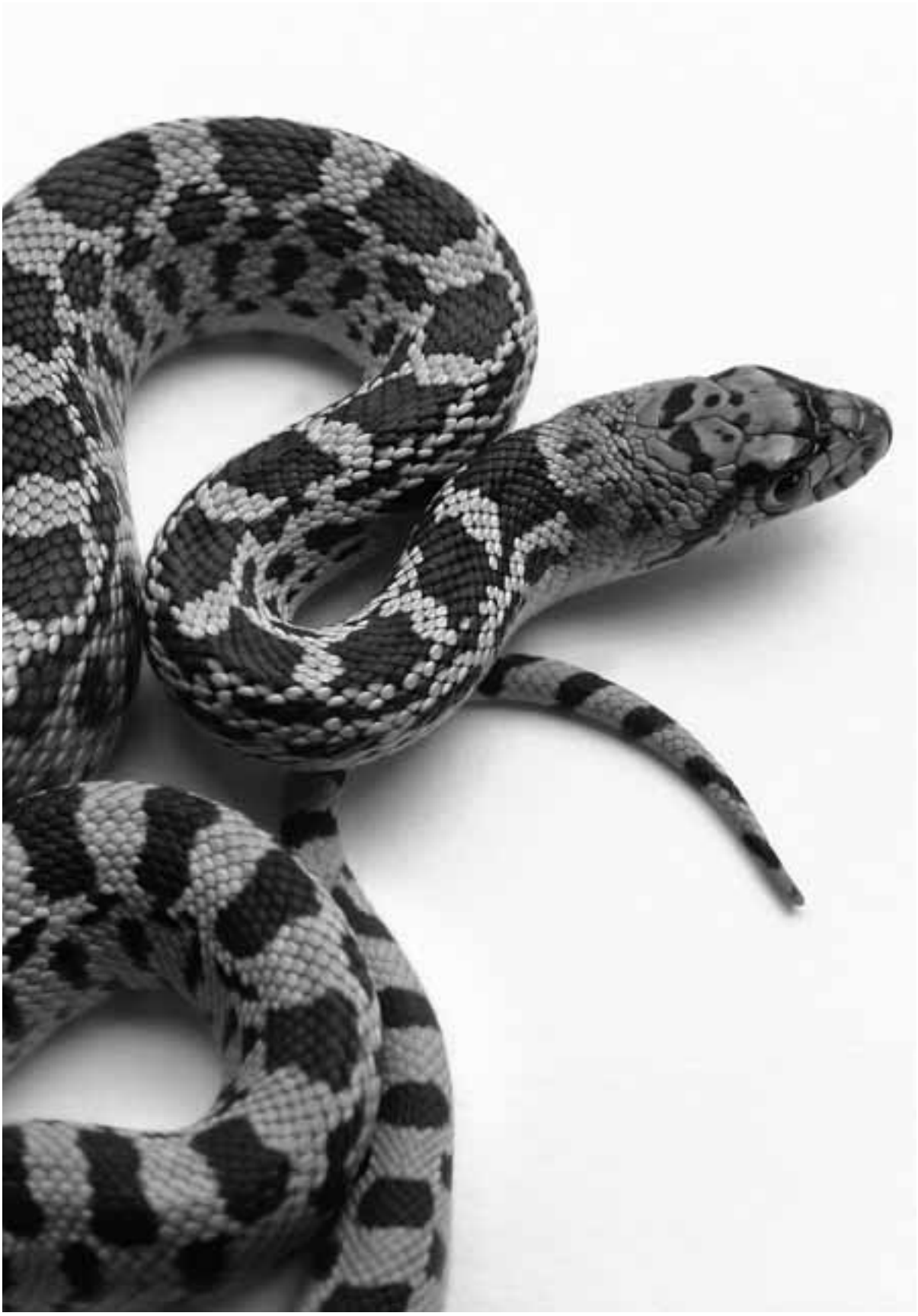

Bullsnakes (*Pituophis catenifer sayi*) are arguably the most impressive snakes in the upper midwestern United States.

Chasing Bullsnakes (*Pituophis catenifer sayi*) in Wisconsin: On the Road to Understanding the Ecology and Conservation of the Midwest's Giant Serpent

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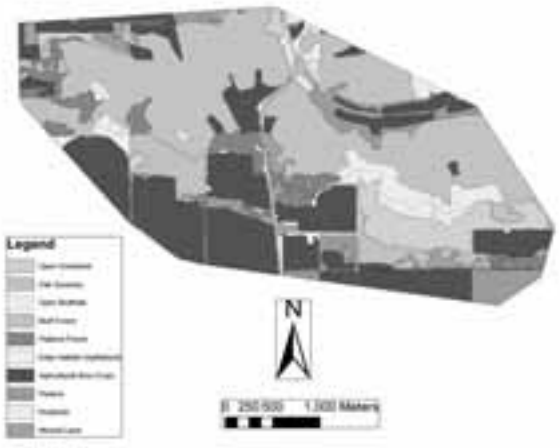
Photographs by the author except the facing page and where indicated.

When herpetologists weigh their options for new study locales, the upper midwestern United States (UMUS) does not leap to mind. This is particularly true of Wisconsin, which might evoke visions of Holstein cattle and knee-high snow for six months out of the year. To those who were born in warm climates, the "Badger State" might as well be the North Pole — certainly not a destination for herpetofaunal research. Also for this reason, graduate students in herpetology searching for tiny bits of space or funding to eke out an academic existence do not first cast their eyes northward. In addition to the cold, they perceive a lack of herpetofaunal diversity, which is true when compared to the tropics. However, the UMUS has a *nice* number of native species (I like to say a "manageable" number[1]), about many of which surprisingly little is known. Couple this with the fact that, for many of these species, the UMUS represents the periphery of their geographic distributions and an intersection of various habitat communities, interesting research questions start coming to mind. Therefore, conducting herpetological research in the UMUS (or, specifically, Wisconsin) can be a rewarding endeavor for those who pursue it.

Snakes are the most speciose group in this region, with slightly over 20 native species occurring here. Of these, the subfamily Colubrinae is largest, represented by six species: Smooth Greensnakes (*Opheodrys vernalis*), Racers (*Coluber constrictor*), Eastern Milksnakes (*Lampropeltis triangulum triangulum*), Western Foxsnakes (*Pantherophis vulpinus*), Gray Ratsnakes (*Pantherophis spiloides*), and Bullsnakes (*Pituophis catenifer sayi*). Among the true constrictors in this sub-family, Bullsnakes are arguably the most impressive in stature, often exceeding 5 ft (~150 cm) in snout-to-vent length (but I've received unconfirmed reports of 8 ft, or 240+ cm, individuals in Wisconsin). While this may not sound impressive to those who are fortunate enough to study boas and pythons, in a region where people mostly encounter gartersnakes that are less than a foot (~30 cm) in length, a five-foot plus snake is impressive.

The distribution of the Bullsnake in North America once was vast. In fact, members of the genus *Pituophis* have a historic range that covers much of the United States, from the eastern to western coasts, north into Canada, and south into Mexico. Bullsnakes are the most widely distributed species within this group, and their range encompasses most of the Great Plains Region and a portion of the Midwest. The Great Plains Region once was dominated by prairies and grasslands, and this habitat has become synonymous with Bullsnakes and Gophersnakes. Much of this habitat has been converted to agriculture since the time of European settlement, and, because of this, Bullsnakes now are most often associated with agriculture and the rural landscapes where they persist. In fact, the Bullsnake is often referred to as a "friend of the farmer" because of the voracity with which it consumes rodents. As early as 1926, Hisaw and



A map outlining habitat types available to radio-tagged Bullsnakes within the author's southwestern Wisconsin (USA) study area from 2003 to 2005 (permission to use copyrighted material granted by the American Society of Ichthyologists and Herpetologists).

[1] Wisconsin has 22 species of snakes, 11 species of turtles, four species of lizards, and 19 species of frogs, toads, and salamanders.

Gloyd reported on this species' ability to control "injurious" rodents and, more recently, Rodríguez-Robles (2002) reported that mammals such as pocket gophers, mice, and ground squirrels make up 75% of the diet. Unfortunately, this association with agricultural habitats often leads to mortality, as Bullsnakes spending an appreciable amount of time in agricultural fields often are killed inadvertently by farm equipment (see below and Kapfer et al. 2008a).

Despite their nearly pan-geographic distribution in North America, their importance in rodent control, and reported declines in several Midwestern states, relatively little research has been conducted on members of this genus. Although some studies have focused on habitat selection and movement patterns of Great Basin Gophersnakes in Utah, California, and British Columbia (Parker and Brown 1980, Shewchuk 1996, Rodríguez-Robles 2003) and the Northern Pinesnake in Tennessee and Florida (Gerald et al. 2006a, 2006b; Burger and Zappalorti 1998), the Bullsnake has received less attention. Until recently, the most thorough research on habitat associations and movements of this species had been conducted by Fitch (1999), who spent 50 years studying an entire snake assemblage in Kansas, and an unpublished report from Nebraska by Fox (1986), whose goal was to control snakes that were eating waterfowl eggs on a wildlife refuge. With the exception of Moriarty and Linck (1998), no studies of their ecology in the Midwest had been conducted. Although interesting, this study focused on the movement patterns of transplanted Bullsnakes that had been re-introduced into a recreated prairie, and the results may not be indicative of natural populations.

In Wisconsin, Bullsnakes are known primarily from disjunct populations in the southern and western parts of the state. Many factors are believed to have contributed to the decline of this species in the UMUS. Likely explanations include loss of preferred habitat via conversion to agriculture or encroachment of woody vegetation and mortality due to anthropogenic causes. Only a handful of Bullsnake sites in Wisconsin are found on public land, to which access for research is easily granted. Few of these sites control vegetative succession (invasion of grasslands by woody vegetation resulting from fire suppression), and the persistence of Bullsnake populations at such locations remains uncertain. This, coupled with their rarity in the state, makes them a difficult species to study if one hopes to achieve the large sample sizes necessary for conclusive results.

The Evolution of a Graduate Student Project

In 2002, my master's research at the University of Wisconsin-La Crosse was drawing to a close. At that time, I remember becoming intensely interested in the colubrine snakes of Wisconsin. Prior to that, I had focused my attention on the survival of tadpoles in agricultural ponds. However, even while collecting data for that research, I recall spending a substantial amount of time digging through piles of debris and flipping cover-boards in hopes of finding a snake or two at my study sites. Although I had enjoyed my research on frogs, my interests obviously were shifting. Soon, I was scouring literature databases for published information on colubrine snakes in the upper Midwest … and finding very little beyond what was contained in field guides. Clearly, this was the avenue I wanted to pursue as a researcher. Most snakes in this group were interesting ecologically, research on them was uncharted territory in the UMUS, and, most importantly, they were big constrictors (and big equals more fun in my book). Of species native to the region, the biggest (and therefore, likely to be the most fun to research) was the Bullsnake.

Looking back, I realize that I had been fortunate as a graduate student. I wanted to conduct research on Bullsnakes, but that was only half the battle. I needed a home at a university, a graduate advisor, and funding (for my research and to pay my bills). Luckily, I was able to convince Dr. James Coggins at the University of Wisconsin-Milwaukee that, although he was a parasitologist by trade, he really needed to take on a wannabe herpetologist as a grad student. I also had the support of the Wisconsin Department of Natural Resources, Bureau of Endangered Resources Herpetologist Bob Hay (an outstanding field herpetologist), who proved a source of excellent advice on countless occasions. In addition, Dr. Erik Wild, a herpetologist I had known for several years from the University of Wisconsin-Stevens Point, agreed to be an adjunct member of my graduate committee, for which I am forever grateful. Had these three individuals not been willing to be a part of my research, it would not have happened. On the downside, I would have to conduct my research on a very tight budget. I was able to acquire small grants that covered transmitters and implantation, PIT tags, and a GPS

This male Bullsnake was the first snake captured and implanted with a transmitter.

This Bullsnake was the only female that survived all three years of radio-telemetry research.

The author holds a male Bullsnake, the largest individual tracked during the study. Unfortunately, it was killed and eaten by a coyote.

This female was killed by a plow during the crop harvest in early fall 2005.

unit. The rest was borrowed or out-of-pocket, but I didn't care — I was going to conduct research.

In the spring of 2003, I began work in southwestern Wisconsin, an area associated with the "Lower Wisconsin River Valley." At the time, I decided that radio-telemetry, a well-established method for studies of snake ecology, would be employed to track snakes for three years. Prior to this research, I had been involved in a USGS radio-telemetry study on Leopard Frogs (*Lithobates pipiens*) in Minnesota, and had learned the subtleties of using the technology, which seemed (and still seems) to be the best possible option for elucidating detailed information about the habitat selection and movement of such secretive critters. With help, by April of '03 I had found a site likely to yield enough snakes to make good use of the transmitters I could afford (approximately 20).

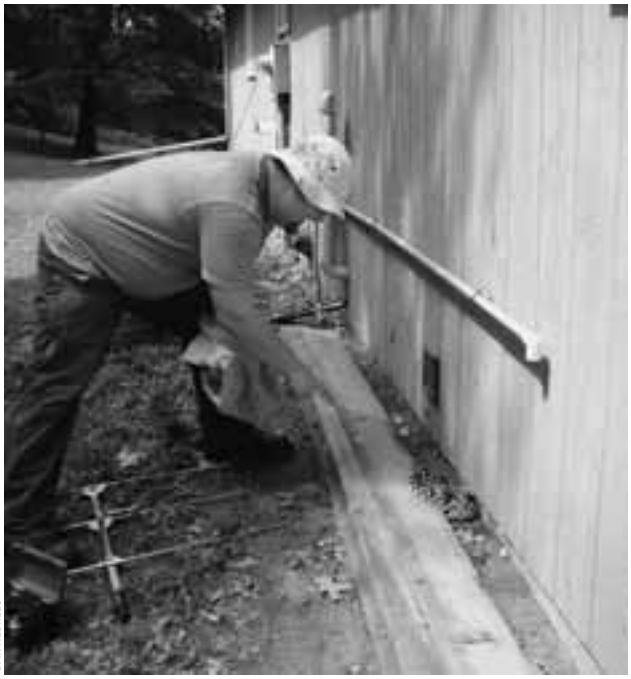
The first day of fieldwork was quite an experience. Bob (Hay) and I went to the study site in late April, hoping that the snakes had started to emerge from hibernation. We began walking across the prairie on a cloudy day and after only 15 or 20 minutes, I heard Bob say, "There's one, right there!" Sure enough, moving across the edge of a sandblow was a beautiful male Bullsnake. We were both pretty excited. Those who study amphibians and reptiles know that you can spend hours or days searching for some species and not find a single individual.

With our first snake in the bag, we split up. I went west, scouring brushy hillsides, and Bob went straight ahead, toward a more open hillside. As I worked over the slope, I occasionally glanced over at Bob to see if he was having any luck, but never got the feeling that he was finding anything. "That's alright," I remember thinking to myself, "If I can catch one snake every time I come out here, I'll still have a decent sample by May." About an hour later, we met in the middle on a large open hillside, with exposed rocky shelves and outcroppings around us. For a few minutes, we considered quitting. What we didn't realize was that things were about to get very busy. After deciding that we shouldn't give up so easily, we both started poking around brushpiles on the hillside where we had met. Within minutes we found another snake — a big one, then another. A few minutes later, we found yet another. I was amazed at how our luck had changed! We could hardly get the pillowcases ready fast enough to hold one snake before finding another. All in all, our day ended with eight Bullsnakes captured and ready for transmitter implantation. What a great start for the research project! At that time, I had no idea how fortunate we had been. Later I was to learn just how difficult these snakes are to find.

Bullsnake Populations and Sources of Mortality

That first year (2003), I ended with 21 adult Bullsnakes with implanted transmitters. This included the eight found on the first day of the study and four found with help from a UW-Madison Vertebrate Zoology class of approximately 50 students. This would be my most productive year for finding new snakes. In 2004 and 2005, I found 20 and 15 individuals, respectively. The most troublesome part of this decline in the number of new snakes was that females were encountered less frequently than males. In general, despite the large number of snakes caught that first day, Bullsnakes were not very abundant at this site, and I estimated a density of only 0.42 adults per hectare at the end of the study. Recapturing snakes without the aid of telemetry equipment also was very difficult. The low number of recaptures with only one surveyor present (i.e., me) made it unlikely that an adequate estimate of population size could be made. Only with the help of the UW-Madison students was I able to get recaptures within a reasonable amount of time. My only consolation was that low recapture rates in snakes of this genus are not uncommon (Fox 1986, Diller and Wallace 1996, Shewchuk 1996, Fitch 1999).

Bullsnakes face numerous daily pressures in addition to the long-term loss of suitable habitat. Traffic, farm equipment, wanton killing by unknowing landowners, and (I found during my research) predators all pose significant threats (Kapfer et al. 2008a). When I began tracking Bullsnakes in '03, I felt confident that few, if any, natural predators would consider taking an adult snake. I was fairly certain that birds of prey probably consumed juveniles and numerous predators likely ate hatchlings. However, I never believed that mammalian predators (such as coyotes) would be much of an issue, thinking that more abundant prey would result in a greater caloric payoff per unit effort than snakes. In fact, on numerous occasions, I saw coyote kill sites containing the remains of rabbits, turkeys, pocket gophers, and even deer. However, my assumptions were incorrect. In one year (2004), nearly all of the snakes consumed were taken by coyotes. Most of this mortality corresponded with heavy spring



DAN NEDRELO

Snakes frequently came into contact with humans. This individual was found near a farmhouse and might have been killed if the landowner had not been sympathetic toward snakes.

rains, which Jackson (1961) suggested could result in higher than normal leveret (= baby rabbit) mortality due to exposure. Could this have caused coyotes to shift from a preferred prey of rabbits to snakes? Possibly, but without having examined prey availability more closely, I can't say for certain.

In 2003 and 2005, farm equipment was, by far, the greatest cause of mortality in radio-tagged snakes, with females invariably experiencing higher mortality rates than males. In fact, in all three years pooled, the mortality rate for females with implanted transmitters was nearly 44%, compared to 14% in males (and nearly 27% for all snakes). Furthermore, most of the females taken by coyotes were gravid and likely killed prior to egg deposition, which is not a good omen for the persistence of these snakes in the region.

I did find that, despite equipment-related mortality, most local farmers were sensitive to this species. Many actually liked having Bullsnakes around, due to their effectiveness as rodent predators. Several of the local landowners actually accompanied me when I tracked my test subjects, hoping to get a look at them and see exactly what I was doing. Yet, agricultural equipment posed a definite threat to Bullsnake survival at this site. I found it strange that, despite the presence of suitable non-agricultural habitat readily available to the snakes I was tracking, many ventured into agricultural fields and often died. Considering my low Bullsnake density estimates compared to apparently abundant prey, competition for food seemed an unlikely reason for them to enter agricultural fields. Regardless, the tendency of this species to enter a burrow when danger approached did not save them from the digging tines of equipment used to harvest crops. Although most of the local farmers would not actively harm Bullsnakes, snakes hidden in burrows below crops were inadvertently killed by plows on several occasions.

Preferred Habitat and Movement Patterns

Aside from determining sources of mortality, a principal goal of my research was to document movements and habitat selection. The best available information on preferred habitat of this snake in Wisconsin was anecdotal, and came from Richard C. Vogt's (1981) field guide, *Natural History of Amphibians and Reptiles in Wisconsin* (Milwaukee Public Museum Press). Because Bullsnakes are considered rare or declining in several states in the UMUS (i.e., Minnesota, Iowa, and Wisconsin), a rigorous study on preferred habitats and movement patterns was necessary to facilitate their conservation.

Generally, this species is reported to prefer open canopy, short-grass prairie, or grassland habitats. I believed that these would be the habitats selected by the snakes I was tracking as well. The result of my research, however, was not so cut-and-dried. Throughout the year, I located individuals in habitats that I would never have imagined them using. For example, on more than one occasion, I followed individuals through dense underbrush in closed canopy hardwood forests on bluff sides (not a desirable task in the high humidity, 90°-days of July or August). I found later that these habitats were not preferred when their availability was considered (combined with agriculture, they equaled nearly 65% of the available habitat). This was not terribly surprising. What did surprise me, however, was that the traditional Bullsnake habitat (i.e., prairie and grassland) also was not preferred when based on its availability.

The habitat that was preferred by males and females in all three years of the study was open canopy, south- or west-facing bluffs. This was despite the fact that this habitat comprised only ~3% of available habitat (Kapfer et al. 2008b). Communal denning sites often are found on exposed bluff slopes such as these, so I had previously believed this habitat would be important to the Bullsnakes only immediately before and after winter dormancy. I had not anticipated that it would be used by snakes more than other available habitats in every season.

What I believe is important regarding my results on habitat preferences is that most long-term plans for prairie habitat management with which I have experience seem to focus mostly on eliminating woody vegetation (even native species, such as oaks) in flatland habitats. While helping native herbaceous

Table 1. Comparison of the percentage of the study site comprised of different habitats and proportion of total snake locations occurring in each habitat type.

Habitat Type	Percent Snakes in Habitat Types	Percent Availability of Habitat Types
Bluffside Forest	10	37
Row Crop	7	28
Flatland Forest	4	5
Pasture	3	5
Roadside	2	2
Edge (ag/nat)	6	3
Open Grassland	13	7
Oak Savanna	15	6
Open Bluff	33	3

Bullsnakes have a unique pattern unlike that of any other snake in the midwestern United States.

prairie vegetation proliferate is obviously important, a habitat with greater structural heterogeneity might be of greater value to wildlife — including reptiles, for which the elimination of woody vegetation tends to eliminate thermoregulatory opportunities. Ground temperatures on sand prairies are very high and often exceed 50 °C (pers. obs.). Although some reptiles may be able to tolerate such temperatures, I found that the average ground temperature where I observed Bullsnakes ranged from 29.8–30.7 °C (with body temperatures of 25.2–26.7 °C; Kapfer et al. 2008c).

Very open, short-grass habitats also contain fewer types of refugia from predators. Bullsnakes, for example, often were observed seeking shelter in fallen oak trees, brushpiles, or tangles of native woody vegetation (e.g., raspberry). If large expanses of such open flatland habitat are the goal for habitat managers, maintenance of edges or savanna-type habitats should also be considered. These can create refuges and movement corridors for wildlife. Regardless, in the UMUS, open south- or west-facing bluffs are critical habitats for this species. Therefore, clearing these slopes, if they are present on a particular site, may be necessary for the persistence of these snakes.

Snakes might be attracted to agricultural fields because winter-wheat fields look like grasslands in early spring. Tim Muehlfeld is an enthusiast and a good friend who assisted the author on numerous occasions.

Understanding the spatial ecology of this species is also important for their conservation. For example, knowing the distances that individuals travel or the areas they typically patrol during the active season can provide insights into the critical sizes of habitats that should be preserved. Something that became apparent early in the study was that these snakes are capable of moving long distances. On average, individuals moved nearly 35 m/day (Kapfer et al. 2008b). They also patrolled large home ranges. I measured home range using two different methods: (1) Minimum convex polygons are determined by simply connecting the outermost locations of an individual on a map, which then becomes the boundary of its home-range; and (2) Kernel estimates use the density and spread of location points for a radio-tagged individual as if they were plotted on a histogram, resulting in a greater proportion of the home range centered around areas where the highest density, or intensity, of locations occurs. Isopleth lines are generated, based on relative intensity of point concentrations, which allows core areas of the home range to be delineated. With this method, one can estimate the area that the animal is likely to patrol, while eliminating locations determined to be outliers. Minimum convex polygon home ranges ranged from 20 to nearly 50 hectares in tracked snakes, whereas kernel estimates for the same snakes ranged from 40–95 hectares. Both methods, however, indicated that these snakes moved about in large areas, suggesting that very large habitat preserves might reduce travel into agricultural fields or across roads, where mortality is high.

Although I rarely found snakes in the same location in subsequent observations, they often returned to the same locations after varying periods of time, resulting in a high fidelity for specific spots within their home ranges. This has obvious conservation and management implications: (1) Snakes that return to the same spots frequently may be accidentally killed during intense management practices (i.e., burning or cutting of undesirable vegetation that are conducted at the same locations annually); and (2) unscrupulous snake collectors can have a profound effect on Bullsnake populations by checking the same locations annually.

Finale

The following example of this species' tendency to end up in strange places also illustrates how the unpredictable nature of field research generates a need for future exploration of observed phenomena. This particular event came on a day when a friend of mine (Tim Muehlfeld) and I were tracking a male Bullsnake around a farmhouse. I had heard the snake's signal in the vicinity two days prior, but had not yet been able to ask the landowner for permission to enter his property. On this day, however, we did talk to the gentlemen who owned the property, and he was very willing to let us track the snake. I told him that it might be near his house and he seemed to become even more eager, wanting the snake moved so it would not scare his wife. We obliged and began searching for this snake's signal around the house's foundation, but I was surprised to find that the signal was very weak unless I pointed the antenna almost straight up.

At first I thought the snake might have moved to the backyard, and the signal became slightly stronger when we made our way around to the back of the house and into the entrance to his garage. I wondered if the snake was in the garage, behind the

An open bluff used by Bullsnakes in the upper Midwest. Note also the extensive agriculture in the adjacent flatlands.

garbage cans, or in a corner hunting rodents, but the signal seemed to be overhead. Not only was it overhead, it grew stronger as we moved toward the entrance to his house from the garage. I could tell that the landowner was uncomfortable with the thought of the snake being in his house. He looked at us and said, "Do you want to go inside the house?"

Within minutes, and after removing our dirty field shoes, we were cautiously moving about his living room in our stocking feet (I have to admit, it felt strange having to worry about breaking ornamental glassware with a telemetry antenna, which was something I never thought I would have to consider during my research). The signal strength quickly guided us to the upper level of the house, down a hallway, and into the bathroom. My first thought was "you're kidding! This snake is actually going to be in the toilet — the urban legend will come to life before our eyes!" Fortunately, that was not the case. What we did determine was that the signal was higher still, and strongest in a small area of the ceiling directly above the shower. The landowner immediately turned to me and asked, "Do you want to go into the attic?"

Although snakes used this incredibly thick understory vegetation under a dense canopy, it was used infrequently compared to its prevalence at my study site.

So, with him as our guide, the three of us marched to a ladder that led to a small rectangular opening in the ceiling of his home. Upon entering the attic, Tim and I shared the same feeling of dread. It was incredibly hot and not at all what I imagined a place where I would find a Bullsnake to be like. My first thought was that the animal had been eaten by a raccoon, which had swallowed the transmitter and was now in this man's attic. Looking back on it, such a scenario was as unlikely as us finding a Sasquatch, but strange things come to mind when you're in bizarre situations.

The next problem was that the attic was pitch black and not a "finished" room. We had to walk across cross beams between which insulation had been packed. Wearing only socks, balancing on narrow wooden beams in the dark, and holding a large telemetry antenna, I attempted to locate the snake in the beam of two small flashlights. The increasingly strong transmitter signal told us that the snake (or at least its transmitter) was somewhere in the attic.

Trying to get my bearings in the dark, I swung the antenna to the left and the signal got stronger. "It's somewhere over there," I said. "We've got to get this snake out of here before my wife gets home," the landowner replied uncomfortably. So, carefully stepping on crossbeams and grabbing anything overhead that we could use to stabilize ourselves, we moved in that direction. As the roof sloped downward, we noticed a long crack that allowed a small amount of light into that corner of the attic and, upon our arrival, saw a small group of birds make a hasty exit through the crack. At that point, I knew if that crack was large enough for birds to get in, it was large enough for a snake — and maybe we weren't looking for a dead snake after all. Then Tim spoke up: "I see it," as the beam of his flashlight rested on a Bullsnake coil, barely visible in the insulation. "Can you grab him?" I asked, as my hands were full and Tim was closest to the snake. He leaned against a nearby support beam so that he was almost vertical and snatched up the visible coil. He later confessed to me that he was certain the snake would be "mush" in his hand when he grabbed it (i.e., he'd be grabbing the decaying body of a dead snake). On the contrary, the second he laid a finger on the animal, it instantly curved its neck into a defensive posture and hissed loudly. It was alive and, we determined later, in perfect health.

The man asked me to remove the snake from his property. Although I was reluctant to do this, as it would confound the data I was collecting, he had been pretty understanding about the whole incident. So, I moved the snake nearly half a mile (0.8 kilometers) away and released it within its normal home range. A few days later, however, I discovered that the snake had obviously known where it wanted to be. It had returned to this specific property again, and was resting comfortably in the hollow of a maple tree along the landowner's driveway.

I've always wondered what that snake was doing in that hot, stuffy attic. Eating baby birds? It was too dark to see if any nests were present. What was a "prairie" snake species that is not thought to be very arboreal doing in the attic of a farmhouse? How did it find enough purchase on the house's exterior to climb up there? Was the attic part of its normal home range (it never did return to the attic)? I have no answers to these questions, but a desire to find such answers (in other words, curiosity) drives

In addition to open grasslands, management should consider preservation of Oak savanna and other habitats that are structurally heterogeneous and could provide refugia for wildlife.

those of use who choose to engage in science. Fortunately for me, snakes seem particularly effective in raising new questions.

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The infamous "attic snake" nearly scared a local landowner and his wife to death!

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