FINAL
ENVIRONMENTAL ASSESSMENT

Small Scale Exotic Species Removal in the San Rafael Valley, Arizona

Prepared By: U.S. Fish and Wildlife Service
2321 West Royal Palm Road, Suite 103
Phoenix, Arizona 85021

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SECTION I: PURPOSE AND NEED FOR ACTION

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A. Introduction

The U.S. Fish and Wildlife Service (FWS) has prepared this Environmental Assessment (EA) to analyze potential effects to physical, biological, social, and cultural resources that may result from renovation (removal of exotic species) of four stock tanks in the San Rafael Valley (SRV), Santa Cruz County, Arizona (Figure 1). The proposal stems from a grant proposal that was funded through a FWS funding source (Appendix 1). The EA was prepared in accordance with the National Environmental Policy Act (NEPA), Council on Environmental Quality regulations (40 CFR 1500-1508), and FWS NEPA Reference Handbook (January 1997). Relevant laws, policies, plans, and guidance are listed in Appendix 2.

This document is organized into sections:

- ***Section 1 – Purpose and Need for Action****:* Presents information on the purpose of and need for the project and the FWS's proposal for achieving that purpose and need. This section also details how the FWS will inform and solicit comment from the public regarding the proposal.

- ***Section 2 – Description of Alternatives, including the Preferred Alternative****:* Provides a detailed description of the three alternatives evaluated in this EA, including the no action alternative, exotic species removal by mechanical means, and the preferred alternative - exotic species removal by chemical and mechanical means.

- ***Section 3 – Affected Environment****:* Describes the environmental setting in which the proposed action would occur, including sites where the proposed action would be implemented.

- ***Section 4 – Environmental Consequences****:* Describes the environmental effects of implementing the three alternatives. The analysis is organized by resource topic (physical biological, social, and cultural environment). Effects are described for each alternative – no action and the two action alternatives.

- ***References****:* Lists documents used in the preparation of this EA.

- ***Appendices****:* The appendices provide more detailed information to support the analysis presented in this EA.

B. Purpose of the Proposed Action

The purpose of the proposed action is to remove exotic species (i.e., bullfrogs [larvae and adults] and exotic fishes) from four earthen stock tanks within a discrete geographical area in the SRV (Figure 1). Our ability to effectively conserve and manage native species at these tanks is limited because competitive and predatory interactions of exotic species have reduced reproduction and recruitment of native species. Removal of exotic species would reduce threats to native species and create opportunities to conserve their populations in the selected stock tanks. In particular, the endangered Sonora tiger salamander (*Ambystoma tigrinum stebbinsi*, STS), which is known from the area, would benefit from this action. In addition, the renovated sites could become habitat for other native species, such as Gila topminnow (*Poeciliopsis occidentalis*), Gila chub (*Gila intermedia*), Chiricahua leopard frog (*Rana chiricahuensis*), and Mexican gartersnake (*Thamnophis eques megalops*).

C. Need for Taking the Proposed Action

The action alternatives would contribute to conservation of native aquatic species by eliminating competing and predatory exotic species. Conservation of native species, through renovation of habitat, is consistent with the Arizona Game and Fish Department's (AGFD) Wildlife 2006 Nongame and Endangered Wildlife subprogram narrative, a goal of which is restoration of native biological diversity and recovery of imperiled species. Additional documents, such as work plans and job descriptions for the State of Arizona's Heritage Program and the Endangered Species Act (ESA) Section 6 Agreement between the FWS and AGFD, support similar objectives. The action also supplements the AGFD's Comprehensive Wildlife Conservation Strategy and contributes towards implementing the FWS's STS Recovery Plan, the Gila topminnow Draft Recovery Plan, Chiricahua leopard frog Draft Recovery Plan, and Gila chub Recovery outline.

Furthermore, through a Cooperative Agreement, the FWS and AGFD have mutually agreed to cooperatively implement exotic species removal in the SRV. The 1986 Coronado National Forest Land and Resource Management Plan has, among others, a goal of maintaining populations of all native wildlife. A 1990 "Arizona Wildlife and Fisheries Comprehensive Plan" signed by the AGFD Director and the Forest Service's Regional Director has the same goal and calls for cooperative efforts.

Action regarding stock tank renovation in the SRV is needed because:

- Exotic species use stock tanks as source-sites from which they spread to surrounding areas during the summer monsoon season,

- Native species are declining as exotic species are increasing in numbers and range; self-sustaining populations of native species may not persist in the long term if action is not taken. Actions taken now would prevent continued declines or losses that are probable in the foreseeable future, in addition to allowing conservation actions for native species to occur.

- The geographical and hydrological isolation of the stock tanks provides conditions where renovation actions are likely to be the most effective. Probability of long-term success

and lower likelihood of reinvasion by exotic species is enhanced through the local hydrological and topographical situations.

- The SRV has potential to contribute to recovery of native species due to involvement and cooperation of local ranchers and permittees, stakeholders, and land management agencies, who make it possible to implement Recovery Plans on their land.

- This project helps to further develop effective methods for removal of bullfrogs that could be used on a larger scale in the SRV, and likely elsewhere where bullfrogs are an invasive species.

A potential future use of the renovation sites (after exotic species removal) could be for implementation of Recovery Plans. One species that would benefit is the STS (Appendix 3 summarizes STS biology and current status) of which populations are currently present in a number of stock tanks throughout the SRV. If the renovated stock tanks would be used for the recovery of species, additional listed or sensitive species such as Gila topminnow, Gila chub, Chiricahua leopard frog, and Mexican gartersnake could also benefit from the renovated sites, which after treatment, would lack exotic predators and competitors (i.e., in accordance with Recovery Plans). These latter species are now limited to just a few localities in the SRV, mainly due to invasion and subsequent competition and or predation by exotic species.

D. Decision to be made by the Responsible Official:

The proposed action would be undertaken cooperatively by the Arizona Ecological Services Office of the FWS (AESO) and AGFD. Our decision is whether we will, in cooperation with AGFD and others, 1) take no action on renovation of four stock tanks in the SRV, 2) remove exotic species from four SRV stock tanks with mechanical means, or 3) remove exotic species from four SRV stock tanks with mechanical and chemical means. Our decision will occur after a 30-day public review of this EA, and after consideration of all public comments received during the comment period. If the alternative selected would cause significant adverse impacts on the human or natural environment, an Environmental Impact Statement will be prepared before implementing that alternative. If no significant adverse impacts are anticipated, we will prepare a Finding of No Significant Impact and a final environmental assessment. These documents will be posted on our website (http://www.fws.gov/arizonaes/) and mailed to those who provided comments on this draft or who request copies.

The Coronado National Forest is also conducting NEPA and other compliance for their role in this action, in accordance with their regulations. The Coronado must approve a Pesticide Use Plan, if the Preferred Alternative is selected.

Section II. Public Involvement

Agency Involvement

The development of this EA was coordinated with the AGFD's Nongame Branch, Phoenix, Arizona, and the USFS (Coronado National Forest, Sierra Vista Ranger District, Sierra Vista, and Supervisor's Office, Tucson, Arizona).

Public Review

This document was made available for public review from April 17 to May 17, 2006. It was

mailed to 32 individuals, agencies, organizations, and libraries that were likely to be interested and potentially affected by the proposed action. A news release was mailed to news outlets in southern Arizona. The news release and the draft EA were also posted on our website (http://www.fws.gov/arizonaes/) where we requested comments.

One comment letter was received, from the AGFD Habitat Branch in Phoenix, Arizona, dated May 16, 2006. Below we summarize their comments and present our response.

Comment a. The AGFD recommended use of "would" instead of "will" and "anticipate" instead of "expect" to keep the document objective in terms of outcomes. They also recommended deleting "that" where it is used as a filler, and suggested full justification for smooth transitions and readability.

Response. The suggestions were adopted, except consistent with office guidance, we did not use full justification in the font.

Comment b. Cattle tanks may lose their seal when they become dry and necessary steps may need to be considered for resolution if this occurs.

Response. We are not aware of this being a problem in the San Rafael Valley. We are unlikely to drain any tank completely because water is needed for cattle, and in some cases STS. Also, replacing large quantities of water would be a challenge. However, if a decision is made to completely drain a tank, we will consult with the Coronado National Forest's Range Conservation and if there is a likelihood the tank's seal could be damaged, we will leave some water in the tank.

Comment c. Multiple treatments of rotenone may be needed to eliminate exotic fishes.

Response. We would monitor the tanks post-treatment for exotic fishes and bullfrogs. If these species are found, chemical and/or mechanical treatments would be applied as appropriate and consistent with the alternatives described herein, to eliminate them.

Comment d. In the preferred alternative, rotenone can take up to 48 hours to kill fish. Hence, STS may need to be held for more than 48 hours before conditions are safe for repatriation.

Response. We have noted in the preferred alternative that STS would be salvaged and held until conditions are safe, which may be more than 48 hours.

Comment e. Exotic species should be used to test water toxicity after rotenone is neutralized.

Response. We have revised the preferred alternative so that only exotic species would be used to test the toxicity of the water.

Comment f. In the preferred alternative, the timing of rotenone treatments may be key to overall success. Rotenone does not kill fish eggs, thus treatments should occur when fish are not spawning.

Response. Green sunfish have been found in Rosemary Tank and is probably the fish most likely to occur in other tanks. Sunfish can spawn any time of the year, although they are

probably less likely to spawn in the fall. Other species, if present, may be spawning in June or July when we propose the work. As we described in our response to comment c, we would monitor exotic species presence post treatment, and if such species are found, we would repeat mechanical and/or chemical treatments as needed to achieve control.

Section III: ALTERNATIVES, INCLUDING THE PREFERRED ALTERNATIVE

The action proposed by FWS will, in cooperation with AGFD, the Coronado National Forest, and others, meet the purpose and need to remove exotic species from stock tanks in the SRV. Elements of the actions described in this section are common to the two action alternatives discussed in this EA.

During the dry season, the status of native amphibians and fishes are at their weakest because of the limiting number of perennial sites. In addition, exotic species reliant on water for survival during the dry season are similarly limited. Therefore, we intend to conduct exotic species removal (alternatives 1 and the preferred alternative) in June or July 2006, prior to the monsoon season when water sources in SRV are limited. If necessary, we may conduct additional control work outside of this timeframe and until June 2008.

1. No Action Alternative

Under the no action alternative, FWS would not implement proposed renovation of the stock tanks in the SRV. The no action alternative provides the baseline for comparison of environmental effects of the action alternatives.

1.1 Points of concern

It is our anticipation that the no action alternative would result in the following:

- During the wet season, exotic species would spread from stock tanks into surrounding drainages and prey upon native species and compete for food.
- Exotic species would persist in the stock tanks and continue to disrupt native ecological communities at tanks where they are present.
- Present native species (e.g., STS) would continue to decline and/or become extirpated.
- Recovery of other listed or sensitive species would not occur at the stock tanks due to presence of exotic species.

2. Alternative 1 (mechanical removal of exotic species)

Under this alternative, FWS would, in cooperation with AGFD, Coronado National Forest, and others, pursue renovation of four stock tanks in the SRV (Table 1, Figure 1, Appendix 4), according to the procedures and schedules detailed in FWS/AGFD's proposal. Three of the tanks (Rosemary, Bwoods, and Dan tanks) are located on Coronado National Forest lands. Upper 21 tank (sometimes referred to as Doug's Tank) is located on the privately-owned San Rafael Ranch.

To summarize, FWS/AGFD's renovation proposal (Appendix 1) calls for a cooperative effort among the participants to: 1) Remove exotic species from selected stock tanks, 2) monitor and adaptively manage as needed to ensure native species survival, and 3) continue coordination among participants to ensure issues and concerns are addressed appropriately. These three primary elements of the plan, and conservation measures to protect threatened and endangered species and their habitats, are described briefly below.

2.1 Removing exotic species from stock tanks

Native and exotic fish and amphibians present in the stock tanks would be captured using mechanical methods (e.g., seining, gill netting, gigging, and electrofishing) in combination with the draining or partial draining of stock tanks. Table 1 describes techniques we anticipate to use at each of the four tanks, based on a March 2006 reconnaissance and assessment of project needs. However, depending on conditions, various combinations of draining or partial draining of tanks and the mechanical methods just listed above could be used at any of the tanks. Captured individuals of native species would be placed in holding tanks (we anticipate no longer than 48 hours) and released back into the stock tanks once removal of exotic species has been completed. Exotic species (e.g., bullfrog and exotic fishes) captured using the above methods, would be euthanized on site. Mechanical removal would end when on-site biologists determine that exotic species are apparently eliminated. If any of the four stock tanks dry up for several weeks before the monsoon season, they would not be treated because drying for several weeks will eliminate exotic species.

Table 1.
Description of mechanical treatments anticipated to be used for removal of exotic species from the four stock tanks.

Tank	Renovation treatments
Rosemary	Drain part way, mechanical treatment
Bwoods	Mechanical treatment
Dan	Drain part way, depending on presence of STS
Upper	Drain part way, mechanical treatment

2.2 Monitoring and Adaptive Management

Dynamics of native and exotic species' populations remaining in the treatment area, and the quality of stock tanks, would be monitored using visual encounter surveys over a 2-year period.

Water levels and other environmental conditions at the renovation sites would also be regularly monitored.

Monitoring data would be used to assess success. If exotic species are detected during the two-year monitoring period, we would control them through non-chemical means, if possible, or supplementary proposals for the use of alternative methods would be written.

2.3 Continued Coordination

All aspects of the renovations would be coordinated through FWS and AGFD, who would call meetings with the Coronado National Forest and affected landowners, permittees, and others a minimum of annually during the project. Especially important would be input from cooperators and affected parties regarding the analysis of monitoring data and recommendations for adaptive management. Adaptive management would be employed within the constraints of the project described herein to improve the likelihood of success of the project and to reduce any potential adverse effects on resources or affected parties. For instance, in coordination with our cooperators and affected landowners, permittees, and others, we may continue mechanical control methods for exotic species at the four tanks, if we fail to eradicate them before the monsoon season in 2006. If such action is needed, it would occur as described herein, including all conservation measures.

2.4 Conservation Measures

The following measures would be implemented as part of the proposed action to minimize any potential effects to the environment:

- All monitoring work that may result in forms of take of regulated native or exotic species will be conducted under FWS and AGFD permits, and will conform to all conditions of those permits.

- All field work shall conform to amphibian disease prevention protocols as described in the Recovery Plan for the Sonoran tiger salamander. Equipment would either be disinfected between uses at different sites, or air dried.

- To minimize fire risk, no camp fires will occur during any backcountry camping needed during project activities. Field workers will not smoke while conducting field work.

- When STS are encountered, the tank would not be drained completely and STS would be salvaged and held in aquaria or other suitable artificial environments until mechanical treatments that may injure or kill STS are completed.

- Where needed for cattle, water removed from tanks would be replaced or alternative water sources would be provided until rains refill the stock tanks. The need to provide alternative waters for cattle will be coordinated with the Coronado National Forest, Sierra Vista Ranger District, and the permittees, or in the case of Upper 21 Tank, with Ross Humphreys, the ranch owner.

2.5 Points of concern

Probability of removing all exotic species using mechanical means (e.g., seining, dip netting,

electro fishing, gill netting and gigging) alone is unpredictable but likely low. Mechanical methods do not catch all individuals present in the water. For example during a March 2006 survey we encountered situations where bullfrogs were apparently not susceptible to mechanical removal. Additional points of concern include:

- Individuals of exotic species could elude capture by hiding in the water away from the area where mechanical methods are applied.

- Partly draining of tanks would provide a higher probability to capture individuals as mechanical means would be more effective in capturing exotic species when water levels are low.

- When individuals of exotic species remain, these individuals could rapidly build up a viable population (e.g., a single female bullfrog could lay thousands of eggs in a stock tank, which could then be a source-site for metamorphosed bullfrogs to re-invade adjacent tanks).

3. Alternative 2 (Mechanical and chemical removal of exotic species) (Preferred Alternative)

Under this alternative, FWS and AGFD would, in cooperation with others, pursue renovation of the four stock tanks in the SRV, according to the procedures and schedules detailed in FWS/AGFD's proposal (Appendix 1). Three of the tanks (Rosemary, Bwoods, and Dan tanks) are located on Coronado National Forest lands (Figure 1, Appendix 4). Upper 21 Tank is located on the privately-owned San Rafael Ranch (Figure 1, Appendix 4).

To summarize, FWS/AGFD's renovation proposal calls for a cooperative effort among the participants to: 1) Remove exotic species from selected stock tanks, 2) monitor and adaptively manage as needed to ensure native species survival, and 3) continue coordination among participants to ensure issues and concerns are addressed appropriately. These three primary elements of the plan, and conservation measures to protect threatened and endangered species and their habitats, are described briefly below.

Past renovations of native species' habitats prevented immediate extirpations of native species' populations, stabilized those populations, and replicated them, all essential steps in a rare species recovery program. Except for unique circumstances, renovation of stock tanks with an approved pesticide or complete draining and drying of the tank are the only methods that have a likelihood of total removal of exotic species. Rotenone is the most effective pesticide for renovation of stock tanks, and it has been used extensively in the southwestern US for several decades (McClay 2000).

Table 2 describes our best estimate of the techniques needed to remove exotic species at the four tanks. Techniques were identified during a March 2006 reconnaissance of the tanks. Techniques may be modified depending on the conditions present when the work is conducted. However, rotenone would only be used at Rosemary, Dan, and Upper 21 tanks. Any of the mechanical means described in alternative 1 and draining of tanks could be used at any or all of the four tanks.

3.1 Removal of native species from stock tanks before chemical treatment

Any native fishes and amphibians present in the stock tanks would be salvaged alive using mechanical methods (e.g., seining, dip netting, or electro fishing). During this process, tanks may be partly drained to ensure a better result of these mechanical methods. It is anticipated that during these activities both native and exotic species would be captured. Exotic species (e.g., bullfrog and exotic fishes) captured using the above methods, would be euthanized on site. Captured individuals of native species would be placed in holding tanks (we anticipate no longer than 48 hours) and released back into the stock tanks following pesticide treatment. Small samples of non-native fish would be held in live cages in the treated stock tank to ensure the tank is no longer toxic, before releasing salvaged natives. If they appeared distressed, we would remove them and wait several hours before testing the water again.

Table 2. Description of mechanical and chemical treatments anticipated to be used for removal of exotic species from the stock tank.

Tank name	Renovation treatments
Rosemar	Drain part way, mechanical & chemical treatment
Bwoods	Drain and dry
Dan	Drain part way or completely, depending on presence of STS detected during draining
Upper 21	Drain part way, mechanical & chemical treatment

3.2 Removal of exotic species from stock tanks (chemical treatment)

The preferred alternative would be especially applicable when treated stock tanks are needed as water sources for cattle, and/or when native species (e.g., STS) are present. In both cases, complete draining of stock tanks is undesirable because water is needed for cattle, STS, or both. If any of the four stock tanks dry up for several weeks before the monsoon season, they would not be treated, as complete drying will eliminate exotic species.

Chemical removal of any non-native fishes present would follow the salvage of native species and removal of exotic species using mechanical methods (see alternative 1). The pesticide rotenone would be applied to Rosemary, Dan, and or Upper 21 tanks to remove fishes from the remaining water. We also anticipate incidental kill of any bullfrog tadpoles present in treated tanks. In tanks with salvaged native species, we would detoxify the water to speed repatriation. When enough time has passed for rotenone to have effectively euthanized exotic species, potassium permanganate ($KMnO_4$) or sodium permanganate ($NaMnO_2$) would be applied to the water to neutralize the rotenone. These compounds are strong oxidizing agent and quickly break down to naturally occurring compounds that are non-toxic (Archer 2001). It is anticipated that the water is detoxified within several hours. Metamorphosed bullfrogs are not likely to be killed by rotenone and would need to be removed mechanically.

3.3 Rerelease of native species, monitoring, and adaptive management

Native fishes and amphibians, salvaged prior to the chemical treatment, would be released near their point of capture once the stock tanks have been detoxified. Dynamics of native and exotic species' populations in the treatment area, and aspects of stock tank habitats, would be monitored over a 2-year period. Presence, numbers, and evidence of reproduction of exotic and native species would be monitored using visual encounter surveys. Water levels, vegetation, and other species at the renovation sites would also be monitored. Monitoring data would be used to assess success. If exotic species are detected during the two-year monitoring period, we would control them through chemical or mechanical means as described in this alternative, if possible.

3.4 Continued Coordination

All aspects of the renovation action would be coordinated through FWS and AGFD, which would call meetings with the Coronado National Forest and affected landowners, permittees, and others a minimum of annually during the project. Especially important would be input from regarding the analysis of monitoring data and recommendations for adaptive management. Adaptive management would be employed within the constraints of the project described herein to improve the likelihood of success of the project and to reduce any potential adverse effects on resources or affected parties.

3.5 Conservation Measures

The following measures would be implemented as part of the proposed action to minimize any potential effects to the natural environment:

- All monitoring work that may result in forms of take of regulated native and exotic species will be conducted under FWS and AGFD permits, and will conform to all conditions of those permits.

- All field work shall conform to amphibian disease prevention protocols in the STS Recovery Plan. Equipment would either be disinfected between uses at different sites, or air dried.

- Prior to use of rotenone, gill nets, or electroshockers, and prior to draining a tank, we would seine the tanks several times and salvage any STS found in the tanks. STS would be held on-site in aquaria or other suitable aquatic habitats until potentially hazardous mechanical methods are completed and until toxic conditions due to rotenone treatments are abated. In tanks with STS, we would use sodium or potassium permanganate to neutralize the rotenone and reduce the amount of time until we can return STS to the tank. These compounds are strong oxidizing agents and quickly break down to naturally occurring compounds that are non-toxic (Archer 2001). The time from the application of rotenone to the time when the tank is completely detoxified (using sodium or potassium permanganate) is anticipated to be less than 48 hours.

- To minimize fire risk, no camp fires will occur during any backcountry camping needed during project activities. Field workers will not smoke while conducting field work.

- Rotenone would only be applied in accordance with a Pesticide Use Plan and by a certified pesticide use applicator. Pesticide Use Plans are required by National Forest

regulations and identify methods, sensitive areas, and precautions to be taken to minimize or eliminate adverse effects to non-target species, resources, and people.

- Personnel will remain on-site at tanks treated with rotenone to prevent recreational use of the tanks until toxic conditions are neutralized. The time from the application of rotenone to the time when the tank is completely detoxified (using potassium permanganate) is anticipated to be less than 48 hours if potassium or sodium permanganate is used. Detoxification without these compounds would likely take one to several days.

- When STS are encountered, the tank would not be drained completely or the STS would be salvaged and held in aquaria or other suitable artificial environments until the tank refills.

- Where needed for cattle, water removed from tanks would be replaced or alternative water sources would be provided until rains refill the stock tanks. The need to provide alternative waters for cattle would be coordinated with the Coronado National Forest, Sierra Vista Ranger District, and the permittees, or in the case of Upper 21 Tank, with Ross Humphreys, the ranch owner.

3.6 Points of concern

In addition to the Point of Concern (using mechanical methods to remove exotic species) described in 2.5, there are several points of concern when using rotenone and potassium permanganate to treat tanks:

- Rotenone use requires proper mixing of this chemical throughout the water, otherwise it may not affect all parts of the tank. However, the stock tanks are small (relative to other water bodies this chemical has been applied to) and the water is standing. These characteristics greatly reduce the likelihood of rotenone not being effective when applied in concentrations suitable for this situation.

- It is unlikely that all STS can be salvaged from stock tanks using mechanical methods prior to rotenone application. Some STS would likely be affected by rotenone treatments. Affected animals typically float to the surface. If STS are found, they would be salvaged immediately and placed in untreated, aerated water in the hope of reviving them. However, some STS would likely be killed. These short-term losses would be offset by longer-term benefits that would accrue to STS populations due to removal of exotics.

Section III: AFFECTED ENVIRONMENT

Environmental Setting

The four stock tanks lie in the southeastern portion of the SRV in the upper Santa Cruz River watershed. The vegetation community is a plains grassland-oak woodland transition between the valley bottom and the foothills of the Huachuca Mountains. Elevations range from about 5,000 to 5,300 feet. The tanks lie along interconnected drainages between Jones Mesa and Dove Canyon. They are geographically and hydrologically separated to some degree from other tanks in the region by mesas and ridgelines. The tanks have a history of supporting exotic species, but

are also habitat for STS and have potential for other sensitive species. If exotics can be eliminated from these tanks, natural recolonization by exotics would likely be slow due to the geographical and hydrological barriers.

Biology and Status of the affected species

Native species

Recent and historical survey records show STS to be present in five stock tanks in the region where the proposed action would be implemented (see Table 3, Figure 1, Appendix 5). If removal of competitive and predatory exotic species is successful, it is anticipated the number of stock tanks containing STS in the focus area of this proposal would increase. However, dispersal of STS would occur naturally (meaning STS are anticipated to move throughout the area and establish populations in suitable habitats without human assistance). Reinvasion of stock tanks by exotics could take several years due to natural barriers.

In addition to contributing to recovery of STS, the renovated tanks could be used for recovery of additional species such as Gila topminnow, Gila chub, Chiricahua leopard frog, and Mexican gartersnake (i.e., in accordance with Recovery Plans, where applicable). With the exception of the Mexican gartersnake, which may occur nearby, colonization of the tanks by these species is unlikely to occur except through active introductions. No such introductions are proposed herein, and if considered in the future would be subject to additional NEPA, Endangered Species Act, and other applicable compliance, including coordination with affected and interested parties and agencies.

Exotic species

Survey data (historical and/or recent) collected throughout the focus area of this proposal, show presence of exotic species in the stock tanks which appears to shift between years (see Table 3). During the wet season, stock tanks act as source-sites from which exotic species re-invade the focus area. Fishes are probably moved among stock tanks and from Parker Canyon Lake by anglers who use fish for bait, or who wish to establish a fishery. Data from the March 2006 reconnaissance suggest exotic species (especially bullfrogs) currently occur in several stock tanks throughout the focus area. Predatory exotic species of concern for this proposal are summarized in Appendix 3. Table 3 shows survey records of stock tanks within the focus area of this proposal, including presence of exotic species in each tank.

The survey data summarized in Table 3 present an incomplete picture of exotic species presence in the area. The survey protocol for the salamander, which involves up to three seine pulls through a tank, is not adequate to definitively inventory aquatic vertebrates. Rosas and Minello (1997) found that seining has relatively low and variable catch efficiency, and is ineffective in aquatic vegetation or through soft substrates. Some species of fish and size classes of fish are more susceptible to capture in seines than others, and seining techniques also influence catchability (Bayley and Herendon 2000). Marsh *et al.* (2003) report on loach minnow (*Tiaroga cobitis*) collected from Eagle Creek, Arizona, in 1950, but which were not observed again, despite many repeated samplings using a variety of techniques, including seines, until 1994. In the March 2006 surveys of the four tanks, bullfrogs were observed at Dan Tank, but no frogs or tadpoles were seined from the tank.

Given the presence of green sunfish at Rosemary Tank in previous surveys, the proximity of Parker Canyon Lake, which is a popular fishing location, and the tendency of anglers to move

bait and sport fish to aquatic sites, it is likely that exotic fishes occur in one or more of the four tanks proposed for treatment.

Description of renovation sites

The four stock tanks were selected for renovation due to presence of exotic species and, in some cases, their value for STS (see Table 4); other tanks in the region were not selected due to absence of exotic species during the March 2006 survey (see Table 3). All tanks are impounded with dirt dams on the downstream side and fill when surface runoff occurs into the tanks. Stock tanks had $\leq$ 5% vegetation cover in each of three categories (see Table 4), and some tanks either had a partly open fence around the perimeter or a fence through the middle of the tank. Water depths varied from 2.0 to 5.6 feet, but the volume of water is highly variable and corresponds to recent runoff events. Table 4 also shows the UTM coordinates and elevation for each of the stock tanks.

Rosemary, Bwoods, and Dan tanks are in the Forest Service's Lone Mountain grazing allotment. Bwoods and Dan tanks are in the Paloma Pasture, which is scheduled to have 175 head of cattle from mid-May through the end of July. Rosemary Tank is in the Jones Pasture and is not scheduled to be grazed until Spring of 2007. Upper 21 Tank is on the privately-owned San Rafael Ranch in an actively grazed pasture.

Section IV: ENVIRONMENTAL CONSEQUENCES

Effects of the no action, alternative 1, and preferred alternative are summarized in the "Summary Table of Environmental Consequences". The no action alternative would likely result in continuation of current conditions under which native species, especially STS, are either absent from stock tanks or present but declining. Possible concerns and issues related to removal of exotic species from the stock tanks, when the no action alternative, alternative 1, or the preferred alternative are implemented, are discussed below, including:

1) How would the alternatives affect land use, such as livestock grazing?

2) What are the economic impacts of exotics removal?

3) How would removal of exotic species (mainly bullfrogs) affect threatened and endangered species and their habitats?

Table 3. Description of historic and recent survey records at each of the stock tanks within the focus area.

Tank name	Historical data (1980-2005)	Survey (March 2006)
Rosemary	Exotic fish, RACA, STS	RACA
Max	No Detects	No Detects
Jack	STS	STS
Bwoods	STS and RACA	RACA
Dan	STS and RACA	STS and RACA
Missing	Dr	Dr
Paloma spring	Dr	Dr
KDT	Dr	Dr
Astrgl	Dr	Dr
T396	RACA	STS
Upper 21	RACA (via Ross)	RACA

ST	Sonoran tiger salamander
RACA	Bullfrog
Exotic fish	e.g., Green sunfish
No Detects	No amphibians or fishes captured during surveys
Dry	Tank was dry during survey

Table 4. Descriptions and historical and recent survey records at the four stock tank renovation sites.

Tank name	March 2006 Survey			Location of stock tanks		
	Shorelin vegetation (%)	Submerge vegetatio (%)	Emergen vegetatio (%)	UTM-	UTM-	Elevation (ft
Rosemary	0	1	5	545063	3472777	5069
Bwoods	0	1	1	547716	3475495	5145
Dan	0	1	1	544841	3474583	5240
Upper 21	na	na	na	541146	3475565	4821

Important to our analyses are effects of proposed removal and monitoring activities on endangered species and livestock grazing in the SRV. Minor effects would also occur to recreational uses and opportunities in these areas, and removal would have minor economic costs. These negative effects are contrasted with longer-term benefits that would accrue to native species conservation.

With implementation of alternative 1 or the preferred alternative, we anticipate no long-term effects to water quality; and no effects to air quality, cultural and historical resources, visual resources, soils, or geology. We do anticipate water quantity to decline temporarily in some stock tanks with implementation of alternative 1or the preferred alternative, as some stock tanks would be partly drained. Water quality would be temporarily impaired in the preferred alternative due to rotenone treatments. However, this would occur in agreement with USFS and permittees. Alternative water sources for cattle would be made available where needed.

Land use

No Action Alternative

Under no action, removal of exotic species would not occur at the four tanks in the SRV. This would result in no changes in land management.

Alternative 1 the Preferred Alternative

Alternative 1 and the preferred alternative would involve removal of exotics. Most removal of exotic species from selected stock tanks would be conducted in a timeframe of approximately 3 weeks in June or July 2006. During this time, not all tanks would be treated simultaneously. However, the order of treatment would depend upon several factors and would need to be decided shortly before treatment. Factors include: presence of cattle near stock tanks, water level, and presence of native (e.g. STS) or exotic (e.g. bullfrog) species at the tank during treatment.

We discuss here land uses potentially affected.

Livestock grazing activities

Water availability at the treated tanks may be limited due to partial draining of stock tanks. If cattle are in the pastures where the tanks are located during treatment (all but Rosemary Tank), we would ensure sufficient water is available for cattle, including refilling tanks or providing an alternative water source if necessary until the stock tanks refill with the summer rains. When STS are present in stock tanks, those tanks would not be drained completely to ensure survival of STS after treatment.

We anticipate no additional restrictions or changes in livestock management as a result of implementing alternative 1 or the preferred alternative. We believe if management is adequate to maintain stock tanks as they are, the populations of STS would persist and expand as a result of the removal of exotic species. Cattle ranching and STS have coexisted for many decades in the SRV. There is no reason to believe they could not continue to coexist.

Fire Management

If fire management, including mechanical thinning, prescribed fire, or wildfire suppression, were proposed or conducted in the focus area of this proposal, we anticipate no effects of proposed exotic species removal on those activities. If fire activities occurred during the proposed renovations, we would halt our activities until conditions were safe and we could reenter the area.

Recreation

Bullfrogs and exotic fishes can be harvested by anglers and sportsmen with appropriate licenses from the AGFD. Alternative 1 and the preferred alternative would reduce, by a small amount, opportunities for harvesting these species. However, we believe the effects are minimal, as these species can be pursued elsewhere at many other places in the SRV and surrounding areas. Parker Canyon Lake is where most fishing occurs in the SRV, and recreational use there would be unaffected by proposed exotic removal.

Removal of exotic species may increase native species, which may enhance recreational experiences for those who value biodiversity. If successful, the focus area of this proposal would be one of the places in the SRV where the STS, possibly in combination with other

threatened, endangered, and sensitive species, could be observed in the wild. Visitors on USFS land in particular, come to see a variety of birds, wildlife, and plants. Some visitors may, on occasion, experience temporary reduced solitude due to exotic removal or monitoring activities.

Economics

No Action Alternative

Under the no action alternative, the FWS would take no action to remove exotics from stock tanks in the SRV; thus no Federal funds would be expended beyond those already obligated in this and other planning processes, and no economic impacts would occur.

Alternative 1 and the Preferred Alternative

Some minor costs could be incurred due to mitigation for the native species present in the focus area (e.g., STS) that may be built into land-use proposals, such as any fire projects. We anticipate these costs would be minor (see discussion of effects to land use, above) and the likelihood of a project being proposed that would affect native species habitat is probably low.

The benefits of removal of exotics are difficult to quantify, in terms of dollars. Benefits are mostly intangible, e.g. recovery of native species (e.g., STS) and with that enrichment of biodiversity. However, there would likely be some economic benefits as well, in terms of enhanced recreational opportunities. Many ecotourists visit southern Arizona to view rare birds and other borderland species. These recreationists expend considerable money in these nature-based pursuits. For instance, in 1991-1992, the economic impact on total industry output in the Sierra Vista area associated with nature-based visitors to Ramsey Canyon and the San Pedro River was roughly $2.7 million per year (Crandall *et al.* 1992). The presence of increased biodiversity is anticipated to attract some visitors or enhance the experience of others, with associated economic benefits. We anticipate economic effects to fishing and bullfrog harvest recreation (see “Recreation” above) to be insignificant, as anglers and those hunting bullfrogs have many other and better opportunities for pursuing these activities in the SRV and surrounding areas.

Threatened and Endangered Species

No Action Alternative

Under the no action alternative, the FWS would take no action to remove exotics from stock tanks in the SRV. Competitive and predatory activities of exotic species (e.g., bullfrogs) would continue to affect populations of STS or other native species that may occur in the area.

Alternative 1 and the Preferred Alternative

Sonora tiger salamander

The status of STS populations in the SRV is described in Appendix 3. The following summarizes effects of alternative 1 and the preferred alternative on STS, including long-term effects of exotic species removal on STS. In general, short-term effects would be adverse, but alternative 1 and the preferred alternative are anticipated to have longer-term benefits to the species.

Alternative 1 and the preferred alternative would involve salvaging STS from stock tanks by mechanical means (i.e., seining, dip netting, electro fishing, draining/drying of tanks). Chemical treatment euthanizes aquatic species that remain in the water, which is why STS would be salvaged by mechanical means prior to application of chemicals. Salvaged STS would be placed in holding tanks and released in the stock tanks from which they were salvaged after exotics have been removed and any toxic conditions (rotenone) abate. When STS would be released back into a tank, water levels may be lower (e.g., lower water levels ensure a more complete salvage of species present in the water). Prior to release of STS into the tanks, water quality would be tested (rotenone would be sufficiently neutralized), and the water level would be sufficient to ensure STS survival until the summer rains increase water levels.

Because mechanical removal is unlikely to be 100 percent effective, some STS would likely remain in the tanks when rotenone is applied. We would look for STS in distress and immediately salvage and revive (if possible) any STS found during rotenone applications; however, some animals are likely to be killed. Rotenone is a naturally occurring substance derived from roots of tropical plants in the bean family. It has been used for modern fishery management since the 1930's and is also used as an insecticide on crops and livestock (Finlayson *et al*. 2000). Houf and Campbell (1977) studied rotenone effects on aquatic macro-invertebrates in ponds and concluded that rotenone is not detrimental to benthic communities in ponds when applied at the dosages used for fish removal. Rotenone can be detected by fish and evaded in areas of incomplete mixing. Its effects are reversible if fish can be moved to untreated waters, and rotenone does not kill fish eggs. Because of some poorly-administered projects in streaming water that resulted in undesired downstream fish kills, rotenone use has become publicly controversial in some cases (i.e., Lake Davis, Ca) (Finlayson *et al.* 2000). However, for this proposal, rotenone would be applied in relatively small treatment areas of standing water, and controversial use of rotenone does not appear to apply to the focus area in the SRV. Where STS are present, sodium or potassium permanganate would be used to neutralize the rotenone and reduce the length of time treated ponds remain toxic. Breakdown components (sodium, potassium, manganese, and water) are common in nature and have no deleterious environmental effects at concentrations used for neutralization of rotenone (Finlayson *et al.* 2000). Kemp *et al.* (1966) found $KMnO_4$ formed a biologically inert residue when it reacted with organic material.

We have conducted an intra-service formal section 7 consultation to describe in more detail the effects of rotenone and other aspects of the proposed alternatives on the STS (Fish and Wildlife Service 2006). The biological opinion, which concludes consultation, found that the proposed action (the preferred alternative) is not likely to jeopardize the continued existence of the STS. The opinion anticipated that incidental take of STS would occur, but did not include any mandatory terms and conditions because the Conservation Measures, which are part of the proposed action, are adequate to minimize incidental take.

Additional endangered, threatened, and sensitive species potentially affected

No other listed or sensitive species have been found in or near the four tanks targeted for treatment (results of March 2006 surveys and FWS files). However, Gila topminnow, Gila chub, Chiricahua leopard frog, and Mexican gartersnake all occur in the SRV and are all potential candidates for reestablishment projects into the renovated stock tanks (i.e., in accordance with Recovery Plans, where applicable). Reestablishment of these species is not proposed herein, but would be considered in future NEPA and other compliance documents. Alternative 1 and the

preferred alternative; however, provide greater opportunity for recovery (involving reestablishment) of these native species in the SRV.

Cumulative Impacts

The Council on Environmental Quality defines cumulative impacts as the incremental impact of multiple present and future actions with individually minor, but collectively significant, effects. Cumulative impacts can be concisely defined as the total effects of the multiple land uses and development, including their interrelationships, on the environment.

Most of the current land uses and developments in the focus area of this proposal were described in the "Affected Environment" herein. The primary uses of the area are recreation and livestock grazing. In recent years the area has been increasingly used as a route for illegal immigration and smuggling into the United States from Mexico. These activities and corresponding law enforcement response have resulted in new trails and roads in some areas. Undocumented immigrants have started fires in some cases. These fires are primarily in the Huachuca Mountains. None of the resources in the focus area would be anticipated to incur significant cumulative impacts from these activities.

Summary Table of Environmental Consequences

Resources	**No Action Alternative** (No participation by Fish and Wildlife Service in exotic species removal in the SRV)	**Proposed Alternative 1** (Exotic species removal at four stock in the SRV tanks via mechanical means)	**Proposed Alternative 2** (Exotic species removal at four stock in the SRV tanks via mechanical and chemical means)
Land Use	No effects.	No or few temporary effects to cattle ranching due to draining of tanks. Alternative water sources would be supplied where needed. Minor positive and negative effects to recreational values and opportunities.	No or few temporary effects to cattle ranching due to draining and chemical treatment of tanks. Alternative water sources would be supplied where needed. Minor positive and negative effects to recreational values and opportunities.
Economics	No effects	Costs of stock tank renovations are relatively low. Benefits of the program may include minor increase in expenditures by recreationists that could benefit local economies.	Costs of stock tanks renovations are relatively low. Benefits of the program may include minor increase in expenditures by recreationists that could benefit local economies.
Threatened, Endangered, and Sensitive Species	Ongoing presence of exotic species would result in continued declines and losses of threatened, endangered, and sensitive species in the focus area.	Incidental loss of individual STS in the short term would be offset by long-term benefits to conservation and recovery opportunities. Measures included as part of the proposed action would minimize loss of STS.	Incidental loss of individual STS in the short term would be offset by long-term benefits to conservation and recovery opportunities. Measures included as part of the proposed action would minimize loss of STS.
Soils and Geology	No effects	No effects	No effects
Cultural and Historical Resources	No effects	No effects	No effects
Air Quality	No effects	No effects	No effects
Water Quantity	No effects	Stock tanks would be partly drained to ensure all exotics are removed by mechanical means. Replacement water sources for cattle would be supplied, as needed.	Stock tanks would be partly drained to ensure all exotics are removed by mechanical means. Replacement water sources for cattle would be supplied, as needed.
Water Quality	No effects	No effects	Water quality in stock tanks would be impaired temporarily due to treatments with the pesticide rotenone to euthanize all exotic species. Potassium permanganate would be applied after treatment to neutralize the effects of rotenone. After nuetralization, water quality would be restored.
Visual	No effects	No effects	No effects
Cumulative effects	Minor effects to resources in the focus area due to cumulative impacts	Minor effects to resources in focus area due to cumulative impacts	Minor effects to resources in focus area due to cumulative impacts

List of preparers and partners consulted during preparation of EA

- US Fish and Wildlife Service Ecological Services, Phoenix,
  Jim Rorabaugh
  Brian Wooldridge
  Pamela Keyes
  Maaike Schotborgh

- Arizona Game and Fish Department Nongame Branch (AGFD), Phoenix
- US Forest Service (USFS), Sierra Vista Ranger District
- Arizona State Parks, San Rafael State Park

- Ross Humphreys, San Rafael Ranch
- Sonora tiger salamander Recovery Team

List of Acronyms

AESO = Arizona Ecological Services Office of the U.S. Fish and Wildlife Service
AGFD = Arizona Game and Fish Department
EA = draft Environmental Assessment
FWS = U.S. Fish and Wildlife Service
NEPA = National Environmental Policy Act
RACA = bullfrog (*Rana catesbeiana*)
SRV = San Rafael Valley
STS = Sonora tiger salamander
USFS = U.S. Forest Service
UTM = Universal Trans Mercator (a coordinates system)

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U.S. Fish and Wildlife Service. 2006. Gila chub (*Gila intermedia*) recovery outline. U.S. Fish and Wildlife Service, Region 2, Albuquerque, NM.

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Appendix 1: Collaborative Conservation Grant Proposal, Funded in 2006

Collaborative Conservation Project Proposal

Date: 19 Jan 2006
Office: AZ Ecological Services Office
Principle Project Officer (PPO): Tom Jones (AGFD), Jim Rorabaugh (USFWS)
Phone:(602) 789-3735 (TJ) (602) 242-0210 x238 (JR)
Email address: TJones@azgfd.gov, Jim_Rorabaugh@fws.gov

Project Title: Small Scale Exotic Species Removal in the San Rafael Valley

Project Description (This section limited to 2 paragraphs and 250 words):

This project addresses five aquatic or semi-aquatic species that have declined in large part as a result of competition, predation, or disease transmission from invasive exotic species. Four are federally listed (*Poeciliopsis occidentalis, Gila intermedia, Ambystoma tigrinum stebbinsi* and *Rana chiricahuensis*); a 90 day finding has been published for the fifth (*Thamnophis eques megalops*). This project would maximize time, money, and effort spent on habitat restoration for multiple declining species through eradication of invasive exotic species -- a "high priority" threat identified in the Arizona Comprehensive Wildlife Conservation Strategy (provisional revision). It would also contribute toward implementing the Sonoran Tiger Salamander Recovery Plan, Gila topminnow Draft Recovery Plan, Chiricahua leopard frog Draft Recovery Plan and Gila chub Recovery Outline.

We propose to eliminate bullfrogs (larvae and adults), exotic fishes and crayfish from 4-6 earthen stock tanks within a discrete geographic area in the San Rafael Valley, Santa Cruz Co., AZ. We would use a small scale, hydrologic and topographic approach, with historical data and ground surveys to identify tanks, all of which are within a few kilometers of historical habitat. This should increase probability of longer term success and lower likelihood of reinvasion. As appropriate, we would incorporate mechanical removal (seines, dipnets), tank drying, or chemical treatment. Renovated sites would be evaluated as refugia for fishes or a combination of species. We would conduct follow up surveys for up to two years to monitor sites for presence of exotic and native species. This project would be used as a test and a pilot for future aquatic, non-native eradication projects. We request $10,000 for this project. However, with $5,000 we would treat 2-3 tanks.

Cooperators (including FWS programs):

U.S. Fish and Wildlife Service, Arizona Game and Fish Department, Arizona State Parks (San Rafael Ranch State Park), U.S. Forest Service (Coronado National Forest, Sierra Vista Ranger District), Mr. Ross Humphreys (owner, San Rafael Ranch).

Distribution of species:

P. occidentalis, G. intermedia, R. chiricahuensis, T. eques – AZ, NM, Mexico
A.t. stebbinisi – AZ; Sonora, Mexico

Match:

Arizona Game and Fish Department would match costs with in-kind services, including personnel and equipment.

Innovative approach:

The approach is innovative in terms of the level of cooperation among private individuals and government agencies, and incorporating a comprehensive, intensive exotic species removal. Other intensive attempts at bullfrog removal have concentrated on single life history stages, and thus have experienced limited success, or have taken place in relatively uniform habitats with little physical relief. This project would incorporate topography and hydrology as natural physical barriers to isolate these sites from reinvasion

Appendix 2: Relevant Laws, Policies, Plans, and Guidance

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Appendix 3: Status of Sonoran tiger Salamander

Source:

U.S. Fish and Wildlife Service. 2002. Sonora tiger salamander (*Ambystoma tigrinum stebbinsi*) recovery plan. U.S. Fish and Wildlife Service, Region 2, Albuquerque, New Mexico.

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 (Collins, 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 (1997) 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 or tanks 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, 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*), 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.). In the past, a copper smelter at Cananea, Sonora, less than 25 miles south of the border, might have released 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 smelter, and the smelter is now closed. 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. Ponds in which introduced barred salamanders are most likely to occur are those that are most accessible, i.e. adjacent to roads on public lands, those that have a history of angling, and those near existing populations of barred salamanders. 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). Microsatellite genetic analysis of 73 salamanders from the six ponds suggested five of them may be hybrids. Morphologically, some salamanders were intermediate between the two subspecies. The authors concluded that introduction of barred salamanders may be altering the gene pool of STS (Storfer *et al.* 2004).

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 has 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.

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Appendix 4: Photos of stock tanks targeted for renovations

Rosemary tank

Bwoods tank

Dan Tank

Upper 21 tank

Appendix 5: Photos from the March 2006 survey

1

2

3

4

5

Photos from March 2006 survey:

1 & 2) Sonora tiger salamander.

3 & 4) Sonora tiger salamander eggs laid on a turtle trap set out during the overnight survey.

5) Staff disinfecting gear after surveying at Jack tank.