

# Distribution, Ecology, and Management Recommendations for the Narrow-headed Garter Snake (*Thamnophis rufipunctatus*) in Oak Creek, Arizona- part I of II

Adapted from an unpublished final report to Arizona Game and Fish Department in fulfillment of Heritage Grant 199007

Erika M. Nowak and Manuel A. Santana-Bendix, Northern Arizona University, USGS Colorado Plateau Field Station

## Introduction

The narrow-headed garter snake (*Thamnophis rufipunctatus*) is found in permanent drainages of the Mogollon Rim and White Mountains of Arizona and New Mexico and in the Sierra Madre Occidental range of Mexico (Tanner 1990, Rossman et al. 1996). It is threatened over much of its range due to the loss of habitat from development, modification, and siltation of creekside microhabitats,

the disappearance of native fish which appear to make up its primary diet, the introduction of non-native predators (e.g. fish and bullfrogs), and human predation (Rosen and Schwalbe 1988, Rossman et al. 1996, C. Painter, pers. comm.). The narrow-headed garter snake is considered a species of “special concern” in Arizona (Arizona Game and Fish Department in prep.) and was formerly listed under Category 2 of the Endangered Species Act.

Oak Creek in north-central Arizona (originating north of Sedona and terminating near Cottonwood) has

historically contained one of the largest populations of this species in the United States (Rosen and Schwalbe 1988, Fowle 1965). However, after intensive surveys for narrow-headed garter snakes in Oak Creek from 1985 to 1988 by Phil Rosen and Cecil Schwalbe (1988), it was estimated that the creek contained fewer than 1000 sub-adults and adults. Since those surveys, no further research had been conducted on the Oak Creek populations of narrow-headed garter snakes. However, biologists and others who looked for this species over the past decade reported that it was increasingly difficult to find in Oak Creek Canyon (J. O’Reilly, L. Luedecker, and R. Gasaway, pers. comm.). In 1999, we began a three-year study of the status, distribution, potential and actual prey, and habitat use of narrow-headed garter snakes in Oak Creek.

## Methods

Oak Creek is located in north-central Arizona, cutting through the Mogollon Rim in Coconino County near Sedona, and terminating at the Verde River

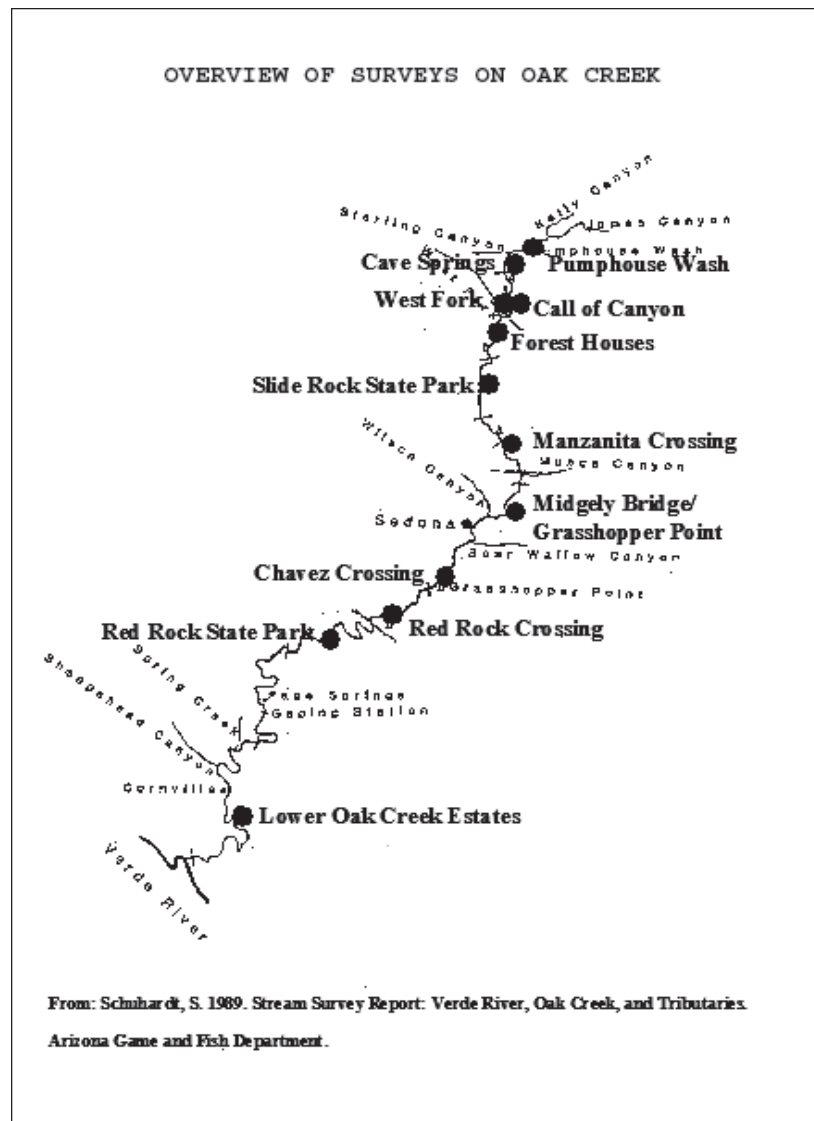


Figure 1. Location of 11 survey areas (indicated by circles and named) for *Thamnophis rufipunctatus* along Oak Creek, Arizona. Surveys were conducted from 1999 to 2001.

near Cottonwood in Yavapai County. The Creek is divided into two main physiographic areas: Oak Creek Canyon, from approximately 4300 to 5700 feet elevation; and the lower section south and west of the canyon, ending at approximately 3160 feet elevation.

Our primary method of detecting narrow-headed garter snakes was a form of visual encounter survey described by Crump and Scott (1994). We systematically walked time-recorded transects (each approximately one kilometer long) in eleven areas along Oak Creek and its tributaries one to two times a year between June and September 1999-2001. Each survey consisted of at least two people wading or walking along the edge of the creek, looking for the snakes basking on boulders, in rock crevices, on vegetation, or foraging in shallow water. We focused special effort on resurveying the area between Grasshopper Point and Midgley Bridge (approximately two km in length). We attempted to assess population trends of narrow-headed garter snakes in Oak Creek since Rosen and Schwalbe's (1988) surveys by replicating their methods as closely as possible, following detailed discussions with Phil Rosen. We conducted at least three walking surveys from Grasshopper Point to Midgley Bridge between June and August each year.

We also installed five to ten fabric or wire mesh minnow traps in each of four one-km locations along both banks of Oak Creek. Trapping occurred twice a month from June to August 2000-2001 over four days per session. These traps were also used to detect potential prey species (primarily fish) available to the snakes. We compared this capture information to that obtained by regurgitating prey from the snakes to determine prey use versus availability.

To ensure permanent individual identification of adult and subadult snakes, we injected unique 11 to 12 mm passive integrated microchip transponder (PIT) tags following the methods of Fagerstone and Johns (1987). Due to the potential for infections (J. O'Reilly and T. Hoffnagle, pers. comm.), we decided against using scale-clipping as a permanent identification method. We also sealed the injection site with veterinary skin glue to minimize potential infections. We scanned all snakes captured to determine if they had been previously tagged. Neonates were given an identifying paint mark on their backs to permit short-term identification, as they were judged too small for PIT-tagging.

Lastly, we described habitat conditions along five-meter wide plots running perpendicular from the middle of Oak Creek and extending five m<sup>2</sup> onto either the randomly-selected right or left bank (after McMahon et al. 1996 and Reinert 1993). We recorded 22 biotic and abiotic habitat variables for each plot that we felt could be important to the snakes. Two types of habitat plots were designated and

compared: "snake plots" corresponded to those locations where one or more snakes were observed and/or captured; and "random plots" corresponded to five randomly selected points in each of the 11 surveyed locations along the creek. If one of the habitat variables measured was of particular importance for the snakes, that particular variable would be present more often in snake plots than with random plots. As well, the higher or lower relative abundance of the snakes in one particular locality may have been an indication of a habitat variable that has particular importance for the snakes. To sort out which habitat variables were most important, we first performed a cluster analysis using the 22 habitat variables in order to establish the "ecological resemblance" between the eleven study sites (Ludwig and Reynolds 1988). Habitat variables within the resulting groups were then compared against each other using non-parametric procedures (e.g. Fisher Exact, Wilcoxon-Mann-Whitney U test, and Kruskal-Wallis tests, Sokal and Rohlf 1981).

## Results and Discussion

**Effort.** We conducted over 640 person-hours (number of hours spent in a given survey multiplied by the number of people in a survey) of fieldwork on narrow-headed garter snakes in 11 locations along Oak Creek (Figure 1). We set a total of 50 minnow traps every other week in four locations from June-September in 2000 and 2001, for a total of 1542 trap-nights (number of traps multiplied by the number of nights they were open). In the Grasshopper Point-Midgely Bridge resurvey area, we spent a total of 184 person-hours and 632 trap-nights.

**Snakes.** We found a total of 129 narrow-headed garter snakes in seven locations along Oak Creek (see Figure 2). Of the 129 snakes detected, 41 were neonates (SVL = 18-23 cm), 26 were subadults (SVL = 24-39 cm), 61 were adults (SVL  $\geq$  40 cm), and one's age was not determined. Only three individuals were recaptured: one adult in 2000 and two (one adult, one neonate) in 2001. This extremely low recapture rate does not permit us to calculate estimated population sizes for either the canyon as a whole nor for individual locations.

When the number of snakes detected per unit effort (person-hours or trap-night) by each method was compared among all 12 locations surveyed, walking surveys were the most effective. Walking surveys in all areas detected 61 total snakes, an average of 0.20 snakes per person-hour, i.e., five person-hours of walking were needed to detect one snake. Checking traps (not including snakes encountered inside traps) detected 32 total snakes, an

---

biologists and others who looked for this species over the past decade reported that it was increasingly difficult to find in Oak Creek Canyon

---

average of 0.15 snakes per person-hour (6.7 person-hours required to detect one snake). Finally, simply being out in the creek not especially looking for snakes was also somewhat effective: a total of 10 snakes, an average of 0.08 snakes per person-hour, were also seen during habitat surveys (i.e. 12.5 person-hours were required to detect one snake when not looking for them). As with many inventory projects, (e.g. Nowak et al. 2002), simply increasing time spent in the field increases the chances of encountering a target species through chance encounters.

We detected the most snakes per unit effort at the Call of the Canyon Recreation Area (Figure 2). This area also contained the highest total number of snakes detected (42). There was no clear pattern of distribution and

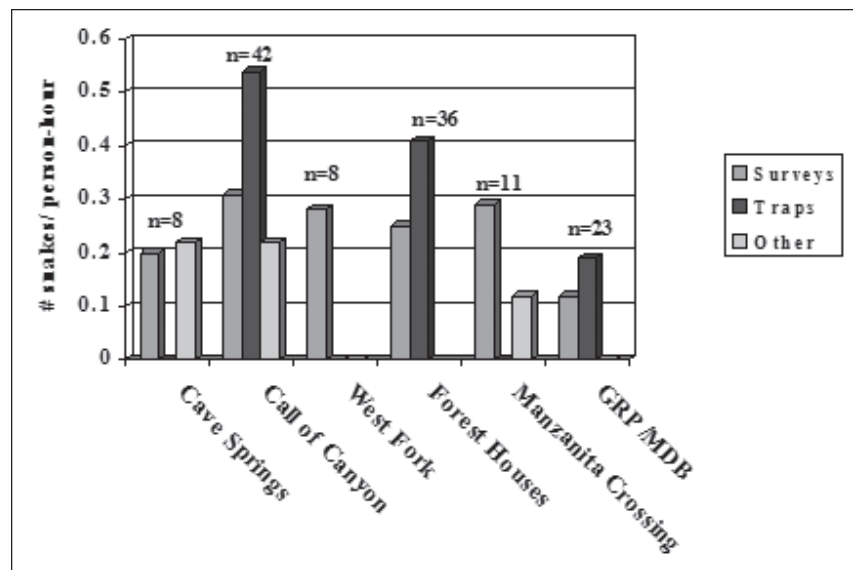
abundance in Oak Creek from higher to lower elevation, except that no snakes were found outside (south of) the canyon. However, most of the narrow-headed garter snakes were found in the upper-middle reaches of the creek (in the locations nearest Call of the Canyon).

Traps captured a total of 24 snakes, an average of 0.01 snakes detected per trap-night, or 66.6 trap-nights needed to detect one snake. These results are in contrast to those from narrow-headed garter surveys in San Francisco River, New Mexico, in which minnow traps proved far more effective than walking surveys in detecting and recapturing garter snakes (C. Painter, pers. comm.). We suspect this difference may be due to differences in the type of habitat available in the two areas: the San Francisco River study area contains a large number of vertical cracks in lava flows adjacent to the creek in which the snakes hide and bask. Oak Creek does not contain equivalent hiding places for the snakes.

We found fewer narrow-headed garter snakes per unit effort of walking surveys in the Midgley Bridge-Grasshopper Point area when compared with other areas. These results are in sharp contrast to those of Rosen and Schwalbe (1988) and Rosen, unpubl. data, who

conducted surveys for narrow-headed garter snakes in five of the same areas of Oak Creek as us from 1985-1988. Rosen and Schwalbe found more narrow-headed garter snakes per person-hour than we did in three of the four areas where we have comparable data (Rosen and Schwalbe 1988 and unpubl. data). Overall, they conducted a total of 222 person-hours of walking surveys (their only method) and found a total of 146 snakes (0.66 snakes per person-hour). They had five recaptures. To compare, we conducted a total of 299 person-hours of walking surveys and found 61 snakes

(no recaptures) using this method, or 0.20 snakes per person-hour. In the Midgley Bridge-Grasshopper Point area, we conducted a total of 68 person-hours of walking surveys and found 8 narrow-headed garter snakes



**Figure 2.** Number of *Thamnophis rufipunctatus* detected by unit effort (in person-hours) at each of six locations in Oak Creek, Arizona, during 1999-2001 by different methods. Methods include walking surveys, checking minnow traps (including snakes caught in traps), and habitat surveys and random encounters ("Other"). The total number of snakes caught per site is given above each set of columns, and does not include one snake seen at Slide Rock State Park.

(0.09 snakes/person-hour), and Rosen and Schwalbe found 136 snakes during 182 person-hours of walking surveys, or 0.75 snakes/person-hour. Results from these previous surveys are compared to ours in Figure 3.

**Potential and Actual Snake Prey.** We found a total of eight fish species (445 individuals), one frog species (31 individuals), and unknown crayfish species (21 individuals) in the minnow traps. The species include: brown trout *Salmo trutta*, Gila sucker *Catostomus insignis*, speckled dace *Rhinichthys osculus*, lowland leopard frog *Rana yavapaiensis*, mosquitofish *Gambusia affinis affinis*, green sunfish *Chaenobryttus cyanellus*, rock bass *Ambloplites rupestris*, largemouth bass *Micropterus salmoides*, and smallmouth bass *Micropterus dolomieu*. No species was captured at all four sites. Brown trout and speckled dace were the most wide-ranging (although captured only within Oak Creek Canyon). Rock bass were the most numerous captured species, but the majority of their numbers came from Midgley Bridge.

An interesting pattern of distribution emerges when the native versus non-native status of the potential prey species and their body type are

examined. Of the total vertebrate species detected in traps, 67% were non-native fish (and there were a few non-native crayfish at Red Rock State Park as well). Perhaps more importantly from a predator perspective, 44% were spiny-rayed fish. These (all non-native) bass and sunfish are compressed laterally rather than ventrally, so they have tall body profiles, and they also have stiff, spiny dorsal rays and/or pectoral fins (Minckley 1973). The other fish and frog species detected are dorsal-ventrally compressed and do not have bony dorsal and/or pectoral fins, giving them a smooth, flattened appearance. We detected no native fish with spiny rays in Oak Creek. Figure 4 shows the number of fish of each of the three status and body types captured in each location.

A clear pattern emerges: there are more native potential prey species higher in Oak Creek Canyon, while none were detected outside the canyon. Equally importantly, the percent of soft-rayed species of both status types declines as one moves south and out of the canyon. Native, soft-rayed species within the canyon become replaced by non-native spiny fishes as one moves from north to south in Oak Creek (also observed by Rosen and Schwalbe, 1988). This trend closely parallels narrow-headed garter snake abundance within our survey areas of Oak Creek.

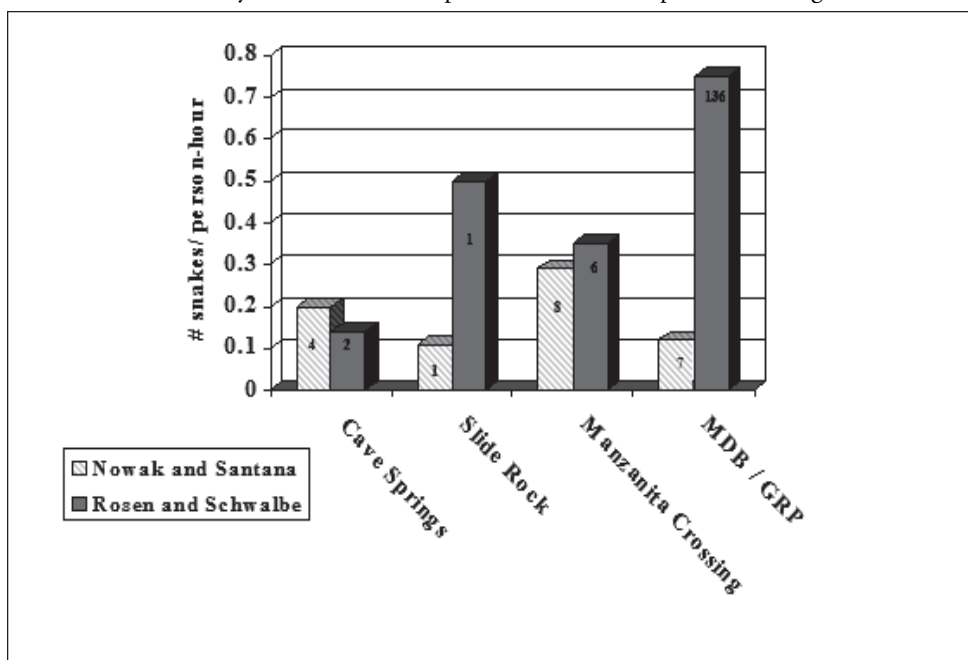
We feel that the spiny nature of the non-native fish species widespread lower in Oak Creek may make them

unsuitable as narrow-headed garter snake prey. Snakes occasionally choke to death while eating spiny food, so there may be an innate or learned tendency to avoid such prey items (pers. obs.). Another reason that non-native fishes may be unsuitable as prey items for narrow-headed garter snakes may be their preferred

location in the water column. De Quieroz (2002) found that narrow-headed garter snakes predominately forage by crawling on the substrate bottom and striking at prey underwater (as compared to other garter snakes which only use these behaviors in deep water). We have observed that native suckers are predominately bottom-dwellers, while non-natives such as bass appear to spend more active time higher in the water column.

The predatory behavior of non-native fish as well as their unsuitability as food items may also have influenced any declines in garter snake populations within Oak Creek, especially in the Midgley Bridge area and reaches south of the canyon. Rosen and Schwalbe (1988, 2002) have shown that non-native fish species such as small-and large-mouth bass are major predators on garter snakes elsewhere in the state. During surveys between 1983 and 1988 across the range of narrow-headed garter snakes in Arizona, they tended to not find this snake species in locations that contained non-native fish species (Rosen and Schwalbe 2002). In addition to this negative association with exotic fishes, they also showed a significant positive association with native fishes. They pointed out that since 1973 the proportion of non-native fish species has increased in many historic *T. rufipunctatus* locations across the state, while native fish species have declined. Twelve percent of the narrow-headed garter snakes we found had bite marks or other scars on their bodies (however, we do not know exactly how these injuries were caused), compared to 41% of the snakes Rosen and Schwalbe (1988) found during their surveys.

Garter snakes tended to be trapped more often in traps that caught fish and frogs rather than those that did not: at Forest Houses Resort, four of seven snake captures occurred in traps that also caught fish; at



**Figure 3.** Number of *Thamnophis rufipunctatus* detected per person-hour of walking surveys in four areas of Oak Creek, Arizona. Comparison by Nowak and Santana – Bendix (this report, 1999-2001) and Rosen and Schwalbe (1988 and unpubl. data). Methods between the two studies are assumed to be comparable. Total number of snakes found at each location is given in each column

Midgley Bridge nine of 12 snake captures occurred in traps that caught fish and/or frogs; and at Call of the Canyon four of five snakes were found captured in traps that caught fish. At both Forest Houses Resort and Midgley Bridge, we caught snakes that were sitting on top of traps with fish (speckled dace or brown trout) captured in them.

Part II continued next month