

## 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

## Appendix F-76: Mammals

- 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

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- 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

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- 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

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- 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)

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- 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

## Appendix F-76: 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 habitats 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

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- 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

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- 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 = Mammals 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

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[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](http://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 brevicauda*; 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 bobcats 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

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[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]

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]

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]

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[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 abundance 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

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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

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- 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.

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- 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

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- 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

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- 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.

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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

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- 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

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- 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

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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

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- 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

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- 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 by other organizations for all mammals 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

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- 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

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- 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)

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- 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:

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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

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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

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- 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

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- 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:

<b>Inventory and assessment techniques for all mammal habitats</b>	<b>Used</b>	<b>Not used but possible with existing technology and data</b>	<b>Not economically feasible</b>
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

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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

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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

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- 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. Towell. 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

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- 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