



United States
Department of
Agriculture

Forest
Service

Southwestern
Region



Final Environmental Assessment

Redrock Canyon Renovation Project

**Coronado National Forest
Santa Cruz County, Arizona**



For More Information Contact:

Coronado National Forest
Sierra Vista Ranger District
Attn: Glenn Frederick
5990 South Highway 92
Hereford, AZ 85615

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because of all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means of communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410, or call (800) 79503272 (voice) or (202) 720-6382 (TDD).

USDA is an equal opportunity provider and employer.

Printed on recycled paper—September 2010

TABLE OF CONTENTS

CHAPTER 1—PURPOSE AND NEED.....	7
1.1 INTRODUCTION	7
1.2 BACKGROUND	8
1.3 PURPOSE AND NEED	12
1.4 PROPOSED ACTION.....	13
1.5 DECISION FRAMEWORK.....	14
1.6 PUBLIC INVOLVEMENT	14
1.7 ISSUES.....	16
1.8 FOREST PLAN CONSISTENCY	17
1.9 PROJECT RECORD	17
CHAPTER 2 – ALTERNATIVES, INCLUDING THE PROPOSED ACTION	18
2.1 NO ACTION	18
2.2 PROPOSED ACTION.....	18
2.2.1 Native Species Salvage	19
2.2.2 Nonnative Fish and Frog Removal.....	20
2.2.3 Restoration of Native Fish and Amphibians	22
2.2.4 Monitoring.....	23
2.3 MITIGATION FOR ACTION ALTERNATIVES.....	23
2.4 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED ANALYSIS	23
2.4.1 Construction of a Fish Barrier in Redrock Canyon.....	24
2.4.2 Stock Tank Breaching	24
CHAPTER 3 – ENVIRONMENTAL CONSEQUENCES	26
3.1 WATER QUALITY	27
3.1.1 Affected Environment	27
3.1.2 Environmental Consequences	31

3.1.3 Cumulative Effects	33
3.2 HUMAN HEALTH AND SAFETY	33
3.2.1 Affected Environment	33
3.2.2 Environmental Consequences	34
3.2.3 Cumulative Effects	44
3.3 SOILS AND WATERSHED	44
3.3.1 Affected Environment	44
3.3.2 Environmental Consequences	44
3.3.3 Cumulative Effects	45
3.4 AIR QUALITY	45
3.4.1 Affected Environment	45
3.4.2 Environmental Consequences	46
3.4.3 Cumulative Effects	47
3.5 VEGETATION	47
3.5.1 Affected Environment	47
3.5.2 Environmental Consequences	48
3.5.3 Cumulative Effects	48
3.6 WILDLIFE	48
3.6.1 Terrestrial Wildlife	48
3.6.2 Fish and Aquatic Wildlife	51
3.6.3 Federally Listed and Candidate Species	58
3.6.4 Forest Sensitive Species (FSS)	61
3.6.5 Management Indicator Species (MIS)	64
3.6.6 Migratory Bird Species Analysis	68
3.7 CULTURAL RESOURCES	70
3.7.1 Affected Environment	70

3.7.2 Environmental Consequences	71
3.7.3 Cumulative Effects	72
3.8 SOCIOECONOMIC EFFECTS—LIVESTOCK GRAZING	72
3.8.1 Affected Environment	72
3.8.2 Environmental Consequences	73
3.8.3 Cumulative Effects	74
3.9 RECREATION	74
3.9.1 Affected Environment	74
3.9.2 Environmental Consequences	74
3.9.3 Cumulative Effects	75
3.10 ENVIRONMENTAL JUSTICE	75
3.10.1 Affected Environment	75
3.10.2 Environmental Consequences	75
CHAPTER 4 – CONSULTATION AND COORDINATION	76
4.1 LIST OF PREPARERS	76
4.2 OTHER CONTRIBUTORS	76
4.2 AGENCIES AND PERSONS CONTACTED	76
REFERENCES	78
APPENDIX A. Earthen stock tanks in Redrock Canyon Watershed	
APPENDIX B. Location records for native and nonnative species in and adjacent to Redrock Canyon.	
APPENDIX C. Index of the Administrative Record (Project Record).	

List of Figures

Figure 1. Location of the Redrock Canyon Renovation Project.	10
Figure 2. Map of the Redrock Canyon Watershed.....	11
Figure 3. Registered wells in the Redrock Canyon Watershed.....	30

List of Tables

Table 1. Issues identified during scoping process and where they are addressed in this EA.....	16
Table 2: Summary of studies on rotenone as a model for Parkinson’s Disease.....	41
Table 3. Federally listed species and candidates for listing found in or near the Redrock Canyon watershed. Species in bold were addressed in the Biological Opinion (FWS 2008).	58
Table 4. Forest Service Sensitive Species found in or near the project location. Sources include AGFD Heritage Data Management System and Forest Service project files.	61
Table 5. Management Indicator Species identified in the LRMP for the Forest. Species in bold are found in or near the project area or suitable habitat exists and have not been considered for analysis in other sections of this EA.	65
Table 6. Priority species in Arizona State Partners in Flight Bird Conservation Plan (Latta 1999) that occur or have potential habitat in the project.	69

CHAPTER 1—PURPOSE AND NEED

1.1 INTRODUCTION

The U.S. Department of Agriculture Forest Service Coronado National Forest (Forest) is proposing the Redrock Canyon Renovation Project. This Environmental Assessment (EA) was prepared by the Forest to analyze the potential direct, indirect, and cumulative effects of the proposed action on physical, biological, and cultural resources. The proposed action includes removal of nonnative fish and bullfrogs and reestablishment of the native fish and amphibian fauna in Redrock Canyon, Sierra Vista Ranger District, Santa Cruz County, Arizona.

This EA was prepared in accordance with the National Environmental Policy Act (NEPA) Council on Environmental Quality (CEQ) regulations (40 CFR 1500-1508), Forest Service Handbook 1909.15 (Environmental Policy and Procedures), and other relevant Federal and State laws and regulations. Supporting documentation, including more detailed analyses of project area resources, is on file in the project planning record in the Sierra Vista Ranger District Office in Sierra Vista, Arizona. Throughout this EA, references to supporting documentation are shown in parentheses. For example, a reference “(PR# 21)” would indicate that a specific passage in the EA is linked to information contained in document No. 21 in the project record. Each project record and the corresponding document title and author is listed in Appendix C.

This document is organized into four chapters, references, and appendices:

- **Chapter 1 – Purpose and Need:** This chapter presents information on the history of the proposed action, the purpose of and need for the action, and the proposal for achieving that purpose and need. This section also describes key issues raised by the public, project proponents, and other agencies, and the public involvement process.
- **Chapter 2 – Alternatives, including the Proposed Action:** This chapter provides a detailed description of the proposed action and alternative methods for satisfying the stated purpose and need. The discussion also identifies mitigation measures to minimize potential adverse impacts. Finally, this chapter provides a summary table of the environmental consequences associated with each alternative.
- **Chapter 3 – Environmental Consequences:** This chapter describes the anticipated environmental effects of implementing the proposed action and other alternatives, including no action. Within each section, the affected environment is described first, followed by a discussion of the potential effects of each alternative.
- **Chapter 4 – Consultation and Coordination:** This chapter identifies persons who contributed to the preparation of this EA and lists agencies and persons consulted during the NEPA process.
- **References:** This chapter lists documents used in preparation of this EA.
- **Appendices:** The appendices provide more detailed information to support the analysis presented in this EA.

1.2 BACKGROUND

The proposed action would be implemented in the Redrock Canyon watershed¹ in the Canelo Hills, Santa Cruz County in southeastern Arizona (Figure 1). Land ownership in the 20,000-acre watershed is mostly Forest Service, with two private land inholdings. No actions are proposed on the private land. There are no state, tribal, or other lands in the project area. The project area does not contain unique characteristics such as designated wilderness, eligible wild and scenic river segments, research natural areas, zoological botanical areas or other areas that would require special management by regulation or Forest Plan direction (PR#117). The project area is within the Gila River Basin. Elevations range from approximately 5,900 feet at the crest of the Canelo Hills to 4,075 feet near the mouth of Redrock Canyon (Figure 2).

Redrock Canyon supports a subset of the Gila River Basin native² aquatic fauna. Four native species of fish are known from the canyon: longfin dace, speckled dace, desert sucker, and the endangered Gila topminnow³. Several native amphibians are known from the watershed, most notably the federally listed Chiricahua leopard frog and Sonora tiger salamander. Three notable aquatic or semi-aquatic reptiles occur in Redrock Canyon: Sonora mud turtle, black-necked gartersnake, and Northern Mexican gartersnake.

Five nonnative aquatic fish and the American bullfrog are known to exist in Redrock Canyon. Some were present during the first sampling in the late 1970s and may have been for many years prior. Largemouth bass, green sunfish, and bluegill have declined since their introduction and now may be absent. Mosquitofish and bullfrogs have multiplied and occur throughout the drainage. Invasive species are substantial impediments to native species recovery (Hayes and Jennings 1986; Rosen and Schwalbe 1995).

While initial declines of native fish and amphibian populations in the Gila River Basin resulted primarily from habitat destruction and modification, currently, the effects of nonnative species are the major contributing factor (Minckley 1991; Clarkson et al. 2005; Marsh and Pacey 2005). Nonnative fishes and bullfrogs impact native species through predation, competition, hybridization, habitat alteration, and parasite and pathogen transmission (Propst and Bestgen 1991; Minckley 1991; Douglas et al. 1994; Rosen and Schwalbe 2002; Bonar et al. 2004). Predation on early life stages (eggs, larvae, juveniles) is considered the primary avenue by which nonnative species depress and eliminate native species (Minckley 1991; Johnson et al. 1993; Kupferberg 1997; Snyder 2006). These effects are often

¹ A watershed (also known as a basin or catchment) is the area above a specific point in a stream or stream system in which all water drains towards the stream. This includes all areas up to ridgelines, from where precipitation flows downhill to the stream.

² “Native” (also indigenous, endemic, and aboriginal) refers to organisms that occur, or formerly occurred, in a particular region as a result of evolutionary or ecological processes. This is as opposed to organisms that have been intentionally or accidentally introduced outside their natural historic ranges by human activity. Organisms translocated outside their natural range by human activities are referred to as “nonnative” (also exotic, alien, introduced, nonindigenous, and invasive).

³ For scientific names of all mentioned species, see Tables 1, 2, 3, and 4.

exacerbated by habitat degradation. Gila topminnow and Sonora tiger salamander can live and reproduce in degraded habitats but they commonly wane or disappear when nonnatives become established (Minckley et al. 1977; Pacey and Marsh 1998). Such has been the case in Redrock Canyon where Gila topminnow has been all but eliminated.

Introduction and spread of nonnative aquatic species have occurred for a variety of reasons. Some are purposefully introduced to increase the diversity of, or food for, the sport fishery; for biological control; or for ornamental use. Others are accidentally released as bait or aquaculture species or introduced as a result of human transfers of water. Regardless of their mode of arrival, nonnative fishes have had a drastic detrimental effect on native aquatic species.

The status of Gila topminnow in Redrock Canyon has declined recently. Only one Gila topminnow has been found in surveys of the canyon since 2005. Although range and riparian conditions have largely improved, the area has been in drought since 1995, reducing the extent of perennial stream habitats. The Gila topminnow appears to be less tolerant of crowding than are mosquitofish, thus giving mosquitofish a competitive edge during drought conditions (Dean 1987). In previous years, Gila topminnow occupied certain areas of Redrock Canyon where mosquitofish managed to sustain only small numbers. With drought, those areas are now dry seasonally or retain only very small areas of water during dry months. Gila topminnow have survived major droughts, such as that of the 1950s, but at that time, nonnative fish and frogs were not present and Gila topminnow probably survived by retreating into more permanent waters, such as in Cott Tank drainage. Now those waters also support large populations of mosquitofish and bullfrogs. Crowded into shrinking pools with aggressive nonnatives, Gila topminnow are apparently unable to survive.

Figure 1. Location of the Redrock Canyon Renovation Project.

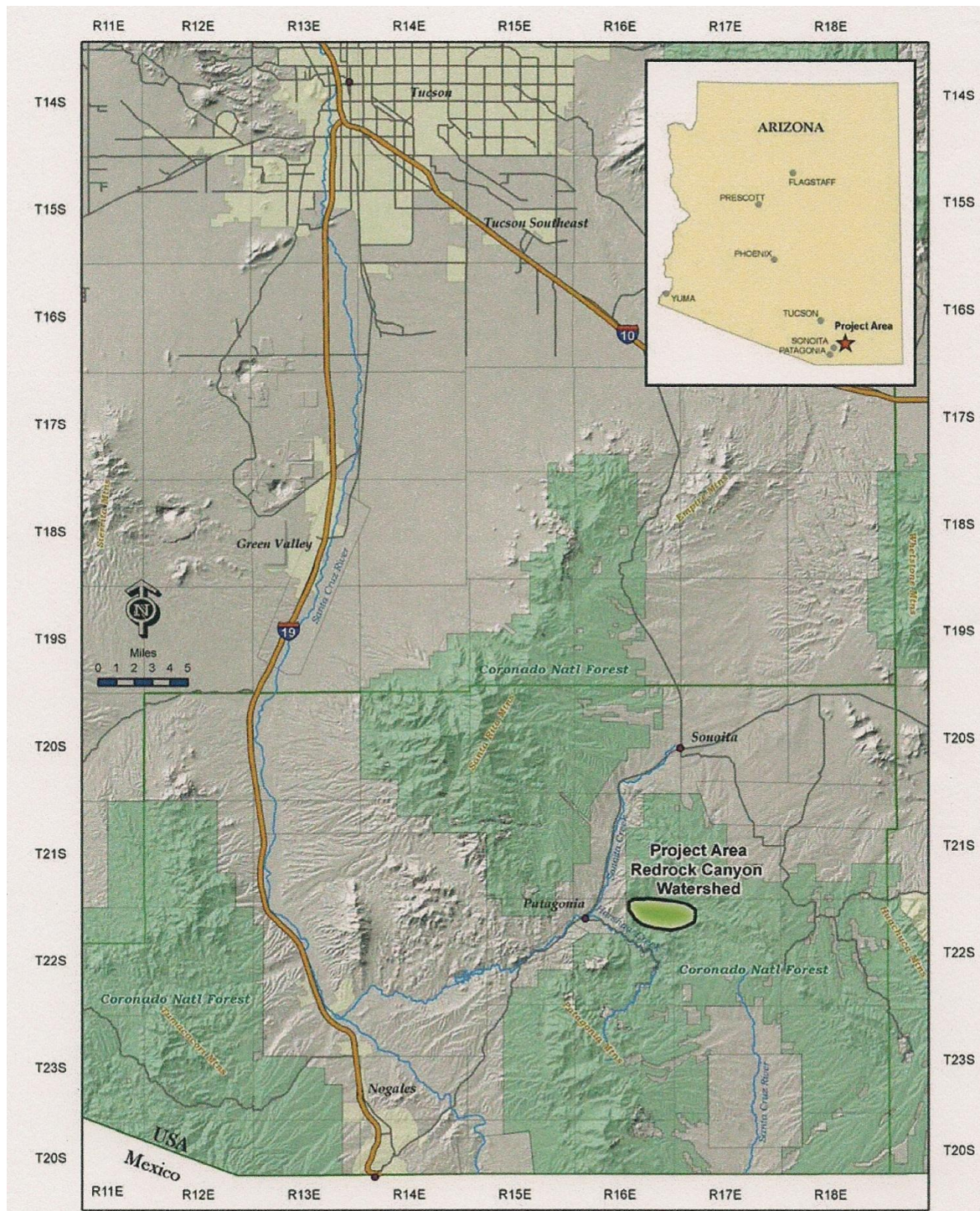
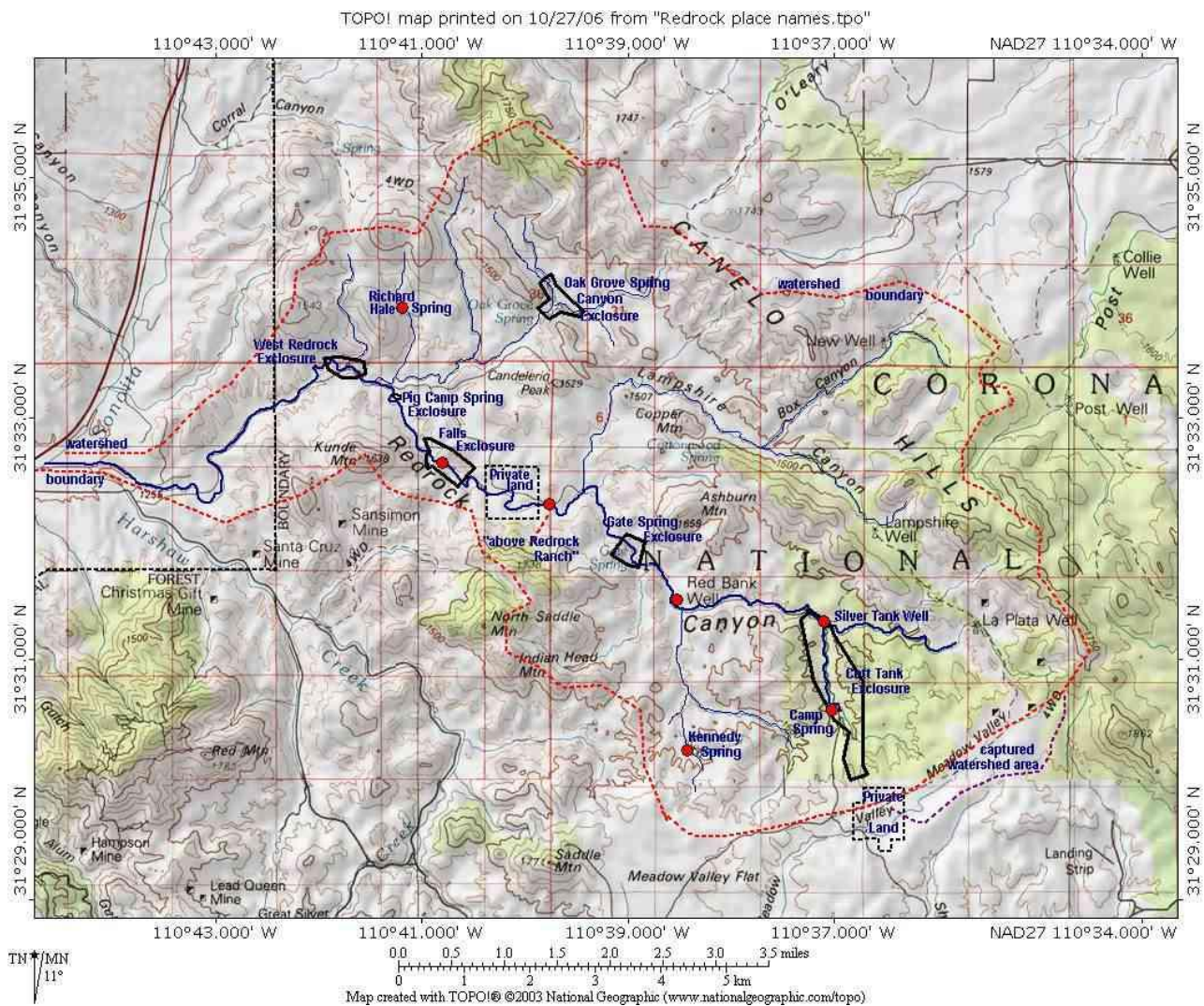


Figure 2. Map of the Redrock Canyon Watershed.



1.3 PURPOSE AND NEED

The purpose for the proposed project is to remove nonnative fishes and bullfrogs from all surface water in the Redrock Canyon watershed to create conditions that would provide suitable habitat for native fish. In order for AGFD and FWS to implement the actions needed to accomplish this purpose, the Forest Service must approve the use of piscicides and other actions, necessary to successfully accomplish the project.

The Forest Service action is needed:

- To facilitate the recovery of a Federally listed species in its native habitat. The action is responsive to section 4 (a)(1) of the Endangered Species Act (ESA), which directs Federal agencies to use their authorities to carry out affirmative conservation programs that recover endangered and threatened species (50 CFR 402.01) and is responsive to the objectives and recovery actions identified in the Gila Topminnow Recovery Plan (FWS 1984).
- A decline of native fish and amphibian populations in Redrock Canyon has continued despite marked improvement in riparian and upland conditions, and the decline is directly linked to the presence of nonnative fishes and bullfrogs.
- The Forest Service has devoted considerable effort to protect and enhance Redrock Canyon and its aquatic fauna, yet this effort may be negated unless nonnative species are removed.
- Present drought conditions concentrate nonnative fish and amphibians into small areas, which provide optimal conditions for their removal.
- Renovation would create suitable habitat for sensitive species and aid Arizona Game and Fish Department (AGFD) plans to reestablish native fishes, which would contribute to their recovery.
- Forest Service Manual (FSM) 2670 directs the agency to ensure its actions do not contribute to loss of viability of any native or desired nonnative animal.
- Executive Order 13112, signed by President Clinton on February 3, 1999, states: Each Federal agency whose actions may affect the status of invasive species shall, to the extent practicable and permitted by law:
 - Prevent the introduction of invasive species;
 - Detect and respond rapidly to and control populations of such species;
 - Provide for restoration of native species and habitat conditions in ecosystems that have been invaded.

In addition, the proposed action is responsive to the following goals, objectives, standards and guidelines in the Coronado National Forest Land and Resource Management Plan (USDA-FS 1986, as amended) regarding management of threatened and endangered species in Forest Management Areas 4 and 7, where the project area is located:

- Improve the habitat of and the protection for local populations of Threatened and Endangered species to meet the goals of the Endangered Species Act of 1973. [Amendment 6 (1992), replacement p. 10]
- With cooperation of federal, Arizona and New Mexico wildlife agencies, develop overall direction for listed threatened and endangered species. Delist federally and state listed threatened and endangered species in accordance with species recovery plans. Reoccupy historical habitat Forest-wide with other identified species. (p. 31-1)
- Reintroduce extirpated native species into historical habitats in accordance with cooperative interagency plans. (p. 31-1)
- Delist federally and state listed threatened and endangered species in accordance with species recovery plans. Reoccupy historical habitat Forest-wide with other identified species. (p. 31-1)
- Transplant listed threatened and endangered and other identified species into suitable habitat following guidelines of species recovery plans and memorandums of understanding. (p. 37)
- Delist threatened and endangered species and reoccupy historical habitat with other identified species following guidelines in approved species recovery plans and memorandums of understanding. (pp. 64, 68, 72)
- Maintain and improve current habitat for federally listed threatened and endangered plants and animals and work toward delisting. (pp. 62, 68, 71)

1.4 PROPOSED ACTION

To satisfy the purpose and need, the Forest Service proposes to approve an AGFD proposal to remove nonnative fish and bullfrogs using an integrated control approach from the Redrock Canyon watershed. An EPA-registered piscicide (rotenone, antimycin-A, or both, depending on stream conditions) would be used to eradicate nonnative fish. Piscicide application, including timing, frequency, concentration and neutralization, would be implemented by AGFD as prescribed on the pesticide label(s) for each product. Prior to project implementation, a Forest Service pesticide use proposal (PUP) will be approved by the Forest Supervisor. The PUP would be developed and approved concurrently with the NEPA review and would be an integral part of the decision to approve this proposal.

In general, the AGFD proposal includes the following activities: (1) salvage native fish, amphibians, and reptiles prior to treatment; (2) piscicide treatment of all surface waters in Redrock Canyon to remove nonnative fish; (3) removal of bullfrogs using mechanical methods including netting, gigging, shooting (firearms), and euthanasia, (4) pumping of stock tanks and stream pools where necessary to facilitate bullfrog and fish removal; (5) return salvaged species to capture site; (6) restore Gila topminnow, then once a stable population has been established, an evaluation would be completed to determine if adding

additional species is appropriate; and (7) post-treatment monitoring. Up to four native fish species and two amphibians potentially could be reestablished in all suitable locations within the Redrock Canyon watershed. These include longfin dace, speckled dace, desert sucker, Gila topminnow, Chiricahua leopard frog, and Sonora tiger salamander. Due to the dependence on appropriate weather and stream flow conditions, full completion of the project may require 1-5 years. None of the actions would be completed on private land. A more detailed description of the proposed action is provided in Chapter 2.

1.5 DECISION FRAMEWORK

The Forest Supervisor is the deciding official and will approve or disapprove the proposed action. The decision is to authorize AGFD to use mechanical and chemical treatments to remove nonnative aquatic species. Treatments may include (1) application of piscicides rotenone and antimycin A to cienega pools, springs, stream sections, and stock tanks; and (2) mechanical draw down of cienegas pools, stream sections, and stock tanks. This decision would not consider approval of animal capture, holding, release, or monitoring because these actions would be conducted by AGFD under their existing authority. As part of this decision, she will consider the following:

- the nature and scale of potential impacts that will result if the proposed action is implemented;
- the mitigation measures that must be implemented to avoid or minimize impacts to natural resources; and
- the consistency of the proposed action with direction in the Forest Plan.

Based on these considerations, the Forest Supervisor will decide whether to approve the action, as proposed; recommend an alternative to the proposed action; or recommend no action be taken.

1.6 PUBLIC INVOLVEMENT

Scoping for this assessment was based predominately on comments received during 2007 and 2008 on a related project titled Native Fish Restoration in Redrock Canyon (PR#95). In addition to the use of the piscicides antimycin A and rotenone to renovate all surface waters in the watershed, the proposal included construction of a fish barrier on Forest land in Redrock Canyon to prevent upstream migration by nonnative fishes originating from Sonoita Creek. The proposed project was part of a Bureau of Reclamation (Reclamation) program to construct fish barriers within the Gila River Basin.

The Native Fish Restoration in Redrock Canyon project was listed on the Forest website in a Schedule of Proposed Actions (SOPA) on January 1, 2007. On January 18, 2007, Reclamation posted a scoping notice on its Phoenix Area Office website (www.usbr.gov/lc/phoenix) and mailed scoping notices to 53 potentially interested individuals, organizations, and agencies (PR #46). A press release was sent to ten newspapers with distribution in Southeast Arizona (PR #47). In addition, a scoping meeting was held in Sonoita on February 8, 2007, to discuss the project with grazing permittees with allotments in the project area. Reclamation and the Forest received 11 letters of comment (including electronic mail) during the 30-day scoping period which ended on February 16, 2007 (PR #48-58).

The interdisciplinary team evaluated the issues raised during public scoping and categorized each according to possible significance or lack thereof. Based on comments received during public scoping, the following significant issues were identified:

- Effects of the project on nontarget species
- Effects of the project on water quality and quantity
- Effects of the project on visual aesthetics and scenery
- Effects of the project on livestock grazing
- Effects of the project on soils

The pre-decisional draft EA (PR#68) was mailed to 58 potentially affected or interested individuals and agencies for a 30-day public comment period on September 14, 2007 (PR# 69). In addition, a public notice was published in the Arizona Daily Star, and news releases were sent to several other major news media outlets serving central and southern Arizona regarding the availability of the draft EA (PR#70-71). The draft EA was also available on Reclamation's Phoenix Area Office web site. The 30-day public review period ended on October 13, 2007. Five respondents submitted written comments concerning the proposed project during the 30-day public comment period (PR#74-75, 78-80). These comments and the agencies' responses were included in Appendix G of the Final EA (PR #95).

A Finding of No Significant Impact was signed by Reclamation's Area Manager, Phoenix Area Office on July 1, 2008 (PR #95). A Decision Notice, with a Finding of No Significant Impact was signed by the Forest Supervisor on July 14, 2008 (PR #96). The legal notice was published in the Arizona Daily Star and Tucson Citizen on July 17, 2008 and the Sierra Vista Herald and Bisbee Daily Review on July 21st, 2008 (PR#98, 100). All notices were made available on the Forest public web site. Reclamation's Area Manager, Phoenix Area Office sent a letter to those who previously commented and other interested parties, organizations, and agencies on July 18, 2010 (PR#99). The 45-day public appeal period began on July 17, 2008 and ended September 1, 2008. One appeal letter was received (PR#103). Prior to the Forest Service conducting a formal appeals review, the Forest Supervisor withdrew her decision on October 14, 2008 because there was an identified need for further analysis on the effects of piscicides on human health, particularly ground water contamination. The Legal Notice was published in the Arizona Daily Star and Tucson Citizen on October 21, 2008, the Sierra Vista Herald and Bisbee Daily Review on October 23, 2008, and the Nogales International on October 24, 2008 (PR#107-109).

AGFD held a meeting with members of the Canelo Hills Coalition, members of the Patagonia Town Council, local ranchers and residents of Patagonia on March 23, 2009, in Patagonia, AZ (PR#114). At the meeting AGFD informed attendees that a fish barrier would not be constructed in Redrock Canyon, but that they had requested permission from the Forest Service to pursue chemical renovation (application of piscicides) efforts for the protection of Gila topminnow populations in the watershed. The meeting was not a public meeting and was intended for those who expressed concerns with the application of piscicides during the scoping of the 2008 EA. The Forest Service was not invited, nor attended the meeting; however, AGFD passed on the concerns of the attendees to help develop issues and refine the analysis in the EA.

The Proposed Action, as described in sections 1.4 and 2.2, was listed on the Forest website (www.fs.fed.us/r3/coronado) in a SOPA on April 1, 2009. The pre-decisional draft EA (PR #125) was mailed to 31 potentially affected or interested individuals and agencies for a 30-day public comment period beginning on February 2, 2010. In addition, a public notice was published in the *Arizona Daily Star* on February 4, 2010 and *Sierra Vista Herald*, *Bisbee Daily Review*, and *Nogales International* on February 5, 2010 regarding the availability of the draft EA (PR#127-129). A Notice of Opportunity to Comment flyer was posted at 3 locations in Patagonia (inside the Patagonia post office, and on the bulletin boards outside the Gathering Ground and the Patagonia Public Library entrance) (PR#144). The draft EA was also available on the Forest's website (PR#126). The 30-day public review period ended on March 8, 2010. Twelve respondents submitted written comments concerning the EA during the comment period (PR#131-139, 141-143).

1.7 ISSUES

Issues are defined as a point of disagreement, debate, or dispute about anticipated environmental effects on implementing the proposal. Significant issues must have a cause and corresponding effect relationship with the proposed action. Potential issues are collected and screened to ascertain which issues are significant to the proposed action within the context of NEPA (40 CFR 1501.7 (a)(3)). Significant issues are used to develop alternatives to the proposed action. Significant issues are those that meet the following criteria:

- Within the scope of the analysis
- Not decided by law, regulation, or previous decision
- Related to the decision, and
- Amenable to scientific analysis rather than conjecture.

Based on public involvement described above, the topics listed in Table 1 were identified as issues for the analysis.

Table 1. Issues identified during scoping process and where they are addressed in this EA.

Issue	Concern	Location Addressed
Effects of the project on human health and safety.	• Effects of drinking piscicide-treated water or eating piscicide-killed fish. • Effects of entering piscicide-treated waters. • Connection between rotenone and Parkinson's disease.	3.2 Human Health

Issue	Concern	Location Addressed
Effects of the project on water quality and quantity.	- Contamination of surface and ground waters by piscicides and its ability to pollute water supplies. - The effects of piscicides on drinking water. - Effects of water drawdown on wildlife and livestock operations.	3.1 Water Quality 3.2 Human Health 3.6 Wildlife 3.8 Socioeconomic Effect—Livestock Grazing
Effects non nontarget species, federally-listed species, state-listed wildlife species of concern, Forest Service sensitive species and Forest management indicator species	- Effects of wildlife eating piscicide-killed fish and drinking treated water - Effects of diminished food supply on native wildlife - Possible loss of endangered and sensitive aquatic species	3.6 Wildlife
Effects of the project on livestock grazing	- Effects to cattle from drinking treated water. - Rotation schedules may need to be interrupted to implement the project. - Annual operations may be impacted by introducing federally listed and sensitive species that have terms and conditions associated with their presence.	3.6 Wildlife 3.8 Socioeconomic Effect—Livestock Grazing

1.8 FOREST PLAN CONSISTENCY

The National Forest Management Act (16 USC §§ 1600-1614, August 17, 1974) requires that all proposed actions be reviewed for consistency with each Forest's Plan. The project area is located within Management Area 7 (Riparian) and is managed to protect riparian values and to perpetuate unique wildlife or vegetative species (Forest Plan, p. 67). A review of the proposed action relative to the standards and guidelines of the Forest Plan has indicated that it is consistent with the Forest Plan, and that no amendments to the plan are necessary prior to implementation of the action.

1.9 PROJECT RECORD

This analysis incorporates by reference its Project Record, which contains specialist reports and other technical documentation used in disclosing the effects discussed in the analysis. Regulations require that all EAs shall be analytical rather than encyclopedic and that EAs shall provide enough supporting information to demonstrate a reasonable consideration of the environmental impacts of the alternatives, without repeating detailed analysis and information available elsewhere (40 CFR 1500.4). The Project Record is available for review at the Sierra Vista Ranger District Office, located in Hereford, AZ.

CHAPTER 2 – ALTERNATIVES, INCLUDING THE PROPOSED ACTION

This chapter describes the alternatives considered for the proposed project in greater detail. These include the proposed action alternative and no action alternative. Also described are alternatives that were considered but eliminated from further evaluation.

2.1 NO ACTION

In accordance with CEQ regulations at 40 CFR 1502.14 (d), no action must be considered as an alternative in each NEPA review. No action provides the baseline for comparison of environmental effects of the action alternatives.

If no action is taken, AGFD would not be authorized to use piscicides to treat surface waters in Redrock Canyon watershed. Water levels in stock tanks, cienegas, and pools would not be pumped to facilitate bullfrog removal. Existing habitat would continue to be unsuitable for reestablishment of native fish species. Gila topminnow and other native aquatic species would not be stocked within the watershed. Current levels of bullfrog predation on native amphibians and aquatic reptiles would continue without a concerted effort to remove bullfrogs from the watershed.

2.2 PROPOSED ACTION

The proposed action includes the following activities: (1) salvage native fish, amphibians, and reptiles prior to treatment; (2) piscicide treatment of all surface waters in Redrock Canyon to remove nonnative fish; (3) removal of bullfrogs using mechanical methods including netting, gigging, shooting (firearms), and euthanasia; (4) pumping of stock tanks and stream pools where necessary to facilitate bullfrog and fish removal; (5) return salvaged species to capture site; (6) restore Gila topminnow, then once a stable population has been established, an evaluation would be completed to determine if adding additional species is appropriate; and (7) post-treatment monitoring. Up to four native fish species and two amphibians potentially could be reestablished in all suitable locations within the Redrock Canyon watershed. These include longfin dace, speckled dace, desert sucker, Gila topminnow, Chiricahua leopard frog, and Sonora tiger salamander. Due to the dependence on appropriate weather and stream flow conditions, full completion of the project may require 1-5 years. None of the actions would be completed on private land.

AGFD has statutory authority to manage fish and wildlife resources of Arizona and ultimately would approve and oversee activities associated with native species salvage, bullfrog control, and native fish and amphibian transplant. The actions beyond authorizing AGFD to use mechanical and chemical means to remove nonnatives are included in the proposed action and considered in the full analysis because these are connected actions. CEQ defines a connected action as an action that is closely related and therefore should be discussed in the same impact statement. Actions are connected if they (1) automatically trigger other actions; (2) cannot or will not proceed unless other actions are taken previously or simultaneously; (3) are interdependent parts of a larger action and depend on the larger action for their justification (40 CFR 1508.25).

2.2.1 Native Species Salvage

Native species salvage would begin several days prior to application of piscicides.

Because of the strong resemblance between Gila topminnow and nonnative mosquitofish, no attempt would be made to salvage topminnow. The process of sorting topminnow from mosquitofish is difficult and would only increase the chances of the project failing if salvage and quarantine was attempted. The Forest Service consulted with FWS on take of Gila topminnow for take of this project (PR#89).

Before application of piscicides, efforts would be made to locate and salvage Chiricahua leopard frogs and native fish, including longfin dace, desert sucker, and speckled dace. Any individuals salvaged, of any life stage, would be removed to a temporary holding facility, either on site or at an appropriate AGFD-approved facility elsewhere. Identification upon salvage and upon release from quarantine would be confirmed by at least two biologists knowledgeable of, and experienced with, identification of these species and their discrimination from nonnative species.

Prior to application of piscicides, salamanders would be salvaged and placed into a temporary holding facility, on site or at an appropriate AGFD-approved location elsewhere. Any stock tank with water present would be sampled prior to piscicide application to test for salamander presence. Salamanders from each tank would be held separately because of the inability to make definitive identifications as to subspecies.

Sonora mud turtles are common native occupants of Redrock Canyon. There is some indication that rotenone is toxic to freshwater turtles (Fontenot et al. 1994; McCoid and Bettoli 1996; AGFD, unpublished). During salvage operations for fish, frogs, and salamanders, Sonoran mud turtles would be salvaged and held in temporary holding facilities, either on site or at an appropriate location elsewhere.

If Northern Mexican gartersnakes are found during project activities, they would be salvaged and placed into a holding facility identified by AGFD.

Native species would be captured using a combination of dip nets, seines, hoop nets, minnow traps, electrofishing, and other appropriate techniques. All salvaged individuals would be transported from the capture site to holding tanks in 2- or 5-gallon buckets containing stream/pond water and battery-powered air stones for any gilled breathing individuals. Location of holding facilities for salvaged longfin dace, desert sucker, speckled dace, and native amphibians cannot be specifically identified at this time. Temporary holding in aerated tanks or soft-sided swimming pools may occur on site. Although detoxification of the stream would occur within a week, not all salvaged fish and amphibians may be returned immediately, depending on water conditions and continued presence of bullfrogs or other nonnative animals in Redrock Canyon. If longer-term holding is required, stocks would be transferred to appropriate holding facilities.

Water for on-site holding facilities would be obtained from the stream, from water transported in from elsewhere, or from groundwater from an area well. All water placed into the holding facilities would be screened with fine mesh to ensure that no nonnative fish or amphibians are inadvertently introduced into the holding facilities. Any water transported from outside the basin would be from a source that is guaranteed free of nonnatives and pathogens, such as groundwater or treated water. All holding site

facilities and equipment would be treated in accordance with protocols in the Chiricahua leopard frog recovery plan (FWS 2007, Appendix G) to prevent the spread of chytrid fungus and other diseases.

The Chiricahua leopard frog recovery plan describes a protocol for holding, transport, and treatment of salvaged frogs. The protocol would be followed for all transported frogs (FWS 2007, Appendix F). For all other species without a written protocol for salvage and transport, AGFD would provide that direction.

2.2.2 Nonnative Fish and Frog Removal

Nonnative fish would be removed from all surface waters in Redrock Canyon, with the exception of water on private land, using an integrated approach (Dawson and Kolar 2003) that includes several removal techniques combined with management to reduce the risk of reinvasion. Efforts to remove all bullfrogs would be made, but lack of personnel and funding limit the amount of time available to complete an intensive eradication. Mosquitofish and bullfrogs are widely dispersed in the watershed and capable of using small, isolated, temporary waters as refugia and stepping stones for reinvasion; therefore, all surface waters in the Redrock watershed, except for private land, would be subject to nonnative removal actions.

Nonnative removal would also occur in two earthen stock tanks in Meadow Valley and any surface waters in the Meadow Valley drainage upstream of those tanks. Although the natural drainage of these tanks is a south trending tributary of the Santa Cruz River, they presently drain to Cott Tank in upper Redrock Canyon watershed via a constructed ditch and are thus an artificial “captured” portion of the Redrock Canyon watershed. Inter-basin diversions from Meadow Valley to other pipelines and troughs or tanks within the Redrock watershed would be inspected and a determination made as to whether or not they require treatment and nonnative removal. Other imports of water from outside the watershed (e.g., in upper Box Canyon and in Oak Grove Spring Canyon) would also be identified, inspected, and included in treatment, as necessary.

To remove nonnative fish species, the piscicides rotenone and/or antimycin-A would be applied to all surface waters within the Redrock Canyon watershed, except for waters on private land. Rotenone is a naturally occurring compound extracted from certain species of legume. It has been routinely used in the United States to manage fish populations since the 1930's. Formulations of rotenone are manufactured in both powdered and liquid formulations under the brand names Pro-Noxfish®, Nusyn-Noxfish®, Prenfish®, and others. Antimycin-A is an organic compound isolated from the bacterium *Streptomyces* that has been in use as a piscicide since 1964. Formulations of antimycin-A are registered under the brand name Fintrol®. Both compounds interrupt cellular respiration in gill-breathing animals by blocking the transfer of electrons in the mitochondria, which reduces the uptake of blood oxygen. Recommended doses for fish control are 0.005 to 0.250 mg/L for rotenone and 5-25 µg/L for antimycin-A. The choice of the appropriate piscicide would depend on the stream, water flow, and water chemistry conditions at the time of treatment.

Piscicide application, including timing, frequency, concentration, and neutralization (potassium and/or sodium permanganate), would be implemented by AGFD according to product label directions and specifications established in a Forest Service Pesticide Use Proposal (PUP) approved by the Forest Supervisor (Appendix D). All product label requirements and safety precautions would be followed. Surface waters would be accessed by foot or vehicle.

Piscicide would be applied when water levels are at a minimum (typically May-June) and in concentrations directed by the manufacturer on the product label. Piscicides would be applied using a variety of methods depending on surface water conditions. If areas of continuous flow are present, drip

station applications would be used, as described in Stefferud and Propst (1996) and Weedman et al. (2005). In isolated pools and tanks, piscicide would be applied by backpack or shore-mounted sprayers or by bucket. Mechanical agitation may be used to mix pooled water where appropriate. Rotenone-coated sand would be spread over the surface in deeper (>3 feet) areas. Arizona State certified pesticide applicators (AGFD staff) will be on site to supervise piscicide applications. State certified Forest Service pesticide applicators would review and recommend approval of the pesticide use proposal and may also be on site during treatment efforts. Individual surface water treatment periods would vary according to conditions, but on average would last between 8 and 12 hours. Effectiveness would be monitored by use of live cages containing locally captured mosquitofish (and any other nonnative fish present at the site) in each pool, tank, or area of flow.

To ensure effectiveness of the treatment, a second piscicide application to all waters would occur within 2 weeks of the first treatment. Total eradication of all nonnative fish is the objective; however, this may not be accomplished in the first year. Post-treatment monitoring of fish in the treated waters would provide information on whether or not additional treatment is needed. If so, piscicides would continue to be applied until AGFD is satisfied that all nonnative fish have been removed, up to 4 years after the initial treatment.

Some death of bullfrog tadpoles and eggs is expected from piscicide use. Bullfrog tadpoles and eggs would be manually removed during salvage, piscicide application, and monitoring, then euthanized. Metamorphosed bullfrogs are not likely to be significantly affected by piscicides. Metamorphosed bullfrogs would be captured by hand, netting or gigging. Shooting of bullfrogs would occur where legal and only after all other control methods have been exhausted.

If deemed necessary to complete bullfrog and nonnative fish eradication at stock tanks with a high density invasive species population, the stock tank may be pumped down or dried completely and all nonnative aquatic species found would be manually removed. These mechanical treatments to control bullfrogs would be repeated as necessary for up to 4 years.

The project area is lightly used by the public but would be signed in English and Spanish at key access points to notify users of considerations necessary to avoid exposure to treated waters. A temporary closure order would be issued for the treatment sites. Coordination with permittees of the four allotments within the project area (Seibold-Crittenden, Kunde, Papago, and San Rafael) would occur to avoid any impacts to cattle or disruption to grazing operations.

No disposal of dead fish and frogs is expected to be necessary. The volume of carcasses is anticipated to be small and would disappear within hours because of scavengers, desiccation, and decay. However, if necessary, disposal would be by on-site burial.

Neutralization of piscicides is not expected to be necessary, but potassium and sodium permanganate, acceptable chemicals for detoxifying rotenone and antimycin A (Marking and Bills 1975), would be available on site during piscicide application in case they are needed. Neutralization chemicals would be used if surface water is flowing from inside the treatment area into adjacent areas downstream of the Forest boundary, or if neutralization needs to be expedited to reduce the holding time of captured native fauna. Detoxification would be allowed to occur through natural oxidation. Detoxification, either natural or chemical, would be determined using sentinel cages containing native fishes and/or amphibians.

Recently, the United States Court of Appeals for the 6th Circuit issued an opinion overturning the EPA rule that exempted pesticides applied to and near waters of the US from the National Pollutant Discharge Elimination System (NPDES) permitting program. The ruling takes effect on April 9, 2011. Arizona Department of Environmental Quality (ADEQ) anticipates preparing a general permit to provide AZPDES coverage for pesticide application on or near waters in the US. The permit would be attained prior to applying piscicides for all applications occurring after April 9, 2011.

Effects of piscicides on human health are addressed in this EA at section 3.2.

2.2.3 Restoration of Native Fish and Amphibians

Following successful nonnative removal, AGFD would restore Gila topminnow. Once it is determined that a stable Gila topminnow population has been established, an evaluation would be completed to determine if it would be appropriate (e.g. carrying capacity of available suitable habitat, sustainable food sources) to add additional species. Up to three additional native fish and two amphibians could be repatriated into Redrock Canyon, including longfin dace, desert sucker, speckled dace, Chiricahua leopard frog, and Sonora tiger salamander.

Gila topminnow. Gila topminnow from captive populations would be restocked into the watershed after the treatment area has been detoxified. Currently, there are three captive populations derived from individuals taken at Cott Tank drainage and Falls area in 2002. If sufficient surface water to support Gila topminnow does not exist, the species would be stocked as soon as possible. Population augmentation would occur until a stable population has been established. Consultation with FWS for Gila topminnow has been completed (PR #89).

Longfin dace, Desert Sucker, and Speckled Dace. Each species removed during salvage would be returned to the stream in the area of their capture following a determination of treatment detoxification. If Redrock Canyon can support additional species, one species would be reestablished at a time. After each population is stable, suitability and appropriateness of adding additional species would be evaluated. If it is determined that longfin dace can be reestablished in Redrock Canyon, additional fish would be obtained from Harshaw Canyon or the nearest available population on public land. If it is determined that desert sucker and/or speckled dace can be reestablished, stocks would be obtained from Sonoita Creek (either above or below Patagonia Dam for desert sucker and above Patagonia Lake for speckled dace). Fish taken from outside the Redrock Canyon drainage would be quarantined and triple sorted by experienced individuals to ensure that no nonnative fish are accidentally transported into Redrock Canyon. All transport water would be obtained from a guaranteed nonnative free source. Pathogen testing would not be necessary for fish obtained from Harshaw Canyon or Sonoita Creek above Patagonia Lake because they are from a source with frequent episodic connection with Redrock Canyon. Pathogen testing would be conducted on fish obtained below Patagonia Dam, and, if necessary, appropriate treatment would be given to ensure that the possibility of disease transmission is minimized. Augmentation stockings may be repeated until a self-sustaining population is established.

Chiricahua leopard frog, Sonora tiger salamander, and Sonora mud turtle. Any native frog, salamander or turtle found during the salvage operation would be released near the capture site following a determination of detoxification and appropriate habitat conditions. Consultation with FWS for the federally listed Chiricahua leopard frog and Sonora tiger salamander has been completed (PR #89).

Northern Mexican gartersnake. Northern Mexican gartersnakes salvaged during pre-treatment would either be returned to the wild near the site of capture or retained in captivity for breeding purposes. Upon attainment of sufficient captive stock, or using stock obtained from another appropriate source, Northern Mexican gartersnake would be translocated into suitable habitat in the Redrock Canyon watershed.

2.2.4 Monitoring

Following the initial treatment, an intensive monitoring effort would target all waters within Redrock Canyon and Meadow Valley watersheds to which piscicide or other removal methods were applied. Methods would include visual observation, dip nets, minnow traps, seines, and other nets, electrofishing, and any other appropriate techniques. Monitoring would be conducted in cooperation with AGFD and FWS. The primary purpose of the monitoring would be to detect the presence or absence of nonnative fish and bullfrogs, but also to document presence/absence, relative abundance, reproduction, and recruitment of native fish, Chiricahua leopard frog, and Sonora tiger salamander.

Following the last treatment, AGFD would monitor for 2 years and would continue as spring or early summer monitoring conducted by AGFD as part of the Gila topminnow recovery program monitoring.

2.3 MITIGATION FOR ACTION ALTERNATIVES

Mitigation measures are prescribed to avoid, reduce, or compensate for adverse effects of an action. The following measures would be implemented for the action alternatives:

- Key public access points to Redrock Canyon would be posted in English and Spanish prior to application of the piscicide. Additionally, a closure order would be issued for treatment areas during piscicide application.
- The Forest Service's Pesticide Use Proposal would clearly prescribe strict adherence to piscicide labels.
- Piscicide applications would be conducted only during periods of low stream flow by certified applicators.
- Temporary changes in livestock management (e.g. pasture rotation, temporary fencing) would occur if a water source is drained. If changes in management are not possible, an alternative water source would be provided.
- Water pumped out of stock tanks and pools during draw down would be spread onto the uplands and not returned to the stream.
- Terms and conditions of the reasonable and prudent measures stipulated by FWS in its 2008 biological opinion on the project would be implemented.

2.4 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED ANALYSIS

Preventing nonnative fish from reinvading Redrock Canyon is critical to reestablishing native fish in the watershed. Two possible pathways for reinvasion are natural movement of fish from source populations

adjacent (downstream) to the Forest and deliberate release of nonnative fish into surface waters within the watershed. These threats were addressed in the following two alternatives but the alternatives were eliminated from detailed analysis because they would not meet the stated purpose and need for the proposed action.

2.4.1 Construction of a Fish Barrier in Redrock Canyon

Construction of a drop-type fish barrier in lower Redrock Canyon below the Falls (lowest elevation natural barrier) was an alternative considered and analyzed in the 2008 Native Restoration in Redrock Canyon EA (PR#95). On January 30, 2009, the Central Arizona Project (CAP) Gila River Basin Native Fishes Conservation Program Policy and Technical Committee met to review fish barrier projects proposed by Reclamation. At this meeting, the team determined that constructing a barrier on Sonoita Creek would be preferred over the Redrock Canyon barrier because it would protect more of the watershed, including Redrock Canyon (PR#112). AGFD supported the CAP Technical Committee's decision to not construct a barrier in Redrock Canyon in a letter to Bruce Ellis (Environmental Resource Management Division Chief of the Bureau of Reclamation) dated April 24, 2009 (PR#115). AGFD presented the Forest with a new proposal in a letter to the Forest Supervisor dated March 4, 2009 (PR#113). The proposal stated that construction of a fish barrier in Redrock Canyon was dropped in favor of another location and that they remained committed to the protection of Gila topminnow in the watershed. They requested permission to move forward with chemical renovation of the drainage to remove nonnative fish species.

While the FWS has issued biological opinions to the Forest Service calling for elimination of nonnative fish species in Redrock Canyon (FWS 2002), construction of a fish barrier has not been a term and condition of any incidental take permit issued to the Forest Service. The Gila topminnow recovery plan recommends construction of barriers in Gila topminnow suitable habitat; however, it does not specifically mention Redrock as a required site (FWS 1984). Moreover, the AGFD does not support construction of a fish barrier in Redrock Canyon. Without a constructed barrier below the Falls, fish could conceivably swim upstream from Sonoita Creek to reinvade this reach of Redrock Canyon. However, only native fish (speckled dace and Sonoran sucker) apparently have made such a move (Stefferd and Stefferd 2007). There is no evidence nonnative fish have moved upstream into lower Redrock Canyon (D. Mitchell, AGFD, personal communication, Nov. 2009, PR# 118). Mosquitofish found in lower Redrock Canyon apparently originated from stock above the Falls. Due to a combined lack of need for a constructed barrier in Redrock Canyon and lack of AGFD/BOR/FWS support for such a barrier, the Forest Service has not considered this alternative in further detail.

2.4.2 Stock Tank Breaching

Stock tanks are usually accessible by road (mostly unimproved). They provide opportunity for people to stock nonnative fish or amphibians they find desirable or to dump unwanted pets or ornamental animals. It is illegal under Arizona State laws to release live fish into a body of water if they did not come from that body of water or without a proper stocking permit. (A.R.S. 17-306 and 17-309A 1, R12-4-315 and R12-4-316; PR #121). Stock tanks can also provide stepping stones enabling nonnative species, such as bullfrogs, to move across an otherwise dry landscape between natural surface waters (FWS 2007).

There are 15 known earthen stock tanks and 2 concrete dams in the project area. The dams are filled with sediment (non functional) and 10 stock tanks are ephemeral. Three stock tanks either have fish now or

have the potential to support fish in the future because they are perennial. These waters and all other surface waters in the project area would be treated in the proposed action but no stock tanks would be permanently drained or breached. For at least one of the tanks (Oak Tank), a locked gate is already in place to limit access to the general public.

Earthen stock tanks provide needed water for livestock and wildlife. These waters are also very important sites for breeding activities and year-long occupancy of the Sonora tiger salamander and potential habitat for Chiricahua leopard frog and Northern Mexican gartersnake. Guidelines for stockpond management and maintenance on the Coronado National Forest were developed specifically to protect habitat for these species and incorporate terms and conditions of a biological opinion on Forest Plans, as amended (USFWS 1998). The guidelines, which have been included in all allotment management plans and referenced during other projects involving stock tanks, state that actions shall be taken to ensure that the spread of neither nonnative predators nor disease is facilitated by project activities. Some of the measures include not refilling a stock tank with water from another tank, Parker lake, or other sources of water that may support fish, salamanders, or bullfrogs and reinforce AGFD regulations against the release of live fish and crayfish, bullfrogs, leopard frogs, salamanders or other aquatic species into livestock tanks or other aquatic sites on the Forest (PR # 119-120). Because the stock tanks in the Redrock Canyon watershed are necessary for proper livestock distribution and are managed to minimize the risk of reinvasion by nonnatives, permanent removal (breaching) of any stock tank was considered unnecessary at this time and eliminated from further consideration as an element of the proposed action.

CHAPTER 3 – ENVIRONMENTAL CONSEQUENCES

This section summarizes the physical, biological, social and economic environments of the affected project area and the potential changes to those environments due to implementation of the alternatives. The summary provides a baseline against which project impacts can be measured. The section is organized by resource. Within each section, the affected environment is briefly described, followed by the environmental consequences (effects) of implementing each alternative. The description of the affected environment and the impact analyses that follow are based on the best scientific information available.

While AGFD does not intend to use antimycin A, the Forest Service has included it in this analysis in case their needs change during the five years.

Past, present and future activities identified for consideration of cumulative effects.

Cumulative effects are the past, present and reasonably foreseeable future actions that add to the direct and indirect effects considered in this EA. The following activities have been identified as potentially contributing to the effects analyzed herein. These activities and occurrences have contributed or may contribute incrementally to changes in ecological conditions in the project area and may continue to influence conditions in the project area over the term of the project. Foreseeable future actions are those for which a proposed action has been approved or those proposed for NEPA analysis in the future. Other possible future actions are considered too speculative to include in this analysis.

Fires and Fuels Management. In 2003, the Redrock Fire burned 2763 acres in Lampshire Canyon in the Redrock Canyon watershed. Post-fire ash and sediment run-off caused minor scouring and sedimentation in Lampshire and Redrock Canyons. Today there is minimal evidence of fire scarring and damage caused from sediment and ash deposition within the Redrock Canyon watershed. Huachuca FireScape is a landscape scale project that intends to integrate fire and fuels management activities of three Federal agencies across 400,000 acres of Federal lands. The project uses a combination of prescribed fire and mechanical treatments, such as mastication, to restore and sustain ecological processes in fire-dependent ecosystems; create and maintain fuel conditions that produce manageable fire behavior and intensity; and encourage the restoration of fuel conditions toward their historic conditions. Site specific projects would be created for each project within the overall Huachuca FireScape project area, which includes the Redrock Canyon watershed. Associated activities could result in short-term effects including soil disturbance and possible deposition of ash and sediment from fire treatments into water sources.

Livestock Grazing. Historically, poor livestock grazing management practices in the watershed reduced cover in the drainage and potentially destabilized soils. More recently, improved grazing practices have resulted in improved range conditions. The project area is located within four active grazing allotments (Seibold-Crittenden, Kunde, Papago, and San Rafael). In 2002, the Forest Service consulted on continuation of livestock grazing on the Coronado National Forest including the Seibold-Crittenden and San Rafael allotments. A separate consultation occurred in 2004 for the issuance of 10-year grazing permits (2003-2013) for the Kunde and Papago allotments and implementation of Allotment Management Plans. A proposal to re-authorize grazing in the Redrock Pasture is under analysis and a decision is anticipated in late 2010 (PR #110). The proposed action includes authorizing yearlong grazing, increasing permitted numbers, and construction of two water developments.

Human Activities. There are no developed recreational facilities (campgrounds and picnic areas) in proximity to the treatment areas. Some dispersed camping may occur in the project area. Recreational activities such as hiking, birding, hunting and off-highway vehicle driving are expected to continue within

the project area over the life of the project. Hunting is regulated by the Arizona Game and Fish Department and is restricted to relatively few hunters, generally during the fall and winter. Hiking, birding and off-highway vehicle driving occur year-round, but levels of activity are low and confined to a few roads and trails, including the popular Arizona Trail.

The project area contains numerous roads and trails used by undocumented immigrants and drug smugglers from Mexico. Trash left behind, including clothing, food, and water containers, as well as human waste create environmental and safety hazards. Warming and cooking fires started by undocumented immigrants or drug smugglers may contribute to a greater risk of fire in the area. In addition, the area has seen a substantial but unquantified increase in vehicle traffic related to drug and immigration interdiction efforts on the part of the U.S. Border Patrol and other enforcement agencies. These activities result in localized disturbance within and around the project area.

Private Land. Rural and urban development on private lands on the northwestern edge of the watershed boundary, including the Town of Patagonia, and two private inholdings within the project area is ongoing.

Water Pumping. There is an extensive system of surface water capture, groundwater pumping, storage, and transport in and around the project area from federal, state, and private lands.

3.1 WATER QUALITY

3.1.1 Affected Environment

Average annual precipitation in the project area is about 18 inches. Daily precipitation is highly variable and can be greater than 4 inches (Sellers and Hill 1974). Precipitation is primarily rain, but some snow may occur at the higher elevations. The precipitation follows a bimodal monsoonal pattern, with winter storms originating in the northern Pacific Ocean and summer storms resulting from convective thunderstorms that form from moisture drawn into the region from the Gulf of Mexico and the Gulf of California.

Redrock Canyon is a major headwater tributary of Sonoita Creek, comprising approximately 15 percent of the drainage area above the Sonoita Creek gauging station (USGS gage #09481500), which is located 8 miles downstream of Patagonia. There is no discharge gage in Redrock Canyon. The collection of daily stream flow data at the Sonoita Creek gage was discontinued in 1972, although peak flows were recorded at this gage in 1977 and 1983. Peak flow for the period of record⁴ was 16,000 cubic feet per second (cfs), recorded in October 1983. Mean annual discharge for the period of record was 8 cfs. Flood recurrence estimates are 3,130 cfs for a 2-year event, 7,190 cfs for a 10-year event, and 15,100 cfs for a 100-year event (Pope et al. 1998).

The Redrock Canyon watershed is approximately 8-miles long and 5-miles wide. It is bounded on the north and east by the Canelo Hills, on the south by the Patagonia Mountains, and the north edge of the San Rafael escarpment. The mainstream of Redrock Canyon proper is approximately 12 miles in length, which flows seasonally from upstream of Down Under Tank downstream to join with Harshaw Canyon

⁴ The period of record for gage #09481500 is 1930-1933, 1935-1972, 1977, and 1983.

and from there into Sonoita Creek in the town of Patagonia. There are two major tributaries inflowing from the south: Cott Tank drainage (about 1.75-miles long), and the unnamed tributary containing Kennedy Spring (approximately 3-miles long). Two major northern tributaries originate on the slope of the Canelo Hills and then run on a northwest/southeast axis behind a subsidiary ridge of the Canelo crest before turning abruptly to drop through short bedrock canyons into the main basin. The most upstream of these is Lampshire Canyon, with about 4.5 miles of mainstem and several tributaries, including Box Canyon, about 2.25-miles long. The second is Oak Grove Spring Canyon, with a mainstem of about 2.25 miles below the bedrock canyon and about 3-miles upstream in two main forks. Oak Grove Spring Canyon has two main tributaries downstream of the bedrock canyon, both unnamed about 2 miles in length and the other about 1.25 miles (Figure 2).

Areas of perennial or semi-perennial water are located at certain stream reaches, cienegas, springs, and stock tanks. Stock tanks may occupy sites of former natural springs. Over the past 15 years, perennial water has been found at Falls and Falls Exclosure⁵, Gate Spring and Gate Spring Exclosure, Cott Tank Exclosure (including Cott Tank drainage and Redrock Canyon proper below its confluences with Cott Tank drainage), West Redrock Riparian Pasture⁶, and a semi-perennial area referred to as “above Redrock Ranch” approximately 0.25 miles upstream from Redrock Ranch (private) on the border of Sections 7 and 12 (Figure 2). A number of named and unnamed springs exist. Stock tanks, small dams, watering troughs, wells, and trick tanks⁷ are scattered throughout the watershed. These are used primarily for livestock water, but a few were constructed for wildlife purposes. Stock tank locations are listed in Appendix A.

The drought that began in the Southwest in 1995 has substantially reduced the amount of surface water in Redrock Canyon watershed. Some areas that had water year-round in the early 1990s may now occasionally be dry. Where surface water persists, it is significantly reduced in extent. Despite good precipitation in 2000-2001, prompting periods of continuous flow through the mainstem, accumulating effects of the drought resulted in loss of most of the water that supported native fish during the late 1970s to early 1990s when the majority of existing fish data was being gathered. The presence of native fish above natural barriers in Redrock Canyon and Cott Tank drainage indicates these areas have always retained enough surface water to support aquatic life even during earlier extended droughts, such as occurred in the late-1800s and 1950s.

In 2009, Redrock Canyon’s surface water was documented in an annual evaluation of fish by private individuals (PR#122). They documented most of the downstream surface flow about 1 mile upstream of the Forest boundary. Within the Redrock Riparian Pasture, only small reaches of interrupted surface flow were present, with most flow being subsurface due to burial under extensive sediment deposition by October/November. Surface water was present at Pig Camp Spring, but somewhat less than usually present in October/November. At the Falls, continuous flow was present from about 1500 feet above the drop to the drop. Below the drop, surface flow has been greatly reduced with the plunge pools shallower

⁵ Exclosures are fenced areas intended to exclude livestock.

⁶ A riparian pasture is fenced for greater control of livestock grazing in riparian habitat.

⁷ A trick-tank consists of a rainwater catchment, water storage tank and drinker.

than usual and reaches of the channel buried in sediment. Homestead Spring had minimal surface water. Overall surface flow that was typically present in November had been buried by sediment and only small wetted areas were present. There was no surface water from Oak Grove Spring and Pig Camp Spring and Cott Tank Enclosure was noted as having an amount and distribution of surface water comparative to June 2006, previously the driest seen in this reach.

Complex water systems have been constructed within the Redrock Canyon watershed to transport water long distances to service livestock. In addition to the 15 earthen stock tanks, approximately 45 wells exist within the Redrock Canyon watershed, although some may no longer be in use. Approximately 15 miles of pipeline deliver water to troughs throughout the drainage. About half a dozen trick tanks capture water in various locations. Some water is imported into the Redrock Canyon watershed from wells in the Meadow Valley, Cienega Creek, and Babocomari watersheds to serve livestock troughs in upper Redrock Canyon, portions of Oak Grove Spring Canyon, and upper Box Canyons. The imported water originates from groundwater with no contact with surface water outside Redrock Canyon, thus eliminating any potential for transport of nonnative aquatic vertebrates (T. Lorenz, CNF, Sierra Vista Ranger District, personal communication, Aug. 2009).

There are approximately 45 registered wells within the Redrock Canyon watershed, according to the Arizona Department of Water Resources (DWR) online well registry database (Figure 3). These include 19 domestic wells, 25 stock wells, and one irrigation well⁸. Seventeen domestic wells, including the City of Patagonia's well field, are >0.5 mile⁹ from the Forest Boundary (i.e., on private land). Three domestic wells are within the forest boundary. One well is on the private Redrock Ranch (T. 22, R. 16, sec. 12). Water can be drawn from this well between 80 and 160 feet because perforation starts at 80 feet. The second domestic well is approximately 1 mile north of Redrock Ranch along Forest Road 138 (T. 22, R. 16, sec. 2) and >0.3 miles from an intermittent portion of Redrock Creek. This well is registered as abandoned. The third well is located at the northern boundary of the watershed (T. 21, R. 17, sec. 30) and is >2.0 miles from the closest stream that could be treated with piscicides.

There are 25 registered stock wells within the watershed; most are <500 feet from a stream bed. Two stock wells are outside the Forest boundary but within 500 feet of Redrock Creek. Twenty-two stock wells are registered to the Forest Service. There is one irrigation well approximately 1.3 miles east of the forest boundary and about 375 feet from Redrock Creek (Figure 3).

A water balance model was developed in 2000 and used to determine how much of the water produced in the Redrock watershed is intercepted by water usage (stockponds and wells). In an average year, about 3% of the water is intercepted by stockponds and spring developments. However, less than 1% of the base flow is intercepted. In addition, only 0.12% is pumped from the groundwater. The driest year on record (1996) was used to determine the worst case scenario. Using the worst case scenario, the model

⁸ Wells are classified by the primary use. Domestic wells are used for human consumption, have special features, such as filters, that make the water suitable for drinking, and are periodically tested. Stock wells are used for watering livestock and do not have any special features or get tested for water quality. Irrigation wells are used for irrigating crops.

⁹ All distance measurements are approximate and based off map and Geographic Information System (GIS) computer measurements. Well locations are from UTM coordinates associated with the well registry.

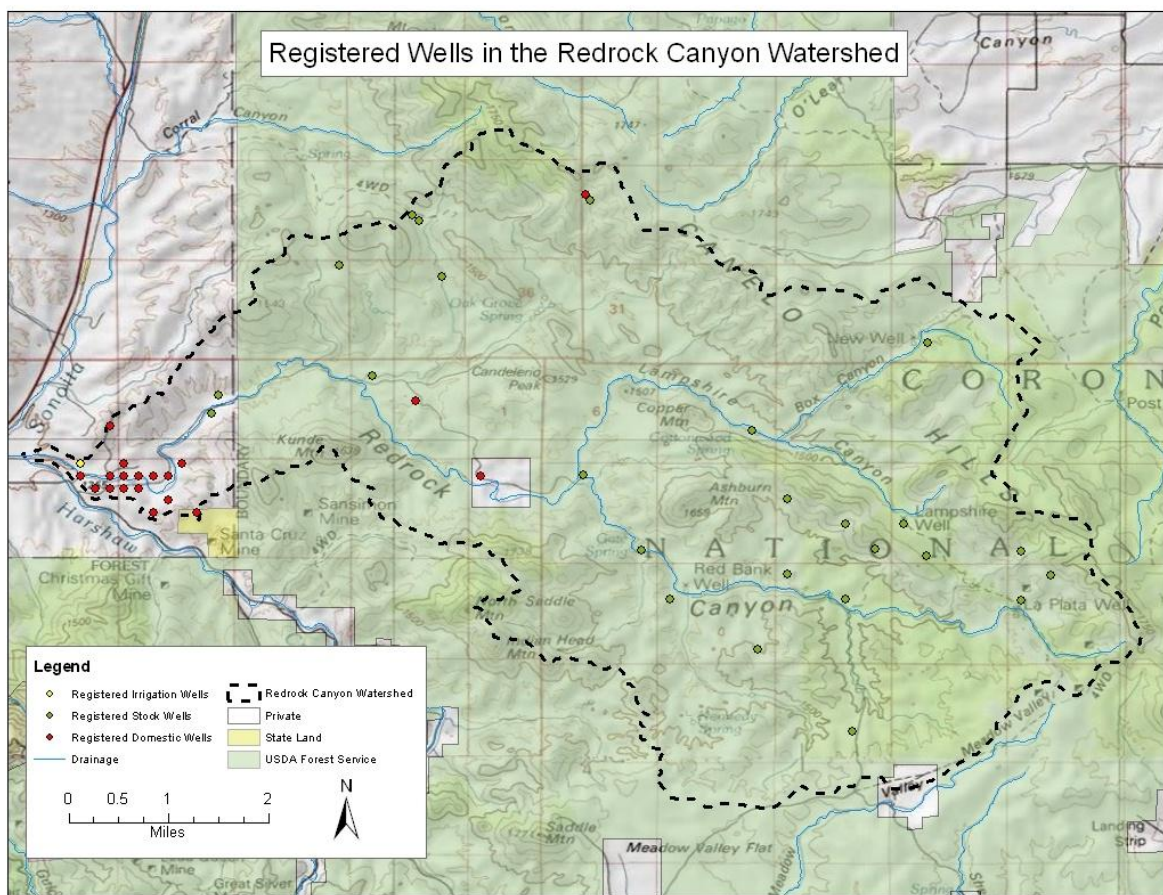
estimates that 6% of the surface flow is intercepted by stockponds and spring developments and 0.22% of the groundwater is pumped from wells. During the worst case scenario 1.84% of the base flow may be intercepted by spring development, but none by stockponds. (PR#146)

Although the present scarcity of surface water is a major detriment to native fish and amphibians, it provides optimum conditions for removal of nonnative fishes. Reduced volume of water and elimination of marshy areas substantially reduces the complexity of application of piscicides and other control methods.

The ADEQ sets narrative and numeric standards for water quality based on the uses people and wildlife make of the water. For Redrock Canyon, uses are classified as live aquatic life, warm water, full body contact, and fish consumption. The 2004 Integrated 305(b) Water Quality Assessment and 303(d) Listing Report indicated that surface water in Redrock canyon was in attainment of water quality standards for all designated uses.

There are no streams in the project area that are either congressionally designated as or eligible for Wild and Scenic River status.

Figure 3. Registered wells in the Redrock Canyon Watershed



3.1.2 Environmental Consequences

3.1.2.1 No Action

Water resources would not change if no action is taken.

3.1.2.2 Proposed Action

No impacts are anticipated to the hydrology or geomorphology in the project area. There are no anticipated effects to the floodplains. The proposed project would not adversely impact wetland functions or values and there would be no physical loss of habitat.

Pumping of stock tanks and possibly cienega pools to facilitate nonnative species removal may affect surface water availability in the short term. Water drawn from tanks and pools would be spread onto adjacent terraces and hillsides and would not be placed into the stream channel to prevent spreading nonnatives. Water availability for livestock would be affected if livestock are present during or shortly after pumping. Temporary changes in livestock management (e.g. pasture rotation, temporary fencing) would occur if a water source is made unavailable by draining. If changes in management are not possible, an alternative water source would be provided. Water availability for terrestrial wildlife would be adversely affected for the short term. Current below-normal precipitation patterns provide insufficient runoff and base flow to keep all earthen tanks and in-channel pools filled year-round. Water removed by pumping may not be replaced for weeks or months depending on weather conditions. This could impact native fish restoration following nonnative species removal. To avoid this, stock tanks and in-channel pools would not be pumped dry unless it is the only means available to ensure total eradication of nonnative fish and/or bullfrogs.

Effects to water quality from application of piscicides and neutralization compounds would be short term, restricted to the project area, and insignificant. Piscicides would not be applied during periods of precipitation and runoff to avoid downstream water quality impacts. If, however, unexpected heavy precipitation and runoff occur after application has begun, piscicide in the downstream flow from the project area would detoxify rapidly because of dilution in floodwaters and the effects of turbulence, sediment, and organic material (Schnick 1974b, Dawson et al. 1991; Lee et al. 1971). In the event of any potential movement of piscicides downstream of the project area, detoxification with potassium or sodium permanganate would be completed.

Rotenone is not very persistent in water and field dissipation half-lives are reported in the range of less than one day to about 10 days (SERA 2008). The product labels recommend that rotenone concentrations should be kept in the lethal range for at least 2 hours. The time for natural neutralization of rotenone is governed primarily by temperature. Warmer temperatures naturally degrade rotenone faster than colder temperatures. Studies in standing, icefree waters in California show that rotenone completely degrades within one to eight weeks within the temperatures range of 50°F to 68°F (CDFG 1994, Siepmann and Finlayson 1999); the estimated half-life values of 13.9 hour to 10.3 days, respectively. Other studies indicate half-life values of 13.9 hours to 10.3 days for water temperatures of 41°F to 75°F (Gilderhus et al. 1968, Gilderhus 1988). Rotenone dissipates in flowing waters relatively quickly (less than 24 hours) due to dilution and increased rates of hydrolysis (Borrison Laboratories 1983) and photolysis (Cheng et al. 1972, Biospherics 1982).

Depending on environmental conditions the expected half-life of antimycin A ranges from several minutes to approximately 12 hours. Antimycin A degrades slower in lower temperature water, but it is also less effective (Chapman et al. 2003). Degradation occurs quickly under natural stream conditions because of dilution, adsorption to organic material and sediments, and oxidation created by sunlight and water turbulence (Lee et al. 1971). Other compounds that readily bind with antimycin to detoxify it include leafy vegetation and water plants (Grisak 2003). Potassium permanganate reduced the half-life of antimycin A to 7 to 11 minutes in a laboratory setting.

Rotenone does not easily enter the groundwater because it tends to bind rapidly with organic material in soil and surface water (DOE 2004). In a California groundwater study, no trace of rotenone (including any of the compounds in the formulated product) was detected in 26 wells that were placed in aquifers adjacent to and downstream of nine rotenone-treated water bodies (CDFG 1994). A similar study at Tetrault Lake, Montana, failed to detect rotenone in a nearby domestic well that was sampled 2 and 4 weeks after treatment of the lake with 90 ug/L of the piscicide (DOE 2004). The Tetrault Lake well site was studied because it was down gradient from the lake and drew water from the same aquifer that fed and drained the lake. In another study, water from a well located 65 feet from a rotenone-treated pond near Kalispell, Montana, was analyzed and showed no sign of piscicide contamination (DOE 2004).

Contamination of domestic wells with piscicides and neutralization chemicals is not anticipated and is highly unlikely. Rotenone moves only 2 cm (<1 inch) in most types of soils (EPA 2007a, SERA 2008). An exception would be in sandy soils where the movement is about 8 cm (slightly more than 3 inches) (EPA 2007a, SERA 2008). Antimycin A, with a faster degradation rate than rotenone, readily binds to organic material and is not expected to be bioavailable. Any amount of piscicides that may be released from sediment is expected to degrade rapidly given its short half-life (EPA 2007b). The well on Forest land near Redrock Creek is not in use and is registered abandoned so this well is not considered to have any potential for contamination. The second well on Forest land, at the boundary of the watershed, is at a distance greater than what is believed to have any adverse effects. The well at Redrock Ranch on the private in holding is highly unlikely to become contaminated by rotenone. The closest that any surface water would be treated to this well is 600 feet to the east and 2500 feet to the west because none of the proposed treatments would occur on private land. Treated flowing water is not of concern on the private land because of the intermittent nature of the stream. All other domestic wells are outside the Forest boundary and >0.75 miles, or 4500 feet, from the closest possible location where surface water could be treated should it be present.

There are 7 stock wells in Redrock Canyon, one in Box Canyon, and two in Lampshire Canyon that are <1000 feet from the stream channel. The remaining 15 are >1.5 miles from a stream channel that would be treated and should not have any adverse impacts from treatment because of the unlikely chance that rotenone would travel these distances. No stock well in this watershed is operational year long. Typically they only run until the storage tank is full and/or when the pasture is in use. All of the pastures along Redrock Canyon are currently only winter use. The livestock grazing permittees would be notified of the impending piscicide treatment. In the event that the well is in use during implementation, it is unlikely that the wells would be contaminated because of the rapid breakdown of rotenone in soil and lack of movement. If cattle or humans were to drink from an operational well during this period adverse health impacts are not expected. See section 3.8 Socioeconomic Effects—Livestock Grazing and section 3.2 Human Health for a more detailed analysis on the effects of rotenone on livestock and humans.

Potassium and sodium permanganate, neutralizing agents of piscicides, are environmentally acceptable and safe methods to treat water sources. Potassium permanganate is one of the most widely used inorganic chemicals for the treatment of municipal drinking and wastewater. According to the American Waterworks Association's Water Industry Data Base, potassium permanganate is listed as the second most widely used chemical for predisinfection and oxidation by treatment plants processing surface waters. Hundreds of drinking water treatment plants use this chemical to oxidize iron, manganese, and arsenic; to remove color; and to treat for biofilm in raw water intake pipes. Sodium permanganate is used for in situ chemical oxidation of chlorinated organic contaminants in soil and groundwater. Liquid sodium permanganate is injected into the soil or groundwater and allowed to disperse through the contaminated media. In situ chemical oxidation using sodium permanganate is an effective method of remediating contaminated soil and groundwater.

The AZPDES permit will be acquired prior to implementing the proposed action for treatments that occur after April 2011 and once ADEQ issues its permit.

3.1.3 Cumulative Effects

Past, present and reasonably foreseeable actions in the project area are identified at the beginning of this chapter. Erosion remains a concern within the watershed, and the Forest Service has undertaken several projects to control specific sites of channel erosion. When all cumulative actions are considered, they may collectively contribute small amounts of sediment to the streams in the project area through disturbance on the watersheds. However, because no lasting direct or indirect impacts are expected as a result of either alternative, significant cumulative effects on water resources are not expected.

The extensive water system and pumping in and around the project area is reducing the amount of available water; however, they water budget as described in the affected environment, indicates that the minor amount of water pumped for this project would be insignificant and not have a significant cumulative effect on water availability.

3.2 HUMAN HEALTH AND SAFETY

3.2.1 Affected Environment

Rotenone would be applied to all surface waters on Forest Service land within the project area. Rotenone has been used on National Forest System lands since the 1930s. Rotenone is the most extensively used piscicide in the United States (Finlayson et al. 2000). Most treatments have occurred without incident but a small number have resulted in adverse public reaction and negative publicity in the news media (McClay 2000). Public concerns in the use of rotenone usually focus on public health and safety.

Rotenone and antimycin A are registered by the Environmental Protection Agency (EPA) for general use in the United States under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). By law, the EPA is authorized to register a pesticide only if it will not cause unreasonable adverse effects on human health or the environment. Rotenone is available in powders or liquid formulations.

FIFRA requires that all persons who apply pesticides classified as restricted use (such as piscicides) be certified according to the provisions of the Act, or that they work under the supervisions of a certified applicator. Commercial and public applicators must demonstrate a practical knowledge of the principles

and practices of pest control and safe use of pesticides. In addition, applicators using or supervising the use of any restricted-use pesticides purposefully applied to standing or running water are required to pass an exam (Aquatic Pest Control) to demonstrate competency as described in the Code of Federal Regulations (CFR) (40 CFR 171.4), as follows:

Aquatic applicators shall demonstrate practical knowledge of the secondary effects which can be caused by improper application rates, incorrect formulations, and faulty application of restricted pesticide used in the category. They shall demonstrate practical knowledge of various water use situations and the potential for downstream effects. Further, they must have practical knowledge concerning potential pesticide effects on plants, fish, birds, beneficial insects, and other organisms which may be present in aquatic environments. Applicants in this category must demonstrate practical knowledge of the principles of limited area application.

Here, we describe the consequences of human contact, direct or indirect, with rotenone and antimycin A. Piscicide applicators are the group most at risk of contact with piscicides. Other groups with potential to come into contact with the piscicides are people who bathe in or drink from a stock tank or stream pool with active piscicide concentrations or drink from a contaminated well. There is very little chance any person would enter a stock tank with active piscicide concentrations because all treatment areas will be closed (signed) to entry through an administrative closure order. Contamination of wells is also unlikely because treatment sites are far (>600 feet) from any registered wells (Figure 3). The City of Patagonia's well field is located >0.5 mile from the Forest boundary. While, as explained in section 3.1, the piscicides are incapable of moving such distances underground to contaminate a well, we explain the consequences to human health from consuming water or food that has been contaminated with rotenone and/or antimycin A.

3.2.2 Environmental Consequences

3.2.2.1 No Action

There would be no effect to human health, under this alternative.

3.2.2.2 Proposed Action

Rotenone

Millions of dollars have been spent on research to determine the safety of rotenone before approval of use from the EPA. Much of this research has been directed toward potential effects on public health. This research has established that rotenone does not cause birth defects (Hazleton Raltech Laboratories 1982), reproductive dysfunction (Spencer and Sing 1982), gene mutations (Biotech Research 1981; Goethem et al. 1981; NAS 1983), or cancer (EPA 1981; Tisdell 1985). When used according to label instructions for the control of fish, rotenone poses little, if any, hazard to public health. The EPA has concluded that the use of rotenone for fish control does not present a risk of unreasonable adverse effects to humans (EPA 1981, 1989, 2007).

Exposure to the General Public

There are substantial uncertainties in the exposure assessments for workers and members of the general public. The major uncertainty for members of the public involves the plausibility of any exposure

scenarios (SERA 2008). The likelihood that members of the general public would be exposed to rotenone in Forest Service applications appears to be low (SERA 2008). Rotenone does not persist in the environment, treatment periods occur only over a very short period of time, typically a few hours, and residual rotenone would be eliminated through natural degradation and neutralization agents, if necessary.

Consuming Rotenone-treated Water or Rotenone-tainted Food. The National Academy of Science (NAS 1983) has recommended a Suggested No-Adverse Response Level (SNARL) for rotenone in drinking water of 0.014 mg rotenone per liter of water (14 ppb), assuming a 155-pound person drinks 2 liters (0.5 gallon) per day for a lifetime. The California Department of Health Services has suggested an Action Level (level of concern) for rotenone in drinking water of 0.004 mg rotenone per liter of water (4 ppb). These proposed lifetime allowable levels for drinking water are based on applying a 1,000-fold safety factor to the chronic feeding study of Ellis et al. (1980). These levels assume a lifetime of exposure to rotenone. For comparison, most rotenone treatments are completed within a range of 0.025-0.25 mg rotenone per liter of water (25-200 ppb), and rotenone generally persists for no longer than a few weeks. In addition, rotenone treatments are only infrequently applied to a given body of water.

The EPA has set a chronic reference dose¹⁰ (RfD) for humans of 4 micrograms per kilogram (4 µg/kg). This dose includes a safety factor of 100, meaning that the data supports that there are no harmful effects observed below a dose of 400 µg/kg. The lower value with the safety factors corresponds to a dose of 280 µg for a 178 pound (70 kg) adult. To obtain this dose from piscicide concentrations of rotenone (40 µg/L), this adult could safely ingest 7 liters of 40 ppb rotenone treated water every day, for life. The average adult consumes around 2 liters of water per day up to 4 liters per day during the hot summer months. For a lethal dose, it is estimated that an average adult would have to consume 300-500 mg/kg of body weight (Gleason et al. 1969), equivalent to drinking 500,000 liters of water or 1/5 of the water in an Olympic sized pool. Hence, a 160-pound person would have to drink over 87,000 liters (23,000 gallons) of water treated at 0.25 mg of rotenone per liter of water (highest allowable treatment rate for fisheries management) at one sitting to receive a lethal dose. For comparison, the lethal dose of caffeine is estimated to be 192 mg/kg in humans (as opposed to 300-500 mg/kg of rotenone); this would be like drinking 80-100 cups of coffee in rapid succession. It is probably more feasible to die from caffeine poisoning from drinking too much coffee than from drinking rotenone-treated water at piscicide concentrations. Similarly, it is extremely unlikely that a 22-pound child would drink over 5,400 liters (1,427 gallons) of water. An intake of 0.7 mg of rotenone per kilogram of body weight per day is considered safe (Haley 1978), far greater than the expected exposure resulting from the maximum fisheries management treatment rate of 0.25 mg of rotenone per liter of water.

The hazards associated with drinking water containing rotenone are very small because of the low concentration of rotenone used in the treatment (0.025-0.25 mg of rotenone per liter of water [25-250 ppb]) and the rapid breakdown of rotenone. Studies of residual concentrations in water treated with liquid piscicide formulations indicate that solvent levels are below toxic thresholds (Ling 2003). In a study of rotenone-treated streams and lakes in California, concentrations of trichloroethylene never exceeded the Federal drinking water standard (Maximum Contaminant Level) of 5 ug/L and similarly the

¹⁰ A reference dose is an estimate of the level of daily exposure to a pesticide residue, which, over a 70-year life span, is believed to have no significant deleterious effects.

concentrations of xylene never exceeded the drinking water standard (Health Advisory) of 620 ug/L (Finlayson et al. 2001). Drinking water standards for naphthalene and methylnaphthalenes have not been established. Finlayson et al. (2001) noted that all the volatile and semi volatile organic compounds disappeared before rotenone dissipated from the treated waters.

Tolerances¹¹ for rotenone in potable and irrigation water have not been established by the EPA, even though the studies required for setting tolerances have been completed. This does not mean that rotenone concentrations in drinking or irrigation water would create problems; it just means that EPA has not established rotenone tolerances. As a result, water containing residues of rotenone cannot be legally allowed for use as a domestic water source or on crops. During a treatment and for the period of time that rotenone residues are present, alternative water sources must be used for domestic and irrigation uses. Depending on initial rotenone concentration and environmental factors (e.g. temperature), this period can vary from 1 to 8 weeks (CDFG 1994, Finlayson and J. Harrington, unpublished data, presented at Chemical Rehabilitation Projects Symposium, Bozeman, Montana, 1991). It is possible that humans, particularly undocumented immigrants, could consume water from stock wells, but it is highly unlikely that they could consume enough water at the concentration levels used during treatment to have adverse health effects. Moreover, treatment sites would be closed to the public by an administrative closure order. See section 3.1 (Water Quality) for a complete effects analysis on wells and surface water.

In the case of Lake Davis, California¹², public health concerns were not related to the use of rotenone itself but primarily due to concerns over reputed carcinogens in the chemical dispersants of the liquid formulation proposed (La Ganga 1997). The formulation consisted of 95 percent petrochemical solvents and contained significant quantities of trichloroethylene (TCE). While TCE is undoubtedly toxic, it is not classified as a human carcinogen as claimed by local residents. Opposition was especially vehement in this case because Lake Davis acts as the drinking water supply for the local town of Portola. TCE is present in CFT Legumine™, but the concentration of this substance in water immediately following treatment (~0.0000073 mg/L) is far below the level permissible in drinking water (Fisher 2007).

People are not at risk from consuming fish stocked into a recently treated water body. Fish are not stocked into a treated area until all of the toxic effects are gone and rotenone has dissipated. Hence, stocked fish cannot accumulate residues of rotenone from the water. Residues of rotenone in tolerant fish that survive a rotenone treatment will not last for more than several days because the bioaccumulation potential for rotenone is low and the half-life of rotenone in fish is about 1 day (Gingerich and Rach 1985; Gingerich 1986). The EPA has not established guidelines for consuming fish killed with rotenone. Therefore, agencies cannot condone this practice. Additionally, there is a valid concern of risk of salmonella and other bacteriological poisoning from consuming fish that have been dead for a period of time. Research has shown that the rotenone level in fish considered safe for human consumption has been estimated at 10 ppm (Lehman 1950). Consumption of fish found dead from piscicides are no more of a health risk than consumption of fish found dead from natural causes.

¹¹ The level of pesticide residue on food that is used to set the ***tolerances***, which are the legal maximum amount of pesticide that may remain in or on food.

¹² Lake Davis, near Portola, CA, was treated with rotenone to eliminate nonnative Northern Pike from the reservoir.

Marking (1988) administered 75 mg/kg (nearly 20,000 times that of the safe reference dose for humans) to rats for a period of 2 years. Gross and microscopic examination of tissues of the rats indicated no abnormalities. According to data compiles in ExToxNet and EPA's Integrated Risk Information System (IRIS) database, there is no conclusive evidence for rotenone having reproductive, teratogenic, mutagenic, or carcinogenic effects, particularly at piscicide concentrations. There are no data to suggest rotenone is an endocrine disruptor.

Exposure to Rotenone during Recreation. Rotenone has a low acute toxicity via the dermal route of exposure and is not an eye or skin irritant nor is it a skin sensitizer. The public is prohibited from entering the treatment area during treatment but may be exposed to rotenone by swimming, wading, fishing, or performing other recreational activities in treated water. The EPA uses the term "post-application" to describe exposures to individuals in an environment that has been previously treated with a pesticide. For all adult post-application scenarios, short-term risks for swimmers on the day of application do not exceed the EPA's level of concern. For all toddler post-application scenarios, short-term risks for swimming on the day of the application exceed the Agency's level of concern and suggest a 3 day waiting period when the application is at 200 ppb in 25°C (77°F) water. The EPA (2007a) ruled that reentry interval was not needed for adults who swim in waters with rotenone based on an assessment of the toxicology data (e.g. skin, oral water intake) and exposure level, but recommended approximately 3 days for toddlers. The reentry statement on the product labels—"do not swim in rotenone-treated water until the application has been completed and all the pesticide has been thoroughly mixed into the water according to labeling instructions"—indicates the safety of rotenone use for fish control. The reason for this slight waiting period for adults is esthetic. Any threat to recreational users during treatment would be mitigated through cautionary signage at access points, temporary closures, and posting agency personnel within the treatment area.

No public health effects from airborne rotenone use as a piscicide have been reported. See section 3.3 (Air Quality) for a complete effects analysis on air quality and airborne rotenone.

Exposure to Sensitive Subgroups. Women of child-bearing age, particularly women who are pregnant, as well, as individuals that have a predisposition to develop Parkinson's disease are groups that appear to be at increased risk from exposure to rotenone. Rotenone exposures are associated with fetal resorption in mice (SERA 2008). The fetus may be at risk as well, not only because of potentially lethal effects (i.e. resorption) but because of the potential for longer-term neurological effects that might not be displayed until later in life (EPA 2006).

The acute RfD uses information from both the range-finding phase of the developmental study in mice as well as the subsequent full study. Both phases of this study involved dosing pregnant females over a 12-day period—i.e. Days 6 to 17 of gestation. When the lowest-observed-adverse-effect level (LOAEL) was administered (24 mg/kg body weight/day) a 760% increase in resorptions was observed. The dose was also associated with a 41% decrease in body weight gain (EPA 2006). No adverse effects were noted at levels below 24 mg/kg body weight/day (SERA 2008). Haag (1931) conducted a single generation reproduction study in guinea pigs. At a dietary concentration of 150 ppm, all young were either born dead or died within 5 days of birth. In a chick embryo screening assay, Roa and Chauhan (1971) noted a complete arrest of embryo development at 1 mg/L but no effect at 0.1 mg/L. These levels are beyond those used in fisheries management and are highly unlikely if a pregnant woman consumes or comes into

contact with rotenone-treated water or fish. They may be more sensitive to rotenone but the RfD levels issued by EPA are specifically intended to protect women of child-bearing age (SERA 2008). These levels were used to determine the effects as discussed in the consumption of rotenone treated waters and rotenone-contaminated fish sections.

Individuals with Parkinson's disease are a group identified as being at special risk because of the ability of rotenone to cause neurological damage resembling the effects of Parkinson's disease. Whether or not rotenone causes Parkinson's disease is not clear; nonetheless, it is evident that rotenone causes neurological damage. Because Parkinson's disease is more prevalent among the elderly, they may also be a sensitive subgroup.

Effects on Endocrine System. Assessment of the direct effects of chemicals on endocrine function are most often based on mechanistic studies on estrogen, androgen, or thyroid hormone systems and changes in structure of major endocrine glands—i.e., the adrenal, hypothalamus, pancreas, parathyroid, pituitary, thyroid, ovary, and testis (SERA 2008). Several studies report weight loss in experimental mammals after exposure to rotenone (Marking 1988; Hansen et al. 1965; Brooks and Price 1961). While changes in body weight might be associated with effects on endocrine function, body weight loss is a very common observation in toxicity studies and could be due to a variety of other factors secondary to general adverse effects. In the absence of any indication of effects on endocrine tissue, there is no basis for asserting that decreases in body weight as associated with changes in endocrine function (SERA 2008).

Alam and Schmidt (2004a) report that intraperitoneal doses of 2 mg/kg body weight/day to rats over a period of 30-60 days causes a decrease in plasma testosterone. The effect was attributed to diminished bioenergetics—i.e., a decrease in ATP in adrenal and testicular tissue—as well as general oxidative damage to adrenal and testicular tissue. The effect, however, did not appear to involve changes in thyroid or pituitary hormones by did alter the testosterone level would clearly be regarded as a disruption in the endocrine system (SERA 2008).

EPA does not have standardized screen tests for endocrine disruptors but has concluded that “In the available toxicity studies on rotenone, there was no estrogen, androgen, and/or thyroid mediated toxicity shown (EPA 2005).” All of the studies suggesting endocrine effects involve scenarios—i.e., intraperitoneal or intravenous doses of rotenone—that a member of the general public would not be exposed to from the way rotenone is used in fisheries management. Thus possible endocrine effects are highly remote and extremely unlikely.

Alleged Link between Rotenone and Parkinson's Disease. There is a substantial body of literature concerning the use of rotenone to develop animal models for Parkinson's disease, and this literature is subject of numerous published reviews (Drechsel and Patel 2008; Gomez et al. 2007; Hoglinger et al. 2006; Uversky 2004; Greenamyre et al. 2003; Hirsch et al. 2003; Perier et al. 2003; Trojanowski 2003; Orr et al. 2002; and Jenner 2001). Interest in the ability of rotenone to cause Parkinson's disease is focused on two issues: the prevention of Parkinson's disease by limiting exposures to agents that may cause the disease and an understanding of the pathogenicity of Parkinson's disease with the goal of developing effective treatments for this condition.

Parkinson's disease is a progressive degenerative neurological disorder characterized by resting tremor, rigidity, the inability to maintain posture, and generally slow movement. The pathogenesis of the disease involves the loss (progressive degeneration) of dopamine-secreting nerved cells in the middle section of the brain (substantia nigra). The cause of Parkinson's disease is not well-understood. The development of Parkinson's disease appears to involve both genetic predisposition and as well as environmental factors, including exposures to agricultural chemicals. Environmental factors may include relatively common agents such as cigarette smoking and the consumption of coffee (McCulloch et al. 2008) as well as general exposure to pesticides in populations of farmers (Brown et al. 2006). In terms of exposure to pesticides, the most consistent relationships noted in epidemiology studies is the positive correlation in the increased risk of the development of Parkinson's disease with the duration of pesticide exposure (Drechsel and Patel 2008). Nonetheless, no epidemiology studies specifically linking rotenone exposures to Parkinson's disease are found in the literature (SERA 2008). Because pesticide exposures in farmers as well as other groups of individuals tend to involve exposures to many different pesticides as well as various other risk factors, the lack of an epidemiology study specifically linking rotenone to the development of Parkinson's disease should not be overly interpreted. In other words, no epidemiology studies are available indicating that populations exposed to rotenone are at the same level of risk of Parkinson's disease as population not exposed to rotenone (SERA 2008).

Marking (1988) observed no changes in the brains of rats given oral doses of up to 75 mg/kg per day for two years. Oral administration results in efficient metabolism of rotenone in the gut, and so little, if any gets into the blood stream and into the brain. These observations argue against oral introduction of rotenone as being a risk for the development of Parkinson's disease, especially at piscicidal concentrations and the corresponding small doses to humans that might result from drinking a substantial quantity of rotenone-treated water.

Rotenone has recently been reported to cause effects in rats similar to those of Parkinson's disease. Lesions were observed in dopamine producing neurons of the substantia nigra of the brains of rats continuously exposed by I.V. infusion for 5 weeks to 2.3 mg/kg body weight per day (Betarbet et al. 2000). The stated goal of the research was not to study health effects of pesticides, but rather "To develop a more accurate in vivo model of Parkinson's Disease" to enable a method to induce Parkinsonism in lab animals to further the study of the onset and development of the disease (Betarbet et al. 2000). Rats were infused rotenone directly into the jugular veins at a dose of 2-3 mg/kg. They choose to use direct injection rather than feed the animal's rotenone because "rotenone seems to have little toxicity when administered orally (Betarbet et al. 2000)." This study was cited in the previous EA appeal as evidence of rotenone having a significant effect to human health (PR#49).

Thiffault et al. (2000) attributed rotenone-induced damage of the substantia nigra to effects related to increased turnover of dopamine. They found that acute high doses caused increased dopamine turnover in mice although low subchronic doses did not. Other toxins known to cause Parkinsonism were, like rotenone, thought to affect mitochondrial ATP production leading to the production of reactive oxygen within cells, however, this has been discounted by Lotharius and O.Malley (2000). Therefore the mechanism by which rotenone induces lesions in the substantia nigra remains unclear. It is important to note, however, only a small fraction of people that die from Parkinson's disease have shown abnormal electron transport chemistries in their tissues—the majority have normal function (Jenner 2001).

Table 2 summarizes the experimental studies concerning the ability of rotenone to induce signs of toxicity consistent with the signs and symptoms of Parkinson's disease. This table summarizes the species tested, route of exposure, dose, duration of exposure, and a general indication of the endpoints observed: biochemical changes such as the inhibition of NADH oxidation or decreases in brain dopamine concentrations morphological damage to brain tissue characteristic of Parkinson's disease and gross signs of toxicity characteristic of Parkinson's disease. The early study by Ferrante et al. (1997) indicates damage to brain tissue; however, the specific nature of the damage was not characteristic of Parkinson's disease. As explained earlier, Betarbet et al. (2000) noted specific damage to in the midbrain of rats that appeared to be characteristic of Parkinson's disease. As noted in Table 2, both of these studies involved intravenous administration. While the study by Ferrante et al. (1997) involved higher doses of rotenone, the study by Betarbet et al. (2000) involved a longer period of exposure. While some additional studies indicate that single doses of rotenone causes midbrain damage (e.g. Crutchfield and Dluzen 2006), most of the studies reporting effects consistent with Parkinson's disease involve multiple doses, and note an association between the duration of exposure and the development of signs of toxicity consistent with Parkinson's disease (e.g. Antkiewicz-Michaluk et al. 2003; Bashkatova et al. 2004).

The recent study by Inden et al. (2007), reports Parkinson like effects in mice after oral administration of rotenone by gavage. Inden et al. (2007) treated mice with gavage doses of 0, 0.25, 1.0, 2.5, 5.0, 10, or 30 mg/kg rotenone for 28 days. At doses of 10 and 30 mg/kg body weight/day, effects included degeneration of dopaminergic neurons as well as decreased endurance in a roto-rod test (a standard assay for motor function). Effects on dopamine neurons were sporadic at 10mg/kg body weight but were seen in nearly all mice at 30mg/kg body weight. Furthermore, Inden et al. (2007) discovered an accumulation of protein (synuclein) within viable neurons which may be consistent with Lewy body formation. While this study is clearly the most relevant publication to the project with respect to the experimental induction of signs of toxicity consistent with Parkinson's disease, it is also important to recognize that Inden et al. (2007) did not demonstrate that that rotenone causes Parkinson's disease. Specifically the Inden et al. (2007) publication states "*These results suggest that rotenone-treated mice may be useful for understanding mechanism of DA [dopamine] neurodegeneration in PD [Parkinson's disease] and may be a model of the interaction of genetic and environmental factors involved in the pathogenesis of PD* (Inden et al. 2007, pg 1503)."

All of the early and most of the subsequent studies on rotenone studies on rotenone and Parkinson's disease involve routes of exposure that are not directly relevant to a human health risk—i.e. subcutaneous infusion, intravenous administration, or direct instillation into the brain. The normal exposure to rotenone in humans from its use in fisheries management would be ingestion, inhalation, or through the skin. Rotenone that is ingested by mammals (and birds) is rapidly broken down by enzymatic action in the gut and excreted by the liver and kidney. Approximately 20 percent of the oral dose (and probably most of the absorbed dose) is excreted within 24 hours (Ray 1991). These observations argue against the oral introduction of rotenone being a risk for the development of Parkinson's disease, especially at piscicide concentrations and the corresponding small doses to humans that might result from drinking a substantial quantity of rotenone-treated water.

Several of the researchers involved in the study of agents used in studying Parkinson's disease express reservations in the use of rotenone as an animal model for Parkinson's disease because of the broader

spectrum of neurological effects induced by rotenone relative to the neurological effects seen in Parkinson's disease (Ravenstijn et al. 2008; Richter et al. 2007; and Lapointe et al. 2004).

These and many other published studies argue against a direct link with rotenone in Parkinson's disease in humans, even among individuals with a life-long exposure to pesticides. There is not a documented link between rotenone use for agricultural or piscicide applications and the development of Parkinson's disease. Parkinson's disease predates the onset of use of rotenone. There is no documented increased occurrence of Parkinson's disease among native Peruvians that were exposed to significant amounts of rotenone through the pounding of cubé roots to extract rotenone for their use in fishing, which included swimming in rotenone-treated waters and consuming rotenone-killed fish.

Table 2: Summary of studies on rotenone as a model for Parkinson's Disease

Species	Route ^a	Dose mg/kg bw ^b	Duration ^c	Response ^d			Reference
				Bio-chem	Morph	Signs	
Rats	i.p.	1.5, 2.5	2 m	+	+	+	Alam and Schmidt 2002
Rats	i.p.	2.5	48 d	+		+	Alam and Schmidt 2004b
Rats	brain	6µg	20 min	+		+	Alam et al. 2004
Rats	s.c.	12	1 d	-		-	Antkiewicz-Michaluk et al. 2003
Rats	s.c.	12	7 d	+		+	
Rats	brain	2 µg	N.S.	+			Antkiewicz-Michaluk et al. 2004
Rats	s.c.	10	1 d	-			Antkiewicz-Michaluk et al. 2004
Rats	s.c.	10	7 d	+			Antkiewicz-Michaluk et al. 2004
Rats	s.c.	1.5	1 to 10 d	-			Bashkatova et al. 2004
Rats	s.c.	1.5	20 to 30 d	+		+	Bashkatova et al. 2004
Rats	i.v.	2.5-2.75	1-5 w	+	+	+	Betarbet et al. 2000
Rats	s.c.	3	5 w	+	+		Betarbet et al. 2006
Rats	s.c.	3	5-6 d	+	+		Caboni et al. 2004
Mice	i.p.	0.65	single	-			Crutchfield and Dluzen 2006
Mice	i.p.	1.3, 2.6	single	+			Crutchfield and Dluzen 2006
Rats	i.v.	10-18	7-9 d	-	-		Ferrante et al. 1997
Rats	i.v.	2-3.5	21 d	+		+	Fleming et al. 2004
Rats	s.c.	2-3.5	21 d	+		+	Fleming et al. 2004
Rats	i.v.	2.5	28 d		+	+	Garcia-Garcia et al. 2005
Mice	oral	0.25-5	28 d		-		Inden et al. 2007
Mice	oral	10, 30	28 d		+		Inden et al. 2007
Rats	s.c.	2.5	8 d		-	-	Lapointe et al. 2004
Rats	s.c.	3	5 d		+	+	Luo et al. 2007
Rats	s.c.	2	35 d	+		+	Nehru et al. 2008
Rats	s.c.	3	6 d	+			Panov et al. 2005
Rats	s.c.	3	28 d		-/+	+	Ravenstijn et al. 2008
Rats	brain	0.5–5µg	28 d		+		Ravenstijn et al. 2008
Mice	s.c.	2.5-5	30-45 d		-	+	Richter et al. 2007
Mice	nasal	2.5	30 d		-	-	Rojo et al. 2007
Rats	i.p.	1.5, 2.5	20-60 d		+	+	Schmidt and Alam 2006

^a brain (intracerebral), i.p. (intraperitoneal), s.c. (subcutaneous), oral (gavage), nasal (nasal instillation to mimic inhalation exposure).

^b does as mg/kg bw except for injections/instillation into the brain. For the later, the dose units per animal/brain are specified.

^c m (months), min (minutes), d (days), w (weeks), N.S. (duration intracerebral injection not specified)

^d Biochem (biochemical changes characteristic of Parkinson's disease); Morph (morphological changes to the brain characteristics of Parkinson's disease); Signs (frank signs of toxicity characteristics of Parkinson's disease). A plus sign (+) indicates an effect and a minus sign (-) indicates no effect. A blank indicates that no observations were made for the particular endpoint.

Exposure to Workers.

The major risks to human health from rotenone come from exposure during application. This is the only time when humans (applicators) are exposed to high concentrations of the piscicide (SERA 2008). Personal protective equipment is required by the product label and material safety data sheet to reduce respiratory and dermal exposure. For liquid and powder rotenone formulation application, personnel must wear approved air purifying respirators, goggles, rubber gloves, and protective clothing.

Antimycin A

Consuming Antimycin A-treated Water or Antimycin A-tainted Food. The subchronic effects to humans from antimycin A exposure have been estimated from toxicology studies using mice, a common approach to defining acceptable risk for a wide variety of compounds including pharmaceuticals. Literature estimates of sub chronic safe levels of antimycin A exposure have been developed using EPA risk assessment protocols. Toxicity studies aimed at determining these values develop a concentration where there is a “No Observed Adverse Effect Level: (NOAEL) of exposure determined in mice. The EPA protocol prescribes a method to apply a ‘safety factor’ in interpreting the mouse data for use in extrapolating to the toxicity in humans and computes a reference, that is the upper limit of antimycin that could be consumed daily for the rest of one’s life without observable effects. Using the values of NOAEL for antimycin determined by toxicology studies to be 0.5 mg/kg/day, and a very conservative value for the risk factor of 300, the reference dose has been estimated to be 1.7 µg/kg/day. This is the estimated and conservative safe dose. For a grown adult weighing 154 pounds (70 kg) who consumes the average daily intake of 2 liters of water (a little more than a half gallon), the safe concentration of antimycin in that water that this adult could consume for life is 60 µg per liter, or 60 ppb. Thus, an adult could safely drink his daily intake of water for the rest of his life with no adverse effects from an antimycin treated stream. Montana’s Division of Environmental Quality (1999) determined “there would be no effect on human health even if the chemicals (antimycin and rotenone) were not detoxified, did not break down, and people drank the “contaminated” water continuously for the rest of their lives.” In the State of New Mexico, a very conservative approach has also been considered, using a daily intake of 4 liters/day for a 154-pound (70 kg) adult, with similar conclusions (Wust, 2004).

The hazards associated with drinking water containing antimycin A are very small because of the low concentration of antimycin A used during treatment. If a person weighing 70 kg consumed 1.5 liters from a stream treated with 200 ug/L antimycin (recommended concentrations typically range from 5 to 25 ug/L), that person would ingest 300 ug of antimycin, or 0.0042 mg/kg of body weight. A 154-pound person would have to drink about 167 gallons of treated water during the period that antimycin is active to ingest the amount required to achieve the lethal dose for the most sensitive mammal tested (Guinea pig). This translates to a water consumption rate of about 28 gallons per hour during an active treatment period lasting 6 hours.

Consumption of antimycin in water was alleged to have caused organ abnormalities and stillbirth of two lambs in northern New Mexico in 1998 (Begel 2001). However, no evidence implicating antimycin in the still birth of the two lambs was produced, and no adverse effects on animals in the surrounding area were reported (AFSFMCS et al. 2001). In addition, an independent medical microbiologist contracted by Grant and Catron Counties in New Mexico to review the potential public health hazards of antimycin concluded that it was an effective and safe fish control agent for removal of fishes from streams with no

potential for public health issues when applied at recommended concentrations (Brooks and Propst 2001). Vezina (1967) reported that antimycin is not hazardous to humans, livestock, and wildlife when applied at concentrations appropriate for fisheries management.

The potential effects of consuming dead fish produced by stream renovation are poorly studied, but there have never been any reports of negative effects to humans or wildlife from ingestion of antimycin-killed fish (Berger et al. 1967; Gilderhus et al. 1969). Ritter and Strong (1966) reported that 21 humans who consumed between one and five 4-ounce servings of fish killed by antimycin suffered no ill effects. Schnick (1974a) reported that antimycin is not hazardous to humans whether it is consumed in food or water.

Because the toxicological effects of antimycin A on humans cannot be estimated, the EPA made the conservative assumption that exposure from consuming treated water may pose risks of concern. To mitigate the potential risks, flowing water (including outflow from standing water such as lakes and aquaculture ponds) from treatment areas must be deactivated with potassium permanganate and, when drinking water intakes are present within the treatment area, the intakes must be closed during treatment and until monitoring samples demonstrate antimycin A levels are below the limit of detection (0.015 ppb). There are no drinking water intakes in the project area.

Because the toxicological effects of antimycin A on humans cannot be estimated, the EPA made the conservative assumption that exposure from consuming treated fish may pose risks of concern. Humans could potentially consume treated fish from a fish management program use (complete kill) or an aquaculture use (complete or selective kill). To mitigate the potential risks from the fish management program use, consumption of dead fish taken from treatment areas would be prohibited through posting and access area closures. Coupled with the low likelihood that humans would scavenge for and consume dead fish, the EPA believes posting a prohibition on consuming dead fish would preclude human exposure to antimycin A.

Exposure to Antimycin A During Recreation. Because the toxicological effects of antimycin A on humans cannot be estimated, EPA made the conservative assumption that exposure from performing recreational activities in treated water may pose risks of concern. To mitigate the potential risks, through posting and access area closures, the Certified Applicator or designee under his/her direct supervision must prohibit recreational access (e.g., wading, swimming, boating and fishing) to the treatment area during treatment and for 48 hours after treatment. Depending on environmental conditions, the expected half-life of antimycin A ranges from several minutes to approximately 12 hours. Based on the conservative estimate that antimycin A will have a half-life of 12 hours, the EPA estimates that at least 99 percent of the compound will have degraded after 7 days. Coupled with the relatively low exposure expected from performing recreational activities, the EPA believes a 7-day prohibition on recreational access will preclude human exposure to antimycin A. (EPA 2007b)

The major risks to human health from antimycin A come from exposure during application. This is the only time when humans (applicators) are exposed to high concentrations of the piscicide. Personal protective equipment is required by the product label and material safety data sheet to reduce respiratory and dermal exposure. For liquid and powder rotenone formulation application, personnel must wear approved air purifying respirators, goggles, rubber gloves, and protective clothing.

3.2.3 Cumulative Effects

Sources of human health hazard in the Redrock Canyon watershed stem mainly from illegal activities including human and drug smuggling. Soiled baby diapers, empty food containers and water bottles, clothes, human waste and other personal items are just a few of the things left in or near rivers, streams, washes and wildlife and livestock waters. These discards cause health hazards through transfer of bacterial and viral disease. Incremental effects on human health from either action alternative would be discountable and insignificant.

3.3 SOILS AND WATERSHED

3.3.1 Affected Environment

Geological units within the Redrock Canyon watershed include surficial alluvium, volcanic, metamorphic, and sedimentary rock. Nearly 85 percent of upland soils are grouped within the Lampshire-Graham-Rock Outcrop and Chiricahua-Lampshire associations (NRCS 2007). These soils consist of cobble or heavy clay loam and very cobble loam formed on hillsides. Alluvial deposits eroded from upland areas fill the canyon bottom and underlie stream terraces.

Moderately to steeply sloping canyon walls entrench the stream throughout the project area. The channel alluvium consists of fine sand, gravel, and cobbles. Boulders and bedrock are present along the channel and occur at various depths within the alluvium.

Private individuals conducting an annual evaluation of fish in Redrock Canyon documented a large flood event that occurred over Labor Day weekend 2009 (PR#122). Based on flow debris and sediment deposition, the flow appeared to originate from the upper headwaters of Redrock Canyon proper near Downunder Tank. A large sediment fan extruded from Redrock proper at the confluence. Flow level indicators in Cott Tank drainage, lower Lampshire Canyon, lower Oak Grove Spring Canyon, and the unnamed drainage joining Redrock proper at Pig Camp Spring showed signs of only a moderate flow. However, downstream of the confluence of Redrock proper and Cott Tank drainage, there were indicators of a substantial flood event and sediment had been deposited in most of the pools and runs. In the channel in Redrock Riparian Pasture and at the Falls, debris indicates a flood water level of about 4-6 feet above base flow level. A large amount of sediment was moved by this flood event, consisting mostly of silt, sand, and gravel, although large cobble/small boulder was also present. The active channel near the Falls has been shifted by the sediment. Additionally there is and continues to be substantial sediment captured by the increased riparian vegetation. This is especially evident in the exclosures.

Lands potentially affected by implementation do not contain prime or unique farmland or soils that are conducive to agriculture production.

3.3.2 Environmental Consequences

3.3.2.1 No Action

Existing conditions would prevail into the foreseeable future. Unnatural rates of erosion and sedimentation would continue as a result of human-induced disturbances within the watershed.

3.3.2.2 Proposed Action

There would be minimal impact on soils from pedestrian traffic associated with stream renovation and native fish and amphibian restoration.

The breakdown of rotenone in soil lags one to two weeks behind water levels. Retention of rotenone on streambed soils depends upon temperature. The concentration of absorbed rotenone on soils has been measured to drop below the limits of detection in under three days during the summer months when water temperatures are at their peak (Dawson et al. 1991). Rotenone is not believed to break down soil into its mineral constituents. There would be a localized and short term effect on soil of the treated areas if rotenone is used.

The ability of antimycin A to move through soil is unknown. It is possible that sediment may provide a substrate for antimycin A absorption and that it may shield the piscicide from breaking down in water. However, antimycin A bound to sediment is not expected to be bioavailable, and any amount of compound that may be released is expected to degrade rapidly given the short half-life (EPA 2007b). Antimycin is not believed to break down soil into its mineral constituents. There would be no anticipated effects on soil or geology of the treated area if antimycin A is used.

3.3.3 Cumulative Effects

Because there will be no significant direct or indirect effects, no cumulative effects to soils are anticipated.

3.4 AIR QUALITY

3.4.1 Affected Environment

Air quality is determined by the ambient concentrations of pollutants that are known to have detrimental effects on human health. The EPA has promulgated National Ambient Air Quality Standards (NAAQS) for six criteria pollutants: carbon monoxide, nitrogen dioxide, particulate matter (PM₁₀ and PM_{2.5}), ozone, sulfur dioxide, and lead. Areas with air quality that do not meet the standards are designated as “nonattainment areas.” Designation of nonattainment submits an area to regulatory control of pollutant emissions so that attainment of the NAAQS can be achieved within a designated time period. The Redrock Canyon watershed is located in an attainment area for all regulated NAAQS (EPA 2007c). Ambient air quality in the area is excellent.

The Clean Air Act (CAA) provides special protection for visibility and other air quality values in specially designated Class I areas where the cleanest and most stringent protection from air quality degradation is considered important. These areas include National Parks and Wilderness Areas which have been specifically designated Class I under Section 162(a) of the CAA. There are no Class I areas near Redrock Canyon.

The primary sources of air pollutants (PM₁₀) affecting the watershed include traffic on unpaved roads, fire (both wildland and prescribed fire), and natural events such as windstorms.

3.4.2 Environmental Consequences

3.4.2.1 No Action

No change in air quality would result from taking no action.

3.4.2.2 Proposed Action

A direct effect to air quality would result from vehicles transporting employees and equipment over the unpaved FSR 138. Integration of ADEQ and Forest Service Best Management Practices (BMPs) for dust suppression would minimize the impact of particulate emissions on air quality. In addition, the operation of vehicles would produce tailpipe combustion products such as nitrogen oxides, carbon monoxide, sulfur dioxides, and reactive organic gases which would locally degrade ambient air quality for very short periods of time. These emissions would not result in measureable changes in ambient concentrations of regulated pollutants and a change in attainment status for the air quality region.

The use of the powder Pro-Noxfish and the liquid formulation Nusyn-Noxfish have been monitored for airborne drift into adjacent areas. Airborne rotenone concentrations immediately adjacent to the treatment site, monitored in California during a treatment in 1997, varied from a high of 0.02 ppb rotenone (0.00053 mg of rotenone per cubic meter) immediately after application to nondetectable levels two weeks later (CARB 1997). The highest levels were approximately 1,000-fold lower than the estimated no observed effect level (NOEL) of 0.43 mg of rotenone per cubic meter of air for a 24-hour period estimated by the California Office of Environmental Health and Hazard Assessment and the California Department of Pesticide Regulation (CARB 1997). In the same monitoring program, carcinogen trichloroethylene (TCE) was detected only once at a trace amount in air at one spillway. The heavier hydrocarbons (naphthalene and methylnaphthalene) were found at 281 ppb (1.74 mg per cubic meter) in air immediately after treatment and diminished to 1.61 ppb (0.010 mg per cubic meter) in air within two weeks. Individuals can normally detect naphthalene and methylnaphthalene at levels between 40 and 84 ppb in the air. The highest levels of all materials in the 1997 monitoring program were found at a dam spillway because of water turbulence. The highest levels were determined not to be responsible for any effects (CDPR 1998).

Non-lethal symptoms have been reported in humans following prolonged occupational exposure to rotenone dusts during large-scale fisheries operations (Ling 2003). Headaches, sore throats and other cold-like symptoms were reported due to inhalation of dusts. Contact symptoms included sores on mucous membranes, skin rashes and severe irritation of the eyes. Poisoning is more likely as a result of inhalation rather than ingestion, since intestinal absorption of water insoluble rotenone is relatively inefficient. However, some forms of liquid-formulated rotenone contain aromatic solvents that make it soluble in water. Ingested carrier solvents may greatly increase intestinal absorption and enhance toxicity. Applicators would have the greatest contact with the aromatic solvents, however, they would wear respirators, as the product label recommends. The solvent smell can last for several hours to several days, depending on air and water temperatures and wind direction. These relatively “heavy” organic compounds tend to sink (remain close to the ground) and move downwind. The California Department of Pesticide Regulation (CDPR 1998) found no health effects from this smell.

Solvents should not be a concern for the proposed project because AGFD intends to use the new formulation CFT Legumine™. In comparison to conventional rotenone formulations on the market today,

CFT Legumine™ has several advantages, including a special emulsifier and solvent package that reduces the presence of petroleum hydrocarbon solvents. CFT Legumine™ was designed with the goal of reducing or eliminating petroleum hydrocarbon solvents such as toluene, xylene, benzene and naphthalene. By reducing these petroleum solvents, the manufacturer has been able to reduce many of the negative properties inherent with the conventional liquid formulations on the market today. CFT Legumine™ is virtually odor-free, and retains its efficacy without the use of any synergist.

No information is available on effects of antimycin A on air quality. The effects are expected to be similar to that of rotenone.

Dead fish would result from this project and may cause objectionable odors. Odors from dead fish are expected to be short term and minor.

3.4.3 Cumulative Effects

Because there will be no significant direct or indirect effects, no cumulative effects to soils are anticipated.

3.5 VEGETATION

3.5.1 Affected Environment

Following is a general discussion of vegetation in the project area. Vegetation that comprises Forest Service-designated sensitive plant species in the Redrock Canyon watershed is addressed in Sections 3.6.3 and 3.6.4

Redrock Canyon lies in the upper Sonoran life zone (Lowe 1964). Dominant vegetation types are broadleaf woodland (evergreen), with an overstory of Madrean oaks, predominately Emory oak (*Quercus emoryi*), Mexican blue (*Q. oblongifolia*), and Arizona white (*Q. arizonica*), and alligator juniper (*Juniperus deppeana*). Semi-desert grassland (Brown 1994) is also present in the watershed, with mesquite (*Prosopis velutina*) and catclaw acacia (*Acacia greggii*) the predominant overstory species. Curly mesquite (*Hilaria belangeri*), gramma grasses (*Bouteloua spp.*) and lovegrass (*Erogrostis spp.*) is the common understory species for semi-desert grassland (USFS 2003).

Riparian vegetation is found discontinuously along Redrock Canyon proper and many of its tributaries (Danzon et al. 2001; Stefferud and Stefferud 2004). Fremont cottonwood (*Populus fremontii*), Arizona ash (*Fraxinus velutina*), Arizona walnut (*Juglans major*), Arizona sycamore (*Plantanus wrightii*), Goodding willow (*Salix gooddingii*), and yew-leaf willow (*S. taxifolia*) are a major component of the riparian areas. Understory vegetation includes deer grass (*Muhlenbergia rigens*), seepwillow (*Baccharis glutinosa*), and a variety of sedges (*Carex spp.*), rushes (*Juncus spp.*), and upland grasses. Small areas of mesquite bosque and sacaton (*Sporobolus wrightii*) are present on terraces.

In the stream channel, submergent and emergent vegetation in areas of surface flow includes a variety of algae, duckweed (*Lemna minor*), cattails (*Typha latifolia*), and spike-rushes (*Eleocharis spp.*). Nonnative vegetation in the riparian area includes tree of heaven (*Ailanthus altissima*), tamarisk (*Tamarix pentandra*), Johnson grass (*Sorghum halepense*), rabbit-foot grass (*Polypogon monseliensis*), Bermuda grass (*Cynodon dactylon*), and watercress (*Rorippa nasturtium-aquaticum*).

3.5.2 Environmental Consequences

3.5.2.1 No Action

If no action is taken, vegetation would not be impacted.

3.5.2.2 Proposed Action

Minor disturbance of riparian or upland vegetation would occur during removal of nonnative fauna and native species restoration. Effects to aquatic vegetation would be localized and minimal. Aquatic vegetation may be removed during salvage and piscicide treatment to allow for adequate distribution of the chemicals. Emergent vegetation, such as cattails, may be cut off below the water line but would grow back quickly after treatment. Duckweed may be scraped from the ponds and watercress from streams and springs to allow access to the water but would quickly recover following treatment.

Piscicide applications would be made directly to water. Thus, the primary route of exposure for aquatic plants and algae would be through piscicide concentrations in the water. For applications made above the water, exposure to emergent plants could result from direct application or drift. While data are lacking to support any definitive conclusions, the likelihood that either piscicide would penetrate into plant cells and tissues seems low, except that it may be possible for root uptake from sediments where the piscicide has adsorbed to particulate matter. There are no data, even for terrestrial plants, to assess the potential uptake of piscicides through roots. Rotenone was formerly registered for use as an insecticide for agriculture crops. There was a long history of use without any apparent incidents affecting crops or the vegetation surrounding the fields. No significant effects are anticipated on vegetation from the application of piscicides.

3.5.3 Cumulative Effects

Effects to vegetation are ongoing from other human activities in the area, including undocumented immigrant use. This kind of human use creates a higher probability of wildland fire as a result of unextinguished or uncontrolled warming or signal fires. The duration and extent of the effects of burning on vegetation are dependent on the size of the fire and the quantity and type of vegetation that burns.

Impacts to vegetation from livestock grazing in the watershed have been fully explored in the EA completed by the Forest Service on livestock management (USFS 2003). Incremental effects on vegetation from either action alternative would be discountable.

3.6 WILDLIFE

3.6.1 Terrestrial Wildlife

3.6.1.1 Affected Environment

Redrock Canyon provides a wildlife movement corridor connecting Sonoita Creek to the Canelo Hills. Habitat diversity is increased by a diverse mix of vegetation, from high-elevation oak woodlands to low-elevation desert grasslands. Surface water and riparian vegetation support a diversity and abundance of species that would not otherwise be found in these arid lands.

This section discusses terrestrial wildlife in the Redrock Canyon watershed. Federally listed and candidate species are considered in section 3.6.3. Forest Service's Region 3 sensitive species are

considered in section 3.6.4. Management indicator species (MIS) are considered in section 3.6.5. Migratory bird species are considered in section 3.6.6.

3.6.1.2 Environmental Consequences

3.6.1.2.1 No Action

If no action is taken, terrestrial wildlife would not be impacted.

3.6.1.2.2 Proposed Action

The proposed activities of field-going personnel may have indirect impacts to terrestrial wildlife. Project noise and trampling vegetation, for example, could result in minor, temporary, localized disturbance to wildlife habitat.

Piscicides may have direct affects to non-target organisms but these impacts are predicted to be insignificant and discountable. Terrestrial wildlife may drink or have body contact with water containing rotenone or antimycin A, but terrestrial vertebrates do not uptake piscicides through body contact. Both piscicides are not likely to present significant drinking water exposure to wild mammals because human presence would temporarily drive away wildlife and the compounds would rapidly degrade (in standing and flowing water) and become diluted (in flowing water) and move beyond (in flowing water) treatment areas (EPA 2007a; EPA 2007b).

When applied at recommended doses for fish control (0.005 to 0.250 mg/L), rotenone has low toxicity to non-aquatic organisms. Extensive research has demonstrated that rotenone does not cause birth defects (Hazelton 1982), reproductive dysfunction (Spencer and Sing 1992), gene mutations (Biotech Research 1981, Goethem et al. 1981, NAS 1983) or cancer (EPA 1981, Tisdell 1985) in higher animals.

Terrestrial wildlife has the potential to consume tainted fish, vegetation, or water. All animals including fish, insects, birds, and mammals have natural enzymes in the digestive tract that neutralize rotenone and antimycin, and the gastrointestinal absorption of both piscicides is inefficient. Fish and some forms of amphibians and aquatic invertebrates are more susceptible because rotenone is readily absorbed directly into their blood through their gills (non-oral route) and thus, digestive enzymes cannot neutralize it. Piscicide residues in dead fish are generally very low (<0.1 ppm), unstable like those in water and not readily absorbed through the gut of the animal eating the fish. For these reasons, birds and mammals that eat dead fish and drink treated water would not be affected.

The results of chronic feeding studies in which rats and dogs were fed forms of rotenone as part of their diet for 6 months to 2 years resulted in non-lethal effects such as diarrhea, decreased food consumption, and weight loss (Skaar 2001). No adverse chronic effects were reported when rats were given 100 mg/L Pro-Noxfish® (2.5 percent rotenone) in drinking water for 70 weeks (Brooks and Price 1961). Ellis et al. (1980) found that 10 mg/kg/day rotenone administered orally to beagles for 26 weeks had no adverse chronic effect. Skaar (2001) reported that a 20-pound dog would have to consume 660,000 pounds of rotenone-tainted fish to receive a lethal dose.

Rotenone is slightly toxic to wildfowl, and birds are extremely unlikely to be affected by normal fisheries management programs. Studies that examined avian exposure report that a 1,000 to 10,000-fold increase in levels normally used for fisheries management would be required for lethality (Skaar 2001). A bird weighing a quarter of a pound would have to eat more than 40 pounds of fish and invertebrates killed by

rotenone within 24 hours before receiving a lethal dose (Finlayson et al. 2000). In a study on waterfowl, Vezina (1967) found that consumption of 2,900 mg antimycin/kg body weight was required to cause mortality of 50 percent of test mallard ducks in the laboratory.

A review of toxicity studies relating to antimycin indicates that vertebrate animals must ingest high dosages before any adverse effect is apparent (Schnick 1974a). In laboratory tests, oral LD50 values for mammals ranged from 1.0 mg/kg for lambs to 55 mg/kg for mice (Herr et al. 1967). Oral LD50 is defined as the amount of antimycin administered orally over a specified period of time that causes the death of 50 percent of the group of test animals. Tests on 4.5 kg domestic dogs required consumption of 5,000 mg/kg antimycin to cause mortality to 50 percent of the test population. An 800-pound horse would have to ingest about 860 gallons of water with levels similar to piscicide treatment before there could be a significant chance of death (Herr et al. 1967).

Antimycin rapidly degrades in aqueous environments to non-toxic, readily biodegradable fragments. Detailed studies on the accumulation of antimycin in body tissue have not been performed in any number due to the low concentrations commonly applied, higher rate of decomposition in vivo compared with in-stream, and the difficulty in assaying the compound in water much less in tissue samples. There is one study that used radio-labeled antimycin to assess bioaccumulation (Greselin and Herr 1974). The ability to detect radioactivity is straightforward and sensitive, and so is often used in cases such as this. Still, the results are open to interpretation, as any radioactivity detected may arise from not only antimycin, but from any of its degradation products, as well. Nonetheless, assuming the entire amount of radioactivity that was detected in this study is due to antimycin, the authors determined that antimycin does not bioaccumulate in fish to a concentration above what was in the stream. Compounds that would bioaccumulate typically do so because there is no metabolic route to decompose them to readily excretable fragments.

There is a low potential for bioconcentration of rotenone in fish. In a Wisconsin field study by Gilderhus (1986, in EPA, 2007c), residues of fish that were killed by the treatment were analyzed for parent rotenone residues, including fish reintroduced after the application. These residues were up to 696 parts per billion (ppb), or less than 3 times the intended aquatic concentration of 0.25 ppm rotenone. Although this kind of study is not readily comparable with standard bioconcentration studies, the results do support the laboratory findings that rotenone is not a concern for bioconcentrations within organisms or bioaccumulation across trophic levels. No quantitative data were found on bioaccumulation and food chain transfer for rotenone in either aquatic or terrestrial systems. Fish residue data indicate that body burdens are so low as to not be of significance in food chains.

Based on an acute oral toxicity study using formulated product, antimycin A is classified as very highly toxic to water fowl and highly toxic to upland game birds (EPA 2007b). However, since antimycin A is applied directly to water, there is little likelihood that terrestrial forage items for birds will contain antimycin A residues from this use. While it is possible that some piscivorous birds may feed opportunistically on dead or dying fish located on the surface of treated waters, it is not expected that the number of fish available would have adverse impacts and, given sufficient time, the fish would sink or be consumed by other animals and would not be available for consumption by birds.

Overall, terrestrial wildlife are not expected to be affected by the use of piscicide if they consume tainted water, vegetation, or fish. The piscicide levels for this project would be at the levels listed on the label or

lower, which are significantly less than amounts used in studies where any effects were observed. Terrestrial wildlife would have an exposure period of a couple of weeks, in which time they could not consume or come in contact with toxic levels of piscicide that would have adverse effects.

During recent treatments in California, fish-eating birds and mammals were found foraging on dying and recently dead fish for several days following treatment (CDFG 1994). Following this abundance of dead fish, a temporary reduction in food supplies for fish- or invertebrate-eating birds and mammals would result until the fish and invertebrates are restored. There is no indication that this temporary reduction results in any significant impacts to most bird or mammal populations because most animals can utilize other water bodies and sources for food. However, temporary loss in food resources for sensitive animals may cause unavoidable impacts (Finlayson et al. 2000).

3.6.2 Fish and Aquatic Wildlife

3.6.2.1 Affected Environment

Among the many species of native aquatic fauna that have been recorded in Redrock Canyon are four species of fish, Chiricahua leopard frog, canyon treefrog, Sonora tiger salamander, Sonora mud turtle, black-necked gartersnake, and Northern Mexican gartersnake. No records of rare invertebrate species were located for this EA; however, invertebrates as a group have received little attention. Gila topminnow, leopard frog, and salamander, all federally listed species, are discussed in Section 3.6.3. Desert sucker, longfin dace, and Northern Mexican gartersnake are Forest Service sensitive species discussed in Section 3.6.4. In this section, we address speckled dace, canyon treefrog, Sonora mud turtle, and black-necked gartersnake. Additionally, nonnative species are discussed. Location records for native and nonnative species are found in Appendix B.

Speckled dace. Speckled dace have occurred for decades in Sonoita Creek near its junction with Redrock Canyon (Minckley 1969). Although it was once a common species throughout the Gila River Basin and remains relatively widespread in the northern part of the basin, Sonoita Creek is one of a small handful of speckled dace populations remaining in the southern part of the basin (Desert Fishes Team 2004).

Speckled dace prefer fast water and coarse substrates and are most often found in riffles. No early records of speckled dace exist in Redrock Canyon, but the first recorded fish surveys did not occur until the 1970s. By that time, substantial anthropogenic changes had occurred in the watershed and the availability of water and suitable habitat had likely changed dramatically. Stefferud and Stefferud (2004) reported speckled dace in the west Redrock Riparian Pasture in November 2001 following good summer rains. Despite more sampling, no additional sightings of speckled dace have occurred in Redrock Canyon. Speckled dace apparently swam upstream from Sonoita Creek when continuous flow linked it temporarily with Redrock Canyon.

Canyon treefrog. Based on incidental sightings during fish sampling, canyon treefrog is common in the lower portion of Redrock Canyon, including Oak Grove Spring Canyon (Stefferud unpub. data). Suitable habitat for the species is found at water sources throughout the watershed. Tadpoles are aquatic herbivores, while adults feed on small invertebrates, both aquatic and terrestrial.

Sonora mud turtle. The Sonora mud turtle is an opportunistic predator that prefers pools and slow-moving waters. It is found throughout Redrock Canyon. It is common within the Cott Tank enclosure

and has been seen at Gate Spring, Falls, several miles upstream in Lampshire Canyon, in tributaries of Oak Grove Spring Canyon above the springs, and in Down Under and Martin Tanks (Stefferdun unpub. data; Mitchell 2002). Given most surveys have been by biologists looking for fish, only a small proportion of mud turtle observations are likely recorded. Bullfrogs prey on young Sonora mud turtles (Ernst et al. 1994).

Black-necked gartersnake. The black-necked gartersnake has been observed at Gate Spring, near Red Bank Well, and there were two probable sighting, one in upper Lampshire Canyon and one about a mile up a tributary that feed into Redrock Canyon in the West Redrock Riparian Pasture (Stefferdun unpub. data). This snake has also been reported in the Oak Grove Spring Canyon (AGFD unpub. data). These records were taken during fish surveys, and other records of the species in the watershed may exist. Black-necked gartersnakes feed primarily on frogs and toads.

Nonnative species. Five nonnative aquatic species are known to have invaded Redrock Canyon: mosquitofish, largemouth bass, green sunfish, bluegill, and bullfrog (see Appendix B).

Mosquitofish have been recorded throughout Redrock Canyon, from the Cott Tank enclosure downstream to the Forest boundary. They and longfin dace have been the only species of fish found in surveys of Redrock Canyon since 2005, with the exception of one Gila topminnow found in Cott Tank enclosure during 2008(PR #63). Mosquitofish have been implicated in declines of many native fish and amphibians (Grubb 1972, Casterlin and Reynolds 1977; Courtenay and Meffe 1989). They are highly aggressive, preying on fish eggs and larvae in addition to invertebrates, even in heavily vegetated and shallow areas, habitats typically safe from larger predators (Baber and Babbitt 2004). Mosquitofish also harass and nip individuals larger than themselves, leading to damage, disease, exhaustion, and death (Hurlbert et al. 1972; Fuller et al. 1999; Lawler et al. 1999). This behavior may also result in non-lethal interactions that have significant long-term adverse consequences to the harassed individuals and populations (Lima 1998). In Redrock Canyon, Gila topminnows show a high incidence of fin damage when mosquitofish are present (Dean 1987). Snyder (2006) found that although Sonora tiger salamander can persist in the presence of mosquitofish, they cannot establish a viable population where mosquitofish are present. Mosquitofish may also present substantial competition to native species, particularly during times of severe habitat constriction (Meffe 1983) such as drought.

Cienega pools in the Cott Tank drainage provide suitable habitat for largemouth bass. Earthen stock ponds also provide habitat. Largemouth bass established a reproducing population within the Cott Tank drainage during the late 1980s and 1990s, declining only when drought limited habitat for the species. A mechanical removal of largemouth bass in Cott Tank drainage was carried out in 1989. Largemouth bass are aggressive predators; adults feed almost exclusively on fish, tadpoles, and crayfish (Moyle 2002). They prey on native Gila basin fishes with adverse impacts to their populations and may completely extirpate some native fish in small habitats (Minckley 1969; Minckley et al. 2002; Bonar et al. 2004).

Green sunfish and bluegill records are limited to Redrock Canyon and Cott Tank drainage from Down Under and Cott tanks downstream to just beyond the confluence of the two channels. These two species are aggressive invaders in the Gila River Basin and are well-adapted to small waters. They easily establish reproducing populations, even in spatially intermittent streams such as Redrock Canyon (Capone and Kushlan 1991). Green sunfish and bluegill are opportunistic predators, consuming eggs, larvae, and small adult fish, as well as frog eggs and tadpoles and salamander eggs and young, with

adverse effects to native fish, frog, and salamander populations (Lemly 1985; Collins et al. 1988; Rosen et al. 1995; Dudley and Matter 2000). Green sunfish and bluegill have shown to contribute to the establishment of bullfrogs by preying upon macroinvertebrates that prey upon bullfrogs (Adams et al. 2003). Because of the substantial similarities between bluegill and sunfish food habits, it is likely that green sunfish may play the same role in bullfrog invasion.

Bullfrogs are predatory in both tadpole and adult stages and reach high densities in southwestern waters (Kane et al. 1992; Rosen and Schwalbe 1995; Mueller et al. 2006). Bullfrog tadpoles are also known to produce chemicals that inhibit growth in tadpoles of other species and inhibit reproduction in guppies (*Poecilia reticulata*), a live-bearer similar to Gila topminnow (Boyd 1975; Kupferberg 1997). They have been implicated in the decline of several native fish and amphibian species (Lawler et al. 1999; Rosen and Schwalbe 2002; Bradford et al. 2004). Bullfrogs need permanent water but can migrate long distances overland to find a new water source, and it is not unusual to find them occupying small areas of isolated water. Most long distance overland dispersal takes place during wet times of the year, such as the summer monsoon. They have been present in Redrock Canyon since at least 1988 but did not become abundant until mid-1990s. Their spread appears to be associated with stock tanks in the drainage (at least five tanks in the drainage have been recorded to support bullfrogs). Bullfrogs are common to abundant in Cott Tank drainage and at some of the stock tanks. Records from elsewhere in the basin are sporadic.

3.6.2.2 Environmental Consequences

3.6.2.2.1 No Action

If no action is taken, nonnative aquatic species in the Redrock Canyon watershed would likely persist and may even expand in distribution and abundance, which may result in the extirpation of most native aquatic species. Although persistent drought may suppress some populations of aquatic species, it is not expected to eliminate mosquitofish or bullfrogs. Green sunfish and bluegill, if still present in the basin, also may survive extended drought. Only largemouth bass, if still present, would likely be eliminated by drought conditions because it requires relatively large pools.

Adult speckled dace are not believed to be particularly susceptible to mosquitofish predation and harassment or adverse impacts from bullfrogs because of differences in preferred habitat use. Larval stages use backwater and vegetated stream edge habitats extensively where they are preyed upon by mosquitofish, sunfish, and perhaps bullfrogs.

The Falls is a natural barrier to upstream fish migration (Stefferd and Stuefferud 2007; D. Mitchell, AGFD, personal communication Oct. 2009). Below the Falls, speckled dace may be able to retain a periodic colonization pattern from Sonoita Creek but will not be able to expand their occupation of Redrock Canyon nor establish self-sustaining populations there. This limited range increases their vulnerability to predation, drought, fire and other negative factors.

3.6.2.2.2 Proposed Action

Removal of mosquito fish, bullfrogs and other nonnative aquatic species would benefit speckled dace, canyon treefrog, black-necked gartersnake, and Sonora mud turtle. With predation pressure eliminated or reduced, speckled dace may establish a self-sustaining population in Redrock Canyon. The treefrog, gartersnake, and mud turtle also would be released from predation and competition by nonnative aquatic species, allowing their populations to expand in numbers and distribution.

Adequate data are not available to quantitatively estimate chronic risk of piscicides to aquatic wildlife. However, the likelihood of long-term exposure to rotenone and antimycin A is low because: 1) the piscicides have a relatively short period of toxicity, 2) flowing waters eventually would flush piscicides through the system, and 3) in-flow from untreated tributaries would dilute the chemicals.

Fish. Antimycin A and rotenone are expected to kill fish when applied at concentrations specified in the Pesticide Use Proposal. Even for the least sensitive fish and aquatic invertebrates tested, treatment concentrations would exceed acute risk levels of concern (EPA 2007b). Any fish not salvaged before treatment would be killed by the piscicide. Potassium permanganate can be toxic to fish (Tucker and Boyd 1977; Archer 2001). When applied at 1.5 mg/L in the absence of readily oxidizable substances, potassium permanganate achieved lethality in west slope cutthroat after 16 to 24 hours of exposure (Grisak et al. 2002). Fish would not be returned to the stream until all piscicides and neutralizers are no longer harmful. Restocking of salvaged fish following nonnative removal, with possible augmentation stocking from captive or nearest-neighbor stocks, is expected to result in increased abundance and distribution of native species.

There is always the potential for nonnative fish to reinvade or for some individuals to be missed during treatments. Monitoring four years post-treatment would determine if retreatment is necessary for complete eradication. To date there is no evidence that nonnative fish have found their way upstream into Redrock Canyon (D. Mitchell, AGFD, personal communication, Oct. 2009). The only fish data that shows movement into the Canyon below the natural barriers are from native species, specifically speckled dace and Sonoran suckers.

Amphibians. Lesser (1970) found that antimycin A was not toxic to northern leopard frog tadpoles in label-directed concentrations. Rotenone, however, is toxic to northern leopard frog tadpoles at piscicide application levels (Hamilton 1941, as reported in Fontenot et al. 1994; Chandler and Marking 1982, as reported in Fontenot et al. 1994; Burress 1982). Larvae that are wholly or partially dependent upon gill respiration are far more sensitive to rotenone than those that are fully metamorphosed and breathing air, indicating that rotenone is far more readily absorbed across gill epithelium than skin. It is likely that the proposed application of rotenone would result in mortality of some canyon treefrog tadpoles. Adult frogs should be less affected because they breathe air (Fontenot et al. 1994). Bronmark and Edenhamn (1994) reported common treefrog (*Hyla arborea*) not only survived treatment of a pond with rotenone but established a reproducing population.

Grisak et al. (in prep) conducted laboratory studies on long-toed salamanders, tailed frogs, and Columbia spotted frogs and concluded that the adult life stages of these species would not suffer an acute response to rotenone, but the larval and tadpole stages could be affected by rotenone at fish-killing concentrations. Their data indicate that at piscicide concentrations and anticipated application times of antimycin, risk to tadpoles is small. These authors recommended implementing rotenone treatments at times when the larvae and tadpoles have metamorphosed, or physically remove the tadpoles from the stream until after treatment.

Nonnative bullfrog tadpoles may be affected by the piscicide, but mortality of all larval bullfrogs, particularly late-stage tadpoles, is unlikely. Adult bullfrogs would not likely be affected. Mechanical methods would be used to capture and kill adult bullfrogs, including netting, gigging, and limited use of firearms.

Reptiles. Adverse effects to black-necked gartersnake could occur as a result of reduced food supply (i.e., fish, frogs, toads, tadpoles, worms, salamanders, and crustaceans). During the period between the time fish are completely removed from the system and the time native fish are restocked, the prey base would be reduced. However, other prey items such as metamorphosed frogs and some late-stage tadpoles would survive. Gartersnakes also eat lizards, small mammals, and birds, which would not be reduced by piscicides.

Black-necked gartersnakes are not expected to be affected by either antimycin A or rotenone because they breathe air (Fontenot et al. 1994). Sonora mud turtles could be affected by both piscicides because of their use of aquatic respiration (absorption of oxygen through the buccopharyngea, skin, and/or cloaca) (Fontenot et al. 1994). Use of Rotenone in Lake Conroe in Texas resulted in mortality of many mud turtles (*Kinosternon subrubrum*) at levels within rotenone label levels for piscicide use (McCoid and Bettoli 1996). Unpublished AGFD data also suggest the potential for mortality of Sonora mud turtles when rotenone is applied at recommended label levels. No data is available regarding antimycin A toxicity, but in Fossil Creek where an extensive nonnative removal project using high concentrations of antimycin A occurred in 2004 (with no turtle salvage), Sonora mud turtles were commonly found during post-treatment monitoring in 2005 (Marsh et al. 2006). Sonora mud turtles were also abundant in O'Donnell Creek following a treatment with antimycin A in 2001. To limit mortalities, Sonora mud turtles would be salvaged prior to piscicide application and returned after detoxification. However, not all turtles would be salvaged, and some of those remaining in the stream may fail to leave the water before receiving a potentially lethal dose of piscicide.

Aquatic invertebrates. The large number of species of invertebrates that may reside in a stream, and the fact that stream invertebrate population makeup can vary significantly depending on location, stream flows, temperatures, etc. have made gaining a consistent set of data a large and difficult task. Impacts on aquatic invertebrates are a concern because of their role in ecosystem processes and their importance as food sources for fish (Vinson et al. 2010). Some believe that impacts to invertebrates are short-term and minimal (e.g. Williams 2007; Finlayson et al. 2005; Ling 2003), while others claim that piscicides cause irrevocable damage (CBD 2003).

Standardized toxicity test data on aquatic invertebrates is quite limited. Most invertebrate data have been from field observations following rotenone treatments. These data largely relate to changes in populations and/or diversity after rotenone applications. Recovery of invertebrate populations is reported in most field studies that monitor the populations over a prolonged period of time. The reported recovery periods may range from weeks (Neves 1975), to months (Linn 2002; Lintermans and Raadik 2001; Cook and Moore 1969), or even years (Morrison 1977; Anderson 1970). Some studies involving relatively short post-application observation periods, report a lack of full recovery (e.g., Burress 1982; Oglesby 1964). On the other hand, Magnum and Madrigal (1999) report that some macroinvertebrate populations did not fully recover (in the sense that some groups of macroinvertebrate populations were missing) over a 5-year observation period after an application of rotenone (150 ppb) to a river.

Bradbury (1986) provides substantial data on benthic and zooplanktonic invertebrates by species and on zooplankton communities. The conclusions from various studies indicate that zooplankton, especially cladocerans and copepods, are the most severely affected group of aquatic invertebrates with many studies reporting 95-100 percent loss. Complete recovery can take 17 weeks to 4 years to achieve.

Sensitivity to rotenone is highly variable among aquatic invertebrates. Many species are highly susceptible (Skaar 2001), but most populations quickly recover to pre-treatment levels (Ling 2003; Morrison 1977; Schnick 1974b, Lennon 1970). Burress (1982) reported rotenone caused reductions in benthic pond invertebrates and zooplankton but that the populations rebounded rapidly. They also found substantial increases in phytoplankton because of released nutrients and reduced plankton-feeding animals.

Applications of rotenone in lakes and ponds to kill fish usually cause significant declines in zooplankton and may also affect some bottom fauna. These populations of more sensitive animals usually recover over periods of one to eight months following treatment (Ling 2003). Zooplankton species like *Daphnia* are generally more sensitive to rotenone than the larger benthic macroinvertebrates such as mollusks, crayfish, freshwater prawns, amphipods, oligochaete worms, and chironomid midge larvae (Morrison 1977). Cladocerans and copepods seem to be the most susceptible invertebrate groups (Ling 2003). Although copepod populations quickly recover following rotenone treatments, cladoceran abundance may take many months to recover to pretreatment levels. Inchausti and Heckmann (1997) found that the incidence of a fish parasite (*Diplostomum*) decreased by nearly 100% for at least five years following the very large-scale treatment of Strawberry Reservoir, Utah, in 1990. This was attributed to the loss of invertebrate species such as snails that acted as intermediate hosts for the parasite.

Treatments in streams and rivers also cause significant loss of invertebrate fauna but effects are usually most noticeable close to rotenone application stations (Ling 2003). Not all invertebrate losses in stream treatments are due to death of animals because rotenone also causes increases in invertebrate drift downstream (Morrison 1977). A five year study of the Strawberry River, Utah, following a 48 hour treatment to remove coarse fish showed that up to 33% of the benthic invertebrate species were unaffected by the treatment (Mangum and Madrigal 1999). Forty-six percent of species had recovered after one year but a further 21 percent were still missing after five years. Most of the species that were most sensitive to rotenone and which failed to recover were mayflies, stoneflies and caddis flies, although some members of each of these groups were also resistant to rotenone treatment. Although some species that were present before the treatment were still missing five years later, other species not present before the rotenone treatment had appeared and were possibly filling vacated niches (Mangum and Madrigal 1999). Houf and Campbell (1977) found no effects to species diversity, emergence, seasonal dynamics, abundance, or relative numbers of taxa from rotenone exposure.

The widely varying durations for reported recovery periods may be attributable as much to differences in the definitions of recovery as to differences in the actual patterns of recovery. In some cases, the nature of the recovery may be incomplete in that long-term shifts in invertebrate populations may occur (Blakely et al. 2005; Prejs et al. 1997; Sanni and Waevagen 1990). The extent to which these differences in recovery patterns are attributable to differences in the nature and extent of the treatments and/or differences in the initial structure of the invertebrate communities is unclear (SERA 2008).

Published studies on antimycin effects on invertebrates appear scarce compared to the occurrence of antimycin treatments (Vinson et al. 2010). Several laboratory studies (Kotila 1978; Kawatski 1973; Walker et al. 1964) suggest a wide range of sensitivity to antimycin. Sensitivity increases with increasing water temperatures (Walk et al. 1964) and decreases at pH > 8.5 (Marking 1975). Kotila (1978) tested 18 stream invertebrate taxa to various concentrations, exposure times, and water chemistry and documented

a range of tolerances with some taxa surviving 1,000 ppb over 48 hours and others suffering 50% mortality at concentrations as low as 16.9 ppb over 8 hours.

Initial response to antimycin in lentic habitats appears greater for zooplankton than benthic invertebrates, where reported impacts on assemblages have been slight (Vinson et al. 2010). Recovery following treatments suggest little short or long-term effects of antimycin on lentic macroinvertebrate assemblages (Houf and Campbell; Snow 1974).

Similar to the effects observed with rotenone, zooplankton appeared more sensitive than large benthic invertebrates, small lentic invertebrates, and aquatic insects appeared more sensitive than non-insects, and the insect groups Ephemeroptera, Plecoptera, and Trichoptera appeared more sensitive than Coleoptera and Diptera (Hamilton et al. 2009; Dinger and Marks 2007; Moore et al. 2005; Minckley and Mihalick 1981). Studies of aquatic invertebrate assemblage recovery following antimycin treatment generally reported recovery within one year (Hamilton et al. 2009; Dinger and Marks 2007; Moore et al. 2005; Cerrato 2004; Walker 2003; Morrison 1979; Jacobi and Degan 1977). Invertebrate assemblage abundances returned to pre-treatment levels quicker than biodiversity and taxonomic composition measures (Vinson et al. 2010).

Stefferdud (1977) found short-term increases in invertebrate drift in high-elevation streams but no change in species composition following treatment. Kiner et al. (2000) found no significant differences in species abundance for pre- and post-treatment sites but found differences in relative abundances of some invertebrate groups. In Arizona, Minckley and Mihalik (1981) concluded that long-term changes in the aquatic invertebrate fauna resulting from antimycin A treatment of Ord Creek were minimal but that a few taxa may have been locally eliminated. Cerreto et al. (2003) found that antimycin had little to no effect on aquatic macroinvertebrates in high elevation (approximately 7,900 feet) streams in Bridger-Teton National Forest in Wyoming. Others (Morrison 1979; Houf and Campbell 1977; Snow 1974; Lennon and Berger 1970; Gilderhus et al. 1969; Vezina 1967; Walker et al. 1964) failed to discern adverse effects of antimycin A on invertebrates in general.

Longer-term studies of recovery (one or more years of post-treatment sampling) are limited to the studies by Dinger and Marks (2007) and Hamilton et al. (2009). Dinger and Marks (2007) observed shifts in species composition at Fossil Creek, Arizona towards more tolerant species, but after 24 months, they concluded that there were no discernable pattern in why certain species were eradicated and others were not. Hamilton et al. (2009) reported all pre-treatment taxa were collected within one year post-treatment.

Overall, there have been too few published studies with little comparability with respect to treatment methods and invertebrate sampling efforts to allow for any sweeping statements on the overall effects of rotenone and antimycin on aquatic invertebrates in general and stream invertebrates in particular (Vinson et al. 2010). The effects on invertebrates should be considered on a case-by-case basis; however, recent work suggests that impacts to invertebrate assemblages can be reduced and mortality to target fish species maintained at lower concentrations than have generally been used in the past (Finlayson et al. 2010). To further reduce the impacts and enhance recolonization, the following actions have been recommended: (1) chemical treatments of larger drainages should stage treatments with intermediate barriers and allow time to avoid potential cumulative impacts; (2) headwater and tributary fishless stream reaches should not be treated so they can serve as refuges for invertebrates; and (3) piscicides should be neutralized downstream of the project area to protect downstream colonization sources (Vinson et al. 2010). All of these

recommendations would be met with the proposed project because of the intermittent nature of the Redrock Canyon watershed.

3.6.3 Federally Listed and Candidate Species

3.6.3.1 Affected Environment

The FWS identifies 12 species (9 listed and 3 candidate) with potential to occur in the Canelo Hills area of Santa Cruz County (Table 2). Huachuca water umbel and Canelo Hills ladies tresses have not been found in surveys of suitable habitat in the project area (i.e. perennial springs and stream stretches, particularly within the riparian exclosures), and it is highly unlikely these species were missed in the surveys (J. Douglas, FWS, personal communication, Mar. 2007– PR#87). There are no known State records for jaguar or ocelot from the Canelo Hills (Brown and Gonzalez 2001). Mexican spotted owl has not been found in surveys of Redrock Canyon (G. Frederick, USFS, personal communication). Huachuca springsnail and yellow-billed cuckoo are discussed in Section 3.5.4. Consultation for the Redrock Canyon Native Fish Restoration Project (FWS 2008) included transplant of Gila chub but this activity has been dropped from the current proposal. Effects to the remaining four listed species in Table 3 were reported in a Biological Assessment (USFS and Reclamation 2007, PR#65) and Biological Opinion (FWS 2008, PR#89) prepared for this project. The FS determined that the BO issued June 13, 2008 is sufficient for the new proposed action and no additional section 7 analysis is necessary due to the changed proposed action. A letter was mailed to Steve Spangle on June 17, 2010 notifying the agency that the proposed action has changed and that the reinitiation criteria have not been triggered. A discussion of these species follows below.

Table 3. Federally listed species and candidates for listing found in or near the Redrock Canyon watershed. Species in bold were addressed in the Biological Opinion (FWS 2008).

Common Name	Scientific Name	Status	Occurrence
Amphibians			
Sonora tiger salamander	<i>Ambystoma mavortium stebbinsi</i>	Endangered	Recorded in project area
Chiricahua leopard frog	<i>Lithobates [Rana] chiricahuensis</i>	Threatened	Recorded in project area
Birds			
Mexican spotted owl	<i>Strix occidentalis lucida</i>	Threatened	Nearest Protected Activity Center is 1 mile south. No roosting/nesting habitat in project area.
Yellow-billed cuckoo	<i>Coccyzus americanus</i>	Candidate	1993 record from Falls area
Fish			
Gila topminnow	<i>Poeciliopsis occidentalis</i>	Endangered	Recorded in the project area
Gila chub	<i>Gila intermedia</i>	Endangered	Suitable habitat but no records

Common Name	Scientific Name	Status	Occurrence
Mammals			
Lesser long-nosed bat	<i>Leptonycteris curasoae yerbabuenae</i>	Endangered	Foraging habitat in project area
Jaguar	<i>Panthera onca</i>	Endangered	One record in the southern portion of the Patagonia Mountains in 1965
Ocelot	<i>Leopardus pardalis</i>	Endangered	One record from the Whetstone Mountains in 2010.
Plants			
Huachuca water umbel	<i>Lilaeopsis schaffneriana</i> var. <i>recurva</i>	Endangered	Not recorded in project area
Canelo Hills ladies tresses	<i>Spiranthes delitescens</i>	Endangered	Closest known population is at O'Donnell Creek
Reptiles			
Northern Mexican gartersnake	<i>Thamnophis eques megalops</i>	Candidate	Recorded in project area
Snails			
Huachuca springsnail	<i>Pyrgulopsis thompsoni</i>	Candidate	Not recorded in project area

Sonora tiger salamander. Listed as endangered in 1997, the salamander was only recently discovered in the Redrock Canyon watershed. In February 2003, Sonora tiger salamanders were found in Oak Tank in Oak Grove Spring Canyon (AGFD records – the record is referred to as Kunde Tank, as synonym for Oak Tank)¹³(PR#39). No salamanders were found there in 2009 (USFS records). The 2002 Recovery Plan for Sonora tiger salamander prescribes removal of nonnative species from ponds that contain Sonora tiger salamander (FWS 2002b).

Chiricahua leopard frog. This species was listed as threatened in 2002. It was known from a developed spring at Oak Grove Spring Canyon, a tributary of Redrock Canyon (Scott 1995) but has not been found there for over 10 years. Chiricahua leopard frogs were recorded at a concrete drinker in a drainage west of Oak Grove Spring Canyon in August 1997 (AGFD files). The most recent record of Chiricahua leopard frog was from 2003 at Oak Tank, the same stock tank where Sonora tiger salamanders were found. It is likely the species historically was widely distributed in Redrock Canyon but was greatly reduced or eliminated from the watershed by drought, arrival of nonnative fishes and bullfrogs, and

¹³ The salamanders from Oak Tank have been identified as Sonora tiger salamanders through analysis of mtDNA, but nuclear genetic markers needs to be assessed to rule out the possibility that they are hybrids.

chytrid fungus. The Recovery Plan for Chiricahua Leopard Frog calls for elimination of nonnative predators at or near Chiricahua leopard frog populations, measures to prevent their reinvasion, and establishment of new or reestablishment of former populations (FWS 2007).

Gila topminnow. The species was listed endangered in 1967. Although the population in Redrock Canyon was first documented in 1978, *Gila topminnow* was known from Sonoita Creek before then, and there were earlier unverified reports from Redrock Canyon (Rinne et al. 1980). Current distribution of *Gila topminnow* in Redrock Canyon and the vicinity is described in Appendix B. This population is only one of two naturally occurring populations on Federal lands. The other population is on BLM land in Cienega Creek. Redrock Canyon is an important recovery area for the species because most of the watershed above the Forest boundary is in federal ownership, thus eliminating many potential threats from upstream land and water use. The Recovery Plan for *Gila topminnow* calls for building and maintaining barriers against nonnative fishes, removal of nonnatives present in *Gila topminnow* occupied habitats, and protection and enhancement of existing populations (FWS 1984). Repatriation into historic habitats is a major element of the recovery program.

Lesser long-nosed bat. The lesser long-nosed bat was listed in 1988. This species overwinters in Mexico and moves north in the spring to maternity colonies and lower elevations near blooming columnar cacti. Three known post-maternity bat roosts of greater than 250 bats occur in the vicinity of the proposed project (USFS 2003). The closest roost, Patagonia Bat Cave, is typically occupied from mid-July through mid-September (FWS 1997). Lesser long-nosed bats likely forage in the Redrock Canyon watershed. The two columnar cacti used by the bats are not present in Redrock Canyon, but both paniculate agaves are present. The extent to which lesser long-nosed bats use the most common agave in Redrock Canyon, Scott agave, or amole (*Agave schottii*) is unknown (FWS 2002).

3.6.3.2 Environmental Consequences

3.6.3.2.1 No Action

With no action, nonnative species would continue to pose a threat to federally listed aquatic species in the Redrock Canyon watershed, and future invasions, via upstream migration and through upstream stock tanks, are likely. Because of natural barriers, extirpated federally listed fish are not likely to recolonize Redrock Canyon without human intervention.

If no action is taken, populations of *Gila topminnow*, Chiricahua leopard frog, and Sonora tiger salamander would likely continue to decline in the Redrock Canyon watershed.

Declining water availability in the presence of mosquitofish and bullfrogs is likely to result in extirpation of the native fish and frogs but is unlikely to completely exterminate nonnatives. Once areas become rewatered, mosquitofish will move out to recolonize available water. Bullfrogs would likely be more vulnerable than mosquitofish to the effects of drought; Snyder (2006) found that bullfrogs are eliminated from stock tanks that dry completely. Bullfrog tadpoles would likely persist in permanent water in the creek, such as in Cott Tank Exclosure.

3.6.3.2.2 Proposed Action

Federally listed amphibians and fish would benefit from reduced predation pressure by invasive species. Following successful renovation, restocking salvaged, captive-bred, or translocated *Gila topminnow*,

Chiricahua leopard frog, and Sonora tiger salamander into Redrock Canyon would increase their abundance and distribution. Experience has shown that restocking Gila topminnow without complete removal of mosquitofish would likely fail (Lydeard and Belk 1993). The benefits to listed species from nonnative species removal would persist as long as the target species do not become reestablished in the watershed.

Federally listed species not removed during salvage activities may die from piscicides. Revival of natives affected by rotenone has been reported (Finlayson et al. 2000), such as Sonora tiger salamanders recovered from rotenone treatment of earthen stock tanks in the San Rafael Valley (J. Rorabaugh, FWS, pers. comm. Aug. 2006). It may also be effective for Chiricahua leopard frog adults, although there are no data on this species. The loss of a few individuals of these two species would be acceptable when compared with the substantial improvement in the long-term status of their populations in the Redrock Canyon watershed that would be afforded by the Proposed Action (FWS 2008).

Implementation of the project may affect, likely to adversely affect Gila topminnow, Chiricahua leopard frog, and the Sonora tiger salamander (FWS 2008; PR#89).

The likelihood that lesser long-nosed bats would be in the action area during renovation is discountable because these actions would not occur from mid-July to mid-September when nearby post-maternity roosts are occupied, and the distance of the action area to known maternity roosts is beyond the known foraging range of roosting bats. Agaves would not be harmed. Implementation of the proposed action may affect, but is not likely to adversely affect individuals of lesser long-nosed bat (FWS 2008; PR#89).

3.6.4 Forest Sensitive Species (FSS)

FSS are those species that are likely to occur or have habitat on National Forest Service System lands and that have been identified by the Regional Forester as of concern for reduction in population viability as evidenced by downward trends in population numbers and/or downward trends in habitat capability that would reduce the species distribution. The Region 3 Regional Forester's Sensitive Species list applies to the Forest.

3.6.4.1 Affected Environment

The FSS identified in Table 3 have been recorded in the project area or have the potential to occur in the project area because apparently suitable habitat exists there. See Biological Evaluation and Management Indicators Species Analysis (PR #62) for a complete record of species considered for analysis.

Implementation of the project would have no impact on individuals.

Table 4. Forest Service Sensitive Species found in or near the project location. Sources include AGFD Heritage Data Management System and Forest Service project files.

Common Name	Scientific Name	Occurrence
Birds		
Northern gray hawk	<i>Accipiter gentilis apache</i>	Nests in the watershed. The species uses riparian woodland with large trees, usually near mesquite forests, and forages on lizards and small mammals.

Common Name	Scientific Name	Occurrence
Northern beardless tyrannulet	<i>Campostoma imberbe</i>	Inhabit fairly open riparian woodlands, including lower canyons and heavily wooded dry washes. Surface water is frequently found near occupied locations, but not required.
Western yellow-billed cuckoo	<i>Coccyzus americanus occidentalis</i>	Nests in the watershed. Primarily restricted to densely wooded rivers and streams and damp thickets with relatively high humidity. Found locally along lowland drainages where stands of multistructured native riparian woodlands occur.
Rose-throated becard	<i>Pachyramphus aglaiae</i>	Primarily encountered in tall, shady riparian woodlands along small perennial or intermittent mountain foothill drainages and canyons. Occupied nesting locations typically have large Arizona sycamore, Fremont cottonwood, and velvet ash and an understory of velvet mesquite, netleaf hackberry, and tree saplings.
Thick-billed kingbird	<i>Tyrannus crassirostris</i>	Primarily among riparian gallery woodlands along perennial or intermittent creeks and rivers. Most occupied drainages have broader flood plains. The birds rarely found nesting in steeper and narrower mountain canyons.
Fish		
Longfin dace	<i>Agosia chrysogaster</i>	Until mid-1990s, they were common throughout the mainstem of Redrock Canyon from above Camp Spring downstream to below the Forest Service boundary and in Lampshire Canyon below Lampshire Dam and in the lower half of Oak Grove Spring Canyon and its two main tributaries (Steffered unpub. data).
Desert sucker	<i>Pantosteus clarki</i>	Periodically found in Redrock Canyon below the Falls.
Plants		
Greene milkweed	<i>Asclepias uncialis</i> ssp. <i>uncialis</i>	Recorded within 1 mile of project location (near Lampshire Canyon), potential habitat exists. The plant has a broad range, but is always rare and has small populations.
Sonoran noseburn	<i>Tragia laciniata</i>	Found within the project location. Suitable habitat exists. This plant grows along streams, canyon bottoms, and shaded hillsides at 3,500 to 5,650 feet in elevation.
Reptiles		
Northern Mexican Gartersnake	<i>Thamnophis eques megalops</i>	Reported in Redrock Canyon near the Cott Tank enclosure (L. Jones pers. comm.). Riparian obligate species and uses cienegas, stock tanks, rivers, streams, and springs.
Snails		

Common Name	Scientific Name	Occurrence
Huachuca springsnail	<i>Pyrgulopsis thompsoni</i>	Found in springs and cienegas at 4,500 to 7,200 feet elevation at nine sites in the upper San Pedro River drainage (Huachuca Mountains, Canelo Hills, San Rafael Valley), and four in the upper Santa Cruz River drainage (Sonoita Creek drainage, San Rafael Valley, Santa Cruz River drainage—Sonora). Surveys did not report the species from Redrock Canyon (Landye 1981)

3.6.4.2 Environmental Consequences

3.6.4.2.1 No Action

The No Action alternative could negatively affect species that would benefit from aquatic nonnative species removal and native fish reestablishment. The only species likely to be adversely affected by not implementing the project would be aquatic FSS known or likely to occur in Redrock Canyon (i.e., longfin dace, desert sucker and Northern Mexican gartersnake) because predation pressure from nonnative aquatic species would continue.

3.6.4.2.2 Proposed Action

Birds. Potential effects of rotenone and antimycin A on birds, as previously explained, are predicted to be insignificant and discountable at concentrations authorized for use in fisheries management. Nesting birds, if present during implementation, may be disturbed by project personnel but the disturbance would be short term (i.e. less than 8 hours) and not likely to impact reproduction. Riparian habitat loss is the primary threat for the birds listed in Table 3. No riparian habitat would be lost as a result of implementing the proposed action, and no other effects are expected to the vegetation used as habitat for these birds or to their food sources (e.g. insects, small mammals, etc.). For these reasons, the proposal may impact individuals of northern grey hawk, northern beardless tyrannulet, western yellow-billed cuckoo, rose-throated becard, and thick-billed kingbird, but it is unlikely to result in a trend toward federal listing or a loss of viability (PR#62).

Fish. Beneficial effects to FSS fish species from removal of nonnatives would be long term. Release of existing populations from the pressure of nonnative predation would allow them to reoccupy all available habitats, subject to constraints of precipitation and surface water availability. Removal of nonnatives would promote more suitable habitat for the species.

Piscicides may kill longfin dace and desert sucker that were missed in salvage operations. However, restocking following detoxification would result in higher abundance and wider distribution of these species and a net gain. Desert sucker are uncommon in the watershed and unlikely to be present during treatments conducted at the time of year with little to no stream-flow. Implementation of the proposed

action, may impact individuals of longfin dace and desert sucker, but is unlikely to result in a trend toward federal listing or a loss of viability (PR#62).

Plants. All of the plant species in Table 3 are closely tied to wet areas and, therefore, could be present in the treatment sites. Foot traffic could damage plants but the impacts would not be of sufficient volume or intensity to destroy individuals or harm populations. Implementing the proposed action, may impact individuals of Greene milkweed and Sonoran noseburn, but is unlikely to result in a trend toward federal listing or a loss of viability (PR#62).

Reptiles. Northern Mexican gartersnakes are not expected to be affected by piscicides because they breathe air (Fontenot et al. 1994). During the period between the time nonnative fish are removed from the system and the time native fish are stocked, the fish prey base for the snake would be eliminated. Alternative prey, such as frogs would remain, and some tadpoles are also expected to survive. AGFD would attempt to capture and temporarily hold any Northern Mexican gartersnakes in specially designed facilities until an adequate prey base has been reestablished. For these reasons, implementing the proposed action, may impact individuals of Northern Mexican gartersnake, but is unlikely to result in a trend toward federal listing or a loss of viability (PR#62).

Snails. Huachuca springsnail is typically found in the shallower areas of springs or cienegas, often in rocky seeps at the spring source. The species has a low potential to occur in areas subject to piscicide treatment. If the species is present, it would occur in springheads in the more peripheral areas of the drainage network. These areas would be treated with antimycin, which has a low toxicity to snails. Project personnel working in springs that may have potential Huachuca springsnail habitat would be trained to look for springsnails during pre-project reconnaissance, salvage operations, and piscicide application. If present, the snail would be salvaged and restocked into the area of their capture following treatment. However, even with salvage, some limited mortality may occur. Although the project may impact individual Huachuca springsnails, it is unlikely to result in a trend toward Federal listing or a loss of viability (PR#62).

3.6.5 Management Indicator Species (MIS)

National Forest Management Act (NFMA) implementing regulations (36 CFR 219.19) and Forest Service Manual (FSM) 2600 guidance require that Forest Plans identify certain vertebrate and/or invertebrate species as management indicator species (MIS) and that these species be monitored “in order to assess the effects of management activities on their populations and the populations of other species with similar habitat needs which they may represent (FSM 2620.5).” The Land and Resource Management Plan (LRMP) identifies thirty-three MIS and one group (primary and secondary cavity-nesters) in 8 indicator groups (U.S. Forest Service 1986, Appendix G, pages 128-129). In general, LRMP direction for MIS is to “maintain or improve occupied habitat for...management indicator species.”

3.6.5.1 Affected Environment

The LRMP identifies thirty-three MIS and one group (primary and secondary cavity-nesters) in 8 indicator groups (USFS 1986, Appendix G, pages 128-129). Nine species and one group (cavity nesters) were selected for analysis as management indicators at the project level based on their known occurrence within the project area, the presence of suitable habitats or the potential for the species to be affected by the proposed actions (Table 5, selected species in bold). The remaining 24 species were eliminated from

consideration in the analysis because: 1) their known distributions are well outside the project area, 2) the project area does not contain suitable habitats for the species, 3) the species or its habitat may be present in the project area but the nature of the proposed action is such that the species would not be affected by the action, and/or 4) the species is not identified as an indicator for a specific habitat type in the LRMP. The fourth category includes species that are Threatened, Endangered, or Forest Service Sensitive species for which effects are analyzed in the biological assessment and evaluation (PR#62).

Table 5. Management Indicator Species identified in the LRMP for the Forest. Species in bold are found in or near the project area or suitable habitat exists and have not been considered for analysis in other sections of this EA.

Group		Species	Evaluation for Analysis
1	Cavity Nesters	Coppery-tailed (Elegant) Trogon	Potential habitat exists in the project area.
		Sulphur-bellied Flycatcher	Recorded in or near project area. Suitable habitat exists.
		Other primary and secondary cavity nesters*	Occur near the project area. Suitable habitat is available near the project area. Monitored through breeding bird surveys.
2	Riparian Species	Gray hawk	Nests within analysis area. Suitable habitat exists. See section 3.6.4
		Blue-throated hummingbird	Recorded in or near project area. Suitable habitat exists.
		Coppery-tailed (elegant) trogon	Potential habitat exists in the project area.
		Rose-throated becard	Recorded in or near project area. Suitable habitat exists. See section 3.6.4
		Thick-billed kingbird	Recorded in or near project area. Suitable habitat exists. See section 3.6.4
		Sulphur-bellied flycatcher	Recorded in or near project area. Suitable habitat exists.
		Northern Beardless tyrannulet	Recorded in or near project area. Suitable habitat exists. See section 3.6.4
		Bell's vireo	Recorded in or near project area. Suitable habitat exists.
		Black bear	Occurs near the project area with suitable habitat.
3	Species Needing	White-tailed deer	Occurs near the project area with suitable habitat. Monitored by Arizona Game and Fish Department (AGFD).

Group		Species	Evaluation for Analysis
	Diversity	Merriam's turkey	Outside the known range of the species.
		Coppery-tailed (elegant) trogon	Potential habitat exists in the project area.
		Sulphur-bellied flycatcher	Recorded in or near project area. Suitable habitat exists.
		Buff-breasted flycatcher	Not recorded in or near project area.
		Black bear	Occurs near the project area with suitable habitat.
4	Species Needing Herbaceous Cover	White-tailed deer	Occurs near the project area with suitable habitat. Monitored by Arizona Game and Fish Department (AGFD).
		Mearn's quail	Occurs near project area. Suitable habitat available adjacent to some of the project area.
		Pronghorn antelope	Does not occur within the analysis area; no suitable habitat.
		Desert massasauga	Outside the known range of the species.
		Baird's sparrow	No suitable habitat in the project area.
5	Species Needing Dense Canopy	Bell's vireo	Recorded in or near project area. Suitable habitat exists.
		Northern beardless tyrannulet	Recorded in or near project area. Suitable habitat exists.
		Gray hawk	Nests within analysis area. Suitable habitat exists.
6	Game Species	White-tailed deer	Occurs near the project area with suitable habitat. Monitored by Arizona Game and Fish Department (AGFD).
		Mearn's quail	Occurs near project area. Suitable habitat available adjacent to some of the project area.
		Pronghorn antelope	Does not occur within the analysis area; no suitable habitat.
		Desert bighorn sheep	Outside the known range of the species. Not a habitat indicator.
		Merriam's turkey	Outside the known range of the species.
		Black bear	Occurs near the project area with suitable habitat.
7	Special Interest Species	Mearn's quail	Occurs near project area. Suitable habitat available adjacent to some of the project area.
		Gray hawk	Nests within analysis area. Suitable habitat exists.
		Blue-throated hummingbird	Recorded in or near project area. Suitable habitat exists.
		Coppery-tailed (elegant) trogon	No suitable habitat exists in the project area.
		Rose-throated becard	Recorded in or near project area. Suitable habitat exists.

Group		Species	Evaluation for Analysis
		Thick-billed kingbird	Recorded in or near project area. Suitable habitat exists.
		Sulphur-bellied flycatcher	Recorded in or near project area. Suitable habitat exists.
		Buff-breasted flycatcher	Not recorded in or near project area.
		Northern beardless tyrannulet	Recorded in or near project area. Suitable habitat exists.
		Five-striped sparrow	Potential habitat exists, but no confirmed nesting in project area.
8	Threatened and Endangered Species	Desert bighorn sheep	Outside the known range of the species. Not a habitat indicator.
		Gray hawk	Nests within analysis area. Suitable habitat exists.
		Peregrine falcon	No suitable habitat in the project area. Not a habitat indicator.
		Blue-throated hummingbird	Recorded in or near project area. Suitable habitat exists.
		Coppery-tailed (Elegant) trogon	No suitable habitat exists in the project area.
		Rose-throated becard	Recorded in or near project area. Suitable habitat exists.
		Thick-billed kingbird	Recorded in or near project area. Suitable habitat exists.
		Sulphur-bellied flycatcher	Recorded in or near project area. Suitable habitat exists.
		Buff-breasted flycatcher	Not recorded in or near project area.
		Northern beardless tyrannulet	Recorded in or near project area. Suitable habitat exists.
		Bell's vireo	Recorded in or near project area. Suitable habitat exists.
		Baird's sparrow	No suitable habitat in the project area.
		Five-striped sparrow	Potential habitat exists, but no confirmed nesting in project area.
		Mexican stoneroller	Outside the known range of the species.
		Arizona (Apache) trout	Outside the known range of the species.
		Gila topminnow	Found in project area. See section 3.6.3
		Gila chub	Not recorded in the project area.
		Sonora chub	Outside the known range of the species.
		Desert massasauga	Outside the known range of the species.
		Twin-spotted rattlesnake	Outside the known range of the species.
		Arizona ridge-nosed rattlesnake	Potential habitat exists. See Biological Evaluation (PR#19)
		Sonora tiger salamander	Outside the known range of the species.

Group	Species	Evaluation for Analysis
	Tarahumara frog	Outside the known range of the species.
	Western barking frog	No suitable habitat exists in the project area.
	Spikedace	Outside of the known range of the species.
	Arizona treefrog	Potential suitable habitat. Not a habitat indicator.
	Mt. Graham spruce (red) squirrel	Outside the known range of the species.
	Gould's turkey	Occurs near the project area. Not a habitat indicator. See discussion in Biological evaluation (PR#19).

* Primary Cavity Nesters

ladder-backed woodpecker, Arizona woodpecker, northern flicker, Gila woodpecker, acorn woodpecker, hairy woodpecker

* Secondary Cavity Nesters

American kestrel, elf owl, flammulated owl, whiskered screech owl, western screech owl, northern pygmy-owl, brown-crested flycatcher, ash-throated flycatcher, dusky capped flycatcher, Cordilleran flycatcher, violet green swallow, juniper titmouse, bridled titmouse, white-breasted nuthatch, house wren, Bewick's wren, eastern bluebird, European starling, Lucy's warbler.

3.6.5.2 Environmental Consequences

3.6.5.2.1 No Action

If no action is taken, MIS would not be impacted, except for Gila topminnow, Sonora tiger salamander, and Arizona treefrog. See section 3.6.3 and 3.6.4

3.6.5.2.2 Proposed Action

All species in bold in Table 5 are expected to have the same effects as the Terrestrial or Aquatic Wildlife species considered in section 3.6.1 and section 3.6.2. Implementation of the proposed action would not result in a net loss of habitat for MIS. While human activities associated with nonnative fish removal and native fish reestablishment may disturb nesting birds, the disturbance would be short-lived and would not cause a detectable change in population numbers and trends of species. MIS may have short-term exposure to water treated with piscicides or piscicide-killed fish, but no significant effects are anticipated. See sections 3.6.1 and 3.6.2 for further analysis on the effects of eating piscicide-killed fish or drinking piscicide-tainted water.

3.6.6 Migratory Bird Species Analysis

Executive Order 13186, of January 10, 2001 directs Federal agencies to support migratory bird conservation and to “ensure that environmental analyses of Federal actions required by the NEPA or other established environmental review processes evaluate the effects of actions and agency plans on migratory birds, with emphasis on species of concern.” Advice from the Forest Service Southwestern Regional Office is to analyze effects in the following manner: (1) effects to Species of Concern listed in the Arizona Partners in Flight Bird Conservation Plan; (2) effects to Important Bird Areas (IBAs) identified by the National Audubon Society; and (3) effects to important overwintering areas.

3.6.6.1 Affected Environment

The Arizona State Partners in Flight Bird Conservation Plan (Latta et al. 1999) lists priority species of concern by vegetation type. A review of all species of concern for vegetation types found in this project area was completed. Table 5 displays the species that may occur in or near the project area.

Five species classified as Low Elevation Riparian were not considered in the analysis because the project area does not contain suitable habitat or the project area is outside of the known range for the species. The species include: thick-billed parrot, common black-hawk, southwestern willow flycatcher, McGillivray's warbler, and red-faced warbler.

Two species classified as Desert grassland were not considered in the analysis because the project area does not contain suitable habitat, or the project area is outside of the known range for the species. These species include: Aplomado falcon and rufous-winged sparrow.

Table 6. Priority species in Arizona State Partners in Flight Bird Conservation Plan (Latta 1999) that occur or have potential habitat in the project.

Species	Habitat Type	Habitat Description/Comments
Western yellow-billed cuckoo	Low Elevation Riparian	Cottonwood/willow at highest occurrence and density. Does not require a dense understory but dense mid-high level canopy.
Lucy's warbler	Low Elevation Riparian	Mesquite, willow, cottonwood. Require a dense midstory. Secondary cavity nester.
Botteri's sparrow	Desert grassland	Bunch grasses, shrub component. Require ground cover of tall high stem densities.
Cassin's sparrow	Desert grassland	Grasses (Gramas, three-awns, Sporobolus) and a shrub component (mesquite, acacia, ocotillo, yucca). Ground cover is important but not quantified (grasses not forbs).
Baird's sparrow	Desert grassland	Bunchgrasses (Gramas, three-awns, lovegrasses, bluestem). Found in rolling grasslands between 3,000 and 5,000 feet elevation. Require ground cover and no canopy.
Grasshopper sparrow	Desert grassland	Bunchgrasses (Gramas, three-awns, lovegrasses, bluestem). Found in rolling grasslands between 3,000 and 5,000 feet elevation. Require ground cover and no canopy.

Important Bird Areas (IBA)

The Arizona Important Bird Areas (IBA) Program is an effort to inventory Arizona's natural areas, and is part of a worldwide program overseen by National Audubon and Bird Life International. IBA Program

goals are to: 1) identify, document, and recognize the most important areas for birds, 2) engage people in citizen-science and conservation projects, and 3) partner with others to bring resources to IBAs in need of conservation. IBAs may support significant populations of endangered or species of concern. They may support significant concentrations of birds (waterfowl, waterbirds, shorebirds, raptors, landbirds), or be sites with rare or exceptional representative habitat and bird assemblages, or with long-term research or educational programs. To date, 26 IBAs in Arizona have been identified.

Three sites have been identified as an IBA by the National Audubon Society (<http://www.tucsonaudubon.org/azibaprogram/ibalist.htm>) near the project area. These include the Huachuca Mountains, Sonoita Creek State Natural Area/Patagonia Lake, and Appleton-Whittle Audubon Research Ranch.

3.6.6.2 Environmental Consequences

3.6.6.2.1 No Action

If no action is taken, Migratory Birds would not be impacted.

3.6.6.2.2 Proposed Action

Implementation of the proposed action is not expected to have any effect on the designation of the IBA or to affect the characteristics that led to the designation of the IBA. Birds may be susceptible to consuming piscicide-tainted water or piscicide-killed fish, but no effects are anticipated. See sections 3.6.1 for further analysis of the proposed action on birds and terrestrial wildlife. Human presence during proposed activities may disturb nesting birds, but the disturbance would be short-lived and would not cause a detectable change in population numbers and trends of species in this group. Birds listed in Table 6 and birds found in the IBAs are not expected to be affected by any of the proposed actions.

3.6.7 Cumulative Effects

All actions listed at the beginning of chapter 3 have the potential to negatively affect wildlife species, through disturbance or habitat degradation, but implementation of this project is not expected to cause significant cumulative effects.

Loss of surface water in Redrock Canyon is a potentially serious impediment to native aquatic species conservation. According to the water budget created for Redrock Canyon, the cumulative effects of groundwater pumping and creation of present and future water sources for livestock or private use is not considered significant. These cumulative actions along with implementing the proposed action would not result in significant impacts to wildlife.

3.7 CULTURAL RESOURCES

3.7.1 Affected Environment

Southern Arizona was occupied by small mobile bands of hunter-gathers from the beginning of the Paleoindian period about 11,000 B.C. to the end of the Archaic period around 1200 B.C. By the end of the Archaic, pithouse villages were established near agricultural fields along the larger streams, while procurement and campsites continued to be located away from major river valleys. Probably Archaic sites are represented by lithic scatters and possible campsites on ridge tops and near water sources in and around the Patagonia Mountains.

An agriculture economy, combined with hunting and wild plant collecting, continued to be followed throughout the rest of the Early Agricultural and Ceramic period (ending ca. AD 1450) in southern Arizona. Ceramic period occupation in the Redrock Canyon area is indicated by scattered habitation sites along major drainages as well as smaller, probably special use sites. Ceramics and other artifacts from identified sites suggest interaction with the Trincheras Culture to the south as well as the Hohokam to the north.

The O'odham occupied the area around Redrock Canyon and nearby Sonoita Creek when the Spanish first visited the area in the 1690s. After settling in the Santa Cruz Valley, Spanish settlers also used the area for limited mining, charcoal production, and grazing until increased Apache hostilities forced its abandonment in the mid to late 1700s. The Patagonia areas was used intermittently by the O'odham, Mexicans and Americans after the Gadsden Purchase (1854) when southern Arizona became a territory of the United States. Mining and grazing became better established after Apache hostilities declined in the 1880s, and grazing continues to be the major land use in the area today.

Most archaeological surveys in the project area have been conducted by the Forest Service in association with a number of range management projects, including fence lines, riparian exclosures, and stock tanks. Four previously identified archaeological sites are located within a mile of the project area, but none are close enough to be affected by implementation. All four represent prehistoric ceramic period occupations. The closest site is situated on the north bank of Redrock Creek. This habitation site's location on a high terrace above the stream precludes any impact from implementation.

The scoping letter for the Native Fish Restoration Project was sent to 12 Native American tribes with traditional ties to southeastern Arizona; no comments were received. Archaeologists from Reclamation and the Forest conducted a Class III Survey of the areas that would undergo ground-disturbing activities. No cultural resources were identified within the footprint of the analysis area. A finding of "no historic properties affected" was made by Reclamation following the survey. The CNF concurred with this finding in an Inventory Standards and Accounting form, signed by Forest Archaeologist Mary Farrell and Forest Supervisor Jeanine Derby on December 8, 2006 (PR#38). The State Historic Preservation Office concurred with this determination on January 11, 2007 (PR#41).

3.7.2 Environmental Consequences

3.7.2.1 No Action

There would be no change in existing conditions. Current land use and management practices would continue, as would Federal protection to cultural properties now in place. Minimal impact to cultural resources would be anticipated as the result of not implementing the Redrock Canyon fish restoration project.

3.7.2.2 Proposed Action

The proposed fish restoration activities (native salvage, nonnative removal, native restoration, monitoring) would have minimal to no impact to any potential cultural resources in the area. Nonnative species removal and native fish restoration would not involve any ground-disturbing activities and would largely take place in the immediate vicinity of water resources with margins previously disturbed by flooding or tank construction. These activities would have no effect on cultural resources within the fish restoration area.

3.7.3 Cumulative Effects

Because there would be no direct or indirect impacts to vegetation, cumulative impacts would be precluded.

3.8 SOCIOECONOMIC EFFECTS—LIVESTOCK GRAZING

3.8.1 Affected Environment

The Redrock Canyon watershed encompasses all or portions of four livestock grazing allotments administered by the Forest Service. These allotments are Seibold-Crittenden, Kunde, Papago, and San Rafael. Livestock management on each of these allotments is guided by an allotment management plan (AMP). Implementation of the AMP is documented in the Annual Operating Instructions (AOI). The AOI sets forth the maximum permissible grazing use authorized for the upcoming grazing season, the planned sequence of grazing, improvements to be constructed, reconstructed or maintained; allowable use or other standards to be followed by the permittee; and required monitoring for the grazing season. Management of the four allotments is described below.

Seibold-Crittenden Allotment. The allotment was created by combination of the Crittenden and Seibold allotments in 2005. The allotment contains 10 pastures, of which six occur within the Redrock Canyon watershed. The Corral Canyon, Red Bear, Oak Grove, and Moonshine are grazed by the main herd as part of a six-pasture rotation. The East and West Redrock Pastures are grazed with 30 head of heifers and or/cows for up to 90 days (90 animal unit months (AUMs)¹⁴) during the winter (November-April); except that once every 3 to 5 years, the entire herd may graze these two pastures for 1 month (130 AUMs) in the winter.

Kunde Allotment. The Kunde Allotment occupies the middle portion of the drainage and consists of four pastures: Holding, Lower Lampshire, Upper Lampshire, and Redrock. Redrock Canyon passes through the Redrock Pasture. Livestock management was changed in 1991 to require only winter use is pastures along Redrock Creek. Permitted numbers were reduced from 100 cattle yearlong (CYL)¹⁵ to 53 CYL. In October 2003, the Forest issued a decision to make Redrock Pasture a riparian pasture to improve riparian and watershed conditions. Permitted numbers were reduced to 31 CYL to reflect the reduction in available capable acres. The AMP signed in 2006 established a three-pasture rotational grazing schedule using Upper Lampshire, Lower Lampshire, and Holding pastures to allow growing season rest in all pastures, at least every other year.

Papago Allotment. The allotment consists of a 14-pasture deferred rotation grazing system, of which Lampshire pasture is the only one within the Redrock Canyon watershed. Lampshire pasture is grazed annually during December-January or February-March.

¹⁴ One AUM is equivalent to enough forage to support one adult cow without a calf for 1 month's time.

¹⁵ CYL represents the number of adult cattle that are being raised year-round.

San Rafael Allotment. The upper part of the drainage is included in the San Rafael allotment. Of a 23 pasture run operation, only two pastures are within the Redrock Canyon watershed: North Redrock and South Redrock. These two pastures are grazed in rotation during winter from October through March.

3.8.2 Environmental Consequences

3.8.2.1 No Action

There would be no effect to livestock grazing under this alternative.

3.8.2.2 Proposed Action

3.8.2.2.1 Nonnative Species Removal

Nonnative species removal from stock tanks and surface waters would occur on all four of the allotments within the project area. The Forest Service would cooperate with livestock grazing permittees to avoid disruption of grazing operations. Pumping of stock tanks to facilitate nonnative removal may affect surface water availability in the short term for livestock if livestock are present during or shortly after pumping. Coordination with the permittee and temporary management changes would occur if a stock tank is pumped dry or drawn down to a point that it is not useable.

Piscicides would be applied in accordance with a Forest Supervisor-approved Pesticide Use Proposal during periods of low stream flow. There are four reaches of Redrock Canyon mainstem that have perennial surface water, all of which are in exclosures. A fifth area in the Redrock pasture of the Kunde allotment may have surface water that would be treated. Additional surface water may be present outside the exclosures during treatments. Livestock in all allotments, except the Kunde allotment, would not be affected by piscicides because implementation would occur in May or June when cattle are not grazed in these pastures. If a decision to re-authorize grazing on the Redrock Pasture is issued, cattle could potentially be present in the pasture during the proposed renovation; however, it is highly unlikely because the permittees have alternative pastures to use (J. Heitholt, USFS, personal communication, Sept. 2009). The only area of naturally occurring surface water in the Redrock Pasture would be fenced to exclude livestock. If the decision is not signed, cattle would not be present during the renovation project and there would be no effect on cattle or the grazing rotation.

Piscicides would also be applied to surface water outside of riparian exclosures, such as earthen stock tanks. There are approximately 17 stock tanks in the watershed, although only three are perennial. Effects to cattle are not anticipated (see section 3.6.1 for effects to animals) when rotenone or antimycin A are used. Rotenone was used as a control for grub on dairy and beef cattle for many years with no adverse effects although this practice has since been discontinued per EPA. Although, EPA has reported that there is no need to restrict livestock consumption of treatment waters (Finlayson et al. 2000).

3.8.2.2.2 Native Species Transplants

In 2002, the Forest Service consulted on continuation of livestock grazing on the Coronado National Forest including the Seibold-Crittenden and San Rafael allotments. A separate consultation also occurred in 2004 for the issuance of 10-year grazing permits (2003-2013) for the Kunde and Papago allotments and implementation of Allotment Management Plans. The consultation included the four allotments contained in the project area. Terms and conditions for incidental take were issued. Implementing the proposed action would result in no additional restrictions or limitations to ongoing livestock operations

(FWS 2008). Livestock grazing permittees in the Redrock Canyon watershed would continue to follow Forest Standards and guidelines for grazing and their approved AMP, and the Forest Service would ensure all terms and conditions for incidental take statements are followed.

3.8.3 Cumulative Effects

Neither action alternative is expected to alter existing livestock grazing practices within the watershed. Therefore, the proposed project would not have incremental or additive socioeconomic effects on grazing operations.

3.9 RECREATION

3.9.1 Affected Environment

3.9.1.1 Visual Quality

Landscape character in the project area is comprised of rolling topography covered with a mosaic of vegetation that includes semi-desert grassland, evergreen oak woodland, and mesquite-prickly pear. Along the creek through Redrock Canyon is riparian vegetation comprising cottonwood, willow, and lush grasses. Existing condition of visual quality in the area is generally good.

Visual Quality Objectives (VQO) established for National Forest lands provide standards that govern proposed alteration of the landscape. The Forest Plan designates the project area with a VQO of “modification,” which means that while management activities may visually dominate the characteristic landscape, they must utilize naturally established form, line, color, and texture. According to the VQO inventory, the nearest visually sensitive travel ways in the project area include Highway 82 (Sensitivity Level 1: High) and FSR 85 (Sensitivity Level 2: Average). In addition, a project-level review reveals that the Arizona Trail passes through the project area, and this route would qualify as a Sensitivity Level 1 travel way.

3.9.1.2 Recreation

There are no developed recreation sites in the project area. Dispersed uses throughout this part of the forest include scenic driving, hiking, bird watching, camping, and hunting. In the project area, Arizona Trail use (including hiking, horseback riding, and mountain biking) and exploration of backroads on off-highway vehicles are popular recreation activities. However, there is poor access and rugged terrain in the Redrock Canyon watershed, so most recreational use occurs on existing roads and trails. The Arizona Trail bisects the upper watershed, crossing the creek at several locations that would be subject to piscicide treatments. Access for high clearance, four-wheel-drive vehicles is provided by Forest roads. The historic road that formerly ran the length of Redrock Canyon has been closed to vehicles for many years.

3.9.2 Environmental Consequences

3.9.2.1 No Action

There would be no effect to visual quality or recreational use, under this alternative.

3.9.2.2 Proposed Action

There would be no effect to visual quality under this alternative. There may be a slight disturbance to recreational users in the areas where piscicide application and bullfrog eradication activities are being conducted. Piscicide application areas would be closed to the public during treatments.

Piscicides would be applied at the driest time of year, which also tends to be the hottest. No data are available on the amount and seasonality of recreation use but the closure order issued in May/June is not expected to have a measurable impact to the recreating public.

3.9.3 Cumulative Effects

Because there would be no direct or indirect impacts to vegetation, cumulative impacts would be precluded.

3.10 ENVIRONMENTAL JUSTICE

Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Executive Order 12898 (February 11, 1994) directed all Federal agencies to evaluate their proposed actions to determine the potential for disproportionate adverse impacts to minority and low-income populations. The memorandum from the President to heads of departments and agencies that accompanied the Executive Order states that “each Federal agency shall analyze the environmental effects, including human health, economic and social effects, of Federal actions, including effects on minority communities and low-income communities, when such analysis is required by [NEPA].”

3.10.1 Affected Environment

The population of Santa Cruz County in 2008 was estimated at 42,923 and a density of 31 people per square mile reported in 2000. In 2007, it was estimated that 97 percent of the population was white, 0.6 percent black, and 1 percent American Indian. Of the 97 percent of the population that is white, 80.2 percent classify themselves as having Hispanic or Latino origin. Median household income in 2007 was estimated at \$35,661 with 21.1 percent of the population with incomes below the national poverty level. The population center nearest to the project area is Patagonia, AZ

3.10.2 Environmental Consequences

There would be no displacement of minorities or increases in taxes or fees that would constitute an economic hardship to minorities under any of the alternatives. Implementation of either of the alternatives evaluated in this EA would not result in adverse impacts to environmental resources and socioeconomic conditions. Therefore, disproportionate direct, indirect or cumulative adverse impacts on low income or minority populations would not occur.

CHAPTER 4 – CONSULTATION AND COORDINATION

4.1 LIST OF PREPARERS

Melinda Fisher, USDA Forest Service, Coronado National Forest, Biologist
Glenn Frederick, USDA Forest Service, Coronado National Forest, District Biologist
Rick Gerhart, USDA Forest Service, Coronado National Forest, Wildlife Program Manager
Andrea Campbell, USDA Forest Service, Coronado National Forest, NEPA Coordinator
James Heitholt, USDA Forest Service, Coronado National Forest, Range Conservationist
Tom Lorenz, USDA Forest Service, Coronado National Forest, District Range Staff
William Gillespie, USDA Forest Service, Coronado National Forest, Archaeologist
Debby Kriegel, USDA Forest Service, Coronado National Forest, Landscape Architect
Bob Lefevre, USDA Forest Service, Coronado National Forest, Hydrologist
Don Mitchell, Arizona Game and Fish Department, Biologist

4.2 OTHER CONTRIBUTORS

Amy Unthank, USDA Forest Service, Southwestern Region, Biologist
Doug Duncan, US Fish and Wildlife Service, Biologist
Mima Falk, US Fish and Wildlife Service, Botanist
Jim Rorabaugh, US Fish and Wildlife Service, Biologist
Jeff Servoss, US Fish and Wildlife Service, Biologist
Jerome Stefferud, Biologist
Sally Stefferud, Marsh & Associates, LLC, Biologist
Tom Jones, Arizona Game and Fish Department, Biologist
Mike Sredl, Arizona Game and Fish Department, Biologist
Ross Timmons, Arizona Game and Fish Department, Biologist
Rob Clarkson, Bureau of Reclamation, Biologist
Marci Donaldson, Bureau of Reclamation, Archaeologist
John McGlothlen, Bureau of Reclamation, NEPA Specialist
Henry Messing, Bureau of Reclamation, Biologist

4.2 AGENCIES AND PERSONS CONTACTED

Libraries

Patagonia Public Library

Chamber of Commerce

Nogales/Santa Cruz County Chamber of Commerce

Indian Communities

Ak-Chin Indian Community	Tohono O'odham Nation
Fort Sill Apache Tribe	Pascua Yaqui Tribe
Gila River Indian Community	Pueblo of Zuni
Mescalero Apache Tribe	White Mountain Apache Tribe
Salt River Pima-Maricopa Indian Community	Yavapai Apache Nation
San Carlos Apache Tribe	The Hopi Tribe

Town Agencies

Patagonia Town Council

County Agencies

Santa Cruz Board of Supervisors

Santa Cruz County Health Services

State Agencies

Arizona Department of Agriculture

Arizona Department of Environmental

Arizona Department of Water Resources

Arizona Game and Fish Department

Arizona State Historic Preservation Office

Federal Agencies

US Fish and Wildlife Service

US Army Corps of Engineers

Conservation and Environmental Organizations

American Rivers

Arizona Riparian Council

Center for Biological Diversity

Desert Fishes Council

The Nature Conservancy

Friends of Arizona Rivers

Forest Guardians

Sierra Club

Sky Island Alliance

Grazing Organizations

Arizona Cattle Growers Association

Canelo Hills Coalition

Livestock Grazing Permittees

Other Organizations

Arizona Cooperative Extension Service

Arizona People for the American Way

REFERENCES

- Adams, M.J., C.A. Pearl, and B.R. Bury. 2003. Indirect facilitation of an anuran invasion by nonnative fishes. *Ecology Letters* 6:343-351.
- ADWR (Arizona Department of Water Resources). 2009. Well Registry Database available at <https://gisweb.azwater.gov/waterresourcedata/>.
- AFSFMCS (American Fisheries Society Fish Management Chemicals Subcommittee) and eight coauthors. 2001. Fisheries forum opinion: response to Begel (2001). *Fisheries* 26(8):40.
- Alam M., and W.J. Schmidt. 2002. Rotenone destroys dopaminergic neurons and induces Parkinsonian symptoms in rats. *Behavioural Brain Research* 136(1):317-324.
- Alam M., and W.J. Schmidt. 2004a. L-DOPA reverses the hypokinetic behavior and rigidity in Rotenone-treated rats. *Behavioural Brain Research* 153(2):439-446.
- Alam M., and W.J. Schmidt. 2004b. Mitochondrial complex I inhibition depletes plasma testosterone in the Rotenone model of Parkinson's Disease. *Physiology and Behavior* 83(3): 395-400.
- Alam M., A. Mayerhofer, and W.J. Schmidt. 2004. The neurobehavioral changes induced by bilateral rotenone lesion in medial forebrain bundle of rats are reversed by L-DOPA. *Behavioural Brain Research* 151(1-2): 117-124.
- Allen, Y., S. Kirby, G.H. Copp, and M. Brazier. 2006. Toxicity of rotenone to topmouth gudgeon *Pseudorasbora parva* for eradication of this nonnative species from a tarn in Cumbria, England. *Fisheries Management and Ecology* 13:337-340.
- Antkiewicz-Michaluk L., B. Karolewicz, I. Romańska, J. Michaluk, A.J. Bojarski, and J. Vetulani. 2003. 1-Methyl-1,2,3,4-Tetrahydroisoquinoline protects against rotenone-induced mortality and biochemical changes in rat brain. *European Journal of Pharmacology* 466(3): 263-269.
- Antkiewicz-Michaluk L., J. Wardas, J. Michaluk, I. Romańska, A.J. Bojarski, and J. Vetulani. 2004. Protective effect of 1-Methyl-1,2,3,4-Tetrahydroisoquinoline against dopaminergic neurodegeneration in the extrapyramidal structures produced by intracerebral injections of rotenone. *The International Journal of Neuropsychopharmacology* 7(2): 155-163.
- Archer, D.L. 2001. Rotenone neutralization methods. Pp 5-8 in *Rotenone in fisheries: are the rewards worth the risks?* R.L. Cailteux, L. DeMong, B.J. Finlayson, W. Horton, W. McClay, R.A. Schnick, and C. Thompson, editors. American Fisheries Society, Trends in Fisheries Science Management. Bethesda, MD.
- Baber, M.J. and K.J. Babbitt. 2004. Influence of habitat complexity on predator-prey interactions between the fish (*Gambusia holbrooki*) and tadpoles of *Hyla squirella* and *Gastrophryne carolinensis*. *Copeia* 2004(1): 173-177.
- Bahre, C.J. 1991. A legacy of change: historic human impact on vegetation in the Arizona borderlands. University of Arizona Press. Tucson, AZ.

- Bashkatova V., M. Alam, A. Vanin, W.J. Schmidt. 2004. Chronic administration of rotenone increases levels of nitric oxide and lipid peroxidation products in rat brains. *Experimental Neurology* 186(2): 235-241.
- Begel, D. 2001. Debate rages over fish poisoning. *High Country News* 33(9):5.
- Berger, B.L., P.A. Gilderhus, and R.E. Lennon. 1967. Attempted reclamation of Whitewater Lake, Valentine National Wildlife Refuge, Nebraska. Unpublished report, US Fish and Wildlife Service, Fish Control Laboratory. La Crosse, WI.
- Betarbet R., T.B. Sheerer, G. MacKenzie, M. Garcia-Osuna. A.V. Panov, J.T. Greenamyre. 2000. Chronic systemic pesticide exposure reproduces features of Parkinson's disease. *Nature Neuroscience* 3:1301-1306.
- Betarbet R., R.M. Canet-Aviles, TB Sherer, P.G. Mastroberardino, C. McLendon, J. Kim, S. Lund, H. Na, G. Taylor, N.F. Bence, R. Kopito, B.B. Seo, T. Yagi, A. Yagi, G. Klinefelter, M.R. Cookson, and J.T. Greenamyre. 2006. Intersecting pathways to neurodegeneration in Parkinson's disease: effects of the pesticide rotenone on DJ-1 and α -Synuclein and the ubiquitin-proteasome system. *Neurobiology of Disease* 22: 404-420.
- Biospherics. 1982. Aqueous photodegradation of ^{14}C -rotenone. Report to US Geological Survey. Upper Midwest Environmental Sciences Center. US Fish and Wildlife Study 14-16-990-81-042). La Crosse, WI.
- Biotech Research. 1981. Analytical studies for detection of chromosomal aberrations in fruit flies, rats, mice, and horse bean. Report to US Geological Survey. Upper Midwest Environmental Sciences Center. US Fish and Wildlife Study 14-16-990-80-54. La Crosse, WI.
- Bonar, S.A., L.L. Leslie, and C.E. Velez. 2004. Influence of species, size class, environment, and season on introduced fish predation on native fishes in the Verde River system, Arizona. University of Arizona, US Geological Survey Cooperative Fish and Wildlife Research Unit. Tucson, AZ.
- Borrison Laboratories. 1983. Hydrolysis of ^{14}C -rotenone. Report to US Geological Service, Upper Midwest Environmental Sciences Center. US Fish and Wildlife Service Study. La Crosse, WI.
- Boyd, S.H. 1975. Inhibition of fish reproduction by *Rana catesbeiana* larvae. *Physiological Zoology* 48(3):225-234.
- Bradbury, A. 1986. Rotenone and trout stocking. Washington Department of Game, Fisheries Management Report 86-2. 181 p.
- Bradford, D.F., J.R. Jaeger, and R.D. Jennings. 2004. Population status and distribution of a decimated amphibian, the relict leopard frog (*Rana onca*). *The Southwestern Naturalist* 49(2):218-228.
- Bronmark, C., and P. Edenhamn. 1994. Does the presence of fish affect the distribution of tree frogs (*Hyla arborea*)? *Conservation Biology* 8(3):841-845.
- Brooks, I.C. and R.W. Price. 1961. Studies on the chronic toxicity of Pro-Noxfish, a proprietary synergized rotenone fish-toxicant. *Toxicology and Applied Pharmacology*. 3:49-56.

- Brooks, J.E. and D.L. Propst. 2001. Use of antimycin-A in Gila trout recovery: response to public concerns. Pp. 15-16 in Practical approaches for conserving native inland fishes of the west: a symposium. June 6-8, 2001. Missoula, MT.
- Brown, D.E. 1994. Biotic communities, southwestern United States and northwestern Mexico. University of Utah Press. Salt Lake City, UT.
- Brown, D.E. and C.L. Gonzalez. 2001. Borderland jaguars. Tigres de la Frontera, University of Utah Press. Salt Lake City, UT. 170pp.
- Brown, T.P., P.C. Rumsby, A.C. Capleton, L. Rushton, and L.S. Levy. 2005. Pesticides and Parkinson's disease—is there a link?. Environmental Health Perspective 114 (2): 156-164.
- Burress, R.M. 1982. Effects of synergized rotenone on nontarget organisms in ponds. US Fish and Wildlife Service Investigations in Fish Control 91:1-7.
- Caboni, P., T.B. Sherer, N. Zhang, G. Taylor, H.M. Na, J.T. Greenamyre, and J.E. Casida. 2004. Rotenone, Deguelin, their metabolites, and the rat model of Parkinson's disease. Chemical Research in Toxicology 17(11): 1540-1548.
- Capone, T.A. and J.A. Kushlan. 1991. Fish community structure in dry-season stream pools. Ecology 72(3):983-992.
- CARB (California Air Resource Board). 1997. Lake Davis fish kill emergency response – final report. CARB. Sacramento, CA.
- Casterlin, M.E. and W.W. Reynolds. 1977. Aspects of habitat selection in the mosquitofish, *Gambusia affinis*. Hydrobiologia 55(2):125-127.
- Cerreto, K.M., R.O. Hall Jr., and H. Sexauer. 2003. Short-term effects of antimycin and rotenone on invertebrates in first-order, high-elevation streams. Paper presented at the North American Benthological Society annual meeting. Athens, GA.
- CDFG (California Department of Fish and Game). 1994. Rotenone use for fisheries management – final programmatic environmental impact report (SCH 92073015). CDFG, Environmental Services Division. Sacramento, CA.
- CDPR (California Department of Pesticide Regulation). 1998. A report on the illnesses related to the application of rotenone to Lake Davis. CDPR, Worker Health and Safety Branch, Report HS-1772. Sacramento, Ca.
- Chandler, J. and L. Marking. 1982. Toxicity of rotenone to selected aquatic invertebrates and frog larvae. Progressive Fish-Culturist 44:78-80.
- Chapman, D., J. Fairchild, B. Carollo, J. Deters, K. Feltz, and C. Witte. 2003. An examination of the sensitivity of bighead carp and silver carp to antimycin A and rotenone. US Geological Survey. Columbia, MO.
- Cheng, H. M. I., I. Yamamoto, J.E. Casida. 1972. Rotenone photodecomposition. Journal of Agricultural and Food Chemistry 20:850-856.

- Clarkson, R.W., P.C. Marsh, S.E. Stefferud, and J.A. Stefferud. 2005. Conflicts between native fish and nonnative sport fish management in the southwestern United States. *Fisheries* 30(9):20-27.
- Collins, J.P., T.R. Jones, and H.J. Berna. 1988. Conservation and management of genetically distinctive populations: The case of the Huachuca tiger salamander (*Ambystoma tigrinum stebbinsi* Lowe). pp. 45-53. In: Szaro, R.C., K.E. Severson, and D.R. Patton (eds.) *Proc. Symp. Management of Amphibians, Reptiles and Small Mammals in North America*.
- Cook, S.F., Jr. and R.L. Moore. 1969. The effects of a rotenone treatment on the insect fauna of a California stream. *Transactions of the American Fisheries Society* 3: 539-544.
- Courtenay, W.R., Jr. and G.K. Meffe. 1989. Small fishes in strange places: a review of introduced Poeciliids. Pp. 319-331 in Meffe, G.K. and F.F. Snelson, Jr., editors. *Ecology and evolution of livebearing fishes (Poeciliidae)*. Prentice Hall. Englewood Cliffs, NJ.
- Crutchfield K.C., and D.E. Dluzen. 2006. Rotenone produces opposite effects upon mouse striatal dopamine function as a result of environmental temperature. *Neurotoxicity Research* 9(1): 15-21.
- Danzer, S.J., R. Jemison, and D.P. Guertin. 2001. Riparian plant communities in the mountains of southeastern Arizona. *The Southwestern Naturalist* 46(2):191-199.
- Davis, G.P., Jr. 1986. *Man and wildlife in Arizona*. Arizona Game and Fish Department. Phoenix, AZ.
- Dawson, V.K. and C.S. Kolar. 2003. Integrated management techniques to control nonnative fishes. Final Report to US Bureau of Reclamation, Phoenix Area Office, Interagency Agreement 01-AA-32-0040. US Geological Survey, Upper Midwest Environmental Sciences Center, LaCrosse, WI.
- Dawson, V.K., W.H. Gingerick, R.A. Davis, and P.A. Gilderhus. 1991. Rotenone persistence in freshwater ponds: effects of temperature and sediment adsorption. *North American Journal of Fisheries Management* 11:226-231.
- Dean, S.A. 1987. The Sonoran topminnow (*Poeciliopsis occidentalis*) and the mosquitofish (*Gambusia affinis*): a test of emigratory behavior. Unpublished Master's Thesis, University of Arizona, Tucson, AZ.
- Desert Fishes Team. 2004. Report Number 2. Status of unlisted native fishes of the Gila River Basin, with recommendations for management. Desert Fishes Team. Phoenix, AZ.
- Dinger, E.C. and J.C. Marks. 2007. Effects of high levels of antimycin A on aquatic invertebrates in a warmwater Arizona stream. *North American Journal of Fisheries Management* 27: 1243-1256.
- Dobyns, H.F. 1981. From fire to flood: historic human destruction of Sonoran Desert riverine oases. Bellona Press Anthropological Papers No. 20.
- DOE (Department of Energy). 2005. South fork flathead watershed west slope cutthroat trout conservation program. Draft environmental impact statement. DOE/EIS-0353. Bonneville Power Administration. Portland, OR.
- Douglas, M.E., P.C. Marsh, and W.L. Minckley. 1994. Indigenous fishes of western North American and the hypothesis of competitive displacement: *Meda fulgida* (Cyprinidae) as a case study. *Copeia* 1994(1):9-19.

- Drechsel D.A., and M. Patel. 2008. Role of reactive oxygen species in the neurotoxicity of environmental agents implicated in Parkinson's disease. *Free Radical Biology and Medicine* 44(11): 1873-1886.
- Dudley, R.K. and W.J. Matter. 2000. Effects of small green sunfish (*Lepomis cyanellus*) on recruitment of Gila Chub (*Gila intermedia*) in Sabino Canyon, Arizona. *The Southwestern Naturalist* 45(1):24-29.
- Dunshee, B.R., C. Leben, G.W. Keitt, and F.M. Strong. 1949. The isolation and properties of antimycin A. *Journal of the American Chemical Society* 71:2436-2437.
- Ellis, H.V., S. Unwin, J. Cox, I.S. Elwood, E.A. Castillo, and J. Carter. 1980. Subchronic oral dosing study for safety evaluation of rotenone using dogs. Midwest Research Institute Project No. 4853-B. La Crosse, WI.
- EPA (US Environmental Protection Agency). 1981. Completion of pre-RPAR review of rotenone. EPA, Office of Toxic Substances. EPA Report 540/RS-89-039. Washington, D.C.
- EPA (US Environmental Protection Agency). 1989. Guidance for the reregistration of pesticide products containing rotenone and associated resins as the active ingredient. EPA Report 540-RS-89-039. Washington, D.C.
- EPA (US Environmental Protection Agency). 2005. Rotenone; decision on critical effects and endpoint selection. Results of the meeting of the HED Hazard Science Policy Council. PC Code: 071003. DP Barcode: D307370. June 28, 2005.
- EPA (US Environmental Protection Agency). 2006. Rotenone: Final HED Chapter of the Reregistration Eligibility Decision Document. June 28, 2006.
- EPA (US Environmental Protection Agency). 2007a. Reregistration Eligibility Decision for Rotenone. EPA, Office of Prevention, Pesticides and Toxic Substances. EPA Report 738-R-07-005.
- EPA (US Environmental Protection Agency). 2007b. Reregistration Eligibility Decision for Antimycin A. EPA, Office of Prevention, Pesticides and Toxic Substances. EPA Report 738-R-07-007.
- EPA (US Environmental Protection Agency). 2007c. Attainment status information available at <http://epa.gov/oar/oaqps/greenbk/anc13.html>.
- Ernst, C.H., J.E. Lovich, and R.W. Barbour. 1994. *Turtles of the United States and Canada*. Smithsonian Institution Press. Washington, D.C.
- Fagan, W.F., P.J. Unmack, C. Burgess, and W.L. Minckley. 2002. Rarity, fragmentation, and extinction risk in desert fishes. *Ecology* 83(12):3250-3256.
- Fajt, J.R. and J.M. Grizzle. 1998. Blood respiratory changes in common carp exposed to a lethal concentration of rotenone. *Transactions of the American Fisheries Society* 127:512-516.
- Ferrante R.J., J.B. Schulz, N.W. Kowall, and M.F. Beal. 1997. Systemic administration of rotenone produces selective damage in the striatum and globus pallidus, but not in the substantia nigra. *Brain Research* 753:157-162.

- Finlayson, B.J., R.A. Schnick, R.L. Cailteux, L. DeMong, W.D. Horton, W. McClary, C.W. Thompson, and G.J. Tichacek. 2000. Rotenone use in fisheries management: administrative and technical guidelines manual. American Fisheries Society, Bethesda, MD.
- Finlayson, B.J., W. Somer, D. Duffield, D. Propst, C. Mellison, T. Pettengil, H. Sexauer, T. Nesler, S. Surtin, and J. Elliot. 2005. Native inland trout restoration on national forests in the western United States: time for improvement? *Fisheries* 30(5): 10-19.
- Finlayson, B.J., W. Somer, and M.R. Vinson. 2010. Rotenone toxicity to rainbow trout and several mountain stream insects. *North American Journal of Fisheries Management* 30: 102-111.
- Fisher, J.P. 2007. Screening level risk analysis of previously unidentified rotenone formulation constituents associated with treatment of Lake Davis. Report prepared for California Department of Fish and Game, ENVIRON International Corporation, Seattle, WA.
- Flemming S.M., C. Zhu, P.O. Fernagut, A. Mehta, C.D. Dicarlo, R.L. Seaman, and M.F. Chesselet. 2004. Behavioral and immunohistochemical effects of chronic intravenous and subcutaneous infusions of varying doses of rotenone.
- Fontenot, L.W., G.P. Noblet, and S.G. Platt. 1994. Rotenone hazards to amphibians and reptiles. *Herpetological Review* 25(4):150-156.
- Fuller, P.L., L.G. Nico, and J.D. Williams. 1999. Nonindigenous fishes introduced into inland waters of the United States. American Fisheries Society Special Publication 27. Bethesda, MD.
- FWS (US Fish and Wildlife Service). 1984. Recovery Plan for Gila topminnow (*Poeciliopsis occidentalis*). US Fish and Wildlife Service. Albuquerque, NM.
- FWS (US Fish and Wildlife Service). 1997. Lesser long-nosed bat *Leptonycteris curasoae yerbabuenae* recovery plan. US Fish and Wildlife Service, Phoenix, Arizona.
- FWS (US Fish and Wildlife Service). 1998. Gila topminnow, *Poeciliopsis occidentalis occidentalis*, revised recovery plan (Draft). Albuquerque, NM.
- FWS (US Fish and Wildlife Service). 2002. Biological opinion and conference opinion on continuation of livestock grazing on the Coronado National Forest 2-21-98-F-399R1. Phoenix, AZ.
- FWS (US Fish and Wildlife Service). 2002b. Sonora tiger salamander (*Ambystoma tigrinum stebbinsi*) recovery plan. US Fish and Wildlife Service, Phoenix, Arizona.
- FWS (US Fish and Wildlife Service). 2007. Chiricahua leopard frog (*Rana chiricahuensis*) recovery plan. Albuquerque, NM.
- FWS (US Fish and Wildlife Service). 2008. Biological opinion on the proposed construction of a fish barrier in Redrock Canyon and the subsequent removal of nonnative fish and frogs and restoration of a native aquatic fauna. June 13, 2008. Phoenix, AZ.
- Garcia-Garcia, F., S. Ponce, R. Brown, V. Cussen, and J.M. Krueger. 2005. Sleep disturbances in the rotenone animal model of Parkinson Disease. *Brain Research* 1042(2):160-168.

- Gary, L.J. 1981. Species composition and life histories of aquatic insects in a lowland Sonoran desert stream. *The American Midland Naturalist* 106(2):229-242.
- Gary, L.J. and S.G. Fisher. 1981. Postflood recolonization pathways of macroinvertebrates in a lowland Sonoran desert stream. *The American Midland Naturalist* 106:249-257.
- Gilderhus, P.A. 1972. Exposure times necessary for antimycin and rotenone to eliminate certain freshwater fish. *Journal of the Fisheries Research Board of Canada* 29(2):199-202.
- Gilderhus, P.A., B.L. Berger, and R.E. Lennon. 1969. Field trials of antimycin A as a fish toxicant. US Bureau of Sport Fisheries and Wildlife, Investigations in Fish Control No. 27. Washington, D.C.
- Gilderhus, P.A., V.K. Dawson, and J.L. Allen. 1986. Persistence of rotenone in aquatic environments at different temperatures. Report No. ROT 83-988-02. Unpublished Study by the National Fishery Research Laboratory, US Fish and Wildlife Service.
- Gilderhus, P.A., V.K. Dawson, and J.L. Allen. 1988. Deposition and persistence of rotenone in shallow ponds during cold and warm seasons. US Fish and Wildlife Service. Investigations in Fish Control. Report No. 92. Available at <http://pubs.er.usgs.gov/usgspubs>
- Gingerich, W. 1986. Tissue distribution and elimination of rotenone in rainbow trout. *Aquatic toxicology* 8:27-40.
- Gingerich, W. and J. Rach. 1985. Uptake, accumulation and depuration of ¹⁴C-rotenone in bluegills (*Lepomis macrochirus*) *Aquatic toxicology* 6:170-196.
- Gleason, M., R. Gosselin, H. Hodge, and P. Smith. 1969. Clinical toxicology of commercial products. The William and Wilkins Company. Baltimore, MD.
- Goethem, D., B. Barnhart, and S. Fotopoulos. 1981. Mutagenicity studies on rotenone. Report to the US Geological Society. US Fish and Wildlife Service Study 14-16-009-80-076. La Cross, WI.
- Gomez C., M.J. Bandez, and A. Navarro. 2007. Pesticides and impairment of mitochondrial function in relation with the Parkinsonian Syndrome. *Frontiers in Bioscience* 12: 1079-1093.
- Greenamyre J.T., R. Betarbet, and T.B. Sherer. 2003. The rotenone model of Parkinson's disease: genes, environment and mitochondria. *Parkinsonism and Related Disorders* 9: S59-64.
- Greselin E. and F. Herr. 1974. Further Toxicity Studies with Antimycin, a Fish Eradicator. *Journal of Agricultural Food Chemistry* 22:996.
- Grisak, G., G. Michael, J. Cavigi, and D. Skaar. 2002. Determination of lethal doses of rotenone and potassium permanganate to westslope cutthroat trout, and ability of potassium permanganate to neutralize rotenone in the presence of fish. Draft report. Montana Fish, Wildlife, and Parks.
- Grubb, J.C. 1972. Differential predation by *Gambusia affinis* on the eggs of seven species of anuran amphibians. *The American Midland Naturalist* 88(1):102-108.
- Haag H. 1931. Toxicological studies of *Derris elliptica* and its constituents. *Journal of Pharmacology and Experimental Therapeutics* 43: 193-208.

- Haley, T. 1978. A review of the literature of rotenone. *Journal of Environmental Pathology and Toxicology* 1: 315-337.
- Hamilton, H.L. 1941. The biological action on freshwater animals. *Proceedings of the Iowa Academy of Science* 48:467-479.
- Hamilton, B.T., S.E. Moore, T.B. Williams, N. Darby, and M.R. Vinson. 2009. Comparative effects of rotenone and antimycin on benthic macroinvertebrate diversity in two streams in Great Basin National Park. *North American Journal of Fisheries Management* 29: 1620-1635.
- Hansen W.H., K.J. Davis, and O.G. Fitzhugh 1965. Chronic toxicity of Cubé. *Toxicology and Applied Pharmacology* 7:535-542.
- Hayes, M.P. and M.R. Jennings. 1986. Decline of ranid frog species in western North America: are bullfrogs (*Rana catesbeiana*) responsible? *Journal of Herpetology* 20(4):490-509.
- Hazleton Raltech Laboratories. 1982. Teratology studies with rotenone in rats. Report to US Geological Survey. Upper Midwest Environmental Sciences Center. US Fish and Wildlife Service Study 81-178. La Crosse, WI.
- Heer, F., E. Greselin, and C. Chappel. 1967. Toxicology studies of antimycin, a fish eradicator. *Transactions of the American Fisheries Society* 96:320-326.
- Hendrickson, D.A. 1988. Letter of March 1, 1988 to U.S. Fish and Wildlife Service transmitting a proposal to renovate Bog Hole. Arizona Game and Fish Department, Phoenix, AZ
- Hirsch E.C., G. Hoglinger, E. Rousselet, T. Breidert, K. Parain, F. Feger, M. Ruberg, A. Prigent, C. Cohen-Salmon, and J.M. Launay. Animal models of Parkinson's disease in rodents induced by toxins: an update. *Journal of Neural Transmission Supplementum* (65):89-100. In R. Horoski, Y. Mizuno, C.W. Olanow, W.H. Poewe, P.F. Riederer, J. Stoessl, M.B.H. Youdim (eds.) *Advances in research on neurodegeneration*, Volume 10 *Journal of Neural Transmission Supplement* 65. Austria. 2003
- Hoglinger G.U., W.H. Oertel, E.C. Hirsch. 2006. The rotenone model of Parkinsonism—the five years inspection. *Journal of Neural Transmission Supplementum* (70): 269-272.
- Houf, L.J. and R.S. Campbell. 1977. Effects of antimycin A and rotenone on macrobenthos in ponds. US Fish and Wildlife Service, Investigations in Fish Control No. 80. Washington, D.C.
- Hurlbert, S.H., J. Zedler, and D. Fairbanks. 1972. Ecosystem alteration by mosquitofish (*Gambusia affinis*) predation. *Science* 175:639-641.
- Inden M., Y. Kitamura, B. Takeuchi, T. Yanagida, K. Takata, Y. Kobayashi, T. Taniguchi, K. Yoshimoto, M. Kaneko, Y. Okuma, T. Taira, B. Ariga, and S. Shimohama. 2007. Neurodegeneration of mouse nigrostriatal dopaminergic system induced by repeated oral administration of rotenone is prevented by 4-phenylbutyrate, a chemical chaperone. *Journal of Neurochemistry* 101(5):1491-1504.
- Jacobi, G.Z., and D.J. Deagan. 1977. Aquatic macroinvertebrates in a small Wisconsin trout stream before, during, and two years after treatment with the fish toxicant antimycin. US Fish and Wildlife Service, Investigations in Fish Control 81, Washington, D.C.

- Jenner P. 2001. Parkinson's disease, pesticides and mitochondrial dysfunction. *Trends Neuroscience* 24: 245–246.
- Johnson, J.E., M.G. Pardew, and M.M. Lyttle. 1993. Predator recognition and avoidance by larval razorback sucker and northern hog sucker. *Transactions of the American Fisheries Society* 122(6):1139-1145.
- Kane, A.S., R. Reimschuessel, and M.M. Lipsky. 1992. Effect of tadpoles on warmwater fish pond production. *Fisheries* 17(2):36-39.
- Kiner, L., A.A. Echelle, and W. Fisher. 2000. Effects of a chemical restoration project using antimycin-A on the fauna of Diamond Creek, Pecos County, Texas; year 2000. Abstract No. 948742402-25. American Fisheries Society Annual Meeting, August 20-24. St. Louis, MO.
- Kupferberg, S.J. 1997. Bullfrog (*Rana catesbeiana*) invasion of a California river: the role of larval competition. *Ecology* 78:1736-1751.
- La Ganga, M.L. 1997. Town upset by poisoning to kill fish. *The Seattle Times*: 16/10/97.
- Landye, J.J. 1981. Current status of endangered, threatened, and/or rare mollusks of New Mexico and Arizona. US Fish and Wildlife Service. Albuquerque, NM.
- Lapointe N., M. St. Hilaire, M.G. Martinoli, J. Blanchet, P. Gould, C. Rouillard, and F. Cicchetti. 2004. Rotenone induces non-specific central nervous system and systemic toxicity. *FASEB Journal* 18(6): 7171-719.
- Latta, M., Beardmore, C. and T. Corman. Version 1.0. 1999. Arizona Partners in Flight Bird Conservation Plan. Technical Report 142. Nongame and Endangered Wildlife Program. Arizona Game and Fish Department. 2221 W. Greenway rd., Phoenix, AZ 85023-4399. 331 pp.
- Lawler, S.P., D. Dritz, T. Strange, and M. Holyoak. 1999. Effects of introduced mosquitofish and bullfrogs on the threatened California red-legged frog. *Conservation Biology* 13(3):613-622.
- Lee, T.H. P.H. Derse, and S.D. Morton. 1971. Effects of physical and chemical conditions on the detoxification of antimycin. *Transactions of the American Fisheries Society* 100:13-17.
- Lehman, A.J. 1950. Some toxicological reasons why certain chemicals may or may not be permitted as food additives. *Quarterly Bulletin of the Association of Food and Drug Officials of the United States* 14:82.
- Lemly, A.D. 1985. Suppression of native fish population by green sunfish in first-order streams of Piedmont North Carolina. *Transactions of the American Fisheries Society* 114(5):705-712.
- Lennon, R.E. 1970. Control of freshwater fish with chemicals. Pp 129-137 in *Proceedings of the 4th Vertebrate Pest Conference*. March 1970. Sacramento, Ca
- Lennon, R.E. and B.L. Berger. 1970. A resume of field applications of antimycin A to control fish. US Bureau of Sport Fisheries and Wildlife, Investigations in Fish Control No. 40. Washington, D.C.
- Lima, S.L. 1998. Nonlethal effects in the ecology of predator-prey interactions. *BioScience* 48:25-34.

- Ling, N. 2003. Rotenone—a review of its toxicity and use for fisheries management. New Zealand Department of Conservation, Science for Conservation 211. Wellington, New Zealand. Available at: www.doc.govt.nz/upload/documents/science-and-technical/SFC211.pdf
- Lotharius, J.; O.Malley, K.L. 2000. The Parkinsonism-inducing drug 1-methyl-4-phenylpyridinium triggers intracellular dopamine oxidation: a novel mechanism of toxicity. *Journal of Biological Chemistry* 275: 38581-38588.
- Lowe, C.H. 1964. The vertebrates of Arizona with a major section on Arizona habitats. University of Arizona Press. Tucson, AZ.
- Luo C., A.H. Rajput, S. Akhtar, and A. Rajput. 2007. α -synuclein and tyrosine hydroxylase expression in acute rotenone toxicity. *International Journal of Molecular Medicine* 19(3):517-521.
- Lydiard, C. and M.C. Belk. 1993. Management of indigenous fish species impacted by introduced mosquitofish: an experimental approach. *The Southwestern Naturalist* 38(4):370-373.
- Mangum, F.A. and Madrigal, J.L. 1999. Rotenone effects on aquatic invertebrates of the Strawberry River, Utah: a five-year summary. *Journal of Freshwater Ecology* 14: 125-135.
- Marking L. 1988. Oral toxicity of rotenone to mammals. US Fish and Wildlife Service, Investigations in Fish Control 94;5-9. Available at <http://pubs.er.usgs.gov/usgspubs>
- Marking, L.L. and T.D. Bills. 1975. Toxicity of potassium permanganate to fish and its effectiveness for detoxifying antimycin. *Transactions of the American Fisheries Society* 1975(3):579-583.
- Marsh, P.C. and C.A. Pacey. 2005. Immiscibility of native and nonnative species. Pp. 59-63 in *Restoring native fish to the lower Colorado River: interactions of native and nonnative fishes*. US Fish and Wildlife Service, Phoenix, AZ, and US Bureau of Reclamation. Boulder City, NV.
- Marsh, P.C., J.A. Stefferud, and S.E. Stefferud. 2006. Fossil Creek fish monitoring Annual report to US Bureau of Reclamation, Phoenix Area Office, Contract 05-CS-32-0180, May 8, 2006.
- McClay, W. 2000. Fisheries Management-Rotenone Use in North America (1988-1997). *Fisheries* 25(5): 15-21.
- McCoid, M.J. and P.W. Bettoli. 1996. Additional evidence for rotenone hazards to turtles and amphibians. *Herpetological Review* 27(2): 70-71.
- McCulloch C.C., D.M. Kay, S.A. Factor, A. Samii, J.G. Nutt, D.S. Higgins, A. Griffith, J.W. Roberts, B.C. Leis, J.S. Montimurro, C.P. Zabetian, and H. Payami. 2008. Exploring gene-environment interactions in Parkinson's disease. *Human Genetics* 123(3):257-265.
- Meffe, G.K. 1983. Ecology of species replacement in the Sonoran topminnow (*Poeciliopsis occidentalis*) and the mosquitofish (*Gambusia affinis*) in Arizona. Arizona State University. Tempe, AZ.
- Meronek, T.G., P.M. Bouchard, E.R. Buckner, T.M. Burri, K.K. Demmerly, D.C. Hatleli, R.A. Klumb, S.H. Schmidt, and D.W. Coble. 1996. A review of fish control projects. *North American Journal of Fisheries Management* 16(1):63-74.

- Minckley, W.L. 1969. Aquatic biota of the Sonoita Creek basin, Santa Cruz County, Arizona. The Nature Conservancy, Ecological Studies Leaflet No. 15. Washington, D.C.
- Minckley, W.L. 1991. Native fishes of the Grand Canyon region: an obituary? Pp. 124-177 in Colorado River ecology and dam management. Proceedings of a symposium May 24-25, 1990, Santa Fe, NM. National Academy Press. Washington, D.C.
- Minckley, W.L., J.E. Deacon, P.C. Marsh, W.J. Matthews and P.B. Moyle. 1997. Sustainability of western native fish resources. Pp. 63-79 in Aquatic ecosystems symposium: a report to the Western Water Policy Review Advisory Committee. W.L. Minckley, editor. Tempe, AZ.
- Minckley, W.L. and P. Mihalik. 1981. Effects of chemical treatment for fish eradication on stream-dwelling invertebrates. Journal of the Arizona-Nevada Academy of Science 16:79-82.
- Minckley, W.L., R.R. Miller, and S.M. Norris. 2002. Three new pupfish species, *Cyprinodon* (Teleostei, Cyprinodontidae), from Chihuahua, Mexico, and Arizona, USA. Copeia 2002(3):687-705.
- Minckley, W.L., J.N. Rinne, and J.E. Johnson. 1977. Status of the Gila topminnow and its co-occurrence with mosquitofish. USDA Forest Service Research Paper RM-198. Ft. Collins, CO.
- Mitchell, D. 2002. Redrock Canyon stock tank and stream survey. Final Report, September 2002. Arizona Game and Fish Department. Tucson, AZ.
- Moore, S.E., M.A. Kulp, J. Hammonds, and B. Rosenlund. 2005. Restoration of Sams Creek and an assessment of brook trout restoration methods. US National Park Service Technical Report NPS/NRWRD/NRTR2005, Fort Collins, CO.
- Morrison, B.R.S. 1977. The effects of rotenone on the invertebrate fauna of three hill streams in Scotland. Fisheries Management 8: 128.138.
- Morrison, B.R.S. 1979. An investigation into the effects of the piscicide antimycin A on the fish and invertebrates of a Scottish stream. Fisheries Management 10:111-122.
- Moyle, P.B. 2002. Inland fishes of California. University of California Press. Berkeley, CA.
- Mueller, G.A., J. Carpenter, and D. Thornburgh. 2006. Bullfrog tadpole (*Rana catesbeiana*) and red swamp crayfish (*Procambarus clarki*) predation on early life stages of endangered razorback sucker. The Southwestern Naturalist 51(2):258-261.
- NAS (National Academy of Science). 1983. Drinking water and health, Volume 5. Safe Drinking Water Committee Board of Toxicology and Environmental Health Hazards. Commission on Life Sciences. National Research Council. National Academy Press. Washington, D.C.
- Nehru B., R. Verma, P. Khanna, and S.K. Sharma. 2008. Behavioral alterations in rotenone model of Parkinson's disease: attenuation by co-treatment of centrophenoxine. Brain Research 1201:122-127.
- NRCS (Natural Resources Conservation Service). 2007. Web soil survey available at <http://websoilsurvey.nrcs.usda.gov/app/>.

- Orr C.F., D.B. Rowe, and G.M. Halliday. 2002. An inflammatory review of Parkinson's disease. *Progress in Neurobiology* 68(5): 325-340.
- Pacey, C.A. and P.C. Marsh. 1998. Resource use by native and nonnative fishes of the lower Colorado River: literature review, summary, and assessment of relative roles of biotic and abiotic factors in management of an imperiled indigenous ichthyofauna. Final report to US Bureau of Reclamation, Lower Colorado Regional Office, Agreement No. 7-MT-30-R0012. Arizona State University. Tempe, AZ.
- Panov A.V., S. Dikalov, N. Shalbuyeva, G. Taylor, T. Sherer, and J.T. Greenamyre. 2005. Rotenone model of Parkinson's disease: multiple brain mitochondria dysfunctions after short-term systemic rotenone intoxication. *Journal of Biological Chemistry* 280: 42026-42035.
- Perier C., J. Boveacute, M. Vila, and S. Przedborski. 2003. The rotenone model of Parkinson's disease. *Trends in Neurosciences* 26(7): 345-346.
- Pope, G.L., P.D. Rigas, and C.F. Smith. 1998. Statistical summaries of streamflow data and characteristics of drainage basins for selected streamflow-gauging stations in Arizona through water year 1996. US Geological Survey, Water Resources Investigations Report 98-4225. Tucson, AZ.
- Propst, D.L. and K.R. Bestgen. 1991. Habitat and biology of the loach minnow, *Tiaroga cobitis*, in New Mexico. *Copeia* 1991(1):29-38.
- Ravenstijn, P.G., M. Merlini, M. Hameetman, T.K. Murray, M.A. Ward, H. Lewis, G. Ball, C. Mottart, C. De Ville De Goyet, T. Lemarchand, K. Van Belle, M.J. O'neill, M. Danhof, and E.C. De Lange. 2008. The exploration of rotenone as a toxin for inducing Parkinson's disease in rats, for application in BBB transport and PK-PD experiments. *Journal of Pharmacological and Toxicological Methods* 57(2):114-130.
- Richter F., M. Hamann, and A. Richter. 2007. Chronic rotenone treatment induces behavioral effects but no pathological signs of Parkinson's in mice. *Journal of Neuroscience Research* 85(3): 681-691.
- Rinne, J.N., B. Rickel, and D.A. Hendrickson. 1980. A new Gila topminnow locality in southern Arizona. USDA Forest Service, Research Note RM-382. Ft. Collins, CO.
- Rinne, J.N., and P.R. Turner. 1991. Reclamation and alteration as management techniques, and a review of methodology in stream renovation. Pp. 219-244 in: W.L. Minckley and J.E. Deacon, eds. *Battle against extinction*. University of Arizona Press, Tucson, AZ.
- Ritter, P.O. and F.M. Strong. 1966. Residues in tissues of fish killed by antimycin. *Journal of Agriculture and Food Chemistry* 14:403-407.
- Rojo, A.I., C. Cavada, M.R. Sagarra, and A. Cuadrado. 2007. Chronic inhalation of rotenone or paraquat does not induce Parkinson's disease symptoms in mice or rats. *Experimental Neurology* 208(1): 120-126.
- Rosen, P.C. and C.R. Schwalbe. 1995. Bullfrogs: introduced predators in southwestern wetlands. Pp. 452-452 in *Our living resources: a report to the nation on the distribution, abundance, and health of US plants, animals, and ecosystems*. LaRoe, E.T., Farris: G.S., C.E. Puckett, P.D. Doran, and M.J. Mac, editors. US Department of the Interior, National Biological Service. Washington, D.C.

- Rosen, P.C. and C.R. Schwalbe. 2002. Widespread effects of introduced species on reptiles and amphibians in the Sonoran Desert region. Pp. 220-240 *in* Invasive exotic species in the Sonoran Region. B. Tellman, editor. University of Arizona Press. Tucson, AZ.
- Rosen, P.C., C.R. Schwalbe, D.A. Parizek, Jr., P.A. Holm, and C.H. Lowe. 1995. Introduced aquatic vertebrates in the Chiricahua region: effects on declining native ranid frogs. Pp. 251-261 *in* Biodiversity and management of the Madrean archipelago: the sky islands of southwestern United States and northwestern Mexico. DeBano, L.F., G.J. Gottfried, R.H. Hamre, C.B. Edminster, P.F. Ffolliott, and A. Ortega-Rubio, editors. September 19-23, 1994, Tucson, AZ. US Forest Service Rocky Mountain Forest and Range Experiment Station General Technical Report RM-GTR-264. Ft. Collins, CO.
- Schmidt W.J., and M. Alam. 2006. Controversies on new animal models of Parkinson's disease pro and con: the rotenone model of Parkinson's disease (PD). Journal of Neural Transmission Supplemental (70): 273-276. *In* P. Riederer, H. Reichmann, M.B.H. youdim, and M. Gerlach (eds.). Parkinsons Disease and Related Disorders Journal of Neural Transmission Supplemental. 2006. Volume 70.
- Schnick, R.A. 1974a. A review of the literature on the use of antimycin in fisheries. US Fish and Wildlife, Bureau of Sport Fisheries, Fish Control Laboratory. La Crosse, WI.
- Schnick, R.A. 1974b. A review of the literature on the use of rotenone in fisheries. US Fish and Wildlife, Bureau of Sport Fisheries, Fish Control Laboratory. La Crosse, WI.
- Scott, J.E. 1995. Memo: Location of frogs, possibly leopard frogs. Arizona Game and Fish Department. Tucson, AZ.
- Sellers, W.D. and R.H. Hill. 1974. Arizona climate. University of Arizona Press. Tucson, AZ.
- SERA (Syracuse Environmental Research Associates, Inc.) 2008. Rotenone human health and ecological risk assessment—final report. USFS Contract A6-3187-C-06-0010. Report dated September 17, 2008.
- Siepmann, S. and B. Finlayson. 1999. Chemical residues in water and sediment following rotenone application to Lake Davis, California. California Department of Fish and Game, Office of Spill Prevention and Response Administrative Report 99-2. Sacramento, CA.
- Skaar, D. 2001. Summary of persistence and toxic effects of rotenone. Status report. Montana Fish, Wildlife, and Parks. Helena, MT.
- Snyder, J.D. 2006. Ecology, management, and intellectual history of native and introduced species. Unpublished Master's Thesis, Arizona State University. Tempe, AZ.
- Spencer, F. and L. Sing. 1982. Reproductive responses to rotenone during decidualized pseudogestation and gestation in rats. Bulletin of Environmental Contamination and Toxicology 228:360-368.
- Stefferdud, J.A. and D.L. Propst. 1996. A lightweight, constant-flow device for dispensing liquid piscicides into streams in remote areas. North American Journal of Fisheries Management 16(1):228-230.

- Stefferd, J.A. and S.E. Stefferud. 2004. Aquatic and riparian surveys of selected stream courses on Sierra Vista and Nogales Ranger Districts, Coronado National Forest, Cochise and Santa Cruz Counties, Arizona. Final Report to US Forest Service, Agreement 11CS110305-17-032. Arizona State University. Tempe, AZ.
- Stefferd, S.E. 1988. Trip report for June 22, 1988; Bog Hole. U.S. Fish and Wildlife Service. Phoenix, AZ.
- Stefferd, S.E. 2008. Aquatic invertebrate monitoring: brown trout control program, South Fork Kern River, September 1976. Appendix 1 in E.P. Pister. Restoration of the California golden trout in the South Fork Kern River, Kern Plateau, Tulare County, California, 1966-2004, with reference to Golden Trout Creek. California Department of Fish and Game. Central Region Administrative Report No. 2008-1.
- Stefferd, S.E. and J.A. Stefferud. 2007. Fish movement through intermittent stream channels: a case history study. Final Report to US Bureau of Reclamation, August 17, 2007. Phoenix, AZ.
- Thiffault, C.; Langston, J.W.; Di Monte, D.A. 2000. Increased striatal dopamine turnover following acute administration of rotenone to mice. *Brain Research* 885: 283-288.
- Tisdale, M. 1985. Chronic toxicity study of rotenone in rats. Report to the US Geological Survey. Upper Midwest Environmental Sciences Center. US Fish and Wildlife Service Study No. 6005-100. La Crosse, WI.
- Trojanowski J.Q. 2003. Rotenone neurotoxicity: a new window on environmental causes of Parkinson's disease and related brain Amyloidoses. *Experimental Neurology* 179(1): 6-8.
- Tucker, C.S. and C.E. Boyd. 1997. Relationships between potassium permanganate treatment and water quality. *Transactions of the American Fisheries Society* 106:481-488.
- USFS (US Forest Service). 2003. Environmental assessment: Seibold/Kunde/Crittenden, Papago allotment management plans. Coronado National Forest, Tucson, AZ.
- USFS (US Forest Service) and US Bureau of Reclamation (Reclamation). 2007. Biological Assessment. Redrock Canyon native fish restoration project. Sierra Vista Ranger District, Coronado National Forest, and Bureau of Reclamation, Phoenix Area Office. Tucson and Phoenix, AZ.
- Uversky, V.N. 2004. Neurotoxicant-induced animal models of Parkinson's disease: understanding the role of rotenone, maneb and paraquat in neurodegeneration. *Cell and Tissue Research* 318(1):225-241.
- Vezina, C. 1967. Antimycin A, a teleocidal antibiotic. *Antimicrobial Agents and Chemotherapy* 6:757-766.
- Vinson, M.R., E.C. Dinger, and D.K. Vinson. 2010. Piscicides and Invertebrates: after 70 years, does anyone really know? *Fisheries* 35(2): 61-71.
- Walker, C.A. 2003. Effects of antimycin treatment on benthic macroinvertebrates in Sams Creek and Starkey Creek, Grant Smoky Mountains National Park, Blount/Sevier counties, Tennessee. Masters thesis, University of Tennessee. Knoxville, TN.

- Walker, C.R., R.E. Lennon, and B.L. Berger. 1964. Preliminary observations of the toxicity of antimycin A to fish and other aquatic animals. Bureau of Sport Fisheries and Wildlife Circular 186 Investigations in Fish Control. Washington, D.C.
- Weedman, D.A. 1994. Memo to Kirk Young, AGFD, re Bog Hole watershed survey results. Arizona Game and Fish Department. Phoenix, AZ.
- Weedman, D.A., P.J. Sponholtz, and S. Hedwall. 2005. Fossil Creek native fish restoration project. Final project report, November 2005. US Bureau of Reclamation, Arizona Game and Fish Department, US Fish and Wildlife Service. Phoenix, AZ.
- Williams, T. 2007. Native fish: some environmentalists don't get it. High Country News. Available at www.hcn.org/wotr/14782
- Wust, S. 1994. Sworn testimony of Dr. Stephen Wust, Division Director, Water and Waste Management, NM Environmental Department, NM Water Quality Control Commission. (August 12, 2004).

Appendix A. Earthen stock tanks in Redrock Canyon Watershed—not including windmills, wells, metal and cement troughs, small concrete sills, or pipelines. (Tank names in bold correspond to names used on the map in Figure 2)

Tank Name on USGS 15' Topo Maps	Other Names	UTM (12R) NAD 27	Date of Observation	Water Present?	Observer Citation
Meadow Valley Tank (Sec. 23 T22S R17E)	#338048 (USFS maps 2006)	0539006 E 3485510 N	22 June 1988	Yes	Stefferd 1988
			7 November 1988	Yes	Stefferd unpub. data
			20 October 1994	Yes	Weedman 1994
			June 2002	Yes	Mitchell 2002
			11 June 2003	Yes	Stefferd & Stefferd 2004
			29 June 2006	Yes	Stefferd unpub. data
			16 March 2009	Yes	USDA unpub. data
Unnamed (in Meadow Valley Sec. 27 T22S R17E)	Tank #4 (Stefferd 1988) Unnamed tank #5 (#4 on map)(Hendrickson 1988) Divide Tank (Weedman 1994) Meadow Valley Flat Tank #1 (USFWS 2006b) No Name Tank #6 (Mitchell 2002) Lower Meadow Valley Tank (Stefferd vernacular) ADWR#33-42408 (ADWR Records) Hudson Tank #338035 (USFS maps 2006)	0537722 E 3485510 N	22 June 1988	Yes	Stefferd 1988
			7 November 1988	Yes	Stefferd unpub. data
			20 October 1994	Yes	Weedman 1994
			June 2002	No	Mitchell 2002
			August 2002	No	Mitchell 2002
			11 June 2003	No	Stefferd & Stefferd 2004
			29 June 2006	No	Stefferd unpub. data
Cott Tank (Sec. 27 T22 R17E)		0536908 E 3484579 N	7 November 1988	Yes	Stefferd unpub. data
			17 October 1993	Yes	Stefferd & Stefferd in prep.
			9 November 1997	No	Stefferd & Stefferd in prep.
			7 November 1999	Yes	Stefferd unpub. data
			8 October 2000	Yes	Stefferd unpub. data
			3 November 2001	Yes	Stefferd unpub. data
			12 October 2002	Yes	Stefferd unpub. data
			10 June 2003	No	Stefferd & Stefferd 2004
			1 November 2003	Yes	Stefferd unpub. data
			10 June 2004	No	Stefferd unpub. data
			27 October 2004	Yes	Stefferd unpub. data
			8 October 2005	Yes	Stefferd unpub. data
			15 April 2006	No	Stefferd unpub. data
Down Under Tank (Sec. 15. T22S R17E)	ADWR # 38-18694 (Lefevre 2000) #338042 (USFS maps	0538292 E 3487026 N	7 November 1988	Yes	Stefferd unpub. data
			28 June 1993	Yes	Stefferd & Stefferd

Tank Name on USGS 15' Topo Maps	Other Names	UTM (12R) NAD 27	Date of Observation	Water Present?	Observer Citation
	2006)				in prep.
			28 June 1996	Yes	Stefferdun unpub, data
			21 June 2001	Yes	Stefferdun unpub. data
			June 2002	No	Mitchell 2002
			August 2002	Yes	Mitchell 2002
			November 2002	Yes	Fonseca 2002
			10 June 2003	No	Stefferdun & Stefferdun in prep.
			16 June 2005	No	Frederick 2005
Not shown (Concrete dam in mainstem below Down Under Tank, Sec. 15 T22S R17E)		0538122E 3486949 N	7 November 1988	No filled in w/ Sediment	Stefferdun unpub, data
			21 June 2001	No filled in w/ Sediment	Stefferdun unpub, data
			10 June 2003	No filled in w/ Sediment	Stefferdun unpub, data
			28 June 2006	No filled in w/ Sediment	Stefferdun unpub, data
Unnamed (in east fork of Kennedy Spring tributary to Redrock Canyon, Sec. 15 T22S R17E)	No Name Tank #2 (Mitchell 2002) Kennedy Tank (Stefferdun vernacular) Ant Bite Tank (AGFD vernacular) North Stock Tank (Lefevre 2000)* ADWR #38-14948 (Lefevre 2000)* ADWR 38-14958 (ADWR records) Ada Tank (ADWR records) Unnamed Tank #30 (Frederick 2005) First Tank (USFS maps 2006) #338029 (USFS maps 2006)	0535822 E 3485392 N	June 2002	Yes	Mitchell 2002
			14 October 2002	Yes	Stefferdun & Stefferdun 2004
			15 April 2006	Yes	Stefferdun unpub. data
			June 2005	Yes	Frederick 2005
			6 June 2006	Yes	Stefferdun & Stefferdun in prep.
Saddle Mountain Tank (Sec. 20 T22S R17E)	North Kennedy Tank (Lefevre 2000, USFS maps 2006) ADWR #38-14957 (Lefevre 2000) #338031 (USFS maps 2006)	0533863 E 3485572 N	June 2002	No	Mitchell 2002
			August 2002	No	Mitchell 2002
			14 October 2002	No	Stefferdun & Stefferdun 2004
Not shown (just upstream of Saddle Mountain Tank Sec. 20 T22S R17E)	This may be the original Saddle Mountain Tank as shown on USGS topo map	0533863 E 3485392 N	14 October	No filled in with sediment & breeched	Stefferdun & Stefferdun 2004
Unnamed (in unnamed tributary to Lampshire Canyon Sec. 10 T22S R17E)	#14 - not found in survey (Mitchell 2002) Unnamed tank just north of Kennedy	0534091 E 3485176 N	14 May 1987	Yes	Simons 1987

Tank Name on USGS 15' Topo Maps	Other Names	UTM (12R) NAD 27	Date of Observation	Water Present?	Observer Citation
	Spring tank in center Sec. 20 (Simons 1987) Kennedy Tank (Lefevre 2000, 2001) ADWR #38-14954 (Lefevre 2000) Bergier No.1 (Lefevre 2001) Kennedy Dev. Spring (USFS maps 2006) #338032 (USFS maps 2006)				
Not Shown (Sec. 18 T22S R17E)	Hells Canyon Tank (Lefevre 2000) ADWR #38-11460	0532571 E 3486668 N			
Unnamed (in unnamed tributary to Lampshire Canyon Sec. 10 T22S R17E)	No Name Tank #5 (Mitchell 2002) Sink Hole Tank (Lefevre 2000 and USFS maps 2006) ADWR #38-14945 #334054 (USFS maps 2006)	0538127 E 3489335 N	June 2002 August 2002	No No	Mitchell 2002 Mitchell 2002
Not Shown (Lower Lampshire Canyon Sec. 6 T22S R17E)	Lampshire Dam (Lefevre 2000) ADWR #38-14951	0532802 E 3490191 N	19 November 2003	No (pool below dam)	Stefferdud & Stefferud 2006
			14 July 2001	No (pool below dam)	Stefferdud unpub. data
			18 August 2001	Yes (filled in w/ sediment)	Stefferdud unpub. data
Lampshire Tank (Sec. 10 T22S R17E)	ADWR #38-14951 (Lefevre 2000) #338039 (USFS maps 2006)	0537507 E 3488244 N	June 2002	No	Mitchell 2002
			August 2002	Yes	Mitchell 2002
			16 June 2005	No	Frederick 2005
			28 June 2006	No	Stefferdud unpub. data
White Tank (upper Box Canyon Sec. 3 T22S R17E)	ADWR #38-12528 (Lefevre 2000) #334037 (USFS maps 2006)	0538188 E 3491181 N	June 2002	No	Mitchell 2002
			August 2002	Yes	Mitchell 2002
Unnamed (in drainage to NW of Down Under Tank Sec. 15 T22S R17E)	No Name Tank #1 (Mitchell 2002) Martin Tank (Lefevre 2000, USFS map 2006) ADWR #38-14959 NE Quarter Tank (ADWR records, Lefevre 2001) #338040 (USFS maps 2006)	0537859 E 3487755 N	June 2002 August 2002 28 June 2006	No Yes No	Mitchell 2002 Mitchell 2002 Stefferdud unpub. data
Unnamed (upper end of unnamed tributary to Oak Grove Spring Canyon in East ½ Sec. 35—tank in Sec. 26 T21S R16E)	No Name Tank #3 (Mitchell 2002) Dry Tank (USFS maps 2006) #314012 (USFS maps 2006)	0530763 E 3493563 N	June 2002 August 2002	No Yes	Mitchell 2002 Mitchell 2002
Unnamed	No Name Tank #4	0532158 E	June 2002	Yes	Mitchell 2002

Tank Name on USGS 15' Topo Maps	Other Names	UTM (12R) NAD 27	Date of Observation	Water Present?	Observer Citation
(upper Oak Grove Spring Canyon, tributary to east fork of the north fork Sec. 36 T21S R16E)	(Mitchell 2002) Kunde Tank (AGFD CLF database—per Collins 2003) Oak Tank (Lefevre 2000, USFS maps 2006) ADWR #38-16987 #314013 (USFS maps 2006)	3492777 N			

* The name North Stock Tank and the number 38-14948 as used in Lefevre 2000 and 2001 actually belong to a tank in the Harshaw drainage in SE NW Sec. 14, T22S R16E.

Appendix B. Location records for native and nonnative species in and adjacent to Redrock Canyon.

Species	Location	In Project Area?	Latest Record	Source
Chiricahua leopard frog <i>Rana chiricahuensis</i>	Unnamed tributary from north to Oak Grove Spring Canyon in west 112 Sec. 35	Yes	1997	Scott 1995
	Unnamed tank in north fork Oak Grove Spring Canyon (Oak Tank)	Yes	2003	M. Sredl, pers. comm. 2006
	Harshaw Creek near Harshaw town site	No	1998	USFWS 2006b
	Sonoita Creek near Patagonia	No	1945	USFWS 2006b
	Monkey Spring	No	2000	USFWS 2006b
	Flower Tank in Western Canyon	No	1979	USFWS 2006b
	O'Donnell Canyon	No	2000	USFWS 2006b
	San Rafael Valley Tanks	No	1999	USFWS 2006b
Sonora tiger salamander <i>Ambystoma tigrinum stebbinsi</i>	Unnamed tank in north fork Oak Grove Spring Canyon (Oak Tank)	Yes	2002 2003	Mitchell 2002* M. Sredl, pers. comm. 2006
	Meadow Valley Tank & unnamed tank downstream (Hudson Tank)	Yes	1998	AGFD, unpub. data
	Bog Hole	No	2005	AGFD, unpub data
	San Rafael Valley	No	2006	USFWS 2006b
Sonoran mud turtle <i>Kinosternon sonoriense</i>	Lampshire	Yes	2001	Stefferdud unpub. data
	Oak Grove Spring Canyon	Yes	2002	Mitchell 2002
	Unnamed tributary from north to Oak Grove Spring Canyon in (west side Sec. 35)	Yes	2005	AGFD unpub. data
	Redrock Canyon Lampshire to Red Bank Well (inc. Gate Spring)	Yes	2001	Stefferdud unpub. data
	Redrock Canyon in Cott Tank Exclosure	Yes	2003	Stefferdud unpub. data
	Cott Tank drainage below barriers	Yes	2006	Stefferdud unpub. data
	Cott Tank drainage above barriers	Yes	2006	Stefferdud unpub. data
	Martin Tank	Yes	2002	Mitchell 2002
	Down Under Tank	Yes	2002	Mitchell 2002
	O'Donnell Canyon	No	2007	Clarkson et. al. 2007
	Santa Cruz River in San Rafael Valley (US only)	No	2005	Stefferdud unpub. data
	Sheehy Spring	No	2005	Stefferdud unpub. data
	Post Canyon	No	2002	Stefferdud unpub. data
	Meadow Valley	Yes	2009	USDA unpub data

Species	Location	In Project Area?	Latest Record	Source
Black-necked garter snake <i>Thamnophis cyrtopsis</i>	Gate Spring	Yes	1989	Stefferdun unpub. data
	Red Bank Well	Yes	1990	Stefferdun unpub. data
	Lampshire Canyon	Yes	2001	Stefferdun unpub. data
Mexican garter snake <i>Thamnophis eques</i>	Redrock Canyon—Cott Tank drainage	Yes	Questionable records, 1989, 2006	Stefferdun unpub. data A. Karam, pers. comm. 2006
	O'Donnell Creek @ Finley Tank	No	2000	Rosen et al. 2001
	Bog Hole	No	1986	Rosen and Schwalbe 1988
	Sheehy Spring	No	2000	Rosen et al. 2001
	FS 799 Tank (4.3 air km SSE Cott Tank drainage)	No	2007	AGFD unpub. data
	Santa Cruz River in San Rafael Valley	No	2000	Rosen et al. 2001
	Cott Tank	Yes	2008	Jones unpub. data
Gila topminnow <i>Poeciliopsis occidentalis</i>	Redrock Canyon below Falls	Yes	2003	Stefferdun unpub. data
	Pig Camp Spring	Yes	2001	Stefferdun unpub. data
	Oak Grove Spring Canyon	Yes	1987	Simons 1987a
	Unnamed tributary from north to Oak Grove Spring Canyon in west side Sec. 35	Yes	1987	Simons 1987a
	Lampshire Canyon	Yes	2001	Stefferdun unpub. data
	Redrock Canyon, Falls to Lampshire Canyon	Yes	2001	Stefferdun unpub. data
	Redrock Canyon Lampshire to Red Bank Well (inc. Gate Spring)	Yes	2001	Stefferdun unpub. data
	Redrock Canyon in Cott Tank Exclosure	Yes	2002	Stefferdun unpub. data
	Cott Tank drainage below barriers	Yes	2005	Stefferdun unpub. data
	Cott Tank drainage above barriers	Yes	2008	Stefferdun unpub. data
	Santa Cruz River in San Rafael Valley (US only)	No	1993	Weedman and Young 1997
	Sheehy Spring	No	1987	Bagley et al. 1991
	Monkey Spring	No	2007	Stefferdun unpub. data
	Sonoita Creek near Patagonia	No	2005	Killen 2005
	Harshaw Creek	No	1982--reintro	Voeltz 2003

Species	Location	In Project Area?	Latest Record	Source
	O'Donnell Canyon	No	2004	D. Foster pers. comm. 2004
Desert Sucker <i>Pantosteus clark</i>	Redrock Canyon below Falls	Yes	2002	AGFD unpub. data, Stefferud unpub. data
	Sonoita Creek near Patagonia	No	2005	Foster and Mitchell 2005
	Santa Cruz River in the San Rafael Valley	No	1995	Stefferud unpub. data
Gila Chub <i>Gila intermedia</i>	O'Donnell Canyon	No	2007	Clarkson et al. 2007
	Monkey Spring	No	1969	Weedman et al. 1996
	Sheehy Spring	No	2005	Stefferud unpub. data
Speckled dace <i>Rhinichthys osculus</i>	Redrock Canyon below Falls	Yes	2001	Stefferud unpub. data
	Sonoita Creek near Patagonia	No	2005	Foster & Mitchell 2005
Longfin dace <i>Agosia chrysogaster</i>	Redrock Canyon below Falls	Yes	2008	Stefferud unpub. data
	Pig Camp Spring	Yes	2007	Stefferud unpub. data
	Oak Grove Spring Canyon	Yes	2001	Stefferud unpub. data
	Unnamed tributary from north to Oak Grove Spring Canyon (west side Sec. 35)	Yes	2002	Mitchell 2002
	Lampshire Canyon	Yes	1992	Stefferud unpub. data
	Redrock Canyon Falls to Lampshire Canyon	Yes	2001	Stefferud unpub. data
	Redrock Canyon Lampshire to Red Bank Well (inc. Gate Spring)	Yes	2001	Stefferud unpub. data
	Redrock Canyon in Cott Tank Exclosure	Yes	1993	Stefferud unpub. data
	Redrock Canyon above Cott Tank drainage	Yes	1989	Stefferud unpub. data
	Cott Tank Drainage below barriers	Yes	1994	Stefferud unpub. data
	Harshaw Canyon	No	2002	Stefferud & Stefferud 2004
	Cottonwood Spring	No	2001	Stefferud unpub. data
	Sonoita Creek near Patagonia	No	2005	Killeen 2005
	O'Donnell Canyon	No	2004	D. Foster pers. comm. 2004

Species	Location	In Project Area?	Latest Record	Source
	Santa Cruz River in the San Rafael Valley	No	2002	Voeltz 2003
	West Redrock Riparian Pasture	Yes	2008	Stefferdun unpub. data
Bullfrog <i>Rana catesbeiana</i>	Oak Grove Spring Canyon, SE Fork	Yes	2002	Mitchell 2002
	Oak Grove Spring Canyon, middle tributary to North Fork	Yes	2002	Mitchell 2002
	Pig Camp Spring	Yes	2007	Stefferdun unpub. data
	Lampshire Canyon	Yes	2001	Stefferdun unpub. data
	Redrock Canyon, Gate Spring	Yes	2004	Stefferdun unpub. data
	Redrock Canyon below confluence with Cott Tank drainage	Yes	2000	Stefferdun unpub. data
	Cott Tank drainage below barriers	Yes	2006	Stefferdun unpub. data
	Cott Tank drainage above barriers	Yes	2004	Stefferdun unpub. data
	Down Under Tank	Yes	1996	Stefferdun unpub. data
	Unnamed tank in east fork of Kennedy Spring tributary to Redrock Canyon (First tank)	Yes	2006	Stefferdun unpub. data
	Unnamed tank in unnamed tributary to Lampshire Canyon (Sink Hole Tank)	Yes	2002	Mitchell 2002
	Unnamed tank in unnamed tributary to Oak Grove Spring Canyon in east ½ Sec. 35 = Dry tank	Yes	2002	Mitchell 2002
	Meadow Valley Tank & unnamed tank downstream (Hudson Tank)	Yes	2002	Mitchell 2002 AGFD unpub. data
	Bog Hole	No	2002	Fonseca 2002
	FS 799 Tank (4.3 air km SSE Cott Tank drainage)	No	2007	AGFD unpub. data
	Sonoita Creek near Patagonia	No	2006	Killeen, M. pers. comm.
Largemouth bass <i>Micropterus salmoides</i>	Redrock Canyon Lampshire to Red Bank Well (inc. Gate Spring)	Yes	1985	Brooks 1986
	Redrock Canyon above confluence with Cott Tank drainage	Yes	1987	Simons 1987
	Redrock Canyon below confluence with Cott Tank drainage	Yes	1987	Simons 1987

Species	Location	In Project Area?	Latest Record	Source
	Cott Tank drainage below barriers	Yes	1995	Weedman & Young 1997
	Cott Tank drainage above barriers	Yes	1993	Stefferdun unpub. data
	Down Under Tank	Yes	1987	Simons 1987
	Meadow Valley Tank	Yes	1988	Stefferdun 1988
	Bog Hole	No	1994	Weedman 1994
	Sonoita Creek near Patagonia	No	1994	Gori 1997
	O'Donnell Canyon	No	2007	R. Clarkson pers. comm.
	Santa Cruz River in San Rafael Valley	No	2000	Stefferdun unpub. data
Mosquitofish <i>Gambusia affinis</i>	Redrock Canyon below Falls	Yes	2007	Stefferdun unpub. data
	Oak Grove Spring Canyon	Yes	1990	Stefferdun unpub. data
	Lampshire Canyon	Yes	1987	Simons 1987
	Redrock Canyon, Falls to Lampshire Canyon	Yes	2001	Stefferdun unpub. data
	Redrock Canyon, Lampshire to Red Bank Well (inc. Gate Spring)	Yes	2001	Stefferdun unpub. data
	Redrock Canyon in Cott Tank Exclosure	Yes	2009	Stefferdun unpub. data
	Cott Tank drainage below barriers	Yes	2007	Stefferdun unpub. data
	Cott Tank drainage above barriers	Yes	2002	Stefferdun unpub. data
	Redrock Canyon above confluence with Cott Tank drainage	Yes	1988	Stefferdun unpub. data
	Down Under Tank	Yes	1996	Stefferdun unpub. data
	Unnamed tank in east fork of Kennedy Spring tributary to Redrock Canyon (First Tank)	Yes	2005	Frederick 2005
	Cott Tank	Yes	1986	Simons 1987
	Lampshire Tank	Yes	1985	Scott 1995
	Sonoita Creek near Patagonia	No	2000	Rodgeveller 2000
	Harshaw Canyon	No	2002	Stefferdun & Stefferdun 2004
	Bog Hole	No	1997	Stefferdun unpub. data
	FS 799 Tank (4.3 air km SSE Cott Tank drainage)	No	2007	AGFD unpub. data
	Santa Cruz River in San Rafael Valley	No	2005	Stefferdun unpub. data
	Sheehy Spring	No	2005	Stefferdun unpub. data

Species	Location	In Project Area?	Latest Record	Source
	Sharp Spring	No	2009	Stefferd unpub. data
Green sunfish <i>Lepomis cyanellus</i>	Redrock Canyon in Cott Tank enclosure	Yes	1987	Simons 1987
	Redrock Canyon above confluence with Cott Tank drainage	Yes	1987	Simons 1987
	Cott Tank drainage above barrier	Yes	1996	Stefferd unpub. data
	Lampshire Tank	Yes	1985	Brooks 1986
	Down Under Tank	Yes	1987	Simons 1987
	O'Donnell Canyon	No	2007	Clarkson et al. 2007
	Sonoita Creek near Patagonia	No	2005	Killeen 2005
	Bog Hole	No	1997	Stefferd unpub. data
	Santa Cruz River in San Rafael Valley	No	2005	Stefferd unpub. data
Bluegill <i>Lepomis macrochirus</i>	Redrock Canyon upstream of Redrock Well	Yes	1990	Stefferd unpub. data
	Cott Tank drainage below barrier	Yes	1993	Stefferd unpub. data
	Cott Tank drainage above barrier	Yes	1996	Stefferd unpub. data
	Unnamed tank in east fork of Kennedy Spring tributary to Redrock Canyon (First Tank)	Yes	1987	Simons 1987
	Cott Tank	Yes	1985	Stringer et al. 1985
	Down Under Tank	Yes	1986	SONFISHES database
	Lampshire Tank	Yes	1985	Brooks 1986
	Bog Hole	No	1994	Weedman 1994

Appendix C. Index of the Administrative Record (Project Record).

Tab	Description	Author	Recipient	Date
1	Chronic toxicity of cube	Hansen et al.	File	1965
2	Antimycin A, a Teleocidal Antibiotic	C. Vezina	File	1966
3	Field Trials of Antimycin A as a Fish Toxicant	Gilderhus et al.	File	1969
4	Control of Freshwater Fish with Chemicals	R.E. Lennon	File	1970
5	Effects of Physical and Chemical Conditions on the Detoxification of Antimycin	Lee et al.	File	1971
6	A Review of the Literature on the Use of Antimycin in Fisheries	R.A. Schnick	File	1974
7	Deposition and Persistence of Rotenone in Shallow Ponds during Cold and Warm Seasons	Gilderhus et al.	File	1988
8	Oral Toxicity of Rotenone to Mammals	L.L. Marking	File	1988
9	Guidance for the Reregistration of Pesticide Products Containing Rotenone as the Active Ingredient	EPA	File	1989
10	Systemic Administration of Rotenone Produces Selective Damage in the Striatum and Globus Pallidus, but not in the Substantia Nigra	Ferrante et al.	File	1997
11	Rotenone Hazards to Amphibians and Reptiles	Fontenot et al.	File	1994
12	Rotenone Use in North America (1988-1997)	W. McClay	File	2000
13	Parkinson's Disease, Pesticides, and Mitochondrial Dysfunction	P. Jenner	File	2001
14	Rotenone Destroys Dopaminergic Neurons and Induces Parkinsonian Symptoms in Rats	Alam and Schmidt	File	2002
15	An Inflammatory Review of Parkinson's Disease	Orr et al.	File	2002
16	Rotenone—a Review of its Toxicity and Use for Fisheries Management	N. Ling	File	2003
17	The Rotenone Model of Parkinson's Disease: Genes, Environment and Mitochondria	Greenamyre et al.	File	2003

Tab	Description	Author	Recipient	Date
18	1-Methyl-1,2,3,4-tetrahydroisoquinoline Protects Against Rotenone-induced Mortality and Biochemical Changes in Rat Brain	Antkiewicz-Michaluk et al.	File	2003
19	Lawsuit Forces Reevaluation of Wilderness Stream Poisoning Project Consideration of Alternatives Sought for Paiute Cutthroat Trout Restoration	Center for Biological Diversity	File	2003
20	Rotenone Neurotoxicity: A New Window on Environmental Causes of Parkinson's Disease and Related Brain Amyloidoses	J.Q Trojanowski	File	2003
21	The Rotenone Model of Parkinson's Disease	Perier et al.	File	2003
22	Chronic Administration of Rotenone Increases Levels of Nitric Oxide and Lipid Peroxidation Products in Rat Brain	Bashkatova et al.	File	2004
23	Protective Effect of 1-Methyl-1,2,3,4-tetrahydroisoquinoline Against Dopaminergic Neurodegeneration in the Extrapyramidal Structures Produced by Intracerebral Injection of Rotenone	Antkiewicz-Michaluk et al.	File	2004
24	L-DOPA Reverses the Hypokinetic Behaviour and Rigidity in Rotenone-treated Rats	Alam and Schmidt et al.	File	2004
25	Behavioral and Immunohistochemical Effects of Chronic Intravenous and Subcutaneous Infusion of Varying Doses of Rotenone	Fleming et al.	File	2004
26	Rotenone Induces Non-specific Central Nervous System and Systemic Toxicity	Lapointe et al.	File	2004
27	Rotenone, Deguelin, Their Metabolites, and the Rat Model of Parkinson's Disease	Caboni et al.	File	2004
28	Neurotoxicant-induced Animal Models of Parkinson's Disease: Understanding the Role of Rotenone, Maneb and Paraquat in Neurodegeneration	V.N. Uversky	File	2004

Tab	Description	Author	Recipient	Date
29	Mitochondrial Complex I Inhibition Depletes Plasma Testosterone in the Rotenone Model of Parkinson's Disease	Alam and Schmidt	File	2004
30	The Neurobehavioral Changes Induced by Bilateral Rotenone Lesion in Medial Forebrain Bundle of Rats are Reversed by L-DOPA	Alam et al.	File	2004
31	Sleep Disturbances in the Rotenone Animal Model of Parkinson Disease	García-García et al.	File	2005
32	Rotenone Model of Parkinson Disease Multiple Brain Mitochondria Dysfunctions After Short Term Systemic Rotenone Intoxication	Panov et al.	File	2005
33	Intersecting Pathways to Neurodegeneration in Parkinson's Disease: Effects of the Pesticide Rotenone on DJ-1, α -synuclein, and the Ubiquitin—Proteasome System	Betarbet et al.	File	2006
34	Rotenone Produces Opposite Effects Upon Mouse Striatal Dopamine Function as a Result of Environmental Temperature	K.C. Crutchfield and D.E. Dluzen	File	2006
35	Pesticides and Parkinson's Disease—Is There a Link?	T.P. Brown et al.	File	2006
36	IDT Meeting—Redrock Canyon Watershed Aquatic Ecosystem Restoration Project Kick-Off Meeting Agenda, Notes, and Attendance	IDT	File	11/1/2006
37	Controversies on New Animal Models of Parkinson's Disease Pro and Con: the Rotenone Model of Parkinson's Disease (PD)	Schmidt and Alam	File	2006
38	Archaeological Clearances—SHPO	M. Farrel and J. Derby	SHPO, R. Clarkson	12/8/2006
39	Record of Salamanders for Kunde Tank	T. Jones	J. Rorabaugh, S. Stefferud, G. Frederick, P. Rosen, R. Clarkson	12/15/2006

Tab	Description	Author	Recipient	Date
40	Chronic Rotenone Treatment Induces Behavioral Effects but No Pathological Signs of Parkinsonism in Mice	Richter et al.	File	2006
41	Section 106 Consultation—Red Rock Fish Barrier (SHPO Cover Letter)	B. D. Ellis	J. Garrison	12/18/2006
42	Lake Davis Pike Eradication Project Final EIR/EIS (SCH#2005-09-2070)—pages 14-1 to 14-65; J-i to J-150	California Department of Fish and Game	File	01/2007
43	Pesticides and Impairment of Mitochondrial Function in Relation with the Parkinsonian Syndrome	Gomez et al.	File	2007
44	α -synuclein and Tyrosine Hydroxylase Expression in Acute Rotenone Toxicity	Luo et al.	File	2007
45	Neurodegeneration of Mouse Nigrostriatal Dopaminergic System Induced by Repeated Oral Administration of Rotenone is Prevented by 4-phenylbutyrate, a Chemical Chaperone	Inden et al.	File	2007
46	Notice of Public Scoping Period Regarding Preparation of an Environmental Assessment (EA) on Restoration of Native Aquatic Species in the Redrock Canyon Watershed, Coronado National Forest; Mailing List	C.L. Erwin	Mailing List	1/18/2007
47	News Release	BOR	Media	1/18/2007
48	Comment Received during Scoping—S. Stefferud	S. Stefferud	J. McGlothlen	1/27/2007
49	Comment Received during Scoping—L. Peterson	L. Peterson	J. McGlothlen	1/31/2007
50	Comment Received during Scoping—J. Notestine	J. Notestine	J. McGlothlen	2/1/2007
51	Comment Received during Scoping—P. Marsh	P.C. Marsh	J. McGlothlen	2/1/2007
52	Comment Received during Scoping—C. Peterson	C.J. Peterson	J. McGlothlen	2/5/2007

Tab	Description	Author	Recipient	Date
53	Comment Received during Scoping—D. Bertelsen	D. Bertelsen	J. McGlothlen	2/8/2007
54	Comments Received during Scoping—Canelo Hills Coalition	R. Collins	J. McGlothlen	2/11/2007
55	Comments Received during Scoping—A. McGreevy	A. McGreevy	J. McGlothlen	2/11/2007
56	Comments received during Scoping—P. Rosen	P. Rosen	J. McGlothlen	2/16/2007
57	Comments received during Scoping—Sky Island Alliance	T. Hare	J. McGlothlen	2/16/2007
58	Comments received during Scoping—Justification for a constructed barrier on lower Redrock Canyon	S. Stefferud	F. Frederick	2/26/2007
59	Gila Topminnow Habitat and Redrock Watershed Visitation Meeting Agenda and Notes	C. Peterson	File	3/1/2007
60	Chronic inhalation of rotenone or paraquat does not induce Parkinson's disease symptoms in mice or rats	A. Rojo et al.	File	3/29/2007
61	Redrock Canyon Fish Barrier Feasibility Investigation	R. Clarkson	USFWS, USFS	8/2007
62	Biological Evaluation and Management Indicator Species Analysis of Effects and addendum to include species on 2007 FS Sensitive Species list	G. Frederick, M. Fisher	File	6/20/2007
63	Risk assessment for Piscicidal Formulations of Rotenone	L. Turner et al.	File	6/29/2007
64	Material Safety Data Sheet	CWE Properties Ltd.	File	7/12/2007
65	Biological Assessment for Redrock Canyon Native Fish Restoration Project	D. Hardy	S. Spangle	8/3/2007
66	Fish Movement Through Intermittent Stream Channels	S. Stefferud, J. Stefferud	File	8/13/2007

Tab	Description	Author	Recipient	Date
67	Response to a BA—R. Collins	R. Collins	G. Frederick	8/31/2007
68	Draft Environmental Assessment Native Fish Restoration Project	BOR	File	9/2007
69	Legal Notice, Opportunity to Comment Environmental Assessment	BOR	Mailing List	9/14/2007
70	Affidavit of Publication	Sierra Vista Herald/ Bisbee Daily Review	File	9/14/2007
71	Affidavit of Publication	Tucson's Newspapers	File	9/14/2007
72	Response to Biological Assessment— L. Peterson	L. Peterson	D. Hardy	9/25/2007
73	Response to Biological Assessment—L. Peterson	L. Peterson	J. McGlothlen	9/25/2007
74	Comment on Draft EA—Office of Division of Natural Resources White Mountain Apache Tribe	P. Stago Jr.	J. McGlothlen	9/27/2007
74	Comment on Draft EA—J. Burgess	J. Burgess	J. McGlothlen	9/27/2007
76	Email Re: Redrock Fish Barrier BA	R. Collins	G. Frederick	10/04/2007
77	Request for Inclusion in Project	E. Ryberg	CNF	10/8/2007
78	Comment on Draft EA—S. Stefferud	S. Stefferud	C. Erwin	10/13/2007
79	Comment on Draft EA—Canelo Hills Coalition	R. Collins	J. McGlothlen	10/14/2007
80	Comment on Draft EA—L. Peterson	L. Peterson	J. Derby	10/24/2007
81	Request for Additional 60 Days to Complete Section 7 Consultation	S. Spangle	D. Hardy	10/26/2007
82	Exploration of Rotenone inducing Parkinson's Disease in rats	P. Ravenstijn et al.	File	2008
83	Exploring gene environments interactions in Parkinson's-C. McCulloch et al.	C. McCulloch et al.	File	2008

Tab	Description	Author	Recipient	Date
84	Behavioral alterations in Rotenone model of Parkinson's: Attenuation by co-treatment of Centrophenoxine	B. Nehru et al.	File	2008
85	Request for Additional 60 Days to Complete Section 7 Consultation	S. Spangle	D. Montez	2/28/2008
86	Role of reactive oxygen species in the neurotoxicity of environmental agents implicated in Parkinson's	D. Drechsel, M. Patel	File	2008
87	Email Re: Water umbel and Huachuca Springsnail in Redrock	J. Douglas, M. Falk	G. Frederick	3/06/2008
88	Request for Additional 60 Days to Complete Section 7 Consultation	S. Spangle	D. Montez	4/15/2008
89	Final Biological Opinion (AESO/SE 22410-2008-F-0119a)	S. Spangle	D. Montez	6/13/2008
90	Review of Draft BO for Redrock Canyon Native Fish Project	J. Derby	S. Spangle	6/16/2008
91	Biological Evaluation and Management Indicator Species Analysis of Effects	G. Frederick	File	6/20/2008
92	Native Fish: Some environmentalist don't get it	T. Williams	File	7/16/2008
93	Chemical residues in water and sediment following Rotenone applications to Lake Davis 07	S. McMillin, B. Finlayson	File	2008
94	Rotenone Ecological Risk and Health Assessment	Syracuse Environmental Research Associates, Inc.	File	9/17/2008
95	Final Environmental Assessment Native Fish Restoration Project in Redrock Canyon	BOR, USFS	File	June 2008
96	Decision Notice, with a Finding of No Significant Impact	J. Derby	File	July 2008
97	Legal Notice, DN/FONSI	USFS	Media	Unknown

Tab	Description	Author	Recipient	Date
98	Affidavit of Publication	Tucson Newspapers	File	7/17/2008
99	Availability of Decision Notice (DN)/Finding of No Significant Impact (FONSI) and Final Environmental Assessment for Native Fish Restoration in Redrock Canyon, Arizona	C. Erwin	Interested Persons, Organizations, Agencies	7/18/2008
100	Affidavit of Publication	Sierra Vista Herald	File	07/21/2008
101	Notice of NEPA Decision in PALS	PALS	File	7/21/2008
102	Comment on DN/FONSI—L. Peterson	L. Peterson	J. McGlothlen	8/8/2008
103	Notice of Appeal	D. Parker	C. Newman	8/26/2008
104	Appeal of DN/FONSI; New Information Presented at Informal Disposition of Appeal Meeting	D. Parker	J. Derby	9/15/2008
105	Appeal Resolution Meeting Notes and Attendance List	M. Fisher	File	9/16/2008
106	Appeal of Decision and Non-Acceptance of Information	G. Zepeda	D. Parker	9/28/2008
107	Affidavit of Publication	Sierra Vista Herald, Bisbee Daily Review	File	10/23/2008
108	Affidavit of Publication	Nogales International	File	10/24/2008
109	Affidavit of Publication	Tucson Newspapers	File	10/29/2008
110	Redrock Pasture (Kunde Allotment) Proposed Action	J. Heitholt	File	12/02/2008
111	Freedom of Information Act Request	R. Silver	J. Derby	1/13/2009
112	Gila River Basin Native Fish Conservation Program Technical Team Meeting Agenda and Notes	J. Storenson	File	1/30/2009

Tab	Description	Author	Recipient	Date
113	Renovation of Redrock Canyon Watershed Letter Re: barrier decision	L. Ordway	J. Derby	3/04/2009
114	Redrock Coalition Meeting with Game and Fish and other Interested Parties	L. Kennedy	File	3/3/2009
115	AGFD support for Bureau of Reclamation Barriers for Native Fish Conservation	M. Senn	B. Ellis	4/24/2009
116	Notes from IDT Meeting	M. Fisher	File	6/22/2009
117	Special interest areas in and around the Redrock renovation project	M. Fisher	File	10/21/2009
118	Email Re: Meadow Valley and Hudson Tanks being treated; formulation of piscicides that AGFD intends to use; potential for nonnatives to reinvade stream below the Falls	D. Mitchell	M. Fisher	11/06/2009
119	Stockpond management and management plan for the Sonoran Tiger Salamander in the San Rafael Valley	USFS	File	Unknown
120	Stockpond and aquatic habitat management and management guidelines for the Chiricahua Leopard Frog on CNF	USFS	File	unknown
121	Arizona Revised Statutes, Titles 17 Laws	Arizona State Legislature	File	Unknown
122	Reports of Annual Fish Surveys in Redrock Canyon (2004-2009)	S. Stefferud	A. Chavez	12/14/2009
123	Fish management piscicides and invertebrates	M. Vinson et al.	File	2010
124	Scoping Comment Analysis Redrock Canyon Renovation	M. Fisher	File	1/29/2010
125	Draft Environmental Assessment for the Redrock Canyon Renovation Project	J. Derby	Mailing List	2/02/2010
126	Verification of Availability on the Forest Website	J. Able	M. Fisher	2/04/2010

Tab	Description	Author	Recipient	Date
127	Affidavit of Publication	Sierra Vista Herald, Bisbee Daily Review	File	2/05/2010
128	Affidavit of Publication	Nogales International	File	2/05/2010
129	Affidavit of Publication	Tucson Newspapers	File	2/12/2010
130	Email Attempt to Contact J. Notestine Re: returned mail	M. Fisher	J. Notestine	2/9/2010
131	Comment on Draft EA—G. Proctor	G. Proctor	M. Fisher	2/09/2010
132	Comment on Draft EA—Arizona Department of Environmental Quality Air Quality	D. Arnst	M. Fisher	2/19/2010
133	Comments on Draft EA—Canelo Hills Coalition	R. Collins, M. Donaldson, B. Hudson	M. Fisher	2/23/2010
134	Comment on Draft EA—S. Stefferud	S. Stefferud	A. Chavez	2/25/2010
135	Comment on Draft EA—Arizona Department of Environmental Quality Water Quality	W. LeStarge	M. Fisher	2/25/2010
136	Comment on Draft EA—S. Stefferud	S. Stefferud, J. Stefferud	J. Derby	3/02/2010
137	Comment on Draft EA—Marsh & Associates	P. Marsh	M. Fisher	3/02/2010
138	Comments on Draft EA—D. parker	D. Parker	M. Fisher	3/02/2010
139	Comments on Draft EA-F. Koutz	F. Koutz	M. Fisher	3/03/2010
140	CAP BO on SCR barriers	D. Duncan	G. Frederick	3/04/2010
141	Comment on Draft EA—AGFD	R. Vega	J. Derby	3/05/2010
142	Comment on Draft EA—Center for Biological Diversity	R. Silver	J. Derby	3/05/2010
143	Comment on Draft EA—D. Parker	D. Parker	A. Chavez	3/10/2010
144	Notice of Availability Fliers Posted In Patagonia	M. Fisher	File	4/16/2010

Tab	Description	Author	Recipient	Date
145	Notice of a Change in Proposed Action and Reinitiation Criteria Not Triggered	J. Derby	S. Spangle	6/17/2010
146	Redrock Creek Water Balance	P. Ffolliott and R. Lefevre	File	9/26/2000
147	Arizona Revised Statutes Chapter 2 Article 5, 3-341 (Definitions), 3-351 (Registration, Fee; confidential information)	Arizona State Legislature	File	Unknown
148	Response to Arizona Department of Environmental Quality Air Quality Comment on Draft EA	M. Fisher	D. Arnst	08/24/2010
149	Response to Canelo Hills Coalition Comment on Draft EA	M. Fisher	R. Collins, M. Donaldson, B. Hudson	08/24/2010
150	Response to S. Stefferud Comment on Draft EA	M. Fisher	S. Stefferud	08/24/2010
151	Response to Arizona Department of Environmental Quality Water Quality Comment on Draft EA	M. Fisher	W. LeStarge	08/24/2010
152	Response to S. Stefferud and J. Stefferud Comment on Draft EA	M. Fisher	S. Stefferud, J. Stefferud	08/24/2010
153	Response to Marsh & Associates Comment on Draft EA	M. Fisher	P. Marsh	08/24/2010
154	Response to D. Parker Comments on Draft EA	M. Fisher	D. Parker	08/24/2010
155	Response to F. Koutz Comments on Draft EA	M. Fisher	F. Koutz	08/24/2010
156	Response to AGFD Comment on Draft EA	M. Fisher	R. Vega	08/24/2010
157	Response to Center for Biological Diversity Comment on Draft EA	M. Fisher	R. Silver	08/24/2010
158	Response to D. Parker Comment on Draft EA	M. Fisher	D. Parker	08/24/2010
159	Final EA, Decision Notice/ Finding of No Significant Impact	R. Laford	File, Mailing List	

Tab	Description	Author	Recipient	Date
CD 1	Toxicology studies of antimycin, a fish eradicator.	Herr et al.	File	1967
CD 2	A resume of field applications of antimycin A to control fish	Lennon and Berger	File	1970
CD 3	Effects of chemical treatment for fish eradication on stream-dwelling invertebrates.	Minckley and Mihalik	File	1981
CD 4	Sonoran topminnow (Gila and Yaqui) Recovery Plan	US Fish and Wildlife Service	File	1984
CD 5	Coronado National Forest Land and Resource Management Plan	US Forest Service	File	1986, as amended
CD 6	FSM 2620—Habitat Planning and Evaluation	US Forest Service	File	1991
CD 7	Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations	William J. Clinton	File	1994
CD 8	A report on the illnesses related to the application of rotenone to Lake Davis.	California Department of Pesticide Regulation	File	1998
CD 9	Gila topminnow, <i>Poeciliopsis occidentalis occidentalis</i> , revised recovery plan.	US Fish and Wildlife Service	File	1998
CD 10	Effects of introduced mosquitofish and bullfrogs on the threatened California red-legged frog.	Lawler et al.	File	1999
CD 11	Invasive Species	William J. Clinton	File	1999
CD 12	Chronic systemic pesticide exposure reproduces features of Parkinson's disease	Betarbet et al.	File	2000
CD 13	Rotenone use in fisheries management: administrative and technical guidelines manual.	Finlayson et al.	File	2000

Tab	Description	Author	Recipient	Date
CD 14	Responsibilities of Federal Agencies to Protect Migratory Birds	William J. Clinton	File	2001
CD 15	Biological opinion and conference opinion on continuation of livestock grazing on the Coronado National Forest 2-21-98-F-399R1.	US Fish and Wildlife Service	File	2002
CD 16	Sonora tiger salamander (<i>Ambystoma tigrinum stebbinsi</i>) recovery plan.	US Fish and Wildlife Service	File	2002
CD 17	Integrated management techniques to control nonnative fishes.	Dawson and Kolar	File	2003
CD 18	Rotenone—a review of its toxicity and use for fisheries management.	Ling	File	2003
CD 19	Conflicts between native fish and nonnative sport fish management in the southwestern United States.	Clarkson et al.	File	2005
CD 20	FSM 2670—Threatened, Endangered, and Sensitive Plants and Animals	US Forest Service	File	2005
CD 21	South fork flathead watershed west slope cutthroat trout conservation program	Department of Energy	File	2005
CD 22	Chiricahua leopard frog (<i>Rana chiricahuensis</i>) recovery plan.	US Fish and Wildlife Service	File	2007
CD 23	Effects of high levels of antimycin A on aquatic invertebrates in a warmwater Arizona stream.	Dinger and Marks	File	2007
CD 24	Reregistration Eligibility Decision for Rotenone.	US Environmental Protection Agency	File	2007
CD 25	Reregistration Eligibility Decision for Antimycin A.	US Environmental Protection Agency	File	2007

Tab	Description	Author	Recipient	Date
CD 26	Biological opinion on the proposed construction of a fish barrier in Redrock Canyon and the subsequent removal of nonnative fish and frogs and restoration of a native aquatic fauna.	US Fish and Wildlife Service	File	2008