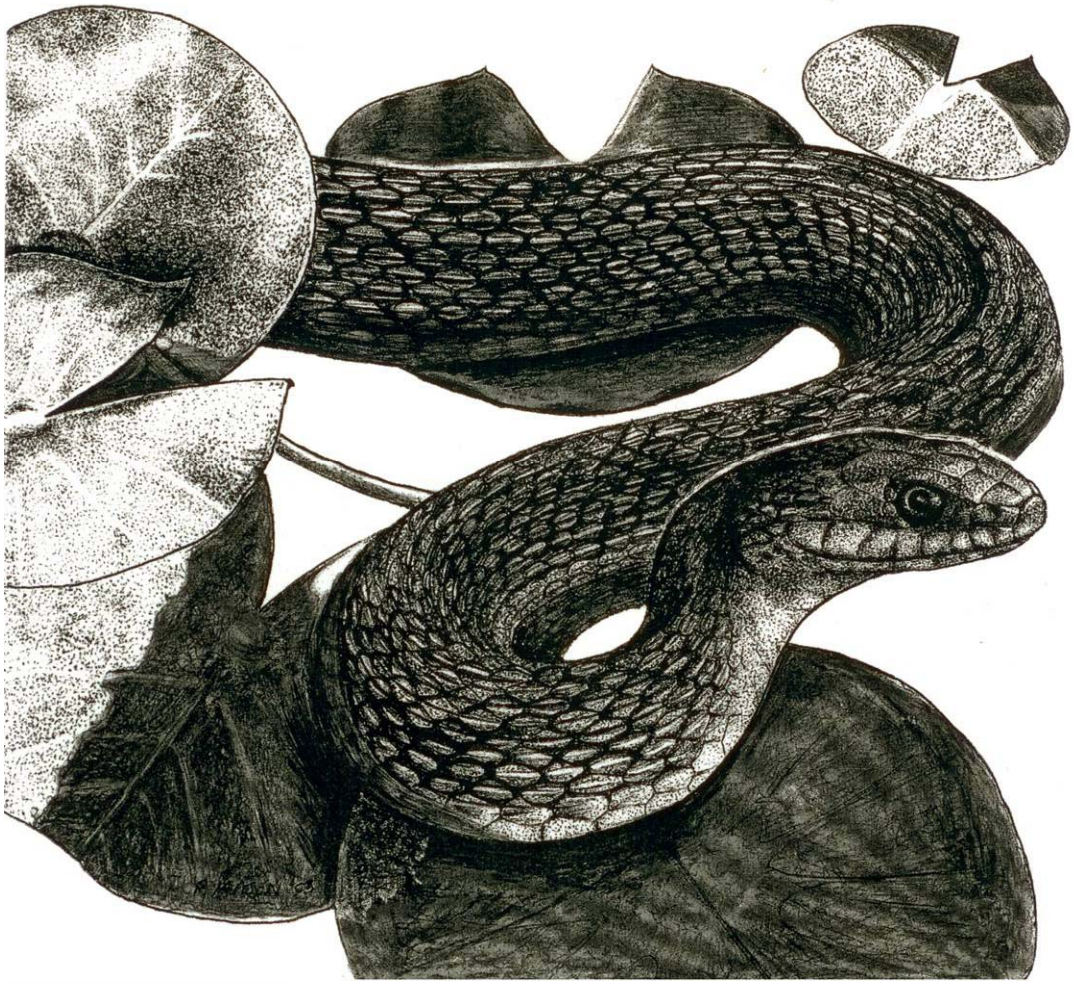
Northern Population Segment of the Copperbelly Water Snake (*Nerodia erythrogaster neglecta*) Recovery Plan



December 2008

Department of the Interior
U.S. Fish and Wildlife Service
Midwest Region
Fort Snelling, MN

Cover graphic

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Northern Population Segment of the Copperbelly Water Snake (*Nerodia erythrogaster neglecta*)

Recovery Plan

December 2008

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for

Midwest Region
U.S. Fish & Wildlife Service
Fort Snelling, Minnesota

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Date: Dec. 5, 2008

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LITERATURE CITATION SHOULD READ AS FOLLOWS:
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Finally, we acknowledge the contributions of the cover art and many photographs used throughout the recovery plan. The cover art was drawn by Peri Mason and reproduced from the book, North American Watersnakes: A Natural History, with the permission of the authors, J. Whitfield Gibbons and Michael E. Dorcas. Photographs are used with permission of the photographers—Omar Attum, John Roe, Bruce Kingsbury, Edward Laurent, and Scott Gibson—as indicated in the figure captions.

EXECUTIVE SUMMARY

Current Species Status:

The northern population of the copperbelly water snake (*Nerodia erythrogaster neglecta*) is listed as threatened by the U.S. Fish and Wildlife Service as a Distinct Population Segment (DPS). The DPS consists of populations north of the 40th Parallel, in Indiana, Michigan, and Ohio. Surveys over the last twenty years have documented an ongoing decline in these populations. Many populations are now extirpated, and the five that remain are very small. Even the largest population, located in Ohio, is in decline with adults likely numbering in the low hundreds, or less.

Habitat Requirements and Limiting Factors:

Copperbelly water snakes have both wetland and terrestrial habitat requirements but are associated most often with wetland complexes characterized by a preponderance of shallow wetlands, many of which draw down seasonally. Thus, the species needs habitat complexes of isolated wetlands distributed in a forested upland matrix, floodplain wetlands fed by seasonal flooding, or a combination of both. Individuals move hundreds of meters or more between wetlands and routinely use multiple wetlands over the course of an active season. They also spend substantial periods of time in upland situations, aestivating, foraging, and shedding. In addition, fishless wetlands that have high anuran (frog and toad) productivity are required to provide habitat and a suitable prey base.

The principal limiting factor for copperbellies is the availability of wetland/upland habitat complexes of sufficient size. Research indicates that copperbellies require many hundreds of hectares of contiguous habitat in order to persist. Additional threats are human persecution, inadequate habitat management, and road crossings.

Recovery Strategy:

The principal recovery strategy is to establish and conserve multiple wetland/upland habitat complexes that provide adequate habitat for population persistence. The existence of several such landscape complexes will greatly reduce the risk of extinction due to catastrophic or otherwise unanticipated losses of populations. Our recovery strategy focuses on targeted habitat restoration and implementation of "best management practices" for land managers. Additional efforts will also focus on reducing take due to collection by humans and malicious killing. Outreach materials will be developed regarding the species' presence in the community as part of the natural environment and to reduce the fear of snakes.

Recovery Goal: To remove the species from the Federal list of Endangered and Threatened Wildlife (50 CFR 17.11).

Recovery Objectives: (1) To ensure long-term persistence of multiple viable populations across the geographic range of the DPS; (2) to conserve sufficient

wetland/upland habitat complexes to support these populations; (3) to reduce known threats to the extent possible; and (4) to develop and distribute educational materials on the natural history of copperbellies, their habitat requirements, and appropriate management guidelines for the species and its habitat.

Recovery Criteria:

Delisting Criteria

Delisting of the species will be considered when the five factors (see Threats discussion) are assessed and when the following criteria are met:

Criterion 1. Multiple population viability is assured:

a) Five geographically distinct populations have population sizes of more than 500 adults, with at least one population exceeding 1000 adults; or three populations must have a total population size of 3000 adults, with none less than 500, and

b) These populations must persist at these levels for at least ten years.

Criterion 2. Sufficient habitat is conserved and managed:

a) Wetland/upland habitat complexes sufficient to support the populations described in Criterion 1 are permanently conserved.

    1) A population of 1000 adults will require at least five square miles of landscape matrix with a high density and diversity of shallow wetlands imbedded in largely forested uplands.

    2) A population of 500 adults will require at least three square miles of the same type of habitat.

b) Multiple (two or more) hibernacula for each population are permanently conserved. A minimum of two hibernacula will be available within one kilometer of all suitable habitat included above.

Criterion 3. Significant threats due to lack of suitable management, adverse land features and uses, collection and persecution have been reduced or eliminated:

a) Habitat management and protection guidelines have been developed, distributed, and maintained.

b) Adverse land features and uses, such as row crops, roads and accompanying traffic, have been removed, minimized, or managed within occupied Criterion 1 landscape complexes to the extent possible.

c) A comprehensive education and outreach program, including persecution and collection deterrence, has been developed and implemented.

Reclassification Criteria

The copperbelly water snake will be considered for reclassification from threatened to endangered status when the five factors (see Threats discussion) are assessed and when either of the following criteria is met:

Criterion 1: There are no known populations of more than 500 adults.

Criterion 2: The cumulative population size is estimated at less than 1000 adults.

Actions Needed:

1. Identify and conserve habitat complexes sufficient for recovery
2. Monitor known copperbelly water snake populations and their habitat
3. Improve baseline understanding of copperbelly water snake ecology
4. Develop recovery approaches to enhance recruitment and population size
5. Develop and implement public education and outreach efforts
6. Review and track recovery progress
7. Develop a plan to monitor copperbelly water snake after it is delisted

Estimated Cost of Recovery for FY 2009 – 2039 (in $1000): Details are found in the Implementation Schedule**.**

Year(s)	Action 1	Action 2	Action 3	Action 4	Action 5	Action 6	Action 7	TOTAL
1	190	45	35	20	9	1	0	**300**
2	210	45	65	50	9	1	0	**380**
3	200	55	65	70	9	1	0	**400**
4-30	305+	535	45	5+	72	37	15	**1014+**
TOTAL	**905+**	**680**	**210**	**145+**	**99**	**40**	**15**	**2094+**

Date of Recovery: Contingent on funding and implementation of recovery actions, full recovery of this species may occur by 2039.

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PART I. BACKGROUND

Status of the Species

The U.S. Fish and Wildlife Service (Service), in accordance with its Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Act (61 FR 4722), determined that the copperbelly water snake (*Nerodia erythrogaster neglecta*) consisted of two distinct population segments (DPS), the northern population segment and the southern population segment, and designated the northern population a threatened species on January 29, 1997 (62 FR 4183), under the provisions of the Endangered Species Act (ESA) of 1973, as amended.

The Service has developed guidelines for assigning priorities to the development and implementation of recovery plans for listed species (48 FR 43098). The recovery priority number for the copperbelly water snake is 3C, indicating that it is: (1) taxonomically, a subspecies; (2) facing a high degree of threat; (3) rated high in terms of recovery potential; and (4) in conflict with construction or other development project(s) or other forms of economic activity. The Service regularly reviews the taxonomy, threats, recovery potential, and degree of associated conflict(s) and may change the recovery priority based on that review.

Taxonomy and Nomenclature

The copperbelly water snake is a subspecies of the plain-bellied water snake (*Nerodia erythrogaster*) (Conant 1949). There are currently five additional recognized subspecies of *N. erythrogaster* in North America (Gibbons and Dorcas 2004). The yellowbelly water snake (*Nerodia erythrogaster flavigaster*) is geographically the next closest subspecies, with a contact zone between copperbellies and yellowbellies in southern Illinois. Inspecting water snakes from Michigan, Clark (1903) considered the copperbelly to be sufficiently distinct from the "common water snake," then listed as *Natrix fasciata sipedon*, to reasonably be its own subspecies, *Natrix f. erythrogaster*. This taxonomy followed Cope (1900). Clark (1903) was one of the early investigators who recognized the extent of variability of both forms, and the confusion about species identity that this variation causes.

In early efforts to clarify the taxonomy of North American *Natrix*, Stejneger and Barbour (1933) did not recognize the validity of *N. erythrogaster* as a species, whereas Clay (1938) did. Clay, however, did not acknowledge the presence of a northern form. Conant (1934) noted the confusion in the literature of the day and first wrote about the presence of the distinct "red-bellied water snake" in Ohio as *Natrix sipedon erythrogaster*. Fifteen years later, he fully clarified the regional presence of a form of the snake as a subspecies of *Natrix erythrogaster*, coining the new subspecies *N. e. neglecta* (Conant 1949).

More recently, the taxonomic revision of the water snakes resulted in a change in the North American forms of *Natrix* to *Nerodia* (Rossman and Eberle 1997). Consequently,

the currently accepted scientific name for the copperbelly is *Nerodia erythrogaster neglecta*. This assignment appears stable and robust.

Considerable variation in the common names used for the species has resulted in additional confusion. Conant (1934) referred to the species as the "red-bellied water snake," and then in 1949 introduced the name "northern copperbelly," recognizing the subspecies (Conant 1949). In the first edition of "Amphibians and Reptiles of Indiana," Minton, Jr. (1972) used "northern copperbelly," although there was no "southern copperbelly." In his second edition (2001), he switched to "copperbelly." Conant and Collins (1991, 1998) used the name "copperbelly water snake." As a last example, in his work on herpetofauna of the Great Lakes, Harding (1997) uses Copper-bellied Water Snake.

Recently, efforts have been underway by several taxonomists to standardize the common names of all reptiles and amphibians. Unfortunately, there is even variability in the currently accepted common name depending on the preferred naming convention. The lists published by the Center for North American Herpetology (CNAH) (Collins and Taggart 2002) and the Society for the Study of Amphibians and Reptiles (SSAR) (Crother 2000) are not in agreement on the common name for *N. e. neglecta*, with the former suggesting "Copperbelly Water Snake," and the latter "Copper-bellied Watersnake." Given that "copperbelly water snake," "copperbelly watersnake," and the "copperbelly" are used most frequently by the Service, we have elected to use "copperbelly water snake" or "copperbelly" throughout this Recovery Plan.

As noted above, usage of the term "northern" in the common name has introduced further confusion. It is therefore important to reiterate that use of "northern," "northern population," "northern population segment" "southern," "southern population," or "southern population segment" does not indicate separate subspecies or distinct taxonomic status based on geographic location. Rather, throughout this recovery plan, "northern," "southern," etc., refer to the appropriate DPS of the species (see the Distribution section for additional discussion on DPSs).

Description

Copperbelly water snakes have a solid dark, usually black, back with a bright orange-red underside that is visible from a side view (Figure 1). They grow 3 to 5 feet in length and are non-venomous. The head and eyes of the copperbelly water snake are proportionally larger than those of similar species (Clay 1938, Conant 1938, Conant 1951, Minton, Jr. 1972).

To the south, the copperbelly water snake is most often confused with the yellowbelly water snake (*N. e. flavigaster*), a conspecific occurring to the south and west in Illinois and Kentucky. The copperbelly water snake generally has a bright orange-red underside, whereas the yellowbelly water snake usually has a pale yellow belly. Furthermore, the copperbelly water snake has "fingers" of dark pigment extending onto the ventral scales that may meet or nearly meet at the belly, whereas the yellowbelly water snake has dark

pigment encroaching onto only the edge of the ventral scales (Conant 1938, Conant 1949, Minton, Jr. 1972, Brandon and Blanford 1995). The distinction between these subspecies is problematic. There is some variation in both subspecies, and intergrades may also occur (Brandon and Blanford 1995).

Figure 1. An adult copperbelly water snake. Note the very dark dorsal coloration and orange ventral coloration. Orange also more or less completely covers the labial (lip) scales. Photo by Omar Attum.

Under some circumstances, individuals from the listed populations of copperbelly water snake may be confused with the northern water snake. Adult northern water snakes have a variable pattern on the back and sides, and a pattern of half-moon shaped spots on the belly (Figures 2 and 3). Adult individuals may be quite dark such that the dorsal background color blends closely with that of the bands. As a result, the snake may appear uniformly dark in color (especially when the skin is dry), and then be easily confused with the copperbelly. However, closer examination reveals dark crescents on the belly that are not found on the copperbelly. Juvenile copperbelly water snakes and northern water snakes may look quite similar, as copperbellies retain obvious dorsal banding for the first year or two of life (Figure 4). When specimens are in hand, a key distinction remains the lack of dark crescents of color on the belly of juvenile copperbellies. There are also differences between the dorsal coloration of the juvenile northern water snakes and copperbellies that might be used to distinguish young *Nerodia erythrogaster* (copperbellies and related species) from young *Nerodia sipedon* (northerns, midlands, etc.), but they are subtle and inconsistent, so it is most straightforward to rely only on the ventral differences.

Figure 2. The northern water snake (*Nerodia sipedon sipedon*), a close relative of the copperbelly water snake. Figure 2a. A northern water snake with a very common color pattern of distinct light and dark dorsal banding. Figure 2b. Also a northern water snake, but the dorsal background color is very dark, hiding the banding pattern. Note the complex belly coloration, particularly the intermixture of orange and black forming crescents. See Figure 3 for pictures of the bellies of the two species for a better view of this contrast. Photos by Omar Attum.

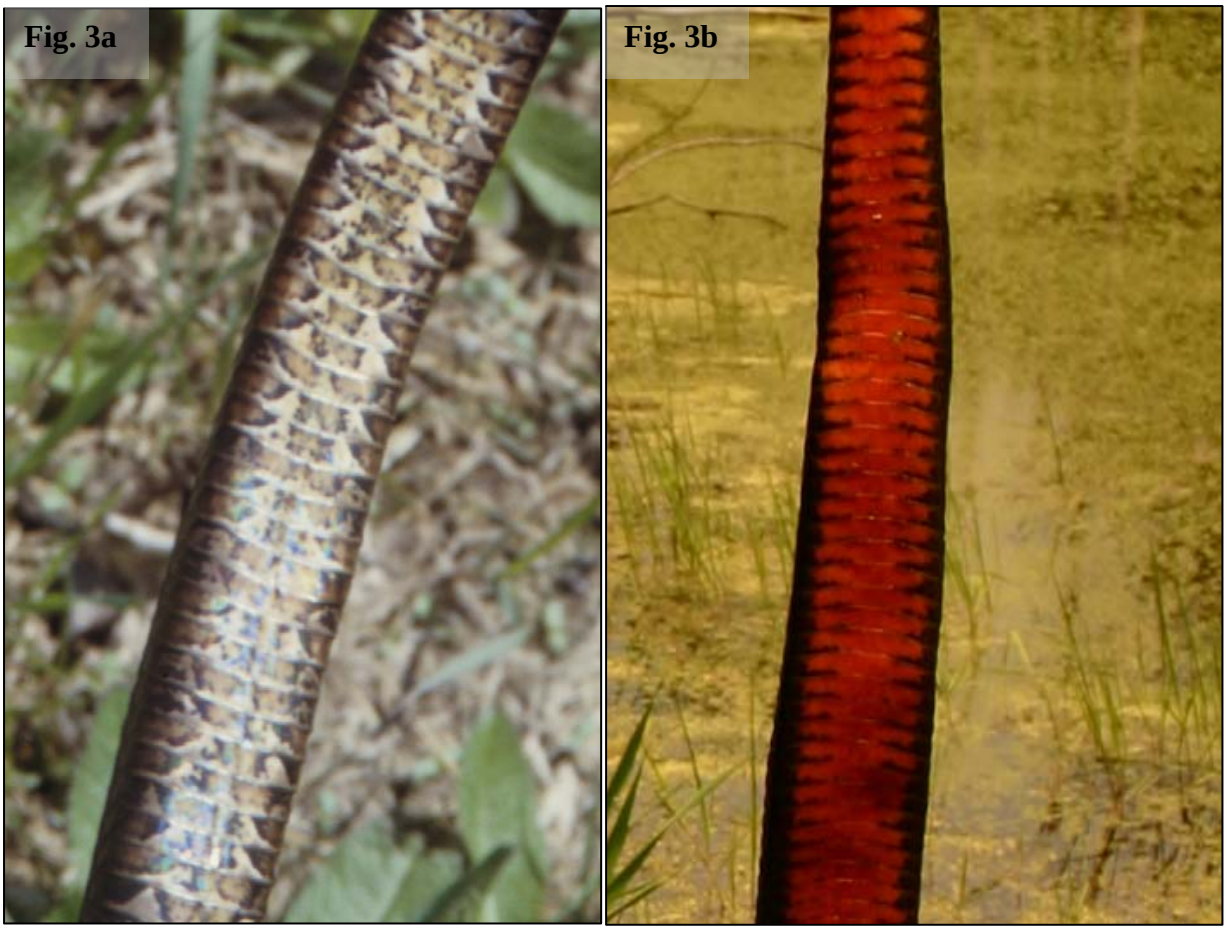

Figure 3. Ventral views of a northern water snake (left) and copperbelly water snake (right). Ventral patterns are highly variable. Northern water snakes have dark crescents on a light background that copperbellies never have (Figure 3a). The background color of copperbelly water snakes is yellow to orange, with the dark dorsal color intruding along the edges (Figure 3b). Northern water snake photo by Bruce Kingsbury. Copperbelly water snake photo by John Roe.

Figure 4. A copperbelly water snake juvenile (Figure 4a) in comparison with a northern water snake juvenile (Figure 4b), a species with which it commonly occurs. While the backs of adult copperbellies characteristically are dark and unmarked (Figure 1), juveniles retain the banding typical of many water snake species, including the northern water snake. As copperbellies mature, the banding is gradually lost, replaced by the typical solid dark coloration. In contrast, the banding is generally retained in the northern water snake (although this is not always the case; refer to Figure 2), leading to the distinct pattern differences between adults. As with adults, the coloration of the juveniles of either species is variable. Consequently, individuals viewed side by side may appear more similar than illustrated here. Copperbelly water snake photo by Mike Redmer. Northern water snake photo by Scott Gibson.

Distribution and Population Trends

Historic Distribution

Our understanding of the historic distribution of the copperbelly water snake is incomplete as museum specimens were often miscataloged by early herpetologists as the northern water snake. Correction of the mislabeled specimens is difficult due to the rapid fading of colors of preserved specimens. As a result, the original range and distribution of copperbelly water snake is not precisely known. After recognition as a subspecies, the known historical range was described by Schmidt (1953) as "south central Michigan and northwestern Ohio, southwestward through Indiana to extreme southeastern Illinois and adjacent Kentucky." Although some early authors such as Wright and Wright (1957) depicted the northern populations as connected continuously across much of Indiana to populations further south, a notable gap exists in actual location records between the southern and northern populations (Figure 5).

Little is known about the historic densities of copperbelly water snake in the northern populations; however, in southern populations, copperbellies are certainly as abundant as other water snakes. They are often the most abundant water snake in suitable habitat. Consequently, they may not have naturally low densities in the north. Nevertheless, the listed populations are on the northern margin of the range, and thus may always have had lower densities than populations further south.

Distinct Population Segments (DPSs)

Given the extensive gap between the northern and southern populations, the northern populations qualified as distinct under the Service's Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the ESA (61 FR 4722). The following designations were adopted for the two population segments: Northern Population Segment (NPS)-Michigan, Ohio, and Indiana north of 40 degrees north latitude (approximately Indianapolis, IN) and Southern Population Segment (SPS)-Illinois, Kentucky, and Indiana south of 40 degrees north latitude.

The determination of two DPSs enabled the Service to treat each DPS as a species and make separate listing determinations for each of them. The Service determined that Conservation Agreements in Kentucky, Illinois, and Indiana significantly reduced the threats from surface coal mining (the predominant threat) for the southern population segment; therefore, the Service determined that listing the southern population segment as threatened was not warranted. Threats affecting the northern population segment were not addressed in the Conservation Agreements, and the Service determined that the northern population warranted listing as a threatened species.

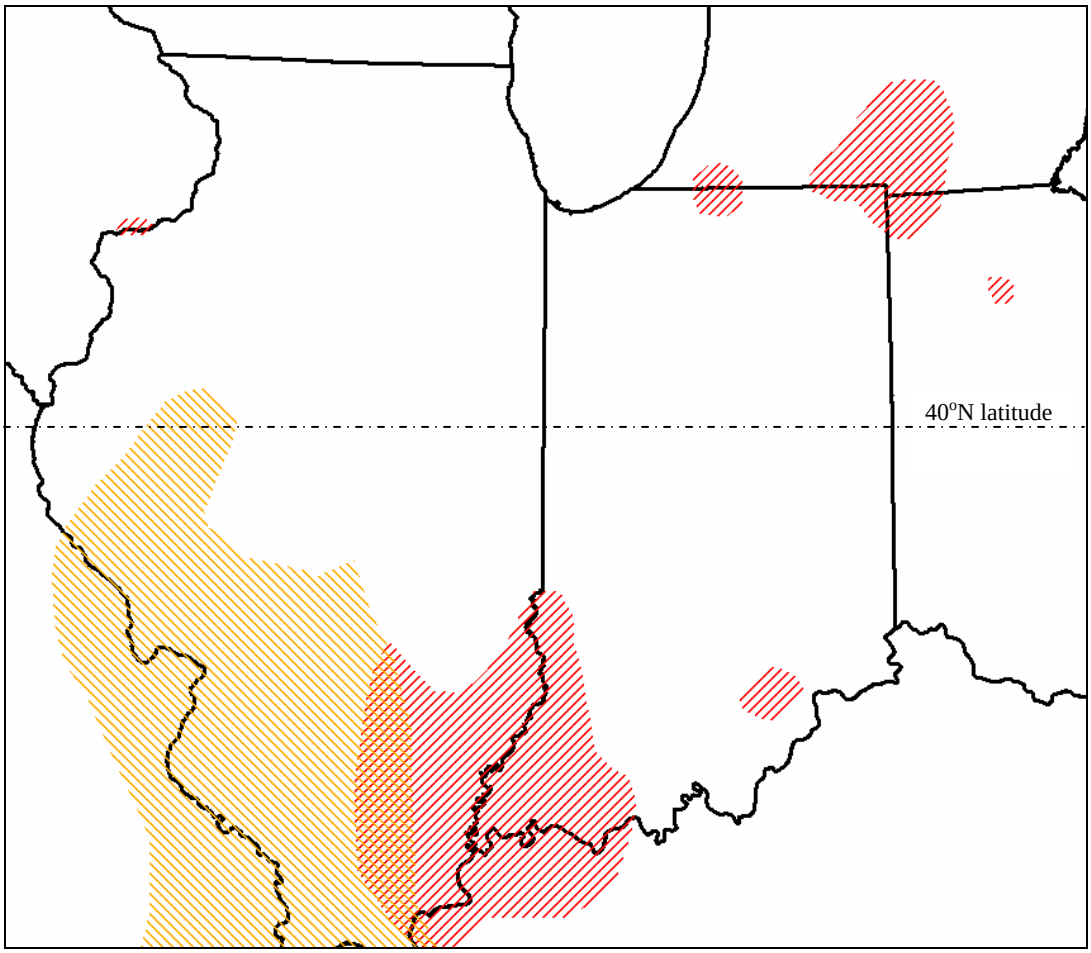

Figure 5. Historic distribution of the copperbelly water snake in the Midwest (six polygons with red hatching). To the northeast, north of the 40th North Parallel, are the isolated remaining copperbelly populations of the listed DPS. All known remaining populations of the DPS are within 15 miles of the intersection of Indiana, Michigan, and Ohio. Neither the southern populations nor the southeastern disjunct population near Seymour, Indiana, are federally listed, nor is the northwestern population along the Mississippi River in northwestern Illinois and eastern Iowa. Also shown (yellow hatching) is the Midwestern extension of the distribution of the yellowbelly water snake, the closest relative of the copperbelly, whose distribution continues south, and for which there is no Federal protection.

Current Distribution

The current distribution of the northern DPS of the copperbelly water snake is limited to only a few small isolated populations in south-central Michigan, northeastern Indiana, and northwestern Ohio (Figure 6) (Kingsbury et al. 2003, Lee et al. 2005, Lee et al. 2007, Sellers 1991, USFWS 1997). Despite repeated efforts to locate copperbellies at historic or new sites, these surveys have confirmed the presence of only five populations over approximately the last 10 years.

During extensive survey work during the 1980s, Sellers (1987a, 1987b, 1991) reported specimens from 16 sites (eight in Michigan, four in Ohio, and four in northeastern Indiana) within the range of the listed DPS. Surveys during the ten years prior to listing in 1997 indicated eight local populations in the range of what is now the NPS. The majority of the populations were found on private property. Two of the eight populations had a portion of their area protected by state ownership, one was partially owned by a private conservation organization, and five were on private property.

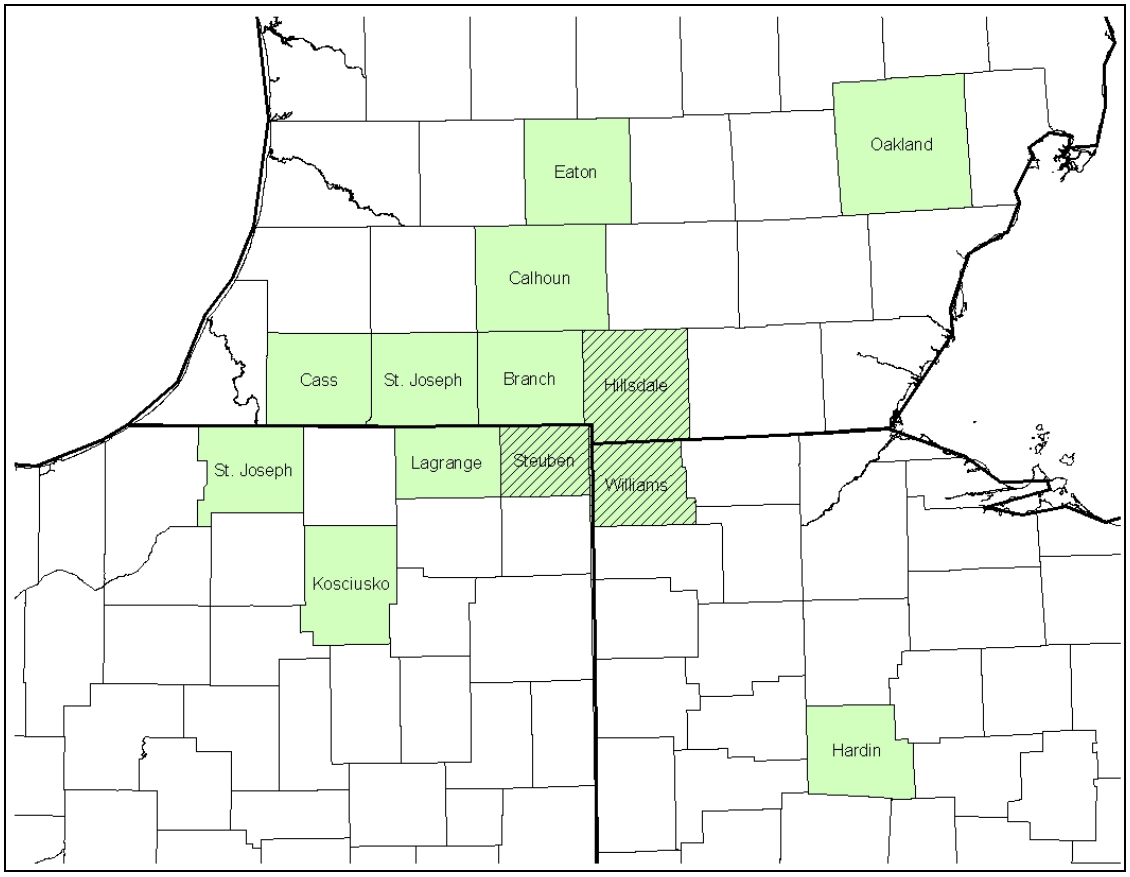

Figure 6. Historic and current county distribution of the copperbelly water snake (Northern DPS). Shaded counties are those with historic records. Hatching indicates counties with extant populations (confirmed in the past five years).

In 1996, surveys indicated a decline, as copperbelly water snakes were found to occur in only five local populations (USFWS 1997). Since listing, many surveys have been conducted throughout the northern range of the species. Recent surveys (2001-2006) (Kingsbury et al. 2003, Lee et al. 2007) have shown a continued decline; the extent of range and numbers of the copperbelly water snake are likely less than what had been estimated during the listing process.

Indiana and Ohio

Surveys conducted in 2001-2006 indicate that only one substantive population remains in either the northeastern Indiana or northwestern Ohio portions of the NPS (Kingsbury et al. 2003, Lee et al. 2007). The largest remaining population occurs in Ohio and is centered on state-owned land but also extends north into southern Michigan. Only a single copperbelly was observed in Indiana and Ohio at a locality outside of this population in the last five years, at a site in northeastern Indiana bordering Ohio (Kingsbury et al. 2003). Another site nearby, also on the border with Ohio, had copperbelly observations within the last ten years (Kingsbury and Cortwright 1994). Populations further west in Indiana appear extirpated; surveys in 2003 found little habitat remaining, and no individuals were found (Kingsbury et al. 2003). The most recent reliable records are from 1986, for St. Joseph County (Sellers 1991, based on photo interpretation) and Kosciusko County (Sellers 1987a, based on snake "scoped" but not in hand).

Michigan

Michigan Natural Features Inventory (MNFI) conducted extensive surveys of suitable habitat throughout the historic range in Michigan. Historically, the copperbelly water snake was known from 13 locations or occurrences in seven counties in southern Michigan (Branch, Calhoun, Cass, St. Joseph, Eaton, Hillsdale, and Oakland Counties) (Lee et al. 2002). Of the 13 occurrences, only three were thought possibly to contain reproducing populations (two in Hillsdale and one in Cass and St. Joseph Counties), based on surveys conducted prior to 2001 (Yu Man Lee, Michigan Natural Features Inventory, pers. comm. 2003). During surveys conducted in 2001-2006, three copperbelly water snake occurrences were documented in extreme southern Hillsdale County, with evidence of reproduction found for two of the occurrences (Lee et al. 2007). One of these occurrences is part of the population in Ohio. Surveys during this period did not locate copperbelly water snakes at the site in Cass and St. Joseph Counties.

<u>Population Status</u>

Surveys for copperbelly populations have shown declines in population size. Extensive surveys by Kingsbury (Kingsbury 1995, Kingsbury et al. 2003) and MNFI (Lee et al. 2002, Lee et al. 2005, Lee et al. 2007) have confirmed the presence of five populations over approximately the last 10 years, four of which have been confirmed within the last five years.

Preliminary mark-recapture studies were conducted on copperbellies in selected northern Ohio areas (Kingsbury et al. 2003). Results from these studies suggested that the estimated population size of copperbellies at the study site was tentatively in the hundreds, but samples were so small that accurate estimates were not possible. Extensive additional surveys in 2005 and 2006 intended to estimate the number of adults in the remaining populations resulted in 89 copperbelly observations and 37 unique individuals captured (Lee et al. 2007). Given that copperbellies, when present, are relatively reliably observed under good surveying conditions, this low rate of observations was alarming, considering the extensive amount of effort put into the surveys.

In 2006, distance sampling was used to estimate the population size and density of the largest known population of copperbellies (Lee et al. 2007). Thirty four wetlands, each surveyed four times, produced an estimate for the population of 113 $\pm$ 27 individuals, and a population density of 1.76 $\pm$ 0.42 snakes per hectare. A total of 49 copperbellies was confirmed in nine of the wetlands. The density of the more common northern water snake, *Nerodia sipedon sipedon*, in the same areas, was estimated at 8.16 $\pm$ 0.90 snakes per hectare. Although the technique employed has limitations, these results were consistent with previous observations.

In comparison, population estimates of copperbellies in the SPS have been much higher. In areas of the southern population segment where they are doing well, copperbellies appear to be the most abundant water snake, and perhaps even the most abundant large snake. For a population from southern Indiana, Lacki et al. (1994) estimated densities of 10-14 snakes per hectare. Kingsbury and Laurent (2000) used mark-recapture at a site near Henderson, Kentucky, and estimated copperbelly density at approximately 11 snakes per hectare over the 100 hectare area surveyed.

Another way to evaluate trends in population is to compare observation rates in the same areas over time. Figure 7 shows the mean number of snakes observed per visit in five of the wetlands where copperbellies were most reliably seen in the NPS. The results shown here are consistent with observation rates from other occupied copperbelly wetlands in the NPS (Lee et al. 2007). Clearly the observation rate is in decline.

Copperbelly densities in the NPS may never have been as high as those observed in the SPS. Clark (1903) and Conant (1949) remarked on the low numbers of copperbellies observed, and all recent work would appear to be consistent with those early observations. The NPS is on the northern extreme of the distribution of the species and thus may also occur at the limits of environmental factors that the species can tolerate. The landscape also lacks the large floodplain wetland systems that occur in the south.

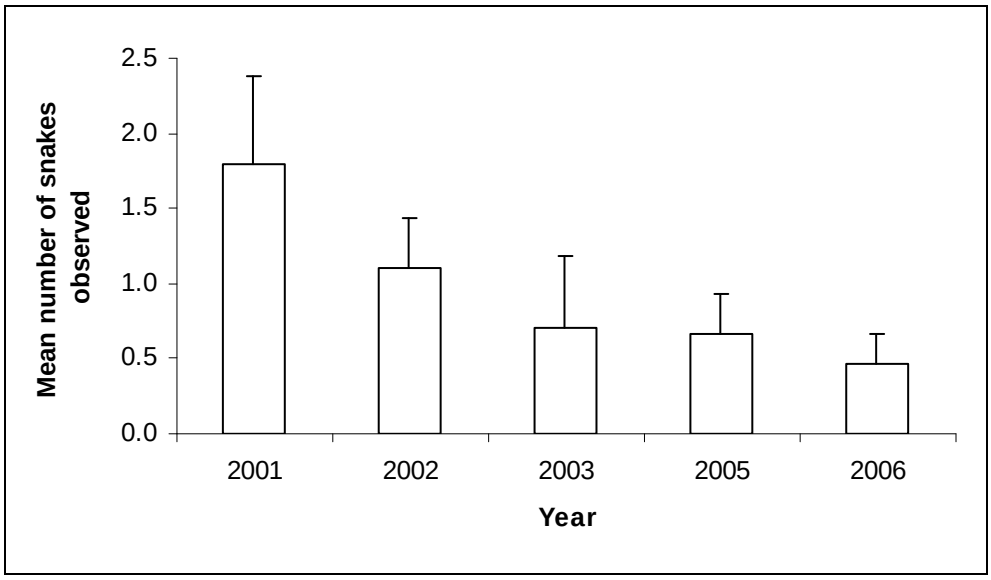

Figure 7. Mean number of copperbelly water snakes observed per visit in five core or high use wetlands in La Su An Wildlife Area between 2001-2006. All wetlands were surveyed using the same protocol between April and June. In 2001-2005, wetlands were surveyed three times per year, and in 2006, wetlands were surveyed four times. Taken from Lee et al. 2007.

Summary

The copperbelly water snake is the northern Midwest representative of the plain-bellied water snake. Populations of copperbelly water snake span from western Kentucky and southern Illinois to northern Indiana and Ohio and southern Michigan. The northern population segment in northern Indiana and Ohio and southern Michigan is listed as a Threatened Distinct Population Segment. Surveys over the last twenty years have documented an ongoing decline in populations in the NPS. Conclusions from surveys and mark-recapture efforts indicate that populations continue to be lost, and those that remain are in decline. A total of three populations are confirmed for Michigan and Ohio, and two additional populations have had confirmed observations within the last ten years. Mark-recapture modeling estimates the number of adults in the low hundreds, and surveys of the wetlands with the most frequent observations of copperbellies show a decline in numbers observed. Only one population may harbor more than 100 individuals.

Life History and Ecology

Patterns of Annual Activity

Copperbelly water snakes are generally in hibernacula, underground and inactive, from late October until late April (Kingsbury 1996, Kingsbury et al. 2003). Although snakes in more southerly populations have been observed on the surface during winter warm spells (Susan Knowles, U.S. Fish and Wildlife Service, pers. comm. 1997), such activities seem to be limited, and may be limited to injured or sick individuals. The exact dates of the onset and termination of hibernation vary from year to year depending upon weather patterns of the season. When copperbellies first emerge from their hibernacula, they stay nearby, and may re-enter the ground if the weather turns cold. Within a few days, however, they begin to move into adjacent wetlands.

As the weather warms, copperbellies become more active, searching for food and also for mates. Courtship and mating occur largely in the spring. Individuals engage in what becomes the standard pattern of behavior, spending a few days to weeks in one wetland, then move upland or to another wetland (Kingsbury 1996, Kingsbury et al. 2003, Roe et al. 2003, Roe et al. 2004). In the middle of the summer when air and water temperatures are relatively high, copperbellies are more crepuscular, although some will remain active during the day. They will also spend extended periods underground aestivating or in shallow water. By September, individuals are less active and begin exploring hibernation locations. By mid-October, most individuals are in hibernacula.

Patterns of Movement

Copperbellies concentrate their activities in several small areas within their home ranges, termed activity centers. These areas are not necessarily centrally located. Seasonal ranges were determined using the boundaries of these widespread centers of activity rather than the limits of excursions from a single core area. Seasonal ranges were defined as the cumulative area used by individuals over one active season and were measured in various ways, in this case by the minimum convex polygon (MCP) method. Multiple activity centers might result from patchy resource distribution (Conant 1934, Gregory et al. 1987, Minton, Jr. 1972). Snakes may shift their position in the landscape as particular wetlands are drying, possibly concentrating the food supply in disjunct ephemeral pools. Sometimes snakes use an activity center only once during a season, while other times snakes shuttled between two activity centers (Kingsbury 1996, Kingsbury et al. 2003, Roe et al. 2003).

Copperbellies travel relatively long distances for snakes of their size. Within the NPS, seasonal ranges averaged 11 ha in a small scale study in northeastern Indiana (Kingsbury 1996), and 16 ha (Roe et al. 2004) in northwestern Ohio. Seasonal ranges for individuals are quite variable. This variability would not appear to be unusual for snakes (Gregory et al. 1987, Macartney et al. 1988) even for congeners such as *N. sipedon* (Tiebout and Cary 1987, Roe et al. 2004). The larger activity centers of the male snakes in the spring may

be a result of the males searching widely for females (Madsen 1984, Weatherhead and Hoysak 1989).

Because of the limited amount of time snakes spend in transit between activity centers, observations of behavior under such circumstances are rare, thus limiting our ability to confirm routes used by copperbellies to travel from one site to another. Snakes appear to travel relatively directly from activity center to activity center across apparently suitable habitats, or use habitat edges as corridors, as suggested by Kingsbury (1996). They do not cross expansive agricultural areas readily, nor do they appear to detour extensively to follow streams or other aquatic thoroughfares. The latter view was supported by observations and occurrence of activity centers along habitat edges in more recent studies on Threatened populations (Kingsbury et al. 2003), as well work on populations further south (Kingsbury 1998, Coppola 1999, Hyslop 2001).

There are no clear differences in patterns of movement between males and females. Males may move about somewhat more than females early in the season, but females tend to occupy larger areas than do males; however, these trends have not been found to be statistically significant. Females suspected to be gravid reduce their activity and tend not to travel away from refugia such as burrows (Kingsbury et al. 2003), a common pattern for snakes. Pregnancy can affect patterns of movement and size of the areas occupied by restricted movements, and habitat utilization by selection of more secure resting sites (Fitch and Shirer 1971, Brown et al. 1982, Madsen 1984, Weatherhead and Hoysak 1989).

Growth and Reproduction

Neonate (newly born) copperbellies are quite small. Data is scarce for the NPS, but neonate plain-bellied water snakes sampled from a variety of locations average about 250-270 mm (10-11 in) snout to vent length (SVL) and 5-6 g (0.18-0.20 oz) (summarized in Gibbons and Dorcas 2004). Observations of neonates in the fall are rare, and it appears that they may hibernate at—or at least near—their birthing site. Consequently, they are approximately the same size the following spring when they emerge.

The limited recaptures of marked individuals in the listed populations hinder estimates of typical rates of growth for the NPS; however, patterns observed from data collected from the SPS (Kingsbury and Laurent 2000) likely approximate patterns expected for the NPS. Furthermore, copperbellies would appear to follow growth trajectories similar to other species in their genus (*Nerodia*). Much of the growth and reproduction information presented here is from copperbellies in the SPS or closely related species.

Growth is rapid, and most individuals appear to reach adult size within two full seasons of activity. The largest data set for the species comes from a study at Sloughs Fish and Wildlife Area, Henderson County, Kentucky (Kingsbury and Laurent 2000). Adults grew 2-8 cm/year (Figure 8). On average, adult males grew 3.6 cm (SD = 2.2, n = 9) per year, and adult females grew 4.9 cm (SD = 3.2, n = 14) per year. Although the sample

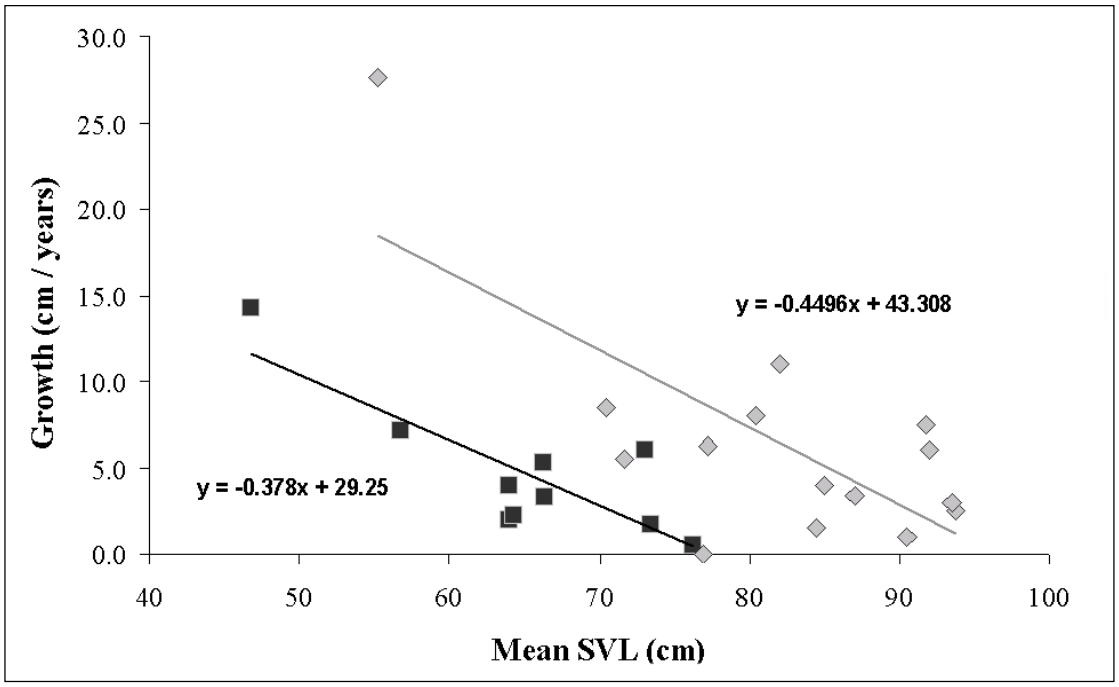

Figure 8. Growth indices for male (squares) and female (diamonds) copperbellies from Henderson County, Kentucky. Values are for snakes recaptured in years other than the year marked. Indices are based on the difference between recapture SVL and original SVL divided by years between captures [(recapture SVL – original SVL)/(years between captures)] and are plotted as the relationship between growth rate and mean SVL between captures. Taken from Kingsbury and Laurent (2000).

size is small, a steady decrease in growth rate over time for both males and females is evident. One subadult male grew an average of 14.3 cm over a two-year period whereas a subadult female grew 27.6 cm over a one-year period. Juveniles may grow 20-30 cm per year. Based on growth trajectories, copperbellies are typically ready to breed in their third spring because this would be the first time that they would be large enough during a principal breeding period.

Copperbellies exhibit sexual dimorphism in terms of size. Almost all individuals from the NPS that are greater than 400 g are female (B. Kingsbury and O. Attum, Indiana-Purdue University Fort Wayne, unpublished data, 2001-2006) (Figure 9). Males above 75 cm SVL, or above 300 g, are rare for the species (Kingsbury 1998). For a given SVL, male and female masses are about the same, even for the unusually large males. Males might shift energy for growth to searching for mates, and they may be more susceptible to predation. Large males from Henderson County, Kentucky appeared to have low rates of growth (Kingsbury and Laurent 2000) (Figure 10).

Little is known about survivorship; however, mortality during radiotelemetry studies suggests survival rates may be 70-80 percent per year for adults. Snakes PIT (Passive Integrated Transponder) tagged as adults in 2001 were found in 2005, indicating ages of at least 6-7 years (Omar Attum, Indiana-Purdue University Fort Wayne, pers. comm. 2006).

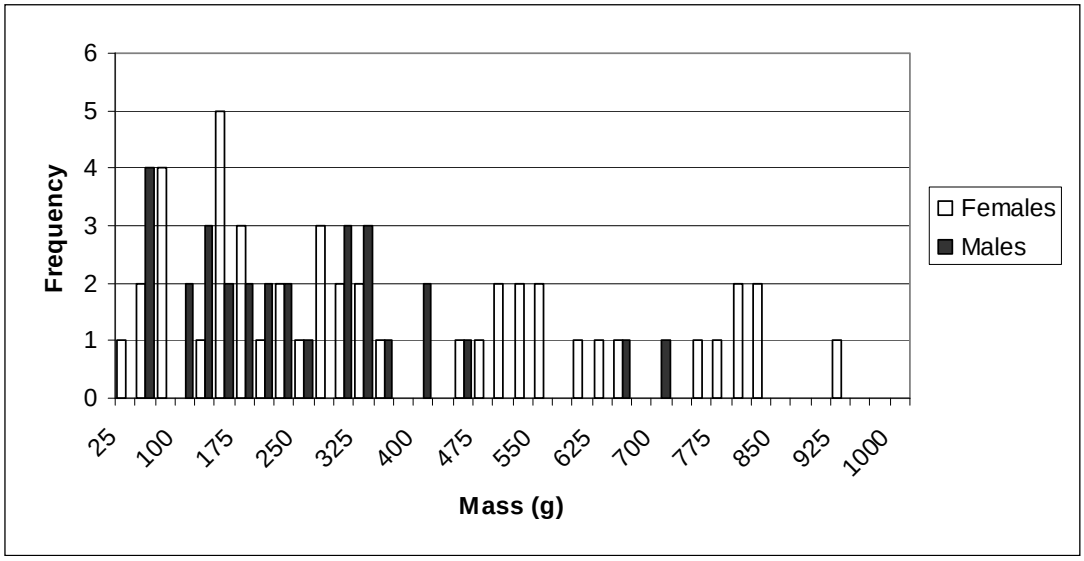

Figure 9. Distribution of body masses of male and female copperbellies from the NPS. (B. Kingsbury and O. Attum, Indiana-Purdue University Fort Wayne, unpublished data, 2001-2006).

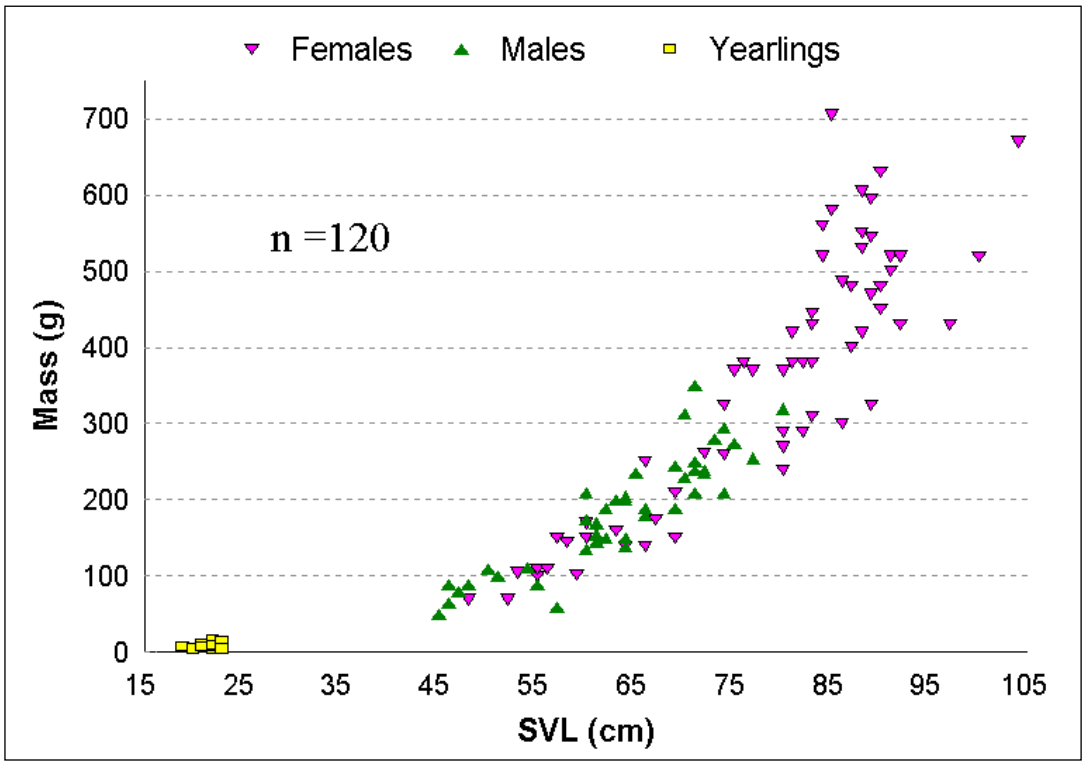

Figure 10. A comparison of length versus mass for copperbellies from Henderson County, Kentucky. Taken from Kingsbury 1998.

Courtship and breeding principally occur in spring, although this activity may continue into summer (Conant 1934, Kingsbury 1996, Kingsbury et al. 2003). Males seek females and may aggregate around them. Mating "balls" may be observed where the female remains relatively immobile but alert while multiple males endeavor to mate with her, a mating behavior typical for natricine snakes.

It is unknown whether copperbellies breed annually or less frequently, and we also lack significant information on clutch size. Gibbons and Dorcas (2004) summarized litter size for *N. erythrogaster* as a whole and reported that they ranged from 2 to 55, but averaged 17.7 across 53 records. Not enough data are currently available to state whether or not litter size is correlated with adult body size.

Prey and Foraging Behavior

Plain-bellied water snakes eat primarily amphibian adults and larvae, particularly frogs of the genus *Rana*, such as the green frog (*Rana clamitans*) (Mushinsky and Hebrard 1977, Diener 1957, Kofron 1978). However, they are opportunistic and will eat a variety of small fish and amphibians. A regurgitated gut contents survey found only amphibians and a single crayfish claw in copperbellies, whereas northern water snakes sampled in the same way from the same area had about half amphibians and half small fish (Kingsbury et al. 2003).

Copperbellies forage both aquatically and terrestrially. In aquatic settings, copperbellies forage in water only several (< 10-20) centimeters deep (Bruce Kingsbury, Indiana-Purdue University Fort Wayne, personal observation 2000). Small fish and larval amphibians (tadpoles) are captured by being trapped against folds of the body or debris in the water. Seasonal wetlands, important sources for recruitment into the amphibian prey base, are also favored foraging areas. Their gradual drying provides excellent foraging opportunities as tadpoles become stranded and accessible to the snakes. Copperbellies do not forage in open deeper water and do not take larger live fish; however, water snakes will scavenge on larger dead fish (Kingsbury, personal observation 1996). Roe et al. (2005) reported on terrestrial feeding events in which adult American toads (*Bufo americanus*) were consumed away from water.

Predators

Copperbellies are susceptible to a host of predators (Harding 1997). Predators include egrets and herons hunting in shallow water, and raptors hunting from the air. Raccoons, skunks, opossums, snapping turtles, and large fish represent additional predators.

Habitat Characteristics

Wetlands

Like other water snakes, copperbellies are generally affiliated with wetlands. Copperbellies prefer shallow wetlands, such as shrub-scrub wetlands dominated by

buttonbush (*Cephalanthus occidentalis*), emergent wetlands, or the margins of palustrine open water wetlands (Kingsbury 1996, Herbert 2003, Kingsbury et al. 2003, Laurent and Kingsbury 2003). Copperbellies use buttonbush swamps as basking or "loafing" areas. Foraging occurs in shallower margins of such systems, or in ephemeral, emergent wetlands. Areas frequented by copperbellies generally have an open canopy, shallow water, and short dense vegetation. Thus, they are less likely to be found in forested wetlands, unless they could find a gap in the canopy, or were otherwise on the edge of forest.

Copperbellies have also been observed to make routine use of many types of refugia, including rip-rap (Nathan Herbert, Indiana-Purdue University Fort Wayne, pers. comm. 2003), a discarded top-loading freezer (Kingsbury 1998), a sheet of plywood and the hollow trunk of a shrub in early successional forest (Kingsbury 1996). These refugia may not be immediately adjacent to foraging or basking areas. The plywood sheet used by two copperbellies over two years was in an old field about 15 meters from a forested ravine frequently used for foraging. The snakes returned to it day after day even after foraging hundreds of meters away. A similar pattern was noted for the snake using the shrub trunk, although the time intervals were more protracted. The snake would visit a wetland for two days, and then return to the trunk, then to a gap in the forest canopy for a few days, then back to the trunk. This pattern persisted for many weeks.

Copperbellies also use seeps and springs. During a telemetry study of the SPS at the Patoka River National Fish and Wildlife Refuge and Wildlife Management Area, numerous copperbellies, including four different radio-tagged individuals, used a spring and a small drainage creek (Kingsbury 1998). The area had very little standing water and was over 100 m away from other wetlands. The seep was dominated by grasses and shrubs, and there was no tree canopy. Copperbellies foraged in the seep and in the forest and old fields nearby. They also moved to and from other wetlands in the area.

Uplands and the Upland/Wetland Matrix

Uplands, defined here simply as areas elevated above wetlands, are important to copperbellies both as primary habitat and as corridors between adjacent wetlands. Copperbellies are more terrestrial than most other *Nerodia* (Clark 1903, Conant 1934, Sellers 1987a). Copperbellies from the NPS that were tracked using telemetry spent substantial time away from wetlands. In one study in northwestern Ohio, copperbellies occurred in uplands about one in four times (Kingsbury et al. 2003, Roe et al. 2004). In an earlier study in northeastern Indiana, Kingsbury (1996) found that copperbellies primarily occurred in uplands after mid-May; however, those snakes routinely visited wetlands, often hundreds of meters away, about every two weeks, then returned to their favored upland sites and refugia.

Uplands are important to copperbellies as primary habitat for several reasons. Copperbellies use uplands for foraging (Kingsbury 1996, Roe et al. 2004) and aestivating (Kingsbury et al. 2003). Copperbellies in the NPS appear to be more terrestrial than populations studied using similar techniques in southern Indiana (Coppola 1999) and northwestern Kentucky (Kingsbury 1998, Coppola 1999, Hyslop 2001, Laurent and

Kingsbury 2003). The reason for this difference is not clear but may be due to regional differences in innate behavior or differences in the availability of habitat.

Telemetry work by Kingsbury (1996) showed that copperbellies using uplands spent substantial time in forest gaps and at the margins of forests and fields. This pattern has since been generalized to many locations across the range of the copperbelly (southern Indiana: Coppola 1999, northwestern Kentucky: Hyslop 2001, northwestern Ohio and adjacent Michigan: Kingsbury et al. 2003). In the latter study, it was also noted that the shift to upland habitats in the summer by copperbellies coincided with the drying of ephemeral wetlands. These wetlands tended to hold water through the middle of June, but completely dried by July or August.

An important component of both upland and wetland use by copperbellies is movement from wetland to wetland in the landscape. In a comparative study of copperbellies and northern water snakes in northwestern Ohio and southern Michigan, copperbellies used twice as many wetlands as the northern water snakes (4.1 vs. 2.1) per year (Kingsbury et al. 2003, Roe et al. 2004). Copperbellies also moved between the wetlands three times more often (9.1 vs. 2.8 times) per year than the northern water snake. This study showed that not only are uplands important fundamental habitat for copperbelly water snakes, these uplands are necessary for copperbellies to traverse to adjacent wetlands.

Hibernacula

Prior to extensive use of radiotelemetry to study this species, the predominant view was that copperbellies hibernated in upland sites (Sellers 1991, John MacGregor, Kentucky Department of Fish and Wildlife Resources, pers. comm. 1994, Brandon and Blanford 1995) and that they might migrate as far as several miles to reach a suitable location (Sellers 1991). But, as studies at several sites now demonstrate, hibernacula are typically burrows of crayfish of the family Cambaridae, in palustrine forested wetlands and the immediately adjacent upland forest (Kingsbury 1996, Kingsbury and Coppola 2000, Hyslop 2001, Kingsbury et al. 2003). Such a site selection is similar to that observed for other snake species associated with wetlands (Carpenter 1953, Maple 1964, Keck 1998). For the purposes of discussion in this document, “hibernacula” and “hibernation sites” are equivalent and refer to areas containing one or more suitable crayfish burrows or other subterranean structures supporting successful hibernation.

Presently, it is not known if copperbellies hibernate in the burrows of specific species of crayfish. Specific hibernation sites for the listed populations have now been examined in Steuben County, Indiana and Williams County, Ohio. They have also been examined in the southern population in Daviess and Jennings Counties in southern Indiana, and Henderson County, Kentucky. The burrows used have large openings (5 cm diameter) and drop relatively vertically down into the ground. Crayfish that build such burrows and occur in the same areas as copperbellies include species from the genera *Cambarus* and *Fillicambarus*. The burrows used appear to be no longer occupied by crayfish. Although hibernation sites are not inundated at onset of hibernation, they may flood without harming the snakes. Several radio-tracked snakes were found covered with 2-3 m of water from sheet flooding lasting several weeks. During this time, the snakes remained

underground. Two weeks later, when flooding receded, all snakes emerged with no mortality. It is believed that cold water temperatures reduce metabolism, and thus oxygen demands, sufficiently to allow survival under such circumstances (Kingsbury and Coppola 2000).

Critical Habitat

"Critical habitat" is defined by the ESA; thus, it is a legal definition of the areas considered essential to a species' conservation. Section 3(5)(A) of the ESA defines critical habitat as: (a) specific areas within the geographical area occupied by a species at the time of listing on which are found those physical or biological features essential to the conservation of the species and that may require special management consideration or protection, and (b) specific areas outside the geographical area occupied by a species at the time of listing if determined by the Secretary to be essential for the conservation of the species. Critical habitat designation directly affects only Federal agency actions through consultation under section 7(a)(2) of the ESA. This section requires Federal agencies to ensure that the activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of a listed species or destroy or adversely modify its critical habitat. These regulatory provisions are in effect as long as the species remains listed under the ESA. "Conservation" means the use of all methods and procedures needed to bring the species to the point at which listing under the ESA is no longer necessary.

At the time of listing, it was determined that designation of critical habitat would not be prudent for the copperbelly water snake because of the following reasons: (1) the species is threatened by taking or other human activity, and identification of critical habitat can be expected to increase the degree of threat to the species and (2) such designation of critical habitat would not be beneficial to the species because it would not provide significant additional protection over that afforded through the normal recovery process, section 7 consultation, and the prohibitions of section 9 of the ESA. The listing rule concluded that any potential benefit from designating critical habitat would be offset by an increase in collection and persecution resulting from publishing snake locations. Habitat protection for the snake can be accomplished through section 7 consultation in the event of Federal agency action (50 CFR Part 17), or otherwise via ESA sections 9 and 10.

If, following completion of this plan, we find that it is prudent and determinable to designate critical habitat for the species, the Service will prepare a critical habitat proposal at such time as our available resources and other listing priorities under the ESA allow. This proposal will be based on the essential habitat features needed to ensure the conservation and recovery of the species, many of which are documented earlier in the Habitat Characteristics section of the Recovery Plan.

Threats

In determining whether to list, delist, or reclassify (change from endangered to threatened status, or vice versa) a taxon under section 4(a)(1) of the ESA, the Service evaluates the role of five factors potentially affecting the species. These factors are: (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; and (E) other natural or manmade factors affecting its continued existence. At the time of listing in 1997 (62 FR 4183), the Service determined that the threats to the northern population segment of copperbelly water snake were sufficient to list the DPS as threatened. The Service determined that the species did not warrant listing in the southern portion of its range due to Conservation Agreements which resulted in a substantial reduction in threats related to surface coal mining and reclamation practices (USFWS 1997). Habitat loss and modification are the primary threats to the copperbelly water snake, with associated causes of mortality as secondary factors.

A. Habitat Destruction and Modification

Habitat loss and fragmentation were the primary causes of copperbelly decline prior to listing and continue to serve as the major factors threatening the continued existence of the species. Much of the species' wetland habitat has been modified or destroyed through conversion of land to agricultural use, dredging, stream channelization, and commercial and residential development. The need for many wetlands over a large area and the patterns of movement associated with that requirement make copperbellies more susceptible to habitat alterations that change the spatial distribution of wetlands in the landscape, including loss of small isolated wetlands (Kingsbury et al. 2003, Roe et al. 2003, Roe et al. 2004). The loss of hibernation sites and the forested uplands that connect these isolated wetlands further contribute to the copperbelly's population decline.

During the period from 1986 to 1997, copperbellies occupied only eight sites in four southern Michigan counties, one northwestern Ohio county, and one northeastern Indiana county. In the period from 2000 to 2005, the copperbelly water snake has been relegated to even fewer locales. Recent surveys have found copperbelly populations at only four sites in Michigan, Indiana, and Ohio (Kingsbury et al. 2003, Lee et al. 2007). These populations are largely separated from each other by unsuitable habitat comprised of agricultural land, rural residences, and roads. Fragmented habitat is unsuitable for copperbellies. Furthermore, the species' vagile habits lead to encounters with cars, farm equipment, pets, and people who may be afraid of snakes.

Impacts caused by roads and the vehicles traversing them have also likely increased as suitable habitat becomes more fragmented by transportation corridors. As landscapes are fragmented, wetland complexes become fragmented even when the wetlands themselves are not all lost. Movement amongst wetlands and uplands may increase the risk of road mortality. Roe et al. (2006) explored the potential impacts of roads on copperbellies and

northern water snakes via mathematical and GIS models, integrating road maps, traffic volume, and snake movements. The results suggest that road networks and traffic volumes typical of areas where these species occur may account for mortality of 14% to 20% of the adult population per year in the more vagile, terrestrial, and imperiled copperbelly, but only 3% to 5% mortality in the more sedentary, aquatic, and common northern water snake. The majority (> 91%) of road crossings and associated mortality are predicted to occur during travel between wetlands, suggesting roads bisecting travel routes between wetlands may present a special lethal hazard.

Potential mortalities on roads may be reduced by snakes avoiding roads. In fact, copperbellies are more likely to occupy wetlands further from roads than is the more common northern water snake (Attum et al. 2007). While the reduction of mortality is desirable, the tradeoffs of road avoidance are the disruption of normal patterns of behavior and the isolation of subgroups within populations, increasing the potential for the inbreeding effects and risks of local extirpations discussed below. Based on these theoretical and empirical findings, the interaction of the copperbelly's tendency to move frequently and the presence of road networks in areas where they occur may be an important cause of the imperiled status of the copperbelly.

Landscape fragmentation and isolation of local clusters increases the risk of extinction by causing each local cluster to function as an independent, but much smaller, population. Very small populations are far more susceptible to local extirpation from factors such as drought (environmental stochasticity), random variation in births and deaths (demographic stochasticity), genetic irregularities caused by inbreeding, and combinations of all of such factors. These effects are discussed in more detail in (E) below.

Other factors that may adversely affect copperbelly water snake habitat include increased sedimentation and contamination caused by fertilizer runoff. Sedimentation, usually resulting from agricultural activities, but also caused by construction, may change hydrological characteristics and plant succession, as well as reduce the numbers of amphibians and fish used by the snake as food.

B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Collectors who take wild snakes also impact the species. The copperbelly water snake is collected because of its rarity, large size, unique coloration, and value in the pet trade (Sellers 1991). During the first 30 years after its discovery and formal publication of its description, many copperbellies were collected as specimens for museums. Although museums have abandoned this practice, amateur collectors may continue to take wild snakes (USFWS 1997).

C. Disease or Predation

Predation by itself is not a threat to the population as a whole; however, when it occurs concurrently with or in addition to habitat fragmentation or other threats, predation can

become a threat. During their migrations, copperbellies are vulnerable to predators (e.g., skunks, raccoons, raptors, and snapping turtles), especially when cleared areas such as roads, mowed areas, and farmlands interrupt their migration routes. Due to habitat fragmentation, the ability to use suitable cover to migrate safely throughout its home range is a limiting factor in the life cycle of the copperbelly.

During recent surveys (2004-2006), several copperbelly water snakes were observed with blisters and other skin abnormalities indicative of blister disease (Lee, pers. comm. 2006, Lee et al. 2007). Blister disease may occur in captive snakes and is typically associated with very humid or wet conditions. During surveys in 2004-2006, several wild copperbellies were observed with bumps or lesions on the body and face (Herbert, pers. comm. 2006, Lee, pers. comm. 2006). Occasional blistering is a fairly common and generally benign condition in copperbellies and other wild snakes, particularly in snakes recently emerged from hibernation (Kingsbury, pers. comm. 2007, Lee et al. 2007). Snakes often recover from blister disease after several sheds, but in more extreme and rare cases, some individuals may be unable to recover from this condition. In some cases, blister disease can result in adverse effects to the snake (e.g., facial deformities, especially around the eyes and mouth, could affect ability to forage) (Lee et al. 2007). The prevalence and degree to which this is a potential threat to the species needs further investigation.

D. The Inadequacy of Existing Regulatory Mechanisms

Prior to listing under the ESA, the copperbelly water snake received varying degrees of protection through state listings as an endangered, threatened, or non-game species throughout its range. Michigan, Indiana, and Ohio confer full legal protection to the copperbelly; it is illegal to collect, kill, or injure the snake in these three states. Listing under the ESA offers additional protection to this species, primarily through the recovery and consultation processes. The Federal protections offered by the ESA are described in the Conservation Measures section.

In addition, discharge of fill material into wetlands is regulated under section 404 of the Clean Water Act. In Michigan, authority to issue section 404 permits has been assumed by the State of Michigan; however, non-contiguous wetlands were not regulated in counties with a population less than 100,000 unless a wetland inventory had been performed. This included Hillsdale County, which holds populations of copperbelly. In December 2006, the State completed wetland inventories for all of the counties in Michigan as required by the state's wetland protection law. Now that the wetland inventories are complete, all non-contiguous wetlands over five acres in size are regulated regardless of county population, making permit requirements uniform in all counties and providing an increased level of protection to wetlands within the Michigan range of the copperbelly.

E. Other Natural or Manmade Factors Affecting its Continued Existence

The small, isolated nature of the copperbelly NPS makes them especially vulnerable to extirpation due to chance events. Any population is subject to stochastic (random) events of an environmental or demographic nature. The former is exemplified by unusually cold winters or dry summers, while an example of the latter might be that, by chance, a female had a smaller or larger than average litter size. This sort of variation occurs all of the time and, even when all else is equal, might lead to good or bad years for a population. In large populations that occupy extensive areas, this stochasticity is generally absorbed successfully and populations rebound. As populations become smaller, however, they become more vulnerable to extirpation due to the chance occurrence of multiple negative events (Shaffer 1981). For example, a dry and cold winter might cause hibernation mortality and also impede reproductive success of amphibians the following spring as a consequence of poor wetland filling. Snakes that survive the winter thus have trouble finding food and are more vulnerable to starvation and disease, resulting in lower reproductive success. The smaller the population, the more possible that all of these random events and their outcomes might tip the population to extirpation. In fact, Sellers (1991) felt that a severe drought in the late 1980s may have adversely impacted population sizes of copperbelly water snake, due to reduced wetland availability (i.e., fewer wetlands and shorter hydroperiods) and reduced prey base.

Small populations can also suffer from inbreeding depression effects. Mating of related individuals may lead to expression of deleterious alleles, causing declines in health or reproductive output. While the research on reptiles is limited, work on other vertebrates shows increased risk of mortality from severe winters in inbred birds (Keller et al. 1994) and mice (Jimenez et al. 1994).

Rusty crayfish (*Orconectes rusticus*), a species native to the Ohio River drainage, has been found at sites in southern Michigan. This invasive species is more aggressive than other crayfish and can displace native crayfish or hybridize with them (Taylor and Redmer 1996, Klocker and Strayer 2004). Rusty crayfish typically inhabit permanent pools and fast moving streams; they do not construct burrows or chimneys. At this time, the potential for rusty crayfish to displace the native crayfish population within the copperbelly's range, and the resulting impact to copperbelly hibernacula, is not known.

Conflicting natural resource management efforts may also threaten copperbellies. Radiotelemetry studies (Kingsbury 1995, 1996, 1998; Hyslop 2001; Herbert 2003) have repeatedly shown that copperbellies rarely venture far into upland (terrestrial) areas that lack tree or shrub canopy. This is the case despite an affinity for small forest gaps and forest/field margins. Thus, planting and maintenance of row crops, placed next to or between wetlands, may create risks and barriers for copperbellies. Managing large areas as grassland for upland birds also likely negates use of those areas by copperbellies. Wetland management practices that stabilize and/or deepen water levels in wetlands remove key shallow and ephemeral wetland components from the landscape. Adding game fish to wetlands inhibits amphibian reproduction, thus impacting the prey base for

copperbellies. Impacts from other management efforts, such as ash tree removal or chemical applications to control the emerald ash borer, are unknown.

A general aversion for snakes also potentially threatens copperbellies. Many persons are afraid of snakes or view them as harmful, and some people may kill them out of fear. Given that copperbellies are relatively large, these concerns are exacerbated for the species. The propensity to travel far from wetlands also makes copperbellies particularly vulnerable to human impact.

Conservation Measures

Since the copperbelly water snake was listed as threatened in 1997, many efforts have been underway to conserve and recover the species. These efforts, described below, stem from Federal regulatory protection, state protection, and pro-active efforts taken by the Service, state, universities, and conservation organizations, among others.

Federal Regulatory Protection

The ESA contains several sections that provide regulatory protections for copperbelly water snake:

Section 9 – Prohibition against Take

Section 9 of the ESA prohibits any person subject to the jurisdiction of the United States from "taking" federally listed threatened and endangered species. The term "take" is defined to include harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting these species. It is also unlawful to attempt such acts, solicit another to commit such acts, or cause such acts to be committed. Regulations implementing the ESA (50 CFR 17.21) define "harm" to mean an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation that results in the killing or injury to wildlife by significantly impairing essential behavioral patterns, such as breeding, feeding, or sheltering. "Harass" means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to disrupt normal behavioral patterns, which include, but are not limited to, breeding, feeding, or sheltering, significantly. These restrictions apply to all listed species not covered by a special rule. No special rule has been published for copperbelly water snake. There are several sections of the ESA that provide for exemptions from the take prohibition through the consultation and permitting processes, described below.

Section 7 – Interagency Cooperation with Federal Agencies

Regulations implementing interagency cooperation provisions of the ESA are codified at 50 CFR Part 402. Section 7(a)(2) of the ESA requires Federal agencies to consult with the Service when federally permitted, authorized, or funded actions may affect listed species, including copperbelly water snake. This consultation process promotes

interagency cooperation in finding ways to avoid or minimize adverse effects to listed species. If a Federal action is likely to adversely affect any listed species, the Federal action agency must enter into formal consultation with the Service. The consultation process is intended to ensure that the action is not likely to jeopardize the continued existence of listed species, nor destroy or adversely modify critical habitat. Critical habitat has not been designated for this species. Section 7(a)(1) requires all Federal agencies to use their authorities to further the conservation of federally listed species. Since its listing, only a few section 7 consultations have been completed for copperbelly water snake, including consultations on recovery-related research activities and habitat management.

Section 10 – Permits for Scientific Research and Conservation Actions, and Incidental Take Permits

Section 10(a)(1)(A) of the ESA provides for permits to authorize activities otherwise prohibited under section 9 for scientific purposes or to enhance the propagation or survival of a listed species. Several of these permits have been issued for copperbelly water snake research activities.

Section 10(a)(1)(A) permits will continue to permit activities that contribute to the conservation and recovery of the species. Section 10(a)(1)(A) permits are also issued to participants in the Safe Harbor Program. The Safe Harbor Policy encourages private landowners to conserve threatened and endangered species voluntarily. Under a Safe Harbor Agreement, a private landowner would agree to create, restore or maintain habitats for the benefit of a listed species. In return, the Service would provide assurances that future landowner activities will not be subject to restriction from the ESA above those applicable to the property at the time of enrollment in the agreement. There are currently no Safe Harbor agreements in place for copperbelly water snake.

Section 10 (a)(1)(B) permits can also provide for take that is incidental to an otherwise lawful activity, provided certain conditions have been met. In order to obtain an incidental take permit, an applicant must prepare a Habitat Conservation Plan (HCP). The HCP is designed to offset any harmful effects that the proposed activity may have on the species by minimizing and mitigating the effects of the authorized incidental take. No HCPs have been developed for copperbelly water snake.

Section 6 – Cooperation with States

State conservation agencies and their designated agents have certain take authority for species listed as threatened or endangered if the state agency has a section 6 Cooperative Agreement with the Service. In addition, section 6 of the ESA allows the Service to grant money to states for the conservation of listed and candidate species.

State Protection

The copperbelly water snake is state listed as endangered in Michigan (Part 365 of the Natural Resources and Environmental Protection Act of 1994), Ohio (Ohio Administrative Code, Title XV, Chapter 1518), and Indiana (Nongame and Endangered Species Act of 1973). These state laws also prohibit take of the snake.

Conservation Efforts

Since listing, extensive surveys to monitor existing occurrences and to locate new occurrences have been conducted in Michigan, Indiana, and Ohio (Kingsbury et al. 2003, Lee et al. 2007). Numbers of snakes documented during these surveys have been low, and distribution has been limited. Continued surveys and monitoring should continue to track the status of the species and its distribution.

Research has been conducted to enhance our understanding of the copperbelly water snake's habitat requirements. Radiotelemetry has been used to investigate copperbelly habitat use at a site in southern Michigan and northern Ohio (Herbert 2003, Kingsbury et al. 2003, Roe et al. 2003). These studies have provided valuable information on copperbelly movement about the landscape, home range sizes, use of multiple wetlands, and upland habitat usage. Habitat modeling, using GIS, has been initiated to determine potential distribution and areas of suitable habitat for copperbelly water snake (Kingsbury et al. 2003, Roe et al. 2003, Lee et al. 2005, Lee et al. 2007).

Marshall et al. (2008) analyzed copperbelly populations within and outside of the listed DPS to examine the genetic structure within and amongst populations. The results of this work suggest that inbreeding in the NPS has not yet been substantial, but that some structure does exist within the populations. The populations in the NPS were most similar to those in Kentucky, rather than those in southeastern Indiana.

Habitat management activities have been initiated to increase the availability of suitable habitat and reduce fragmentation. Conservation organizations, such as The Nature Conservancy and Michigan Nature Association, as well as many private landowners, have actively restored habitat to benefit copperbelly water snake. Programs such as Partners for Fish and Wildlife Program (USFWS), Conservation Reserve Enhancement Program (Farm Service Agency (FSA)), and Conservation Reserve Program (FSA) have provided funding and technical assistance for restoration and protection of copperbelly water snake habitat. The CRP State Acres for Wildlife Enhancement (SAFE) program (FSA) in Ohio is aimed at creating conservation practices to address the highest priority wildlife objectives in the State through the use of targeted restoration of vital habitat. Williams County is within one of Ohio's SAFE priority areas, and the copperbelly is listed as a target species. The Federal Landowner Incentive Program, implemented by the Michigan Department of Natural Resources, has supported recovery by providing funding and technical assistance to private landowners for copperbelly habitat management. Additional programs, such as the Wetland Reserve Program (Natural Resources Conservation Service (NRCS)) and Wildlife Habitat Incentives Program

(NRCS) are also available in areas where copperbellies occur and may provide additional opportunities for habitat restoration and enhancement. In addition, conservation easements have been obtained on parcels of private property in Michigan. As habitat loss and fragmentation are the principal causes for the copperbelly's decline and continue to be the main threat to this species' persistence, additional habitat restoration and enhancement activities, as well as suitable land management, are necessary to recover the species.

In an effort to inform the public of the presence of copperbelly water snake and other rare species, education and outreach efforts have been conducted since this species was listed. Educational materials have been developed and distributed, and contacts (i.e., through mailings, meetings, and phone calls) have been made with landowners within the range of the species, providing information on how to identify the species, its rare and protected status, habitat requirements, ecology, and opportunities for habitat management and restoration. These efforts will continue and be expanded through implementation of this recovery plan.

Biological Constraints and Needs

Given the ecology and behavior of the copperbelly water snake, the species requires relatively large (3-5 square miles for a population of 500-1000 individuals) landscape areas for maintenance of viable populations. Such areas, while historically abundant, are now rare. Habitat loss, particularly wetland loss, and habitat fragmentation, resulting from roads, agriculture, and development, will make restoring and maintaining suitable landscapes challenging. Threatened populations are at the northern extreme of the likely historic distribution of the species. Consequently, these remaining populations are in less than ideal habitat and subsequently at densities below those observed further south.

Copperbellies eat predominantly amphibian larvae (tadpoles) and adult frogs. Any areas expected to contain high densities of copperbelly water snake must have high densities of amphibians. Thus, these areas must be managed to have high water quality, numerous fishless shallow wetlands to promote amphibian success, and extensive forested uplands for the habitat needed by many species of adult amphibians. Fortunately, habitat requirements for these amphibian species and for the copperbelly water snake are similar; thus, no additional habitat specific to amphibians is needed.

Hibernation areas appear to be somewhat limited in extent and primarily constrained to the burrows of crayfish of the family Cambaridae. Suitable burrows are found in areas near shallow wetlands and streams, often on a slope, that have water near, but not at, the ground surface. Such suitable hibernation areas must be readily available within the habitat matrix of all populations in such a way as to remove the need to migrate through areas containing barriers, such as roads or farm fields.

PART II. RECOVERY

Recovery Strategy

The principal strategy for species recovery is the establishment of landscape units capable of sustaining copperbelly water snakes at target levels. Direct habitat loss, plus degradation and fragmentation of remaining habitat, have resulted in a landscape that limits or prevents recovery of the species. The recovery strategy will focus on, but not be limited to, habitat restoration that is prioritized and conducted to reach and sustain population goals.

Both upland and wetland cover types, including areas that support hibernacula, are included within the plan's focus. Specifically, each landscape unit must feature high densities of shallow wetlands, embedded in a forested upland matrix, with limited barriers and hazards. These areas should also allow for overland movement through suitable corridors, as the species requires access to numerous wetland complexes. Landscape unit size will occur on the order of square miles but will ultimately be determined by the interplay of size and quality of the available suitable habitat.

Future habitat planning models can assist in better understanding the extent of habitat necessary for recovery. Habitat suitability models with parameters expressing varied quality will be developed to link population and habitat objectives and help generate habitat conservation goals. However, risks associated with limited distribution and limited abundance will drive landscape needs for species recovery. Recovery planning must encompass multiple populations to assure species presence across its historic range.

Several areas appear to exhibit recent extirpations or have perilously low numbers. Efforts to restore habitat and connectivity are expected to help support viable populations. The heart of the species' largest remaining population occurs on state-owned land, yet much of the remaining available habitat is privately owned. Successful development of landscape units for multiple viable populations will rely on cooperative ventures and community and state-led activities. In addition, best management practices for land managers will be developed to enhance recruitment within sites, and relocation of snakes from more robust populations to restored landscapes may be conducted, if feasible and appropriate. Captive rearing and headstarting should be explored as possible future conservation tools.

Incidental collection by humans and malicious killing, along with threats posed by vehicular traffic and road networks, present additional conservation challenges and opportunities. Another component of the recovery strategy will focus on education and outreach regarding the snakes' presence in the region as part of the natural environment.

Recovery Goal and Objectives

The goal of this recovery plan is the removal of the copperbelly water snake from the Federal list of "Endangered and Threatened Wildlife" (50 CFR 17.11). The recovery plan's objectives are: (1) to ensure long-term persistence of multiple viable populations across the geographic range of the DPS; (2) to conserve sufficient landscape complexes to support these populations; (3) to reduce known threats to the extent possible; (4) to develop and distribute educational materials on the natural history of copperbellies, their habitat requirements, and appropriate management guidelines for the species and its habitat.

Recovery Criteria

The Service may consider delisting the copperbelly water snake when the delisting criteria outlined below are met. We anticipate that achieving the recovery criteria will take 30 years, if fully funded and provided that action is taken immediately to begin recovery of required habitat and prevent inbreeding. Criteria for reclassifying the species to Endangered are also described. The criteria are based on the most recently available scientific information. The population sizes and numbers for delisting and reclassification may be updated based on further research (e.g., population viability analysis) on viable population sizes of copperbelly water snake or surrogate species.

Delisting Criteria

Delisting of the species will be considered when the five factors (see Threats discussion) are assessed and when the following criteria are met:

<u>Criterion 1. Multiple population viability is assured:</u>

a) Five geographically distinct populations have population sizes of more than 500 adults, with at least one population exceeding 1000 adults; or three populations must have a total population size of 3000 adults, with none less than 500, and

b) These populations must persist at these levels for at least ten years.

<u>Criterion 2. Sufficient habitat is conserved and managed:</u>

a) Wetland/upland habitat complexes sufficient to support the populations described in Criterion 1 are permanently conserved.

    1) A population of 1000 adults will require at least five square miles of landscape matrix with a high density and diversity of shallow wetlands embedded in largely forested uplands.

2) A population of 500 adults will require at least three square miles of the same type of habitat.

b) Multiple (two or more) hibernacula for each population are permanently conserved. A minimum of two hibernacula will be available within one kilometer of all suitable summer habitat included above.

Criterion 3. Significant threats due to lack of suitable management, adverse land features and uses, collection, and persecution have been reduced or eliminated:

a) Habitat management and protection guidelines have been developed, distributed, and maintained.

b) Adverse land features and uses, such as row crops, roads and accompanying traffic have been removed, minimized or managed within occupied Criterion 1 landscape complexes to the extent possible.

c) A comprehensive education and outreach program, including persecution and collection deterrence, has been developed and implemented.

Reclassification Criteria

The copperbelly water snake will be considered for reclassification from threatened to endangered status when the five factors (see Threats discussion) are assessed and when either of the following criteria is met:

Criterion 1. There are no known populations of more than 500 adults.

Criterion 2. The cumulative population size is estimated at less than 1000 adults.

Rationale

Population Size Criteria

The International Union for Conservation of Nature (IUCN) developed a system for classifying species in different categories of risk of extinction. The species thus classified are placed on the IUCN's "Red List." The International Union for Conservation of Nature Red List Categories and Criteria: Version 3.1 (IUCN 2001) summarizes the criteria used to place species in the Red List categories. These criteria state that a taxon should be listed as Endangered (which corresponds to the USFWS designation of "threatened") when the population size is estimated to be less than 2500 adults and is decreasing in size (Criterion EN C). The criteria also recommends that population size should be measured as numbers of mature individuals (i.e., adults) only.

Considering the IUCN recommendations and the best available information for copperbelly, the size of a population that would be robust into the foreseeable future would number in the thousands. Thus, we propose that at least one population with a census size of greater than 1000 adults (in the worst years) and total size across all populations ranging from at least 2500 to 3000 adults is sufficient to avoid inbreeding, resist stochastic (random) environmental or demographic events, and retain some capacity for evolutionary change. The copperbelly recovery criteria also state that three to five populations are needed to assure long-term survival. This ensures redundancy across the landscape to prevent stochastic events from eliminating the entire population of copperbelly.

As the recovery plan is implemented, research will generate important information on the copperbelly population dynamics. Results of research outlined in the recovery plan will also increase our knowledge of population viability and whether the current population size goals are sufficient for recovery. Recovery criteria will be revised and updated as new information about the species becomes available.

Duration of Population Trends for Delisting

The Delisting Criteria require population trends to be stable for at least ten years in order to achieve delisting Criterion 1. Population trends vary over time as a natural consequence of demographic and environmental stochasticity. For example, periods of drought likely impact this shallow wetland specialist. By sampling the populations over ten years, the patterns of fluctuations, including their highs and lows, are better understood. As a result, steps to delist will not occur simply because stochastic factors were in its favor for a particular year. Further, ten years allows enough time for several generations of snakes to demonstrate successful reproduction and recruitment.

Extent of Protected Habitat

At the present time, no landscape complex appears sufficient in size and quality to support a viable population, and the dynamics of the interaction between population

density and landscape size are only partially understood. Populations require extensive areas of suitable habitat to flourish, such that viable populations likely require several square miles of high-quality habitat to persist in the thousands. Pending improvements in our understanding, the recovery plan sets a goal of five square miles of suitable landscape for a population of 1000 adults. This goal may be an underestimate, particularly if the habitat characteristics are not ideal. Although smaller populations require smaller landscapes, snake densities appear to decline as landscape units become less than hundreds of hectares. Thus, population size is not directly proportional to area.

Minimum Number of Populations to Protect

The chances of complete extinction of any organism increase as the number of remaining populations decline. Redundancy in populations allows for local extirpation without overall extinction. In a partially developed landscape, creating continuous habitat necessary for multiple populations becomes increasingly challenging and expensive. A reasonable and achievable goal is three to five populations, dependent upon the populations' sizes and configuration relative to one another. Flexibility is built into the strategy, allowing for fewer populations should they be larger in size, while precluding reliance on only one or two populations.

Reduction of Human-Induced Take

The extent to which human-induced take is a threat to this species is not known. Human-induced take could result from malicious killing or collection for the pet trade. People fear snakes but are generally more tolerant of them once educated. Outreach materials and programs which educate land managers will help reduce unintended mortality and maximize positive impacts of management. Materials developed for the general public will help demystify the snake and promote local pride in this unique species, leading to reductions in malicious killing out of fear or ignorance. Take related to collection of wild snakes by amateur collectors may also be reduced through outreach efforts, and through coordination with appropriate law enforcement agencies.

Reclassification Criteria

The existence of only a single population of the copperbelly water snake (NPS) would make the species particularly vulnerable to extinction. If only one or no populations are perceived as viable (i.e., population size greater than 500 adults), or multiple populations exist and the total number of adults is less than 1000 individuals, then the genetic complement would likely be small enough to elevate the risk of inbreeding and multiple population failure. If either of these situations occurs, the five listing factors should be assessed to determine if the species is in danger of extinction throughout all or a significant portion of its range.

Stepdown Recovery Outline

The stepdown outline lists actions required to meet the recovery objectives of this Recovery Plan. The stepdown outline and narrative are presented in order of action category. Priority level of each sub-action is indicated at the end of the action description in parentheses. Implementation of all actions with Priority **(1)** is essential to prevent copperbelly water snake from becoming extinct in the foreseeable future. Implementation of all actions with Priority level **(2)** is necessary to prevent a significant decline in population numbers or habitat quality and quantity. Actions assigned Priority **(3)** are all other actions necessary to provide for full recovery of copperbelly water snake.

1. Identify and conserve habitat complexes sufficient for recovery

    1.1. Develop landscape-level habitat characterization of copperbelly water snake habitat (1)

    1.2. Predict other areas that may contain copperbellies based on the above characterization (2)

    1.3. Identify focal management areas for application of restoration and conservation actions (1)

    1.4. Conduct habitat restoration and enhancement

        1.4.1. Develop guidelines for habitat restoration and enhancement (1)

        1.4.2. Work with community leaders, landowners, and state and Federal agency private land programs, conservation organizations, and other cooperators to restore suitable wetlands and associated uplands for the copperbelly (1)

    1.5. Identify, assess, and reduce threats at known sites and focal management areas

        1.5.1. Identify critical road, agricultural, residential, other man-made features and activities, or natural features that may adversely affect copperbelly water snake (1)

        1.5.2. Clarify the influence of roads on migration of individual snakes and the connectivity of subpopulations (1)

        1.5.3. For identified threats, assess the relevant importance to a population (1)

        1.5.4. Research and implement techniques to create road crossings for snakes to reduce road mortality and remove barriers to movement (1)

        1.5.5. Develop and implement techniques to avoid or reduce other significant identified threats (1)

    1.6. Develop and implement habitat conservation programs (e.g., landowner contact, voluntary registration, and conservation agreements with landowners) (1)

    1.7. When possible, obtain habitat from willing landowners and increase conservation through voluntary agreements, fee title purchase, conservation easements, deed restrictions, etc.

        1.7.1. Develop and maintain boundaries of focal management areas (2)

1.7.2. Prioritize properties for conservation easements and acquisition and purchase, protect, and/or manage these properties based on priority and availability (1)

2. Monitor known copperbelly water snake populations and their habitat

2.1. Develop standard monitoring techniques for copperbelly water snake populations and habitat

2.1.1. Develop standard techniques for ascertaining presence/absence of copperbelly water snake (2)

2.1.2. Develop standard techniques for estimating population size for copperbelly water snake populations (2)

2.1.3. Develop a standard approach using GIS to monitor availability and extent of suitable habitat landscape (2)

2.2. Monitor known populations of copperbelly water snake

2.2.1. Monitor West Branch (Ohio and Michigan) (2)

2.2.2. Monitor Clear Fork (Michigan) (2)

2.2.3. Monitor Fish Creek (Indiana and Ohio) (2)

2.3. Survey historic and potential sites for copperbelly water snake

2.3.1. Survey Clear Lake (Indiana and Michigan) (2)

2.3.2. Survey Jones (Michigan) (2)

3. Improve baseline understanding of copperbelly water snake ecology

3.1. Clarify characteristics of high quality hibernacula (2)

3.2. Clarify gestation site requirements (2)

3.3. Establish genetic relationships among populations and determine level of inbreeding (2)

3.4. Examine other factors potentially limiting the species' numbers and range (2)

4. Develop recovery approaches to enhance recruitment and population size

4.1. Develop and implement techniques for enhancing remaining populations by increasing recruitment and reducing mortality (2)

4.2. Evaluate translocation as a method of population augmentation, and discuss potential for reintroductions into historic/suitable habitats (2)

5. Develop and implement public education and outreach efforts

5.1. Maintain lists of stakeholders (3)

5.2. Develop and distribute printed, audio, and visual outreach materials

5.2.1. Develop printed, web, and audio-visual materials

5.2.1.1. Publish and distribute a semiannual newsletter to local residents, visitors, and government agency personnel (3)

5.2.1.2. Develop and deliver educational presentations about the copperbelly water snake (3)

5.2.1.3. Promote positive media coverage regarding copperbelly water snake issues (3)

5.2.2. Establish mechanisms for dissemination of information (3)

6. Review and track recovery progress

6.1. Convene meetings of researchers, state and Federal agency personnel, and other stakeholders to evaluate progress and identify additional recovery needs (2)

6.2. Review Recovery Plan and update or revise as needed and as resources allow (3)

7. Develop a plan to monitor copperbelly water snake after it is delisted (3)

Recovery Narrative

1. Identify and conserve habitat complexes sufficient for recovery

Persistence of copperbelly populations will require landscapes that are suitable in quality and sufficient in extent to maintain them. We must identify what the required habitat components are, how much is needed, and where these landscape units are or will be.

1.1. Develop landscape-level habitat characterization of copperbelly water snake habitat (1)

Based on our understanding of the ecology of copperbellies, determine and describe the features of landscapes suitable for supporting copperbelly water snake. Use GIS and field monitoring to model and predict landscape quality and extent for use in planning and conservation.

1.2. Predict other areas that may contain copperbellies (2)

Use GIS and other tools to combine known requirements of copperbellies and landscape features to identify areas potentially holding copperbellies or that might be managed so that they could sustain viable populations of copperbellies.

1.3. Identify focal management areas for application of restoration and conservation actions (1)

Areas should be identified in which to focus efforts and expend limited resources efficiently. Scientific data and methods, such as GIS as developed in item 2.1.3, will be used to assist in this action. New information may influence opinion on which areas are most important for copperbelly conservation, thus the extent and position of these areas will be routinely re-examined and may be adjusted.

1.4. Conduct habitat restoration and enhancement

Presently the available habitat appears inadequate to sustain multiple viable populations of copperbelly water snake. Existing habitat will need to be enhanced, and additional habitat restored if copperbelly water snake populations are to have sufficiently suitable landscape in which to recover.

1.4.1. Develop guidelines for habitat restoration and enhancement (1)

Preliminary guidelines are provided in Appendix D. Habitat restoration guidelines will be updated as new information on the copperbelly and its habitat are available. Tools for disseminating this information must also be developed.

1.4.2. Work with community leaders, landowners, and state and Federal agency private land programs, conservation organizations, and other cooperators to restore suitable wetlands and associated uplands for the copperbelly (1)

Training should occur for personnel implementing conservation programs on the needs of the copperbellies and how to best recover the species as state and federal programs are implemented.

1.5. Identify, assess, and reduce threats at known sites and focal management areas

Working to identify and remove threats within landscape complexes will enhance their value and minimize the area required to sustain populations.

1.5.1. Identify critical road, agricultural, residential, other man-made features and activities, or natural features that may adversely affect copperbelly water snake (1)

Use observations and landscape modeling to recognize or project significant adverse features, such as road mortality sites, and identify locations to apply conservation measures, such as road crossings.

1.5.2. Clarify influence of roads on migration of individual snakes and the connectivity of subpopulations (1)

Roads appear to be detrimental to populations either as sources of mortality or as barriers to migration. Research will be conducted to provide a more thorough understanding of the impacts of roads on copperbelly patterns of movement and mortality.

1.5.3. For identified threats, assess the relevant importance to a population (1)

Continually review and assess observations and other data to identify and compare effects of various adverse land features and adjust conservation measures as appropriate.

1.5.4. Research and implement techniques to create road crossings for snakes to reduce road mortality and remove barriers to movement (1)

Research techniques, such as culverts, overpasses, and drift fencing, to create points at which snakes can safely cross roads. Develop guidance about minimizing road mortality and developing best management practices for roads and associated habitat and corridors.

1.5.5. Develop and implement techniques to avoid or reduce other significant identified threats (1)

Review previous efforts to ameliorate adverse features and explore new techniques, then implement them to reduce mortality.

1.6. Develop and implement habitat conservation programs (e.g., landowner contact, voluntary registration, and conservation agreements with landowners) (1)

Efforts should focus on facilitating cooperation and participation by private and government landowners in the copperbelly conservation effort.

1.7. When possible, obtain habitat from willing landowners and increase conservation through voluntary agreements, fee title purchase, conservation easements, deed restrictions, etc.

Securing suitable habitat extensive enough to sustain viable populations is required for recovery. This will come as a result of acquisition of land from willing landowners and by securing conservation easements. As conditions change and opportunities evolve, the conservation value of particular parcels will also change and evolve.

1.7.1. Develop and maintain boundaries of focal management areas (2)

Within a broader landscape where copperbelly conservation is a priority, Management Units will be identified within which to concentrate habitat protection efforts. Management Units are comprised of one or more Habitat Blocks and surrounding buffer areas. These areas will be large enough to contain one or more populations and have enough connectivity to support metapopulation structure. Developing these areas is intended to facilitate meeting delisting criterion 2 (Habitat Protection and Management).

1.7.2. Prioritize properties for conservation easements and acquisition and purchase, protect, and/or manage these properties based on priority and availability (1)

A system will be developed to identify properties to target for conservation within Management Units. The goal will be to establish blocks of habitat which contribute substantively to the persistence of populations and viable metapopulations. To accomplish this goal, individual parcels will be targeted for conservation or restoration efforts, with priority given first to those with immediate value to preclude extirpation of existing populations, followed by tracts that further enhance the value of blocks of suitable habitat or connectivity between such blocks. Once properties have been prioritized for value to copperbelly, efforts will be made to protect or manage these areas through conservation easements or to purchase the properties from willing sellers.

2. Monitor known copperbelly water snake populations and their habitat

All known populations of copperbelly water snake should be monitored to ensure an accurate understanding of their status. Recovery of the copperbelly water snake will require multiple viable populations. Monitoring of known populations will help determine the status and contribution of each population to recovery. Monitoring also is vital for assessment of conservation efforts, to assess the health of individuals, to identify potential emerging or changing threats, and to inform adaptive management.

2.1. Develop standard monitoring techniques for copperbelly water snake populations and habitat

The use of standardized monitoring techniques will promote consistency of approach and comparability of findings from place to place and among surveyors.

2.1.1. Develop standard techniques for ascertaining presence/absence of copperbelly water snake (2)

A standardized survey method should be developed that describes the frequency, timing, and techniques that are likely to determine copperbelly presence or absence at a site.

2.1.2. Develop standard techniques for estimating population size for copperbelly water snake populations (2)

Determination of the status and viability of a population will require confidence in knowing its size. Decisions about conservation effort will require understanding the comparability of different populations, and this will require standards for population determination.

2.1.3. Develop a standard approach using GIS to monitor availability and extent of suitable habitat landscape (2)

As with population size, having knowledge of the extent of suitable habitat is required to understand the status and viability of a population accurately. Use of GIS to portray these areas will allow quantitative monitoring and the sharing of relevant information about the areas.

2.2. Monitor known populations of copperbelly water snake

This will require first establishing a baseline population size for each known population, then conducting follow-up surveys. Surveys of each population will allow estimation of its size to help determine its viability and potential contribution to the species' recovery.

2.2.1. Monitor West Branch (Ohio and Michigan) (2)

Two populations are found within the area of the West Branch of St. Joseph River, including the largest population of copperbelly water snake.

2.2.2. Monitor Clear Fork (Michigan) (2)

The Clear Fork of the East Branch of St. Joseph River appears to have the second largest population of copperbelly water snake.

2.2.3. Monitor Fish Creek (Indiana and Ohio) (2)

Two small populations of copperbelly water snake remain in the Fish Creek watershed of Indiana and Ohio. Extensive habitat, though fragmented, remains.

2.3. Survey historic and potential sites for copperbelly water snake

Historic sites should be surveyed until we have met the standard for determining the local extirpation of the species. Sites adjacent to other areas containing copperbelly water snake may be recolonized. If new information suggests that copperbelly water snake might occur in an area, then it should be surveyed.

2.3.1. Survey Clear Lake (Indiana and Michigan) (2)

Copperbelly water snakes were last seen in the area east of Clear Lake, Steuben County, Indiana, in 1993. The area still retains extensive suitable habitat on private property.

2.3.2. Survey Jones (Michigan) (2)

The vicinity of Jones, Michigan (Cass and St. Joseph Counties), retains suitable habitat, but copperbelly water snake have not been observed in the area during recent surveys.

3. Improve baseline understanding of copperbelly water snake ecology

A thorough understanding of the ecological requirements of the copperbelly water snake is needed to ensure its recovery. Although we have learned a great deal about this species in recent years, we still need to understand its ecology, demographic relationships, and threats more completely.

3.1. Clarify characteristics of high quality hibernacula (2)

Hibernation sites appear to be limited. We require a better understanding of what landscape features are necessary for suitable hibernation sites.

3.2. Clarify gestation site requirements (2)

Many species of snakes use specific habitat types while carrying young. Presently we lack sufficient information on this aspect of copperbelly water snake ecology.

3.3. Establish genetic relationships among populations and determine level of inbreeding (2)

Studying the genetic relationships within and among populations will help clarify the uniqueness of each population, the extent of inbreeding occurring, and the suitability of source populations for translocations.

3.4. Examine other factors potentially limiting the species' numbers and range (2)

Population demography should be examined in existing populations to determine important factors such as adult survivorship, reproductive success, age class structure, and to determine whether low recruitment is a concern. This information can be used to assess population viability and confirm whether current recovery criteria on population size are sufficient based on effective population size estimates.

Other factors that may potentially limit the species' numbers and range should also be examined, including the prevalence of disease and the prospect of invasion by rusty crayfish.

4. Develop recovery approaches to enhance recruitment and population size

Small population sizes are more vulnerable to extirpation. Low recruitment levels protract the recovery process and leave populations more vulnerable.

4.1. Develop and implement techniques for enhancing remaining populations by increasing recruitment and reducing mortality (2)

Populations will be more likely to grow towards carrying capacity when recruitment is increased and mortality is reduced. Captive breeding and headstarting should be explored as possible future conservation tools.

4.2. Evaluate translocation as a method of population augmentation, and discuss potential for reintroductions into historic/suitable habitats (2)

The goal of multiple viable populations will be more likely achieved if we have the means to enhance or reintroduce populations in disjunct habitat.

5. Develop and implement public education and outreach efforts

Stakeholder cooperation and participation in the recovery process will be facilitated by effective communication about the copperbelly water snake and recovery efforts.

5.1. Maintain lists of stakeholders (3)

The impact of outreach efforts will be maximized by targeting the most appropriate array of stakeholders, including agency personnel, non-government organization personnel, and private landowners. Maintenance of stakeholder lists will promote effective release of information.

5.2. Develop and distribute printed, audio, and visual outreach materials

Recovery of the copperbelly water snake will be enhanced by providing stakeholders accurate, comprehensive information about the species, its habitat needs and protection, and the relationship between conservation and stakeholders, including an emphasis on deterring persecution and collection. Communication should occur via multiple formats.

5.2.1. Develop printed, web, and audio-visual materials

Outreach materials that provide quality information on copperbelly water snake biology, conservation, and the recovery status should be provided in multiple formats to maximize the benefits of the outreach materials.

5.2.1.1. Publish and distribute a semiannual newsletter to local residents, visitors, and government agency personnel (3)

A regularly printed newsletter provides an opportunities to update stakeholders and the general public about research activities, proper management, and ongoing conservation efforts. Distribution of a newsletter can help raise awareness about the copperbelly water snake, reducing malicious killing due to fear and ignorance about snakes, and educating people about the ecology and appropriate management of the species.

5.2.1.2. Develop and deliver educational presentations about the copperbelly water snake (3)

As with written material, oral presentations provide opportunity to update stakeholders and the general public about research activities, proper management, and ongoing conservation efforts. Oral presentations allow for more dynamic interactions with the audience,

including answering questions from the public.

5.2.1.3. Promote positive media coverage regarding copperbelly water snake issues (3)

Accurate information regarding the copperbelly water snake will encourage conservation and discourage malicious killing. Agency personnel and researchers will be available for interviews and presentations.

5.2.2. Establish mechanisms for dissemination of information (3)

Outreach materials should be regularly distributed to current stakeholder lists as appropriate. A web site should also be maintained with diverse, downloadable materials. Web site presentation of resources provides instant access to information. This information can also be rapidly updated to allow interested parties easy access to the latest information on the species and recovery efforts.

In addition to providing information through the mail and internet, it will be important to meet with members of the public to distribute informational materials in person, and discuss the copperbelly water snake and conservation of its habitat.

6. Review and track recovery progress

6.1. Convene meetings of researchers, state and Federal agency personnel, and other stakeholders to evaluate progress and identify additional recovery needs (2)

Regular meetings of various stakeholders will maintain collaborative bonds and facilitate transfer of information. Maintaining effective relationships will enhance the likelihood of, and rate of progress towards, delisting.

6.2. Review Recovery Plan and update or revise as needed and as resources allow (3)

Routine review of the Recovery Plan will help it be as accurate and useful as possible. As we learn more about the biology of the copperbelly water snake and the environment in which it lives, or as current conditions change, the recovery plan will be updated or revised accordingly, as resources allow.

7. Develop a plan to monitor copperbelly water snake after it is delisted (3)

As it becomes clear that the delisting criteria for the species have been met, a plan for periodically monitoring the status of the species should be developed.

PART III. IMPLEMENTATION

The following Implementation Schedule outlines actions and estimated costs for the recovery program for the copperbelly water snake for the next 30 years. It is a guide for meeting the objectives discussed in the RECOVERY section. The Implementation Schedule lists and ranks recovery actions, provides action descriptions and duration, identifies partner agencies, and provides estimated costs. The listing of a partner in the Implementation Schedule does not require, nor imply requirement, that the identified partner has agreed to implement the action(s) or to secure funding for implementing the action(s). However, partners willing to participate may benefit by being able to show that their funding request is for a recovery action identified in an approved recovery plan and is therefore considered a necessary action for the overall coordinated effort to recover copperbelly water snake. Also, section 7(a)(1) of the ESA directs all Federal agencies to utilize their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of threatened and endangered species. This schedule will be reviewed periodically until the recovery objective is met, and priorities and actions will be subject to revision. Actions are presented in order of priority.

Key to Implementation Schedule

Column 1: Action Priority

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2: An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to meet the recovery objectives.

Column 2: Action Description

A short description of the recovery action which coincides with the STEPDOWN RECOVERY OUTLINE (PART II)

Column 3: Action Number

The number from the STEPDOWN RECOVERY OUTLINE (PART II)

Column 4: Action Duration

The number of years that it is expected to take before the action is completed. The letter “O” indicates that the action is currently ongoing. The letter “C” indicates that the action will be continuous throughout the recovery period. Actions may be both ongoing and continuous.

Column 5 and 6: Recovery Partner

This designates the USFWS programs and other organizations that may be involved in carrying out the action. A key to the acronyms is provided here.

ES	USFWS Division of Ecological Services
IDNR	Indiana Department of Natural Resources
LCO	Local Conservation Organizations and other non-profits (e.g., Michigan Nature Association, The Nature Conservancy, Land trust organizations, etc.)
LG	Local Government (e.g., County Road Commissions, Conservation Districts)
MDNR	Michigan Department of Natural Resources
NRCS	Natural Resources Conservation Service
ODNR	Ohio Department of Natural Resources
OTHERS	Other individuals or groups willing to participate (e.g., private landowners)
PFW	USFWS Partners for Fish and Wildlife Program
RSCH	Universities and Research Institutions (e.g., Indiana-Purdue University Fort Wayne, Michigan Natural Features Inventory, U.S. Geological Survey, etc.)
USFWS	U.S. Fish and Wildlife Service

Columns 7-11: FY09, FY10, FY11 and beyond

This column gives the estimated cost for carrying out the action during the next three years and years four through thirty. Costs are listed in thousands of dollars. TBD means costs are yet to be determined.

Column 12: Comments

Explanatory comments. For more detailed information, refer to the RECOVERY section. TBD = To be determined.

Table 1. Implementation Schedule for the Northern Population Segment of the Copperbelly Water Snake

				Recovery Partner		Est. Cost ($1,000)					
Priority	Description	Action number	Action duration	R3 FWS	Other	Year 1	Year 2	Year 3	Years 4-30	Total Cost	Comments
1	Develop landscape-level habitat characterization of copperbelly water snake habitat	1.1	3	ES	RSCH	10	20	15	0	45	
1	Identify focal management areas for application of restoration and conservation actions	1.3	O, 3	ES, PFW	LG, MDNR, ODNR, IDNR, RSCH, NRCS, OTHERS	5	10	10	50	75	Areas should be identified in which to focus efforts and expend limited resources efficiently.
1	Develop guidelines for habitat restoration and enhancement	1.4.1	O, 3	ES, PFW	RSCH	5	5	5	0	15	
1	Work with community leaders, landowners, and state and Federal agency private land programs, conservation organizations, and other cooperators to restore suitable wetlands and associated uplands for the copperbelly	1.4.2	O, 20	ES, PFW	LCO, LG, MDNR, ODNR, IDNR, RSCH, NRCS, OTHERS	100	100	100	TBD	300+	

Priority	Description	Action number	Action duration	Recovery Partner: R3 FWS	Recovery Partner: Other	Est. Cost ($1,000): Year 1	Year 2	Year 3	Years 4-30	Total Cost	Comments
1	Identify critical road, agricultural, residential, other man-made features and activities, or natural features that may adversely affect copperbelly water snake	1.5.1	O	ES, PFW	LCO, LG, MDNR, ODNR, IDNR, RSCH, NRCS, OTHERS	10	20	20	50	100	
1	Clarify the influence of roads on migration of individual snakes and the connectivity of subpopulations	1.5.2	5	ES	RSCH	10	10	10	10	40	
1	For identified threats, assess the relevant importance to a population	1.5.3	C	ES	RSCH	5	5	5	25	40	
1	Research and implement techniques to create road crossings for snakes to reduce road mortality and remove barriers to movement	1.5.4	10	ES	RSCH	20	15	10	100	145	

Priority	Description	Action number	Action duration	Recovery Partner: R3 FWS	Recovery Partner: Other	Est. Cost ($1,000): Year 1	Year 2	Year 3	Years 4-30	Total Cost	Comments
1	Develop and implement techniques to avoid or reduce other significant identified threats	1.5.5	10	ES	RSCH	10	10	10	50	80	
1	Develop and implement habitat conservation programs (e.g., landowner contact, voluntary registration, and conservation agreements with landowners)	1.6	10	ES, PFW	LG, MDNR, ODNR, IDNR, RSCH, NRCS, OTHERS	5	5	5	20	35	Success highly dependent on overall education and outreach.
1	Prioritize properties for conservation easements and acquisition and purchase, protect, and/or manage these properties based on priority and availability	1.7.2	C	ES	LCO, LG, MDNR, ODNR, IDNR, RSCH, NRCS, OTHERS	0	10	10	TBD	20+	Cost for acquisition will depend on availability of willing landowners.
2	Predict other areas that may contain copperbellies	1.2	2	ES	RSCH	0	0	0	TBD		Completion of this action is contingent upon completion of Recovery Action 3.1.

Priority	Description	Action number	Action duration	Recovery Partner		Est. Cost ($1,000)					Comments
				R3 FWS	Other	Year 1	Year 2	Year 3	Years 4-30	Total Cost	
2	Develop and maintain boundaries of focal management areas	1.7.1	1	ES	RSCH	10	0	0	0	10	
2	Develop standard techniques for ascertaining presence/absence of copperbelly water snake	2.1.1	5	ES	RSCH	5	20	20	5	50	
2	Develop standard techniques for estimating population size for copperbelly water snake populations	2.1.2	5	ES	RSCH	5	5	5	10	25	
2	Develop a standard approach using GIS to monitor availability and extent of suitable habitat landscape	2.1.3	3	ES	RSCH	10	5	5	0	20	

Priority	Description	Action number	Action duration	Recovery Partner R3 FWS	Recovery Partner Other	Est. Cost ($1,000) Year 1	Year 2	Year 3	Years 4-30	Total Cost	Comments
	Monitor known populations and landscapes potentially having copperbelly water snake:	2.2									
2	*West Branch (OH, MI)*	2.2.1	O, C	ES	LCO, RSCH, OTHERS	5	5	5	130	145	
2	*Clear Fork (MI)*	2.2.2	O, C	ES	LCO, RSCH, OTHERS	5	5	5	130	145	
2	*Fish Creek (IN, OH)*	2.2.3	O, C	ES	LCO, RSCH, OTHERS	5	5	5	130	145	
	Survey historic and potential sites for copperbelly water snake:	2.3									
2	*Clear Lake (IN, MI)*	2.3.1	O, C	ES	LCO, RSCH, OTHERS	5	0	5	65	75	
2	*Jones (MI)*	2.3.2	O, C	ES	LCO, RSCH, OTHERS	5	0	5	65	75	
2	Clarify characteristics of high quality hibernacula	3.1	5	ES	RSCH	5	15	15	5	40	
2	Clarify gestation site requirements	3.2	5	ES	RSCH	10	10	10	10	40	

Priority	Description	Action number	Action duration	Recovery Partner		Est. Cost ($1,000)					Comments
				R3 FWS	Other	Year 1	Year 2	Year 3	Years 4-30	Total Cost	
2	Establish genetic relationships among populations and determine level of inbreeding	3.3	5	ES	RSCH	10	30	30	20	90	
2	Examine other factors potentially limiting the species' numbers and range	3.4	5	ES	RSCH	10	10	10	10	40	
2	Develop and implement techniques for enhancing remaining populations by increasing recruitment and reducing mortality	4.1	TBD	ES	RSCH	10	20	20	5	55	
2	Evaluate translocation as a method of population augmentation, and discuss potential for reintroductions into historic/suitable habitats	4.2	TBD	ES	LCO, LG, MDNR, ODNR, IDNR, RSCH, NRCS, OTHERS	10	30	50	TBD	90+	Costs for years 4-30 will depend on the success of Action 4.1 and availability of willing landowners for potential reintroductions.

Priority	Description	Action number	Action duration	Recovery Partner: R3 FWS	Recovery Partner: Other	Est. Cost ($1,000): Year 1	Year 2	Year 3	Years 4-30	Total Cost	Comments
2	Convene meetings of researchers, state and Federal agency personnel, and other stakeholders to evaluate progress and identify additional recovery needs	6.1	C	ES	LCO, LG, MDNR, ODNR, IDNR, RSCH, NRCS, OTHERS	1	1	1	27	30	
3	Maintain lists of stakeholders	5.1	C	ES	LG	1	1	1	10	13	
3	Publish and distribute a semiannual newsletter to local residents, visitors, and government agency personnel	5.2.1.1	C	ES	LCO, LG, MDNR, ODNR, IDNR, RSCH, NRCS, OTHERS	1	1	1	27	30	
3	Develop and deliver educational presentations about the copperbelly water snake	5.2.1.2	C	ES	LCO, LG, MDNR, ODNR, IDNR, RSCH	5	5	5	20	35	
3	Promote positive media coverage regarding copperbelly water snake issues	5.2.1.3	C	ES	LCO, LG, MDNR, ODNR, IDNR, RSCH	1	1	1	10	13	

Priority	Description	Action number	Action duration	Recovery Partner: R3 FWS	Recovery Partner: Other	Est. Cost ($1,000): Year 1	Year 2	Year 3	Years 4-30	Total Cost	Comments
3	Establish mechanisms for dissemination of information	5.2.2	C	ES	MDNR, ODNR, IDNR, RSCH	1	1	1	5	8	
3	Review Recovery Plan and update or revise as needed and as resources allow	6.2	C	ES		0	0	0	10	10	
3	Develop a plan to monitor copperbelly water snake after it is delisted	7	1	ES		0	0	0	15	15	

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APPENDICES

Appendix A. List of Acronyms and Abbreviations Used in the Recovery Plan

CFR	Code of Federal Regulations
cm	centimeters
CNAH	Center for North American Herpetology
DPS	Distinct Population Segment
ESA	Endangered Species Act of 1973, as amended
FR	Federal Register
FSA	Farm Service Agency
g	grams
GIS	Geographic Information System
ha	hectares
HCP	Habitat Conservation Plan
in	inches
IUCN	International Union for Conservation of Nature
m	meters
MCP	minimum convex polygon
mm	millimeters
MNFI	Michigan Natural Features Inventory
N	Census population size
n	sample size
N*e*	Effective population size
NPS	Northern Population Segment
oz	ounces
PIT	Passive Integrated Transponder
SD	standard deviation
SPS	Southern Population Segment
SSAR	Study of Amphibians and Reptiles
SVL	Snout to vent length
USFWS	United States Fish and Wildlife Service

Note that additional acronyms used in the Implementation Table can be found in the key on page 44.

Appendix B. Glossary

Captive rearing: rearing snakes in captivity, usually from neonates (newborn snakes) collected from gravid females. See also headstarting.

Crepuscular: active at dusk and dawn.

Critical habitat: As defined by the ESA, includes (i) the specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the provisions of the ESA, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the ESA, upon a determination by the Secretary that such areas are essential for the conservation of the species.

Effective population size: the size of an ideal population (a population with 1:1 sex ratio, random mating, constant size over time, equal contribution of all adults to subsequent generations) having the same genetic characteristics as the real population of concern (see page 33 of the plan for additional discussion on effective population size).

Endangered: the classification provided to an animal or plant in danger of extinction within the foreseeable future throughout all or a significant portion of its range.

Headstarting: raising neonates (newborn snakes) collected from gravid females captured from the wild to an older stage for release back into the wild. This technique is expected to reduce the high mortality anticipated for the smallest size classes due to predation.

Hibernacula: areas containing one or more suitable crayfish burrows or other subterranean structures capable of supporting successful hibernation.

Inbreeding: mating of related individuals. Severe inbreeding is often associated with declines in health and reproductive potential of subsequent offspring, termed “inbreeding depression.” Inbreeding is of conservation relevance when small population sizes obligate individuals to mate with relatives as they are the only ones available.

Lacustrine: permanently flooded lakes and reservoirs and intermittent lakes that contain extensive areas of unvegetated water or deep water.

Metapopulation: a collection of populations that are adjacent to one another and among which snakes can migrate. Metapopulations have the potential to recolonize adjacent landscapes should their populations be extirpated.

Palustrine: vegetated wetlands such as marshes, swamps, bogs, fens, and prairies. It also includes small, shallow, permanent or intermittent water bodies often called ponds.

Population: individuals occurring within the same contiguous landscape of suitable habitat that is unbroken by impermeable barriers such as roads.

Radiotelemetry: a technique whereby a signal emitted from a transmitter is received remotely by an investigator carrying a receiver. It is used with animals to allow relocation without repeated capture, facilitating the study of patterns of movement and habitat preference. The radiotelemetry signals may also carry other information, such as temperature.

Snout-vent length (SVL): a standard measurement of body length for reptiles. The measurement is from the tip of the nose (snout) to the anus (vent), and excludes the tail.

Subpopulation: a part of a population incompletely separated from the rest of a population. A population might be divided by a road, across which snakes occasionally, but irregularly move, the result being two subpopulations.

Take: as defined by the ESA, is harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting a federally listed species, or attempting to engage in any such conduct. "Harm" is further defined to include significant habitat modification or degradation that results in death or injury to a listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering.

Threatened: the classification provided to an animal or plant likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Translocation: any artificial movement of individuals from one location to another.

Appendix C. Summary of Threats and Recommended Recovery Actions for the Northern Population Segment of the Copperbelly Water Snake

Listing Factor	Threat	Recovery (Delisting) Criteria[1]	Recovery Action
A	Loss and degradation of suitable habitat; habitat fragmentation	1, 2	Identify and protect habitat landscape sufficient for recovery (1.1-1.7); Monitor known copperbelly water snake populations and their habitat (2.1-2.3); Improve baseline understanding of copperbelly water snake ecology (3.1-3.4); Review and track recovery progress (6.1-6.2)
A, E	Road related mortality and barriers	1, 2	Identify and protect habitat landscape sufficient for recovery (1.1-1.7); Review and track recovery progress (6.1-6.2)
B	Collection	1, 3	Develop and implement public education and outreach efforts (5.1-5.2); Review and track recovery progress (6.1-6.2)
C	Disease and Predation	1, 3	Identify and protect habitat landscape sufficient for recovery (1.1-1.7); Monitor known copperbelly water snake populations and their habitat (2.1-2.3); Improve baseline understanding of copperbelly water snake ecology (3.4); Review and track recovery progress (6.1-6.2)
E	Risks associated with small, isolated populations	1, 2	Monitor known copperbelly water snake populations and their habitat (2.1-2.3); Improve baseline understanding of copperbelly water snake ecology (3.3); Develop recovery approaches to enhance recruitment and population size (4.1-4.2); Review and track recovery progress (6.1-6.2)
E	Incompatible land management efforts	1, 2, 3	Identify and protect habitat landscape sufficient for recovery (1.1-1.7); Monitor known copperbelly water snake populations and their habitat (2.1-2.3); Improve baseline understanding of copperbelly water snake ecology (3.1, 3.3-3.4); Develop and implement public education and outreach efforts (5.1-5.2); Review and track recovery progress (6.1-6.2)
E	General public dislike of snakes	3	Develop and implement public education and outreach efforts (5.1-5.2); Review and track recovery progress (6.1-6.2)

Listing Factors:
A. The Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range
B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes
C. Disease or Predation
D. The Inadequacy of Existing Regulatory Mechanisms (Not applicable)
E. Other Natural or Manmade Factors Affecting its Continued Existence

[1] Recovery Criteria can be found on page 30-31 of the Recovery Plan

Appendix D. Concise Guidelines for Copperbelly Management
Bruce Kingsbury, Center for Reptile and Amphibian Conservation and Management

Introduction

The following guidelines are intended to provide a framework for development of conservation and management planning and work on the ground. A large and growing body of work is available to refer to for greater detail, but the underlying principals are intended to be captured here.

These guidelines will be updated as additional information becomes available. Given that hard copies are static, the user is advised to periodically check with our staff for the latest version of these recommendations.

The approach is to highlight the important conceptual element and follow with a brief rationale. We also try to provide "rules of thumb" that are simple but not overly simplistic.

Overarching Landscape Matrix Considerations

The details of upland management are presented in a separate section below. However, here we emphasize the importance keeping the overall landscape matrix, that is, the combination of appropriate wetlands and uplands, in mind.

Conservation planning at the large (landscape) level is absolutely necessary for successful protection of the copperbelly. Populations are unlikely to persist without square miles of appropriate landscape. A square mile of ideal landscape may be nearly able to support a viable population, but less appropriate landscape must be increasing expansive. In truth, areas with multiple uses such as game management or limited agriculture must be at least several square miles in extent, even more if the copperbelly is not the focal species.

Initial conservation efforts should be focused at or within a mile of areas known to have recently contained copperbelly records. Given that the copperbelly is in immediate peril of extirpation and conservation resources are limited, the first goal should be to protect existing subpopulations from disappearing.

Wetlands should be viewed in the context of wetland complexes. Copperbellies need numerous, adjacent wetlands to persist because of their diverse habitat needs and vagile habits.

How many wetlands are needed? The capacity for a landscape to hold wetlands will depend upon soil and topography, but several operational rules can be followed:

> **Restore every apparent historical wetland whenever possible.** Copperbelly habitat will naturally have numerous wetlands and successful restoration will revive that type of habitat.

In striving for ideal habitat, strive for a wetland every two to three hectares. This may seem high, but would include wetlands of tenths of a hectare. This calculation does not include aquatic systems such as lakes and streams. Note also that this calculation does not suggest that every third hectare is all wetland.

What kinds of wetlands are needed? The kinds of wetlands to protect, restore, or even create, are discussed in detail below. However, in the context of the landscape, several important points can be introduced here. The following rules of thumb are intended to encourage thinking and action which promote wetland heterogeneity. Failure to provide this heterogeneity within a complex will lead to the failure of that unit to support copperbellies. The rules should be liberally applied when considering management in any wetland complex, management unit, or recovery plan.

The Third's Rule. Wetlands in a complex should include permanent bodies of water, wetlands that retain water most years, and wetlands that almost always dry down by mid-summer each year. The rationale is that the best breeding pools for most amphibians are the ephemeral pools, but that in drier years, the semi-permanent wetlands will provide some reproductive capacity for amphibians, and in droughts, the permanent wetlands will provide

The 50-50 Rule. Wetland complexes must also be diverse in terms of canopy cover. To promote that, the 50-50 Rule provides a way of visualizing targeting different kinds of wetlands in an incremental fashion. In a given unit, half of the palustrine wetlands might have open canopy, i.e., open water. Of the wetlands with canopy, half might be forested, and half not. Of the not forested wetlands, half of them might be shrub-scrub, the other half emergent. The goal is to end up with a high degree of canopy and hydrological heterogeneity within a given area. Lacustrine and riverine systems are not included in this rationale.

The Hectare Rule. Average wetland size will approach one hectare and vary widely in size and depth. Size distribution will depend upon the terrain, but the most valuable wetlands should range from tenths of a hectare to several hectares.

The activity of beavers should not be discouraged unless clearly detrimental. Over time, dam construction forms desirable wetland structure, as well as refugia for the snakes, and beaver foraging activity helps to maintain an open canopy within forested areas of the wetlands. Streams with active beaver will be for more valuable as corridor between wetland complexes.

Upland habitats adjacent to wetlands also provide corridors to other wetland patches. Copperbellies have been shown to use upland areas for direct movement from one wetland to another, as resting, basking, and refugia sites, and occasionally for hibernation. Adequate upland must be available to satisfy these needs. Upland areas surrounding wetlands should principally be closed canopy forest but include some open terrain, providing necessary forest edge.

Conservation and Management of Existing Wetlands

Shallow wetlands should be vigorously protected, especially those that dry out in the summer (ephemeral/seasonal wetlands). Shallow wetlands are vulnerable to draining or deepening, but a variety of studies now show that they are critically important.

Existing shallow wetlands should not be modified to form deeper systems. If deeper systems are desired, they could be constructed at sites that have already been disturbed so severely that shallow wetland recovery is unlikely, or simply inappropriate.

Wetlands with clay as the surface substrate are superior to those with a muck bottom. While any wetlands in the region of the threatened population are likely underlain by the impermeable clay layer which permits water retention, copperbellies appear to prefer wetlands with firm clay bottoms. A simple observation is that one can walk out into a copperbelly wetland without sinking significantly into the substrate.

Most wetlands should not be stocked with fish. Many fish prey on amphibian eggs and larvae of frogs, the chief food source for copperbellies. Introducing fish thus potentially impacts the prey base of the copperbelly. Areas could, however, be stocked with eggs or larvae of amphibians native to the region and obtained locally.

Debris such as logs and flotsam provide important structures for refugia and basking for many wetland species, including copperbellies, and thus should be left on-site rather than "cleaned up." To make constructed wetland areas more "friendly" to amphibians and reptiles in general, debris can be added.

Managing Adjacent Uplands

Management efforts for copperbellies that focus only on the protection of wetlands will fail. Copperbellies are one of the more terrestrial semi-aquatic snakes and have been observed using upland areas at substantial distances from wetlands. Uplands are used for numerous activities, including foraging, refugia, and shedding. Such uplands are also important for other species whose life history requires seasonal migrations away from wetlands, including many of the amphibian prey of copperbellies.

Wetlands must be buffered from Intact land-water interfaces protect adjoining aquatic resources by filtering chemical pollutants, moderating temperatures, and reducing siltation from activities in the surrounding landscape. This is standard wetland buffering and should follow best management practices for wetlands. These areas will also have the heaviest snake use, and so activities in these zones could lead to direct mortality. A starting point for such a buffer might be 50 meters. However, the following logic also applies.

Copperbellies require extensive upland matrix as part of the "core habitat." The term buffer is misleading for this additional habitat, as it does not relate directly to protection of wetland water quality. However, its use is so embedded in conservation language that the

term may be unavoidable. Although copperbellies will benefit from greater areas, core widths of 100 meters, or 250 meters between wetlands in a complexes (roughly two merged buffer zones), will likely be the most beneficial. An implication is that adjacent wetlands should be linked by upland habitat that lacks barriers such as roads, row crops, or other development. This core upland habitat would best itself be buffered from disturbance, and so should be considered to be conservative.

Timber management and harvesting should be limited around and between wetlands. While forest edges confer thermoregulatory opportunities, and appear to provide a staging ground for the snakes to forage in adjacent woodlands and wetlands, extensive openings are not needed. Perhaps ten percent or less of the canopy need be open. In fact, openings caused by tree falls may be adequate for the snakes when away from wetlands.

Reforestation efforts should initially be aimed at achieving a complete canopy. Thinning or old field development could take place once the forest matures when less dense areas, or "thin" spots, can be readily identified.

Park-like management practices (i.e., mowed lawns, etc.) should be avoided anywhere but in the immediate vicinity of buildings or other sites where personal safety is a concern. Otherwise, rank growth, small trees, and other “wild” habitat attributes should be left intact.

Corridors between wetlands and wetland complexes should be of sufficient quality and width to be attractive and safe to use. To function, corridors cannot be intimidating, and they must also be adequately safe to protect the snake and other wildlife from elevated predator and human encounters. They could include habitats such as riparian buffer strips, short stretches of upland forest, and more narrow stretches of ephemeral wetland complexes. At the simplest level, corridor “design” may involve avoiding intensive farming of land in between wetlands. Corridors should be as short and as wide as possible: a width/length ratio of 1/5 is suggested as a lower limit.

Agricultural fields should be offset from forest instead of running right up to the tree line. An unfarmed strip of a width equal to the height of adjacent forest should be cleared but not planted to crop. This margin will ease maintenance of crop fields, provide thermoregulatory and foraging benefits to the snakes, and deter them from activity in the crops themselves.

If agricultural areas are not too extensive or intrusive in terms of breaking up wetland complex structure, then perhaps the greatest immediate concerns are timing and implementation of management and farming practices. Agricultural practices adjacent to copperbelly wetlands, as well as in travel corridors, could favor crops that require the least amount of manipulation during the activity season (May-October). Similarly, any maintenance activities on these areas, such as brush hogging or mowing, should be implemented in winter, before the snakes emerge from hibernation.

Wetland Restoration and Construction

When designing and constructing wetlands within the range of copperbellies, emphasis should be placed on shallow systems. Wetlands with extensive areas of less than 30 cm (~ one foot) in depth are vitally important for copperbellies. They are conducive for anuran breeding, and consequently provide important food resources for copperbellies.

Shorelines of constructed wetlands should be complex, undulating in form rather than being relatively straight. This will increase the available shoreline, as well as shallow water areas close to shore. Levee and wetland design should take advantage of existing topography to maximize this effect, by backing water against substrate of gradual, undulating form.

Whenever possible, wetland shores should not have steep banks. Strive for slope ratios 1:5 or better in levee areas, and much less steep along the rest of the shore (1:20 or less).

Hydrology should be spatially and temporally variable. Most, but not necessarily all, of the wetlands should be ephemeral in nature, such that they completely dry down every 1-3 years. Refer back to the Third's Rule. This prohibits the development of fish populations, and allows the germination of vegetation requiring complete drying of the wetland.

When replanting areas, native vegetation, preferably from the immediate area, should be used whenever possible. Buttonbush (*Cephalanthus occidentalis*) should be planted in those areas that tend to stay the most predictably flooded, and bottomland forest trees planted in those areas that tend to dry down. Willows (*Salix* sp.) should not be used in place of buttonbush.

Copperbellies hibernate predominantly in crayfish burrows that, at least at the onset of hibernation, were not flooded. Snakes were not found to utilize structures that were flooded, or beneath water at the onset of hibernation, although snakes tolerated days to weeks of flooding after beginning hibernation. Given the tendency for copperbellies to not use modified habitat for hibernation, known hibernacula should be protected from any development. Nevertheless, reclaimed substrates within which we hope copperbellies might eventually hibernate should support crayfish colonization and have extensive areas just above (20-50 cm) most flooding.

When feasible, the water supply for wetlands should be fed by spring or surface runoff rather than floodwaters from riverine systems. Floodwater is sediment-laden and may be otherwise of questionable water quality. It will also contain fish. In many cases such influxes are unavoidable, so to minimize the influx of sediment with the water, settling areas should be included in wetland system designs. Whenever possible, floodwaters should back into wetland systems to maximize sediment deposition before the water infiltrates the habitat.

Appendix E. Summary of Comments on Draft Recovery Plan and U.S. Fish and Wildlife Service Responses

On September 6, 2007, the U.S. Fish and Wildlife Service (Service) released the Copperbelly Water Snake (*Nerodia erythrogaster neglecta*) Draft Recovery Plan (Draft Plan), for a 60-day review and comment period ending on November 5, 2007. Availability of the Draft Plan was announced in the Federal Register (72 FR 51242) and via a news release to media contacts throughout the species' U.S. range.

In accordance with Service policy, requests for peer review of the Draft Plan were sent to experts outside the Service. Requests for peer review were sent to the following individuals:

Dr. Richard B. King, Northern Illinois University, DeKalb, Illinois
Ms. Yu Man Lee, Michigan Natural Features Inventory, Lansing, Michigan
Dr. John Shuey, The Nature Conservancy, Indianapolis, Indiana

The Service received comments from 17 individuals/agencies during the official comment period. Affiliations of these commenters are tabulated below:

Peer reviews	2 reviewers
State governments	2 states
Environmental/non-government organizations	1 organization
Individuals/Private citizens	12 individuals

Each correspondence contained one or more comments or questions, and some letters raised similar issues. Most letters requested explanation or clarification of points made in the plan and included suggestions for changes. Many commenters expressed strong support for the conservation of this species. Most comments were incorporated into the approved recovery plan. Information and comments not incorporated into the approved plan were considered and noted. The majority of comments received are summarized below, including significant comments that were not incorporated or that required further clarification.

All of the comments that the Service received on the Draft Plan are on file at the U.S. Fish and Wildlife Service, 2651 Coolidge Road, Suite 101, East Lansing, Michigan, 48823.

Comments from Peer Reviewers with Service Responses

- **Comment:** One reviewer stated that recovery goals should be written in terms of numbers of adult water snakes.

  Response: We concur with this comment. Recovery goals were written in terms of adults. We have edited the Recovery Plan, where necessary, to clarify this.

- **Comment:** One reviewer recommended that "metapopulations" and "populations" be clearly defined. The reviewer questioned what criteria will be used to decide whether a given element occurrence constitutes a population or a sub-population within a metapopulation.

  Response: As defined in the glossary, a population consists of individuals occurring within the same contiguous landscape of suitable habitat that is unbroken by impermeable barriers such as roads, and a metapopulation is a collection of populations that are adjacent to one another and among which snakes can migrate. We have added a definition of "subpopulation" to the glossary.

- **Comment:** One reviewer suggested identifying areas with high road mortality. Two reviewers recommended research and development of strategies to reduce road mortality.

  Response: Recovery action #1.5.2 recommends identifying significant adverse features, such as road mortality sites. We have edited the Stepdown Outline and Narrative to reflect the need for development of safe road crossing techniques to reduce road mortality.

- **Comment:** One reviewer indicated that it is unclear whether the vehicle-caused mortality rates cited on page 21 are for adults or all age classes.

  Response: The mortality rates are for adults. We have clarified this under Habitat Destruction and Modification in the Threats section of the Recovery Plan.

- **Comment:** One reviewer stated that small populations are also more strongly affected by demographic stochasticity.

  Response: We refined the wording on page 22 under Habitat Destruction and Modification and page 24 under Other Natural or Manmade Factors Affecting its Continued Existence to reflect our agreement with this comment.

- **Comment:** One reviewer indicated that the criteria for reclassification from threatened to endangered have been met.

  Response: The listing classification of the copperbelly water snake will be examined in the 5-year review for the copperbelly. Any recommendations regarding its listing

classification will be made at that time.

- **Comment:** One reviewer recommended clarifying the copperbelly water snake is a different species by inserting the current name of the northern water snake taxon on page 1.

  Response: The Taxonomy and Nomenclature section of the Recovery Plan discusses the taxonomy of the copperbelly water snake, clearly identifying its genus, species, and subspecies.

- **Comment:** One reviewer suggested including a discussion about potential genetic differentiation between the northern and southern population segments.

  Response: Recently published research analyzed copperbelly populations within and outside of the listed DPS to examine the genetic structure within and amongst populations. We have updated this discussion in the Conservation Efforts section of on page 27 to include this new information.

- **Comment:** One reviewer stated that the Illinois/Iowa segregate is as geographically isolated from the southern DPS as is the officially recognized northern DPS and suggested an inconsistency in recognition and designation.

  Response: The final listing rule established two distinct population segments: the southern DPS in Illinois, Indiana, and Kentucky south of 40 degrees north latitude and the northern DPS in Michigan, Indiana, and Ohio north of 40 degrees north latitude. The Illinois/Iowa segregate is north of 40 degrees north latitude but is geographically isolated from both the northern and southern DPSs. Little information about the status of the Illinois/Iowa segregate was available at the time the northern DPS was listed, and the Illinois/Iowa population was not considered for listing.

- **Comment:** One reviewer suggested inserting "northern DPS" in the first paragraph on page 9.

  Response: We inserted the recommended phrase under the Current Distribution discussion on page 9 to clarify the meaning.

- **Comment:** One reviewer asked if NPS in the second paragraph on page 9 referred to the northern DPS.

  Response: Yes. NPS is defined on page 7.

- **Comment:** One reviewer asked if the Indiana/Ohio occurrence on page 10 is part of the referenced metapopulation.

  Response: We modified the text under the *Indiana and Ohio* discussion on page 10 to clarify that the referenced population is the largest population, which does not extend

into Indiana.

- **Comment:** One reviewer recommended including a discussion under "Population Status" about the southern population isolates along the Mississippi River and in southern Indiana/Kentucky/Illinois.

  Response: The Population Status section of the Recovery Plan addresses the status of the listed DPS only; thus, the status of the southern population isolates is not included in this discussion.

- **Comment:** One reviewer suggested clarifying if copperbelly water snakes are born in the hibernacula, or if the hibernacula are adjacent to the birthing site. The reviewer indicated this would have implications for headstarting programs.

  Response: We modified the Growth and Reproduction discussion on page 14 to address the point that copperbelly neonates appear to be deposited at or near their initial overwintering site. We agree that this aspect of their natural history may have implications for any headstarting and translocation efforts that might occur in the future.

- **Comment:** One reviewer asked if the adult survival rates (on page 15) were per year.

  Response: Survival rates presented are on a per year basis. We have clarified this point in the text.

- **Comment:** One reviewer recommended providing a range for the depth of water in which copperbellies forage.

  Response: We adjusted the Prey and Foraging Behavior discussion on page 17 to clarify that the snakes have been observed to forage in water 10-20 cm deep.

- **Comment:** Two reviewers suggested that inbreeding may be a concern worth noting and recommended a discussion about potential genetic issues under the Threats section.

  Response: We agree with this suggestion and have added a discussion to the Threats section on page 24 and have added this to recovery action #3.

- **Comment:** One reviewer suggested that managing wetlands to maximize duck production may have an impact on habitat quality for the copperbelly water snake and recommended the inclusion of a discussion about wetland management under the Threats section.

  Response: Managing for migratory waterfowl does not necessarily impact copperbelly conservation efforts negatively; however, landscape modifications that specifically favor deeper, more stable water levels at the expense of shallow wetlands

will hamper conservation of the copperbelly. Text was added under Other Natural or Manmade Factors Affecting its Continued Existence on page 24 to highlight this point.

- **Comment:** One reviewer suggested some discussion about the impact that the agricultural landscape, especially corn production, has on raccoon densities, leading to predation on all kinds of herptiles.

  Response: We address predation and its relation to land cover on pages 22-23 in the Disease or Predation discussion.

- **Comment:** One reviewer asked if interagency cooperation with Federal agencies included the implementation of Pittman-Robertson funded activities by states and suggested that game management activities may contribute to the loss and fragmentation of upland habitat.

  Response: The Interagency Cooperation with Federal Agencies section of the Recovery Plan describes requirements of all Federal agencies for actions they authorize, fund, or carry out. Pittman-Robertson funds are Federal funds made available to states and are used to buy, develop, maintain, and operate wildlife management areas. Thus, issuance of Pittman-Robertson funds to states is subject to the consultation process, as is any Federal action. If an action funded by Pittman-Robertson may affect copperbelly water snake through impacts to habitat, then the Service would work with the land managers to avoid or minimize adverse effects through the consultation process.

- **Comment:** One reviewer recommended defining suitable habitat. The reviewer recommended that parameters, such as size and depth of wetlands, density of wetlands per square mile, and maximum distance between wetlands, should be included to support implementation of habitat conservation and restoration.

  Response: General guidelines can be found in Appendix D.

- **Comment:** One reviewer indicated that the recovery budget will achieve only 10-15% of the recovery criteria in the next 20 years.

  Response: We estimated the cost of each recovery action based on the best available information. As the recovery program for copperbelly progresses, we will review the priorities, actions, and associated costs identified in the Implementation Schedule. The recovery budget will be reviewed periodically and will be revised if it is insufficient to achieve all of the recovery criteria.

- **Comment:** One reviewer recommended referring to Appendix D (Concise Guidelines for Copperbelly Management) in the text.

  Response: We have added this reference under Recovery Action #1.4.1 on page 38.

Other Significant Comments and Responses

- **Comment:** One commenter indicated that although the Recovery Plan identifies killing by humans as a major threat to the copperbelly water snake, the plan does not directly discuss this in the section on threats. The commenter would not oppose reducing the emphasis on killing by humans, given the lack of data supporting the threat; however, if killing by humans remains a focus of the Recovery Plan, then the threat should be explicitly described in the threats section.

  Response: The recovery plan was modified to clarify that killing by humans is not known to be a major threat to the copperbelly.

- **Comment:** One commenter stated that vehicle-caused mortality and injury is not directly addressed in the delisting criteria or rationale section. This commenter recommended amending the sub-criteria under Criterion 2 to reflect the need to manage road density and fragmentation to minimize vehicle-caused mortality and injury and amending the rationale section to address the issue.

  Response: Although Criterion 2 addresses habitat concerns, we feel these threats are more appropriately addressed in Criterion 3(b), which includes road-related impacts to copperbelly.

- **Comment:** One commenter suggested the inclusion of three conservation easements in Michigan in the description of programs that support copperbelly water snake habitat management (provided that the easements are funded).

  Response: We have inserted this suggestion in the Conservation Efforts discussion on page 27.

- **Comment:** Two commenters voiced support for reclassifying the copperbelly water snake from threatened to endangered.

  Response: The listing classification of the copperbelly water snake will be examined in the 5-year review for the copperbelly. Recommendations regarding its classification will be made at that time.

- **Comment:** One commenter interpreted the Recovery Plan's discussion of inbreeding as suggesting that inbreeding reduces capacity for evolutionary change. This commenter stated that inbreeding is problematic because it increases the expression of recessive deleterious alleles through increased homozygosity and that genetic drift is a more important factor contributing to the loss of evolutionary potential in small populations. The commenter recommended clarification of the actual effects of inbreeding and justification of the goals for effective population size in terms of a balance between the rate at which new alleles are introduced through mutation and gene flow and the rate at which other alleles are lost through genetic drift.

Response: Both inbreeding and genetic drift will reduce heterozygosity, and consequently the potential for evolutionary change. To explain the effects of inbreeding, we added text under "Other Natural or Manmade Factors Affecting its Continued Existence" on page 27.

- **Comment:** One commenter recommended clarification of the discussion of the copperbelly's capacity to resist inbreeding.

  Response: The capacity of the copperbelly to resist inbreeding is assumed to be similar to other *Nerodia*. We have no evidence to suggest otherwise. We have added discussion about inbreeding in the copperbelly under "Other Natural or Manmade Factors Affecting its Continued Existence"on page 27.

- **Comment:** One commenter recommended including "purchase/protect/manage properties based on priority and availability" to Action 1.7 in the step-down recovery outline.

  Response: We agree with this comment and have modified Action 1.7 accordingly.

- **Comment:** One commenter recommended clarifying whether the definition of multiple hibernacula in recovery criterion 2 refers to an individual crayfish burrow or a complex of underground burrows with multiple chimneys. The commenter also recommended clarifying whether crayfish burrows are the only know hibernacula for copperbelly water snakes.

  Response: We clarified the definition of hibernacula, as well as the copperbelly's use of crayfish burrows, in the "Hibernacula" discussion on page 19.

- **Comment:** One commenter questioned whether the northern population of copperbelly water snake will ever reach the density of the southern population due to being at the northern edge of its range.

  Response: As indicated in the recovery plan, we do not know that the northern population is capable of ever reaching the density of southern populations. Recovery planning for the NPS should not rely on such densities.

- **Comment:** One commenter recommended including data to support the statement that vehicle-caused mortality and injury has increased.

  Response: Presently, no data explicitly demonstrates that vehicle-caused mortality and injury have increased. Roe et al. (2006) used modeling to demonstrate that increased road densities differentially impact copperbellies more than northern water snakes. Under "Habitat Destruction and Modification" on page 21, we have clarified the impact of roads on copperbelly water snakes.

- **Comment:** One commenter asked if analysis exists to determine whether population declines may be linked to limited genetic diversity resulting in reduced reproductive vigor.

  Response: We are not aware of any analysis that shows evidence of loss of reproductive vigor. Under "Conservation Efforts" on page 27, we have added discussion about the Marshall et al. (2008) study that examined the genetic structure within and amongst the listed DPS populations.

- **Comment:** One commenter stated that no data exists to support the statement that management of large areas as grassland for upland birds likely negates use of those areas by copperbellies. The commenter recommended removing the statement from the Recovery Plan.

  Response: Radiotelemetry does show that copperbellies do not enter extensive terrestrial areas with an open canopy. This is consistent with the natural history of the species. We have edited the text on page 24 to clarify this aspect of land management.

- **Comment:** One commenter stated that if the main threat to copperbelly water snake is habitat loss and fragmentation, then a larger proportion of the recovery budget should be linked to conservation and enhancement of habitat.

  Response: Habitat loss and fragmentation are a significant threat and will require a large proportion of the recovery budget. We estimate that approximately half of the overall cost of recovery will be needed to fulfill recovery actions which relate to conservation of copperbelly habitat. The priorities, actions, and associated costs identified in the Implementation Schedule will be reviewed periodically and are subject to revision.

- **Comment:** One commenter recommended reconsidering the comparison of the copperbelly water snake to the Lake Erie water snake and recalculating the copperbelly population goals using a more suitable species for comparison.

  Response: Work done for the Lake Erie Water Snake Recovery Plan was utilized as a rationale to determine the effective population size of the copperbelly. The two species are congeners and have similar life histories; thus, we maintain that this analysis is appropriate.

- **Comment:** One commenter recommended that the goals for habitat conservation should be more specific and include the size and proportion of wetland to forested uplands.

  Response: General guidelines for habitat conservation and restoration can be found in Appendix D.

- **Comment:** One commenter stated that if copperbellies reach sexual maturity in three years, two generations would reach sexual maturity in six years, which is long enough to ensure sufficient time for recruitment of adults within the recovery period. The recovery criterion that populations must persist for a minimum of 10 years, therefore, is arbitrary unless there are other unexplained reasons.

  Response: Based on our current understanding of copperbelly biology and the threats facing this species, several generations of copperbellies would be produced within a ten year period, providing us with data to determine the population trends (i.e., increasing, declining, or stable). If future modeling work and research indicate that ten years is insufficient to determine these trends, we will modify Delisting Criterion 1 as appropriate.

- **Comment:** Eleven commenters recommended curtailing the use of methodologies requiring handling of snakes, e.g., radiotelemetry, mark-recapture, and passive integrated transponder (PIT) tags. One commenter suggested that radiotelemetry and PIT tags are a direct cause of mortality of the marked snakes. The commenter believes that they disrupt behavior, affect health, cause disease, and have contributed to the decline of the copperbelly water snake population. One commenter stated that tongs or other apparatuses to capture snakes cause trauma and potential damage to the snakes and recommended against the use of tongs to handle snakes. One commenter recommended that a specialist examine the cause and type of any disease.

  Response: These comments stem from concerns about impacts to the snakes due to research, and we agree that great effort should be made to minimize the impact of research on species' conservation. Research on this species, including work using telemetry and PIT tags, has contributed substantially to our current understand of the ecological needs of the species. Although there may be some short-term impacts to individuals from research activities, we anticipate long-term benefits to the species through data generated in these studies. To the extent possible, researchers minimize the risks associated with adverse impacts of these studies by using good capture and handling techniques and the best available protocols for surgical techniques and timing. Despite using the best techniques, some adverse effects are expected. For example, one study of the effects of radiotelemetry on the black rat snake has shown slowed weight gain in snakes implanted with transmitters (Weatherhead and Blouin-Demers 2004). Complications may arise from the use of anesthesia during implantation of transmitters, and there is a risk of infection following the surgery. These complications, however, are typically rare and impact a small percentage of the study animals. We have no evidence that research on copperbellies has accelerated the underlying trends in population declines or that PIT tags are a cause of mortality to copperbellies. When considering these types of studies, the Service will carefully weigh the positive and negative impacts to copperbelly and will ensure potential risks are minimal prior to approving this type of research.

- **Comment:** Two commenters recommended surveys and monitoring of the copperbelly population.

Response: Routine monitoring is a component of the Recovery Plan, and these surveys will help us monitor the status of all populations.

- **Comment:** One commenter recommended that copperbellies no longer be removed from the wild and that diseased snakes should not be released. One commenter suggested efforts are needed to prevent illegal collection, disturbance, harassment, taking, and killing.

  Response: Recovery Action 5.2 discusses means to deter persecution and prevent collection of copperbelly water snakes from the wild. Recovery Action 3.4 encourages examination of disease.

- **Comment:** One commenter suggested that breeding of copperbellies in captivity has not been proven successful and recommended that captive breeding and reintroduction of copperbellies should be tested first in the Southern Population Segment. One commenter stated that diseased individuals have been found after captive snakes were released.

  Response: We are not aware of any copperbelly water snakes held in captivity or of efforts to breed copperbellies in captivity. Recovery Actions 4.1 and 4.2 discuss approaches to enhance recruitment and population size, including captive breeding, headstarting, and reintroduction as possible future conservation tools.

- **Comment:** One commenter questioned whether copperbelly water snake populations would decline if crayfish populations declined, resulting in few or no burrows for copperbelly hibernacula.

  Response: The nature of copperbelly water snake hibernation remains only partially understood, but it is clear that they rely heavily on Cambarid crayfish burrows and that suitable patches of burrows are limited. Local declines in burrowing crayfish populations may well lead to declines in copperbelly populations.

- **Comment:** One commenter indicated that adult copperbellies will use high water levels during spring floods as a means to move to other areas or to cross rivers or streams.

  Response: Research in Kentucky does suggest that copperbelly water snakes will use high water periods to traverse greater distances and use areas they would not visit during drier periods.

- **Comment:** One commenter stated that suggestions in the Recovery Plan were very informative; another commenter indicated that the Recovery Plan, if implemented, would enhance natural areas and property values.

Response: Comments acknowledged.

- **Comment:** One commenter stated that the Recovery plan looks great and expressed appreciation for recognizing Clark's work on copperbelly.

  Response: Comment acknowledged.

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