  - GIS mapping would be the most cost affective means for creating an inventory of emergent plant species that would support Canada geese in emergent wetlands
  - Systematic water sampling of high use areas would determine nutrient loading and water quality. (US Fish and Wildlife Service Draft Environmental Impact Statement, Resident Canada Goose Management, Feb.2002)

- Reports from state fish and wildlife areas

- Updating and ground truthing Wetland Inventory maps

- Pit-fall traps and cover boards can be used to assess population size and use of ephemeral wetlands for breeding; mark and recapture can be used to determine migration patterns and use of specific ephemeral wetlands for breeding

- Blanding's turtles: Monitor wetland vegetation; Blanding's prefer floating emergents (e.g., duckweed) and get crowded out by cattail expansion

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 effective conservation for all wetland habitats. Their responses included:

- Some components of habitat monitoring should be specifically designed to monitor the effects/utility of management efforts. This remains a very under represented area.

Appendix F-65: Wetlands

Technical experts did not provide input on a representative species for this habitat.

There are no species of greatest conservation need in this guild.

EMERGENT WETLAND HABITATS NARRATIVE

Habitat description

Wetlands are areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al.

Emergent herbaceous wetlands are areas where perennial herbaceous vegetation accounts for 75 to 100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

Problems affecting species and habitats

Species threats

Respondents ranked the following threats to wildlife in emergent wetland habitats in Indiana:

Rank	Threats to wildlife in emergent wetland habitats
1	Habitat loss (breeding range)
2	Habitat loss (feeding/foraging areas)
3	Bioaccumulation of contaminants
4	Dependence on irregular resources (cyclical annual variations) (e.g., food, water, habitat limited due to annual variations in availability)
5	Predators (native or domesticated)
6 (tie)	Invasive/non-native species
6 (tie)	High sensitivity to pollution
7	Diseases/parasites (of the species itself)
8	Species overpopulation
9	Genetic pollution (hybridization)
10	Unintentional take/ direct mortality (e.g., vehicle collisions, power line collisions, by-catch, harvesting equipment, land preparation machinery)
11	Regulated hunting/fishing pressure (too much)

Respondents offered additional threats to wildlife in emergent wetland habitats in Indiana (not ranked):

- Continued loss and degradation of emergent wetland habitat in portions of state due to development and poor agricultural practices
- Human interaction with some wildlife species: trapping, relocation, scaring
- Reproductive intervention by humans
- Devaluing of some wildlife species due to overpopulation
- Restricted management options

Respondents listed top threats to wildlife in emergent wetland habitats in Indiana (not ranked):

- Agricultural practices/development/urbanization:
  - Loss of shallow marshes due to drainage
  - Loss of winter feed due to fall tillage
- Habitat loss through annual cycle
- Predators
- Degradation of habitat by invasive plant species
- Water Quality
- Human intervention during nesting process
- Overpopulation/disease
  - Possible disease outbreaks due to large concentrations of birds often in small areas
- Continuing loss and/or degradation of emergent wetlands

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the threats to wildlife in emergent wetland habitats. There were no responses.

Habitat threats

Respondents ranked threats to emergent wetland habitats in Indiana:

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

Respondents noted other threats to emergent wetland habitats in Indiana (not ranked):

- Drainage of wetlands
- Legal jurisdiction issues currently unclear; draft of state isolated wetland law out for comment

Respondents listed top threats to emergent wetland habitats in Indiana (not ranked):

- Commercial and residential development; road construction
- Stream and lake renovation have degraded habitat back to where it was when the original habitat destruction occurred
- Agricultural practices
- Drainage practices
- Degradation of plant community by exotic plants invading wetland habitats.
- Destruction of nesting trees
- Canada Geese are their own worst enemy. Concentrations of large numbers on small wetlands can pollute the water and cause increased erosion due to their feeding habits

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

- Invasive species threats are more important than they are ranked.

Additional research and survey efforts

Current body of research

Species research

Half of respondents stated that the current body of science is adequate or complete, up to date and extensive for wildlife in emergent wetland habitats in Indiana. Half of respondents stated that the current body of science is inadequate or nonexistent.

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

Title = Spring Breeding Duck Survey;
Author = Kristen Chodacheck;
Date = 2003;
Publisher = IDNR

Title = Waterfowl Ecology & Management;
Author = Compiled by: Ratti, Flake, Wentz;
Date = 1982;
Publisher = The Wildlife Society

Title = The Birds of Indiana;
Author = Russel E. Mumford, Charles E. Keller;
Date = 1984;
Publisher = Indiana University Press

Title = Atlas of Breeding Birds of Indiana;
Author = John S. Castrale, Edward M. Hopkins, Charles E. Keller;
Date = 1998;
Publisher = Indiana Department of Natural Resources

Title = Managing Canada Geese in Urban Environments;
Author = Arthur E. Smith, Scott R. Craven and Paul D. Curtis;
Date = 1199;
Publisher = Cornell Cooperative Extension

Title = Prevention and Control of Wildlife Damage;
Date = 1994;
Publisher = University of Nebraska

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 wildlife in emergent wetland habitats. Their responses included:

- Canada Goose Environmental Impact Statement

  Ducks, Geese, and Swans of North America
  Frank C. Bellrose
  1976

Habitat research

Three quarters of respondents stated that the current body of science is adequate for emergent wetland habitats in Indiana. One quarter said that it is nonexistent.

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

Title = Waterfowl & Wetlands- Integrated Review;
Author = Edited : Bookhout;
Date = 1979;
Publisher = The Wildlife Society

Title = Creating Freshwater Wetlands;
Author = Hammer;
Date = 1997;
Publisher = CRC Press

Title = Managing Canada Geese in Urban Environments;
Author = Arthur E. Smith, Scott R. Craven and Paul D. Curtis;
Date = 1999;
Publisher = Cornel Cooperative Extension

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 emergent wetland habitats. Their responses included:

- Wetlands 2nd ed. 1993
  Mitch and Gosselink
  Van Nostrand Reinhold

Research needs

Species research

Respondents ranked research needs for wildlife in emergent wetland habitats in Indiana:

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

Respondents noted additional research needs for wildlife in emergent wetland habitats in Indiana (not ranked):

- To justify extending or modifying hunting seasons to eliminate the problem of the so-called nuisance goose in urban areas, around lakes and golf courses
- Food availability throughout annual cycle
- Ways to deter use
- Impact of high snow goose populations on Canada geese nesting sites
- Develop more effective dispersal, relocation or removal techniques for maxima geese

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

- Need to determine movement patterns of nuisance geese. If they never leave the urban areas hunting will not be a viable management option to control populations. Allowing hunting on golf courses might be an option but you have to convince the golf course manager to allow it. In Michigan there are very few golf courses that allow people to hunt on them.

  Snow goose populations are not high enough in Indiana to affect Canada geese nesting sites. Snow geese do not even nest in Indiana.

Habitat research

Respondents ranked research needs for emergent wetland habitats in Indiana:

Rank	Research needs for emergent wetland habitats
1 (tie)	Distribution and abundance (fragmentation)
1 (tie)	Threats (land use change/competition, contamination/global warming)
2	Growth and development of individual components of the habitat

3	Successional changes
4	Relationship/dependence on specific site conditions

Respondents noted additional research needs for emergent wetland habitats in Indiana (not ranked):

- Habitat needs should be researched in an attempt to find and propagate habitats that are aesthetically pleasing to humans for urban settings yet displeasing for geese
- Availability throughout annual cycle

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

- Invasive species research.
  - how wide spread
  - control methods

Conservation actions necessary

Species actions

Respondents ranked conservation efforts by how well they address threats to wildlife in emergent wetland habitats in Indiana:

Rank	Conservation efforts for wildlife in emergent wetland habitats
1 (tie)	Reintroduction (restoration)
1 (tie)	Stocking
2	Regulation of collecting
3 (tie)	Habitat protection
3 (tie)	Food plots
3 (tie)	Protection of migration routes
4	Disease/parasite management
5	Population management (hunting, trapping)
6 (tie)	Limiting contact with pollutants/contaminants
6 (tie)	Native predator control
6 (tie)	Public education to reduce human disturbance
6 (tie)	Exotic/invasive species control
6 (tie)	Translocation to new geographic range
6 (tie)	Culling/selective removal
6 (tie)	Threats reduction

Respondents noted no other current conservation practices for wildlife in emergent wetland habitats in Indiana.

Respondents recommended these practices for more effective conservation of wildlife in emergent wetland habitats in Indiana (not ranked):

- Restoring wetlands and providing quality upland nesting cover adjoining these wetlands
- Habitat protection throughout annual cycle
- Continue five-year surveys
- Modify hunting seasons and opening of urban areas to hunting to reduce numbers of so-called nuisance geese populations in lieu of nest destruction and egg shaking
- Enhancement of migratory/staging habitat
- Enhancement of breeding habitat where populations do not conflict with land use
- Develop practices and procedures to increase harvest of local birds

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the practices for more effective conservation for wildlife in emergent wetland habitats. Their responses included:

- I'm not sure about what species are being stocked. Fish should not be stocked in emergent wetlands.

  Exotic/invasive species control should be higher on the list.

  If translocation refers to Canada Goose removal studies need to show they do not come back to the original site.

  In many urban areas nest destruction and egg shaking are going to be the only means of reducing the number of geese. You cannot open urban areas to hunting.

Habitat actions

Respondents ranked conservation efforts by how well they address threats to emergent wetland habitats in Indiana:

Rank	Conservation efforts for emergent wetland habitats
1	Habitat protection on public lands
2	Cooperative land management agreements (conservation easements)
3	Habitat restoration on public lands
4 (tie)	Succession control (fire, mowing)
4 (tie)	Land use planning
5 (tie	Protection of adjacent buffer zone
5 (tie)	Habitat restoration through regulation
5 (tie)	Corridor development/protection
6 (tie)	Habitat protection incentives (financial)
6 (tie)	Habitat restoration incentives (financial)
6 (tie)	Artificial habitat creation (artificial reefs, nesting platforms)

7	Managing water regimes
8	Habitat protection through regulation
9 (tie)	Restrict public access and disturbance
9 (tie)	Technical assistance
10 (tie)	Selective use of functionally equivalent exotic species in place of extirpated natives
10 (tie)	Pollution reduction

Respondents listed no additional conservation practices for emergent wetland habitats in Indiana.

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

- Habitat regulations
  - To protect small wetlands
- Habitat incentives
  - Restoration programs for private landowners (financial help)
  - Protection incentives
  - Easements on private lands to protect existing wetlands or restore wetlands
- Continue efforts to protect and enhance wetland and riparian habitats
- Control plant species, such as cattail, that spread by vegetative means from thick colonies
- Food plots
- Refuge areas

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the practices for more effective conservation of emergent wetland habitats. Their responses included:

- Need to protect private land.

Proposed plans for monitoring

Current monitoring

Species monitoring

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

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

Appendix F-66: Emergent

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

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

Respondents ranked monitoring efforts by state agencies based on their importance for conservation of wildlife in emergent wetland habitats in Indiana:

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

Respondents ranked monitoring efforts by other organizations based on their importance for conservation of wildlife in emergent wetland habitats in Indiana:

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

Respondents listed regional or local monitoring by state agencies for wildlife in emergent wetland habitats in Indiana (not ranked):

- Currently only when a permit for work in a wetland is applied for (smaller, more numerous wetlands have little oversight)
- IDNR: Selected fish and wildlife areas and reservoir properties conduct counts during fall migration period
  - As part of weekly waterfowl survey from August to January
- At selected sites
  - Weekly and mid-winter waterfowl counts
- Statewide for existing and new colonies every five years
- Neck collar observations statewide as encountered

Respondents listed regional or local monitoring by other organizations for wildlife in emergent wetland habitats in Indiana (not ranked):

- Some wildlife species are not monitored. Habitat changes requiring permits are checked by IDNR, IDEM and ACOE (in some cases)
- Lake associations, businesses and anyone living around an emergent wetland. Those that have yards and Canada goose complaints will monitor populations to prove they have a problem so they can destroy nests or eggs
- Christmas bird count

Respondents listed organizations that monitor wildlife in emergent wetland habitats in Indiana (not ranked):

- Waterfowl USA
- Ducks Unlimited
- The Nature Conservancy
- IDNR – Division of Fish and Wildlife
- IDNR – Division of Reservoirs
- Audubon Society
- U.S. Fish and Wildlife Service

Respondents considered monitoring techniques for wildlife in emergent wetland habitats in Indiana:

Monitoring techniques for wildlife in emergent wetland habitats	Used	Not used but possible with existing technology and data	Not economically feasible
Radio telemetry and tracking	X	X	--
Modeling	X	X	--
Coverboard routes	--	X	--
Spot mapping	X	--	--
Driving a survey route	X	--	--

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

Respondents noted other monitoring techniques for wildlife in emergent wetland habitats in Indiana (not ranked):

- Aerial surveys

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for wildlife in emergent wetland habitats. There were no responses.

Habitat inventory and assessment

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

- Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
- Occasional statewide (less than once a year and not 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 emergent wetland habitats in Indiana (not ranked):

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

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

Rank	Inventory and assessment by state agencies for conservation of emergent wetland habitats
1	Statewide annual inventory and assessment
2 (tie)	Statewide once-a-year inventory and

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

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

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

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

- On state land
- Isolated wetlands law

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

- Indiana wetland inventory maps
- County aerial maps for NRCS
- Soils mapping county maps

Respondents listed organizations that monitor emergent wetland habitats in Indiana (not ranked):

- U.S. Fish and Wildlife Service
- Natural Resources Conservation Service
- Indiana Department of Environmental Management

Respondents considered inventory and assessment techniques for emergent wetland habitats in Indiana:

Inventory and assessment techniques for emergent wetland habitats	Used	Not used but possible with existing technology and data	Not economically feasible
GIS mapping	X	X	--
Aerial photography and analysis	X	X	--
Systematic sampling	X	X	--
Regulatory information	X	--	--
Participation in land use programs	X	X	--
Modeling	X	X	--
Voluntary landowner reporting	X	X	--

Respondents listed no additional inventory and assessment techniques for emergent wetland habitats in Indiana.

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 emergent wetland habitats. There were no responses.

Recommended monitoring

Species monitoring

Respondents recommended the following monitoring techniques for effective conservation of wildlife in emergent wetland habitats in Indiana (not ranked):

- Aerial surveys
- Banding
- Continue current state surveys every 5 years
- Mark and recapture: A means to track species movement and association with non-target species and times of interaction with non-target species
- Mark and harvest: Eliminates and reduces concentrations in undesirable areas
- Banding and neck collaring: Procedures in place, nationally accepted, good national data base maintained
- Weekly waterfowl counts at selected sites: Samples most of the major concentration areas. Very good historical data for trend analysis
- Nesting and brood counts statewide

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for effective conservation of wildlife in wildlife in emergent wetland habitats. There were no responses.

Habitat inventory and assessment

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

- Aerial surveys and photos:
  - Wetlands should be monitored by overhead photo methods with ground truth checks. This should occur on a regular basis with aggressive enforcement against illegal wetlands destruction
  - Analysis of county aerial photos as these are done on a somewhat regular basis
- GIS mapping would be the most cost affective means for creating an inventory of emergent plant species that would support Canada Geese in emergent wetlands
- Systematic water sampling of high use areas would determine nutrient loading and water quality regarding Canada geese. (U.S. Fish and Wildlife Service Draft Environmental Impact Statement, Resident Canada Goose Management, February 2002)
- Reports from state FWAs
- Updating and ground-truthing Wetland Inventory maps

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 emergent wetland habitats. There were no responses.

Technical experts and conservation organizations offered the following additional comments:

- Protection of this habitat is critical for nesting and migrating waterfowl.

EPHEMERAL WETLAND HABITATS NARRATIVE

Habitat description

Wetlands Ephemeral: Areas temporarily flooded often supporting aquatic plants and animals.

Problems affecting species and habitats

Species threats

Respondents ranked the following threats to wildlife in ephemeral wetland habitats in Indiana:

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

Respondents offered no additional threats to wildlife in ephemeral wetland habitats in Indiana.

Respondents listed top threats to wildlife in ephemeral wetland habitats in Indiana (not ranked):

- Habitat loss and degradation
  - Causes increase to migration breeding sites
  - Loss of ephemeral wetlands
  - Loss of upland forested habitat
  - Invasive species like reed canary grass are proliferating in remaining habitats, decreasing plant diversity, cover and overall wetland health
  - Extreme rarity of ephemeral wetlands

A respondent noted, "Unfortunately, most existing ephemeral wetlands have been destroyed in Indiana. Even more unfortunately, many of them were destroyed with the misguided notion that deep water was better for wildlife - landowners were advised to dredge out the ephemeral wetlands to provide duck habitat. These fish-infested deep waters have no habitat for Plains leopard frog."

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

- Loss of ephemeral wetlands may also affect waterfowl. Ephemeral wetlands are used as pair ponds by mallards and may be used by migrating waterfowl as rest stops.

Habitat threats

Respondents ranked threats to ephemeral wetland habitats in Indiana:

Rank	Threats to ephemeral wetland habitats
1	Habitat degradation
2	Habitat fragmentation
3	Agricultural/forestry practices
4 (tie)	Commercial or residential development (sprawl)
4 (tie)	Drainage practices (stormwater runoff)
5	Nonpoint source pollution (sedimentation and nutrients)
6	Point source pollution (continuing)
7 (tie)	Invasive/non-native species
7 (tie)	Residual contamination (persistent toxins)
7 (tie)	Mining/acidification
8 (tie)	Impoundment of water/flow regulation
8 (tie)	Successional change
9	Stream channelization
10	Counterproductive financial incentives or regulations

Respondents noted no additional threats to ephemeral wetland habitats in Indiana.

Respondents listed top threats to ephemeral wetland habitats in Indiana (not ranked):

- Habitat loss, degradation and fragmentation
- Invasion of wetlands by species like reed canary grass, cattails, purple loosestrife or other invasives that create monocultures
- Agricultural practices that destroy ephemeral wetlands

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

- A big threat to these wetlands is people generally do not consider them wetlands unless they hold water year round. Education on wetlands would be beneficial.

Additional research and survey efforts

Current body of research

Species research

All respondents stated that the current body of science is either inadequate or nonexistent for wildlife in Ephemeral wetland habitats in Indiana.

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

Title = Amphibians and reptiles from 23 counties of Indiana.;
Author = Robert Brodman;
Date = 2003;
Publisher = Proceedings of the Indiana Academy of Science, 112: 43-54.

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 wildlife in ephemeral wetlands habitats. There were no responses.

Habitat research

All respondents stated that the current body of science is inadequate for Ephemeral wetland habitats in Indiana.

Respondents did not identify citations (title, author, date, publisher) that would give the best overview of Ephemeral wetland habitats in Indiana.

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 ephemeral wetlands habitats. There were no responses.

Research needs

Species research

Respondents ranked research needs for wildlife in ephemeral wetland habitats in Indiana:

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

Respondents noted additional research needs for wildlife in ephemeral wetland habitats in Indiana (not ranked):

- Information on metapopulation dynamics and migration distances to and from ephemeral wetlands
- Information on how many ephemeral wetland habitats within the landscape are needed to maintain healthy populations of wildlife species
- Information on buffer size and vegetation

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the additional research for wildlife in ephemeral wetlands habitats. There were no responses.

Habitat research

Respondents ranked research needs for ephemeral wetland habitats in Indiana:

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

Respondents noted additional research needs for ephemeral wetland habitats in Indiana (not ranked):

- Information on metapopulation dynamics and migration distances to and from ephemeral wetlands
- Information on how many ephemeral wetland habitats within the landscape are needed to maintain healthy populations of wildlife species
- Information on buffer size and vegetation

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

- Need to know what species are using these wetlands. Are they stopover points for waterfowl? Permanent home for amphibians?

Conservation actions necessary

Species actions

Respondents ranked conservation efforts by how well they address threats to wildlife in ephemeral wetland habitats in Indiana:

Rank	Conservation efforts for wildlife in ephemeral wetland habitats
1	Threats reduction
2	Habitat protection (use below for details)
3 (tie)	Exotic/invasive species control
3 (tie)	Regulation of collecting
3 (tie)	Public education to reduce human disturbance

Respondents noted other current conservation practices for wildlife in ephemeral wetland habitats in Indiana:

- Wetland restoration

Respondents recommended these practices for more effective conservation of wildlife in ephemeral wetland habitats in Indiana:

- Wetland and forested habitat protection and restoration
  - Within the range of species

A respondent noted, “Ephemeral wetlands are not protected or valued as much as other wetlands via regulation.”

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the practices for more effective conservation of wildlife in ephemeral wetlands habitats. There were no responses.

Habitat actions

Respondents ranked conservation efforts by how well they address threats to ephemeral wetland habitats in Indiana:

Rank	Conservation efforts for ephemeral wetland habitats
1	Habitat protection on public lands
2	Habitat protection through regulation
2	Habitat protection incentives (financial)
3 (tie)	Protection of adjacent buffer zone
3 (tie)	Habitat restoration on public lands
3 (tie)	Land use planning
3 (tie)	Habitat restoration through regulation
3 (tie)	Habitat restoration incentives (financial)
3 (tie)	Artificial habitat creation (artificial reefs, nesting platforms)
3 (tie)	Corridor development/protection
3 (tie)	Managing water regimes
3 (tie)	Pollution reduction
3 (tie)	Technical assistance

Respondents listed no additional current conservation practices for ephemeral wetland habitats in Indiana. One respondent commented, “Many current conservation practices promoted by biologists seem to be aimed at ducks and actually manage against some wildlife species.”

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

- Wetland, forest and buffer restoration and protection
  - Buffers needed for migrating amphibians for breeding
  - When creating wetlands under a landowner incentive program, create ephemeral wetlands whenever possible, rather than duck ponds
  - Protection on private and public lands

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

- The landowner incentive programs do not create ponds. They usually create emergent wetlands. Are wildlife species using ephemeral wetlands not also using the edges of emergent wetlands?

Proposed plans for monitoring

Current monitoring

Species monitoring

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

- Statewide once-a-year monitoring
- 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

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

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

Respondents ranked monitoring efforts by state agencies based on their importance for conservation of wildlife in ephemeral wetland habitats in Indiana:

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

Respondents ranked monitoring efforts by other organizations based on their importance for conservation of wildlife in ephemeral wetland habitats in Indiana:

Rank	Monitoring efforts by other organizations for conservation of wildlife in ephemeral wetland habitats
1 (tie)	Occasional statewide (less than once a year and not regularly scheduled) monitoring
1 (tie)	Regional or local once-a-year monitoring
1 (tie)	Statewide once-a-year monitoring
1 (tie)	Periodic regional or local (less than once a year

	but still regularly scheduled) monitoring
2	Periodic statewide (less than once a year but still regularly scheduled) monitoring
3	Occasional regional or local (less than once a year and not regularly scheduled) monitoring
4 (tie)	Regional or local year-round monitoring
4 (tie)	Statewide year-round monitoring

Respondents listed regional or local monitoring by state agencies for wildlife in ephemeral wetland habitats in Indiana (not ranked):

- IDNR – Division of Fish and Wildlife
  - Nongame herpetologist incorporates this as part of annual field season
  - NAAMP frog monitoring program

Respondents listed regional or local monitoring by other organizations for wildlife in ephemeral wetland habitats in Indiana (not ranked):

- Spencer Cortwright, IUN
- Robert Brodman, Saint Joseph's College
- University professors and members of the Herpetology TAC for the State of Indiana as part of their annual field season
- NW Indiana (Newton, Jasper, Pulaski, Lake, Porter counties)

Respondents listed organizations that monitor wildlife in ephemeral wetland habitats in Indiana (not ranked):

- Spencer Cortwright, IUN
- Robert Brodman, Saint Joseph's College

Respondents considered monitoring techniques for wildlife in ephemeral wetland habitats in Indiana:

Monitoring techniques for wildlife in ephemeral wetland habitats	Used	Not used but possible with existing technology and data	Not economically feasible
Radio telemetry and tracking	--	X	--
Modeling	X	X	--
Coverboard routes	X	X	--
Spot mapping	--	X	--
Driving a survey route	X	--	--
Mark and recapture	--	X	--
Professional survey/census	X	--	--

Volunteer survey/census	X	X	--
Trapping (by any technique)	X	X	--
Representative sites	X	--	--
Probabilistic sites	X	--	--

Respondents noted other no other monitoring techniques for wildlife in ephemeral wetland habitats 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 wildlife in ephemeral wetlands habitats. There were no responses.

Habitat inventory and assessment

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

- Occasional statewide (less than once a year and not 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 ephemeral wetland habitats in Indiana (not ranked):

- 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 ranked inventory and assessment efforts by state agencies based on their importance for conservation of ephemeral wetland habitats in Indiana:

Rank	Inventory and assessment by state agencies for conservation of ephemeral wetland habitats
1 (tie)	Statewide once-a-year inventory and assessment
1 (tie)	Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
1 (tie)	Regional or local once-a-year inventory and assessment
1 (tie)	Periodic regional or local (less than once a

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

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

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

Respondents listed no regional or local inventory and assessment by state agencies for ephemeral wetland habitats in Indiana.

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

- Cortwright monitors populations in Brown and Porter counties

- Kankakee Sands and other Conservancy preserves: Staff evaluate restored/created habitat to judge its ability to support plains leopard frog and other species of concern
- Robert Brodman, Saint Joseph's College in NW Indiana; Owens County
- Northwest Indiana (Newton, Jasper, Pulaski, Lake & Porter Counties)

Respondents listed organizations that monitor ephemeral wetland habitats in Indiana (not ranked):

- IDNR (nongame herpetologist)
- University professors
- Indiana Herpetology Technical Advisory Committee
- Robert Brodman, St. Joseph's College

Respondents considered inventory and assessment techniques for ephemeral wetland habitats in Indiana:

Inventory and assessment techniques for ephemeral wetland habitats	Used	Not used but possible with existing technology and data	Not economically feasible
GIS mapping	X	X	--
Aerial photography and analysis	X	X	--
Systematic sampling	X	X	--
Modeling	X	X	--
Voluntary landowner reporting	--	X	--

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

- Pit-fall trapping and coverboard objects adjacent to ephemeral wetlands; mark and recapture
- Visual estimate of amount of appropriate habitat being provided in restored areas

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 ephemeral wetlands habitats. There were no responses.

Recommended monitoring

Species monitoring

Respondents recommended the following monitoring techniques for effective conservation of wildlife in ephemeral wetland habitats in Indiana (not ranked):

- Professional survey, mark and recapture, radio telemetry
- Pit-fall traps, coverboard objects
- Fall surveys at breeding sites
- Call surveys and systematic sampling
- Minnow trapping, mark and recapture or radio telemetry

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for wildlife in ephemeral wetlands habitats. There were no responses.

Habitat inventory and assessment

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

- Pit-fall traps and coverboards to assess population size and use of ephemeral wetlands for breeding; mark and recapture to determine migration patterns and use of specific ephemeral wetlands for breeding
- Systematic survey/sampling and GIS

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 effective conservation in ephemeral wetlands habitats. There were no responses.

Appendix F-68: Forested

Technical experts did not provide input on a representative species for this habitat.

There are no species of greatest conservation need in this guild.

HERBACEOUS MARSH WETLAND HABITATS NARRATIVE

Habitat description

Wetlands are areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al.

Emergent herbaceous wetlands are areas where perennial herbaceous vegetation accounts for 75 to 100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

Problems affecting species and habitats

Species threats

The respondent listed no "critical threats," but listed as "serious threats" to wildlife in herbaceous marsh wetland habitats in Indiana: (not ranked):

- Invasive/non-native species
- Dependence on other species (mutualism, pollinators)
- Unintentional take/direct mortality (e.g., vehicle collisions, power line collisions, by-catch, harvesting equipment, land preparation machinery)
- Habitat loss (breeding range)
- Habitat loss (feeding/foraging areas)

The respondent cited "unregulated collection pressure" as "somewhat of a threat."

The respondent listed as "slight threats" to wildlife in herbaceous marsh wetland habitats in Indiana (not ranked):

- Predators (native or domesticated)
- Large home range requirements

The respondent listed additional threats to wildlife in herbaceous marsh wetland habitat in Indiana:

- Artificial manipulation of water levels in wetlands seems likely to increase mortality of over-wintering snakes. Snakes hibernate underground at the groundwater interface. Raising water levels in the winter could drown snakes, and lowering the water table could expose them to extreme cold temperatures. Both activities are likely to kill over-wintering snakes

The respondent listed top threats to wildlife in herbaceous marsh wetland habitats in Indiana (not ranked):

- Artificial manipulation of water levels in wetlands increases mortality of over-wintering snakes (see Q8)
- 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 rattlesnakes that have been disked on DNR lands

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the threats to wildlife in herbaceous marsh wetland habitats. There were no responses.

Habitat threats

The respondent listed the following threat to herbaceous marsh wetland habitats in Indiana as "critical":

- Impoundment of water/flow regulation

The respondent listed the following threats to herbaceous marsh wetland habitats as "serious" (not ranked):

- Habitat fragmentation
- Successional change
- Habitat degradation

The respondent listed "agricultural/forestry practices" as "somewhat of a threat" to herbaceous marsh wetland habitats in Indiana.

The respondent listed no other threats to herbaceous marsh wetland habitats in Indiana.

The respondent listed top threats to herbaceous marsh wetland habitats in Indiana (not ranked):

- 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
- Artificial manipulation of water levels in wetlands increases mortality of over-wintering snakes (see Q8)

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the threats to herbaceous marsh wetland habitats. There were no responses.

Additional research and survey efforts

Current body of research

Species research

The respondent stated that the current body of science for wildlife in herbaceous marsh wetland habitats in Indiana is adequate.

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

Title = various theses;
Author = Bruce Kingsbury et al

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 wildlife in herbaceous marsh wetland habitats. There were no responses.

Habitat research

The respondent stated that the current body of science for herbaceous marsh wetland habitats is adequate.

Respondents did not identify citations (title, author, date, publisher) that would give the best overview of herbaceous marsh wetland habitats in Indiana.

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 herbaceous marsh wetland habitats. There were no responses.

Research needs

Species research

The respondent listed the following research needs for wildlife in herbaceous marsh wetland habitats in Indiana as "greatly needed" (not ranked):

- Life cycle
- Limiting factors (food, shelter, water, breeding sites)
- Threats (predators/competition, contamination)
- Population health (genetic and physical)

The respondent listed the following research as "needed" for wildlife in herbaceous marsh wetland habitats in Indiana (not ranked):

- Distribution and abundance
- Relationship/dependence on specific habitats

The respondent listed no other research needs for wildlife in herbaceous marsh wetland habitats in Indiana.

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for wildlife in herbaceous marsh wetland habitats. There were no responses.

Habitat research

The respondent listed no research as "urgently needed," but listed the following for herbaceous marsh wetland habitats in Indiana as "greatly needed" (not ranked):

- Successional changes
- Relationship/dependence on specific site conditions

The respondent listed the following as "needed" research for herbaceous marsh wetland habitats in Indiana (not ranked):

- Distribution and abundance (fragmentation)
- Threats (land use change/competition, contamination/global warming)

The respondent listed additional research needs for herbaceous marsh wetland habitats in Indiana (not ranked):

- Spatial relationships between occupied wetlands relative to population dynamics
- Physical characteristics of over-wintering sites

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for herbaceous marsh wetland habitats. There were no responses.

Conservation actions necessary

Species actions

The respondent stated that these conservation efforts address threats to wildlife in herbaceous marsh wetland habitats in Indiana "very well:"

- Exotic/invasive species control

The respondent indicated that the following conservation efforts address threats to wildlife in herbaceous marsh wetland habitats "somewhat" (not ranked):

- Regulation of collecting
- Habitat protection

The respondent listed another current conservation practice for wildlife in herbaceous marsh wetland habitats in Indiana:

- Invasive species control (buckthorn, autumn olive, phargmites) to keep open herbaceous habitat suitable for Massasauga rattlesnakes

The respondent recommended the following practices for more effective conservation of wildlife in herbaceous wetland habitats in Indiana:

- Design and management of 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 (water level manipulations, late spring prescribed fire), these management decisions seem likely to result in the direct mortality of adults.

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the practices for more effective conservation of wildlife in herbaceous marsh wetland habitats. There were no responses.

Habitat actions

The respondent stated that none of the listed conservation efforts address threats to herbaceous marsh wetland habitats in Indiana "very well."

The respondent indicated that the following conservation efforts address threats to herbaceous marsh wetland habitats in Indiana "somewhat" (not ranked):

- Habitat protection through regulation
- Habitat protection on public lands
- Succession control (fire, mowing)
- Protection of adjacent buffer zone

The respondent offered no other current or recommended practices for herbaceous marsh wetland habitats in Indiana.

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the conservation efforts for herbaceous marsh wetland habitats. There were no responses.

Proposed plans for monitoring

Current monitoring

Species monitoring

Appendix F-69: Herbaceous Marsh

The respondent listed the following monitoring effort by state agencies and other organizations for wildlife in herbaceous marsh wetland habitats in Indiana:

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

The respondent listed the following monitoring efforts by state agencies as "very crucial" for wildlife conservation in herbaceous marsh wetland habitats in Indiana:

- Periodic statewide (less than once a year but still regularly scheduled) monitoring

The respondent listed the following monitoring efforts by state agencies as "somewhat crucial" (not ranked):

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

The respondent listed as "slightly crucial" the following monitoring efforts by state agencies for conservation of wildlife in herbaceous marsh wetland habitats in Indiana (not ranked):

- 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
- Periodic regional or local (less than once a year but still regularly scheduled) monitoring

The respondent listed no monitoring efforts by other organizations as "very crucial" for wildlife conservation in herbaceous marsh wetland habitats in Indiana. The respondent listed the following as "somewhat crucial:"

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

The respondent listed no regional or local monitoring by state agencies or other organizations for wildlife in herbaceous marsh wetland habitats in Indiana.

The respondent listed the following organization that monitors wildlife in herbaceous marsh wetland habitats in Indiana:

- The Nature Conservancy (funded research at Cline Lake Fen)

The respondent listed the following monitoring technique as "frequently used" for wildlife in herbaceous marsh wetland habitats in Indiana:

- Radio telemetry and tracking

The respondent listed the following as "occasionally used" (not ranked):

- Spot mapping
- Mark and recapture
- Professional survey/census

The respondent cited no techniques that fall into the categories of "not used but possible with existing technology or data" or "not economically feasible" for wildlife in herbaceous marsh wetland habitats in Indiana.

The respondent listed no other monitoring techniques for wildlife in herbaceous marsh wetland habitats in Indiana.

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring efforts for wildlife in herbaceous marsh wetland habitats. There were no responses.

Habitat inventory and assessment

The respondent listed the following monitoring effort by state agencies and other organizations for herbaceous marsh wetland habitats in Indiana:

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

The respondent listed that the following efforts by state agencies are "very crucial" for conservation of herbaceous marsh wetland habitats in Indiana:

- Occasional statewide (less than once a year and not regularly scheduled) inventory and assessment

The respondent listed no efforts by other organizations as "crucial" for conservation of herbaceous marsh wetland habitats in Indiana.

The respondent listed no regional or local inventory and assessment by state agencies or other organizations for herbaceous marsh wetland habitats in Indiana. The respondent listed no organizations that monitor this habitat.

The respondent listed no current monitoring techniques for herbaceous marsh wetland habitats that are "frequently used" or indicate feasibility of other monitoring techniques. The respondent listed the following techniques that are "occasionally used" (not ranked):

- GIS mapping
- Aerial photography and analysis

The respondent cited no techniques that fall into the categories of "not used but possible with existing technology or data" or "not economically feasible."

The respondent listed no inventory and assessment techniques for herbaceous marsh wetland habitats in Indiana.

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the inventory and assessment techniques herbaceous marsh wetland habitats. There were no responses.

Recommended monitoring

Species monitoring

The respondent recommended no monitoring techniques for effective wildlife conservation in herbaceous marsh wetland habitats 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 effective conservation of wildlife in herbaceous marsh wetland habitats. There were no responses.

Habitat inventory and assessment

The respondent recommended no inventory and assessment techniques for effective conservation of herbaceous marsh wetland habitats in Indiana.

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 effective conservation of herbaceous marsh wetland habitats. There were no responses.

Technical experts and conservation organizations offered the following additional comments:

- Need more than one respondent. This habitat is probably not used to much by waterfowl unless it is in close proximity to other types of wetlands. It would however be used by many song bird species such as Yellowthroats, Sparrows, Wrens, Red-wing Blackbirds. There will also be use by amphibians.

Appendix F-70: Mudflats

Technical experts did not provide input on a representative species for this habitat.

There are no species of greatest conservation need in this guild.

PERMANENT WETLAND HABITATS NARRATIVE

Problems affecting species and habitats

Species threats

Respondents ranked the following threats to wildlife in permanent wetland habitats in Indiana:

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

Respondents offered additional threats to wildlife in permanent wetland habitats in Indiana (not ranked):

- Loss of wetlands (muckland)
- Muskrat threats: Although not habitat specific, the inability to responsibly and proactively manage muskrats according to the wildlife conservation model, as opposed to reactive measures through nuisance practices, is a concern regarding the conservation of muskrats. This concern applies across the landscape, not just in urban and suburban environments

Respondents listed top threats to wildlife in permanent wetland habitats in Indiana (not ranked):

- Green salamanders: Only a few locations are known to have green salamanders in Indiana and this is a habitat specialist needing rocky outcrops in forested areas
- Habitat loss, fragmentation and degradation
  - Due to farming or development
  - Including loss of huge open/prairie buffer zones for nesting
  - Wetlands are managed as landscape scale systems relative to Blanding's turtle fragmentation results in metapopulation disruption and potential metapopulation decline. Because of low densities and small population sizes, populations that have become isolated are likely not viable
- Overland movement for nesting invites road kill of otherwise long-lived adults
- Suboptimal size nesting areas focuses nest depredation
- Inappropriate management of nesting areas: Sandy fire breaks in managed areas are disked at inappropriate times, or are managed in inappropriate cover types
- Loss of connectivity

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

- Loss of permanent wetlands affects waterfowl.
  - loss of nesting sites
  - loss of brood rearing sites
  - loss of staging areas for migrating waterfowl

Habitat threats

Respondents ranked threats to permanent wetland habitats in Indiana:

Rank	Threats to permanent wetland habitats
1 (tie)	Habitat fragmentation
1 (tie)	Habitat degradation
2	Agricultural/forestry practices
3 (tie)	Commercial or residential development (sprawl)
3 (tie)	Climate change
4 (tie)	Nonpoint source pollution (sedimentation and nutrients)
4 (tie)	Impoundment of water/flow regulation
5 (tie)	Successional change
5 (tie)	Point source pollution (continuing)

6	Mining/acidification
7 (tie)	Counterproductive financial incentives or regulations
7 (tie)	Invasive/non-native species
8 (tie)	Drainage practices (stormwater runoff)
8 (tie)	Stream channelization
9	Residual contamination (persistent toxins)

Respondents noted no other threats to permanent wetland habitats in Indiana.

Respondents listed top threats to permanent wetland habitats in Indiana (not ranked):

- Habitat degradation, fragmentation, loss
  - Due to deforestation
  - Due to farming
  - Due to development
  - Due to coal mining
  - Due to wetland drainage/tiny stream ditching
  - Conversion of sand prairie nesting habitat to cropland (e.g., forestation via fire prevention)

- Blanding's turtle habitat:
  - 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 turtles 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 (ether 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

A respondent added, "The participant has to speculate about the meaning of successional change. Is a change an increase or decrease in early successional habitats? Climate change also is speculative. Agriculture/Forestry practices have different effects. Grouping these practices into a single category does not appropriately represent each individual practice. Point and nonpoint pollution may have a positive or negative effect."

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the threats to permanent wetland habitats. There were no responses.

Additional research and survey efforts

Current body of research

Species research

Seventeen percent of respondents stated that the current body of science is adequate for wildlife in permanent wetland habitats in Indiana; sixty seven percent said that it is inadequate.

A respondent noted, “Literature is not habitat specific for muskrats in Indiana.”

Seventeen percent of respondents stated that the current body of science is adequate for wildlife in permanent wetland habitats in Indiana; sixty seven percent said that it is inadequate.

A respondent noted, “Literature is not habitat specific for muskrats in Indiana.”

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

Mumford and Whitaker 1982

Title = Fur animals of Indiana;
Author = David Brooks;
Date = 1959;
Publisher = IDF&W

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

Title = ongoing background work in NE & MN

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

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 wildlife in permanent wetland habitats. Their responses included:

- Indiana Breeding Bird Survey

Habitat research

Seventeen percent of respondents stated that the current body of science is adequate for permanent wetland habitats in Indiana; sixty seven percent said that it is inadequate.

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

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

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 permanent wetland habitats. There were no responses.

Research needs

Species research

Respondents ranked research needs for wildlife in permanent wetland habitats in Indiana:

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

Respondents noted other research needs for permanent wetland habitats in Indiana (not ranked):

- Research as related to muskrats is not habitat specific
- Long-term fidelity to specific sites
- Limits to sand prairie needs for nesting
- Limits to recruitment when forced to nest in row crop areas

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for wildlife in permanent wetland habitats. There were no responses.

Habitat research

Respondents ranked research needs for permanent wetland habitats in Indiana:

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

Respondents noted additional research needs for permanent wetland habitats in Indiana (not ranked):

- Prairie restoration and fire management to perpetuate small sand blowouts
- Relationship between upland nesting habitat, dispersal distance, barriers to dispersal, etc., might be critical information for conservation of the Blanding's turtle.

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for permanent wetland habitats. There were no responses.

Conservation actions necessary

Species actions

Respondents ranked conservation efforts by how well they address threats to wildlife in permanent wetland habitats in Indiana:

Rank	Conservation efforts for wildlife in permanent wetland habitats
1	Population management (hunting, trapping)
2 (tie)	Regulation of collecting
2 (tie)	Public education to reduce human disturbance
2 (tie)	Threats reduction
2 (tie)	Limiting contact with pollutants/contaminants
2 (tie)	Habitat protection (use below for details)

Respondents noted other current conservation practices for wildlife in permanent wetland habitats in Indiana:

- Preserve wetlands

Respondents recommended these practices for more effective conservation of wildlife in permanent wetland habitats in Indiana (not ranked):

- Habitat protection
- Although not habitat specific, outreach programs are needed to effectively and accurately educate citizens about wildlife (game and nongame), the wildlife conservation model (for game and nongame), and the need for effective muskrat management programs
- Restoration in new, very large natural areas in Northwest Indiana
- Raccoon reduction near constrained small areas of occupied habitat in Northeast Indiana
- Design and management of conservation areas that specifically incorporate life history requirements of the species across relatively large habitats (>1,000 acres). Blanding's turtles are 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
- Restoration of habitat and connectivity

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the practices for more effective conservation of wildlife in permanent wetland habitats. There were no responses.

Habitat actions

Respondents ranked conservation efforts by how well they address threats to permanent wetland habitats in Indiana:

Rank	Conservation efforts for permanent wetland habitats
1	Protection of adjacent buffer zone
2 (tie)	Habitat protection on public lands
2 (tie)	Habitat restoration on public lands
2 (tie)	Succession control (fire, mowing)
3 (tie)	Habitat restoration through regulation
3 (tie)	Habitat restoration incentives (financial)
3 (tie)	Managing water regimes
3 (tie)	Cooperative land management agreements (conservation easements)
3 (tie)	Habitat protection incentives (financial)
3 (tie)	Pollution reduction
3 (tie)	Land use planning
3 (tie)	Artificial habitat creation (artificial reefs, nesting platforms)
3 (tie)	Habitat protection through regulation

Respondents listed no other current conservation practices for permanent wetland habitats in Indiana.

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

- Wetland protection
- Use fire to maintain large sand prairies near appropriate wetlands
- Acquire/purchase easements on additional blocks of land that have permanent wetlands associated with large, sandy uplands
- Protection, restoration and appropriate management of adjacent uplands as nesting habitat around known populations
- Restore habitat and connectivity; allow beaver activity

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the practices for more effective conservation of permanent wetland habitats. There were no responses.

Proposed plans for monitoring

Current monitoring

Species monitoring

Respondents were aware of the following monitoring efforts by state agencies for wildlife in permanent wetland 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

Appendix F-71: Permanent

Respondents were aware of the following monitoring efforts by other organizations for wildlife in permanent wetland 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

Respondents ranked monitoring efforts by state agencies based on their importance for conservation of wildlife in permanent wetland habitats in Indiana:

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

Respondents ranked monitoring efforts by other organizations based on their importance for conservation of wildlife in permanent wetland habitats in Indiana:

Rank	Monitoring efforts by other organizations for conservation of wildlife in permanent wetland habitats
1	Occasional regional or local (less than once a year and not regularly scheduled) monitoring
2	Occasional statewide (less than once a year and not regularly scheduled) monitoring
4	Periodic regional or local (less than once a year but still regularly scheduled) monitoring
3	Periodic statewide (less than once a year but still regularly scheduled) monitoring

Respondents listed regional or local monitoring by state agencies for wildlife in permanent wetland habitats in Indiana (not ranked):

- IDNR – Division of Nature Preserves
- Agencies that issue drainage permits
- Fish Creek, Patoka River, Pigeon Creek

Appendix F-71: Permanent

Respondents listed regional or local monitoring by other organizations for wildlife in permanent wetland habitats in Indiana:

- Robert Brodman, St. Joseph's College
- "BioBlitz" in Lake County
- Herp Center at IUPFW in possibly Steuben and LaGrange counties
- Fish Creek, Patoka River, Pigeon Creek, Muscatatuck River

Respondents listed organizations that monitor wildlife in permanent wetland habitats in Indiana (not ranked):

- Ball State University; Tom Morrell
- Muskrat: Indiana Division of Fish and Wildlife: Population monitoring efforts at state, regional and local scales are to monitor annual trends. Monitoring programs used by the division are not habitat specific for muskrat
- TNC has funded some work at Cline Lake Fen to better understand population dynamics, habitat use, etc.
- Bruce Kingsbury, IUPU - Fort Wayne

Respondents considered monitoring techniques for wildlife in permanent wetland habitats in Indiana:

Monitoring techniques for wildlife in permanent wetland habitats	Used	Not used but possible with existing technology and data	Not economically feasible
Radio telemetry and tracking	X	X	--
Modeling	X	X	--
Coverboard routes	--	X	--
Spot mapping	X	--	--
Reporting from harvest, depredation, or unintentional take (road kill, by-catch)	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	--	--
Probabilistic sites	X	--	--

Respondents noted other monitoring techniques for wildlife in permanent wetland habitats in Indiana:

- Look for burrows in muck

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for wildlife in permanent wetland habitats. There were no responses.

Habitat inventory and assessment

Respondents were aware of the following inventory and assessment efforts by state agencies for permanent wetland habitats in Indiana:

- Occasional statewide (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 permanent wetland habitats in Indiana:

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

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

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

Appendix F-71: Permanent

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

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

A respondent listed regional or local inventory and assessment by state agencies for permanent wetland habitats in Indiana (not ranked):

- Northwest Indiana
- Northeast Indiana

A respondent listed regional or local inventory and assessment by other organizations agencies for permanent wetland habitats in Indiana:

* IUPU-FW faculty and students work in wetlands and this species in Northeast Indiana

A respondent listed organizations that monitor permanent wetland habitats in Indiana (not ranked):

- Ball State University, Northeast Indiana
- Indiana State University, Northwest Indiana

Respondents considered inventory and assessment techniques for permanent wetland habitats in Indiana:

Inventory and assessment techniques for permanent wetland habitats	Used	Not used but possible with existing technology and data	Not economically feasible
GIS mapping	X	X	--
Aerial photography and analysis	X	X	--
Systematic sampling	X	--	--
Regulatory information	X	--	--
Participation in land use programs	X	--	--

A respondent listed additional inventory and assessment techniques for permanent wetland habitats in Indiana:

* Look for runways in muck and trap them

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 permanent wetland habitats. There were no responses.

Recommended monitoring

Species monitoring

Respondents recommended the following monitoring techniques for effective conservation of wildlife in permanent wetland habitats in Indiana:

- Professional surveys
- Look for burrows in muck connected with trapping
- Muskrat: IDNR – Division of Fish and Wildlife uses harvest reports and professional surveys. The assumption is that aquatic systems include all habitat types occupied by muskrat
- Radio-track females to nesting sites; monitor nests for depredation (both are labor intensive for at least one person)

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for effective conservation of wildlife in permanent wetland habitats. There were no responses.

Habitat inventory and assessment

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

- Systematic sampling and GIS
- Blanding's turtle:

  - High resolution aerial photography
  - Monitor wetlands vegetation: Blanding’s turtles prefer floating emergents (e.g., duck weed) and get crowded out by cattail expansion**)**

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 effective conservation of permanent wetland habitats. There were no responses.

Technical experts and conservation organizations offered the following additional comments:

- The respondent is mostly concerned with Blanding's turtle. This is an important species but should also have input about other wildlife.

SHRUB/SCRUB WETLAND HABITATS NARRATIVE

Habitat description

Wetlands are areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al.

Shrub/scrub wetlands are areas where shrubland vegetation accounts for 25 to 100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

Problems affecting species and habitats

Species threats

The respondent listed no "critical threat", but cited the following as "serious threat" to wildlife in shrub/scrub wetland habitats in Indiana (not ranked):

- Habitat loss (breeding range)
- Habitat loss (feeding/foraging areas)
- Genetic pollution (hybridization)

The respondent listed the following as "somewhat of a threat" to wildlife in shrub/scrub wetland habitats in Indiana (not ranked):

- Invasive/non-native species
- Predators (native or domesticated)
- Near limits of natural geographic range
- Viable reproductive population size or availability
- Genetic pollution (hybridization)

The respondent listed the following as "slight threat" to wildlife in shrub/scrub wetland habitats in Indiana (not ranked):

- Unintentional take/direct mortality (e.g., vehicle collisions, power line collisions, by-catch, harvesting equipment, land preparation machinery)
- Small native range (high endemism)
- Specialized reproductive behavior or low reproductive rates

The respondent listed no other threats to wildlife in shrub/scrub wetland habitats in Indiana.

The respondent listed top threats to wildlife in shrub/scrub wetland habitats in Indiana (not ranked):

- Loss of early succession habitat
- Hybridization with blue-winged warbler

Habitat threats

The respondent listed the following as "serious threat" to shrub/scrub wetland habitats in Indiana:

- Successional change

The respondent listed as "somewhat of a threat" to shrub/scrub wetland habitats in Indiana (not ranked):

- Commercial or residential development (sprawl)
- Counterproductive financial incentives or regulations
- Habitat degradation
- Agricultural/forestry practices

The respondent listed the following as “slight threat” to shrub/scrub wetland habitats in Indiana (not ranked):

- Habitat fragmentation
- Impoundment of water/flow regulation

The respondent listed no other threats to shrub/scrub wetland habitats in Indiana.

The respondent listed top threats to shrub/scrub wetland habitats in Indiana (not ranked)

- Loss of early successional woody habitat
- Habitat loss due to development

Additional research and survey efforts

Current body of research

Species research

The respondent stated that the current body of science for wildlife in shrub/scrub wetland habitats is inadequate.

Respondents identified the following citations (title, author, date, publisher) that would give the best overview of wildlife in shrub/scrub wetland habitats in Indiana.

Title = BNA Account - Golden-winged Warbler;
Author = JL Confer;
Date = 1992;
Publisher = American Ornithologists' Union

Title = Birds of Indiana;
Author = R Mumford and C. Keller;
Date = 1984;
Publisher = Indiana Univerisity Press

Habitat research

The respondent stated that the current body of science for shrub/scrub wetland habitats is inadequate.

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

Title = see previous sources

Research needs

Species research

The respondent indicated that the following research for wildlife in shrub/scrub wetland habitats in Indiana is “greatly needed” (not ranked):

- Limiting factors (food, shelter, water, breeding sites)
- Threats (predators/competition, contamination)
- Relationship/dependence on specific habitats
- Population health (genetic and physical)

The respondent ranked the following research for wildlife in shrub/scrub wetland habitats in Indiana is “needed” (not ranked):

- Life cycle
- Distribution and abundance

The respondent cited no additional research needs for wildlife in shrub/scrub wetland habitats in Indiana.

Habitat research

The respondent indicated that the following research for shrub/scrub wetland habitats in Indiana is “greatly needed” (not ranked):

- Successional changes
- Relationship/dependence on specific site conditions
- Growth and development of individual components of the habitat

The respondent listed the following research as “needed” for shrub/scrub wetland habitats in Indiana (not ranked):

- Distribution and abundance (fragmentation)
- Threats (land use change/competition, contamination/global warming)

The respondent cited no additional research needs for shrub/scrub wetland habitats in Indiana.

Conservation actions necessary

Species actions

The respondent indicated that none of the listed conservation efforts address threats to wildlife in shrub/scrub wetland habitats in Indiana “very well.” The following efforts address threats “somewhat” (not ranked):

- Habitat protection
- Threats reduction
- Regulation of collecting
- Protection of migration routes
- Public education to reduce human disturbance

The respondent listed no other current conservation practices for wildlife in shrub/scrub wetland habitats in Indiana.

The respondent recommended the following for more effective conservation of wildlife in shrub/scrub habitats in Indiana (not ranked):

- Habitat protection
- Habitat manipulation

Habitat actions

From a list of conservation efforts presented, the respondent said the following addresses threats to shrub/scrub wetland habitats in Indiana "very well:"

- Succession control (fire, mowing)

The respondent stated that the following efforts address threats to shrub/scrub wetland habitats in Indiana "somewhat" (not ranked):

- Habitat protection through regulation
- Habitat protection on public lands
- Habitat protection incentives (financial)
- Habitat restoration on public lands
- Habitat restoration incentives (financial)
- Corridor development/protection
- Protection of adjacent buffer zone
- Restrict public access and disturbance
- Land use planning
- Technical assistance
- Cooperative land management agreements (conservation easements)

The respondent listed no other current conservation practices for shrub/scrub wetland habitats in Indiana.

The respondent recommended the following practices for more effective conservation of shrub/scrub habitats in Indiana (not ranked):

- Retard succession to desired habitat stage
- Incentives to conserve shrubby habitats

Proposed plans for monitoring

Current monitoring

Species monitoring

The respondent was aware of no monitoring efforts by state agencies for wildlife in shrub/scrub habitats in Indiana.

The respondent noted the following monitoring effort by other organizations for wildlife in shrub/scrub habitats in Indiana:

- Statewide once-a-year monitoring

The respondent listed no monitoring efforts by state agencies or other organizations as "very crucial" for conservation of wildlife in shrub/scrub wetland habitats in Indiana. The respondent listed as "somewhat crucial" the monitoring effort conducted by other organizations:

- Statewide once-a-year monitoring

The respondent listed no regional or local monitoring by state agencies for wildlife in shrub/scrub wetland habitats in Indiana.

The respondent listed the following regional or local monitoring by other organizations for wildlife in shrub/scrub wetland habitats in Indiana (not ranked):

- Federal Breeding Bird Survey statewide
- May Day bird count
- Summer bird count

The respondent listed the following organizations that monitor wildlife in shrub/scrub wetland habitats in Indiana (not ranked):

- USGS
- Birding groups

The respondent listed the following "frequently used" monitoring techniques for wildlife in shrub/scrub wetland habitats in Indiana (not ranked):

- Driving a survey route
- Volunteer/survey census

The respondent stated that the following techniques are "occasionally used" (not ranked):

- Modeling
- Spot mapping
- Mark and recapture
- Professional survey/census
- Trapping (by any technique)
- Representative sites
- Probabilistic sites

The respondent stated that "radio telemetry and tracking" are "not used but possible with existing technology and data" for wildlife in shrub/scrub wetland habitats in Indiana. The respondent listed no techniques that are "not economically feasible."

The respondent listed no monitoring techniques for wildlife in shrub/scrub wetland habitats in Indiana.

Habitat inventory and assessment

The respondent was aware of no inventory and assessment efforts by state agencies for shrub/scrub wetland habitats in Indiana.

The respondent listed the following inventory and assessment effort is conducted by other organizations for shrub/scrub wetland habitats in Indiana:

- Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment

The respondent ranked no efforts by state agencies or other organizations as "very crucial" for conservation of shrub/scrub wetland habitats in Indiana. Listed as "somewhat crucial" is the following monitoring technique conducted by other organizations:

- Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment

The respondent listed no regional or local inventory and assessment by state agencies for shrub/scrub wetland habitats in Indiana.

The respondent listed the following regional or local inventory and assessment by other organizations for shrub/scrub wetland habitats in Indiana:

- Statewide aerial imagery

The respondent cited the following organizations that monitor shrub/scrub wetland habitats in Indiana:

- USDA

The respondent cited no inventory and assessment techniques for shrub/scrub wetland habitats in Indiana that are "frequently used," "not used but possible with existing technology or data" or "not economically feasible." The respondent listed the following techniques as "occasionally used" (not ranked):

- GIS mapping
- Systematic sampling
- Modeling

The respondent offered no other inventory and assessment techniques for shrub/scrub wetland habitats in Indiana.

Recommended monitoring

Species monitoring

The respondent recommended the following monitoring technique for effective conservation of wildlife in shrub/scrub wetland habitats in Indiana:

- Spot mapping in appropriate habitats

Habitat inventory and assessment

The respondent recommended the following inventory and assessment technique for effective conservation of shrub/scrub wetland habitats in Indiana:

- Aerial/satellite imagery coupled with modeling

ALL AMPHIBIANS IN ALL HABITATS NARRATIVE

Problems affecting species and habitats

Species threats

Respondents ranked the top threats to all amphibians in all habitats in Indiana:

Rank	Threats to all amphibians in all habitats
1	Habitat loss (breeding range)
2	Habitat loss (feeding/foraging areas)
3 (tie)	Near limits of natural geographic range
3 (tie)	Dependence on irregular resources (cyclical annual variations) (e.g., food, water, habitat limited due to annual variations in availability)
4	Degradation of movement/migration routes (overwintering habitats, nesting and staging sites)
5	Small native range (high endemism)
6	High sensitivity to pollution
7	Invasive/non-native species
8	Predators (native or domesticated)
9	Bioaccumulation of contaminants
10	Dependence on other species (mutualism, pollinators)

A respondent listed additional threats to all amphibians in all habitats in Indiana (not ranked):

- Changes in burrowing crawfish or rodent populations that would impact the availability of burrows
- Introduction of fish into formally fishless breeding waters
- Development of barriers between the Crawfish frog's burrow and breeding waters

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

- Habitat loss and degradation
  - Ephemeral wetland. Most ephemeral wetlands have been destroyed in Indiana to provide deep-water habitats for ducks under the misguided notion that deeper was better for wildlife. These fish-infested deep waters have no habitat for plains leopard frog
  - Upland forested habitat
  - Land use changes or other factors impact the availability and persistence of suitable burrows. Development of barriers between the Crawfish frog's burrow and breeding waters
  - Increase of migration distance to breeding sites as a result of habitat loss.
- Invasive species

  - *Oxidus gracilis* is a non-native millipede that invades caves and impacts cave salamanders by preying on native food base; potential impact is unknown but could be significant
  - Reed canary grass, purple loosestrife and other invasive species decrease plant diversity, cover and overall wetlands health
- Extreme rarity and habitat specialization
  - Only two sites are known to have green salamanders in Indiana and this is a habitat specialist needing rocky outcrops in forested areas.
  - Hellbenders have a small geographic range and population size in Indiana. In other states, there is concern about low reproductive rates, but this is unknown in Indiana populations
- Introduction of fish into formerly fishless waters
  - Impacts Crawfish frogs

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the threats to all amphibians in all habitats. There were no responses.

Habitat threats

Respondents ranked the top threats to all amphibian habitats in Indiana:

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

Respondents did not list additional threats to amphibian habitats in Indiana

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

- Habitat loss, degradation and fragmentation
  - Due to deforestation
  - Of streams

  - Of ephemeral wetlands
  - Forestry practices that open the forest canopy around cave entrances can greatly impact habitat for cave salamanders, drying out the entrance to the point that it is not usable by salamanders
  - Cattle grazing, farming and development activities that affect the persistence of burrows for Crawfish frog in formally flooded or moist grasslands
  - Draining of breeding ponds and ditches and introduction of fish into breeding waters
- Invasive species in wetlands
  - Invasion by species like reed canary grass, cattails, purple loosestrife and other invasives create monocultures

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the threats to all amphibian habitats. There were no responses

Additional research and survey efforts

Current body of research

Species research

Eighty-seven percent of respondents consider the current body of science for all amphibians in all habitats in Indiana to be inadequate or non-existent. Twelve percent of respondents consider current body of science to be adequate.

Title = Amphibians and reptiles from 23 counties of Indiana.;
Author = Robert Brodman;
Date = 2003;
Publisher = Proceedings of the Indiana Academy of Science, 112: 43-54.

Title = The Status of Amphibians in Rural Northwest Indiana;
Author = Brodman, R., and M. Kilmurry;
Date = 1998;
Publisher = Iowa University Press, Iowa City, Iowa

Title = Discovery of green salamanders in Indiana and a distributional survey. In Status & Conservation of Midwestern Amphibians;
Author = Robert Madej;
Date = 1998;
Publisher = University of Iowa Press, Iowa City

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

Title = Multivariate analyses of the influences of water chemistry and habitat parameters on the abundances of pond-breeding amphibians.;
Author = Robert Brodman et al;
Date = 2003;
Publisher = Journal of Freshwater Ecology 18: 425-436.

Title = Ten- to eleven-year population trends of two pond-breedong amphibian species, red-spotted newts and green frogs. In Status & Conservation of Midwester;
Author = Spencer Cortwright;
Date = 1998;

Publisher = University of Iowa Press, Iowa City

Title = Green salamander: Family plethodontidae, Aneides aeneus Cope and Packard, 1881.;
Author = Pauley, T. K. and M.B. Watson;
Date = 2005;
Publisher = In: Amphibian Declines: The Conservation Status of United States Species. M. Lannoo, (ed.), University of

Author = www.natureserve.org/explorer

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 amphibians in all habitats. There were no responses.

Habitat research

All respondents consider the current body of science for all amphibian habitats in Indiana to be inadequate or nonexistent.

Title = Amphibians and reptiles from 23 counties of Indiana.;
Author = Robert Brodman;
Date = 2003;
Publisher = Proceedings of the Indiana Academy of Science, 112: 43-54.

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 amphibian habitats. There were no responses.

Research needs

Species research

Respondents indicated research needs for all amphibians in all habitats in Indiana, ranked in order of importance:

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

Respondents cited additional research needs for all amphibians in all habitats in Indiana as follows (not ranked):

- Quite little is known about much of the basic natural history of some amphibians
- Very little is known about the basic natural history, population ecology and abundance in Indiana of the lesser siren
- Some amphibians are in great need of study on all aspects of its ecology
- Metapopulation dynamics and migration distances to and from ephemeral wetlands for Spotted salamander
- How many ephemeral wetlands habitats within the landscape are needed to maintain healthy populations of some amphibians
- Buffer size and vegetation composition around ephemeral wetlands

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for all amphibians in all habitats. There were no responses.

Habitat research

Respondents indicated research needs for all amphibian habitats in Indiana, ranked in order of importance:

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

Respondents were specific about research needs for all amphibian habitats in Indiana:

- Factors that limit the distribution of sirens in Indiana
- Crawfish frog habitat needs to be adequately described
- Metapopulation dynamics and migration distances to and from ephemeral wetlands
- How many ephemeral wetlands habitats within the landscape are needed to maintain healthy populations of some amphibians
- Buffer size and vegetation composition around ephemeral wetlands

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for all amphibian habitats. There were no responses.

Conservation actions necessary

Species actions

Of a variety of potential actions, respondents ranked the following conservation efforts in order of ability to address threats to all amphibians in all habitats in Indiana:

Rank	Conservation efforts for all amphibians in all habitats
1	Habitat protection
2	Regulation of collecting
3	Threats reduction
4 (tie)	Exotic/invasive species control
4 (tie)	Public education to reduce human disturbance
5	Translocation to new geographic range

Respondents listed other current conservation practices for all amphibians in all habitats in Indiana (not ranked):

- Bullfrog tadpoles could be introduced into an area as by-product to fish stocking or from released pet tadpoles
- Study burrow-making crawfish and their burrows
- Wetland restoration

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

- Habitat protection and restoration. See list of habitats needing protection:
  - Ephemeral wetlands and wetland complexes
  - Forested upland habitat protection
  - Fishless breeding habitat
  - Historic ranges of species in question
    - Crawfish frog
    - Main threat to green salamander populations is deforestation resulting in loss, degradation or fragmentation of habitat. Logging activities should keep at least 100 meters of buffered forest habitat around rock outcrops and cliffs
  - Cave entrances from inappropriate management activities
- More species information
  - Green salamander: Little is known about the population biology, lifespan, mortality rates, dispersal, colonization of habitats, metapopulation dynamics and extent of arboreal activity
  - Sirens: We need to better understand factors that limit siren abundance and distribution

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the effective conservation of all amphibians in all habitats. There were no responses.

Habitat actions

Of a list of possible actions, respondents ranked the ability of the following conservation efforts to address threats to all amphibian habitats in Indiana:

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

Respondents listed other conservation practices for all amphibian habitats in Indiana (not ranked):

- Many current conservation practices and incentives programs promoted by biologists seem to be aimed at ducks and actually manage against some amphibians
- Development and retention of stormwater retention ponds

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

- Habitat protection and restoration. Habitats to be protected include:
  - Ephemeral wetlands
  - Forest protection
  - Those on public and private lands
  - Protect cave entrances from disturbance
  - Protection of buffers needed for amphibians migrating to ephemeral wetlands for breeding

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the effective conservation of all amphibian habitats. There were no responses

Proposed plans for monitoring

Current monitoring

Species monitoring

Respondents indicated knowledge about monitoring efforts conducted by state agencies for all amphibians in all habitats in Indiana (not ranked):

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

Respondents indicated knowledge of monitoring efforts conducted by other organizations for all amphibians in all habitats in Indiana (not ranked):

- Occasional regional or local (less than once a year and not regularly scheduled) monitoring
- Regional or local once-a-year monitoring
- Periodic regional or local (less than once a year but still regularly scheduled) monitoring
- Regional or local year-round monitoring

Respondents considered ranked the importance of monitoring efforts by state agencies for conservation of all amphibians in all habitats in Indiana:

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

5	Regional or local once-a-year monitoring

Appendix F-73: Amphibians

Respondents ranked the importance of monitoring efforts by other organizations for conservation of all amphibians in all habitats in Indiana:

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

Respondents listed the following regional or local monitoring efforts by state agencies for all amphibians in all habitats in Indiana (not ranked):

- IDNR Division of Fish and Wildlife's NAAMP and Frog Watch programs collectively are the statewide effort to monitor frog and toad populations in Indiana, including bullfrogs. The data can be analyzed regionally
- IDNR Division of Nature Preserves
- IDNR non-game herpetologist incorporates monitoring as part of annual field season

Respondents listed the following regional or local monitoring efforts by other organizations for all amphibians in all habitats in Indiana (not ranked):

- NW Indiana (Newton, Jasper, Pulaski, Lake, Porter counties)
- Chicago Wilderness
- Spencer Cortwright, IUN
- Robert Brodman, St. Joseph's College
- University professors and members of the Herpetology TAC for Indiana as part of their annual field season

Respondents listed the following organizations that monitor all amphibians in all habitats in Indiana (not ranked):

- Robert Brodman, St. Joseph's College
- Spencer Cortright, IUN
- Chicago Wilderness

The following table reflects the opinions of multiple respondents, thus multiple check marks are possible. Additionally, some of these differences may reflect different taxonomic group bias.

Respondents ranked existing monitoring techniques for all amphibians in all habitats in Indiana:

Monitoring techniques for all amphibians in all habitats	Used	Not used but possible with existing technology or data	Not economically feasible
Professional survey/census	X		
Probabilistic sites	X		
Trapping (by any technique)	X	X	
Representative sites	X		
Volunteer survey/census	X	X	
Driving a survey route	X		
Coverboard routes	X	X	
Reporting from harvest, depredation, or unintentional take (road kill, by-catch)	X		
Modeling	X	X	
Spot mapping		X	
Radio tracking and telemetry		X	
Mark and recapture		X	

Respondents listed these additional monitoring techniques for all amphibians in all habitats in Indiana (not ranked):

- Bullfrog tadpoles and adults are often recorded during amphibian surveys of particular sites, such as a military base or superfund site. Bullfrogs also are encountered and recorded during fish survey
- Sampling for eggs or larva

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for all amphibians in all habitats. There were no responses

Habitat inventory and assessment

Respondents noted their awareness of current inventory and assessment efforts by state agencies for all amphibian habitats in Indiana (not ranked):

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

Respondents noted their awareness of current inventory and assessment efforts by other organizations for all amphibian habitats in Indiana (not ranked):

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

Respondents ranked the importance of the following inventory and assessment efforts by state agencies for conservation of all amphibian habitats in Indiana:

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

	assessment

Respondents ranked the importance of inventory and assessment efforts by other organizations for conservation of all amphibian habitats in Indiana:

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

Respondents cited additional methods for regional or local inventory and assessment by state agencies for all amphibian habitats in Indiana (not ranked):

- Division of Fish and Wildlife nongame
- Frog call surveys include rural and agricultural areas throughout the state

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

- Indiana Karst Conservancy and local grottos
- Kankakee Sands and other Conservancy preserves. Staff evaluate the restored/cleared habitat to judge its ability to support plains leopard frog and other species of concern
- NW Indiana (Newton, Jasper, Pulaski, Starke, Lake and Porter counties), Robert Brodman
- Chicago Wilderness
- Robert Brodman, St. Joseph's College
- Cortwright monitors populations in Brown and Porter counties.
- Robert Brodman monitors populations in Owens County

Respondents listed organizations that conduct inventory and assessments for all amphibian habitats in Indiana (not ranked):

- Indiana Karst Conservancy and local grottos
- The Nature Conservancy
- Robert Brodman, St. Joseph's College

- IDNR nongame herpetologist
- University professors
- Members of the Herpetology TAC for Indiana

The following table reflects the opinions of multiple respondents, thus multiple check marks are possible. Additionally, some of these differences may reflect different taxonomic group bias.

Respondents ranked current inventory and assessment techniques for all amphibian habitats in Indiana:

Inventory and assessment techniques for all amphibian habitats	Used	Not used but possible with existing technology or data	Not economically feasible
Systematic sampling	X	X	
GIS mapping	X	X	
Aerial photography and analysis	X	X	
Modeling	X	X	
Voluntary landowner reporting		X	

Respondents summarized other inventory and assessment techniques for all amphibian habitats in Indiana as follows (not ranked)

- Visual estimation – has the entrance been changed in anyway from its historical configuration (forest canopy opened up, entrance enlarged or blocked, etc.)
- Visual estimate of amount of appropriate habitat being provided in restored areas
- If there was a significant decline in bullfrog habitat on state-owned properties, the state would hear about it from frog hunters
- Pit-fall trapping and coverboard objects adjacent to ephemeral wetlands; mark and recapture

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 amphibian habitats. There were no responses.

Recommended monitoring

Species monitoring

Respondents recommended the following monitoring techniques for all amphibians in all habitats in Indiana (not ranked):

- Trapping
  - Minnow trapping (mark recapture or telemetry)
  - Trapping during breeding migration

    - Pit-fall traps and coverboard objects near ephemeral wetland breeding sites
- Surveys and systematic sampling
    - Frog call
    - Tadpole
    - Eggs and larva
    - Near rocky outcrops
    - To determine how far adults are traveling to deposit eggs
    - During the fall at breeding sites

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for all amphibians in all habitats. There were no responses.

Habitat inventory and assessment

Respondents recommended the following inventory and assessment techniques for all amphibian habitats in Indiana (not ranked):

- Systematic sampling and GIS
- Systematic sampling (intensive) and GIS (less intensive)
- Urban residents could be encouraged to participate in the Frog Watch program
- Crawfish frog habitat can be described by a combination of hydrology, soil type, proximity to breeding waters and vegetation. These factors should be investigated to develop a model for crawfish frog habitat
- Pit-fall traps and coverboards can be used to assess population size and use of ephemeral wetlands for breeding. Mark and recapture can be used to determine migration patterns and use of specific ephemeral wetlands for breeding

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 amphibian habitats. There were no responses.

ALL BIRDS IN ALL HABITATS NARRATIVE

Problems affecting species and habitats

Species threats

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

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

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

- Natural succession/lack of periodic vegetative disturbance
  - Occurring in remaining shrub/scrub habitats
  - Fire suppression is a major threat to many, many wildlife species in the state. Savannah habitats are seriously degraded because fire suppression has allowed shade tolerant species to dominate the understory, changing the open savannah structure into a dense forest with an impenetrable understory. Fire keeps the structure open and results in a varied mosaic of habitats, including fire killed trees which provide both food and shelter
  - Ruffed grouse
    - Lack of periodic vegetative disturbance (man-made or natural every five to 10 years) that adequately opens the forest canopy, especially in the large contiguous areas in public ownership which form the core or heart of the residual and current grouse range
    - Potential habitat on private lands is fragmented due to small ownership and different ownership objectives that does not provide a consistent continuum of acceptable habitat for successful population dispersal. A recent population model analysis based on current habitat conditions and actual grouse population data for Indiana projects that ruffed grouse will potentially disappear as a viable species in much of their current range by 2007. Ruffed grouse population indices are now at the lowest levels recorded in over 40+ years
  - Serious reduction in timber management and sales on public lands, consequently endangered species habitats are disappearing in forests. Private timber sales and management is too haphazard to replace the severe losses of young forests on public lands
- Genetic pollution
  - Urbanization and domestication of "wild" mallards leading to the hybridization with domestic stock of ducks. The threat is one of unusual circumstance. As opposed to typical habitat loss or fragmentation, this threat constitutes displacement of Mallards into undesirable/unnatural areas creating nuisance problems and genetic integrity concerns. The developed land itself creates wild scale loss of high quality habitat for mallards. However, mallard ducks are adaptable creatures and have adapted to this developed environment. Nonetheless, their adaptability could also be their downfall in developed lands
- Overpopulation
  - Urban Canada geese are a real problem in Indiana. I deal specifically with Fort Wayne (Allen County). Canada geese have benefited from the way humans have altered the landscape within urban areas. Human-goose conflicts within the urban environment will increase
  - Devaluing of birds due to overpopulation
- Habitat loss due to agricultural practices/development
  - Mowing in June, July and August
  - Early harvesting of hay crops
  - Impacts of herbicides and pesticides drifting over from nearby agricultural lands in unknown
  - Continued loss and degradation of emergent wetland habitat in portions of the state due to development and poor agricultural practices

- Other human activity/interaction
  - Human interaction with some wildlife species (trapping, relocation, scaring)
  - Reproductive intervention by humans
  - Tolerance by building managers of nesting sites
  - Disturbance by recreational boating
- Restricted wildlife management options
- Lack of public knowledge/information
  - Ruffed grouse: Regarding the importance of disturbances and early successional habitat in forested areas is the main contributing factor to the near extirpation of the ruffed grouse. The lack of early successional habitats in forested areas is causing major declines in the ruffed grouse population
- Lack of research
  - We need to know the affect of silviculture and other land management, and how these effect demography (Cerulean Warbler)
- Parasitism
  - Brood parasitism by brown-headed cowbird likely has moderate to strong negative impact on population's success
  - Cowbird affects cerulean warblers

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

- Loss or change in farm programs
  - Loss or shortening of primary nesting season dates established by the USDA. Mowing or haying during the quail nesting season would be allowed on enrolled acreage if these dates were eliminated or shortened
- Habitat loss, degradation, fragmentation
  - Of brood-rearing, foraging and nesting areas
  - Of escape cover
  - Due to urbanization, clean farming and development
  - Redheaded woodpecker: Is more of an obligate to open areas with scattered dead trees than most Indiana species. Outright loss of this habitat configuration is probably the leading threat
  - Degradation of movement/migration routes
    - Isolation of habitat or islands of habitat with no connecting travel lanes
  - Loss of shallow marshes due to drainage for development and farming
  - Loss of winter feed due to fall tillage
  - Loss of water quality
  - Degradation of habitat by invasive plant species
  - Loss of early successional forest age class
  - Loss of emergent wetlands and adjacent foraging areas of native vegetation
  - Lack of large areas in native grass

  - Mowing during the breeding season
  - Degradation due to sedimentation, pollution
  - Degradation due to invasion by exotic species
  - Loss of large blocks of mature forest and increases in forest fragmentation that causes and increase in cowbird nest parasitism and increases edge nest predators (e.g., blue jays). This causes a decrease in recruitment
    - Habitat loss and fragmentation create small, isolated patches where nest predation and brood parasitism tend to increase
  - Because this is an area-sensitive species, a loss of large tracts of mature forest on both the breeding and wintering grounds is a critical threat
  - Timing and frequency of haying, as well as the cover type (alfalfa) can negatively affect nest success and limit productivity
  - With prevailing land management that does not generate early succession habitat (such as maturation of forest on former farm lands), habitat is reduced.
  - Loss of contiguous blocks of mature forest
- Natural succession/lack of periodic vegetative disturbance
  - Ruffed grouse
    - Lack of periodic vegetative disturbance (man-made or natural every five to 10 years) that adequately opens the forest canopy, especially in the large contiguous forested areas in public ownership which form the core of residual and current grouse range
    - Potential habitat on private lands is fragmented due to small ownership and different ownership objectives (lack of active timber management) that does not provide a consistent continuum of acceptable habitat for successful population dispersal
  - Fire suppression
- Genetic pollution
- Overpopulation and its effects
  - Population explosions and accompanying diseases, nuisance concerns, etc.
  - Canada geese: In developed lands habitats, the biggest threats are overpopulation and aggressive behavior during courtship/nesting
- Disease
  - Redheaded woodpecker: West Nile Virus is threat
  - Possible disease outbreaks due to large concentrations of birds in small areas
  - Loss of habitat (primarily American sycamores along riparian areas) in breeding areas
  - Loss and degradation of breeding and foraging habitats along river corridors and uplands
  - Loss of mature floodplain forest as nesting habitat
  - Loss of wintering habitat may be a primary threat
- Invasive species/predators
  - Domesticated animals

  - Loss of large blocks of mature forest and increases in forest fragmentation that causes and increase in cowbird nest parasitism and increases edge nest predators (e.g., blue jays). This causes a decrease in recruitment
  - House sparrow preemption of nests
  - Habitat loss and fragmentation create small, isolated patches where nest predation and brood parasitism tend to increase (cowbirds, blue jays)
  - Loss of nests and nesting females to cats, chipmunks, snakes and other ground predators
- Genetic pollution
  - Hybridization with blue-winged warbler
- Lack of management to maintain/create these types of habitats
- Preservationist (anti-management folks) and their influence on the politics of timber management and legal challenges to sound timber/wildlife management activities
- Lack of public knowledge/information
  - Ruffed grouse: Regarding the importance of disturbances and early successional habitat in forested areas is the main contributing factor to the near extirpation of the ruffed grouse. The lack of early successional habitats in forested areas is causing major declines in the ruffed grouse population
- Lack of research
  - We still have very little information on Cerulean Warblers. We need to assess basic demography in Indiana and across the breeding range, learn how this species responds to land management, develop an understanding of post-fledging habitat use, and determine the effect of the brown-headed cowbird on this species
- Human disturbance
  - Vandalism potential at nesting colonies
  - Human intervention during nesting process
- Low reproductive output
  - Possibly 'sink' populations due to poor habitat quality
- Collisions with buildings, power lines, other structures
- Low population size/edge of range

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

- Yes, although a few of the additional threats listed separately are important and consequential enough to be included in the initial table. The negative effects of brown-headed cowbird parasitism and improper habitat management on publicly-owned and private property(controlled burns in prairie and sanvannas, removal of invasive plants and propagation of native vegetation in forests, etc.) should be evaluated more exclusively. In addition, a lack of public education/involvement in conservation issues and funding for such efforts should also be considered as a threat to birds in all habitats.
- Loss of wetlands affects
  - staging areas for waterfowl
  - nesting and brood rearing sites.

  Grassland and prairie loss reduces nesting sites for waterfowl.

Habitat threats

Respondents ranked threats to all bird habitats in Indiana:

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

Respondents noted other threats to all bird habitats in Indiana (not ranked):

- Habitat loss, degradation, fragmentation
  - Drainage of wetland areas
  - Loss of wetlands due to off site changes in the water table, i.e. multiple well sites in suburban/rural areas
- Pollution can reduce productivity of aquatic habitats over which cliff swallows feed
- Public opinion and policy
  - Public acceptance of periodic vegetative disturbance (timber management) is necessary because the forest cover across the landscape no longer exists in the same continuum and natural forces no longer operate (or are allowed to operate, e.g., regional firestorms) as they did prior to settlement. The public needs to accept that man-made disturbances (e.g., even-age timber management) can be used to mimic natural disturbances on a smaller and controlled scale to create a diversity of habitats in the residual forested landscape where once such natural disturbances operated at a larger scale

  - Another threat is excessive environmental review and assessment that makes timber management on public lands so costly in agency resources that it is deemed unaffordable within budgeted resources and attracts public ire as being too costly
  - Legal jurisdiction issues presently unclear, draft of state isolated wetland law out for comment
  - If Farm Bill programs (e.g. CRP) were to be eliminated the negative effects on Indiana's northern bobwhite population would be substantial
- Lack of research
  - Exact habitat associations of some birds are not known -- not clear what is optimal habitat in Indiana in my view
- Mallards: Developed land itself creates a threat to "quality habitat" for mallards. Mallards in an urban/suburban setting face and create a whole host of problems (genetic pollution, nuisance ducks, possible fecal contamination, etc.)
- Loss of disturbance regimes/fire suppression
  - Loss of disturbance regimes that maintained the open structure of savannahs (and swamp-forests) where the redheaded woodpecker resides
  - Suppression of natural disturbances such as fire has resulted in a shift in some birds composition, structural complexity and landscape pattern across much of the region. Fire-intolerant species such as sugar maple and American beech have become established at the expense of fire-adapted oak and hickory species.
  - Before European settlement, fires, beavers, floods, and windstorms created extensive openings. The restoration of natural landscapes requires the re-introduction or simulation of these disturbances
- Invasive species/predators/parasites
  - Lack of fire results in an increase of shade-tolerant invasive species like garlic mustard and Asian bush honeysuckle, further degrading the savannah habitat
  - Not clear what is causing decline of the Cerulean Warbler; regionally brood parasitism and forest fragmentation may be negative impacts
- Climate: It may be possible the birds geographic range is shifting (climate?)

Respondents listed top threats to all bird <u>habitats</u> in Indiana (not ranked):

- Loss of disturbance regimes/fire suppression
  - Succession of the grassland habitat is a major threat if mid-contract activities are not performed
  - Lack of active timber management that adequately opens or removes the overhead forest canopy and allows for natural regeneration back into a forest cover
  - Absence of early successional habitat in forests. Absence of clear-cutting, and other disturbance types in forested habitats is the major cause of ruffed grouse habitat declines. Forestry practices that do not lead to early successional habitat development are the problem
- Agricultural or other development practices
  - Another threat is mowing or haying during the primary nesting season. These activities are not currently allowed until after July 15 but mowing during late July and early August still destroys some nests and young

  - Clean farming
  - Any changes in farming practices that causes the loss of escape cover (including along tree lines, fence lines and wood's edge)
  - Agricultural/forestry practices: Lack of active management to create/maintain habitats
  - Intensive agriculture and land use development have put a lot of pressure on remaining wetlands
  - Soil runoff caused by poor agricultural practices and urban development
  - Conversion of hayfields to row-crop or urban cover types
  - Frequent haying, mowing, or over-grazing (though some disturbance is necessary every one to five years to maintain the proper vegetation structure)
  - Changes in design of bridges and causeways to make them less suitable for nest placement
  - Design of buildings that do not provide nesting ledges
  - Urban sprawl; commercial or residential development
- Loss and fragmentation of wetlands
  - Of forested wetlands
  - Degradation of wetlands/plant communities by exotic plants invading wetland habitats
  - Of isolated wetlands
  - Destruction of beneficial areas for mallards (and other puddle ducks), i.e., wetlands, streams, small ponds, etc. These areas are converted to retention/detention ponds
  - Destruction of natural wetland habitats by development, agriculture and continued road construction
  - The loss of wetlands by draining to accommodate commercial and residential development still occurs at an alarming rate
- Shoreline habitat loss, fragmentation, degradation
  - Modification of stream shoreline habitats
  - Residential development around lake shorelines
  - Degradation of aquatic plants and wetlands around lake shorelines
- Channelization causing habitat loss, fragmentation, degradation
  - Loss due to stream channelization
  - Loss of nesting sites and brood habitat
  - Loss of vegetative and invertebrate communities. Channelization also alters the natural water flow which results in a much degraded habitat
- Riparian habitat loss, fragmentation, degradation
  - Stream and lake renovation have degraded habitat back to where it was when the original habitat destruction occurred
- Forest habitat loss, fragmentation, degradation
  - Loss of bottomland hardwoods continues to be a threat. These area provide a high quality food source and nesting sites for wood ducks
  - Destruction of nesting trees

  - Loss of high quality forest habitat (over mature uneven-aged forest)
  - Forest fragmentation enables cowbirds and blue jays to compete/predate. This results in lower quality habitat available to ceruleans
  - The cerulean's dependence on large tracts of mature deciduous forests, make the species especially sensitive to continuing forest fragmentation and isolation. The mechanism by which fragmentation affects populations in Indiana is unknown, but the response of this species to habitat fragmentation may be related to other factors associated with fragment size
  - Loss of floodplain sycamores and upland pine forests
  - Loss of cavity trees and harvest of older forests
  - Loss and habitat degradation of forested habitat along riparian areas and in uplands
  - Conversion of habitat to other than pine forests
- Grassland habitat loss
  - Conversion of savannah to agricultural and other development
  - Loss of large areas of warm season grasses and early mowing/haying
- General habitat loss, degradation, fragmentation
  - Habitat fragmentation that limits seasonal movements and population expansion; loss of connectivity
  - Drainage practices
- Urban sprawl creating attractive areas
  - For mallards to become "more domesticated" (i.e., retention/detention ponds)
  - Commercial and residential development with lakes and ponds offer all the resources Canada geese need to survive. With an overpopulation of Canada geese in urban areas; it's hard to say there is a habitat threat
- Public opinion/policy
  - Lack of public understanding and acceptance of timber management, especially even-age timber management
  - Lack of public understanding and acceptance that vegetative disturbance whether natural or man-made
  - Regulations
  - Grouse and many songbirds, need early forest successional stages and due to the current policies of the USDA Forest Service and some state properties, the grouse is being "not-managed" to extirpation
- Other human intervention
  - Feeding of birds by people
  - Human disturbance
  - Urban sprawl; commercial or residential development
- Overpopulation
  - Canada geese are their own worst enemy. Their concentrations by large numbers of geese on small wetlands have the capacity to pollute the water and cause increased erosion due to their feeding habits
- Predation/invasive species/competition

  - Brood parasitism by the brown-headed cowbird (Molothrus ater), and high rates of nest predation by generalist predators such as blue jay (Cyanocitta cristata) and raccoon (Procyon lotor). Fragmentation of forest in Indiana especially in predominately agricultural landscapes has resulted in small patches of forest surrounded by open habitat that cowbirds require for feeding and nest searching
  - Threats by gulls
- Lack of research
  - We still do not know the specific habitat preferences for this some birds. The types of habitats where some birds were especially abundant in the past (i.e. old-growth bottomland forest) no longer exist
- Specific dune habitat configuration
- Reduction in quantity and quality of prey populations
- Factors that affect food availability

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

- This is fairly reasonable, although it is a bit troubling that most of the additional comments, with the exception of cerulean warblers, are focused on waterfowl and upland game species. Certainly the protection of habitat utilized by ruffed grouse, for instance, will benefit other non-game brushland and successional forest species, but the strategy should also place greater emphasis on reversing the declination of neotropical migratory species like Black-billed Cuckoo, Blue-winged Warbler, Hooded Warbler, etc., which share similar habitats and are experiencing broader declines throughout their range. An additional threat which should also be assessed in this respect is monotypical habitat management strategies, especially when considering most publicly and privately-owned wetlands and their respective ecologies. Very few, if any, of these habitats are managed to support long-distance migratory shorebirds during both their north-bound and south-bound flights. It would appear that wetland management, when considering the waterlevels and surrounding vegetation, is narrowly focused on the support of waterfowl. At least a few of these properties should adequately and directly address the habitat needs of threatened species such as American Golden-Plover, Piping Plover, Marbled Godwit, Red Knot, etc., during migratory periods.

Additional research and survey efforts

Current body of research

Species research

Forty-six percent of respondents stated that the current body of science is complete, up to date and extensive or adequate for all birds in all habitats in Indiana; forty-four percent stated that information is inadequate or nonexistent.

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

Title = Bobwhite Quail Investigation;
Author = Maurice C. Reeves;
Date = 1954;

Publisher = Indiana Department of Conservation

Title = On the edge: a guide to managing for bobwhite quail;
Author = T. Dailey and T. Hutton;
Date = 2003;
Publisher = Missouri Department of Conservation

Title = Ducks, Geese & Swans of North America;
Author = Frank C. Bellrose;
Date = 1976;
Publisher = Stackpole Books

Title = Population status of ruffed grouse in Indiana;
Author = Steven E. Backs;
Date = Annual Progress Reports;
Publisher = Indiana Div. Fish and Wildlife

Title = The historic and present distribution of ruffed grouse in Indiana;
Author = Steven E. Backs;
Date = 1984;
Publisher = Ind. Acad. Sci. 93:161-166.

Title = Managing Canada Geese in Urban Environments;
Author = Arthur E. Smith, Scott R. Craven and Paul D. Curtis;
Date = 1199;
Publisher = Cornell Cooperative Extension

Title = Prevention and Control of Wildlife Damage;
Date = 1994;
Publisher = University of Nebraska

Title = Ducks,Geese &Swans of North America;
Author = Frank C. Bellrose;
Date = 1976;
Publisher = Stack Pole Books

Title = Waterfowl & Wetlands an Intergarted review;
Author = Theodore A. Bookout;
Date = 1979;
Publisher = LaCrosse Printing

Title = Ecology and Management of the Wood Duck;
Author = Bellrose and Holm;
Date = 1994;
Publisher = Stackpole Books

Title = Ducks, Geese and Swans of North america;
Author = Bellrose;
Date = 1976;
Publisher = Stackpole Books

Title = Red-headed Woodpecker (Melanerpes erythrocephalus). In The Birds of North America, No. 518;
Author = Smith, K. G., J. H. Withgott, and P. G. Rodewald.;
Date = 2000;
Publisher = The Birds of North America, Inc., Philadelphia, PA.

Title = 1998. Atlas of Breeding Birds of Indiana Atlas of Breeding Birds of Indiana;

Author = Castrale, John S., Edward M. Hopkins, and Charles E. Keller.;
Date = 1998;
Publisher = Indiana Department of Natural Resources

Title = 2003 Breeding Population Index of Northern Bobwhite Quail;
Author = James C. Pitman;
Date = July 16, 2004;
Publisher = IDNR F&W

Title = Population Ecology of the Bobwhite;
Author = John L Roseberry;
Date = 1984;
Publisher = SIU Press

Title = Canada Goose Management;
Author = Clarence Schoenfield/Ruth L. Hine;
Date = 1977;
Publisher = University of Wisconsin, Stevens Point

Title = Managing Canada Geese in Urban Environments;
Author = Smith/Craven/Curtis;
Date = 1999;
Publisher = Jack Berryman Institute Publication #16/ Cornell University Cooperative Extension, Ithaca, NY

Title = Spring Breeding Duck Survey;
Author = Kristen Chodacheck;
Date = 2003;
Publisher = IDNR

Title = Waterfowl Ecology & Management;
Author = Compiled by: Ratti, Flake, Wentz;
Date = 1982;
Publisher = The Wildlife Society

Title = The Birds of Indiana;
Author = Russel E. Mumford, Charles E. Keller;
Date = 1984;
Publisher = Indiana University Press

Title = Atlas of Breeding Birds of Indiana;
Author = John S. Castrale, Edward M. Hopkins, Charles E. Keller;
Date = 1998;
Publisher = Indiana Department of Natural Resources

Title = Unknown/Quail Investigations;
Author = Maurice Reeves;
Date = Unknown/Old;
Publisher = IDNR/Divsion of Fish & Wildlife

Title = Ruffed Grouse Restoration in IN;
Author = Steve Backs;
Date = 1984;
Publisher = N. Central Section of the Wildlife Soc.

Title = Characteristics of Drumming Habitat of Grouse in IN;
Author = Backs, Kelly, Major, Miller;
Date = 1984;

Publisher = Proceedings of Indiana Academy of Science: 94:227-230

Title = Atlas of Breeding Bird of Indiana;
Author = Castrale, Hopkins & Keller;
Date = 1998;
Publisher = Indiana Dept. of Natural Resources

Title = Birds of Indiana;
Author = Mumford;
Date = ?;
Publisher = Indiana University Press?

Title = Cerulean Warbler MS Thesis;
Author = Kirk Roth;
Date = 2004;
Publisher = Ball State University

Title = Cerulean Warbler MS Thesis;
Author = Cindy Basile;
Date = 2002;
Publisher = Ball State University

Title = HESPS in mine land MS Thesis;
Author = Travis Devault;
Date = 2000;
Publisher = Indiana State Univ

Title = Forest and Grassland Bird Productivity;
Author = Robb et. al.;
Date = 1998;
Publisher = USFWS internal report

Title = Habitat Selection and Territory Size of Cerulean Warblers in Southern Indiana;
Author = Cynthia M. Basile;
Date = 6/02;
Publisher = N/A

Title = Master's Thesis (Title Unknown);
Author = Kirk Roth;
Date = 6/2004

Title = Atlas of Breeding Birds of Indiana;
Author = J.S. Castrale, E.M. Hopkins, & C.E. Keller;
Date = 1998;
Publisher = IDNR

Title = Effects of management practices on grassland birds: Bobolink;
Author = Dechant, J.A., M.L. Sondreal, D.H. Johnson, L.D. Igl, C.M. Goldade, A.L. Zimmerman and B.R. Euliss;
Date = 2001;
Publisher = Northern Prairie Wildlife Research Center

Title = Eastern Towhee, Birds of North American account #262;
Author = Greenlaw, J.S.;
Date = 1996;
Publisher = The Birds of North America, Inc.

Title = Decline of the Rufous-sided Towhee in the eastern United States;

Author = Hagan, J.M.;
Date = 1993;
Publisher = Auk 110:863-874.

Title = Habitat selection and reproductive success of Cerulean Warblers in Southern Indiana;
Author = Kamal Islam and Kirk L.Roth;
Date = December 2004;
Publisher = Department of Biology Technical Report No. 4, Ball State University, submitted to U.S. Fish & Wildlife Service, Fort Snelling, MN

Title = Relative abundance and habitat selection of Cerulean Warblers in Southern Indiana;
Author = Kamal Islam and Cynthia Basile;
Date = December 2002;
Publisher = Department of Biology Technical Report No. 1, Ball State university, final report submitted to U.S. Fish & Wildlife Service, Fort Snelling, MN

Title = Peregrine Falcon nesting and management in Indiana;
Author = Castrale, J.S., and A. Parker;
Date = 1999;
Publisher = Indiana Audubon Quaterly 77:65-74.

Title = Midwest Peregrine Falcon Restoration - 2004 Annual Report;
Author = Tordoff, H.B., J.A. Goggin, J.S. Castrale;
Date = 2004;
Publisher = The Raptor Center at the Univ. of Minnesota

Title = Atlas of Breeding Birds in Indiana;
Author = Castrale, J.S., E. Hopkins, C.E. Keller;
Date = 1998;
Publisher = IDNR

Title = Piping Plover Recovery Plan;
Author = USFWS;
Date = unknown;
Publisher = USFWS

Title = Breeding Bird Atlas of Indiana;
Author = Castrale, J.S., E. Hopkins, C. Keller;
Date = 1988;
Publisher = IDNR

Title = BNA Account - Yellow-throated Warbler;
Author = G.A. Hall;
Date = 1996;
Publisher = American Ornitholgists' Union

Title = Breeding Bird Atlas of Indiana;
Author = Castrale, Hopkins, Keller;
Date = 1988;
Publisher = IDNR

Title = BNA Account - Pileated Woodpecker;
Author = E.L. Bull and J.A. Jackson;
Date = 1995;
Publisher = American Ornitholgists' Union

Title = Atlas of Breeding Birds of Indiana;

Author = Castrale, JS., E Hopkins, C Keller;
Date = 1988;
Publisher = IDNR

Title = BNA Account - Red-shouldered Hawk;
Author = ST Crocoll;
Date = 1994;
Publisher = American Ornithologists' Union

Title = Atlas of Breeding Birds of Indiana;
Author = Castrale, JS, E Hopkins, C Keller;
Date = 1988;
Publisher = IDNR

Title = BNA Account - Savannah;
Author = Wheelwright and Rising;
Date = 1993;
Publisher = American Ornithologists' Union

Title = BNA Account - Golden-winged Warbler;
Author = JL Confer;
Date = 1992;
Publisher = American Ornithologists' Union

Title = Birds of Indiana;
Author = R Mumford and C. Keller;
Date = 1984;
Publisher = Indiana Univerisity Press

Title = Atlas of Breeding Birds in Indiana;
Author = Castrale, Hopkins, and Keller;
Date = 1998;
Publisher = Indiana Department of Natural Resources

Title = Cerulean Warbler Status Assessment;
Author = Paul Hamel;
Date = 2000;
Publisher = US Fish & Wildlife Service

Title = BNA Species Account - Cerulean Warbler;
Author = Paul Hamel;
Date = 2000;
Publisher = American Ornitholgists' Union

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 birds in all habitats. Their responses included:

- No. With the exception of DeVault's MS thesis, much of the published research by the Peter Scott and Steven Lima (Indiana State University) regarding the productivity of reclaimed strip mines for grassland species has been omitted. Given the relative size of these areas in southwestern Indiana and the decline which grassland species are experiencing across their range, more emphasis should be placed on this type of research and documentation. Two published examples include "Breeding bird communities of reclaimed coal-mine grasslands in the American midwest" (J. Field Ornithology, 73(3):268-275, 2002) and "Reclaimed coal mine grasslands and their significance for Henslow's sparrows in the American midwest" (The Auk 118(2):422-431, 2001). Another noted omissions include "Partners in Flight

Continental Priorites and Objectives Defined at the State and Bird Conservation Region Levels - Indiana" (Kenneth V. Rosenberg) and "Partners in Flight North American Landbird Conservation Plan". These reports, utilizing BBS data, present the best population estimates for most landbird species both in Indiana and in the United States.

Habitat research

Forty percent of respondents stated that the current body of science is complete, up to date and extensive or adequate for all bird habitats in Indiana; fifty-two percent stated that information is inadequate or nonexistent.

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

Title = Vegetation management practices on conservation reserve program fields to improve northern bobwhite habitat quality;
Author = Greenfield, K. C.; W. B. Burger Jr.; M. J. Chamberlain, E. W. Kurzejeski;
Date = 2002;
Publisher = Wildlife Society Bulletin

Title = Statewide Forest Inventory;
Author = ?;
Date = periodic;
Publisher = US Forest Service/IDNR

Title = Managing Canada Geese in Urban Environments;
Author = Arthur E. Smith, Scott R. Craven and Paul D. Curtis;
Date = 1999;
Publisher = Cornel Cooperative Extension

Title = Soil Survey's of Indiana Counties;
Author = U.S. Dept. of Agriculture, SCS;
Date = 1990;
Publisher = U.S. Dept. of Agriculture

Title = Management of Seasonally Flooded Impoundments;
Author = Leigh H. Fredrickson, T. Scott Taylor;
Date = 1982;
Publisher = U.S. Fish and Wildlife Service

Title = Wetlands; Author = Mitsch & Gosselink;
Date = 1993;
Publisher = Van Nostrand Rheinhold

Title = Southern Forested Wetlands;
Author = Messina & Conner;
Date = 1998;
Publisher = CRC Press LLC

Title = Surviving where ecosystems meet: ecotonal animal communities of midwestern oak savannas and woodlands;
Author = Temple, Stanley A.;
Date = 1998;
Publisher = Transactions of the Wisconsin Academy of Sciences, Arts and Letters 86:206-222

Title = Savannas, barrens, and rock outcrop plant communities of North America;
Author = Anderson, Roger C., Fralish, James S. , and Baskin, Jerry M.;
Date = 1999;
Publisher = Cambridge University Press

Title = Some Aspects of the Relationship between Land and Utilization and Bobwhite Quail;
Author = John L. Roseberry;
Date = 1960;
Publisher = SIU Press

Title = The Bobwhite Quail - Its Life and Management;
Author = Walter Rosene;
Date = 1969;
Publisher = Rutgers University Press

Title = Canada Gose Management;
Author = uk;
Date = uk;
Publisher = uk

Title = Waterfowl & Wetlands- Integrated Review;
Author = Edited : Bookhout;
Date = 1979;
Publisher = The Wildlife Society

Title = Creating Freshwater Wetlands;
Author = Hammer;
Date = 1997;
Publisher = CRC Press

Title = Cerulean Warbler MS Thesis;
Author = Kirk Roth;
Date = 2004;
Publisher = Ball State University

Title = Cerulean Warbler MS Thesis;
Author = Cindy Basile;
Date = 2002;
Publisher = Ball State University

Title = Strip mine grassland birds;
Author = Travis Devault;
Date = 2000;
Publisher = Indiana State Univ.

Title = The natural regions of Indiana;
Author = Homoya, M.A., D.B. Abrell, J.R. Aldrich, and T.W. Post;
Date = 1985;
Publisher = Proceedings of the Indiana Academy of Science 94:245-268

Title = Indiana Natural Heritage Data Center Community Classifications;
Publisher = Unpublished Data

Title = The Natural Regions of Indiana;
Author = Homoyo, Abrell, Aldrich, and Post;
Date = 1985;
Publisher = Indiana Academy of Science

Title = Indiana Natural Heritage Data Center;
Publisher = unpublished data

Title = The Natural Regions of Indiana;
Author = Homoya, Abrell, Aldrich, and Post;
Date = 1985;
Publisher = Indiana Academy of Science

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 bird habitats. Their responses included:

- Yes, but please include the research noted in the above box addressing reclaimed coal mine grasslands.

Research needs

Species research

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

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

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

- Bobwhite quail: Research to determine the extent to which mowing and haying negatively impact production following the end of the primary nesting season (as defined by the USDA). Following July 15 in Indiana landowners can mow or hay there enrolled lands. I believe a substantial proportion of bobwhites are still nesting at that time
- Ruffed grouse: Whether the distribution of early successional habitat is now so poor and low (as are ruffed grouse populations) that the disappearance of ruffed grouse from local areas now expand into a more regional or complete extinction
- Mallards
  - To determine the genetic integrity of mallards in developed areas
  - To determine effective management tools and a management plan of mallards in developed lands
- Canada geese
  - Movement pattern of urban Canada geese
  - Affinity for Canada geese hatched in an urban environment to move or migrate back to a similar environment

  - Research is needed to justify extending or modifying the hunting seasons to eliminate the problem of the so-called nuisance goose in urban areas, around lakes and golf courses
  - Ways to reduce urban populations
  - Impact of high snow goose populations on Canada geese nesting sites
- Develop more effective dispersal, relocation or removal techniques for maxima geese
- How to reduce clean farming and increasing field size
- Detailed demographic data need to be gathered and the effects of habitat structure and fragmentation on those demographic parameters understood
- Harvest; survival/nest success
- Food availability throughout annual cycle; ways to deter use
- Dispersal and repopulation methods of isolated habitats
- Cerulean warblers: Effects of Forestry practices on demography and presence and absence of cerulean warblers (TNC) proposed study
- Timing of agricultural practices in relation to the timing of breeding; reproductive loss due to agricultural practices
- Eastern towhee: It is a well-known, fairly common species. The general life-history literature is extensive. Population trends, habitat needs and threats are not well defined for Indiana. The documented population declines in databases such as the Breeding Bird Surveys are poorly explained

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

- No. Although research for Canada Geese and Mallards may be needed, it should not exceed the prioritization of species experiencing significant decline in both population and preferred habitat. More research emphasis should be placed on the productivity and survivability of birds facing the greatest declines - for instance, Henslow's sparrow (96% decline in the last 30 years), Short-eared Owl (30%), Cerulean Warbler (80%), Loggerhead Shrike (77%), Grasshopper Sparrow (77%), etc.
- Snow goose populations are not affecting Canada goose nesting sites in Indiana.

Habitat research

Respondents ranked research needs for all bird habitats in Indiana:

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

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

- Seeding mixtures and mid-contract management activities currently utilized on farm bill lands need to be evaluated to determine their value to bobwhite nesting and brood rearing
- Mallards
  - To determine the long term effects of mallards in developed lands on the overall mallard population
  - To device management tools and concepts to help professionals manage better for mallards in developed lands
- How to create and maintain quality grassland habitat on a permanent basis
- Affects of channelization on stream bank communities and the affects on adjacent oxbows, bottomland hardwoods and other riparian areas
- Relationship of fire to habitat structure needs to be better elucidated
- Canada geese
  - Habitat needs should be researched in an attempt to find and propagate habitats that are esthetically pleasing to humans for urban settings yet displeasing to geese.
  - Ways to exclude geese
  - How to keep emergent wetlands more attractive to Canada geese to reduce their use of manmade habitats in the urban community
- Availability throughout annual cycle
- Location and distribution of shrub/scrub habitat
- Cerulean warblers: Effects of forestry practices on cerulean warbler presence or absence and on demography
- Timing and frequency of haying and other agricultural disturbances
- Eastern towhees: Forest succession is well understood in Indiana. But the relationship between towhee occupancy and habitat age is not explicitly well studied here

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

- See previous comments

Conservation actions necessary

Species actions

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

Rank	Conservation efforts for all birds in all habitats
1	Stocking
2	Population management (hunting, trapping)

3	Habitat protection
4	Protection of migration routes
5	Regulation of collecting
6	Reintroduction (restoration)
7	Food plots
8 (tie)	Threats reduction
8 (tie)	Disease/parasite management
9	Culling/selective removal
10 (tie)	Exotic/invasive species control
10 (tie)	Limiting contact with pollutants/contaminants
11 (tie)	Population enhancement (captive breeding and release)
11 (tie)	Native predator control
11 (tie)	Translocation to new geographic range
12	Public education to reduce human disturbance

Respondents noted additional conservation practices for all birds in all habitats in Indiana (not ranked):

- Habitat alteration
- Fire management in savannahs; water level management in swamp forests
- Restoration of native grasslands and increased enrollment in Conservation Reserve Program provide refuges from agricultural disturbances (provided the proper vegetation structure is maintained)
- Education of public to reduce losses due to exotic predators such as cats is probably important to some local populations

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

- Bobwhite quail: The most important practice that would benefit bobwhites in shrub/scrub habitat would be to spend more time educating the public about what constitutes suitable quail habitat
- Mallards
    - Habitat protection
    - Population management makes use of surplus numbers and regulates take ("The Mallard" by John Madson, Olin Mathieson Chemical Corporation)
- Eastern towhees
    - The major need is regional land management plans that retain young forest age classes and mixes of habitats within regional landscapes
    - Exotic plant control: Garlic mustard and Amur honeysuckle have the ability to change vegetative structure of ground and understory layers. As ground nester and ground forager, towhees could be affected, but this is unstudied

- Canada geese
  - Modification of hunting seasons and opening of urban areas to hunting to reduce numbers of so-called nuisance geese populations in lieu of nest destruction and egg shaking
  - Population reduction
- Pine warblers: Prescription burning to maintain sparse understory in mature pine forests may potentially help this species, for example on DNR lands. (Suggested reference: Rodewald, P.G., J.H. Withgott, and K.G. Smith. 1999. Pine Warbler (Dendroica pinus). In The Birds of North America, No. 438 (A. Poole and F. Gill, eds.). The Birds of North America, In., Philadelphia, PA)
- Ruffed grouse
  - Habitat decline must be addressed. Methods to initiate active timber/wildlife management on the landscape is necessary to stem the serious decline of ruffed grouse
  - Immediate production of early successional stages of vegetation on public lands. Forestry practices such as clear-cutting and certain select cutting methods are needed to provide the habitat that is essential to returning ruffed grouse populations to earlier levels
- Cerulean warblers
  - We desperately need to learn how silvicultural activities and land management affect this species. Are there silvicultural activities (such as single-tree selection) that actually improve cerulean warbler habitat
  - Increasing the size and reducing the fragmentation of forest blocks within the state will likely improve habitat for this species
  - Habitat protection (maintenance of old-growth/mature forest components in Indiana)
  - Additional research (nest productivity, annual monitoring of populations to assess trends in population numbers)
    - Hamel, P.B. 2000. Cerulean Warbler (Dendroica cerulea). In The Birds of North America, no. 511 (A. Poole and F. Gill, Eds.). The Birds of North America, Inc., Philadelphia
    - Islam, K. and K.L. Roth. 2004. Habitat Selection and Reproductive Success of Cerulean Warblers in Southern Indiana. Final report submitted to U.S. Fish and Wildlife Service, Fort Snelling, MN, December 2002. Department of Biology Technical Report No. 4, Ball State University, Muncie, Indiana 51pp. Islam, K. and C. Basile. 2002. Relative abundance and habitat selection of Cerulean Warblers in Southern Indiana. Final report submitted to U.S. Fish and Wildlife Service, Fort Snelling, MN, December 2002. Department of Biology Technical Report No. 1, Ball State University, Muncie, Indiana 76pp
- Forestlands
  - Active timber management, especially on the larger blocks of public forestlands, especially those timber management practices that remove at least 75 percent of the overhead canopy
  - Increasing the area of mature forest in the landscape and decreasing fragmentation. The conservation of existing forestland is also critical
  - Incentives to conserve wooded riparian corridors and responsible forestry practices

- Wetlands
  - Restore wetlands and providing quality upland nesting cover adjoining these wetlands
  - Reduce fall tillage near wetlands
- Shrub/scrub habitat
  - Establishment of more shrub/scrub habitat
- Grasslands
  - Permanent protection of grassland habitat; long-term fire management
  - Conservation and active management of grassland habitats
- Limit disturbance
  - By humans and predators if birds ever recolonize Indiana's Lake Michigan shoreline
  - In nesting/migration habitat
- Habitat protection (intensive); reproduction and protection (Ducks, Geese and Swans of North America, Bellrose); protection of migration routes (intensive)
- Hunting
- Hen houses; habitat conservation; buffer zones
- Enhance migratory/staging habitat; enhance breeding habitat where populations do not conflict with land use
- Continue 5-year surveys
- Remove habitat in urban zones
- Vegetative succession control to provide early successional plant species
- Develop practices and procedures to increase harvest of local birds
- Exotic/invasive species control
- Nesting habitat needs to be improved in areas where possible, thereby reducing nest depredation; traditional migration corridors of Indiana should be improved and enhanced through water level management where possible
- Time and haying and grazing around the breeding cycle, before May or after June
- Continued use of bridge architecture that favors nest placement
- Education/awareness of falcon needs for feeding and nesting
- Prevention of stream channelization and other (pollution) habitat factors
- Require mid-contract management (e.g., discing or burning) between three to five years after establishment on all Farm Bill acreage planted to grasses

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

- Absolutely not - habitat protection should be the first priority for conservation efforts. Stocking typically can only advance the populations of waterfowl and upland gamebirds in the short-term; this leaves the conservation needs of non-game passerines and non-passerines as well as the long-tern stabilization of game species' populations unaddressed.

- The effects of urban hunting on Canada goose populations need to be addressed. If the urban geese do not enter areas that are suitable for hunting changing seasons will have no affect on the problem.

  Habitat protection is the most important issue to address.

Habitat actions

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

Rank	Conservation efforts for all bird habitats
1	Habitat restoration on public lands
2	Artificial habitat creation (artificial reefs, nesting platforms)
3 (tie)	Habitat restoration incentives (financial)
3 (tie)	Succession control (fire, mowing)
4 (tie)	Land use planning
4 (tie)	Habitat protection on public lands
5	Managing water regimes
6	Cooperative land management agreements (conservation easements)
7	Habitat restoration through regulation
8	Corridor development/protection
9	Habitat protection incentives (financial)
10	Restrict public access and disturbance
11	Habitat protection through regulation
12	Selective use of functionally equivalent exotic species in place of extirpated natives
13	Technical assistance
14	Pollution reduction
15	Protection of adjacent buffer zone

Respondents listed other current conservation practices for all bird habitats in Indiana (not ranked):

- Some states have policies or regulations that specifically mandate that a certain percentage of their public lands will be maintained in early successional and transitional forest types

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

- Habitat protection through regulation/legislation

  - This is the only sure way to protect habitat without public ownership
  - Making mid-contract management mandatory on enrolled acreage
  - Habitat conservation regulations
  - Habitat protection and restoration through incentives are the best means to conserve the Canada goose in emergent wetlands. However, it is difficult for the government to compete financially with developers
  - Lobby for legislation that would protect any remaining wetlands

- Create incentives for landowners
  - Provide incentives to prevent landowners from haying or grazing during the breeding season
  - INDFW already provides financial incentives to maintain or establish bobwhite habitat on private land. These incentives do help some to provide quality bobwhite habitat
  - Restoration bottomland hardwoods through the Farm Bill and other incentive programs
  - Create easements to protect existing wetlands or to restore wetlands
  - Incentives to conserve floodplain forests
  - Incentives to preserve forests and use good timber managements practices
  - Incentives to conserve wooded riparian corridors
  - Incentives for conserving and managing grasslands
  - Incentives to conserve shrubby habitats
  - Encourage tree plantings in floodplain areas where forest has been removed
- Control succession
  - Setting back succession with burning or discing
  - Active timber management that removes at least 75 percent of the existing forest canopy on a proportion every five to 10 years on an 80 to 120 year rotation (depending on site constraints and management objectives) using primarily even-age timber management techniques
  - Implement forestry practices that will benefit early successional species including gray fox, bobcat and woodcock, as well as ruffed grouse
  - Due to natural succession and the reduction of natural disturbance, sugar maple and American beech are increasing in stand density and basal area at the expense of the oak-hickory overstory throughout many of the forests in the state. A shift in forest composition from oak-hickory to maple-beech dominated forests has implications for many wildlife species. This shift could result in a reduction of species richness and abundance within forest bird communities and may negatively influence the cerulean warbler. Differences in foliage and bark structure may affect arthropod (spiders and related species) availability for this species. And, the short-petioled leaves and furrowed bark of oak trees compared to maples may provide better foraging opportunities for these birds
  - Encourage forest management plans that retain/create mix of young and older forest should retain towhees in regional avifaunas. Forest habitat restoration provides habitat in early stages
  - Retard succession to desired habitat stage

- Purchase, protect and restore public land; prevent habitat loss, fragmentation, degradation
  - Purchase of remnant savannahs, restoration of savannahs that have undergone succession to forest or have been farmed
  - Maintain mature floodplain forest
  - Reduce or eliminate stream and ditch channelization
  - Create buffers
  - Protect and enhance wetland and riparian habitats
  - Woodland edge feathering
  - Develop shrub corridor/hedgerows
  - Critical habitat for cliff swallows is nesting sites, most are on public (DOT) structures (bridges)
  - Improve water quality, etc. for feeding areas
  - Habitat protection (maintenance of old growth/mature forest components in Indiana)
  - Protection of nesting habitat along streams
- Control invasives
  - Control plant species that spread by vegetative means that from thick colonies such as cattail
  - Get rid of the invasive species degrading savannah habitats, including those invasive species deliberately plant by wildlife agencies
- Land use planning
  - Landscaping to exclude Canada geese
  - Removal of habitat in urban zones

- Create food plots
- Technical assistance
  - To maintain habitat in shrub/scrub type
  - Educate landowners about the importance of their land to the persistence of some birds
- Public education
  - Educate the public to understand that habitat management in this day and age is necessary if we are to provide habitat for specialist species whose populations are in peril
  - Education/awareness programs for building managers
- Promote wildlife-friendly agricultural practices
  - Preventing early mowing/haying
- Manage water regimes
  - Actively manage the water levels if at all possible to insure ducklings will fledge and to encourage use by spring and fall migrants
  - Water regime management for migration habitat

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

- Yes.
- Removing habitat in urban zones will be difficult. The ponds in the urban areas attracts ducks and geese and then the green grass the people have in there yards feeds the geese. People want there grass to be green and until they let it go brown and die the geese and ducks are going to eat it.

  Need to protect private lands.

Proposed plans for monitoring

Current monitoring

Species monitoring

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

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

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

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

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

Rank	Monitoring efforts by state agencies for conservation of all birds in all habitats
1	Statewide once-a-year monitoring
2	Regional or local once-a-year monitoring

3	Statewide year-round monitoring
4	Occasional statewide (less than once a year and not regularly scheduled) monitoring
5	Periodic statewide (less than once a year but still regularly scheduled) monitoring
6	Regional or local year-round monitoring
7	Periodic regional or local (less than once a year but still regularly scheduled) monitoring
8	Occasional regional or local (less than once a year and not regularly scheduled) monitoring

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

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

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

- The Indiana Division of Fish and Wildlife conducts annual spring whistle counts on 77 established routes across the state. The division also conducts biennial surveys of small game license holders to assess bobwhite harvest. However, neither of these surveys are focused directly on shrub/scrub habitat or Farm Bill habitat
- Division of Fish and Wildlife properties in northern Indiana
- Ruffed grouse
    - Eight roadside spring drumming survey (drumming indices) conducted in primarily in south central Indiana
    - Activity Center counts on the 900-acre Maumee Grouse Study Area in Jackson/Brown counties
- Regionally (throughout the state): Waterfowl breeding status surveys, population surveys
- Regionally (throughout the state): Statewide trapping, banding, and recapture efforts

- Geese
  - Division of Fish and Wildlife conducts Canada goose banding yearly. This consists of neck collars and leg bands
  - Waterfowl surveys
  - Hunter harvest reports
- Interlake Property, Division of Outdoor Recreation ownership
- State monitoring: banding and nest box surveys
- Wood duck
  - Several fish and wildlife areas perform annual wood duck banding. These properties include Hovey Lake, Glendale, Minnehaha, Willow Slough, Jasper-Pulaski, LaSalle, Pigeon River and Tri-County fish and wildlife areas. There may be others
  - Many of these properties also conduct nest box monitoring activities on an annual basis
  - Indiana participates in the Harvest Information Program which can provide information about migration, population index and/or trends, as well as information about the amount of hunting pressure
- Routes throughout the state by Division of Fish and Wildlife biologists
- Fish and wildlife areas and reservoirs as part of the weekly waterfowl survey from August to January
- Hovey Lake, Tri-County, Jasper Pulaski, Pigeon River, Winamac, Willow Slough, LaSalle fish and wildlife areas
- At present only when a permit for work in a wetland is applied for; smaller more numerous wetlands have little oversight
- Statewide for existing and new colonies every five years
- Quail
  - Quail whistling counts in selected counties
  - Hunter/Harvest surveys by geographic regions
  - Bird Breeding survey in survey blocks
  - Winamac FWA conducts annual bobwhite whistle call survey on that property
- In southern Indiana in the unglaciated forested region
- All state fish and wildlife properties
- Local breeding bird surveys done on state properties and private land. State cooperates in national breeding bird survey. State biologists also survey in local habitats (e.g., Patoka River)
- IDNR Nongame and Endangered Wildlife Program
- Indiana Breeding Bird Atlas project through DNR determines statewide distribution periodically. Does not produce quantitative measure of population size. These are not tied to this habitat type, but frequency of the other cerulean habitats in the BBS coverage is low so most data refer to this habitat
- Statewide breeding bird atlas efforts are coordinated by the state DNR. This atlas effort was done in the 1980s, and is being redone now. Also the state DNR nongame bird program coordinates publication of a summer bird count that generates some data on towhee numbers (along with all other summer birds. No analysis is done, however

- DNR monitors most nest sites in the state and obtains information from others
- Breeding Bird Atlas statewide every 20 years
- Awareness of reports by bird watchers
- Periodic statewide Breeding Bird Atlas

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

- Breeding Bird Survey
  - Is conducted by the National Audubon Society and observers counts the number of bobwhites seen along with other bird species. Again this survey is not directly focused on Farm Bill habitats
  - Includes routes in Indiana that incorporate sites occupied by the redheaded woodpecker. This annual survey will therefore potentially count redheaded woodpeckers at a few sites yearly
  - BBS routes and work done on strip-mined lands in southwest Indiana and Big Oaks National Wildlife Refuge
  - BBS routes provide some information for this species. However, most routes are located along roads and do not adequately monitor interior forest species such as the cerulean
  - Hoosier National Forest conducts breeding bird point counts each year along points located in interior forest blocks or varying fragment size. Although the cerulean is not the focus of this study, data is collected on its occurrence
  - U.S. Geological Survey roadside Breeding Bird Survey. These are not tied to this habitat type, but frequency of the other cerulean habitats in the BBS coverage is low so most data refer to this habitat
  - At Big Oaks National Wildlife Refuge
  - At Hoosier National Forest
- Christmas, May Day and summer bird counts
  - Audubon supports May Day count throughout state that detects cerulean warblers.
  - Different Audubon members and clubs may be involved in Christmas Bird Counts and with an intensive Bird-a-Thon in the spring
- Species occurrence noted during the Statewide Breeding Bird Atlas Project (only one ever done)
- Population surveys
- Fish and wildlife properties in northern Indiana, natural lakes and nature preserves
- Ducks Unlimited conducts waterfowl surveys
- Muscatatuck National Wildlife Refuge (performs wood duck banding)
- Quail Unlimited chapters
- Lake associations, businesses and anyone living around a emergent wetland with a yard and has Canada Goose complaints will monitor populations to prove they have a problem so they can destroy nests or eggs
- Habitat changes requiring permits are checked by, IDNR, IDEM, U.S. Army Corps of Engineers (in some cases)

- On state properties or USDA Forest Service land where populations have been known to exist
- The major state watersheds, particularly Kankakee and St Joseph river watersheds in the north, Tippecanoe and Wabash river in central and Wabash Ohio river watersheds in the south
- Various university personnel may also be involved in surveying wetlands periodically throughout the year
- Cornell Lab of Ornithology collects data on the cerulean warbler for the Birds in Forested Landscapes program. I am unsure whether data has been collected and submitted in Indiana.
- The Nature Conservancy is working on developing a research project in the state for cerulean warblers
- Local intensive surveys, nest monitoring, or mark-recapture studies
- Eastern towhees: Other bird monitoring efforts that collect data nationwide generate information on eastern towhees. These include the Breeding Bird Surveys, Christmas Bird Counts (towhees are rare in winter though) and Cornell University nest record program. Hoosier National Forest conducts breeding bird monitoring on the forest since 1991
- Building managers and volunteers report nesting activity at many nests
- Indiana Dunes National Lakeshore biologists stay abreast of sightings along Lake Michigan

Respondents listed organizations that monitor all <u>birds</u> in all habitats in Indiana:

- National Audubon Society, Indiana Audubon Society, local Audubon chapters (Breeding Bird Survey, Christmas bird counts)
- Ducks Unlimited
- Indiana Division of Fish and Wildlife
- Indiana Division of Parks and Reservoirs
- U.S. Fish and Wildlife Service, Big Oaks and Muscatatuck national wildlife refuges
- Waterfowl USA
- U.S. Geological Survey in Porter, Indiana has conducted studies of oak savannah birds, including the redheaded woodpecker
- Quail Unlimited
- The Nature Conservancy
- American Bird Conservancy, MAPS program (Point Reyes Bird Observatory)
- Local bird clubs, NRCS (thru WRP program monitoring)
- Indiana State University
- USDA Forest Service, Hoosier National Forest
- Various universities
- Indiana Academy of Science, Indiana Audubon Society, an local chapters of NAS worked with IDNR to complete Breeding Bird Atlas (1985-1990)
  USGS Bird Banding Lab coordinates BBS
  Universities such as Purdue complete local-level research projects

- U.S. Geological Survey (roadside bird surveys)
- Cornell's Laboratory of Ornithology collects nest records
- Ball State University, Department of Biology has been monitoring Cerulean Warbler populations at Big Oaks National Wildlife Refuge, Hoosier National Forest, and Yellowwood and Morgan-Monroe state forests during the last five years
- Private companies (NIPSCO, Ispat Inland, building managers)
- Birdwatchers/volunteers

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

Monitoring techniques for all birds in all habitats	Used	Not used but possible with existing technology and data	Not economically feasible
Radio telemetry and tracking	X	X	X
Modeling	X	X	--
Coverboard routes	--	X	X
Spot mapping	X	X	X
Driving a survey route	X	X	--
Reporting from harvest, depredation, or unintentional take (road kill, by-catch)	X	X	--
Mark and recapture	X	X	X
Professional survey/census	X	X	X
Volunteer survey/census	X	X	--
Trapping (by any technique)	X	X	X
Representative sites	X	X	--
Probabilistic sites	X	X	--

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

- Nest box survey
- Distance sampling
- Aerial surveys

- Nest monitoring, territory mapping, call playback and color banding
- Surveys for colonies and periodic censuses of nests/populations
- Point count surveys

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

- Yes.

Habitat inventory and assessment

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

- Statewide annual inventory and assessment
- Periodic statewide (less than once a year but still regularly scheduled) 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 bird habitats in Indiana (not ranked):

- Statewide annual inventory and assessment
- Statewide once-a-year inventory and assessment
- Periodic statewide (less than once a year but still regularly scheduled) 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 ranked inventory and assessment efforts by state agencies based on their importance for conservation of all bird habitats in Indiana:

Rank	Inventory and assessment by state agencies for conservation of all bird habitats
1	Statewide annual inventory and assessment
2	Periodic statewide (less than once a year but

	still regularly scheduled) inventory and assessment
3	Statewide once-a-year inventory and assessment
4	Regional or local year-round inventory and assessment
5	Periodic regional or local (less than once a year but still regularly scheduled) inventory and assessment
6	Regional or local once-a-year inventory and assessment
7	Occasional regional or local (less than once a year and not regularly scheduled) inventory and assessment
8	Occasional statewide (less than once a year and not regularly scheduled) inventory and assessment

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

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

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

- Natural lakes in northern Indiana
- Continuous Statewide Forest Inventory jointly conducted by the USDA Forest Service and the Indiana Division of Forestry, IDNR
- Interlake Property
- Nearly all of river and stream habitats in Indiana falls under state and/or federal jurisdiction, so obtaining and maintaining accurate and current information on these habitats is always occurring on a statewide basis
- IDNR Division of Nature Preserves has inventoried habitats across the state over the past three decades. Savannahs mainly occur in the northern third of the state
- Isolated wetlands law
- The state examines habitat on state properties periodically and uses GAP and other habitat modeling programs to assess forest habitats
- Habitats on state areas are occasionally surveyed for quality and quantity
- Managers of public properties are responsible for maintenance and assessment of wetland habitat on their areas
- Annual and 5-year census, county-level reports of acreage planted to various hay cover types and acreage harvested
- Forest inventory plots in established forest management lands give some information on trends in early succession habitat. I am unaware of any regular coordinated effort by state or other agencies to monitor young forest age classes. Analysis of remote sensing data can provide some trend information where young forest classes can be mapped
- Opportunistic statewide determination of potential nest sites in Indiana with the idea of erecting a nest box
- Lake Michigan shoreline/Gibson Lake

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

- Farm Service Agency keeps track of the location and acreage associated with each contract
- Many local zoning boards, planning commissions and drainage boards also keep and maintain their own records in regard to land use patterns within these habitats
- In the northern third of the state
- Statewide by regions
- Indiana wetland inventory maps
    - County aerial photos for NRCS
    - Soils mapping county maps
- The Nature Conservancy, U.S. Fish and Wildlife Service and USDA Forest Service use habitat models to examine forest habitat in Indiana (Hoosier National Forest and Big Oaks National Wildlife Refuge)
- U.S. Fish and Wildlife Service, The Nature Conservancy and Indiana State University have surveyed quality and quantity of habitats for HESP's

- Natural Resources Conservation Service and other federal offices dealing with compliance review may be involved in inventory of habitat types as they pertain to the Farm Bill. However, these folks are not making habitat assessments as it relates specifically to mallards
- Hoosier National Forest and Ball State University are collecting data on habitat use by cerulean warblers on the northern portion of the forest
- Cornell's "Birds in Forested Landscapes" collects some data on cerulean warbler habitat use. I am not sure if data has been submitted from Indiana
- Lake Michigan shoreline
- Statewide aerial imagery of habitats in Indiana
- U.S. Department of Agriculture
- U.S. Geological Survey

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

- Bobwhite quail:
    - Indiana Division of Fish and Wildlife will initiate some type of bobwhite quail monitoring program to determine the success of the newest continuous CRP practice (CP33).
    - Farm Services Agency monitors acreage and location of tracts enrolled in each USDA program
    - Natural Resources Conservation Service provides technical support or administers most farm programs and I believe they conduct regular inspections
- Indiana Department of Natural Resources
    - Division of Fish and Wildlife
    - Division of Nature Preserves
- U.S. Fish and Wildlife Service
- U.S. Department of Agriculture
- Indiana Department of Environmental Management
- U.S. Army Corps of Engineers
- Environmental Protection Agency
- Local government entities (area plan commissions, zoning boards etc.)
- The Nature Conservancy
- Chicago Wilderness
- U.S. Geological Survey
- National Park Service
- Quail Unlimited
- USDA Forest Service (Hoosier National Forest; North Central Research Station)
- Natural Resources Conservation Service
- Ducks Unlimited
- Waterfowl USA
- Indiana State University

- Cornell Lab of Ornithology
- USDA National Agricultural Statistics Service for Indiana http://www.nass.usda.gov/in/
- Ball State University, Department of Biology

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

Inventory and assessment techniques for all bird habitats	Used	Not used but possible with existing technology and data	Not economically feasible
GIS mapping	X	X	--
Aerial photography and analysis	X	X	X
Systematic sampling	X	X	--
Property tax estimates	X	--	--
Regulatory information	X	X	--
Participation in land use programs	X	X	--
Modeling	X	X	--
Voluntary landowner reporting	X	X	--

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

- Bobwhite quail: I recently correlated the number of acres enrolled in USDA programs with our annual bobwhite whistle indices on a statewide scale. I am planning on modeling regional bobwhite indices and USDA idled acreage
- Remote sensing
- Visual driving surveys and soil surveys
- Samples at known nest sites are compared with random sites at Big Oaks National Wildlife Refuge
- There have been several master's degree projects on habitat selection for the Cerulean Warbler in Indiana. These studies have collected the following information on habitat use: diameter at breast height (DBH) and identification of tree species in a nested plot at the center of a territory, number of saplings (trees <3cm DBH), number and DBH of standing dead trees (snags), canopy cover, ground cover, canopy height, percent canopy coverage, and vertical stratification of foliage
- Habitat for some birds is suitable nesting sites near water. Volunteer participation in building a database of known breeding colonies and volunteer periodic censusing of colony sizes

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 bird habitats. Their responses included:

- Yes.

Recommended monitoring

Species monitoring

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

- Bobwhite quail
    - To monitor bobwhite populations in Farm Bill habitats, I suggest selecting a random sample of contracts and conducting flushing transects
    - Another intensive method would be to have hunters complete "report cards" when hunting on Farm Bill acreage
    - Annual harvest surveys
    - A less intensive method would be to request that landowners conduct whistle counts on their enrolled lands each spring
    - I would like to see a radio telemetry study of bobwhites in Indiana because we are lacking most of the baseline data for bobwhites in Indiana. Much of the information we use to manage quail populations comes from studies in other states
    - Whistle counts that are already conducted provide a less intensive (but important) method of tracking the statewide population
- Professional surveys or counts on fish and wildlife areas during migration periods (tracts annual migration trends and is index to population levels). Harvest surveys on fish and wildlife areas (tracts annual numbers taken) "Wildlife Investigational Techniques" by The Wildlife Society
- Ruffed grouse: Roadside drumming indices
- Mallards
    - Mark and recapture
    - Modeling: To determine population dynamics and evaluate genetic integrity of mallards in developed lands versus "wild" Mallards (i.e., mallards in undeveloped areas)
- Neck collars and leg bands
- Driving surveys
- Aerial surveys
- Fall covey counts
- Brood surveys
- Populations surveys
- Mark/recapture-banding (intensive) (Reference: Ducks, Geese and Swans of North America, Frank C. Bellrose); Harvest data collection (less intensive) (Reference: Wildlife Management Vol. 2, Reuben Edwin Trippensee)

- Continued participation in HIP is perhaps the most cost effective method for monitoring the flyway population; Banding operations help in determining the status of populations on a local or statewide level
- Point counts in potential habitats using distance sampling. This technique is relatively simple to implement and provides density information rather than an index. Observers count birds from points randomly located in the studied habitat and measure or estimate distance to observed birds. Calculation of density from the data, however, does require some technical expertise (Reference: Buckland, S. T., D. R. Anderson, et al. (2001). Introduction to distance sampling. Oxford, UK, Oxford University Press)
- Mark and recapture. Means to track species movement and association with non-target species and times of interaction with non target species; Mark and harvest eliminates and reduces concentrations in non desirable areas
- Continue current state surveys every five years
- Monitoring throughout annual cycle
- Weekly waterfowl counts at selected sites. Samples most of the major concentration areas. Very good historical data for trend analysis
- Ruffed grouse: On particular or "study areas", complete spring drumming counts for accurate breeding densities. Assumes a low number of non-drumming males and requires at least three opportunities, on good mornings, to hear a drumming bird in any portion of the study area
- Hunter harvest surveys
- A study that experimentally tests how forest management influences demography and presence and absence. Some birds need basic life history studied, too
- The use of GIS technology may be an economical and efficient method to monitor and classify wetlands throughout Indiana. Selective sampling within each geographical region may provide baseline data of mallard use and abundance. A more intensive approach may involve DNR staff, volunteers, and University staff that would conduct a statewide inventory of wetlands during one week in April
- Cerulean warblers
    - We would benefit from obtaining basic demography data on this species. Mist netting is not particularly feasible because the species stays so high in the canopy. Due to the difficulty of locating nests of ceruleans and of capturing adults, especially females, determination of reproductive success is problematic. Assessing survivorship of eggs, nestlings, and fledglings is also difficult. Until such reproductive success and survivorship information is available, the dynamics of populations will continue to be unknown
    - Point counts, spot mapping, and territory mapping provide important information about ceruleans
    - Banding individual birds could supply information on site fidelity and survivorship
    - Regular monitoring of migratory stopover and winter habitats will also be an important part of the conservation of the cerulean warbler
    - Professional survey/census to locate warblers
    - Nest search and monitoring to assess productivity to determine if Indiana has a 'source' or 'sink' population of cerulean warblers (Reference: Hutto, R.L., S.M. Pletschett, and T.P. Hendricks. 1986. A fixed-radius point-count method for nonbreeding and breeding season use. Auk 103:593-602)

- Establish more Breeding Bird Survey routes http://www.pwrc.usgs.gov/bbs/; conduct point counts on private lands. If possible estimate nest success too
- Surveys for colonies and periodic censuses of nests/ populations
- Roadside bird surveys on selected routes maximizing forest habitats; repeated point count surveys in representative forest sites
- Primary technique used is point counts of singing birds in breeding season, either by roadside counts (BBS) or set survey points (e.g., Hoosier National Forest monitoring). Roadside surveys are probably most effective because towhees are edge/early successional species, using habitats found near roads. Long term banding programs (e.g., MAPS) provide demographic information not gained with other monitoring, but are more intensive
- Nest monitoring of all known nests (or representative sample) with two to three visits according to U.S. Fish and Wildlife Service protocol
- Directed surveys (canoe surveys, migration counts) most intensive; general breeding bird surveys less intensive
- Because the Piping Plover rarely occur in Indiana, keep track of all reports by birders and have Indiana Dunes personnel systematically survey appropriate habitat along Lake Michigan
- Spot-mapping in appropriate habitats
- Sampling potential nesting areas for some birds to obtain additional information on the species abundance and distribution.
- Sampling of mature pine forest habitat to better determine distribution

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

- Yes.

Habitat inventory and assessment

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

- GIS mapping
  - See "Wildlife Investigational Techniques" by The Wildlife Society
  - Along with aerial surveys (See reference: Wildlife Management Techniques Manual, Fourth Edition, Sanford D. Schemnitz)
  - As the most cost affective means to create an inventory of emergent plant species that would support Canada geese in emergent wetlands
  - GIS modeling, and intensive study to determine habitat quality (source vs. sink)
  - GIS mapping and participation in land use programs (CRP)
  - GIS technology appears to be the system of choice. NRCS offices have statewide distribution and a close relationship with landowners so I would recommend utilizing their resources if possible
  - As stated before, I am unaware of efforts to monitor young age classes of forest. GIS mapping can certainly generate amounts and trends of habitat if forest type and age

are mapped. Aerial photography can be used when young age classes appear distinct from other habitat classes

- Aerial photography in concert with other methods
    - Wetlands should be monitored by overhead photo methods with ground truth checks. This should occur on a regular basis with aggressive enforcement against illegal wetlands destruction
    - Aerial photography and analysis and soil surveys are already being done and could provide a cheap way to monitor and assess emergent wetlands. Any of the USDA's soil surveys for the individual counties can be used as a resource
    - Aerial imagery of riparian and pine habitats coupled with habitat modeling
- Bobwhite quail
    - Flush counts or more intensive whistle counts on farm program lands would be a useful method of evaluating their quality when compared to the same indices on non-Farm Bill lands
    - Remotely sensed data to monitor changes in statewide and regional acreage and distribution. It would be interesting and useful to see how trends in shrub/scrub habitat relate to the Indiana Division of Fish and Wildlife bobwhite whistle indices
- Canada geese
    - Systematic water sampling of high use areas would determine nutrient loading and water quality. (See U.S. Fish and Wildlife Service Draft Environmental Impact Statement, Resident Canada Goose Management, Feb. 2002)
- Cerulean warbler
    - I think that a crucial piece of habitat data for the cerulean warbler is the size and distribution of canopy gaps within territories. At this point, researchers have not determined an effective means to quantify this data
    - Another important habitat inventory would be looking at landscape characteristics of cerulean occurrence and distribution in relation to forest fragmentation. Monitoring should incorporate the occurrence of the species in relation to landscape characteristics such as proportion of agricultural use, tract size and shape, and amount of edge
    - Systematic sampling/survey techniques to locate Cerulean Warblers
      Hutto et al. 1986. Auk 103:593-602
- Pine warbler: Statewide inventory and mapping of mature pine forest communities to determine more accurate potential distribution of pine warbler. (References suggested would be Flora of Indiana by Charles Deam 1940 and unpublished data/files from Division of Forestry)
- Survey of hay harvest dates and frequencies each year
- Habitat for some birds is suitable nesting sites near water. Volunteer participation in building a database of known breeding colonies and volunteer periodic censusing of colony sizes
- Spring, summer, fall and winter surveys
- Reports from state fish and wildlife areas
- Habitat association studies to determine which habitat types used/preferred
- Only casual assessment needed
- Statewide Forest Inventory

- Grassland mapping by major plant species type
- Permanent plot monitoring to assess changes in canopy cover and woody species size and composition
- Participation in land use programs
- Aerial spring counts

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 effective conservation of all bird habitats. Their responses included:

- Yes.

ALL FISH IN ALL HABITATS NARRATIVE

Problems affecting species and habitats

Species threats

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

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

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

- Stream channelization
- High stream flows following spawning can seriously reduce year class strength. Reducing ditching in headwaters, installing grass waterways and WASCOBS, and maintaining riparian corridors, can reduce this threat. All of these measures will slow stream flows and reduce siltation
- Egg predation, nutritional requirements, early mortality syndrome
- Commercial fishing and overexploitation
    - Results in low spawner stock abundance
- Orangethroat darter
    - It prefers high functioning, high quality riffle habitat in headwater streams. Headwater streams, are not always given as much protection or value as larger rivers downstream
    - Threats to species colonization include aquatic passage problems through culverts
    - Threats to the species watersheds include such as pollution, clearing of the riparian vegetation, creek gravel mining and channelization

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

- Habitat loss, destruction and degradation
    - Loss of instream cover (snagging and log removal), riparian destruction which allows water to warm and will reduce opportunity for logs and woody debris to enter stream
    - Many reservoirs are getting very old and the once abundant standing timber is now diminishing which reduces cover for white crappie
    - Channelization
    - Loss of undisturbed natural lake habitat
    - Habitat loss is serious threat to rock bass: They relate closely to structure/cover therefore any habitat loss is a threat
    - Annual and seasonal variations in habitat availability
    - Loss of high quality riffles: Threats to riffle habitat result from water quality degradation and loss of stream channel stability due to land management activities such as dredging, channelization, roads, and clearing of riparian vegetation
    - Habitat loss due to dredging (removal of aquatic vegetation and increasing depth of ditch)
    - Degradation of stream channel will also increase the velocity of the current (if straightened or cleared of debris) which will remove tadpole madtoms' preferred current-free, quiet habitat
    - Point and nonpoint source pollution (see below)
    - Causes migration/passage problems. (See "Threats to migration/aquatic passage problems" below)

- Habitat loss or degradation, causing loss of spawning/feeding habitat

- Northern pike have suffered a major loss of spawning habitat due to the prevalence of dredging within the watershed. This practice along with levee construction has resulted in the near elimination of instream an emergent wetland vegetation throughout the majority of the watershed
- Hornyhead chub are sight feeders and mound builders for spawning; thus, muddy water will hamper their chances of survival and if the silt covers gravel and their nest, chances for successful reproduction will be limited
- Breeding and feeding/foraging habitat loss due to sedimentation from farm fields and stream banks as well as the removal of natural riparian vegetation
- Tadpole madtoms feed in dense vegetation and hide from predators in the leaf litter, dead wood and other cover. By removing vegetation and cover in the stream, tadpole madtoms also loses spawning areas (tadpole madtoms typically lay eggs under submerged objects)
- Slough darter prefers a mud or silt bottom with little current velocity and vegetation to deposit eggs on. They also spawn few eggs so reproduction is lower in places where vegetation is lacking
- Eastern sand darter requires sandy bottoms in fast flowing streams to bury eggs, hide from predators, ambush prey, conserve energy and maintain position in unstable/shifting sandbars
- Siltation of small headwater streams is limiting the population of southern redbelly dace because the species spawn over gravel substrates. Also, the removal of vegetation could decrease food availability to the herbivorous species. They occupy streams that have a permanent flow of clear water; thus siltation or alterations in flow regimes could also affect the species
- Degradation of nesting and staging sites: pools or riffles with slow current beneath flat rocks
- Some fish require shallow clear water with little current in weedy areas over gravel, sand, and silt to feed on insects and lay reproduce
- Pollution (see below)

- Point and nonpoint pollution; loss of water quality
  - The acute effects of toxicants are recognized as a threat to organisms, but there is little knowledge on ecosystems or regional effects on chronic insults. Toxicants are more destructive to the embrolarva stages, but these are poorly documented. Pollution controls do not have definite focus on chronic effects
  - Possible sensitivity to pollution as indicated by some fish species rarity in the Ohio River reach in Indiana
  - Long-term declines in water quality associated with lake eutrophication
  - Nonpoint sources runoff resulting from loss of riparian buffers due to development
  - High sediment loads during spring rains
  - Runoff (increases flow of stream, turbidity and siltation of needed substrates)
  - Pesticides
  - Point sources of pollution particularly sewage and spills of chemicals being transported along roads and railroads
  - Siltation which reduces spawning areas and fills pools

  - Pollution which triggers fish kills or repels smallmouth from the area
  - Point source pollution which triggers fish kills or repels rock bass from the area
  - Cold, clear water is critical for cisco survival; increased runoff and nutrient loading have degraded the habitat for this species in many of the 50+ lakes it once occurred in. Few lakes still have the species, and there is apparently little to no reproduction

- Low reproduction rates/reproductive issues
  - Eastern sand darter: Low reproductive rates/small populations since darters reach maturity at age one, but only live a few years
  - Lack of successful spawning, possibly related to bioenergetics; too much egg predation
  - Possible lack of reproductive success as indicated by poor length frequency distribution
  - Year class failure related to low spawner stock abundance
  - Eastern sand darter has low reproductive rates: Males reach sexual maturity at two while females can reproduce at one, and they only have a life span of about three years

- Threats to migration/aquatic passage problems
  - Orangethroat darter: Experiences aquatic passage problems through stream crossing structures
  - Water level control regimes at impoundments
  - Dams on rivers block migration

- Dependence on irregular sources
  - In many reservoirs, shad is the dominant forage base for crappie. If shad are growing extremely fast, crappie can only utilize shad for a short period of time before the shad outgrow the size crappie can consume

- Predation, competition and invasive species
  - Deliberate stocking of predator fish in cisco lakes has been a threat to this species for years; if this hasn't been stopped, it needs to
  - Competition with invasives, namely gizzard shad
  - Competition with non-native species for limited available food resources
  - Exotic species competition, specifically the round goby
  - Hornyhead chub experience competition from other species better adapted to muddy and silty stream conditions
  - Slough darter competes with other darters for insects and high mortality due to stagnation and freezing in the pools they desire to live in

- Harvesting
  - Overharvest by commercial anglers

  - Mortality immature or male fish as commercial by catch
  - Northern pike: Over harvest and illegal harvest (This doesn't seem to be a major threat as of now)
  - Commercial fishing
- Overpopulation

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

- Yes, however, surprised there was not direct mention of Asian Carp, they will be a major threat to juvenile fish of all type...especially in the Ohio River Basin

Habitat threats

Respondents ranked threats to all fish habitats in Indiana:

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

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

- Riparian corridor destruction
- Loss of shading
- Sedimentation
- Competition with round goby for nearshore habitat
- Dumping refuge in sinkholes; these often contain persistent toxins associated with transformers, tires, appliances, pesticide containers and electronic devices

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

- Habitat loss, alteration, fragmentation and degradation
  - Sedimentation
    - Results in smothering of substrates and turbidity
  - Channelization
    - Channelization of many streams in the upper Kankakee watershed and associated fragmentation of wetland habitat has altered severely the state of aquatic habitat in general
    - Eastern sand darter: Stream channelization will directly affect sediment transfer and microhabitat
    - Development in Ohio River drainage habitats in Indiana
    - Destruction of clear shaded waters
  - Cover/debris removal
    - Removal of debris speeds up transfer of water off the land and into the receiving stream
    - Removal of natural riparian vegetation, especially through drainage maintenance activities
  - Riparian removal/loss of riparian zone
  - Loss of high quality riffles and outside bend deep fast runs
  - Removal of vegetation and shallow water
  - Shoreline and lakebed alterations
  - Dams fragmenting habitats in Indiana
  - Loss of habitat due to development in headwater areas
  - Crappie: The natural decomposition of flooded timber and woody debris is lessening available cover for crappie. Also, siltation covers root wads left in bottom of impoundments, eliminating useable crappie cover
  - Agricultural practices causing a variety of habitat loss, pollution and degradation
    - Destruction of clear, shaded waters
  - Removal of substrate for spawning and sedimentation for covering substrate needed to spawn
  - Northern pike: Emergent bulrush and wetland habitat loss. It is well documented in northern states that northern pike prefer flooded vegetation for spawning during spring. Loss of this habitat from boating and wildlife (waterfowl and muskrat feeding) may reduce reproductive behavior for northern pike in some natural lakes
  - Pollution (see below)

- Regulation of impounded water/dams
  - Crappie: Extreme water fluctuations in mainly USACOE reservoirs can negatively impact crappie populations, especially if fluctuations occur during spawning
  - Northern pike: Bulkhead seawall development reduces emergent vegetation used by northern pike for reproduction and cover during feeding

- Successional change

- Point and nonpoint source pollution
  - Point source: These ecoregions have major threats from large cities causing fish kills from wastewater treatment plants. Also confined feeding operations in rural areas are a major threat to stream fish communities
  - Any practices that create more erosion/sediment deposition and eliminates instream cover are serious threats
  - Water quality degradation that leads to cloudy water

    - Resulting from increasing human population in Southern Indiana and development of area
    - Caused by agricultural practices

- Competition, invasive species
    - Competition with non-native species for habitat. Need quality habitat so fish is not in competition with round goby
    - Round goby
    - Emergent bulrush

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

- nonpoint source pollution is a major threat, siltation is affecting the fisheries of Ohio River tributaries

Additional research and survey efforts

Current body of research

Species research

Thirty-eight percent of respondents stated that the current body of science is adequate for all fish in all habitats in Indiana; fifty-seven percent find the current body of science as inadequate or non-existent.

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

Title = A survey of fish communities and aquatic habitats at Indiana's major steams with emphasis on smallmouth bass distribution and abundance;
Author = Stuart T. Shipman;
Date = 12/1997;
Publisher = DNR fisheries section

Title = A survey of fish communities and aquatic habitats at Indiana's major streams with emphasis on smallmouth bass distribution and abundance;
Author = Stuart Shipman;
Date = 12/1997;
Publisher = DNR/Fisheries section

Title = A survey of fish communities and aquatic habitats at Indiana's major streams with emphasis on smallmouth bass distribution and abundance;
Author = Stuart Shipman;
Date = 12/1997;
Publisher = DNR/Fisheries section

Title = Many in AFS journal of fish management and transactions of AFS

Title = A survey of fish communities and aquatic habitats at Indiana's major streams with emphasis on smallmouth bass distribution and abundance.;
Author = Stuart T. Shipman;
Date = December 1997;
Publisher = IDNR

Title = Surveys of the fish communties and aquatic habitats in 16 small streams in Indiana from 1996 through 1997.;

Author = Douglas C. Keller;
Date = 1999;
Publisher = IDNR

Title = A survey of fish communities and aquatic habitats at Indiana's major streams with emphasis on smallmouth bass distribution and abundance.;
Author = Stuart T. Shipman;
Date = December 1997;
Publisher = IDNR

Title = Surveys of the fish communties and aquatic habitats in 16 small streams in Indiana from 1996 through 1997.;
Author = Douglas C. Keller;
Date = 1999;
Publisher = IDNR

Title = Impoundments Strategic Plan;
Author = IDNR - Fish and Wildlife;
Date = 1997;
Publisher = IDNR - Fish and Wildlife

Title = DFW largemouth bass database;
Author = Jed Pearson;
Date = unpublished;
Publisher = unpublished

Title = Largemouth bass size limits at Indiana natural lakes - a 30-year history;
Author = Jed Pearson;
Date = 2003;
Publisher = unpublished

Title = Cisco population status and management in Indiana;
Author = Jed Pearson;
Date = 2001;
Publisher = Division of Fish and Wildlife

Title = The Fishes of Missouri;
Author = William L. Plieger;
Date = 1997;
Publisher = Missouri Conservation Commission

Title = Lake Trout Restoration Plan;
Date = In progress

Title = Lake Trout Impediments Docuement;
Author = Numerous,;
Date = 2003;
Publisher = Lake Trout Task group/LMTC

Title = Fishery, Habitat, and Recreational Use Surveys for the Kankakee River;
Author = Price and Robertson;
Date = 2005;
Publisher = DNR - Division of Fish and Wildlife (in review)

Title = A fishery survey of the Kankakee River in Indiana;
Author = Robertson and Ledet;
Date = 1981;

Publisher = DNR - Division of Fish and Wildlife

Title = Preliminary Results of 2004 Ball State University Yellow Perch Research in Indiana Waters of Lake Michigan;
Author = Paul Allen and Thomas Lauer;
Date = Cctober 2004;
Publisher = Ball State University

Title = Yellow Perch Research and Management in Lake Michgian, Evaluating Progress in a Cooperative Effort, 1997-2001;
Author = David Clapp and John Dettmers;
Date = November 2004;
Publisher = American Fisheries Society, Fisheries

Title = Fisheries Survey of the East Branch of the Little Calumet River Watershed;
Author = Neil Ledet;
Date = 1978;
Publisher = IDNR Fisheries Section

Title = Stream Survey of the East Arm of the Little Calumet River;
Author = Edward Braun;
Date = 1974;
Publisher = IDNR Division of Fish and Wildlife

Title = Wabash River Catfish Reports;
Author = Rob Columbo;
Date = 2002,2003,2004,2005;
Publisher = SIU/INDFW

Title = numerous INDFW FMR's;
Author = numerous;
Date = numerous;
Publisher = INDFW

Title = annual Ohio River sauger reports;
Author = ORFMT;
Date = annually since 1999;
Publisher = ORFMT

Title = various INDFW FMR's;
Author = various;
Date = various;
Publisher = INDFW

Title = Northern Pike Spawning Habitat Investigations At Two Narural Lake In Indiana;
Author = Cwalinski, Tim A.;
Date = September 2001;
Publisher = Indiana Department of Natural Resources

Title = Distribution and status of the northern cavefish;
Author = Pearson, W. D. and C. Boston;
Date = 1995;
Publisher = Final report to IN Department of Nat. Res.Div. of F&W

Title = Age, growth and fin erosion of the northern cavefish, Amblyopsis spelaea, in KY and IN;
Author = Louis, M.;
Date = 1999;

Publisher = Unpubl. M.S. Thesis, University of Louisville

Title = Handbook of freshwater fishery biology;
Author = Kenneth D. Carlander;
Date = 1997;
Publisher = Iowa University Press

Title = fishes of Tennessee;
Author = Etnire and Starnes

Title = Fishes of Ohio;
Author = Milt Troutman;
Publisher = OSU Press

Title = FW fishes of Canada;
Author = Scott & Crossman

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 fish in all habitats. Their responses included:

- There seems to be limited data on fish communtiy health in large river tributaries cited. I know we have a good handle on the reserviors, what about the large creeks on the Ohio River like in the Cannelton Pool

Habitat research

Thirteen percent respondents stated that the current body of science is adequate; eighty-three percent found it inadequate or nonexistent for all fish habitats in Indiana.

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

Title = A survey of fish communities and aquatic habitats at Indiana's major streams with emphasis on smallmouth bass distribution and abundance;
Author = Stuart Shipman;
Date = 12/1997;
Publisher = DNR/Fisheries section

Title = A survey of fish communties and aquatic habitats at Indiana's major streams with emphasis on smallmouth bass distribution and abundance.;
Author = Stuart T. Shipman;
Date = December 1997;
Publisher = IDNR

Title = Surveys of the fish communities and aquatic habitats in 16 small streams in Indiana from 1996 through 1997.;
Author = Douglas C. Keller;
Date = 1999;
Publisher = IDNR

Title = A survey of fish communities and aquatic habitats at Indiana's major streams with emphasis on smallmouth bass distribution and abundance.;
Author = Stuart T. Shipman;
Date = December 1997;

Publisher = IDNR

Title = Surveys of the fish communities and aquatic habitats in 16 small streams in Indiana from 1996 through 1997.;
Author = Douglas C. Keller;
Date = 1999;
Publisher = IDNR

Title = Cisco population status and management in Indiana;
Author = Jed Pearson;
Date = 2001;
Publisher = Division of Fish and Wildlife

Title = Fishery, Habitat, and Recreational Use Surveys for the Kankakee River;
Author = Price and Robertson;
Date = 2005;
Publisher = DNR - Div. of F & W

Title = A Fishery survey of the Kankakee River in Indiana;
Author = Robertson and Ledet;
Date = 1981;
Publisher = DNR - Div. of F & W

Title = Fisheries Survey of the East Branch of the Little Calumet River Watershed;
Author = Neil Ledet;
Date = 1978;
Publisher = IDNR-Fish and Wildlife

Title = Stream Survey-Little Calument River East Arm;
Author = Edward Braun;
Date = 1974;
Publisher = IDNR-Fish and Wildlife

Title = Ohio River Mainstem Study;
Author = USACOE;
Date = 2000?;
Publisher = USACOE

Title = Ohio River Mainstem Study;
Author = USACOE;
Date = 2000?;
Publisher = USACOE

Title = Cave adaptation in Amblyopsid fishes;
Author = Poulson, T.;
Date = 1963;
Publisher = Amer. Midl. Nat. 70(2):257-290

Title = A faunal inventory of subterranean streams using a modified index of biotic integrity;
Author = Jones, T.G.;
Date = 1997;
Publisher = Unpubl. Ph.D. Disst. University of Louisville

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 fish habitats. Their responses included:

- Need more recent smallmouth info

Research needs

Species research

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

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

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

- How to produce more, larger crappie
- Limiting factors and impacts of competition and predation
- Continued research on movement and survival as part of rehabilitation strategy
- Determine population limiting factors in Ohio River
- Population persistent
- Impact of commercial harvests
- Metapopulation dynamics
- Extent of populations in subterranean systems which cannot be entered by humans

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for all fish in all habitats. There were no responses.

Habitat research

Respondents ranked research needs for all fish habitats in Indiana:

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

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

- Water quality variations and impacts of land use and shoreline alterations
- Water quality requirements
- Cavefishes
    - Assessment of the physical dimensions of the phreatic environment available to cavefishes, and the connections between known windows into the system.
    - Toxin concentrations in cave sediments and their recruitment rates into underground waters
- Effects of roads and stream crossings on some fish; Is aquatic passage through culverts and other stream crossing structures adequate or are these crossings causing aquatic habitat fragmentation?

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

- I think land use changes are of high priority

Conservation actions necessary

Species actions

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

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

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

- Regulation of sport harvest/closure of commercial fishery to allow spawning stock biomass to increase, thus allowing for the production of offspring that can add to the spawning stock biomass

- Hornyhead chub
  - To greatly reduce turbidity in streams for hornyhead chub feeding and breeding behaviors
  - Exotic/invasive species control
  - Limiting contact with pollutants/contaminants
  - Control regulation of collecting since hornyhead chub is a popular bait fish

- Orangethroat darter
  - Habitat protection occurs in the form of the Clean Water Act, National Forest Management Act and other state and federal regulations that protect aquatic habitat and aquatic species. These regulations may or may not be enough for the sake of orangethroat darter conservation

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

- Pollution/contaminants control and reduction
  - Includes activities of wastewater treatment plants and confined feeding operations
  - See “Habitat protection” (below)

- Habitat protection, restoration, enhancement and management
  - Add more woody cover to old impoundments where former woody cover has decomposed
  - Continue stocking for rehabilitation efforts
  - Cisco: Greatly limit/mitigate new development on cisco lakes, particularly addressing runoff from lawns and other lawn quality issues
  - Cisco: Work with farmlands adjacent to cisco lakes to use no-till practices
  - Protect habitat through land use regulation
  - Protect migration routes
  - Implement ecozones in undeveloped areas to conserve vegetation present
  - Acquire and protect a reserve at Blue Spring Caverns
  - Erosion controls
  - Declare moratorium on channel/drainage “improvement” projects that do not mitigate losses
  - Eastern sand darter: Reduce sedimentation covering sand substrate
  - Restore stream channels so that riffle habitats are protected and enhanced
  - Restore riparian vegetation to protect stream channels from runoff or impacts
  - Maintain road and stream crossing so that stream channel function and aquatic passage are maintained

- Create/maintain aquatic passage for fish and other species

  - Northern pike: Restore connection between streams and wetlands that were formerly associated with them to allow pike access to spawning areas. Current water regimes often rely on pumping to fill restored wetlands, thus fish passage is still restricted

- Harvest/collecting management and regulation; limit human disturbance
  - Completely eliminate commercial fishing. This appears to have reduced the spawning stock to a level that could not maintain a fishery
  - Implement a catch-and-release only regulation in lakes with low densities
  - Limit public access to population concentrations already under agency control at Spring Mill State Park and Harrison-Crawford State Forest

- Public education
  - To reduce habitat disturbance
  - To reduce agricultural runoff
  - To teach land use planning

- Continue stocking for rehabilitation efforts
  - Change genetic suite of strains to be stocked; utilize at least one deep water strain

- Control predators/invasive species
  - Cisco: Assure there is no stocking of predators in cisco lakes
  - Make possession of exotic species illegal (must dispose of fish properly and not release back into stream)

- Reintroduction
  - Of the least darter into suitable habitats that have been restored

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

- We always support increasing habitat and reducing non point source pollution.

  From a stocking standpoint, our members would like to have more opportunities to catch smallmouth and spotted bass out of our reserviors....there seem to be plenty of wipers and hybrids...lets stock bass

Habitat actions

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

Rank	Conservation efforts for all fish habitats
1	Pollution reduction
2	Protection of adjacent buffer zone
3	Corridor development/protection
4	Habitat restoration incentives (financial)
5	Habitat protection incentives (financial)

6 (tie)	Cooperative land management agreements (conservation easements)
6 (tie)	Habitat restoration through regulation
7	Managing water regimes
8 (tie)	Restrict public access and disturbance
8 (tie)	Habitat protection through regulation
9 (tie)	Habitat restoration on public lands
9 (tie)	Land use planning
10	Habitat protection on public lands
11 (tie)	Technical assistance
11 (tie)	Artificial habitat creation (artificial reefs, nesting platforms)
11 (tie)	Succession control (fire, mowing)

Respondents listed other current conservation practices for all fish habitats in Indiana (not ranked):

- Closing and/or year around gating of caves with large populations of hibernating or reproducing bats will ensure normal trophic cascades for those systems
    - Restricting recreational caving in some caves might reduce periodic disturbances, increases in turbidity, and remobilization of toxins in sediments.
- Eastern sand darter, hornyhead chub (and other species)
    - Habitat protection
    - Restore flood plain to reduce sedimentation reaching stream beds
    - Manage water regimes to reduce settling of sediments in stream (thus dam removal may be appropriate)
    - Protect adjacent buffer zone to stop deleterious effects of erosion and sedimentation in the stream
    - Land use planning and conservation easements to minimize runoff

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

- Habitat protection, restoration and management
    - Create and protect buffer strips and adjacent buffer/riparian zones
    - Stabilize banks
    - Protect corridors
    - Create woody debris/instream cover
    - Through regulation
    - Reduce point and nonpoint pollution
    - Determine and create critical habitat
    - Minimize fragmentation
    - Create artificial structures during lake construction projects
    - Protect and restore riffles
    - Implement ecozones in undeveloped areas to conserve vegetation
    - Reduce inlet and upstream degradation

  - Establish a reserve at Blue Spring Cavern
  - Restrict dredging
  - Restrict removal of debris
  - Restore and stabilize streambanks and streams (reconstruct channels to reconnect to its natural floodplain elevation)
  - Restore riparian vegetative communities through tree planting, etc.
  - Improve culverts or stream crossing structures (replace non-functioning culverts or other crossing structures and replace wit ones that function and are at the right elevation/location within the streams longitudinal profile

- Create financial incentives/conservation easements
  - To protect habitat
  - For land use planning
  - Riparian conservation easements
  - Obtain conservation easement/agreements with selected cave owners in Orange, Washington, Lawrence and Harrison counties

- Improve land use practices/education
  - To reduce sedimentation in impoundments and reduce nutrient inputs
  - To maintain riparian buffer strips since most headwater areas run through agricultural areas
  - Reduce nutrient inputs: This would allow a deeper thermocline important for crappie growth
  - Land use rezoning
  - Increase awareness and cooperation of landowners to create better shoreline and tributary habitat

- Manage water regimes
  - In USACOE impoundments, alterations in water level control would likely benefit crappie
  - Need to move toward natural regulation of water levels instead of artificial means

- Manage/create aquatic passage/reduce habitat fragmentation
  - Restore wetlands with connectivity to stream or corridors, allowing passage to wetlands

- Reduce human disturbance
  - Restrict entry to selected caves at Harrison-Crawford State Forest

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

- yes, the idea of creating financial incentives for all types of habitat improvement or conservation is important

Proposed plans for monitoring

Current monitoring

<u>Species monitoring</u>

Appendix F-75: Fish

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

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

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

- Regional or local year-round monitoring
- Regional or local once-a-year monitoring
- Periodic regional or local (less than once a year but still regularly scheduled) monitoring
- Occasional regional or local (less than once a year and not regularly scheduled) monitoring

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

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

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

Rank	Monitoring efforts by other organizations for conservation of all fish in all habitats
1	Regional or local once-a-year monitoring
2	Periodic regional or local (less than once a year but still regularly scheduled) monitoring

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

4 Statewide year-round monitoring

5 Periodic statewide (less than once a year but still regularly scheduled) monitoring

6 Statewide once-a-year monitoring

7 Occasional statewide (less than once a year and not regularly scheduled) monitoring

8 Regional or local year-round monitoring

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

- General locations listed for a variety of species monitoring
  - Wabash River
  - West Fork - White River
  - East Fork - White River
  - Ohio River
  - Patoka River watershed
  - Blue River (Harrison County)
  - Sugar Creek (Shelby County)
  - Indian Creek (Greene County)
  - Patoka Lake
  - Hovey Lake
  - Dogwood Lake
  - Lake Sullivan
  - Wabash River, Lafayette area, annual spring monitoring; occasional stream surveys
  - Newburgh and McApline Tailwater fall/winter annual monitoring
  - Stream surveys

- IDNR Division of Fish and Wildlife monitoring efforts
  - Spring assessment out of Michigan City
  - Fall spawning assessment, Indiana waters of Lake Michigan
  - Nine-month creel survey for harvest information
  - DNR fishery surveys are occasionally conducted on the Iroquois River, the Yellow River, and the Kankakee River
  - IDNR periodically conducts fish stream surveys
  - Headwater streams surveys were conducted in 2001 through 2004 by Lake Michigan Fisheries Office

- 1999 Wabash River, 2003 East Fork White River, 2004 West Fork White River, 2004 Main Stem White River, 1993 Patoka River, 2004 Ohio River Cannelton Pool, annual commercial fish harvest monitoring
- IDNR Special Studies on T&E species: IDNR, Brant Fisher, did a study on the population of eastern sand darters in Indiana over the past five years. IDNR-regional fish collection surveys may have collected some specimens of the eastern sand darter
- Tracking study conducted in two Indiana natural lakes in the late 1990s IDNR to better understand reproductive habitat of northern pike
- Northeast Indiana studies (Jed Pearson)
- IDEM/DNR Nongame program also conduct fish monitoring during the field season. These above fish surveys are not specific to the orangethroat darter, but would include the darter
- IDEM and IDNR collect fish community samples in this area; thus, they may have data on the distribution of least darters
- Northern Pike are monitored via general fish surveys conducted to update lake status. There is now monitoring of northern pike on a general schedule
- Monitoring cisco at cisco lakes
- Largemouth bass
  - Division of Fish and Wildlife standardized largemouth bass sampling protocols
  - Tournament fishing monitoring by the Division of Fish and Wildlife
- Smallmouth bass
  - In early to mid 1990s the Division of Fish and Wildlife conducted a smallmouth bass inventory
  - Five streams have been sampled every other year from 1998 to 2004 to estimate smallmouth bass populations. The goal was to determine smallmouth bass population changes due to the imposition of a 12-inch black bass size limit in 1998
- Crappie: Many impoundments throughout the state have general fisheries survey conducted on them; crappie are caught during these
- See IDNR Fisheries Section work plans

- Indiana Department of Environmental Management monitoring
  - Cisco: Department of Environmental Management water quality monitoring
  - Eastern sand darters: IDEM occasionally collected eastern sand darters as part of their Surface Water Quality Monitoring Strategy evaluating fish community structure in certain watersheds every five
  - IDEM conducts stream health surveys using fish and invertebrates
  - IDEM occasionally samples fish for contaminants analysis for the annual Fish Consumption Advisory
  - IDEM annual ecoregion sampling
  - IDEM probabilistic sampling
  - Horneyhead chub: IDEM monitors the Great Lakes Drainage once every five years; thus, they may have data available for hornyhead chub captured in the basin as part

of the fish community assessments. IDNR may also sample fish communities in this area and have data on the hornyhead chub

- IDEM and IDNR collect fish community samples in this area; thus, they may have data on the distribution of least darters
- Tadpole madtoms: IDEM monitors the Kankakee River basin once every five years to determine if the stream are supporting a well-balanced warmwater aquatic community. Tadpole madtoms may have been captured while sampling headwater streams
- IDEM Office of Water Quality's Surface Water Quality Monitoring Strategy and project work plans and IDNR Fisheries Section Work Plans
- Southern redbelly dace: IDEM monitors the health of major river basins every five years by looking at chemical, physical and biological data collected at random locations within the watershed. Southern redbelly dace have been captured in the Ohio River drainage habitat; however, specific monitoring for the species has not occurred to my knowledge by any one state or other organization
- Orangethroat darter: IDEM and the DNR Nongame program conduct fish monitoring during the field season. These above fish surveys are not specific to the Orangethroat Darter, but would include the orangethroat darter

Respondents listed regional or local monitoring <u>by other organizations</u> for all <u>fish</u> in all habitats in Indiana (not ranked):

- West Fork – White River and tributaries (Muncie area)
- U.S. Fish and Wildlife Service and Illinois Natural History Survey complete egg and fry assessments at the Port of Indiana; this is part of a Fish and Wildlife Restoration Grant
- In some cities, stream health also is assessed by fish and invertebrate surveys
- Ohio, White and Wabash rivers
- Wabash River
- Ball State University fish sampling near Michigan City and Gary
- University of Louisville has been monitoring the Northern Cavefish at irregular intervals and locations in Southern Indiana since 1994
- City of Elkhart and St. Joseph counties
  - Elkhart Public Works and Utilities has a fisheries biologist on staff to actively collect fish community samples from the Great Lakes Basin (one to two times per summer). He may have data on hornyhead chub as well
- Eastern sand darter: While collecting fish community samples to evaluate the community structure and ability of the stream to support a healthy fish community, these organizations may have collected Eastern Sand Darters: Soil and Water Conservation Districts within those ecoregions, Purdue University, Wildcat Creek Watershed Alliance. (Please check with the Scientific Collectors Permit office for a list of organizations collecting in those ecoregions and also check with the IDEM Section 319 webpage for project summaries where fish or habitat in those ecoregions were studied)
- U.S. Environmental Protection Agency
- USGS Water Resources Division
- Ohio River Valley Water Sanitation Commission
- Midwest Biodiversity Institute
- U.S. Army Corps of Engineers
- Muncie Bureau of Water Quality
- Consulting firms
- Hoosier National Forest conducts yearly fish surveys within two or more 5th level HUCs that encompass the Hoosier National Forest, which includes the Ohio River drainage,

Eastern cornbelt/interior plateau ecoregions. These above fish surveys are not specific to the orangethroat darter, but would include it.

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

- IDNR – Division of Fish and Wildlife
- Bass fishing clubs that hold tournaments on Lake Wawasee and Syracuse Lake
- Muncie Bureau of Water Quality
- Illinois Natural History Survey
- U.S. Fish and Wildlife Service
- IDEM
- Purdue University
- Ball State University
- Southern Illinois University
- University of Louisville, Biology Department
- University of Michigan through a coastal program grant
- City of Elkhart (Elkhart and St. Joseph counties)
- Cinergy and other electric utilities
- USDA Forest Service
- U.S. Environmental Protection Agency
- USGS Water Resources Division
- Ohio River Valley Water Sanitation Commission
- Midwest Biodiversity Institute
- U.S. Army Corps of Engineers
- Soil and Water Conservation Districts
- Wildcat Creek Watershed Alliance

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

Monitoring techniques for all fish in all habitats	Used	Not used but possible with existing technology and data	Not economically feasible
Radio telemetry and tracking	X	X	X
Modeling	X	X	X
Coverboard routes	--	--	X
Spot mapping	X	X	X
Driving a survey route	X	--	X
Reporting from harvest, depredation, or unintentional take (road kill, by-catch)	X	X	X
Mark and recapture	X	X	X
Professional survey/census	X	X	--
Volunteer survey/census	X	X	X
Trapping (by any technique)	X	X	X
Representative sites	X	X	--
Probabilistic sites	X	X	--

Respondents noted other monitoring techniques for all fish in all habitats in Indiana (not ranked):

- Larval sampling to check for reproduction
- Long term monitoring through gillnets and trawling has been conducted at three sites along the Lake Michigan lakefront since the mid 197's by Ball State University during the summer season.
- Creel census conducted by IDNR-Fish and Wildlife division for approximately 20 years
- Commercial monitoring was conducted until the halt of the commercial fishing industry in 1996
- Delury or survey/removal techniques have been used at Donaldson Cave in the 1990s
- Unintentional take could be monitored from fish kill cadaver counts if officers could be trained to identify northern hog suckers instead of not counting them or lumping them into the generic class of "round bodied suckers"
- Electrofishing and seining are appropriate methods for monitoring the orangethroat darter

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

- Seems thorough…how easily can the public obtain this info

Habitat inventory and assessment

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

- Statewide annual inventory and assessment
- Statewide once-a-year inventory and assessment
- Periodic statewide (less than once a year but still regularly scheduled) 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 fish habitats in Indiana (not ranked):

- Statewide once-a-year inventory and assessment
- Periodic statewide (less than once a year but still regularly scheduled) 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 ranked inventory and assessment efforts by state agencies based on their importance for conservation of all fish habitats in Indiana:

Rank	Inventory and assessment by state agencies for conservation of all fish habitats in Indiana
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	Occasional statewide (less than once a year and not regularly scheduled) inventory and assessment
4	Regional or local once-a-year inventory and assessment
5	Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
6	Statewide once-a-year inventory and assessment
7	Regional or local year-round inventory and assessment
8	Statewide annual inventory and assessment

Respondents ranked inventory and assessment efforts by other organizations based on their importance for conservation of

Rank	Inventory and assessment by other organizations for conservation of
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	Regional or local once-a-year inventory and assessment
4	Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment
5	Regional or local year-round inventory and assessment
6	Occasional statewide (less than once a year and not regularly scheduled) inventory and assessment
7	Statewide once-a-year inventory and assessment
8	Statewide annual inventory and assessment

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

- West Fork - White River; East Fork - White River; Wabash River

- Blue River (Harrison County), Sugar Creek (Shelby County), Indian Creek (Greene County)
- Blue River (Harrison County)
- By IDNR Division of Fish and Wildlife, Indiana Department of Environmental Management, City of Elkhart, statewide QHEI
    - For sand darter
    - For least darter
- Recently the IDNR has begun sampling/mapping emergent plant species in some Indiana natural lakes. These plants may be used as reproductive habitat for northern pike
- Northeast Indiana, IDNR – Division of Fish and Wildlife, Jed Pearson
- Habitat mapping and shoreline aerial imagery.
- Lake Michigan
    - In all major tributaries
    - Along the shoreline in nearshore area less than 30 feet in depth
- IDNR Division of Fish and wildlife in this drainage habitat in Indiana
- Habitat evaluations are conducted as part of general stream surveys by DNR biologists. Such surveys have been conducted on the Iroquois, Yellow and Kankakee rivers
- Trail Creek, East Branch of Little Calumet River, Reynolds Creek, Salt Creek, West Branch of Little Calumet River Deep River
- IDEM ecoregion surveys
- ORSANCO

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

- West Fork - White River; East Fork - White River; Wabash River
- Muncie BWQ - WFWR and tributaries in the Muncie area
- St. Joseph River
- Lake Michigan proper along the shoreline in nearshore area less than 30 feet in depth
- City of Elkhart
- USACOE on Ohio River
- Hoosier National Forest; Harrison-Crawford State Forest; Spring Mill State Park; caves of south-central Indiana
- USGS/WRD
- Two or more 5th level HUC watersheds a year that encompass the Hoosier National Forest are sampled; a random sampling of streams found within these 5th level HUCs occurs

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

- IDNR – Division of Fish and Wildlife
- USFWS/GLFC
- IDEM

- City of Elkhart and South Bend
- Ball State University
- University of Michigan
- USACOE Ohio River
- USDA Forest Service
- University of Louisville

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

Inventory and assessment techniques for all fish habitats	Used	Not used but possible with existing technology and data	Not economically feasible
GIS mapping	X	X	--
Aerial photography and analysis	X	X	--
Systematic sampling	X	X	--
Property tax estimates	--	--	X
State revenue data	--	--	X
Regulatory information	X	--	X
Participation in land use programs	X	X	X
Modeling	X	X	X
Voluntary landowner reporting	X	X	X

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

- QHEI
- Bottom mapping of habitat
- IBI for representative sites
- REMAP protocols for northern forested streams
- Stream channel cross-sections and longitudinal profiles
- Substrate analysis
- Descriptions of riparian vegetation
- Water quality parameters using probes and hydro-labs

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 fish habitats. Their responses included:

- yes, but again I feel data availability and format is important

Recommended monitoring

Species monitoring

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

- Electrofishing
  - Catch rate data
  - In swift water habitats
  - Periodic electrofishing surveys and mark recapture techniques probably provide the best information about the pike populations
  - Get results from probabilistic and representative sites
- Stream sampling using electrofishing techniques and seining. This should be done every 5 years to get a clear picture of changes that occur to habitat, water quality and invasive species introductions and distribution
- Mark and recapture/radio telemetry
- Hoop nets (by scientists and professional fishermen)
  - To verify presence followed by intensive netting to confirm low levels or absence
- Trap netting surveys
- Gill netting surveys
- Kick netting
- Seining
- Population estimates
- Angler creel surveys
- Professional survey (fish management surveys) will show size structure, relative abundance, and provide age and growth information
- Tournament monitoring by the Indiana Division of Fish and Wildlife and bass clubs
- I would like to see all lake trout stocked in Lake Michigan to be coded wire tagged. That will allow for better understanding of survival after stocking and movement of the fish. It will also allow for better understanding of spawning site fidelity
- Monitor commercial catch (Quist, M.C., C.S. Guy, P.J. Braaten, C.L. Pierce, and V.H. Travnichek. 2002. Potential influence of harvest on shovelnose sturgeon populations in the Missouri River system. North American Journal of Fisheries Management 22:537-549)
- Fall trawl sampling for young of the year production. Possible incorporation of hydracoustic models for the nearshore area
- Rotational sampling at reference sites along the headwaters. Historical comparisons from the early 1980s will be compared with the sampling that was completed 2001 to 2004
- Fall/winter Ohio River tailwater sampling and occasional stream surveys
- Periodic stream surveys
- Large fyke-nets are used in Lake Webster (Kosciusko County) to collected brood stock for muskellunge. These nets would be useful in capturing northern pike as well. This would allow biologist to capture enough fish to get a representative sample of adult fish. There is still no effective method of sampling young esocids without mortality

- Cavefishes
  - Development of an index of biotic integrity (IBI) for vertebrate cave communities in southern Indiana
  - Select five to 10 locations for survey/counts every two to five years. A similar survey schedule has been established for cavefish populations in Mammoth Cave National Park and could be used as a model (both IBI and survey)
- Eastern sand darter: See where populations of the darter have been captured in the past. With seines or electrofishing equipment, mark and recapture darters to document habitat characteristics, water quality information and land use characterization. You will need to target habitat and not the exact location since the sandbars will probably shift over time. Look on the Web for mark and recapture surveys as well as other eastern sand darter publications. I found many by just searching the web
- Smallmouth bass
  - Stream fish community surveys: to determine smallmouth bass distribution and abundance. There may be a correlation of smallmouth abundance to the species richness to the overall fish community
  - Smallmouth bass population estimates
- Orangethroat darter
  - Electrofishing streams to take a random sampling of streams within a watershed (5th or 6th level HUC) and standardize the stream reach length for the survey (usually 15 times the stream width)
  - Seining is an appropriate method for sampling, especially in the riffle habitats
- Least darter: Survey representative sites or look for sites where the habitat is suitable for the least darter and seine in the vegetation over rocky substrate

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

- yes

Habitat inventory and assessment

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

- GIS
- QHEI
  - In conjunction with a stream community survey or sampling specifically for smallmouth bass. This can show which habitat components most strongly correlate with smallmouth bass abundance and or size structure
- Systematic sampling would probably be best to determine the abundance of cover that is available, but could be very difficult as most of the habitat is hidden under the surface of the water
- Digital satellite imagery to conduct bottom contour mapping in nearshore spawning areas.

- Record habitat when fish are collected during a survey
- Systematic sampling of the habitat along the length of the stream to provide baseline data for comparison across time
- Telemetry Surveys
- Lidar mapping would help identify spawning areas within the nearshore zone along Indiana's coastline
- Sampling using electrofishing and seining in headwater areas. Completing IBI and QHEI and water quality analysis for these sites.
- Emergent bulrush and wetland monitoring and protection via ecozones
- Evaluate land and water use practices to reduce in lake and upstream degradation of vegetation and shoreline
- Population surveys every five years and development of an IBI to be applied at five to 10 locations, including Blue Spring Caverns, Spring Mill State Park and Harrison-Crawford State Forest
- Orangethroat darter: Protocols that I recommend for reference:
    - Harrelson, C.C., C.L. Rawlins, and J.P. Potyondy. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. USDA Forest Service. General Technical Report RM-245. (The above reference offers useful guidance on measuring stream channel cross-sections and substrate within the stream. This information can be used to determine if a stream channel is stable and if the substrate is available within riffle habitats, which are the preferred habitat of the Orangethroat darter
    - Simon, T. P. and P.M. Stewart. 1998. Standard Operating Procedures For Development of Watershed Indicators In REMAP: Northern Lakes and Forest Streams (The above reference is very useful for developing a watershed level sampling design and includes useful methods for measuring stream channel and stream habitat parameters)

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 effective conservation of all fish habitats. Their responses included:

- we need a simple on-line system for bass tournament directors to submit catch information...easy data to acquire bass info

Technical experts and conservation organizations offered the following additional comments:

- Smallmouth and spotted bass seem to get little attention in our resevior system, and many anglers would enjoy the opportunities these fish provide

  We also see Asian carp as a serious threat to the Ohio River fishery and the fishermen themselves. These carp are dangerous to the native fish and to boaters. Is there anything that can be done?

ALL MAMMALS IN ALL HABITATS NARRATIVE

Problems affecting species and habitats

Species threats

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

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

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

- Captive cervids

- Genetic contamination from farmed whitetails

- Habitat fragmentation/loss
  - Removal of fence rows
  - Loss of small farms habitat
  - Urban sprawl, added roads, traffic, construction
  - Loss of forest habitat/surrounding winter hibernacula/caves
  - Sporadic occurrence of early and mid successional fields is the greatest deterrent to higher abundance
  - Loss of wetlands (muckland)
  - Destruction of trees
    - By disease
    - By insects
  - See various threats to individual species below

- Undesirable/invasive species
  - Spread of honeysuckle

- Unregulated collection pressure/human disturbance/human interference
  - Related to research/monitoring
  - Bats: Unregulated human activity in hibernacula

- Cottontail rabbit threats
  - Habitat loss to natural succession is a critical threat to cottontail populations in Indiana
  - Cottontail numbers are proportional to available habitats. To increase or decrease in numbers, depend on available habitats
  - Agricultural policy (i.e., production without supply side considerations influence the availability of habitats)
  - Competing human needs: Cottontails are a game species and utilized heavily as a recreational resource and is therefore a luxury. The tradeoff concerning the cottontail is that we the American public, want beef, corn and related foodstuffs at low cost. The cottontail will not prevail here as being necessary under those societal needs

- Raccoons, coyotes, opossums, red fox, muskrats threats
  - Although not habitat specific, the inability to responsibly and proactively manage these species according to the wildlife conservation model, as opposed to reactive measures through nuisance practices, is a concern regarding the conservation of these species. This concern applies across the landscape, not just in urban and suburban environments

- Red fox threats
  - There are competition and disease concerns about red fox populations but they are not limited to grasslands

- Otter threats
  - As adjacent states initiate harvest seasons for otters, there might be added pressure to take otters accidentally trapped in Indiana across state lines to market fur. I wouldn't expect this to have a significant impact at a statewide or even regional scale

Indiana myotis
- Unregulated human activity in hibernacula

Eastern pipistrelle

  - Needs caves or mines for hibernation within probably 60 miles of its summering ground

- Cottontail rabbit threats
  - Cold wet weather when first litters appear (Late March and early April)

Respondents listed top threats for all mammals in all habitats in Indiana (not ranked):

- Habitat loss (nesting, foraging, feeding)/degradation/fragmentation (see individual species entries below)
  - Due to urban sprawl/development/rural development
  - Due to uncontrolled vegetative succession
  - Habitat loss in relatively specialized (early successional) habitat is the primary threat to the short-tailed shrew
  - Loss of grassland habitat
    - Loss of ground squirrel populations
  - Due to agriculture
  - Due to natural succession
  - Build-up of dense urban development around roost location without adequate greenspace for foraging
  - Exclusion of maternity colonies from buildings
  - Loss/degradation of migration habitat and routes
    - Large-scale mortality being reported from wind turbines and other sources is the most threatening issue for the Eastern red bat
    - Loss of winter range is a slight concern since we really don't know where they are going

- Near limits of natural geographic range/small native range

- Franklin's Ground Squirrel: Small, nomadic populations in restricted portion of state (maybe only 3 to 6 counties) that is subjected to developmental and agricultural pressures. Indiana is at the easternmost periphery of the historic range in North America. Their range in NW Indiana coincides with some of the most productive agricultural lands in the state (i.e., Benton County) or some of the most densely populated areas (i.e., Lake, Porter counties). Principal threats are primarily habitat related:
  - Direct loss of grassy/herbaceous cover
  - Conversion of smaller farms (that used to maintain fencerows, etc.) to agribusiness entities
  - Invasion of extensive woody components into existing grassland communities

- Species competition/predators
  - Competition with coyotes affects some wildlife species
  - Domestic predation

- Human disturbance (Also see entries for bats, bobcats)
  - Human removal of species from lawns and gardens
- Agricultural policy
- Migratory information
  - We also need information about how some bird species migrate to begin thinking about where not to place such structures
- Invasive/non-native vegetative species
  - Fescue does not provide cover, nutrition and is thought to be toxic
- Pollution/degradation of aquatic systems
  - Reproductive performance of otters can be compromised by high levels of PCBs and heavy metals that bioaccumulate in the aquatic food chain
- Bats threats
  - Human disturbance of hibernating bats (e.g., Ray's Cave in Greene County)
  - Alterations to microclimate within hibernacula
  - Major threats are closure of roosts (both hibernacula and maternal)
  - Incidental take from collisions
  - Some traditional hibernacula have been rendered unsuitable or degraded due to cave development/commercialization (including disturbance of hibernating bats by human visitation), modification of cave environment, or alternation of surface features
  - Threats also occur on summer habitat (not addressed here because it is not captured within the "cave habitat" category)
  - Loss of typical maternal roosting structures (large snags with sloughing bark)
  - Indiana bats: The major two threats are loss of summer and winter (caves) habitat. In addition, education of cavers and continued improvements to cave gates are important to the Indiana bat survival
- Deer threats
  - Overpopulation will lead to an unmanageable resource and severe habitat degradation
  - Captive cervids contaminate genetic integrity and increase chance of infection for wild deer
  - CWD, EHD and tuberculosis could be devastating to a deer herd of our density
  - Trophy management and associated leasing will lead to overpopulation and fewer active hunters
- Coyote threats

  - People are generally "anti-coyote" fearing predation on pets, livestock and wildlife

- Fox squirrel threats
  - Overall loss of habitat
  - Fragmentation of remaining forest tracts

- Beaver and mink threats
  - Although not habitat specific, the inability to responsibly and proactively manage these species according to the wildlife conservation model, as opposed to reactive measures through nuisance practices, is a concern regarding their conservation. This concern applies across the landscape, not just in urban and suburban environments

- Otter threats
  - Pollution/degradation of aquatic systems: reproductive performance of otters can be compromised by high levels of PCBs, heavy metals, etc. that bioaccumulate in the aquatic food chain
  - Direct loss of aquatic habitats such as wetlands, marshes, etc. also impact otters

- Short-tailed shrew threats
  - Habitat loss in this relatively specialized habitat is the primary threat to the short-tailed shrew. Early successional grassland habitats provide marginal habitat requirements for this specialized species. The short-tailed shrew is an insectivore/vermivore. Early successional grassland habitat occurs in abandoned land associated with either agricultural, industrial or urban land uses. Only in isolated situations do grasslands develop as a dominant habitat type in Indiana. Most grasslands will eventually be dominated by shrub or tree cover. By definition early successional grassland habitat is a temporary habitat type

- Bobcat threats
  - Human-related factors such as direct mortality (incidental take, road-kills, persecution) and habitat loss
  - Conversion of native communities and habitats for human use cause direct loss of habitats for bobcats and their prey items

- Allegheny woodrat threats: The Allegheny woodrat occupies cliffs, caves, and other rocky habitats in deciduous forests. When forests become fragmented, for whatever reasons, several negative impacts to woodrat populations can result.
  - Habitat loss: Loss of mature mast-producing trees can occur; changes in forest composition can also result
  - Corridor loss: Woodrats may have to cross non-forested areas to reach preferred feeding areas (i.e., hard mast or soft mast crops, etc.)
  - Predation: While crossing non-forested areas, they may become exposed to ubiquitous predators (great horned owls, raccoons)

  - Disease: Raccoon densities may be higher in non-forested settings (such as farmed areas on top of cliffs), which could expose woodrats to higher levels of raccoon roundworm

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

- I also feel that a lack of public education on the need to conserve our wildlife is a huge threat.

Habitat threats

Respondents ranked threats to all mammal habitats in Indiana:

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

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

- Habitat loss/destruction/degradation
  - Due to urban spread and construction
  - Modern farm practices: The creation of large open, clean farm fields leaves no habitat for deer or many other mammals

        - Fence row removal
    - Mowing or burning for aesthetic purposes such that badger prey population or badger cover are diminished
    - Certain bats need caves or mines

- No financial incentive to develop/maintain/manage these habitats

- Pesticide contamination
    - Can affect certain bats

A respondent noted, "The participant has to speculate about the meaning of successional change. Is a change an increase or decrease in early or late successional habitats? Climate change also is speculative. Agriculture/forestry practices have different effects. Grouping these practices into one category does not appropriately represent the individual practice. Point and non-point pollution may be positive or negative to the habitat as related to beaver."

Respondents listed top threats to all mammal <u>habitats</u> in Indiana (not ranked):

- Habitat fragmentation/degradation/loss
    - Fragmentation in farmed/heavily populated regions prevents historical movements from summer to winter ranges
    - Due to urban sprawl, commercial and residential development
    - Due to agricultural/forestry practices
    - Due to regulations that allow loss of habitat
        - The human/beaver interface usually results with either the habitat being eliminated or the beaver being eradicated
    - Successional change results in habitat degradation as grasslands are invaded by woody vegetation
    - Fragmentation of habitat forces unnatural movement and increases accidental mortality as well as the opportunity to spread disease
    - Fragmentation restricts movement and constricts genetic mixing
    - Habitat degradation reduces food sources as well as reproductive potential
    - Adverse modifications to cave entrances (e.g., poorly designed bat gates), which cause a change in interior microclimates/temperatures
    - Bats: Loss/degradation/fragmentation of forested areas surrounding caves used by bats during the fall swarming period
    - Bats: Loss/degradation of traditional hibernacula
    - Bats: Loss of breeding habitat for bats (note that breeding habitat also occurs in areas of the state not associated with caves)
    - Red bats: Our unpublished work on eastern red bats suggests critical habitat is a combination of forests for roosting and edge habitat for roosting. As such the main threats are:
        - Loss of forest habitat
        - Loss of suitable foraging habitat to development

  - Loss of habitat due to invasive species: Loss of early successional grasslands by tall fescue
  - Loss of habitat due to successional change
  - Loss of wetlands reduces amount of suitable habitat for otters
  - Loss of forests reduced suitable habitat for fox squirrels
  - Bobcats: Top threats to bobcat habitat are loss of forested habitats (or any native or non-developed habitats) to residential, commercial, industrial, etc. uses. Conversion of habitats to types dominated for human activity, on a cumulative scale, are problematic. Fragmentation, to a lesser extent, also negatively impacts bobcat habitats, but is probably less of a factor because the species is somewhat adaptable and highly mobile
  - Loss of existing grassland/herbaceous cover to a number of factors (development, sprawl, agriculture) and fragmentation of remaining suitable habitats (potentially isolating small, remnant FGS populations)
  - Forested communities in association with cliffs, however, are vulnerable to development, fragmentation, loss of hard mast producing species, etc.

- Agricultural policy

- Degradation by overpopulation

- Water pollution and run-off
  - Not only impacts otter reproduction, but may also impact the quantity/quality of aquatic prey
  - Degradation of caves by potential migration of chemicals alter the cave ecosystem

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the threats to all mammals in all habitats. There were no responses.

Additional research and survey efforts

Current body of research

Species research

(Q33) Five percent of respondents stated that the current body of science is complete, up to date and extensive for all mammals in all habitats in Indiana. Thirty-seven percent say that it is adequate. Thirty two percent said that it is inadequate. Three percent said that the body of science is nonexistent.

Respondents made additional comments on the body of science (not ranked):

- There is lots of research but also great need due to endangered status
- There is very little habitat specific research on coyotes in Indiana, particularly when generalizing across generalist habitat types
- Literature focus on rural, as opposed to urban, areas and does not encompass all generalist habitats

- I am not aware of opossum literature as it pertains to generalist habitats in Indiana
- I am not aware of literature devoted strictly to the red fox's use of grassland habitat
- I am not familiar with literature related to beaver habitat use in Indiana
- Literature is not habitat specific for muskrats in Indiana
- I am not aware of literature on mink focused strictly to rivers and streams

Title = White-tailed Deer Ecology and Management; Author = Halls, L. K. (editor); Date = 1984; Publisher = Stackpole Books
[No Answer Entered]
Title = Mammels of Indiana; Author = Mumford/Whitaker; Date = 1982; Publisher = IU Press
[No Answer Entered]
Title = IN Mammals; Author = Whittaker
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
Title = Mammals of Indiana; Author = Mumford; Date = ?; Publisher = ?
Title = Mammals of the Great Lake States; Author = ?; Date = ?; Publisher = ?
Title = Mammals of Indiana; Author = Russell E. Mumford/ John Whitaker, Jr.; Date = 1982; Publisher = Bloomington Indiana University Press
[No Answer Entered]
Title = Population Ecology and Harvest of the Cottontail Rabbit; Author = Heraold A.Demaree, Jr; Date = 1978; Publisher = Indiana DFW
[No Answer Entered]
Title = White-tailed Deer Ecology & Management; Author = Wildlife Management Institute Book; Date = 1984; Publisher = Stackpole Books
[No Answer Entered]
Title = Mammals of IN; Author = Russel Mumford & John Whitaker Jr; Date = 1982; Publisher = IN Universty Press
[No Answer Entered]
Title = None known
Title = None known
Title = White-tailed Deer Ecology and Management; Author = Lowell K. Halls; Date = 1984; Publisher = Stackpole Books
Title = Mammals of Indiana; Author = Russell E. Mumford and John O. Whitaker, Jr.; Date = 1982; Publisher = Indiana University Press
Title = Wintering populations of bats in Indiana, with emphasis on the endangered Indiana Myotis, Myotis sodalis; Author = Virgil Brack, Jr., Scott A. Johnson, and R. Keith Dunlap; Date = 2003; Publisher = Proceedings of the IN Academy of Science
[No Answer Entered]
Title = I can't
Title = I can't
Title = Management of hibernacula in the state of Indiana; Author = Johnson, Brack, Dunlap; Date = 2002; Publisher = Bat Conservation International
Title = Biennial hibernacula survey reports; Publisher = reports submitted to IDNR
Title = Population ecology and harvest of the cottontail rabbit on the Pigeon River fish and wildlife area, 1962-1970; Author = Harold Demaree Jr.; Date = 1978; Publisher = Indiana Division of Fish and Wildlife
[No Answer Entered]
Title = Gray and Fox Squirrel Management in Indiana; Author = John M. Allen; Date = 1964; Publisher = Indiana Department of Conservation
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
Title = Ecology of coyotes as influenced by landscape fragmentation; Author = Todd Attwood; Date = May 2002; Publisher = Purdue University
[No Answer Entered]
Title = Raccoon density, home range, and habitat use on south-central Indiana farmland.; Author = Larry Lehman; Date = 1984; Publisher = IDF&W

Appendix F-76: Mammals

[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
Title = Fur animals of Indiana; Author = David Brooks; Date = 1959; Publisher = IDF&W
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
Title = Distribution of the western harvest mouse in Indiana; Author = Leibacher and Whitaker; Date = 1998; Publisher = Ind, Acad. Sci. 107:167-170
Title = see above for more
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
Title = Indiana River Otter Reintroduction Program, 2000-2001; Author = Scott A. Johnson; Date = November 2001; Publisher = Internal report, Indiana Department of Natural Resources, Bloomington, IN
Title = Restoring river otters in Indiana; Author = Scott A. Johnson and Kim A. Berkley; Date = 1999; Publisher = Wildlife Society Bulletin 27:419-427.
Title = Mammals of the Eastern United States; Author = J.O. Whitaker, Jr. and W. J. Hamilton, Jr.; Date = 1998; Publisher = Cornell University Press
Author = www. natureserve.org/explorer
Title = Home range near hibernacula in spring and autumn; Author = Russell C. Romme, Amy B. Henry, R. Andrew King, T. Glueck, and K. Tyrell; Date = 2002; Publisher = The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International
Title = The nonhibernating ecology of bats in Indiana with emphasis on the endangered Indiana bat, Myotis sodalis; Author = Virgil Brack, Jr.; Date = 1983; Publisher = Purdue University
Title = A 14-year study of BLARINA BREVICAUDA in east-central Illinois.; Author = Getz, L. L.; Date = 1989; Publisher = J. Mammalogy 70:58-66.
Title = Blarina bravicauda; Author = George,S. B., J. R. Choate, and H. H. Genoways; Date = 1986; Publisher = Mammalian Species 261:1-9
Author = Mumford and Whitaker 1982
[No Answer Entered]
Title = Brack, Johnson and Dunlap, 2003.; Publisher = Proc. Ind. Acad, Sci. 112:-61-74.
Title = Mumford and Whitaker 1982
Title = Mammals of Indiana; Author = John Whitaker; Date = IN Press; Publisher = IU Press
Title = Nocturnal Behavior of Eastern Red Bats; Author = Brianne Everson; Date = 2005?; Publisher = MS Thesis, Indiana State University (not yet complete)
Title = The bobcat in Illinois; Author = Alan Woolf and Clayton Nielsen; Date = 2002; Publisher = Southern Illinois University Carbondale
Title = Status and management of bobcas in the United States over three decades; Author = Woolf, A. and G.F. Hubert, Jr.; Date = 1998; Publisher = Wildlife Society Bulletin 26:287-293.
Title = Reduction in the Eastern Limit of the Range of the Franklin's Ground Squirrel; Author = Scott Johnson and Jane Choromanski-Norris; Date = 1992; Publisher = American Midland Naturalist 128:325-331.
Title = Franklin's Ground Squirrel in Illinois: A Declining Prairie Mammal?; Author = Jason Martin, Edward Heske, Joyce Hofman; Date = 2003; Publisher = American Midland Naturalist 150:130-138.
Title = Reassessment of the Allegheny woodrat in Indiana; Author = Scott Johnson; Date = 2002; Publisher = Proceedings of the Indiana Academy of Science 111:56-66.
Title = 2002 Allegheny woodrat monitoring program; Author = Scott Johnson, Heather Walker, Cassie Conrad, Aaron Holbrook; Date = 2003; Publisher = Indiana Department of Natural Resources (internal report)
Title = Mammals of Indiana; Author = John Whitaker; Date = 2005 (currently in press); Publisher = IU Press
Title = Foraging-habitat selection by bats at an urban-rural interface: comparison between a successful and a less successful species.; Author = Duchamp, Sparks, Whitaker; Date = 2004; Publisher = Canadian Journal of Zoology
Title = Mamm. IN; Author = M & W 1982

[No Answer Entered]

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 mammals in all habitats. There were no responses.

Habitat research

Two percent of respondents stated that the current body of science is complete, up to date and extensive for all mammal habitats in Indiana. Thirty-four percent say that it is adequate. Thirty seven percent said that it is inadequate. Three percent said that the body of science is nonexistent.

Title = White-tailed Deer Ecology and Management; Author = Halls, L. K. (editor); Date = 1984; Publisher = Stackpole Books
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
Title = Not aware of any
[No Answer Entered]
Title = Mammals of Indiana; Author = Russell E. Mumford; Date = 1982; Publisher = Bloomington Indiana University Press
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
Title = Mammals of Indiana; Author = Mumford/Whitaker; Date = 1982; Publisher = IU Press
[No Answer Entered]
Title = Unknown
Title = Unknown
Title = White-tailed Deer Ecology and Management; Author = Lowell K. Halls; Date = 1984; Publisher = Stackpole Books
[No Answer Entered]
Title = see previous reference
[No Answer Entered]
Title = I can't
Title = I can't
Title = same as Q34
Title = same as Q35
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]

[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]; Title = Habitat-relative abundance relationship for bobcats in southern Illinois; Title = Habitat-relative abundance relationship for bobcats in southern Illinois.; Title = The bobcat in Illinois; Author = C.K. Nielsen and A. Woolf; Author = Nielsen, C.K. and A. Woolf; Author = A. Woolf and C. Nielsen; Date = 2002; Date = 2002; Date = 2002; Publisher = Wildlife Society Bulletin 30:222-230.; Publisher = SIU-Carbondale; Publisher = Wildlife Society Bulletin 30:222-230.
[No Answer Entered]; [No Answer Entered]; [No Answer Entered]; Title = Habitat-relative abudance relationship for bobcats in southern Illinois; Author = Nielsen, C.K, and A. Woolf; Date = 2002; Publisher = Wildlife Society Bulletin 30:222-230
[No Answer Entered]
[No Answer Entered]
Title = Hibernacula of the endangered Indiana bat in Indiana; Author = Brack, Virgil Jr., A.M. Wilkenson, R.E. Mumford; Date = 1984; Publisher = Proceedings of the Indiana Academy of Science, vol. 93:463-468
Title = Distribution and ecology in Indiana. Pp 48-54 in Indiana Bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, Eds.); Author = John Whitaker Jr. & Virgil Brack Jr.; Date = 2002; Publisher = Bat Conservation International
Title = A4-year study study of BLARINA BREVICAUDA un east-central Illinois; Author = Getz, L. L.; Date = 1989; Publisher = J. Mammalogy 70:58-66.
[No Answer Entered]
[No Answer Entered]
[No Answer Entered]
Title = Mumford and Whitaker 1982
Title = Veilleux et al. 2003.; Publisher = J. Mamm, 841068-1075.
Title = Natural Heritage of Indiana; Author = Marion Jackson; Date = 1999; Publisher = IU Press
Title = Nocturnal Behavior of Eastern Red Bats; Author = Brianne Everson; Date = 2005?; Publisher = Unpublished MS Thesis (should be complete by may 2005)
Title = The bobcat in Illinois; Author = Alan Woolf and Clayton Nielsen; Date = 2002; Publisher = Southern Illinois University Carbondale
[No Answer Entered]
Title = not aware of any!!
Title = not aware of any!!
Title = Natural Features of Indiana?; Author = Alton Lindsey (editor); Date = 1966; Publisher = Indiana Academy of Science
[No Answer Entered]
Title = Natural Heritage of Indiana; Author = MT Jackson; Publisher = IU Press
Title = Indiana GAP data; Date = Unpublished available form ISU dept of Geography
[No Answer Entered]
[No Answer Entered]

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 mammal habitats. There were no responses.

Research needs

Species research

Appendix F-76: Mammals

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

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

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

- Deer
  - A deer harvest analysis and modeling program
  - Baseline life history data
  - CWD all aspects
  - The aging techniques (tooth wear) biologists use were developed in New York and may not be accurate for deer of the Midwest. My personal experience with deer of known ages indicates that wear is less than the aging charts we currently use. Additional local research needs to be done if we are interested in accurately aging deer over 2 1/2 years of age
  - Research needs explore the role of age and social structure in deer herd health

- Indiana myotis: We urgently need to determine effects of forest habitat loss, fragmentation and timber management on summer habitat for maternity colonies and reproductive success

- Bats:
  - More information is needed on autumn swarming and spring staging. Similarly new hibernacula need to be recorded
  - Need to know more about rabies in this species
  - We desperately need to know how bats interact with each other in terms of competition
  - We desperately need to know how this omnipresent bat influences other species

  Eastern mole
  - We need more information on the reproduction of this species in various habitats

- Cottontail rabbits: Determine what affect feral cats have on a local cottontail population

- Fox squirrels: Due to the high fragmentation of forest tracts in Indiana (especially northern Indiana) I believe that dispersal distance is a critical area of research. I also would like to see a research project that evaluates the amount of harvest pressure can be sustained by isolated metapopulations of squirrels

- Badgers: The relationship between badgers and land use and soil type, especially soil types that support borrows both for the badger and its prey

- Relationship(s) between population levels and population indices

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for all mammals in all habitats. There were no responses.

Habitat research

Respondents ranked research needs for all mammal habitats in Indiana:

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

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

- Research needs explore the effects of land development

- Indiana bats:
  - How much forest habitat needs to remain around a hibernaculum to sustain a population of size during the fall swarming period?
  - How does cave environment, especially temperature and temperature stability, affect suitability and use of cave by Indiana bats
  - What components of the habitat immediately surrounding the cave are most important to Indiana bats during fall swarming and spring staging. How is this habitat used?

- Obtaining data on habitat for the Big brown bat would provide a nearly complete picture of the status of various habitat types in Indiana.

- Distribution and dispersal factors with regard to habitat factors including streams the larger rivers

- Badgers: The difference between native, warm-season-grass/native forb grasslands; planted, non-native, cool-season grasslands; and CRP grasslands relative to suitability for badgers

- Recommend a detailed analysis of forest canopy to openness ratio and habitat intricacies that provide preferred home range requirements (e.g. primary roosts, secondary roosts, water, night roosts, food)

- Need to know more of the relationship between winter and summer habitat, and also of migration

- Additional information on all phases of the biology of some mammals would be helpful. However, others are in no current danger

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for all mammals habitats. There were no responses.

Conservation actions necessary

Species actions

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

Rank	Conservation efforts for all mammals in all habitats
1	Culling/selective removal
2	Protection of migration routes
3	Population management (hunting, trapping)
4	Regulation of collecting
5	Threats reduction
6	Food plots
7	Habitat protection
8	Exotic/invasive species control
9	Public education to reduce human disturbance
10 (tie)	Limiting contact with pollutants/contaminants
10 (tie)	Native predator control
10 (tie)	Disease/parasite management

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

- Contraceptives: Currently not used due to efficacy and economics

- Vegetative succession control
- Indiana myotis: Posting signs at caves, installing-bat friendly gates, land acquisition, installing fake video cameras to deter cave visits, using light sensitive "speloggers" to monitor levels of human visitation
- Protect home caves and mines in which the Eastern pipistrelle occurs
- Cottontail rabbits: Provide additional habitats through programs, agricultural and other
- Preserve wetlands
- Protect grasslands/woodlands

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

- Deer management
  - Population management via hunting
  - Ban cervid farming and canned hunting
- Habitat protection and habitat creation/management
  - Control habitat fragmentation
  - Protect woodlands/forest tracts
  - Early successional habitat
  - Protect and develop corridors
- Regulated trapping and nuisance animal control policies
- Population management
- Regulate collecting
- Invasive species control
- Bat species:
  - Negotiate with the owner of Ray's Cave and other hibernacula to allow them to be gated or employ one or more of the other techniques above
  - Gating, securing conservation easements, or purchasing unprotected hibernacula (prioritizing based on current numbers or potential of hibernacula to harbor large numbers if disturbance is presently limiting numbers)
  - Protecting surface features and forest cover surrounding hibernacula and managing for high quality swarming habitat
  - Protect bats as part of historic home preservation

- Further research into how to allow peaceful and safe coexistence between bats and homeowners
- General conservation measures for bats are described in Mammals of Indiana, America's Backyard Bats (MD Tuttle, Bat Conservation International), and Sparks, D. W., and J. R. Choate. 2000. Distribution, natural history, conservation status, and biogeography of bats in Kansas. Pp: 173-228 In Reflections of a naturalist: papers honoring professor Eugene D. Fleharty (J. R. Choate, ed.), Fort Hays Studies, Special Issue 1: 1-241
- The purchasing and protection of recorded Indiana bat hibernacula and summer habitat. Similarly, public education is needed on the importance of caves, snags, and the importance of this species to man
- Protect caves and mines
- Continued education of people about bats

Cottontail rabbit

- Promote early succession associated with structure similar to L. japonica

- Furbearer management: Coyote, raccoon, opossum, red fox, beaver, muskrat, mink
  - Public education and outreach programs are needed to effectively and accurately educate citizens about wildlife (game and nongame), the wildlife conservation model (game and nongame) and the need for effective species management programs

- Otters
  - Protection of aquatic and riverine habitats
  - More programs or efforts to restore lost or degraded systems
  - Educational programs aimed to reduce incidental take, especially where population densities are lower
  - Protect natural communities and habitats
  - Manage forested lands to provide early-/mid-successional stage habitats

- Franklin's ground squirrels and pocket gophers
  - Conservation and restoration of populations
  - Limit human access to all parts of large grasslands

- Franklin's ground squirrels: There are not any truly active, ongoing conservation efforts for Franklin's ground squirrels in Indiana. Most of the work has been focused on documenting distribution and relative abundance:
  - Periodic burning of railroad right of ways (an important land use type for Franklin's ground squirrels in Indiana) to maintain a strong grassy component has been beneficial in the past
  - Before effective conservation strategies can be implemented, one must know the limiting factors for the species. Franklin's ground squirrels will probably always have a tenuous status in Indiana. They were never common and suitable habitats are now limited to railroad rows and widely scattered tracts of natural grasslands.

Additionally, populations are reported to be cyclic, have a discontinuous or patchy distribution, and appear to be somewhat nomadic or transitory in nature

- Studies of migration routes are needed so these areas can be protected

- Care should be taken in approving wind turban power stations because of the large direct take associated with these structures. We also need some studies of these power stations in this section of the Midwest (Indiana, Illinois, Ohio)

- Allegheny woodrats
  - Research aimed to identify factors that limit woodrat populations is a high priority
  - Periodic monitoring of extant populations
  - Revisit previously-occupied sites to assess recolonization potential

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

- Reduce and reverse the effects of urban sprawl by buying more farmland/woodland that is up for sale (money from environmental license plates, etc.) and protecting this land from further development.

Habitat actions

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

Rank	Conservation efforts for all mammal habitats
1	Selective use of functionally equivalent exotic species in place of extirpated natives
2	Habitat protection on public lands
3 (tie)	Technical assistance
3 (tie)	Succession control (fire, mowing)
3 (tie)	Restrict public access and disturbance
4	Land use planning
5	Habitat restoration on public lands
6	Protection of adjacent buffer zone
7 (tie)	Corridor development/protection
7 (tie)	Cooperative land management agreements (conservation easements)
8	Habitat protection incentives (financial)
9	Habitat protection through regulation

10 Habitat restoration incentives (financial)

11 (tie) Pollution reduction

11 (tie) Artificial habitat creation (artificial reefs, nesting platforms)

11 (tie) Managing water regimes

11 (tie) Habitat restoration through regulation

Respondents listed other current conservation practices for all mammal habitats in Indiana (not ranked):

- Restrict motorized access into habitat
- Strip spraying/reseeding
- Fire and mowing for grassland habitats to benefit red fox
- Educate public on retaining old, dead or dying trees that provide wildlife habitat, including for the Indiana bat

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

- Habitat protection, restoration and management
  - Restore habitat on public lands
  - Use financial incentives
  - Preserve and manage habitat types
    - Wetlands
    - Agricultural habitats
    - Successional habitat types
    - Forest habitat types
  - Use financial incentives
  - Purchase habitat
  - Grassland management/controlled burn issues
    - Prescribed burning to control vegetative succession. (Uncontrolled vegetative succession eventually excludes rabbits and makes future management difficult due to concerns for Indiana bat) (Stribling, H.L. and Speake, D. W. 1991. Responses of Bobwhite Quail and Eastern Cottontail Rabbit Populations to Prescribed Burning, Cover Enhancement and Food Plots. Alabama Game and Fish Division/Auburn University)
    - Controlled burns are becoming more difficult to conduct due to lack of trained personnel, restricted burn windows, and encroaching development. Grassland management difficulties need to be addressed
  - Create corridors
  - Restrict housing development in forested areas
  - Conservation easements
    - On private property containing important swarming habitat and connected karst features around key hibernacula
- Otters
  - Proper land use planning, at a watershed scale, would not only benefit otters but other aquatic and riparian species
  - Strict enforcement of existing pollution regulations, and if needed, development of stricter laws would be beneficial
- Franklin's ground squirrels

  - Considering current land use practices in Northwest Indiana, railroad right of ways may provide the most abundant source of grassland communities. Prescribed burning to maintain grass/forb and prairie communities along right of ways is important. Larger blocks of grassland habitats in the range are often found in state nature preserves. These are often isolated from one another, reducing fragmentation to the extent possible would be another beneficial habitat tool

- Allegheny woodrats: Encourage retention and development of hard mast trees (oaks, hickories) in close proximity to woodrat cliffs

- Bat species
  - Reduce human disturbance
  - Avoid removal of hibernacula and maternal sites
  - We should also remind those interested in preserving historical buildings and sites, that the bat colonies may also be part of that history (References available in Mammals of Indiana and Bats of Kansas)

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the conservation for all mammal habitats. There were no responses.

Proposed plans for monitoring

Current monitoring

Species monitoring

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

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

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

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

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

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

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

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

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

- Staff at the Bloomington IDNR office monitor for species on a statewide basis

- The only monitoring for coyotes is the fur harvest report; coyotes might be included on small game harvest questionnaires

- IDNR – divisions of State Parks, Nature Preserves, Division of Fish and Wildlife

- Fur buyer surveys

- Beavers
  - State and county highway departments monitor beaver activity only as flooding of roadways occur
  - IDNR property monitor and attempt to eliminate problems associated with flooding of adjacent private property
  - State furbearer biologist tracks and monitors trapping harvest data

- Cottontail rabbits: Division of Fish and Wildlife logged rabbit sightings during quail whistle counts

- Annual Bowhunter Survey

- Hunter harvest data on state fish and wildlife properties

- State deer check stations

- DNR property harvest data/annual small game survey of licensed hunters

- Bats
  - IDNR conducts biennial hibernacula surveys in all known Indiana bat hibernacula in the state (except Batwing and Twin Domes Caves, which are surveyed under a separate federal contract)
  - Occasional monitoring/research is conducted in cave habitats on a localized basis by state agencies for specific purposes (such as the swarming habitat study at Wyandotte Cave)
  - Monitoring is occasionally conducted in summer habitat (not included in this survey)
  - State rabies laboratory
  - IDNR monitors and records bat mist net captures

- Indiana bats: Caves in southern Indiana are monitored. Currently there are 33 hibernacula reported for the Indiana bat in southern Indiana. This confidential information is available upon request

- Red bats

  - Monitored as part of the regular bat sampling that occurs at Indianapolis Airport, Camp Atterbury, Newport Chemical Depot
  - Population trends may be assessed via animals submitted to the state rabies lab

- Bat species
  - Indiana State University (John Whitaker) and the state board of health keep detailed records of bats submitted for rabies testing
  - Wildlife biologists at various military bases conduct regular mist net and hibernacula surveys as do some state parks and Scott Johnson and USFWS Indiana bat surveys collect some of this data

- Fox squirrels: The small game harvest questionnaire is the only monitor of fox squirrel population. The survey is conducted in odd years

- Otters
  - IDNR monitors otter mortality (road-kills, trap-related, etc.) at a statewide level
  - IDNR conducts winter bridge/stream surveys for otter sign. These are conducted on a county basis at a statewide level

- Badgers: Indiana divisions of Fish and Wildlife and Nature Preserves maintain data on the occurrence location of road-kill, accidentally trapped or other verified human encounters with badgers

- Bobcats: Ongoing ecological studies of bobcats in southwestern section of Indiana, primarily Greene, Lawrence, and Martin counties

- When monitoring is done, it has been limited to the species historic range in the state. (16 to 17 contiguous counties in Northwest Indiana)

- Species monitored in Harrison and Crawford counties

Respondents listed regional or local monitoring <u>by other organizations</u> for all <u>mammals</u> in all habitats in Indiana (not ranked):

- Some municipalities; university properties

- Purdue University

- Beverly Shores, U.S. National Lakeshore, Wesselman woods (Evansville)

- Private groups have helped with counts in some state parks

- Bats

- Rick Clawson, Missouri Department of Conservation, conducts the biennial winter surveys at Twin Domes and Batwing caves. The Indiana Karst Conservancy (Keith Dunlap) also assists with monitoring efforts, especially at hibernacula that they own or oversee. The Indiana bat population in Reeves Cave in Monroe County has also been monitored.

- There are surveys conducted at localized locations throughout the State of Indiana, primarily in summer habitat but also some cave habitat work, to address specific management or research needs. For example, surveys are conducted at all Department of Defense properties
- Monitored twice, 1975 by Ford, and 1998 by Leibacher and Whitaker
- Indiana State University, most recently by John O. Whitaker, Jr. (Public survey soliciting for information on known bat locations)
- Biyearly monitoring for cave bats in about 18 caves in which Indiana myotis is known to hibernate
- Indianapolis Airport Authority

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

- State universities
  - Purdue University
  - Indiana State University
  - Ball State University (Tom Morrell)
- Indiana Farm Bureau and agricultural groups
- IDNR – Division of Fish and Wildlife
  - Bats: Scott Johnson; Virgil Brack, ESI; Keith Dunlap
  - Beaver, red foxes, opossums, raccoons, muskrat, mink (state, regional and local levels)
  - Bobcats
  - Franklin's ground squirrel
- IDNR – Division of Nature Preserves
- IDNR – Division of State Parks
- U.S. Army Corps of Engineers
- USDA Forest Service
- U.S. Fish and Wildlife Service
- Department of Defense (wildlife biologists at military bases)
  - Crane Naval Base
  - Newport Chemical Depot
- Private conservation organizations
- Bats

- Indiana Karst Society
- NSS Grotto members
- Indiana Cave Society
- Indianapolis Airport Authority
- IDNR – Scott Johnson
- Virgil Brack, ESI
- Keith Dunlap

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

Monitoring techniques for wildlife	Used	Not used but possible with existing technology and data	Not economically feasible
Radio telemetry and tracking	X	X	X
Modeling	X	X	X
Coverboard routes	X	X	--
Spot mapping	X	X	--
Driving a survey route	X	X	X
Reporting from harvest, depredation, or unintentional take (road kill, by-catch)	X	X	--
Mark and recapture	X	X	X
Professional survey/census	X	X	X
Volunteer survey/census	X	X	X
Trapping (by any technique)	X	X	--
Representative sites	X	X	X
Probabilistic sites	X	X	--

Respondents noted other monitoring techniques for all mammals in all habitats in Indiana (not ranked):

- Coyote
  - Howling counts
  - Depredation reports

- Variety of bat species
  - AnaBat/acoustic and/or video monitoring of cave entrances to assess bat presence and use. (AnaBat is a bat detector that uses vocalizations to identify species)

  - Stable isotope analysis, genetic genotyping of individuals (through guano analysis), thermal imagery surveys, contaminant analysis/monitoring through guano and/or whole body analysis
  - Mist netting stream
  - Cave counts
  - Rabies lab reports
  - Trapping cave and mine entrances

- Look for burrows in muck

- Track plates have been used in other Midwestern states (Missouri, Wisconsin) but not in Indiana

- Allegheny woodrat: Presence/absence can generally be determined by searching cliff lines for fresh sign (latrines, food caches, maintained nests) usually in fall. Research underway in other areas to determine if woodrats can be genotyped through scats

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for all mammals in all habitats. There were no responses.

Habitat inventory and assessment

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

- Statewide once-a-year inventory and assessment
- Periodic statewide (less than once a year but still regularly scheduled) 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 mammal habitats in Indiana (not ranked):

- Statewide once-a-year inventory and assessment
- Periodic statewide (less than once a year but still regularly scheduled) 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 ranked inventory and assessment efforts by state agencies based on their importance for conservation of all mammal habitats in Indiana:

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

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

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

assessment

Statewide annual inventory and assessment

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

- IDNR - Division of Forestry; state forests
  - Keeps track of changes in forest cover
- IDNR - Division of Nature Preserves; nature preserves
- IDNR – Division of Fish and Wildlife
- IDNR/contractor monitors cave environment in most major hibernacula
  - Cave habitat is assessed when the winter surveys of hibernacula are conducted statewide
  - Human disturbance in key hibernacula is also monitored
  - The contractor who conducts the biennial hibernacula surveys also documents information on cave condition (e.g., breakdown) and makes management recommendations
  - Karst regions and summer habitat
- Aquatic habitats: I suspect some state agencies monitor and assess aquatic habitats at a statewide level, maybe not on an annual basis, but perhaps every few years. This is an important component of inventorying otter habitat in Indiana
- Badger habitats
  - Purdue University and NRCS keep track of grasslands created as part of the Farm Bill Programs. There are also occasional statewide assessments of grassland as part of remote-sensing, GIS based studies such as the GAP Analysis
  - Division of Nature Preserves keeps track of good examples of remnant native grassland. I am not sure any agencies collect grassland habitat data specifically for badgers but other agencies applied the information to badgers
- Northeast and Northwest Indiana
- South central Indiana
- Forest habitats
  - Most, if not all, public properties in the state (Hoosier National Forest, Crane NSWC, state forests, state reservoirs, etc.) periodically inventory and assess forested habitats under their jurisdiction.
  - Commercial timbered lands are probably also inventoried on a regular basis
  - The Nature Conservancy may also have access to data
- Franklin’s ground squirrel habitats

  - I suspect that some agencies (perhaps SWCD, SCS on a county level) have data on distribution and abundance of grassland habitats

- Allegheny woodrat habitats
  - Division of Nature Preserves might inventory cliff habitat
  - Division of Fish and Wildlife has these data on cliff habitats used by woodrats

- Given that the Big brown bat uses almost any class of habitat, any effort aimed at documenting landscape cover would count, including tax records assessment

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

- Beverly Shores, National Lakeshore, Hoosier National Forest, Wesselman Woods (Evansville)

- Various bat habitats:
  - Completed by Rick Clawson, Missouri Department of Conservation, for Twin Domes and Batwing caves
  - Several organizations collect information on location and condition of caves, as well as the presence of bats in caves, which provides useful information
  - U.S. Fish and Wildlife Service inventories Reeves Cave and others
  - Karst regions and summer habitat in Indiana
  - ISU -- 1995 by Ford. 1998 by Leibacher and Whitaker; ISU; 1975 by Ford, 1998 by Leibacher and Whitaker

- There are Farm Bill/CRP type inventories but none done specifically for cottontail rabbits

- Indiana GAP project categorizes land use cover types from Landsat imagery. I assume that the change in cover types is being calculated over a specified period of time

- Local planning boards monitor land use in most localities

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

- State universities
  - Purdue University
  - ISU -- 1995 by Ford. 1998 by Leibacher and Whitaker; ISU; 1975 by Ford, 1998 by Leibacher and Whitaker
  - Ball State University (Northeast Indiana)
  - Indiana State University (Northwest Indiana)

- For bats
  - Indiana Karst Society
  - NSS Grottos
  - U.S. Fish and Wildlife Service

  - I-69 bat consultants
  - TNC
  - USGS
  - Indiana Cave Survey
  - USDA Forest Service
  - Indiana Department of Natural Resources
  - Ecological consultants
  - Universities (federal permit holders)
  - Virgil Brack, ESI

- Indiana GAP Project

- Forested lands
  - Indiana Hardwood Lumberman's Association or other private groups might monitor forested lands, particularly those in private ownership
  - Division of Forestry keeps forest data
  - Local communities constantly are reassessing zones and tax roles

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

Inventory and assessment techniques for all mammal habitats	Used	Not used but possible with existing technology and data	Not economically feasible
GIS mapping	X	X	--
Aerial photography and analysis	X	X	--
Systematic sampling	X	X	X
Property tax estimates	X	X	X
State revenue data	X	X	X
Regulatory information	X	X	X
Participation in land use programs	X	X	X
Modeling	X	X	X
Voluntary landowner reporting	X	X	X

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

- Temperature and relative humidity monitoring with remote data loggers
- Look for runways in muck and trap for them
- Cave surveys

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 mammal habitats. There were no responses.

Recommended monitoring

Species monitoring

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

- Reporting from harvest, depredation, or unintentional take
- Modeling
- Regulated trapping
- Collection of harvest data from mandatory check stations
- Continue Indiana Bowhunter Survey and trapper survey
- Trap periphery of known range in Indiana
- Look for burrows in muck connected with trapping
- Live-trapping and mark/recapture
- Radio telemetry
- Standardized, live trapping for two nights is effective for determining distribution and relative abundance
- If we wanted to survey this species I would develop a system counting hills
- Cottontail rabbits
    - Trapping and visual surveys (Trapping is expensive and visual surveys are less expensive and can be combined with other surveys. McWheter, Gary Randolph, 1991, Estimating Abundance of Cottontail Rabbits using live trapping and visual surveys, Master's thesis, University of Tennessee)
    - Specifically being done for the cottontail is not warranted. However, an analysis of vegetative structure by specie or species group in early successional habitats and then correlated with selected early successional species would be relevant
    - I would like to see a rural mail carrier survey initiated that would be useful for monitoring rabbits and several other wildlife species. Another method to monitor

rabbit populations would be to include rabbit observations on the division's annual bobwhite whistle counts

- Bat species
  - Continue ongoing biennial winter surveys at all known hibernacula
  - Biennial hibernacula surveys (which I would classify as "professional survey/census") are the only means currently available to track Indiana bat population trends on a statewide or range wide basis. These surveys are conducted range wide
  - Survey and monitoring activities conducted in summer habitat are used to 1) evaluate summer distribution in the state, and 2) evaluate roosting and foraging habitat use/needs. These surveys are conducted in Indiana as well as other states throughout the range of the species
  - Trapping for Indiana bat includes mist netting and harp trapping. Internal cave surveys are important and more emphasis should be placed on the use of AnaBat
  - Hibernacula counts to track population levels (already being done)
  - Intensive radio telemetry that tracks roost and foraging movements of specific colonies in representative areas across the state
  - Mark and recapture monitoring of representative colonies across the state
  - Survey sample of Indiana residents every 10 years as to whether they have bats in their home. (Follow-up affirmative responses with a visit to confirm species)
  - We need make sure someone continues to examine all animals submitted for rabies testing
  - A regular monitoring program (using traps, echolocation calls, and mist nets) for bats should be initiated on a statewide basis. This should be a combined effort by IDNR, universities, and private organizations
  - This bat should simply be monitored by keeping track of capture rates from permit reports and the state board of health
  - A statewide bat monitoring effort should also be developed

Bobcat Continued documentation of sightings, road-kills, and accidental captures. Obtain pertinent biological data from recovered specimens such as age and reproductive parameters (pregnancy rate, litter size). These data could be used to model populations or build life tables in future years

- Fox squirrels
  - A hunter report card sent out to dedicated squirrel hunters would be a useful tool to provide an index to the fox squirrel population
  - I would also like to see a radio-telemetry project in northern Indiana to document fox squirrel dispersal between forest tracts
  - Another objective of this proposed radio-telemetry project would be to evaluate the possibility of overharvesting fox squirrel metapopulations

- IDNR – Division of Fish and Wildlife uses harvest reports and professional surveys. However, these techniques are not habitat specific nor do they cover the full spectrum of habitats associated with generalist species

- Otters
  - Stream surveys for otter sign
  - Reporting (number, location, etc.) of unintentional take and biological data obtained from recovered specimens (reproductive parameters). (Melquist, W.E., P.J. Polechla, Jr., and D. Toweill. 2003. River Otter. Pages 708-734 in Wild Mammals of North America: biology, management, and conservation. 2nd edition. G.A. Feldhamer, B.C. Thompson, and J.A. Chapman (eds.), John Hopkins University Press, Baltimore, MD, 1216 pages)
  - Continue to monitor road-kills, accidental captures and other verified sightings. Review this data and if warranted (a number of verified sightings near grassland habitat) attempt a telemetry and tracking study

- Bobcats
  - Some form of questionnaire or survey that is sent to trappers, hunters, professional resource managers could also be useful
  - Indiana Bowhunter Survey is a good example although reporting rates for bobcats are so low they may not be effective to detect changes and monitor trends

- Allegheny woodrats
  - Searches for woodrat sign at new sites or previously occupied sites to assess recolonization potential

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for effective conservation for all mammals in all habitats. There were no responses

Habitat inventory and assessment

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

- GIS habitat modeling, Landsat data, mapping and aerial photo analysis
  - GIS technology appears to be the most feasible means for inventory and assessment of otter habitat at a statewide scale. Analysis of aerial photos could be useful also, perhaps at a local scale
  - Statewide habitat mapping
  - GIS is a logical tool to inventory and assess all aspects of forested habitats in Indiana (species composition, age & size class, ownership, management regime, etc.). It would be nice to have GIS coverage of rock outcrops in the state to supplement forest data
  - GIS is logical tool to use to depict grassland/herbaceous communities
  - GIS is the best tool available to depict (inventory) cliff, outcrops, talus slopes, caves, or other rocky habitats within the range of Allegheny woodrats

- Collect hunter data from DNR properties and private lands hunters

- Bat species
  - Cave microclimate monitoring with dataloggers should continue. A range-wide protocol for monitoring cave temperature and humidity has been developed by Bat Conservation International and is being widely used (contact Jim Kennedy or Merlin Tuttle at BCI). I believe Scott Johnson has been following this protocol in Indiana
  - Cave microclimate data used in conjunction with results of hibernacula surveys
  - Techniques to link summer/winter populations (new genetic techniques such as stable isotope analysis; pit tagging)
  - Information on habitat use/needs in the vicinity of caves during swarming is a critical need. At present, radio telemetry represents the best potential to collect this information
  - Cave survey in winter and net survey in summer
  - Habitat for this bat should simply be assessed by examining large-scale changes in land use patterns

- Monitor larger grasslands in Indiana (both native and man-made such as the grassland created by strip mining). Especially monitor the quality and quantity of these area

- Property tax assessments can be used as a proxy as well

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 effective conservation for all mammal habitats. There were no responses

ALL MUSSELS IN ALL HABITATS NARRATIVE

Problems affecting species and habitats

Species threats

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

Rank	Threats to all mussels in all habitats
1 (tie)	Habitat loss (breeding range)
1 (tie)	Habitat loss (feeding/foraging areas)
2	Specialized reproductive behavior or low reproductive rates
3	Viable reproductive population size or availability
4	High sensitivity to pollution
5	Unintentional take/ direct mortality (e.g., vehicle collisions, power line collisions, by-catch, harvesting equipment, land preparation machinery)
6	Dependence on other species (mutualism, pollinators)
7	Invasive/non-native species
8	Small native range (high endemism)
9	Predators (native or domesticated)
10	Genetic pollution (hybridization)

Respondents offered no additional threats to all mussels in all habitats in Indiana.

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

- Instream dredging/habitat modifications
  - Dredging of headwater streams
  - From land use changes
  - Dredging/habitat loss of Kankakee drainage can result in large amounts of creek heelsplitters being lost
- Pollution/Runoff introducing streams, even if only temporary
  - Mostly agricultural
  - Pollution from Tippecanoe River system in Indiana
- Zebra mussels
- Unintentional take can result in large amounts of creek heelsplitters being lost
- Insuring that populations maintain critical larva-host connections
  - Dependence on other species: Requires fish host to reproduce; if fish populations decrease for any of a variety of reasons, then creek heelsplitter reproduction could decrease substantially
- Any factor that reduces reproductive population size

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

- While habitat loss is important, I would not necessarily rank it #1 threat. Suitable mussel habitats exist in many areas of IN but in these areas historic mussel populations continue to decline (EnviroScience, Inc. 2005 in prep). Reasons for declines are unknown but may be due to changes in river temperature and fish host assemblages from overall landscape level changes, but perhaps not necessarily water "quality".

  I would rank non-point pollution from agriculture and development as the no 1 cause for declines. Also, loss of headwater streams to dredging and loss of wetlands or riverine buffers.

  "unintentinal take can result in loss of creek heelsplitters" is a vaugue statement and should be removed.

Habitat threats

Respondents ranked threats to mussel habitats in Indiana:

Rank	Threats to mussel habitats
1 (tie)	Habitat degradation
1 (tie)	Stream channelization
2	Nonpoint source pollution (sedimentation and nutrients)
3	Point source pollution (continuing)
4 (tie)	Drainage practices (stormwater runoff)
4 (tie)	Habitat fragmentation
5	Agricultural/forestry practices
6	Impoundment of water/flow regulation
7	Residual contamination (persistent toxins)
8	Commercial or residential development (sprawl)
9	Mining/acidification
10	Invasive/non-native species
11	Successional change

Respondents noted no other threats to mussel habitats in Indiana.

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

- Habitat degradation/instream modifications
  - There are large expanses of Wabash and East Fork – White River where relic valves once were common, but the living species is absent

    - Dredging (mining, ACOE)
    - Channelization
        - Any that reduces the shallow (less than 1.5 feet) sand/gravel substrate can critically reduce or fragment habitat
        - Cause temporary loss of habitat and impact mussels directly by killing them or taking them out of their habitat
    - Loss of riparian corridor
    - Impoundments
- Any significant sedimentation into the stream can become a major threat
- Any toxins or pollutants are a major threat
    - Agricultural runoff

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

- Add dams and the regulation of dam discharges. Mussels downstream of the Norway Dam on the Tippecanoe will continue to decline from cold water discharges and uneven flow regime.

Additional research and survey efforts

Current body of research

Species research

Twenty percent of respondents stated that the current body of science is adequate, while eighty percent find it inadequate for all mussels in all habitats in Indiana.

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

Title = Occurrence and distribution of freshwater mussels in the small streams of Tippecanoe County, Indiana;
Author = Myers-Kinzie, M., S. Wente, & A. Spacie;
Date = 2001;
Publisher = Proc. Ind. Acad. Sci.

Title = Federal Recovery Plan;
Author = USFWS;
Date = 1993;
Publisher = USFWS

Title = Field guide to freshwater mussels of Midwest;
Author = Cummings & Mayer;
Date = 1992;
Publisher = INHS

Title = Federal Recovery Plan;
Author = USFWS;
Date = 1991;
Publisher = USFWS

Title = Life history and propagation...;

Author = Jones & Neves;
Date = 2002;
Publisher = JNABS

Title = Freshwater mussels of Tennessee;
Author = Parmalee & Bogan;
Date = 1998;
Publisher = U of Tennessee Press

Title = Freshwater mussels of the Midwest;
Author = Cummings & Mayer;
Date = 1992;
Publisher = INHS

Title = Naiades of Pennsylvania;
Author = Ortmann;
Date = 1919;
Publisher = Carnegie Museum

Title = Freshwater Mollusca of WI;
Author = Baker;
Date = 1919;
Publisher = WI Geol. Nat. Hist. Surv.

Title = 'Clubshell';
Author = USFW, Division of Endangered Species;
Publisher = Online

Title = (Numerous internet sites, including USF&W)

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

- Mussels of Alabama (P. Parmalee & A. Bogan) and Ohio (G.T. Watters) should be released w/ in the next 6 months and would be good to add in eventually.

Habitat research

Thirty percent respondents stated that the current body of science is adequate, while seventy percent find it inadequate for mussel habitats in Indiana.

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

Title = Federal Recovery Plan;
Author = USFWS;
Date = 1993;
Publisher = USFWS

Title = Naiades of Pennsylvania;
Author = Ortmann;
Date = 1919;
Publisher = Carnegie Museum

Title = Federal Recovery Plan;
Author = USFWS;
Date = 1991;
Publisher = USFWS

Title = Freshwater Mollusca of WI;
Author = Baker;
Date = 1928;
Publisher = WI Geol. Nat. Hist. Surv.

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

- Yes, see comments above.

Research needs

Species research

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

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

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

- Habitat needs are not completely understood. I have seen fresh dead cylindrical papershells in channelized agricultural ditches. Other small streams with good habitat have only weathered dead fragments
- To find out why the clubshell has depopulated most of its former distribution in Indiana. Developing some sort of timeline (late Pleistocene, Holocene (usually archaeological), or historic) for relic valve distribution might narrow the possibilities of critical limiting factors (post-settlement siltation, etc.)

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

- Population health, threats, enforcement, and dist & abundance are very important to understanding overall trends in IN. The other factors are being fairly thoughoughly investigated in other states/institutions.

Habitat research

Respondents ranked research needs for mussel habitats in Indiana:

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

Respondents noted no additional research need for mussel habitats in Indiana.

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

- Yes.

Conservation actions necessary

Species actions

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

Rank	Conservation efforts for all mussels in all habitats
1 (tie)	Limiting contact with pollutants/contaminants
1 (tie)	Public education to reduce human disturbance
1 (tie)	Habitat protection (use below for details)
1 (tie)	Threats reduction
1 (tie)	Regulation of collecting
1 (tie)	Population management (hunting, trapping)

Respondents noted no additional conservation practices for all mussels in all habitats in Indiana.

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

- Educate anglers that it is illegal to use mussels as fishing bait. This applies to all mussel species
- Limit instream modification/strict enforcement of laws regulating instream modification
  - See Watters, 2000. Proc. 1st FMCS Symposium)
  - Including impoundment
- Incentives to farmers
- CREP/other incentives for BMPs
- Propagation
- Remove existing dams whenever possible (See Watters, 2000. Proc. 1st FMCS Symposium)
- Restore free-flowing systems (See Watters, 2000. Proc. 1st FMCS Symposium)
- Intensive quantitative sampling of known populations. Need to understand demography of Clubshells(See Strayer and Smith, 2003. AFS Monogram 8)
- Less intensive qualitative sampling of new or not recently surveyed areas. Need to determine distribution and status of Clubshells (See Strayer and Smith, 2003. AFS Monogram 8)
- Restore riparian corridor (See Watters, 2000. Proc. 1st FMCS Symposium)
- Protect shallow sand/gravel habitat from siltation and channelization
- Protect habitat against pollution and toxins

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

- Yes, propagation should be highly ranked. Prop. should really be done with IN mussel species soon before further declines & loss of genetic diversity.

Habitat actions

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

Rank	Conservation efforts for mussel habitats
1	Cooperative land management agreements (conservation easements)
2 (tie)	Pollution reduction
2 (tie)	Protection of adjacent buffer zone
2 (tie)	Corridor development/protection
2 (tie)	Habitat protection on public lands
2 (tie)	Habitat protection incentives (financial)
2 (tie)	Habitat restoration through regulation
2 (tie)	Habitat restoration on public lands
2 (tie)	Habitat restoration incentives (financial)
2 (tie)	Land use planning
2 (tie)	Technical assistance
2 (tie)	Habitat protection through regulation

2 (tie) Managing water regimes

2 (tie) Restrict public access and disturbance

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

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

- Increase and maintain habitat using/considering:
  - Incentives/CREP and other incentives for BMPs
  - Regulation
    - Restrict instream modifications (channelization, instream dredging, etc.) (See Watters, 2000. Proc. 1st FMCS Symposium)
    - Treat small streams as biological resources and not just drainage ditches. At the least require that a mussel survey be done before dredging
  - Protect adjacent buffer zones
  - Limiting runoff through incentives or other means (See Watters, 2000. Proc. 1st FMCS Symposium)
  - Assessing and promote riparian corridors
  - Restoring free-flowing systems
- Manage pollutants and toxins
  - Water quality monitoring (See Watters, 2000. Proc. 1st FMCS Symposium)

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

- Yes, actually.

Proposed plans for monitoring

Current monitoring

Species monitoring

Respondents were aware of the following monitoring efforts by state agencies for all mussels 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

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

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

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

Rank	Monitoring efforts by state agencies for

	conservation of all mussels in all habitats
1	Periodic statewide (less than once a year but still regularly scheduled) monitoring
2 (tie)	Periodic regional or local (less than once a year but still regularly scheduled) monitoring
2 (tie)	Occasional regional or local (less than once a year and not regularly scheduled) monitoring
3 (tie)	Statewide once-a-year monitoring
3 (tie)	Occasional statewide (less than once a year and not regularly scheduled) monitoring
4	Regional or local once-a-year monitoring
5	Regional or local year-round monitoring
6	Statewide year-round monitoring

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

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

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

- IDNR nongame biologist does mussel surveys
  - He is only one person, and there are thousands of miles of streams in the state
- IDNR nongame biologist monitors yellow sandshell habitat: Two surveys have been done 10 years apart, completed by biologists for the Wabash, Tippecanoe and East Fork – White rivers; results are pending. This is prime yellow sandshell habitat
- Tippecanoe River (periodic – usually annual – monitoring by IDNR
- Maumee River
- Ohio River
- Wabash River

- Kankakee drainage (random locations)

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

- Commonwealth Biomonitoring: Frequently does habitat evaluations in small streams as part of watershed studies. If I happen to see a shell, I make a note in field notes. These are not official mussel surveys
- Tippecanoe River
- Maumee System
- Ohio River
- Wabash System

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

- TNC
- USFWS
- Consultants

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

Monitoring techniques for all mussels in all habitats	Used	Not used but possible with existing technology and data	Not economically feasible
Radio telemetry and tracking	--	--	X
Modeling	X	X	--
Spot mapping	X	--	--
Driving a survey route	X	--	--
Reporting from harvest, depredation, or unintentional take (road kill, by-catch)	--	--	X
Mark and recapture	X	--	--
Professional survey/census	X	--	--
Volunteer survey/census	X	X	--
Representative sites	X	--	--
Probabilistic sites	X	X	--

Respondents noted no other monitoring techniques for all mussels in all habitats 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 mussels in all habitats in Indiana. Their responses included:

- No. IDNR biologists are working on a statewide mussel atlas. EnviroScience (Stow, OH) is working w/ IDNR on final results of Wabash, Tippecanoe, and East Fork White R. Surveys (2003-2004).

Habitat inventory and assessment

Respondents were aware of the following inventory and assessment efforts by state agencies for mussel habitats in Indiana:

- 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 mussel habitats in Indiana:

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

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

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

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

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

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

- Tippecanoe River
- Maumee System
- Ohio River
- Wabash System
- Usually species inventories are made with relevant habitat information
- IDNR primarily monitors mussel species, making habitat notations. No real habitat monitors are made
- IDEM and IDNR – Division of Water do monitor water quality as a component of habitat

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

- Tippecanoe River
- Maumee System
- Ohio River
- Wabash System
- Commonwealth Biomonitoring do habitat evaluations on small streams as part of watershed studies. These evaluations are not specific to mussels, but are Ohio EPA QHEI methods

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

- TNC
- USFFWS

- Consultants

Respondents considered inventory and assessment techniques for mussel habitats in Indiana:

Inventory and assessment techniques for	Used	Not used but possible with existing technology and data	Not economically feasible
GIS mapping	X	X	--
Aerial photography and analysis	--	--	X
Systematic sampling	X	--	--
Property tax estimates	--	--	X
State revenue data	--	--	X
Participation in land use programs	X	X	--
Modeling	X	X	--
Voluntary landowner reporting	X	--	X

Respondents listed additional inventory and assessment techniques for mussel habitats in Indiana:

- Water quality monitoring

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 mussel habitats in Indiana. There were no responses.

Recommended monitoring

Species monitoring

Respondents recommended the following monitoring techniques for effective conservation of all mussels in all habitats in Indiana:

- Intensive quantitative sampling of known populations. (Need to understand demography of species. See Strayer & Smith, 2003. AFS Monogram 8)
- Less intensive qualitative sampling of new or not recently surveyed areas. (Need to determine distribution and status of species. See same for protocols)
- Systematic monitoring of probabilistic sites (professional)
  - Professional surveys using timed searches and systematic sampling (Strayer and Smith 2003)-A guide to sampling freshwater mussel populations. American Fisheries Society Monograph 8. American Fisheries Society. Bethesda, Maryland. 103 pp.)
- Use of volunteer census/monitoring:

    - Development of trained, select volunteer core to undertake surveys at probabilistic sites, particularly where the species should, or could occur and has not been documented in recent years

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

- Yes, we used some of these techniques in EnviroScience/IDNR surveys.

Habitat inventory and assessment

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

- CREP/farmer incentives for no-till, riparian corridors, etc.
- Strictly control instream modifications: mining, snagging, etc.
- Assess zebra mussel infestations. Contact P. Morrison, USFWS, Parkersburg, WV
- Assess riparian corridor presence
- Water quality monitoring
- More extensive use of GIS-modeled habitat probabilities
    - To look at saturation of potential habitat. With GIS construction of existing potential habitat (based upon known factors) and overlaying the current distribution of the yellow sandshell

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 effective conservation of mussel habitats in Indiana. Their responses included:

- Yes. Focus on watershed and landuse-based approaches like CREP, etc. Use GIS models to identify and manage mussel pops.

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):

- 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 over wintering 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 over wintering 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 over wintering 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 disced 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

- 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

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 be 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,

populations seem small. Small isolated populations ale 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 (ether 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 of 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 though 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, m 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 over wintering snakes. In addition, herbaceous wetlands are lost under this management regime, replaced by open water wetlands

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

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;

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:

- 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

Appendix F-78: Reptiles

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

  - 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, wit 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

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

  - 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

Appendix F-78: Reptiles

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

Appendix F-78: Reptiles

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

- 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	--

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

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

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
- IUPU-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

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 bated 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 know populations to determine population structure, density and potential for

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.

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.

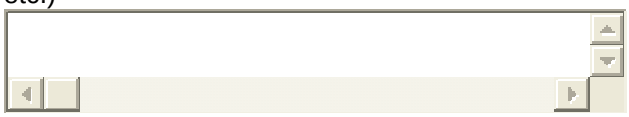
Appendix G: Indiana Wildlife and Habitat Conservation Organizations Survey form

Indiana Wildlife and Habitat Conservation Organizations

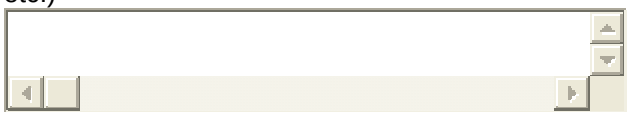
We are looking for partners to assist in the development and implementation of the Indiana Comprehensive Wildlife Strategy (CWS). Please complete the following survey to help us determine how your organization and the issues you are working on can best be incorporated into the CWS. Please fill out as much as you can. We recognize that some questions will not be appropriate for all organizations.

1) Name of your organization:

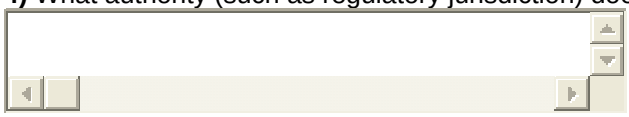
2) What is the mission of your organization? (e.g. to protect key wildlife Habitat in Indiana, etc.)



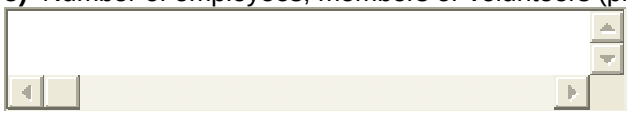
3) What are the goals of your organization? (e.g. to restore 50 acres of wetlands per year, etc.)



4) What authority (such as regulatory jurisdiction) does your organization have?



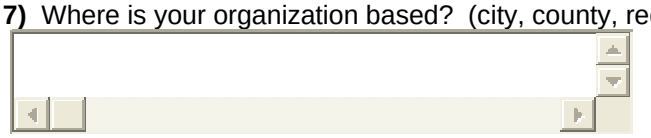
5) Number of employees, members or volunteers (please list all that apply):



6) Is your organization:

- ☐ Non-profit
- ☐ For profit
- ☐ Local Government
- ☐ State Government
- ☐ Federal Government

7) Where is your organization based? (city, county, region or area)



8) Where do your efforts typically occur? (Please select the best option)

- ○ Locally
- ○ Statewide
- ○ Regionally
- ○ Nationally

9) On which of the following types of habitats does your organization focus its efforts?

☐ **Agricultural** (row crop, cereal grain, vineyards, feedlots, residue management, confined livestock operations, orchards)

Percent of your total time spent on efforts in this habitat: **%**
Please briefly describe the types of activities your organization does in this habitat.

☐ **Aquatic systems** (Lake Michigan, rivers and streams, impounded rivers and streams, ditches, oxbows, creeks, natural lakes, impoundments, near-shore tributaries, potholes)

Percent of your total time spent on efforts in this habitat: **%**
Please briefly describe the types of activities your organization does in this habitat.

☐ **Barren lands** (active mineland, active quarries, bare dunes, rock out-crops, cliffs)

Percent of your total time spent on efforts in this habitat: **%**
Please briefly describe the types of activities your organization does in this habitat.

☐ **Developed Land** (industrial land, road and trail, commercial, right-of way, golf courses, soccer/recreation areas, towers, storm-water retention ponds, borrow pits)

Percent of your total time spent on efforts in this habitat: **%**
Please briefly describe the types of activities your organization does in this habitat.

☐ **Forest Lands** (pre-forest, early forest, pole stage, mature high canopy stage, old forest stage)

Percent of your total time spent on efforts in this habitat: ____ **%**
Please briefly describe the types of activities your organization does in this habitat.

☐ **Grasslands** (prairies, pasture, haylands, reclaimed mine lands, fescue, early successional areas, vegetated dunes and swales, savannahs)

Percent of your total time spent on efforts in this habitat: ____ **%**
Please briefly describe the types of activities your organization does in this habitat.

☐ **Subterranean Systems** (caves, cave aquatic and terrestrial features, karst)

Percent of your total time spent on efforts in this habitat: ____ **%**
Please briefly describe the types of activities your organization does in this habitat.

☐ **Wetlands/ephemeral (**forested, shrub/scrub, emergent, herbaceous, native, restored, created and permanent wetlands including forested, shrub/scrub, emergent native, restored, created, herbaceous, native, restored, created, potholes, farmed wetlands, drained wetlands, ditched wetlands, mudflats, mitigation wetlands)

Percent of your total time spent on efforts in this habitat: ____ **%**
Please briefly describe the types of activities your organization does in this habitat

10) What is/are your primary wildlife species of interest?

11) What are your group's specific objectives with this/these species?

12) What is your primary source of funding?

- ☐ foundation grants
- ☐ state
- ☐ federal
- ☐ individual contributions
- ☐ dues
- ☐ other (please describe)

13) Please indicate your total annual budget category. This will allow us to estimate how much organizations are spending on conservation in Indiana.

- ☐ $0 - $9,999
- ☐ $10,000 - $24,999
- ☐ $25,000 - $49,999
- ☐ $50,000 - $99,999
- ☐ $100,000 - $249,999
- ☐ > $250,000

14) Please describe your organization's projects (current or proposed) that could contribute to a local, regional or statewide conservation strategy.

15) What resources or capabilities does your organization have that could contribute to a conservation strategy?

16) What kinds of conservation partnerships has your organization developed in the past and with whom?

17) What do you perceive is needed to improve existing partnerships, resources or programs focused on resource for conservation?

18) Please provide additional information you feel is relevant to our efforts in developing the Indiana Comprehensive Wildlife Strategy.

19) What would be the best way to communicate with you and your organization about the CWS and similar conservation efforts?

	Very effective	Somewhat effective	Not effective
Indiana CWS website	☐	☐	☐
Electronic newsletter	☐	☐	☐
E-mail announcements	☐	☐	☐
Articles in select magazines, newsletters, and newspapers	☐	☐	☐
Press release to radio, television and print publications	☐	☐	☐
Customized presentations to your organization at your regular meetings	☐	☐	☐

20) What would be other very effective ways to communicate with you and your organization?

21) What do you feel would be the best way to communicate with the general public about the CWS and similar conservation efforts?

	Very effective	Somewhat effective	Not effective
Indiana CWS website	☐	☐	☐
Electronic newsletter	☐	☐	☐
E-mail announcements	☐	☐	☐
Articles in select magazines, newsletters, and newspapers	☐	☐	☐
Press release to radio, television and print publications	☐	☐	☐

22) What do you feel would be other very effective ways to communicate with the general public?

23) Please provide the following contact information:
Primary contact person

Street Address or PO Box

City

State

ZIP Code

Telephone Number

FAX Number

E-mail

Secondary contact person

Telephone Number

E-mail

24) Does your organization have strategic or operational documents that could help us identify how to incorporate your efforts into the Indiana Comprehensive Wildlife Strategy? If so please provide the title, publication date, and how to obtain copies (call for a copy, on the web, etc.)

Also, please send a copy of these documents to:
D. J. Case & Associates
317 E. Jefferson Blvd.
Mishawaka, IN 46545
FAX: (574)258-0189
e-mail: cws@djcase.com

Should we continue to notify you about CWS progress and plans?

- No
- Yes

(if yes, please complete the contact information above)

Thank you for your time and interest in the Indiana Comprehensive Wildlife Strategy.

Appendix G: Indiana Wildlife and Habitat Conservation Organizations Survey form

Submit