Conservation Assessment for Kirtland's Snake (Clonophis kirtlandii)

Photo by M. Redmer

USDA Forest Service, Eastern Region

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This Conservation Assessment was prepared to compile the published and unpublished information for the Kirtland's snake. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service - Threatened and Endangered Species Program at 626 East Wisconsin Avenue, Milwaukee, Wisconsin 53202.

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EXECUTIVE SUMMARY

Kirtland's snakes occupy moist, open meadow or wet prairie habitats, and old fields, and are found almost exclusively in the Midwest, with the core of their range centered on Ohio, Indiana, and Illinois. Within the Midwest, Kirtland's snake populations have declined dramatically, apparently largely as a result of loss of habitat, and are now isolated and widely separated. The Kirtland's snake was previously reported from more than 100 counties in eight states, but since 1980 it has been observed in only one quarter of those counties (Wilsmann and Sellers 1988). The Kirtland's snake has no federal protection, but is considered imperiled in all states where it occurs. It is listed as state endangered in Indiana, Michigan, and Kentucky, and state threatened in Illinois and Ohio. Within the Eastern Region of the USDA National Forest Service, the Kirtland's snake is designated as a Regional Forester Sensitive Species (RFSS) on the Hoosier National Forest in Indiana and on the Huron-Manistee National Forest in Michigan.

Literature on this small, secretive snake is scant, and very little is known about it. The majority of information available on the Kirtland's snake comes from urban and rural settings (Conant 1943). In fact, very little data has been contributed to the ecology of this species since Conant stated in 1943 (p. 313) that "the paucity of information on *kirtlandii* is attested by the frequency with which authors have quoted their predecessors, meanwhile adding little or no information of their own."

The protection and management of all remaining habitats of known Kirtland's snake populations should be foremost among conservation and management plans for this species. In addition, since the ecology and behavior of the Kirtland's snake is so poorly understood, management guidance would be greatly improved by an increase in research on the species.

ACKNOWLEDGEMENTS

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NOMENCLATURE AND TAXONOMY

The original scientific name given to the Kirtland's snake was *Regina kirtlandii.* Robert Kennicott named the species in 1856 after his mentor Jared P. Kirtland, a physician and naturalist from Ohio (Conant 1943). The species was later given the new monotypic genus *Clonophis* by Cope in 1888. The Kirtland's snake is currently recognized as *Clonophis kirtlandii*.

SCIENTIFIC NAME:	*Clonophis kirtlandii* (Kennicott, 1856)	
COMMON NAME:	Kirtland's snake	
FAMILY:	Colubridae	
SYNONYMS:	*Regina kirtlandii*	Kennicott, 1856
	Tropidoclonion kirtlandii	Cope, 1860
	Storeria kirtlandi	Jan, 1863
	Ischnognathus kirtlandi	Jan, 1865
	Tropidoclonium kirtlandii	Cope, 1875
	Tropidoclonium kirtlandi	Jordan, 1876
	Regina kirtlandii	Smith, 1879
	Tropidonotus kirtlandii	Garman, 1883
	Tropidoclonium kirtlandi	Hoy, 1883
	Clonophis kirtlandii	Cope, 1888
	Regina kirtlandi	Garman, 1884
	Natrix kirtlandi	Hay, 1892
	Tropidonotus kirtlandi	Hay, 1893
	Ischnognathus kirtlandii	Boulenger, 1893
	Natrix kirtlandii	Cope, 1895
	Clonophis kirtlandi	Blatchley, 1900
	Regina kirtlandii	Smith and Huheey, 1960
	Clonophis kirtlandii	Rossman, 1963
	Kirtland's water snake	
	Red-bellied garter snake	
	New-ground snake	
	Cora Kennicott's Snake	
	Kirtland('s red) snake	
	Little Red Snake	
	Ohio Valley Water Snake	
	Spread Head	

Please note that this is a partial synonymy list.

DESCRIPTION OF SPECIES

The Kirtland's snake is a small species, with adults reaching lengths of approximately 30-60cm. The dorsal background color is typically reddish brown to grayish brown, and is patterned with four longitudinal lines of dark, rounded blotches. The outer rows of blotches do alternate with the inner row on each side. While the blotches are generally prominent, they tend to become indistinct posteriorly, and may even be relatively inconspicuous in some individuals. The side of the body, below the blotches, is usually gray in coloration. The ventral surface is pink, red, or orange, and the edges of each scute are marked with a round black spot. With spots on every scute, the ventrum appears to be patterned with two parallel longitudinal rows of spots (Conant 1951). In some individuals the scutes between these outer most spots may also be marked with smaller dark colored dots, and their presence may be quite numerous, especially posteriorly (Conant 1951). The ventral coloration changes anteriorly, becoming more yellowish, and the chin, throat and labials are typically cream or yellowish (Conant 1943). The head of the Kirtland's snake is small, and is not readily distinguishable from the neck and body. It is generally dark in coloration and may be plain, mottled, or spotted yellowish to olive brown. The dorsal scales, particularly the middorsal scales, of the Kirtland's snake are strongly keeled.

Juvenile Kirtland's snakes are darker than adults, and their dorsal blotches may appear indistinguishable from the background. However, their dorsal pattern may be discerned when the skin between scales is stretched, as after ingesting food (Conant 1943). They are also still readily identified by the species' characteristic reddish ventral surface (which is generally darker colored in juveniles when compared to an adult) that is bordered by a single pair of round black spots on the edges of each scute.

Female Kirtland's snakes are typically larger in girth, and longer than males (Conant 1943). Tail length has been found to differ between the sexes: Conant (1943) found that tail length in males averaged 25% of total length, while in females it averaged 22%.

If disturbed, the Kirtland's snake will flatten its body to the extent that it appears almost ribbon-like (Conant 1951). Once an individual has assumed this appearance it will remain rigid, but if it is further disturbed it will wiggle erratically. Individuals may also strike, but their mouths will remain closed.

LIFE HISTORY

Reproduction

The majority of information on reproduction in Kirtland's snakes comes from a small number of snakes observed in captivity. In the wild, mating of Kirtland's snake has been documented and observed on only a handful of occasions: on May 1st in Indiana (Minton

2001), on May 10 and 14 in Illinois (Smith 1961), and on May 18 (D. Wynn, pers. comm.). While courtship and mating are believed to occur in the spring, there is also evidence that courtship and mating may occur in late summer. Anton et al. (2003) observed courtship behavior in mid-to-late September in captivity, and Minton (2001) similarly noted late summer (specific dates were not provided) mating in captivity.

Gravid females have been observed as early as May (Wilsmann and Sellers 1988). Minton (2001) observed 6 gravid females on June 16 in a "rubbish heap" in an Indianapolis vacant lot. There is some evidence that gestation sites may be limiting, and that gravid females will share gestation sites. Conant (1943) describes William Gessing discovering three gravid females all under the same rock.

Parturition has only been documented from captive situations. Young are born in late summer and early fall with dates ranging from July 30 (Minton 2001) through September 24 (Conant 1943), and clutch size has been reported to vary from 4 (Conant 1943) to 15 (Tucker 1976). Most neonates will shed their skins within 24 (Conant 1951, Tucker 1976) to 36 hours (Conant 1943).

Ecology

Due to the lack of research on the Kirtland's snake, very little is known about its ecology. The species inhabits moist, open environments, and the scant literature that is available mostly describes specimens observed in urban situations.

The majority of Kirtland's snakes have been observed during April, and it has been speculated that this time of year represents a peak in abundance (Minton 2001). However, this peak may also be due to other factors such as reduced vegetative cover and an increased need for basking after emergence from hibernation (Conant 1943). During this time of year individuals are often encountered under cover objects, such as stones, boards, logs, and other items of debris (Conant 1943). During warmer weather, particularly during summer, it is unknown where this species goes, as it is rarely encountered. Conant (1943) believed that it may retreat to moister environments, such as below ground, and may even go into temporary aestivation. Kirtland's snakes have also been associated with crayfish burrows (Wilsmann and Sellers 1988, Bavetz 1993).

More recent studies have suggested that the Kirtland's snake utilizes the burrows of some crayfish species as hibernacula, for seeking prey and moisture, and as a refuge to escape severe temperatures (Wilsmann and Sellers 1988). They may also use cracks in the substrate in areas of wetlands that have dried down for similar reasons (T. Anton, pers. comm.). Wilsmann and Sellers (1988) documented an association with the burrows of the chimney crayfish, *Cambarus Diogenes.* Bavetz (1993) reported that the crayfishes *Procambarus gracilis* and *Fallicambarus fodiens* share similar habitats in central Illinois, and are thus likely utilized by Kirtland's snakes. The use of burrows constructed by these two species has been recently supported from observations by Anton et al. (2003) in Will County, Illinois: four Kirtland's snakes were observed using a crayfish burrow in an area that contained the burrows of both *P. gracilis* and *F. fodiens*.

These data may be supported somewhat by Tucker's (1994) research on the fossorial behavior of the Kirtland's snake. Tucker found that Kirtland's snakes do not construct their own burrows, but will readily utilize pre-constructed burrows. In addition, Kirtland's snakes are more often found in burrows than exposed, and similarly will more frequently seek shelter under debris than remain in the open (Tucker 1994). The Kirtland's snakes propensity to seek refuge further attests to notes in the literature that the species is difficult to find.

The diet of the Kirtland's snake is comprised predominately of earthworms (Conant 1943, 1951, Minton 2001) and slugs (Conant 1943, Tucker 1977, Minton 2001). More recently, Thurow (1993) observed a Kirtland's snake regurgitate a water strider (*Gerris* sp.), and Bavetz (1993) found unidentifiable crayfish species in the stomachs of two Kirtland's snakes from Illinois. Tucker (1994) noted Kirtland's snakes eating earthworms within earthworm burrows, and interestingly observed that while Kirtland's snakes ate the native slug *Deroceras* sp., they did not eat the non-native European slug *Limax maximus.*

In captivity, Kirtland's snakes have eaten leeches (Tucker 1977) and fish (Conant 1951, Minton 2001), but have not shown an interest in amphibians (Conant 1943, 1951, Tucker 1977).

Dispersal/Migration

No studies have been conducted on the population biology of the Kirtland's snake, and no data is available on the home range size, or the dispersal abilities of this species. Accounts in the literature of individual Kirtland's snakes being found repeatedly in the same location have been suggestive of the species favoring refuges within their home ranges (Ernst and Barbour 1989). For example Minton (1972) caught individuals at the same spot on three different occasions in one year (capture dates included April 12, June 23, and September 22), and D. Wynn (pers. comm.) reports capturing an individual on May 21, and later recapturing the same individual at the same location on July 25, at which time it gave birth. However, this information may also indicate that Kirtland's snakes maintain very small home ranges. A further possibility is that the highly fragmented and isolated condition of their preferred habitat acts as a deterrent for the maintenance of larger home ranges, and dispersal.

Obligate Associations

Kirtland's snakes are known predominately from relatively open areas, within the immediate vicinity of a water source, such as a pond, lake, or sluggish stream. Another commonality between sites supporting Kirtland's snakes is that the area is prone to seasonal flooding, and that burrowing crayfish species are present. Crayfish species noted from areas supporting Kirtland's snakes include *Cambarus diogenes* (Wilsmann and Sellers 1988), *Procambarus gracilis* (Bavetz 1993, Anton et al. 2003), and *Fallicambarus fodiens* (Bavetz 1993, Anton et al. 2003).

HABITAT

Range-wide

While the habitat preferences of the Kirtland's snake have yet to be extensively quantified, the species is chiefly an occupant of moist, open meadow or wet prairie habitats. Much of this habitat has vanished from across the species range, and Kirtland's snakes are now largely confined to small patches of suitable habitat. Some of the most documented, largest known populations of Kirtland's snakes exist in old fields, parks and other urban settings, where the species may be found in open grassy areas with a nearby water source, such as a creek, pond, or ditch (Minton 2001). Outside of these urban areas, Kirtland's snakes may be found in wet grasslands, along the margins of ditches, ponds, lakes, creeks (Conant 1943, Bavetz 1994), and swamps, and within areas of swamp forest and meadowlands (Conant 1943). While open prairie-like habitats appear to be their favored environment, particularly within the central glaciated part of their range, Kirtland's snakes may also be found in forested settings. However, in these areas they will always be associated with aquatic (often seasonal) habitats such as woodland pools, small streams, and bogs (Conant 1943). Another common feature of sites supporting Kirtland's snakes is the presence of crayfish burrows (Wilsmann and Sellers 1988, Bavetz 1993, Anton et al. 2003).

National Forests

Kirtland's Snakes have been documented on the Hoosier National Forest in Indiana, and on the Huron-Manistee National Forest in Michigan. Two records exist for the Kirtland's snake from the Hoosier National Forest. One record was documented from Brown County and the second from Orange County. Unfortunately, specific habitat information is unavailable for these records. There are also two documented occurrences on the Kirtland's snake on the Huron-Manistee National Forest (MNFI). Both were recorded from within Muskegon County. The observed habitat at site one included a lake shoreline of mucky to sandy substrate, with crayfish burrows present. At this location the snake was observed under damp leaf litter. The second site within the Huron-Manistee comprised a brushy shoreline, surrounded by forested upland habitat.

Site Specific

Much of the documented specific habitat information on the Kirtland's snake comes from populations observed in parks and other urban settings in the core portion of the species range, i.e. in Indiana, Illinois, and Ohio. Site specific habitat requirements from within the core of the species range appear to include relatively open habitat, within the vicinity of a water body, which is prone to seasonal flooding, and where crayfish are active.

The majority of Kirtland's snake observations in Indiana have taken place in urban areas, predominately from in or near Indianapolis, and New Albany. For example, Minton

(1972) recorded 63 specimens between 1931 and 1935 from within the vicinity of New Albany, and Brown (1986) documented the collection of 54 specimens from a vacant lot in Indianapolis. Urban sites where Kirtland's snakes were observed within Indiana were reported to have certain features in common (Minton 1972). These included open, grassy areas with few trees, a water source (often in the form of a sluggish creek, or less frequently ponds and ditches), clay soil, and the presence of earthworms and crayfish burrows. Many of these sites were also noted to contain numerous cover items, often in the form of trash, such as sheet metal, cardboard (Minton 1972), old tires, and building materials (Brown 1986). Habitat in undisturbed areas was very similar to that observed in urban areas: wet, grassy areas along creeks, around the edges of swamp forest, and around the borders of ponds (Minton 2001). At most of these undisturbed sites, crayfish burrows were also evident (Minton 2001). Recent surveys in southern Indiana have also discovered the species in wet mature forest that had been heavily logged within the past three years (Z. Walker pers. comm.). All specimens were observed seeking shelter under cover items such as bark, old carpeting, and also within heavy grass (Z. Walker pers. comm.).

A recent study on the distribution of Kirtland's snakes in southern and western Illinois, found that extant populations are largely isolated in scattered patches of suitable habitat, ranging from wet forest to vacant suburban lots (Bavetz 1993). Habitat in these areas included the margins of creeks and man-made impoundments (for example, ponds and lakes), adjacent to open or mowed ground prone to immersion from seasonal flooding, and that also supports an active crayfish population (as evidenced by the presence of chimneys on the burrows) (Bavetz 1993). Kirtland's snakes were found under rocks in a stream during rains at a site in Illinois in May, 1985. They have also been found in every month of the year, including when snow was present (Avila, pers. comm., 1985).

Historically, the Kirtland's snake has been largely documented from urban situations in Ohio (Conant 1943). However, the best populations within the state are now found in wildlife areas (D. Wynn, pers. comm., C. Caldwell, pers. comm.). Habitats from these areas have been noted as primarily flat, open, meadowlands prone to seasonal flooding in early spring. Populations have also been observed in areas with more variable situations, ranging along smaller watercourses and ravines, and even on adjacent hillsides (Conant 1943).

Results from a range-wide survey of the Kirtland's snake, conducted by Wilsmann and Sellers (1988), also noted a strong association between Kirtland's snakes and a lake, pond, stream, or seasonally flooded habitat. Crayfish burrows were also commonly found at many locations.

DISTRIBUTION AND ABUNDANCE

Range-wide Distribution

Historically, the range of the Kirtland's snake included extreme southeastern Wisconsin, eastern Illinois, most of Indiana and the glaciated portion of Ohio, southern Michigan,

north central Kentucky, and western Pennsylvania (Conant 1943). Additional disjunct populations were also noted from Trenton, New Jersey and Delaware County, Pennsylvania (Conant 1943). The Kirtland's snake was also reported from West Virginia and Alabama in the 1930's, however these records were discounted by Conant (1943). Wright and Wright (1952) listed the presence of the Kirtland's snake in Ontario, Canada in their *List of Snakes of the United States and Canada by States and Provinces*; however, no other author has reported the presence of Kirtland's snakes in Canada, and this report is considered questionable (Bavetz 1993). The historical records from Wisconsin, eastern Pennsylvania, and New Jersey have since been questioned (Brandon and Bavetz 1992, Bavetz 1993), and the current range of the Kirtland's snake, as displayed by Conant and Collins (1991) extends from Ohio west to eastern Missouri, north to southern Michigan and south to northern Kentucky (see Figure 1). A small disjunct set of historical populations is also known from western Pennsylvania (including Allegheny, Butler, Forest, and Westmoreland Counties), however, the species has not been verified in the state since 1965 despite repeated survey efforts (Hulse et al. 2001). While Conant and Collins (1991) show the Kirtland's snake in northeast Missouri, Bavetz (1993) reports that its presence is based on a single record (Jones 1967 reported in Bavetz 1993), and that surveys in the state have failed to locate any additional individuals (Johnson 1988 reported in Bavetz 1993).

While the core of the Kirtland's snakes range in the Midwest appears contiguous, in reality populations are disjunct and widely separated. A range-wide survey of the Kirtland's snake between 1980 and 1987 concluded that the distribution of this species is currently restricted to greatly isolated populations in Michigan, Ohio, Illinois, Indiana, and Kentucky (Wilsmann and Sellers 1988, Bavetz 1993).

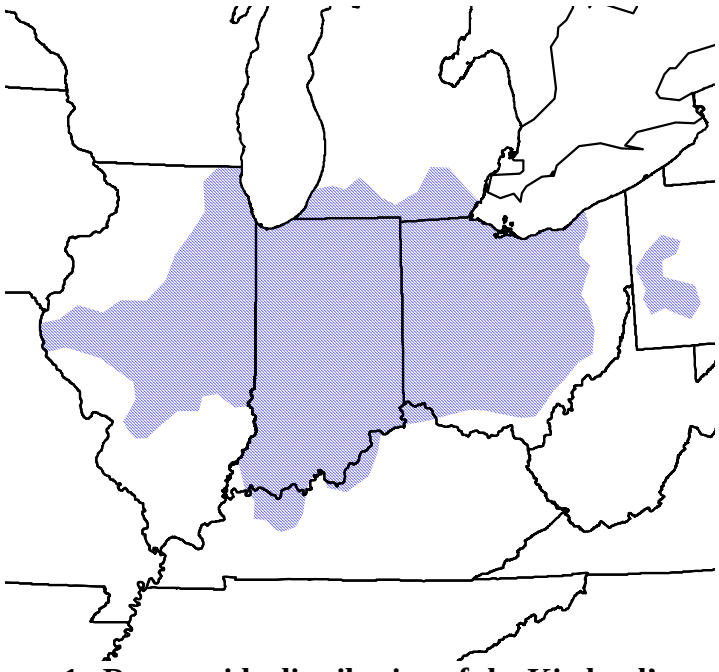

Figure 1. Range-wide distribution of the Kirtland's snake

State and National Forest Distribution

The current distribution of the Kirtland's snake is patchy at best, and recent surveys have had only limited success in locating individuals. Over the past 24 years (since 1980), Kirtland's snakes have been recorded from 58 counties across Illinois (14 counties), Indiana (20 counties), Kentucky (5 counties), Ohio (13 counties), and Michigan (6 counties) (please refer to Figure 2. Source information for this figure can be provided on request). More recently, within the last 14 years (since 1990), the Kirtland's snake has been reported from 39 counties: Illinois (10 counties), Indiana (13 counties), Kentucky (3 counties), Ohio (8 counties), and Michigan (5 counties) (please refer to Figure 3. Source information for this figure can be provided on request).

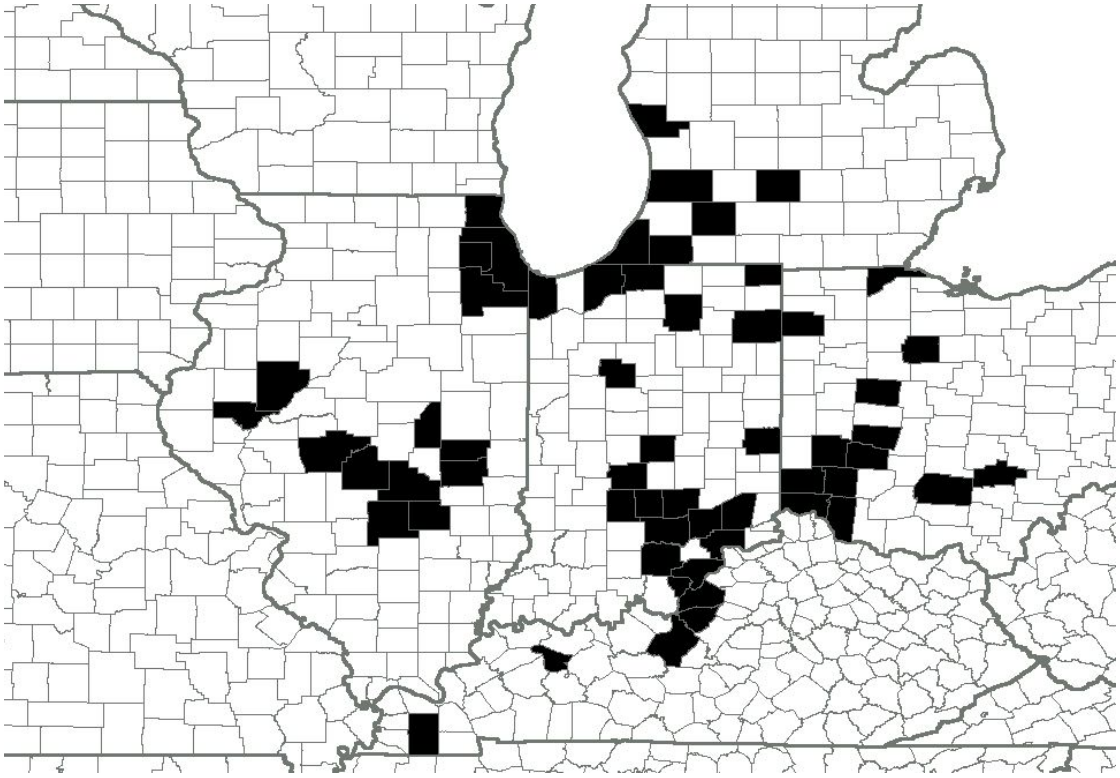

Figure 2. Counties where Kirtland's snakes have been documented from 1980 to the present.

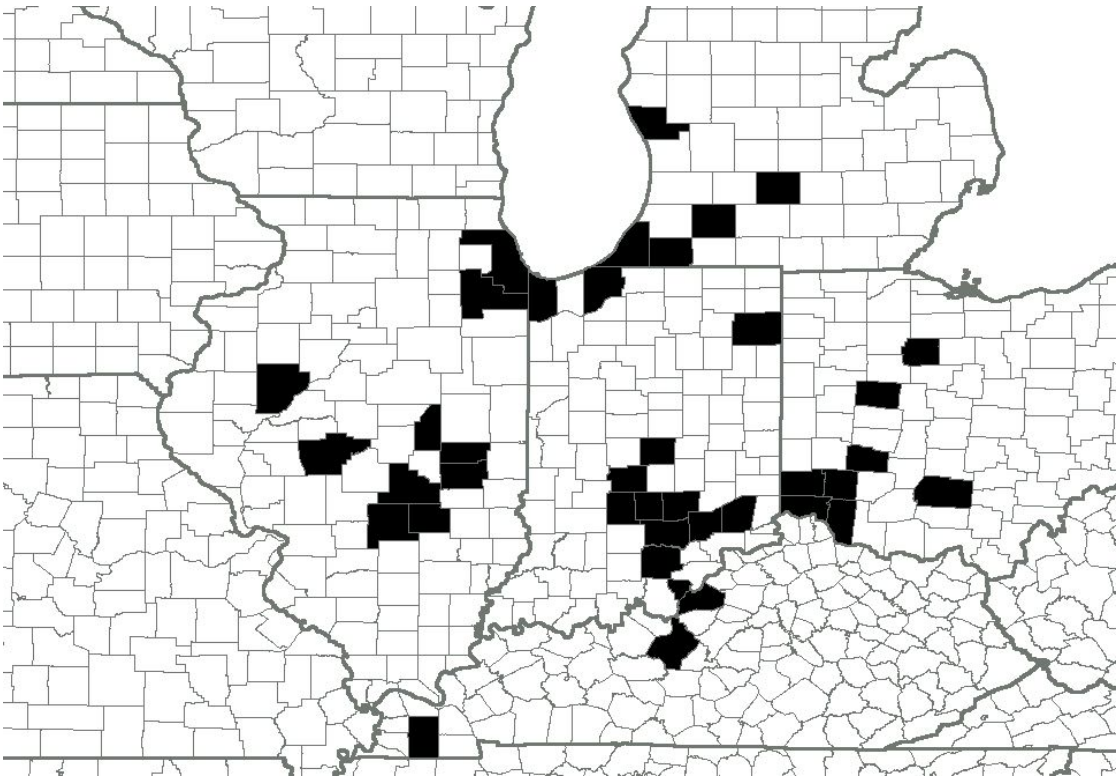

Figure 3. Counties where Kirtland's snakes have been documented since 1990.

Within the Eastern Region of National Forests, the Kirtland's snake has been documented on the Hoosier National Forest in Indiana and on the Huron-Manistee National Forest in Michigan. The Hoosier National Forest sightings were documented from Orange and Brown Counties, and were recorded in 1972 and 1985 respectively (Indiana Natural Heritage Database). Sightings from the Huron-Manistee National Forest were recorded from Muskegon County 1988 (Michigan Natural Features Inventory). More recent occurrences of this species at either the Hoosier or Huron-Manistee National Forests are unknown.

Other National Forests, and lands administered by the USDA Forest Service within Region 9, which also lie within the current distribution of the Kirtland's Snake, include the Midewin National Tallgrass Prairie in Illinois, and the Wayne National Forest in Ohio. No Kirtland's snakes have been documented from these areas, however the species has been detected close to the Wayne National Forest in Ohio (Hocking County). The Shawnee National Forest in southern Illinois is outside of the current accepted range of the Kirtland's snake, and the species presence there is thought to be unlikely (C. Phillips, pers. comm.).

RANGE WIDE STATUS

Across its range, the Kirtland's snake appears to be declining. Because the Kirtland's snake has been found with relative ease in some urban habitats, it was presumed that the

species was widespread and "common." However, current Kirtland's snake populations are of small size, and exist in mostly isolated patches of habitat that are highly prone to disturbance. While the Kirtland's snake has no federal protection, it is considered imperiled in all states where it currently occurs. It is listed as state endangered in Indiana, Michigan, and Kentucky, and state threatened in Illinois and Ohio. In addition, within the Eastern Region of the USDA National Forest Service, the Kirtland's snake is listed as a Regional Forester Sensitive Species (RFSS) on the Hoosier National Forest in Indiana, and on the Huron-Manistee National Forest in Michigan.

POPULATION BIOLOGY AND VIABILITY

As no ecological studies have been conducted on the Kirtland's snake, information is unavailable on its population biology or viability.

POTENTIAL THREATS

Present or Threatened Risks to Habitat

Habitat loss and degradation are important factors contributing to the decline of the Kirtland's snake. Habitat-altering activities such as urban development and agriculture have destroyed much of the native moist, open prairie habitats on which these snakes formerly survived. While many of these impacts occurred some time ago, such activities continue to threaten remaining populations. Most of the known populations of Kirtland's snakes currently reside in urban areas, which are at risk from future development. Few sites that currently support populations of Kirtland's snakes are actively conserved and managed with the species in mind.

Because of their preference for crayfish burrows, and their apparent heavy reliance on earthworms as prey, any activity affecting either of these groups of species will consequently affect Kirtland's snake populations. These activities may include changes to the hydrology of an area (such as the flooding or draining of wetlands), as well as soil and water pollution from urban and agricultural sources (Wilsmann and Sellers 1988). Researchers have noted the absence of Kirtland's snakes in areas of suitable habitat that were contaminated by chemicals (Wilsmann and Sellers 1988).

Ecological succession, as a result of the alteration of adjacent habitats, or through natural processes, also threatens this species, especially as remaining populations are isolated in highly fragmented patches of habitat. In these remnant patches of habitat, individuals are unlikely to succeed in migrating to more suitable areas. In addition, land managers controlling for ecological succession may also be inadvertently affecting the Kirtland's snake. Fire, once used as a control tool to maintain prairie habitat has been replaced in some areas by herbicides. These chemicals may ultimately affect the Kirtland's snake by adversely affecting other species that they rely on, notably earthworms and crayfish. However, fire may also lead to inadvertent direct take of snakes.

Over utilization

The pet trade industry has had an important effect on the abundance of the Kirtland's snake. When discovered, populations are often exploited by collectors. This is especially disappointing as these snakes do poorly in captivity: Conant (1943) noted that of the "considerable number" of wild-caught and adult specimens he kept, none survived over the winter months in captivity.

Disease or Predation

There has been one identified account of predation of a Kirtland's snake in the literature: a Black King Snake in Indiana (Minton 2001). Other predators of the Kirtland's snake may include other snakes, birds, and mammals. There is currently no information available on diseases that affect the Kirtland's snake.

Inadequacy of Existing Regulatory Mechanisms

Noted declines of Kirtland's snake populations across the species range suggest that current regulatory mechanisms and management practices are inadequate. While the species is listed as a Regional Forester Sensitive Species on the Huron-Manistee and Hoosier National Forests, management approaches are not specifically detailed for the Kirtland's snake. This is largely due to insufficient information on the species ecology, and even distribution, which makes management protocols difficult to implement, and monitor for success.

State regulatory mechanisms, for example the Kirtland's snake is listed as state endangered in Indiana, Michigan, and Kentucky, and state threatened in Illinois and Ohio, also appear to be inadequate for this species. While the Kirtland's snake is afforded protection by these states, public education, and management activities directly targeted at the species are unknown.

Research into the population ecology and distribution of the Kirtland's snake on the Hoosier and Huron-Manistee National Forests, and in other areas within the species range, would facilitate the creation of management approaches for this species. In particular, research efforts should focus on an assessment of the distribution of the Kirtland's snake within the Hoosier and Huron-Manistee National Forests, as well as on in-depth population ecology studies that focus on the daily and seasonal activity patterns of the species. Results from such initiatives would determine where regulatory mechanisms must be enforced, and when certain management activities may be safely conducted. In the short-term however, regulatory mechanisms may be improved by restricting management activities, such as mowing, burning, and logging, to those times when Kirtland's snakes are least active (for example, during winter months).

Other Natural or Human Factors

Human-related factors threatening the Kirtland's snake include vehicular traffic, mowers, and controlled burns. Mortality of Kirtland's snakes from vehicular traffic has been reported by Minton (1972), Bavetz (1993), and Walker (pers. comm.). Minton (1972) reported finding 18 dead individuals along a 0.4mile section of road; Bavetz (1993) noted that six of the specimens examined in his study were road kills; and Walker (pers. comm.) discussed that within an area containing a known colony in Indiana 186 Kirtland's snakes have been reported as road kill since 1989. In addition, Dalrymple and Reichenbach (1984) observed a total of 56 dead snakes (10 of which were their study animal *Thamnophis radix radix*) killed on roads during a six-hour period in the fall at their study site in Ohio. While Dalrymple and Reichbach (1984) did not disclose the exact number of each species killed, the authors did note that Kirtland's snakes were present at the site. More recently, in 2003, from the same study area in Ohio N. Yaussy (information referred by D. Wynn pers.comm.) recorded 469 road kill snakes, 17 of which were Kirtland's snakes.

Mowing may also threaten the Kirtland's snake, particularly given their preference for open, grassy habitats (particularly those in urban parks and rural settings). Dalrymple and Reichenbach (1984) observed 39 dead snakes (17 of which were *T. r. radix* – their study animal) at their study site directly following mowing operations. Again, while Dalrymple and Reichenbach (1984) did not disclose the exact number of each species killed from mowing operations, the authors did note that Kirtland's snakes were present at the site.

Controlled burns may also threaten the Kirtland's snake. While there have been no documented reports of Kirtland's snake mortality from burns, literature does exist on mortality of other snake species which share habitat types (Erwin and Stasiak 1979, Seigel 1986).

SUMMARY OF LAND OWNERSHIP & EXISTING HABITAT PROTECTION

Kirtland's snakes are likely found on a mix of both public and private lands across their range. However, due to difficulties involved in observing this species and a lack of in-depth information accompanying snake observation records, an accurate summary of land ownership details for Kirtland's snake populations is currently unavailable. In addition, because of the difficulties associated with observing Kirtland's snakes in the field, and the paucity of information on their ecology, habitat requirements, and distribution, existing habitat protection activities are likely inadequate.

On the Hoosier and Huron-Manistee National Forests, the Kirtland's snake is listed as a Regional Forester Sensitive Species. Though protection is afforded from this listing, no guidelines have been specifically developed for the protection of Kirtland's snake habitat, based on the species' ecology or needs, as part of the Forest Plan (A. Timm pers. comm.).

Appropriate habitat protection guidelines for the Kirtland's snake can only be developed as a result of research on their population ecology, habitat requirements, and distribution.

SUMMARY OF EXISTING MANAGEMENT ACTIVITIES

Paucity of literature on the Kirtland's snake is severely hampering the ability to make wise management decisions for protecting this snake. As a consequence, management activities would greatly benefit from long-term surveys, and also from detailed studies on its ecology.

While management activity does occur on the Hoosier and Huron-Manistee National Forests, these activities are very general, and targeted habitat improvement activities or specific management for the Kirtland's snake currently do not exist. While research on Kirtland's snake populations is sorely needed to assist in management recommendations, some management activities can be suggested based largely on research conducted on other snake species that share similar habitats to the Kirtland's snake such as the eastern massasauga (*Sistrurus catenatus catenatus*) and the plains garter snake (*Thamnophis radix radix*). Studies conducted on these species have highlighted their susceptibility to road and mower mortality (Dalrymple and Reichenbach 1984, Seigel 1986), as well as to mortality during controlled burning events (Erwin and Stasiak 1979, Seigel 1986). However, these studies also found that by monitoring the daily and seasonal activities patterns of these species, management strategies could be implemented to minimize snake mortality.

Road mortality has been found to vary seasonally, and is related to traffic volume and snake activity (Seigel 1986). Studies have found that by monitoring traffic volume, and snake activity patterns it is possible to identify when mortality is likely to be highest. By identifying periods of heightened sensitivity for snakes, management techniques can be adjusted, and even additionally implemented to alleviate mortality. Several management techniques have been suggested to help mitigate snake mortality on roads. These include erecting signs warning of the presence of snakes on roads, and asking drivers to show caution, erecting speed bumps to slow traffic, and enforcing seasonal road closures, particularly for stretches of road that see high snake mortality (Dalrymple and Reichenbach 1984, Seigel 1986).

Mowing operations are also responsible for snake mortality (Dalrymple and Reichenbach 1984, Seigel 1986). However, similarly to road mortality, mowing mortality may also be minimized by monitoring the daily seasonal activities of snakes, and consequently identifying those times when snake activity at the surface is minimal (Dalrymple and Reichenbach 1984, Seigel 1986). Based on studies conducted on snake species that share habitats similar to the Kirtland's snake, mortality may be mitigated by mowing during early morning hours when temperatures are likely to inhibit snake activity (Dalrymple and Reichenbach 1984, Seigel 1986). However, it is important to note that daily, seasonal activity does vary between snake species, geographic location, and is influenced by local weather conditions (for example, Kirtland's snakes may be active during early

morning hours, especially after rain). As such, recommendations specifically aimed at the Kirtland's snake should be made from data collected on the species at the local level.

Controlled burns may also be responsible for snake mortality, particularly if they are conducted during those times when snakes are active on the surface. Burning would thus be best scheduled during those times when surface activity is minimal. By monitoring Kirtland's snake daily and seasonal activity patterns at the local level, the best times to burn may be elucidated. Winter burns are least likely to impact Kirtland's snakes (because they are hibernating), however burning during this season is often impractical. Early spring or late fall burns are likely to mitigate mortality, but only if conducted before spring rains, and after migration to overwintering sites (in fall). Slow area burns are preferred, and it is best if habitat is burnt in patches, leaving a mosaic of burned and unburned areas (thus providing refuge areas to escape the burn) (Kingsbury et al., 2002).

Management plans should also consider the apparent importance of cover items to the Kirtland's snake. If unnatural ground debris is removed, it should be replaced with "natural" debris such as branches, bark, straw, etc. (Wilsmann and Sellers 1988).

Relatively open habitats, in close proximity to a water source, that are prone to seasonal flooding, appear to provide important habitat for the Kirtland's snake, particularly within the core of the species' range. Management activities on the Hoosier and Huron-Manistee National Forests should concentrate on identifying areas of suitable habitat, and protecting them. A buffer of upland habitat around these areas should also be preserved. While it is unknown to what extent Kirtland's snakes rely on upland habitat, activities within at least 100 m of presumed suitable habitat should be maintained until more data is available on Kirtland's snake ecology. Roe et al. (2003) found that an upland buffer of 125m would protect the majority of habitat used by *Nerodia erythrogaster neglecta.* Semlitsch and Bodie (2003) determined core habitat requirements from the edge of an aquatic site based on data compiled from five species of snake, and mean minimum and maximum distances included 168m and 304m respectively.

Whatever management activities take place in an area that may hold Kirtland's snakes, risk of soil compaction should be considered. In those areas where Kirtland's snakes are suspected to occur, activities which cause compaction should be avoided, or conducted only when the ground is frozen.

PAST AND CURRENT CONSERVATION ACTIVITIES

The Kirtland's snake is listed as state endangered in Indiana and Michigan, and state threatened in Illinois and Ohio. In addition, the species is listed as a Regional Forester Sensitive Species on the Hoosier and Huron-Manistee National Forests. However, aside from these listings, no conservation activities specifically targeting the Kirtland's snake have been implemented in any of the states mentioned.

RESEARCH AND MONITORING

Existing Surveys, Monitoring, and Research

Little research has been conducted on the Kirtland's snake, and current research activities in any state within the species range are unknown. Previous survey efforts have included a range wide survey between mid-April and late June 1985 (Wilsmann and Sellers 1988), a survey across mostly southern and western Illinois between June 1991 and October 1992 (Bavetz 1993), and a survey of 15 localities in Michigan in 1986 (Weatherby 1986). Recent efforts in Indiana have focused on the Muscatatuck River bottoms, Salt Creek Bottoms (Z. Walker pers. comm.) and Beanblossom Bottoms (V. Meretsky, pers. comm.).

Survey Protocol

A peer-reviewed and accepted survey protocol is currently unavailable for the Kirtland's snake, however a general protocol can be described from surveys that have been conducted in the past.

Previous surveys have been conducted in areas of suitable habitat from early spring to early summer, during periods of suitable weather, for example warm, rainy weather (Wilsmann and Sellers 1988, Bavetz 1993). The surveys have involved overturning (and replacing) cover items and debris, including natural and artificial items, particularly where these items are nearby the waters edge (Wilsmann and Sellers 1988, Bavetz 1993). The areas around crayfish burrows should also be searched (Wilsmann and Sellers 1988, Bavetz 1993), however it is important that the burrows are not physically disturbed. Cover boards placed over such burrows has proven to be productive in Illinois (T. Anton, pers. comm.).

Other survey techniques that have been employed include evening and early morning (for example, 2 hours after sunset and one hour before sunrise) road searches during warm rainy weather (Wilsmann and Sellers 1988). Drift-fencing has also been employed and has had mixed success. For example, Wilsmann and Sellers (1988) captured only five Kirtland's snakes from drift-fences constructed at ten survey sites. At one of these sites the drift-fence was run for two months without success, but during the same period four individuals were found within two meters of the fence buried under debris. The authors note that had the drift-fencing been installed earlier in the spring, or maintained through fall, the effort may have proved more successful.

Sites with suitable habitat should be visited on multiple occasions, particularly due to the noted difficulty of observing Kirtland's snakes. It should be stressed that failure to observe a Kirtland's snake does not necessarily mean that the species does not exist at a site, for example Wilsmann and Sellers (1988) note that even herpetologists who regularly visit sites with known Kirtland's snake populations report only occasional success in observing individuals.

Upon collecting a snake, standard morphometric data should be collected. It is important that snakes are returned to their exact point of capture after this data is collected.

Research Priorities

Ecological studies on the Kirtland's snake, from either urban/rural settings, or from areas of more "natural" habitat are long overdue, and the data gathered from such research would greatly benefit management and conservation plans for this little-known species. Research priorities must include the identification and status assessment of existing Kirtland's snake populations, particularly those in natural habitats (Wilsmann and Sellers 1988). As part of this effort, a survey protocol should be developed.

Intensive survey efforts are warranted, particularly within the core portion of the species range, and these should target areas of high quality habitat. While the identification of high quality, natural habitat should be a priority; populations existing in urban and rural settings also merit the focus of research activities.

Radio telemetry which details patterns of movement and habitat use would be extremely beneficial. Snakes could be monitored over their activity period to learn about how they move about their environment, and what macro and microhabitat components they prefer. Given the small size of the snakes, care will have to be taken on transmitter selection and placement.

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