

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

Appendix F-60: Aggregated Subterranean Systems

- 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

Appendix F-60: Aggregated Subterranean Systems

- 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.

Appendix F-60: Aggregated Subterranean Systems

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

Appendix F-60: Aggregated Subterranean Systems

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

Appendix F-60: Aggregated Subterranean Systems

- 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.

Appendix F-60: Aggregated Subterranean Systems

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

Appendix F-60: Aggregated Subterranean Systems

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

Appendix F-60: Aggregated Subterranean Systems

- 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

Appendix F-60: Aggregated Subterranean Systems

- 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

Appendix F-60: Aggregated Subterranean Systems

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:

Appendix F-60: Aggregated Subterranean Systems

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):

Appendix F-60: Aggregated Subterranean Systems

- 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
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Appendix F-60: Aggregated Subterranean Systems

- 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
- 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 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)

Appendix F-60: Aggregated Subterranean Systems

- 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

Appendix F-60: Aggregated Subterranean Systems

- 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.