DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

50 CFR Part 17

[Docket No. FWS–R2–ES–2013–0071; 4500030113]

RIN 1018–AY23

Endangered and Threatened Wildlife and Plants; Threatened Status for the Northern Mexican Gartersnake and Narrow-headed Gartersnake

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Proposed rule.

SUMMARY: We, the U.S. Fish and Wildlife Service (Service), propose to list the northern Mexican gartersnake (*Thamnophis eques megalops*) and narrow-headed gartersnake (*Thamnophis rufipunctatus*) as threatened species under the Endangered Species Act of 1973, as amended (Act). If we finalize this rule as proposed, it would extend the Act's protections to these species. The effect of this regulation is to conserve northern Mexican and narrow-headed gartersnakes under the Act.

DATES: We will accept comments received or postmarked on or before September 9, 2013. Comments submitted electronically using the Federal eRulemaking Portal (see **ADDRESSES** section, below) must be received by 11:59 p.m. Eastern Time on the closing date. We must receive requests for public hearings, in writing, at the address shown in the **FOR FURTHER INFORMATION CONTACT** section by August 26, 2013.

ADDRESSES: You may submit comments by one of the following methods:

(1) *Electronically:* Go to the Federal eRulemaking Portal: *http://www.regulations.gov.* Search for Docket No. FWS–R2–ES–2013–0071, which is the docket number for this rulemaking. When you locate this document, you may submit a comment by clicking on ''Comment Now!''

(2) *By hard copy:* Submit by U.S. mail or hand-delivery to: Public Comments Processing, Attn: FWS–R2–ES–2013–0071; Division of Policy and Directives Management; U.S. Fish and Wildlife Service; 4401 N. Fairfax Drive, MS 2042–PDM; Arlington, VA 22203.

We request that you send comments only by the methods described above. We will post all comments on *http://www.regulations.gov.* This generally means that we will post any personal information you provide us (see the Information Requested section below for more information).

FOR FURTHER INFORMATION CONTACT: Steve Spangle, Field Supervisor, U.S. Fish and Wildlife Service, Arizona Ecological Services Field Office, 2321 West Royal Palm Road, Suite 103, Phoenix, AZ 85021; telephone: 602–242–0210; facsimile: 602–242–2513. If you use a telecommunications device for the deaf (TDD), call the Federal Information Relay Service (FIRS) at 800–877–8339.

SUPPLEMENTARY INFORMATION:

Executive Summary

Why we need to publish a rule. Under the Endangered Species Act (Act), if a species is determined to be an endangered or threatened species throughout all or a significant portion of its range, we are required to promptly publish a proposal in the **Federal Register** and make a determination on our proposal within one year. Listing a species as an endangered or threatened species can only be completed by issuing a rule. Elsewhere in today's **Federal Register**, we propose to designate critical habitat for the northern Mexican and narrow-headed gartersnakes under the Act.

This document consists of:

• A proposed rule to list the northern Mexican and narrow-headed gartersnakes as threatened species throughout their ranges, and

• A proposed special rule under section 4(d) under the Act that outlines the prohibitions necessary and advisable for the conservation of the northern Mexican gartersnake.

The basis for our action. Under the Act, we can determine that a species is an endangered or threatened species based on any of five 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; or (E) other natural or manmade factors affecting its continued existence. In the case of the northern Mexican and narrow-headed gartersnakes, we have determined that harmful nonnative species (spiny-rayed fish, bullfrogs, and crayfish), wildfires, and land uses that divert, dry up, or significantly pollute aquatic habitat have solely or collectively affected these gartersnakes, and several of their native prey species, such that their resiliency, redundancy, and representation across their ranges have been significantly compromised.

We will seek peer review. We are seeking comments from knowledgeable individuals with scientific expertise to review our analysis of the best available science and application of that science and to provide any additional scientific information to improve this proposed rule. Because we will consider all comments and information received during the comment period, our final determinations may differ from this proposal.

Information Requested

We intend that any final action resulting from this proposed rule will be based on the best scientific and commercial data available and be as accurate and as effective as possible. Therefore, we request comments or information from other concerned governmental agencies, Native American tribes, the scientific community, industry, or any other interested parties concerning this proposed rule. We particularly seek comments concerning:

(1) The species' biology, range, and population trends, including:

(a) Habitat requirements for feeding, breeding, and sheltering;

(b) Genetics and taxonomy;

(c) Historical and current range, including distribution patterns;

(d) Historical and current population levels, and current and projected trends; and

(e) Past and ongoing conservation measures for these species, their habitat or both.

(2) The factors that are the basis for making a listing determination for these species under section 4(a) of the Act (16 U.S.C. 1531 *et seq.*), which 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; or

(e) Other natural or manmade factors affecting its continued existence.

(3) Biological, commercial trade, or other relevant data concerning any threats (or lack thereof) to these species and existing regulations that may be addressing those threats.

(4) Additional information concerning the historical and current status, range, distribution, and population size of these species, including the locations of any additional populations of these species.

(5) Any information on the biological or ecological requirements of these species, and ongoing conservation measures for the species and their habitats.

(6) Any information on the projected and reasonably likely impacts of climate

change on the northern Mexican gartersnake and narrow-headed gartersnake.

Please include sufficient information with your submission (such as scientific journal articles or other publications) to allow us to verify any scientific or commercial information you include.

Please note that submissions merely stating support for or opposition to the action under consideration without providing supporting information, although noted, will not be considered in making a determination, as section 4(b)(1)(A) of the Act directs that determinations as to whether any species is a threatened or endangered species must be made ''solely on the basis of the best scientific and commercial data available.''

You may submit your comments and materials concerning this proposed rule by one of the methods listed in the **ADDRESSES** section. We request that you send comments only by the methods described in the **ADDRESSES** section.

If you submit information via *http://www.regulations.gov,* your entire submission—including any personal identifying information—will be posted on the Web site. If your submission is made via a hardcopy that includes personal identifying information, you may request at the top of your document that we withhold this information from public review. However, we cannot guarantee that we will be able to do so. We will post all hardcopy submissions on *http://www.regulations.gov.* Please include sufficient information with your comments to allow us to verify any scientific or commercial information you include.

Comments and materials we receive, as well as supporting documentation we used in preparing this proposed rule, will be available for public inspection on *http://www.regulations.gov,* or by appointment, during normal business hours, at the U.S. Fish and Wildlife Service, Arizona Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**).

Previous Federal Actions

The northern Mexican and narrow-headed gartersnakes were placed on the list of candidate species as Category 2 species on September 18, 1985 (50 FR 37958). Category 2 species were those for which existing information indicated that listing was possibly appropriate, but for which substantial supporting biological data to prepare a proposed rule were lacking. In the 1996 Candidate Notice of Review (February 28, 1996; 61 FR 7596), the use of Category 2 candidates was discontinued, and the northern Mexican and narrow-headed gartersnakes were no longer recognized as candidates.

On December 19, 2003, we received a petition from the Center for Biological Diversity (''petitioner'') dated December 15, 2003, requesting that we list the northern Mexican gartersnake as threatened or endangered, and that we designate critical habitat concurrently with the listing. The petition was clearly identified as a petition for a listing rule and contained the names, signatures, and addresses of the requesting parties. Included in the petition was supporting information regarding the species' taxonomy and ecology, historical and current distribution, present status, and actual and potential causes of decline. We acknowledged the receipt of the petition in a letter to the petitioner, dated March 1, 2004. In that letter, we also advised that, due to funding constraints in fiscal year (FY) 2004, we would not be able to begin processing the petition at that time.

On May 17, 2005, the petitioner filed a complaint for declaratory and injunctive relief, challenging our failure to issue a 90-day finding for the northern Mexican gartersnake in response to the petition as required by 16 U.S.C. 1533(b)(3)(A) and (B). In a stipulated settlement agreement, we agreed to submit a 90-day finding to the **Federal Register** by December 16, 2005, and if substantial, submit a 12-month finding to the **Federal Register** by September 15, 2006 (*Center for Biological Diversity* v. *Norton,* CV–05–341–TUC–CKJ (D. Az)). The settlement agreement was signed and adopted by the District Court of Arizona on August 2, 2005.

On December 13, 2005, we made our 90-day finding that the petition presented substantial scientific information indicating that listing the northern Mexican gartersnake may be warranted; the finding and our initiation of a status review was published in the **Federal Register** on January 4, 2006 (71 FR 315).

On September 26, 2006, we published a 12-month finding that listing of the northern Mexican gartersnake was not warranted because we determined that not enough information on the subspecies' status and threats in Mexico was known at that time (71 FR 56227). On November 17, 2007, the petitioner filed a complaint for declaratory and injunctive relief pursuant to section 11 of the Act (16 U.S.C. 1540), seeking to set aside the 12-month finding. Additionally, a formal opinion was issued by the Solicitor of the Department of the Interior, ''The Meaning of In Danger of Extinction Throughout All or a Significant Portion of Its Range'' (U.S. DOI 2007), which provides further guidance on how to conduct a detailed analysis of whether a species is in danger of extinction throughout a significant portion of its range. In December 2007, the Service withdrew the September 26, 2006, 12-month finding in order to consider the new ''Significant Portion of the Range'' policy. In a stipulated settlement agreement with the petitioner, we agreed to submit a new 12-month finding to the **Federal Register** by November 17, 2008 (*Center for Biological Diversity* v. *Kempthorne,* CV–07–596–TUC–RCCJ (D. Az)). The settlement agreement was signed and adopted by the District Court of Arizona on June 18, 2008.

On May 28, 2008, we published notice (73 FR 30596) of our intent to initiate a status review for the northern Mexican gartersnake and solicited the public for information on the status of, and potential threats to, this species.

On November 25, 2008, we published a second 12-month finding that listing of the northern Mexican gartersnake was warranted but precluded by other listing priorities at that time (73 FR 71788). The petitioner described three potentially listable entities of northern Mexican gartersnake for consideration by the Service: (1) Listing the U.S. population as a distinct population segment (DPS); (2) listing the subspecies throughout its range in the United States and Mexico based on its rangewide status; or (3) listing the subspecies throughout its range in the United States and Mexico based on its status in the United States. Because we found that listing the northern Mexican gartersnake rangewide was warranted, there was no need to conduct any further analysis of the remaining two options, which are smaller geographic entities and are subsumed by the rangewide listing.

Status Assessments for Northern Mexican and Narrow-headed Gartersnakes

Background

Northern Mexican Gartersnake

Subspecies Description

The northern Mexican gartersnake ranges in color from olive to olive-brown or olive-gray with three lighter-colored stripes that run the length of the body, the middle of which darkens towards the tail. It may occur with other native gartersnake species and can be difficult for people without specific expertise to identify. The snake may reach a maximum known length of 44 inches (in) (112 centimeters (cm)). The pale yellow to light-tan lateral (side of body) stripes distinguish the northern Mexican gartersnake from other sympatric (co-occurring) gartersnake species because a portion of the lateral stripe is found on the fourth scale row, while it is confined to lower scale rows for other species. Paired black spots extend along the olive dorsolateral fields (region adjacent to the top of the snake's back) and the olive-gray ventrolateral fields (region adjacent to the area of the snake's body in contact with the ground). The scales are keeled (possessing a ridge down the center of each scale). A more detailed subspecies description can be found in our September 26, 2006 (71 FR 56227), or November 25, 2008 (73 FR 71788) 12-month findings for this subspecies, or by reviewing Rosen and Schwalbe (1988, p. 4), Rossman *et al.* (1996, pp. 171–172), Ernst and Ernst (2003, pp. 391–392), or Manjarrez and Garcia (1993, pp. 1–5).

Taxonomy

The northern Mexican gartersnake is a member of the family Colubridae and subfamily Natricinae (harmless live-bearing snakes) (Lawson *et al.* 2005, p. 596). The taxonomy of the genus *Thamnophis* has a complex history, partly because many of the species are similar in appearance and arrangement of scales, but also because many of the early museum specimens were in such poor and faded condition that it was difficult to study them (Conant 2003, p. 6).

Prior to 2003, *Thamnophis eques* was considered to have three subspecies, *T. e. eques, T. e. megalops,* and *T. e. virgatenuis* (Rossman *et al.* 1996, p. 175). In 2003, an additional seven new subspecies were identified under *T. eques*: (1) *T. e. cuitzeoensis*; (2) *T. e. patzcuaroensis*; (3) *T. e. insperatus*; (4) *T. e. obscurus*; (5) *T. e. diluvialis*; (6) *T. e. carmenensis*; and (7) *T. e. scotti* (Conant 2003, p. 3). Common names were not provided, so in this proposed rule, we use the scientific name for all subspecies of Mexican gartersnake other than the northern Mexican gartersnake. These seven new subspecies were described based on morphological differences in coloration and pattern; have highly restricted distributions; and occur in isolated wetland habitats within the mountainous Transvolcanic Belt region of southern Mexico, which contains the highest elevations in the country (Conant 2003, pp. 7–8). The validity of the current taxonomy of the 10 subspecies of *T. eques* is accepted within the scientific community. A more detailed description of the taxonomy of the northern Mexican gartersnake is found in our September 26, 2006 (71 FR 56227) and November 25, 2008 (73 FR 71788) 12-month findings for this subspecies. Additional information regarding this subspecies' taxonomy can be found in de Queiroz *et al.* (2002, p. 323), de Queiroz and Lawson (1994, p. 217), Rossman *et al.* (1996, pp. xvii–xviii, 171–175), Rosen and Schwalbe (1988, pp. 2–3), Liner (1994, p. 107), and Crother *et al.* (2012, p. 70).

Habitat and Natural History

Throughout its rangewide distribution, the northern Mexican gartersnake occurs at elevations from 130 to 8,497 feet (ft) (40 to 2,590 meters (m)) (Rossman *et al.* 1996, p. 172) and is considered a ''terrestrial-aquatic generalist'' by Drummond and Marcías-García (1983, pp. 24–26). The northern Mexican gartersnake is a riparian obligate (restricted to riparian areas when not engaged in dispersal behavior) and occurs chiefly in the following general habitat types: (1) Source-area wetlands (e.g., cienegas (mid-elevation wetlands with highly organic, reducing (basic or alkaline) soils), or stock tanks (small earthen impoundment)); (2) large-river riparian woodlands and forests; and (3) streamside gallery forests (as defined by well-developed broadleaf deciduous riparian forests with limited, if any, herbaceous ground cover or dense grass) (Hendrickson and Minckley 1984, p. 131; Rosen and Schwalbe 1988, pp. 14–16). Emmons and Nowak (2013, p. 14) found this subspecies most commonly in protected backwaters, braided side channels and beaver ponds, isolated pools near the river mainstem, and edges of dense emergent vegetation that offered cover and foraging opportunities when surveying in the upper Verde River region. Additional information on the habitat requirements of the northern Mexican gartersnake within the United States and Mexico can be found in our 2006 (71 FR 56227) and 2008 (73 FR 71788) 12-month findings for this subspecies and in Rosen and Schwalbe (1988, pp. 14–16), Rossman *et al.* (1996, p. 176), McCranie and Wilson (1987, pp. 11–17), Ernst and Ernst (2003, p. 392), and Cirett-Galan (1996, p. 156).

The northern Mexican gartersnake is surface active at ambient (air) temperatures ranging from 71 degrees Fahrenheit (°F) to 91 °F (22 degrees Celsius (°C) to 33 °C) and forages along the banks of waterbodies (Rosen 1991, p. 305, Table 2). Rosen (1991, pp. 308–309) found that northern Mexican gartersnakes spent approximately 60 percent of their time moving, 13 percent of their time basking on vegetation, 18 percent of their time basking on the ground, and 9 percent of their time under surface cover; body temperatures ranged from 75 to 91 °F (24 to 33 °C) and averaged 82 °F (28 °C), which is lower than other, similar species with comparable habitat and prey preferences. Rosen (1991, p. 310) suggested that lower preferred body temperatures exhibited by northern Mexican gartersnakes may be due to: (1) Their tendency to occupy cienega-like habitat, where warm air temperatures are relatively unavailable; and (2) their tendency to remain in dense cover. In the northern-most part of its range, the northern Mexican gartersnake appears to be most active during July and August, followed by June and September.

The northern Mexican gartersnake is an active predator and is believed to heavily depend upon a native prey base (Rosen and Schwalbe 1988, pp. 18, 20). Northern Mexican gartersnakes forage along vegetated banklines, searching for prey in water and on land, using different strategies (Alfaro 2002, p. 209). Generally, its diet consists of amphibians and fishes, such as adult and larval (tadpoles) native leopard frogs (e.g., lowland leopard frog (*Lithobates yavapaiensis*) and Chiricahua leopard frog (*Lithobates chiricahuensis*)), as well as juvenile and adult native fish species (e.g., Gila topminnow (*Poeciliopsis occidentalis occidentalis*), desert pupfish (*Cyprinodon macularius*), Gila chub (*Gila intermedia*), and roundtail chub (*Gila robusta*)) (Rosen and Schwalbe 1988, p. 18). Drummond and Marcías-García (1983, pp. 25, 30) found that as a subspecies, Mexican gartersnakes fed primarily on frogs. Auxiliary prey items may also include young Woodhouse's toads (*Anaxyrus woodhousei*), treefrogs (Family Hylidae), earthworms, deermice (*Peromyscus* spp.), lizards of the genera *Aspidoscelis* and *Sceloporus,* larval tiger salamanders (*Ambystoma tigrinum*), and leeches (Gregory *et al.* 1980, pp. 87, 90–92; Rosen and Schwalbe 1988, p. 20; Holm and Lowe 1995, pp. 30–31; Degenhardt *et al.* 1996, p. 318; Rossman *et al.* 1996, p. 176; Manjarrez 1998, p. 465). In situations where native prey species are rare or absent, this snake's diet may include nonnative species, including larval and juvenile bullfrogs (*Lithobates catesbeianus*), mosquitofish (*Gambusia affinis*) (Holycross *et al.* 2006, p. 23; Emmons and Nowak 2013, p. 5), or other soft-rayed fish species. Chinese mystery snails (*Cipangopaludina chinensis*) have been reported as a prey item for northern Mexican gartersnakes at the Page Springs and Bubbling Ponds State Fish

Hatcheries in Arizona, but some predation attempts on snails have proven fatal for gartersnakes because of their lower jaw becoming permanently lodged in the snails' shell (Young and Boyarski 2012, p. 498). Venegas-Barrera and Manjarrez (2001, p. 187) reported the first observation of a snake in the natural diet of any species of *Thamnophis* after documenting the consumption by a Mexican gartersnake (subspecies not provided) of a Mexican alpine blotched gartersnake (*Thamnophis scalaris*).

Marcías-García and Drummond (1988, pp. 129–134) sampled the stomach contents of Mexican gartersnakes and the prey populations at (ephemeral) Lake Tecocomulco, Hidalgo, Mexico. Field observations indicated, with high statistical significance, that larger Mexican gartersnakes fed primarily upon aquatic vertebrates (fishes, frogs, and larval salamanders) and leeches, whereas smaller Mexican gartersnakes fed primarily upon earthworms and leeches (Marcías-García and Drummond 1988, p. 131). Marcías-García and Drummond (1988, p. 130) also found that the birth of newborn *T. eques* tended to coincide with the annual peak density of annelids (earthworms and leeches). There is also preliminary evidence that birth may coincide with a pronounced influx of available prey in a given area, especially with that of explosive breeders, such as toads, but more research is needed to confirm such a relationship (Boyarski 2012, pers. comm.). Positive correlations were also made with respect to capture rates (which are correlated with population size) of *T. eques* to lake levels and to prey scarcity; that is, when lake levels were low and prey species scarce, Mexican gartersnake capture rates declined (Marcías-García and Drummond 1988, p. 132). This indicates the importance of available water and an adequate prey base to maintaining viable populations of Mexican gartersnakes. Marcías-García and Drummond (1988, p. 133) found that while certain prey items were positively associated with size classes of snakes, the largest of specimens consume any prey available.

Native predators of the northern Mexican gartersnake include birds of prey, other snakes (kingsnakes (*Lampropeltis* sp.), whipsnakes (*Coluber* sp.), regal ring-necked snakes (*Diadophis punctatus regalis*), etc.), wading birds, mergansers (*Mergus merganser*), belted kingfishers (*Megaceryle alcyon*), raccoons (*Procyon lotor*), skunks (*Mephitis* sp.), and coyotes (*Canis latrans*) (Rosen and Schwalbe 1988, pp. 18, 39; Brennan *et al.* 2009, p. 123). Historically, large, highly predatory native fish species such as Colorado pikeminnow may have preyed upon northern Mexican gartersnake where the subspecies co-occurred. Native chubs (*Gila* sp.) may also prey on neonatal gartersnakes.

Parasites have been observed in northern Mexican gartersnakes. Boyarski (2008b, pp. 5–6) recorded several snakes within the population at the Page Springs and Bubbling Ponds fish hatcheries with interior bumps or bulges along the anterior one-third of the body. The cause of these bumps was not identified or speculated upon, nor were there any signs of trauma to the body of these snakes in the affected areas. Dr. Jim Jarchow, a veterinarian with herpetological expertise, reviewed photographs of affected specimens and suggested the bumps may likely contain plerocercoid larvae of a pseudophyllidean tapeworm (possibly *Spirometra* spp.), which are common in fish- and frog-eating gartersnakes. This may not be detrimental to their health, provided the bumps do not grow large enough to impair movement or other bodily functions (Boyarski 2008b, p. 8). However, Gúzman (2008, p. 102) documented the first observation of mortality of a Mexican gartersnake from a larval *Eustrongylides* sp. (endoparasitic nematode) which ''raises the possibility that infection of Mexican gartersnakes by *Eustrongylides* sp. larvae might cause mortality in some wild populations,'' especially if those populations are under stress as a result of the presence of other threats.

Sexual maturity in northern Mexican gartersnakes occurs at 2 years of age in males and at 2 to 3 years of age in females (Rosen and Schwalbe 1988, pp. 16–17). Northern Mexican gartersnakes are viviparous (bringing forth living young rather than eggs). Mating has been documented in April and May followed by the live birth of between 7 and 38 newborns (average is 13.6) in July and August (Rosen and Schwalbe 1988, p. 16; Nowak and Boyarski 2012, pp. 351–352). However, field observations in Arizona provide preliminary evidence that mating may also occur during the fall, but further research is required to confirm this hypothesis (Boyarski 2012, pers. comm.). Unlike other gartersnake species, which typically breed annually, one study suggests that only half of the sexually mature females within a population of northern Mexican gartersnake might reproduce in any one season (Rosen and Schwalbe 1988, p. 17).

Historical Distribution

Within the United States, the northern Mexican gartersnake historically occurred predominantly in Arizona at elevations ranging from 130 to 6,150 ft (40 to 1,875 m). It was generally found where water was relatively permanent and supported suitable habitat. The northern Mexican gartersnake historically occurred in every county and nearly every subbasin within Arizona, from several perennial or intermittent creeks, streams, and rivers as well as lentic (still, non-flowing water) wetlands such as cienegas, ponds, or stock tanks. Northern Mexican gartersnake records exist within the following subbasins in Arizona: Colorado River, Bill Williams River, Agua Fria River, Salt River, Tonto Creek, Verde River, Santa Cruz River, Cienega Creek, San Pedro River, Babocomari River, and the Rio San Bernardino (Black Draw) (Woodin 1950, p. 40; Nickerson and Mays 1970, p. 503; Bradley 1986, p. 67; Rosen and Schwalbe 1988, Appendix I; 1995, p. 452; 1997, pp. 16–17; Holm and Lowe 1995, pp. 27–35; Sredl *et al.* 1995b, p. 2; 2000, p. 9; Rosen *et al.* 2001, Appendix I; Holycross *et al.* 2006, pp. 1–2, 15–51; Brennan and Holycross 2006, p. 123; Radke 2006, pers. comm.; Rosen 2006, pers. comm.; Holycross 2006, pers. comm.; Cotton *et al.* 2013, p. 111). Numerous records for the northern Mexican gartersnake (through 1996) in Arizona are maintained in the Arizona Game and Fish Department's (AGFD) Heritage Database (1996a).

Historically, the northern Mexican gartersnake had a limited distribution in New Mexico that consisted of scattered locations throughout the Upper Gila River watershed in Grant and western Hidalgo Counties, including the Upper Gila River, Mule Creek in the San Francisco River subbasin, and the Mimbres River (Price 1980, p. 39; Fitzgerald 1986, Table 2; Degenhardt *et al.* 1996, p. 317; Holycross *et al.* 2006, pp. 1–2).

One record for the northern Mexican gartersnake exists for the State of Nevada, opposite Fort Mohave, in Clark County along the shore of the Colorado River that was dated 1911 (De Queiroz and Smith 1996, p. 155). The subspecies may have occurred historically in the lower Colorado River region of California, although we were unable to verify any museum records for California. Any populations of northern Mexican gartersnakes that may have historically occurred in either Nevada or California were likely associated directly with the Colorado River, and we believe them to be currently extirpated.

Within Mexico, northern Mexican gartersnakes historically occurred within the Sierra Madre Occidental and the Mexican Plateau in the Mexican states of Sonora, Chihuahua, Durango, Coahuila, Zacatecas, Guanajuato, Nayarit, Hidalgo, Jalisco, San Luis Potosí, Aguascalientes, Tlaxacala, Puebla, México, Veracruz, and Querétaro, comprising approximately 85 percent of the total rangewide distribution of the subspecies (Conant 1963, p. 473; 1974, pp. 469–470; Van Devender and Lowe 1977, p. 47; McCranie and Wilson 1987, p. 15; Rossman *et al.* 1996, p. 173; Lemos-Espinal *et al.* 2004, p. 83). We are not aware of any systematic, rangewide survey effort for the northern Mexican gartersnake in Mexico and have not found survey data for the subspecies in Mexico to be published in the scientific literature or otherwise readily available, outside of the information already obtained. Therefore, we use other, tightly correlated ecological surrogates (such as native freshwater fish) to inform discussion on the status of aquatic communities and aquatic habitat in Mexico, and therefore on the likely status of northern Mexican gartersnake populations. This discussion is found below in the subheadings pertinent to Mexico.

Current Distribution and Population Status

Where northern Mexican gartersnakes are locally abundant, they are usually reliably detected with significantly less effort than populations characterized as having low densities. Northern Mexican gartersnakes are well-camouflaged, secretive, and very difficult to detect in structurally complex, dense habitat where they could occur at very low population densities, which characterizes most occupied sites. Water clarity can also affect survey accuracy. We considered factors such as the date of the last known records for northern Mexican gartersnakes in an area, as well as records of one or more native prey species in making a conclusion on occupancy of the subspecies. We used the year 1980 to qualify occupancy because the 1980s marked the first systematic survey efforts for northern Mexican gartersnakes across their range (see Rosen and Schwalbe (1988, entire) and Fitzgerald (1986, entire)) and the last, previous records were often dated several decades prior and may not accurately represent the likelihood for current occupation. Several areas where northern Mexican gartersnakes were known to occur have received no, or very little, survey effort in the past several decades. Variability in survey design and effort makes it difficult to compare population sizes or trends among sites and between sampling periods. For each of the sites discussed in Appendix A (available at *http://www.regulations.gov* under Docket No. FWS–R2–ES–2013–0071), we have attempted to translate and quantify search and capture efforts into comparable units (*i.e.,* person-search hours and trap-hours) and have conservatively interpreted those results. Because the presence of suitable prey species in an area may provide evidence that the northern Mexican gartersnake may still persist in low density where survey data are sparse, a record of a native prey species was considered in our determination of occupancy of this subspecies.

Data on population status of northern Mexican gartersnakes in the United States are largely summarized in gray literature provided through agency reports and related documents. In our literature review efforts that resulted in our 2006 and 2008 12-month findings (71 FR 56227 and 73 FR 71788, respectively), we found that the status of the northern Mexican gartersnake has declined significantly in the last 30 years. We found that, in as much as 90 percent of the northern Mexican gartersnakes' historical distribution in the United States, the subspecies occurs at low to very low population densities or may even be extirpated. The decline of the northern Mexican gartersnake is primarily the result of predation by and competition with harmful nonnative species, such as spiny-rayed fish, bullfrogs, and crayfish, that have been intentionally released, accidentally released, or dispersed through natural mechanisms. Regardless of how they got into the wild, harmful nonnative species are now virtually ubiquitous throughout the range of the northern Mexican gartersnake. Land uses that result in the dewatering of habitat, combined with increasing drought, have destroyed significant amounts of habitat throughout the northern Mexican gartersnake's range and have also contributed to population declines.

Holycross *et al.* (2006, p. 66) detected the northern Mexican gartersnake at only 2 of 11 historical localities along the northern-most part of its range from which the subspecies was previously known. The only viable northern Mexican gartersnake populations in the United States where the subspecies remains reliably detected are all located in Arizona: (1) The Page Springs and Bubbling Ponds State Fish Hatcheries along Oak Creek, (2) lower Tonto Creek, (3) the upper Santa Cruz River in the San Rafael Valley, (4) the Bill Williams River, and (5) the upper Verde River. In New Mexico, the northern Mexican gartersnake may occur in extremely low population densities within its historical distribution; limited survey effort is inconclusive to determine extirpation. The status of the northern Mexican gartersnake on tribal lands, such as those owned by the White Mountain or San Carlos Apache Tribes, is poorly known due to historically limited survey access. As stated previously, less is known specifically about the current distribution of the northern Mexican gartersnake in Mexico due to limited access to information on survey efforts and field data from Mexico.

In Table 1 below, we summarize the population status of northern Mexican gartersnakes at all known localities throughout their United States distribution, as supported by museum records or reliable observations. For a detailed discussion that explains the rationale for site-by-site conclusions on occupancy, please see Appendix A (available at *http://www.regulations.gov* under Docket No. FWS–R2–ES–2013–0071). General rationale is provided in the introductory paragraph to this section, "Current Distribution and Population Status."

TABLE 1—CURRENT POPULATION STATUS OF THE NORTHERN MEXICAN GARTERSNAKE IN THE UNITED STATES. REFERENCES CITED ARE PROVIDED IN APPENDIX A

Location	Last record	Suitable physical habitat present	Native prey species present	Harmful non-native species present	Population status
Gila River (NM, AZ)	2002	Yes	Yes	Yes	Likely not viable.
Spring Canyon (NM)	1937	Yes	Possible	Likely	Likely extirpated.
Mule Creek (NM)	1983	Yes	Yes	Yes	Likely not viable.

TABLE 1—CURRENT POPULATION STATUS OF THE NORTHERN MEXICAN GARTERSNAKE IN THE UNITED STATES. REFERENCES CITED ARE PROVIDED IN APPENDIX A—Continued

Location	Last record	Suitable physical habitat present	Native prey species present	Harmful non-native species present	Population status
Mimbres River (NM)	Likely early 1900s.	Yes	Yes	Yes	Likely extirpated.
Lower Colorado River (AZ)	1904	Yes	Yes	Yes	Likely extirpated.
Bill Williams River (AZ)	2012	Yes	Yes	Yes	Likely viable.
Agua Fria River (AZ)	1986	Yes	Yes	Yes	Likely not viable.
Little Ash Creek (AZ)	1984	Yes	Yes	Yes	Likely not viable.
Lower Salt River (AZ)	1964	Yes	Yes	Yes	Likely extirpated.
Black River (AZ)	1982	Yes	Yes	Yes	Likely not viable.
Big Bonito Creek (AZ)	1986	Yes	Yes	Yes	Likely not viable.
Tonto Creek (AZ)	2005	Yes	Yes	Yes	Likely viable.
Upper Verde River (AZ)	2012	Yes	Yes	Yes	Likely viable.
Oak Creek (AZ) (Page Springs and Bubbling Ponds State Fish Hatcheries).	2012	Yes	Yes	Yes	Likely viable.
Spring Creek (AZ)	1986	Yes	Yes	Yes	Likely not viable.
Sycamore Creek (AZ)	1954	Yes	Possible	Yes	Likely extirpated.
Upper Santa Cruz River/San Rafael Valley (AZ).	2012	Yes	Yes	Yes	Likely viable.
Redrock Canyon (AZ)	2008	Yes	Yes	Yes	Likely not viable.
Sonoita Creek (AZ)	1974	Yes	Possible	Yes	Likely extirpated.
Scotia Canyon (AZ)	2009	Yes	Yes	No	Likely not viable.
Parker Canyon (AZ)	1986	Yes	Possible	Yes	Likely not viable.
Las Cienegas National Conservation Area and Cienega Creek Natural Preserve (AZ).	2012	Yes	Yes	Possible	Likely not viable.
Lower Santa Cruz River (AZ)	1956	Yes	Yes	Yes	Likely extirpated.
Buenos Aires National Wildlife Refuge (AZ)	2000	Yes	Yes	Yes	Likely not viable.
Bear Creek (AZ)	1987	Yes	Yes	Yes	Likely not viable.
San Pedro River (AZ)	1996	Yes	Yes	Yes	Likely not viable.
Babocomari River and Cienega (AZ)	1986	Yes	Possible	Yes	Likely not viable.
Canelo Hills-Sonoita Grasslands Area (AZ)	2012	Yes	Yes	Yes	Likely not viable.
San Bernardino National Wildlife Refuge (AZ).	1997	Yes	Yes	Yes	Likely not viable.

Notes: "Possible" means there were no conclusive data found. "Likely extirpated" means the last record for an area pre-dated 1980 and existing threats suggest the species is likely extirpated. "Likely not viable" means the last record for an area pre-dated 1980 and existing threats suggest the species is likely extirpated. "Likely viable" means that the species is reliably found with minimal to moderate survey effort and the population is generally considered viable.

Table 1 lists the 29 known localities for the northern Mexican gartersnake in the United States. Appendix A (available at *http://www.regulations.gov* under Docket No. FWS–R2–ES–2013–0071) discusses such considerations as the physical condition of habitat, the composition of the aquatic biological community, the existence of significant threats, and the length of time since the last known observation of the subspecies in presenting rationale for determining occupancy status at each locality. We have concluded that in as many as 24 of 29 known localities in the United States (83 percent), the northern Mexican gartersnake population is likely not viable and may exist at low population densities that could be threatened with extirpation or may already be extirpated. In most localities where the species may occur at low population densities, existing survey data are insufficient to prove extirpation. Only five populations of northern Mexican gartersnakes in the United States are considered likely viable where the species remains reliably detected. When considering the total number of stream miles in the United States that historically supported the northern Mexican gartersnake that are now permanently dewatered (except in the case of temporary flows in response to heavy precipitation), we concluded that as much as 90 percent of historical populations in the United States either occur at low densities or are extirpated. As displayed in Table 1, harmful nonnative species are a concern in almost every northern Mexican gartersnake locality in the United States and the most significant reason for their decline, as discussed in depth in our threats analysis below.

Listed as threatened throughout its range in Mexico by the Mexican Government, our understanding of the northern Mexican gartersnake's specific population status throughout its range in Mexico is less precise than that known for its United States distribution because survey efforts are less, and sufficient, available records do not exist or are difficult to obtain. However, we have assembled and reviewed an extensive body of scientific information on known, regional threats to northern Mexican gartersnakes and to their primary prey species. This information is presented in greater detail below in our specific discussion of threats to the species in Mexico.

Narrow-Headed Gartersnake

Species Description

The narrow-headed gartersnake is a small to medium-sized gartersnake with a maximum total length of 44 in (112 cm mm) (Painter and Hibbitts 1996, p. 147). Its eyes are set high on its unusually elongated head, which narrows to the snout, and it lacks striping on the dorsum (top) and sides, which distinguishes its appearance from other gartersnake species with which it could co-occur (Rosen and Schwalbe 1988, p. 7). The base color is usually tan or grey-brown (but may darken) with conspicuous brown, black, or reddish spots that become indistinct towards the tail (Rosen and Schwalbe 1988, p. 7; Boundy 1994, p. 126). The scales are keeled. Degenhardt *et al.* (1996, p. 327), Rossman *et al.* (1996, pp. 242–244), and Ernst and Ernst (2003, p. 416) further describe the species.

Taxonomy

The narrow-headed gartersnake is a member of the family Colubridae and subfamily Natricinae (harmless live-bearing snakes) (Lawson *et al.* 2005, p. 596). The taxonomy of the genus *Thamnophis* has a complex history partly because many of the species are similar in appearance and scutelation (arrangement of scales), but also because many of the early museum specimens were in such poor and faded condition that it was difficult to study them (Conant 2003, p. 6). The narrow-headed gartersnake has a particularly complex taxonomic history due to its morphology and feeding habits. There are approximately 30 species described in the gartersnake genus *Thamnophis* (Rossman *et al.* 1996, pp. xvii–xviii). Two large overlapping clades (related taxonomic groups) of gartersnakes have been identified called the ''Mexican'' and ''widespread'' clades, supported by allozyme and mitochondrial DNA genetic analyses (de Queiroz *et al.* 2002, p. 321). *Thamnophis rufipunctatus* is a member of the ''Mexican'' clade and is most closely related taxonomically to the southern Durango spotted gartersnake (*Thamnophis nigronuchalis*) (de Queiroz and Lawson 1994, p. 217; de Queiroz *et al.* 2002; p. 321).

Due to the narrow-headed gartersnake's morphology and feeding habits, there has been considerable deliberation among taxonomists about the correct association of this species within seven various genera over time (Rosen and Schwalbe 1988, pp. 5–6); chiefly, between the genera *Thamnophis* (the ''gartersnakes'') and *Nerodia* (the ''watersnakes'') (Pierce 2007, p. 5). Chaisson and Lowe (1989, pp. 110–118) argued that the pattern of ultrastructural (as revealed by an electron microscope) pores in the scales of narrow-headed gartersnakes provided evidence that the species is more appropriately placed within the genus *Nerodia.* However, De Queiroz and Lawson (1994, p. 217) rejected this premise using mitochondrial DNA (mtDNA) genetic analyses to refute the inclusion of the narrow-headed gartersnake in the genus *Nerodia* and maintain the species within the genus *Thamnophis.*

The narrow-headed gartersnake was first described as *Chilopoma rufipunctatum* by E. D. Cope (in Yarrow, 1875). Recently, *Thamnophis rufipunctatus nigronuchalis* and *T. r. unilabialis* were recognized as subspecies under *T. rufipunctatus* and comprised what was considered the *T. rufipunctatus* complex. However, Rossman *et al.* (1996, pp. 244–246) elevated *T. r. nigronuchalis* to full species designation and argued recognition of *T. r. unilabialis* be discontinued due to the diagnostic differences being too difficult to discern. Wood *et al.* (2011, p. 14) used genetic analysis of the *T. rufipunctatus* complex to propose the elevation of these three formerly recognized subspecies as three distinct species, as a result of a combination of interglacial warming, ecological and life-history constraints, and genetic drift, which promoted differentiation of these three species throughout the warming and cooling periods of the Pleistocene epoch (Wood *et al.* 2011, p. 15). We use these most recent and complete data in acknowledging these three entities as unique species: *T. rufipunctatus* (along the Mogollon Rim of Arizona and New Mexico), *T. unilabialis* (Chihuahua, eastern Sonora, and northern Durango, Mexico), and *T. nigronuchalis* (southern Durango, Mexico).

Several common names have been used for this species including the red-spotted gartersnake, the brown-spotted gartersnake, and the currently used, narrow-headed gartersnake (Rosen and Schwalbe 1988, p. 5). Further discussion of the taxonomic history of the narrow-headed gartersnake is available in Crother (2012, p. 71), Degenhardt *et al.* (1996, p. 326); Rossman *et al.* (1996, p. 244), De Queiroz and Lawson (1994, pp. 213–229); Rosen and Schwalbe (1988, pp. 5–7); and De Queiroz *et al.* (2002, p. 321).

Habitat and Natural History

The narrow-headed gartersnake is widely considered to be one of the most aquatic of the gartersnakes (Drummond and Marcias Garcia 1983, pp. 24, 27; Rossman *et al.* 1996, p. 246). This species is strongly associated with clear, rocky streams, using predominantly pool and riffle habitat that includes cobbles and boulders (Rosen and Schwalbe 1988, pp. 33–34; Degenhardt *et al.* 1996, p. 327; Rossman *et al.* 1996, p. 246; Ernst and Ernst 2003, p. 417). Rossman *et al.* (1996, p. 246) also note the species has been observed using lake shoreline habitat in New Mexico. Narrow-headed gartersnakes occur at elevations from approximately 2,300 to 8,200 ft (700 to 2,500 m), inhabiting Petran Montane Conifer Forest, Great Basin Conifer Woodland, Interior Chaparral, and the Arizona Upland subdivision of Sonoran Desertscrub communities (Rosen and Schwalbe 1988, p. 33; Brennan and Holycross 2006, p. 122). An extensive evaluation of habitat use of narrow-headed gartersnakes along Oak Creek in Arizona is provided in Nowak and Santana-Bendix (2002, pp. 26–37). Rosen and Schwalbe (1988, p. 35) found narrow-headed gartersnake densities may be highest at the conjunction of cascading riffles with pools, where waters were deeper than 20 in (0.5 m) in the riffle and deeper than 40 in (1 m) in the immediately adjoining area of the pool, but more than twice the number of snakes were found in pools rather than riffles.

Where narrow-headed gartersnakes are typically found in the water, little aquatic vegetation exists (Rosen and Schwalbe 1988, p. 34). However, bank-line vegetation is an important component to suitable habitat for this species. Narrow-headed gartersnakes will usually bask in situations where a quick escape can be made, whether that is into the water or under substrate such as rocks (Fleharty 1967, p. 16). Common plant species associations include Arizona alder (*Alnus oblongifolia*) (highest correlation with occurrence of the narrow-headed gartersnake), velvet ash (*Fraxinus pennsylvanica*), willows (*Salix* ssp.), canyon grape (*Vitis arizonica*), blackberry (*Rubus* ssp.), Arizona sycamore (*Platanus wrightii*), Arizona black walnut (*Juglans major*), Freemont cottonwood (*Populus fremontii*), Gambel oak (*Quercus gambelii*), and ponderosa pine (*Pinus ponderosa*) (Rosen and Schwalbe 1988, pp. 34–35). Rosen and Schwalbe (1988, p. 35) noted that the composition of bank-side plant species and canopy structure were less important to the species' needs than was the size class of the plant species present; narrow-headed gartersnakes prefer to use shrub- and sapling-sized plants for thermoregulating (basking) at the waters' edge (Degenhardt *et al.* 1996, p. 327).

Narrow-headed gartersnakes may opportunistically forage within dammed reservoirs formed by streams that are occupied habitat, such as at Wall Lake (located at the confluence of Taylor Creek, Hoyt Creek, and the East Fork Gila River) (Fleharty 1967, p. 207) and most recently at Snow Lake in 2012 (located near the confluence of Snow Creek and the Middle Fork Gila River) (Hellekson 2012b, pers. comm.) in New Mexico, but records from impoundments are rare in the literature. The species evolved in the absence of such habitat, and impoundments are generally managed as sport fisheries (Wall Lake and Snow Lake are) and often maintain populations of harmful nonnative species that are incompatible with narrow-headed gartersnakes.

The narrow-headed gartersnake is surface-active generally between March and November (Nowak 2006, p. 16). Little information on suitable temperatures for surface activity of the narrow-headed gartersnake exists; however, it is presumed to be rather cold-tolerant based on its natural history and foraging behavior that often involves clear, cold streams at higher elevations. Along Oak Creek in Arizona, Nowak (2006, Appendix 1) found the species to be active in air temperatures ranging from 52 to 89 °F (11 to 32 °C) and water temperatures ranging from 54 to 72 °F (12 to 22 °C). Jennings and Christman (2011, pp. 12–14) found body temperatures of narrow-headed gartersnakes along the Tularosa River averaged approximately 68 °F (20 °C) during the mid-morning hours and 81 °F (27 °C) in the late afternoon during the period from late July and August. Variables that affect their body temperature include the temperature of the microhabitat used and water temperature (most predictive), but slope aspect and the surface area of cover used also influenced body temperatures (Jennings and Christman 2011, p. 13). Narrow-headed gartersnakes have a lower preferred temperature for activity as compared to other species of gartersnakes (Fleharty 1967, p. 228), which may facilitate their highly aquatic nature in cold streams.

Narrow-headed gartersnakes specialize on fish as their primary prey item (Rosen and Schwalbe 1988, p. 38; Degenhardt *et al.* 1996, p. 328; Rossman *et al.* 1996, p. 247; Nowak and Santana-Bendix 2002, pp. 24–25; Nowak 2006, p. 22) and are believed to be mainly visual hunters (Hibbitts and Fitzgerald 2005, p. 364), heavily dependent on visual cues when foraging based on comparative analyses among other species of gartersnakes (de Queiroz 2003, p. 381). Unlike many other species of gartersnakes that are active predators (actively crawl about in search of prey), narrow-headed gartersnakes are considered to be ambush predators (sit-and-wait method) (Brennan and Holycross 2006, p. 122; Pierce *et al.* 2007, p. 8). The specific gravity (ratio of the mass of a solid object to the mass of the same volume of water) of the narrow-headed gartersnake was found to be nearly 1, which means that the snake can maintain its desired position in the water column with ease, an adaptation to facilitate foraging on the bottom of streams (Fleharty 1967, pp. 218–219). Native fish species most often associated as prey items for the narrow-headed gartersnake include Sonora sucker (*Catostomus insignis*), desert sucker (*C. clarki*), speckled dace (*Rhinichthys osculus*), roundtail chub (*Gila robusta*), Gila chub (*Gila intermedia*), and headwater chub (*Gila nigra*) (Rosen and Schwalbe 1988, p. 39; Degenhardt *et al.* 1996, p. 328). Nonnative species used as prey by narrow-headed gartersnakes are most often salmonid species (trout); most commonly brown (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*), as these species are commonly stocked in, or near, occupied narrow-headed gartersnake habitat (Rosen and Schwalbe 1988, p. 39; Nowak 2006, pp. 22–23). Fleharty (1967, p. 223) reported narrow-headed gartersnakes eating green sunfish, but green sunfish is not considered a suitable prey item.

Several reviews (Stebbins 1985, p. 199; Deganhardt *et al.* 1996, p. 328; Ernst and Ernst 2003, p. 418) state that the narrow-headed gartersnake will also prey upon frogs, tadpoles, and salamanders. Fitzgerald (1986, p. 6) referenced the Stebbins (1985) account as the only substantiated account of the species accepting something other than fish as prey, apparently as the result of finding a small salamander larvae in the stomach of an individual in Durango, Mexico. Formerly recognized as a subspecies of *Thamnophis rufipunctatus,* that individual is now recognized as *T. unilabialis* (Wood *et al.* 2011, p. 3). We found an account of narrow-headed gartersnakes consuming red-spotted toads in captivity (Woodin 1950, p. 40). Despite several studies focusing on the ecology of narrow-headed gartersnakes in recent times, there are no other records of narrow-headed gartersnakes, under current taxonomic recognition, feeding on prey items other than fish. We, along with species experts, do not consider amphibians as ecologically important prey for this species based on our review of the literature.

Native predators of the narrow-headed gartersnake include birds of prey, other snakes such as kingsnakes, whipsnakes, or regal ring-necked snakes, wading birds, mergansers, belted kingfishers, raccoons, skunks, and coyotes (Rosen and Schwalbe 1988, pp. 18, 39; Brennan *et al.* 2009, p. 123). Historically, large, highly predatory native fish species such as Colorado pikeminnow may have preyed upon narrow-headed gartersnakes where the species co-occurred. Native chubs (*Gila* sp.) may also prey on neonatal gartersnakes.

Sexual maturity in narrow-headed gartersnakes occurs at 2.5 years of age in males and at 2 years of age in females (Deganhardt *et al.* 1996, p. 328). Narrow-headed gartersnakes are viviparous. The reproductive cycle for narrow-headed gartersnakes appears to be longer than other gartersnake species; females begin the development of follicles in early March, and gestation takes longer (Rosen and Schwalbe 1988, pp. 36–37). Female narrow-headed gartersnakes breed annually and give birth to 4 to 17 offspring from late July into early August, perhaps earlier at lower elevations (Rosen and Schwalbe 1988, pp. 35–37). Sex ratios in narrow-headed gartersnake populations can be skewed in favor of females (Fleharty 1967, p. 212).

Historical Distribution

The historical distribution of the narrow-headed gartersnake ranged across the Mogollon Rim and along its associated perennial drainages from central and eastern Arizona, southeast to southwestern New Mexico at elevations ranging from 2,300 to 8,000 ft (700 to 2,430 m) (Rosen and Schwalbe 1988, p. 34; Rossman *et al.* 1996, p. 242; Holycross *et al.* 2006, p. 3). The species was historically distributed in headwater streams of the Gila River subbasin that drain the Mogollon Rim and White Mountains in Arizona, and the Gila Wilderness in New Mexico; major subbasins in its historical distribution included the Salt and Verde River subbasins in Arizona, and the San Francisco and Gila River subbasins in New Mexico (Holycross *et al.* 2006, p. 3). Holycross *et al.* (2006, p. 3) suspect the species was likely not historically present in the lowest reaches of the Salt, Verde, and Gila rivers, even where perennial flow persists. Numerous records for the narrow-headed gartersnake (through 1996) in Arizona are maintained in the AGFD's Heritage Database (1996b). The narrow-headed gartersnake as currently recognized does not occur in Mexico.

Current Distribution and Population Status

Where narrow-headed gartersnakes are locally abundant, they can usually be detected reliably and with significantly less effort than populations characterized as having low densities. Narrow-headed gartersnakes are well-camouflaged, secretive, and very difficult to detect in structurally complex, dense habitat where they could occur at very low population densities, which characterizes most occupied sites. Water clarity can also affect survey accuracy. We considered factors such as the date of the last known records for narrow-headed gartersnakes in an area, as well as records of one or more native prey species in making a conclusion on species occupancy. We used all records that were dated 1980 or later because the 1980s marked the first systematic survey efforts for narrow-headed gartersnakes species across their range (see Rosen and Schwalbe (1988, entire) and Fitzgerald (1986, entire)), and the last, previous records were often dated several decades prior and may not accurately represent the likelihood for current occupation. Several areas where narrow-headed gartersnakes were known to occur have received no, or very little, survey effort in the past several decades. Variability in survey design and effort makes it difficult to compare population sizes or trends among sites and between sampling periods. Thus, for each of the sites discussed in Appendix A (available at *http://www.regulations.gov* under Docket No. FWS–R2–ES–2013–0071), we have attempted to translate and quantify search and capture efforts into comparable units (*i.e.,* person-search hours and trap-hours) and have conservatively interpreted those results. Because the presence of suitable prey species in an area may provide evidence that northern Mexican gartersnake may still persist in low density where survey data are sparse, a record of a native prey species was considered in our determination of occupancy of this species.

Population status information, based on our review of the best scientific and commercial data available, suggests that the narrow-headed gartersnake has experienced significant declines in population density and distribution along streams and rivers where it was formerly well-documented and reliably detected. Many areas where the species may occur likely rely on emigration of individuals from occupied habitat into those areas to maintain the species, provided there are no barriers to movement. Holycross *et al.* (2006) represents the most recent, comprehensive survey effort for narrow-headed gartersnakes in Arizona. Our most current information on the species' status in New Mexico comes from a species expert who is completing a graduate degree focused on the relationship between narrow-headed gartersnake populations and fish communities in the upper Gila and San Francisco river drainages (Helleckson 2012a, pers. comm.). Narrow-headed gartersnakes were detected in only 5 of 16 historical localities in Arizona and New Mexico surveyed by Holycross *et al.* (2006) in 2004 and 2005. Population densities have noticeably declined in many populations, as compared to previous survey efforts (Holycross *et al.* 2006, p. 66). Holycross *et al.* (2006, pp. 66–67) compared narrow-headed gartersnake detections based on results from their effort and that of previous efforts in the same locations and found that significantly more effort is required to detect this species in areas where it was formerly robust, such as along Eagle Creek (AZ), the East Verde River (AZ), the San Francisco River (NM), the Black River (AZ), and the Blue River (AZ).

As of 2011, the only remaining narrow-headed gartersnake populations where the species could reliably be found were located at: (1) Whitewater Creek (New Mexico), (2) Tularosa River (New Mexico), (3) Diamond Creek (New Mexico), (4) Middle Fork Gila River (New Mexico), and (5) Oak Creek Canyon (Arizona). However, populations found in Whitewater Creek and the Middle Fork Gila River were likely significantly affected by New Mexico's largest wildfire in State history, the Whitewater-Baldy Complex Fire, which occurred in June 2012. In addition, salvage efforts were initiated for these two populations, which included the removal of 25 individuals from Whitewater Creek and 14 individuals from the Middle Fork Gila River before the onset of summer rains in 2012. The status of those populations has likely deteriorated as a result of subsequent declines in resident fish communities due to heavy ash and sediment flows, resulting fish kills, and the removal of snakes, but subsequent survey data have not been collected. If the Whitewater Creek and Middle Fork Gila River populations did decline as a result of these factors, only three remaining populations of this species remain viable today across their entire distribution. Such unnaturally large wildfires have become increasingly common across the Mogollon Rim of Arizona and New Mexico where the narrow-headed gartersnake historically occurred. The status of the narrow-headed gartersnake on tribal land is poorly known, due to limited survey access.

In Table 2 below, we summarize the population status of the narrow-headed gartersnake at all known localities throughout its distribution, as supported by museum records or reliable observations. For a detailed discussion that explains the rationale for site-by-site conclusions on occupancy, please see Appendix A (available at *http://www.regulations.gov* under Docket No. FWS–R2–ES–2013–0071). General rationale is provided in the introductory paragraph to this section, ''Current Distribution and Population Status.''

TABLE 2—CURRENT POPULATION STATUS OF THE NARROW-HEADED GARTERSNAKE. REFERENCES CITED ARE PROVIDED IN APPENDIX A

Location	Last record	Suitable physical habitat present	Native prey species present	Harmful non-native species present	Population status
West Fork Gila River (NM)	2011	Yes	Yes	Yes	Likely not viable.
Middle Fork Gila River (NM)	2012	Yes	Yes	Yes	Likely not viable.
East Fork Gila River (NM)	2006	Yes	Yes	Yes	Likely not viable.
Gila River (AZ, NM)	2009	Yes	Yes	Yes	Likely not viable.
Snow Creek/Snow Lake (NM)	2012	Yes	No	Yes	Likely not viable.
Gilita Creek (NM)	2009	Yes	Yes	No	Likely not viable.
Iron Creek (NM)	2009	Yes	Yes	No	Likely not viable.
Little Creek (NM)	2010	Yes	Possible	Yes	Likely not viable.
Turkey Creek (NM)	1985	Yes	Yes	Possible	Likely not viable.
Beaver Creek (NM)	1949	Yes	Possible	Yes	Likely extirpated.
Black Canyon (NM)	2010	Yes	Yes	No	Likely not viable.
Taylor Creek (NM)	1960	Yes	No	Yes	Likely extirpated.
Diamond Creek (NM)	2011	Yes	Yes	Yes	Likely viable.
Tularosa River (NM)	2012	Yes	Yes	Yes	Likely viable.
Whitewater Creek (NM)	2012	Yes	Yes	Yes	Likely not viable.
San Francisco River (NM)	2011	Yes	Yes	Yes	Likely not viable.
South Fork Negrito Creek (NM)	2011	Yes	Possible	Yes	Likely not viable.

TABLE 2—CURRENT POPULATION STATUS OF THE NARROW-HEADED GARTERSNAKE. REFERENCES CITED ARE PROVIDED IN APPENDIX A—Continued

Location	Last record	Suitable physical habitat present	Native prey species present	Harmful nonnative species present	Population status
Blue River (AZ)	2007	Yes	Yes	Yes	Likely not viable.
Dry Blue Creek (AZ, NM)	2010	Yes	Possible	Yes	Likely not viable.
Campbell Blue Creek (AZ, NM)	2010	Yes	Possible	Yes	Likely not viable.
Saliz Creek (NM)	2012	Yes	Possible	Yes	Likely not viable.
Eagle Creek (AZ)	1991	Yes	Yes	Yes	Likely not viable.
Black River (AZ)	2009	Yes	Yes	Yes	Likely not viable.
White River (AZ)	1986	Yes	Yes	Possible	Likely not viable.
Diamond Creek (AZ)	1986	Yes	Possible	Possible	Likely not viable.
Tonto Creek (tributary to Big Bonita Creek, AZ).	1915	Yes	Possible	Possible	Likely extirpated.
Canyon Creek (AZ)	1991	Yes	Yes	No	Likely not viable.
Upper Salt River (AZ)	1985	Yes	Yes	Yes	Likely not viable.
Cibeque Creek (AZ)	1991	Yes	Yes	Possible	Likely not viable.
Carrizo Creek (AZ)	1997	Yes	Yes	Possible	Unreliably detected.
Big Bonito Creek (AZ)	1957	Yes	Yes	Yes	Likely extirpated.
Haigler Creek (AZ)	Early 1990s	Yes	Yes	Yes	Likely not viable.
Houston Creek (AZ)	2005	Yes	Yes	Yes	Likely not viable.
Tonto Creek (tributary to Salt River, AZ)	2005	Yes	Yes	Yes	Likely not viable.
Deer Creek (AZ)	1995	No	No	No	Likely extirpated.
Upper Verde River (AZ)	2012	Yes	Yes	Yes	Likely not viable.
Oak Creek (AZ)	2012	Yes	Yes	Yes	Likely viable.
East Verde River (AZ)	1992	Yes	Yes	Yes	Likely not viable.

"Possible" means there were no conclusive data found.

"Likely extirpated" means the last record for an area pre-dated 1980 and existing threats suggest the species is likely extirpated. "Likely not viable" means there is a post-1980 record for the species, it is not reliably found with minimal to moderate survey effort, and threats exist which suggest the population may be low density or could be extirpated, but there is insufficient evidence to confirm extirpation. "Likely viable" means that the species is reliably found with minimal to moderate survey effort and the population is generally considered viable.

Table 2 lists the 38 known localities for narrow-headed gartersnakes throughout their range. Appendix A (available at *http://www.regulations.gov* under Docket No. FWS–R2–ES–2013–0071) discusses such considerations as the physical condition of habitat, the composition of the aquatic biological community, the existence of significant threats, and the length of time since the last known observation of the species in presenting rationale for determining occupancy status at each locality. We have concluded that in as many as 29 of 38 known localities (76 percent), the narrow-headed gartersnake population is likely not viable and may exist at low population densities that could be threatened with extirpation or may already be extirpated but survey data are lacking in areas where access is restricted. In most localities where the species may occur at low population densities, existing survey data are insufficient to conclude extirpation. As of 2012, narrow-headed gartersnake populations are considered likely viable in 3 localities (8 percent) where individuals are reliable detected. As displayed in Table 2, harmful nonnative species are a concern for almost every narrow-headed gartersnake population throughout their range. The ramifications of this are significant because of the effect these harmful nonnative species have on the resident native fish communities and the fact that this species is a specialized, fish-only predator. We discuss this and other important factors that have contributed to the decline of narrow-headed gartersnakes throughout their range in our threats analysis below.

Summary of Factors Affecting the Species

Section 4 of the Act (16 U.S.C. 1533), and its implementing regulations at 50 CFR part 424, set forth the procedures for adding species to the Federal Lists of Endangered and Threatened Wildlife and Plants. Under section 4(a)(1) of the Act, we may list a species based on any of the following five 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; and (E) other natural or manmade factors affecting its continued existence. Listing actions may be warranted based on any of the above threat factors, singly or in combination.

In the following threats analysis, we treat both gartersnake species in a combined discussion because of partially overlapping ranges, similar natural histories, similar responses to threats, and the fact that many threats are shared in common throughout their ranges.

The Weakened Status of Native Aquatic Communities

Riparian and aquatic communities in both the United States and Mexico have been significantly impacted by a shift in species' composition, from one of primarily native fauna, to one being increasingly dominated by an expanding assemblage of nonnative animal species. Many of these nonnative species have been intentionally or accidentally introduced, including crayfish, bullfrogs, and nonnative, spiny-rayed fish. Harmful nonnative species have been introduced or have spread into new areas through a variety of mechanisms, including intentional and accidental releases, sport stocking, aquaculture, aquarium releases, and bait-bucket release.

The occurrence of harmful nonnative species, such as the bullfrog, the northern (virile) crayfish (*Orconectes virilis*), red swamp crayfish (*Procambarus clarkii*), and numerous species of nonnative, spiny-rayed fish, has contributed to rangewide declines in both species of gartersnake, and continues to be the most significant threat to the northern Mexican and narrow-headed gartersnakes, and to their prey base, as a result of direct predation, competition, and modification of habitat as evidenced in a broad body of literature, the most recent of which extends from 1985 to the present (Meffe 1985, pp. 179–185; Propst *et al.* 1986, pp. 14–31, 82; 1988, p. 64; 2009, pp. 5–17; Minckley 1987, pp. 2, 16; 1993, pp. 7–13; Rosen and Schwalbe 1988, pp. 28, 32; 1997, p. 1; Bestgen and Propst 1989, pp. 409–410; Clarkson and Rorabaugh 1989, pp. 531, 535; Papoulias *et al.* 1989, pp. 77–80; Marsh and Minckley 1990, p. 265; Jakle 1992, pp. 3–5; 1995, pp. 5–7; ASU 1994, multiple reports; 1995, multiple reports; 2008, multiple reports; Stefferud and Stefferud 1994, p. 364; Douglas *et al.* 1994, pp. 9–19; Rosen *et al.* 1995, pp. 257–258; 1996b, pp. 2, 11–13; 2001, p. 2; Springer 1995, pp. 6–10; Degenhardt *et al.* 1996, p. 319; Fernandez and Rosen 1996, pp. 8, 23–27, 71, 96; Richter *et al.* 1997, pp. 1089, 1092; Weedman and Young 1997, pp. 1, Appendices B, C; Inman *et al.* 1998, p. 17; Rinne *et al.* 1998, pp. 4–6; 2004, pp. 1–2; Jahrke and Clark 1999, pp. 2–7; Minckley *et al.* 2002, pp. 696; Nowak and Santana-Bendix 2002, Table 3; Propst 2002, pp. 21–25; DFT 2003, pp. 1–3, 5–6, 19; 2004, pp. 1–2, 4–5, 10, Table 1; 2006, pp. iii, 25; Marsh *et al.* 2003, p. 667; Bonar *et al.* 2004, pp. 13, 16–21; Rinne 2004, pp. 1–2; Clarkson *et al.* 2005, p. 20; 2008, pp. 3–4; Fagan *et al.* 2005, pp. 34, 34–41; Knapp 2005, pp. 273–275; Olden and Poff 2005, pp. 82–87; AGFD 2006, p. 83; Turner 2007, p. 41; Holycross *et al.* 2006, pp. 13–15; Brennan and Holycross 2006, p. 123; Brennan 2007, pp. 5, 7; Turner and List 2007, p. 13; USFWS 2007, pp. 22–23; Burger 2008, p. 4; Caldwell 2008a, 2008b; Duifhuis Rivera *et al.* 2008, p. 479, Jones 2008b; d'Orgeix 2008; Haney *et al.* 2008, p. 59; Luja and Rodríguez-Estrella 2008, pp. 17–22; Probst *et al.* 2008, pp. 1242–1243; Rorabaugh 2008a, p. 25; USFS 2008; Wallace *et al.* 2008, pp. 243–244; Witte *et al.* 2008, p. 1; Bahm and Robinson 2009a, pp. 2–6; 2009b, pp. 1–4; Brennan and Rosen 2009, pp. 8–9; Karam *et al.* 2009; pp. 2–3; Minckley and Marsh 2009, pp. 50–51; Paroz *et al.* 2009, pp. 12, 18; Robinson and Crowder 2009, pp. 3–5; Pilger *et al.* 2010, pp. 311–312; Stefferud *et al.* 2011, pp. 11–12; C. Akins 2012, pers. comm.; Young and Boyarski 2013, pp. 159–160; Emmons and Nowak 2013, p. 5).

The Decline of the Gartersnake Prey Base

The documented decline of the northern Mexican and narrow-headed gartersnakes was typically subsequent to the declines in their prey base (native amphibian and fish populations). These declines in prey base result from predation following the establishment of nonnative bullfrogs, crayfish, and numerous species of nonnative, spiny-rayed fish as supported by an extensive body of literature referenced immediately above.

Northern Mexican and narrow-headed gartersnakes appear to be particularly vulnerable to the loss of native prey species (Rosen and Schwalbe 1988, pp. 20, 44–45). Rosen *et al.* (2001, pp. 10, 13, 19) examined this issue in detail with respect to the northern Mexican gartersnake, and proposed two reasons for its decline following a loss of, or decline in, the native prey base: (1) The species is unlikely to increase foraging efforts at the risk of increased predation; and (2) the species needs adequate food on a regular basis to maintain its weight and health. If forced to forage more often for smaller prey items, a reduction in growth and reproductive rates can result (Rosen *et al.* 2001, pp. 10, 13). Rosen *et al.* (2001, p. 22) concluded that the presence and expansion of nonnative predators (mainly bullfrogs, crayfish, and green sunfish (*Lepomis cyanellus*)) is the primary cause of decline in northern Mexican gartersnakes and their prey in southeastern Arizona. In another example, Drummond and Marcias Garcia (1983, pp. 25, 30) found that Mexican gartersnakes fed primarily on frogs, and functioned as a local specialist in that regard. When frogs became unavailable, the species simply ceased major foraging activities. This led the author to conclude that frog abundance is probably the most important correlate, and main determinant, of foraging behavior in this species. Alternatively, terrestrial prey species were consumed, but the gartersnakes were never documented as having these prey items as a major dietary component, even when the gartersnakes were in dire need (Drummond and Marcias Garcia 1983, p. 37).

With respect to narrow-headed gartersnakes, the relationship between harmful nonnative species, a declining prey base, and gartersnake populations is clearly depicted in one population along Oak Creek. Nowak and Santana-Bendix (2002, Table 3) found a clear partition in the distribution of nonnative, spiny-rayed fish and soft-rayed fish in the vicinity of Midgely Bridge, where nonnative, spiny-rayed fish increased in abundance in the downstream direction and soft-rayed fish increased in abundance in the upstream direction. These fish community distributions closely parallel that of narrow-headed gartersnakes along Oak Creek, where gartersnake populations increase in density in the upstream direction and decrease notably in the downstream direction (Nowak and Santana-Bendix 2002, p. 23). Numerous historical records for narrow-headed gartersnakes document the species in the lower reach of Oak Creek, but the species is currently rarely detected in this reach of Oak Creek (Nowak and Santana-Bendix 2002, pp. 13–14), providing evidence of the decline of narrow-headed gartersnakes in the presence of nonnative, spiny-rayed fish.

Fish—Northern Mexican and narrow-headed gartersnakes can successfully use nonnative, soft-rayed fish species as prey, including mosquitofish, red shiner, and introduced trout (*Salmo* sp.) (Nowak and Santana-Bendix 2002, pp. 24–25; Holycross *et al.* 2006, p. 23). However, all other nonnative species, most notably the spiny-rayed fish, are not considered prey species for northern Mexican or narrow-headed gartersnakes and, in addition, are known to prey on neonatal and juvenile gartersnakes. Nowak and Santana-Bendix (2002, p. 24) propose two hypotheses regarding the reluctance of narrow-headed gartersnakes to prey on nonnative, spiny-rayed fish: (1) The laterally-compressed shape and presence of sharp, spiny dorsal spines present a choking hazard to gartersnakes that has been observed to be fatal; and (2) nonnative, spiny-rayed fish tend to occupy the middle and upper zones in the water column, while narrow-headed gartersnakes typically hunt along the bottom (where native fish tend to occur). As a result, nonnative, spiny-rayed fish may be largely ecologically unavailable as prey. It is likely the shape and presence of sharp, spiny dorsal spines on these nonnative fish species also present a choking hazard to both northern Mexican and narrow-headed gartersnakes.

Nonnative, spiny-rayed fish invasions can indirectly affect the health, maintenance, and reproduction of northern Mexican and narrow-headed gartersnakes by altering their foraging strategy and compromising foraging success. Rosen *et al.* (2001, p. 19), in addressing the northern Mexican gartersnake, proposed that an increase in energy expended in foraging, coupled by the reduced number of small to medium-sized prey fish available, results in deficiencies in nutrition, affecting growth and reproduction. This occurs because energy is allocated to maintenance and the increased energy costs of intense foraging activity, rather than to growth and reproduction. In contrast, a northern Mexican gartersnake diet that includes both fish and amphibians, such as leopard frogs, reduces the necessity to forage at a higher frequency, allowing metabolic energy gained from larger prey items to be allocated instead to growth and reproductive development. Myer and Kowell (1973, p. 225) experimented with food deprivation in common gartersnakes, and found significant reductions in lengths and weights of juvenile snakes that were deprived of regular feedings versus the control group that were fed regularly at natural frequencies. Reduced foraging success of both northern Mexican and narrow-headed gartersnakes means that individuals are likely to become vulnerable to effects from starvation, which may increase mortality rates of juveniles and, consequently, affect recruitment.

Northern Mexican gartersnakes have a more varied diet than narrow-headed gartersnakes. We are not aware of any studies that have addressed the direct relationship between prey base diversity and northern Mexican gartersnake recruitment and survivorship. However, Krause and Burghardt (2001, pp. 100–123) discuss the benefits and costs that may be associated with diet variability in the common gartersnake (*Thamnophis sirtalis*), an ecologically similar species to the northern Mexican gartersnake. Foraging for mixed-prey species may impede predator learning, as compared to specialization, on a certain prey species, but may also provide long-term benefits (Krause and Burghardt 2001, p. 101). Krause and Burghardt (2001, p. 112) stated that varied predatory experience played an important role in the feeding abilities of gartersnakes through the first 8 months of age. These data suggest that a varied prey base might also be important for neonatal and juvenile northern Mexican gartersnakes (also a species with a varied diet) and that decreases in the diversity of the prey base during the young age classes might adversely affect the ability of individuals to capture prey throughout their lifespan, in addition to the more obvious effects of reduced prey availability.

A wide variety of native fish species, now listed as endangered, threatened, or candidates for listing, were historically primary prey species for northern Mexican and narrow-headed gartersnakes (Rosen and Schwalbe 1988, pp. 18, 39). Aquatic habitat destruction and modification is often considered a leading cause for the decline in native fish in the southwestern United States. However, Marsh and Pacey (2005, p. 60) predict that despite the significant physical alteration of aquatic habitat in the southwest, native fish species could not only complete all of their life functions but could flourish in these altered environments, but for the presence of (harmful) nonnative fish species, as supported by a ''substantial and growing body of evidence derived from case studies.'' Northern Mexican and narrow-headed gartersnakes depend on native fish as a principle part of their prey base, although nonnative, soft-rayed fish are also common prey items where they overlap in distribution with these gartersnakes (Nowak and Santana-Bendix 2002, pp. 24–25; Holycross *et al.* 2006, p. 23). Nonnative, spiny-rayed fish compete with northern Mexican and narrow-headed gartersnakes for prey. In their extensive surveys, Rosen and Schwalbe (1988, p. 44) only found narrow-headed gartersnakes in abundance where native fish species predominated, but did not find them abundant in the presence of robust nonnative, spiny-rayed fish populations. Minckley and Marsh (2009, pp. 50–51) found nonnative fishes to be the single-most significant factor in the decline of native fish species and also their primary obstacle to recovery. Of the 48 conterminous States in the United States, Arizona has the highest proportion of nonnative fish species (66 percent) represented by approximately 68 species of nonnative fish (Turner and List 2007, p. 13).

Collier *et al.* (1996, p. 16) note that interactions between native and nonnative fish have significantly contributed to the decline of many native fish species from direct predation and, indirectly, from competition (which has adversely affected the prey base for northern Mexican and narrow-headed gartersnakes). The AGFD considers native fish in Arizona as the most threatened taxa among the State's native species, largely as a result of predation and competition with nonnative species (AGFD 2006, p. 83). Holycross *et al.* (2006, pp. 52–61) documented significantly depressed or extirpated native fish prey bases for northern Mexican and narrow-headed gartersnakes along the Mogollon Rim in Arizona and New Mexico. Rosen *et al.* (2001, Appendix I) documented the decline of several native fish species in several locations visited in southeastern Arizona, further affecting the prey base of northern Mexican gartersnakes in that area.

Stocked for sport, forage, or biological control, nonnative fishes have been shown to become invasive where released, do not require natural flow regimes, and tend to be more phylogenetically advanced than native species (Kolar *et al.* 2003, p. 9) which contributed to their expansion in the Gila River basin. Harmful nonnative fish species tend to be nest-builders and actively guard their young which may provide them another ecological advantage over native species which are broadcast spawners and provide no parental care to their offspring (Marsh and Pacey 2005, p. 60). It is therefore likely that recruitment and survivorship is greater in nonnative species than native species where they overlap, providing them with an ecological advantage. Table 2–1 in Kolar *et al.* (2003, p. 10) provides a map depicting the high degree of overlap in the distribution of native and nonnative fishes within the Gila River basin of Arizona and New Mexico as well as watersheds thought to be dominated by nonnative fish species. The widespread decline of native fish species from the arid southwestern United States and Mexico has resulted largely from interactions with nonnative species and has been captured in the listing rules of 13 native species listed under the Act, and whose historical ranges overlap with the historical distribution of northern Mexican and narrow-headed gartersnakes. Native fish species that were likely prey species for these gartersnakes and are now listed under the Act, include the bonytail chub (*Gila elegans,* 45 FR 27710, April 23, 1980), Yaqui catfish (*Ictalurus pricei,* 49 FR 34490, August 31, 1984), Yaqui chub (*Gila purpurea,* 49 FR 34490, August 31, 1984), Yaqui topminnow (*Poeciliopsis occidentalis sonoriensis,* 32 FR 4001, March 11, 1967), beautiful shiner (*Cyprinella formosa,* 49 FR 34490, August 31, 1984), humpback chub (*Gila cypha,* 32 FR 4001, March 11, 1967), Gila chub (*Gila intermedia,* 70 FR 66663, November 2, 2005), Colorado pikeminnow (*Ptychocheilus lucius,* 32 FR 4001, March 11, 1967), spikedace (*Meda fulgida,* 77 FR 10810, February 23, 2012), loach minnow (*Tiaroga cobitis,* 77 FR 10810, February 23, 2012), razorback sucker (*Xyrauchen texanus,* 56 FR 54957, October 23, 1991), desert pupfish (*Cyprinodon macularius,* 51 FR 10842, March 31, 1986), and Gila topminnow (*Poeciliopsis occidentalis,* 32 FR 4001, March 11, 1967). In total, within Arizona, 19 of 31 (61 percent) native fish species are listed under the Act. Arizona ranks the highest of all 50 States in the percentage of native fish species with declining trends (85.7 percent) and New Mexico ranks sixth (48.1 percent) (Stein 2002, p. 21; Warren and Burr 1994, p. 14). Recovery of native fishes in the Southwest has been fraught with complicating factors, both natural and sociopolitical, which have presented significant challenges to the recovery of many imperiled native fish species (Minckley and Marsh 2009, pp. 52–53), including many that are important prey species for the northern Mexican and narrow-headed gartersnakes.

In an evolutionary context, many native fishes co-evolved with very few predatory fish species, whereas most of the nonnative species co-evolved with many predatory species (Clarkson *et al.* 2005, p. 21). A contributing factor to the decline of native fish species cited by Clarkson *et al.* (2005, p. 21) is that most of the nonnative species evolved behaviors, such as nest guarding, to protect their offspring from these many predators, while native species are generally broadcast spawners that provide no parental care. In the presence of nonnative species, the reproductive behaviors of native fish fail to allow them to compete effectively with the nonnative species, and, as a result, the viability of native fish populations is reduced.

Olden and Poff (2005, p. 75) stated that environmental degradation and the proliferation of nonnative fish species threaten the highly localized and unique fish faunas of the American Southwest. The fastest expanding nonnative species are red shiner (*Cyprinella lutrensis*), fathead minnow (*Pimephales promelas*), green sunfish, largemouth bass (*Micropterus salmoides*), western mosquitofish, and channel catfish (*Ictalurus punctatus*). These species are considered to be the most invasive in terms of their negative impacts on native fish communities (Olden and Poff 2005, p. 75). Many nonnative fishes, in addition to those listed immediately above, including yellow and black bullheads (*Ameiurus* sp.), flathead catfish (*Pylodictis olivaris*), and smallmouth bass (*Micropterus dolomieu*), have been introduced into formerly and currently occupied northern Mexican or narrow-headed gartersnake habitat and are predators on these species and their prey (Bestgen and Propst 1989, pp. 409–410; Marsh and Minckley 1990, p. 265; Sublette *et al.* 1990, pp. 112, 243, 246, 304, 313, 318; Abarca and Weedman 1993, pp. 6–12; Stefferud and Stefferud 1994, p. 364; Weedman and Young 1997, pp. 1, Appendices B, C; Rinne *et al.* 1998, pp. 3–6; Voeltz 2002, p. 88; Bonar *et al.* 2004, pp. 1–108; Fagan *et al.* 2005, pp. 34, 38–39, 41; Probst *et al.* 2008, pp. 1242–1243). Nonnative, spiny-rayed fish species, such as flathead catfish, may be especially dangerous to narrow-headed gartersnake populations through competition and direct predation, because they are primarily piscivorous (fish-eating) (Pilger *et al.* 2010, pp. 311–312), have large mouths, and have a tendency to occur along the stream bottom, where narrow-headed gartersnakes principally forage.

Rosen *et al.* (2001, Appendix I) and Holycross *et al.* (2006, pp. 15–51) conducted large-scale surveys for northern Mexican gartersnakes in southeastern and central Arizona and narrow-headed gartersnakes in central and east-central Arizona, and documented the presence of nonnative fish at many locations. Holycross *et al.* (2006, pp. 14–15) found nonnative fish species in 64 percent of the sample sites in the Agua Fria subbasin, 85 percent of the sample sites in the Verde River subbasin, 75 percent of the sample sites in the Salt River subbasin, and 56 percent of the sample sites in the Gila River subbasin. In total, nonnative fish were observed at 41 of the 57 sites surveyed (72 percent) across the Mogollon Rim (Holycross *et al.* 2006, p. 14). Entirely native fish communities were detected in only 8 of 57 sites surveyed (14 percent) (Holycross *et al.* 2006, p. 14). It is well documented that nonnative fish have now infiltrated the majority of aquatic communities in the southwestern United States as depicted in Tables 1 and 2, above, as well as in Appendix A (available at *http://www.regulations.gov* under Docket No. FWS–R2–ES–2013–0071).

Several authors have identified both the presence of nonnative fish as well as their deleterious effects on native species within Arizona. Many areas have seen a shift from a predominance of native fishes to a predominance of nonnative fishes. On the upper Verde River, native species dominated the total fish community at greater than 80 percent from 1994 to 1996, before dropping to approximately 20 percent in 1997 and 19 percent in 2001. At the same time, three nonnative species increased in abundance between 1994 and 2000 (Rinne *et al.* 2004, pp. 1–2). In an assessment of the Verde River, Bonar *et al.* (2004, p. 57) found that in the Verde River mainstem, nonnative fishes were approximately 2.6 times more dense per unit volume of river than native fishes, and their populations were approximately 2.8 times that of native fishes per unit volume of river. Haney *et al.* (2008, p. 61) declared the northern Mexican gartersnake as nearly lost from the Verde River but also suggested that diminished river flow may be an important factor. Similar changes in the dominance of nonnative fishes have occurred on the Middle Fork Gila River, with a 65 percent decline of native fishes between 1988 and 2001 (Propst 2002, pp. 21–25). Abarca and Weedman (1993, pp. 6–12) found that the number of nonnative fish species was twice the number of native fish species in Tonto Creek in the early 1990s, with a stronger nonnative species influence in the lower reaches, where the northern Mexican gartersnake is considered to still occur, and Burger (2008, p. 8) confirmed their continued existence there. Surveys in the Salt River above Lake Roosevelt indicate a decline of roundtail chub and other natives with an increase in flathead and channel catfish numbers (Voeltz 2002, p. 49).

In New Mexico, nonnative fish have been identified as the main cause for declines observed in native fish populations (Voeltz 2002, p. 40; Probst *et al.* 2008, pp. 1242–1243). Fish experts from the U.S. Forest Service, U.S. Bureau of Reclamation, U.S. Bureau of Land Management (BLM), University of Arizona, Arizona State University, the Nature Conservancy, and others declared the native fish fauna of the Gila River basin to be critically imperiled, and they cite habitat destruction and nonnative species as the primary factors for the declines. They call for the control and removal of nonnative fish as an overriding need to prevent the decline, and ultimate extinction, of native fish species within the basin (DFT 2003, p. 1). In some areas, nonnative fishes may not dominate the system, but their abundance has increased. This is the case for the Cliff-Gila Valley area of the Gila River, where nonnative fishes increased from 1.1 percent to 8.5 percent, while native fishes declined steadily over a 40-year period (Propst *et al.* 1986, pp. 27–32). At the Redrock and Virden valleys on the Gila River, the relative abundance in nonnative fishes in the same time period increased from 2.4 percent to 17.9 percent (Propst *et al.* 1986, pp. 32–34). Four years later, the relative abundance of nonnative fishes increased to 54.7 percent at these sites (Propst *et al.* 1986, pp. 32–36). The percentage of nonnative fishes increased by almost 12 percent on the Tularosa River between 1988 and 2003, while on the East Fork Gila River, nonnative fishes increased to 80.5 percent relative abundance in 2003 (Propst 2005, pp. 6–7, 23–24).

Nonnative fishes are also considered a management issue in other areas including Eagle Creek, the San Pedro River, West Fork Gila River, and to a lesser extent, the Blue River.

In addition to harmful nonnative species, various parasites may affect native fish species that are prey for northern Mexican and narrow-headed gartersnakes. Asian tapeworm was introduced into the United States with imported grass carp (*Ctenopharyngodon idella*) in the early 1970s. It has since become well established in areas throughout the southwestern United States. The definitive host in the life cycle of Asian tapeworm is a cyprinid fish (carp or minnow), and therefore it is a potential threat to native cyprinids in Arizona and New Mexico. The Asian tapeworm adversely affects fish health by impeding the digestion of food as it passes through the digestive track. Emaciation and starvation of the host can occur when large enough numbers of worms feed off the fish directly. An indirect effect is that weakened fish are more susceptible to infection by other pathogens. Asian tapeworm invaded the Gila River basin and was found during the Central Arizona Project's fall 1998 monitoring in the Gila River at Ashurst-Hayden Dam. It has also been confirmed from Bonita Creek in 2010 (USFWS National Wild Fish Health Survey 2010). This parasite can infect many species of fish and is carried into new areas along with nonnative fishes or native fishes from contaminated areas.

Another parasite (*Ichthyophthirius multifiliis*) (Ich) usually occurs in deep waters with low flow and is a potential threat to native fish. Ich has occurred in some Arizona streams, probably encouraged by high temperatures and crowding as a result of drought. This parasite was observed being transmitted on the Sonora sucker (*Catostomus insignis*), although it does not appear to be host-specific and could be transmitted by other species (Mpoame 1982, p. 46). It has been found on desert and Sonoran suckers, as well as roundtail chub (Robinson *et al.* 1998, p. 603), which are important prey species for the northern Mexican and narrow-headed gartersnakes. This parasite becomes embedded under the skin and within the gill tissues of infected fish. When Ich matures, it leaves the fish, causing fluid loss, physiological stress, and sites that are susceptible to infection by other pathogens. If Ich is present in large enough numbers, it can also impact respiration because of damaged gill tissue.

Anchor worm (*Lernaea cyprinacea*), an external parasite, is unusual in that it has little host specificity, infecting a wide range of fishes and amphibians. Infection by this parasite has been known to kill large numbers of fish due to tissue damage and secondary infection of the attachment site (Hoffnagle and Cole 1999, p. 24). Presence of this parasite in the Gila River basin is a threat to native fishes. In July 1992, the BLM found anchor worms in Bonita Creek. They have also been documented in the Verde River (Robinson *et al.* 1998, pp. 599, 603–605).

The yellow grub (*Clinostomum marginatum)* is a parasitic, larval flatworm that appears as yellow spots on the body and fins of a fish. Because the intermediate host is a bird and therefore highly mobile, yellow grubs are easily spread. When yellow grubs infect a fish, they penetrate the skin and migrate into its tissues, causing damage and potentially hemorrhaging. Damage from one yellow grub may be minimal, but in greater numbers, yellow grubs can kill fish (Maine Department of Inland Fisheries and Wildlife 2002a, p. 1). Yellow grubs occur in many areas in Arizona and New Mexico, including Oak Creek (Mpoame and Rinne 1983, pp. 400–401), the Salt River (Amin 1969, p. 436; Bryan and Robinson 2000, p. 19), the Verde River (Bryan and Robinson 2000, p. 19), and Bonita Creek (Robinson 2011, pers. comm.).

The black grub (*Neascus* spp.), also called black spot, is a parasitic larval fluke that appears as black spots on the skin, tail base, fins, and musculature of a fish. When an intermediate life stage of black grubs migrates into the tissues of a fish they are called ''cercaria.'' The damage caused by one cercaria is negligible, but in greater numbers they may kill a fish (Lane and Morris 2000, pp. 2–3; Maine Department of Inland Fisheries and Wildlife 2002b, p. 1). Black grubs are present in the Verde River (Robinson *et al.* 1998, p. 603; Bryan and Robinson 2000, p. 21), and are prevalent in the San Francisco River in New Mexico (Paroz 2011, pers. comm.).

To date, we have no information on the effect of parasite infestation in native fish on both gartersnake populations.

The Decline of Native Fish Communities in Mexico—The first tabulations of freshwater fish species at risk in Mexico occurred in 1961, when 11 species were identified as being at risk (Contreras-Balderas *et al.* 2003, p. 241). As of 2003, of the 506 species of freshwater fish recorded in Mexico, 185 (37 percent) have been listed by the Mexican Federal Government as either endangered, facing extinction, under special protection, or likely extinct (Alvarez-Torres *et al.* 2003, p. 323), almost a 17-fold increase in slightly over four decades; 25 species are believed to have gone extinct (Contreras-Balderas *et al.* 2003, p. 241). In the lower elevations of Mexico, within the distribution of the northern Mexican gartersnake, there are approximately 200 species of native freshwater fish documented, with 120 native species under some form of threat and an additional 15 that have gone extinct (Contreras-Balderas and Lozano 1994, pp. 383–384). The Fisheries Law in Mexico empowered the country's National Fisheries Institute to compile and publish the National Fisheries Chart in 2000, which found that Mexico's fish fauna has seriously deteriorated as a result of environmental impacts (pollution), water basin degradation (dewatering, siltation), and the introduction of nonnative species (Alvarez-Torres *et al.* 2003, pp. 320, 323). The National Fisheries Chart is regarded as the first time the Mexican government has openly revealed the status of its freshwater fisheries and described their management policies (Alvarez-Torres *et al.* 2003, pp. 323–324).

Industrial, municipal, and agricultural water pollution, dewatering of aquatic habitat, and the proliferation nonnative species are widely considered to be the greatest threats to freshwater ecosystems in Mexico (Branson *et al.* 1960, p. 218; Conant 1974, pp. 471, 487–489; Miller *et al.* 1989, pp. 25–26, 28–33; 2005, pp. 60–61; DeGregorio 1992, p. 60; Contreras Balderas and Lozano 1994, pp. 379–381; Lyons *et al.* 1995, p. 572; 1998, pp. 10–12; va Landa *et al.* 1997, p. 316; Mercado-Silva *et al.* 2002, p. 180; Contreras-Balderas *et al.* 2003, p. 241; Domínguez-Domínguez *et al.* 2007, Table 3). A shift in land use policies in Mexico to encourage free market principles in rural, small-scale agriculture has been found to promote land use practices that threaten local biodiversity (Ortega-Huerta and Kral 2007, p. 2; Randall 1996, pp. 218–220; Kiernan 2000, pp. 13–23). These threats have been documented throughout the distribution of the northern Mexican gartersnake in Mexico and are best represented in the scientific literature in the context of fisheries studies. Contreras-Balderas *et al.* (2003, pp. 241, 243) named Chihuahua (46 species), Coahuila (35 species), Sonora (19 species), and Durango (18 species) as Mexican states that had some of the most reports of freshwater fish species at risk. These states are all within the distribution of the northern Mexican gartersnake, indicating an overlapping trend of declining prey bases and threatened ecosystems within the range of the northern Mexican gartersnake in Mexico. Contreras-Balderas *et al.* (2003, Appendix 1) found various threats to be adversely affecting the status of freshwater fish and their habitat in several states in Mexico: (1) Habitat reduction or alteration (Sonora, Chihuahua, Durango, Coahuila, San Luis Potosí, Jalisco, Guanajuato); (2) water depletion (Chihuahua, Durango, Coahuila, Sonora, Guanajuato, Jalisco, San Luis Potosí); (3) harmful nonnative species (Durango, Chihuahua, Coahuila, San Luis Potosí, Sonora, Veracruz); and (4) pollution (México, Jalisco, Chihuahua, Coahuila, Durango). Within the states of Chihuahua, Durango, Coahuila, Sonora, Jalisco, and Guanajuato, water depletion is considered serious, with entire basins having been dewatered, or conditions have been characterized as ''highly altered'' (Contreras-Balderas *et al.* 2003, Appendix 1). All of the Mexican states with the highest numbers of fish species at risk are considered arid, a condition hastened by increasing desertification (Contreras-Balderas *et al.* 2003, p. 244).

Aquaculture and Nonnative Fish Proliferation in Mexico—Nonnative fish compete with and prey upon northern Mexican gartersnakes and their native prey species. The proliferation of nonnative fish species throughout Mexico happened mainly by natural dispersal, intentional stockings, and accidental breaches of artificial or constructed barriers by nonnative fish. Lentic water bodies such as lakes, reservoirs, and ponds are often used for flood control, agricultural purposes, and most commonly to support commercial fisheries. The most recent estimates indicate that Mexico has 13,936 of such water bodies, where approximately 96 percent are between 2.47–247 acres (1–100 hectares) and approximately half are artificial (Sugunan 1997, Table 8.3; Alvarez-Torres *et al.* 2003, pp. 318, 322). Areas where these landscape features are most prevalent occur within the distribution of the northern Mexican gartersnake. For example, Jalisco and Zacatecas are listed as two of four states with the highest number of reservoirs, and Chihuahua is one of two states known for a high concentration of lakes (Sugunan 1997, Section 8.4.2). Based on the data presented in Sugunan (1997, Table 8.5), a total of 422 dammed reservoirs are located within the 16 Mexican states where the northern Mexican gartersnake is thought to occur. Mercado-Silva *et al.* (2006, p. 534) found that within the state of Guanajuato, ''Practically all streams and rivers in the [Laja] basin are truncated by reservoirs or other water extraction and storage structures.'' On the Laja River alone, there are two major reservoirs and a water diversion dam; 12 more reservoirs are located on its tributaries (Mercado-Silva *et al.* 2006, p. 534). As a consequence of dam operations, the main channel of the Laja remains dry for extensive periods of time (Mercado-Silva *et al.* 2006, p. 541). The damming and modification of the lower Colorado River in Mexico, where the northern Mexican gartersnake occurred, has facilitated the replacement of the entire native fishery with nonnative species (Miller *et al.* 2005, p. 61). Each reservoir created by a dam is either managed as a nonnative commercial fishery or has become a likely source population of nonnative species, which have naturally or artificially colonized the reservoir, dispersed into connected riverine systems, and damaged native aquatic communities.

Mexico, as with other developing countries, depends in large part on freshwater commercial fisheries as a source of protein for both urbanized and rural human populated areas. Commercial and subsistence fisheries rely heavily on introduced, nonnative species in the largest freshwater lakes (Soto-Galera *et al.* 1999, p. 133) down to rural, small ponds (Tapia and Zambrano 2003, p. 252). At least 87 percent of the species captured or cultivated in inland fisheries of Mexico from 1989–1999 included tilapia, common carp, channel catfish, trout, and black bass (*Micropterus* sp.), all of which are nonnative (Alvarez-Torres *et al.* 2003, pp. 318, 322). In fact, the northern and central plateau region of Mexico (which comprises most of the distribution of the northern Mexican gartersnake's distribution in Mexico) is considered ideal for the production of harmful, predatory species such as bass and catfish (Sugunan 1997, Section 8.3). Largemouth bass are now produced and stocked in reservoirs and lakes throughout the distribution of the northern Mexican gartersnake (Sugunan 1997, Section 8.8.1). The Secretariat for Environment, Natural Resources and Fisheries, formed in 1995 and known as SEMARNAP, is the Mexican federal agency responsible for management of the country's environment and natural resources. SEMARNAP dictates the stocking rates of nonnative species into the country's lakes and reservoirs. For example, the permitted stocking rate for largemouth bass in Mexico is one fish per square meter in large reservoirs (Sugunan 1997, Table 8.8); therefore, a 247-acre (100-ha) reservoir could be stocked with 1,000,000 largemouth bass. The common carp, the subject of significant aquaculture investment since the 1960s in Mexico, is known for altering aquatic habitat and consuming the eggs and fry of native fish species, and is now established in 95 percent of Mexico's freshwater systems (Tapia and Zambrano 2003, p. 252).

Basins in northern Mexico, such as the Rio Yaqui, have been found to be significantly compromised by harmful nonnative fish species. Unmack and Fagan (2004, p. 233) compared historical museum collections of nonnative fish species from the Gila River basin in Arizona and the Yaqui River basin in Sonora, Mexico, to gain insight into the trends in distribution, diversity, and abundance of nonnative fishes in each basin over time. They found that nonnative species are slowly, but steadily, increasing in all three parameters in the Yaqui Basin (Unmack and Fagan 2004, p. 233). Unmack and Fagan (2004, p. 233) predicted that, in the absence of aggressive management intervention, significant extirpations or range reductions of native fish species are expected to occur in the Yaqui Basin of Sonora, Mexico, which may have extant populations of the northern Mexican gartersnake, as did much of the Gila Basin before the introduction of nonnative species. Loss of native fishes will impact prey availability for the northern Mexican gartersnake and threaten its persistence in these areas. Black bullheads (*Ameiurus melas*) were reported as abundant, and common carp were detected from the Rio Yaqui in southern Sonora, Mexico (Branson *et al.* 1960, p. 219). Bluegill (*Lepomis macrochirus*) were also reported at this location, representing a significant range expansion that the authors expected was the result of escaping nearby farm ponds or irrigation ditches (Branson *et al.* 1960, p. 220). Largemouth bass, green sunfish, and an undetermined crappie species have also been reported from this area (Branson *et al.* 1960, p. 220). Hendrickson and Varela-Romero (1989, p. 479) conducted fish sampling along the Río Sonoyta of northern Sonora, Mexico, and found over half of the fish collected were nonnative, both predatory species and prey species for the northern Mexican gartersnake.

Domínguez-Domínguez *et al.* (2007, p. 171) sampled 52 localities for a rare freshwater fish, the Picotee goodeid (*Zoogoneticus quitzeoensis*), along the southern portion of the Mesa Central (Mexican Plateau) of Mexico and found 21 localities had significant signs of pollution. Of the 29 localities where the target species was detected, 28 of them also had harmful nonnative species present, such as largemouth bass, cichlids (*Oreochromis* sp.), bluegill, Pátzcuaro chub (*Algansea lacustris*) (Domínguez-Domínguez *et al.* 2007, pp. 171, Table 3). Other nonnative fish species reported are soft-rayed and small bodied, and may be prey items for younger age classes of northern Mexican gartersnakes. Several examples of significant aquatic habitat degradation or destruction were also observed by Domínguez-Domínguez *et al.* (2007, Table 3) in this region of Mexico, including the draining of natural lakes and cienegas for conversion to agricultural purposes, modification of springs for recreational swimming, diversions, and dam construction. As of 2006, native fish species comprised the most prevalent in species composition and abundance in the Laja Basin; however the basin is trending towards a nonnative fishery based on historical data whereas nonnative species were most recently collected from 16 of 17 sample sites, largemouth bass have significantly expanded their distribution within the headwaters of the basin, and bluegill are now widespread in the Laja River (Mercado-Silva *et al.* 2006, pp. 537, 542, Table 4).

The ecological risk of nonnative, freshwater aquaculture production has only recently been acknowledged by the Mexican government as compared to decades of aquaculture production, mainly because conservation of biodiversity was not valued as highly as the benefits garnered by nonnative fish production, most notably in the country's rural, poorest regions (Tapia and Zambrano 2003, p. 252). In fact, recent amendments to Mexico's fishing regulations allow for relaxation of existing regulations imposed by other government regulations and expansion of opportunities for investment in commercial fishing to promote growth in Mexico's aquaculture sector (Sugunan 1997, Section 8.7.1). Between the broad geographic extent of commercial or sustenance fisheries, the important source of protein they represent, and the many mechanisms introduced nonnative fish have to naturally or artificially expand their distribution, few areas within the range of the northern Mexican gartersnake in Mexico have avoided adverse impacts associated with nonnative species. Harmful nonnative fish species therefore pose a significant threat to the prey base of northern Mexican gartersnakes and to the gartersnakes themselves throughout most of their range in Mexico.

Amphibian decline—Matthews *et al.* (2002, p. 16) examined the relationship of gartersnake distributions, amphibian population declines, and nonnative fish introductions in high-elevation aquatic ecosystems in California. Matthews *et al.* (2002, p. 16) specifically examined the effect of nonnative trout introductions on populations of amphibians and mountain gartersnakes (*Thamnophis elegans elegans*). Their results indicated the probability of observing gartersnakes was 30 times greater in lakes containing amphibians than in lakes where amphibians have been extirpated by nonnative fish. These results supported a prediction by Jennings *et al.* (1992, p. 503) that native amphibian declines will lead directly to gartersnake declines. Matthews *et al.* (2002, p. 20) noted that, in addition to nonnative fish species adversely impacting amphibian populations that are part of the gartersnake's prey base, direct predation on gartersnakes by nonnative fish also occurs. However, Shah *et al.* (2010, pp. 188–190) found that native tadpoles may exhibit anti-predator learning behavior that may assist their persistence in habitat affected by nonnative, spiny-rayed fish.

Declines in the native leopard frog populations in Arizona have contributed to declines in the northern Mexican gartersnake, one of the frog's primary native predators. Native ranid frog species, such as lowland leopard frogs, northern leopard frogs, and federally threatened Chiricahua leopard frogs, have all experienced declines in various degrees throughout their distribution in the Southwest, partially due to predation and competition with nonnative species (Clarkson and Rorabaugh 1989, pp. 531, 535; Hayes and Jennings 1986, p. 490). Rosen *et al.* (1995, pp. 257–258) found that Chiricahua leopard frog distribution in the Chiricahua Mountain region of Arizona was inversely related to nonnative species distribution and, without corrective action, predicted that the Chiricahua leopard frog may be difficult to conserve in this region. Along the Mogollon Rim, Holycross *et al.* (2006, p. 13) found that only 8 sites of 57 surveyed (15 percent) consisted of an entirely native anuran community, and that native frog populations in another 19 sites (33 percent) had been completely displaced by invading bullfrogs. However, such declines in native frog populations are not necessarily irreversible. Ranid frog populations have been shown to rebound strongly when nonnative fish are removed (Knapp *et al.* 2007, pp. 15–18).

Scotia Canyon, in the Huachuca Mountains of southeastern Arizona, is a location where corresponding declines of leopard frog and northern Mexican gartersnake populations have been documented through repeated survey efforts over time (Holm and Lowe 1995, p. 33). Surveys of Scotia Canyon occurred during the early 1980s, and again during the early 1990s. Leopard frogs in Scotia Canyon were infrequently observed during the early 1980s, and were apparently extirpated by the early 1990s (Holm and Lowe 1995, pp. 45–46). Northern Mexican gartersnakes were observed in decline during the early 1980s, with low capture rates continuing through the early 1990s (Holm and Lowe 1995, pp. 27–35). Surveys documented further decline of leopard frogs and northern Mexican gartersnakes in 2000 (Rosen *et al.* 2001, pp. 15–16).

A former large, local population of northern Mexican gartersnakes at the San Bernardino National Wildlife Refuge (SBNWR) in southeastern Arizona has also experienced a correlative decline of leopard frogs, and northern Mexican gartersnakes are now thought to occur at very low-population densities or may be extirpated there (Rosen and Schwalbe 1988, p. 28; 1995, p. 452; 1996, pp. 1–3; 1997, p. 1; 2002b, pp. 223–227; 2002c, pp. 31, 70; Rosen *et al.* 1996b, pp. 8–9; 2001, pp. 6–10).

Survey data indicate that declines of leopard frog populations, often correlated with nonnative species introductions, the spread of a chytrid fungus (*Batrachochytrium dendrobatidis,* Bd), and habitat modification and destruction, have occurred throughout much of the northern Mexican gartersnake's U.S. distribution (Nickerson and Mays 1970, p. 495; Vitt and Ohmart 1978, p. 44; Ohmart *et al.* 1988, p. 150; Rosen and Schwalbe 1988, Appendix I; 1995, p. 452; 1996, pp. 1–3; 1997, p. 1; 2002b, pp. 232–238; 2002c, pp. 1, 31; Clarkson and Rorabaugh 1989, pp. 531–538; Sredl *et al.* 1995a, pp. 7–8; 1995b, pp. 8–9, 1995c, pp. 7–8; 2000, p. 10; Holm and Lowe 1995, pp. 45–46; Rosen *et al.* 1996b, p. 2; 2001, pp. 2, 22; Degenhardt *et al.* 1996, p. 319; Fernandez and Rosen 1996, pp. 6–20; Drost and Nowak 1997, p. 11; Turner *et al.* 1999, p. 11; Nowak and Spille 2001, p. 32; Holycross *et al.* 2006, pp. 13–14, 52–61). Specifically, Holycross *et al.* (2006, pp. 53–57, 59) documented potential extirpations of the northern Mexican gartersnake's native leopard frog prey base at several currently, historically, or potentially occupied locations, including the Agua Fria River in the vicinity of Table Mesa Road and Little Grand Canyon Ranch, and at Rock Springs, Dry Creek from Dugas Road to Little Ash Creek, Little Ash Creek from Brown Spring to Dry Creek, Sycamore Creek (Agua Fria subbasin) in the vicinity of the Forest Service Cabin, the Page Springs and Bubbling Ponds fish hatchery along Oak Creek, Sycamore Creek (Verde River subbasin) in the vicinity of the confluence with the Verde River north of Clarkdale, along several reaches of the Verde River mainstem, Cherry Creek on the east side of the Sierra Ancha Mountains, and Tonto Creek from Gisela to ''the Box,'' near its confluence with Rye Creek.

Rosen *et al.* (2001, p. 22) identified the expansion of bullfrogs into the Sonoita grasslands, which contain occupied northern Mexican gartersnake habitat, and the introduction of crayfish into Lewis Springs, as being of particular concern in terms of future recovery efforts for the northern Mexican gartersnake. Rosen *et al.* (1995, pp. 252–253) sampled aquatic herpetofauna at 103 sites in the Chiricahua Mountains region, which included the Chiricahua, Dragoon, and Peloncillo mountains, and the Sulphur Springs, San Bernardino, and San Simon valleys. They found that 43 percent of all cold-blooded aquatic and semi-aquatic vertebrate species detected were nonnative. The most commonly encountered nonnative species was the bullfrog (Rosen *et al.* 1995, p. 254). Witte *et al.* (2008, p. 1) found that the disappearance of ranid frog populations in Arizona were 2.6 times more likely in the presence of crayfish. Witte *et al.* (2008, p. 7) emphasized the significant influence of nonnative species on the disappearance of ranid frogs in Arizona.

In addition to harmful nonnative species, disease and nonnative parasites have been implicated in the decline of the prey base of the northern Mexican gartersnake. In particular, the outbreak of chytridiomycosis or ''Bd,'' a skin fungus, has been identified as a chief causative agent in the significant declines of many of the native ranid frogs and other amphibian species. In addition, regional concerns exist for the native fish community due to nonnative parasites, such as the Asian tapeworm (*Bothriocephalus acheilognathi*) in southeastern Arizona (Rosen and Schwalbe 1997, pp. 14–15; 2002c, pp. 1–19; Morell 1999, pp. 728–732; Sredl and Caldwell 2000, p. 1; Hale 2001, pp. 32–37; Bradley *et al.* 2002, p. 206). As indicated, Bd has been implicated in both large-scale declines and local extirpations of many amphibians, chiefly anuran species, around the world (Johnson 2006, p. 3011). Lips *et al.* (2006, pp. 3166–3169) suggest that the high virulence and large number of potential hosts make Bd a serious threat to amphibian diversity. In Arizona, Bd infections have been reported in several of the native prey species of the northern Mexican gartersnake within the distribution of the snake (Morell 1999, pp. 731–732; Sredl and Caldwell 2000, p. 1; Hale 2001, pp. 32–37; Bradley *et al.* 2002, p. 207; USFWS 2002, pp. 40802–40804; USFWS 2007, pp. 26, 29–32). Declines of native prey species of the northern Mexican gartersnake from Bd infections have contributed to the decline of this species in the United States (Morell 1999, pp. 731–732; Sredl and Caldwell 2000, p. 1; Hale 2001, pp. 32–37; Bradley *et al.* 2002, p. 207; USFWS 2002, pp. 40802–40804; USFWS 2007, pp. 26, 29–32). Evidence of Bd-related amphibian declines has been confirmed in portions of southern Mexico (just outside the range of northern Mexican gartersnakes), and data suggest declines are more prevalent at higher elevations (Lips *et al.* 2004, pp. 560–562). However, much less is known about the role of Bd in amphibian declines across much of Mexico, in particular the mountainous regions of Mexico (including much of the range of northern Mexican gartersnakes in Mexico) as the region is significantly understudied (Young *et al.* 2000, p. 1218). Because narrow-headed gartersnakes feed on fish, Bd has not affected their prey base. Also, research shows that the fungus *Batrachochytrium* can grow on boiled snakeskin (keratin) in the laboratory (Longcore *et al.* 1999, p. 227), indicating the potential for disease outbreaks in wild snake populations if conditions are favorable; however no observations have been made in the field, and we found no other data that propose a direct linkage between Bd and snake mortality.

The Effects of Bullfrogs on Native Aquatic Communities

Bullfrogs are generally considered one of the most serious threats to northern Mexican gartersnakes throughout their range (Conant 1974, pp. 471, 487–489; Rosen and Schwalbe 1988, pp. 28–30; Rosen *et al.* 2001, pp. 21–22). Bullfrogs have and do threaten some populations of narrow-headed gartersnakes, but differing habitat preferences between the two temper their effect on narrow-headed gartersnakes. Bullfrogs adversely affect northern Mexican and narrow-headed gartersnakes through direct predation of juveniles and sub-adults. Bullfrogs also compete with northern Mexican gartersnakes. Bullfrogs are not native to the southwestern United States or Mexico, and first appeared in Arizona in 1926, as a result of a systematic introduction effort by the State Game Department (now, the AGFD) for the purposes of sport hunting and as a food source (Tellman 2002, p. 43). We are not certain when bullfrogs were first reported from New Mexico but presume it was many decades ago. Bullfrogs are extremely prolific, are strong colonizers, and may disperse distances of up to 10 mi (16 km) across uplands, and likely further within drainages (Bautista 2002, p. 131; Rosen and Schwalbe 2002a, p. 7; Casper and Hendricks 2005, p. 582; Suhre 2008, pers. comm.).

Bullfrogs are large-bodied, voracious, opportunistic, even cannibalistic predators that readily attempt to consume any living thing smaller than them. Bullfrogs have a highly varied diet, which has been documented to include vegetation, invertebrates, fish, birds, mammals, amphibians, and reptiles, including numerous species of snakes (eight genera, including six different species of gartersnakes, two species of rattlesnakes, and Sonoran gophersnakes (*Pituophis catenifer affinis*)) (Bury and Whelan 1984, p. 5; Clarkson and DeVos 1986, p. 45; Holm and Lowe 1995, pp. 37–38; Carpenter *et al.* 2002, p. 130; King *et al.* 2002; Hovey and Bergen 2003, pp. 360–361; Casper and Hendricks 2005, pp. 543–544; Combs *et al.* 2005, p. 439; Wilcox 2005, p. 306; DaSilva *et al.* 2007, p. 443; Neils and Bugbee 2007, p. 443; Rowe and Garcia 2012, pp. 633–634). In one study, three different species of gartersnakes (*Thamnophis sirtalis, T. elegans,* and *T. ordinoides*) totaling 11 snakes were found inside the stomachs of resident bullfrogs from a single region (Jancowski and Orchard 2013, p. 26). Bullfrogs can significantly reduce or eliminate the native amphibian populations (Moyle 1973, pp. 18–22; Conant 1974, pp. 471, 487–489; Hayes and Jennings 1986, pp. 491–492; Rosen and Schwalbe 1988, pp. 28–30; 2002b, pp. 232–238; Rosen *et al.* 1995, pp. 257–258; 2001, pp. 2, Appendix I; Wu *et al.* 2005, p. 668; Pearl *et al.* 2004, p. 18; Kupferberg 1994, p. 95; Kupferburg 1997, pp. 1736–1751; Lawler *et al.* 1999; Bury and Whelan 1986, pp. 9–10; Hayes and Jennings 1986, pp. 500–501; Jones and Timmons 2010, pp. 473–474), which are vital for northern Mexican gartersnakes. Different age classes of bullfrogs within a community can affect native ranid populations via different mechanisms. Juvenile bullfrogs affect native ranids through competition, male bullfrogs affect native ranids through predation, and female bullfrogs affect native ranids through both mechanisms depending on body size and microhabitat (Wu *et al.* 2005, p. 668). Pearl *et al.* (2004, p. 18) also suggested that the effect of bullfrog introductions on native ranids may be different based on specific habitat conditions, but also suggested that an individual ranid frog species' physical ability to escape influences the effect of bullfrogs on each native ranid community.

Bullfrogs have been documented throughout the State of Arizona. Holycross *et al.* (2006, pp. 13–14, 52–61) found bullfrogs at 55 percent of sample sites in the Agua Fria subbasin, 62 percent of sites in the Verde River subbasin, 25 percent of sites in the Salt River subbasin, and 22 percent of sites in the Gila River subbasin. In total, bullfrogs were observed at 22 of the 57 sites surveyed (39 percent) across the Mogollon Rim (Holycross *et al.* 2006, p. 13). A number of authors have also documented the presence of bullfrogs through their survey efforts throughout many subbasins in Arizona and New Mexico adjacent to the historical distribution of the northern Mexican or narrow-headed gartersnake, including northern Arizona (Sredl *et al.* 1995a, p. 7; 1995c, p. 7), central Arizona and along the Mogollon Rim of Arizona and New Mexico (Nickerson and Mays 1970, p. 495; Hulse 1973, p. 278; Sredl *et al.* 1995b, p. 9; Drost and Nowak 1997, p. 11; Nowak and Spille 2001, p. 11; Holycross *et al.* 2006, pp. 15–51; Wallace *et al.* 2008; pp. 243–244; Helleckson 2012a, pers. comm.), southern Arizona (Rosen and Schwalbe 1988, Appendix I; 1995, p. 452; 1996, pp. 1–3; 1997, p. 1; 2002b, pp. 223–227; 2002c, pp. 31, 70; Holm and Lowe 1995, pp. 27–35; Rosen *et al.* 1995, p. 254; 1996a, pp. 16–17; 1996b, pp. 8–9; 2001, Appendix I; Turner *et al.* 1999, p. 11; Sredl *et al.* 2000, p. 10; Turner 2007; p. 41), and along the Colorado River (Vitt and Ohmart 1978, p. 44; Clarkson and DeVos 1986, pp. 42–49; Ohmart *et al.* 1988, p. 143). In one of the more conspicuous examples, bullfrogs were identified as the primary cause for collapse of both the northern Mexican gartersnake and its prey base on the SBNWR (Rosen and Schwalbe 1988, p. 28; 1995, p. 452; 1996, pp. 1–3; 1997, p. 1; 2002b, pp. 223–227; 2002c, pp. 31, 70; Rosen *et al.* 1996b, pp. 8–9).

Perhaps one of the most serious consequences of bullfrog introductions is their persistence in an area once they have become established, and the subsequent difficulty in eliminating bullfrog populations. Rosen and Schwalbe (1995, p. 452) experimented with bullfrog removal at various sites on the SBNWR, in addition to a control site with no bullfrog removal in similar habitat on the Buenos Aires National Wildlife Refuge (BANWR). Removal of adult bullfrogs, without removal of eggs and tadpoles, resulted in a substantial increase in younger age-class bullfrogs where removal efforts were the most intensive (Rosen and Schwalbe 1997, p. 6). Contradictory to the goals of bullfrog eradication, evidence from dissection samples from young adult and sub-adult bullfrogs indicated these age-classes readily prey upon juvenile bullfrogs (up to the average adult leopard frog size) as well as juvenile gartersnakes, which suggests that the selective removal of only the large adult bullfrogs (presumed to be the most dangerous size class to leopard frogs and gartersnakes), favoring the young adult and sub-adult age classes, could indirectly lead to increased predation of leopard frogs and juvenile gartersnakes (Rosen and Schwalbe 1997, p. 6). These findings illustrate that in addition to large adults, subadult bullfrogs also negatively impact northern Mexican gartersnakes and their prey species. It also indicates the importance of including egg mass and tadpole removal during efforts to control bullfrogs and timing removal projects to ensure reproductive bullfrogs are removed prior to breeding. Some success in regional bullfrog eradication has been had in a few cases described below in the section entitled ''*Current Conservation of Northern Mexican and Narrow-headed Gartersnakes.*''

Bullfrogs not only compete with the northern Mexican gartersnake for prey items but directly prey upon juvenile and occasionally sub-adult northern Mexican and narrow-headed gartersnakes (Rosen and Schwalbe 1988, pp. 28–31; 1995, p. 452; 2002b, pp. 223–227; Holm and Lowe 1995, pp. 29–29; Rossman *et al.* 1996, p. 177; AGFD *In Prep.*, p. 12; 2001, p. 3; Rosen *et al.* 2001, pp. 10, 21–22; Carpenter *et al.* 2002, p. 130; Wallace 2002, p. 116). A well-circulated photograph of an adult bullfrog in the process of consuming a northern Mexican gartersnake at Parker Canyon Lake, Cochise County, Arizona, taken by John Carr of the Arizona Game and Fish Department in 1964, provides photographic documentation of bullfrog predation (Rosen and Schwalbe 1988, p. 29; 1995, p. 452). The most recent, physical evidence of bullfrog predation of northern Mexican gartersnakes is provided in photographs of a dissected bullfrog at Pasture 9 Tank in the San Rafael Valley of Arizona that had a freshly-eaten neonatal northern Mexican gartersnake in its stomach (Akins 2012, pers. comm.).

A common observation in northern Mexican gartersnake populations that co-occur with bullfrogs is a preponderance of large, mature adult snakes with conspicuously low numbers of individuals in the newborn and juvenile age size classes due to bullfrogs more effectively preying on young small snakes, which ultimately leads to low reproductive rates and survival of young (Rosen and Schwalbe 1988, p. 18; Holm and Lowe 1995, p. 34). In lotic (flowing water) systems, bullfrogs prefer sites with low or limited flow, such as backwaters, side channels, and pool habitat. These areas are also used frequently by northern Mexican and narrow-headed gartersnakes, which likely results in increased predation rates and likely depressed recruitment of gartersnakes. Potential recruitment problems for northern Mexican gartersnakes due to effects from nonnative species are suspected at Tonto Creek (Wallace *et al.* 2008, pp. 243–244). Rosen and Schwalbe (1988, p. 18) stated that the low recruitment at the SBNWR, a typical characteristic of gartersnake populations affected by harmful nonnative species, is the likely cause of that populations' decline and possibly for declines in populations throughout their range in Arizona. Specific localities within the distribution of northern Mexican and narrow-headed gartersnakes where bullfrogs have been detected are presented in Appendix A (available at *http://www.regulations.gov* under Docket No. FWS–R2–ES–2013–0071).

The Effects of Crayfish on Native Aquatic Communities

Crayfish are a nonnative species in Arizona and New Mexico and are a primary threat to many prey species of northern Mexican and narrow-headed gartersnakes, and may also prey upon juvenile gartersnakes themselves (Fernandez and Rosen 1996, p. 25; Voeltz 2002, pp. 87–88; USFWS 2007, p. 22). Fernandez and Rosen (1996, p. 3) studied the effects of crayfish introductions on two stream communities in Arizona, a low-elevation semi-desert stream and a high mountain stream, and concluded that crayfish can noticeably reduce species diversity and destabilize food chains in riparian and aquatic ecosystems through their effect on vegetative structure, stream substrate (stream bottom; *i.e.*, silt, sand, cobble, boulder) composition, and predation on eggs, larval, and adult forms of native invertebrate and vertebrate species. Crayfish fed on embryos, tadpoles, newly metamorphosed frogs, and adult leopard frogs, but they did not feed on egg masses (Fernandez and Rosen 1996, p. 25). However, Gamradt and Kats (1996, p. 1155) found that crayfish readily consumed the egg masses of California newts (*Taricha torosa*). Crayfish are known to also eat fish eggs and larva (Inman *et al.* 1998, p. 17), especially those bound to the substrate (Dorn and

Mittlebach 2004, p. 2135). Fernandez and Rosen (1996, pp. 6–19, 52–56) and Rosen (1987, p. 5) discussed observations of inverse relationships between crayfish abundance and native reptile and amphibian populations, including narrow-headed gartersnakes, northern leopard frogs, and Chiricahua leopard frogs. Crayfish may also affect native fish populations. Carpenter (2005, pp. 338–340) documented that crayfish may reduce the growth rates of native fish through competition for food and noted that the significance of this impact may vary between species.

Crayfish alter the abundance and structure of aquatic vegetation by grazing on aquatic and semiaquatic vegetation, which reduces the cover needed by frogs and gartersnakes, as well as the food supply for prey species such as tadpoles (Fernandez and Rosen 1996, pp. 10–12). Fernandez and Rosen (1996, pp. 10–12) found that crayfish frequently burrow into stream banks, leading to increased bank erosion, stream turbidity, and siltation of stream bottoms. Creed (1994, p. 2098) found that filamentous alga (*Cladophora glomerata*) was at least 10-fold greater in aquatic habitats that lacked crayfish. Filamentous alga is an important component of aquatic vegetation that provides cover for foraging gartersnakes, as well as microhabitat for prey species.

Crayfish have recently been found to also act as a host for the amphibian disease-causing fungus, Bd (McMahon *et al.* (2013, pp. 210–213). This could have serious implications for northern Mexican gartersnakes because crayfish can now be considered a source of disease in habitat that is devoid of amphibians but otherwise potentially suitable habitat for immigrating amphibians, such as leopard frogs, which could serve as a prey base. Because crayfish are so widespread throughout Arizona, New Mexico, and portions of Mexico, this could have broad, negative implications for the recovery of native leopard frogs, and therefore the recovery of northern Mexican gartersnakes.

Inman *et al.* (1998, p. 3) documented crayfish as widely distributed and locally abundant in a broad array of natural and artificial free-flowing and still-water habitats throughout Arizona, many of which overlap the historical and current distribution of northern Mexican and narrow-headed gartersnakes. Hyatt (undated, p. 71) concluded that the majority of waters in Arizona contained at least one species of crayfish. In surveying for northern Mexican and narrow-headed gartersnakes, Holycross *et al.* (2006, p. 14) found crayfish in 64 percent of the sample sites in the Agua Fria subbasin; in 85 percent of the sites in the Verde River subbasin; in 46 percent of the sites in the Salt River subbasin; and in 67 percent of the sites in the Gila River subbasin. In total, crayfish were observed at 35 (61 percent) of the 57 sites surveyed across the Mogollon Rim (Holycross *et al.* 2006, p. 14), most of which were sites historically or currently occupied by northern Mexican or narrow-headed gartersnakes, or sites the investigators believed possessed suitable habitat and may be occupied by these gartersnakes based upon the their known historical distributions.

A number of authors have documented the presence of crayfish through their survey efforts throughout Arizona and New Mexico in specific regional areas, drainages, and lentic wetlands within or adjacent to the historical distribution of the northern Mexican or narrow-headed gartersnake, including northern Arizona (Sredl *et al.* 1995a, p. 7; 1995c, p. 7), central Arizona and along the Mogollon Rim of Arizona and New Mexico (Sredl *et al.* 1995b, p. 9; Fernandez and Rosen 1996, pp. 54–55, 71; Inman *et al.* 1998, Appendix B; Nowak and Spille 2001, p. 33; Holycross *et al.* 2006, pp. 15–51; Brennan 2007, p. 7; Burger 2008, p. 4; Wallace *et al.* 2008; pp. 243–244; Brennan and Rosen 2009, p. 9; Karam *et al.* 2009; pp. 2–3; Helleckson 2012a, pers. comm.), southern Arizona (Rosen and Schwalbe 1988, Appendix I; Inman *et al.* 1998, Appendix B; Sredl *et al.* 2000, p. 10; Rosen *et al.* 2001, Appendix I), and along the Colorado River (Ohmart *et al.* 1988, p. 150; Inman *et al.* 1998, Appendix B). Specific localities within the distribution of northern Mexican and narrow-headed gartersnakes where crayfish have been detected are presented in Appendix A (available at *http://www.regulations.gov* under Docket No. FWS–R2–ES–2013–0071).

Like bullfrogs, crayfish can be very difficult, if not impossible, to eradicate once they have become established in an area, depending on the complexity of the habitat (Rosen and Schwalbe 1996a, pp. 5–8; 2002a, p. 7; Hyatt undated, pp. 63–71). The use of biological control agents such as bacteria, nematodes, and viruses were explored in addressing the invasion and persistence of crayfish in the southwestern United States, using the organisms' cannibalistic nature as a vector (Davidson *et al.* 2010, pp. 297–310). The use of biological control agents tested found them to be ineffective or infeasible in controlling crayfish, but a number of other biological pathogens have been described in freshwater crayfish that may lend promise to finding an appropriate control agent in the future (Davidson *et al.* 2010, pp. 307–308). In addition, recent experimentation with ammonia as a piscicide indirectly found that crayfish were also effectively eradicated in field trials; the first successful and most promising control method for this harmful nonnative species in recent times (Ward *et al.* 2013, pp. 402–404). However, it could be potentially several years before ammonia is licensed for such use, if ever.

The Effects of Predation-Related Injuries to Gartersnakes

The tails of gartersnakes are often broken off during predation attempts by bullfrogs or crayfish and do not regenerate. The incidence of tail breaks in gartersnakes can often be used to assess predation pressure within gartersnake populations. Attempted predation occurs on both sexes and all ages of gartersnakes within a population, although some general trends have been detected. For example, female gartersnakes may be more susceptible to predation as evidenced by the incidence of tail damage (Willis *et al.* 1982, pp. 100–101; Rosen and Schwalbe1988, p. 22; Mushinsky and Miller 1993, pp. 662–664; Fitch 2003, p. 212). This can be explained by higher basking rates associated with pregnant females that increase their visibility to predators. Fitch (2003, p. 212) found that tail injuries in the common gartersnake occurred more frequently in adults than in juveniles. Predation on juvenile snakes likely results in complete consumption of the animal, which would limit observations of tail injury in their age class.

Tail injuries can have negative effects on the health, longevity, and overall success of individual gartersnakes from infection, slower swimming and crawling speeds, or impeding reproduction. Mushinsky and Miller (1993, pp. 662–664) commented that, while tail breakage in gartersnakes can save the life of an individual snake, it also leads to permanent handicapping of the snake, resulting in slower swimming and crawling speeds, which could leave the snake more vulnerable to predation or affect its foraging ability. Willis *et al.* (1982, p. 98) discussed the incidence of tail injury in three species in the genus *Thamnophis* (common gartersnake, Butler's gartersnake (*T. butleri*), and the eastern ribbon snake (*T. sauritus*)) and concluded that individuals that suffered nonfatal injuries prior to reaching a length of 12 in (30 cm) are not likely to survive and that physiological stress during post-injury hibernation may play an important role in subsequent mortality. While northern Mexican or narrow-headed gartersnakes may survive an individual predation attempt from a bullfrog or crayfish with tail damage, secondary effects from infection of the wound may significantly contribute to mortality of individuals. Perry-Richardson *et al.* (1990, p. 77) described the importance of tail-tip alignment in the successful courtship and mating in Thamnophiine snakes and found that missing or shortened tails adversely affected these activities and, therefore, mating success. In researching the role of tail length in mating success in the red-sided gartersnake (*Thamnophis sirtalis parietalis*), Shine *et al.* (1999, p. 2150) found that males that experienced injuries or the partial or whole loss of the tail experienced a three-fold decrease in mating success.

The frequency of tail injuries can be quite high in a given gartersnake population; for example at the SBNWR (Rosen and Schwalbe 1988, pp. 28–31), 78 percent of northern Mexican gartersnakes had broken tails with a ''soft and club-like'' terminus, which suggests repeated injury from multiple predation attempts by bullfrogs. While medically examining pregnant female northern Mexican gartersnakes, Rosen and Schwalbe (1988, p. 28) noted bleeding from the posterior region, which suggested to the investigators the snakes suffered from ''squeeze-type'' injuries inflicted by adult bullfrogs. In another example, Holm and Lowe (1995, pp. 33–34) observed tail injuries in 89 percent of northern Mexican gartersnakes during the early 1990s in Scotia Canyon in the Huachuca Mountains, as well as a skewed age class ration that favored adults over subadults, which is consistent with data collected by Willis *et al.* (1982, pp. 100–101) on other gartersnake species. Bullfrogs are largely thought to be responsible for the significant decline of northern Mexican gartersnake and its prey base at this locality, although the latter has improved through recovery actions. In the Black River, crayfish are very abundant and have been identified as the likely cause for a high-frequency of tail injuries to narrow-headed gartersnakes (Brennan 2007, p. 7; Brennan and Rosen 2009, p. 9). Brennan (2007, p. 5) found that in the Black River, 14 of 15 narrow-headed gartersnakes captured showed evidence of damaged or missing tails (Brennan 2007, p. 5). In 2009, 16 of 19 narrow-headed gartersnakes captured in the Black River showed evidence of damaged or missing tails (Brennan and Rosen 2009, p. 8). In the upper Verde River region, Emmons and Nowak (2013, p. 5) reported that 18 of 49 (37 percent) northern Mexican gartersnakes captured had scars (n = 17) and/or missing tails tips (n = 7).

Vegetation or other forms of protective cover may be particularly important for gartersnakes to reduce the effects of harmful nonnative species on populations. For example, the population of northern Mexican gartersnakes at the Page Springs and Bubbling Ponds State Fish Hatcheries occurs with harmful nonnative species (Boyarski 2008b, pp. 3–4, 8). Yet, only 11 percent of northern Mexican gartersnakes captured in 2007 were observed as having some level of tail damage (Boyarski 2008b, pp. 5, 8). The relatively low occurrence of tail damage, as compared to 78 percent of snakes with tail damage found by Rosen and Schwalbe (1988, pp. 28–31), may indicate: (1) Adequate vegetation density was used by gartersnakes to avoid harmful nonnative species predation attempts; (2) a relatively small population of harmful nonnative species may be at a comparatively lower density than sites sampled by previous studies (harmful nonnative species population density data were not collected by Boyarski (2008b)); (3) gartersnakes may not have needed to move significant distances at this locality to achieve foraging success, which might reduce the potential for encounters with harmful nonnative species; or (4) gartersnakes infrequently escaped predation attempts by harmful nonnative species, were removed from the population, and were consequently not detected by surveys.

The Expansion of the American Bullfrog and Crayfish in Mexico

Bullfrogs have recently been documented as a significant threat to native aquatic and riparian species throughout Mexico. Luja and Rodríguez-Estrella (2008, pp. 17–22) examined the invasion of the bullfrog in Mexico. The earliest records of bullfrogs in Mexico were Nuevo Leon (1853), Tamaulipas (1898), Morelos (1968), and Sinaloa (1969) (Luja and Rodríguez-Estrella 2008, p. 20). By 1976, the bullfrog was documented in seven more states: Aguacalientes, Baja California Sur, Chihuahua, Distrito Federal, Puebla, San Luis Potosi, and Sonora (Luja and Rodríguez-Estrella 2008, p. 20). The bullfrog was recently verified from the state of Hidalgo, Mexico, at an elevation of 8,970 feet (2,734 m), which indicates the species continues to spread in that country and can exist even at the uppermost elevations inhabited by northern Mexican gartersnakes (Duifhuis Rivera *et al.* 2008, p. 479). As of 2008, Luja and Rodríguez-Estrella (2008, p. 20) have recorded bullfrogs in 20 of the 31 Mexican States (65 percent of the states in Mexico) and suspect that they have invaded other States, but were unable to find documentation.

Sponsored by the then Mexican Secretary of Aquaculture Support, bullfrogs have been commercially produced for food in Mexico in Yucatan, Nayarit, Morelos, Estado de Mexico, Michoacán, Guadalajara, San Luis Potosi, Tamaulipas, and Sonora (Luja and Rodríguez-Estrella 2008, p. 20). However, frog legs ultimately never gained popularity in Mexican culinary culture (Conant 1974, pp. 487–489), and Luja and Rodríguez-Estrella (2008, p. 22) point out that only 10 percent of these farms remain in production. Luja and Rodríguez-Estrella (2008, pp. 20, 22) document instances where bullfrogs have escaped production farms and suspect the majority of the frogs that were produced commercially in farms that have since ceased operation have assimilated into surrounding habitat.

Luja and Rodríguez-Estrella (2008, p. 20) also state that Mexican people deliberately introduce bullfrogs for ornamental purposes, or ''for the simple pleasure of having them in ponds.'' The act of deliberately releasing bullfrogs into the wild in Mexico was cited by Luja and Rodríguez-Estrella (2008, p. 21) as being ''more common than we can imagine.'' Bullfrogs are available for purchase at some Mexican pet stores (Luja and Rodríguez-Estrella 2008, p. 22). Luja and Rodríguez-Estrella (2008, p. 21) state that bullfrog eradication efforts in Mexico are often thwarted by their popularity in rural communities (presumably as a food source). Currently, no regulation exists in Mexico to address the threat of bullfrog invasions or prevent their release into the wild (Luja and Rodríguez-Estrella 2008, p. 22).

Rosen and Melendez (2006, p. 54) report bullfrog invasions to be prevalent in northwestern Chihuahua and northwestern Sonora, where the northern Mexican gartersnake is thought to occur. In many areas, native leopard frogs were completely displaced where bullfrogs were observed. Rosen and Melendez (2006, p. 54) also demonstrated the relationship between fish and amphibian communities in Sonora and western Chihuahua. Native leopard frogs, a primary prey item for the northern Mexican gartersnake, only occurred in the absence of nonnative fish, and were absent from waters containing nonnative species, which included several major waters. In Sonora, Rorabaugh (2008a, p. 25) also considers the bullfrog to be a significant threat to the northern Mexican gartersnake and its prey base, substantiated by field observations made during surveys conducted in Chihuahua and Sonora in 2006 (Rorabaugh 2008b, p. 1).

Few data were found on the presence or distribution of nonnative crayfish species in Mexico. However, in a 2-week gartersnake survey effort in 2006 in northern Mexico, crayfish were observed as ''widely distributed'' in the valleys of western Chihuahua (Rorabaugh 2008b, p. 1). Based on the invasive nature of crayfish ecology and their distribution in the United States along the Border region, it is reasonable to assume that, at a minimum, crayfish are likely distributed along the entire Border region of northern Mexico, adjacent to where they occur in the United States.

Risks to Gartersnakes From Fisheries Management Activities

The decline in native fish communities from the effects of harmful nonnative fish species has spurred resource managers to take action to help recover native fish species. While we fully support activities designed to help recover native fish, recovery actions for native fish, in the absence of thorough planning, can have significant adverse effects on resident gartersnake populations.

Piscicides—Piscicide is a term that refers to a ''fish poison.'' The use of piscicides, such as rotenone or antimycin A, for the removal of harmful nonnative fish species has widely been considered invaluable for the conservation and recovery of imperiled native fish species throughout the United States, and in particular the Gila River basin of Arizona and New Mexico (Dawson and Kolar 2003, entire). Antimycin A is rarely used anymore, and has been largely replaced by rotenone in field applications. Experimentation with ammonia as a piscicide has shown promising results and may ultimately replace rotenone in the future as a desired control method if legally registered for such use (Ward *et al.* 2013, pp. 402–404). Currently, rotenone is the most commonly used piscicide. The active ingredient in rotenone is a natural chemical compound extracted from the stems and roots of tropical plants in the family Leguminosae that interrupts oxygen absorption in gill-breathing animals (Fontenot *et al.* 1994, pp. 150–151). In the greater Gila River subbasin alone, 57 streams or water bodies have been treated with piscicide, some on several occasions spanning many years (Carpenter and Terrell 2005; Table 6). However, this practice has been the source of recent controversy due to a perceived link between rotenone and Parkinson's disease in humans, as well as potential effects to livestock. Speculation of the potential role of rotenone in Parkinson's disease was fueled by Tanner *et al.* (2011, entire) which correlated the incidence of the disease with lifetime exposure to certain pesticides, including rotenone. As a result, in 2012, the Arizona State Legislature proposed two bills that called for the development of an environmental impact statement prior to the application of rotenone or antimycin A (S.B. 1453, see State of Arizona Senate (2012b)) and urged the U.S. Environmental Protection Agency to deregister rotenone from use in the United States (S.B. 1009, see State of Arizona Senate (2012b)). Public safety considerations were fully evaluated by a multi-disciplined technical team of specialists that found no correlation between rotenone applications performed, according to product label instructions, and Parkinson's disease (Rotenone Review Advisory Committee 2012, pp. 24–25). Nonetheless, continued anxiety regarding the use of piscicides for conservation and management of fish communities leaves an uncertain future for this invaluable management tool. Should circumstances result in the discontinued practice of using piscicides for fish recovery and management, the likelihood of recovery for listed or sensitive aquatic vertebrates in Arizona, such as northern Mexican and narrow-headed gartersnakes, would be substantially reduced, if not eliminated outright.

We are supportive of the use of piscicides and consider the practice a vital and scientifically sound tool, the only tool in most circumstances, for reestablishing native fish communities and removing threats related to nonnative aquatic species in occupied northern Mexican and narrow-headed gartersnake habitat. However, it is equally important that effects of such treatments to these gartersnakes be evaluated during the project planning phase, specifically the amount of time a treated water body remains fishless post-treatment. The time period between rotenone applications and the subsequent restocking of native fish is contingent on two basic variables, the time it takes for piscicide levels to reach nontoxic levels and the level of certainty required to ensure that renovation goals and objectives have been met prior to restocking. Implementation of the latter consideration may vary from weeks, to months, to a year or longer, depending on the level of certainty required by project proponents. Carpenter and Terrell (2005, p. 14) reported that standard protocols, used by the Arizona Game and Fish Department for Apache trout renovations, required two applications of piscicide before repatriating native fish to a stream, waiting a season to see if the renovation was successful, and then continuing to renovate if necessary. Another recommendation of past protocols included a goal for the renovated water body to remain fishless an entire year before restocking (Carpenter and Terrell 2005, p. 14). At a minimum and according to our files, reaches of Big Bonito Creek, the West Fork Black River, West Fork Gila River, Iron Creek, Little Creek, Black Canyon, and O'Donnell Creek have all been subject to fish renovations using these or similarly accepted protocols (Carpenter and Terrell 2005; Table 6; Paroz and Probst 2009, p. 4; Hellekson 2012a, pers. comm.). Therefore, northern Mexican or narrow-headed gartersnake populations in these streams have likely been adversely affected, due to the eradication of a portion of, or their entire, prey base in these systems for varying periods of time. Big Bonito Creek was restocked with salvaged native fish shortly after renovation occurred. However, we are uncertain how long other stream reaches remained fishless post-treatment, but presume a minimum of weeks in each instance, and possibly a year or longer in some instances.

Future planning in fisheries management has identified several streams within the distribution of narrow-headed gartersnakes in New Mexico for potential fish barrier construction, for which piscicide applications are likely necessary. These streams include Little Creek, West Fork Gila River, Middle Fork Gila River, Turkey Creek, Saliz Creek, Dry Blue Creek, and the San Francisco River (Riley and Clarkson 2005, pp. 4–5, 7, 9, 12; Clarkson and Marsh 2012, p. 8; 2013, pp. 1, 4, 6). Of these, the Middle Fork Gila River and Turkey Creek appear to the most likely-chosen for renovation (Clarkson and Marsh 2013, p. 8). Mule Creek and Cienega Creek, both occupied by northern Mexican gartersnakes, as well as Whitewater Creek (occupied by narrow-headed gartersnakes) are under consideration but ultimately may not be chosen for renovation for undisclosed reasons (Clarkson and Marsh 2013, pp. 8–9).

In addition to fish, rotenone is toxic to amphibians in their gill-breathing, larval life stages; adult forms tend to avoid treated water (Fontenot *et al.* 1994, pp. 151–152). Rotenone has not been found to be directly toxic to aquatic snakes, but Fontenot *et al.* (1994, p. 152) suggested that effects from ingesting affected fish, frogs, or tadpoles may occur, but have not been adequately researched. The current standard operating procedures for piscicide application, as adopted nationally and provided in Finlayson *et al.* (2010, p. 23), provide guidance for assuring that non-target, baseline environmental conditions (the biotic community) are accounted for in assessing whether mitigation measures are necessary. This procedural protocol states, ''Survival and recovery of the aquatic community may be demonstrated by sampling plankton, macroinvertebrates (aquatic insects, crustacea, leeches, and mollusks), and amphibians (frogs, tadpoles, and larval and adult salamanders)'' (Finlayson *et al.* 2010, p. 23). This protocol, adopted by the Arizona Game and Fish Department (see AGFD 2012), does not consider the effects of leaving a treated water body without a prey base for a sensitive species, such as the narrow-headed gartersnake, for extended periods of time. In fact, considerations for non-target aquatic reptiles, in general, are not mentioned anywhere in this broadly applied piscicide application protocol. Consequently, we have no reason to assume that effects to either northern Mexican or narrow-headed gartersnake populations from the partial or whole-scale removal of their prey base have been historically considered in piscicide applications, at least through 2006.

The potentially significant effects to northern Mexican or narrow-headed gartersnakes described above pertaining to piscicide application are largely historical in nature in Arizona, and new methodologies have been developed in Arizona to prevent adverse effects to gartersnake populations. As of 2012, a new policy was finalized by the Arizona Game and Fish Department that includes an early and widespread public notification and planning process that involves the approval of several decision-makers within four major stages: (1) Piscicide project internal review and approval; (2) preliminary planning and public involvement; (3) intermediate planning and public involvement; and (4) project implementation and evaluation (AGFD 2012, p. 3). Within the Internal Review and Approval stage of the process, sensitive, endemic, and listed species potentially impacted by the project must be identified (AGFD 2012, p. 13), such as northern Mexican or narrow-headed gartersnakes. In addition, the Arizona Game and Fish Department, through their Conservation and Mitigation Program developed as part of their sport fish stocking program through 2021, has committed to quickly restocking renovated streams that are occupied by either northern Mexican or narrow-headed gartersnakes (USFWS 2011, Appendix C).

Although significant efforts are generally made to salvage as many native fish as possible prior to treatment, logistics of holding fish for several weeks prior to restocking limit the number of individuals that can be held safely. Therefore, not every individual fish is salvaged, and native fish remaining in the stream are subsequently lost during the treatment. The number of fish subsequently restocked is, therefore, smaller than the number of fish that were present prior to the treatment. The full restoration of native fish populations to pre-treatment levels may take several years, depending on the size of the treated area and the size and maturity of the founding populations. Restocking salvaged fish in the fall may allow natural spawning and recruitment to begin in the spring, which would provide a more immediate benefit to resident gartersnake populations. With regard to New Mexico and Mexico, we are uncertain what measures have been considered in the past, or implemented currently, to prevent significant adverse impacts to northern Mexican or narrow-headed gartersnakes from piscicide applications.

Mechanical Methods—In addition to chemical renovation techniques, mechanical methods using electroshocking equipment are often used in fisheries management, both for nonnative aquatic species removal and fisheries survey and monitoring activities that often occur in conjunction with piscicide treatments. Northern Mexican and narrow-headed gartersnakes often flee into the water as a first line of defense when startled. In occupied habitat, gartersnakes present within the water are often temporarily paralyzed from electrical impulses intended for fish, and are, therefore, readily detected by surveyors (Hellekson 2012a, pers. comm.). We are not aware of any research that has investigated potential short- or long-term consequences of such electrocutions to gartersnakes. In addition to the occupied streams noted above that have received piscicide applications (and therefore received electroshock surveys), Hellekson (2012, pers. comm.) reported narrow-headed gartersnakes being detected via electroshocking in the mainstem Gila River from Cliff Dwellings to Little Creek, the East Fork Gila River, Little Creek, Black Canyon, the Tularosa River, and Dry Blue Creek. Pettinger and Yori (2011, p. 11) reported detecting two narrow-headed gartersnakes as a result of electroshocking in the West Fork Gila River. Thus, electroshock surveys may be a source of additional data related to the occurrence and distribution of both northern Mexican and narrow-headed gartersnakes.

Trapping methods are also used in fisheries surveys, for other applications in aquatic species management, and for the collection of live baitfish in recreational fishing. One such common method to study aquatic or semi-aquatic wildlife (including populations of aquatic snakes such as gartersnakes) is through the use of self-baiting wire minnow traps. When used to monitor gartersnake populations, wire minnow traps are anchored to vegetation, logs, etc., along the shoreline (in most applications) and positioned so that half to one-third of the trap, along its lateral line, is above water surface to allow snakes to surface for air. These traps are then checked according to a predetermined schedule. Because the wire, twine, etc., used to anchor these traps is fixed in length, these traps may become fully submerged if there is a sudden, unanticipated rise in water levels (e.g., storm event). During the monsoon in Arizona and New Mexico, these types of storm events are common and river hydrographs respond accordingly with rapid and dynamic increases in flow. We are aware of examples where northern Mexican gartersnakes, intentionally captured in minnow traps, have drowned as a direct result of a rapid, unexpected rise in water levels. Some examples include an adult female northern Mexican gartersnake along lower Tonto Creek in 2004, and an adult and two neonates at the Bubbling Springs Hatchery in 2009 and 2010, respectively (Holycross *et al.* 2006, p. 41, Boyarski 2011, pp. 2–3). In another example, involving an underwater funnel trap used to survey for lowland leopard frogs, a large adult female northern Mexican gartersnake was discovered deceased in the trap (T. Jones 2012a, pers. comm.). Death of that individual was likely due to drowning or predation by numerous crayfish that were also confined in the funnel trap with the gartersnake (T. Jones 2012a, pers. comm.). There are likely additional cases where northern Mexican or narrow-headed gartersnake mortality from trapping have not been reported, where trapping has occurred in occupied habitat prone to flash flooding.

Minnow traps are often deployed for monitoring fully aquatic species, such as fish, and are, therefore, intentionally positioned in the water column where they are fully under water. Traps used for this purpose may be checked less frequently, because risks to fully aquatic species are less if held in the trap for longer periods of time. As fish collectively become trapped, the trap becomes incidentally self-baited for gartersnakes and, if deployed in habitat occupied by either northern Mexican or narrow-headed gartersnakes, these traps may accidentally attract, capture, and drown gartersnakes that are actively foraging under water and are lured to the traps because of captured prey species. Neonatal northern Mexican and narrow-headed gartersnakes can also wriggle through the mesh of some wire minnow traps and become lodged halfway through, depending on the pore size of the wire mesh (Jaeger 2012, pers. comm.). If not found in time, this situation would likely result in their death from drowning, predation, or exposure.

The use of minnow traps is also allowed in recreational fishing in Arizona and New Mexico (AGFD 2013, p. 57; NMDGF 2013, p. 17). In Arizona and New Mexico, it is lawful to set minnow traps for the collection of live baitfish (AGFD 2013, pp. 56–57; NMDGF 2013, p. 17). In Arizona, minnow traps used for collecting live baitfish must be checked once daily (AGFD 2013, pp. 56–57); in New Mexico, there is no stipulation on time intervals in the regulations to check minnow traps (NMDGF 2013, p. 17). In either scenario in either state, these minnow traps are likely to be fully submerged when in use and pose a drowning hazard to resident gartersnakes while foraging underwater, as they can be lured into the traps by fish already caught.

The extent to which trapping-related mortality can affect northern Mexican or narrow-headed gartersnake populations is uncertain, but there is reason for concern if adult females are lost from populations where recruitment appears low or nonexistent, especially in low-density populations. While we are less certain about northern Mexican or narrow-headed gartersnake mortality from trapping efforts intended for other species, we assume such events have historically been unreported, but also acknowledge that the percentage of snakes intentionally caught in minnow traps that actually drown is likely to be comparatively low. We also note that the aquatic community data generated from field research using these traps are critical to our understanding of northern Mexican and narrow-headed gartersnake ecology, population trends, and responses to threats on the landscape, and we believe that better communication and coordination among programs with regard to gartersnake concerns can help.

Intentional Dewatering—Lastly, dewatering or water fluctuation techniques are sometimes considered for eliminating undesirable fish species from water bodies (Finlayson *et al.* 2010, p. 4). Dewatering of occupied northern Mexican or narrow-headed gartersnake habitat would have obvious deleterious effects to affected populations by removing a primary habitat feature and eliminating the prey base. Depending on the availability of suitable habitat regionally and the length of time water is absent, these activities may ultimately cause local extirpations of gartersnake populations. Because northern Mexican gartersnakes often occupy lentic water bodies or intermittently watered canyon bottoms, where this practice is most feasible, effects of dewatering activities may disproportionately affect that species. This technique is being considered by the AGFD for pools within Redrock Canyon where northern Mexican gartersnakes could be adversely affected; however it is expected that northern Mexican gartersnakes are being considered by the AGFD in their implementation planning process.

Summary

In our review of the scientific and commercial literature, we have found that over time, native aquatic communities, specifically the native prey bases for northern Mexican and narrow-headed gartersnakes, have been significantly weakened to the point of near collapse as a result of the cumulative effects of disease and harmful nonnative species such as bullfrogs, crayfish, and spiny-rayed fish. Harmful nonnative species have been intentionally introduced or have naturally moved into virtually every subbasin throughout the distribution of northern Mexican and narrow-headed gartersnakes in the United States and Mexico. According to Geographic Information System GIS analyses, nonnative, spiny-rayed fish are known to occur in 90 percent of the historical distribution of the northern Mexican gartersnake and 85 percent of the historical distribution of the narrow-headed gartersnake in the United States. Bullfrogs are known to occur in 85 percent of the historical distribution of the northern Mexican gartersnake and 53 percent of the historical distribution of the narrow-headed gartersnake in the United States. Crayfish are known to occur in 77 percent of the historical distribution of the northern Mexican gartersnake and 75 percent of the historical distribution of the narrow-headed gartersnake in the United States. Nonnative, spiny-rayed fish, bullfrogs, and crayfish are known to occur simultaneously in 65 percent of the historical distribution of the northern Mexican gartersnake and 44 percent of the historical distribution of the narrow-headed gartersnake in the United States.

Native fish are important prey for northern Mexican gartersnakes but much more so for narrow-headed gartersnakes. Predation by and competition with primarily nonnative, spiny-rayed fish species, and secondarily with crayfish, are widely considered to be the primary reason for major declines in native fish communities throughout the range of both gartersnakes. This fundamental premise is captured by the fact that in Arizona, 19 of 31 (61 percent) of all native fish species are listed under the Act. Consequently, Arizona ranks the highest of all 50 States in the percentage of native fish species with declining trends (85.7 percent). Similar trends in the loss of native fish biodiversity have been described in New Mexico and Mexico. Native amphibians such as the Chiricahua leopard frog, an important component of the northern Mexican gartersnake prey base, have declined significantly and may face future declines as a result of Bd and harmful nonnative species. We cite numerous examples where historical native frog populations have been wholly replaced by harmful nonnative species, both on local and regional scales. These declines have directly contributed to subsequent northern Mexican gartersnake population declines or extirpations in these areas. Collectively, the literature confirms that an adequate native prey base is essential to the conservation and recovery of northern Mexican gartersnakes, and that this native ranid frog prey base may face an uncertain future if harmful nonnative species continue to persist and expand their distributions in occupied habitat.

We have found that the best available commercial and scientific information supports the fact that harmful nonnative species are the single most important threat to northern Mexican and narrow-headed gartersnakes and their prey bases, and therefore have had a profound role in their decline. A large body of literature documents that northern Mexican and narrow-headed gartersnakes are uniquely susceptible to the influence of harmful nonnative species in their biotic communities. This sensitivity is largely the result of complex ecological interactions that result in direct predation on gartersnakes; shifts in biotic community structure from largely native to largely nonnative; and competition for a diminished prey base that can ultimately result in the injury, starvation, or death of northern Mexican or narrow-headed gartersnakes followed by reduced recruitment, population declines, and extirpations.

Lastly, we found that fisheries management activities can have significant negative effects on resident gartersnake populations when gartersnakes are not considered in project planning and implementation. We fully support the continued use of rotenone and other fisheries management techniques in the conservation and recovery of native fish. However, we also acknowledge the potential and significant threat rotenone use may pose to these gartersnakes if their habitat is left with a fish community that is dangerously depleted or entirely removed for extended periods of time. New policies and mitigation measures have been developed in Arizona that will reduce the likelihood of these activities having significant effects on either northern Mexican or narrow-headed gartersnake populations. However, some level of effect should still be expected, based on logistical complications and complexities of restoring fish populations to pre-treatment levels. We expect to coordinate with resource managers in New Mexico as we do in Arizona, to ensure gartersnake populations are not significantly affected by these activities. Other mechanisms or activities used in fisheries management, such as electroshocking, trapping, or dewatering, can result in the injury or death of northern Mexican or narrow-headed gartersnakes, where these activities coincide with extant populations, and if they have not been considered in the planning or implementation processes. The significance of these losses depends on the status of the gartersnake population affected. We found no evidence to conclude that fisheries management techniques threaten the northern Mexican gartersnake in Mexico.

On the most basic level, the presence of harmful nonnative species ultimately affects where northern Mexican and narrow-headed gartersnakes can live as viable populations. Collectively, the ubiquitous presence of harmful nonnative species across the landscape has appreciably reduced the quantity of suitable gartersnake habitat and changed its spatial orientation on the landscape. Most northern Mexican and narrow-headed gartersnake populations, even some considered viable today, live in the presence of harmful nonnative species. While they continue to persist, they do so under constant stress from unnatural levels of predation and competition associated with harmful nonnative species. This weakens their resistance to other threats, including those that affect the physical suitability of their habitat (discussed below). This ultimately renders populations much less resilient to stochastic, natural, or anthropogenic stressors that could otherwise be withstood. Over time and space, subsequent population declines have threatened the genetic representation of each species because many populations have become disconnected and isolated from neighboring populations. Expanding distances between extant populations coupled with increasing populations of harmful nonnative species prevents normal colonizing mechanisms that would otherwise reestablish populations where they have become extirpated. This subsequently leads to a reduction in species redundancy when isolated, small populations are at increased vulnerability to the effects of stochastic events, without a means for natural recolonization. Ultimately, the effect of scattered, small, and disjunct populations, without the means to naturally recolonize, is weakened species resiliency as a whole, which ultimately enhances the risk of either or both species becoming endangered. Therefore, based on the best available scientific and commercial information, we conclude that harmful nonnative species are the most significant threat to both the northern Mexican and narrow-headed gartersnake, rangewide, now and in the foreseeable future.

Main Factors That Destroy or Modify the Physical Habitat of Northern Mexican and Narrow-Headed Gartersnakes

The Relationship Between Harmful Nonnative Species and Adverse Effects to Physical Habitat

As discussed at length above, we found harmful nonnative species to be a significant and widespread factor that continues to drive further declines in and extirpations of gartersnake populations. Also in our review of the literature, we found various threats have affected, and continue to affect, primary components of the physical habitat required by northern Mexican and narrow-headed gartersnakes. These activities result in the loss of stream flow, and include examples such as dams, water diversions, groundwater pumping, and development. Researchers agree that the period from 1850 to 1940 marked the greatest loss and degradation of riparian and aquatic communities in Arizona, many of which were caused by anthropogenic (human-caused) land uses and the primary and secondary effects of those uses (Stromberg *et al.* 1996, p. 114; Webb and Leake 2005, pp. 305–310). An estimated one-third of Arizona's pre-settlement wetlands has dried or been rendered ecologically dysfunctional (Yuhas 1996, entire). However, not all aquatic and riparian habitats in the United States that support northern Mexican or narrow-headed gartersnakes have been significantly degraded or lost. Despite the loss or modification of aquatic and riparian habitat we describe below, large reaches of the Verde, Salt, San Pedro, and Gila Rivers, as well as several of their tributaries, remain functionally suitable as physical habitat for either gartersnake species. When we use the term ''physical habitat,'' we refer to the structural integrity of aquatic and terrestrial components to habitat, such as plant species richness, density, available water, and any feature of habitat that does not pertain to the animal community. The animal community (the prey and predator species that co-occur within habitat) is not considered in our usage of ''physical habitat,'' for reasons described immediately below.

Our treatment of how various threats may affect the northern Mexican or narrow-headed gartersnake is based, in part, on recent observations made in Mexico that illustrate the relationship of gartersnakes' physical habitat suitability to the presence of native prey species and the lack of harmful nonnative species (predators on or competitors with the northern Mexican gartersnake and narrow-headed gartersnake), and the presence, or lack thereof, of attributes associated with these gartersnakes' physical habitat. In 2007, two groups consisting of agency biologists (including U.S. Fish and Wildlife Service staff), species experts, and field technicians conducted numerous gartersnake surveys in Durango and Chihuahua, Mexico (Burger 2007, p. 1). In the state of Durango, 19 survey sites provided observation records for 144 gartersnakes, representing five different species, including the northern Mexican gartersnake (Burger *et al.* 2010, p. 13). In the state of Chihuahua, 12 survey sites provided observation records for 50 gartersnakes, representing two species, including the northern Mexican gartersnake (Burger *et al.* 2010, p. 13). A main reason for this survey trip was to collect genetic samples from the subspecies described, at that time, under *Thamnophis rufipunctatus,* chiefly *T. r. unilabialis* and *T. r. nigronuchalis.* The genetic samples collected ultimately provided the evidence for the current taxonomic status of the narrow-headed gartersnake proposed by Wood *et al.* (2011, entire).

While considerable gartersnake habitat in Mexico is affected by the presence of harmful nonnative species (Conant 1974, pp. 471, 487–489; Contreras Balderas and Lozano 1994, pp. 383–384; Unmack and Fagan 2004, p. 233; Miller *et al.* 2005, pp. 60–61; Rosen and Melendez 2006, p. 54; Luja and Rodríguez-Estrella 2008, pp. 17–22), Burger (2007, pp. 1–72) surveyed several sites in remote areas that appeared to be free of nonnative species. In some sites, the physical habitat for northern Mexican gartersnakes and similar species of gartersnakes appeared to be in largely good condition, but few or no gartersnakes were detected. At other sites, the physical habitat was drastically affected by overgrazing, rural development, or road crossings; however, gartersnakes were relatively easily detected, which indicated that population densities were adequate. It should be noted that we do not have the necessary data to calculate population trends at sampled localities. Riparian and aquatic habitats in Arizona and New Mexico are in relatively better physical condition compared to observations of these habitats made in Durango and Chihuahua, Mexico. However, nonnative species are also ubiquitous in these same habitats across the landscape in the southwestern United States, based on our literature review and GIS modeling. Several sites visited by Burger (2007, pp. 1–72) in Durango and Chihuahua, Mexico, had physical habitat in poor to very poor condition, but were largely free of nonnative species. These situations are rarely encountered in Arizona and New Mexico and, therefore, provided Burger (2007, pp. 1–72) a unique opportunity to examine differences in gartersnake population densities based on condition of the physical habitat, without the confounding effect of nonnative species on resident gartersnake populations.

Burger (2007, pp. 6, 12, 36, 41, 58, 63) detected moderate to high densities of gartersnakes at six sites where their physical habitat was moderately to highly impacted by land uses, but were largely free of nonnatives. Burger (2007, pp. 18, 26, 32, 61, 64, 66, 67, 69, 72) also detected either low densities or no gartersnakes at nine sites where the physical habitat was in moderate to good condition, but where nonnative species were detected. Eight streams surveyed by Burger (2007, pp. 15, 22, 46, 49, 51–52, 54, 62) were largely dewatered and without fish, and had few to no gartersnake observations. One site presented an anomaly, 19 northern Mexican gartersnakes and two *T. unilabialis* were observed at Rio Papigochic at Temosachic, where crayfish were noted as abundant, but no other nonnatives were detected (Burger 2007, p. 67). The disproportionate number of northern Mexican gartersnakes detected, as compared to the more aquatic *T. unilabialis,* may be due to differences in habitat preference, or the potential disproportionate effect of crayfish on *T. unilabialis* because of their more aquatic behavior. Similar data were not collected from the remaining seven sites, which prevents further evaluation of these sites in these contexts.

Our observations of gartersnake populations in Mexico provide evidence for the relative importance of native prey species and the lack of nonnative species in comparison to the physical attributes of gartersnake habitat. As a result, we have formulated three general hypotheses: (1) Northern Mexican and narrow-headed gartersnakes may be more resilient to adverse effects to physical habitat in the absence of harmful nonnative species, and therefore, more sensitive to adverse effects to physical habitat in the presence of harmful nonnative species; (2) the presence of an adequate prey base is important for persistence of gartersnake populations regardless of whether or not harmful nonnative species are present; and (3) detections and effects from harmful nonnative species appear to decrease from north to south in the Mexican states of Chihuahua and Durango (from the United States–Mexico International Border), as discussed in Unmack and Fagan (2004, pp. 233–243).

Based on field data collected by Burger (2007, entire) and on the above hypotheses, we evaluated the significance of effects to physical habitat in the context of the presence or absence of nonnative species. Effects to the physical habitat of gartersnakes can have varying effects on the gartersnakes themselves depending on the composition of their biotic community. In the presence of harmful nonnative species, effects to physical habitat that negatively affect the prey base for northern Mexican or narrow-headed gartersnakes are believed to be comparatively more significant than those that do not. As previously discussed, harmful nonnative species are largely ubiquitous throughout the range of northern Mexican and narrow-headed gartersnakes and therefore exacerbate the effects from threats to their physical habitat.

Altering or Dewatering Aquatic Habitat

Dams and Diversions—The presence of water is critical for northern Mexican and narrow-headed gartersnakes, as well as their prey base. Of all the activities that may threaten their physical habitat, none are more serious than those that reduce flows or dewater habitat, such as dams, diversions, flood-control projects, and groundwater pumping. Such activities are widespread in Arizona. For example, municipal water use in central Arizona increased by 39 percent from 1998 to 2006 (American Rivers 2006), and at least 35 percent of Arizona's perennial rivers have been dewatered, assisted by approximately 95 dams that are in operation in Arizona today (Turner and List 2007, pp. 3, 9). Larger dams may prevent movement of fish between populations (which affects prey availability for northern Mexican and narrow-headed gartersnakes) and dramatically alter the flow regime of streams through the impoundment of water (Ligon *et al.* 1995, pp. 184–189). These diversions also require periodic maintenance and reconstruction, resulting in potential habitat damages and inputs of sediment into the active stream.

Flow regimes within stream systems are a primary factor that shape fish community assemblages. The timing, duration, intensity, and frequency of flood events has been altered to varying degrees by the presence of dams, which has an effect on fish communities. Specifically, Haney *et al.* (2008, p. 61) suggested that flood pulses may help to reduce populations of nonnative species and efforts to increase the baseflows may assist in sustaining native prey species for northern Mexican and narrow-headed gartersnakes. However, the investigators in this study also suggest that, because the northern Mexican gartersnake preys on both fish and frogs, it may be less affected by reductions in baseflow of streams (Haney *et al.* 2008, pp. 82, 93). Collier *et al.* (1996, p. 16) mentions that water development projects are one of two main causes of the decline of native fish in the Salt and Gila rivers of Arizona. Unregulated flows with elevated discharge events favor native species, and regulated flows, absent significant discharge events, favor nonnative species (Probst *et al.* 2008, p. 1246). Interactions among native fish, nonnative fish, and flow regimes were observed in the upper reaches of the East Fork of the Gila River. Prior to the 1983 and 1984 floods in the Gila River system, native fish occurrence was limited, while nonnative fish were moderately common. Following the 1983 flood event, adult nonnative predators were generally absent, and native fish were subsequently collected in moderate numbers in 1985 (Propst *et al.* 1986, p. 83). These relationships are most readily observed in canyon-bound streams, where shelter sought by nonnative species during large-scale floods is minimal (Probst *et al.* 2008, p. 1249). Probst *et al.* (2008, p. 1246) also suggested the effect of nonnative fish species on native fish communities may be most significant during periods of natural drought (simulated by artificial dewatering).

Effects from flood control projects threaten riparian and aquatic habitat, as well as threaten the northern Mexican gartersnake directly in lower Tonto Creek. Kimmell (2008, pers. comm.), Gila County Board of Supervisors (2008, pers. comm.), Trammell (2008, pers. comm.), and Sanchez (2008, pers. comm.) all discuss a growing concern of residents that live within or adjacent to the floodplain of Tonto Creek in Gila County, Arizona, both upstream and downstream of the town of Gisela, Arizona. Specifically, there is growing concern to address threats to private property and associated infrastructure posed by flooding of Tonto Creek (Sanchez 2008, pers. comm.). An important remaining population of northern Mexican gartersnakes within the large Salt River subbasin occurs on Tonto Creek. In Resolution No. 08–06–02, the Gila County Board of Supervisors proactively declared a state of emergency within Gila County as a result of the expectation for heavy rain and snowfall causing repetitive flooding conditions (Gila County Board of Supervisors 2008, pers. comm.). In response, the Arizona Division of Emergency Management called meetings and initiated discussions among stakeholders in an attempt to mitigate these flooding concerns (Kimmell 2008, pers. comm., Trammell 2008, pers. comm.).

Mitigation measures that have been discussed include removal of riparian vegetation, removal of debris piles, potential channelization of Tonto Creek, improvements to existing flood control structures or addition of new structures, and the construction of new bridges. Adverse effects from these types of activities to aquatic and riparian habitat, and to the northern Mexican gartersnake or its prey species, will result from the physical alteration or destruction of habitat, significant increases to flow velocity, and removal of key foraging habitat and areas to hibernate, such as debris jams. Specifically, flood control projects permanently alter stream flow characteristics and have the potential to make the stream unsuitable as habitat for the northern Mexican gartersnake by reducing or eliminating stream sinuosity and associated pool and backwater habitats that are critical to northern Mexican gartersnakes and their prey species. Threats presented by these flood control planning efforts are considered imminent.

Many streams in New Mexico, currently or formerly occupied by northern Mexican or narrow-headed gartersnakes, have been or could be affected by water withdrawals. Approximately 9.5 river mi (15.3 km) of the Gila River mainstem in New Mexico, from Little Creek to the Gila Bird Area, are in private ownership and have been channelized, and the water is largely used for agricultural purposes (Hellekson 2012a, pers. comm.). In addition, the Hooker Dam has been proposed in the reach above Mogollon Creek and below Turkey Creek as part of the Central Arizona Project, but remains in deferment status (Hellekson 2012a, pers. comm.). If constructed, Hooker Dam would significantly alter or reduce stream flow; favor nonnative, spiny-rayed fish species; and likely render the affected reach unsuitable for narrow-headed gartersnakes. Below the Gila Bird Area, but above the Middle Box of the mainstem Gila River, several water diversions have reduced stream flow (Hellekson 2012a, pers. comm.). Channelization has also affected a privately owned reach of Whitewater Creek from the Catwalk downstream to Glenwood, New Mexico (Hellekson 2012a, pers. comm.). The Gila River downstream of the town of Cliff, New Mexico, flows through a broad valley where irrigated agriculture and livestock grazing are the predominant uses. Human settlement has increased since 1988 (Propst *et al.* 2008, pp. 1237–1238). Agricultural practices have led to dewatering of the river in the Cliff-Gila valley at times during the dry season (Soles 2003, p. 71). For those portions of the Gila River downstream of the Arizona-New Mexico border, agricultural diversions and groundwater pumping have caused declines in the water table, and surface flows in the central portion of the river basin are diverted for agriculture (Leopold 1997, pp. 63–64; Tellman *et al.* 1997, pp. 101–104).

The San Francisco River in New Mexico has undergone sedimentation, riparian habitat degradation, and extensive water diversion, and at present has an undependable water supply throughout portions of its length. The San Francisco River is seasonally dry in the Alma Valley, and two diversion structures fragment habitat in the upper Alma Valley and at Pleasanton (NMDGF 2006, p. 302). An approximate 2-stream-mi (3.2-km) reach of the lower San Francisco River between the Glenwood Diversion and Alma Bridge, which would otherwise be good narrow-headed gartersnake habitat, has been completely dewatered by upstream diversions (Hellekson 2012a, pers. comm.).

Additional withdrawals of water from the Gila and San Francisco Rivers may occur in the future (McKinnon 2006d). Implementation of Title II of the Arizona Water Settlements Act (AWSA) (Pub. L. 108–451) would facilitate the exchange of Central Arizona Project water within and between southwestern river basins in Arizona and New Mexico, and may result in the construction of new water development projects. Section 212 of the AWSA pertains to the New Mexico Unit of the Central Arizona Project. The AWSA provides for New Mexico water users to deplete 140,000 acre-feet of additional water from the Gila Basin in any 10-year period. The settlement also provides the ability to divert that water without complaint from downstream pre-1968 water rights in Arizona. New Mexico will receive $66 million to $128 million in non-reimbursable federal funding. The Interstate Stream Commission (ISC) funds may be used to cover costs of an actual water supply project, planning, environmental mitigation, or restoration activities associated with or necessary for the project, and may be used on one or more of 21 alternative projects ranging from Gila National Forest San Francisco River Diversion/Ditch improvements to a regional water supply project (the Deming Diversion Project). At this time, it is not known how the funds will be spent, or which potential alternative(s) may be chosen. While multiple potential project proposals have been accepted by the New Mexico Office of the State Engineer (NMOSE) (NMOSE 2011a, p. 1), implementation of the AWSA is still in the planning stages on these streams, and final notice is expected by the end of 2014. Should water be diverted from the Gila or San Francisco Rivers, flows would be diminished and direct and indirect losses and degradation of habitat for the narrow-headed gartersnake and its prey species would result.

In addition to affecting the natural behavior of streams and rivers through changes in timing, intensity, and duration of flood events, dams create reservoirs that alter resident fish communities. Water level fluctuation can affect the degree of benefit to harmful nonnative fish species. Reservoirs that experience limited or slow fluctuations in water levels are especially beneficial to harmful nonnative species whereas reservoirs that experience greater fluctuations in water levels provide less benefit for harmful nonnative species. The timing of fluctuating water levels contributes to their effect; a precipitous drop in water levels during harmful nonnative fish reproduction is most deleterious to their recruitment. A drop in water levels outside of the reproductive season of harmful nonnative species has less effect on overall population dynamics.

The cross-sectional profile of any given reservoir also contributes to its benefit for harmful nonnative fish species. Shallow reservoir profiles generally provide maximum space and elevated water temperatures favorable to reproduction of harmful nonnative species, and deep reservoir profiles with limited shallow areas provide commensurately less benefit. Examples of reservoirs that benefit harmful nonnative species, and therefore adversely affect northern Mexican and narrow-headed gartersnakes (presently or historically), include Horseshoe and Bartlett Reservoirs on the Verde River, the San Carlos Reservoir on the Gila River, and Roosevelt, Saguaro, Canyon, and Apache Lakes on the Salt River. The Salt River Project (SRP) operates the previously mentioned reservoirs on the Verde and Salt Rivers and, in the case of Horseshoe and Bartlett Reservoirs, received section 10(a)(1)(B) take authorization under the Act for adverse effects to several avian and aquatic species (including northern Mexican and narrow-headed gartersnakes) through a comprehensive threat minimization and mitigation program found in SRP's habitat conservation plan (SRP 2008, entire). There is no such minimization and mitigation program developed for the operation Lake Roosevelt, where limited fluctuation in reservoir levels benefit harmful nonnative species and negatively affect northern Mexican or narrow-headed gartersnakes and their prey bases in Tonto Creek and the upper Salt River. A detailed analysis of the effects of reservoir operations on aquatic communities is provided in our intra-Service biological and conference opinion provided in USFWS (2008, pp. 112–131).

The Effect of Population Growth and Development on Water Demands and Gartersnake Habitat—Arizona's population is expected to double from 5 million to 10 million people by the year 2030, which will put increasing pressure on water demands (Overpeck 2008). Arizona increased its population by 474 percent from 1960 to 2006 (Gammage 2008, p. 15), and is second only to Nevada as the fastest growing State in terms of human population (Social Science Data Analysis Network (SSDAR) 2000, p.1). Over approximately the same time period, population growth rates in Arizona counties where northern Mexican or narrow-headed gartersnake habitat exists have varied by county but are no less remarkable, and all are increasing: Maricopa (463 percent); Pima (318 percent); Santa Cruz (355 percent); Cochise (214 percent); Yavapai (579 percent); Gila (199 percent); Graham (238 percent); Apache (228 percent); Navajo (257 percent); Yuma (346 percent); LaPaz (142 percent); and Mohave (2,004 percent) (SSDAR 2000). From 1960 to 2006, the Phoenix metropolitan area alone grew by 608 percent, and the Tucson metropolitan area grew by 356 percent (Gammage 2008, p. 15). Population growth in Arizona is expected to be focused along wide swaths of land from the international border in Nogales, through Tucson, Phoenix, and north into Yavapai County (called the Sun Corridor ''Megapolitan''), and is predicted to have 8 million people by 2030, an 82.5 percent increase from 2000 (Gammage *et al.* 2008, pp. 15, 22–23). If build-out occurs as expected, it could indirectly affect (through increased recreation pressure and demand for water) currently occupied habitat for the northern Mexican or narrow-headed gartersnake, particularly regional populations in Red Rock Canyon in extreme south-central Arizona, lower Cienega Creek near Vail, Arizona, and the Verde Valley.

The effect of the increased water withdrawals may be exacerbated by the current, long-term drought facing the arid southwestern United States. Philips and Thomas (2005, pp. 1–4) provided stream flow records that indicate that the drought Arizona experienced between 1999 and 2004 was the worst drought since the early 1940s and possibly earlier. The Arizona Drought Preparedness Plan Monitoring Technical Committee (ADPPMTC) (2012) determined the drought status within the Arizona distributions of northern Mexican and narrow-headed gartersnakes, through June 2012, to be in ''severe drought.'' Ongoing drought conditions have depleted recharge of aquifers and decreased base flows in the region. While drought periods have been relatively numerous in the arid Southwest from the mid-1800s to the present, the effects of human-caused impacts on riparian and aquatic communities have compromised the ability of these communities to function under the additional stress of prolonged drought conditions. We further discuss the effect of climate change-induced drought below.

The Arizona Department of Water Resources (ADWR) manages water supplies in Arizona and has established five Active Management Areas (AMAs) across the State (ADWR 2006, entire). An AMA is established by ADWR when an area's water demand has exceeded the groundwater supply and an overdraft has occurred. In these areas, groundwater use has exceeded the rate where precipitation can recharge the aquifer. Geographically, these five AMAs overlap the historical distribution of the northern Mexican or narrow-headed gartersnake, or both, in Arizona. The establishment of these AMAs further illustrates the condition of and future threats to riparian habitat in these areas and are a cause of concern for the long-term maintenance of northern Mexican and narrow-headed gartersnake habitat. Such overdrafts reduce surface water flow of streams that are hydrologically connected to the aquifer, and these overdrafts can be further exacerbated by surface water diversions, placing further stress on the aquifer. The presence of water is a primary habitat component for northern Mexican and narrow-headed gartersnakes. Existing water laws in Arizona and New Mexico are inadequate to protect gartersnake habitat from the dewatering effects of groundwater withdrawals. New Mexico water law does not include provisions for instream water rights to protect fish and wildlife and their habitats. Arizona water law does recognize such provisions; however, because this change is relatively recent, instream water rights have low priority, and are often never fulfilled because more senior diversion rights have priority. Gelt (2008, pp. 1–12) highlighted the fact that existing water laws are outdated and reflect a legislative interpretation of the resource that is not consistent with current scientific understanding, such as the important connection between groundwater and surface water.

Water for development and urbanization is often supplied by groundwater pumping and surface water diversions from sources that include reservoirs and Central Arizona Project's allocations from the Colorado River. The hydrologic connection between groundwater and surface flow of intermittent and perennial streams is becoming better understood. Groundwater pumping creates a cone of depression within the affected aquifer that slowly radiates outward from the well site. When the cone of depression intersects the hyporheic zone of a stream (the active transition zone between two adjacent ecological communities under or beside a stream channel or floodplain between the surface water and groundwater that contributes water to the stream itself), the surface water flow may decrease, and the subsequent drying of riparian and wetland vegetative communities can follow. Continued groundwater pumping at such levels draws down the aquifer sufficiently to create a water-level gradient away from the stream and floodplain (Webb and Leake 2005, p. 309). Finally, complete disconnection of the aquifer and the stream results in strong negative effects to riparian vegetation (Webb and Leake 2005, p. 309). The hyporheic zone can promote ''hot spots'' of productivity where groundwater upwelling produces nitrates that can enhance the growth of vegetation, but its significance is contingent upon its activity and extent of connection with the groundwater (Boulton *et al.* 1998, p. 67; Boulton and Hancock 2006, pp. 135, 138). If complete disconnection occurs, the hyporheic zone could be adversely affected. Such ''hot spots'' can enhance the quality of northern Mexican and narrow-headed gartersnake habitat. Conversely, changes to the duration and timing of upwelling can potentially lead to localized extinctions in biota (Boulton and Hancock 2006, p. 139), reducing or eliminating gartersnake habitat suitability.

The arid southwestern United States is characterized by limited annual precipitation, which means limited annual recharge of groundwater aquifers; even modest changes in groundwater levels from groundwater pumping can affect above-ground stream flow as evidenced by depleted flows in the Santa Cruz, Verde, San Pedro, Blue, and lower Gila rivers as a result of regional groundwater demands (Fernandez and Rosen 1996, p. 70; Stromberg *et al.* 1996, pp. 113, 124–128; Rinne *et al.* 1998, p. 9; Voeltz 2002, pp. 45–47, 69–71; Haney *et al.* 2009 p. 1). Demands are expected to exceed flows in Arivaca Creek, Babocomari River, lower Cienega Creek, San Pedro River, upper Verde River, and Agua Fria River (Haney *et al.* 2009 p. 3, Table 2), which historically or currently support northern Mexican or narrow-headed gartersnake populations. The complete loss of surface flow would result in local or regional extirpations of both species, or limit the species' recovery in these areas.

Water depletion is a concern for the Verde River (American Rivers 2006; McKinnon 2006a). Barnett and Hawkins (2002, Table 4) reported population census data from 1970, as well as projections for 2030, for communities situation along the middle Verde River or within the Verde River subbasin as a whole, such as Clarkdale, Cottonwood, Jerome, and Sedona. From 1970–2000, population growth was recorded as Clarkdale (384 percent), Cottonwood (352 percent), Jerome (113 percent), and Sedona (504 percent) (Barnett and Hawkins 2002, Table 4). Projected growth in these same communities from 1970–2030 was tabulated at Clarkdale (620 percent), Cottonwood (730 percent), Jerome (292 percent), and Sedona (818 percent) (Barnett and Hawkins 2002, Table 4). These examples of documented and projected population growth within the Verde River subbasin indicate ever-increasing water demands that have impacted base flow in the Verde River and are expected to continue. The middle and lower Verde River has limited or no flow during portions of the year due to agricultural diversion and upstream impoundments, and has several impoundments in its middle reaches, which could expand the area of impacted northern Mexican and narrow-headed gartersnake habitat. Blasch *et al.* (2006, p. 2) suggests that groundwater storage in the Verde River subbasin has already declined due to groundwater pumping and reductions in natural channel recharge resulting from stream flow diversions.

Also impacting water in the Verde River, the City of Prescott, Arizona, experienced a 22 percent increase in population between 2000 and 2005 (U.S. Census Bureau 2010, p. 1), averaging around 4 percent growth per year (City of Prescott 2010, p. 1). In addition, the towns of Prescott Valley and Chino Valley experienced growth rates of 66 and 67 percent, respectively (Arizona Department of Commerce 2009a, p. 1; 2009b, p. 1). This growth is facilitated by groundwater pumping in the Verde River basin. In 2004, the cities of Prescott and Prescott Valley purchased a ranch in the Big Chino basin in the headwaters of the Verde River, with the intent of drilling new wells to supply up to approximately 4,933,927 cubic meters (4,000 acre-feet (AF)) of groundwater per year. If such drilling occurs, it could have serious adverse effects on the mainstem and tributaries of the Verde River.

Scientific studies have shown a link between the Big Chino aquifer and spring flows that form the headwaters of the Verde River. It is estimated that 80 to 86 percent of baseflow in the upper Verde River comes from the Big Chino aquifer (Wirt 2005, p. G8). However, while these withdrawals could potentially dewater the upper 26 mi (42 km) of the Verde River (Wirt and Hjalmarson 2000, p. 4; Marder 2009, pp. 188–189), it is uncertain that this project will occur given the legal and administrative challenges it faces; however, an agreement in principle was signed between various factions associated with water rights and interests on the Verde River (Citizens Water Advocacy Group 2010; Verde Independent 2010, p. 1). An indepth discussion of the effects to Verde River from pumping of the Big Chino Aquifer is available in Marder (2009, pp. 183–189). Within the Verde River subbasin, and particularly within the Verde Valley, where the northern Mexican and narrow-headed gartersnakes could occur, several other activities continue to threaten surface flows (Rinne *et al.* 1998, p. 9; Paradzick *et al.* 2006, pp. 104–110). Many tributaries of the Verde River are permanently or seasonally dewatered by water diversions for agriculture (Paradzick *et al.* 2006, pp. 104–110). The demands for surface water allocations from rapidly growing communities and agricultural and mining interests have altered flows or dewatered significant reaches during the spring and summer months in some of the Verde River's larger, formerly perennial tributaries such as Wet Beaver Creek, West Clear Creek, and the East Verde River (Girmendonk and Young 1993, pp. 45–47; Sullivan and Richardson 1993, pp. 38–39; Paradzick *et al.* 2006, pp. 104–110), which may have supported either the northern Mexican or narrow-headed gartersnake, or both. Groundwater pumping in the Tonto Creek drainage regularly eliminates surface flows during parts of the year (Abarca and Weedman 1993, p. 2).

Further south in Arizona, portions of the San Pedro River are now classified as formerly perennial (The Nature Conservancy 2006), and water withdrawals are a concern for the San Pedro River. The Cananea Mine in Sonora, Mexico, owns the land surrounding the headwaters of the San Pedro. There is disagreement on the exact amount of water withdrawn by the mine, Mexicana de Cananea, which is one of the largest open-pit copper mines in the world. However, there is agreement that it is the largest water user in the basin (Harris *et al.* 2001; Varady *et al.* 2000, p. 232). Along the upper San Pedro River, Stromberg *et al.* (1996, pp. 124–127) found that wetland herbaceous species, important as cover for northern Mexican gartersnakes, are the most sensitive to the effects of a declining groundwater level. Webb and Leake (2005, pp. 302, 318–320) described a correlative trend regarding vegetation along southwestern streams from historically being dominated by marshy grasslands preferable to northern Mexican gartersnakes, to currently being dominated by woody species that are more tolerant of declining water tables due to their deeper rooting depths.

Another primary groundwater user in the San Pedro subbasin is Fort Huachuca. Fort Huachuca is a U.S. Army installation located near Sierra Vista, Arizona. Initially established in 1877 as a camp for the military, the water rights of the Fort are predated only by those of local Indian tribes (Varady *et al.* 2000, p. 230). Fort Huachuca has pursued a rigorous water use reduction plan, working over the past decade to reduce groundwater consumption in the Sierra Vista subbasin. Their efforts have focused primarily on reductions in groundwater demand both on-post and off-post and increased artificial and enhanced recharge of the groundwater system. Annual pumping from Fort Huachuca production wells has decreased from a high of approximately 3,200 acre-feet (AF) in 1989, to a low of approximately 1,400 AF in 2005. In addition, Fort Huachuca and the City of Sierra Vista have increased the amount of water recharged to the regional aquifer through construction of effluent recharge facilities and detention basins that not only increase stormwater recharge, but mitigate the negative effects of increased runoff from urbanization. The amount of effluent that was recharged by Fort Huachuca and the City of Sierra Vista in 2005 was 426 AF and 1,868 AF, respectively. During this same year, enhanced stormwater recharge at detention basins was estimated to be 129 AF. The total net effect of all the combined efforts initiated by Fort Huachuca has been to reduce the net groundwater consumption by approximately 2,272 AF (71 percent) since 1989 (USFWS 2007, pp. 41–42).

Groundwater withdrawal in Eagle Creek, primarily for water supplying the large open-pit copper mine at Morenci, Arizona, dries portions of the stream (Sublette *et al.* 1990, p. 19; USFWS 2005; Propst *et al.* 1986, p. 7) that otherwise supports habitat for narrow-headed gartersnakes. Mining is the largest industrial water user in southeastern Arizona. The Morenci mine on Eagle Creek is North America's largest producer of copper, covering approximately 24,281 hectares (ha) (60,000 acres (ac)). Water for the mine is imported from the Black River, diverted from Eagle Creek as surface flows, or withdrawn from the Upper Eagle Creek Well Field (Arizona Department of Water Resources 2009, p. 1).

The Rosemont Copper Mine proposed to be constructed in the north-eastern area of the Santa Rita Mountains in Santa Cruz County, Arizona, will include a mine pit that will be excavated to a depth greater than that of the regional aquifer. Water will thus drain from storage in the aquifer into the pit. The need to dewater the pit during mining operations will thus result in ongoing removal of aquifer water storage. Upon cessation of mining, a pit lake will form, and evaporation from this water body will continue to remove water from storage in the regional aquifer. This aquifer also supplies baseflow to Cienega Creek, immediately east of the proposed project site. Several groundwater models have been developed to analyze potential effects of expected groundwater withdrawals. However, the latest independent models did not indicate that significant effects to baseflows in Cienega Creek are expected from the Rosemont Copper Mine into the foreseeable future.

The best available scientific and commercial information indicates that, regardless of the scenario, any reduction in the presence or availability of water is a significant threat to northern Mexican and narrow-headed gartersnakes, their prey base, and their habitat. This is because water is a fundamental need that supports the necessary aquatic and riparian habitats and prey species needed by both species of gartersnake. Through GIS analyses, we found that approximately 32 percent of formerly perennial streams have been dewatered within the historical distribution of the northern Mexican gartersnake. Within the historical distribution of the narrow-headed gartersnake, approximately 13 percent of formerly perennial streams have been dewatered.

Climate Change and Drought—Our analyses under the Act include consideration of ongoing and projected changes in climate. The terms ''climate'' and ''climate change'' are defined by the Intergovernmental Panel on Climate Change (IPCC). ''Climate'' refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007, p. 78). The term ''climate change'' thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007, p. 78). Various types of changes in climate can have direct or indirect effects on species. These effects may be positive, neutral, or negative and they may change over time, depending on the species and other relevant considerations, such as the effects of interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007, pp. 8–14, 18–19). In our analyses, we use our expert judgment to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change and their predicted effects on northern Mexican and narrow-headed gartersnakes.

The ecology and natural histories of northern Mexican and narrow-headed gartersnakes are strongly linked to water. As discussed above, the northern Mexican gartersnake is a highly aquatic species and relies largely upon other aquatic species, such as ranid frogs and native and nonnative, soft-rayed fish as prey. The narrow-headed gartersnake is the most aquatic of the southwestern gartersnakes and is a specialized predator on native and nonnative, soft-rayed fish found primarily in clear, rocky, higher elevation streams. Because of their aquatic nature, Wood *et al.* (2011, p. 3) predict they may be uniquely susceptible to environmental change, especially factors associated with climate change. Together, these factors are likely to make northern Mexican and narrow-headed gartersnakes vulnerable to effects of climate change and drought discussed below.

Several climate-related trends have been detected since the 1970s in the southwestern United States including increases in surface temperatures, rainfall intensity, drought, heat waves, extreme high temperatures, average low temperatures (Overpeck 2008, entire). Annual precipitation amounts in the southwestern United States may decrease by 10 percent by the year 2100 (Overpeck 2008, entire). Seager *et al.* (2007, pp. 1181–1184) analyzed 19 different computer models of differing variables to estimate the future climatology of the southwestern United States and northern Mexico in response to predictions of changing climatic patterns. All but 1 of the 19 models predicted a drying trend within the Southwest; one predicted a trend toward a wetter climate (Seager *et al.* 2007, p. 1181). A total of 49 projections were created using the 19 models, and all but 3 predicted a shift to increasing aridity (dryness) in the Southwest as early as 2021–2040 (Seager *et al.* 2007, p. 1181). Northern Mexican and particularly narrow-headed gartersnakes, and their prey bases, depend on permanent or nearly permanent water for survival. A large percentage of habitats within the current distribution of northern Mexican and narrow-headed gartersnakes are predicted to be at risk of becoming more arid with reductions in snow pack levels (Seager *et al.* 2007, pp. 1183–1184). This has severe implications for the integrity of aquatic and riparian ecosystems and the water that supports them. In assessing potential effects of predicted climate change to river systems in New Mexico, Molles (2007) found that: (1) Variation in stream flow will likely be higher than variation in precipitation; (2) predicted effects such as warming and drying are expected to result in higher variability in stream flows; and (3) high-elevation fish and non-flying invertebrates (which are prey for gartersnake prey species) are at greatest risk from effects of predicted climate change. Enquist and Gori (2008, p. iii) found that most of New Mexico's mid- to high-elevation forests and woodlands have experienced either consistently warmer and drier conditions or greater variability in temperature and precipitation from 1991 to 2005. However, Enquist *et al.* (2008, p. v) found the upper Gila and San Francisco subbasins, which support narrow-headed gartersnake populations, have experienced very little change in moisture stress during the same period.

Cavazos and Arriaga (2010, entire) found that average temperatures along the Mexican Plateau in Mexico could rise by as much as 1.8 °F (1 °C) in the next 20 years and by as much as 9 °F (5 °C) in the next 20 years, according to their models. Cavazos and Arriaga (2010, entire) also found that precipitation may decrease up to 12 percent over the next 20 years in the same region, with pronounced decreases in winter and spring precipitation.

Potential drought associated with changing climatic patterns may adversely affect the amphibian prey base for the northern Mexican gartersnake. Amphibians may be among the first vertebrates to exhibit broad-scale changes in response to changes in global climatic patters due to their sensitivity to changes in moisture and temperature (Reaser and Blaustein 2005, p. 61). Changes in temperature and moisture, combined with the ongoing threat to amphibians from the persistence of disease causing bacteria such as *Batrachochytrium dendrobatidis* (Bd) may cause prey species to experience increased physiological stress and decreased immune system function, possibly leading to disease outbreaks (Carey and Alexander 2003, pp. 111–121; Pounds *et al.* 2006, pp. 161–167). Of the 30 different vertebrate species in the Sky Island region of southeastern Arizona, the northern Mexican gartersnake was found to be the fifth-most vulnerable (total combined score) to predicted climate change; one of its primary prey species, the Chiricahua leopard frog, was determined to be the fourth most vulnerable (Coe *et al.* 2012, p. 16). Both the northern Mexican gartersnake and the Chiricahua leopard frog ranked the highest of all species assessed for vulnerability of their habitat to predicted climate change, and the Chiricahua leopard frog was also found to be the most vulnerable in terms of its physiology (Coe *et al.* 2012, p. 18). Relative uncertainty for the vulnerability assessment provided by Coe *et al.* (2012, Table 2.2) ranged from 0 to 8 (higher score means greater uncertainty), and the northern Mexican gartersnake score was 3, meaning that the vulnerability assessment was more certain than not. Coe *et al.* (2012, entire) focused their assessment of species vulnerability to climate change on those occurring on the Coronado National Forest in southeastern Arizona. However, it is not unreasonable to hypothesize that results might be applicable in a larger, regional context as applied in most climate models.

The bullfrog, also assessed by Coe *et al.* (2012, pp. 16, 18, Table 2.2), was shown to be significantly less vulnerable to predicted climate change than either northern Mexican gartersnakes or Chiricahua leopard frogs with an uncertainty score of 1 (very certain). We suspect bullfrogs were found to be less vulnerable by Coe *et al.* (2012) to predicted climate change in southeastern Arizona due to their dispersal and colonization capabilities, capacity for self-sustaining cannibalistic populations, and ecological dominance where they occur. Based upon climate change models, nonnative species biology, and ecological observations, Rahel *et al.* (2008, p. 551) concluded that climate change could foster the expansion of nonnative aquatic species into new areas, magnify the effects of existing aquatic nonnative species where they currently occur, increase nonnative predation rates, and heighten the virulence of disease outbreaks in North America.

Rahel and Olden (2008, p. 526) expect that increases in water temperatures in drier climates such as the southwestern United States will result in periods of prolonged low flows and stream drying. These effects from changing climatic conditions may have profound effects on the amount, permanency, and quality of habitat for northern Mexican and narrow-headed gartersnakes as well as their prey base. Changes in amount or type of winter precipitation may affect snowpack levels as well as the timing of their discharge into high-elevation streams. Low or no snowpack levels would jeopardize the amount and reliability of stream flow during the arid spring and early summer months, which would increase water temperatures to unsuitable levels or eliminate flow altogether. Harmful nonnative species such as largemouth bass are expected to benefit from prolonged periods of low flow (Rahel and Olden 2008, p. 527). These nonnative predatory species evolved in river systems with hydrographs that were largely stable, not punctuated by flood pulses in which native species evolved and benefit from. Probst *et al.* (2008, p. 1246) also suggested that nonnative fish species may benefit from drought.

Changes to climatic patterns may warm water temperatures, alter stream flow events, and increase demand for water storage and conveyance systems (Rahel and Olden 2008, pp. 521–522). Warmer water temperatures across temperate regions are predicted to expand the distribution of existing harmful nonnative species, which evolved in warmer water temperatures, by providing 31 percent more suitable habitat. This conclusion is based upon studies that compared the thermal tolerances of 57 fish species with predictions made from climate change temperature models (Mohseni *et al.* 2003, p. 389). Eaton and Scheller (1996, p. 1,111) reported that while several cold-water fish species (such as trout, a prey species for narrow-headed gartersnakes) in North America are expected to have reductions in their distribution from effects of climate change, several harmful nonnative species are expected to increase their distribution. In the southwestern United States, this situation may occur where the quantity of water is sufficient to sustain effects of potential prolonged drought conditions but where water temperature may warm to a level found suitable to harmful nonnative species that were previously physiologically precluded from occupation of these areas. Species that are particularly harmful to northern Mexican and narrow-headed gartersnake populations such as the green sunfish, channel catfish, largemouth bass, and bluegill are expected to increase their distribution by 7.4 percent, 25.2 percent, 30.4 percent, and 33.3 percent, respectively (Eaton and Scheller 1996, p. 1,111).

Vanishing Cienegas—Cienegas are particularly important habitat for the northern Mexican gartersnake and are considered ideal for the species because these areas present ideal habitat characteristics for the species and its prey base and have been shown to support robust populations of both (Rosen and Schwalbe 1988, p. 14). Hendrickson and Minckley (1984, p. 131) defined cienegas as ''mid-elevation (3,281–6,562 ft (1,000–2000 m)) wetlands characterized by permanently saturated, highly organic, reducing [lowering of oxygen level] soils.'' Many of these unique communities of the southwestern United States, Arizona in particular, and Mexico have been lost in the past century to streambed modification, intensive livestock grazing, woodcutting, artificial drainage structures, stream flow stabilization by upstream dams, channelization, and stream flow reduction from groundwater pumping and water diversions (Hendrickson and Minckley 1984, p. 161). Stromberg *et al.* (1996, p. 114) state that cienegas were formerly extensive along streams of the Southwest; however, most were destroyed during the late 1800s, when groundwater tables declined several meters and stream channels became incised.

Many sub-basins, where cienegas have been severely modified or lost entirely, wholly or partially overlap the historical distribution of the northern Mexican gartersnake, including the San Simon, Sulphur Springs, San Pedro, and Santa Cruz valleys of southeastern and south-central Arizona. The San Simon Valley in Arizona possessed several natural cienegas with abundant vegetation prior to 1885, and was used as a watering stop for pioneers, military, and surveying expeditions (Hendrickson and Minckley 1984, pp. 139–140). In the subsequent decades, the disappearance of grasses and commencement of severe erosion were the result of historical grazing pressure by large herds of cattle, as well as the effects from wagon trails that paralleled arroyos, occasionally crossed them, and often required stream bank modification (Hendrickson and Minckley 1984, p. 140). Today, only the artificially maintained San Simon Cienega exists in this valley. Similar accounts of past conditions, adverse effects from historical anthropogenic activities, and subsequent reduction in the extent and quality of cienega habitats in the remaining valleys are also provided in Hendrickson and Minckley (1984, pp. 138–160).

Development and Recreation within Riparian Corridors—Development within and adjacent to riparian areas has proven to be a significant threat to riparian biological communities and their suitability for native species (Medina 1990, p. 351). Riparian communities are sensitive to even low levels (less than 10 percent) of urban development within a subbasin (Wheeler *et al.* 2005, p. 142). Development along or within proximity to riparian zones can alter the nature of stream flow dramatically, changing once-perennial streams into ephemeral streams, which has direct consequences on the riparian community (Medina 1990, pp. 358–359). Medina (1990, pp. 358–359) correlated tree density and age class representation to stream flow, finding that decreased flow reduced tree densities and generally resulted in few to no small-diameter trees. Small-diameter trees assist northern Mexican and narrow-headed gartersnakes by providing additional habitat complexity, thermoregulatory opportunities, and cover needed to reduce predation risk and enhance the usefulness of areas for maintaining optimal body temperature. The presence of small shrubs and trees may be particularly important for the narrow-headed gartersnake (Deganhardt *et al.* 1996, p. 327). Development within occupied riparian habitat also likely increases the number of human-gartersnake encounters and therefore the frequency of adverse human interaction, described below.

Obvious examples of the influence of urbanization and development can be observed within the areas of greater Tucson and Phoenix, Arizona, where impacts have modified riparian vegetation, structurally altered stream channels, facilitated nonnative species introductions, and dewatered large reaches of formerly perennial rivers where the northern Mexican gartersnake historically occurred (Santa Cruz, lower Gila, and lower Salt Rivers, respectively). Urbanization and development of these areas, along with the introduction of nonnative species, are largely responsible for the likely extirpation of the northern Mexican gartersnake from these regions.

Development near riparian areas usually leads to increased recreation. Riparian areas located near urban areas are vulnerable to the effects of increased recreation. An example of such an area within the existing distribution of both the northern Mexican and narrow-headed gartersnake is the Verde Valley. The reach of the Verde River that winds through the Verde Valley receives a high amount of recreational use from people living in central Arizona (Paradzick *et al.* 2006, pp. 107–108). Increased human use results in the trampling of near-shore vegetation, which reduces cover for gartersnakes, especially newborns. Increased human visitation in occupied habitat also increases the potential for adverse human interactions with gartersnakes, which frequently leads to the capture, injury, or death of the snake (Rosen and Schwalbe 1988, p. 43; Ernst and Zug 1996, p. 75; Green 1997, pp. 285–286; Nowak and Santana-Bendix 2002, pp. 37–39).

Oak Creek Canyon, which represents an important source population for narrow-headed gartersnakes, is also a well-known example of an area with very high recreation levels. Recreational activities in the Southwest are often heavily tied to water bodies and riparian areas, due to the general lack of surface water on the landscape. Increased recreational impacts on the quantity and quality of water, as well as the adjacent vegetation, negatively affect northern Mexican and narrow-headed gartersnakes. The impacts to riparian habitat from recreation can include movement of people or livestock, such as horses or mules, along stream banks, trampling, loss of vegetation, and increased danger of fire starts (Northern Arizona University 2005, p. 136; Monz *et al.* 2010, pp. 553–554). In the arid Gila River Basin, recreational impacts are disproportionately distributed along streams as a primary focus for recreation (Briggs 1996, p. 36). Within the range of the northern Mexican and narrow-headed gartersnakes in the United States, the majority of the occupied areas occur on Federal lands, which are managed for recreation and other purposes. On the Gila National Forest, heavy recreation use within occupied narrow-headed gartersnake habitat is thought to impact populations along the Middle Fork Gila River, the mainstem Gila River between Cliff Dwellings and Little Creek, and Whitewater Creek from the Catwalk to Glenwood (Hellekson 2012a, pers. comm.).

Urbanization on smaller scales can also impact habitat suitability and the prey base for the northern Mexican or narrow-headed gartersnakes, such as along Tonto Creek, within the Verde Valley, and the vicinity of Rock Springs along the Agua Fria River (Girmendonk and Young 1997, pp. 45–52; Voeltz 2002, pp. 58–59, 69–71; Holycross *et al.*2006, pp. 53, 56; Paradzick *et al.* 2006, pp. 89–90). One of the most stable populations of the northern Mexican gartersnake in the United States, at the Page Springs and Bubbling Ponds fish hatcheries along Oak Creek, is threatened by ongoing small-scale development projects that may adversely affect the northern Mexican gartersnake directly through physical harm or injury or indirectly from effects to its habitat or prey base (AGFD 1997a, p. 8; AGFD 1997b, p. 4). Current and future management and maintenance of Bubbling Ponds include a variety of activities that would potentially affect snake habitat, such as the maintenance of roads, buildings, fences, and equipment, as well as development (residences, storage facilities, asphalt, resurfacing, etc.) and both human- and habitat-based enhancement projects (AGFD 1997b, pp. 8–9; Wilson and Company 1991, pp. 1–40; 1992, pp. 1–99). However, we expect adaptive management in relation to activities at the hatcheries, as informed by population studies that have occurred there, will help reduce the overall effects to this critical northern Mexican gartersnake population and avoid extirpation of this important population.

Diminishing Water Quantity and Quality in Mexico—While effects to riparian and aquatic communities affect both the northern Mexican gartersnake and the narrow-headed gartersnake in the United States, Mexico provides habitat only for the northern Mexican gartersnake. Threats to northern Mexican gartersnake habitat in Mexico include intensive livestock grazing, urbanization and development, water diversions and groundwater pumping, loss of vegetation cover and deforestation, and erosion, as well as impoundments and dams that have modified or destroyed riparian and aquatic communities in areas of Mexico where the species occurred historically. Rorabaugh (2008, pp. 25–26) noted threats to northern Mexican gartersnakes and their native amphibian prey base in Sonora, which included disease, pollution, intensive livestock grazing, conversion of land for agriculture, nonnative plant invasions, and logging. Ramirez Bautista and Arizmendi (2004, p. 3) stated that the principal threats to northern Mexican gartersnake habitat in Mexico include the drying of wetlands, intensive livestock grazing, deforestation, wildfires, and urbanization. In addition, nonnative species, such as bullfrogs and nonnative, spiny-rayed fish, have been introduced throughout Mexico and continue to disperse naturally, broadening their distributions (Conant 1974, pp. 487–489; Miller *et al.* 2005, pp. 60–61; Luja and Rodríguez-Estrella 2008, pp. 17–22).

Mexico's water needs for urban and agricultural development, as well impacts to aquatic habitat from these uses, are linked to significant human population growth over the past century in Mexico. Mexico's human population grew 700 percent from 1910 to 2000 (Miller *et al.* 2005, p. 60). Mexico's population increased by 245 percent from 1950 to 2002, and is projected to grow by another 28 percent by 2025 (EarthTrends 2005). Growth is concentrated in Mexico's northern states (Stoleson *et al.* 2005, Table 3.1) and is now skewed towards urban areas (Miller *et al.* 2005, p. 60). The human population of Sonora, Mexico, doubled in size from 1970 (1.1 million) to 2000 (2.2 million) (Stoleson *et al.* 2005, p. 54). The population of Sonora is expected to increase by 23 percent, to 2.7 million people, in 2020 (Stoleson *et al.* 2005, p. 54). Increasing trends in Mexico's human population will continue to place additional stress on the country's freshwater resources and continue to be the catalyst for the elimination of northern Mexican gartersnake habitat and prey species.

Much knowledge of the status of aquatic ecosystems in Mexico has come from fisheries research, which is particularly applicable to assessing the status of northern Mexican gartersnakes because of the gartersnakes' dependency on a functioning prey base. Fisheries research is also particularly applicable because of the role fishes serve as indicators of the status of the aquatic community as a whole. Miller *et al.* (2005) reported information on threats to freshwater fishes, and riparian and aquatic communities in specific water bodies from several regions throughout Mexico within the range of the northern Mexican gartersnake: the Río Grande (dam construction, p. 78 and extirpations of freshwater fish species, pp. 82, 112); headwaters of the Río Lerma (extirpation of freshwater fish species, nonnative species, pollution, dewatering, pp. 60, 105, 197); Lago de Chapala and its outlet to the Río Grande de Santiago (major declines in freshwater fish species, p. 106); medium-sized streams throughout the Sierra Madre Occidental (localized extirpations, logging, dewatering, pp. 109, 177, 247); the Río Conchos (extirpations of freshwater fish species, p. 112); the ríos Casas Grandes, Santa María, del Carmen, and Laguna Bustillos (water diversions, groundwater pumping, channelization, flood control practices, pollution, and introduction of nonnative species, pp. 124, 197); the Río Santa Cruz (extirpations, p. 140); the Río Yaqui (nonnative species, pp. 148, Plate 61); the Río Colorado (nonnative species, p. 153); the ríos Fuerte and Culiacán (logging, p. 177); canals, ponds, lakes in the Valle de México (nonnative species, extirpations, pollution, pp. 197, 281); the Río Verde Basin (dewatering, nonnative species, extirpations, Plate 88); the Río Mayo (dewatering, nonnative species, p. 247); the Río Papaloapan (pollution, p. 252); lagos de Zacapu and Yuriria (habitat destruction, p. 282); and the Río Pánuco Basin (nonnative species, p. 295).

Excessive sedimentation also appears to be a significant problem for aquatic habitat in Mexico. Recent estimates indicate that 80 percent of Mexico is affected by soil erosion caused by vegetation removal related to grazing, fires, agriculture, deforestation, etc. The most serious erosion is occurring in the states of Guanajuato (43 percent of the state's land area), Jalisco (25 percent of the state's land area), and México (25 percent of the state's land area) (va Landa *et al.* 1997, p. 317), all of which occur within the distribution of the northern Mexican gartersnake. Miller *et al.* (2005, p. 60) stated that ''During the time we have collectively studied fishes in México and southwestern United States, the entire biotas of long reaches of major streams such as the Río Grande de Santiago below Guadalajara (Jalisco) and Río Colorado (lower Colorado River in Mexico) downstream of Hoover (Boulder) Dam (in the United States), have simply been destroyed by pollution and river alteration.'' These streams are within the distribution of the northern Mexican gartersnake. The geographic extent of threats reported by Miller *et al.* (2005) across the distribution of the northern Mexican gartersnake in Mexico is evidence that they are widespread through the country, and encompass a large proportion of the distribution of the northern Mexican gartersnake in Mexico.

In northern Mexico, effects of development, such as agriculture and irrigation practices on streams and rivers in Sonora have been documented at least as far back as the 1960s. Branson *et al.* (1960, p. 218) found that the perennial rivers that drain the Sierra Madre are ''silt-laden and extremely turbid, mainly because of irrigation practices.'' Smaller mountain streams, such as the Rio Nacozari in Sonora were found to be ''biological deserts'' from the effects of numerous local mining practices (Branson *et al.* 1960, p. 218). These perennial rivers and their mountain tributaries were historically occupied by northern Mexican gartersnakes and their prey species whose populations have since been adversely affected and may be extirpated.

Minckley *et al.* (2002, pp. 687–705) provided a summary of threats (p. 696) to three newly described (at the time) species of pupfish and their habitat in Chihuahua, Mexico, within the distribution of the northern Mexican gartersnake. Initial settlement and agricultural development of the area resulted in significant channel cutting through soil layers protecting the alluvial plain above them, which resulted in reductions in the base level of each basin in succession (Minckley *et al.* 2002, pp. 696). Related to these activities, the building of dams and diversion structures dried entire reaches of some regional streams and altered flow patterns of others (Minckley *et al.* 2002, pp. 696). This was followed by groundwater pumping (enhanced by the invention of the electric pump), which lowered groundwater levels and dried up springs and small channels and reduced the reliability of baseflow in ''essentially all systems'' (Minckley *et al.* 2002, pp. 696). Subsequently, the introduction and expansion of nonnative species in the area successfully displaced or extirpated many native species (Minckley *et al.* 2002, pp. 696). Conant (1974, pp. 486–489) described significant threats to northern Mexican gartersnake habitat within its distribution in western Chihuahua, Mexico, and within the Rio Concho system where it occurs. These threats included impoundments, water diversions, and purposeful introductions of largemouth bass, common carp, and bullfrogs.

In the central portions of the northern Mexican gartersnakes' range in Mexico, such as in Durango, Mexico, population growth since the 1960s has led to regional effects such as reduced stream flow, increased water pollution, and largemouth bass introductions, which ''have seriously affected native biota'' (Miller *et al.* 1989, p. 26). McCranie and Wilson (1987, p. 2) discuss threats to the pine-oak communities of higher elevation habitats within the distribution of the northern Mexican gartersnake in the Sierra Madre Occidental in Mexico, specifically noting that '' . . . the relative pristine character of the pine-oak woodlands is threatened . . . every time a new road is bulldozed up the slopes in search of new madera or pasturage. Once the road is built, further development follows; pueblos begin to pop up along its length. . . .'' Several drainages that possess suitable habitat for the northern Mexican gartersnake occur in the area referenced above by McCranie and Wilson (1987, p. 2) including the Rio de la Cuidad, Rio Quebrada El Salto, Rio Chico, Rio Las Bayas, Rio El Cigarrero, Rio Galindo, Rio Santa Barbara, and the Rio Chavaria.

In the southern portion of the northern Mexican gartersnakes' range in Mexico, growth and development around Mexico City resulted in agricultural practices and groundwater demands that dewatered aquatic habitat and led to declines, and in some cases, extinctions of local native fish species (Miller *et al.* 1989, p. 25). In the region of southern Coahuila, Mexico, habitat modification and the loss of springs, water pollution, and irrigation practices has adversely affected native fish populations and led to the extinction of several native fish species (Miller *et al.* 1989, pp. 28–33). Considerable research has been focused in the central and west-central regions of Mexico, within the southern portion of the northern Mexican gartersnake's range, where native fish endemism (unique, narrowly distributed Suite of species) is high, as are threats to their populations and habitat. Since the 1970s in central Mexico, significant human population growth has resulted in the overexploitation of local fisheries and water pollution; these factors have accelerated the degradation of stream and riverine habitats and led to fish communities becoming reduced or undergoing significant changes in structure and composition (Mercado-Silva *et al.* 2002, p. 180). These shifts in fish community composition, population density, and shrinking distributions have adversely affected the northern Mexican gartersnake prey base in the southern portion of its range in Mexico. The Lerma River basin is the largest in west-central Mexico and is within the distribution of the northern Mexican gartersnake in the states of Jalisco, Guanajuato, and Querétaro in the southern portion of its range. Lyons *et al.* (1995, p. 572) reported that many fish communities in large perennial rivers, isolated spring-fed streams, or spring sources themselves of this region have been ''radically restructured'' and are now dominated by a few nonnative, generalist species. Lowland streams and rivers in this region are used heavily for irrigation and are polluted by industrial, municipal, and agricultural discharges (Lyons and Navarro-Perez 1990, p. 37; Lyons *et al.* 1995, p. 572).

Native fish communities of west-central Mexico have been found to be in serious decline as a result of habitat degradation at an ''unprecedented'' rate due to water withdrawals (diversions for irrigation), as well as untreated municipal, industrial, and agricultural discharges (Lyons *et al.* 1998, pp. 10–11). Numerous dams have been built along the Lerma River and along its major tributaries to support one of Mexico's most densely populated regions during the annual dry period; the water is used for irrigation, industry, and human consumption (Lyons *et al.* 1998, p. 11). From 1985 to 1993, Lyons *et al.* (1998, p. 12) found that 29 of 116 (25 percent) fish sampling locations visited within the Lerma River watershed were completely dry and another 30 were too polluted to support a fish community. These figures indicate that over half of the localities visited by Lyons *et al.* (1998, p. 12) that maintained fish populations prior to 1985 no longer support fish, which has likely led to local northern Mexican gartersnake population declines or extirpations. Soto-Galera *et al.* (1999, p. 137) reported fish and water quality sampling results from 20 locations within the Rio Grande de Morelia-Lago de Cuitzeo Basin of Michoacán and Guanajuato, Mexico, and found that over the past several decades, diminishing water quantity and worsening water quality have resulted in the elimination of 26 percent of native fish species from the basin, the extinction of two species of native fish, and declining distributions of the remaining 14 species. These figures provide evidence for widespread concern of native aquatic communities of this region, in particular for habitat and prey species of northern Mexican gartersnakes. Some conservation value, however, is realized when headwaters, springs, and small streams are protected as parks or municipal water supplies (Lyons *et al.* 1998, p. 15), but these efforts do little to protect larger perennial rivers that represent valuable habitat for northern Mexican gartersnakes.

Mercado-Silva *et al.* (2002, Appendix 2) reported results from fish community sampling and habitat assessments along 63 sites across central Mexico, the eastern-most of which include most of the northern Mexican gartersnakes' southern range. Specifically, sampling locations in the Balsas, Lerma, Morelia, Pánuco Moctezuma, and Pánuco Tampaón basins each occurred within the range of the northern Mexican gartersnake in the states of Guanajuato, Queretaro, Mexico, and Puebla; approximately 30 locations in total. The purpose of this sampling effort was to score each site in terms of its index of biotic integrity (IBI) and environmental quality (EQ), with a score of 100 representing the optimum score for each category. The IBI scoring method has been verified as a valid means to quantitatively assess ecosystem integrity at each site (Lyons *et al.* 1995, pp. 576–581; Mercado-Silva *et al.* 2002, p. 184). The range in IBI scores in these sampling locations was 85 to 35, and the range in EQ scores was 90 to 50 (Mercado-Silva *et al.* 2002, Appendix 2). The average IBI score was 57, and the average EQ score was 74, across all 30 sites and all four basins (Mercado-Silva *et al.* 2002, Appendix 2). According to the qualitative equivalencies assigned to scores (Mercado-Silva *et al.* 2002, p. 184), these values indicate that the environmental quality score averaged across all 30 sites was ''good'' and the biotic integrity scores were ''fair.'' It should be noted that 14 of the 30 sites sampled had IBI scores equal to or less than 50, and five of those ranked as ''poor.'' Of all the basins throughout central Mexico that were scored in this exercise, the two Pánuco basins represented 20 of the 30 sites sampled and scored the worst of all basins (Mercado-Silva *et al.* 2002, p. 186). This indicates that threats to the northern Mexican gartersnake, its prey base, and its habitat pose the greatest risk in this portion of its range in Mexico.

Near Torreón, Coahuila, where the northern Mexican gartersnake occurs, groundwater pumping has resulted in flow reversal, which has dried up many local springs, drawn arsenic-laden water to the surface, and resulted in adverse human health effects in that area (Miller *et al.* 2005, p. 61). Severe water pollution from untreated domestic waste is evident downstream of large Mexican cities, such as Mexico City, and inorganic pollution from nearby industrialized areas and agricultural irrigation return flow has dramatically affected aquatic communities through contamination (Miller *et al.* 2005, p. 60). Miller *et al.* (2005, p. 61) provide an excerpt from Soto Galera *et al.* (1999) addressing the threats to the Río Lerma, Mexico's longest river, which is occupied by the northern Mexican gartersnake: ''The basin has experienced a staggering amount of degradation during the 20th Century. By 1985–1993, over half of our study sites had disappeared or become so polluted that they could no longer support fishes. Only 15 percent of the sites were still capable of supporting sensitive species. Forty percent (17 different species) of the native fishes of the basin had suffered major declines in distribution, and three species may be extinct. The extent and magnitude of degradation in the Río Lerma basin matches or exceeds the worst cases reported for comparably sized basins elsewhere in the world.''

In the Transvolcanic Belt Region of the states of Jalisco, Mexico, and Veracruz in southern Mexico, Conant (2003, p. 4) noted that water diversions, pollution (e.g., discharge of raw sewage), sedimentation of aquatic habitats, and increased dissolved nutrients were resulting in decreased dissolved oxygen in suitable northern Mexican gartersnake habitat. Conant (2003, p. 4) stated that many of these threats were evident during his field work in the 1960s, and that they are ''continuing with increased velocity.''

High-Intensity Wildfires and Sedimentation of Aquatic Habitat

Low-intensity fire has been a natural disturbance factor in forested landscapes for centuries, and low-intensity fires were common in southwestern forests prior to European settlement (Rinne and Neary 1996, pp. 135–136). Rinne and Neary (1996, p. 143) discuss effects of recent fire management policies on aquatic communities in Madrean Oak Woodland biotic communities in the southwestern United States. They concluded that existing wildfire suppression policies intended to protect the expanding number of human structures on forested public lands have altered the fuel loads in these ecosystems and increased the probability of high-intensity wildfires. The effects of these high-intensity wildfires include the removal of vegetation, the degradation of subbasin condition, altered stream behavior, and increased sedimentation of streams. These effects can harm fish communities, as observed in the 1990 Dude Fire, when corresponding ash flows resulted in fish kills in Dude Creek and the East Verde River (Voeltz 2002, p. 77). Fish kills, also discussed below, can drastically affect the suitability of habitat for northern Mexican and narrow-headed gartersnakes due to the removal of a portion or the entire prey base. The Chiricahua leopard frog recovery plan cites altered fire regimes as a serious threat to Chiricahua leopard frogs, a prey species for northern Mexican gartersnakes (USFWS 2007, pp. 38–39).

The nature and occurrence of wildfires in the Southwest is expected to also be affected by climate change and ongoing drought. Current predictions of drought and/or higher winter low temperatures may stress ponderosa pine forests in which the narrow-headed gartersnake principally occurs, and may increase the frequency and magnitude of wildfire. Ganey and Vojta (2010, entire) studied tree mortality in mixed conifer and ponderosa pine forests in Arizona from 1997–2007, a period of extreme drought. They found the mortality of trees to be severe; the number of trees dying over a 5-year period increased by over 200 percent in mixed-conifer forest and by 74 percent in ponderosa pine forest during this time frame. Ganey and Vojta (2010) attributed drought and subsequent insect (bark beetle) infestation to the die-offs in trees. Drought stress and a subsequent high degree of tree mortality from bark beetles make high-elevation forests more susceptible to high-intensity wildfires. Climate is a top-down factor that synchronizes with fuel loads, a bottom-up factor. Combined with a predicted reduction in snowpack and an earlier snowmelt, these factors suggest wildfires will be larger, more frequent, and more severe in the southwestern United States (Fulé 2010). Wildfires are expected to reduce vegetative cover and result in greater soil erosion, subsequently resulting in increased sediment flows in streams (Fulé 2010, entire). Increased sedimentation in streams reduces the visibility of gartersnakes in the water column, hampering their hunting ability as well as resulting in fish kills (which is also caused by the disruption in the nitrogen cycle post-wildfire), which reduce the amount of prey available to gartersnake populations. Additionally, unnaturally high amounts of sediment fill in pools in intermittent streams, which reduces the amount and availability of habitat for fish and amphibian prey.

In the last 2 years, both Arizona (2011 Wallow Fire) and New Mexico (2012 Whitewater-Baldy Complex Fire) have experienced the largest wildfires in their respective State histories; indicative of the last decade that has been punctuated by wildfires of massive proportion. The 2011 Wallow Fire consumed approximately 540,000 acres (218,530 ha) of Apache-Sitgreaves National Forest, White Mountain Apache Indian Tribe, and San Carlos Apache Indian Reservation lands in Apache, Navajo, Graham, and Greenlee counties in Arizona as well as Catron County, New Mexico (InciWeb 2011). The 2011 Wallow Fire impacted 97 percent of perennial streams in the Black River subbasin, 70 percent of perennial streams in the Gila River subbasin, and

78 percent of the San Francisco River subbasin and resulted in confirmed fish kills in each subbasin (Meyer 2011; p. 3, Table 2); each of these streams is known to support populations of either northern Mexican or narrow-headed gartersnakes.

Although the Black River drainage received no moderate or high-severity burns as a result of the 2011 Wallow Fire, the Fish and Snake Creek subbasins (tributaries to the Black River) were severely burned (Coleman 2011, p. 2). Post-fire fisheries surveys above Wildcat Point in the Black River found no fish in a reach extending up to the confluence with the West Fork of Black River. This was likely due to subsequent ash and sediment flows that had occurred there (Coleman 2011, p. 2). Post-fire fisheries surveys at ''the Box,'' in the Blue River, detected only a single native fish. This was also likely due to ash and sediment flows and the associated subsequent fish kills that had occurred there, extending down to the Gila River Box in Safford, Arizona (Coleman 2011, pp. 2–3). The East Fork Black River subbasin experienced moderate to high-severity burns in 23 percent of its total acreage that resulted in declines in Apache trout and native sucker populations, but speckled dace and brown trout remained prevalent as of 2011 (Coleman 2011, p. 3). These fire data suggest that the persistence of the prey base for northern Mexican and narrow-headed gartersnakes in the Black River, and narrow-headed gartersnakes in the lower Blue River, will be precarious into the near- to midterm future, as will likely be the stability of gartersnake populations there.

Several large wildfires, which have resulted in excessive sedimentation of streams and affected resident fish populations that serve as prey for narrow-headed gartersnakes, have occurred historically on the Gila National Forest. From 1989–2004, numerous wildfires cumulatively burned much of the uplands within the Gila National Forest, which resulted in most perennial streams in the area experiencing ash flows and elevated sedimentation (Paroz *et al.* 2006, p. 55). More recently, the 2012 Whitewater-Baldy Complex Fire in the Gila National Forest in New Mexico is the largest wildfire in that State's history. This wildfire was active for more than 5 weeks and consumed approximately 300,000 acres (121,406 ha) of ponderosa, mixed conifer, pinyon-juniper, and grassland habitat (InciWeb 2012). Over 25 percent of the burn area experienced high-moderate burn severity (InciWeb 2012) and included several subbasins occupied by narrow-headed gartersnakes such as the Middle Fork Gila River, West Fork Gila River, Iron Creek, the San Francisco River, Whitewater Creek, and Mineral Creek (Brooks 2012, Table 1). Other extant populations of the narrow-headed gartersnake in Gilita and South Fork Negrito Creeks are also expected to be impacted from the 2012 Whitewater-Baldy Complex Fire. Narrow-headed gartersnake populations in the Middle Fork Gila River and Whitewater Creek formerly represented two of the four most robust populations known from New Mexico, and two of the five known rangewide, and are expected to have been severely jeopardized by post-fire effects to their prey base. Thus, we now consider them currently as likely not viable, at least in the short to medium term. In reference to Gila trout populations, Brooks (2012, p. 3) stated that fish populations are expected to be severely impacted in the West Fork Gila River and Whitewater Creek. The loss of fish communities in affected streams is likely to lead to associated declines, or potential extirpations, in affected narrow-headed gartersnake populations as a result of the collapse in their prey base.

Since 2000, several wildfires have affected occupied narrow-headed gartersnake habitat on the Gila National Forest. The West Fork Gila subbasin was affected by the 2002 Cub Fire, the 2003 Dry Lakes Fire, and the 2011 Miller Fire; each resulted in post-fire ash and sediment flows, which adversely affected fish populations used by narrow-headed gartersnakes (Hellekson 2012a, pers. comm.). In 2011, the Miller Fire significantly affected the Little Creek subbasin and has resulted in substantive declines in abundance of the fish community (Hellekson 2012a, pers. comm.). Dry Blue and Campbell Blue creeks were affected by the 2011 Wallow Fire (Hellekson 2012a, pers. comm.). Saliz Creek was highly affected by the 2006 Martinez Fire (Hellekson 2012a, pers. comm.). Turkey Creek was heavily impacted by the Dry Lakes Fire in 2002, which resulted in a complete fish kill, but the fish community has since rebounded (Hellekson 2012a, pers. comm.). It is not certain how long the fish community was sparse or absent from Turkey Creek, but it is suspected that the narrow-headed gartersnake population there suffered significant declines from the loss of their prey base, as evidenced by the current low population numbers. Prior to the 2002 Dry Lakes Fire, Turkey Creek was largely populated by nonnative, spiny-rayed fish species, but has since been recolonized by native fish species almost exclusively (Hellekson 2012a, pers. comm.), and may provide high-quality habitat for narrow-headed gartersnakes, once the subbasin has adequately stabilized.

Affects to northern Mexican and narrow-headed gartersnake habitat from wildfire should be considered in light of effects to the structural habitat and effects to the prey base. Post-fire effects vary with burn severity, percent of area burned within each severity category, and the intensity and duration of precipitation events that follow (Coleman 2011, p. 4). Low-severity burns within riparian habitat can actually have a rejuvenating effect by removing decadent ground cover and providing nutrients to remaining vegetation. As a result, riparian vegetative communities may be more resilient to wildfire, given that water is present (Coleman 2011, p. 4). Willows, an important component to narrow-headed gartersnake habitat, can be positively affected by low-severity burns, as long as the root crowns are not damaged (Coleman 2011, p. 4). High severity burns that occur within the floodplain of occupied habitat are expected to have some level of shorter-term effect on resident gartersnake populations through effects to the vegetative structure and abundance, which may include a reduction of basking sites and a loss of cover, which could increase the risk of predation. These potential effects need further study. Post-fire ash flows, flooding, and impacts to native prey populations are longer term effects and can occur for many years after a large wildfire (Coleman 2011, p. 2).

Post-fire flooding with significant ash and sediment loads can result in significant declines, or even the collapse, of resident fish communities, which poses significant concern for the persistence of resident gartersnake populations in affected areas. Sedimentation can adversely affect fish populations used as prey by northern Mexican or narrow-headed gartersnakes by: (1) Interfering with respiration; (2) reducing the effectiveness of fish's visually based hunting behaviors; and (3) filling in interstitial (spaces between cobbles, etc., on the stream floor) spaces of the substrate, which reduces reproduction and foraging success of fish (Wheeler *et al.* 2005, p. 145). Excessive sediment also fills in intermittent pools required for amphibian prey reproduction and foraging. Siltation of the rocky interstitial spaces along stream bottoms decreases the dissolved oxygen content where fish lay their eggs, resulting in depressed recruitment of fish and a subsequent reduction in prey abundance for northern Mexican and narrow-headed gartersnakes through the loss of prey microhabitat (Nowak and Santana-Bendix 2002, pp. 37–38). As stated above, sediment can lead to several effects in resident fish species used by northern Mexican or narrow-headed gartersnakes as prey, which can ultimately cause increased direct mortality, reduced reproductive success, lower overall abundance, and reductions in prey species composition as documented by Wheeler *et al.* (2005, p. 145). The underwater foraging ability of narrow-headed gartersnakes (de Queiroz 2003, p. 381) and likely northern Mexican gartersnakes is largely based on vision and is also directly compromised by excessive turbidity caused by sedimentation of water bodies. Suspended sediment in the water column may reduce the narrow-headed gartersnake's visual hunting efficiency from effects to water clarity, based on research conducted by de Queiroz (2003, p. 381) that concluded the species relied heavily on visual cues during underwater striking behaviors.

The presence of adequate interstitial spaces along stream floors may be particularly important for narrow-headed gartersnakes. Hibbitts and Fitzgerald (2009, p. 464) reported the precipitous decline of narrow-headed gartersnakes in a formerly robust population in the San Francisco River at San Francisco Hot Springs from 1996 to 2004. The exact cause for this significant decline is uncertain, but the investigators suspected that a reduction in interstitial spaces along the stream floor from an apparent conglomerate, cementation process may have affected the narrow-headed gartersnake's ability to successfully anchor themselves to the stream bottom when seeking refuge or foraging for fish (Hibbitts and Fitzgerald 2009, p. 464). These circumstances would likely result in low predation success and eventually starvation. Other areas where sedimentation has affected either northern Mexican or narrow-headed gartersnake habitat are Cibecue Creek in Arizona, and the San Francisco River and South Fork Negrito Creek in New Mexico (Rosen and Schwalbe 1988, p. 46; Arizona Department of Water Resources 2011, p. 1; Hellekson 2012a, pers. comm.). The San Francisco River in Arizona was classified as impaired due to excessive sediment from its headwaters downstream to the Arizona–New Mexico border (Arizona Department of Water Resources 2011, p. 1). South Fork Negrito Creek is also listed as impaired due to excessive turbidity (Hellekson 2012a, pers. comm.).

Summary—The presence of water is critical to both northern Mexican and narrow-headed gartersnakes and their primary prey species because their ecology and natural histories are strongly linked to water. Several factors, both natural and manmade, contribute to the continued degradation and dewatering of aquatic habitat throughout the range of northern Mexican and narrow-headed gartersnakes. Increasing human population growth is driving higher and higher demands for water in both the United States and Mexico. Water is subsequently secured through dams, diversions, flood-control projects, and groundwater pumping, which affects gartersnake habitat through reductions in flow and complete dewatering of stream reaches. Entire reaches of the Gila, Salt, Santa Cruz, and San Francisco Rivers, as well as numerous other rivers throughout the Mexican Plateau in Mexico which were historically occupied by either or both northern Mexican or narrow-headed gartersnakes, are now completely dry due to diversions, dams, and groundwater pumping. Several groundwater basins within the range of northern Mexican and narrow-headed gartersnakes in the United States are considered active management areas where pumping exceeds recharge, which is a constant threat to surface flow in streams and rivers connected to these aquifers. Reduced flows concentrate northern Mexican and narrow-headed gartersnakes and their prey with harmful nonnative species, which accelerate and amplify adverse effects of native-nonnative community interactions. Where surface water persists, increasing land development and recreation use adjacent to and within riparian habitat has led to further reductions in stream flow, removal or alteration of vegetation, and increased frequency of adverse human interactions with gartersnakes.

Exacerbating the effects of increasing human populations and higher water demands, climate change predictions include increased aridity, lower annual precipitation totals, lower snow pack levels, higher variability in flows (lower low-flows and higher high-flows), and enhanced stress on ponderosa pine communities in the southwestern United States and northern Mexico. Increased stress to ponderosa pine forests places them at higher risk of high-intensity wildfires, the effects of which are discussed below. Climate change has also been predicted to enhance the abundance and distribution of harmful nonnative species, which adversely affect northern Mexican and narrow-headed gartersnakes.

Cienegas, a unique and important habitat for northern Mexican gartersnakes, have been adversely affected or eliminated by a variety of historical and current land uses in the United States and Mexico, including streambed modification, intensive livestock grazing, woodcutting, artificial drainage structures, stream flow stabilization by upstream dams, channelization, and stream flow reduction from groundwater pumping and water diversions. The historical loss of the cienega habitat of the northern Mexican gartersnake has resulted in local population declines or extirpations, negatively affecting its status and contributing to its decline rangewide.

Wildfire has historically been a natural and important disturbance factor within the range of northern Mexican and narrow-headed gartersnakes. However, in recent decades, forest management policies in the United States have favored fire suppression, the result of which has led to wildfires of unusual proportions, particularly along the Mogollon Rim of Arizona and New Mexico. These policies are generally not in place in Mexico, and consequently, wildfire is not viewed as a significant threat to the northern Mexican gartersnake in Mexico. However, in the last 2 years, both Arizona (2011 Wallow Fire) and New Mexico (2012 Whitewater-Baldy Complex Fire) have experienced the largest wildfires in their respective State histories, which is indicative of the last decade having been punctuated by wildfires of significant magnitude. High-intensity wildfire has been shown to result in significant ash and sediment flows into habitat occupied by northern Mexican or narrow-headed gartersnakes, resulting in significant reductions of their fish prey base and, in some instances, total fish kills. The interstitial spaces between rocks located along the stream floor are important habitat for the narrow-headed gartersnake as a result of its specialized foraging strategy and specialized diet. They area also important for several fish species relied upon as prey. When these spaces fill in with sediment, the narrow-headed gartersnake may be unable to forage successfully and may succumb to stress created by a depressed prey base. A significant reduction or absence of a prey base results in stress of resident gartersnake populations and can result in local population extirpations. Also, narrow-headed gartersnakes are believed to rely heavily on visual cues while foraging underwater; increased turbidity from suspended fine sediment in the water column is likely to impede their ability to use visual cues at some level. Factors that result in depressed foraging ability from excessive sedimentation are likely to be enhanced when effects from harmful nonnative species are also acting on resident northern Mexican and narrow-headed gartersnake populations. We consider the narrow-headed gartersnake to be particularly threatened by the effects of wildfires as described because they occur throughout its range, the species is a fish-eating specialist that is unusually vulnerable to localized fish kills, and wildfire has already significantly affected two of the last remaining five populations that were formerly considered viable, pre-fire. We have demonstrated that high-intensity wildfires have the potential to eliminate gartersnake populations through a reduction or loss of their prey base. Since 1970, wildfires have adversely impacted the native fish prey base in 6 percent of the historical distribution of northern Mexican gartersnakes in the United States and 21 percent of that for narrow-headed gartersnakes rangewide, according to GIS analysis.

All of these conditions affect the primary drivers of gartersnake habitat suitability (the presence of water and prey) and exist in various degrees throughout the range of both gartersnake species. Collectively, they reduce the amount and arrangement of physically suitable habitat for northern Mexican and narrow-headed gartersnakes over their regional landscapes. The genetic representation of each species is threatened when populations become disconnected and isolated from neighboring populations because the length or area of dewatered zones is too great for dispersing individuals to overcome. Therefore, normal colonizing mechanisms that would otherwise reestablish populations where they have become extirpated are no longer viable. This subsequently leads to a reduction in species redundancy when isolated, small populations are at increased vulnerability to the effects of stochastic events, without a means for natural recolonization. Ultimately, the effects of scattered, small, and disjunct populations, without the means to naturally recolonize, is weakened species resiliency as a whole, which ultimately enhances the risk of either or both species becoming endangered or going extinct. Therefore, based on the best available scientific and commercial information, we conclude that land uses or conditions described above that alter or dewater northern Mexican and narrow-headed gartersnake habitat are threats rangewide, now and in the foreseeable future.

The Cumulative and Synergistic Effect of Threats on Low-Density Northern Mexican and Narrow-Headed Gartersnake Populations

In most locations where northern Mexican or narrow-headed gartersnakes historically occurred or still occur currently, two or more threats are likely acting in combination with regard to their influence on the suitability of those habitats or on the species themselves. Many threats could be considered minor in isolation, but when they affect gartersnake populations in combination with other threats, become more serious. We have concluded that in as many as 24 of 29 known localities in the United States (83 percent), the northern Mexican gartersnake population is likely not viable and may exist at low population densities that could be threatened with extirpation or may already be extirpated. We also determined that in as many as 29 of 38 known localities (76 percent), the narrow-headed gartersnake population is likely not viable and may exist at low population densities that could be threatened with extirpation or may already be extirpated but survey data are lacking in areas where access is restricted. We have also discussed how harmful nonnative species have affected recruitment of gartersnakes across their range. In viable populations, gartersnakes are resilient to the loss of individuals through ongoing recruitment into the reproductive age class. However, when northern Mexican or narrow-headed gartersnakes occur at low population densities in the absence of appropriate recruitment, the loss of even a few adults, or even a single adult female, could drive a local population to extirpation. Below, we discuss threats that, when considered in combination, can appreciably threaten low-density populations with extirpation.

Historical and Unmanaged Livestock Grazing and Agricultural Land Uses

Currently in the United States, livestock grazing is a largely managed activity, but in Mexico, livestock grazing is much less managed or unmanaged altogether. The effect of livestock grazing on resident gartersnake populations must be examined as a comparison between historical and current management, and in the presence of harmful nonnative species, or not. Historical livestock grazing has damaged approximately 80 percent of stream, cienega, and riparian ecosystems in the western United States (Kauffman and Krueger 1984, pp. 433–435; Weltz and Wood 1986, pp. 367–368; Cheney *et al.* 1990, pp. 5, 10; Waters 1995, pp. 22–24; Pearce *et al.* 1998, p. 307; Belsky *et al.* 1999, p. 1). Fleischner (1994, p. 629) found that ''Because livestock congregate in riparian ecosystems, which are among the most biologically rich habitats in arid and semiarid regions, the ecological costs of grazing are magnified at these sites.'' Stromberg and Chew (2002, p. 198) and Trimble and Mendel (1995, p. 243) also discussed the propensity for cattle to remain within or adjacent to riparian communities. Expectedly, this behavior is more pronounced in more arid regions (Trimble and Mendel 1995, p. 243). Effects from historical or unmanaged grazing include: (1) Declines in the structural richness of the vegetative community; (2) losses or reductions of the prey base; (3) increased aridity of habitat; (4) loss of thermal cover and protection from predators; (5) a rise in water temperatures to levels lethal to larval stages of amphibian and fish development; and (6) desertification (Szaro *et al.* 1985, p. 362; Schulz and Leininger 1990, p. 295; Schlesinger *et al.* 1990, p. 1043; Belsky *et al.* 1999, pp. 8–11; Zwartjes *et al.* 2008, pp. 21–23). In one rangeland study, it was concluded that 81 percent of the vegetation that was consumed, trampled, or otherwise removed was from a riparian area, which amounted to only 2 percent of the total grazing space, and that these actions were 5 to 30 times higher in riparian areas than on the uplands (Trimble and Mendel 1995, pp. 243–244). However, according to one study along the Agua Fria River, herbaceous ground cover can recover quickly from heavy grazing pressure (Szaro and Pase 1983, p. 384). Additional information on the effects of historical livestock grazing can be found in Sartz and Tolsted (1974, p. 354); Rosen and Schwalbe (1988, pp. 32–33, 47); Clary and Webster (1989, p. 1); Clary and Medin (1990, p. 1); Orodho *et al.* (1990, p. 9); and Krueper *et al.* (2003, pp. 607, 613–614).

Szaro *et al.* (1985, p. 360) assessed the effects of historical livestock management on a sister taxon and found that western (terrestrial) gartersnake (*Thamnophis elegans vagrans*) populations were significantly higher (versus controls) in terms of abundance and biomass in areas that were excluded from grazing, where the streamside vegetation remained lush, than where uncontrolled access to grazing was permitted. This effect was complemented by higher amounts of cover from organic debris from ungrazed shrubs that accumulate as the debris moves downstream during flood events. Specifically, results indicated that snake abundance and biomass were significantly higher in ungrazed habitat, with a five-fold difference in number of snakes captured, despite the difficulty of making observations in areas of increased habitat complexity (Szaro *et al.* 1985, p. 360). Szaro *et al.* (1985, p. 362) also noted the importance of riparian vegetation for the maintenance of an adequate prey base and as cover in thermoregulation and predation avoidance behaviors, as well as for foraging success. Direct mortality of amphibian species, in all life stages, from being trampled by livestock has been documented in the literature (Bartelt 1998, p. 96; Ross *et al.* 1999, p. 163). Gartersnakes may, on occasion, be trampled by livestock. A black-necked gartersnake (*Thamnophis cyrtopsis cyrtopsis*) had apparently been killed by livestock trampling along the shore of a stock tank in the Apache-Sitgreaves National Forest, within an actively grazed allotment (Chapman 2005).

Subbasins where historical grazing has been documented as a suspected contributing factor for either northern Mexican or narrow-headed gartersnake declines include the Verde, Salt, Agua Fria, San Pedro, Gila, and Santa Cruz (Hendrickson and Minckley 1984, pp. 140, 152, 160–162; Rosen and Schwalbe 1988, pp. 32–33; Girmendonk and Young 1997, p. 47; Hale 2001, pp. 32–34, 50, 56; Voeltz 2002, pp. 45–81; Krueper *et al.* 2003, pp. 607, 613–614; Forest Guardians 2004, pp. 8–10; Holycross *et al.* 2006, pp. 52–61; McKinnon 2006d, 2006e; Paradzick *et al.* 2006, pp. 90–92; USFS 2008). Livestock grazing still occurs in these subbasins but is a largely managed land use and is not likely to pose significant threats to either northern Mexican or narrow-headed gartersnakes where closely managed. In cases where poor livestock management results in fence lines in persistent disrepair, providing unmanaged livestock access to occupied habitat, adverse effects from loss of vegetative cover may result, most likely in the presence of harmful nonnative species. As we described above, however, we strongly suspect that northern Mexican and narrow-headed gartersnakes are somewhat resilient to physical habitat disturbance where harmful nonnative species are absent.

The creation and maintenance of stock tanks is an important component to livestock grazing in the southwestern United States. Stock tanks associated with livestock grazing may facilitate the spread of harmful nonnative species when they are intentionally or unintentionally stocked by anglers and private landowners (Rosen *et al.* 2001, p. 24). The management of stock tanks is an important consideration for northern Mexican gartersnakes in particular. Stock tanks associated with livestock grazing can be intermediary ''stepping stones'' in the dispersal of nonnative species from larger source populations to new areas (Rosen *et al.* 2001, p. 24). The effects of livestock grazing at stock tanks on northern Mexican gartersnakes depend on how they are managed. Dense bank and aquatic vegetation is an important habitat characteristic for the northern Mexican gartersnake in the presence of harmful nonnative species. This vegetation can be affected if the impoundment is poorly managed. When harmful nonnative species are absent, the presence of bank line vegetation is less important. Well-managed stock tanks provide important habitat for northern Mexican gartersnakes and their prey base, especially when the tank: (1) Remains devoid of harmful nonnative species while supporting native prey species; (2) provides adequate vegetation cover; and (3) provides reliable water sources in periods of prolonged drought. Given these benefits of well-managed stock tanks, we believe well-managed stock tanks are an important, even vital, component to northern Mexican gartersnake conservation and recovery.

Road Construction, Use, and Maintenance

Roads can pose unique threats to herpetofauna, and specifically to species like the northern Mexican gartersnake, its prey base, and the habitat where it occurs. The narrow-headed gartersnake, alternatively, is probably less affected by roads due to its more aquatic nature. Roads fragment occupied habitat and can result in diminished genetic viability in populations from increased mortality from vehicle strikes and adverse human encounters as supported by current research on eastern indigo snakes (Breininger *et al.* 2012, pp. 364–366). Roads often track along streams and present a mortality risk to gartersnakes seeking more upland, terrestrial habitat for brumation and gestation. Roads may cumulatively impact both species through the following mechanisms: (1) Fragmentation, modification, and destruction of habitat; (2) increase in genetic isolation; (3) alteration of movement patterns and behaviors; (4) facilitation of the spread of nonnative species via human vectors; (5) an increase in recreational access and the likelihood of subsequent, decentralized urbanization; (6) interference with or inhibition of reproduction; (7) contributions of pollutants to riparian and aquatic communities; (8) reduction of prey communities; (9) effects to gartersnake reproduction; and (10) acting as population sinks (when population death rates exceed birth rates in a given area) (Rosen and Lowe 1994, pp. 146–148; Waters 1995, p. 42; Foreman and Alexander 1998, p. 220; Trombulak and Frissell 2000, pp. 19–26; Carr and Fahrig 2001, pp. 1074–1076; Hels and Buchwald 2001, p. 331; Smith and Dodd 2003, pp. 134–138; Angermeier *et al.* 2004, pp. 19–24; Shine *et al.* 2004, pp. 9, 17–19; Andrews and Gibbons 2005, pp. 777–781; Wheeler *et al.* 2005, pp. 145, 148–149; Roe *et al.* 2006, p. 161; Sacco 2007, pers. comm.; Ouren *et al.* 2007, pp. 6–7, 11, 16, 20–21; Jones *et al.* 2011, pp. 65–66; Hellekson 2012a, pers. comm.).

Perhaps the most common factor in road mortality of snakes is the propensity for drivers to unintentionally and intentionally run them over, both because people tend to dislike snakes (Rosen and Schwalbe 1988, p. 43; Ernst and Zug 1996, p. 75; Green 1997, pp. 285–286; Nowak and Santana-Bendix 2002, p. 39) and because they make easy targets crossing roads at perpendicular angles (Klauber 1956, p. 1026; Langley *et al.* 1989, p. 47; Shine *et al.* 2004, p. 11). Mortality data for northern Mexican gartersnakes have been collected at the Bubbling Ponds Hatchery since 2006. Of the 15 dead specimens, eight were struck by vehicles on roads within or adjacent to the hatchery ponds, perhaps while crossing between ponds to forage (Boyarski 2011, pp. 1–3). Van Devender and Lowe (1977, p. 47), however, observed several northern Mexican gartersnakes crossing the road at night after the commencement of the summer monsoon (rainy season), which highlights the seasonal variability in surface activity of this snake. Wallace *et al.* (2008, pp. 243–244) documented a vehicle-related mortality of a northern Mexican gartersnake on Arizona State Route 188 near Tonto Creek that occurred in 1995.

Adverse Human Interactions With Gartersnakes

A fear of snakes is generally and universally embedded in modern culture, and is prevalent in the United States (Rosen and Schwalbe 1988, p. 43; Ernst and Zug 1996, p. 75; Green 1997, pp. 285–286; Nowak and Santana-Bendix 2002, p. 39). We use the phrase ''adverse human interaction'' to refer to the act of humans directly injuring or killing snakes out of a sense of fear or anxiety (ophidiophobia), or for no apparent purpose. One reason the narrow-headed gartersnake is vulnerable to adverse human interactions is because of its appearance. The narrow-headed gartersnake is often confused for a venomous water moccasin (cottonmouth, *Agkistrodon piscivorus*), because of its triangular-shaped head and propensity to be found in or near water (Nowak and Santana-Bendix 2002, p. 38). Although the nearest water moccasin populations are located over 700 miles (1,127 km) to the east in central Texas, these misidentifications prove fatal for narrow-headed gartersnakes (Nowak and Santana-Bendix 2002, p. 38).

Adverse human interaction may be largely responsible for highly localized extirpations in narrow-headed gartersnakes based on the collection history of the species at Slide Rock State Park along Oak Creek, where high recreation use is strongly suspected to result in direct mortality of snakes by humans (Nowak and Santana-Bendix 2002, pp. 21, 38). Rosen and Schwalbe (1988, p. 42–43) suggested that approximately 44 percent of the estimated annual mortality of narrow-headed gartersnakes in the larger size classes along Oak Creek may be human-caused. Declines in narrow-headed gartersnake populations in the North and East Forks of the White River have also been attributed to humans killing snakes (Rosen and Schwalbe 1988, pp. 43–44). Locations in New Mexico where this unnatural form of mortality is believed to have historically affected or currently affect narrow-headed gartersnakes include Wall Lake (Fleharty 1967, p. 219), Middle Fork of the Gila River, the mainstem Gila River from Cliff Dwellings to Little Creek, in Whitewater Creek from the Catwalk to Glenwood (L. Hellekson 2012a, pers. comm.), and near San Francisco Hot Springs along the San Francisco River (Hibbitts and Fitzgerald 2009, p. 466).

Environmental Contaminants

Environmental contaminants, such as heavy metals, may be common at low background levels in soils and, as a result, concentrations are known to bioaccumulate in food chains. A bioaccumulative substance increases in concentration in an organism or in the food chain over time. A mid- to higher-order predator, such as a gartersnake, may, therefore, accumulate these types of contaminants over time in their fatty tissues, which may lead to adverse health effects (Wylie *et al.* 2009, p. 583, Table 5). Campbell *et al.* (2005, pp. 241–243) found that metal concentrations accumulated in the northern watersnake (*Nerodia sipedon*) at levels six times that of their primary prey item, the central stoneroller (a fish, *Campostoma anomalum*). Metals, in trace amounts, can be sequestered in the skin of snakes (Burger 1999, p. 212), interfere with metabolic rates of snakes (Hopkins *et al.* 1999, p. 1261), affect the structure and function of their liver and kidneys, and may also act as neurotoxins, affecting nervous system function (Rainwater *et al.* 2005, p. 670). Based on data collected in 2002–2010, mercury appears to be bioaccumulating in fish found in the lower reaches of Tonto Creek, where northern Mexican gartersnakes also occur (Rector 2010, pers. comm.). In fact, the State record for the highest mercury concentrations in fish tissue was reported in Tonto Creek from this investigation by Rector (2010, pers. comm.). Mercury levels were found to be the highest in the piscivorous smallmouth bass and, secondly, in desert suckers (a common prey item for northern Mexican and narrow-headed gartersnakes). Because gartersnakes eat fish, mercury may be bioaccumulating in resident populations, although no testing has occurred.

Specific land uses such as mining and smelting, as well as road construction and use, can be significant sources of contaminants in air, water, or soil through point-source and non-point source mechanisms. Copper mining has occurred in Arizona (Pima, Pinal, Yavapai, and Gila Counties) and adjacent Mexico for centuries, and many of these sites have smelters (now decommissioned), which are former sources of airborne contaminants. The mining industry in Mexico is largely concentrated in the northern tier of that country, with the State of Sonora being the leading producer of copper, gold, graphite, molybdenum, and wollastonite, as well as the leader among Mexican States with regard to the amount of surface area dedicated to mining (Stoleson *et al.* 2005, p. 56). The three largest mines in Mexico (all copper) are found in Sonora (Stoleson *et al.* 2005, p. 57). The sizes of mines in Sonora vary considerably, as do the known environmental effects from mining-related activities (from exploration to long after closure), which include contamination and drawdown of groundwater aquifers, erosion, acid mine drainage, fugitive dust, pollution from smelter emissions, and landscape clearing (Stoleson *et al.* 2005, p. 57). We are aware of no specific research on potential effects of mining or environmental contaminants acting on northern Mexican gartersnakes in Mexico, but presume, based on the best available scientific and commercial information, that where this land use is prevalent, contaminants may be a contributing threat to resident gartersnakes or their prey.

Northern Mexican Gartersnake Competition With Marcy's Checkered Gartersnake

Preliminary research suggests that Marcy's checkered gartersnake (*Thamnophis marcianus marcianus*) may impact the future conservation of the northern Mexican gartersnake in southern Arizona, although supporting data are limited. Rosen and Schwalbe (1988, p. 31) hypothesized that bullfrogs are more likely to eliminate northern Mexican gartersnakes when Marcy's checkered gartersnakes are also present. Marcy's checkered gartersnake is a semi-terrestrial species that is able to co-exist to some degree with harmful nonnative predators. This might be due to its apparent ability to forage in more terrestrial habitats, specifically during the vulnerable juvenile size classes (Rosen and Schwalbe 1988, p. 31; Rosen *et al.* 2001, pp. 9–10). In every age class, the northern Mexican gartersnake forages in aquatic habitats where nonnative spiny-rayed fish, bullfrogs, and crayfish are present, which increases not only the encounter rate between predator and prey, but also the juvenile mortality rate of the northern Mexican gartersnake, which negatively affects recruitment. As northern Mexican gartersnake numbers decline within a population, space becomes available for occupation by Marcy's checkered gartersnakes. One hypothesis suggests that the Marcy's checkered gartersnake might affect the maximum number of northern Mexican gartersnakes that an area can maintain based upon available resources, and could potentially accelerate the decline of, or preclude re-occupancy by, the northern Mexican gartersnake (Rosen and Schwalbe 1988, p. 31). Rosen *et al.* (2001, pp. 9–10) documented the occurrence of Marcy's checkered gartersnakes replacing northern Mexican gartersnakes at the San Bernardino National Wildlife Refuge and surrounding habitats of the Black Draw. Rosen and Schwalbe (1988, p. 31) report the same at the mouth of Potrero Canyon near its confluence with the lower Santa Cruz River. They suspected that drought, extending from the late 1980s through the late 1990s, played a role in the degree of competition for aquatic resources, provided an advantage to the more versatile Marcy's checkered gartersnake, and expedited the decline of the northern Mexican gartersnake. More research is needed to confirm these relationships.

Mortality From Entanglement Hazards

In addressing the effects of soil erosion associated with road construction projects or post-fire remedial subbasin management, erosion control materials placed on the ground surface are often used. Erosion control is considered a best management practice for most soil-disturbing activities, and is broadly required as mitigation across the United States, in particular to avoid excess sedimentation of streams and rivers. Rolled erosion control products, such as temporary erosion control blankets and permanent turf reinforcement mats, are two methods commonly used for these purposes (Barton and Kinkead 2005, p. 34). These products use stitching or net-like mesh products to hold absorbent media together. At a restoration site in South Carolina, 19 snakes (15 dead) representing five different species were found entangled in the netting and had received severe lacerations in the process of attempting to escape their entanglement (Barton and Kinkead 2005, p. 34). Stuart *et al.* (2001, pp. 162–164) also reported the threats of net-like debris to snake species. Kapfer and Paloski (2011, p. 4) reported at least 31 instances involving six different species of snake (including the common gartersnake) in Wisconsin that had become entangled in the netting used for either erosion control or as a wildlife exclusion product. In their review, Kapfer and Paloski (2011, p. 6) noted that 0.5 in. by 0.5 in. mesh has the greatest likelihood of entangling snakes.

Similar snake mortalities have not been documented in Arizona or New Mexico, according to our files. However, given the broad usage of these materials across the distribution of the northern Mexican and narrow-headed gartersnakes, it is not unlikely that mortality occurs but goes unreported. The likelihood of either gartersnake species becoming entangled depends on the distance these erosion control materials are used from water in occupied habitat and the density of potentially affected populations. Because erosion control products are usually used to prevent sedimentation of streams, there is a higher likelihood for gartersnakes to become entangled. This potential threat will require public education and additional monitoring and research, with emphasis in regions with occupied habitat.

Finally, discarded fishing nets have also been documented as a source of mortality for northern Mexican gartersnakes in the area of Lake Chapala, Jalisco, Mexico (Barragán-Ramírez and Ascencio-Arrayga 2013, p. 159). Netting or seining is not an authorized form of recreational fishing for sport fish in Arizona or New Mexico, but the practice is allowed in either state for the collection of live baitfish (AGFD 2013, p. 57; NMDGF 2013, p. 17). We are not certain of the frequency in which these techniques are used for such purposes in either state, but do not suspect that discarded nets or seines are commonly left on-site where they could ensnarl resident gartersnakes. However, this practice is used in Mexico as a primary means of obtaining freshwater fish as a food source and may be a significant threat to local northern Mexican gartersnake populations where this practice occurs.

Disease

Our review of the scientific literature did not find evidence that disease is a current factor contributing to the decline in northern Mexican or narrow-headed gartersnakes. However, a recent wildlife health bulletin announced the emergence of snake fungal disease (SFD) within the eastern and Midwestern portions of the United States (Sleemen 2013, p. 1). SFD has now been diagnosed in several terrestrial and aquatic snake genera including *Nerodia, Coluber, Pantherophis, Crotalus, Sistrurus,* and *Lampropeltis.* Clinical signs of SFD include scabs or crusty scales, subcutaneous nodules, abnormal molting, white opaque cloudiness of the eyes, localized thickening or crusting of the skin, skin ulcers, swelling of the face, or nodules in the deeper tissues (Sleemen 2013, p. 1). While mortality has been documented as a result of SFD, population-level impacts have not, due to the cryptic and solitary nature of snakes and the lack of long-term monitoring data (Sleemen 2013, p. 1). So far, no evidence of SFD has been found in the genus *Thamnophis* but the documented occurrence of SFD in ecologically similar, aquatic colubrids such as *Nerodia* is cause for concern. We recommend resource managers remain diligent in looking for signs of SFD in wild gartersnake populations.

Summary

We found numerous effects of livestock grazing that have resulted in the historical degradation of riparian and aquatic communities that have likely affected northern Mexican and narrow-headed gartersnakes. The literature concluded that mismanaged or unmanaged grazing can have disproportionate effects to riparian communities in arid ecosystems due to the attraction of livestock to water, forage, and shade. We found current livestock grazing activities to be more of a concern in Mexico. The literature is clear that the most profound impacts from livestock grazing in the southwestern United States occurred nearly 100 years ago, were significant, and may still be affecting some areas that have yet to fully recover. Unmanaged or poorly managed livestock operations likely have more pronounced effects in areas significantly impacted by harmful nonnative species through a reduction in cover. However, land managers in Arizona and New Mexico currently emphasize the protection of riparian and aquatic habitat in allotment management planning, usually through fencing, rotation, monitoring, and range improvements such as developing remote water sources. Collectively, these measures have reduced the likelihood of significant adverse impacts on northern Mexican or narrow-headed gartersnakes, their habitat, and their prey base. We also recognize that while the presence of stock tanks on the landscape can benefit nonnative species, well-managed stock tanks are an invaluable tool in the conservation and recovery of northern Mexican gartersnakes and their prey.

Other activities, factors, or conditions that act in combination, such as road construction, use, and management, adverse human interactions, environmental contaminants, entanglement hazards, and competitive pressures from sympatric species, occur within the distribution of these gartersnakes and have the propensity to contribute to further population declines or extirpations where gartersnakes occur at low population densities. An emerging skin disease, SFD, has not yet been documented in gartersnakes but has affected snakes of many genera within the United States, including ecologically similar species, and may pose a future threat to northern Mexican and narrow-headed gartersnakes. Where low density populations are affected these types of threats described above, even the loss of a few reproductive adults, especially females, from a population can have significant population-level effects, most notably in the presence of harmful nonnative species. Continued population declines and extirpations threaten the genetic representation of each species because many populations have become disconnected and isolated from neighboring populations. This subsequently leads to a reduction in species redundancy and resiliency when isolated, small populations are at increased vulnerability to the effects of stochastic events, without a means for natural recolonization. Based on the best available scientific and commercial information, we conclude these threats have the tendency to act synergistically and disproportionately on low-density gartersnake populations rangewide, now and in the foreseeable future.

The Inadequacy of Existing Regulatory Mechanisms

Below, we examine whether existing regulatory mechanisms are inadequate to address the threats to the northern Mexican and narrow-headed gartersnakes discussed under other factors. Section 4(b)(1)(A) of the Endangered Species Act requires the Service to take into account ''those efforts, if any, being made by any State or foreign nation, or any political subdivision of a State or foreign nation, to protect such species.'' We interpret this language to require us to consider relevant Federal, State, and Tribal laws, regulations, and other such mechanisms that may minimize any of the threats we describe in the threats analysis under the other four factors, or otherwise influence conservation of the species. We give strongest weight to statutes and their implementing regulations, and management direction that stems from those laws and regulations. They are nondiscretionary and enforceable, and are considered a regulatory mechanism under this analysis. Having evaluated the significance of the threat as mitigated by any such conservation efforts, we analyze under Factor D the extent to which existing regulatory mechanisms are inadequate to address the specific threats to the species. Regulatory mechanisms, if they exist, may reduce or eliminate the impacts from one or more identified threats. In this section, we review existing State and Federal regulatory mechanisms to determine whether they effectively reduce or remove threats to the species.

A number of Federal statutes potentially afford protection to northern Mexican and narrow-headed gartersnakes or their prey species. These include section 404 of the Clean Water Act (33 U.S.C. 1251 *et seq.*), Federal Land Policy and Management Act (43 U.S.C. 1701 *et seq.*), National Forest Management Act (16 U.S.C. 1600 *et seq.*), National Environmental Policy Act (NEPA; 42 U.S.C. 4321 *et seq.*), and the Act. However, in practice, these statutes have not been able to provide sufficient protection to prevent the currently observed downward trend in northern Mexican and narrow-headed gartersnakes or their prey species, and the concurrent upward trend in threats.

Section 404 of the Clean Water Act regulates placement of fill into waters of the United States, including the majority of northern Mexican and narrow-headed gartersnake habitat. However, many actions with the potential to be highly detrimental to both species, their prey base, and their habitat, such as gravel mining and irrigation diversion structure construction and maintenance, may be exempted from the Clean Water Act. Other detrimental actions, such as bank stabilization and road crossings, are covered under nationwide permits that receive limited environmental review. A lack of thorough, site-specific analyses for projects can allow substantial adverse effects to northern Mexican or narrow-headed gartersnakes, their prey base, or their habitat.

The majority of the extant populations of northern Mexican and narrow-headed gartersnakes in the United States occur on lands managed by the U.S. Bureau of Land Management (BLM) and U.S. Forest Service. Both agencies have riparian protection goals that may provide habitat benefits to both species; however, neither agency has specific management plans for northern Mexican or narrow-headed gartersnakes. As a result, some of the significant threats to these gartersnakes, for example, those related to nonnative species, are not addressed on these lands. The BLM considers the northern Mexican gartersnake as a ''Special Status Species,'' and agency biologists actively attempt to identify gartersnakes observed incidentally during fieldwork for their records (Young 2005). Otherwise, no specific protection or land-management consideration is afforded to that species on BLM lands.

The U.S. Forest Service does not include northern Mexican or narrow-headed gartersnakes on their Management Indicator Species List, but both species are included on the Regional Forester's Sensitive Species List (USFS 2007, pp. 38–39). This means they are considered in land management decisions, but no specific protective measures are conveyed to these species. Individual U.S. Forest Service biologists who work within the range of either northern Mexican or narrow-headed gartersnakes may opportunistically gather data for their records on gartersnakes observed incidentally in the field, although it is not required. The Gila National Forest mentions the narrow-headed gartersnake in their land and resource management plan, which includes standards relating to forest management for the benefit of endangered and threatened species as identified through approved management and recovery plans (CBD *et al.* 2011, p. 18). Neither species is mentioned in any other land and resource management plan for the remaining national forests where they occur (CBD *et al.* 2011, p. 18).

The New Mexico Department of Game and Fish lists the northern Mexican gartersnake as State-endangered and the narrow-headed gartersnake as State-threatened (NMDGF 2006, Appendix H). A species is State-endangered if it is in jeopardy of extinction or extirpation within the State; a species is State-threatened if it is likely to become endangered within the foreseeable future throughout all or a significant portion of its range in New Mexico (NMDGF 2006, p. 52). ''Take,'' defined as ''to harass, hunt, capture or kill any wildlife or attempt to do so'' by NMSA 17–2–38.L., is prohibited without a scientific collecting permit issued by the New Mexico Department of Game and Fish as per NMSA 17–2–41.C and New Mexico Administrative Code (NMAC) 19.33.6. However, while the New Mexico Department of Game and Fish can issue monetary penalties for illegal take of either northern Mexican gartersnakes or narrow-headed gartersnakes, the same provisions are not in place for actions that result in loss or modification of their habitats (NMSA 17–2–41.C and NMAC 19.33.6) (Painter 2005).

Prior to 2005, the Arizona Game and Fish Department allowed for take of up to four northern Mexican or narrow-headed gartersnakes per person per year as specified in Commission Order 43. The Arizona Game and Fish Department defines ''take'' as ''pursuing, shooting, hunting, fishing, trapping, killing, capturing, snaring, or netting wildlife or the placing or using any net or other device or trap in a manner that may result in the capturing or killing of wildlife.'' The Arizona Game and Fish Department subsequently amended Commission Order 43, effective January 2005. Take of northern Mexican and narrow-headed gartersnakes is no longer permitted in Arizona without issuance of a scientific collecting permit (Ariz. Admin. Code R12–4–401 *et seq.*), or special authorization. While the Arizona Game and Fish Department can seek criminal or civil penalties for illegal take of these species, the same provisions are not in place for actions that result in destruction or modification of the gartersnakes' habitat. In addition to making the necessary regulatory changes to promote the conservation of northern Mexican and narrow-headed gartersnakes, the

Arizona Game and Fish Departments' Nongame Branch continues to be a strong partner in research and survey efforts that further our understanding of current populations, and assist with conservation efforts and the establishment of long-term conservation partnerships.

Throughout Mexico, the Mexican gartersnake is listed at the species level of its taxonomy as ''Amenazadas,'' or Threatened, by the Secretaria de Medio Ambiente y Recursos Naturales (SEMARNAT) (SEDESOL 2001). Threatened species are ''those species, or populations of the same, likely to be in danger of disappearing in a short or medium timeframe, if the factors that negatively impact their viability, cause the deterioration or modification of their habitat or directly diminish the size of their populations continue to operate'' (SEDESOL 2001 (NOM–059–ECOL–2001), p. 4). This designation prohibits taking of the species, unless specifically permitted, as well as prohibits any activity that intentionally destroys or adversely modifies its habitat (SEDESOL 2000 (LGVS) and 2001 (NOM–059–ECOL–2001)). Additionally, in 1988, the Mexican Government passed a regulation that is similar to the National Environmental Policy Act of the United States. This Mexican regulation requires an environmental assessment of private or government actions that may affect wildlife or their habitat (SEDESOL 1988 (LGEEPA)).

The Mexican Federal agency known as the Instituto Nacional de Ecología (INE) is responsible for the analysis of the status and threats that pertain to species that are proposed for listing in the Norma Oficial Mexicana NOM–059 (the Mexican equivalent to an endangered and threatened species list), and, if appropriate, the nomination of species to the list. INE is generally considered the Mexican counterpart to the United States' Fish and Wildlife Service. INE developed the Method of Evaluation of the Risk of Extinction of the Wild Species in Mexico (MER), which unifies the criteria of decisions on the categories of risk and permits the use of specific information fundamental to listing decisions. The MER is based on four independent, quantitative criteria: (1) Size of the distribution of the taxon in Mexico; (2) state (quality) of the habitat with respect to natural development of the taxon; (3) intrinsic biological vulnerability of the taxon; and (4) impacts of human activity on the taxon. INE began to use the MER in 2006; therefore, all species previously listed in the NOM–059 were based solely on expert review and opinion in many cases. Specifically, until 2006, the listing process under INE consisted of a panel of scientific experts who convened as necessary for the purpose of defining and assessing the status and threats that affect Mexico's native species that are considered to be at risk, and applying those factors to the definitions of the various listing categories. In 1994, when the Mexican gartersnake was placed on the NOM–059 (SEDESOL 1994 (NOM–059–ECOL–1994), p. 46) as a threatened species, the decision was made by a panel of scientific experts.

Although the Mexican gartersnake is listed as a threatened species in Mexico and based on our experience collaborating with Mexico on transborder conservation efforts, no recovery plan or other conservation planning occurs because of this status and enforcement of the regulation protecting the gartersnake is sporadic, depending on available resources and location. Based upon the best available scientific and commercial information on the status of the species, and the historic and continuing threats to its habitat in Mexico, our analysis concludes that regulatory mechanisms enacted by the Mexican government to conserve the northern Mexican gartersnake are not adequate to address threats to the species or its habitat.

In summary, there are a number of existing regulations that potentially address issues affecting the northern Mexican and narrow-headed gartersnakes and their habitats. However, existing regulations within the range of northern Mexican and narrow-headed gartersnakes typically only address the direct take of individuals without a permit, and provide little, if any, protection of gartersnake habitat. Arizona and New Mexico statutes do not provide protection of habitat and ecosystems. Legislation in Mexico prohibits intentional destruction or modification of northern Mexican gartersnake habitat, but neither that, nor prohibitions of take, appear to be adequate to address ongoing threats.

Current Conservation of Northern Mexican and Narrow-Headed Gartersnakes

Several conservation measures implemented by land and resource managers, private land owners, and other stakeholders can directly or indirectly benefit populations of northern Mexican and narrow-headed gartersnakes. For example, the AGFD's conservation and mitigation program (implemented under an existing section 7 incidental take permit) has committed to either stocking (with captive bred stock) or securing two populations each of northern Mexican and narrow-headed gartersnakes to help minimize adverse effects to these species from their sport fish stocking program through 2021 (USFWS 2011, Appendix C). However, to achieve these goals, challenges must be overcome. First, captive propagation of both gartersnake species remains problematic. After approximately 5 years of experimentation with captive propagation at five institutions, using two colonies of northern Mexican gartersnakes and three colonies of narrow-headed gartersnakes, success has been limited (see GCWG 2007, 2008, 2009, 2010). In 2012, approximately 40 northern Mexican gartersnakes were produced at one institution, and they were subsequently marked and released along Cienega Creek. These were the first gartersnakes of either species to be produced under this program, but their current status in the wild remains unknown. No narrow-headed gartersnakes have been produced in captivity under this program since its inception. Secondly, in order to be successful, the process of ''securing'' a population of either species will likely involve an aggressive nonnative removal strategy, and will have to account for habitat connectivity to prevent reinvasion of unwanted species. Therefore, securing a population of either species may involve removal of harmful nonnatives from an entire subbasin.

To improve the status of northern Mexican gartersnakes in this subbasin, the AGFD recently purchased the approximate 200-acre (81-ha) Horseshoe Ranch along the Agua Fria River located near the Bloody Basin Road crossing, east of Interstate 17 and southeast of Cordes Junction, Arizona. The AGFD plans to introduce northern Mexican gartersnakes as well as lowland leopard frogs and native fish species into a large pond, protected by bullfrog exclusion fencing, located adjacent to the Agua Fria River. The bullfrog exclusion fencing around the pond will permit the dispersal of northern Mexican gartersnakes and lowland leopard frogs from the pond, allowing the pond to act as a source population to the Agua Fria River. The AGFD's short- to mid-term conservation planning for Horseshoe Ranch will help ensure the northern Mexican gartersnake persists in this historical stronghold.

In 2007, the New Mexico Department of Game and Fish completed a recovery plan for narrow-headed gartersnakes in New Mexico (Pierce 2007, pp. 13–15) that included the following management objectives: (1) Researching the effect of known threats to, and natural history of, the species; (2) acquiring funding sources for research, monitoring, and management; (3) enhancing education and outreach; and (4) managing against known threats to the species. Implementation of the recovery plan was to occur between the second half of 2007 through 2011, and was divided into three main categories: (1) Improve and maintain knowledge of potential threats to the narrow-headed gartersnake; (2) improve and maintain knowledge of the biology of the narrow-headed gartersnake; and (3) develop and maintain high levels of cooperation and coordination between stakeholders and interested parties (Pierce 2007, pp. 16–17). Our review of the plan found that it lacked specific threat-mitigation commitments on the landscape, as well as stakeholder accountability for implementing activities prescribed in the plan. We also found that actions calling for targeted nonnative species removal or management were absent in the implementation schedule provided in Pierce (2007; p. 17). As we have discussed at length, harmful nonnative species are the primary driver of continued declines in both gartersnake species. No recovery plan, conservation plan, or conservation agreement currently exists in New Mexico with regard to the northern Mexican gartersnake (NMDGF 2006, Table 6–3).

Both northern Mexican and narrow-headed gartersnakes are considered ''Candidate Species'' in the Arizona Game and Fish Department draft document, Wildlife of Special Concern (WSCA) (AGFD *In Prep.,* p. 12). A ''Candidate Species'' is one ''whose threats are known or suspected but for which substantial population declines from historical levels have not been documented (though they appear to have occurred)'' (AGFD *In Prep.,* p. 12). The purpose of the WSCA list is to provide guidance in habitat management implemented by land-management agencies. Additionally, both northern Mexican and narrow-headed gartersnakes are considered a ''Tier 1b Species of Greatest Conservation Need (SGCN)'' in the Arizona Game and Fish Department document, Arizona's Comprehensive Wildlife Conservation Strategy (CWCS) (AGFD 2006a, pp. 499–501). The purpose for the CWCS is to ''provide an essential foundation for the future of wildlife conservation and a stimulus to engage the States, federal agencies, and other conservation partners to strategically think about their individual and coordinated roles in prioritizing conservation efforts'' (AGFD 2006a, p. 2). A ''Tier 1b SGCN'' is one that requires immediate conservation actions aimed at improving conditions through intervention at the population or habitat level (AGFD 2006a, p. 32). In the 2011 draft revised State wildlife action plan (an updated version of the CWCS), northern Mexican gartersnake is a Tier 1a SGCN. Tier 1a species ''comprise a large percentage of [AGFD's] management resource allocation'' and ''are [their] highest priorities.'' Neither the WSCA nor the CWCS are regulatory documents and, consequently, do not provide and specific protections for either the gartersnakes themselves, or their habitats. The Arizona Game and Fish Department does not have specified or mandated recovery goals for either the northern Mexican or narrow-headed gartersnake, nor has a conservation agreement or recovery plan been developed for either species.

Indirect benefits for both gartersnake species occur through recovery actions designed for their prey species. Since the Chiricahua leopard frog was listed as threatened under the Act, significant strides have been made in its recovery, and the mitigation of its known threats. The northern Mexican gartersnake, in particular, has likely benefitted from these actions, at least in some areas, such as at the Las Cienegas Natural Conservation Area and in Scotia Canyon of the Huachuca Mountains. However, much of the recovery of the Chiricahua leopard frog has occurred in areas that have not directly benefitted the northern Mexican gartersnake, either because these activities have occurred outside the known distribution of the northern Mexican gartersnake or because they have occurred in isolated lentic systems that are far removed from large perennial streams that typically provide source populations of northern Mexican gartersnakes. In recent years, significant strides have been made in controlling bullfrogs on local landscape levels in Arizona, such as in the Scotia Canyon area, in the Las Cienegas National Conservation Area, on the BANWR, and in the vicinity of Pena Blanca Lake in the Pajarito Mountains. Recent efforts to return the Las Cienegas National Conservation Area to a wholly native biological community have involved bullfrog eradication efforts, as well as efforts to recover the Chiricahua leopard frog and native fish species. These actions should assist in conserving the northern Mexican gartersnake population in this area. Bullfrog control has been shown to be most effective in simple, lentic systems such as stock tanks. Therefore, we encourage livestock managers to work with resource managers in the systematic eradication of bullfrogs from stock tanks where they occur, or at a minimum, ensure they are never introduced.

An emphasis on native fish recovery in fisheries management and enhanced nonnative species control to favor native communities may be the single most efficient and effective manner to recover these gartersnakes, in addition to all listed or sensitive native fish and amphibian species which they prey upon. Alternatively, resource management policies that either directly benefit or maintain nonnative community assemblages to the exclusion of native species are likely to significantly reduce the potential for the conservation and recovery of northern Mexican and narrow-headed gartersnakes.

Fisheries managers strive to balance the needs of the recreational angling community against those required by native aquatic communities. Fisheries management has direct implications for the conservation and recovery of northern Mexican and narrow-headed gartersnakes in the United States. Clarkson *et al.* (2005) discuss management conflicts as a primary factor in the decline of native fish species in the southwestern United States, and declare the entire native fish fauna as imperiled. The investigators cite nonnative species as the most consequential factor leading to rangewide declines of native fish, and that such declines prevent or negate species' recovery efforts from being implemented or being successful (Clarkson *et al.* 2005, p. 20). Maintaining the status quo of current management of fisheries within the southwestern United States will have serious adverse effects to native fish species (Clarkson *et al.* 2005, p. 25), which will affect the long-term viability of northern Mexican and narrow-headed gartersnakes and their potential for recovery. Clarkson *et al.* (2005, p. 20) also note that over 50 nonnative species have been introduced into the Southwest as either sportfish or baitfish, and some are still being actively stocked, managed for, and promoted by both Federal and State agencies as nonnative recreational fisheries.

To help resolve the fundamental conflict of management between native fish and recreational sport fisheries, Clarkson *et al.* (2005, pp. 22–25) propose the designation of entire subbasins as having either native or nonnative fisheries and manage for these goals aggressively. The idea of watershed-segregated fisheries management is also supported by Marsh and Pacey (2005, p. 62). As part of the Arizona Game and Fish Department's overall wildlife conservation strategy, the AGFD has planned an integrated fisheries management approach (AGFD 2006a, p. 349), which is apparently designed to manage subbasins specifically for either nonnative or native fish communities. The AGFD has not yet decided how fisheries will be managed in Arizona's subbasins. However, angler access, existing fish communities, and stream flow considerations are likely to inform such broadly based decisions. Several of Arizona's large perennial rivers present an array of existing sport fishing opportunities and access points, contain harmful nonnative fish species, and also serve as important habitat for either northern Mexican or narrow-headed gartersnakes. These rivers may be targeted though this planning exercise for nonnative fisheries management, which would likely remove any recovery potential for gartersnakes in these areas, and, perhaps, even result in the local extirpations of populations of northern Mexican and narrow-headed gartersnakes. Alternatively, subbasins that are targeted for wholly native species assemblages would likely secure the persistence of northern Mexican and narrow-headed gartersnakes that occur there, if not result in their complete recovery in these areas. Specific subbasins where targeted fisheries management is to occur were not provided in AGFD (2006a), but depending on which areas are chosen for each management emphasis, the potential for future conservation and recovery of northern Mexican and narrow-headed gartersnakes could either be significantly bolstered, or significantly hampered. Close coordination with the Arizona Game and Fish Department on the delineation of fisheries management priorities in Arizona's subbasins will be instrumental to ensuring that conservation and recovery of northern Mexican and narrow-headed gartersnakes can occur.

Conservation of these gartersnakes has been implemented in the scientific and management communities as well. The AGFD recently produced identification cards for distribution that provide information to assist field professionals with the identification of each of Arizona's five native gartersnake species, as well as guidance on submitting photographic vouchers for university museum collections. Arizona State University and the University of Arizona now accept photographic vouchers in lieu of physical specimens, in their respective museum collections. These measures appreciably reduce the necessity for physical specimens (unless discovered postmortem) for locality voucher purposes and, therefore, further reduce impacts to vulnerable populations of northern Mexican or narrow-headed gartersnakes.

Despite these collective efforts we have described above, northern Mexican and narrow-headed gartersnakes have continued to decline throughout their ranges.

Proposed Determination

In our review of the best available science, we found that aquatic ecosystems which northern Mexican and narrow-headed gartersnakes rely on and are part of have been significantly compromised by harmful nonnative species. We found this threat to be the most significant and pervasive of all threats affecting both species. Harmful nonnative species have been intentionally released or have naturally moved into virtually every subbasin throughout the range of the northern Mexican and narrow-headed gartersnakes. This has resulted in widespread declines in native fish and amphibian communities, which are integral to the continued survival of the northern Mexican and narrow-headed gartersnakes. In addition to widespread competitive pressures, harmful nonnative species have directly impacted both gartersnake species through predation. In combination, these factors have resulted in widespread population declines and extirpations in both species, as neither gartersnake nor their prey evolved in their presence.

In addition to the declining status of the biotic communities where the northern Mexican and narrow-headed gartersnakes occur, land use activities, drought, and wildfires threaten vital elements of their habitat that are important for their survival. Dams, diversions, flood-control projects, and groundwater pumping have dewatered entire reaches of historically occupied habitat for both species, rangewide. Large dams planned in the future threaten to dewater additional reaches. Climate change predictions include increased aridity, lower annual precipitation totals, lower snow pack levels, higher variability in flows (lower low-flows and higher high-flows), and enhanced stress on ponderosa pine communities in the southwestern United States and northern Mexico. Increasing water demands from a rapidly growing human population in the arid southwestern United States, combined with a drought-limited supply of surface water, fuels future needs for even more dams, diversions, and groundwater pumping. Due in part to the fire management policies of recent decades, wildfires in the arid southwestern United States have grown more frequent and severe. Since 2011, both Arizona and New Mexico experienced the largest wildfires in their respective State histories. High-intensity wildfires that affect large areas contribute to significant flooding and sedimentation, resulting in fish kills and the filling-in of important pool habitat. These conditions remove a portion of, or the entire prey base, for northern Mexican and narrow-headed gartersnakes for extended periods of time. This scenario places significant stress on resident gartersnake populations through starvation.

Other activities, factors, or conditions that act in combination, such as mismanaged or unmanaged livestock grazing; road construction, use, and management; adverse human interactions; environmental contaminants; erosion control techniques; and competitive pressures from sympatric species, occur within the distribution of these gartersnakes and have the tendency to contribute to further population declines or extirpations where gartersnakes occur at low population densities. In the presence of harmful nonnative species, the negative effects of these threats on northern Mexican and narrow-headed gartersnakes are amplified. Yet, there are currently no regulatory mechanisms in place to address the threats to these species that specifically target the conservation of northern Mexican or narrow-headed gartersnakes or their habitat in the United States or Mexico.

Collectively, the ubiquitous nature of these threats across the landscape has appreciably reduced the quality and quantity of suitable gartersnake habitat and changed its spatial orientation on the landscape. This ultimately renders populations much less resilient to stochastic, natural, or anthropogenic stressors that could otherwise be withstood. Over time and space, subsequent population declines have threatened the genetic representation of each species because many populations have become disconnected and isolated from neighboring populations. Expanding distances between extant populations coupled with threats that prevent normal recolonizing mechanisms leave existing populations vulnerable to extirpation. This subsequently leads to a reduction in species redundancy when isolated, small populations are at increased vulnerability to the effects of stochastic events, without a means for natural recolonization. Ultimately, the effect of scattered, small, and disjunct populations, without the means to naturally recolonize, is weakened species resiliency as a whole, which ultimately enhances the risk of the species becoming endangered.

The Act defines an endangered species as any species that is ''in danger of extinction throughout all or a significant portion of its range'' and a threatened species as any species ''that is likely to become endangered throughout all or a significant portion of its range within the foreseeable future.'' We have carefully assessed the best scientific and commercial information available regarding the past, present, and future threats to the species, and have determined that the northern Mexican gartersnake and narrow-headed gartersnake both meet the definition of a threatened species under the Act. Significant threats are occurring now and are likely to continue in the foreseeable future, at a high intensity, and across these species' entire ranges; therefore, we have determined these species are likely to become endangered throughout all or a significant portion of their ranges within the foreseeable future. Because these threats are likely to cause these gartersnakes to become endangered throughout all or a significant portion of their ranges within the foreseeable future, we find these species are threatened, not endangered. Therefore, on the basis of the best available scientific and commercial information, we propose listing the northern Mexican gartersnake and narrow-headed gartersnake as threatened species in accordance with sections 3(20) and 4(a)(1) of the Act. The current status of the northern Mexican and narrow-headed gartersnakes meets the definition of threatened, not endangered, because while we found numerous threats to be significant and rangewide, our available survey data conclude that the remaining small number of populations are viable. Alternatively and based upon the data available, the northern Mexican and narrow-headed gartersnakes appear to remain extant, as low-density populations with the threat of extirpation, in most subbasins where they historically occurred.

Special Rule for Northern Mexican Gartersnake Under Section 4(d) of the Act

Whenever a species is listed as a threatened species under the Act, the Secretary may specify regulations that she deems necessary and advisable to provide for the conservation of that species under the authorization of section 4(d) of the Act. These rules, commonly referred to as ''special rules,'' are found in part 17 of title 50 of the Code of Federal Regulations (CFR) in §§ 17.40–17.48. This proposed special rule for § 17.42 would exempt take of northern Mexican gartersnakes as a result of livestock use at or maintenance activities of livestock tanks located on private, State, or Tribal lands.

The proposed special rule would replace the Act's general prohibitions against take of the northern Mexican gartersnake with special measures tailored to the conservation of the species on all non-Federal lands. Through the maintenance and operation of the stock tanks for cattle, habitat is provided for the northern Mexican gartersnake and numerous prey species; hence there is a conservation benefit to the species. Under the proposed special rule, take of northern Mexican gartersnake caused by livestock use of or maintenance activities at livestock tanks located on private, State, or Tribal lands would be exempt from section 9 of the Act. A livestock tank is defined as an existing or future impoundment in an ephemeral drainage or upland site constructed primarily as a watering site for livestock. The proposed special rule targets tanks on private, State, and Tribal lands to encourage landowners and ranchers to continue to maintain these tanks as they provide habitat for the northern Mexican gartersnake. Livestock use and maintenance of tanks on Federal lands would be addressed through the section 7 process. When a Federal action, such as permitting livestock grazing on Federal lands, may affect a listed species, consultation between us and the action agency is required under section 7 of the Act. The conclusion of consultation may include mandatory changes in livestock programs in the form of measures to minimize take of a listed animal or to avoid jeopardizing the continued existence of a listed species. Changes in a proposed action resulting from consultations are almost always minor.

Available Conservation Measures

Conservation measures provided to species listed as endangered or threatened under the Act include recognition, recovery actions, requirements for Federal protection, and prohibitions against certain practices. Recognition through listing results in public awareness and conservation by Federal, State, Tribal, and local agencies, private organizations, and individuals. The Act encourages cooperation with the States and requires that recovery actions be carried out for all listed species. The protection required by Federal agencies and the prohibitions against certain activities are discussed, in part, below.

The primary purpose of the Act is the conservation of endangered and threatened species and the ecosystems upon which they depend. The ultimate goal of such conservation efforts is the recovery of these listed species, so that they no longer need the protective measures of the Act. Subsection 4(f) of the Act requires the Service to develop and implement recovery plans for the conservation of endangered and threatened species. The recovery planning process involves the identification of actions that are necessary to halt or reverse the species' decline by addressing the threats to its survival and recovery. The goal of this process is to restore listed species to a point where they are secure, self-sustaining, and functioning components of their ecosystems.

Recovery planning includes the development of a recovery outline shortly after a species is listed, preparation of a draft and final recovery plan, and revisions to the plan as significant new information becomes available. The recovery outline guides the immediate implementation of urgent recovery actions and describes the process to be used to develop a recovery plan. The recovery plan identifies site-specific management actions that will achieve recovery of the species, measurable criteria that determine when a species may be downlisted or delisted, and methods for monitoring recovery progress. Recovery plans also establish a framework for agencies to coordinate their recovery efforts and provide estimates of the cost of implementing recovery tasks. Recovery teams (comprised of species experts, Federal and State agencies, nongovernment organizations, and stakeholders) are often established to develop recovery plans. When completed, the recovery outline, draft recovery plan, and the final recovery plan will be available on our Web site (*http://www.fws.gov/endangered*), or from our Arizona Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**).

Implementation of recovery actions generally requires the participation of a broad range of partners, including other Federal agencies, States, Tribal, nongovernmental organizations, businesses, and private landowners. Examples of recovery actions include habitat restoration (e.g., restoration of native vegetation), research, captive propagation and reintroduction, and outreach and education. The recovery of many listed species cannot be accomplished solely on Federal lands because their range may occur primarily or solely on non-Federal lands. To achieve recovery of these species requires cooperative conservation efforts on private, State, and Tribal lands.

If these species are listed, funding for recovery actions will be available from a variety of sources, including Federal budgets, State programs, and cost share grants for non-Federal landowners, the academic community, and nongovernmental organizations. In addition, under section 6 of the Act, the States of Arizona and New Mexico would be eligible for Federal funds to implement management actions that promote the protection and recovery of the northern Mexican and narrow-headed gartersnakes. Information on our grant programs that are available to aid species recovery can be found at: *http://www.fws.gov/grants.*

Although the northern Mexican and narrow-headed gartersnakes are only proposed for listing under the Act at this time, please let us know if you are interested in participating in recovery efforts for this species. Additionally, we invite you to submit any new information on these species whenever it becomes available and any information you may have for recovery planning purposes (see **FOR FURTHER INFORMATION CONTACT**).

Section 7(a) of the Act requires Federal agencies to evaluate their actions with respect to any species that is proposed or listed as endangered or threatened and with respect to its critical habitat, if any is designated. Regulations implementing this interagency cooperation provision of the Act are codified at 50 CFR part 402. Section 7(a)(4) of the Act requires Federal agencies to confer with the Service on any action that is likely to jeopardize the continued existence of a species proposed for listing or result in destruction or adverse modification of proposed critical habitat. If a species is listed subsequently, section 7(a)(2) of the Act requires Federal agencies to ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of the species or destroy or adversely modify its critical habitat. If a Federal action may affect a listed species or its critical habitat, the responsible Federal agency must enter into formal consultation with the Service.

Federal agency actions within the species' habitats that may require conference or consultation or both as described in the preceding paragraph include management and any other landscape altering activities on Federal lands administered by the Fish and Wildlife Service, U.S. Bureau of Reclamation, or U.S. Forest Service; issuance of section 404 Clean Water Act permits by the U.S. Army Corps of Engineers; construction and management of gas pipeline and power line rights-of-way by the Federal Energy Regulatory Commission; construction and maintenance of roads or highways by the Federal Highway Administration; and other discretionary actions that effect the species composition of biotic communities where these species or their habitats occur, such as funding or permitting programs that result in the continued stocking of nonnative, spiny-rayed fish.

The Act and its implementing regulations set forth a series of general prohibitions and exceptions that apply to all endangered wildlife. The prohibitions of section 9(a)(2) of the Act, codified at 50 CFR 17.21 for endangered wildlife, in part, make it illegal for any person subject to the jurisdiction of the United States to take (includes harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect; or to attempt any of these), import, export, ship in interstate commerce in the course of commercial activity, or sell or offer for sale in interstate or foreign commerce any listed species. Under the Lacey Act (18 U.S.C. 42–43; 16 U.S.C. 3371–3378), it is also illegal to possess, sell, deliver, carry, transport, or ship any such wildlife that has been taken illegally. Certain exceptions apply to agents of the Service and State conservation agencies. The prohibitions of section 9(a)(2) of the Act, codified at CFR 17.31 for threatened wildlife, make it such that all the provisions of 50 CFR 17.21 apply, except § 17.21(c)(5).

We may issue permits to carry out otherwise prohibited activities involving endangered and threatened wildlife species under certain circumstances. Regulations governing permits are codified at 50 CFR 17.22 for endangered species, and at 17.32 for threatened species. A permit must be issued for the following purposes: for scientific purposes, to enhance the propagation or survival of the species, and for incidental take in connection with otherwise lawful activities.

It is our policy, as published in the **Federal Register** on July 1, 1994 (59 FR 34272), to identify to the maximum extent practicable at the time a species is listed, those activities that would or would not constitute a violation of section 9 of the Act. The intent of this policy is to increase public awareness of the effect of a proposed listing on proposed and ongoing activities within the range of species proposed for listing. The following activities could potentially result in a violation of section 9 of the Act; this list is not comprehensive:

(1) Unauthorized collecting, handling, possessing, selling, delivering, carrying, or transporting of the species, including import or export across State lines and international boundaries, except for properly documented antique specimens of these taxa at least 100 years old, as defined by section 10(h)(1) of the Act;

(2) The unauthorized introduction of harmful nonnative species that compete with or prey upon northern Mexican and narrow-headed gartersnakes, such as the stocking of nonnative, spiny-rayed fish, or illegal transport, use, or release of bullfrogs or crayfish in the States of Arizona and New Mexico;

(3) The unauthorized release of biological control agents that attack any age class of northern Mexican and narrow-headed gartersnakes or any life stage of their prey species;

(4) Unauthorized modification of the channel, reduction or elimination of water flow of any stream or water body, or the complete removal or significant destruction of riparian vegetation associated with occupied northern Mexican or narrow-headed gartersnake habitat; and

(5) Unauthorized discharge of chemicals or fill material into any waters in which northern Mexican and narrow-headed gartersnakes are known to occur.

Questions regarding whether specific activities would constitute a violation of section 9 of the Act should be directed to the Arizona Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**). Requests for copies of the regulations concerning listed animals and general inquiries regarding prohibitions and permits may be addressed to the U.S. Fish and Wildlife Service, Endangered Species Permits, P.O. Box 1306, Albuquerque, New Mexico 87103 (telephone (505) 248–6920, facsimile (505) 248–6922).

Peer Review

In accordance with our joint policy on peer review published in the **Federal Register** on July 1, 1994 (59 FR 34270), we will seek the expert opinions of at least three appropriate and independent specialists regarding this proposed rule. The purpose of peer review is to ensure that our listing determination is based on scientifically sound data, assumptions, and analyses. We have invited these peer reviewers to comment during this public comment period on our specific assumptions and conclusions in this proposed listing determination.

We will consider all comments and information received during this comment period on this proposed rule during our preparation of a final determination. Accordingly, the final decision may differ from this proposal.

Public Hearings

Section 4(b)(5) of the Act provides for one or more public hearings on this proposal, if requested. Requests must be received within 45 days after the date of publication of this proposed rule in the **Federal Register**. Such requests must be sent to the address shown in the **FOR FURTHER INFORMATION CONTACT** section. We will schedule public hearings on this proposal, if any are requested, and announce the dates, times, and places of those hearings, as well as how to obtain reasonable accommodations, in the **Federal Register** and local newspapers at least 15 days before the hearing.

Required Determinations

Clarity of the Rule

We are required by Executive Orders 12866 and 12988 and by the Presidential Memorandum of June 1, 1998, to write all rules in plain language. This means that each rule we publish must:

(1) Be logically organized;

(2) Use the active voice to address readers directly;

(3) Use clear language rather than jargon;

(4) Be divided into short sections and sentences; and

(5) Use lists and tables wherever possible.

If you feel that we have not met these requirements, send us comments by one of the methods listed in the **ADDRESSES** section. To better help us revise the rule, your comments should be as specific as possible. For example, you should tell us the numbers of the sections or paragraphs that are unclearly written, which sections or sentences are too long, the sections where you feel lists or tables would be useful, etc.

National Environmental Policy Act (42 U.S.C. 4321 et seq.)

We have determined that environmental assessments and environmental impact statements, as defined under the authority of the National Environmental Policy Act (NEPA; 42 U.S.C. 4321 *et seq.*), need not be prepared in connection with listing a species as an endangered or threatened species under the Endangered Species Act. We published a notice outlining our reasons for this determination in the **Federal Register** on October 25, 1983 (48 FR 49244).

References Cited

A complete list of references cited in this rulemaking is available on the Internet at *http://www.regulations.gov* and upon request from the Arizona Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**).

Authors

The primary authors of this proposed rule are the staff members of the Arizona Ecological Services Field Office.

List of Subjects in 50 CFR Part 17

Endangered and threatened species, Exports, Imports, Reporting and recordkeeping requirements, Transportation.

Proposed Regulation Promulgation

Accordingly, we propose to amend part 17, subchapter B of chapter I, title 50 of the Code of Federal Regulations, as set forth below:

PART 17—[AMENDED]

■ 1. The authority citation for part 17 continues to read as follows:

Authority: 16 U.S.C. 1361–1407; 1531–1544; and 4201–4245, unless otherwise noted.

■ 2. In § 17.11(h), add entries for ‘‘Gartersnake, northern Mexican’’ and ‘‘Gartersnake, narrow-headed’’ to the List of Endangered and Threatened Wildlife in alphabetical order under REPTILES to read as follows:

§ 17.11 Endangered and threatened wildlife.

* * * * *

(h) * * *

Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
*	*	*	*	*	*		*
REPTILES							
*	*	*	*	*	*		*
Gartersnake, northern Mexican.	*Thamnophis eques megalops*.	U.S.A. (AZ, NM), Mexico.	Entire	T		17.95(d)	17.42(g)
*	*	*	*	*	*		*
Gartersnake, narrow-headed.	*Thamnophis rufipunctatus*.	U.S.A. (AZ, NM)	Entire	T		17.95(d)	NA
*	*	*	*	*	*		*

■ 3. Amend § 17.42 by adding a new paragraph (g) to read as follows:

§ 17.42 Special rules—reptiles.

* * * * *

(g) Northern Mexican gartersnake (*Thamnophis eques megalops*)—(1) *Which populations of the northern Mexican gartersnake are covered by this special rule?* This rule covers the distribution of this species in the contiguous United States.

(2) *What activities are prohibited?* Any activity where northern Mexican gartersnakes are attempted to be, or are intended to be, trapped, hunted, shot, or collected, in the contiguous United States, is prohibited. It is also prohibited to incidentally trap, shoot, capture, pursue, or collect northern Mexican gartersnakes in the course of otherwise legal activities.

(3) *What activities are allowed?* Incidental take of northern Mexican gartersnakes is not a violation of section 9 of the Act if it occurs from any other otherwise legal activities involving northern Mexican gartersnakes and their habitat that are conducted in accordance with applicable State, Federal, tribal, and local laws and regulations. Such activities occurring in northern Mexican gartersnake habitat include maintenance

activities at livestock tanks located on private, State, or Tribal lands. A livestock tank is an existing or future impoundment in an ephemeral drainage or upland site constructed primarily as a watering site for livestock.

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Dated: June 24, 2013.

Daniel M. Ashe,

Director, U.S. Fish and Wildlife Service.

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