SONORA TIGER SALAMANDER
(*Ambystoma tigrinum stebbinsi*)

DRAFT
RECOVERY PLAN

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EXECUTIVE SUMMARY

Current Status: The Sonora tiger salamander is federally listed as endangered without critical habitat. As of this writing, the subspecies has been found in 53 ponds in the San Rafael Valley of Arizona.

Habitat Requirements and Limiting Factors: This salamander requires standing water from January through June for breeding and larval growth. Adult, metamorphosed salamanders inhabit adjacent grassland and oak woodland terrestrial habitat when not in ponds. Threats to Sonora tiger salamanders include the following: 1) restricted distribution, 2) disappearance of natural standing water habitat, 3) predation by non-native fish, bullfrogs, and crayfish, 4) genetic swamping by introduced, non-native barred tiger salamanders, 5) disease, 6) low genetic diversity, 7) collection for bait or translocation by anglers.

Recovery Priority: 3 on a scale of 1 to 18. The priority is based on its being a subspecies (rather than a full species) with a high degree of threat and high recovery potential.

Recovery Objectives: 1) Reclassify from endangered to threatened status. 2) Delist.

Recovery Criteria: The Sonora tiger salamander may be reclassified to threatened status when breeding and upland habitats on approximately 90 percent of salamander's currently-occupied range are protected and maintained to prevent habitat loss and degradation, predator introductions, barred tiger salamander introductions, and collecting of salamanders for bait. Scientifically credible monitoring over a five year period must indicate that the number of Sonora tiger salamander populations is not in decline and that there are no new factors that threaten the persistence of Sonora tiger salamanders.

The Sonora tiger salamander will be considered for delisting when quantitative criteria in terms of number of breeding populations and amount, distribution, and type of available habitat are defined and met. Criteria will be based on research, continued monitoring, and population viability analysis. In addition, regulatory mechanisms and land management commitments must be implemented that provide for adequate long-term protection of the Sonora tiger salamander and its habitat. These commitments and mechanisms should address habitat maintenance and protection, management of non-native predators, disease transmission, introduction and collection of salamanders, interbreeding with non-native salamanders, and public education. Finally, the Sonora tiger salamander must be unlikely to need protection under the Endangered Species Act in the foreseeable future.

Actions Needed:

1. Maintain and enhance habitat where salamanders have been found, and create new habitat, if deemed necessary.
2. Control non-native predators (fish, bullfrogs, and crayfish) by enforcing and enhancing existing policies prohibiting the introduction and pond to pond transport of these taxa and by removing populations of non-native fish and crayfish.

3. Control introduction, transport, and collection of tiger salamanders in the San Rafael Valley by enforcing existing policies prohibiting these acts and by removing populations of barred tiger salamanders.
4. Create and enforce policies to minimize frequency of die-offs.
5. Monitor salamander populations and their habitat on public and, if permitted, private land, to observe threats as they arise and fulfill research objectives.
6. Conduct research to acquire demographic and dispersal information and develop a population viability analysis, better understand salamander disease, conduct genetic analyses, investigate reports of low pH, and determine distribution of crayfish and methods of crayfish removal.
7. Develop public education and information programs.
8. Practice adaptive management.

Total Cost of Recovery (minimum): $1,009,000

Costs, in thousands of dollars:

Year	Minimum Costs: ($000's)
2000	210
2001	253
2002	203
2003	165
2004	178
2005+	To be determined

Date of Recovery: If recovery criteria are met, reclassification to threatened status could be initiated in 2005.

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I. INTRODUCTION

The Sonora tiger salamander, *Ambystoma tigrinum stebbinsi*, was described by Lowe (1954), and subsequent field surveys and genetic analyses in the 1980's and 1990's reinforced the status of Sonora tiger salamanders as a distinct subspecies. Concerns about the threats posed by introduced fish and bullfrogs, frequent disease outbreaks, and genetic swamping by introduced barred tiger salamanders, *A. t. mavortium*, combined with the Sonora tiger salamander's restricted range and the fact that it is found almost exclusively in human-constructed and maintained ponds, led to the Federal listing of the Sonora tiger salamander as endangered on January 6, 1997; no critical habitat was designated.

The Endangered Species Act (ESA) calls for preparation of recovery plans for listed species likely to benefit from the effort. This document establishes recovery goals and objectives, describes site-specific management actions recommended to achieve those goals, and estimates the time and cost required for recovery, as well as who should be responsible for implementation of recovery actions. A recovery plan is not self-implementing, but presents a set of recommendations endorsed by the U.S. Fish and Wildlife Service (USFWS). This plan was developed by the authors with the help of the Sonora Tiger Salamander Participation Team and the USFWS. The Participation Team consists of ranchers and residents of the San Rafael Valley, representatives of State and Federal agencies, and other concerned citizens that were appointed by the Regional Director of the USFWS's Region 2. The Participation Team prepared a report, included as Appendix D, that clarifies how recovery actions should be implemented to minimize social and economic impacts while still promoting the recovery of the Sonora tiger salamander.

Species Description and Taxonomy

The Sonora tiger salamander, *A. t. stebbinsi*, was described by Lowe (1954), who, along with Reed (1951), found the subspecies in ponds in the San Rafael Valley (SRV), where most known Sonora tiger salamander populations exist. The SRV lies between the Huachuca and Patagonia mountains, is bordered by the Canelo Hills to the north, and extends from Santa Cruz County in Arizona approximately 30 km into Sonora, Mexico.

Sonora tiger salamanders begin their life as jelly-coated eggs laid in water. They hatch and grow as aquatic larvae with gills, and then either mature as gilled aquatic adults called branchiate adults, neotenes, or paedomorphs or metamorphose into terrestrial salamanders without gills. Metamorphosed terrestrial Sonora tiger salamanders have a color pattern ranging from "a reticulate pattern with an irregular network of light coloration, often coupled with light spots, on a dark background color", to a pattern of large, well-defined light or yellow spots or transverse bars, some of which encroach on the dark venter (Jones *et al.* 1988). Metamorphosed Sonora tiger salamanders measure from about 45 to 150 mm snout to vent length (SVL). Branchiate adults are gray to olive on the dorsum, head, and tail, and off-white to yellow on the ventral side. They have three external gills on each side of their head, and measure between 65 and 165 mm SVL. Male and female adult salamanders can be distinguished by the presence of two black folds of tissue (cloacal folds) on the caudal side of a male's vent. Larvae are gray on the dorsum,

head, and tail, with little pigment on the ventral surface. They have external gills and hatch without legs, but grow hind and fore-limbs early in development.

Sonora tiger salamanders are one of three subspecies of tiger salamanders found in Arizona; the other two subspecies are Arizona tiger salamanders, *A. t. nebulosum*, and barred tiger salamanders, *A. t. mavortium*. Eggs, larvae, and branchiate adults of the three subspecies appear similar, except that larval and branchiate adult Arizona and barred tiger salamanders sometimes develop into a cannibalistic morph that has a wider head, enlarged vomerine teeth, and feeds preferentially on smaller conspecifics. Out of tens of thousands of salamanders observed in the SRV, only five have had the cannibalistic morph (Snyder and Collins, pers. obs.). Metamorphosed Arizona tiger salamanders have 11-50 irregularly shaped, yellow to olive spots and blotches, often with indistinct edges (Stebbins 1985), on a dark dorsal ground, with a similar pattern on the head and tail. Metamorphosed barred tiger salamanders have large, distinct, yellowish bars, spots, or transverse bars on a darkly grounded dorsum. Some of the spots or bars encroach on the dark venter. The reticulate pattern seen in Sonora tiger salamanders is not seen in Arizona or barred tiger salamanders, but many metamorphosed Sonora tiger salamanders do not have the reticulate pattern and are visually indistinguishable from barred tiger salamanders.

Sonora tiger salamanders possess genetic characteristics that in some respects resemble barred tiger salamanders and in other respects resemble Arizona tiger salamanders. A likely explanation for this pattern is a hybridization event between Arizona and barred tiger salamanders at some point in the distant past (Jones *et al.* 1995). Interviews with long-time residents of the SRV have provided anecdotal evidence of tiger salamanders in the valley during the early 1900's before the introduction of barred tiger salamanders for bait was likely to have taken place (Jones *et al.* 1988). This evidence, combined with the presence of *Ambystoma* fossils on the north side of the SRV and the San Pedro River, suggests that the Sonora tiger salamander is an endemic subspecies that evolved 'naturally,' and not as a result of human introductions of Arizona and barred tiger salamanders (Jones *et al.* 1995, Brattstrom 1955).

The rosy salamander, *Ambystoma rosaceum*, occurs in Durango, Chihuahua, and Sonora, Mexico, including the southern portion of the SRV in Mexico (Shannon 1951, Jones *et al.* 1995). Rosy salamander larvae are pinkish in color with dark patterning on the sides and back (Taylor 1981) and fewer gill rakers (9-15) than tiger salamanders in Arizona and Mexico (15-24) (Collins 1979). Metamorphed rosy salamanders are uniformly dark brown on the sides and back and lighter ventrally (Anderson 1961). Allozyme data suggest that interbreeding between *A. tigrinum* and *A. rosaceum* is rare or non-existent, even when their distributions overlap (Shaffer 1983).

Life History and Population Ecology

Breeding and Eggs

Sonora tiger salamanders begin breeding as early as January, and eggs can be found in ponds as late as early May (Snyder, pers. obs.). Breeding after monsoon rains in July and August is rare (Snyder, pers. obs.). Salamanders ready to breed have swollen, reddish vents. Terrestrial adults, which are often outside the pond during the rest of the year, return to ponds to breed, and

branchiate adults in the pond also breed. Although there is little data on breeding site fidelity for Sonora tiger salamanders, other *Ambystoma* species usually return to breed in the ponds where they were born (Shoop 1965, 1968, Shoop and Doty 1972, Douglas and Monroe 1981, Semlitsch 1981, Madison 1997, Madison and Farrand 1998). Courtship takes place under water, and is difficult to observe in the field. After fertilization, female tiger salamanders lay 200 to 2000 eggs (James Roth, pers. comm.), attaching them to aquatic vegetation, sticks, rocks, or substrate individually or in clumps of up to 50. Eggs take from 2-4 weeks to hatch; the colder the water, the longer the eggs take to develop. Sources of mortality for tiger salamander eggs include freezing, drying, and predation by adult salamanders (Holomuzki 1986) and introduced fish (Snyder 1998). Transition probabilities from one life history stage to the next (*e.g.*, likelihood of an egg becoming a larva or a larva becoming an adult) have not been determined for Sonora tiger salamanders in the field.

Larvae

Following hatching, Sonora tiger salamander larvae can develop to the minimum size necessary to metamorphose in as little as two months. However, because many SRV sites with salamanders hold water all year, larvae often remain in the water longer before metamorphosing, or develop into branchiate adults instead of metamorphosing. Small tiger salamander larvae feed primarily on zooplankton (daphnids, copepods, bosminids, ostracods, *etc.*), but incorporate larger aquatic macroinvertebrates (chironomids, trichopterans, molluscs, zygopterans, *etc.*) into their diet as they grow (Collins and Holomuzki 1984). Sources of mortality for tiger salamander larvae include pond drying, disease (Jancovich *et al.* 1997), and predation by wading birds, introduced fish and bullfrogs (Snyder 1998), aquatic insects (Holomuzki 1986), and adult salamanders (Holomuzki 1986).

Branchiate Adults

Salamander larvae in permanent water often develop into branchiate adults that stay in the pond throughout their lives. SRV ponds that do not dry support up to several hundred branchiates (pers. obs.). Branchiate adult tiger salamanders prey on zooplankton and a variety of macroinvertebrates, and eat salamander eggs and larvae during the breeding season (Holomuzki 1986). Although branchiate adult Sonora tiger salamanders probably eat salamander eggs and larvae, they seldom develop into the cannibalistic morph. Branchiate adults can sometimes metamorphose into the terrestrial form in response to stressful events such as pond drying, but branchiates are often unable to complete metamorphosis or even die during the process (Roth, pers. comm.). Sources of mortality for branchiate adults include pond drying, disease (Jancovich *et al.* 1997), and predation by wading birds and larger introduced fish species (Snyder 1998). The lifespan of branchiate adult Sonora tiger salamanders in the field is not known, but Arizona tiger salamanders have survived as branchiates for up to 8 years in captivity (Roth, pers. comm.). The reason that branchiates have not been kept longer is that they eventually metamorphose, even after years as branchiates.

Metamorphosed Adults

When larvae are large enough (>45 mm SVL), they can metamorphose into terrestrial salamanders. The proportion of larvae that metamorphose depends heavily on pond permanence. In ponds that dry, all larvae that are large enough metamorphose. In ponds that do not dry, approximately 18-40 percent of larvae that are large enough metamorphose (Tom Jones, unpublished data). The number of metamorphs in each population is difficult to estimate because most metamorphosed salamanders leave the pond after breeding, and we do not know what fraction of salamanders in the terrestrial environment return each year to breed. Outside the pond, metamorphosed tiger salamanders consume terrestrial insects and other macroinvertebrates. In the pond, metamorphosed individuals eat aquatic macroinvertebrates and terrestrial insects that fall in the water (Whiteman *et al.* 1994). Metamorphs often re-populate ponds following drying or disease outbreaks that kill most branchiate adults and larvae. Metamorphs are also the only life history stage that can disperse from pond to pond and establish new populations.

The ecology of Sonora tiger salamanders outside the ponds has been little studied, but other *Ambystoma* species spend much of their time in mammal burrows or buried in soft earth to avoid environmental extremes common on land (Shoop 1965, 1968, Shoop and Doty 1972, Douglas and Monroe 1981, Semlitsch 1981, Madison 1997, Madison and Farrand 1998). The dispersal patterns of Sonora tiger salamanders, which are critical for determining metapopulation dynamics, are also unknown. Radio-tracking of other *Ambystoma* species has shown that they frequently move up to 250 m from their breeding ponds (Shoop 1965, 1968, Shoop and Doty 1972, Douglas and Monroe 1981, Semlitsch 1981, Madison 1997, Madison and Farrand 1998). However, *Ambystoma* occasionally disperse longer distances. For example, Allison (pers. comm.) found two Arizona tiger salamanders in ponds between 1.5 and 2 km from the ponds where she found them the previous spring, and Sheridan Stone (Fort Huachuca Wildlife Office, pers. comm.) found 2 metamorphosed tiger salamanders (*A.t. mavortium*?) at sites 3-4 km from the nearest potential source population. In the SRV, Reed (1951) reported that newly created cattle ponds were colonized almost immediately by tiger salamanders, which he attributed to the ability of salamanders to disperse long distances. The above data suggest that only a small proportion of salamanders in a pond are likely to have dispersed from another pond, so salamanders in each pond are referred to as a population. If future data show that pond to pond movements are common, different terminology will be adopted. A lack of genetic variation within Sonora tiger salamanders has so far made it impossible to determine the degree of gene flow using genetic analysis, but sequencing of variable regions of nuclear DNA (microsatellites) may provide further insight into this question.

Sources of mortality for metamorphosed adults include extreme conditions in the terrestrial environment, disease (Jancovich *et al.* 1997), and predation by terrestrial predators and introduced fish and bullfrogs (Snyder 1998). The lifespan of metamorphosed Sonora tiger salamanders in the wild is not known, but metamorphosed Arizona tiger salamanders have survived 17 years in captivity (Roth, pers. comm.). Analysis of growth rings in toe bones (skeletochronology) of 150 Arizona tiger salamanders captured in the field revealed no

salamanders over 6 years old (Allison, unpublished), but it remains to be seen whether the same is true for Sonora tiger salamanders.

Distribution and Abundance

Dr. James Collins began surveying ponds with tiger salamanders in the SRV in 1979. Members of Dr. Collins' lab and employees of Arizona Game and Fish Department (AGFD) have continued surveys throughout the 1980's and 90's (*e.g.*, Collins *et al.* 1988, Abbate 1998). Because so few sites were sampled prior to the 1980's, it is impossible to determine the historical distribution of Sonora tiger salamanders. Surveys for the Sonora tiger salamander have been conducted on public land throughout the Arizona portion of the SRV. Surveys have also been conducted recently on the San Rafael Cattle Ranch, which was acquired by Arizona State Parks (ASP) and The Nature Conservancy (TNC) in 1998. The number of ponds sampled is now well over 100, and tiger salamanders have been found in 53 ponds (Fig 1); 45 of these ponds have had salamanders within the last five years. The number of salamanders supported by each pond is difficult to determine, because metamorphosed salamanders can survive outside the ponds and we do not know what proportion of metamorphs breed each year. In some years, salamanders will be completely absent from a pond, only to return the following year to breed and produce many offspring.

Cattle ponds are the primary habitat for Sonora tiger salamanders, but there are several observations of unidentified salamanders away from cattle ponds. Salamanders suspected of being Sonora tiger salamanders were found in the Los Fresnos cienega in Mexico, 3 km south of the international boundary (Volero-Romero *et al.*, 1992). Tiger salamanders were also found in a cave and vertical mining shaft at the northwestern edge of the SRV (Tom Deecken, pers. comm.).

Because of the similarity between Sonora and barred tiger salamanders and the possibility that barred tiger salamanders have been introduced to ponds in SRV, genetic testing has been performed on salamanders from a number of SRV ponds to determine their identity. Genetic testing showed that some SRV ponds do contain salamanders with genetic characteristics similar to barred tiger salamanders. Salamanders with these "*mavortium*-like" sequences are more common on the outskirts of the SRV and ponds close to Parker Canyon Lake, which is where we might expect to find introduced barred tiger salamanders (Ziemba *et al.* 1998). Tiger salamanders have also been found in areas just outside the SRV, such as Fort Huachuca, Harshaw Canyon, Copper Canyon, and Coronado Memorial. Of these localities, genetic testing has only been performed on salamanders from the Fort, and with the exception of one pond within a kilometer of the SRV, salamanders on the Fort appear to be barred tiger salamanders (Andrew Storfer, University of Florida, pers. comm.).

Habitat Requirements

The most important habitat requirement for Sonora tiger salamanders is the availability of standing water for breeding from January through June. This gives the salamanders enough time to breed, grow as larvae, and metamorphose before the pond dries. Permanent bodies of water can be good breeding sites, except they often contain introduced fish and bullfrogs (Snyder

1998). Erosion and arroyo cutting in the late 19th and early 20th centuries caused the SRV to dry and natural standing water habitats to disappear (Hendrickson and Minckley 1984, Hadley and Sheridan 1995). As a result, ponds created by ranchers for watering their cattle are now almost the only suitable breeding sites remaining. However, there are still some springs on the newly acquired ASP and TNC land (Mike Pruss, pers. comm.), and possibly elsewhere, such as in Scotia Canyon, that may be suitable breeding sites.

Referring to conservation of the California tiger salamander, *A. californiense*, Petranka (1998) found that conservation of a 200-500 m radius of vegetation around a breeding pond would protect the habitat of most of the adult terrestrial population. In the SRV, however, aquatic and bank-line vegetation is missing from many ponds with salamanders, suggesting that these factors, although beneficial, are not necessary for the persistence of Sonora tiger salamanders. The terrestrial plant community in the SRV is plains grassland with oak and juniper woodlands (Brown 1994), but other *Ambystoma tigrinum* subspecies are found in communities ranging from the prairies of Oklahoma to pine forests of Colorado and semi-desert regions in Arizona. Sonora tiger salamanders are tolerant of a wide range of temperatures, with temperatures in ponds varying from less than 5°C at the beginning of the year up to 30°C during summer. Temperatures in the terrestrial environment range from below freezing to over 35°C. Mammal burrows or loosened soils outside the pond likely provide refugia for metamorphosed salamanders in the terrestrial environment, enabling them to burrow underground to avoid extreme environmental conditions.

Present Status

More data are needed to make definitive statements about the long-term viability of Sonora tiger salamanders in the SRV. About half of the 53 Sonora tiger salamander populations have been discovered within the last five years, and only within the last five years were ponds with salamanders sampled consistently, making it difficult to determine trends in the proportion of ponds occupied by salamanders and suitability of those ponds for salamander breeding habitat. Also, more data on the ecology of Sonora tiger salamanders (*e.g.*, life-span, proportion of adults breeding each year, frequency and distance of dispersal events) are required to develop a suitable population viability analysis.

Despite the fact that Sonora tiger salamander populations face threats of introduced predators, disease, genetic swamping, restricted distribution, and habitat dependent on human management, there is little reason to assume *a priori* that Sonora tiger salamanders are in immediate danger of extinction. Salamander populations recovered following observed disease outbreaks (pers. obs.); only a few known populations have been eliminated by fish introductions (Snyder 1998), and ranchers have maintained many cattle ponds so that they hold water long enough to support salamanders but occasionally dry, eliminating fish and reducing bullfrog populations (Snyder 1998). Nevertheless, because Sonora tiger salamanders have such a restricted distribution, and because persistence of Sonora tiger salamander habitat depends directly on human management strategies, Sonora tiger salamanders will always be vulnerable to changes in land management and relatively small changes in environmental variables such as drying frequency, frequency of

disease outbreaks, and frequency with which fish or non-native salamanders are introduced. Research on the ecology and viability of Sonora tiger salamander populations should assist in developing a management strategy to protect salamanders and their habitat that will ensure persistence of salamanders in the SRV. The genetic status of Sonora tiger salamanders is still being studied, but it appears that some (approximately 25 percent) SRV ponds with tiger salamanders contain at least some salamanders with sequences resembling barred tiger salamanders (Ziemba *et al.* 1998). The threat of genetic swamping by introduced barred tiger salamanders is one of the most difficult threats to assess because genetic testing is often required to distinguish between Sonora tiger salamanders, barred tiger salamanders, and (potentially) hybrids of the two subspecies.

Reasons for Listing

U.S. Fish and Wildlife Service (1997a) described seven threats to the Sonora tiger salamander which, when taken together, justified listing: (1) Sonora tiger salamanders have a restricted distribution and a limited number of breeding habitats, making them vulnerable to stochastic events, such as flooding or drought. (2) Most cienegas and standing water habitat presumably used historically by Sonora tiger salamanders for breeding have disappeared, and so today, salamanders in SRV are found almost exclusively in human-constructed cattle ponds that are small and often very dynamic habitats. (3) Many of the salamander's breeding ponds have been invaded by non-native fish and/or bullfrogs, which prey on salamanders and their larvae. Several salamander populations have been extirpated by fish introductions. (4) Sonora tiger salamanders are subject to frequent die-offs as a result of disease caused by an iridovirus that kills almost all salamanders and larvae in the pond at the time. (5) Low genetic heterozygosity for the subspecies might result in reduced fitness. (6) Barred tiger salamanders (*A. t. mavortium*) have apparently been introduced to the SRV and might interbreed with Sonora tiger salamanders, swamping out characteristics that differentiate the two subspecies. (7) Collecting Sonora tiger salamanders for bait or translocation by anglers might reduce population sizes, spread disease, and disperse non-native tiger salamanders. The reasons for listing are discussed in more detail below.

Restricted Distribution

At the time of listing in January of 1997, Sonora tiger salamanders reportedly were found in 36 ponds since the early 1980's. Due to a thorough search of early survey records and continuing survey work in the SRV, the number of ponds where salamanders have been found has increased to 53 (Fig 1), and more populations undoubtedly exist, particularly on unsurveyed private land. Salamanders have disappeared from a few ponds since surveys began in the late 1970's, but there is little indication that there is a general decline in the number of populations in the SRV. Furthermore, the density of ponds supporting salamander populations in the SRV is comparable to that in other regions supporting tiger salamanders. However, the restricted distribution of Sonora tiger salamanders makes them vulnerable to relatively small-scale environmental disturbances and land-use changes.

Habitat Loss

Prior to the 20th century, the SRV contained many more cienegas and vernal pools than it does today. Erosion and arroyo cutting in the late 19th and early 20th centuries caused the SRV water table to drop and natural standing water habitats to disappear (Hendrickson and Minckley 1984, Hadley and Sheridan 1995). However, at the same time natural standing water habitats were disappearing, cattle ponds were built. Many of the remaining springs and cienegas were converted into impoundments at this time, so most of the small standing water habitats remaining in the SRV are cattle ponds. Sonora tiger salamanders breed almost exclusively in these cattle ponds. The fact that Sonora tiger salamanders breed in human-constructed cattle ponds instead of natural habitats does not necessarily threaten persistence of the taxon. Sonora tiger salamanders have successfully bred in cattle ponds for decades, but salamanders are now dependent on humans to maintain the habitat. In particular, cattle ponds require occasional re-excavation because they fill with silt, and pond dams require occasional maintenance.

Cattle pond habitats are also vulnerable to extreme weather conditions. Long term drought could dry many of the ponds, and if ponds remained dry for several years, lack of breeding could lead to local extirpation of the salamander population. Cattle ponds can also wash out during storms or floods.

Predation by Introduced Species

There are reports of introduced fish in the SRV as early as the 1950's, and various introduced fish species now occur in SRV ponds, including mosquito fish (*Gambusia affinis*), green sunfish (*Lepomis cyanellus*), bluegill sunfish (*Lepomis macrochirus*), white crappie (*Poloxis annularis*), black bullheads (*Ameirus melas*), and largemouth bass (*Micropterus salmoides*). Bullfrogs (*Rana catesbeiana*) have been in the valley since at least the early 1970's. Laboratory and field experiments have shown that metamorphosed bullfrogs and all fish species listed above quickly eat salamander larvae, and adult Sonora tiger salamanders have been found in the stomachs of adult bullfrogs (Snyder 1998). In addition, whenever fish are introduced to a pond, the salamanders almost always disappear within the next few years, and do not reappear unless the fish are killed by pond drying (Snyder 1998). For some reason, adult bullfrogs have not maintained consistently high population densities in many SRV ponds, so the potential effect of bullfrogs on Sonora tiger salamanders remains unclear (Snyder 1998). However, given the observation that bullfrogs eat salamanders and the effect of bullfrogs on other native western herpetofauna (*e.g.*, Rosen and Schwalbe 1996, Kupferberg 1997, Kiesecker and Blaustein 1997), bullfrogs should be considered a threat to Sonora tiger salamanders. Occasional drying of cattle ponds due to drought or siltation has limited the number of ponds occupied by fish and/or bullfrogs, because both taxa are vulnerable to drying. Crayfish are potential predators on salamanders as well, but have only been found in a few SRV ponds, and those did not contain salamanders (Pruss, pers. comm.). Crayfish are in many SRV streams, however, and if they are introduced to ponds with salamanders, they will probably harm Sonora tiger salamanders much as they have harmed other western herpetofauna (*e.g.*, Gamradt and Kats 1996, Fernandez and Rosen 1996).

Die-Offs

Sonora tiger salamander populations experience frequent die-offs (approximately 8 percent of populations are affected each year) in which almost all salamanders and larvae in the pond die. *Ambystoma tigrinum* virus (ATV) is the pathogen believed to be responsible for these die-offs (Jancovich *et al.* 1997). It is also possible that some die-offs might occur as a result of low pH (Pruss, pers. comm.). A copper mine at Cananea, Sonora, less than 25 miles south of the border, might release sulfur plumes that could result in acid precipitation (Platz 1989, Blanchard and Stromberg 1987), but currently there is no evidence to connect salamander die-offs with the copper mine. Although almost all the salamanders in the pond perish during die-offs, salamanders have been no less likely to breed in years following die-offs than in years not following die-offs (Snyder, pers. obs.). Presumably, metamorphosed salamanders outside the pond escape the effects of the die-off and are able to breed the following year.

Genetic Swamping

Sonora tiger salamanders also face the threat of genetic swamping by introduced barred tiger salamanders, which are often sold as large larvae or branchiate adults for fishing bait. Genetic analysis has suggested that barred tiger salamanders have been introduced to some SRV ponds, perhaps by anglers using salamanders as bait, or with the hope of establishing a population that could be harvested at a later date. Salamanders with genetic characteristics similar to barred tiger salamanders have been found in six (Chamisa, Gypsy, Heidi, Inez, School Canyon East, and Whiner) out of 23 SRV ponds tested genetically (Ziemba *et al.*, 1998). Very low sample sizes (maximum of three individuals tested from these sites) make it impossible to determine what percentage of salamanders in these ponds had *mavortium*-like sequences and what percentage had *stebbinsi*-like sequences. Although the allozyme sequencing that was used could not determine whether there was any hybridization between the two subspecies, such hybridization is likely when the two sub-species co-occur. A microsatellite genetic analysis is under way to determine the extent of hybridization (Storfer, pers. comm.).

Collecting Salamanders for Bait

If large numbers of salamanders are collected for bait, it could threaten the persistence of Sonora tiger salamander populations. There are no data on the number of salamanders that are collected for bait, but illegal collection from the SRV has been reported (Collins and Jones 1987, Bob Hudson, pers. comm.). Given the popularity of salamanders as bait, it is reasonable to assume that illegal collection of salamanders will continue to occur.

Low Genetic Heterozygosity

Allozyme analysis and allozyme sequencing have both shown very little genetic variability in Sonora tiger salamanders (Jones *et al.* 1988, Jones *et al.* 1995, Ziemba *et al.* 1998). Low genetic variability is a concern because in populations with low heterozygosity, deleterious alleles are expressed more frequently, disease resistance might be compromised, and there is little capacity for evolutionary change in response to environmental change.

Current Management

Federal Regulations and Management

Federal listing under the ESA provided considerable protection to the Sonora tiger salamander and its habitat. Section 9 of the ESA prohibits take of any listed wildlife species, including the Sonora tiger salamander. The definition of "take" includes to harass, harm, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct. "'Harm' in the definition of 'take' in the ESA means an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering" (50 CFR 17.3). Harass is defined in the same regulation as "an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, and sheltering." Anyone who engages in a take is subject to prosecution under Section 9 of the Act. Such taking may occur only under the authority of the USFWS pursuant to Section 7 (through Federal interagency consultation if there is Federal involvement with a project) or through a Section 10(a)(1)(A) or (B) Permit.

Because most of the land, cattle ponds, and salamander populations in the SRV are on Federal lands, most activities that might affect the salamander or its habitat are subject to Section 7 consultation. Federal agencies are required to consult with the USFWS on any discretionary actions they fund, authorize, or carry out that may affect listed species. As a result of these consultations, measures are built into proposed projects to protect the salamander and its habitat. For instance, 1997 and 1999 consultations between USFWS and the Coronado National Forest resulted in the development of stock tank maintenance guidelines to minimize incidental take of salamanders associated with cleaning out tanks (Fish and Wildlife Service 1997b, 1999). The 1997 consultation also provided measures to reduce the possibility that salamanders might be unintentionally killed or moved among stock tanks by fire suppression activities.

Other Federal regulations also play a part in the current management of the salamander. The National Forest Management Act of 1976 (16 U.S.C. 1600 et seq.) directs the U.S. Forest Service (USFS) to prepare programmatic–level management plans that will guide long–term resource management decisions. The goals of the Coronado National Forest Plan include a commitment to maintain viable populations of all native wildlife, fish, and plant species within the Forest's jurisdiction through improved habitat management (Coronado National Forest 1986a). The Plan's endangered species program includes participation in reaching recovery plan objectives for listed species, habitat coordination and surveys for listed species, and habitat improvement (Coronado National Forest 1986b). The Forest considers the salamander a sensitive species and a management indicator species (Coronado National Forest 1986a).

A population of salamanders in upper Garden Canyon of Fort Huachuca is suspected of being Sonora tiger salamanders. In accordance with Army Regulation 200–3, Fort Huachuca is preparing an Integrated Natural Resources Management Plan that will require preparation of Endangered Species Management Plans (ESMPs) for all listed and proposed species and critical

habitat (Sheridan Stone, Fort Huachuca, pers. comm. 1996). Fort Huachuca contracted with Dr. James Collins to prepare a management plan for the Sonora tiger salamander. As of this writing, the plan is in draft form.

Several other Federal regulations affect management of salamander habitat. The National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. § 4321–4370a) requires Federal agencies to consider the environmental impacts of their actions. NEPA requires Federal agencies to describe a proposed action, consider alternatives, identify and disclose potential environmental impacts of each alternative, and involve the public in the decision–making process. Wetlands inhabited by the salamander are also afforded varying protection under Section 404 of the Federal Water Pollution Control Act of 1948 (33 U.S.C. 1251–1376), as amended; and Federal Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands).

Arizona State Regulations

Collecting *Ambystoma* in the SRV is prohibited under Arizona Game and Fish Commission Orders 40 and 41, except under special permit. Furthermore, transport and stocking of live bullfrogs and fishing with live bait fish or *Ambystoma* within the range of this salamander in Arizona are prohibited (R12–4–316). The Sonora tiger salamander is included in AGFD's draft Wildlife of Special Concern in Arizona; however, this designation affords the species and its habitat no legal protection. State of Arizona Executive Order Number 89–16 (Streams and Riparian Resources), signed on June 10, 1989, directs State agencies to evaluate their actions and implement changes, as appropriate, to allow for riparian resources restoration.

Ownership of the San Rafael Cattle Ranch in the center of the San Rafael Valley was recently transferred to ASP and TNC. This ranch is approximately 8,700 hectares and is divided into three sections: 1) The 6,850 hectare San Rafael de la Zanja Spanish land grant, 2) a 450 hectare "Upper 17" portion north of the land grant, and 3) 1,400 hectares south of the land grant boundary and north of the Mexican border. TNC owns the land grant and "Upper 17" portion, and ASP owns the 1,400 hectares south of the land grant and holds a conservation easement over the land grant portion. ASP will retain 1,400 hectares between the land grant boundary and the Mexican border, but TNC is currently looking for a private buyer for the land grant and "Upper 17" portion. The conservation easement on the land grant prohibits subdivision of the affected property; sale, diversion, or transfer of ground and surface waters; mining; stocking or transfer of non-native organisms; activities that use excessive amounts of water; planting of non-native vegetation; and other provisions to maintain the property in a relatively undisturbed state.

Private Ownership and Management

As discussed above, TNC has recently become an important private landowner in the San Rafael Valley. Most other lands in the range of the Sonora tiger salamander are owned by State or Federal agencies. However, private inholdings occur throughout the valley, most notably in Mowry Wash, Adams Canyon, Meadow Valley, Campini Mesa, and lower Sunnyside Canyon. Many of the owners of these lands hold grazing permits on the Coronado National Forest and have a great influence on the management of the stock tanks where the salamander breeds.

Sonora

Salamanders suspected of being Sonora tiger salamanders have been collected from Los Fresnos cienega in the School Canyon drainage approximately 3 km south of the border (Valero-Romero *et al.* 1992). In Mexico, *Ambystoma tigrinum*, including the Sonora tiger salamander, is a species of Special Protection. This designation affords certain protections to the species (Secretaria de Desarrollo Urbano y Ecologia 1994).

II. RECOVERY

Recovery Objective

The objective of this Recovery Plan is the recovery and delisting of the Sonora tiger salamander. An interim objective is to downlist the species from endangered to threatened. Although Sonora tiger salamanders face a variety of threats, a relatively high density of ponds support Sonora tiger salamander populations, and there is no indication that the number of populations is declining, except in ponds where fish were introduced. Consequently, downlisting criteria focus on monitoring and protecting existing Sonora tiger salamanders.

Downlisting Criteria

The Sonora tiger salamander will be considered for downlisting when both of the following criteria have been met:

1. Ponds on approximately 90 percent of salamander's currently-occupied range (lands managed by CNF, ASP, and Fort Huachuca, and possibly lands currently owned by TNC or other private lands) are protected in accordance with management tasks 1.1 through 1.5, are free from introduced fish and crayfish, and are monitored to detect new threats including introductions of predators and non-native salamanders.
2. Scientifically credible monitoring over a five year period indicates that the number of Sonora tiger salamander populations is not in decline and that there are no new factors that threaten the persistence of the Sonora tiger salamander metapopulation.

Delisting Criteria

The Sonora tiger salamander will be considered for delisting when all of the following criteria have been met:

1. Number of breeding populations and amount, distribution, and type of available habitat are adequate to support viable populations of Sonora tiger salamanders in the long term. Research, monitoring, and a population viability analysis (PVA), as described in the Narrative Outline, will provide the information to quantify these variables.
2. Regulatory mechanisms and land management commitments that provide for adequate long term protection of the Sonora tiger salamander and its habitat, such as those described in the step-down narrative, have been implemented. These commitments and mechanisms should address management of non-native predators, disease transmission, introduction and collection of salamanders, interbreeding with non-native salamanders, public education, and other issues as described in the step-down narrative or identified in subsequent revisions of this plan.

3. The Sonora tiger salamander is unlikely to need protection under the Endangered Species Act in the foreseeable future.

Downlisting and delisting criteria are designed to provide a basis for considering a change in the status of the Sonora tiger salamander, but would not trigger automatic downlisting or delisting. Such decisions are made by the USFWS through a rule-making process that involves public review and comment. The recovery criteria will be revised by the USFWS as appropriate as new information pertinent to these topics becomes available. Revisions must be based on the best data available.

Step-Down Outline of Recovery Actions

1. Protect and enhance salamander habitat
    - 1.1. Develop guidelines for watershed use and maintenance
    - 1.2 Implement watershed use and maintenance guidelines
    - 1.3 Implement guidelines for cattle pond use and maintenance
    - 1.4. Develop cleaning and maintenance program for cattle ponds
    - 1.5. Enforce guidelines for cattle pond and watershed use and maintenance
    - 1.6. Enhance bank-line and aquatic vegetation at breeding ponds
    - 1.7. If necessary, implement policies to alleviate low pH in breeding ponds
    - 1.8. Develop cooperative agreements with willing land owners to protect salamander habitats on private lands
    - 1.9. If needed, build more ponds
    - 1.10. Develop at least three self-sustaining cienega habitats that can support salamander populations
2. Control non-native predators (fish, bullfrogs, and crayfish)
    - 2.1. Propose regulation preventing use of crayfish as live bait in SRV
    - 2.2. Enforce regulations prohibiting introduction of non-native predators to SRV ponds
    - 2.3. Remove fish, crayfish, and bullfrog populations from SRV ponds
3. Control introduction, transport, and collection of tiger salamanders in SRV
    - 3.1. Enforce regulations preventing introduction, transport, and collection of tiger salamanders in SRV
    - 3.2. Remove non-native tiger salamander populations from SRV ponds
4. Create and enforce policies to minimize frequency of die-offs
5. Monitor salamander populations and their habitat
    - 5.1. Prepare monitoring schedule and protocol
    - 5.2. Develop agreements with willing land owners to survey for and monitor populations on private lands
    - 5.3 Survey for salamanders on private lands pursuant to agreements developed in 5.2
    - 5.4. Develop interagency cooperation and data repository
    - 5.5. Conduct monitoring
    - 5.6. In coordination with Mexican officials, survey potential habitats in Sonora

6. Research
    6.1. Acquire demographic and dispersal information
        6.1.1. Determine age structure in adult salamanders
        6.1.2. Estimate female fertility and proportion of females breeding
        6.1.3. Acquire transition probabilities from one life history stage to the next
        6.1.4. Acquire information on dispersal patterns through mark/recapture and radiotelemetry
        6.1.5. Determine habitat use of terrestrial metamorphs via radiotelemetry
        6.1.6. Develop a population viability analysis
    6.2. Research spread and environmental triggers of disease
    6.3. Conduct microsatellite analysis
    6.4. Investigate extent and, if necessary, possible causes of low pH in ponds
    6.5 Survey to determine crayfish distribution in the SRV
    6.6. Research methods of crayfish removal
7. Public education
    7.1. Post and maintain signs
    7.2. Prepare brochures and make available to the public
    7.3. Participation Team meetings
8. Practice adaptive management in which recovery tasks are revised by USFWS as pertinent new information becomes available

Narrative Outline for Recovery Actions

1. Protect and enhance salamander habitat. Salamander habitat must be protected. This protection ensures that salamanders have suitable breeding sites and that metamorphs outside the pond are able to safely overwinter and disperse.
    1.1. Develop guidelines for watershed use and maintenance. Land use activities in watersheds and upland habitats should not pollute, lead to excessive sediment deposition, or prevent water from entering ponds. Also, to facilitate salamander dispersal and survival outside ponds, actions that excessively de-vegetate upland habitat should be prevented.
    1.2 Implement watershed use and maintenance guidelines. Once developed, the guidelines should be implemented on public lands and, in the case of willing private landowners, on private lands.
    1.3 Implement guidelines for cattle pond use and maintenance. Current USFS guidelines for grazing and cattle pond use and maintenance (Appendix D, Attachment 2) are sufficient to protect salamanders from use associated with cattle ranching. These guidelines should be implemented on public lands and, in the case of willing private landowners, on private lands.
    1.4. Develop cleaning and maintenance program for stock ponds. Cattle ponds where salamanders have been found should be maintained so that in most years they hold water from January through July. Maintenance activities in ponds containing insufficient water may include removing sediment, reducing leakage, and maintaining dams. Occasional drying (once every few years) is acceptable, even

desirable, since it eliminates fish and bullfrogs and forces a larger proportion of the salamander population to metamorphose.

1.5. Enforce guidelines for cattle pond and watershed use and maintenance. The USFS and ASP should monitor cattle pond and watershed use and maintenance to ensure that guidelines are being followed.

1.6. Enhance bank-line and aquatic vegetation at breeding ponds. Grazing should be managed to maintain or increase aquatic and bank-line vegetation. Partial fencing of some ponds would allow vegetation to grow and still allow cattle access to water.

1.7. If necessary, implement policies to alleviate low pH in breeding ponds. If survey results show that ponds experience low pH (*i.e.*, at least one pond per year with pH below 5), management actions should address this problem. If it is not possible to eliminate the source of low pH, ponds could be treated, with calcium carbonate, for example, to balance the pH.

1.8. Develop cooperative agreements with willing land owners to protect salamander habitats on private lands. If land owners are willing, salamander habitat on private lands should be protected in a similar manner to those on public land. State or Federal government agencies should attempt to provide support and assistance to land owners that improve private ponds to benefit Sonora tiger salamanders. Several stewardship and wildlife habitat improvement programs exist that might help meet these needs (see Appendix D).

1.9. If needed, build more ponds. If population viability analysis suggests more populations are needed in a certain part of their range, establish new habitats to facilitate dispersal among breeding populations.

1.10. Develop at least three self-sustaining cienega habitats that can support salamander populations. To establish habitats that do not require continual human maintenance and to create a greater diversity of available habitat, efforts should be made to restore cienega habitats that can support Sonora tiger salamander populations. This effort includes identifying suitable habitat, ensuring adequate waterflow and suitable vegetation, and removing introduced predators. New ponds should not facilitate dispersal or establishment of non-native organisms that prey on Sonora tiger salamanders. This project should be coordinated with recovery efforts for other cienega species in the region.

2. Control non-native predators (fish, bullfrogs, and crayfish). If left unregulated, non-native predators could pose a serious threat to Sonora tiger salamanders.

2.1. Develop regulation preventing use of live crayfish as bait in SRV. It is currently legal to use live crayfish as bait in Arizona. Use of crayfish as bait could easily lead to introductions of crayfish in SRV ponds with Sonora tiger salamanders, which would threaten the salamanders. Therefore, use of live crayfish as bait in SRV should be prohibited.

2.2. Enforce regulations preventing introduction of non-native predators to SRV ponds. It is currently illegal to transport live bullfrogs or bait fish within the Arizona range of the salamander. Crayfish, fish, and bullfrogs cannot be stocked

without an aquatic stocking permit from AGFD, which considers the potential effects on endangered species before issuing permits. There should be adequate enforcement of these laws. Law enforcement agencies operating in the area, including USFS, USFWS, AGFD, ASP, U.S. Border Patrol, and local law enforcement should be informed of these laws. Ranchers and landowners should be encouraged to report illegal activities that may adversely affect the Sonora tiger salamander

2.3. Remove fish, crayfish, and bullfrog populations from SRV ponds. Non-native predators should be removed from ponds that contain or contained Sonora tiger salamanders. Predator removal should be conducted so as to minimize salamander mortality and effects on cattle and other animals that use the aquatic habitat. One possible method is simply to let ponds silt in and dry before re-excavating. If a pond is small, exhaustive sampling with a seine to remove predators is also feasible. Poison must be used with caution, because poison and agents of poison dispersal might affect cattle that use the pond and will almost certainly affect salamanders. If poison is administered to a pond used by cattle, the cattle must be protected, either by using a method not toxic to cows or by fencing the affected tank and providing an alternative water source. As many salamanders as possible must be removed before poisoning, and returned to the pond after the poison has dissipated or been neutralized.

3. Control introduction, transport, and collection of tiger salamanders in SRV. Human use and transport of tiger salamanders threatens Sonora tiger salamanders because of the possibility of genetic swamping by introduced salamanders and over-collecting by bait harvesters.

3.1. Enforce regulations preventing introduction, transport, and collection of tiger salamanders in SRV. It is currently illegal to transport, introduce, or collect tiger salamanders in the Arizona range of the Sonora tiger salamander. There should be adequate enforcement of these laws. Law enforcement agencies operating in the area, including USFS, USFWS, AGFD, ASP, U.S. Border Patrol, and local law enforcement should be informed of these laws. Ranchers and landowners should be encouraged to report illegal activities that may adversely affect the Sonora tiger salamander.

3.2. Remove non-native tiger salamander populations from SRV ponds. If there are SRV ponds that contain only introduced barred tiger salamanders (verified by genetic testing over multiple years), the introduced salamanders should be removed. Removal must be repeated over a period of at least five years since metamorphosed salamanders in the terrestrial environment might return to breed. See section 2.3 for methods of removal and concerns about poisoning as a removal method.

4. Create and enforce policies to minimize frequency of die-offs. Currently, researchers at Arizona State University and USFWS that study the Sonora tiger salamander scrub mud from nets, waders, and buckets, and soak them in a 10 percent bleach solution between each pond. Buckets are rinsed with water from each new pond to remove bleach that

might poison salamanders. Policy should be made formalizing these guidelines for all researchers to follow. Policy should be modified as appropriate, given new information from disease research.

5. Monitor salamander populations and their habitat. Monitoring salamander populations should minimize threats posed to salamanders by factors such as introduced predators and extended habitat drying because monitoring will enable early detection and management of threats. Monitoring will also yield information about correlations between the state of salamander populations (*e.g.*, presence/absence, breeding/not breeding, diseased/not diseased) and environmental variables, such as pond drying, pH, and presence of aquatic and bank-line vegetation.
   - 5.1. Prepare monitoring schedule and protocol. A protocol needs to be developed that enables monitors to create reproducible results about habitat characteristics, presence of introduced predators, and salamander status, while minimizing the spread of disease. A subset of ponds and cienega habitat with and without salamanders should be surveyed to assess the rate at which salamanders are appearing and disappearing from different habitat and which factors influence these metapopulation dynamics. Sampling should be conducted on an annual basis during the reproductive season and dry season. Every five years, a more thorough sampling should be conducted to determine the distribution of salamanders, fish, bullfrogs, and crayfish throughout the SRV.
   - 5.2. Develop agreements with willing land owners to survey for and monitor populations on private lands. Private landowners in the SRV should be contacted and asked if surveys could be conducted on their lands for salamanders. Surveys should only be conducted in accordance with written agreements developed with willing private landowners. Agreements must respect private property rights and reflect the wishes of the landowner.
   - 5.3 Survey for salamanders on private lands pursuant to agreements developed in 5.2. If landowners are willing, ponds on private lands should be checked for salamanders, and salamander populations on private lands should be monitored.
   - 5.4. Develop interagency cooperation and data repository. Communication and coordination of monitoring efforts between agencies and other involved parties is essential. It is particularly important that a central data repository be established that can be accessed by all involved in research and management of Sonora tiger salamanders.
   - 5.5. Conduct monitoring. Trained individuals should follow the monitoring protocol and schedule, recording information on a data sheet and depositing data in the central repository.
   - 5.6. In coordination with Mexican officials, survey potential habitats in Sonora. Considering the proximity of Sonora tiger salamander populations to the Mexican border, it is likely that Sonora tiger salamander populations exist in Mexico. It would be useful to know the distribution and status of salamanders in Mexico so that conservation efforts could be coordinated.

6. Research. There is still a great deal of information to be learned about the basic ecology of the Sonora tiger salamander. This information will help managers to develop policies to ensure long term persistence of the salamander.

6.1. Acquire demographic and dispersal information

6.1.1. Determine age structure in adult salamanders. Age structure can be determined by counting bone rings in toe and arm bones or by marking and recapturing salamanders in a single pond over several years.

6.1.2. Estimate female fertility and proportion of females breeding. Fertility estimates can be obtained by counting eggs in previously preserved specimens. Proportion of females breeding can be obtained by counting the number of breeding females (*i.e.* those with red, swollen vents) in a pond and dividing by the estimated number of females in the population.

6.1.3. Acquire transition probabilities from one life history stage to the next. Probability of an egg becoming a larva and a larva becoming a branchiate or metamorphosed adult can be obtained by conducting intensive field surveys from when eggs are laid to when salamanders metamorphose, determining the number of individuals at each life history stage through exhaustive sampling and mark/recapture.

6.1.4. Acquire information on dispersal patterns through mark/recapture and radiotelemetry. The likelihood of pond to pond dispersal can be determined by marking as many salamanders as possible in neighboring ponds and revisiting these ponds in following years to check for successful dispersers. Radio-telemetry would provide information about the directions of salamander dispersal and whether they have a preference for a certain environment through which to travel.

6.1.5. Determine habitat use of terrestrial metamorphs. Radio-telemetry would also provide information about where terrestrial metamorphs live when they leave the pond, so that upland habitat could be identified for protection.

6.1.6. Develop a population viability analysis. Using the demographic and dispersal information gathered for the Sonora tiger salamander, a population viability analysis should be conducted that estimates the likelihood of extinction for Sonora tiger salamanders, assesses relative threats of various factors (fish, disease, habitat loss, *etc.*), and compares alternative management strategies. This Recovery Plan would be revised as needed based on the results of this analysis.

6.2. Research spread and environmental triggers of disease. There are a variety of ways that virus might move from one pond to another, and these dispersal mechanisms should be researched so that the spread of disease can be managed, if practical. Environmental conditions, such as low pH, might trigger disease outbreaks, so the conditions associated with disease should also be researched so that outbreaks can be minimized.

6.3. Conduct microsatellite analysis. Microsatellite analysis is needed to determine whether interbreeding has occurred between barred and Sonora tiger salamanders and whether there is any genetic variation and structure among Sonora tiger salamanders that needs to be preserved. Genetic analyses should be conducted at five year intervals to assess the spread of introduced barred tiger salamanders.

6.4. Investigate extent and, if necessary, possible causes of low pH in ponds. The pH in ponds containing salamanders needs to be monitored over the next several years to determine whether there are consistently low pH's or periodic drops in pH level. These data are particularly important in ponds experiencing die-offs. If low pH's are observed, researchers should attempt to correlate them with factors such as smelter output and weather patterns.

6.5. Survey to determine crayfish distribution. A one-year study of the distribution of crayfish in the SRV should be conducted. Surveys should be conducted in streams, ponds, and other water bodies on public lands and, with the permission of willing landowners, on private lands.

6.6. Research methods of crayfish removal. A thorough literature search and communication with experts should be carried out to determine effective methods of crayfish removal.

7. Public education

7.1. Post and maintain signs. General educational signs should be posted at the four major entrances to the SRV (Parker Canyon Lake, Canelo Pass, Montezuma Pass, Harshaw Road). Individual signs should be posted along tank access roads for tanks that are visible from the road. These signs should inform the public about the Sonora tiger salamander and other sensitive species that use cattle pond and/or cienega habitat and the laws protecting the organisms and their habitat. Signs should be regularly inspected and maintained or replaced as needed.

7.2. Prepare brochures and make them available to the public. Interpretive brochures will be prepared and made available at offices of USFS, USFWS, Fort Huachuca, AGFD, and National Park Service at Coronado National Memorial. Brochures should also be available at Parker Canyon Lake, Patagonia Lake, and in the towns of Patagonia and Sonoita.

7.3. Coordinate implementation of recovery plan with Participation Team. The Participation Team should meet at least once annually to review progress in plan implementation; discuss issues, problems, and potential solutions; and to disseminate to interested parties new information on the ecology and status of the Sonora tiger salamander.

8. Practice adaptive management in which recovery tasks are revised by USFWS as pertinent new information becomes available. This recovery plan should be reassessed every three to five years or at any time it becomes apparent that the plan is not fulfilling its function to guide to recovery. The USFWS will depend heavily on input from the Participation Team in determining whether the plan needs revision.

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V. IMPLEMENTATION SCHEDULE

The implementation schedule outlines the tasks discussed in Part II and indicates task numbers, priorities, durations, estimated costs, and agencies that may be involved in implementing the task. If accomplished, these tasks should enable the Sonora tiger salamander to be delisted. The costs for each task are estimates, and actual budgets will have to be determined when each task is undertaken. Cost estimates do not commit funding by any agency.

Priorities in Column 3 of the implementation schedule are assigned as follows:

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2: An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

Task duration in Column 4 indicates the number of years required to complete the task. A continuing task will continue to be conducted once implemented. An ongoing task is one that is already being conducted.

The following abbreviations are used to indicate the responsible agency in column 5:

ASP	Arizona State Parks
ASU	Researchers at Arizona State University
AGFD	Arizona Game and Fish Department
FH	Fort Huachuca
FWS	United States Fish and Wildlife Service
PT	Participation Team
TNC	The Nature Conservancy
CNF	United States Forest Service-Coronado National Forest

TBD= to be determined

IMPLEMENTATION SCHEDULE

Task	Description	Priority	Duration	Responsible Agency	Costs (thousands of dollars) FY 1	FY 2	FY 3	FY 4	FY 5	Total
1.1	Develop guidelines for watershed use and maintenance	1	1	PT, CNF, FH. ASP	1	0	0	0	0	1
1.2	Implement watershed use and maintenance guidelines	1	Indefinite	PT, CNF, FH, ASP	2	2	2	2	2	10
1.3	Implement guidelines for cattle pond use and maintenance	1	Indefinite	PT, CNF, FH, ASP	2	2	2	2	2	10
1.4	Develop cleaning and maintenance program for cattle ponds	1	Indefinite	ASP, CNF, FH, ASP	10	10	10	10	10	50
1.5	Enforce cattle pond and watershed use and maintenance guidelines	1	Indefinite	ASP, CNF, FH	1	1	1	1	1	5
1.6	Enhance aquatic and bank-line vegetation	2	Indefinite	ASP, CNF, AGFD, FWS	10	10	10	10	10	50
1.7	Control pH, if necessary	2	Indefinite	ASP, CNF	TBD	TBD	TBD	TBD	TBD	TBD
1.8	Develop cooperative agreements with private landowners to protect habitat	2	Negotiable	PT, FWS, AGFD	10	10	10	10	10	50
1.9	Build new ponds, if needed	2	Indefinite	ASP, CNF, AGFD, FWS	TBD	TBD	TBD	TBD	TBD	TBD
1.10	Develop 3 self-sustaining cienegas as salamander habitat	3	5 yrs	ASP, CNF, AGFD, FWS	20	20	20	20	20	100

Task	Description	Priority	Duration	Responsible Agency	FY 1	FY 2	FY 3	FY 4	FY 5	Total
2.1	Propose regulation preventing use of live crayfish as bait in the SRV	1	2 yrs	AGFD	5	5	0	0	0	10
2.2	Enforce regulations prohibiting non-native predator introduction	1	Ongoing	AGFD	5	5	5	5	5	25
2.3	Remove introduced predators	1	Indefinite	AGFD, FWS, CNF, ASP, FH	25	25	25	25	25	125
3.1	Enforce laws prohibiting introduction, transport, & collection of tiger salamanders in SRV	1	Ongoing	AGFD, FWS	5	5	5	5	5	25
3.2	Remove introduced salamanders	1	Indefinite	AGFD, FWS, CNF, ASP, FH	10	10	10	10	10	50
4	Develop disease policy	2	1 yr	AGFD, FWS, ASU	3	0	0	0	0	3
5.1	Prepare monitoring schedule and protocol	1	1 yr	AGFD, FWS, ASU, CNF, PT	3	0	0	0	0	3
5.2	Develop agreements with willing land owners to survey on private property	2	Indefinite	AGFD, FWS	1	1	1	1	1	5
5.3	Survey for salamanders on private lands pursuant to agreements developed in 5.2	2	Negotiable	AGFD, FWS, ASU	5	5	2	2	2	16
5.4	Develop interagency cooperation and data repository	1	Indefinite	AGFD, ASU, FWS	5	5	2	2	2	16
5.5	Conduct monitoring	1	Indefinite	AGFD, ASU, FWS	10	10	10	10	10	50

Task	Description	Priority	Duration	Responsible Agency	FY 1	FY 2	FY 3	FY 4	FY 5	Total
5.6	Survey potential habitats in Sonora	3	1 yr	AGFD, FWS, ASU	0	0	15	0	0	15
6.1.1	Determine age structure	3	5 yrs	AGFD, ASU, FWS	5	5	5	5	5	25
6.1.2	Obtain estimates of female fertility and proportion of females breeding	3	5 yrs	AGFD, ASU, FWS	5	5	5	5	5	25
6.1.3	Acquire life history transition probabilities	3	5 yrs	AGFD, FWS, ASU	5	5	5	5	5	25
6.1.4	Mark/recapture studies of dispersal	3	5 yrs	AGFD, FWS, ASU	10	10	10	10	10	50
6.1.5	Radiotelemetry	3	5 yrs	AGFD, FWS, ASU	10	10	10	10	10	50
6.1.6	Develop PVA	3	1 yr	AGFD, FWS, ASU	0	0	0	0	20	20
6.2	Research spread & environmental triggers of disease	3	4 yrs	AGFD, FWS, ASU	10	10	10	10	0	40
6.3	Microsatellite analysis	2	2 yrs	FH, FWS, ASU	10	10	0	0	0	20
6.4	Investigate low pH	2	5 yrs	CNF, AGFD, FWS	0	10	10	0	0	20
6.5	Survey to determine crayfish distribution	3	1 yr	AGFD, FWS, CNF, FH, ASP	0	20	0	0	0	20

Task	Description	Priority	Duration	Responsible Agency	FY 1	FY 2	FY 3	FY 4	FY 5	Total
6.6	Research crayfish removal	3	1 yr	AGFD, FWS, CNF, FH	0	0	10	0	0	10
7.1	Post and maintain signs	2	1 yr	CNF, ASP, FH	10	40	3	3	3	59
7.2	Prepare brochures and make them available to the public	2	1 yr	CNF, FH, ASP, FWS, AGFD	10	0	0	0	0	10
7.3	Participation team meetings	1	5 yrs	FWS, PT, ASU	2	2	2	2	2	10
8.0	Practice adaptive management	1	Indefinite	FWS, PT	0	0	3	0	3	6[1]
Totals					**210**	**253**	**203**	**165**	**178**	**1009**

[1]Costs reflected in part in 7.3

To be Included in the Final Recovery Plan:

Appendix A: Peer Reviews
Appendix B: Summary of Public Comment
Appendix C: Responses to Public Comment and Peer Review

Appendix D:

PARTICIPATION TEAM PLAN FOR IMPLEMENTING THE SONORA TIGER SALAMANDER (*Ambystoma tigrinum stebbinsi*) RECOVERY PLAN

Draft

Prepared by: The Sonora Tiger Salamander Participation Team

The purpose of this draft Participation Plan (Plan) is to describe the means to carry out the tasks/actions outlined in the implementation schedule of the Sonora Tiger Salamander Recovery Plan in a way that provides for timely recovery of the Sonora tiger salamander while minimizing social and economic effects. All parties, public and private, that might be affected by implementation of the Recovery Plan, were formally invited to participate as members of the Sonora Tiger Salamander Participation Team (Team) in the development of this Participation Plan. This diverse group of ranchers, scientists, agency representatives, and other stakeholders worked closely with the preparers of the Recovery Plan and the USFWS to mold recovery actions and define implementation techniques and responsibilities. In evaluating recovery actions, the first consideration was whether the proposed recovery action was necessary to recover

the species; the second was to determine whether the same goal could be attained by another pathway with less economic and social impact on affected stakeholders.

The Team focused on those recovery tasks that were most likely to affect stakeholders. For instance, the Sonora tiger salamander is only known to occur in impoundments that are used primarily for watering livestock. Thus, these impoundments, or tanks, are not only critical for the survival of the salamander, but are also crucial components of viable livestock operations. Any recovery actions for salamanders in cattle tanks must also provide for continued use as a water source for livestock. At some sites, other considerations are equally important, such as the mission of the Army at Fort Huachuca, the diverse mandates of the Coronado National Forest, and the management direction of ASP and TNC on the private lands in the interior of the SRV. These mandates, private property rights, and management needs are reflected in the recommendations made in this Participation Plan.

I. *Socio-Economic Setting*

The area impacted by the implementation of a recovery plan for the Sonora tiger salamander is referred to as the Lone Mountain/San Rafael Valley, consisting of approximately 331 square miles, straddling Santa Cruz and Cochise counties of southern Arizona. The area includes the eastern slopes of the Patagonia Mountains, the western slopes of the Huachuca Mountains, and the mesas and canyons between and south to the border. The following discussion of socio-economic conditions in the SRV derive primarily from Hadley and Sheridan (1995), Orton (1996), Snider and Gum (1993), and U.S. Forest Service (1996)

Elevation ranges from almost 9,500 feet (Miller Peak in the Huachucas) to 4,500 feet at the center of the SRV. The area is a complex geomorphology of many small watersheds, but provides the headwaters for both the Santa Cruz and San Pedro Rivers. Differing elevations and soil types within the area provide for a variety of vegetation zones, including plains grasslands, mixed cottonwood riparian habitat, evergreen woodlands, and ponderosa pine and mixed conifer forests.

Several theories exist about what human population existed in the SRV between 1450 and 1700 AD. The most widely held theory places Hohokam-Pima peoples in the area, living by hunting, fishing, gathering, and farming along the streams. It appears that the Sobaipuri people who occupied the upper Santa Cruz and San Pedro River valleys were probably a frontier population in the area, colonizing new territory in the 15th, 16th, and 17th centuries. By the end of the 17th century, the Spanish explorer Father Kino encountered the Sobaipuri in the area battling other indigenous people, which the Spanish identified as Janos, Jocomes, and Apaches. These groups were also hunters, gatherers, and part-time farmers who frequently shifted residences.

The Spanish did not begin to settle in the area until the middle of the 17th century, when isolated ranching and mining operations began to appear. By the early 1700's, cattle, horses, and mules were present, until the Apache attacks grew too intense toward the end of the century. Throughout the 18th century, stock raising was a sporadic, dangerous and precarious occupation.

In 1821, a resident of the presidio of Santa Cruz petitioned for grazing land at a place called La Zanja, to establish a ranch. The land was surveyed and years later, was finally granted, after four public auctions, to Don Ramon Romero and other associated residents. This eventually became what was known as the San Rafael Cattle Company. It appears that between 1825 and 1843, the parcioneros ran from 2,000 to 5,000 head of cattle on their grant. By 1843, the Apaches had driven off or killed all of the stock, with as many as 30 rancheros killed at one time at a place called "La Boca de la Noria", near the southern boundary of the ranch. In 1854, the area became part of the United States.

Between 1850 and 1870, the California gold rush, mining, cattle, military activities and travel between Tucson and Mexico brought activity to the area. Travelers, according to written accounts, were impressed with the beauty, fertility, abundance of trees, water, grass, and wildlife.
Toward the end of the 19th century, the United States Army increased its presence in southern Arizona and, with the increased protection, mining and settlement increased rapidly. By 1893, the valley was populated with ranches, homesteads, working mines, good wagon roads, and other signs of population.

Ranching in the SRV went through three major stages between the late 1800's and mid-20th century. The first stage was dominated by large landowners such as Colin Cameron on the San Rafael de la Zanja land grant, who attempted to extend control and drive smaller ranchers off the

land. The second stage was a resurgence of small land holdings, particularly after the passage of the Forest Homestead Act and creation of the Huachuca Forest Reserve in 1906. The ranching population was at its highest in the first three decades of the 20th century. Drought and depression drove many ranchers off the land in the 1920's and 1930's and helped bring about the consolidation of the smaller operations into larger ranches (the third stage). Dry land farming was largely abandoned and cattle raising became the most important economic activity in the SRV and surrounding foothills. The San Rafael Cattle Ranch, a large parcel of private land in the center of the SRV, was purchased recently by TNC and ASP.

The expansion and success of ranching activities in the valley brought about the development of many new sources of water, enabling the cattle to spread out and better utilize the forage. Water rights were recorded on stock tanks and other waters for domestic and irrigation purposes on the San Rafael Cattle Company as early as 1822 and 1850. Across the valley, water rights were recorded on tanks on the Lone Mountain and Bercich Cattle Company as early as 1884 and 1885 (Hadley and Sheridan 1995), indicating that stock tanks were constructed with Fresno scrapers and mule teams. Later efforts in the 1950s used Forest Service equipment, with costs shared by the ranchers. Many tanks have been constructed as well as cleaned with private funds. Other water developments include pipelines for dispersing water from springs, and windmills and solar pumps for filling both steel rim and dirt tanks. The dirt tanks filled by pumped water and stock tanks filled by captured run-off are most significant in this discussion, as they provide the habitat which has allowed for the continued existence of species such as the Sonora tiger salamander. This salamander is thought to have been reliant on natural cienegas, which no longer exist or are inhabited by non-native species with which the salamander can not coexist.

A review of developed waters on National Forest lands that are part of grazing permits within the Plan area shows 125 stock ponds, 35 developed springs, and 36 wells. Waters on private land have also been developed for livestock operations. For example, seven water developments on the Lone Mountain Ranch are used. The Sonora tiger salamander has been recorded at about 50 of these waters. No comprehensive inventory of waters suitable for the species has been completed.

It is also significant to recognize that the maintenance and protection of these waters created for the use of cattle is dependent, at this point, upon the financial ability of the ranchers involved. Maintenance of windmills and solar pumps, cleaning of tanks and ditches that feed the tanks, and other items, such as reconstruction of dams and overflows blown out by floods, are very expensive and time consuming activities. These watering facilities and their maintenance are not only critical to the watering of livestock, but have become entwined in and critical to the existence of species such as the salamander. Some costs of maintaining stock tanks can be estimated using cost figures for heavy equipment dispatched for fire suppression. These costs are as follows:

Item	Rate	Amount	Cost
Cat D8-K w/operator	$155/hour	24 hours	$3,720
Transport, 41 tons or more	$85/hour	8 hours	$680
Laborer	$10/hour	24 hours	$240
Government Paperwork	$500/tank	1 pond	$500

TOTAL			$4,460

Costs for maintenance of other water structures vary. These costs range from a rancher spending half of a day repairing a leaky pipe to hiring a pump maintenance company for one to two days to repair windmills or solar pumps. For replacement of fences around waters that further control livestock use, contractors can charge $3,000/ mile for materials, equipment, and labor. Ranchers grazing livestock on Forest lands are expected to cover these costs as part of their permit agreement with the Forest Service.

Cattle ranching remains the most significant factor in the SRV economy. In 1992, it was estimated that approximately 3,100 head of cattle were grazing on just the Forest Service portion of the valley. Revenues of approximately $780,000 were generated from these government permits. Eighteen jobs were directly supported by the ranches, with $216,450 in estimated employee compensation. Revenues of $18,200 were returned to Santa Cruz and Cochise Counties by the Forest Service in lieu of taxes.

The direct financial implications of ranching are a small portion of the economic statistics of Cochise and Santa Cruz counties, as the population and number of ranches in the valley are very small by comparison to the totals in either county. The economic impact is also multiplied by the expenditures of the ranches and their employees in the towns adjacent to the valley.

The other significant economic factor that impacts towns adjacent to the valley (and less so the residents and landowners in the valley) is recreation and eco-tourism. An estimated 30,000 people used the developed recreation facilities at Parker Canyon Lake in 1992. Another estimated 7,500 to 10,000 visitors pursued other recreational activities on the Forest portion of the Valley. These activities included hunting, birdwatching, guided horseback and bicycle rides, and sight-seeing. Costs for each visit include gas, lodging, and equipment. Using an average and conservative figure of $15/visit, recreational use on the Forest portion of the Valley generates $562,500 or more. The percentage of that amount going to local economies is not known. The impact of recreation on the valley, both in economics and landscape character, is also expected to increase with transfer of a portion of the San Rafael Cattle Company's ranch to the ASP.

Other activities on the Forest also contribute to the local and regional economy. These activities include production of minerals and sale of forest products. Actual amounts generated are not known but should be considered quite limited compared to the contribution of ranching and recreation. For example, in 1998 less than 5 permits were issued by the Forest Service for forest products, primarily manzanita harvests.

Impacts of implementing the recovery plan on the above social and economical values of the Valley, particularly ranching and tourism, need to be considered both now and in the foreseeable future. The ranching culture and lifestyle are an important thread in the fabric of life in southern Arizona. It is an integral part of the heritage and history of Arizona and the values which have left the SRV an open, relatively undisturbed landscape. Current market conditions indicate that if economic pressures force ranchers to sell land, it is more likely that developers, not ranchers, will buy the land. Development of ranch land begins a process of fragmentation of open space, soil erosion, depletion of water and riparian areas, vegetation loss, and visual blight. Many people believe that ranching is our best chance for maintaining open space and natural conditions of grasslands, as well as the species that thrive there. The current social setting, in which ranching families and workers derive a living from the land and resources of the SRV, presents management opportunities. Ranchers in the SRV are attentive to resource conditions and problems, and provide a continuity of oversight that can be an asset to wildlife managers and the recovery of the Sonora tiger salamander.

II. ***Participation Plan Preparation***

Participation Team members were appointed by the USFWS's Region 2 Regional Director, and include agency representatives and the public whose interests may be affected by actions deemed necessary to recover the Sonora tiger salamander. Initially, 64 individuals were invited by the Regional Director to serve on the Team. These individuals included local residents and ranchers (including all members of the SRV Association), and representatives of City, County, State and Federal agencies and governments that might be affected by Recovery Plan implementation. Twenty-two individuals accepted the invitation and were appointed to the Team, including thirteen local residents (primarily ranchers), two representatives of the AGFD, and single representatives from TNC, Southwest Center for Biological Diversity, Fort Huachuca, City of Sierra Vista, Grand Canyon University, the Coronado National Forest, and ASP (Attachment 1). At the first meeting of the Team, members reviewed the list of those invited to serve on the Team and concluded it was a complete list. A USFWS representative acted in a support capacity and as a liaison between the Team and the USFWS Regional Director, but was not a member of the Participation Team. The preparers of the Recovery Plan (Dr. Jim Collins and Jon Snyder of Arizona State University) attended all of the Participation Team meetings and worked with Team members to address their concerns in regard to proposed recovery actions. Several other individuals received Participation Team mailings, but elected not to serve as Team members (Attachment 1). Only individuals appointed by the Regional Director received copies of interim draft Recovery Plans for review.

Participation Teams are components of Recovery Teams, and as such are exempt from the requirements of the Federal Advisory Committee Act, which otherwise would require that Team meetings be open to the public. In this case, the Team elected to have meetings open to anyone who wished to attend. Non-members were sometimes invited, and others occasionally came to the meetings, but only those listed in Attachment 1 were regularly notified of upcoming meetings. Organization, structure, decision-making rules, and other process rules were determined by the Team members. The objective was to establish procedural rules that were fair and that would result

in decisions and products representative of the diverse makeup of the Team. Sheridan Stone of Fort Huachuca served as Chairperson of the Team. Jim Rorabaugh of the USFWS prepared meeting notes. These notes were reviewed in draft form by Sheridan Stone and were modified as needed and approved by the Team at the following meeting. The Team decided to make decisions by majority rule, based on those present at the time a decision was made. Any Team member not agreeing with a decision could write a dissenting view which would become part of the decision-making record. As of this writing, no dissenting views had been entered into the record.

This Participation Plan was compiled by the Team and Jim Rorabaugh. The Socio-Economic Setting was authored by Ann Patton, Lone Mountain Ranch, and Tom Deecken, Coronado National Forest. Much of the Plan was derived from the meeting notes.

III. *Alternatives Considered*

The Team considered all aspects of the draft proposed recovery program in determining areas of concern in regard to potential social or economic impacts. As discussed in Part I, Socio-Economic Setting, ranching and tourism are the primary social and economic values of the SRV, and these are the values primarily addressed herein. Ranching is of particular importance for the recovery of the salamander, because the only known breeding habitats of the salamander in Arizona are livestock tanks and impoundments. These tanks require periodic maintenance to remain useful as livestock waters and as habitat for the salamander. Maintenance is currently paid for by the ranchers. Without viable livestock operations, other means would be needed to maintain the tanks and prevent loss of key salamander habitats.

Recreation and tourism are important uses of lands managed by the Coronado National Forest, and to a lesser degree, lands at Fort Huachuca. The implementing regulations of the National Forest Management Act of 1976 require the following in all Forest Plans: "to the degree consistent with needs and demands for all major resources, a broad spectrum of forest and rangeland related outdoor recreation opportunities shall be provided". Thus, the Coronado National Forest is mandated to provide recreational opportunities for the public, but must temper recreational needs with other uses of public lands. The Army's mission comes first at Fort Huachuca, but the Army provides recreational opportunities on their lands where such activities do not conflict with their mission. Recreation has a potential to adversely affect the recovery potential of the salamander, because the public uses some of the tanks as fishing holes, and off-road vehicle enthusiasts have been known to drive through tanks or drive on the edge of tanks, using them as challenging mud bogs. Fishing can result in the introduction of fish or non-native salamanders, or illegal capture and transport of Sonora tiger salamanders, with subsequent deleterious effects described in the Recovery Plan. Off-road vehicles can destroy salamander eggs and possibly salamanders, raise turbidity levels in the tanks, and possibly damage berms or water control structures.

Most of the Team's discussions centered around management of livestock tanks, and how various management alternatives might be applied to maximize benefits to both the salamander and ranching operations. This also included discussion of recreational activities, which the Team generally agreed needed to be controlled at tanks, both from the perspective of salamander recovery and to reduce vandalism of fences and other range improvements.

The Recovery Plan recommends various actions to protect and enhance habitats at and in the watersheds of stock tanks (Task 1), to control the effects of non-native predators at stock tanks (Task 2), and control introduction, transport, and collection of tiger salamanders in the SRV (Task 3). These tasks could affect social and economic values in the SRV, depending on how they are implemented. In many cases, the Recovery Plan does not specify how to implement these tasks, although subtasks provide some general guidance. In the following section, we discuss these tasks and subtasks, and provide details for how they might be funded and implemented on the ground in a manner that minimizes potential social and economic impacts, while providing for the recovery of the Sonora tiger salamander. Other tasks recommended in the Recovery Plan (create and enforce policies to minimize frequency of die-offs, monitoring of salamander populations and their habitat, and research) have much less potential to affect social or economic values so long as private property rights are considered and respected during implementation.

Federal agencies are required to use their authorities to carry out programs for the conservation of threatened and endangered species [section 7(a)(1) of the Endangered Species Act]. AGFD and ASP have similar mandates to conserve species and natural resources. Thus, the burden of recovering the Sonora tiger salamander should fall to Federal and State agencies. Private landowners should be encouraged to participate in the recovery effort, and Federal and State assistance programs should be made available to assist landowners in Recovery Plan implementation.

IV. ***Recovery Task Implementation***

1. Protect and Enhance Habitat

1.1 Develop guidelines for watershed use and maintenance. The Recovery Plan recommends that "land use activities in watersheds and upland habitats should not pollute, lead to excessive sediment deposition, or prevent water from entering ponds. Also, upland habitat should remain vegetated to facilitate salamander dispersal and survival outside ponds." Grazing in accordance with Coronado National Forest standards and guidelines should provide adequate protection of watershed values in regard to potential grazing impacts. Mining, road construction, and other construction or development activities in the watersheds of tanks should not be permitted or should be designed so watershed values and flows into tanks are maintained, and pollution of tanks or excessive sedimentation of tanks does not result.

1.2 Implement watershed use and maintenance guidelines. Most lands upstream of tanks are managed by the Coronado National Forest, thus, the Forest will be primarily responsible for implementing this task. However, Arizona State Parks and Fort Huachuca should also implement the guidelines on their lands.

1.3 Implement guidelines for cattle pond use and maintenance. Guidelines for maintaining tanks in a manner that minimizes impacts to the salamander, but compatible with livestock operations, were developed by the USFWS and the Coronado National Forest. These guidelines, included herein as Attachment 2, should be followed during maintenance activities. Under Endangered Species Act section 7 consultations, the Coronado National Forest is responsible for ensuring that the guidelines are followed on Forest lands; however, permittees typically conduct and fund maintenance activities. Maintenance activities are carried out by permittees as part of their livestock operations. If maintenance is not needed for livestock operations, but is conducted only to support salamander populations, that maintenance should not be the responsibility of the permittee. In these cases, maintenance should be conducted or funded by the Forest, the USFWS, or another management entity.

Under the guidelines, the Forest is responsible for determining presence/absence of salamanders, seining and holding of salamanders as needed, monitoring of "take" of salamanders, and reporting to the USFWS. These guidelines are also recommended for use on Fort Huachuca and private lands where salamanders occur. The section 7 biological opinions provide an exemption from the section 9 take prohibitions if the guidelines are applied voluntarily on private lands within Forest allotments. If applied on private lands, a private landowner could enter into an agreement with a permitted consultant, AGFD, the Coronado National Forest, or the USFWS to conduct presence/absence surveys, seining, and holding of salamanders. The agencies should be prepared to provide this service at no cost to the landowner.

1.4. Develop cleaning and maintenance program for cattle ponds. A tank cleaning and maintenance program should include annual work plans as well as long-term goals for continued maintenance. These programs will need to be developed in close coordination with livestock operators to ensure consistency with ranching operations. As discussed in 1.6., if tank maintenance is solely for the recovery of the salamander, the livestock operator should not be held responsible for funding that maintenance.

1.5. Enforce cattle pond and watershed use and maintenance guidelines . The Coronado National Forest, through its NEPA and permitting processes, will be primarily responsible for ensuring that cattle pond and watershed guidelines are carried out. Private landowners are encouraged to adopt these guidelines, as well. Various programs, discussed in Part V, herein, are available to assist private landowners in recovery task implementation.

1.6 Enhance bank-line and aquatic vegetation. Implementation of this task should be on a case-by-case basis, and will depend on the nature of the site, including existing cover, opportunities for trick tanks or double tanks, effects on livestock operations, availability of funding, and other considerations. An inventory of existing tanks within the range of the salamander should be made with the objective of identifying sites where bankline cover could be efficiently increased with minimal impacts or benefits to livestock operations. Private landowners and permittees should be encouraged to pursue enhancement of bankline cover, but Federal and State agencies should provide most of the support for these projects. The following options are suggested as ways to increase bankline and aquatic vegetation at tanks:

Complete Fencing of Tanks: This option is not recommended because although it would prevent trampling and browsing of bankline cover by cattle, it would also preclude use of the tank by cattle. An option whereby a tank is completely fenced, but water is supplied from the tank to a drinker or trough to which cattle would have access is also not recommended, because it would entail excessive maintenance, and if a valve malfunctions, several years worth of stored water can be lost. Implementing any option to preclude cattle access to a tank could also be difficult, because cattle will attempt to push their way through a fence if they can see or smell water and forage.

Partial Fencing of Tanks: Partial fencing of tanks would allow vegetation to develop on the fenced portion of the tank and would provide access for cattle. Fencing strung through the water of tanks corrodes very rapidly in the SRV (~4 years). Thus, where fencing would be in water, use of vinyl-covered hog wire instead of barbed wire, may be prudent to reduce maintenance costs.

Double Tanks or Trick Tanks: Tanks are sometimes constructed in pairs, with one tank immediately upstream of the other. In these cases, the upper tank acts as a silt trap. Where double tanks occur, one of the tanks could be fenced while leaving the other accessible to livestock. A second tank could also be constructed in some instances where only one tank currently exists. This option has the advantage of increasing the quality and quantity of potential salamander habitat, providing an opportunity to research the value of fenced versus unfenced tanks, and it benefits livestock operations by providing a silt trap and longer life of the downstream tank. Bob Hudson of the Vaca Ranch has volunteered a tank on his ranch (lower Antelope Tank) as a site to experiment with use of double tanks.

1.7. Control pH, if necessary. The need for this task would be clarified after more research to determine the degree to which low pH occurs and whether or how it is correlated with salamander die-offs. If acidic conditions are a problem, this action is probably best addressed by eliminating the source of the low pH. However, this may not be possible or feasible (i.e. if low pH is a result of natural processes, or caused by atmospheric emissions from copper smelters in Mexico). Treatment with calcium carbonate, as suggested in the Recovery Plan, or other measures that would not adversely affect salamander breeding habitat or the value of the tanks as water sources for cattle, may be prudent to counteract low pH levels. Implementation of these measures should be the responsibility of the landowner/manager. Private landowners are encouraged to work with State and Federal biologists to correct low pH in their tanks. As discussed in Part V, Federal and State assistance programs could be made available to help private landowners address this problem.

1.8. Develop cooperative agreements with private land owners to protect habitats. This action is an extension of previous actions that involve Federal and State cooperation and assistance to private landowners. See Part V for further information on government assistance programs.

1.9. Build more ponds, if needed. The need for this task would be clarified after completion of a population viability analysis (task 6.1.6). Construction of new ponds would need to take into account numbers and distribution of breeding sites needed for viable populations of salamanders, whether new ponds may facilitate dispersal of non-native organisms, and how new ponds would affect livestock operations. In general, new tanks have the potential for benefitting livestock operations through better distribution of livestock. But new tanks may not be justified from the perspective of cattle operations alone. Because maintenance of tanks on Forest allotments is generally the responsibility of the permittee, the cost of maintenance should not be greater than potential benefits to a livestock operation, or if tanks are built solely for salamanders, construction and maintenance costs should be the responsibility of the management agency. In either case, construction of new tanks on Forest lands should be closely coordinated with the permittee. Construction of new tanks may not be a viable option unless water rights issues and other legal concerns can be resolved.

1.10. Develop three self-sustaining cienegas as salamander habitat. This task could most efficiently be implemented by restoring more natural cienega conditions to former cienegas that have been altered by impoundments, diversions, channel incisement, and other habitat alteration. Examples of such sites include upper Scotia Canyon, (new) Bog Hole Reservoir, and possible sites on the former San Rafael Cattle Ranch (now owned by ASP and TNC). The upper Scotia Canyon site is currently owned by the Lone Mountain Ranch, but is expected to be exchanged to the Coronado National Forest in the year 2000. Elimination of bullfrogs, re-routing or closure of the road through the canyon, followed by rehabilitation of eroded portions of the road, and restoration of the several impoundments to more natural cienega conditions could provide excellent habitat for the Sonora tiger salamander and other sensitive species, such as Huachuca water umbel, Huachuca springsnail, Mexican garter snake, and leopard frogs (*Rana chiricahuensis* or *R. subaquavocalis*). Restoration plans and funding are in place for Bog Hole (a cooperative AGFD, Forest Service, and USFWS effort), which includes removal of non-native fish and reintroduction of native fishes. The project could also include reintroduction of Sonora tiger salamanders. On the former San Rafael Cattle Ranch, restoration of Heron Springs or other sites may be possible. Funding for these activities should be the responsibility of land managers and State and Federal wildlife agencies.

2. Control non-native predators (fish, bullfrogs, and crayfish).

2.1. Propose regulation preventing use of live crayfish as bait in SRV. Use of live crayfish as bait is currently legal in the SRV and other areas of Arizona. The Arizona Game and Fish Commission should be encouraged to develop rules prohibiting possession of

crayfish or their use as live bait within the range of the Sonora tiger salamander. Anglers, other recreationists, and other publics would have the opportunity to comment through the rule making process.

2.2. Enforce policies preventing introduction of non-native predators to SRV ponds. Arizona Game and Fish Commission Order 40 prohibits the transport and use of live bait fish within the range of the Sonora tiger salamander. Transport and release of live bullfrogs is prohibited by Commission Order 41. The AGFD and the Coronado National Forest would cooperatively pursue posting stock tanks in the SRV as "No Fishing". AGFD should add posted portions of the Coronado National Forest to their closed fishing areas in Commission Order 40. Fort Huachuca, which controls on-post access for taking aquatic wildlife, should post ponds used, or potentially used, by Sonora tiger salamanders as "No Fishing".

2.3. Remove fish, crayfish, and bullfrog populations from SRV ponds. Methods to implement this task include allowing a pond to dry out, seining, gigging of bullfrogs, or using chemicals to kill non-native fish. If chemicals are used, cattle should not be allowed to water at the pond until the chemicals and their carriers have dispersed, or treatment should occur when cattle are using another pasture. Elimination of fish needs to be approved by AGFD, and if it occurs on Federal lands, the Federal land manager will need to complete an environmental review, including a NEPA process, and possibly public involvement. Appropriate State and County regulations will also need to be followed. Some tanks that support fish are used by the public as fishing holes. Anglers that use these sites should be informed and allowed to have input into any decisions to control non-native fish.

3. Control introduction, transport, and collection of tiger salamanders in the SRV.

3.1. Enforce policies preventing introduction, transport, and collection of tiger salamanders in SRV. The efficiency of existing law enforcement authorities could perhaps be increased by cooperative efforts and better awareness by law enforcement officials of existing regulations concerning bait fish, and collection, transport, and release of live bullfrogs and salamanders. A coordination meeting among law enforcement agencies and officials from the Forest Service, Fort Huachuca, AGFD, USFWS, ASP, and the Border Patrol should be organized to find ways to better facilitate detection and enforcement of illegal wildlife activities, including those relevant to Sonora tiger salamanders. A Memorandum of Understanding may be appropriate among agencies to define agency roles and procedures in cases of suspected illegal activities.

Ranchers and landowners are potentially the most important presence in the SRV to notice suspected illegal activities, such as illegal collection or release of salamanders and fish, and use of live fish or salamanders as bait. The AGFD's Operation Game Thief allows ranchers and others to call 1-800-352-0700, toll free, to report potentially illegal activities. AGFD's toll free Operation Vandals (1-800-VANDALS or 1-800-826-3257) responds to reports of wildlife or habitat vandalism.

3.2. Remove non-native tiger salamander populations from SRV ponds. Elimination of non-native salamander populations should be accomplished with chemicals or seining while larval and branchiate salamanders are present. If the pond is allowed to dry, many salamanders will metamorphose and return to breed the next year. Because an unknown portion of the population of any one tank includes terrestrial metamorphs, repeated visits in subsequent years will likely be necessary to ensure the population is eliminated. If chemicals are used, cattle should not be allowed to water at the pond until the chemicals and their carriers have dispersed, or treatment should occur when cattle are using another pasture. Elimination of salamanders needs to be approved by AGFD, and if it occurs on Federal lands, the Federal land manager will need to complete an environmental review, including a NEPA process, and possibly public involvement.

V. *State and Federal Programs to Assist Land Owners and Managers in Recovery Plan Implementation*

Implementation of recovery tasks will, in some cases, require considerable funds and resources. A variety of programs are available to fund these tasks. Programs are typically targeted for specific types of projects, and may be limited to certain categories of applicants (i.e. private party or government agency). Included here is a list of programs that may be useful in implementing the Sonora tiger salamander recovery plan. It is not an exhaustive list, but is meant to provide some guidance to land owners and managers on available funding sources. In addition to these government programs, private foundations and individuals also offer grants that could be used to fund recovery tasks. An annual directory, entitled "Environmental Grantmaking Foundations" contains information about 800 foundations. It is available from the Resources for Global Sustainability, Inc., P.O. Box 3665, Cary, NC 27519-3665 (phone: 800-724-1857, rgs@environmentalgrants.com).

1. USFWS Programs:

A. **Endangered Species Act Section 6 Funds**: These are funds provided to AGFD to implement recovery actions, survey and monitor of sensitive species, candidate assessment, and other related actions. Funds are limited (less than $200,000 annually for Arizona in recent years) and must be distributed among a variety of species. The funds may be used on private, State, or Federal lands.

B. **Partners for Fish and Wildlife**: This program provides technical and financial assistance to willing private landowners who want to improve fish and wildlife habitat on their property. The program is open to private individuals, tribes, counties, and State government. Contact Marty Jakle, USFWS, Phoenix (602/640-2720, marty_jakle@fws.gov)

3. **North American Wetlands Conservation Act**: Designed primarily to implement the North American Waterfowl Management Plan, but may have some application for Sonora tiger salamanders. Proposals are 4-year plans of action supported by an Act grant and

partner funds to conserve wetlands and wetland-dependent fish and wildlife through acquisition (including easements), enhancement, restoration, and other eligible activities. Grants may be used to enhance or restore habitats on private, State, or Federal lands. A 1:1 non-Federal match is required. Contact Coordinator, North American Wetlands Conservation Council, USFWS, 4401 North Fairfax Drive, Room 110, Arlington, Virginia 22203 (703/358-1784, fax: 703/358-2282). Electronic mail address is r9arw_nawwo@mail.fws.gov; the internet address is http://www.fws.gov/rpnawwo/nawcahp.html.

2. Natural Resource Conservation Service Programs:

A. **Conservation Reserve Program**: A voluntary program that offers annual rental payments and cost-share assistance to establish long-term resource conservation. The program provides up to 50 percent of participant costs to establish target management practices on private lands. Could be used to help establish riparian buffers and cienegas on private lands. Contact Frank Toupal, NRCS, Tucson (520/670-6602, ext. 226).

B. **Wildlife Habitat Incentives Program (WHIP)**: Provides technical assistance and cost-share (up to 75 percent) to help establish and improve fish and wildlife habitat, primarily on private lands. Contact Frank Toupal, NRCS, Tucson (520/670-6602, ext. 226).

C. **Wetlands Reserve Program**: A program that can be used to cost-share (NRCS pays up to 75 percent) restoration of privately-owned wetlands or former wetlands on rangelands or farmlands. Contact Frank Toupal, NRCS, Tucson (520/670-6602, ext. 226).

3. AGFD Programs:

A. **Stewardship Program**: Provides technical management assistance, including use of heavy equipment, materials, and labor; or reimbursement of materials and labor, to enhance wildlife habitat and populations. Projects can occur on private or public lands. Contact AGFD's Stewardship Program Coordinator, Tucson (520/628-5376).

4. U.S. Forest Service Programs:

A. **Bring Back the Natives**: This initiative is a national effort by the Department of Interior's Bureau of Land Management and Department of Agriculture's Forest Service in cooperation with the National Fish and Wildlife Foundation to restore health of entire riverine and aquatic systems and their native species. In turn, national, State, and local partners make their own matching contributions to accomplish improved habitat and water quality. Three programs are available through the Forest Service: 1) *Rise to the Future* is a

program to enhance fisheries and aquatic resources, 2) *Every Species Counts* conserves sensitive flora and fauna, and helps recover endangered species, 3) *Get Wild* targets protection and improvement of riparian and wetland habitats and associated species. Forest Service funds must be matched with labor and materials. Contact Tom Deecken, Coronado National Forest, Sierra Vista Ranger District, 5990 S. Highway 92, Hereford, Arizona, 85615, (520/378-0311). Bring Back the Natives funds can also be obtained through the National Fish and Wildlife Foundation (see below).

5. National Fish and Wildlife Foundation:

Challenge Grants: Proposals are funded for habitat protection and restoration, species conservation and applied conservation, applied research and policy development, education, and training for natural resource professionals. Requires a 1:1 non-Federal match in the form of funds, contributed goods and service, or lands. Projects can occur on private or public lands, and invasive exotic species management is an area of emphasis for the Foundation's wildlife and habitat grants. Contact National Fish and Wildlife Foundation, 1120 Connecticut Ave NW, Suite 900, Washington, D.C., 20036 (202/857-0162, projects@nfwf.org).

6. Arizona Department of Water Resources

Arizona Water Protection Fund. The purpose of the fund is to protect water of sufficient quality and quantity to maintain, enhance, and restore rivers and associated riparian habitats, including fish and wildlife dependent on those habitats. In fiscal year 1998, approximately $5,000,000 were available. Contact Ms. Irmalisa Horton, Arizona Department of Water Resources, 500 North Third Street, Phoenix, Arizona 85004, (602/417-2460).

VI. Conclusion

The Recovery Plan, especially the Implementation Schedule, as discussed above, presents a wide array of activities, significant expenditure of funds, and long-term commitments by participating individuals and organizations. For downlisting and eventual removal of the Sonora tiger salamander from the endangered species list to occur, these actions must achieve on-the-ground results. They must also be realistic and flexible. Cost for the most part will be borne by the State and Federal wildlife management agencies and public land managing agencies of the SRV in conjunction with willing private land cooperators. Private property rights will be respected. On public lands, activities shown in the Implementation Schedule must also complement the social and economic setting of the Valley, while achieving the needed biological results. Cooperation among all interested parties must be stressed at all times. While the Recovery Plan focuses on the Sonora tiger salamander, it should be an integral component of the many efforts in the SRV that maintain the health of both

its human residents and the array of wildlife and plants living there. For the Recovery Plan to work, a cooperative effort among the many private and public interests in the SRV that considers the diverse values and uses of the area must be forged and maintained.

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Attachment 2: Stock tank management and maintenance guidelines