

MATURE/HIGH CANOPY FOREST HABITAT NARRATIVE

Habitat description

Typical dominant overstory vegetation is composed primarily of sawtimber sized trees (greater than 9" dbh in softwoods and 11" dbh in hardwoods). The forest canopy is usually higher than in previous stages and predominantly closed with occasional canopy gaps. Older forests that are selectively harvested will usually remain in the Mature/High Canopy condition after harvest while those areas that are clear cut or contain regeneration openings will revert back to the Early Forest Stage.

Problems affecting species and habitats

Species threats

Respondents ranked the following threats to wildlife in mature/high canopy forest habitat in Indiana:

| Rank | Threats to wildlife in mature/high canopy forest habitat | Score |
|----------|--|-------|
| 1 | Degradation of movement/migration routes (overwintering habitats, nesting and staging sites) | 4.75 |
| 2 (tie) | Habitat loss (breeding range) | 4.60 |
| 2 (tie) | Habitat loss (feeding/foraging areas) | 4.60 |
| 3 | Viable reproductive population size or availability | 4.00 |
| 4 | Specialized reproductive behavior or low reproductive rates | 3.60 |
| 5 | Predators (native or domesticated) | 3.00 |
| 6 | Small native range (high endemism) | 2.60 |
| 7 | Large home range requirements | 2.40 |
| 8 | Dependence on irregular resources (cyclical annual variations) (e.g., food, water, habitat limited due to annual variations in availability) | 2.33 |
| 9 | Invasive/non-native species | 2.25 |
| 10 | Unintentional take/ direct mortality (e.g., vehicle collisions, power line collisions, by-catch, harvesting equipment, land preparation machinery) | 2.20 |
| 11 (tie) | Bioaccumulation of contaminants | 2.00 |
| 11 (tie) | Diseases/parasites (of the species itself) | 2.00 |
| 12 | Unregulated collection pressure | 1.80 |
| 13 (tie) | Dependence on other species (mutualism, pollinators) | 1.50 |
| 13 (tie) | High sensitivity to pollution | 1.50 |

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|----|---|------|
| 14 | Near limits of natural geographic range | 1.40 |
| 15 | Genetic pollution (hybridization) | 1.20 |

Respondents offered additional threats to wildlife in mature/high canopy forest habitat in Indiana (not ranked):

- Brown-headed cowbird nest parasitism
 - In cerulean warbler habitat
- Need to know how the Cerulean Warbler is affected by silviculture and other land management, how these affect demography

Respondents listed top threats to wildlife in mature/high canopy forest habitat in Indiana (not ranked):

- Species parasitism/predators
 - Cowbird nest parasitism
 - Increase edge nest predators (e.g. blue jays)
 - Nest predation
- Habitat loss and fragmentation
 - Loss of large blocks of mature forest and increases in forest fragmentation that causes and increase in cowbird nest parasitism and increases edge nest predators (e.g., blue jays). This causes a decrease in recruitment
 - Because the Cerulean Warbler is an area-sensitive species, a loss of large tracts of mature forest on both the breeding and wintering grounds is a critical threat
 - Habitat fragmentation may exacerbate both of these.
 - Loss of contiguous blocks of mature forest
- Low reproductive output
 - Possibly 'sink' populations due to poor habitat quality
- Timber rattlesnake threats
 - Habitat loss
 - Human persecution: Timber rattlesnakes are often killed because they are large venomous snakes. There is also a market for this species in illegal trade. Individual take coupled with low reproductive rates pose a serious threat for this species.

A respondent noted, "We need to assess basic demography in Indiana and across the breeding range, learn how the Cerulean Warbler responds to land management, develop an understanding of post-fledging habitat use, and determine the effect of the brown-headed cowbird on this species."

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the threats to wildlife in mature/high canopy forest habitats. There were no responses.

Habitat threats

Respondents ranked threats to mature/high canopy forest habitat in Indiana:

| Rank | Threats to mature/high canopy forest habitat |
|------|--|
|------|--|

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

Respondents noted additional threats to mature/high canopy forest habitat in Indiana (not ranked):

- Human disturbance
 - Has affected age and species diversity (trees are even-aged and young, with less species diversity, vertical structure, natural canopy gaps, large woody debris and other structural features than pre-European settlement forests)
 - Has resulted in extirpated flora and fauna
- Suppression of natural disturbances (fire, beaver, floods)
 - Results in shift of wildlife species composition, structural complexity and landscape pattern
 - Fire-intolerant species such as sugar maple and American beech have become established at expense of fire-adapted oak and hickory species
 - Restoration of natural landscapes needs reintroduction or simulation of these disturbances
- Not clear what is causing decline of the Cerulean Warbler; regionally brood parasitism and forest fragmentation may be negative impacts. It may be possible the species geographic range is shifting (climate?). Exact habitat associations of the species are not known. It is not clear what is optimal habitat in Indiana.

Respondents listed top threats to mature/high canopy forest habitat in Indiana (not ranked):

- Habitat loss and fragmentation
 - Fragmentation of canopied forest habitats

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- Predators/parasitism
- Cerulean warblers threats
 - Habitat loss and fragmentation
 - Fragmentation may allow predators and parasitism to occur by cowbirds, blue jays and raccoons due to fragment size. Fragmentation of forest in Indiana especially in predominately agricultural landscapes has resulted in small patches of forest surrounded by open habitat that cowbirds require for feeding and nest searching
 - Dependence on large tracts of mature deciduous forests, make the species especially sensitive to continuing forest fragmentation and isolation
 - Predators and parasitism
 - By brown-headed cowbirds (brood parasitism)
 - By blue jays (nest predation)
 - Raccoons (nest predation)
- Timber rattlesnake threats
 - Habitat loss and fragmentation: Rattlesnakes need large continuous blocks of forest habitat)
 - Predation/human disturbance: When habitat is loss or fragmented, rattlesnakes become susceptible to human and predator encounters

A respondent noted, "We still do not know the specific habitat preferences for this species. The types of habitats where these species were especially abundant in the past (i.e. old-growth bottomland forest) no longer exist. This area needs more research."

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the threats to mature/high canopy forest habitats. There were no responses.

Additional research and survey efforts

Current body of research

Species research

All respondents stated that the current body of science is inadequate for wildlife in mature/high canopy forest habitat in Indiana.

Respondents identified the following citations (title, author, date, publisher) that would give the best overview of wildlife in mature/high canopy forest habitats in Indiana.

Title = Cerulean Warbler MS Thesis;
Author = Kirk Roth;
Date = 2004;
Publisher = Ball State University

Title = Cerulean Warbler MS Thesis;
Author = Cindy Basile;
Date = 2002;
Publisher = Ball State University

Title = Habitat Selection and Territory Size of Cerulean Warblers in Southern Indiana;
Author = Cynthia M. Basile;
Date = 6/02;
Publisher = N/A

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Title = Master's Thesis (Title Unknown);
Author = Kirk Roth;
Date = 6/2004

Title = Habitat selection and reproductive success of Cerulean Warblers in Southern Indiana;
Author = Kamal Islam and Kirk L.Roth;
Date = December 2004;
Publisher = Department of Biology Technical Report No. 4, Ball State University, submitted to U.S. Fish & Wildlife Service, Fort Snelling, MN

Title = Relative abundance and habitat selection of Cerulean Warblers in Southern Indiana;
Author = Kamal Islam and Cynthia Basile;
Date = December 2002;
Publisher = Department of Biology Technical Report No. 1, Ball State university, final report submitted to U.S. Fish & Wildlife Service, Fort Snelling, MN

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

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

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 mature/high canopy forest habitats. There were no responses.

Habitat research

Twenty percent of respondents stated that the current body of science is adequate for mature/high canopy forest habitat in Indiana, while 80 percent said that it is inadequate or nonexistent.

Respondents identified the following citations (title, author, date, publisher) that would give the best overview of mature/high canopy forest habitats in Indiana.

Title = Cerulean Warbler MS Thesis;
Author = Kirk Roth;
Date = 2004;
Publisher = Ball State University

Title = Cerulean Warbler MS Thesis;
Author = Cindy Basile;
Date = 2002;
Publisher = Ball State University

Title = The natural regions of Indiana; Author = Homoya, M.A., D.B. Abrell, J.R. Aldrich, and T.W. Post;
Date = 1985;
Publisher = Proceedings of the Indiana Academy of Science 94: 245-268

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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 mature/high canopy forest habitats. There were no responses.

Research needs

Species research

Respondents ranked research needs for wildlife in mature/high canopy forest habitat in Indiana:

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

A respondent noted another research need for wildlife in mature/high canopy forest habitat in Indiana:

- Effects of forestry practices on demography and presence and absence of cerulean warblers (TNC) proposed study

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 mature/high canopy forest habitats. There were no responses.

Habitat research

Respondents ranked research needs for mature/high canopy forest habitat in Indiana:

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

A respondent noted an additional research need for mature/high canopy forest habitat in Indiana:

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- Effects of forestry practice on cerulean warblers presence or absence and on demography

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the research needs for mature/high canopy forest habitats. There were no responses.

Conservation actions necessary

Species actions

Respondents ranked conservation efforts by how well they address threats to wildlife in mature/high canopy forest habitat in Indiana:

| Rank | Conservation efforts for wildlife in mature/high canopy forest habitat |
|---------|--|
| 1 (tie) | Regulation of collecting |
| 1 (tie) | Protection of migration routes |
| 2 | Habitat protection |
| 3 | Threats reduction |
| 4 (tie) | Public education to reduce human disturbance |
| 4 (tie) | Limiting contact with pollutants/contaminants |

Respondents noted no other current conservation practices for wildlife in mature/high canopy forest habitat in Indiana.

Respondents recommended these practices for more effective conservation of wildlife in mature/high canopy forest habitat in Indiana (not ranked):

- Habitat protection/restoration/acquisition
 - Increase area of mature, old growth, contiguous forests
 - Reduce fragmentation of forest blocks
- Public education
- More research needed for cerulean warblers
 - We desperately need to learn how silvicultural activities and land management affect this species. Are there silvicultural activities (such as single-tree selection) that actually improve cerulean warbler habitat
 - Additional research (nest productivity, annual monitoring of populations to assess trends in population numbers)
 - Hamel, P.B. 2000. Cerulean Warbler (*Dendroica cerulea*). In *The Birds of North America*, no. 511 (A. Poole and F. Gill, Eds.). The Birds of North America, Inc., Philadelphia.
 - Islam, K. and K.L. Roth. 2004. Habitat Selection and Reproductive Success of Cerulean Warblers in Southern Indiana. Final report submitted to U.S. Fish and Wildlife Service, Fort Snelling, MN, December 2002. Department of Biology Technical Report No. 4, Ball State University, Muncie, Indiana 51pp.
 - Islam, K. and C. Basile. 2002. Relative abundance and habitat selection of

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- Cerulean Warblers in Southern Indiana. Final report submitted to U.S. Fish and Wildlife Service, Fort Snelling, MN, December 2002. Department of Biology Technical Report No. 1, Ball State University, Muncie, Indiana 76pp.

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 mature/high canopy forest habitats. Their responses included:

- Also, increase the use even-aged management silviculture techniques to promote the regeneration of shade-intolerant oak species in order to sustain the oak-hickory forest cover type on the landscape.

Habitat actions

Respondents ranked conservation efforts by how well they address threats to mature/high canopy forest habitat in Indiana:

| Rank | Conservation efforts for mature/high canopy forest habitat |
|-------------|---|
| 1 | Restrict public access and disturbance |
| 2 | Habitat protection on public lands |
| 3 (tie) | Habitat restoration on public lands |
| 3 (tie) | Cooperative land management agreements (conservation easements) |
| 3 (tie) | Habitat restoration through regulation |
| 4 | Land use planning |
| 5 (tie) | Technical assistance |
| 5 (tie) | Corridor development/protection |
| 5 (tie) | Habitat protection incentives (financial) |
| 5 (tie) | Protection of adjacent buffer zone |
| 5 (tie) | Habitat protection through regulation |
| 5 (tie) | Habitat restoration incentives (financial) |
| 5 (tie) | Pollution reduction |
| 5 (tie) | Succession control (fire, mowing) |

Respondents listed no other current conservation practices for mature/high canopy forest habitat in Indiana.

Respondents recommended the following practices for more effective conservation of mature/high canopy forest habitat in Indiana (not ranked):

- Habitat protection and restoration on public and private land
 - Promote older growth/mature forest components

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- Land use planning
- Additional research needed for cerulean warblers (nest productivity, annual monitoring of populations to assess trends)

A respondent commented on habitat related to cerulean warblers, "Due to natural succession and the reduction of natural disturbance, sugar maple and American beech are increasing in stand density and basal area at the expense of the oak-hickory overstory throughout many of the forests in the state. A shift in forest composition from oak-hickory to maple-beech dominated forests has implications for many wildlife species. This shift could result in a reduction of species richness and abundance within forest bird communities and may negatively influence the cerulean warbler. Differences in foliage and bark structure may affect arthropod (spiders and related species) availability for this species. And, the short-petioled leaves and furrowed bark of oak trees compared to maples may provide better foraging opportunities for these birds."

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 mature/high canopy forest habitats. There were no responses.

Proposed plans for monitoring

Current monitoring

Species monitoring

Respondents were aware of the following monitoring efforts by state agencies for wildlife in mature/high canopy forest 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
- Regional or local once-a-year monitoring
- Periodic regional or local (less than once a year but still regularly scheduled) monitoring
- Occasional regional or local (less than once a year and not regularly scheduled) monitoring

Respondents were aware of the following monitoring efforts by other organizations for wildlife in mature/high canopy forest 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
- Regional or local once-a-year monitoring
- Periodic regional or local (less than once a year but still regularly scheduled) monitoring
- Occasional regional or local (less than once a year and not regularly scheduled) monitoring

Respondents ranked monitoring efforts by state agencies based on their importance for conservation of wildlife in mature/high canopy forest habitat in Indiana:

| Rank | Monitoring efforts by state agencies for conservation of wildlife in mature/high canopy forest habitat |
|------|--|
|------|--|

- | | |
|---|----------------------------------|
| 1 | Statewide once-a-year monitoring |
|---|----------------------------------|

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

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Respondents ranked monitoring efforts by other organizations based on their importance for conservation of wildlife in mature/high canopy forest habitat in Indiana:

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

Respondents listed regional or local monitoring by state agencies for wildlife in mature/high canopy forest habitat in Indiana (not ranked):

- Local breeding bird surveys done on state properties and private land
- State cooperates in national breeding bird survey
- State biologists also survey in local habitats (e.g., Patoka River)
- Indiana Breeding Bird Atlas project through DNR determines statewide distribution periodically. Does not produce quantitative measure of population size. These are not tied to this habitat type, but frequency of the other cerulean habitats in the BBS coverage is low so most data refer to this habitat
- IDNR has monitored timber rattlesnake in Brown, Monroe and Morgan counties

Respondents listed regional or local monitoring by other organizations for wildlife in mature/high canopy forest habitat in Indiana (not ranked):

- Cerulean warblers
 - Audubon Society supports May Day count throughout state which detects cerulean warblers
 - TNC is working on developing a research project in the state for ceruleans
 - BBS routes provide some information for this species. However, most routes are located along roads and do not adequately monitor interior forest species such as the cerulean
 - Hoosier National Forest conducts breeding bird point counts each year along points located in interior forest blocks or varying fragment size. Although the cerulean is not the focus of this study, data is collected on its occurrence
 - Cornell Lab of Ornithology collects data on the cerulean warbler for their program "Birds in Forested Landscapes." I am unsure whether data has been collected and submitted in Indiana

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- USGS roadside Breeding Bird Survey. These are not tied to this habitat type, but frequency of the other cerulean habitats in the BBS coverage is low so most data refer to this habitat
- Ball State has been conducting studies on the Hoosier National Forest and Big Oaks National Wildlife Refuge for cerulean warblers. Currently, students from this university are working in conjunction with the Hoosier National Forest staff
- The USFS has contracted out survey work in the southern portions of the Hoosier National Forest

Respondents listed organizations that monitor wildlife in mature/high canopy forest habitat in Indiana (not ranked):

- U.S. Fish and Wildlife Service
 - Big Oaks National Wildlife Refuge
- IDNR (Breeding Bird Atlas project)
- The Nature Conservancy
- Audubon
- American Bird Conservancy
- MAPS program (Point Reyes Bird Observatory)
- Local bird clubs
- Natural Resources Conservation Service (WRP program monitoring)
- USDA Forest Service, Hoosier National Forest
- U.S. Geological Survey (roadside bird surveys)
- Ball State University, Department of Biology has been monitoring cerulean warbler populations at Big Oaks National Wildlife Refuge, Hoosier National Forest and Yellowwood and Morgan-Monroe state forests during the last five years

Respondents considered monitoring techniques for wildlife in mature/high canopy forest habitat in Indiana:

| Monitoring techniques for wildlife in mature/high canopy forest habitat | Used | Not used but possible with existing technology and data | Not economically feasible |
|--|------|---|---------------------------|
| Radio telemetry and tracking | X | X | -- |
| Modeling | X | X | -- |
| Coverboard routes | -- | X | -- |
| Spot mapping | X | X | -- |
| Driving a survey route | X | X | -- |
| Reporting from harvest, depredation, or unintentional take (road kill, by-catch) | X | -- | -- |
| Mark and recapture | X | X | -- |
| Professional survey/census | X | -- | -- |

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

Respondents noted other monitoring techniques for wildlife in mature/high canopy forest habitat in Indiana (not ranked):

- Nest monitoring, territory mapping, call playback and color banding
- Point count surveys

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for wildlife in mature/high canopy forest habitats. There were no responses.

Habitat inventory and assessment

Respondents were aware of the following inventory and assessment efforts by state agencies for mature/high canopy forest habitat in Indiana (not ranked):

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

Respondents were aware of the following inventory and assessment efforts by other organizations for mature/high canopy forest habitat in Indiana (not ranked):

- Occasional statewide (less than once a year and not regularly scheduled) inventory and assessment
- Regional or local once-a-year 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 mature/high canopy forest habitat in Indiana:

| Rank | Inventory and assessment by state agencies for conservation of mature/high canopy forest habitat |
|---------|--|
| 1 (tie) | Statewide annual inventory and assessment |
| 1 (tie) | Statewide once-a-year inventory and assessment |
| 1 (tie) | Regional or local once-a-year inventory and assessment |
| 2 | Regional or local year-round inventory and assessment |
| 3 | Periodic statewide (less than once a year but |

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

Respondents ranked inventory and assessment efforts by other organizations based on their importance for conservation of mature/high canopy forest habitat in Indiana:

| Rank | Inventory and assessment by other organizations for conservation of mature/high canopy forest habitat |
|---------|---|
| 1 (tie) | Statewide once-a-year inventory and assessment |
| 1 (tie) | Regional or local once-a-year inventory and assessment |
| 2 | Periodic statewide (less than once a year but still regularly scheduled) inventory and assessment |
| 3 (tie) | Statewide annual inventory and assessment |
| 3 (tie) | Periodic regional or local (less than once a year but still regularly scheduled) inventory and assessment |
| 4 (tie) | Occasional regional or local (less than once a year and not regularly scheduled) inventory and assessment |
| 4 (tie) | Occasional statewide (less than once a year and not regularly scheduled) inventory and assessment |
| 4 (tie) | Regional or local year-round inventory and assessment |

Respondents listed regional or local inventory and assessment by state agencies for mature/high canopy forest habitat in Indiana:

- The state examines habitat on state properties periodically and uses GAP and other habitat modeling programs to assess forest habitats

Respondents listed regional or local inventory and assessment by other organizations agencies for mature/high canopy forest habitat in Indiana (not ranked):

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- TNC, USFWS and USDA Forest Service uses habitat models to examine forest habitat in Indiana (Hoosier National Forest and Big Oaks National Wildlife Refuge)
- Hoosier National Forest and Ball State University are collecting data on habitat use by cerulean warblers on the northern portion of the forest
- Cornell's "Birds in Forested Landscapes" collects some data on habitat use. I am not sure if data has been submitted from Indiana

Respondents listed organizations that monitor mature/high canopy forest habitat in Indiana (not ranked):

- INDNR
- USFWS
- USDA Forest Service
- TNC
- Cornell Lab of Ornithology
- Ball State University, Department of Biology
 - Has been monitoring Cerulean Warbler populations at Big Oaks National Wildlife refuge, Hoosier national Forest, and Yellowwood and Morgan-Monroe state forests during the last 5 years

Respondents considered inventory and assessment techniques for mature/high canopy forest habitat in Indiana:

| Inventory and assessment techniques for mature/high canopy forest 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 | -- | -- |
| Modeling | X | -- | -- |
| Voluntary landowner reporting | X | -- | -- |

Respondents listed additional inventory and assessment techniques for mature/high canopy forest habitat in Indiana (not ranked):

- Samples at known nest sites are compared with random sites at Big Oaks National Wildlife Refuge
- There have been several master's degree projects on habitat selection for the Cerulean Warbler in Indiana. These studies have collected the following information on habitat use: diameter at breast height (DBH) and identification of tree species in a nested plot at the center of a territory, number of saplings (trees <3cm DBH), number and DBH of standing dead trees (snags), canopy cover, ground cover, canopy height, percent canopy coverage and ground cover, canopy height, and vertical stratification of foliage

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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 mature/high canopy forest habitats. There were no responses.

Recommended monitoring

Species monitoring

Respondents recommended the following monitoring techniques for effective conservation of wildlife in mature/high canopy forest habitat in Indiana (not ranked):

- A study that experimentally tests how forest management influences demography and presence and absence. Some wildlife species need basic life history studied, too
- Cerulean warblers
 - We would benefit from obtaining basic demography data on this species. Mist netting is not particularly feasible because the species stays so high in the canopy. Due to the difficulty of locating nests of ceruleans and of capturing adults, especially females, determination of reproductive success is problematic. Assessing survivorship of eggs, nestlings, and fledglings is also difficult. Until such reproductive success and survivorship information is available, the dynamics of populations will continue to be unknown
 - Point counts, spot mapping, and territory mapping provide important information about ceruleans. Banding individual birds could supply information on site fidelity and survivorship
 - Regular monitoring of migratory stopover and winter habitats will also be an important part of the conservation of the cerulean warbler
 - Nest search and monitoring to assess productivity to determine if Indiana has a 'source' or 'sink' population of cerulean warblers (Hutto, R.L., S.M. Pletschett, and T.P. Hendricks. 1986. A fixed-radius point-count method for nonbreeding and breeding season use. *Auk* 103:593-602)
- Roadside bird surveys on selected routes maximizing forest habitats
- Repeated point count surveys in representative forest sites
- Timber rattlesnakes
 - Radio telemetry, mark recapture techniques, and transect surveys. Due to the cryptic nature of these snakes, locating individuals without the help of telemetry is extremely difficult. Many studies conducted locally and nationally have included telemetry in their methods

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the monitoring techniques for effect conservation of wildlife in mature/high canopy forest habitats. There were no responses.

Habitat inventory and assessment

Respondents recommended the following inventory and assessment techniques for effective conservation of mature/high canopy forest habitat in Indiana (not ranked):

- GIS modeling, photo analysis and intensive study to determine habitat quality (source vs. sink)
- Cerulean warblers

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- A crucial piece of habitat data for the cerulean warbler is the size and distribution of canopy gaps within territories. At this point, researchers have not determined an effective means to quantify this data
- Another important habitat inventory would be looking at landscape characteristics of cerulean occurrence and distribution in relation to forest fragmentation.
- Monitoring should incorporate the occurrence of the species in relation to landscape characteristics such as proportion of agricultural use, tract size and shape, and amount of edge
- Systematic sampling/survey techniques to locate warblers (Hutto et al. 1986. Auk 103:593-602)
- Habitat association studies to determine which habitat types used/ preferred in Indiana

Technical experts and conservation organizations reviewed the above results and were asked if these were a reasonable representation of the inventory and assessment techniques for effect conservation of mature/high canopy forest habitats. There were no responses.