Species Status Assessment Report

for

Stephan's Riffle Beetle
(*Heterelmis stephani*)

Sylvester Spring. Photo by U.S. Fish and Wildlife Service

Version 1.0

2016

U.S. Fish and Wildlife Service
Region 2
Albuquerque, NM

This document was prepared by David R. Smith with assistance from Mary Richardson, Susan Oetker, Nathan Allan, and Stacey Stanford. We appreciate Cheryl Barr (University of California, Berkeley, retired), William Shepard (University of California, Berkeley), Michael Bogan (University of Arizona, Tucson), Randy Gibson (U.S. Fish and Wildlife Service, San Marcos, Texas), Jeff Sorensen (Arizona Game and Fish Department, Phoenix), Angela Barclay (Coronado National Forest, Tucson) and Jennifer Varin (Coronado National Forest, Tucson) providing peer review of a prior draft of this report.

Suggested reference:

U.S. Fish and Wildlife Service. 2016. Species status assessment report for Stephan's riffle beetle. Version 1.0, August, 2016. Albuquerque, NM. 39 pp.

Species Status Assessment Report for Stephan's Riffle Beetle (*Heterelmis stephani*)

Prepared by the Arizona Ecological Services Field Office
U.S. Fish and Wildlife Service

EXECUTIVE SUMMARY

This species status assessment is a comprehensive biological status review by the U.S. Fish and Wildlife Service (Service) for the Stephan's riffle beetle (*Heterelmis stephani*) and provides a thorough account of the species' overall viability and extinction risk. Stephan's riffle beetle is a small aquatic beetle only known from Bog Springs Campground and Sylvester Spring in Madera Canyon, Santa Rita Mountains in Pima and Santa Cruz Counties, Arizona. It was last documented from Sylvester Spring in 1993.

There is considerable uncertainty whether Stephan's riffle beetle is still extant or if it is extinct. Recent surveys have failed to detect this species. If the species is still extant, the best available information indicates it exists in very low numbers at only one location. Previous surveys in 1993 found only one specimen at Sylvester Spring, and the population may have been already experiencing a downward trend at that time. For the purpose of this species status assessment, we evaluated the Stephan's riffle beetle as if it were still extant, in low numbers, at its last known location in Sylvester Spring.

We expect the most significant stressor to the species would be the future loss of spring discharge that supports the habitat that individuals and populations need to complete their life history. Although Sylvester Spring was modified in the past to provide water to private landowners in Madera Canyon, water diversion to private landowners in Madera Canyon no longer occurs. Other concerns for maintaining local habitat conditions have been largely ameliorated through the management of the Coronado National Forrest (CNF).

We used the best available information to forecast the likely future condition of Stephan's riffle beetle, if the species is still extant. We describe the species viability that addresses the species' needs in terms of resiliency, redundancy, and representation. We considered two potential scenarios that may be important influences on the status of the species, and our results describe the range of possible conditions in terms which Stephan's riffle beetle populations may need to persist into the future, if still extant (Table ES-1).

Table ES-1. The scenario matrix using the primary factor of spring discharge.

Scenario	Factor (Changes in spring discharge)
1	Sylvester Spring experiences **no measureable drop** in spring discharge from drought or future climate change.
2	Sylvester Spring experiences an **elimination** of spring flow from drought or future climate change.

Table ES-2. Overall species status assessment summary for Stephan's riffle beetle.

3Rs	Needs	Current Condition	Future Condition (Viability)
Resiliency: Population (Large populations able to withstand stochastic events)	• Adequate spring discharge • Sufficient water quality • Free-flowing spring ecosystems • Appropriate substrate, aquatic vegetation, and coarse woody debris	2 known historical populations: The Bog Springs Campground population has been extirpated due to elimination of habitat. The Sylvester Spring population was last documented in 1993, but habitat condition remains high.	Projections based on spring flow scenarios: • **No change**: The Sylvester Spring population, if still present, is likely to remain extant into the future • **Spring flow is eliminated**: The Sylvester Spring population would be extirpated.
Redundancy (Number and distribution of populations to withstand catastrophic events)	Multiple populations throughout the range of the species.	Habitat is still present at only 1 of the 2 previously known occupied sites (Sylvester Spring).	Projections based on spring flow scenarios: No redundancy. • **No change**: The Sylvester Spring population is likely to remain extant into the future. • **Spring flow is extremely reduced or eliminated**: The Sylvester Spring population would be vulnerable to extirpation
Representation (genetic and ecological diversity to maintain adaptive potential)	• Genetic variation exists between populations • Ability to survive under different habitat conditions (spring discharge rates, substrate types, and habitat structure)	The level of genetic variation and interbreeding within Sylvester Spring is unknown.	Projections based on spring flow scenarios: No Representation none. • **No change**: The Sylvester Spring population is likely to remain extant into the future, maintaining current genetic variation • **Spring flow is eliminated**: The Sylvester Spring population would be vulnerable to extirpation.

If the species remains extant at the one previously known location, our primary concern for the future persistence of this population is related to the effects of future droughts that could decrease winter precipitation levels and eliminate spring discharge at Sylvester Spring. This would result in the extirpation of the one possibly extant population. In any future circumstance, the best available information suggests the species viability is characterized by one population (with resiliency limited by presumed low numbers of individuals) and no redundancy and no or extremely limited representation.

Table of Contents

EXECUTIVE SUMMARY iii
CHAPTER 1. INTRODUCTION 1
CHAPTER 2. BIOLOGY AND LIFE HISTORY 3
2.1 Taxonomy 3
2.2 Morphological Description 3
2.3 Life History 3
2.4 Reproduction 4
2.5 Ecology 4
2.6 Habitat 6
CHAPTER 3. CURRENT CONDITION 8
3.1 Range and Distribution 8
3.2 Current Condition of Historical Locations 11
3.3 Current Condition of Populations 12
3.4 Current Stephan's Riffle Beetle Habitat Conditions 13
3.5 Summary of Current Conditions 14
CHAPTER 4. FACTORS INFLUENCING VIABILITY 17
4.1 Introduction 17
4.2 Local Habitat Modifications 17
4.3 Natural Stochastic Events 18
4.4 Spring Discharge Loss 18
CHAPTER 5. SPECIES VIABILITY 21
5.1 Introduction 21
5.2 Resiliency 21
5.3 Redundancy 22
5.4 Representation 23
5.5 Status Assessment Summary 23
LITERATURE CITED 24
APPENDIX A A-1

CHAPTER 1. INTRODUCTION

Stephan's riffle beetle, *Heterelmis stephani* (Coleoptera: Elmidae) is known from Bog Springs Campground and Sylvester Spring on the Coronado National Forest in Madera Canyon in the Santa Rita Mountains, Pima and Santa Cruz Counties, Arizona (Barr and Shepard 1993, pp. 2, 11). Stephan's riffle beetle was made a candidate for listing under the Endangered Species Act of 1973, as amended (Act), in 2002 (67 FR 40657, p. 40662). The identified threats used to warrant its candidacy were as follows:

- The springs where Stephan's riffle beetle is known to occur no longer exist in their natural conditions; all have been boxed, capped, or channeled into pipes;
- The type locality, where the species was first collected, no longer exists or provides suitable habitat;
- Recreationists may unwittingly degrade the spring habitat;
- Spring-dependent organisms whose populations exhibit a high degree of geographic isolation, such as Stephan's riffle beetle, are extremely susceptible to random extinction resulting from uncharacteristic natural disasters such as fires, floods, or changes in spring water chemistry; and
- Currently, no State or local government programs exist that address the conservation of rare and imperiled insects such as this beetle.

This Species Status Assessment (SSA Report) was completed recognizing the high level of uncertainty that the Stefan's riffle beetle is actually still extant and not extinct. Extinction of a species is difficult to impossible to prove, and there is inherent uncertainty in drawing an absolute conclusion of extinction. If Stephan's riffle beetle is still extant, we assume the population is in very low numbers.

This SSA Report reviews the species' biology and threats, evaluates its biological status, and assesses the resources and conditions needed to maintain long-term viability, if still extant. This SSA Report will be updated as new information becomes available and will be used to support all functions of the Service's Endangered Species Program from Candidate Assessment to Listing to Consultations to Recovery. This SSA Report is a living document upon which listing rules, recovery plans, and 5-year reviews, would be based if the species warrants listing under the Act.

This SSA Report provides a review of the available information strictly related to the biological status of Stephan's riffle beetle. Importantly, the SSA Report does not result in a decision by the Service on whether this species should be proposed for listing as a threatened or endangered species under the Act. The Service will make a listing decision after reviewing this document and all relevant laws, regulations, and policies, and the results of a proposed decision will be announced in the Federal Register, with appropriate opportunities for public input.

The Service defines viability as the species' ability to sustain populations in natural spring ecosystems beyond a biologically meaningful timeframe. In this case, we chose 50 years as a meaningful timeframe because it is within the range of the available hydrological and climate change model forecasts (see IPCC 2014, entire; Jaeger *et al*. 2014 entire). Additionally, because

of the two to six-year generation time we assume is characteristic of the Stephan's riffle beetle (extrapolated from other riffle beetle life history information in Brown 1987, p. 254), 50 years encompasses approximately 8 to 20 generations, which is a relatively long time in which to observe effects to the species.

CHAPTER 2. BIOLOGY AND LIFE HISTORY

This chapter provides basic biological information about the Stephan's riffle beetle, including its taxonomy and relationships, morphological description, reproductive and other life history traits, and physical environment. Due to the lack of biological and ecological information for the Stephan's riffle beetle, we extrapolated information from other documents discussing other riffle beetle species from the same genus (*Heterelmis*) and different genera where needed.

2.1 Taxonomy

Stephan's riffle beetle is one of five known species in the genus *Heterelmis* found in the United States (Brown 1972, p. 236; Bosse *et al.* 1988, p. 199). The species was originally described by Brown (1972, p. 230) from specimens collected at the Bog Springs Campground in Madera Canyon, Pima County, Arizona. The taxonomy of the species has not been disputed, and *Heterelmis stephani* is considered a valid taxon. There is no specific genetic information available for Stephan's riffle beetle.

Class: Insecta
Order: Coleoptera
Family: Elmidae
Subfamily: Elminae
Genus: *Heterelmis*
Species: *stephani*

2.2 Morphological Description

Brown (1972, pp. 230-233) describes the Stephan's riffle beetle as a small beetle with total length between 2.3 and 2.6 millimeters (mm) (Figure 2.2.1). For a more detailed description and thorough review of the morphological characteristics of Stephan's riffle beetle see Brown (1972, pp. 230-233).

Figure 2.2.1 Pinned specimen of Stephan's riffle beetle (University of Arizona Collection). Photo by University of Arizona.

2.3 Life History

Life history information for Stephan's riffle beetle is limited; most of what we present must be extrapolated from literature on other riffle beetle species from the genus *Heterelmis* and species

from other genera. A brief synopsis of life history requirements is presented below in Table 2.3.1.

Table 2.3.1 Resource requirements for major riffle beetle life stages (extrapolated from general literature on riffle beetles).

Life Stage	Resource Needs (Habitat)
Eggs (5 to 15 days)	• Presence of submerged rocks, logs, or plants to attach eggs. • Perennial water.
Larval Stage (0.5 to 3 years)	• Submerged coarse woody debris with heavy volumes of biofilm and loose bark and/or interstitial spaces that are used as a food base and shelter. • Perennial to semi-perennial water that provides moist or saturated substrate.
Pupa (1 to 2 weeks)	• Shelter sites at or above the waters' edge that provide cover (under moss, within crevices or underneath litter, logs, or rocks).
Adults (Long-lived, but no precise data from natural conditions. Several years in laboratory conditions;)	• Submerged coarse woody debris with heavy volumes of biofilm and loose bark and/or interstitial spaces that are used as a food base and shelter. • Adequate dissolved oxygen levels to support plastron respiration. • Perennial to semi-perennial water that provides moist or saturated substrate.

2.4 Reproduction

All riffle beetles lay eggs underwater, gluing them individually or in clumps to available substrate (Brown 1987, p. 254). Eggs hatch within 5 to 15 days. Riffle beetles may remain in the larval stage over long periods of time, varying from 6 months to 3 years. Riffle beetles generally have six larval instars (developmental stage of a larva between molts) (Brown 1987, p. 254; McCafferty 1998, p. 232; White and Roughly 2008, p. 632).

2.5 Ecology

Riffle beetles are mostly aquatic. They spend their egg, larval and adult stages in water. Larval riffle beetles typically leave the water to pupate along stream banks and areas adjacent to springs and seeps. Riffle beetles, upon metamorphosing from pupa to adults, may immediately return to water or disperse aerially to another location. Upon entering water, adult riffle beetles spend the remainder of their lives underwater and eventually lose the ability to fly (Hinton 1976, p. 1547; Brown 1987, pp. 254-255; Elliott 2008, pp. 193-196). Adult riffle beetles depend upon waters with high levels of dissolved oxygen due to their specific respiratory structures and once the adults re-enter water after pupation, they typically do not leave. In order to obtain oxygen while submerged, adult riffle beetles carry a thin film of air held by patches of dense hydrophobic hairs

over portions of their body. This is referred to as plastron respiration. As oxygen is removed from this film during respiration, it is replaced through diffusion of dissolved oxygen from the surrounding water and enables some riffle beetle species to remain submerged indefinitely if the dissolved oxygen level in the water is adequate (Brown 1987, p. 260). Riffle beetle presence in a stream is indicative of high water quality because of their high dependence upon dissolved oxygen (Elliott 2008, p. 200).

Riffle beetles have two dispersal mechanisms: adult and larval drift in streams and adult flight dispersal (Brown 1987, p. 255; Elliott 2008, p. 196-198). Madera Canyon spring habitats do not provide the stream drainage network to allow adult and larval drift dispersal. Flight dispersal is the only means in which riffle beetles can disperse to other suitable habitats in Madera Canyon. However, the ability for adults to disperse by flight may vary between and within species (Elliott 2008, p. 198). Brown (1972, pp. 230-233) did not provide any detail regarding Stephan's riffle beetle wing structure or functionality. Barr (University of California, Berkeley, pers. comm. 2016a) stated that some of their Stephan's riffle beetle specimens had fully developed wings indicating they were capable of flight. Barr and Shepard (1993, p. 3) assumed that adult Stephan's riffle beetles are capable of dispersal flights of unknown distance and duration upon emergence from pupation. Other *Heterelmis* species, H. *vulnerata*, *H. obesa*, and *H.glabra* (no common names), all have normal wings that would allow aerial dispersal (Gonzales 2008, p. 45).

Riffle beetles feed on algae and detritus by scraping submerged hard surfaces (Brown 1987, p. 262; Elliott 2008, p. 192) and submerged wood (Phillips 1995, p. 122). We have no specific information on Stephan's riffle beetle food habits. We assume, as with other riffle beetles, that Stephan's riffle beetle is an herbivore or detritivore that consumes periphyton and biofilm (complex aggregation of microorganisms composed of microscopic bacteria, algae, and protozoans) that grows on hard surfaces such as rocks, submerged wood, and aquatic plants. Other riffle beetles in the genus *Heterelmis* are associated with submerged wood upon which they feed (Brown 1976, p. 15; Phillips 1995, p. 122). We assume that Stephan's riffle beetle is also associated with submerged wood and woody debris.

The average lifespan of Stephan's riffle beetle is unknown. However, the complete metamorphosis for other riffle beetle species may take several years and adults may only breed in their second year (Brown 1987, p. 254; Elliott 2008, pp. 193-196).

Adult and larval riffle beetles are rarely taken by predatory invertebrates (Elliott 2008, pp. 192-193). Brown (1987, p. 264) and Elliott (2008, p. 193) state that adult riffle beetles have a chemical defense that makes them unpalatable to most predators. We assume that Stephan's riffle beetle may also have this defense mechanism to protect it from predation. The few invertebrate predators (predaceous stoneflies and caddisflies) that were mentioned by Brown (1987, p. 264) and Elliott (2008, p. 193) were not observed at any of the locations sampled by the Service (Appendix A); nor are they known to occupy the Santa Rita Mountains (M. Bogan, University of Arizona, pers. comm. 2016a). There are no invasive or non-native predators found in springs in Madera Canyon. We are unaware if the sympatric *Heterelmis obesa* may compete with Stephan's riffle beetle for resources at Sylvester Spring. There are no invasive or non-native species (invertebrates or vertebrates) found in springs in Madera Canyon.

2.6 Habitat

Stephan's riffle beetle habitat use information is very limited. Brown (1972, p. 234) described the habitat in which the species was first collected as unusual because the stream normally dried up each year. However, the original "type locality" (location where a new species is found) was not in a stream. Stephan's riffle beetle was originally collected in wet soil at a leaking pipe from a water storage tank at a Forest Service campground on the CNF (Barr and Shepard 1993, p. 18). The site was described as wet rocks, located in a ravine, below the dripping pipe (C. Barr, University of California, Berkeley, pers. comm. 2015). Barr and Shepard (1993, p. 3) also collected Stephan's riffle beetle specimens from locations at Sylvester Spring, with the habitats described as seeps and low volume springs associated with leaf litter, water-logged wood, and detritus.

There are other riffle beetle genera, *Microcylloepus* and *Zaitzevia* (no common names), which are known to inhabit springs (Brown 1987, p. 260) and streams with very low flow (Bogan *et al.* 2014, p. 2550) in the West. These genera were also found in springs of the Santa Rita Mountains (Barr and Shepard 1993, p. 9, 10, 12; Appendix A). One other riffle beetle within the same genus as Stephan's riffle beetle, *H. obesa*, has also been found in springs in Madera Canyon (Barr and Shepard 1993, pp. 9, 11, 12, 14; Appendix A). Brown (1987, p. 263) did describe other habitats, including intermittent streams, where riffle beetles, including the genus *Heterelmis*, were found buried within the damp substrate after the surface water of the stream had dried. Bell (1972, pp. 218-219) found riffle beetles from the genera *Zaitzevia* and *Narpus* (no common name) within the subsurface water of an intermittent stream in California. In Mexico, Campbell *et al.* (2008, p. 109) found riffle beetles predominately in perennial waters; intermittently flowing water had fewer individuals and lower species diversity. *Heterelmis obesa* was only found in the perennial flowing reach, whereas *Microcylloepus* was found in the examined perennial and intermittent flowing study sites (Campbell *et al.* 2008, p. 109).

Although Brown (1972, p. 234) stated that Stephan's riffle beetle habitat may dry up each year, we are uncertain whether this species does inhabit intermittent streams, springs, and seeps. The type locality was a leaking pipeline to a water storage tank, where suitable, persistent water may have been available yearlong to support Stephan's riffle beetle. When originally discovered, 71 adult Stephan's riffle beetles and one assumed *H. stephani* larval beetle were found at the pipeline leak (Brown 1972, p. 230). The collected larval beetle may imply either that larval riffle beetles may be transported through the pipeline from Bog Springs or that the water leak was adequately persistent to allow adult riffle beetles to reproduce at that site. Adult Stephan's riffle beetles may have also been transported through the pipeline or aerially dispersed to the type locality.

Based on available information for Stephan's riffle beetle and other riffle beetles, we conclude that the important characteristics of Stephan's riffle beetle habitat may include:

1) Permanent free-flowing springs that provide moist substrate conditions needed to support egg, larval, and adult stages;

2) Relatively shallow, unpolluted water with adequate dissolved oxygen levels for adult riffle beetles. Water quality must be sufficient to sustain Stephan's riffle beetle populations. In general, adult riffle beetles, due to their dependency on plastron respiration, typically require cool water with high levels of dissolved oxygen that is associated with shallow, fast-flowing streams and rivers (Brown 1987, p. 260; Elliott 2008, p. 198-200). Larval riffle beetles have gills; they likely are not as dependent upon high dissolved oxygen levels as the adults. Spring-dwelling riffle beetles, found to date in Madera Canyon, are not found in the typical habitat described above. Many specimens were collected from saturated substrate from overflowing concrete troughs near the spring sources where there is little surface water flow. This implies that these saturated substrate habitats contain adequate levels of dissolved oxygen to support adult riffle beetles;

3) A combination of aquatic macrophytes, algae, periphyton, or submerged leafy and woody debris specifically needed as food sources; and

4) The presence of few or no nonnative predators or competitors.

However, the preponderance of collected Stephan's riffle beetles (n=75) were from artificial habitat created by the leaking pipe at the water storage tank at Bog Springs Campground. Only two specimens were collected from Sylvester Spring, which still provides what we consider important habitat qualities needed by Stephan's riffle beetle to complete its life history. Habitat parameters from the leaking pipe could be limited to saturated soil with some minimal water movement. There is no other specific information on the type locality. The high numbers of Stephan's riffle beetle may have been collected there because they may have been concentrated in a small area with little habitat diversity which made them easier to detect.

CHAPTER 3. CURRENT CONDITION

The following describes the current condition of the Stephan's riffle beetle and its habitat, including references to potential habitat outside of the historically known range.

3.1 Range and Distribution

Stephan's riffle beetle has only ever been collected from two locations: Bog Springs Campground at a leaking storage tank and pipeline, and Sylvester Spring, in Madera Canyon, of the Santa Rita Mountains, Arizona (Barr and Shepard 1993, p. 18-19; Table 3.1; Figure 3.1). Stephan's riffle beetle is assumed to have been historically endemic to Bog Springs in Madera Canyon (Brown 1972, p. 233), however the actual type locality was the Bog Springs Campground area (Barr and Shepard 1993, p. 1). The original specimens were collected where water was leaking from a pipe to the campground water storage tank in 1970 (Barr and Shepard 1993, p. 1). This habitat no longer exists, as the CNF fixed the pipeline leak in 1976. Stephan's riffle beetle was also collected later at the Bog Springs Campground storage tank at another leak in 1972 and where the tank overflowed in 1987. Water from Bog Springs was and continues to be piped to the Bog Springs Campground, however, the habitat for the species no longer exists. The species has never been collected from the immediate Bog Springs outflow. Stephan's riffle beetle was collected from Sylvester Spring in 1987 and 1993 (Barr and Shepard 1993, pp. 2, 11).

An earlier report (Johnson 1992, p. 3) mentioned Kent Spring (Madera Canyon) as a site where Stephan's riffle beetle was collected in 1988. Barr and Shepard (1993, p. 2) dismissed this collection as being in error due to species misidentification. Stephan's riffle beetle has not been found in Madera Canyon since 1993 (Barr and Shepard 1993, p. 11).

Table 3.1.1. Survey results for Stephan's riffle beetle in and near Madera Canyon, Arizona (1969 to 2016). With the exception of the Bog Springs Campground, all locations are within the Mount Wrightson Wilderness in the Coronado National Forest.

Location	Year Surveyed	Number of Specimens	Surveyor	Citation
Bog Springs Campground	1969	7	Stephan	Brown 1972, p. 233
	1970	64	Stephan	Brown 1972, p. 233
	1972	4	Chandler	Barr and Shepard 1993, p. 2
	1987	2	Barr and Shepard	Barr and Shepard 1993, p. 2
Sylvester Spring	1987	1	Barr and Shepard	Barr and Shepard 1993, p. 2
	1993	1	Barr and Shepard	Barr and Shepard 1993, p. 2
Bog & additional springs/seeps/water tanks	1993	0	Barr and Shepard	Barr and Shepard 1993, p. 2
Bog, Sylvester, & additional springs	2012	0	Service	Appendix A
	2015	0	Service	Appendix A
	2016	0	Service	Appendix A

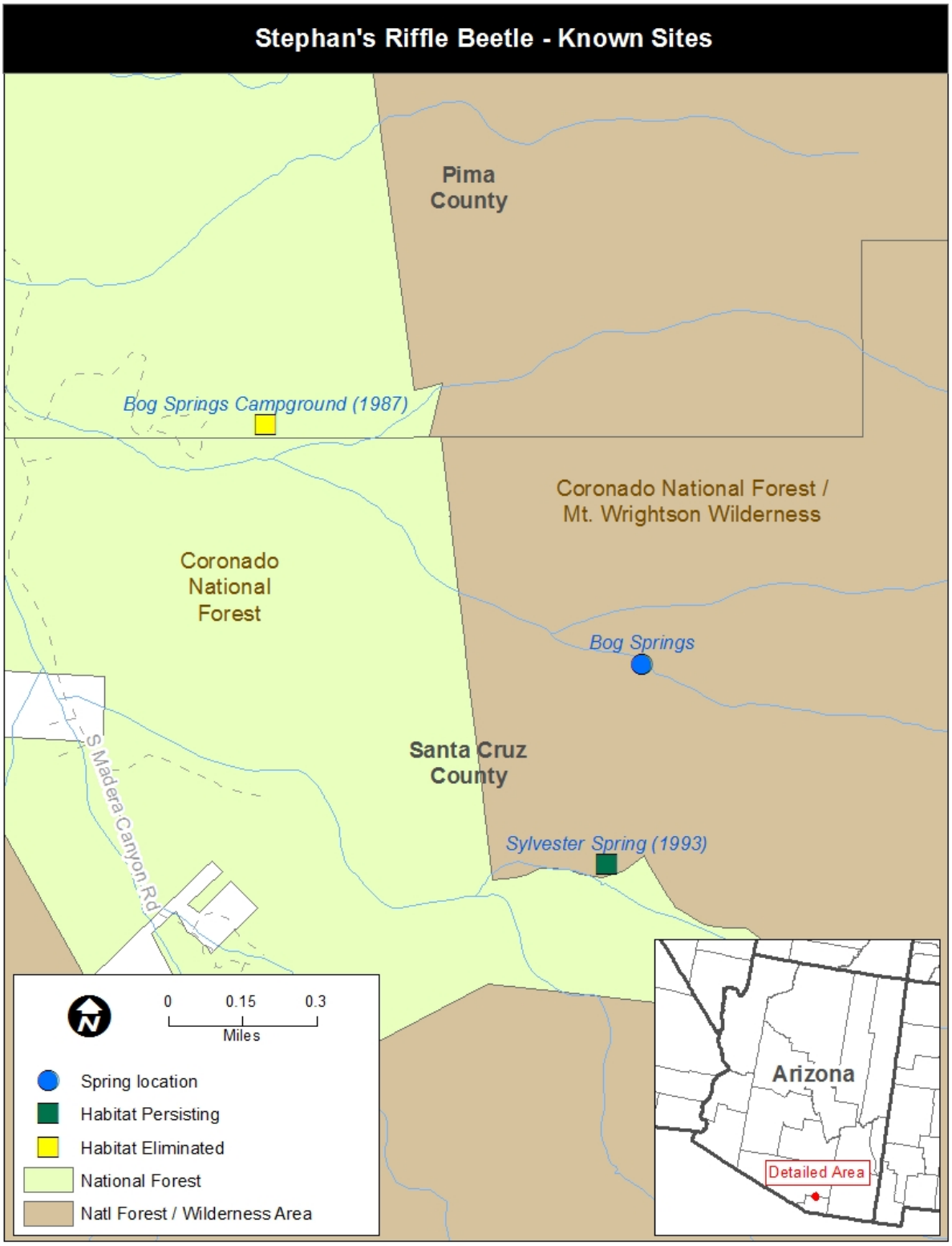

Figure 3.1.1. Known population sites for Stephan's riffle beetle within Arizona. Dates in parentheses indicate the year that Stephan's riffle beetles specimens were last collected. Note: Bog Springs is the water source for the Bog Springs Campground site.

3.2 Current Condition of Historical Locations

Below is a description of the two historical Stephan's riffle beetle sites.

Bog Springs Campground

The Bog Springs Campground receives water from Bog Springs. These springs consists of a cluster of low-volume springs located in the bottom of a small canyon approximately 1.2 miles upslope from the Bog Springs Campground, where Stephan's riffle beetle was collected. The springs are at 5,920 feet (ft) (1,804 meters (m)) elevation. These springs are accessible by a hiking trail from the Bog Springs Campground. The trail goes to a concrete trough that is fed by the spring via an upslope pipeline, and the trail signage identifies the trough as Bog Springs. The trough is currently used as a wildlife water source. Water overspills the edge of the trough creating saturated soils that are inhabited by some aquatic insects. This habitat lacks structure and heterogeneity; it primarily consists of bare wet sand and fine organic matter. The area around the trough experiences trampling impacts from visitation from hikers. There is no live vegetation or woody debris near the trough. Upslope from the tough are two covered spring boxes; there is no seepage or overflow at this site. The free-flowing seeps at the Bog Springs source are located further upslope from these spring boxes. Due to the trail sign location and its undisturbed appearance, we believe that the spring source receives very little visitation. The habitat at this site is much more diverse and structured. The seep has a distinct channel with small pools and riffles and an abundance of woody debris, vegetation, and detritus. Spring water flows for 76 ft (23 m) before moving subsurface (J. Sorensen, AGFD, pers. comm. 2016). Stephan's riffle beetle has not been found at the Bog Springs Campground area since 1987 (Barr and Shepard 1993, p. 2). Other riffle beetle species have been collected at the Bog Springs source site (Appendix A).

Sylvester Spring

Sylvester Spring is located in the next large drainage south of Bog Springs (Figure 3.2.7). It is at an elevation of 6,080 ft (1,853 m) and consists of a number of small seeps originating from a hillside above a hiking trail. Spring water flows for 40 ft (12.3 m) before moving subsurface (J. Sorensen, AGFD, pers. comm. 2016). The upper portion, which also includes a concrete spring box, is enclosed by a chain-link fence. Three other spring boxes are located downslope. The lowest spring box, immediately adjacent to the hiking trail, is managed as a wildlife water source by the Arizona Game and Fish Department. Water overflows the lower concrete trough and moves downslope. The area around the lower trough is not as trampled and disturbed as in the case of the Bog Springs trough. There is plentiful herbaceous vegetation growing near the trough and downslope in addition to saturated substrate and rocks. Other riffle beetle species have also been collected from this site (Appendix A).

Sylvester Spring is managed by the CNF and occurs within the area designated by the U.S. Congress as the Mount Wrightson Wilderness Area in 1984. Sylvester Spring was modified in the past when water from the spring was captured in concrete boxes and piped to divert water for domestic and recreational water supplies. Sylvester Spring is no longer used as a domestic water supply by private landowners as a domestic well was drilled in the bottom of Madera Canyon on

private land in 2013. This is a shallow well, penetrating 103 ft (31.1 m) into the canyon bottom (S. Shafiqullah, USFS, pers. comm. 2016) and the groundwater source for this well is from upslope springs that drain into the canyon bottom. Therefore, water withdrawals from this well are not expected to impact discharge into Sylvester Spring.

3.3 Current Condition of Populations

Appendix A summarizes the past survey efforts and results for Stephan's riffle beetle. The preponderance of Stephan's riffle beetle specimens have been documented in artificial habitat created by a water tank's leaking pipeline and overflow at the Bog Springs Campground. A total of two specimens have ever been documented from Sylvester Spring, the only relatively intact habitat where the species was known to exist. Historically, Stephan's riffle beetle may have only occupied Sylvester and Bog Springs, and populations may have started declining when water from springs in Madera Canyon was first captured in concrete boxes and piped to divert water for domestic and recreational water supplies. Up until 1993 when Stephan's riffle beetle was still documented to be extant, the species likely only existed in extremely low numbers making it very difficult to detect. The species has not been documented as extant since 1993, 23 years ago, when one individual was found at Sylvester Spring as part of a specific effort to survey for Stephan's riffle beetle in Madera Canyon (Barr and Shepard 1993, pp. 18-19). Those surveys were conducted at Bog, Sylvester, Kent and Dutch John Springs, Richardson Cabin seeps, and Robinson, Collister, and Roundup water storage tanks in Madera Canyon and Faber Spring in Faber Canyon. Only one Stephan's riffle beetle specimen was collected from Sylvester Spring as a result of this effort (Barr and Shepard 1993, p. 11).

Beginning in 2012, the Service surveyed Sylvester Spring, the one remaining known population location for Stephan's riffle beetle, and seven other locations with potential habitat on multiple occasions (Appendix A). The springs with potential habitat included Bog, Bellows, Kent, and Sprung Springs in Madera Canyon: McBeth Spring in Josephine Canyon: and Florida and Armour Springs in Florida Canyon. The Service is not aware of any other surveys conducted at these springs for riffle beetles or any other aquatic macroinvertebrates.

The most intensive survey efforts occurred at Sylvester Spring and Bog Springs, the water source for the extirpated Bog Springs Campground population. Three different survey methods were used in an effort to find the species. In 2012, surveys employed two methods that were similar to those used in the 1993 surveys and consisted of: 1) field surveys during which substrates (sands, gravels and organic matter) were sorted on site and beetle specimens were searched for under rocks and submerged wood, and 2) substrate samples were collected in the field and then examined at a later date under laboratory conditions. Beginning in 2015, an additional method of installing cloth lure traps was also employed at some of the spring locations, with the anticipation that this additional method would improve the chances of positive survey results. Both substrate and cloth lure trap samples were later examined under a dissecting scope to search for Stephan's riffle beetle. Identifications of riffle beetles found were confirmed by species experts, and no Stephan's riffle beetles were found (Appendix A).

In their review of the draft SSA Report, Barr (2016b) and Shepard (2016) expressed the opinion that, despite the Service's recent unsuccessful survey efforts to find Stephan's riffle beetle, they

believed the species to still be extant. Barr (2016b) assumed that, since the closely related *Heterelmis obesa* was found in most of the surveyed springs, Stephan's riffle beetle may also be present since their needs are likely similar. Following review of the draft SSA Report, another riffle beetle expert (and Service biologist) expressed the opinion that the existing population might be highly reduced, if not already gone (Gibson 2016).

While Stephan's riffle beetle is small in size and, therefore, difficult to find, adult beetles, if present, should be detected regardless of the time of year surveyed based on their life history (multi-year metamorphosis and relatively long life span). Despite these survey efforts at Sylvester Spring, additional survey efforts at potential spring habitats using three different survey methods, all surveys undertaken since 1993 have had negative results.

We recognize that it is difficult, if not impossible, to verify a species' extinction. There is considerable uncertainty about the actual status of the species, and we acknowledge that, as suggested by peer reviewers, there is some chance that the species remains extant and simply undetectable by recent survey efforts.

We do not know why the Stephan's riffle beetle has declined to the point that we have been unable to document the species existence since 1993. Sylvester Spring and the additional springs surveyed by the Service appear to provide the necessary habitat requirements to support Stephan's riffle beetle, and the presence of other riffle beetle species and aquatic insects in abundance supports this assessment (Service 2016, entire). While the species was never found to be widespread (occurring in only two places in close proximity) or abundant (only one sample had a relatively large number of individuals: 64), we have no clear evidence on substantial changes to the species environment that could have resulted in its decline and extinction.

3.4 Current Stephan's Riffle Beetle Habitat Conditions

For Stephan's riffle beetle to maintain viability, if extant, its populations or some portion of its populations must be resilient. Resiliency is defined as having sufficiently large populations for the species to withstand stochastic events (arising from random factors). We can measure resiliency based on metrics of population health; for example, birth versus death rates and population size. Resilient populations are better able to withstand disturbances such as random fluctuations in birth rates (demographic stochasticity), variations in rainfall (environmental stochasticity), or the effects of anthropogenic activities. Resilient Stephan's riffle beetle populations, if extant, must occupy habitats of sufficient size to sustain reproducing populations. We have no information regarding population demographics however, as Stephan's riffle beetles have not been found at either of these sites since 1993. Recent (2012, 2015, and 2016) surveys have not detected the species at either previously known location or at other springs in the area (Appendix A). We have no information to substantiate population sizes in order to track trends into the future.

A number of factors influence whether Stephan's riffle beetle populations, if extant, would grow to maximize habitat occupancy, which increases the resiliency of a population to stochastic events. Sylvester Spring appears to provide reliable flow to support respiration, food sources in the form of decaying allochthonous material (*e.g.* leaves, roots, woody debris), appropriate water

depth, suitable water quality, and the spring is not inhabited by invasive or non-native predators or competitors. We therefore anticipate that Stephan's riffle beetle, if present, would survive and persist at Sylvester Spring. We base this upon the presence of other riffle beetles species, *Heterelmis obesa* and *Zaitzevia parvula*, and aquatic insect species collected at Sylvester Spring (Appendix A).

Adequate Spring Discharge (Water Quantity) and Sufficient Water Quality

We considered spring discharge level to be reliable if it is flowing at a rate and depth sufficient to develop and maintain aquatic habitat parameters needed by Stephan's riffle beetle (see section 2.6 Habitat). Without specific information on Stephan's riffle beetle requirements, we assume, given the presence of other riffle beetle species in Bog and Sylvester Springs, that water quantity and quality is adequate and reliable to support this species in these same sites.

Free-flowing Spring Ecosystems and Appropriate Habitat Quality

Stephan's riffle beetle would need multiple resilient populations distributed throughout its range to provide for redundancy and representation. The more populations, and the wider the distribution of those populations, the more redundancy the species will exhibit. The two known sites in which Stephan's riffle beetle were found are within adjacent drainages, at almost the same elevation, approximately 0.5 mile (0.8 kilometers (km)) apart. We assume that these two springs are within aerial dispersal range for adult Stephan's riffle beetles.

The Presence of Few or No Non-native Predators or Competitors

There are no fish or non-native crayfish in Madera Canyon, though the springs are inhabited by native predaceous invertebrates that could potentially feed upon Stephan's riffle beetle. Stephan's riffle beetle is assumed to be unpalatable to predators however, and because non-native predators or competitors do not inhabit Madera Canyon this habitat factor will not be further addressed.

3.5 Summary of Current Conditions

Available information cannot verify that Stephan's riffle beetle still inhabits Sylvester Spring in Madera Canyon, and we have not been able to detect this species since 1993. Despite human use of the spring and surrounding land, Stephan's riffle beetles have persisted at least until they were last documented in 1993. We are unaware of any significant changes that may have occurred at Sylvester Spring since that time that would have diminished habitat quality. There are numerous other springs within Madera Canyon and adjacent Florida and Josephine Canyons that may also provide habitat for Stephan's riffle beetle, however we have not detected this species in any of these additional sites either. If Stephan's riffle beetle does inhabit these other springs, they would contribute to redundancy by providing additional and dispersed suitable habitats.

The framework used to analyze current habitat conditions for Stephan's riffle beetle at the two known sites where Stephan's riffle beetles have been collected (Table 3.5.1) suggests that

Sylvester Spring remains in high overall condition while the Bog Springs Campground site provides no habitat for the species (Table 3.5.2).

Table 3.5.1. Relative condition of important habitat factors believed to influence Stephan's riffle beetle population resiliency.

	Condition of Factor		
Habitat Factor	**High**	**Moderate**	**Low**
Adequate spring discharge	water is flowing at a rate sufficient to provide surface water and/or saturated substrates for Stephan's riffle beetle	water is flowing at rate to provide saturated substrates for Stephan's riffle beetle	water is flowing at a rate that is inadequate to provide saturated substrates for Stephan's riffle beetle
Sufficient water quality	water quality appears to provide appropriate conditions for Stephan's riffle beetle	water quality appears to provide marginal conditions for Stephan's riffle beetle	water quality appears unable, or nearly unable, to support Stephan's riffle beetle
Appropriate substrate and aquatic vegetation	Dominated by hard substrates such as cobble, gravel, aquatic vegetation, and coarse woody debris to provide fungal and biofilm growth needed as a food source for Stephan's riffle beetle.	Contain a portion of hard substrates, suitable aquatic vegetation, and coarse woody debris to provide fungal and biofilm growth needed as a food source for Stephan's riffle beetle.	Mostly lacks hard substrates, suitable aquatic vegetation, and coarse woody debris to provide fungal and biofilm growth needed as a food source for Stephan's riffle beetle.

Table 3.5.2. Current condition of the above identified habitat factors we believe needed by Stephan's riffle beetle at Bog and Sylvester Springs.

Spring	**Adequate spring discharge**	**Sufficient water quality**	**Sufficient substrate and aquatic vegetation**	**Current Overall Condition**
Bog Springs Campground	None	None	None	None
Sylvester Spring	High	High	High	High

The overall current condition of Stephan's riffle beetle is characterized by only one possibly extant population at Sylvester Spring where the species was last found in 1993. While habitat at this site remains in high overall condition, the resiliency of that population is considered low due

to presumed extreme small population size, if the species still exists there at all. With only one potential habitat site, if extant, the Stephan's riffle beetle is assumed to have essentially no redundancy or representation because there is only one population currently known that could still persist. If the species does persist, the viability is characterized by very low resiliency and no redundancy or representation.

CHAPTER 4. FACTORS INFLUENCING VIABILITY

In this chapter, we evaluate the past, current, and future factors that may be affecting Stephan's riffle beetle viability if it is still extant. We analyzed pathways for each factor and how each factor (cause) affects the species, and each of the causes is examined for its historical, current, and potential future effects. The current and expected distribution and abundance also determine the viability and vulnerability of the species to extinction.

4.1 Introduction

The primary factor that we believe may affect the future viability of Stephan's riffle beetle, if it is extant, is the loss of spring discharge at inhabited springs. Sylvester Spring was developed in the past to deliver water off-site. Pipeline, spring box, and trough construction may have eliminated specific Stephan's riffle beetle habitat needs. While other riffle beetle species have persisted at Sylvester Spring, Stephan's riffle beetle may have different or more sensitive habitat needs that were eliminated after spring development. Sylvester Spring is no longer used as a municipal water supply, and it is located on the CNF within the Mount Wrightson Wilderness, with specific management actions in place to limit or prevent future habitat alteration and water use at this site. Therefore, the effect of precipitation decline on spring flow is the factor with the greatest potential for affecting the future viability of the species at Sylvester Spring and is discussed in greater detail below.

As discussed above, under Current Stephan's Riffle Beetle Habitat Conditions (section 3.4), we believe the current water quality at Sylvester Spring would meet the requirements needed by Stephan's riffle beetle. The presence of other riffle beetle species at Sylvester Spring supports this belief that water quality is adequate to support Stephan's riffle beetle, as it is assumed that Stephan's riffle beetle has the same water quality tolerances of the other riffle beetle species. We also believe that the current spring flow at Sylvester Spring meets Stephan's riffle beetle habitat requirements. Water from Sylvester Springs is piped to a trough that overflows and provides saturated substrate we believe is consistent with habitat needs of Stephan's riffle beetle. Other portions of Sylvester Spring seep from the spring source and may provide habitat upslope from the trough. Sylvester Spring also has saturated habitat that provides hard substrates such as cobble, gravel, aquatic vegetation, and coarse woody debris to support fungal and biofilm growth assumed needed as a food source for Stephan's riffle beetle.

4.2 Local Habitat Modifications

Many of the identified local threats to Stephan's riffle beetle habitat have changed or been alleviated since the Service made the species a candidate for listing in 2002 (67 FR 40657, p. 40662). For example, recreational use in the past may have degraded the spring habitats of Stephan's riffle beetle, in particular causing a decline in water quality (e.g., inadvertent addition of chemicals, allowing pets into the springs, and trampling) (67 FR 40657, p. 40662). Upon further analysis, we have not found evidence of degraded water quality in the springs. Riffle beetles are intolerant to poor water quality, and we have found other riffle beetles at both Sylvester Spring and other springs in Madera and nearby canyons. Therefore, we conclude that water quality degradation is not a significant concern. Sylvester Spring is located along a

popular hiking trail, and the area around the lower trough receives visitation by hikers, but the remaining portions of the spring and the overflow do not appear to be affected by this use. The spring source is also protected by a chain link fence.

There are currently no State or local government programs that specifically address the conservation of rare and imperiled insects such as this beetle. The Arizona Department of Agriculture, having jurisdiction over insects, does not currently have an insect conservation program. This species is not identified in a State Wildlife Action Plan as the Arizona Game and Fish Department does not have jurisdiction over insects. Thus, there are no existing regulatory mechanisms that are designed to address the threats to this species.

Stephan's riffle beetle's known habitats, however, are located on lands entirely under the administration of the CNF and are within the Mount Wrightson Wilderness. The species' habitat is, therefore, protected from future development and/or modification, and Sylvester Spring is no longer used as a municipal water source. Although grazing has not been identified as a concern to Stephan's riffle beetle, there are no grazing allotments in Madera Canyon, so there are no potential conflicts between livestock grazing and Stephan's riffle beetle habitat. Stephan's riffle beetle is also on the U.S. Forest Service's Region 3 Regional Forester's List of Sensitive Species, and thus its habitat needs and susceptibility to habitat degradation are recognized.

4.3 Natural Stochastic Events

Spring-dependent organisms, whose populations exhibit a high degree of geographic isolation in small populations such as Stephan's riffle beetle, are extremely susceptible to random extinction resulting from stochastic natural disasters such as fires, floods, or changes in spring water chemistry. Wild fires do occur in the Santa Rita Mountains, and the 2005 Florida Fire burned in Florida Canyon and the upper portions of Madera Canyon above Sylvester Spring. Site visits in 2012 and 2015 however, did not show signs of excessive runoff or damage to Sylvester Spring that may have resulted from post-fire flooding after the Florida Fire. This may be due to the relatively small drainage area above the spring source. Also Sylvester Spring is located on a hillside above the drainage bottom, so it is not located in a site that would generate adequate runoff during post-fire flooding to cause damage to the spring source. In addition, other riffle beetle species (Appendix A) and aquatic insect species have been documented in Sylvester Spring post-fire. While the species remains susceptible to extinction from stochastic events, wild fire and floods are not substantial concerns to the Sylvester Spring site.

4.4 Spring Discharge Loss

Madera Canyon receives approximately 36 inches (900 mm) of annual precipitation, most of which occurs as summer thunderstorms in July and August (USGS 2016). Winter precipitation, although less than summer precipitation, is the primary source of recharge for most springs in Madera Canyon (C. Eastoe, University of Arizona, pers. comm. 2016a). This is due to the longer duration of winter precipitation events and the lower evapotranspiration rates during the winter season (Serrat-Capdevila *et al*. 2007, p. 52; Wahi *et al.* 2008, p. 416). Summer thunderstorm events are shorter and of higher intensity, resulting in higher runoff, lower infiltration rates, and

higher evapotranspiration rates at that time of year (Serrat-Capdevila *et al*. 2007, p. 52; Ajami *et al*. 2011, p. 4).

Hydrologists from the University of Arizona collected water isotope data from numerous springs in Madera Canyon in 2010 (C. Eastoe, University of Arizona, pers. comm. 2016a, 2016b). Hydrogen and oxygen isotopes in precipitation ($d^{18}O$) decrease with increasing altitude, therefore, rainfall sampled from a valley will have a heavier $d^{18}O$ isotope than that collected from a nearby mountain top (Wahi *et al.* 2008, p. 5; Singh 2015, p. 1). There are also seasonal differences, with precipitation collected during the winter having lighter $d^{18}O$ values than precipitation collected from the same location in the summer (Wahi *et al.* 2008, p. 5). These relationships allow the determination of when major recharge events for springs in Madera Canyon occur. The University of Arizona water isotope data indicates that most springs in Madera Canyon, including Sylvester Spring, depend strongly upon winter precipitation for spring recharge (Table 4.1.1).

Table 4.1.1 Seasonality of water recharge in Madera Canyon springs (C. Eastoe, University of Arizona, pers. comm. 2016a).

Spring Name (elevation in meters)	**Percent Winter Recharge of Groundwater**	**Percent Summer Recharge of Groundwater**
Bog (1,800 m)[1, 2]	90	10
Sylvester (1,850 m)[1, 2]	90	10
Kent (1,850 m)[2]	90	10
Bellows (2,525 m)	30	70

[1] Stephan's riffle beetle location; [2] other riffle beetle species location

Dominguez *et al.* (2012, pp. 5-6) and Meixner *et al.* (2016, p. 135), analyzing future winter precipitation trends in the southwestern United States, found winter precipitation significantly decreasing in the southwest region as a response to climate change. Decreased winter precipitation would have a direct effect on future spring flow in Sylvester Spring, as winter precipitation accounts for 90 percent of the spring recharge (Table 4.1.1). Recent global climate model data suggest that precipitation during early summer in the Southwest will decrease along with a delayed onset of the North American monsoon (Meixner *et al.* 2016, p. 129), but monsoon precipitation may increase in late summer (Cook and Seager 2013, p. 1697). Summer precipitation is not likely to compensate for decreased recharge from winter precipitation at Sylvester Spring (T. Meixner, University of Arizona, pers. comm. 2016).

We believe a reduction of spring discharge would decrease available habitat at Sylvester Spring. We can estimate the amount of eliminated habitat if spring discharge decreases to a level that can no longer be piped to the trough. If flow is reduced to the Sylvester Spring trough and overflow is discontinued, there would be a loss of approximately 150 square feet of habitat. Spring runoff moves downslope and creates a long stretch of saturated substrate. We do not have specific information on actual spring discharge amounts or predictions on reductions in the future from drought or future climate change.

We do not believe that Stephan's riffle beetle would persist if spring discharge is totally eliminated at Sylvester Spring. Riffle beetles would not persist in systems that dry completely

(M. Bogan, University of Arizona, pers. comm. 2016b). Riffle beetles are not known to have a desiccation-resistant portion of their life history, nor do they enter a diapause period (inactivity period in which growth or development is halted until suitable conditions are present) as eggs or pupa (M. Bogan, University of Arizona, pers. comm. 2016b). Larval and adult life stages require surface water or saturated substrate (Brown 1987, p. 263), and if the moist substrate does not persist or is too deep to be accessible riffle beetles would likely perish (Bogan *et al.* 2014, p 2451). Intermittent stream systems may be re-populated by water-dependent invertebrates from perennial upstream reaches during high flow event (Bogan *et al.* 2014, p 2452-2453), however there is no such re-colonization mechanism available at Sylvester Spring. If spring discharge is eliminated from this spring and from any other springs within dispersal distance, Stephan's riffle beetles will not persist and it would be unlikely that the springs would be recolonized unless flow connectivity to the mainstem of Madera Canyon occurred for an extended period of time (M. Bogan, University of Arizona, pers. comm. 2016b).

CHAPTER 5. SPECIES VIABILITY

We have considered what Stephan's riffle beetle needs for viability and the current condition of the species (Chapters 2 and 3). We then considered the primary factor, spring flow discharge, believed to be driving the potential future conditions for the species, if it is extant (Chapter 4). We now consider what the species' future conditions are likely to be. We describe the species viability that addresses the species' needs in terms of resiliency, redundancy, and representation under the assumption that the species is still extant in Sylvester Spring.

5.1 Introduction

Stephan's riffle beetle was historically known to occupy the Bog Springs Campground area and Sylvester Spring in Madera Canyon. It has not been documented since 1993. We surveyed numerous springs, including Bog and Sylvester, in 2012, 2015, and 2016 and were unable to detect this species. If Stephan's riffle beetle is still present in Madera Canyon, we consider Sylvester Spring to have high habitat quality. We base this assessment upon the presence of free-flowing water and saturated substrates, the presence of other riffle beetle species found at this site, the discontinued use of Sylvester Spring for municipal water, and its location in the Mount Wrightson Wilderness Area. Sylvester Spring will not be modified in the future due to its location on lands administered by the CNF (J. Copeland, CNF, pers. comm. 2016).

Risks from drought resulting in lowered winter precipitation and associated reduction in spring flow remain a concern. We are less certain how and when this will affect spring flow rates in Madera Canyon. The 19 long-term climate models reported in Seager *et al*. (2007) predicted a drying trend within the Southwest and included predictions of fewer frost days; warmer temperatures; greater water demand by plants, animals, and people; and an increased frequency of extreme weather events (heat waves, droughts, and floods) (Archer and Predick 2008, p. 24).

Stephan's riffle beetle viability depends on maintaining resilient populations over time and across its range. Given our uncertainty regarding if and when springs potentially occupied by Stephan's riffle beetle will experience a reduction or elimination of spring flow, we have forecasted the status of Stephan's riffle beetle under two plausible future scenarios over the next 50 years, as follows:

1. No measurable decrease in spring discharge at Sylvester Spring as a result of drought or future climate change.

2. Spring discharge at Sylvester Spring is totally eliminated or insufficient such that Stephan's riffle beetle is no longer able to persist.

5.2 Resiliency

We expect Stephan's riffle beetle would continue to persist at Sylvester Spring, if it persists there now, under scenario 1 (Table ES-1) as long as surface water and/or saturated substrate are available at Sylvester Spring. Even during dry periods when surface water is reduced or eliminated, Stephan's riffle beetle may be able to persist as long as an accessible shallow water

table is present to sustain individual beetles until surface water is returned in the form of precipitation or recharged spring flow (Bell 1972, pp. 218-219; Bogan *et al.* 2014, p. 2550). We therefore do not anticipate a reduction in available habitat at Sylvester Spring under scenario 1 resulting from drought or climate change. As stated earlier, there would be no future habitat modification or resumed municipal water use at Sylvester Spring. Rather, Sylvester Spring feeds a concrete trough that overflows and may be the source that is providing Stephan's riffle beetle habitat. However, if the trough ceases to function or water is no longer piped to it there may be a decrease in available Stephan's riffle beetle habitat at this site. The Sylvester Spring trough would likely be repaired because it is managed as a wildlife water source by the Arizona Game and Fish Department. We assume the Arizona Game and Fish Department would continue to maintain this water source.

We do not believe that Stephan's riffle beetle would persist under scenario 2, where spring discharge is totally eliminated at Sylvester Spring. Riffle beetles would not persist in systems that dry completely (M. Bogan, University of Arizona, pers. comm. 2016b). Riffle beetles are not known to have a desiccation-resistant portion of their life history, nor do they enter a diapause period (inactivity period in which growth or development is halted until suitable conditions are present) as eggs or pupa (M. Bogan, University of Arizona, pers. comm. 2016b). Larval and adult life stages require surface water or saturated substrate (Brown 1987, p. 263), and if the moist substrate does not persist or is too deep to be accessible riffle beetles would likely perish (Bogan *et al.* 2014, p 2451). A total loss of spring discharge flow in this scenario would equate to the complete drying at Sylvester Spring. This would result in the loss of the population. Such events would be catastrophic as any extant populations of Stephan's riffle beetle would likely be extirpated.

Water-dependent invertebrate populations in intermittent stream systems may be re-populated by other populations located in perennial upstream reaches during high flow event (Bogan *et al.* 2014, pp. 2452-2453), however there is no such re-colonization mechanism available at Sylvester Spring. If spring discharge is eliminated from this spring and from any other springs within dispersal distance, Stephan's riffle beetles will not persist and it would be unlikely that the springs would be recolonized unless flow connectivity to the mainstem of Madera Canyon occurred for an extended period of time and additional populations occurred there (M. Bogan, University of Arizona, pers. comm. 2016b).

5.3 Redundancy

Redundancy is defined for this analysis as having sufficient numbers of populations for the species to withstand catastrophic events. A catastrophic event is defined here as the total loss of spring flow at one or both springs. The most likely catastrophic events for Stephan's riffle beetle would involve the loss of spring discharge flow to the only intact spring site known to have been occupied. Therefore, the species does not exhibit redundancy, under either future scenario, over a large geographic area which would have provided for some protection against localized flow declines. However, we do not know if Stephan's riffle beetle ever had a wider distribution, and therefore redundancy, than that which currently occurs (one potentially extant population at Sylvester Spring).

5.4 Representation

Representation is having the genetic and ecological diversity within the species to be able to adapt to changing environmental conditions. We do not have information to determine a level of genetic diversity, since the species is only potentially extant with one population at Sylvester Spring. Although we cannot estimate representation, with only one potential population, representation is either extremely limited (under scenario 1) or absent (under scenario 2).

5.5 Status Assessment Summary

We used the best available information to project the likely future conditions of Stephan's riffle beetle, assuming that the species is still extant in the one spring with intact habitat where it was last documented in 1993. Our goal was to describe the viability of the species in a manner that will address the needs of the species in terms of resiliency, redundancy, and representation. We considered the possible future conditions of the species, and we considered the range of potential scenarios that included important influences on the status of the species. We conclude that under the first scenario, no measurable decline of spring discharge, Sylvester Spring would support a population of Stephan's riffle beetle, if the species is still extant, and Stephan's riffle beetle's specific habitat needs are and will continue to be met at this site. We conclude that under the second scenario, spring discharge is totally eliminated or is discontinued for a prolonged period of time, the species, if extant, would be extirpated. Under either scenario, the best available information indicates the species has essentially no redundancy and presumably no resiliency, as only one potential population is expected to persist under the first scenario.

LITERATURE CITED

Ajami, H., P.A. Troch, T. Maddock III, T. Meixner, and C. Eastoe. 2011. Quantifying mountain block recharge by means of catchment-scale storage-discharge relationships, Water Resources. Research 47, W04504. doi:10.1029/2010WR009598. 14 pages.

Archer, S.R., and K.I. Predick. 2008. Climate change and ecosystems of the southwestern United States. Rangelands 30(3): 23-28.

Barr, C.B. 2015. December 31, 2015, email transmission from C. Barr (University of California, Berkeley) to D. Smith (U.S. Fish and Wildlife Service) Re: Don Chandler's Stephan's riffle beetle collection notes sent to C. Barr on September 12, 1993.

Barr, C.B. 2016a. May 1, 2016, email transmission from C. Barr (University of California, Berkeley) to D. Smith (U.S. Fish and Wildlife Service) Re: Dispersal ability in riffle beetles in the genus Heterelmis.

Barr, C.B. 2016b. May 1, 2016, email transmission from C. Barr (University of California, Berkeley) to D. Smith (U.S. Fish and Wildlife Service) Re: Comments and review on draft Stephen's riffle beetle species status assessment.

Barr, C.B. 2016c. May 1, 2016, email transmission from C. Barr (University of California, Berkeley) to D. Smith (U.S. Fish and Wildlife Service) Re: Species identification on *Heterelmis* specimen.

Barr, C.B. and W.D. Shepard. 1993. Survey for *Heterelmis stephani* Brown (Insecta: Coleoptera: Elmidae) in Madera Canyon and other localities in the Santa Rita Mountains, Arizona. Prepared for the U.S. Department of Agriculture Forest Service, Coronado National Forest, Nogales Ranger District. 48 pages.

Bell, L.N. 1972. Notes on the dry season survival in two species of Elmidae. Pan-Pacific Entomologist 48:218-219.

Bogan, M.T. 2016a. January 21, 2016. Discussion between M. Bogan (University of Arizona) and D. Smith (U.S. Fish and Wildlife Service) Re: Invertebrate distributions in southern Arizona; specifically stoneflies and caddisflies.

Bogan, M.T. 2016b. April 1, 2016, phone call between M. Bogan (University of Arizona) and D. Smith (U.S. Fish and Wildlife Service) Re: Riffle beetle persistence in intermittent and ephemeral water bodies.

Bogan, M.T. 2016c. May 25, 2016, Text message from M. Bogan (University of Arizona) and D. Smith (U.S. Fish and Wildlife Service) Re: Riffle beetle species identification by Barr and Shepard.

Bogan, M.T., K.S. Boersma, and D.A. Lytle. 2014. Resistance and resilience of invertebrate communities to seasonal and supraseasonal drought in arid land headwater streams. Freshwater Biology 60:2547-2558.

Bosse, L.S., D.W. Tuff, and H.P. Brown. 1988. A new species of Heterelmis from Texas (Coleoptera: Elmidae). The Southwestern Naturalist 33:199-203.

Brown, H.P. 1972. A synopsis of the genus Heterelmis Sharp in the United States, with a description of a new species from Arizona (Coleoptera, Dryopoidea, Elmidae). Entomological News 83:229-238.

Brown, H.P. 1976. Aquatic Dryopoid beetles (Coleoptera) of the United States. Water Pollution Control Research Series 18050ELD04-72 Second Printing. Environmental Protection Agency. Cincinnati, Ohio. 92 pages.

Brown, H.P. 1987. Biology of riffle beetles. Annual Review of Entomology 32:352-273.

Campbell, W.B., R. Arce-Perez, and J.A. Gomez-Anaya. 2008. Taxonomic distinctness and aquatic Coleoptera: comparing a perennial and intermittent stream with differing geomorphologies in Hidalgo, Mexico. Aquatic Ecology 42:103-113.

Copeland, J. 2016. January 19, 2016 meeting between the Coronado National Forest and D. Smith (U.S. Fish and Wildlife Service) Re: Stephan's riffle beetle and Madera Canyon springs.

Cook, B.L. and R. Seager. 2013. The response of the North American monsoon to increased greenhouse gas forcing. Journal of Geophysical Research: Atmospheres 118:1690-1699.

Dominguez, F., E. Rivera, D.P. Lettenmaier, and C.L. Castro. 2012. Changes in winter precipitation extremes for the western United States under a warmer climate as simulated by regional climate models. Geophysical Research Letters, 39(5). L05803. 7 pages.

Eastoe, C.J. 2016a. February 18, 2016, phone call and email transmission from C. Eastoe (University of Arizona Environmental Isotope Laboratory) to D. Smith (U.S. Fish and Wildlife Service) Re: water isotope analysis of Madera Canyon Springs.

Eastoe, C.J. 2016b. May 4, 2016, email transmission from C.J. Eastoe (University of Arizona Environmental Isotope Laboratory) to D. Smith (U.S. Fish and Wildlife Service) Re: additional water isotope analysis of Madera Canyon Springs.

Elliott, J.M. 2008. The ecology of riffle beetles (Coleoptera: Elmidae). Freshwater Reviews 1:189-203.

Gibson, J.R., S.J. Harden, and J.N. Fries. 2008. Survey and distribution of invertebrates from selected springs of the Edwards Aquifer in Comal and Hays Counties, Texas. The Southwestern Naturalist 53:74-84.

Gibson, J.R. 2016. April 21, 2016 email transmission from J.R. Gibson (U.S. Fish and Wildlife Service) to S.E. Stanford (U.S. Fish and Wildlife Service) Re: SSA.

Gonzales, T.K. 2008. Conservation genetics of the Comal Springs riffle beetle (*Heterelmis comalensis*) populations in central Texas, with examination of molecular and morphological variation in *Heterelmis ssp.* throughout Texas. Master's Thesis. Texas State University-San Marcos. 79 pages.

Hinton, H.E. 1976. Plastron respiration in bugs and beetles. Journal of Insect Physiology. 22:1529-1550.

Huston, D.C., J.R. Gibson, K.G. Ostrand, C.W. Norris, and P.H. Diaz. 2015. Monitoring and marking techniques for the endangered Comal Springs riffle beetle, *Heterelmis comalensis* Bosse, Tuff, and Brown, 1988 (Coleoptera: Elmidae). The Coleopterists Bulletin 69:793-798.

Intergovernmental Panel on Climate Change (IPCC). 2014. Summary for policymakers. Pages 1-32 *In*: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, New York, United States of America.

Jaeger, K.L., J.D. Olden, and N.A. Pelland. 2014. Climate change poised to threaten hydrologic connectivity and endemic fishes in dryland streams. Proceedings of the National Academy of Sciences 111:13894-13899.

Johnson, R.A. 1992. Location and status of seventeen Arizona invertebrate candidate species: Heterelmis stephani. Final Report. Submitted to the U.S. Fish and Wildlife Service, Ecological Services, Phoenix, Arizona. 7 pages.

McCafferty, W.P. 1998. Aquatic entomology: The fisherman's and ecologist's illustrated guide to insects and their relatives. Jones and Bartlett Publishers, Sudbury, Massachusetts. 448 pages.

Meixner T, A.H. Manning, D.A. Stonestrom, D.M. Allen, H. Ajami, K.W. Blasch, A.E. Brookfield, C.L. Castro, J.F. Clark, D.J. Gochis, A.L. Flint, K.L. Neff, R. Niraula, M. Rodell, B.R. Scalon, K. Singha, and M.A. Walvoord. 2016. Implications of projected climate change for groundwater recharge in the western United States. Journal of Hydrology 31:124-138.

Meixner, T.A. 2016. May 4, 2016. Phone call and email transmission from T. Meixner (University of Arizona Hydrology and Water Resources) to D. Smith (U.S. Fish and Wildlife Service) Re: Seasonality of spring recharge of Madera Canyon Springs.

Phillips, E.C. 1995. Associations of aquatic Coleoptera with coarse woody debris in Ozark streams. The Coleopterists Bulletin 49:119-126.

Seager, R., M. Ting, I. Held, Y. Kushnir, J. Liu, G. Vecchi, H. Huang, N. Harnik, A. Leetma, N. Lau, C. Li, J. Velez, and N. Naik. 2007. Model projections of an imminent transition to a more arid climate in Southwestern North America. Science 316:1181-1184.

Serrat-Capdevila, A., J.B. Valdes, J.G. Perez, K. Baird, L.J. Mata, and T. Maddock. 2007. Modeling climate change impacts – and uncertainty – on the hydrology of a riparian system: The San Pedro River basin (Arizona/Sonora). Journal of Hydrology 347:48-66.

Shafiqulla, S. 2016. March 31, 2016 phone call between S. Shafiqulla (Nogales Ranger District, Coronado National Forest) and D. Smith (Service) Re: Madera Canyon springs.

Shepard, W. 2016. May 1, 2016, email transmission from B. Shepard (University of California, Berkeley) to D. Smith (Service) Re: Comments and review on draft Stephen's riffle beetle species status assessment.

Singh, B.P. 2015. Isotopic composition of water in precipitation falling at different altitudes. Journal of Hydrogeology and Hydrologic Engineering 2:1-7.

Sorensen, J. 2016. April 20, 2016 Email transmission from J. Sorensen (Arizona Game and Fish Department) to D. Smith (U.S. Fish and Wildlife Service) Re: Springsnail habitat survey data from April 15, 2016 Madera Canyon field trip.

U.S. Fish and Wildlife Service (Service). 2002. Endangered and threatened wildlife and plants: A review of species that are candidates or proposed for listing as endangered or threatened; Annual notice of finding on recycled petitions; Annual descriptions of progress on listing actions. Federal Register 67(114): 40657-40679.

U.S. Fish and Wildlife Service (Service). 2012a. Trip notes from May 22 to 24, 2012 riffle beetle surveys in Madera Canyon. Arizona Ecological Services Flagstaff Suboffice.

U.S. Fish and Wildlife Service (Service). 2012b. Trip notes from September 8 to 9, 2012 riffle beetle surveys in Madera Canyon. Arizona Ecological Services Flagstaff Suboffice.

U.S. Fish and Wildlife Service (Service). 2012c. Trip notes from November 26, 2012 riffle beetle surveys in Madera Canyon. Arizona Ecological Services Flagstaff Suboffice.

U.S. Fish and Wildlife Service (Service). 2015a. Trip notes from November 18 to 20, 2015 riffle beetle surveys in Madera Canyon. Arizona Ecological Services Flagstaff Suboffice.

U.S. Fish and Wildlife Service (Service). 2015b. Trip notes from November 29 to 30, 2015 riffle beetle surveys in Madera Canyon. Arizona Ecological Services Flagstaff Suboffice.

U.S. Fish and Wildlife Service (Service). 2016a. Trip notes from January 19 to 21, 2016 riffle beetle surveys in Madera Canyon. Arizona Ecological Services Flagstaff Suboffice.

U.S. Fish and Wildlife Service (Service). 2016b. Trip notes from April 11 to 13, 2016 riffle beetle surveys in Madera Canyon. Arizona Ecological Services Flagstaff Suboffice.

U.S. Fish and Wildlife Service (Service). 2016c. Trip notes from May 9 to 11, 2016 riffle beetle surveys in Madera Canyon. Arizona Ecological Services Flagstaff Suboffice.

U.S. Geological Survey (USGS). 2016. Streamstats website data for Madera Canyon locations. Accessed on February 10, 2016. Available online at: http://water.usgs.gov/osw/streamstats/ssonline.html.

Wahi, A.K., J.F. Hogan, B. Ekwurzel, M.N. Baillie, and C.J. Eastoe. 2008. Geochemical quantification of semiarid mountain recharge. Ground Water 46:414-425.

White, D.S., and R.E. Roughley. 2008. Aquatic Coleoptera [pp. 571–671]. In: An Introduction to the Aquatic Insects of North America (R.W. Merritt, K. W. Cummins, and M.B. Berg, editors). 4th Edition. Kendall/Hunt Publishing Company y, Dubuque, Iowa.

APPENDIX A

Summary of Survey History for Stephan's Riffle Beetle

A.1 Survey History

The following description summarizes the past survey efforts that have been conducted to search for the Stephan' riffle beetle. The only specific surveys for Stephan's riffle beetle, prior to those done by the Service beginning in 2012 were conducted by Barr and Shepard (1993, entire). In addition to Bog and Sylvester Springs, they also surveyed Kent and Dutch John springs, Richardson Cabin seeps, Madera Creek, and Robinson, Collister, and Roundup water storage tanks in Madera Canyon and Faber Spring in Faber Canyon (Barr and Shepard 1993, pp. 8-17). These surveys were conducted specifically to evaluate the distribution and abundance of Stephan's riffle beetle. The results of those surveys found one specimen of Stephan's riffle beetle at Sylvester Spring, but other riffle beetles were collected (Table A.1).

In 2012, the Service began conducting Stephan's riffle beetle surveys in Madera and adjacent Florida and Josephine Canyons. A summary of the sites, the survey dates, and methods used by the Service are listed in Table A.1 and were recorded in field notes (Service 2012a, 2012b, 2015a, 2015b, 2016a, 2016b, and 2016c). On five occasions, the Service surveyed Sylvester Springs and Bog Springs, the source of water for the type location at the Bog Springs Campground. In addition, the Service surveyed seven other springs and any associated constructed troughs and overflows to determine if Stephan's riffle beetle had a wider distribution than previously known (Table A.1). These additional locations included Kent Spring, a trough at Sprung Spring, Bellows Spring (and an associated trough), and Madera Creek within Madera Canyon; a trough at McBeth Spring within Josephine Canyon; and Armour and Florida Springs within Florida Canyon.

Table A.1. Stephan's riffle beetle survey efforts in Madera, Florida and Josephine Canyons (2012, 2015, and 2016 (Service 2012a, 2012b, 2012c, 2015a, 2015b, 2016a, 2016b, and 2016c)).

Spring Sites, Canyon Dates Surveyed	**Methods**
Bog Springs Source and Associated Trough, Madera Canyon	
May 22, 2012	Substrate collection and field sorting
May 24, 2012	Substrate collection
November 30, 2015	Substrate collection set lure traps
January 21, 2016	Cloth lure traps
April 12, 2016	Cloth lure traps, substrate collection
May 10, 2016	Cloth lure traps, field sorting, substrate collection
May 11, 2016	Field sorting
Sylvester Spring and Associated Trough, Madera Canyon	
May 24, 2012	Substrate collection
November 20, 2015	Substrate collection and set cloth lure traps
January 21, 2016	Cloth lure traps
April 12, 2016	Cloth lure traps, substrate collection
May 10, 2016	Cloth lure traps, field sorting, substrate collection
Kent Spring, Madera Canyon	
May 24, 2012	Substrate collection
November 20, 2015	Substrate collection set cloth lure traps
January 21, 2016	Cloth lure traps
April 12, 2016	Cloth lure traps, substrate collection
May 10, 2016	Cloth lure traps, field sorting, substrate collection
Sprung Spring Trough, Madera Canyon	
May 23, 2012	Field sorting and substrate collection
Bellows Spring and Associated Trough, Madera Canyon	
May 23, 2012	Field sorting and substrate collection
April 13, 2016	Field sorting and substrate collection
Madera Creek, Madera Canyon	
November 26, 2012	Substrate collection
McBeth Spring Trough, Josephine Canyon	
May 23, 2012	Field sorting and substrate collection
November 20, 2015	Substrate collection and set lure traps
April 12, 2016	Cloth lure traps
Armour Spring, Florida Canyon	
September 9, 2012	Substrate collection
November 30, 2015	Substrate collection
Florida Spring, Florida Canyon	
September 9, 2012	Substrate collection

A.2 Survey Locations

The specific locations were chosen for surveys because they all contained the habitat features we believe are important for Stephan's riffle beetle, such as the presence of relatively shallow, free-flowing water and saturated substrates. The only sites surveyed by Barr and Shepard that were also surveyed by the Service were Bog, Sylvester, and Kent Springs and Madera Creek. The other locations surveyed by Barr and Shepard, with the exception of Robinson Spring water storage tank, were not surveyed by the Service because riffle beetles (of any species) were not found at those sites (Barr and Shepard 1993, pp. 8-17; Table A.3). While Barr and Shepard did find riffle beetles at the Robinson Spring water storage tank, the Service did not survey this location in order to concentrate on un-surveyed locations elsewhere in the area.

The following is a brief description of the spring sites that were sampled by the Service (Figure A.2). A description of Bog Springs, Bog Springs Campground, and Sylvester Spring are included in Chapter 3, Current Condition.

Kent Spring is located upslope of Sylvester Spring within the same drainage in Madera Canyon. It is at 6,640 ft (2,024 m) elevation. Kent Spring water is piped downslope to a CNF cabin. Surface water is present at the spring in an adjacent drainage.

Bellows Spring is the highest elevation spring (8,200 ft/2,525 m) that was surveyed by the Service. It is located next to the hiking trail to the summit of Mount Wrightson in Madera Canyon. In May 2012, it consisted of a small trough fed by an upslope pipeline and overflowed down the middle of the hiking trail Service 2012a). Overflow flows down the trail forming a very shallow riffle. In April 2016 it was observed that the CNF had previously removed the pipeline to the concrete trough. The spring flows downslope across the trail instead of down the middle of the trail as in the past (Service 2016b).

Sprung Spring is located at 6,980 ft (2,130 m) elevation near Josephine Saddle (divide between Madera and Josephine canyons) in Madera Canyon. It consists of a small concrete trough fed by an upslope buried pipeline. There was no spring source area found to collect samples from (Service 2012a). In May 2012, the trough was filled and overflowing (Service 2012a). Sprung Spring water was piped downslope to private land in Madera Canyon at this time. The CNF removed the aboveground pipeline due to its presence in the Mount Wrightson Wilderness. The trough no longer functions or provides saturated substrate for riffle beetles (Service 2015a).

McBeth Spring is located at 7,160 ft (2,180 m) elevation in Josephine Canyon. It consisted of a small concrete trough fed by an upslope buried pipeline. There was no spring source area found to collect samples from. It was still overflowing and supporting saturated substrate in April 2016 (Service 2016b).

Florida Spring is located at 6,820 ft (2,080 m) elevation in Florida Canyon. Florida Canyon is immediately east of Madera Canyon. It consists of a concrete trough fed by a pipeline. There is saturated substrate and small areas of standing water at this site. It

differed from other surveyed spring locations in containing higher amounts of organic matter (Service 2012b).

Armour Spring is located at 7,780 ft (2,370 m) in Florida Canyon. The spring is undeveloped and consists of a small seep at the base of a cliff. There was very little spring area in which to collect substrate samples (Service 2012b and 2015b).

The Service did not survey these springs as intensely as Sylvester or Bog Springs. The Service is not aware of any previous surveys conducted at these springs for riffle beetles or any other aquatic macroinvertebrate species. The Service also surveyed three locations along Madera Creek in November 2012 (Service 2012c). Madera Creek flows intermittently with surface and subsurface flowing reaches. The three survey locations were selected due to the presence of surface flow and their accessibility.

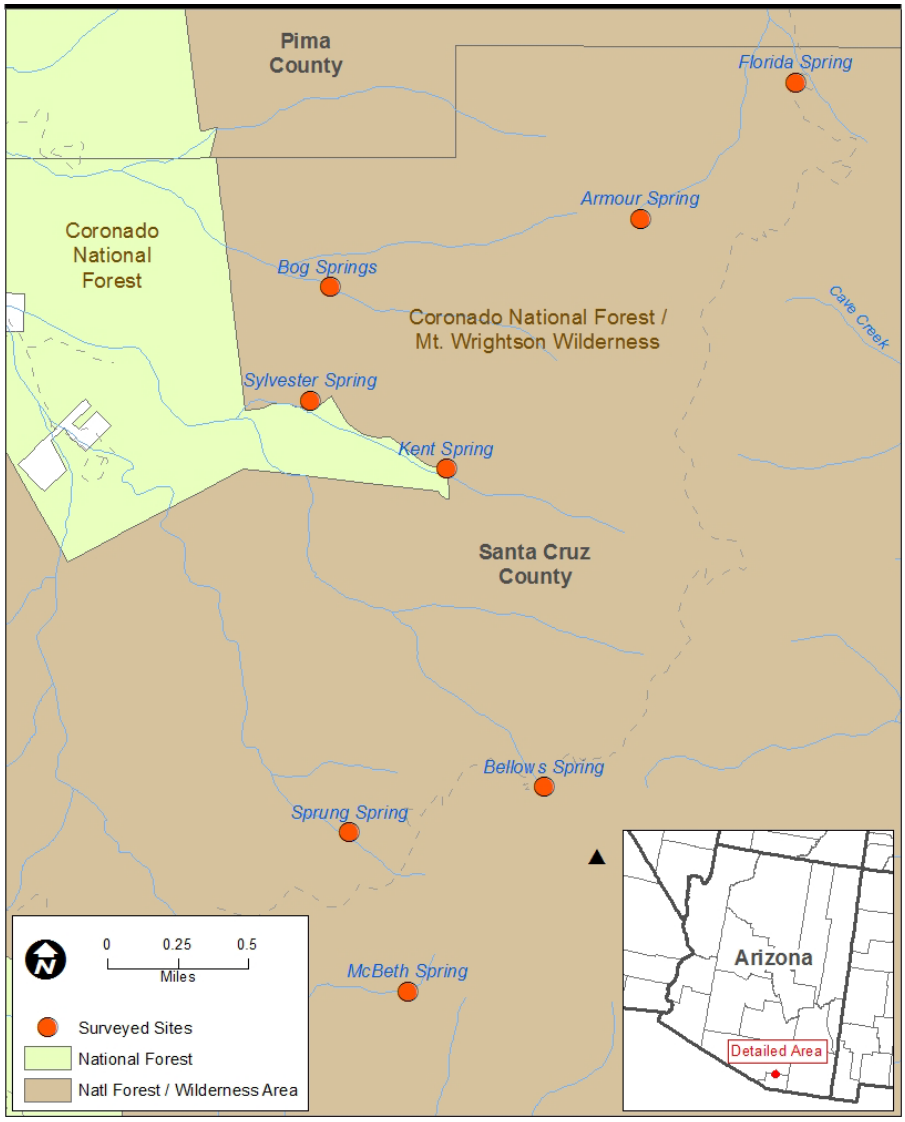

Figure A.2 Service survey locations for Stephan's riffle beetle (2012-2016).

A.3 Survey Methodologies

Barr and Shepard (1993, p. 6) used small nets to collect debris they dislodged in flowing portions of the springs they surveyed and also searched for Stephan's riffle beetles while at each sampled spring. In addition, they searched submerged wood and rocks while at the springs and collected substrate samples to transport back to their laboratory to be examined later.

Initially, the Service collected substrate subsamples at numerous locations at each spring site and/or its associated trough that was surveyed, similar to the methods used by Barr and Shepard (1993, p. 6). Bellows and Kent Springs were the only sites that had sufficient flowing surface water that the Service could use small nets to collect samples (Service 2012a). Each substrate subsample was combined into one sample (approximately 2 to 3 liters) per spring, per visit. Samples were only collected at the existing trough at McBeth and Sprung Springs as there was no visible spring in the area to collect from. The Service collected samples from Bog, Sylvester, Kent, Bellows, Sprung, McBeth, Armour, and Florida Springs and Madera Creek (Service 2012a, 2012b, and 2012c).

In an attempt to improve our opportunity to collect Stephan's riffle beetle, in November 2015 and January 2016, the Service employed a new survey method and installed numerous cloth lure traps (Gibson *et al*. 2008, p. 76; Huston *et al*. 2015, p. 794) in Bog, Sylvester, Kent, McBeth, and Armour Springs, and an unnamed spring in Carrie Nation Canyon (side tributary of Madera Canyon). Due to its isolation and difficulty to access, the unnamed spring was not visited during future surveys and the cloth lure traps were never collected, thus the Service does not have information on the aquatic insect community at this location. Cloth lure traps (small wire baskets with cotton cloth inserted in them) are an alternative sampling technique, and are considered a very effective method for surveying the endangered Comal Springs riffle beetle (*Heterelmis comalensis*) in Comal Springs, Texas (Huston *et al*. 2014, entire). Riffle beetles are attracted to the biofilm, fungi and bacteria that grow on the inserted cloth. As in 2012, this new method was an attempt to determine if Stephan's riffle beetle had a broader distribution than what is currently known. Cloth traps were buried in sediment at each of the springs. Substrate samples were also collected from these springs (Table A.1.2).

Substrate and cloth lure trap samples were examined under a dissecting scope by a Service biologist to identify collected riffle beetles to the genus level. The Service identified riffle beetles to the genus level using the identification key published in White and Roughley (2008, pp. 638-644). Obvious *Heterelmis obesa* specimens were confirmed by the Service at the Entomology Collection at the University of Arizona in Tucson. Unknown *Heterelmis sp.* adults, were sent to riffle beetle experts for species determination, were confirmed as *Heterelmis obesa* (M. Bogan, University of Arizona, pers. comm. 2016c). Specimens of the genus *Heterelmis* were sent to Cheryl Barr (University of California, Berkeley, retired) and Bill Shepard (University of California, Berkeley) to identify to the species level (C. Barr, University of California, Berkeley, pers. comm. 2016c). While Stephan's riffle beetle was not found in any of the locations surveyed by the Service, other riffle beetle species were detected from substrate samples from all locations with the exception of Bellows Spring (and trough) and Amour Spring (Table A.1). No adult riffle beetles, of any species, were found in the cloth lure traps that were examined in January, April, or May 2016.

A.1.2 Survey Results

Barr and Shepard (1993, entire) and the Service found four riffle beetle species at eight locations in Madera, Josephine, ad Florida Canyons (Table A.3).

Table A.3. Riffle beetle presence at surveyed sites in Madera, Josephine and Florida Canyons, Santa Rita Mountains, Arizona.

Taxon	**Bog Springs**	**Kent Spring**	**Sylvester Spring**	**Sprung Spring**	**Florida Spring**	**McBeth Spring**	**Madera Creek**
Heterelmis stephani			*[1]				
Heterelmis obesa	*[1, 2]	*[1, 2]	*[1]				*[1]
Microcylleopus simulis			*[2]				*[1]
Zaitzevia parvula	*[1, 2]	*[1, 2]	*[1, 2]	*[2]	*[2]	*[2]	*[2]

[1]Barr and Shepard 1993, [2]Service reference samples collect in 2012, 2015, and 2016