PETITION TO LIST
The Desert Massasauga (*Sistrurus catenatus edwardsii*)
UNDER THE U.S. ENDANGERED SPECIES ACT

Petition Submitted to the U.S. Secretary of Interior, Acting through the U.S. Fish and Wildlife Service

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INTRODUCTION

The desert massasauga (*Sistrurus catenatus edwardsii*) is a rattlesnake whose range encompasses southeastern Arizona, southcentral and southeastern New Mexico, parts of western Texas, southeastern Colorado, adjacent southwest Kansas, and perhaps northwestern Oklahoma (Mackessy 2005). This subspecies is the smallest type of massasauga and occurs in shortgrass, sandsage, and shinnery oak habitats in the southern Great Plains and Chihuahuan Desert. There are two other subspecies of massasauga: the eastern massasauga (*S. c. catenatus*), which is currently a candidate for Endangered Species Act (ESA) listing (USFWS 2009a), and the western massasauga (*S. c. tergeminus*). The range of the full species *Sistrurus catenatus* extends from Ontario, Canada to Northern Chihuahua (Degenhardt et al. 1996; Hobert et al. 2004; Mackessy 2005). Scientists report that the massasauga is imperiled and declining across its range (Holycross and Mackessy 2002; Hobert et al. 2004; Mackessy 2005; Anderson et al. 2009).

The desert massasauga is likewise imperiled (Anderson et al. 2009). In Arizona, populations have been severely reduced through habitat destruction. *Id*. In Colorado, while a robust population exists in Lincoln County, other populations are generally small and fragmented (Hobert et al. 2004; Mackessy 2005). Even in the Colorado portion of its range where a large population has been studied for more than a decade, scientists warn that this taxon is likely to be threatened in the future due to habitat conversion (Hobert et al. 2004; Mackessy 2005). Kansas, Oklahoma, and Mexico populations are likely small. Populations in Texas and New Mexico have probably declined from historic numbers. The best available information indicates that the desert massasauga has suffered localized declines throughout its range.

This rattlesnake faces a slew of threats, including habitat loss and degradation from conversion to crops, heavy livestock grazing, road-building, urbanization, water diversion and depletion, energy development, and other forms of habitat destruction; intentional killing, being shot on sight, run over by cars, and rounded up and beheaded in contests; collection for the pet trade; loss of genetic diversity due to population isolation and fragmentation; and loss of refugia and prey due to declines in rodent populations. Human population growth drives multiple dangers to this snake, including habitat destruction and killing. Climate change can also adversely affect the massasauga by desertifying its grassland habitats. A potential threat is disease, particulary paramyxovirus, which could be devastating if introduced to the wild (Mackessy 2005). These threats are compounded by the desert massasauga's low reproductive rate, short lifespan, and low survivorship; and the intersection of multiple threats (e.g., more roads degrade habitat and increase the chance of being struck by vehicles). *Id*.

While some regulatory measures exist for this species, there is no evidence they are enforced or sufficient to prevent further population declines. For example, while the massasauga is supposed to be protected from take in Colorado, there is also a state law allowing killing of any rattlesnakes if they are perceived as a danger to "life or property," with no limits on number. Throughout the desert massasauga's range, "rattlesnake

round-ups" take place, during which thousands of rattlesnakes of assorted varieties (including the desert massasauga) may be killed in the course of just a few days. Massasaugas, like other rattlesnakes, face ubiquitous and intense persecution by humans, and it will take federal protection under the ESA to secure a future for this taxon.

Accordingly, WildEarth Guardians petitions the Secretary of Interior, acting through the U.S. Fish and Wildlife Service (FWS) to list, and thereby protect, the desert massasauga as an endangered or threatened species under the ESA. Alternatively, we request listing of a distinct population segment (DPS) in Colorado, Kansas, and Oklahoma.

Applicability of the Endangered Species Act

In light of the imperilment of this rattlesnake, Petitioner requests listing of the desert massasauga under the ESA as either threatened or endangered, throughout its historic and current range. Taxa eligible for ESA listing include "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature" (16 U.S.C. § 1532(16)).[1] Both the statute (16 U.S.C. § 1532) and regulations implementing the Endangered Species Act (50 C.F.R. § 424) are applicable to this petition. Subsections that concern the formal listing of this subspecies as Endangered or Threatened species are:

> "*Endangered species* means a species that is in danger of extinction throughout all or a significant portion of its range."…(k) "species" includes any species or subspecies that interbreeds when mature. *See* 16 U.S.C § 1532(6), 50 C.F.R. § 424.02(e).
>
> "*Threatened species* means any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." *See also* 16 U.S.C § 1532(20), 50 C.F.R. § 424.02(m).

This Petition demonstrates that the desert massasauga is imperiled to the extent that it warrants listing as either Endangered or Threatened under the ESA.

ESA Section 4 (16 U.S.C. § 1533(a)(1)) sets forth listing factors under which a species can qualify for ESA protection (see also 50 C.F.R. § 424.11(c)):

A. The present or threatened destruction, modification, or curtailment of habitat or range;
B. Overutilization for commercial, recreational, scientific, or educational purposes;
C. Disease or predation;

[1]The sole exclusion is for "a species of the Class Insecta determined by the Secretary to constitute a pest whose protection…would present an overwhelming and overriding risk to man." 16 U.S.C. § 1532(6). It is difficult to imagine an insect so imperiled as to warrant ESA protection that presents a grave risk to humans.

D. The inadequacy of existing regulatory mechanisms; and
E. Other natural or manmade factors affecting its continued existence.

Multiple factors set forth in ESA Section 4 (16 U.S.C. § 1533(a)(1)) and in 50 C.F.R. § 424.11(c) have resulted in the continued decline of this taxon and are causing it to face extinction or endangerment in the foreseeable future. The desert massasauga is threatened by habitat destruction and loss. It is also imperiled by intentional and unintentional killing and collection for the pet trade. There are insufficient regulatory mechanisms in place to ensure this taxon's survival. The massasauga's relatively low fecundity, low survivorship, and increasing genetic isolation are threatening its future. Other pressures include climate change, small population size, and cumulative threats. A taxon needs to meet only one of the listing factors outlined in the ESA to qualify for federal listing.

Description of Petitioner

WildEarth Guardians (Guardians) is a non-profit environmental organization with over 12,500 members and supporters throughout the United States. Guardians has an active endangered species protection campaign. As part of this campaign, Guardians works to obtain ESA protection for a wide variety of imperiled wildlife and plants and the ecosystems on which they depend. The organization has a conservation easement in the range of the desert massasauga in Colorado in close proximity to where the taxon was rediscovered in Baca County in 1997. Guardians' staff and members frequently recreate in and around the Comanche National Grassland, where this taxon is found.

Classification and Nomenclature

Common name. The common name for *Sistrurus catenatus edwardsii* is the "desert massasauga," "Edward's massasauga," and "Edward's rattlesnake." Throughout the petition, we refer to *S. c. edwardsii* as the desert massasauga or its scientific name.

Taxonomy. We provide the Petitioned taxon's scientific classification in Table 1. This subspecies is generally recognized as valid. There are two other recognized subspecies of massasauga: the eastern massasauga (*S. c. catenatus*) and the western massasauga (*S. c. tergeminus*) (USFWS 2009a). Its type locality is Tamaulipas, Mexico (AGFD 2001).

Table 1. Taxonomy of the Desert Massasauga.

Phylum	Chordata
Class	Reptilia
Order	Squamata
Family	Viperidae
Genus	*Sistrurus*
Species	*S. catenatus*
Subspecies	*S.c. edwardsii*

While there was some taxonomic debate about whether the massasaugas in Colorado are desert massasaugas (Gloyd 1955; Wright and Wright 1957; Maslin 1965), that debate appears to be settled, and the massasauga rattlesnakes in Colorado should be considered desert massasaugas (Hobert et al. 2004; Mackessy 2005). Genetic research underway may indicate that *S.c. edwardsii* is a valid species, separate from *S. catenatus* (Milne and Mackessy unpublished data, cited in Mackessy 2005).

Species Description[2]

The desert massasauga is the smallest subspecies of the massasauga rattlesnake (Holycross 2001, cited in Mackessy 2005). Adults reach a maximum total length of 588 mm (23.1 inches). *Id*. Snakes within the genus *Sistrurus* are characterized by the nine enlarged scales on the top of the head, a trait that distinguishes them from all other rattlesnakes in the United States (Mackessy 2005). The ground color of desert massasaugas is usually light brown to gray. They have 37 to 40 darker brown semicircular blotches that are outlined in black and form a regular pattern on the dorsal surface. Their tail has alternating bands of gray, brown, and dark gray. Laterally, they have a series of smaller and paler circular blotches in two rows. A dark brown to black stripe extends from their eye to the angle of their jaw, and a lyre-shaped or paired irregular set of stripes extends from the surface of the head to the first blotch on their body. The tip of the tail (at the base of the rattle) in adults is typically black, but in young, the tip is yellow or orange (Reiserer 2002, cited in Mackessy 2005). The young use their tail to lure prey (*Id*. and Holycross 2003). Within a year, the tail changes to the adult form (Holycross 2003).

The snake is venomous, and its venom is toxic. However, because of its small size, venom yields are low (20-40 µl, 4-8 mg). Bites on humans may be serious but likely are not life-threatening (Mackessy 2005).

Geographic Distribution: Historic and Current

The massasauga was historically known from populations in southern Ontario, Canada through parts of the Midwestern and Great Plains states in the U.S. south to northern Mexico (Figure 1) (Mackessy 2005). The taxon occurs over much of the shortgrass prairie habitat in southeastern Colorado, adjacent southwestern Kansas, and perhaps northwestern Oklahoma. *Id*. Its distribution in Kansas is not known but may have been contiguous with populations in Colorado, based on continuity of appropriate shortgrass prairie habitat in western Kansas. *Id*. Mackessy (2005) considers it uncommon in both Colorado and Kansas. Farming and consequent widespread habitat loss in eastern Colorado may now obstruct further gene flow. *Id*. Desert massasaugas also occur in parts of Arizona, New Mexico, Texas, and Mexico. In Arizona, they were once distributed throughout the San Bernardino and San Simon valleys (Holycross 2003). They appear to have been broadly distributed in south-central and southeastern New Mexico (Degenhardt et al. 1996), with a specialized population in shinnery oak habitat

[2]Adapted from Mackessy (2005).

(Zwartjes et al. 2005). They also occurred in western and southern Texas (Werler and Dixon 2000). Their Mexican range included portions of northern Mexico (Chihuahua, Tamaulipas, Coahuila, and Nuevo León) (AGFD 2001; Holycross 2003; Mackessy 2005; NatureServe 2010b).

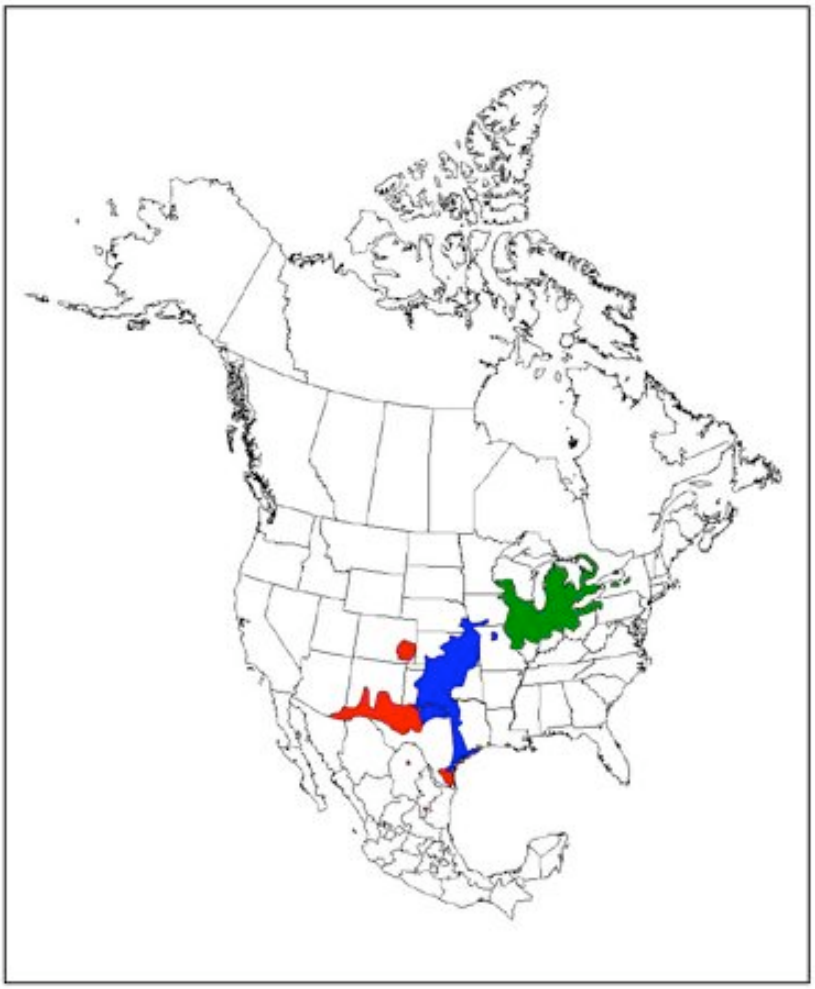

Figure 1: Approximate distribution of the massasauga (*Sistrurus catenatus*) in North America. The desert massasauga is shown in red; the western massasauga in blue; and the eastern massasauga in green. Redrawn largely from Conant and Collins (1991). Note that for most ranges, populations are not continuous and do not occupy the entire area shaded. Source: Mackessy 2005.

While desert massasaugas were likely once continuous over much of their historic range from northern Mexico to eastern Colorado, they are presently fragmented and disjunct (Mackessy 2005; Anderson et al. 2009). Both long-term climatic changes that have altered the shortgrass prairie habitat of the Great Plains and anthropogenic changes causing increased xerification have resulted in extensive habitat loss. *Id*. In Arizona, extensive habitat degradation has limited occupied habitat of this taxon to a relict grassland on the divide between the San Simon and San Bernardino valleys (Holycross 2003; Anderson et al. 2009). The Arizona Game and Fish Department (2001: 3) reports:

"Quantified data are lacking, but the desert massasauga has almost certainly experienced long-term population declines and a general range contraction in Arizona." Within Colorado, the range of the desert massasauga is limited to 11 southeastern counties (Baca, Bent, Cheyenne, Crowley, El Paso, Kiowa, Las Animas, Lincoln, Otero, Prowers, Pueblo) (Hammerson 1999), and recent research has verified occurrence in only 10 counties (none found in Las Animas County). The largest populations occur in Lincoln and Kiowa counties, with much smaller populations occurring in the six most southeastern counties (Mackessy 2005). Loss of Chihuahuan desert grassland and shinnery oak poisoning in New Mexico and Texas may have reduced the extent of the desert massasauga in those states.[3]

Habitat Requirements

This taxon occurs in xeric grasslands, including short-grass prairie, sandsage grasslands, shinnery oak, Chihuahuan desert, and occasionally sand dune habitat (Degenhardt et al. 1996; Mackessy 2007). In Colorado, massasaugas inhabit a range of habitats in the Arkansas River drainage, from arid open sagebrush prairie to shortgrass prairie below 5500 feet (Hammerson 1986, 1999; Hobert et al. 2004; Mackessy 2005, 2007). Areas with greatest desert massasauga abundance have more mesic native shortgrass prairie (including greater surface water availability) with lower levels of crop and livestock agriculture (Mackessy 2005). In Lincoln County, they are found in an area with grama grass (*Bouteloua* spp.), buffalograss (*Buchloe dactyloides*), sandsage (*Artemisia* spp.), and bluestem (*Andropogon* spp.) (Mackessy 2007). In the spring, massasaugas moved from their shortgrass prairie hibernaculum area to sandsage and sandhills for the summer season; in the fall, they reversed movements. *Id*. Prey abundance and diversity was greater in the sandsage/sandhill area than the shortgrass prairie habitat. *Id*. This area appears to provide optimum habitat, with shortgrass prairie providing hibernacula and midgrass prairie furnishing abundant prey and cover from predators (Mackessy 2005).

In Arizona, the desert massasauga is found primarily in tobosa (*Hilaria mutica*) grassland along sloping bajadas with surface rocks (Holycross and Douglas 1996, cited in Hobert et al. 2004). Open shortgrass prairie habit used by the taxon in Colorado is structurally similar to that used in southeastern Arizona (Hobert et al. 2004). In New Mexico, the desert massasauga uses shinnery oak, Chihuahuan desert grassland, and shortgrass prairies with sandy soils (Degenhardt et al. 1996). In both Texas and Mexico, the desert massasauga is associated with water sources such as wetlands or riparian areas (NatureServe 2010b).

Life History

Activity. The desert massasauga hibernates from late October to mid-April (Mackessy 2005). Rodent burrows are likely important refugia during this period (Mackessy 2007;

[3]USFWS (2009b) and WildEarth Guardians (2008) document the severe diminishment of shinnery oak habitat in New Mexico and Texas due to use of herbicides in deliberate oak eradication attempts. This practice harms several imperiled species dependent on shinnery oak, including the sand dune lizard (*Sceloporus arenicolus*) and lesser prairie-chicken (*Tympanuchus pallidicinctus*), which are currently candidates for ESA listing. See also Zwartjes et al. (2005).

NatureServe 2010b). The desert massasauga is most active at temperatures of 14-30°C, with an average ambient temperature during activity of 22.1°C (Mackessy 2005, 2007). Snakes retreat to underground refugia when air temperatures exceed 32.4°C. *Id*. In Colorado, when evening temperatures fall rapidly during the spring and fall, massasaugas were seen crossing roads in morning and late afternoon. During the summer, these snakes are more nocturnal, with their primary active hours between 7-9pm (Mackessy 2005). In Arizona, the taxon is described as nocturnal (Lowe et al. 1986, cited in Hobert et al. 2004).

These snakes can move up to 2 km from their hibernaculum to foraging areas (Mackessy 2005, 2007). During the summer, they generally travel short distances and are often observed at the base of sandsage in ambush or resting coils, which helps with thermoregulation and provides cover from predators (Mackessy 2005, 2007). Mackessy (2005, 2007) documented daily movements ranging from 1-350 m.

Diet. This taxon feeds primarily on lizards, small mammals, and centipedes; this diet comprised nearly 99% of the stomach contents of three populations of massasauga. The diet was homogenous between the sampled populations' groupings (Holycross and Mackessy 2002; Mackessy 2005). In Colorado, lizards comprised 59.4% of the desert massasauga's diet (Mackessy 2007). Prey includes lizards (*Aspidoscelis sexlineata*, *Holbrookia maculata*, *Sceloporus undulatus*), small rodents (*Dipodomys ordii*, *Onychomys leucogaster*, *Perognathus flavescens* and *P. flavus*, *Reithrodontomys megalotis*), and centipedes (*Scolopendra* spp.) (Mackessy 2005). Prey items are related to the snake's size: the longest snakes consumed more mammals; followed by those who fed more on centipedes; and the shortest snakes consumed more lizards (Holycross and Mackessy 2002; Mackessy 2005). Relatedly, juveniles tended to feed more on lizards and less on mammals. *Id*. Desert massasaugas measuring less than 250 mm snout-to-vent length (SVL) appear to feed almost exclusively on lizards. *Id*.

Reproduction and Longevity. Male desert massasaugas likely mature at the end of their second year or beginning of their third year, and females mature during their third year (Mackessy 2005). The average snake encountered in Colorado studies was three years old, despite captive lifespans of more than 14 years and the potential to live 20 years or more. *Id*. This indicates that an adult female desert massasauga may reproduce only once during her lifetime with a total reproductive output of 7 young (Goldberg and Holycross 1999; Mackessy 2005). Only a portion of the sexually mature female population may reproduce each year (Mackessy 2005). Holycross (2003) found just 15% of adult females in Arizona and Colorado studies to be reproductively active.

For approximately three weeks before giving birth, females become very stationary, basking inside or near a rodent burrow (Mackessy 2007). Females give birth to 5-7 young in August or September, although there may be biennial reproduction (Hobert et al. 2004; Mackessy 2005, 2007). They attend their young for at least five days after birth, and the young remain near their natal burrow until their first shed. *Id*. The timing of desert massasauga births closely matches that of lizards, their primary food item. *Id*. Neonates in Arizona measured 162-177 mm SVL and weighed 3.4-5.1 g (Mackessy

2005). In Colorado, average SVL of neonates was 148 mm and weight 3.46 g. *Id*. They may grow by 20% in the month after birth. *Id*. Predation pressure on neonates is likely heavy and a low number of second year snakes were captured in Colorado studies; survivorship may therefore be low. *Id*.

Figure 2: Female Desert Massasauga with young at rodent burrow entrance. Arrowhead indicates female snake's head, and two young snakes are visible to her right. Source: Mackessy 2007.

Courtship behavior has not been observed in the wild, but it has been documented in captivity (Mackessy 2005). As Mackessy (2005: 28) describes:

> The male snake rubs his chin on the female's head and neck, and his tail is looped over the female's tail, perhaps as a precopulatory behavior. Copulation involves insertion of one of the hemipenes in the female's vent, and snakes may remain coupled for several hours.

Figure 3 is a graphical representation of the desert massasauga life cycle.

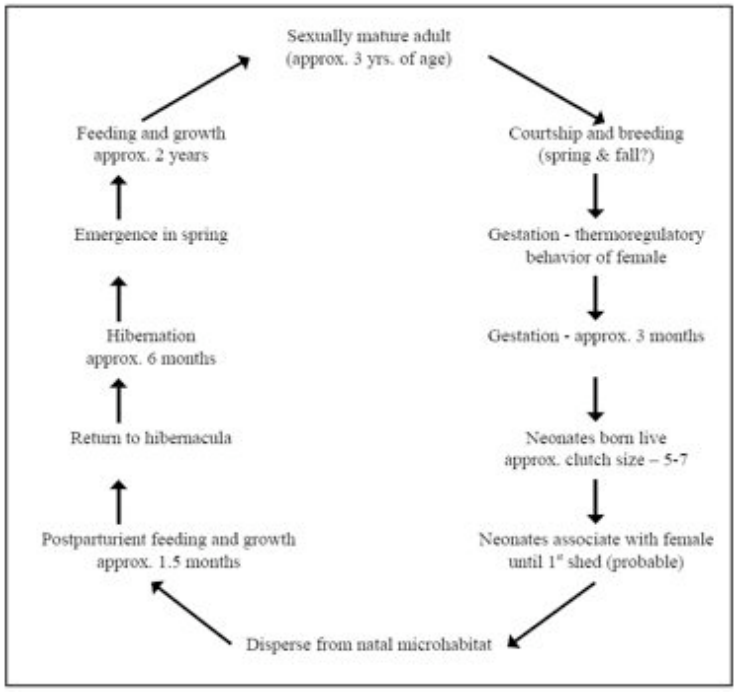

Figure 3: Life cycle of the desert massasauga. Source: Mackessy 2005.

Social Behavior. Unlike communally denning prairie rattlesnakes (Klauber 1956), desert massasaugas had been thought to hibernate individually (Mackessy 1998). However, new information suggests that the massasauga may also communally den (Mackessy 2005, 2007). Home ranges likely overlap, but are estimated at 100-1,000 acres (Mackessy 2005). No records of male-male combat, as occurs among several of the larger rattlesnake species, are known for desert massasaugas. *Id*.

Defensive Behavior. Desert massasauga employ the characteristic rattle to warn of strikes. They are known as passive or shy snakes which often prefer to remain cryptic to avoid threats.

Population Status and Trends

Scientists describe the full species of massasauga as imperiled and suffering from localized declines throughout its range (Holycross and Mackessy 2002; Hobert et al. 2004; Mackessy 2005; NatureServe 2010b). States Mackessy (2005: 7),

> Based on human population growth trends in the southwestern United States and subsequent degradation of habitat quality, it is likely that most populations are in decline, some precipitously, others much more slowly.

The desert massasauga subspecies is also imperiled:

> While the geographic range of this subspecies is often depicted as continuous, it actually consists of a series of isolated populations, many of

> which are declining, extirpated, or perceived at risk (Anderson et al. 2009: 740).

Populations in Arizona are known to be severely reduced from their historic levels due to habitat loss from agriculture and desertification (Lowe et al. 1986; Holycross and Mackessy 2002; Zwartjes et al. 2005; Anderson et al. 2009). The Arizona Game and Fish Department (2001) reports just two populations, located in the southeast portion of the state. Anderson et al. (2009) describe just one extant population in Arizona. This species is believed to once have had a semi-continuous distribution in the lowland grasslands of Arizona and New Mexico (forthcoming C. Anderson and A. Holycross). In New Mexico, the desert massasauga may persist in the lower Rio Grande Valley, but likely only at low densities, as very few individuals have been documented in the past two decades; larger populations occur in the shortgrass prairie of the central Rio Grande Valley, but their habitat is being lost to development (Anderson et al. 2009). The massasauga is considered to be declining in Texas (Werler and Dixon 2000). Populations in Mexico are described as highly localized and disjunct (Mackessy 2005). Ernst and Ernst (2003) consider much of the desert massasauga's original habitat to have been lost in the southwest U.S. to overgrazing. In Colorado, while there is a relatively large population in Lincoln County, elsewhere the taxon has declined or is limited to small populations (Hobert et al. 2004; Mackessy 1998, 2005, 2007). On the national grasslands in Colorado, it is likely that populations have decreased over the last 50 to 100 years, and they are now considered uncommon to rare (Mackessy 2005). Colorado populations of desert massasaugas are discontinuous with all other populations except perhaps those in western Kansas and in western Oklahoma. This lack of connectivity between the various populations may gradually lead to genetic divergence. *Id*. Anderson et al. (2009) and Mackessy (2005, 2007) mention the high conservation value of individual populations of massasaugas to preserve genetic diversity and secure the future of this rattlesnake.

The population of desert massasauga in Lincoln County, Colorado is the largest known to exist (Mackessy 2005, 2007). The size of this population of desert massasaugas may approach 5,000 to 10,000 individuals. *Id*. The landowners managing the habitat of the Lincoln County population are to be commended for preserving the native plant communities that are providing optimum habitat for this taxon. A population was rediscovered in Baca County, Colorado in 1997, but it may be imperiled by conversion to cropland (Mackessy 2005, 2007). Overall, populations in Colorado appear threatened by urbanization and crop agriculture (Hobert et al. 2004; Mackessy 2007). Mackessy (2005) suggests that, given low fecundity and survivorship, the desert massasauga's ability to rebound from significant population declines is likely very poor.

Qualification as Distinct Population Segment

If FWS declines protection for the desert massasauga, Petitioners request the agency consider listing populations of the taxon in Colorado, Kansas, and Oklahoma populations as a DPS under the ESA. The ESA specificies that a DPS can only be designated for vertebrates (16 U.S.C. § 1532(16)). In 1996, FWS (and the National Marine Fisheries

Service) established a set of guiding principles[4] for defining a DPS. 61 FR 4722. To qualify as a DPS, a population must be discrete from other populations of the species and significant to the species:

> *Discreteness:* A population segment of a vertebrate species may be considered discrete if it satisfies either one of the following conditions:
> 1. It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation.
> 2. It is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act.
>
> *Significance:* If a population segment is considered discrete under one or more of the above conditions, its biological and ecological significance will then be considered in light of Congressional guidance…that the authority to list DPS's be used…"sparingly" while encouraging the conservation of genetic diversity. In carrying out this examination, the Services will consider available scientific evidence of the discrete population segment's importance to the taxon to which it belongs. This consideration may include, but is not limited to, the following:
> 1. Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon,
> 2. Evidence that loss of the discrete population segment would result in a significant gap in the range of a taxon,
> 3. Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range, or
> 4. Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

Id. at p. 4725. Notably, the policy does not require absolutive reproductive isolation nor does it require genetic evidence of differentiation.

Discreteness – The Colorado, western Kansas, and western Oklahoma populations of the desert massasauga are discrete from other populations throughout its range. States Mackessy (2005: 15):

> Currently, Colorado populations (including those in National Forest System lands) of desert massasaugas are discontinuous with all other

[4]The Services describe the policy as "non-regulatory in nature" (61 FR 4722 at p. 4723) and "guiding principles" (*Id*. at p. 4725), and they therefore should be considered policy guidance, rather than regulation.

> populations except (perhaps) those in western Kansas (i.e., Cimarron National Grasslands, if they exist) and in western Oklahoma.

Significance – The loss of desert massasaugas from the Colorado, western Kansas, and western Oklahoma portion of its range would produce an important and significant gap in the distribution of the taxon. In addition, the shortgrass prairie and sandsage habitat in this portion of its range is distinct from habitat found farther south in the Chihuahuan Desert. Finally, the lack of connectivity between the populations in Colorado, Kansas, and Oklahoma may lead to genetic divergence with desert massasaugas elsewhere (Mackessy 2005). Mackessy (2005: 32) states: "comparisons between desert massasaugas from Colorado and from Arizona, southern New Mexico, and Texas likely would indicate genetically distinct populations."

After meeting the discreteness and significance tests, the final question is whether the proposed DPS warrants ESA protection. We outlined evidence earlier in this petition that, within the DPS area, the desert massasauga in this area has been reduced to just one sizable and robust population with other populations generally small. Further, as we demonstrate below, the snake is threatened by at least four and possibly five ESA listing factors (even though it need only meet one), and therefore warrants protection as a Threatened or Endangered DPS under the ESA.

Why protect this DPS? In its 1996 DPS policy, FWS provided a compelling reason:

> Listing, delisting, or reclassifying distinct vertebrate population segments may allow the Services to protect and conserve species and the ecosystems upon which they depend before largescale decline occurs that would necessitate listing a species or subspecies throughout its entire range. This may allow protection and recovery of declining organisms in a more timely and less costly manner, and on a smaller scale than the more costly and extensive efforts that might be needed to recover an entire species or subspecies. The Services' ability to address local issues (without the need to list, recover, and consult rangewide) will result in a more effective program.

61 FR 4722 at p. 4725. All of the threats discussed below apply at both the DPS and subspecies level. Populations in Arizona, Colorado, New Mexico, Texas, and Mexico are likely experiencing declining population trends, which will almost certainly become more severe unless: their habitat is protected; research is funded; individuals are safeguarded from killing, round-ups, and collection; and safe road passages are provided. Our petition presents FWS with the opportunity to list either the desert massasauga subspecies or the proposed DPS as steps toward recovering massasaugas across their entire range.

Identified Threats to the Petitioned Species: Criteria for Listing

The Petitioned species meets at least four of the criteria for listing under the ESA (bolded):

A. Present and threatened destruction, modification, and curtailment of habitat and range;
B. Overutilization for commercial and recreational purposes;
C. Disease or predation;
D. The inadequacy of existing regulatory mechanisms; and
E. Other natural or manmade factors affecting its continued existence.

Threats to the petitioned taxon include habitat loss and degradation (Factor A), intentional killing and collection for the pet trade (Factor B), inadequate regulatory protections (Factor D), and low fecundity, low survivorship, loss of genetic diversity, small populations, and climate change (Factor E). Disease and predation may also be threats, as well as the intersection nature of some of the threats, as discussed below. A driver for habitat destruction and intentional killing is human population growth. Scientists recognize that the desert massasauga faces a combination of pressures. For example, Anderson et al. (2009: 740) state:

> …anthropogenic effects such as desertification, encroachment by agriculture, road mortality, and/or extermination have been identified as significant causes of the decline and extirpation of populations.

Petitioners review these threats in more detail below.

A. Present and Threatened Destruction, Modification, or Curtailment of Habitat or Range

Habitat degradation and loss is a primary threat to the Petitioned taxon (Lowe et al. 1986; Werler and Dixon 2000; AGFD 2001; Holycross and Mackessy 2002; Ernst and Ernst 2003; Hobert et al. 2004; Mackessy 2005; Zwartjes et al. 2005; Anderson et al. 2009). Activities and dynamics that are compromising massasauga habitat include urbanization, conversion to crops, heavy livestock grazing, desertification, water diversion and depletion, and proliferation of noxious weeds (Mackessy 2005; Anderson et al. 2009). Mackessy (2005: 24) describes the loss of habitat in Colorado from agricultural uses:

> …in many areas, including much of the eastern portions of Kit Carson, Cheyenne, and Kiowa counties and large parts of the southern section of the Comanche National Grassland in Baca County, habitat alteration (primarily farming) has created large tracts of unusable habitat, leaving a discontinuous mosaic of appropriate native shortgrass prairie habitat. Although cattle grazing *per se* is compatible with conservation of the desert massasaugas, and ranching is highly preferable to other extractive land uses, some regions of formerly usable habitat are severely degraded due to overgrazing.

Urbanization in El Paso and Pueblo counties in Colorado is further reducing grassland habitat. *Id*. Conversion to tract homes in the Rio Grande Valley in New Mexico is destroying occupied shortgrass prairie habitat (Anderson et al. 2009). Urbanization brings with it the particular threat of roads, which both fragment suitable habitat and facilitate more human/massasauga encounters, which generally end in death for the snake, whether humans are on foot or intentionally or unintentionally strike the rattlesnake with their vehicle (Mackessy 2005). The desert massasauga can even suffer heavy mortality from rarely traveled rural dirt roads. *Id*. Loss of intact native habitats can also lead to increasing population isolation. *Id*. Increasing road densities may fragment habitat to such an extent that a minimum threshold for habitat size may be crossed and populations may decline significantly. *Id*.

Energy development, including oil and gas drilling and wind farms, adversely affects desert massasaugas because of the high density road networks and habitat fragmentation that accompany such endeavors. This taxon's range overlaps with the Permian Basin in New Mexico and Texas, which has very high and increasing densities of petroleum wellpads and roads (WildEarth Guardians 2008). Significant new wind energy development is underway in the desert massasauga's range in Kansas, Colorado, New Mexico, Oklahoma and Texas. These states all rank among the top 12 states in the U.S. for wind energy (USFWS 2009b). FWS has documented how this energy development fragments native habitat with roads, transmission lines, and other infrastructure. *Id*.

Because of the importance of rodent burrows for massasauga hibernacula and the critical importance of hibernacula (Mackessy 2005, 2007; NatureServe 2010b), FWS should consider declining rodent populations as a threat to the desert massasauga. A keystone species in the massasauga's range, the black-tailed prairie dog, has undergone declines of more than 98% over the past century (WildEarth Guardians 2007; 75 Fed. Reg. 63343-63366). In the desert massasauga's range in Colorado, extensive sylvatic plague (*Yersinia pestis*) epizootics have resulted in drastic declines of this prairie dog species in southeastern Colorado in recent years (Augustine et al. 2008). These drastic decreases in prairie dog populations will eliminate usable burrows as well as reduce rich prey bases often available on prairie dog colonies.

Mesic areas (including those with more surface water availability) within the desert massasauga's range can create optimum habitat, such as that occupied by the taxon in Lincoln County. However, groundwater overuse, combined with drought, can dry up these mesic areas, limiting suitable habitat and potentially extirpating populations (Mackessy 2005). Desertification of grassland habitat, including shrub encroachment, in Arizona eliminated extensive desert massasauga populations there (Lowe et al. 1986; Holycross and Mackessy 2002; Holycross 2003; Anderson et al. 2009).

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

Wanton killing. Rattlesnakes, including massasaugas, are often killed on sight (Mackessy 2005). Intentional killing of massasaugas, including during organized "rattlesnake round-ups" is a significant threat, even in states where take is restricted. For example,

> In Colorado, the desert massasauga occurs in areas where the possibility for active protection (from take or wanton destruction) by wildlife managers or law enforcement personnel is quite unlikely; personnel are too few and the area is too large. It is probable that most people kill massasaugas and other rattlesnakes on sight... (Mackessy 2005: 9).

During either contest kills or because of the ubiquitous practice of killing rattlesnakes on sight, populations can be extirpated from this threat alone. The Sweetwater, Texas rattlesnake roundup bills itself the "World's Largest Rattlesnake Round-Up!" (See Figures 4 & 5). The best available population data indicate that the edge boundary of desert massasauga habitat extends no farther east than Sweetwater, Texas. See Figure 1.

Figure 4: Online Promotion of Sweetwater, Texas Rattlesnake Roundup.
Source: http://www.themorningnews.org (Accessed October 2010).

Figure 5: Online Promotion of Sweetwater, Texas Rattlesnake Roundup.
Source: http://www.themorningnews.org (Accessed October 2010).

States Mackessy (2005: 40):

> Rattlesnake roundups occur in many states (perhaps all?) where rattlesnakes occur, often with the blessing of local community officials. These campaigns of destruction can be incredibly harmful to populations on a broad scale, as participants may travel long distances to collect snakes. Additionally, once one knows where to look most productively for rattlesnakes, one can efficiently remove significant numbers from a population. At one annual rattlesnake roundup in Sweetwater, Texas, upwards of 10,000 snakes are killed during the several days of "festivities". Since the inception of roundups in Sweetwater in 1958, over 123 tons of western diamondbacks (*Crotalus atrox*) have been killed (http://www.rattlesnakeroundup.com/home.html), yet the organizers still question whether or not this harvest has a deleterious effect on populations.

Notably, FWS (2009a: 5) recognizes this threat for the eastern massasauga:

> The over-collection of massasaugas is well documented, and the effects of past anti-rattlesnake campaigns are still visible today. Several populations have been collected beyond a recoverable threshold, and thus, are functionally extinct. Intentional killing and illegal collection continue.

The same attitude and practices apply to the desert massasauga.

Pet trade. Recreational collection of desert massasauga may be a threat but it is hard to quantify (Mackessy 2005). Desert massasaugas are currently for sale commercially from exotic pet traders and may be prized because of their small size. *Id*. A recent online price for a desert massasauga is $125.00,[5] a value that may increase the incentive for collection for sale both in the U.S. or abroad.

C. Disease or Predation

Predation. Currently predation is not known to be a significant threat to the desert massasauga. However, given its low fecundity, low survivorship, and other threats, predation may compound the risk of population extirpation. FWS (2009a) recognized the intersecting threats of habitat loss and predation for the eastern massasauga. Potential predators of desert massasaugas include raptors, mammals, and several types of snakes (Mackessy 2005). Swainson's hawks (*Buteo swainsoni*) and northern harriers (*Circus cyaneus*) are known snake predators. Most hawks, eagles, and owls, are likely predators of desert massasaugas, as are shrikes. Mammalian predators include badgers (*Taxidea taxus*), coyotes (*Canis latrans*), foxes (*Vulpes* spp.), longtail weasels (*Mustela frenata*), skunks (*Mephitis* spp.), and raccoons (*Procyon lotor*). Potential snake predators include racers (*Coluber constrictor*), coachwhips (*Masticophis flagellum*), milk snakes (*Lampropeltis triangulum*), and kingsnakes (*L. getula holbrookia/splendida*). *Id*.

Disease. While scientists have not yet documented bacterial and viral diseases to be a threat to rattlesnakes in the wild, a potentially devastating fatal disease is paramyxovirus (Mackessy 2005). If released to the wild, it could lead to drastic population declines.

D. The Inadequacy of Existing Regulatory Mechanisms

Because the primary threats to the desert massasauga are habitat destruction and direct killing, sufficient regulatory mechanisms would both safeguard habitat and limit intentional killing. However, most states in the range of this taxon not only do not outlaw killing, but allow organized contests in which thousands of rattlesnakes (including massasaugas) can be killed in the course of just a few days (Mackessy 2005).

There is little protection for the habitat on which the desert massasaugas depend. Mackessy (2005: 3) recommends protected, no-take status rangewide and "[p]rotection and conservation of large, contiguous tracts of native shortgrass prairie habitat" whether on public or private land. To Petitioners' knowledge, binding protections for these tracts – whether through agency action or conservation easements – have not yet been obtained. In addition, road-kill is a significant threat, and scientists recommend barriers and underpasses to reduce this threat (Mackessy 2005; Anderson et al. 2009). We are unaware of whether these mitigations have been implemented within the desert massasauga's range. FWS (2009a) points out that, for the eastern massasauga (an ESA candidate), despite some degree of protection at the state level throughout its range, regulatory shields for its habitat are almost nonexistent. The situation is likely much

[5] See http://www.gherp.com/pricelist.php?filterCat=Venomous (Accessed October 2010).

worse for the desert massasauga, which is neither an ESA candidate nor is it afforded protections throughout its range.

State Regulations

Arizona. There is a year-round closed hunting season for the taxon (Holycross 2003). State law does not allow the taking of desert massasauga from the wild pursuant to Arizona Game and Fish Commission Order 43 (AGFD 2001). However, the general public likely cannot differentiate between the massasauga and other types of rattlesnakes, most of which can be collected or killed in the state, with a bag limit of 4.[6] Anderson et al. (2009) note continued illegal collection in their study area in Arizona.

Colorado. The massasauga is designated as nongame wildlife in the state, and take is therefore prohibited except under specific circumstances, such as scientific collection and rehabilitation (CDOW 2009). The Colorado Division of Wildlife (CDOW) also lists desert massasaugas as a state species of special concern, but this designation confers no protection. The state does not include this taxon in its Conservation Plan for Grassland Species in Colorado.

While take of the massasauga is regulated, there is no evidence that those protections are enforced. A season exists for the prairie rattlesnake from June 15-August 15, with a daily bag limit of 3 and a possession limit of 6 (CDOW 2010). In addition, state law provides additional take by anyone: "Any person may kill skunks or rattlesnakes when necessary to protect life or property." C.R.S. § 33-6-107(9). The general public, including hunters, are unlikely to be able to differentiate between the prairie rattlesnake and the desert massasauga (Mackessy 2005). Moreover, CDOW provides no identification guide for hunters to make this distinction. CDOW also does not mention the massasauga or acknowledge that it is different from the prairie rattlesnake in its online guide of herptiles in the state (CDOW 2001). Mackessy (2005) reports several incidents of illegal collection near the Lincoln County, Colorado population.

Kansas. The Kansas Department of Wildlife and Parks (KDWP) has extensive regulations concerning the conduct of rattlesnake round-ups. However, these regulations provide significant protections to neither prairie rattlesnakes or massasaugas (except that Morton County (the southwesternmost county) is not open for commercial taking of rattlesnakes). Massasaugas and desert massasaugas are nowhere mentioned in these regulations (KDWP 2010), are not differentiated from other rattlesnake species or subspecies, and lack any protections in the state.

Oklahoma. The Oklahoma Department of Wildlife Conservation (ODWC) allows hunting of massasaugas, with no daily limit, from March 1-June 30. ODWC also permits organized rattlesnake round-ups (ODWC 2010).

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[6]See http://www.azgfd.gov/pdfs/h_f/regulations/ReptileAmphibian.pdf and http://www.azgfd.gov/w_c/arizona-rattlesnakes.shtml [Accessed October 2010].

New Mexico. The state annual bag limit on massasaugas is 5. However, the bag limit on prairie rattlesnakes, with which the general public may confuse them, is 20 (NMDGF 2009).

Texas. Texas designates the massasauga a "white-list" species, which means up to 25 snakes can be taken *without* a non-game permit.[7] Rattlesnake round-ups are common and take place in Texas during several months of the year.[8]

Mexico. The taxon is designated as "Subject to Special Protection" in Mexico (Mackessy 2005). It is not known whether legal safeguards are being enforced in Mexico.

Federal Regulations

U.S. Fish and Wildlife Service. Neither the massasauga or desert massasauga benefit from any safeguards under the ESA, as no massasaugas are listed under the statute. The eastern massasauga has awaited federal listing since October 1999 as an ESA candidate (USFWS 2009a). Such status provides no ESA protective regulations.

U.S. Forest Service. The desert massasauga is designated as a sensitive species in the Rocky Mountain Region of the U.S. Forest Service (which covers the Colorado and Kansas portion of its range) (Mackessy 2005). This status confers no regulatory protections. This taxon is known to occur on the Comanche National Grassland in Colorado and may also occur on the Cimarron National Grassland in Kansas (Mackessy 2005). It receives no protection on either of these areas.

U.S. Bureau of Land Management. The desert massasauga is designated as a sensitive species by the Colorado office of the Bureau of Land Management (BLM),[9] but the taxon is not known to occur on BLM lands in the state (Mackessy 2005).

Conservation Rankings

While important for signaling imperilment, these designations provide no regulatory safeguards for species.

NatureServe. NatureServe ranks the desert massasauga as T3, which equates to "vulnerable" (NatureServe 2010a). Its state status is S1 (Critically Imperiled) in Arizona, S2 (Imperiled) in Kansas, and SNR (Species Not Ranked) in Oklahoma. *Id*. For the full species, Colorado is ranked S2 (Imperiled), and New Mexico and Texas are ranked S3S4 (Vulnerable or Apparently Secure) (NatureServe 2010b).

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[7]See http://www.tpwd.state.tx.us/faq/huntwild/white_list.phtml and http://www.tpwd.state.tx.us/faq/huntwild/nongame_permits.phtml (Accessed October 2010).
[8]See http://www.rattlesnakerecipe.us/roundup.htm (Accessed October 2010).
[9]See http://www.blm.gov/co/st/en/BLM_Programs/botany/Sensitive_Species_List_.html (Accessed October 2010).

NatureServe (2010b) indicates that rangewide conservation planning is required for the full species of massasauga. This planning has not occurred. NatureServe scientists further recommend protection of massasauga hibernacula and habitat. *Id*.

IUCN. The IUCN ranks the massasauga as "Least Concern" but does not provide a ranking for the desert massasauga (Frost et al. 2007). The full species is considered to be declining in nearly every U.S. state, in both area occupied and abundance. *Id*. IUCN scientists also recommend further conservation measures. *Id*.

E. Other Natural or Manmade Factors Affecting its Continued Existence

Human-caused mortality. In addition to intentional killing discussed under Listing Factor B, this taxon suffers from heavy mortality from unintentional vehicular collisions, and this should be considered a significant threat. As road densities increase within their range, these mortality rates will likely rise (Mackessy 2005). Massasaugas are vulnerable to road strikes because they gravitate towards warm road surfaces and are especially active at night during the summer (Holycross 2003; Mackessy 2005). Studies have found 35-39 percent of all desert massasauga encounters were road-killed snakes (Mackessy 1998, 2005). In Arizona, half of the desert massasaugas encountered on the road were dead (Holycross 2003).

Biological Vulnerability. The desert massasauga has relatively low fecundity, low survivorship, and a short lifespan in the wild, all of which may make the taxon more vulnerable to extinction (Mackessy 2005). Mackessy (2005: 30) notes that survivorship in the wild averages only 3 years, versus this snake's potential to live 20 years or more, and states:

> Predation, persecution by humans (killing), and/or disease may be important factors greatly limiting the survivorship potential for these small rattlesnakes in the wild.

FWS recognizes low fecundity of the eastern massasauga as a threat to that taxon (USFWS 2009a), and the desert massasauga's fecundity is likely even lower (Mackessy 2005). FWS also recognizes small population size as a threat to the eastern massasauga (USFWS 2009a), and small populations of desert massasaugas in Arizona, Colorado, Mexico, and elsewhere should likewise be considered at-risk.

FWS has also acknowledged the threat of small population size and rarity for other other species. For the Langford's tree snail (*Partula langfordi*), the Service relies on citations not specific to *Partula langfordi* that indicate the threat to survival presented by limited population numbers even without other known threats; for another imperiled snail (*Ostodes strigatus)*, FWS states, "[e]ven if the threats responsible for the decline of this species were controlled, the persistence of existing populations is hampered by the small number of extant populations and the small geographic range of the known

populations."[10] FWS should similarly analyze whether population size and isolation are threats to the desert massasauga or may become threats in the foreseeable future.

Fragmentation and isolation. As noted previously, habitat modification is leading to population isolation of the desert massasaugas and habitat fragmentation may lead to accelerated rates of decline of isolated populations (Holycross and Mackessy 2002; Hobert et al. 2004; Mackessy 2005).

Human population growth. Mackessy (2005) points to human population growth as a threat to this taxon, because this drives habitat loss and degradation, as well as increased intentional or unintentional killing of this rattlesnake. Three of the U.S. states in the desert massasauga's range were among the 10 fastest growing states in the country from 1990-2000: Arizona, Colorado, and Texas.[11] Indeed, population growth in these states has been exponential since 1960 (Figures 6-8).

Figure 6: Human Population Rise in Arizona.
Source: http://www.censusscope.org/ [Accessed October 2010].

Figure 7: Human Population Rise in Texas.
Source: http://www.censusscope.org/ [Accessed October 2010].

[10] Listing Form for *Partula langfordi* (2009), available at: http://ecos.fws.gov/docs/candforms_pdf/r1/G0AI_I01.pdf [Accessed May 2010]; Listing Form for *Ostodes strigatus* (2009), available at: http://ecos.fws.gov/docs/candforms_pdf/r1/G0A5_I01.pdf. [Accessed May 2010].
[11] See http://www.censusscope.org/ [Accessed October 2010].

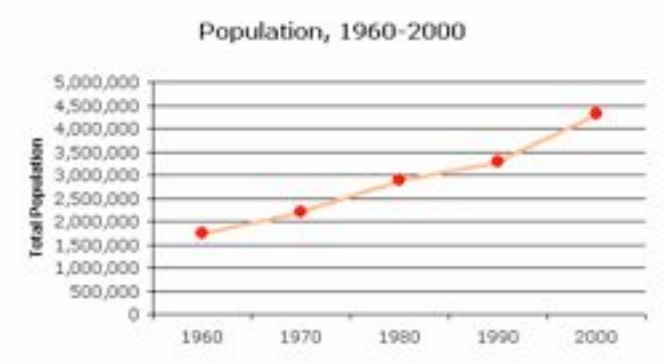

Figure 8: Human Population Rise in Colorado.
Source: http://www.censusscope.org/ [Accessed October 2010].

Drought & Climate Change. Although the desert massasauga occurs in xeric ecosystems, it seems to prefer more mesic habitat within those dry areas (Mackessy 2005). Drought, and more severe and frequent droughts due to climate change, therefore presents an additional limitation to this taxon. Indeed, Holycross (2003) suggested that climate change may be an especial threat to massasauga populations in the southwestern U.S. Anthropogenic climate change poses a fundamental challenge for species survival in coming years and decades. It is already causing a rise in temperatures across the United States and an increase in extreme weather events, such as droughts and increased rainfall (Parmesan et al. 2000; NSC 2003; CCSP 2008; Karl et al. 2009). Temperatures during the latter period of warming have increased at a rate comparable to the rates of warming that conservative projections predict will occur during the next century with continued increases of greenhouse gases. The 2007 report from the Intergovernmental Panel on Climate Change described the rising temperature trend (IPCC 2007: 30):

> Eleven of the last twelve years (1995-2006) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850). The 100-year linear trend (1906-2005) of 0.74 [0.56 to 0.92]°C is larger than the corresponding trend of 0.6 [0.4 to 0.8]°C (1901-2000) given in the TAR (Figure 1.1). The linear warming trend over the 50 years from 1956 to 2005 (0.13 [0.10 to 0.16]°C per decade) is nearly twice that for the 100 years from 1906 to 2005.

As climate change progresses, maximum high and minimum low temperatures are expected to increase, as are the magnitude and duration of regional droughts (IPCC 2001). The most recent IPCC report (IPCC 2007: 48) predicted the following impacts on ecosystems from climate change:

- The resilience of many ecosystems is *likely* to be exceeded this century by an unprecedented combination of climate change, associated disturbances (e.g. flooding, drought, wildfire, insects, ocean acidification) and other global change drivers (e.g. landuse change, pollution, fragmentation of natural systems, overexploitation of resources).

- Over the course of this century, net carbon uptake by terrestrial ecosystems is *likely* to peak before mid-century and then weaken or even reverse, thus amplifying climate change.

- Approximately 20 to 30% of plant and animal species assessed so far are *likely* to be at increased risk of extinction if increases in global average temperature exceed 1.5 to 2.5°C (*medium confidence*).

- For increases in global average temperature exceeding 1.5 to 2.5°C and in concomitant atmospheric CO_2 concentrations, there are projected to be major changes in ecosystem structure and function, species' ecological interactions and shifts in species' geographical ranges, with predominantly negative consequences for biodiversity and ecosystem goods and services, e.g. water and food supply.

In the desert massasauga's Great Plains range, climate change is expected to cause more extreme and frequent weather events that include droughts, heavy rainfall, and heat waves (Karl et al. 2009). Temperatures are expected to increase significantly. See Figure 9. The species may not be able to adapt to these changes. Karl et al. (2009: 126) described the predicted effects of climate change impacts to Great Plains ecosystems:

> Climate-driven changes are likely to combine with other human-induced stresses to further increase the vulnerability of natural ecosystems to pests, invasive species, and loss of native species. Changes in temperature and precipitation affect the composition and diversity of native animals and plants through altering their breeding patterns, water and food supply, and habitat availability. In a changing climate, populations of some pests such as red fire ants and rodents, better adapted to a warmer climate, are projected to increase.

Fischlin et al. (2007) proposed that the productivity, structure, and carbon balance of grassland ecosystems are extremely sensitive to climatic shifts. Root and Schneider (2001: 29) addressed how climate is likely to affect animals tied to particular vegetation types, such as the desert massasauga:

> The anticipated changes in plant ranges will probably have dramatic effects on animals, both on the large biogeographic scale and on the local scale. The ranges of many animals are strongly linked to vegetation. … Consequently, the ranges of various animals that rely on specific vegetation will change as the ranges of these plants shift, assuming that some other factor is not limiting these animals. If the climate changes more rapidly than the dispersal rates of the plants, it could result in extensive plant die-offs in the south or downslope before individuals can disperse and become established in the north and upslope. Thus the ranges of animals relying on these plants could become compressed, and in some instances, both the plants and the animals could become extinct.

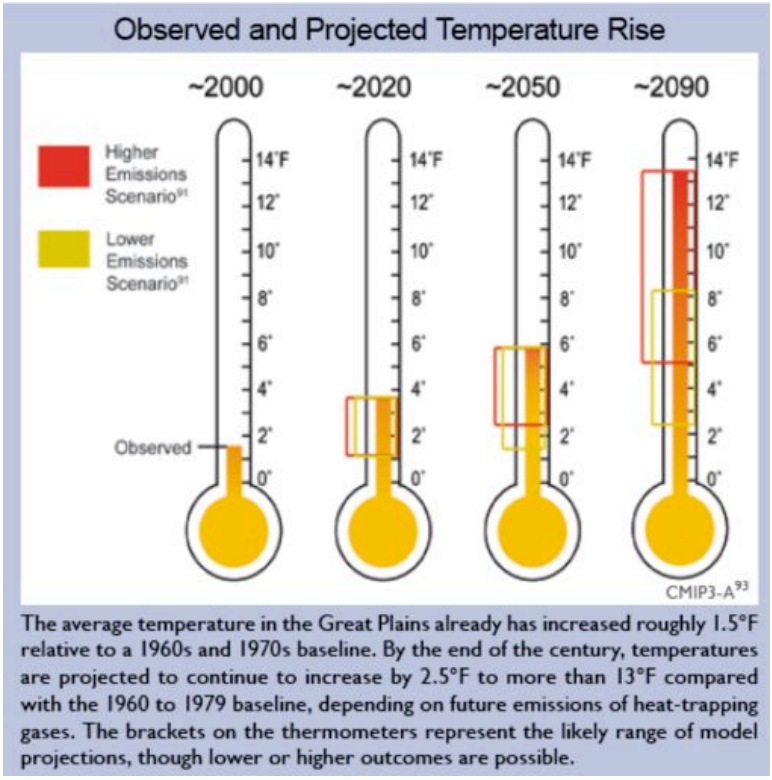

Figure 9: Predicted Temperature Increases in the Great Plains Due to Climate Change. Source: Karl et al. (2009).

Gibbons et al. (2000: 660) discussed the potential impacts of global climate change on reptiles:

> Although many habitats are expected to undergo dramatic change (e.g., Guertin et al.1997, Still et al. 1999), predictions of species habitat shifts in response to global warming cannot be based solely on analyses of climate–space changes, because species distributions are also a function of dispersal ability and biotic interactions (Davis et al. 1998). Existing nature reserves will be inadequate to preserve current biodiversity, because an already fragmented landscape will impede the ability of species to respond to climate-induced habitat changes (Halpin 1997). Because of their limited dispersal abilities, reptiles and amphibians are especially vulnerable to rapid habitat changes and may suffer many more extinctions than birds as a result of a rapid rate of climate change (Schneider and Root 1998).
>
> As with the amphibian studies, few researchers have directly assessed effects of climate change on reptiles. It is nonetheless reasonable to expect that climate changes could result in conditions that eliminate or severely restrict species with limited distributions (Schneider and Root 1998), as has been suggested for some Australian lizards (Brereton et al. 1995) and crotaline snakes of North America and the neotropics (Greene and

> Campbell 1993). Additional effects of warming on some reptiles, based on empirical evidence with freshwater turtles, include enhanced juvenile growth rates, earlier ages at maturity, and shifts in functional sex ratios (Frazer et al. 1993).

Climate change may already be negatively affecting the desert massasauga.

Cumulative threats. Many of the threats discussed under Listing Factors A-E intersect with or compound other perils. For example, greater road densities are both fragmenting habitat and increasing the risk of vehicular collisions, collection, and intentional killing; habitat loss and fragmentation is isolating populations and therefore increasing the risk of extirpation and declining genetic diversity; habitat loss may increase the pressure from predation; and drought and groundwater depletion together may render habitat unsuitable, even if the habitat is not converted to crops or urban uses. Other combinations of threats are possible; this list is not comprehensive. For the eastern massasauga, USFWS (2009a: 9) described synergistic threats as creating an "extinction vortex" for populations affected by multiple pressures. In the course of an ESA status review, FWS should consider how multiple perils are cumulatively threatening to the desert massasauga.

Summary & Requested Designation

The primary threats to desert massasauga populations are habitat loss and degradation due to urbanization, farming, heavy livestock grazing, and water table drawdown due to diversion and well water use; as well as persecution by humans. This snake faces an array of other threats as well. The desert massasauga has suffered declines throughout its range and appears to be rapidly vanishing from the southwestern U.S. and northern Mexico. Petitioner requests that the Secretary of Interior, acting through FWS, lists the desert massasauga rattlesnake under the ESA and designats critical habitat for this imperiled rattlesnake. Alternatively, Petitioner requests ESA listing for the distinct population segment that occurs in Colorado and adjacent Kansas and Oklahoma.

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