

**FINAL REPORT
FOR
TAMARISK ERADICATION AND RESTORATION OF 63 TRIBUTARIES
IN
GRAND CANYON NATIONAL PARK**

Arizona Water Protection Fund Contract Number 99-075WPF

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Please Note: This report, including Appendices, is included on the accompanying compact disk. The disk also contains a complete set of the project photographs and maps.

I. Abstract.....	4
II. Introduction	5
a. Overview of project status.....	5
b. Justification for recent work.....	6
III. Methods.....	7
a. Area of interest in recent analysis	7
Table 1. Preliminary Tamarisk Surveys and Final Project List	8
b. Dates, times and conditions under which work was completed.....	11
Table 2. October 13-31, 2000 Participant List	11
Table 3. October 11-28, 2002 Participant List	12
Table 4. November 8-25, 2002 Participant List.....	12
Table 5. October 3-20, 2003 Participant List	13
Table 6. October 29 - November 15, 2003 Participant List	13
Table 7. May 25-June 14, 2004 Participant List	14
Table 8. October 2002 Itinerary.....	15
Table 9. November 2002 Itinerary.....	16
Table 10. October 2003 Itinerary.....	17
Table 11. November 2003 Itinerary	18
Table 12. May-June 2004 Itinerary	19
c. Tamarisk control methods and conditions.....	19
Manual Removal	20
Garlon Lance Injection.....	20
Girdle Method (a.k.a. Hack and Squirt)	20
Cut Stump Method	20
Basal Bark Application	20
Combination (a.k.a.combo).....	20
Mitigation Measures.....	20
Herbicide Use	21
d. Tamarisk project monitoring methods and conditions.....	21
e. Analysis of methods.....	22
IV. Results	23
a. Results of project implementation	23
b. Graphs, charts and tables pertaining to results	26
Table 13. Tamarisk Treatment Totals.....	26
Table 14. Tamarisk Retreatment Totals	28
Figure 1. Tamarisk Control by Size.....	29
Figure 2. Tamarisk Control by Method.....	29
Figure 3. Tamarisk Retreatment by Size Class	30
Table 15. Percent Tamarisk Reduction Rate 2000 to 2004	30
Figure 4. Frequency of Tamarisk Before and After Treatment.....	31
Figure 5. Mean Number of Tamarisk Before and After Treatment	31
Figure 6. Substrate Frequency Before and After Treatment	32
Figure 7. Percent Occurrence Growth Form Before and After Treatment	32
V. Discussion and Conclusions	33
a. Discussions and conclusions about results	33
Table 16. Tamarisk Retreatment to Date – Percentage by Size Class	33

b. Discussion and conclusions about results with relation to related literature. 33

VI. Management Recommendations35

a. Overview of management options 35

b. Management recommendations and justification 36

VII. Literature Cited.....36

VIII. Appendices.....39

I. Abstract

Tributaries and side canyons of the Colorado River, and seeps and springs in Grand Canyon National Park (GRCA), are among the most pristine watersheds and riparian habitat remaining in the coterminous United States. These riparian systems deserve a high level of protection from non-native plant invasion. The encroachment of tamarisk (*Tamarix ramosissima*, *T. aphylla*) into these tributaries poses a significant threat to the integrity of the natural ecosystems. GRCA and the Grand Canyon Wildlands Council (GCWC) are committed to the preservation of native plant communities and native ecosystems. National Park Service (NPS) Management Policies require park managers “to maintain all the components and processes of naturally evolving park ecosystems, including the natural abundance, diversity, and genetic and ecological integrity of the plant and animal species native to those ecosystems” (NPS 2001b). Park managers are directed to give high priority to the control and management of exotic species that can be easily managed and have substantial impacts on the Park’s resources (NPS 1985, NPS 2001b).

The primary objectives of this project are to remove tamarisk from 63 tributaries of the Colorado River in Grand Canyon National Park and to monitor the success of the tamarisk removal through pre- and post-removal plant monitoring. This project has been ongoing for two years and has significantly reduced tamarisk distribution within the treated areas and allowed native vegetation to reestablish without exotic plant competition. Prior to initiation of the project, park staff completed extensive public scoping in order to prepare an Environmental Assessment / Assessment of Effect (EA/AEF). Under the Director’s Orders on Compliance (NPS 2001a) staff considered the cumulative effects of multiple projects, and included an analysis of tamarisk removal in all of the park’s tributaries. After review of the public comments GRCA issued a Finding of No Significant Impact (FONSI) for the project in June 2002. Upon completion of the FONSI GRCA restoration biologist Lori Makarick worked with the GCWC to revise the Tamarisk Eradication Plan, budget and contract for this project, and then began to plan the logistics for the fall 2002 river trips.

Project leaders and crew members conducted the first two tamarisk control trips in the fall of 2002 and the second two management trips in the fall of 2003. GRCA staff, supported by supplemental funds, completed 3 additional tamarisk management trips to complete follow-up treatment work and initiate this work in other project locations during the timeframe of this contract. During the timeframe of this contract, crews have removed 70,616 tamarisk trees in 70 project areas. This report summarizes the work completed to date on this project and reconfirms the commitment by the NPS and GCWC to the protection of biodiversity.

II. Introduction

a. Overview of project status.

The project entitled “Tamarisk Eradication and Restoration of 63 Tributaries, AWPF Contract Number 99-075WPF)” within Grand Canyon National Park (GRCA) is now completed and the National Park Service (NPS) accepts the responsibility for follow-up maintenance and monitoring. GRCA and Grand Canyon Wildlands Council (GCWC), in partnership, fulfilled the terms of the grant agreement. To date, three previous reports for this grant have been submitted (fall 2000, fall 2002, and fall 2003), along with additional progress reports and memos. This report combines some of the information from previous reports and is the final report for this contract.

Prior to in the field tamarisk management, the NPS worked for two years to complete the first task listed in the above contract. The task was to “obtain all permits and environmental clearances necessary to conduct the proposed work.” The compliance process was longer than anticipated, due to revised NPS compliance guidelines issued in 2001. The new guidelines, Director’s Order #12: Conservation Planning, Environmental Impact Analysis, and Decision Making, required that the NPS complete public scoping and documentation prior to the initiation of this project (NPS 2001a). The documentation aims to ensure the use of interdisciplinary approaches and principles to decision-making, and that all decisions are based on technical and scientific information.

Public scoping and interdisciplinary team discussions about tamarisk management began in 1998. The NPS issued the final Environmental Assessment / Assessment of Effect (EA/AEF) for the project to the public in February 2002. Staff received and analyzed public comments, and prepared a Finding of No Significant Impact Statement (FONSI), signed by the regional office on June 18, 2002. The park received a written response to the Informal Consultation with the U.S. Fish and Wildlife Service (USFWS) on January 25, 2001 and that letter, along with the incorporation of their recommended changes, completed the Section 7 consultation that was necessary for this project. On April 8, 2002, the State Historic Preservation Officer (SHPO) provided the park with written concurrence on the project moving forward.

By mid-June 2002, all of the necessary permits and clearances for this phase of the overall project were in hand. Project leaders revised the Tamarisk Eradication Plan and Final Tributary List to incorporate the new project timeline, as follows:

- October 2000 – 18-day river trip, project monitoring installation
- October 2002 – 18-day river trip, tamarisk eradication trip #1
- November 2002 – 18-day river trip, tamarisk eradication trip #2
- October 2003 – 18-day river trip, tamarisk eradication trip #3
- November 2003 – 18-day river trip, tamarisk eradication trip #4, and post-project monitoring and follow-up maintenance
- Spring 2004 – 18-day river trip, post-project monitoring and follow-up maintenance

With the project initiated and the preliminary funding secured from the Arizona Water Protection Fund (AWPF), the NPS sought and received additional assistance for this project. GRCA staff, along with the NPS Exotic Plant Management Team (EPMT) based in Lake Mead National Recreation Area, completed one additional tamarisk management trip in March of 2003. Colorado River Fund monies supported the

trip, and participants completed follow-up work in 14 of the 63 areas included in this AWPf funded project. During September 2003 volunteers manually retreated eight of the tributaries included in this project; the National Park Service's Cooperative Conservation Initiative funded that work. In March of 2004, the NPS's Colorado Plateau EPMT, the Colorado River Fund, and the Grand Canyon National Park Foundation (GCNPF) supported an 18 day river trip to assist with project work and initiate work in Phase II project locations. Throughout this project the public and volunteers remained enthusiastic and supportive. At this time, the NPS and GCNPF are seeking additional funds to extend this project into Phase II and continue the required maintenance and monitoring of tributaries funded by this AWPf grant. In addition to acquiring funding to support three trips during the period of this contract, the NPS received over \$115,000 to continue this valuable project and essential restoration work between September 2004 and March 2005.

b. Justification for recent work

Tamarisk (*Tamarix sp.*), commonly known as salt cedar, is an invasive, exotic (i.e. nonnative) shrub or tree that grows in dense stands along rivers and streams in the West. Invasive exotic species are ecologically damaging because they crowd out native plants and threaten biodiversity, habitat quality, and natural ecosystem functions. Tamarisk, introduced to the U.S. in the 19th century as an erosion control agent, spread through the West and caused major changes to natural environments. Tamarisk reached the greater Grand Canyon area during the late 1920s and early 1930s, and became a dominant riparian zone species along the Colorado River following completion of Glen Canyon Dam in 1963, with the fastest invasion likely occurring between 1935 and 1955 (Christensen 1962). The impacts caused by tamarisk in the Southwest are well documented (refer to Reference Section of the EA/AEF and Stevens 2001). These prolific nonnative shrubs displace native vegetation and animals, create conditions that are inhospitable for the germination of native plant seeds, and increase fire frequency. Salt cedar is an aggressive competitor, often developing monoculture stands and altering water tables, which can negatively affect wildlife and native vegetative communities (Duncan 1996). In many areas, tamarisk occupies previously open spaces and is adapted to a wide range of environmental conditions. Once established in an area, it typically spreads and persists.

Distinctive soil types, vegetation, and hydrologic conditions characterize riparian areas that contain biologically diverse and productive ecosystems. In the Southwest, riparian areas account for less than 2% of the land, yet over 65% of Southwestern wildlife depend on riparian habitats. These habitats are the most productive, most valuable and most threatened habitats in the American Southwest (Johnson et al. 1985). Desert seeps and springs rank among the most productive and biologically diverse terrestrial ecosystems and commonly host 100- to 500-fold higher concentrations of species than the surrounding landscapes (Grand Canyon Wildlands Council 2003). Southwestern seeps and springs are often isolated islands of habitat that support an unusual proportion of relict and endemic species, contributing significantly to regional biodiversity. Perennial tributaries, seeps, and springs also provide habitat for many of the obligate wetland species and within GRCA including four endemic plant species: Kaibab sedge (*Carex curatorum*), Navajo sedge (*C. specuicola*), an undescribed thistle (*Cirsium sp.*), and McDougall's yellowtops (*Flaveria mcdougallii*) (Spence 2002).

Tributaries and side canyons of the Colorado River, as well as seeps and springs in GRCA, are among the most pristine watersheds and desert riparian habitats remaining in the coterminous United States. These riparian systems deserve a high level of protection from exotic plant invasion. The recent encroachment of tamarisk into these tributaries poses a significant threat to the integrity of the natural ecosystems. GRCA is

committed to the preservation of native plant communities and native ecosystems (NPS 1995a, NPS 1995b). NPS management policies require park managers “to maintain all the components and processes of naturally evolving park ecosystems, including the natural abundance, diversity, and genetic and ecological integrity of the plant and animal species native to those ecosystems” (NPS 2001b). Park managers are directed to give high priority to the control and management of exotic species that can be easily managed and have substantial impacts on the Park’s resources (NPS 1985, NPS 2001b). The central mission of the GCWC is to create and apply a dynamic conservation area network that ensures the existence, health, and sustainability of all native species and natural ecosystems in the Grand Canyon ecoregion, with a primary goal of restoring natural processes. The removal of tamarisk from these tributaries will provide this protection, encourage ecosystem sustainability, promote native plant community recovers, and allow both the NPS and GCWC to adhere to their central missions and policies.

III. Methods

a. Area of interest in recent analysis

Under this contract, crews completed tamarisk control work in more than 63 areas within Grand Canyon National Park. Project leaders selected the tributaries based on the numbers of tamarisk trees found during the preliminary surveys (i.e. feasibility of control at this time) and the extent of the seeps, springs, and riparian habitat found within the project areas. Prior to project initiation, crews conducted tamarisk surveys in all of the tributaries on the approved list (Table 1). Survey crews hiked as far up the tributaries as logistically possible and counted all tamarisk trees. Trees were broken down into the following categories:

Seedling	Newly emerged plants up to 1m tall
Sapling	Plants with less than 5cm diameter at the base of the trunk
Mature	Plants with greater than 5cm diameter at the base of the trunk, or with multiple branching at the base of the trunk

Note: The category of seedling does not adhere to the strict botanical definition, which means that the cotyledon is still attached to the emerging plant. For the purposes of the surveys, seedling denotes a plant that could be manually removed.

Survey crews also recorded ancillary data about the canyons such as general information about the canyon and access from the river. The surveys provided the baseline information necessary for determining trip schedules and logistics. Surveys revealed that the majority of the tamarisk trees that occur in side canyons are seedlings, which can be manually removed. The funding received for this project allowed the NPS and GCWC to initiate control while it was still feasible.

Table 1. Preliminary Tamarisk Surveys and Final Project List

Tamarisk Size Classes								
River Mile	River Side	Canyon	Seedling	Sapling	Mature	TOTAL Tamarisk	SW Willow Flycatcher Habitat Assessment Complete	Archaeological Resources Within 300m
11	R	Soap Creek	2000	62	10	2072	X	X
20.5	R	North Canyon	2	7	16	25	X	
37.7	L	Tatahatso Wash	0	7	1	8	X	
39	R	First redbud alcove	19	8	8	35	X	
39.2	R	Second redbud alcove	0	0	6	6	X	
40.9	R	Buckfarm Canyon	5	5	14	24	X	
41.2	R	Bert's Canyon	0	0	8	8	X	X
56.2	R	Kwagunt Creek	8	35	5	48	X	X
57.5	R	Malgosa Canyon	0	0	80	80	X	X
64.7	R	Carbon Creek	47	49	54	150	X	
65.5	R	Lava Canyon	46	245	161	452	X	X
65.7	L	Palisades Creek	0	4	11	15	●	X
69.8	R	Basalt Canyon	1000	200	40	1240	X	X
74.1	R	74 mile Wash	0	4	0	4	X	
75	R	Escalante Creek	8	19	3	30	X	
75.6	L	75 mile Creek	697	65	14	776	X	X
81	R	Vishnu Creek	10000	71	44	10115	X	
84	L	Lonetree Canyon	130	8	21	159	X	
84	R	Clear Creek	2	4	14	20	X	
85	R	85 mile Spring	5	16	5	26	X	
88	R	Lower Bright Angel Creek	1000	131	135	1266	●	
91.6	R	Trinity Creek	30	101	38	169	●	
92.5	L	Salt Creek	0	0	4	4	X	
93.5	L	Monument Creek	87	74	245	406	X	X
94	R	94 mile Creek	155	202	238	595	X	
94.9	L	Hermit Creek	230	58	25	313	X	
96.7	L	Boucher Creek	40	100	40	180	X	
99	R	Tuna Creek	487	39	70	596	X	
105	L	Ruby Canyon	6	26	36	68	X	
106	L	Serpentine Canyon	0	10	38	48	X	
107.8	R	Hotauta Canyon	11	20	20	51	X	X
107.8	L	South Bass Canyon	3	19	20	42	●	X
111	R	Hakatai Canyon	0	0	100	100	●	
112	R	Waltenberg Canyon	12	20	11	43	X	
114.5	L	Garnet Canyon	10	118	25	153	X	
116.5	L	Elves Chasm	1	10	26	37	X	X
117	L	Bighorn Wash	100	47	14	161	X	
120	R	Lower Blacktail Canyon	40	0	4	44	X	X

120	R	Upper Blacktail Canyon	0	15	16	31	X	
122	R	122 Mile Creek	2	2	10	14	X	X
122.7	L	Forster Canyon	16	83	22	121	X	X
124.9	L	Fossil Canyon	4	10	25	39	X	X
128	R	128 Mile Creek	73	37	110	220	X	
129	L	Specter Chasm	14	35	1	50	X	
130.5	R	Bedrock Canyon	96	200	94	390	X	X
131.8	R	Galloway Canyon	10	34	118	162	X	X
132	R	Stone Creek	0	2	2	4	●	
133	R	133 Mile Creek	4	17	22	43	X	
138.5	R	Cranberry Canyon	9	24	3	36	X	
139	R	Fishtail Canyon	0	1	7	8	X	X
142	R	142 Mile Spring	0	12	2	14	X	
147.8	L	148 Springs	0	0	2	2	X	
147.9	L	Matkatamiba Canyon	500	0	4	504	X	
150	R	150 Mile Canyon	15	14	1	30	X	
152	R	Spring above 152 "Ledges Camp"	19	22	15	56	X	X
155	R	Slimey Tick Canyon	158	9	4	171	X	
155.5	R	Last Chance Canyon	32	14	2	48	X	
164.5	R	Tuckup Canyon	0	3	11	14	X	
168	R	Fern Glen Canyon	0	3	1	4	X	
171	R	Stairway Canyon	3	4	4	11	X	X
174	R	Cove Canyon - Lower	14	47	74	135	X	X
174	R	Cove Canyon - Upper	350	4	7	361	X	X
209	R	209 Mile Canyon	350	102	43	495	X	X
212	R	Bessie's Camp Creek	0	0	15	15	X	
214	R	214 Mile Creek	6	22	14	42	X	X

● Southwest willow flycatcher habitat surveys will be completed in these areas before tamarisk control begins.

A general description of the overall project areas illustrates the importance of protecting and restoring these project areas. High species diversity, high species density, and high productivity generally characterize these riparian areas. Continuous interactions occur among riparian, aquatic, and upland terrestrial ecosystems through exchanges of energy, nutrients, and species. Warren et al. (1982) provided the following description:

“Riparian woodlands (or forests) characterized by cottonwood-willow associations are primarily restricted to the larger perennial streams and drainages of the Colorado Plateau region of northern Arizona. The great biological importance and floristic diversity of these cottonwood-willow riparian forests is disproportionate to their limited total area.... Riparian scrub usually occurs along ephemeral or intermittent watercourses (such as desert arroyos), or in narrow canyons which are periodically scoured by floods. Riparian scrub communities are characterized by a broad continuum of vegetative associations that range from mesic vegetation types to xeric growth along desert arroyos (Brown et al. 1980). These arroyos often contain water only one day or less each year and the resulting vegetation is commonly composed of a mixture of facultative riparian species and upland species. This is in contrast to mesic species, which are generally absent from the surrounding uplands.... Side canyons throughout the park with perennial water support riparian vegetation characterized by cottonwood

(*Populus fremontii*) and willow (*Salix* spp.) which is generally very similar to that found in similar situations throughout northern Arizona (Phillips and Phillips, 1979)....”

Each dry wash, spring, seep, or stream has a different association of species, depending on environmental features including elevation, permanence of water, substrate, frequency of flooding, and colonization (Warren et al. 1982). Riparian vegetation typically occurs in small, discrete stands or patches. The floristic diversity in wetland and riparian composition is highly variable, but is extremely high when compared to the upland vegetation. Typical stands may consist of broad-leaved deciduous trees in the overstory, with a mixture of shrubs and grasses in the understory.

Species typical of drainages with perennial water sources are:

- | | |
|---|---|
| ♣ Fremont cottonwood (<i>Populus fremontii</i>) | ♣ Willow (<i>Salix exigua</i> , <i>Salix goodingii</i>) |
| ♣ Brickellia (<i>Brickellia longifolia</i>) | ♣ Monkey flower (<i>Mimulus cardinalis</i>) |
| ♣ Catclaw acacia (<i>Acacia gregii</i>) | ♣ Mesquite (<i>Prosopis glandulosa</i>) |
| ♣ Apache plume (<i>Fallugia paradoxa</i>) | ♣ Emory baccharis (<i>Baccharis emoryi</i>) |

Species typical of drainages with dry washes or intermittent water are:

- | | |
|--|--|
| ♣ Catclaw acacia (<i>Acacia gregii</i>) | ♣ Mormon tea (<i>Ephedra</i> spp.) |
| ♣ Baccharis (<i>Baccharis</i> spp.) | ♣ Four-wing saltbush (<i>Atriplex canescens</i>) |
| ♣ Snakeweed (<i>Gutierrezia sarothrae</i>) | ♣ Fremont cottonwood (<i>Populus fremontii</i>) |
| ♣ Apache plume (<i>Fallugia paradoxa</i>) | ♣ Skunkbush (<i>Rhus trilobata</i>) |
| ♣ Utah agave (<i>Agave utahensis</i>) | ♣ Red-bud (<i>Cercis occidentalis</i>) |

Upland species, described below, are also present in these dry or intermittent washes. Trees and shrubs tend to be scattered, but may also form dense thickets. Species composition varies depending on moisture availability, elevation, and geographic location in the canyon. Within the park, tamarisk occurs in the many of the side canyon and tributaries; however, the distribution and density is highly variable.

The vegetation surrounding the tributaries is generally from desert scrub communities, which are composed of plant species from three of the four North American desert floras, the Sonoran, Mojave and Great Basin. The Sonoran desert scrub has the highest diversity of species. A two-season rainfall regime and lack of freezing temperatures characterizes the Sonoran desert (Warren, et al. 1982). The Mojave desert scrub has higher local species diversity, but is primarily dominated by shrubs; it is characterized by winter rains and the absence of freezing temperatures (Warren, et al. 1982). The Great Basin desert receives more winter rain than the Mojave, and frequently has severe winter freezes and the lowest diversity of the three (Warren et al. 1982).

Big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus* spp.), Mormon tea (*Ephedra* spp.) and a variety of perennial grasses dominate the Great Basin desert scrub. These associations are typically found in the lower portion of the canyon and comprise the vegetation surrounding some of the middle and lower tributaries. Typical Mojave desert species include blackbrush (*Coleogyne ramosissima*), turpentine broom (*Thamnosma montana*), bladder sage (*Salazaria mexicana*), and other species. The Sonoran desert species include brittle bush (*Encelia farinosa*), catclaw acacia (*Acacia greggii*), ocotillo (*Fouquieria*

splendens) and desert willow (*Chilopsis linearis*). Sonoran associations occur in the lower portion of the canyons, and many of these species can grow directly in infrequently scoured drainages.

b. Dates, times and conditions under which work was completed

In October 2000, crews installed photopoints and vegetation transects. Crews completed the tamarisk control work in October-November 2002 and 2003, and February-March 2004, with supplemental work funded by other sources during March, September and November 2003, and March 2004. The fall months are ideal for tamarisk work since the trees are still actively transporting nutrients and water through the phloem and xylem, thus the insertion of herbicide into the tree yields effective control results. However, crews did complete supplemental project work in the spring, with good results.

Due to the remoteness of the terrain, it was necessary to access the majority of the project areas from the river, with the exception of Monument Creek, South Bass, Hermit Creek and Lower Bright Angel Creek, where crews were able to backpack into. Each of the fall trips launched from Lees Ferry and ended at Diamond Creek, with the exception of the October 2000 trip which proceeded, with shivering cold participants, all the way to Pearce Ferry due to the closure of the Diamond Creek road following a flash flood. On the fall 2002 and 2003 trips there were 16 participants and 5 rafts, on the March trips (supported by other funds) there were 18 participants (including two archeologists) and 6 rafts, and on the October 2000 trip there were 12 participants and four rafts. Backpacking trips into South Bass, Hermit Creek, Monument Creek and Bright Angel Creek occurred in February and March 2004. The strong volunteers not only carried their personal gear, but also strapped tools and project supplies to their backpacks.

On each river trip there was an exchange at Phantom Ranch, where new, invigorated volunteers arrived to assist with the project. Often, the upper half volunteers told horror stories about the long days and blisters, yet the newly arrived workers persevered and climbed into the rafts, waving goodbye to the previous group. On each trip, the workdays were extremely long, with coffee served between 6:00 and 6:30 a.m., and dinner often not ready until long after dark. Yet, on each trip, the participants enjoyed the project work, functioned as an integrated unit, and composed songs and stories about the work. The dedication and perseverance of all of the crew members was truly amazing and contributed to the overall success of the project. The hearty volunteers were absolutely crucial to the project accomplishments. Volunteers donated 800 hours in October 2002, 1005 hours in October 2002, 1248 hours in November 2002, 1620 hours in October 2003, and 959 hours in November 2003, 1000 hours in June 2004, 324 hour in March 2004 through backpacking trips, and more than 1000 additional hours on separately funded river trips supporting this project. In total, volunteers donated 7956 hours to this project during its first four years, a value of more than \$115,000 dollars. Please refer to the previous reports for the complete project hour data.

Table 2. October 13-31, 2000 Participant List

Role	Upper Half	Lower Half
Trip Coordinator / Project Leader	Lori Makarick	Lori Makarick
Head Boatman / Trip Leader	Dave Desrosiers	Dave Desrosiers
Boatman	Tim Stephenson	Tim Stephenson
Boatman	Matt Vandzura	Matt Vandzura
Boatman	Bryan Edwards	Bryan Edwards

Crew Leader #1	Rachel Stanton	Rachel Stanton
Crew Leader #2	Eric North	Chris Moore
Crew Leader #3	Fred Phillips	Fred Phillips
Cook / Worker	Simone Sellin	Simone Sellin
Volunteer	Kelly Burke	Kelly Burke
Volunteer	John Grahame	John Grahame
Volunteer	Roy Zipp	Boone Vandzura
AWPF Representative	Salinda Border	Dave Christina
Volunteer	Donna Koster	Donna Koster
Volunteer	Matt Gontram	Matt Gontram

Table 3. October 11-28, 2002 Participant List

Role	Upper Half	Lower Half
Trip Coordinator / Project Leader	Lori Makarick	Lori Makarick
Head Boatman / Trip Leader	Bob Dye	Bob Dye
Boatman	Kim Crumbo	Kim Crumbo
Boatman	R.J. Johnson	R.J. Johnson
Boatman	Alison Steen	Alison Steen
Boatman (volunteer)	Chris Louderback	Chris Louderback
Crew Leader #1	Kim Fawcett	Kim Fawcett
Crew Leader #2	Kate Watters	Kate Watters
Crew Leader #3	Fred Phillips	Anne Hadley
Cook / Worker	Simone Sellin	Simone Sellin
Archeologist	Lisa Leap	Regis Mayo
Volunteer	Kelly Burke	empty
Volunteer	Herman Griego	Bianca
Volunteer	Emily King	Steve Till
Volunteer	Donna Koster	Donna Koster
Volunteer	Matt Gontram	Matt Gontram

Table 4. November 8-25, 2002 Participant List

Role	Upper Half	Lower Half
Trip Coordinator / Project Leader	Lori Makarick	Lori Makarick
Head Boatman / Trip Leader	Bob Dye	Bob Dye
Boatman	Dan Hall	Dan Hall
Boatman	Alison Steen	Alison Steen
Boatman	Chris Louderback	Chris Louderback
Boatman (volunteer)	Matt Gontram	Matt Gontram
Crew Leader #1	Kim Fawcett	Kim Fawcett
Crew Leader #2	Kate Watters	Kate Watters
Cook/Worker	Simone Sellin	Simone Sellin
Volunteer	Rona Levine	Shawn Edwards
Volunteer	Monty Tillinghass	Steve Lomadafkie (tribal)
Volunteer	Beth Eisenberg	Beth Eisenberg

Volunteer	Donna Koster	Donna Koster
Volunteer	Sheila Yokers	Sheila Yokers
Volunteer	Anne Minard	Tom Schiavone
Volunteer	Margie Erhart	Empty

**Note: Anne Minard and Margie Erhart hiked out at Tanner, and Johanna Divine and Michael Whalen hiked in to take their places until Phantom Ranch.*

Table 5. October 3-20, 2003 Participant List

Role	Upper Half	Lower Half
Trip Coordinator / Project Leader	Lori Makarick	Lori Makarick
Head Boatman / Trip Leader	Jeri Ledbetter	Jeri Ledbetter
Boatman	Larry Stevens	Larry Stevens
Boatman	Alison Steen	Matt Dunn
Boatman	Kim Crumbo	Kim Crumbo
Boatman	Chris Louderback	Kate Thompson
Volunteer	Matt Dunn	John Sterling
Crew Leader #1	Kate Watters	Kate Watters
Crew Leader #2	Kim Fawcett	Kim Fawcett
Volunteer / Crew Leader #3	Johanna Divine	Anne Hadley
Cook / Worker	Simone Sellin	Simone Sellin
Volunteer	Jessica Cortright	Jessica Cortright
Volunteer	Scott Smith	Scott Smith
Volunteer	Heather Millar	Herman Griego
Volunteer	Kelly Watters	Kelly Burke
Volunteer	Dave Gentempo	Margie Erhart

Table 6. October 29 - November 15, 2003 Participant List

Role	Upper Half	Lower Half
Trip Coordinator / Project Leader	EMPTY	Lori Makarick
Head Boatman / Trip Leader	Dan Hall	Dan Hall
Boatman	Chris Louderback	Chris Louderback
Boatman	Alison Steen	Alison Steen
Boatman	Nicole Corbo	Nicole Corbo
Boatman	Michael Whalen	Rachel Schmidt
NPS Rep / Volunteer	Chad Olson	Dave Gentempo
Crew Leader #1	EMPTY	Kate Watters
Crew Leader #2	EMPTY	Kim Fawcett
Crew Leader #3	EMPTY	Angela Sokolowski
Cook / Worker	EMPTY	Simone Sellin
Volunteer	EMPTY	Willow Nelson
Volunteer	EMPTY	Chris Moore
Volunteer	EMPTY	Steven Till
Volunteer	EMPTY	Jessica Cortright
Volunteer	EMPTY	Beach Huntsman

Table 7. May 25-June 14, 2004 Participant List

Role	Upper Half	Lower Half
Trip Coordinator / Project Leader	Lori Makarick	Lori Makarick
Head Boatman / Trip Leader	Dave Edwards	Kim Crumbo
Boatman	Kristin Huisinga	Kristin Huisinga
Boatman	Kim Fawcett	Kim Fawcett
Boatman	Jessica Cortright	Jessica Cortright
Crew Leader #1	Kate Watters	Kate Watters
Crew Leader #2	Steve Till	Fred Phillips
Cook	Rachel Running	Rachel Running
Volunteer	Wendy Hodgson	Heidi Kloeppel
Volunteer	Frank Hays	John Randall
AWPF Representative / Volunteer	Reuben Teran	Amy Prince
Volunteer	EMPTY	Maddie Tighe

Prior to each trip, the project leader prepared itineraries, which were then reviewed and approved by park management. Poor weather conditions and additional time needed at specific sites necessitated the alteration of the itinerary on several occasions; however, in general, the well-designed project itineraries allowed ample time to complete project work. The final itineraries for each trip follow, with the exception of the October 2000 trip which did not have a formal itinerary to allow for flexibility in transect and photopoint installation. During each trip, there were only a few days of rain, with the exception of the October 2000 trip which occurred during extreme weather and flash flooding events. Many of the project areas are in narrow side canyons, which are subject to flash flooding. On rainy days, crews only worked in wide open canyons that would be safe during a flood event and minimized the use of herbicide.

Table 8. October 2002 Itinerary

**Grand Canyon National Park / Grand Canyon Wildlands Council
Tamarisk Eradication Trip #1**

October 11-28, 2002

DATE	CAMP	RM	PROJECTS
10/8-9			Food Pack - Simone, Larry, Kim F. & Lori
10/10	Lees Ferry		Meet at 8:45am at Larry's house in Flagstaff for departure. Once we are at Lees Ferry – rig the boats, have lunch, and spend time working on tamarisk treatment techniques.
10/11	North Canyon	RM 20.5 R	All people going downstream need to be at Lees Ferry by 7:30am for an 8:30am departure!!! We'll get to camp late – 20 mile river day! Get all tools and supplies ready for early departure up North.
10/12	Buckfarm Canyon	RM 41 R	North Canyon
			First Redbud alcove
			Second Redbud alcove
			Tatahatso Wash
10/13	Kwagunt	RM 56.2 R	Buckfarm
			Bert's Canyon
10/14	Kwagunt	RM 56.2 R	Kwagunt
10/15	Carbon	RM 64.7 R	Carbon Canyon
10/16	Basalt	RM 69.8 R	Palisades
			Basalt
10/17	Nevills	RM 75.6 L	74 mile wash
			Escalante
			75 mile Creek
10/18	Grapevine	RM 81.3 L	Vishnu Creek
10/19	Cremation	RM 87.2 L	85 mile spring
			Lonetree Canyon
			Clear Creek
10/20	Schist	RM 96 L	EXCHANGE DAY!!! Let's pick up the new folks and be heading downstream by noon. Orientation to the project for new folks, clean up coolers, organize tools, etc.
10/21	Slash/Parkins Camp	RM 108 L	Boucher Creek
10/22	Bighorn Wash	RM 117 L	Bighorn Wash
10/23	Stone Creek	RM 132 R	122 Mile
			Lower Blacktail
10/24	First Chance	RM 157.7 R	142 Mile Spring
10/25	No name	RM 185.5 R	Transit Day
10/26	Granite	RM 209 L	Transit Day
10/27	222 Mile	RM 222 R	Bessie's Camp Creek 212 R
10/28	Sus casitas		TAKE OUT!!!

Table 9. November 2002 Itinerary

**Grand Canyon National Park / Grand Canyon Wildlands Council
Tamarisk Eradication Trip #2**

November 8-25, 2002

Date	Camp	RM	Projects
11/6			Food Pack - Simone, Kate and Kim
11/7	Lees Ferry – We'll do dinner at VC or MC so bring money.		Meet at 9am at Larry's house in Flagstaff for departure (1705 N. San Francisco). Once we are at Lees Ferry – rig the boats, project orientation, etc.
11/8	Above Tiger Wash	26.3 L	LAUNCH!!!! All people going downstream need to be at Lees Ferry by 7:30am for an 8:30am departure!!!
11/9	Malgosa	57.5 R	Malgosa
11/10	Malgosa	57.5 R	Continue work on Malgosa
11/11	Lava Canyon	65.5 R	Lava Canyon *CRF trip works with us
11/12	Lava Canyon	65.5 R	Finish Lava!
11/13	Phantom Ranch	87.2 L	Clear Creek *CRF folks will do the seedlings Lonetree
11/14	Trinity	91.6 R	EXCHANGE DAY!!! Head downstream EARLY!!!! Really. Trinity
11/15	Boucher	96.7 L	Finish Trinity in the morning Salt Creek (1 boat) Boucher
11/16	Waltenberg	112 R	Boucher – continue with this canyon *CRF folks work with us! Waltenberg Canyon
11/17	Upper Blacktail	120 R	Garnet Elves (may cancel this one depending on time) Upper Blacktail
11/18	Stone Creek	132 R	Forster Stone *CRF folks will do the seedlings
11/19	Across from Deer	136.2 L	Fishtail 148 Springs (L)
11/20	Ledges	151.5 R	Matkatamiba (may cancel this on depending on time) 150 Mile
11/21	Fern Glen	168 R	Spring above 152 at Ledges Fern Glen
11/22	Cove	174.3 R	Stairway Cove Canyon – Lower Cove Canyon - Upper
11/23	Parashant	198.5 R	TRANSIT Day
11/24	222 Mile	222 R	TRANSIT and clean up day!
11/25	Sus casitas		TAKE OUT!

Table 10. October 2003 Itinerary

**Grand Canyon National Park / Grand Canyon Wildlands Council
Tamarisk Eradication Trip #3**

October 3-20, 2003

Date	Camp	RM	Projects
10/1			Food purchase/pack and get boats loaded. Jeri/Matt will pack river equipment, Lori/Kim will pack tools/herbicide & deliver to Larry's, Simone/Jessica will be responsible for shopping and food.
10/2	Lees Ferry – We'll do dinner at VC or MC.		RIGGING DAY! Meet at 9am at Larry's house on N. San Francisco. Once at Lees Ferry – rig the boats, have lunch, and spend afternoon with project briefing.
10/3	Hot Na-Na area	16.4 L	All people going downstream need to be at Lees Ferry by 7:30am for an 8:30am departure!!! Really. We will stop at Soap and re-treat the trees there (just to the boundary).
10/4	Buckfarm Canyon	41 R	North Canyon (Team 1)
			First Redbud alcove (Team 2)
			Second Redbud alcove (Team 2)
			Tatahatso Wash (Team 2)
10/5	Kwagunt	56.2 R	Buckfarm (Team 1)
			Bert's Canyon (Team 2)
10/6	Kwagunt	56.2 R	Kwagunt
10/7	Carbon	64.7 R	Carbon Canyon - just to narrows
10/8	Lava Chuar	65.5 R	Lava Chuar
10/9	Lava Chuar	65.5 R	More Lava Chuar
10/10	Nevills	75.6 L	Basalt (Note - we'll have to prioritize today.....)
			74 Mile Wash (Team 1)
			Escalante (Team 1)
			75 mile canyon (Team 2)
10/11	Cremation	87.2 L	Vishnu (Team 1)
			85 Mile Spring (Team 2)
			Clear Creek (Team 2)
10/12	Schist	96 L	EXCHANGE DAY!!! Let's pick up the new folks and be heading downstream by 11am. No tamarisk work today - but orientation to the project for new folks, clean up coolers, organize tools, and full orientation / training.
10/13	Slash/Parkins Camp	108 L	Boucher (Team 1)
			Tuna Creek (99 R) (Team 2)
10/14	Bighorn Wash	117 L	Hakatai 111 R
			Bighorn Wash (re-check if time)
10/15	Galloway	131.8 R	Specter 129 L (Team 1)
			Galloway (Team 2)
10/16	Fishtail	139 R	Cranberry (Team 1)
			Fishtail, camp (Team 2)
10/17	Tuckup	164.5 R	Tuckup
10/18	Parashant	198.5 R	Transit Day
10/19	222 Mile	222 R	Transit Day - See where others are camping, go low down. Start cleaning up supplies, coolers, etc.
10/20	Sus casitas		TAKE OUT!!! Wakey wakey!!!

Table 11. November 2003 Itinerary

**Grand Canyon National Park / Grand Canyon Wildlands Council
Tamarisk Eradication Trip #4**

October 29-November 15, 2003

Date	Camp	RM	Projects
10/27			Food purchase / pack and get boats loaded. Dan will be responsible for packing equipment, Simone/Kim will be responsible for shopping and packing all food.
10/28	Lees Ferry – Dinner in the big town!		RIGGING DAY! Meet at 9am at Can-ex. Drive to Lees Ferry – rig the boats. The upper portion of this trip will be dedicated to transit, so it will just be boatmen, 1 NPS representative.
10/29	Lone Cedar	23.7 L	Transit Day
10/30	Eminence	44 L	Transit Day
10/31	Carbon	64.5 R	Transit Day
11/1	Cremation	87.1 L	*Folks hiking in will arrive today by 3pm at Roy’s Beach – 4pm briefing / dinner / orientation. People can go over to Phantom after that for phone calls, etc. - but we will not have access to the bunkhouse or other facilities. Note- Hikers meet at 411 S. Taber in Williams at 9:30 for ride to South Rim.
11/2	Granite	93.4 L	Trinity (Team 1)
			Salt (Team 1)
			Monument (everyone else)
11/3	94 Mile	94.3 R	94 Mile Creek
11/4	Slash Camp	108	Ruby
			Serpentine
11/5	Bighorn Wash	117 L	Hotauta
			Garnet
			Bighorn Wash - if time
11/6	Forster	122.7 L	Blacktail (Team 1)
			122 Mile (Team 2)
			Forster (Team 2)
11/7	Stone	132 R	Fossil (Team 1)
			128 Mile (Team 1)
			Bedrock (Team 2)
11/8	Stone	132 R	Stone Creek
11/9	Kanab Area	143	133 Mile Creek
			142 Mile Spring
11/10	Ledges	151 R	148 Spring
			Matkatamiba
11/11	Last Chance	155.7 R	152 Springs
			Slimey Tick
			Last Chance
11/12	Cove	174 R	Fern Glen
			Cove
11/13	202 Mile	202 R	Transit Day - Photodocumentation if time
11/14	223 Mile	223 L	Transit Day, Clean Coolers and Tools, etc.
11/15	YER HOMEYS		Wakey wakey eggs and bay-key!

Table 12. May-June 2004 Itinerary

**Grand Canyon National Park / Grand Canyon Wildlands Council
Monitoring Trip #2**

May 26-June 14, 2004

Date	Camp	RM	Projects
5/25	Lees Ferry		Meet at Larry's house at 8:30am, finish packing, drive to Lees Ferry, rig trip and have project orientation.
5/26	19 Mile L	19 L	Soap Creek
5/27	Tatahatso Wash	37.7 L	North Canyon, Tatahatso Wash
5/28	Malgosa	57.5 R	First Redbud Alcove, Second Redbud Alcove, Buckfarm Canyon, Bert's Canyon, Kwagunt Creek, Malgosa Canyon
5/29	Lava Canyon	65.5 R	Carbon Creek, Lava Canyon
5/30	Nevill's	75.6 L	Palisades Creek, 74 Mile Wash, Escalante Creek, 75 Mile Creek
5/31	Cremation	87.2 L	Vishnu Creek, Lonetree Canyon, Clear Creek, 85 Mile Spring
6/1	Salt Creek	92.5 L	Trinity Creek, Salt Creek
6/2	Ross Wheeler	107.8 L	94 mile Creek, Boucher Creek, Tuna Creek, Serpentine Canyon
6/3	Garnet	114.3 R	Hotauta Canyon, Hakatai Canyon, Waltenberg Canyon
6/4	Bighorn Wash	117 L	Garnet Canyon, Elves Chasm
6/5	Blacktail	120.1 R	Bighorn Wash, Lower and Upper Blacktail Canyon
6/6	Randy's Rock	126.5 R	122 Mile Creek, Forster Canyon
		122.7 L	Forster Canyon
6/7	Galloway	131.8 R	128 Mile Creek, Specter Chasm, Bedrock Canyon
6/8	Ponchos	137 L	Galloway Canyon, Stone Creek, 133 Mile Creek
6/9	Kanab Creek	143.4 R	Cranberry Canyon, Fishtail Canyon, 142 Mile Spring
6/10	No name	159 R	148 Springs, Matkatamiba Canyon, Spring above Ledges – 152 Mile, Slimey Tick Canyon, Last Chance Canyon
6/11	Below Lava	179.7 R	Tuckup Canyon, Fern Glen Canyon, Stairway Canyon, Lower Cove Canyon
6/12	Indian Canyon	206.6 R	Various Stops and Transit
6/13	216.4 Mile Camp	216.4 R	209 Mile Canyon, Bessie's Camp Creek, 214 Mile Creek
6/14	Sus Casitas		TAKE OUT, DE-RIG and CLEAN UP!!!!!!!!!!!!

c. Tamarisk control methods and conditions

Each fall river trip was 18 days long and consisted of 16 people. The trip length allowed for sufficient time to access and work in canyons on the itinerary. The goal of the control work was to target 15+ tributaries per trip, totaling the 63 canyons over the 4 control trips scheduled during the contract period. Some project areas required follow-up visits to complete the initial control of the entire tamarisk population and with commitment to this large-scale project, NPS staff sought additional funding and support for the necessary retreatment work. The Grand Canyon National Park Foundation, the NPS's Cooperative Conservation Initiative, the Colorado River Fund, Canyon Expeditions, Arizona Raft Adventures, Diamond River Outfitters, Arizona River Runners, and many individuals contributed valuable monetary, equipment and psychological support to this project.

After incorporation of public comments into the Environmental Assessment / Assessment of Effect (EA/AEF) document, which is required under the National Environmental Policy Act (NEPA) and the National Historic Preservation Act (NHPA), project managers selected the final control methods. For this project crews used a combination of methods including mechanical and chemical. The project coordinator or field crew leader selected the appropriate method(s) for each project location based on site characteristics and weather conditions; a brief description of each method follows:

Manual Removal

This is the method used for seedlings and saplings in washes, streambeds, and non-sensitive areas. Crews used hand tools (i.e. picks, pulaskis, and shovels) to loosen the soil surrounding the plants and remove then the entire root system, or to at least below the root crown. Crews scatter the pulled plants on site, where they remain to decompose.

Garlon Lance Injection

The lance injector is a 1m long tool with four chambers. Small herbicide capsules (approximately 2cm long by 0.6cm in diameter) are placed inside the chambers, the lance is placed against the trunk of the tree, and as the top of the lance is pushed, the chamber opens and a capsule is inserted into the tree. The diameter of the trunk is used to determine the number of capsules inserted. The capsules are made of metal and should be removed after the herbicide gel inside the capsule is released into the tree, which typically take about 6 months.

Girdle Method (a.k.a. Hack and Squirt)

Following in the footsteps of Prince, this is the method formerly known as Hack and Squirt. With this method crews used hatchets and hand saws to cut downward into the water-conducting tissue (phloem) of standing trees and then applied the herbicide mixture directly into the cut with a hand-pressurized sprayer equipped with a coarse spray nozzle. On larger trees, two or more cuts were often necessary. Based on input from other professional tamarisk crews, project leaders modified this method to include a complete girdle around the trunk of the tree.

Cut Stump Method

Crews cut the tree trunks near ground level with handsaws and then applied a 25% Garlon4® herbicide and 25% penetrating oil (JLB oil) solution to the cut surface and the sides of the trunk to ground level. The tree's phloem absorbs the mixture and transports it to the roots, with quick application increasing the effectiveness. Pressurized hand sprayers allow precision herbicide application with minimum overspray or drift risk. Crews extensively used this method alone, and in combination with girdling, achieving high rates of control success.

Basal Bark Application

With this method, crews treated the entire stem with Garlon4® (same mixture as above) from near ground level up to 1m, depending on the tree size. Crews applied the chemical mixture with hand held pressurized sprayers, which have small nozzles with coarse spray settings, allowing for direct spraying and minimal drift or overspray. This method is much less labor intensive, but is less effective on mature trees, so crews limited use of this method to smaller saplings and seedlings.

Combination (a.k.a.combo)

With this method, crews used a combination of girdling, cut stump and basal bark application. Crews primarily used the combination method in highly visible or sensitive areas.

Mitigation Measures

The following specific measures applied to all methods used for the project:

- Debris was disposed of to minimize visual impact (i.e. off trail, out of the drainage, covering cut stumps).
- Empty herbicide capsules were removed from trees in the year following treatment.
- Cut stumps were hidden from view to the extent possible.
- Soil was replaced and tamped down where manual removal was used to help minimize establishment of other invasive exotic species and to minimize visual impact.
- Tree cuts were made on tree sides least visible to backcountry users.
- When pruning, a minimal number of branches were cut to minimize visual impact.

Much of the debris remains on site to decompose and provide habitat for wildlife. Crews minimized the visual impacts of the project through carefully placed cuts and girdles and the combination of control methods employed at each project site. After the first two control trips, project leaders evaluated the success of the various control methods, which helped ensure greater control success.

Herbicide Use

The herbicide used for control was Garlon4® (triclopyr based), which is a general use herbicide, in a mixture of 25% Garlon4® and 75% JLB oil. Garlon3a® was taken on each trip to use directly next to water, but crews did need to use this herbicide, which poses slightly higher safety risks to applicators but less risk to aquatic organisms. One quart stainless steel sprayers, pressurized with bicycle pumps, were the herbicide application tool.

Pesticide certification is not required for Garlon® application; however, the park vegetation staff adopted the policy of having trained and certified applicators on site during application. During these trips, the project leader, all field crew leaders, and some of the volunteers possessed Arizona State pesticide certification. All project participants received herbicide orientation and training from the project leader. Project participants understood and abided by the established Personal Protective Equipment (PPE) requirements, the rules outlined in the safety plan for the project, and the job hazard analyses (JHAs) for exotic plant removal, herbicide application, boat travel, and backcountry camping. Rubber gloves, long sleeve shirts, long pants, and eye protection were part of the PPE necessary for herbicide applicators. Closed toe shoes, long pants, eye protection and leather gloves were the PPE required of all other project participants.

Project leaders followed all information and instructions on the herbicide label. All herbicide containers were leak- and spill resistant. All application equipment and chemicals were stored in sealed ammunition cans or large silver boxes during transport on rafts, and all storage containers had the product's specimen label and the Material Safety Data Sheet (MSDS) clearly displayed underneath a waterproof plastic sheet. The MSDS contains fire and explosive hazard data, environmental and disposal information, health hazard data, handling precautions, and first aid information. All trip participants reviewed the MSDS with the project leader and understood the first aid instructions described on the MSDS. One boat contained all herbicide and application equipment, herbicide containers, and PPE disposal containers, isolated from food and personal items.

d. Tamarisk project monitoring methods and conditions

As stated in the monitoring plan, vegetation cover data were used to determine the project success. The plan called for vegetation transect data collection in at least 25% (16 tributaries), providing an adequate

measure of change in cover percentages. The location selection process, complete prior to the October 2000 trip, was random. Preliminary stratification of the tributaries, based on preliminary survey data, ensured the inclusion of an adequate sample of canyons with greater than 50 tamarisk and less than or equal to 50 tamarisk in the overall design.

The number of transects installed in each area was based on the extent of the tamarisk populations, with the goal of installing 1 to 3 transects in each area. The location of each transect was stratified so that populations of tamarisk would be bisected; therefore, the transect placement in each area was not random. Crews took Global Positioning System (GPS) readings and photographs at the start and end point of each 50m transect. The relocation of the transects was very easy and was accomplished with good maps that included the GPS points on satellite imagery along with a description of the transect.

Each transect was a 50m line, with crews using the point intercept method at every 0.5m (for a total of 100 hits) along the line. Crews used 2m long, 1cm in diameter pole as the point, with all vegetation, litter, brush, bare ground or water touching the point recorded. With this technique it is important to understand that it is possible to have greater than 100% cover when all the species are added together since there are often more than 100 total hits along each transect line. The following general categories and their attributes were used in data collection:

- Rock – Pieces of rock greater than 2cm to boulders or bedrock/schist
- Bare Ground - No cover on the ground to rock less than 2cm in diameter
- Brush - Dead vegetation larger than 2cm in diameter - primarily dead and down tamarisk in the transects
- Litter - Dead vegetation smaller than 2cm in diameter - primarily leaf litter and grass growth
- Soil Crust - Microbiotic soil layers
- Water - Differentiated into perennial and ephemeral

e. Analysis of methods

Although current scientific literature documents successful control methods for tamarisk, refinement to the methods occurred during the work in Grand Canyon. Please refer to Appendix A for examples of methods and sample photographs, and to the fall 2002 and 2003 reports for preliminary discussion of methods.

Crews used the Garlon lance injection method in 2002. Some benefits include increased safety for applicators, since there is less likelihood of contact with herbicide, and rainy conditions do not preclude the use of this method. When crews revisited Clear Creek in March 2003, the injected trees were still alive. Crews removed the capsules, and cut the trees. During 2003, 75 mile canyon flash flooded, and during the fall revisit, some of the injected trees were not located and likely had washed down the canyon. This was a significant concern since crews could not retrieve the empty capsules. Overall, crews found that the control effectiveness was low with this method and did not use it in 2003. However, park staff will further test this method in a controlled and easily visited setting and make a final determination about future use.

Crews used the hack and squirt method in 2002, but based on the control results and input from the Lake Mead Exotic Plant Management Team on the March 2003 trip, project leaders altered the technique prior to 2003 and renamed it the girdle method. Crews determined that it is necessary to cut into the outer bark (about 1cm deep) all the way around the tree trunk, leaving no section uncut. The cut can be lower to the ground than initially planned. Another key to the success is to spray the tree trunk from the cut to the ground

in addition to herbicide application into the cut. Crews still use this method on scattered individual trees, but it remains difficult to use as the sole method in dense stands.

Crews now extensively use the cut stump method alone, and in combination with girdling, since the control results have been the highest. It is also easiest to retreat those areas. Crews did notice that on previously cut mature trees, the regrowth tended to be a basal cluster affectionately named an “afro”. The retreatment method for the afros was basal application and no additional cutting was necessary.

IV. Results

a. Results of project implementation

With AWPf funding the NPS and GCWC, in cooperation with hundreds of volunteers, treated 70,616 tamarisk trees in Grand Canyon National Park. Complete tamarisk treatment data for this project are found in Tables 13 and 14, and displayed in Figures 1, 2 and 3. Initial treatment work included 47,244 seedlings, 16,998 saplings, and 6,374 mature tamarisk trees, with a total of 1,406 saplings and 1,119 mature trees requiring some form of re-treatment, and 2,289 new seedlings pulled in previously treated project areas.

The total tamarisk canopy cover removed from the project sites was 40,804 square meters. In total, crews removed tamarisk from 1819 hectares (4496 acres) of infested land in 70 separate project locations. The approved project list included tamarisk control in 63 project areas, which was exceeded during project completion. The only project areas in which crews did not implement tamarisk control work by the time of this report were along Bright Angel Creek and in 150 Mile Canyon. However, crews supported by NPS funds will initiate tamarisk control along Bright Angel Creek on September 1, 2004. With AWPf project funding in the spring of 2004, crews installed 15 photopoints along Bright Angel Creek to prepare for the work. In such a highly visited area, Lori Makarick, the NPS coordinator for this project, decided to delay the implementation of work in that area until the fall, when visitation will be slightly decreased and large crews will have access to the NPS bunkhouse, also allowing additional project leaders to be trained and hired for such an extensive area. Crews did not visit 150 Mile Canyon due to logistical constraints and poor weather conditions during project implementation. While the approved tributary list for this contract includes these areas, this decision displays the NPS commitment to this project, and work will be well-underway prior to the end of this contract although numbers are not included in this report.

The amount of herbicide used, a mixture of 75% JLB Oil to 25% Garlon 4®, was surprisingly low over such vast acreage. Herbicide applicators used a total of 62.5 mixed gallons on all trips combined; this is equivalent to 15.625 gallons of Garlon4 concentrate and 46.875 gallons of JLB Oil. The skilled applicators and the direct target application methods used led to such a small amount of herbicide applied.

Crews completed follow-up control work in the majority of the project areas, yet in several areas, the preliminary control work required much more labor than predicted based on the tamarisk surveys. The following sites, due to extensive populations, weather, or lack of time, required additional visits and control implementation:

- Kwagunt Creek
- Carbon Creek
- Monument Creek
- 94 Mile Creek
- Boucher Creek
- Tuna Creek

- Fossil Canyon
- 128 Mile Creek
- Bedrock Canyon
- 142 Mile Springs

- 148 Mile Springs
- Stairway Canyon
- Cove Canyon

A large component of this project is long-term monitoring. On the first river trip (October 2000) participants installed the majority of the monitoring components. The components include vegetation transects and photopoints. On the fall 2002 and 2003 trips, crews installed photopoints in additional project areas, for a total of 376 photopoints and reference points installed. Please refer to the monitoring plan for the overall design and implementation scheme. Appendix B, *Project Photodocumentation*, contains a complete set of the project photodocumentation laid out for future field monitoring efforts, including pre- and post-removal photographs and photographs of the photopoints. Appendix C, *Project Photodocumentation Summary Table*, includes the summary data for all of the photopoints. Appendix A, *Representative Project Photographs*, includes examples of the various methods used during project implementation.

Appendix D, *Monitoring Transect Descriptions*, contains descriptions of each of the 22 vegetation transects and Appendix E, *Monitoring Transect Summary Data for 2000 and 2004*, includes all of the data pre- and post-removal transect data. The results from the transect data showed tamarisk reduction by 100% from 2000 (before tamarisk removal) to 2004 (after tamarisk removal) in 20 of the 22 transects surveyed in canyons of Grand Canyon National Park (Table 15). Carbon 3 transect showed a 93% reduction rate and Last Chance 1 showed a 65% reduction rate in tamarisk from 2000-2004. For all 22 transects combined, the percent frequency of tamarisk before removal (2000) decreased 34-fold when transects were surveyed after removal (2004) (Figure 4). There was 35-fold higher mean tamarisk hits on the 22 combined transects before the removal (2000) than after the removal (2004) ($t= 5.143$, $df= 21$, $p<0.0001$, Figure 5).

The transect data also revealed that rock and bare ground were the most frequently occurring substrate type for the 22 transects combined in both 2000 (51%), and 2004 (61%) (Figure 6). The total vegetation hits in the combined 22 transects decreased by two-fold from 2000 to 2004. This reduction in total vegetation hits from 2000 to 2004 may be due to tamarisk removal, since tamarisk composed of 56% of the total vegetation of the combined 22 transects in 2000 and only 3% of the total vegetation in 2004.

When vegetation was categorized by growth form and combined, the data revealed that trees occurred most frequently (59%) in 2000 and grass occurred most frequently (43%) in 2004 (Figure 7). Again, the reduction in the occurrence of trees on the transects from 2000 to 2004 is likely due to tamarisk removal, a sign of success. A complete vegetation list for the species detected on the individual transects in 2000 and 2004 is in Appendix E, *Monitoring Transect Summary Data for 2000 and 2004*. Appendix F, *Plant List Summary Table for Selected Canyons*, contains more complete plant species list for a subset of the project areas. Appendix G, *Plant Lists for Canyons with Transects*, contains complete plant species lists for a subset of the canyons with transects.

b. Graphs, charts and tables pertaining to results

Table 13. Tamarisk Treatment Totals

Canyon Name	Treatment Method						Tree Size			Cover (m2)	Area Infested (sq. meters)
	Pull	Inject	Combo	Girdle	Basal Bark	Cut Stump	Seedling	Sapling	Mature		
105 Mile Canyon R	0	0	0	0	0	17	0	9	8	40	23200
122 Mile Creek R	2	0	0	10	0	3	0	3	12	19	96437
128 Mile Creek R	426	0	0	0	0	214	453	85	102	356	215212
133 Mile Creek	3	0	0	0	0	56	4	20	35	122	90456
142 Mile Spring	0	0	0	2	0	12	0	5	9	103	32224
148 Spring Above Matkatamiba	0	0	5	1	0	21	0	17	10	88	4463
152 Springs (combined with Ledges)	10	0	0	0	0	72	13	52	17	31	0
1st Redbud Alcove	0	0	0	0	0	49	16	27	6	62	18357
209 Mile Canyon R	8	0	0	0	5	155	9	109	50	393	124211
214 Mile Creek	3	0	0	0	0	40	1	32	10	62	59421
2nd Redbud Alcove	0	0	0	1	0	10	1	6	4	29	52663
75 Mile Creek	261	31	0	0	0	4	267	23	6	74	604040
85 Mile Spring	7	0	0	0	0	40	12	30	5	19	84108
91 Mile Canyon R	0	0	0	0	0	42	0	26	16	125	106260
94 Mile Canyon	67	7	0	0	0	662	41	439	256	1598	1110883
Basalt Canyon	4096	0	0	13	0	105	4093	57	64	452	470046
Bedrock Canyon	89	0	0	0	0	496	126	289	170	935	377162
Bert's Canyon	0	0	0	1	0	14	4	4	7	16	219823
Bessie's Camp Creek	0	0	0	15	0	13	1	9	18	127	60266
Bighorn Wash	193	0	0	52	0	19	223	21	20	135	66457
Blacktail Canyon - Upper	202	0	1	0	0	239	148	267	27	219	2754
Boucher Creek	5098	0	36	99	722	4757	7603	2424	685	3095	143133
Buckfarm Canyon	3	0	0	0	0	51	11	21	22	102	946707
Carbon Creek	1	0	0	18	0	208	5	49	173	1236	367949
Clear Creek	616	36	0	2	23	171	711	114	23	246	227837
Cove Canyon - Lower	33	19	0	192	0	186	7	214	209	853	180895
Cove Canyon - Upper	420	0	2	4	0	6	418	5	9	117	0
Cranberry Canyon	0	0	0	0	0	28	0	21	7	26	44069
Elves Canyon	147	0	0	0	0	49	148	18	30	287	70358
Escalante Creek	0	0	0	20	0	1	0	6	15	52	79750
Fern Glen Canyon	0	0	0	0	0	2	0	1	1	2	40721
Fishtail Canyon	0	0	2	2	0	5	0	5	4	35	47349
Forster Canyon	26	0	1	0	0	126	20	93	40	240	112792
Fossil Canyon	29	0	0	0	0	18	28	12	7	69	248531
Galloway Canyon	343	0	2	0	0	1150	641	462	392	1582	542214
Garnet Canyon	177	0	0	4	0	239	194	154	72	286	153778
Hakatai Canyon	8	0	0	0	0	83	8	54	29	118	33937
Hermit Creek	1870	0	0	0	0	1080	1935	728	287	1545	1064122

Hotauta Canyon	3	0	0	0	0	72		6	39	30		67	276634
Kwagunt Creek	503	43	12	71	145	3178		1748	1628	576		4915	1731154
Last Chance Spring	151	0	0	0	0	92		162	74	7		46	16635
Lava Chuar	100	0	59	33	174	2820		642	1790	754		5814	2340319
Ledges Spring	192	0	1	14	0	45		179	53	20		132	16536
Lonetree Canyon	53	0	0	14	0	214		146	109	26		233	106226
Malgosa Canyon	0	0	0	30	0	12		2	7	33		246	276535
Matkatamiba Canyon	1626	0	5	1	0	43		1439	224	12		1100	71939
Mohawk Canyon	6824	0	0	0	0	0		6824	0	0		750	89497
Monument Creek	2101	0	0	0	3115	5567		6992	3490	301		3014	484412
Monument Spring	50	0	0	0	0	0		50	0	0		10	54850
North Canyon	14	0	0	32	0	30		26	8	42		209	116095
Palisades Creek	0	0	0	0	0	20		3	2	15		59	162566
Rider Canyon	184	0	0	1	2	77		231	25	8		131	212736
Ruby Canyon	0	0	0	0	0	9		0	1	8		0	57827
Saddle Canyon	21	0	0	0	0	46		0	67	0		48	376193
Salt Creek	15	0	0	0	0	27		34	5	3		22	114105
Salt Creek Spring	20	0	0	0	0	0		20	0	0		5	154711
Serpentine Canyon	2	0	0	0	0	102		2	57	45		110	81984
Shinumo Creek	66	0	0	3	31	55		110	29	16		16	141583
Slimey Tick Canyon	2031	0	0	0	0	92		1919	188	16		103	96210
Soap Creek	0	0	0	0	3	40		10	10	23		56	127863
South Bass	2	0	0	0	0	0		0	2	0		1	28173
Specter Chasm	7	0	0	0	0	70		8	35	34		118	402022
Stairway Canyon	2	0	1	0	0	57		6	34	20		136	57577
Stone Creek	4289	0	0	0	103	2134		5467	1035	24		1277	576951
Tatahatso Wash	0	0	0	2	0	8		4	4	2		32	21042
Trinity Creek	44	0	0	0	0	301		137	161	47		261	263089
Tuckup Canyon	839	0	0	0	0	5		807	33	4		5	132248
Tuna Creek	31	0	5	0	14	625		241	344	90		878	84460
Unbar Creek	396	0	0	0	1	399		498	150	148		1327	971344
Upper Redbud	9	0	0	0	0	31		9	2	29		116	11461
Vishnu Creek	7	0	0	40	0	165		83	70	59		351	358507
Waltenberg Canyon	12	0	0	0	0	8		9	5	6		11	57944
NEW TREATMENT TOTALS	33732	136	132	677	4338	26787		44955	15592	5255		36495	18194013

TOTAL NUMBER TAMARISK TREATED 65802

Table 14. Tamarisk Retreatment Totals

Canyon Name	Treatment Method						Tree Size			Cover (m2)
	Pull	Inject	Combo	Girdle	Basal Bark	Cut Stump	Seedling	Sapling	Mature	
122 Mile Creek R	0	0	0	0	0	4	0	0	4	0
128 Mile Creek R	300	0	0	0	0	35	317	10	8	15
142 Mile Spring	0	0	0	0	0	4	0	0	4	21
148 Spring (Above Matkatamiba R)	3	0	0	0	0	14	0	1	16	59
1st Redbud Alcove	0	0	0	0	0	2	0	0	2	1
75 Mile Creek	7	0	0	0	0	1	0	6	2	9
85 Mile Spring	1	0	0	0	2	2	1	3	1	1
94 Mile Canyon	1	0	0	0	0	4	0	1	4	2
Basalt Canyon	0	0	0	0	1	21	0	8	14	85
Bessie's Camp Creek	0	0	1	0	0	7	0	3	5	148
Bighorn Wash	0	0	0	0	0	33	0	19	14	59
Blacktail Canyon - Upper	0	0	0	0	3	7	0	3	7	8
Boucher Creek	135	0	61	0	34	347	206	203	168	347
Buckfarm Canyon	0	0	0	0	0	1	0	1	0	1
Carbon Creek	1	0	0	0	0	8	0	2	7	25
Clear Creek	0	0	0	0	0	21	0	16	5	23
Cove Canyon - Lower	11	0	0	22	1	148	13	18	151	945
Cove Canyon - Upper	2	0	0	0	0	6	2	1	5	12
Fern Glen Canyon	89	0	0	0	0	0	89	0	0	4
Forster Canyon	0	0	0	0	0	60	2	43	15	42
Garnet Canyon	4	0	0	0	0	58	0	43	19	49
Hotauta Canyon	0	0	0	0	0	28	1	5	22	12
Kwagunt Creek	12	0	1	0	1	408	46	238	138	624
Lava Chuar	67	0	10	9	601	874	487	647	427	1081
Ledges Spring	0	0	0	0	0	4	0	1	3	1
Monument Creek	155	0	0	0	0	123	178	98	2	20
North Canyon	3	0	0	0	0	18	2	2	17	159
Ruby Canyon	0	0	0	0	0	11	0	0	11	6
Salt Creek	0	0	0	0	0	3	0	2	1	2
Slimey Tick Canyon	14	0	0	0	0	0	14	0	0	1
Soap Creek	0	0	0	0	0	7	0	1	6	3
Specter Chasm	313	0	0	0	0	0	311	2	0	5
Stairway Canyon	68	0	0	0	0	0	68	0	0	8
Stone Creek	547	0	0	0	0	8	540	13	2	334
Tatahatso Wash	0	0	0	0	0	1	0	0	1	7
Trinity Creek	0	0	0	0	0	15	0	10	5	8
Vishnu Creek	6	0	0	0	0	40	7	6	33	181
Waltenberg Canyon	5	0	0	0	0	0	5	0	0	1
RETREATMENT TOTALS	1744	0	73	31	643	2323	2289	1406	1119	4309

TOTAL NUMBER TAMARISK RETREATED 4814

Figure 1. Tamarisk Control by Size

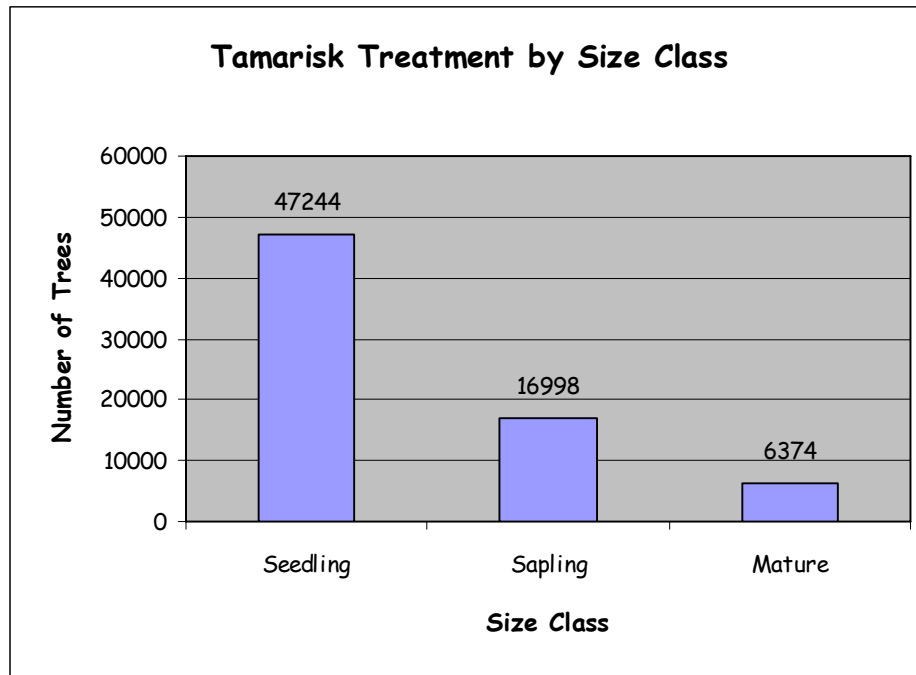


Figure 2. Tamarisk Control by Method

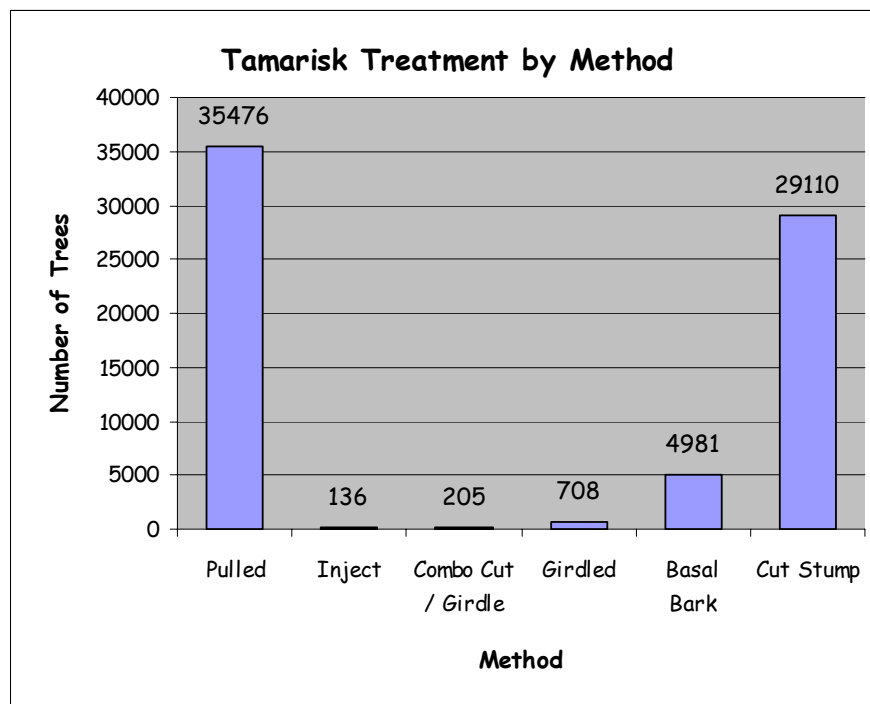


Figure 3. Tamarisk Retreatment by Size Class

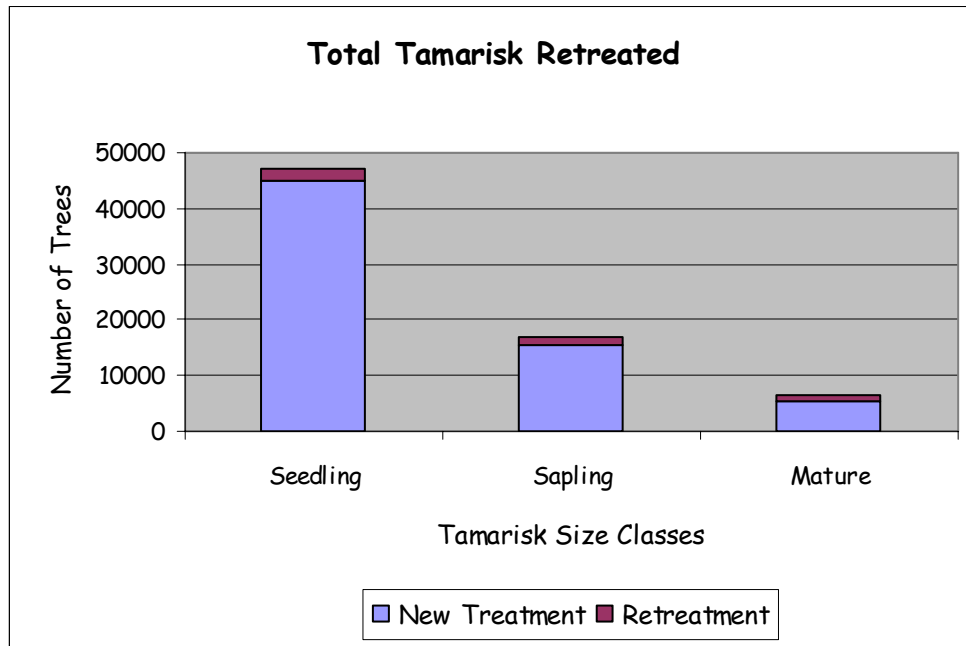
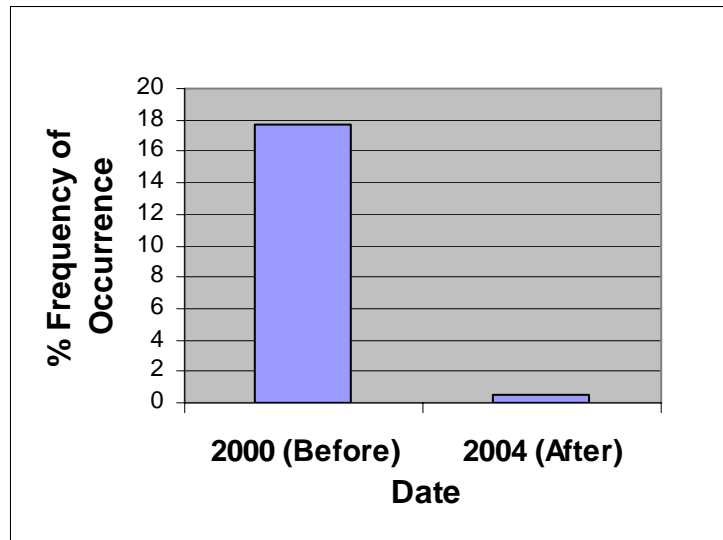


Table 15. Percent Tamarisk Reduction Rate 2000 to 2004

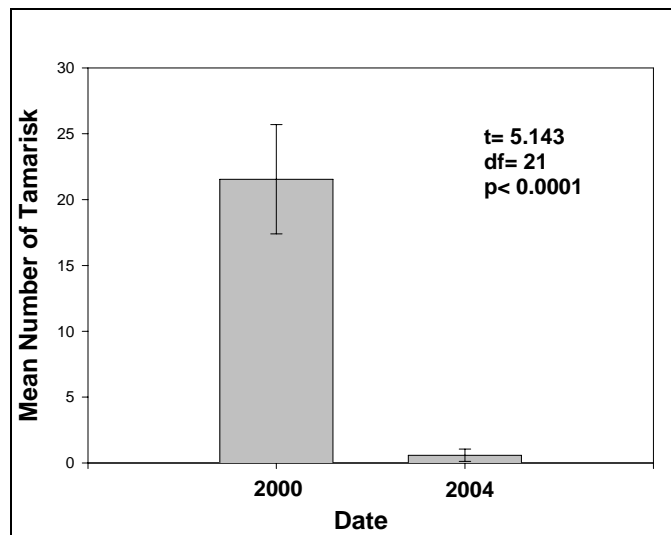
<u>Transect</u>	<u>Reduction Rate (%)</u>
Soap 1	100
Carbon 1	100
Carbon 2	100
Carbon 3	93
Lava Chuar 1	100
Lava Chuar 2	100
Lava Chuar 3	100
Serpentine 1	100
Serpentine 2	100
Hotuata 1	100
Waltenberg 1	100
Garnet	100
Elves Chasm	100
Bighorn Wash	100
Blacktail	100
Forester	100
Specter 1	100
Specter 2	100
Cranberry 1	100
Last Chance 1	65
Cove 1	100
Cove 2	100

Figure 4. Frequency of Tamarisk Before and After Treatment



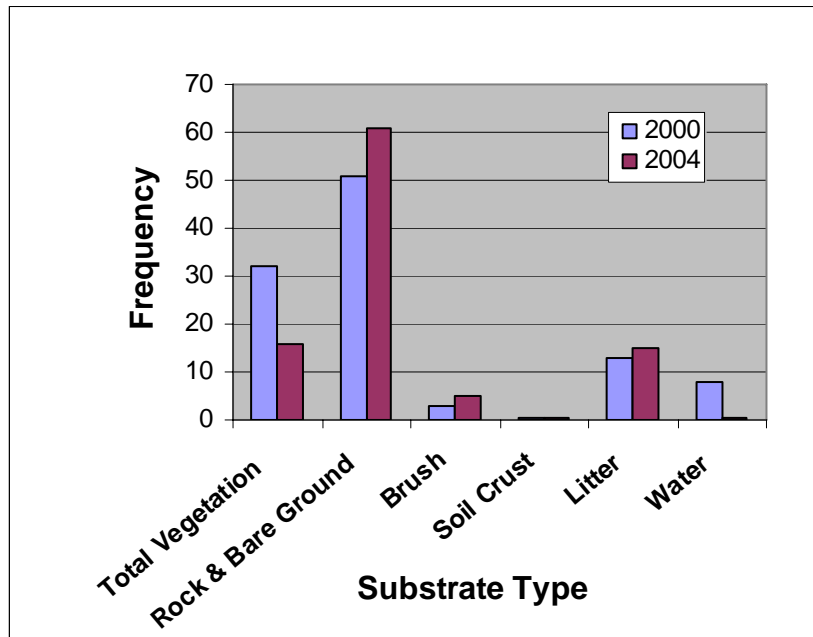
The frequency of tamarisk for total number of hits on 22 combined transects for before (2000) and after (2004) tamarisk removal for canyons in Grand Canyon National Park.

Figure 5. Mean Number of Tamarisk Before and After Treatment



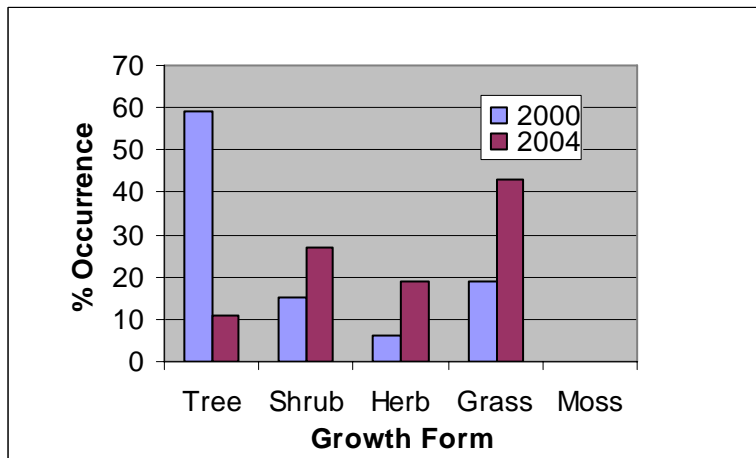
Mean number of tamarisk hits on 22 combined transects for 2000 (before tamarisk removal) and 2004 (after tamarisk removal) for canyons in GRCA. Error bars indicate standard error.

Figure 6. Substrate Frequency Before and After Treatment



Substrate frequency for hits on 22 transects combined in 2000 (Pre-tamarisk removal) and 2004 (Post-tamarisk removal) for canyons in Grand Canyon National Park. All vegetation detected on the transects is combined for total vegetation.

Figure 7. Percent Occurrence Growth Form Before and After Treatment



Percent occurrence of growth forms for total vegetation hits on the 22 transects combined in 2000 (Pre-tamarisk removal) and 2004 (Post-tamarisk removal) for canyons in Grand Canyon National Park.

V. Discussion and Conclusions

a. Discussions and conclusions of results

Grand Canyon National Park and Grand Canyon Wildlands Council staff are extremely satisfied with the results of this large-scale invasive plant management and tributary restoration project. Preliminary survey results revealed 22,589 tamarisk trees within the scope of this project. During project implementation, crews removed 70,616 tamarisk trees from the project area, covering much more ground than project coordinators thought was possible. The retreatment data from the project area shows that only 7% of the initially treated trees required follow-up treatment (Table 16). With the refinement of control techniques, project coordinators anticipate the retreatment needs declining in the future as this project expands.

Table 16. Tamarisk Retreatment to Date – Percentage by Size Class

Size Class	# Tamarisk Retreatment	# Initial Tamarisk Treated	% Retreatment
Seedling	2289	44955	5.091758
Sapling	1406	15592	9.017445
Mature	1119	5255	21.29401
Total	4814	65802	7.315887

The project monitoring design objectives were to display: 1. How successful removing tamarisk from side canyons is in reducing colonization of tamarisk, and 2. How much and to what extent the native plant communities in side canyons recover and benefit from this removal. An acceptable goal was to decrease the tamarisk cover to 5% or less of the pre-management tamarisk cover in the project areas. The results from the transect data showed tamarisk cover and frequency reduction by 100% from 2000 (before tamarisk removal) to 2004 (after tamarisk removal) in 20 of the 22 transects installed in project areas. Only 2 canyons showed a lower rate of tamarisk cover reduction, one with 93% and the other with 65%. The project area with only a 65% cover reduction is a spring in the main Colorado River corridor and due to restrictions in the EA/AEF the project coordinator decided not to remove the tamarisk below the old high water line. Overall, the transect data reveal a very successful project. The project photographs provide supplemental support for the success of this project, with remarkable before and after tamarisk removal changes to these valuable riparian systems.

Public support for this project remains extremely high, another sign of a successful project. A vast cadre of individuals continues to want to donate their time and energy to this project. The project has been documented in the media, with the valuable support from the Arizona Water Protection Fund noted (refer to Appendix H). With Grand Canyon harboring some of the last remaining desert riparian areas, this project has gone a long way in protecting and restoring these valuable ecosystems.

b. Discussion and conclusions about results with relation to related literature.

Tamarisk is an aggressive species that has invaded riparian areas throughout the southwest and often dominates these areas by out-competing the native vegetation. In addition to forming monotypic stands,

biologist have identified many other undesirable attributes for tamarisk, including 1) crowding out native stands of riparian and wetland vegetation (Stevens 1990); 2) increasing the salinity of surface soil rendering the soil inhospitable to native plant species (Hem 1967); 3) providing generally lower wildlife habitat value than native vegetation (Anderson et al. 1977, Engel-Wilson and Ohmart 1978, Kasprzyk and Bryant 1989); 4) drying up springs, wetlands, riparian areas and small streams by lowering surface water tables (Robinson 1965, Weeks et al. 1987); 5) widening floodplains by clogging stream channels (Robinson 1965); 6) increasing sediment deposition due to the abundance of tamarisk stems in dense stands (Everitt 1980); and 7) using more water than comparable native plant communities (Carpenter 1998).

Because non-native plants have become an increasing problem in native riparian habitats, especially in the southwest, the development and implementation of weed management plans have become priorities in order to control non-native species invasion and prevent their introduction. The National Park Service (1990) outlined and defined five control strategies for invasive weeds, including: cultural, biological, physical, genetic, and chemical (herbicides). Later, the Nature Conservancy outlined five methods of effective tamarisk control, including: 1) applying herbicide to foliage of intact plants; 2) removing aboveground stems by burning or mechanical means followed by foliar application of herbicide; 3) cutting stems close to the ground followed by application of herbicide to the cut stems; 4) spraying basal bark with herbicide; and 5) digging or pulling plants (Carpenter 1998). The appropriate method is selected based on the size of the area of removal, chemical restrictions, native species presence, surface water presence, and available funding.

The most effective method for large monotypic stands of tamarisk (>2 hectares) is a foliar application of imazapyr (Arsenal®) herbicide to the intact plants or burning or cutting plants followed by foliar application of imazapyr or triclopyr (e.g. Garlon4® or PathfinderII®) to the resprouted stems (Carpenter 1998). This combination of methods has proven successful for large stands of tamarisk occurring in Afton Canyon, California (Egan et al. 1993), Anza-Borrego Desert State Park, California and Picacho State Recreation Area, California (Jorgensen 1996). However, the burn method by itself has not been successful because burning creates open areas which enables tamarisk to aggressively establish and out compete fire-intolerant native plants. Therefore, the cut-stump/herbicide method provides the most effective tamarisk control over long periods of time.

For modest-sized areas (< 2 hectares), the combination of cut-stump (physical) and herbicide (chemical) controls have shown to be the most effective strategy for tamarisk control (Neill 1990, Egan et al. 1993, Hughes 1996, and Carpenter 1998). The cut-stump method involves cutting individual tamarisk plants as close to the ground as possible, and immediately applying the triclopyr based herbicides (e.g. Garlon4®, Garlon3a®, PathfinderII®) to the cambium ring. Neill (1990, 1996) found that herbicides with triclopyr, appear to be the best choices for killing tamarisk due to higher phytotoxicity, low toxicity to humans, lack of restriction, and cost comparable to other herbicides when diluted as directed. The expected mortality with these herbicides is 95%, with lower mortality probably being the result of not cutting close enough to ground level and/or not treating the circumference of the stump completely (Neill 1990, 1996). Fall is the most effective time to treat tamarisk with this methods since trees are not producing seeds, entering dormancy and transferring reserves to their roots. This method was successfully applied in the Coachella Valley Preserve in California over a 5 year period that resulted in removing tamarisk from 7 ha. (17.5 acre) of wetland that had greater than 80% tamarisk cover over 70% of the wetland (Martin 2001).

Digging or pulling plants alone may be effective if the whole root mass is removed, otherwise resprouting is inevitable. Cutting tamarisk with no follow-up will not be successful, however multiple cuttings or burnings may kill the root system. (Luttrell 1983). Burke (1990) found that scraping a site along the shore of Lake Mead with a bulldozer killed some tamarisk plants, however many resprouted from roots that remained in the soil.

The primary methods used for the tamarisk removal effort in tributaries of Grand Canyon National Park included: manual removal for seedlings and the cut-stump/herbicide treatment for larger trees. These methods followed what the NPS identified as effective control strategies for invasive weeds, including physical (manual removal and cut-stump) and chemical (herbicide) control (NPS 1990). Also, because the proposed area of tamarisk removal in the selected tributaries was usually <2 hectares, tamarisk was integrated with native species in many tributaries, and the access into the tributaries was limited, the cut-stump/herbicide method outlined by The Nature Conservancy (Carpenter 1998) appeared to be the most favorable option. Crews conducted removal trips in October and November in order to coincide with the most effective time to remove tamarisk. The results reveal that tamarisk was successfully reduced, and in many cases effectively removed, in 70 tributary canyons of Grand Canyon National Park.

The cut-stump/herbicide method is very controlled, which is important for ecological systems that may have endangered or rare species present, such as MacDougall's flaveria (*Flaveria macdougalii*), southwestern willow flycatcher (*Empidonax traillii extemis*), and the Kanab ambersnail (*Oxyloma kanabense*) which occur or have been known to occur in Grand Canyon tributaries. Using these methods, herbicide application was limited and localized, preventing the herbicide from contaminating surrounding riparian vegetation, soil, and water. The Bitter Lake National Wildlife Refuge in New Mexico has also successfully managed small areas of tamarisk with the cut-stump/herbicide method in areas with endangered species present (McCown 1998). Overall, this project not only successfully controlled tamarisk in 70 project areas, but also ensured the continued protection of valuable ecosystems and overall biodiversity within Grand Canyon National Park.

VI. Management Recommendations

a. Overview of management options

During the implementation of this project, crews utilized and perfected tamarisk control methods in 70 areas within GCNP. Project leaders should continue to utilize these control and monitoring results to further refine project implementation, and they should continue to visit vegetation transects and project photopoints for a 10 year period. The National Park Service (NPS) has an affirmative responsibility to protect and preserve the resources located within its units. NPS Management Policies require park managers “to maintain all the components and processes of naturally evolving park ecosystems, including the natural abundance, diversity, and genetic and ecological integrity of the plant and animal species native to those ecosystems” (NPS 2001b). Park managers are directed to give high priority to the control and management of exotic species that can be easily managed and have substantial impacts on the Park’s resources (NPS 1985, NPS 2001b).

This project verifies that the control of tamarisk in the park’s side canyons and tributaries is indeed feasible. This project has set back the invasion of tamarisk into project areas by several decades. However, this project requires continued maintenance since the seed source remains in the river corridor remains. A vast body of literature documents the impacts that tamarisk has on southwestern ecosystems,

and Stevens (2001) summarized the impacts and ecology of the species. Since control is feasible and tamarisk poses a substantial impact on the resources located within GRCA, park management should continue and expand this work into other project areas within the park. Park management and the public have been very supportive of this project, and with continued documentation and successful implementation, the support should remain strong.

b. Management recommendations and justification

The EA/AEF for this overall project included three phases of tamarisk management and tributary restoration. The work completed under this contract is Phase I of the overall project. With Phase I successfully complete, funding should be sought to continue this valuable project and expand into Phase II and Phase III project areas. The EA/AEF for this project states that the park will commit to the follow up control necessary for Phase I project sites, and this work (hand pulling seedlings) should be integrated into the overall resource management in the park.

After completion of this report, NPS and GCWC staff should summarize the results and prepare articles for both internal NPS publications and peer-reviewed journals. The NPS should continue to visit re-read the vegetation transects every 3 years and retake photographs every year for a minimum of 10 years. NPS staff should continue to recruit volunteers to assist with the follow-up maintenance needs (i.e. seedling pulling). The NPS should share the project mapping data by displaying the maps on the Park's website.

The funding provided by the AWPf has been essential to getting this project off the ground and protecting and restoring the park's valuable riparian ecosystems. The AWPf was very understanding of the delays in the first task, and allowed the project timeline to be altered to incorporate the time needed to acquire all of the compliance and permits necessary to initiate the project. The partnership between GCNP and the GCWC has been integral to the success of the project, and all parties involved are commended for their dedication. The primary recommendation at this point is to continue the work, and to expand the project to include all of the tamarisk populations in the side canyons and tributaries of the park.

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VIII. Appendices

- Appendix A – Representative Project Photographs
- Appendix B – Project Photodocumentation
- Appendix C – Project Photodocumentation Summary Table
- Appendix D – Monitoring Transect Descriptions
- Appendix E – Monitoring Transect Summary Data for 2000 and 2004
- Appendix F – Plant List Summary Table for Selected Canyons
- Appendix G – Plant Lists for Canyons with Transects
- Appendix H – Project Press and Articles
- Appendix I – Project Implementation Map

APPENDIX A

Tamarisk Eradication and Restoration of 63 Tributaries

Representative Project Photographs

APPENDIX A

Tamarisk Eradication and Restoration of 63 Tributaries Representative Project Photographs – 2004 Final Report



Picture 1. Kim Fawcett, Kate Watters, Lori Makarick – crew leaders for the entire project



Picture 2. Transportation



Picture 3. Plan B Idea



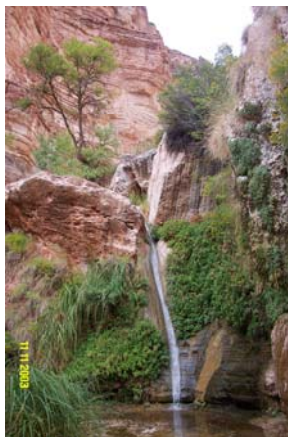
Picture 4. Volunteers making tool covers at Lees Ferry



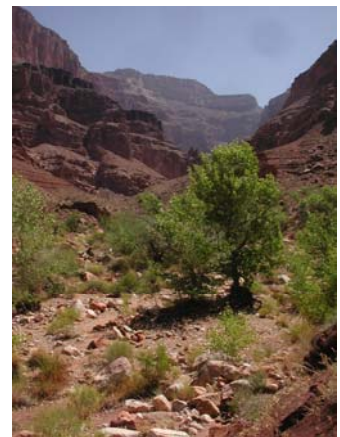
Picture 5. Organizing tools



Picture 6. Tool sharpening



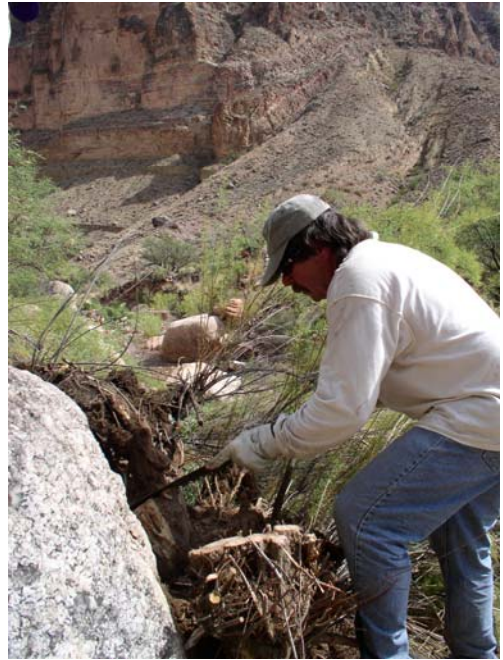
Pictures 7-9. Native riparian vegetation



APPENDIX A
Tamarisk Eradication and Restoration of 63 Tributaries
Representative Project Photographs – 2004 Final Report



Picture 10. Cut stump method on mature trees



Picture 11. Sawing a mature tree



Picture 12. Lopping branches



Picture 13. Record keeping

APPENDIX A
Tamarisk Eradication and Restoration of 63 Tributaries
Representative Project Photographs – 2004 Final Report



Picture 14. Volunteers digging down to roots



Picture 15. Sawing mature clump



Picture 16. Volunteer sawing mature tree



Picture 17. Volunteers hauling brush



Picture 18. Volunteers pulling seedlings

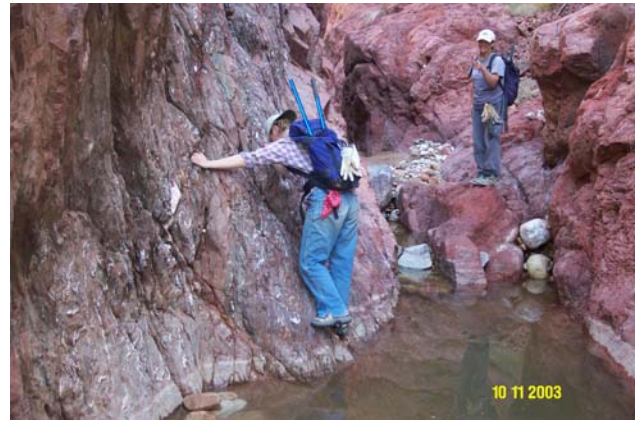


Picture 19. Pulling seedling

APPENDIX A
Tamarisk Eradication and Restoration of 63 Tributaries
Representative Project Photographs – 2004 Final Report



Picture 20. Crews working together



Picture 21. Site access is not always easy!



Picture 22. Herbicide treatment on seedlings



Picture 23. Herbicide treatment on saplings



Picture 24. Cut stump technique



Picture 25. Hack and squirt technique

APPENDIX A

Tamarisk Eradication and Restoration of 63 Tributaries Representative Project Photographs – 2004 Final Report



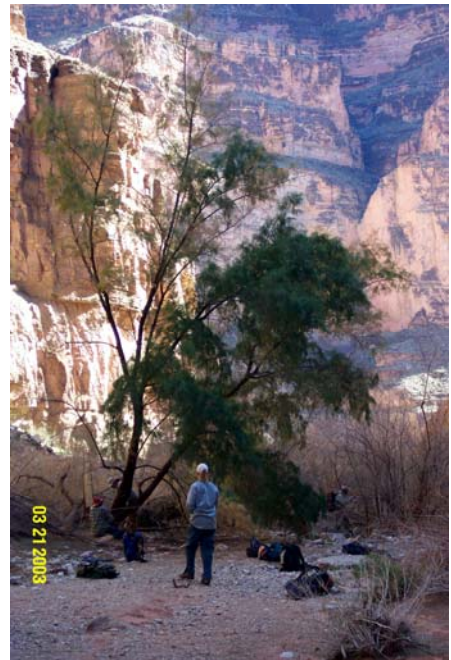
Picture 26. Combination technique



Picture 27. Native vegetation re-colonizing area with dead mature tamarisk



Picture 28. Once a dense tamarisk thicket



Picture 29. Athel (*Tamarix aphylla*) up Cove Canyon

APPENDIX A
Tamarisk Eradication and Restoration of 63 Tributaries
Representative Project Photographs – 2004 Final Report



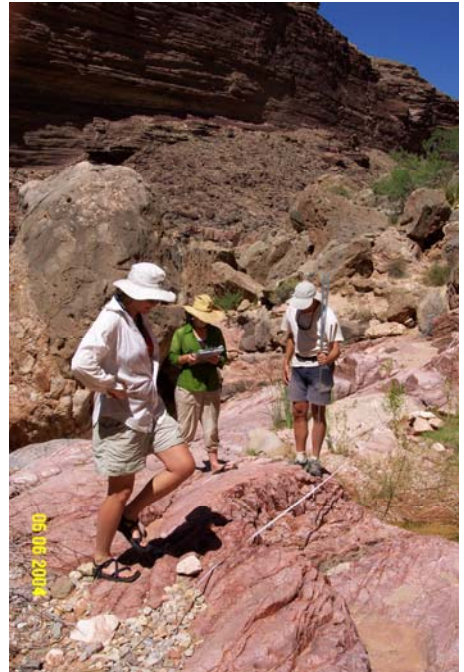
Picture 30. Pulling a mature tree



Picture 31. Hauling brush



Picture 33. Group working together



Picture 34. Transect in rocky area

APPENDIX A
Tamarisk Eradication and Restoration of 63 Tributaries
Representative Project Photographs – 2004 Final Report



Picture 35. Re-locating a transect up Carbon Creek



Picture 36. Volunteer assisting with transect



Picture 37. Recording vegetation



Picture 38. Reuben Teran at work up Lava Canyon



Picture 39. Strange re-growth on mature tamarisk



Picture 40. Crew playing pigs to end the day!

APPENDIX B

Tamarisk Eradication and Restoration of 63 Tributaries

Project Photodocumentation

If you are interested in obtaining the information contained
in this appendix, please contact:

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APPENDIX C

Tamarisk Eradication and Restoration of 63 Tributaries

Project Photodocumentation Summary Table

APPENDIX C
Tamarisk Project Final Photopoint Summary

Photopoint Name	View #	Date	Easting	Northing	GPS Accur. (m)	Bearing	Photopoint Description	View From Photopoint
128 Mile 1	1	3/17/04	366898	4018848		84	Schist layer to the left of stream about 33m from waterfall	Up canyon - pre-work
128 Mile 1a		3/17/04						? at photopoint
128 Mile 2	1	6/7/04	366967	4018833	7	130	0.4 km from river	Up canyon
128 Mile 2a		6/7/04					Looking downstream	
133 Mile 1	1	3/18/04	369445	4025349	6	20	Right before dry falls littered with boulders - big red rock center of path 50m from waterfall	Up canyon
133 Mile 1a		3/18/04						Standing at big red rock center of path 50m from waterfall
133 Mile 2	1	3/18/04	369409	4025291	6	78	About 50 m up canyon from 133 Mile 1, little gully right after 2 giant boulders with a crack between them	Up canyon
133 Mile 2a		3/18/04				20		Standing on top of the left giant boulder huge rock 3m in front
142 mile spring 1	1	10/24/02	356739	4029031	8	50	On beach	View of spring veg
142 mile spring 1	2	10/24/02				120	On beach	Upstream view of spring
142 mile spring 1a		10/24/02				61	From beach	Lori at photopoint - looking up river
148 Mile Spring 1	1	11/19/02	350113	4023425	10	15	Large limestone rock just downstream of spring	Looking upstream at spring
148 Mile Spring 1a		6/10/04				61		148 Spring 1 photopoint
148 Mile Spring 2	1	11/19/02	350120	4023437	33	100	From behind spring on muav shelf	Looking at spring
148 Mile Spring 2a		11/19/02				280		Kate on Muav shelf photopoint
152 Springs 1a		11/11/03				115		Kate at photopoint
152 Springs 1	1	11/11/03	345110	4023248	12	109		View of lower ledge
152 Springs 1	2	11/11/03				110		View of middle ledge
1st Redbud 1a		5/28/04						Person at photopoint
1st Redbud Alcove 1	1	10/15/00	421715	4031518		112	On ledge 3 m below steep cliff, on north side of seepy vegetation	Down into the alcove - horizontal and vertical
214 1b		6/14/04				60	Standing up canyon from photopoint	Looking down canyon to person at photopoint
214 Mile 1	1	11/14/03	289797	3975333	7	250	Standing on rock on creek right 30m above bright angel shale	Up canyon
214 mile 1a		10/14/03				120	Standing upstream of photopoint	Angela at photopoint
2nd Redbud Alcove 1	1	10/15/00	421780	4030845		230	75m from back wall - 2 large boulders on N. side of alcove, point on alcove side	Up into alcove
2nd Redbud Alcove 1	2	10/15/00				174		Focus on fissure on S. side - in redwall across alcove

APPENDIX C
Tamarisk Project Final Photopoint Summary

Photopoint Name	View #	Date	Easting	Northing	GPS Accur. (m)	Bearing	Photopoint Description	View From Photopoint
2nd Redbud Alcove 1	3	10/15/00				86		Toward mouth of alcove
75 mile 1	1	10/17/02	420681	3988485		251	Sitting on red rock on Shinumu on E side of drainage	Looking down canyon
75 mile 1	2	10/17/02				4		Looking up canyon
75 mile 1a		10/17/02				60	Standing on debris near edge of dryfall - up canyon 3km, canyon turns west then past chalkstone and above 2nd dry fall	Shinumu ledge - Kate sitting
75 mile 1b		10/17/02				196	Standing on debris in middle of draining	Looking to east wall - Kate sitting on photopoint
85 mile Spring 1	1	10/19/00	405497	3994012	16	342	Rock in middle of sandy area below spring, ~200m below Zoroaster rapid	Toward spring
85 mile Spring 1	2	10/19/00				118		Up river toward Zoroaster rapid
94 mile 1	1	10/20/00	392163	3995568	6	193	Huge white boulder on creek left ~450m up canyon	
94 mile 1	2	10/20/00				341		
94 mile 1a		10/20/00						94 mile 1 photopoint
94 mile 2	1	10/20/00	392207	3995976		326	760m up canyon, past cave on left, around next corner into gray/pink stretch, ~30m from previous corner	
94 Mile 3	1	11/3/03	392165	3996147	15	346	Above short cobbley climb about 1.12 km up canyon	Up canyon
94 Mile 3a		11/3/03						Lori at 94 Mile 3 photopoint
Bedrock 1	1	6/7/04	369033	4021070	9	115	On top of falls 250m from river	Up canyon
Bedrock 1a		6/7/04					Photopoint	
Berts 1	1	10/13/02	420722	4028259	20	59	100m up canyon to first big rock	Down canyon
Berts 1a		10/13/01				240	Next to sawgrass, looking up	Beginning of photopoint
Bighorn Wash 1	1	10/22/00	369014	4007125		224	Tapeats ledge west of large pour off	Upper basin with TARA and lush riparian vegetation
Bighorn Wash 1a		10/22/00						Bighorn Wash 1
Bighorn Wash 2	1	10/22/00	368902	4007036		62	Start of transect #1	End of transect #1
Bighorn Wash 2a		10/22/00				266		Bighorn Wash 2
Bighorn Wash 2b		10/22/00				104		Start of transect #1
Bighorn Wash 2c		10/22/02				243		View of Bighorn Wash 2 - new photo
Bighorn Wash 3	1	10/22/00	368951	4007061		244	End of transect #1	Start of transect #1 - note riparian veg and cottonwood
Boucher 1	1	10/21/02	389107	3997143		328	Standing on east side of drainage on granite ledge 4 ft up	Looking upstream

APPENDIX C
Tamarisk Project Final Photopoint Summary

Photopoint Name	View #	Date	Easting	Northing	GPS Accur. (m)	Bearing	Photopoint Description	View From Photopoint
Boucher 1a		10/21/02						View of photopoint, upstream on granite outcropping
Boucher 2	1	10/21/02	389052	3997251		227	Standing on east side of drainage on big outcrop	Looking upstream at work to be done
Boucher 2	2	10/21/02				296	Standing high on top of schist outcrop, crouching at cut bank	Looking west
Boucher 2a		10/21/02				50		Photopoint start
Boucher 3	1	10/21/02	389114	3997228		358	Up canyon before big bend to east	Tapeats in view
Boucher 3a		10/21/02						Lori at photopoint
Boucher 4	1	10/21/02	389111	3997256		216	Past big bend	Up canyon
Boucher 4a		10/21/02						Lori at photopoint
Boucher 5	1	3/14/04	388379	3996821	30	310	pink sandstone rock just right of creek	Across canyon to creek left at TARA stand - pre-work
Boucher 5a		3/14/04			30	182		Leslie at pink rock photopoint
Bright Angel 1	1	10/20/00	401594	3995355		286	Lower bridge to water treatment plant - 5th silver post from south side of bridge	Up Bright Angel Creek
Bright Angel 10	1	2/21/04	402338	3997492	11	300	From pipe cover on trail about 1/8 mile above GPS point	Overlooking creek from left bend in creek/trail - pre-work
Bright Angel 10a		2/21/04			11	260		Steve at photopoint standing on pipe cover trail, trail bends to the left - pre-work
Bright Angel 11	1	2/21/04	402813	3997719	8	20	Looking upstream from corner of 3 meter high wall	Looking upstream
Bright Angel 11a		2/21/04			8	250		Steve on corner of rock wall
Bright Angel 12	1	2/21/04	403123	3998076	43	195	Left of trail on blade-like rock	Looking downstream on creek left at large TARA - pre-work
Bright Angel 12a		2/21/04			43	200		Steve on rock left of trail
Bright Angel 13	1	2/21/04	403603	3999388	10	290	From left edge of trail by telephone pole and small electrical outlet box	Looking over creek from left edge of trail across to schist - pre-work
Bright Angel 13a		2/21/04			10	0		Steve on schist by tel pole and sm electrical box
Bright Angel 14	1	2/21/04	405218	4001509	19	190	17 meters off spur trail to Ribbon Falls, before trail climbs up	Looking down canyon at TARA - pre-work
Bright Angel 14a		2/21/04			19	340		Steve on white limestone rock on left side of trail
Bright Angel 15	1	2/21/04	406376	4003054	8	220	Near cottonwood on trail just before/below Cottonwood campground	Looking downstream at TARA just below campground - pre-work

APPENDIX C
Tamarisk Project Final Photopoint Summary

Photopoint Name	View #	Date	Easting	Northing	GPS Accur. (m)	Bearing	Photopoint Description	View From Photopoint
Bright Angel 15a		2/21/04			8	10		Steve at photopoint near campground
Bright Angel 2	1	10/20/00	401430	3995785		170	From Phantom Ranch trail crew bunkhouse, porch steps on down creek side	Down canyon
Bright Angel 3	1	10/20/00	401454	3995553		198	East side of creek - across from second campsite up from stone bathroom in campground - standing on rock on W. side of trail	
Bright Angel 3	1	10/20/00				166		
Bright Angel 3	2	10/20/00				316		
Bright Angel 4	1	2/22/04	401588	3995367	5	240	From lowest bridge (bridge going to the silver bridge) on Bright Angel creek	Looking upstream on creek left - pre-work
Bright Angel 4a		2/22/04			5	100		Steve at photopoint (bridge) end closest to Phantom Ranch
Bright Angel 5	1	2/21/04	401730	3996250	9	210	Above Phantom Ranch on N. Kaibab by water line	Looking downstream - pre-work
Bright Angel 5a		2/21/04			9			Kim at photopoint near water line on left side of trail
Bright Angel 6	1	2/21/04	401739	3996407	8	330	On large granite rock on creek left, right off trail	Looking upstream over TARA thicket on creek left - pre-work
Bright Angel 6a		2/21/04			8	190		Steve on rock
Bright Angel 7	1	2/21/04	401805	3996580	8	260	On white rock left of Clear Creek Trail sign, next to red rock	Overlooking BA creek at Clear Creek trail sign - pre-work
Bright Angel 7a		2/21/04			8	290		Steve on white rock near Clear Creek Trail sign
Bright Angel 8	1	2/21/04	401998	3996661	11	270	2nd rock wall supporting trail and just upstream of this GPS point	Looking across creek at large TARA - pre-work
Bright Angel 8a		2/21/04			11	10		Steve at photopoint on rockwall just left of trail
Bright Angel 9	1	2/21/04	402205	3997332		25	See BA 9a description below - got point from GIS, check	Looking upstream at medium TARA - pre-work
Bright Angel 9a		2/21/04						Steve standing on pipe cover in trail within sight of bridge by large sandstone red rock overhanging trail
Buckfarm 1	1	10/13/02	420687	4029120	53	290	Down canyon from chockstone area with large tamarisk	Up canyon toward large 80m chockstone
Buckfarm 1a		10/13/02					Lori at photopoint	Down canyon

APPENDIX C
Tamarisk Project Final Photopoint Summary

Photopoint Name	View #	Date	Easting	Northing	GPS Accur. (m)	Bearing	Photopoint Description	View From Photopoint
Buckfarm 2	1	10/13/02	420212	4029421		256	East side of drainage after you drop back into drainage from E side climb around - got from GIS layer, test on ground	View of area pre-work
Buckfarm 2a		10/13/02					Lori at photopoint	Down canyon - easy spot to find
Buckfarm 3	1	10/13/02	419217	4029724		282	End of hiked portion of canyon at large dryfall - got from GIS layer, test on ground	Looking up canyon toward large pouroff and pool
Buckfarm 3a		10/13/02					On boulder near end of hiked portion of canyon	Down canyon
Carbon 1	1	10/16/00	425707	4001211		243	Start point of Carbon transect #1	Up canyon toward endpoint of transect #1
Carbon 1	2	10/16/00				82		Down canyon
Carbon 1a		10/16/00					8m down canyon from start point of Carbon transect #1	Shows start point of transect #1
Carbon 2	1	10/16/00	425557	4001213		39	Endpoint of Carbon transect #1	Down canyon toward start point of transect #1
Carbon 3	1	10/16/00	425363	4001185	7	44	Start point of Carbon transect #2	Down canyon toward start point of transect #2
Carbon 3	2	10/16/00				292		Up drainage toward North Rim
Carbon 3a		10/16/00						Shows start point of transect #2 (brain rock in 2000, no longer there in 2004))
Carbon 4	1	10/16/00	425409	4001206		257	Endpoint of Carbon transect #2	Start point of transect #2
Carbon 5	1	10/16/00	425082	4001302	5	82	~200m up Carbon drainage from Carbon 3 (above narrows and where trail to Lava departs) , on ridge on N. side of drainage	Down canyon
Carbon 5	2	10/16/00				216		Up canyon
Carbon 5a		10/16/00						Person at Carbon 5 photopoint
Carbon 6	1	10/16/00	425190	4001275	7	216	Start point of transect #3, read 2m on NW side of tape	End point of transect #3
Carbon 6	2	10/16/00				282		Shows peak through TARA thicket
Carbon 7	1	10/15/02	425362	4001190			From new brain rock	Down narrows
Carbon 7a		10/15/02					Emily at photopoint	Emily at Photopoint - note brain rock
Cove 1	1	10/28/00	318934	4012497	13	196	Start of transect #1 - large boulder clump ~100m below pour off at end of lower Cove	End of transect #1
Cove 1	3	10/28/00				144		

APPENDIX C
Tamarisk Project Final Photopoint Summary

Photopoint Name	View #	Date	Easting	Northing	GPS Accur. (m)	Bearing	Photopoint Description	View From Photopoint
Cove 1	2	10/28/00			13	285		
Cove 1a		10/28/00				68		Chris and Rachel at Cove 1
Cove 2	1	10/28/00	318973	4012476	26	196	30m along transect #1 tape	End of transect #1
Cove 2	2	10/28/00			26	267		Toward west wall
Cove 2	3	10/28/00				98		Toward east wall
Cove 3	1	10/28/00	318924	4012487	20	8	Start of transect #2 - large flat-topped boulder mid-drainage ~135m from transect #1 start	End of transect #2
Cove 3	2	10/28/00			20	292		West seepy wall of drainage
Cove 3a		10/28/00						Rachel and Roy at Cove 3 - start of transect #2
Cove 4	1	10/28/00	318931	4012501	15	8	From 35m on transect #2	Up canyon toward end of transect #2
Cove 5	1	10/28/00	318936	4012535	16	188	End of transect #2	Start of transect #2
Cove 5	2	10/28/00			16	226	End of transect #2	West seepy wall of drainage
Cove 6	1	10/28/00	318957	4012499		321	NE side of drainage where there is a small drainage entering with pour over	
Cove 6	2	10/28/00				292		
Cove 6	3	10/28/00				228		
Cove 6a		10/28/00				60		Chris at Cove 6
Cove 6b		6/11/04				94	Standing on Encelia bench	Lookup up at muav rockfall - Lori at Photopoint
Cove 7	1	10/28/00	318964	4012259		180	mid-drainage rock not far from river - need to update GPS	
Cove 7a		10/28/00						Lori and Chris at Cove 7
Cranberry 1	1	10/25/00	361690	4029521	9	10	Start of transect #1, south end of upper portion of canyon - just above large drop off	End of transect #1, up canyon toward cottonwoods
Cranberry 1	3	10/25/00				214		Down canyon toward river - shows next layer below tpeats, extreme TARA remain.
Cranberry 1	2	10/25/00				357		Up canyon vertical - shows cottonwoods
Cranberry 1a		10/25/00					11.5m from transect #1 start	Dave at Cranberry 1
Cranberry 1b		6/9/04					From 7m along transect, sitting on rock	Lori at start of transect
Elves 1	1	10/22/00	369665	4006613	5	260	Start of transect #1 - E. side of creek just above 1st fall from river	End of transect #1
Elves 1	3	10/22/00				320		Down canyon - trees are below 45,000 cfs
Elves 1	2	10/22/00				222		Up canyon

APPENDIX C
Tamarisk Project Final Photopoint Summary

Photopoint Name	View #	Date	Easting	Northing	GPS Accur. (m)	Bearing	Photopoint Description	View From Photopoint
Elves 1a		10/22/00						Lori at Elves 1 - start of transect #1
Elves 2	1	10/22/00	369626	4006611	8	80	End of transect #1	Start of transect #1
Elves 3	1	10/22/00	369690	4006613		33	Sitting on top of redwall boulder at overhand along trail	Downcanyon - shows baccharis, redbud and acacia
Elves 3a		10/22/00				338	Standing above	Lori at Elves 3
Elves 3b		6/5/04				167		View up canyon of photopoint rock
Elves 4	1	10/22/00	369668	4006579		242	Crack of a house-sized boulder	Scattered TARA
Elves 4	2	10/22/00				253		Toward river
Elves 4a		10/22/00				190		Lori at Elves 4 - can see 3rd waterfall in background
Escalante 1	1	10/17/02	419749	3990340	8	180	Right fork of canyon	Looking upstream from boulder - 2 trees up canyon
Escalante 1a		10/17/02					Emily at photopoint	
Fishtail 1	1	11/20/02	360421	4030792	30	17	20 minute hike up canyon, on creek right, standing on large boulder in rockfall	Looking up canyon
Fishtail 1a		11/20/02				270		Kim in rockfall with camera
Forster 1	1	10/23/00	363435	4011988	9	252	Start of transect #1 - about 27m from river	Up canyon toward end of transect #1
Forster 1	2	10/23/00				68		Down canyon
Forster 1	3	10/23/00						Chris's feet at start point of transect #1
Forster 1a		10/23/00				171	Mid-drainage	Dave and Lori at start of transect #1
Forster 2	1	10/23/00	363390	4011974		68	End of transect #1	Start of transect #1
Forster 2a		6/6/04				46	Up canyon from end of transect, on SE side of drainage	Lori at and of transect
Forster 3	1	10/23/00	363334	4011879	10	20	E. side of bend in creekbed - near small seep 390m from river	Up canyon
Forster 3	2	10/23/00				328		Up canyon showing creek left bank
Forster 3a		10/23/00					From ledge under seedling rodeo ground	Person at Forster 3
Galloway 1	1	10/15/03	369644	4022894	7	46	From creek left on ledge in diabase sill, about 15m up canyon from where trail from Galloway camp drops into drainage - about 100m from river	Up canyon to 1st waterfall area
Galloway 1a		10/15/03					Standing in drainage	Red jug at the photopoint
Galloway 1b		6/8/04				273	Standing upstream of photopoint	Down canyon
Galloway 2	1	10/15/03	369983	4022768	9	292	First bass limestone outcrop about 600m from river	Looking down creek at large bass boulder

APPENDIX C
Tamarisk Project Final Photopoint Summary

Photopoint Name	View #	Date	Easting	Northing	GPS Accur. (m)	Bearing	Photopoint Description	View From Photopoint
Galloway 2a		10/15/03				352		Person at photopoint, looking across drainage at first bass limestone outcrop
Galloway 2b		6/8/04				154	Standing downstream at large bass boulder	Looking upstream to person on 1st bass contact
Galloway 3	1	10/15/03	370289	4022664		223	On large boulder in center of drainage (in Hakatai shale above waterfall)	Down canyon view
Galloway 3	2	10/15/03				32		Up canyon view
Galloway 3a		10/15/03				43		Person at photopoint
Galloway 3b		6/8/04				72	First Hakatai fall	Up canyon
Galloway 4	1	11/9/03	370365	4022699	6	240	On large flat Hakatai boulder on creek left	Down canyon
Galloway 4	2	11/9/03				16		Up canyon
Galloway 4a		11/9/03				269		Person at Galloway 4 photopoint
Galloway 4b		6/8/04				80	Next to big Hakatai boulder, down canyon from photopoint rock	Up canyon
Galloway 5	1	11/9/03	370763	4022804	5	119	518m from previous photopoint, tucked behind HUGE sinumo boulder on creek right, before up climb through Shinumu overhang	Up canyon looking at Shinumo overhang with shale above
Galloway 5a		11/9/03				300	Under big Shinumo boulder on creek right	Person at photopoint
Galloway 5b		6/8/04				316	Upstream of photopoint	Down canyon at person behind huge shinumo boulder
Garnet 1	1	11/17/02	372289	4008469		275	Standing on schist (south) ledge of drainage - first spot after tonto trail drops into drainage	Looking down canyon toward river
Garnet 1	2	11/17/02				84		Looking up canyon with view of redwall
Garnet 1a		11/17/02					Standing just east of photopoint	Kate at photopoint
Garnet 2	1	11/17/02	372380	4008396		330	Standing in middle of drainage on schist rock	Looking down canyon
Garnet 2a		11/17/02				150	From drainage	Looking up canyon at photopoint
Garnet 3a		3/17/03				43	Standing on 3 boulder cluster in center of canyon @ conglomerate merging with tapeats	Lori at start of transect #1 (Garnet 3) - looking up canyon
Garnet 3b		3/17/03						Shows start of transect
Garnet 4	1	3/17/03	372782	4008274	8	302	End of transect #1 in tapeats shelf	Toward start of transect, down canyon, large acacia to the left

APPENDIX C
Tamarisk Project Final Photopoint Summary

Photopoint Name	View #	Date	Easting	Northing	GPS Accur. (m)	Bearing	Photopoint Description	View From Photopoint
Garnet 4a		3/17/03				116	On large boulder in creek	Lori at end of transect #1
Garnet 4b		3/17/03					From end of transect #1	Shows the end of the transect on the boulder
Garnet 4c		3/17/03						Kate on boulder (2a)
Garnet 5	1	3/17/03					From 7m on the transect	Toward end of transect
Garnet 3	1	3/17/03	372741	4008291	6	122	Start of transect #1	Looking up canyon toward end of transect
Hakatai 1	1	10/14/03	375692	4011843	20	50	1st large cobble bar above 1st waterfall - 60m from canyon mouth	View up canyon
Hakatai 1a		10/14/03				208	Standing on cobble bar looking back at schist	View of person at photopoint
Hakatai 2	1	10/14/03	375757	4011925	28	37	On rock at brink of falls	Up canyon with skyline in view in one picture, tapeats in background
Hakatai 2a		10/14/03				2	View of person at photopoint	Down canyon
Hakatai 3	1	10/14/03	375879	4012107	20	138	From Hakatai 2, through 2-3 long schist stretches and around 5-7 bends to large red boulder on creek left	Down canyon
Hakatai 3	2	10/14/03				300		Up canyon
Hakatai 3a		10/14/03				158		Person at photopoint
Hermit 1	1	2/14/04	390816	3993404	6	197	In Tapeats - tree on creek left, creek bends right looking upstream	Large TARA looking upstream in tapeats - pre-work
Hermit 1a		2/14/04				6		Kim on creek right standing in cobble below tapeats outcropping
Hermit 2	1	2/14/04	390570	3993181	19	321	In Bright Angel shale near wall of old river sediment	Several matures - looking downstream - pre-work
Hermit 2a		2/14/04				19		Kim at photopoint near rock on creek right
Hermit 3	1	2/14/04	390523	3993048	6	122	In bright angel shale	Upstream at large mature on creek left
Hermit 3a		2/14/04				6		Kim at photopoint on creek left by stump and rocks
Hermit 4	1	2/28/04	390879	3994090		330	30m below HUGE tapeats boulders in drainage on lag flat rock	Looking downstream at N bend in creek pre-work
Hermit 4a		2/28/04				0		Steve- taken from upstream about 3m above
Hermit 4b	1	2/28/04				170		Steve- taken from the stream looking up
Hermit 5	1	2/28/04	390996	3994239	8	315	Taken atop large white boulder that is topped by conglomerate	Downstream, beneath tapeats - pre-work

APPENDIX C
Tamarisk Project Final Photopoint Summary

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Hermit 5a		2/28/04			8	110	Taken downstream of large boulder	Looking up and upstream
Hermit 6	1	3/13/04	391204	3995356	23	340	About 100m above Colorado river	Looking downstream - pre-work
Hermit 6a		3/13/04			23	170		Steve at photopoint looking upstream about 95 m above CO river
Hotauta 1	1	10/21/00	380797	4010162	7	266	Start of transect #1	Down canyon toward end of transect #1
Hotauta 1a		10/21/00				72		Chris and Lori at Hotauta 1 - transect #1 start point
Hotauta 2	1	10/21/00	380752	4010167	7	94	End of transect #1	Start of transect #1 - Lori in photo
Hotauta 2a		10/21/00				170	Creek bed	Folks at Hotauta 3
Hotauta 3	1	10/21/00	380207	4010244	9	30	Rock ledge on creek left	Up canyon, shows stream bed
Hotauta 3a		6/3/04					From creek bed	People at photopoint - looking down canyon
Kwagunt 1	1	10/13/02	425306	4012996		88	Within 300m walking up canyon, against rock near alluvium on creek left	Down canyon - not the cliff across the river
Kwagunt 10	1	10/14/02	422543	4011993		50	Drainage where fault intersects it	3 matures. View= downstream where fault intersects drainage
Kwagunt 1a		10/13/02				3		View of photopoint
Kwagunt 3	1	10/14/02	423612	4012332		98	Center of drainage	People in drainage
Kwagunt 3a		10/14/02				126	Large boulders	Looking at seedlings
Kwagunt 4	1	10/14/02	423609	4012336		202	Large boulder in drainage	Looking upstream
Kwagunt 4a		10/14/02					In drainage (water)	Looking downstream GPS on boulder
Kwagunt 5	1	10/14/02	423254	4012215			8m downstream of very large redwall boulder - got GPS from GIS - check	View downstream
Kwagunt 5a		10/14/02					In drainage	Orange pack at photo location downstream of large boulder
Kwagunt 6	1	10/14/02	422856	4011911		230	Drainage right across from 1st large supai boulder near drainage on BA shelf	Looking upstream at several saplings
Kwagunt 6a		10/14/02				50	In drainage looking downstream	Pack on right supai boulder on left
Kwagunt 7	1	10/14/02	422762	4011930		270	Drainage center on non descrip debris, canyon begins to open up	Upstream, dox in background with BA talus slopes, TARA on left
Kwagunt 7a		10/14/02				90	In drainage	Pack at photopoint, TARA in background with BA shelf
Kwagunt 8	1	10/14/02	422694	4011961		250	Drainage left; upstream of BA bend; several boulders	on right, large TARA left; dox in background

APPENDIX C
Tamarisk Project Final Photopoint Summary

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Kwagunt 8	2	10/14/02				80	Drainage left; upstream of BA bend; several boulders	saplings foreground, large TARA drainage right
Kwagunt 8a		10/14/02	422694	4011961		269	In drainage	Upstream with pack at photopoint
Kwagunt 9	1	10/14/02	422608	4011973		348	On redwall boulder 5m upstream from large redwall boulder	Across drainage left at the fault line
Kwagunt 9	2	10/14/02				280	On redwall boulder 5m upstream from large redwall boulder	Upstream with RJ & BA talus in back
Kwagunt 9a		10/14/02				60	Drainage right near edge of water	From drainage right, 1 large gray boulder downstream of pack
Last Chance 1	1	10/26/00	342146	4020880		82	Muav slab ~8m from dripping spring - start of transect #1	End of transect #1
Last Chance 1	2	10/26/00				36		Up river toward Zoroaster rapid
Last Chance 1	3	10/26/00				152		Down river
Last Chance 1a		10/26/00						Chris and Lori at Last Chance 1
Last Chance 2	1	10/26/00	342172	4020889		264	25m on transect tape - 45,000 cfs	Start of transect #1
Last Chance 2a		10/26/00						Chris at Last Chance 2
Last Chance 3	1	10/26/00	342176	4020878		284	Sand 4m from drainage - the 2004 photo may be different	Shows TARA at spring with Lori
Last Chance 3a		6/10/04				27	South side of drainage almost due east of dripping spring area	New Baccharis in the foreground
Lava Chuar 1	1	10/16/00	425278	3999814	5	308	Up Lava Chuar drainage from fork where trail drops in from Carbon. Large boulder on creek right.	Up canyon
Lava Chuar 1	3	10/16/00				107		Down canyon
Lava Chuar 1	2	10/16/00				64		Drainage
Lava Chuar 1a		10/16/00						Lava Chuar 1 - with Fred and Chris
Lava Chuar 2	1	10/16/00	425837	3999666	5	144	Start point of Lava Chuar transect #1 - note, more buried than in 2000	Down canyon toward endpoint of Lava Chuar transect #1, boulder slightly buried
Lava Chuar 2	2	10/16/00				346		Tamarisk are gone!
Lava Chuar 2a		10/16/00				268		Lava Chuar 2 - start transect #1 with Chris and Rachel
Lava Chuar 2b		10/16/00				219		View of ridgeline from Lava Chuar transect #1 area
Lava Chuar 3	1	10/16/00	425863	3999630		320	Endpoint of Lava Chuar transect #1	Up canyon toward start point of Lava Chuar transect #1
Lava Chuar 4	1	10/17/00	426119	3999530		138	Start point of Lava Chuar transect #2, 450m from river at large dox boulder.	Down canyon toward end point of Lava Chuar transect #2
Lava Chuar 4	2	10/17/00				310		Shows running water and vegetation

APPENDIX C
Tamarisk Project Final Photopoint Summary

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Lava Chuar 4a		10/17/00				246		Chris at start of transect #2 - on Dox boulder in drainage
Lava Chuar 5	1	10/17/00	426145	3999492		320	End of transect #2	Up canyon toward start of transect #2
Lava Chuar 6	1	10/17/00	426133	3999545		340	From on top of Dox boulder on E. edge of drainage (creek left)	Down into Lava Chuar
Lava Chuar 6	2	10/17/00				235		Person at Lava Chuar 4 photopoint - at boulder
Lava Chuar 6a		10/17/00				46		Person standing at Lava Chuar 6 photopoint
Lava Chuar 7	1	10/17/00	426302	3999482	10	110	Start point of transect #3, 280m from river	Down canyon toward end point of transect #3
Lava Chuar 7	2	10/17/00				234		Up canyon
Lava Chuar 7a		10/17/00						Rachel at start point of transect #3 (Lava Chuar 7)
Lava Chuar 7b		10/17/00						Chris and Rachel dropping point 2m from transect #3
Lava Chuar 8	1	10/17/00	426344	3999466		284	End point of transect #3	Up canyon toward start point of transect #3
Lava Chuar 8	2	10/17/00				240		Shows dense TARA on edge of transect tape
Lava Chuar 9	1	3/11/02	424769	4000013		292	About 400m up creek from the fork, near apex of rocky island below conglomerate	Up canyon
Lava Chuar 9a		3/11/02					Looking down canyon	Lori at the photopoint
Ledges 1	1	10/26/00	345280	4023468	10	210	3rd terrace when looking at spring	Upstream view of spring - shows lower spring veg.
Ledges 1a		10/26/00				340		Lori at Ledges 1
Ledges 2	1	10/26/00	345225	4023452	13	162	Ledge just below falls	Looking down at dead TARA and pool
Ledges 2	2	10/26/00				260		Looking up at old flow of fall - spring changed course from first photo
Ledges 2a		10/26/00				280		Chris at Ledges 2
Lonetree 1	1	10/19/00	407149	3992999		32	~250m from river at pool just below pour off and just before steep climb - got GPS from GIS - check in field	
Lower Blacktail 1	1	10/23/00	367831	4011519		30	Start of transect #1	Up canyon to end of transect #1
Lower Blacktail 1	2	10/23/00				180		Down canyon
Lower Blacktail 1a		10/23/00				192		Rachel at start point of transect #1

APPENDIX C
Tamarisk Project Final Photopoint Summary

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Lower Blacktail 1b		10/23/00					Along transect #1	Shows TARA seedlings present
Lower Blacktail 2	1	10/23/00	367791	4011519		210	End of transect #1	Down canyon to start of transect #1
Malgosa 1	1	11/10/02	424636	4010885	30	104	Midpoint above first cliff	Looking down canyon from large redwall rock
Malgosa 1a		11/10/02				284	Up and around 2nd dry fall - long traverse to 2nd narrows.	View of photopoint - looking up canyon at large limestone rock
Malgosa 2	1	11/10/02	424542	4010871		208		Looking up canyon
Malgosa 2a		11/10/02				28		View of photopoint - looking down canyon
Matkat 1	1	11/10/03	350380	4022367		296	~100m above main amphitheater, in middle of drainage, standing on temple butte boulder - got GPS from map, check in field	Down canyon view
Matkat 1a		11/10/03				96	Standing in drainage	Kim at Matkat 1 photopoint
Monument 1	1	3/13/04	392971	3994265		52	CHECK LOCATION - got from map, could be off. On rock - lower edge of infestation	Tara infestation looking upstream - pre-work
Monument 1a		3/13/04				232	? At photopoint	
Monument 2	1	3/27/04	393252	3993583	14	222	Center of creek bed in front of acacia across from upper end of campground	Looking across creek to creek left at large TARA - pre-work
Monument 2a		3/28/04			14			Kim at photopoint
North 1	1	10/14/00	431426	4053927	30	70	Need description	Need description
North 1	2	10/14/00				236		
North 2	1	5/27/04	431313	4053971		246	20 minutes up canyon on large supai boulder on creek left - got from GIS	Up canyon near areas with lots of seeps
Palisades 1	1	10/16/02	428163	3998476		45	Standing on tapeats/BA contact	Looking down canyon - cochise butte - bearing est. NE
Palisades 1a		10/16/02				225	25m down canyon from photopoint	Looking up toward redwall - bearing estimate of SW
Palisades 2	1	10/16/02	428124	3998548		45	Red boulder	Looking down canyon - temple butte
Palisades 2a		10/16/02				225	On large red boulder	Looking SW at red rock - bearing estimate of SW
Ruby 1	1	11/4/03	381725	405527		194	Creek right up on schist	Looking up canyon at canyon entrance to Ruby
Ruby 1a		11/4/03				13		Kim at photopoint
Salt Creek 1	1	10/20/00	395047	3995125		326	300m up canyon - corners from river	
Salt Creek 1a		10/20/00						Chris at Salt Creek 1
Serpentine 1	1	10/21/00	380566	4007352		3		

APPENDIX C
Tamarisk Project Final Photopoint Summary

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Serpentine 1a		10/21/00						Serpentine 1 - Chris and Fred on rock SSE side of wash
Serpentine 2	1	10/21/00	380140	4007309			540m from beach, just below where canyon opens up - look for sandstone slab	Up canyon
Serpentine 2a		10/21/00						Serpentine 2
Serpentine 3	1	10/21/00	380190	4007327		252	Start of transect #1, 440m from river in vishnu schist	Up canyon toward end of transect #1
Serpentine 3	2	10/21/00				11		
Serpentine 3a		10/21/00						Chris and Lori at Serpentine 3 - start of transect #1
Serpentine 3b		10/21/00						" - wider angle
Serpentine 4	1	10/21/00	380146	4007312		108	End of transect #1	Down canyon toward start of transect #1
Serpentine 5	1	10/21/00	380557	4007355		314	Start of transect #2, 140m from river	Up canyon toward end of transect #2
Serpentine 5a		10/21/00						Chris with board at Serpentine 5
Serpentine 6	1	10/21/00	380505	4007380		134	End of transect #2	Down canyon toward start of transect #2
Slimey Tick 1	1	10/26/00	342562	4021270		300	Before final drop down into the canyon	View of canyon looking up canyon
Slimey Tick 1	2	10/26/00				213		Lower pool above steep Muav drop - downstream river in photo
Slimey Tick 1a		10/26/00				150		Chris at Slimey Tick 1
Slimey Tick 2	1	10/26/00	342533	4021296		340	Muav ledge below stairstep falls	Up canyon to second fall - Shows ash, monkey flowers, phragmites, cattails
Slimey Tick 2	2	10/26/00				155		Down canyon
Slimey Tick 2a		10/26/00				170		Chris at Slimey Tick 2
Soap 1	1	10/13/00	438001	4065951	7	275	About 145 m from river at large boulder on south side of wash - Start point of Soap Transect #1	Up canyon toward endpoint of Soap transect #1
Soap 1	2	10/13/00				96		Down canyon toward river
Soap 1a		10/13/00						Shows start point boulder of transect #1
Soap 1b		10/13/00						Overview of Soap transect #1 - shows start point
Soap 1c		10/13/00	437964	4065967			From on top of gully	Overview of Soap transect showing end point

APPENDIX C
Tamarisk Project Final Photopoint Summary

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Soap 2		5/26/04	438046	4065972	11	86	Near base of second pour over where meander in wash begins - end point of transect #1	Down canyon to start point
Specter 1	1	10/24/00	366742	4020180	6	322	Start of transect #1	Up canyon toward end of transect #1
Specter 1	2	10/24/00				222		Toward wash with TARA opposite transect #1
Specter 1a		10/24/00				16	Wash below transect	Specter 1 - transect #1 start point with Chris and Tim
Specter 1b		10/24/00						TARA washed over
Specter 1c		6/7/04				144	Midpoint in transects	Looking down canyon at start point of transect - shows skyline
Specter 2	1	10/24/00	366705	4020219	9	144	End of transect #1	Start of transect #1
Specter 3	1	10/24/00	366753	4020162	6	267	Start of transect #2	End of transect #2
Specter 3a		10/24/00						Rachel at start of transect #2
Specter 4	1	10/24/00	366702	4020165	6	87	End of transect #2	Start of transect #2
Specter 4a		6/7/04				87	From 5m upcanyon of end of transect 2	Kate at end of transect 2
Specter 4b		6/7/04					From 6m down canyon of end of transect 2	Kate at end of transect 2
Specter 5	1	10/24/00	367261	4019764	22	106	1st bend of canyon near old thicket	Toward river
Specter 5a		10/24/00				332		Lori at Specter 5
Stairway 1	1	11/21/02	323699	4012003		40	10 minute hike, top of first waterfall on creek left in Muav	Looking up canyon and to the right
Stairway 1a		6/11/04				241		
Stairway 2	1	11/21/02	323743	4012056		20	After 2nd waterfall - large boulder on creek left	Up canyon view of drainage
Stairway 2a		11/21/02				194	Left side of drainage on rock	Person at photopoint
Tatahatso 1	1	10/15/00	423771	4032244		305	Climb up above bowl	Down into bowl
Tatahatso 1a		5/28/04					In wash below on limestone ledge	Up at person
Trinity 1	1	11/14/02	396416	3996436	10	8	Schist ledge on creek left - GPS from GIS layer - check	Up canyon
Trinity 1a		11/14/02				176	Up canyon from schist ledge	View down canyon of person standing at photopoint
Trinity 2	1	11/14/02	396296	3996865	10	67	11.5m up canyon from 3m small climb - GPS from GIS layer - check	View up canyon
Trinity 2a		11/14/02				240	Middle of drainage	View of person at photopoint
Tuna 1	1	10/14/03	386964	4000375	18	43	~30m from river, creek right, 6m up on granite dyke	Looking up creek at first TARA thicket
Tuna 1a		10/14/03				204	~38m from river from middle of drainage	Kelly at Tuna 1

APPENDIX C
Tamarisk Project Final Photopoint Summary

Photopoint Name	View #	Date	Easting	Northing	GPS Accur. (m)	Bearing	Photopoint Description	View From Photopoint
Tuna 2	1	10/14/03	387255	4000469	15	10	Creek right, creek bends sharp right, up 4m on bedrock	Looking up creek at first tamarisk thicket
Tuna 2a		10/14/03				270	Creek left on chockstone grey boulder	Across the creek of Jessica at Tuna 2
Unkar 1	1	3/11/04	420384	3992861		1	2.5 km up drainage - on east side of drainage	Up canyon
Unkar 1	2	3/11/04				180	2.5 km up drainage - on east side of drainage	Facing south
Unkar 1	3	3/11/04				58	2.5 km up drainage - on east side of drainage	Facing east
Unkar 1a		3/11/04						Crystal at photopoint
Unkar 1a		3/11/04						From drainage, toward creek right
Unkar 2	1	3/11/04	419643	3993752		0	About 5 km up Unkar on west side of drainage near spring	Up canyon - north
Unkar 2a		3/11/04						Crystal at photopoint
Unkar 3	1	3/11/04	419643	3993805		216		Across canyon south southwest
Unkar 3	2	3/11/04				284		Across canyon west
Unkar 3a		3/11/04						Crystal at photopoint
Unkar 4	1	3/11/04	419641	3993821		154		Down canyon east
Unkar 4a		3/11/04						Crystal at photopoint
Upper Blacktail 1	1	11/17/02	367922	4011815		299	Seep/spring in tapeats layer on creek left	Across seep toward Blacktail canyon
Upper Blacktail 1a		11/17/02				119		Kim at photopoint
Upper Blacktail 2	1	11/17/02	368084	4012322		360	Looking R to L heading upstream across drainage at V in tapeats	Looking at seep up canyon
Upper Blacktail 2a		11/17/02				75		Kim at photopoint
Upper Cove 1	1	11/22/02	318942	4012760		338	Standing on white rock on R side or drainage	View of TARA grove
Upper Cove 1a		11/22/02						View of Kim standing at photopoint
Vishnu 1	1	10/18/02	428114	3998542		17	On schist by agave	View up canyon
Vishnu 1a		10/18/02				200	~20m up creek of large agave - spring on creek left	View of photopoint - looking down creek
Vishnu 2	1	10/18/02	410707	3990731		4	Standing on largest boulder	View up creek of line of TARA mixed with baccharis
Vishnu 2a		10/18/02				180	Boulder with red surface down in drainage	Looking down canyon to photopoint
Vishnu 3	1	10/18/02	411109	3990979		46	Standing next to large white dike on creek right	View up creek toward rock "gate"
Vishnu 3a		10/18/02				281	Large granite boulder midcreek -	Looking down canyon to photopoint

APPENDIX C
Tamarisk Project Final Photopoint Summary

Photopoint Name	View #	Date	Easting	Northing	GPS Accur. (m)	Bearing	Photopoint Description	View From Photopoint
Waltenberg 1	1	10/22/00	373864	4012147		194	Start of transect #,1 near base of large dryfall - GPS from map, check	Down canyon to end of transect #1 - can see tapeats, small TARA stand, baccharis, Aristida, Acacia
Waltenberg 1a		10/22/00				30	12.5m on transect #1 tape	Start point of transect #1 below dry fall
Waltenberg 2	1	10/22/00	373841	4012103		14	End of transect #1	Up canyon to start of transect #1 - shows pools

APPENDIX D

Tamarisk Eradication and Restoration of 63 Tributaries

Monitoring Transect Descriptions

APPENDIX D

Monitoring Transect Data

The following are the descriptions of the vegetation transects used in the tamarisk management project. The transects are 50 meters long, with a point read at every 0.5 meters, for a total of 100 points per transect. The vegetation readings are always taken on the right side of the meter tape, looking up the tape from start to end. The person doing the reading should stand on the opposite side of the tape whenever possible. When locating the transects in the GIS layer, the start point and compass bearing were used for greater accuracy.

Location: Soap Creek

River Mile: 11 R

Date Transect Installed: 10/13/00

Transect Name: Soap 1

Start Point:		End Point:	
Northing	0438001	Northing	0437962
Easting	4065951	Easting	4065973
Accuracy	7m	Accuracy	11m
Bearing:	275°		

2000 Data

Litter	7
Rock	42
Bare Ground	33
Brush	3
Tamarisk	20
Long-leaf brickellbush	1
Arrowweed	6

2004 Data

Litter	2
Rock	46
Bare Ground	48
Ephedra	1
Arrowweed	1
Wire lettuce	2

General Description: The transect start point is about 145 m from river at a large boulder on the south side of the wash, with the end point up canyon. The transect ends at the base of the second pour over where the meander in the wash begins. The wash is frequently scoured and the canyon is open. Tamarisk trees are in small clumps. The transect location is in the shadscale-Mormon tea-beavertail cactus plant community. The vegetation near the transect is primarily baccharis, with a few phragmites patches. The transect occurs in the Toroweap geological layer.

Location: Carbon Creek

River Mile: 64.7 R

Date Transect Installed: 10/16/00

Transect Name: Carbon 1

Start Point:		End Point:	
Northing	0425707	Northing	0425557
Easting	4001211	Easting	4001213
Bearing:	243°		

2000 Data

Litter	18
Bare Ground	56
Rock	14
Brush	12
Tamarisk	19
<i>Happlopappus</i> sp.	3

2004 Data

Rock	43
Bare Ground	57

General Description: The transect installed in the narrows section of Carbon Creek, about 150 meters above where the trail drops down into the narrows. The area has sparse vegetation, but there are a significant number of new tamarisk seedlings during transect installation. The transect is in the shadscale-Mormon tea-beavertail cactus plant community. The beginning of the transect is 372 meters below where the trail goes over to Lava Canyon. There is a large mesquite near the transect start point. The transect end point is up canyon. The transect primarily occurs in the Tapeats sandstone geological layer.

Location: Carbon Creek

River Mile: 64.7 R

Date Transect Installed: 10/16/00

Transect Name: Carbon 2

Start Point:

Northing 0425363

Easting 4001185

Bearing: 44°

End Point:

Northing 0425414

Easting 4001260

2000 Data

Litter	7
Rock	9
Bare Ground	70
Brush	4
Tamarisk	19
Baccharis	1

2004 Data

Rock	46
Bare Ground	53
Brush	1

General Description: The transect start point was the brain rock, which is located where the trails goes to the west-southwest over to Lava Canyon. The brain rock moved during a large flash flood, so the start point was relocated based on the photographs. The end point is down canyon, towards the narrows of Carbon Creek. There are a few mesquite trees located near the transect. The transect occurs in the shadscale-Mormon tea-beavertail cactus plant community. The transect primarily occurs in the Tapeats sandstone geological layer.

Location: Carbon Creek

River Mile: 64.7 R

Date Transect Installed: 10/16/00

Transect Name: Carbon 3

Start Point:

Northing 0425190

Easting 4001275

Bearing: 216°

End Point:

Northing 0425137

Easting 4001254

2000 Data

Litter	77
Rock	0
Bare Ground	0
Brush	5
Tamarisk	93
Unknown forb	1
Phragmites	32
Baccharis	4

2004 Data

Litter	43
Rock	3
Bare Ground	23
Brush	27
Tamarisk	3
Scouring rush	1

General Description: The transect was located in the dense tamarisk thicket above the Carbon Creek narrows. The tape was laid on the northwest side of the drainage, about 2 meters from mid-drainage. The start point is up canyon, with the end point toward the narrows. The transect occurs in the shadscale-Mormon tea-beavertail cactus plant

community. In 2000, there was prince's plume and salt grass about 1m from transect. In 2004, phragmites was growing in the latter ¼ of the transect. The transect occurs in a slump, landslide, and rockfall geological layer.

Location: Lava Chuar Canyon

River Mile: 65.5R

Date Transect Installed: 10/16/00

Transect Name: Lava Chuar 1

Start Point:		End Point:	
Northing	04258237	Northing	0425865
Easting	3999666	Easting	399963
Accuracy	5m		7m
Bearing:	144°		

2000 Data

Litter	12
Rock	19
Bare Ground	56
Brush	0
Tamarisk	20
Mesquite	1

2004 Data

Litter	3
Rock	17
Bare Ground	77
Brush	1
Water	1
Flattop Buckwheat	1

General Description: The transect is installed near where the loop hike from Carbon Creek drops into Lava Canyon. The transect crosses the wash in an area with scattered tamarisk. There are numerous mesquite, very thick in places, above the wash area. The transect location is in the brittlebush-Mormon tea-catclaw acacia plant community and in the geological layer called the Galeros Formation.

Location: Lava Chuar Canyon

River Mile: 65.6 R

Date Transect Installed: 10/17/00

Transect Name: Lava Chuar 2

Start Point:		End Point:	
Northing	0426133	Northing	0426163
Easting	3999535	Easting	3999494
Accuracy	8m		4m
Bearing:	138°		

2000 Data

Litter	8
Rock	18
Bare Ground	62
Tamarisk	17

2004 Data

Litter	3
Rock	17
Bare Ground	73
Water	7

General Description: The transect start point is located .45 kilometers from the Colorado River. The start point is a large blackish purple Dox boulder; located below the Supergroup formation. The transect end point is down canyon, toward the river. There was a large tamarisk on the transect that was not hit during the installation. Also spiny aster was located in the transect and not hit. This transect is dominated by the Dox sandstone geological layer and is in the brittlebush-Mormon tea-catclaw acacia plant community.

Location: Lava Chuar Canyon

River Mile: 65.5 R

Date Transect Installed: 10/17/00

Transect Name: Lava Chuar 3

Start Point:		End Point:	
Northing	0426302	Northing	0426348
Easting	3999482	Easting	3999469
Accuracy	10m		4m

Bearing: 110°

2000 Data

Litter	36
Rock	11
Bare Ground	34
Brush	2
Tamarisk	38
Phragmites	20

2004 Data

Litter	16
Rock	14
Bare Ground	55
Brush	4
Water	2
Phragmites	16

General Description: The start point of transect located 0.28 kilometers from the Colorado River. The transect end point is down canyon, toward river. On the east side of transect is an 8 meter ledge with some large mesquite, just below the super group formation. This transect was located in a very dense tamarisk thicket with phragmites intermingled. Above the transect on a higher terrace is a mesquite bosque. In 2004, large flowered stork's bill (*Erodium texanum*), white brittlebush (*Encelia farinosa*) and skeletonweed (*Eriogonum deflexum*) grew in the drainage, but were not hit on the transect. This transect is dominated by the Dox sandstone geological layer and is in the brittlebush-Mormon tea-catclaw acacia plant community.

Location: Serpentine Canyon

River Mile: 106 L

Date Transect Installed: 10/21/00

Transect Name: Serpentine 1

Start Point:		End Point:	
Northing	0380193	Northing	0380142
Easting	4007295	Easting	4007303
Accuracy	15m		15m
Bearing:	252°		

2000 Data

Litter	3
Rock	38
Bare Ground	34
Brush	18
Tamarisk	6
Three awn	1
Long-leaf brickellbush	5
Ephedra	6
Catclaw acacia	2
Silver beardgrass	1

2004 Data

Litter	36
Rock	22
Bare Ground	38
Catclaw acacia	3
Three awn	3
Ephedra	6
Jimmyweed	2
Red brome	3
Silver beardgrass	1

General Description: The transect is located 0.44 kilometers from river in the Vishnu Schist. The end point is located up canyon in a group of scattered brickellia. The readings were from the creek side of the tape. The drainage started at 2.5 meters on the tape. This transect occurs in the Granodiorite geological layer, a part of the Zoraster plutonic complex. The transect occurs in the brittlebush-Mormon tea-catclaw acacia plant community.

Location: Serpentine Canyon

River Mile: 106 L

Date Transect Installed: 10/21/00

Transect Name: Serpentine 2

Start Point:

Northing 0380551

Easting 4007407

Bearing: 314°

End Point:

Northing 0380539

Easting 4007404

2000 Data

Litter	13
Rock	36
Bare Ground	28
Brush	5
Tamarisk	13
Baccharis	6
Three awn	4
Cassis	1
Brittlebush	4
Catclaw acacia	3
Ephedra	2
Desert trumpet	1

2004 Data

Litter	39
Rock	32
Bare Ground	24
Brush	7
Soil Crust	4
Catclaw acacia	3
Three awn	1
Desert trumpet	1
Ephedra	2
Jimmyweed	3
Red brome	9

General Description: The transect is located in wash channel 0.14 kilometers from the Colorado River. The transect end point is up canyon. The downstream side of tape was read. There were several other tamarisk in the transect that were not hit. The tamarisk trees in this area were scattered. This transect occurs in the Granodiorite geological layer, a part of the Zoraster plutonic complex. The transect occurs in the brittlebush-Mormon tea-catclaw acacia plant community.

Location: Hotauta Canyon

River Mile: 107.8 R

Date Transect Installed: 10/21/00

Transect Name: Hotauta 1

Start Point:

Northing 0380797

Easting 4010162

Accuracy 7m

Bearing: 266

End Point:

Northing 0380746

Easting 4010161

9m

2000 Data

Litter	10
Rock	32
Bare Ground	54
Brush	0
Tamarisk	8

2004 Data

Litter	5
Rock	65
Bare Ground	31
Ephedra	1
Schismus sp.	1

General Description: The transect start point is located up the right fork of the drainage, in the main canyon, at a large house sized boulder, with end point down canyon toward river. Tamarisk were scattered in the wash, with no thick patches. In 2004, the vegetation that was missed during the transect, but occurred in the vicinity included: catclaw acacia (*Acacia greggii*), Arizona three awn (*Aristida arizonica*), *Bothriochloa* sp., brittlebush (*Encelia* sp.), tobacco (*Nicotiana* sp.), *Phacelia* sp., *Lepidium* sp., galleta grass (*Hilaria* sp.), *Eriogonum* sp, and red brome (*Bromus rubens*). The geological layer of this transect consists primarily of diabase intrusives, sills and dikes. The transect occurs in the brittlebush-Mormon tea-catclaw acacia plant community.

Location: Waltenberg Canyon

River Mile: 112 R

Date Transect Installed: 10/22/00

Transect Name: Waltenberg 1

Start Point:

Northing 373909
Easting 4011946
Accuracy 9.4m
Bearing: 194°

End Point:

Northing 0373903
Easting 4011903
8.8m

2000 Data

Litter 4
Rock 69
Bare Ground 20
Brush 1
Tamarisk 14
Three awn 1
Water 2

2004 Data

Litter 4
Rock 41
Bare Ground 49
Brush 4
Long-leaf brickellbush 1
Cryptantha 1
Rock nettle 1
Unknown Grass 1

General Description: The start point of the transect is located up canyon, below a large pour over, with end point toward river. There are barrel cacti on a ledge above transect. The tamarisk trees were scattered and intermittent. This transect occurs in the Vishnu schist geological layer and the brittlebush-Mormon tea-catclaw acacia plant community.

Location: Garnet Canyon

River Mile: 114 L

Date Transect Installed: 3/17/03

Transect Name: Garnet 1

Start Point:

Northing 372741
Easting 4008291
Bearing: 122°

End Point:

Northing 372782
Easting 4008274

2000 Data

Litter 32
Rock 27
Bare Ground 14
Brush 1
Tamarisk 24
Catclaw acacia 10
Alkali sacaton 4
Brittlebush 2
Cane bluestem 3
Ephedra 2
Jimmyweed 4
Poreleaf 1
Three awn 1
Unknown grass 1

2004 Data

Litter 12
Rock 18
Bare Ground 51
Brush 1
Catclaw acacia 5
Cattail 1
Desert straw 1
Ephedra 1
Galleta grass 2
Gutierrezia 1
Jimmyweed 3
Mesa dropseed 1
Spike dropseed 1

General Description: To access the canyon, float past the canyon mouth and go down river to the first substantial beach / gravel area on the left. Hike up that drainage, through the arch, to the Tonto Trail. Follow the trail up river until it drops down into Garnet Canyon. The transect is located up canyon from where the trail drops in, just below where the canyon becomes very narrow. The end point of the transect is up canyon – in the tapeats ledge on creek right. The transect ends at 43.5 meters on the tape. In 2004, tobacco, rock nettle (*Eucnide urens*), desert bedstraw (*Galium stellatum*), brittlebush, cane bluestem (*Bothriochloa barbinooides*), poreleaf (*Porophyllum* sp.), Arizona three awn, brickellia, and *Chenopodium* sp. also occurred in the canyon but were not hit on the transect. The primary

geological layer is the Tapeats sandstone, and the transect is located in the brittlebush-Mormon tea-catclaw acacia plant community.

Location: Lower Elves Chasm

River Mile: 116.5 L

Date Transect Installed: 10/22/00

Transect Name: Elves 1

Start Point:

Northing 0369665

Easting 4006613

Accuracy 5m

Bearing: 260°

End Point:

Northing 0369626

Easting 4006611

8m

2000 Data

Litter	1
Rock	55
Bare Ground	20
Brush	3
Tamarisk	14
Seep willow	1
Water / puddle	5
Water / creek	5
Unknown forb	2
Unknown grass	1
Ephedra	1

2004 Data

Litter	15
Rock	54
Bare Ground	19
Brush	9
Soil Crust	1
Water	3
Brittlebush	2
Rabbitsfoot grass	2
Seep willow	1
Shiny leaved blazing star	1
Six-weeks fescue	2

General Description: The transect is located perpendicular to stream in the lower portion of the canyon. There are scattered redbud trees, catclaw acacia, seep willows, grasses and shrubs. The transect occurs primarily in the Tapeats sandstone geological layer and is located in the Mormon tea-big galleta grass-catclaw acacia plant community.

Location: Bighorn Wash

River Mile: 117 L

Date Transect Installed: 10/22/00

Transect Name: Bighorn Wash 1

Start Point:

Northing 0368911

Easting 4007044

Accuracy 10m

Bearing: 62°

End Point:

Northing 0368944

Easting 4007057

10m

2000 Data

Litter	33
Rock	5
Bare Ground	13
Brush	8
Tamarisk	7
Rush species	17
Scratchgrass	26
Saw grass	6
Satintail	42
Coyote willow	4
Cottonwood	1
Water	3

2004 Data

Litter	43
Rock	4
Bare Ground	8
Brush	26
Soil Crust	1
Aster sp.	1
Baccharis	1
Bushy beardgrass	1
Cane bluestem	3
Cottonwood	6
Coyote willow	7
Goldenrod	5

Buffalo berry	2	Gutierrezia	1
Seep willow	23	Horsetail	1
		Isocoma sp.	2
		Aster sp.	2
		Rush species	3
		Satintail	28
		Saw grass	6
		Scratchgrass	42
		Seep willow	29
		Sporobolus sp.	1

General Description: The transect is located in the upper portion of the canyon, above the massive pour over. The start point is below a small pour over where the main drainage forms. It is located in a dense riparian area with diverse vegetation. From 31 to 38 meters, the transect was under the canopy of a large cottonwood tree. Plant cover was only counted when the 2 meter pole hit plant material, but there was additional vegetation in the canopy. The transect occurs in the Tapeats sandstone geological layer and the brittlebush-Mormon tea-catclaw acacia plant community.

Location: Lower Blacktail Canyon

River Mile: 120 R

Date Transect Installed: 10/23/00

Transect Name: Blacktail 1

Start Point:

Northing 367831

Easting 4011519

Bearing: 30°

End Point:

Northing 367791

Easting 4011519

2000 Data

Litter 0

Rock 45

Bare Ground 50

Brush 0

Tamarisk 5

Water / Creek 2

2004 Data

Litter 3

Rock 79

Bare Ground 18

Brush 0

Waterweed 1

General Description: This transect is located in the narrows of lower Blacktail Canyon. The transect start point located 157 meters from the river, around the first corner from the mouth of the canyon. The transect end point is up canyon. The area gets scoured periodically and primarily only seedlings were present during installation. The geological layer of this transect is Tapeats sandstone. The transect is located in the brittlebush-Mormon tea-catclaw acacia plant community.

Location: Forster Canyon

River Mile: 122.7 L

Date Transect Installed: 10/23/00

Transect Name: Forster 1

Start Point:

Northing 0363435

Easting 4011988

Accuracy 8.5m

Bearing: 252°

End Point:

Northing 0363390

Easting 4011974

2000 Data

Litter 2

2004 Data

Litter 13

Rock	29	Rock	35
Bare Ground	59	Bare Ground	52
Brush	0	Brush	1
Tamarisk	17		

General Description: The transect start point is located in the wash about 0.28 kilometers from the river, with the end point up canyon. There were more tamarisk trees west of this transect in the drainage during installation. In 2000, also noted were Russian thistle, velcro plant, rye grass, ephedra, long-leaved brickellbush, artemesia, primrose, pore leaf and brittlebush and various grasses. In 2004, red brome, *Isocoma* sp., and dropseed grasses were also observed in the canyon. This transect occurs in the Tapeats sandstone geological layer just above the river deposits consisting of recent sand, boulder, and mud. It is located in the Mormon tea-big galleta grass-catclaw acacia plant community.

Location: Specter Canyon

River Mile: 129 L

Date Transect Installed: 10/24/00

Transect Name: Specter 1

Start Point:

Northing 0366742

Easting 4020102

Accuracy 6m

Bearing: 322°

End Point:

Northing 0366705

Easting 4020219

9m

2000 Data

Litter	0
Rock	20
Bare Ground	70
Brush	0
Tamarisk	12
Scratchgrass	1
Water	3

2004 Data

Litter	4
Rock	46
Bare Ground	41
Brush	4
Water	1
Desert straw	1
Jimmyweed	2
Notch-leaved scorpion weed	1
Tobacco	1
Unknown Grass	1

General Description: This transect is located about 690 meters from the river. The start point is near where canyon forks, with end point up canyon. The wash bed is open and well-scoured, with tamarisk scattered during transect installation. In 2004, other vegetation observed in the canyon included *Astragalus* sp., *Mentzelia* sp., desert broom (*Baccharis sergioloides*), long-leaved brickellbush, rock nettle (*Eucnide urens*), *Camissonia* sp., *Cryptantha* sp. This transect occurs in the Bright Angel shale geological layer and the brittlebush-Mormon tea-catclaw acacia plant community.

Location: Specter Canyon

River Mile: 129 L

Date Transect Installed: 10/24/00

Transect Name: Specter 2

Start Point:

Northing 0366753

Easting 4020162

Accuracy 6m

Bearing: 267°

End Point:

Northing 0366702

Easting 4020165

6m

2000 Data

2004 Data

Litter	22	Litter	33
Rock	23	Rock	44
Bare Ground	28	Bare Ground	14
Brush	0	Brush	23
Tamarisk	23	Catclaw acacia	5
Cattail	6	Three awn	2
Long-leaf brickellbush	16	Galleta grass	13
Cane bluestem	13	Snakeweed	7
Galleta grass	2	Jimmyweed	7
Catclaw acacia	4	Unknown Grass	2
Water	1		

General Description: This transect is located about 690 meters from river. The start point is near where canyon forks, with end point up the left fork. It was located in dense riparian vegetation with thick tamarisk. In 2004, vegetation also observed in the canyon was *Andropogon* sp., ephedra, desert straw, bursage (*Ambrosia dumosa*), brittlebush, (*Encelia farinosa*), catclaw acacia (*Acacia greggii*), and spiny-leaved sowthistle (*Sonchus asper*). This transect occurs in the Bright Angel shale geological layer and the brittlebush-Mormon tea-catclaw acacia plant community.

Location: Cranberry Canyon

River Mile: 138.5 R

Date Transect Installed: 10/25/00

Transect Name: Cranberry 1

Start Point:

Northing 0361690

Easting 40295121

Accuracy 8.7m

Bearing: 10°

End Point:

Northing 0361698

Easting 4029563

9.4m

2000 Data

Litter	30
Rock	37
Bare Ground	17
Brush	1
Tamarisk	4
Happlopappus	12
Pore leaf	3
Seep willow	27
Scratchgrass	1
Soil Crust	8
Brittlebush	4

2004 Data

Litter	36
Rock	55
Bare Ground	7
Brush	3
Soil Crust	3
Catclaw acacia	1
Three awn	1
Brittlebush	4
Chuckwalla's delight	4
Jimmyweed	2
Seep willow	18
Waterweed	2

General Description: This transect is located in upper portion of the canyon, above the large tapeats pour over. The access is on the downstream side of the pull-in, 2 drainages down. There is very fragile vegetation and microbiotic soil crusts on the hike up into the canyon. The start point of transect is above large pour over, with end point up canyon. The vegetation is dense riparian with good diversity in the white bursage-Mormon tea-barrel cactus plant community. There are seeps along channel. This transect occurs in the Bright Angel shale geological layer.

Location: Last Chance Canyon

River Mile: 155.5 R

Date Transect Installed: 10/26/00

Transect Name: Last Chance 1

Start Point:

End Point:

Northing 0342146
Easting 4020880
Bearing: 82°

Northing 0342172
Easting 4020889

2000 Data

Litter 5
Rock 17
Bare Ground 10
Brush 1
Tamarisk 19
Seep willow 10
Unknown grass 2
Maidenhair fern 1
Moss 1
Water 1

2004 Data

Litter 23
Rock 16
Bare Ground 7
Brush 9
Water 1
Tamarisk 10
Three awn 2
Long-leaf brickellbush 6
Brittlebush 1
Cattail 1
Common plantain 1
Cudweed 1
Scratchgrass 8
Seep willow 13
Unknown forb 2

General Description: The transect begins at a tamarisk about 8 meters from where spring drips down (on Muav slabs), then heads down to tamarisk at the 45,000 cfs river level. The cover readings ended at 27 meters, which is were the 45,000 cfs level is. The remainder of the cover readings would be bare ground / sand and then water. There were numerous small seedlings on the side of the small channel below the spring. This transect occurs in the Bright Angel shale geological layer and the brittlebush-Mormon tea-catclaw acacia plant community.

Location: Cove Canyon

River Mile: 174 R

Date Transect Installed: 10/28/00

Transect Name: Cove 1

Start Point:

Northing 0318934
Easting 4012497
Accuracy 26m
Bearing: 196°

End Point:

Northing 318938
Easting 4012446

2000 Data

Litter 10
Rock 11
Bare Ground 36
Brush 7
Tamarisk 52
Desert broom 1
Sand dropseed 2

2004 Data

Litter 20
Rock 11
Bare Ground 57
Brush 13
Red brome 7
Sacred datura 1
Spike dropseed 2
Waterweed 3

General Description: The transect is located in lower Cove Canyon, just below the large pour over. The start point is on east side of drainage, on the southwest side of a large boulder pile approximately 75 meters down canyon from the large pour over. It is surrounded by hanging gardens and perennial seeps. There was also one large *Tamarisk aphylla* in this area. In 2004, twining snapdragon (*Maurandella antirrhiniflora*) was observed as an associated species that was not hit on the transect. The start point is up canyon, with end point toward river. This transect occurs in the Muav limestone shale geological layer and the brittlebush-creosotebush-Mormon tea plant community.

Location: Cove Canyon

River Mile: 174 R

Date Transect Installed: 10/28/00

Transect Name: Cove 2

Start Point:

Northing 0318924

Easting 4012487

Accuracy 20m

Bearing: 8°

End Point:

Northing 318936

Easting 4012535

16m

2000 Data

Litter	25
Rock	0
Bare Ground	45
Brush	7
Tamarisk	30
Coyote willow	2
Sacred datura	2
Burroweed	1
Scratchgrass	2
Water	1

2004 Data

Litter	25
Rock	9
Bare Ground	43
Brush	0
Catclaw acacia	3
Long-leaf brickellbush	2
Brittlebush	6
Lepidium sp.	2
Nightshade	3
Red brome	13
Ripgut brome	1
Sacred datura	20
Spike dropseed	5
Tobacco	1

General Description: The start point is on the north side of huge flat-topped boulder in middle of drainage, approximately 135 meters down canyon from the pour over. The end point is up canyon. In 2004, associated species observed in canyon were ivy leaf groundcherry (*Physalis hederifolia*), Louisiana sage (*Artemisia ludoviciana*), paperflower (*Psilostrophe* sp.), bristlegass (*Setaria verticillata*), snakeweed (*Gutierrezia sarothrae*), wolfberry (*Lycium* sp.), six-weeks fescue (*Vulpia octoflora*), *Astragalus* sp., and littleleaf globe mallow (*Sphaeralcea parvifolia*). This transect occurs in the Muav limestone shale geological layer and the brittlebush-creosotebush-Mormon tea plant community.

APPENDIX E

Tamarisk Eradication and Restoration of 63 Tributaries

Monitoring Transect Summary Data for 2000 and 2004

Appendix E
Transect Data Summary 2004

	Soap 1	Carbon 1	Carbon 2	Carbon 3	Lava Chuar 1	Lava Chuar 2	Lava Chuar 3	Serpentine 1	Serpentine 2	Hotauta 1	Waltenberg 1	Garnet 1	Elves 1	Bighorn Wash 1	Blacktail 1	Forster 1	Specter 1	Specter 2	Cranberry 1	Last Chance 1	Cove 1	Cove 2	Average %
Litter	2	0	0	43	3	3	16	36	39	5	4	12	15	43	3	13	4	33	36	23	20	25	17.18
Rock	46	43	46	3	17	17	14	22	32	65	41	18	54	4	79	35	46	44	55	16	11	9	32.59
Bare Ground	48	57	53	23	77	73	55	38	24	31	49	51	19	8	18	52	41	14	7	7	57	43	38.41
Brush	0	0	1	27	1	0	4	0	7	0	4	1	9	26	0	1	4	23	3	9	13	0	6.05
Soil Crust	0	0	0	0	0	0	0	0	4	0	0	0	1	1	0	0	0	0	3	0	0	0	0.41
Water (perennial)	0	0	0	0	0	7	2	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0.59
Water (ephemeral)	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0.09
Tamarisk	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0.59
Catclaw acacia	0	0	0	0	0	0	0	3	3	0	0	5	0	0	0	0	0	5	1	0	0	3	0.91
Arrowweed	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05
Aster sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0.05
Baccharis	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0.05
Brickellia	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	6	0	2	0.41
Brittle bush	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4	1	0	6	0.59
Bushy beardgrass	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0.05
Cane bluestem	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0.14
Cattail	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0.09
Chuckwalla's delight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0.18
Common plantain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0.05
Cottonwood	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0.27
Coyote willow	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0.32
Cryptantha	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0.05
Cudweed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0.05
Desert straw	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0.09
Desert trumpet	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05
Ephedra	1	0	0	0	0	0	0	6	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0.50
Flattop buckwheat	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05
Galleta grass	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	13	0	0	0	0	0.68
Goldenrod	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0.23
Snakeweed	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	7	0	0	0	0	0.41
Horsetail	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0.05
Jimmyweed	0	0	0	0	0	0	0	2	3	0	0	3	0	2	0	0	2	7	2	0	0	0	0.95
Lepidium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.09
Aster sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0.09
Mesa dropseed	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0.05
Nightshade	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0.14
Scorpion-weed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0.05
Phragmites	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.73
Polygogon virgens	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0.14
Red Brome	0	0	0	0	0	0	0	3	9	0	0	0	0	0	0	0	0	0	0	0	7	13	1.45
Ripgut grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.05
Rock nettle	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0.05
Rush	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0.14
Sacred datura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	20	0.95
Satintail	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	0	0	0	0	0	0	1.27
Saw grass	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0.27
Schismus	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0.05
Scratchgrass	0	0	0	0	0	0	0	0	0	0	0	0	0	42	0	0	0	0	0	8	0	0	2.27
Scouring rush	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05
Seep willow	0	0	0	0	0	0	0	0	0	0	0	0	1	29	0	0	0	0	18	13	0	0	2.77
Shiny leaved blazing star	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0.05
Silver beardgrass	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05
Six-weeks fescue	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0.09
Spike dropseed	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	5	0.36
Sporobolus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0.05
Three awn	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	2	1	2	0	0	0.41
Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0.09
Unknown forb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0.09
Unknown grass	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	2	0	0	0	0	0	0.18
Waterweed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3	0	0.23
Wire Lettuce	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.09
Total Hits	100	100	100	100	100	100	107	114	125	103	102	98	109	221	101	101	102	150	136	101	114	133	114.41

	Soap 1	Carbon 1	Carbon 2	Carbon 3	Lava Chuar 1	Lava Chuar 2	Lava Chuar 3	Serpentine 1	Serpentine 2	Hotauta 1	Waltenberg 1	Garnet 1	Elves 1	Big Horn Wash 1	Blacktail 1	Foster 1	Specter 1	Specter 2	Cranberry 1	Last Chance 1	Cove 1	Cove 2	Average %
Total Vegetation Hits	4	0	0	4	1	0	16	18	19	2	4	16	8	139	1	0	6	36	32	45	13	56	13.32
Rock & Bare Ground Hits	94	100	99	26	94	90	69	60	56	96	90	69	73	12	97	87	87	58	62	23	68	52	71.00
Brush	0	0	1	27	1	0	4	0	7	0	4	1	9	26	0	1	4	23	3	9	13	0	6.05
Soil Crust	0	0	0	0	0	0	0	0	4	0	0	0	1	1	0	0	0	0	3	0	0	0	0.41
Litter	2	0	0	43	3	3	16	36	39	5	4	12	15	43	3	13	4	33	36	23	20	25	17.18
Water	0	0	0	0	1	7	2	0	0	0	0	0	3	0	0	0	1	0	0	1	0	0	0.68
Tamarisk	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0.59

Percent Composition of Tamarisk of Total Vegetation	0	0	0	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22.2	0	0	4.44
Percent Composition of Tamarisk to Total Number of Hits	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.9	0	0	0.52

APPENDIX F

Tamarisk Eradication and Restoration of 63 Tributaries

Plant List Summary Table for Selected Canyons

Appendix F
Plant Summary Table for Selected Canyons and Scientific Plant Names

Scientific Name	Common Name	Soap	North	Hakatai	Bighorn Wash	85 Mile Spring	Last Chance	Tatahato	1st Redbud	2nd Redbud	Bert	Saddle	94 Mile	Kwagunt	Lava Chuar	Clear Creek	Garnet	Stone Creek	Boucher	Kanab	209	Hell's Hollow	Waltenberg	Malgosa	Cranberry	Specter	Cove
<i>Abronia elliptica</i>	sand verbena													x			x										
<i>Acacia greggii</i>	catclaw acacia			x	x	x	x					x	x	x	x	x	x	x	x	x	x	x		x	x	x	
<i>Achnatherum hymenoides</i>	indian ricegrass	up											x														
<i>Achnatherum speciosum</i>																	x							x			
<i>Acourtia wrightii</i>	brownfoot		up										x				x	x						x			
<i>Adenophyllum porophylloides</i>	San Felipe Dyssodia																	x									x
<i>Adiantum capillus-veneris</i>	maidenhair fern						x		x	x	x				x	x		x		x				x			
<i>Agave utahensis</i>	century plant								x					x	x	x	x	x		x							
<i>Agave utahensis</i> var. <i>kaibabensis</i>	century plant				x																			x		x	
<i>Agave utahensis</i> var. <i>utahensis</i>	Utah agave												x											x			
<i>Alhagi maurorum</i>	camelthorn																										
<i>Allionia incarnata</i>	trailing four o'clock	x		x																							x
<i>Aloysia wrightii</i>	wright lippia									x																	
<i>Ambrosia dumosa</i>	white bursage																										x
<i>Amsinckia menziesii</i> var. <i>intermedia</i>	coast fiddleneck													x			x	x				x	x				
<i>Andropogon glomeratus</i>	bushy beardgrass				x	x			x					x				x	x						x		
<i>Anemone tuberosa</i>	desert windflower, anemone																x	x			x						
<i>Antirrhinum filipes</i>	Twining Snapdragon										x		x					x				x					
<i>Anulocaulis leiosolenus</i> var. <i>leiosolenus</i>	ringstem		x																								x
<i>Aquilegia chrysantha</i>	golden columbine																										x
<i>Aquilegia</i> sp.									x															x			
<i>Argemone munita</i>	prickle poppy									x																	
<i>Aristida adscensionis</i>	six-weeks three-awn																	x								x	x
<i>Aristida arizonica</i>	Arizona three awn				x		x		x			x	x	x	x	x	x	x			x		x	x	x	x	x
<i>Artemisia dracunculus</i>	drummond rock cress											x															
<i>Artemisia filifolia</i>	sand sagebrush	up																									
<i>Artemisia ludoviciana</i>	Louisiana sage	up					x		x	x		x	x	x	x	x	x			x				x			x
<i>Aster spinosus</i>	spiny aster									x				x								x					
<i>Astragalus lentiginosus</i>	specklepod										x																
<i>Astragalus praelongus</i>																										x	x
<i>Astragalus</i> sp.	astragalus species				x								x		x					x							
<i>Atriplex canescens</i>	four wing saltbush	up		x					x	x	x		x														
<i>Atriplex confertifolia</i>	shadscale																					x					
<i>Atriplex obovata</i>	saltbush	x																									
<i>Atriplex</i> sp.																									x		
<i>Baccharis emoryi</i>	Emory baccharis				x					x	x		x								x						
<i>Baccharis salicifolia</i>	baccharis, seep willow			x	x	x	x		x	x			x	x	x	x	x	x		x				x			x
<i>Baccharis sarothroides</i>	broom baccharis																		x			x					x
<i>Baccharis sergiloides</i>	waterweed						x		x	x			x						x						x	x	
<i>Bahia dissecta</i>	yellow ragweed																		x								
<i>Baileya multiradiata</i>	desert marigold																										up
<i>Bebbia juncea</i> var. <i>aspera</i>	chuckwalla's delight			x			x						x					x							x	x	x
<i>Bothriochloa barbinodis</i>	cane bluestem				x				x				x	x	x	x	x								x	x	

Scientific Name	Common Name	Soap	North	Hakatai	Bighorn Wash	85 Mile Spring	Last Chance	Tatahato	1st Redbud	2nd Redbud	Bert	Saddle	94 Mile	Kwagunt	Lava Chuar	Clear Creek	Garnet	Stone Creek	Boucher	Kanab	209	Hell's Hollow	Waltenberg	Malgosa	Cranberry	Specter	Cove
<i>Bothriochloa saccharoides</i>	silver beardgrass																										x
<i>Bouteloua curtipendula</i>	side oats grama								x				x								x			x			
<i>Brickellia atractyloides</i>	spiny brickellbush		x									x	x				x	x		x						x	
<i>Brickellia coulteri</i>	Coulter brickellbush																							x			
<i>Brickellia longifolia</i>	longleaf brickellbush	x	x	x	x		x		x	x	x	x	x	x	x	x	x	x		x			x	x		x	x
<i>Bromus diandrus</i>	ripgut grass																										x
<i>Bromus rubens</i>	foxtail chess, red brome	up	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x		x	x	x					x
<i>Bromus tectorum</i>	cheatgrass, downy chess										x							x									
<i>Calamagrostis scopulorum</i>	reed grass										x																
<i>Calochortus nuttallii</i>	sego lily															x		x									
<i>Camissonia multijuga</i>	camissonia, frost-stem suncup	x	x				x		x	x			x												x	x	x
<i>Camissonia speculicola</i>	Kaibab suncup													x	x	x	x		x	x	x						
<i>Camissonia sp.</i>	camissonia species																	x									
<i>Carex sp.</i>	sedge species					x			x																		
<i>Celtis laevigata var. reticulata</i>	net-leaf hackberry											x								x							
<i>Centaurium calycosum</i>	Buckley's centaury			x																							
<i>Centaurium exaltatum</i>	Great Basin centaury											x															
<i>Cercis orbiculata</i>	California Redbud							x	x	x	x							x			x			x			
<i>Chaenactis stevioides</i>	Steve's dusty maiden																		x								
<i>Cheilanthes feei</i>	slender lip fern												x														
<i>Chenopodium sp.</i>																		x									
<i>Chilopsis linearis</i>	desert willow																					x					
<i>Chrysothamnus nauseosus</i>	rabbitbrush	up											x														
<i>Cirsium neomexicanum</i>	New Mexico thistle																	x									
<i>Cirsium sp. (unknown not exotic)</i>		x																				x					
<i>Cladium californicum</i>	sawgrass			x	x	x					x				x	x			x						x		
<i>Claytonia perfoliata</i>	miner's lettuce																					x					
<i>Conyza canadensis</i>	horseweed						x									x											x
<i>Cryptantha barbiger</i>	bearded cryptantha								x																		
<i>Cryptantha pterocarya</i>	wing nut cryptantha																									x	
<i>Cryptantha racemosa</i>	woody cryptantha		x						x	x																	
<i>Cryptantha recurvata</i>	arched-calyced cryptantha																										
<i>Cryptantha sp</i>	cryptantha species												x	x	x	x	x	x		x	x						x
<i>Cylindropuntia whipplei</i>	whipple cholla																	x									
<i>Cyperus sp.</i>	sedge species								x																		
<i>Dasyochloa pulchella</i>	fluff grass												x	x	x	x	x	x								x	x
<i>Datura wrightii</i>	sacred datura	x					x		x	x	x	x						x					x		x		
<i>Descurainia pinnata</i>	yellow tansy mustard																										
<i>Descurainia sp.</i>																											x
<i>Draba cuneifolia</i>	whitlow grass																					x					
<i>Echinocactus polycephalus</i>	barrel cactus, cottontop												x														
<i>Echinocactus polycephalus var. xeranthemoides</i>	cottontop cactus		x																								
<i>Echinocactus polycephalus var. polycephalus</i>	multi-headed barrel cactus, cottontop								x															x		x	
<i>Echinocereus engelmannii</i>	englemann hedgehog		x		x		x											x	x								

Appendix F-2

Scientific Name	Common Name	Soap	North	Hakatai	Bighorn Wash	85 Mile Spring	Last Chance	Tatahato	1st Redbud	2nd Redbud	Bert	Saddle	94 Mile	Kwagunt	Lava Chuar	Clear Creek	Garnet	Stone Creek	Boucher	Kanab	209	Hell's Hollow	Waltenberg	Malgosa	Cranberry	Specter	Cove
Echinocereus triglochidiatus	claretcup cactus		x							x							x	x									
Eleocharis sp.					x																						
Elymus elymoides			x																								
Elodea canadensis	waterweed												x														
Encelia farinosa	white brittlebush			x	x		x						x	x	x	x	x	x	x	x	x		x		x	x	x
Encelia frutescens	rayless encelia																	x			x						
Encelia resinifera	white brittlebush	up																x								x	
Encelia sp.	brittlebush species																							x			
Ephedra nevadensis	Nevada mormon tea												x	x				x	x	x							
Ephedra sp. (use when unknown)		up	x		x				x		x		x					x						x		x	x
Ephedra torreyana	torrey mormon tea, torrey joint-fir													x				x									
Epipactis gigantea	giant helleborine								x	x																	x
Equisetum xferriisii	horsetail				x						x			x	x	x	x	x									
Erigeron divergens	spreading fleabane										x																
Erigeron lobatus	fleabane		x	x																							
Eriogonum deflexum	skeleton weed												x	x	x			x								x	
Eriogonum inflatum	desert trumpet	up			x				x				x			x	x	x	x	x	x						x
Erioneuron sp.																		x									
Erodium cicutarium	filaree, stork's bill		x											x	x	x	x	x		x	x	x				x	
Eschscholzia glyptosperma	desert gold poppy																										
Eschscholzia minutiflora	little gold poppy																				x						
Escobaria grahamii var. grahamii	pin cushion cactus, arizona fishhook												x														x
Eucnide urens	rock nettle, sting bush			x														x	x		x		x			x	x
Euphorbia aaron-rossii	Marble canyon spurge	up						x	x	x																	
Fallugia paradoxa	apache plume							x			x				x			x									
Ferocactus cylindraceus var. cylindraceus	California barrel cactus				x													x	x		x					x	
Ferocactus cylindraceus var. eastwoodiae	yellow-spined barrel																	x				x					
Festuca sp.	fescue grass species																	x									
Flaveria macdougalii	macdougal's flaveria																										x
Fraxinus anomala	single leaf ash										x													x			
Funastrum cynanchoides ssp. cynanchoides	climbing milkweed										x		x										x		x		x
Galium stellatum	desert bedstraw			x	x				x				x	x	x	x	x	x	x				x			x	
Gnaphalium chilense	cudweed									x																	
Gnaphalium wrightii	cudweed						x																				
Gutierrezia microcephala	three leaf snakeweed								x																		
Gutierrezia sarothrae	broom snakeweed				x		x						x					x	x		x	x			x	x	x
Hedeoma oblongifolia	mock pennyroyal																	x								x	x
Hesperodoria salicina	burweed									x	x													x			x
Hesperostipa speciosa		x	up																x								
Imperata brevifolia	satintail				x										x	x			x		x				x		
Isocoma pluriflora	jimmyweed			x	x	x						x															
Isocoma sp.													x													x	x
Iva acerosa	copperweed					x																					
Janusia gracilis	janusia sp																			x							
Juncus balticus	wire rush																										
Juncus torreyi	rush																										

Appendix F-3

Scientific Name	Common Name	Soap	North	Hakatai	Bighorn Wash	85 Mile Spring	Last Chance	Tatahato	1st Redbud	2nd Redbud	Bert	Saddle	94 Mile	Kwagunt	Lava Chuar	Clear Creek	Garnet	Stone Creek	Boucher	Kanab	209	Hell's Hollow	Waltenberg	Malgosa	Cranberry	Specter	Cove
<i>Juniperus osteosperma</i>	utah juniper												x	x	x												
<i>Juniperus scopulorum</i>	rocky mountain juniper																										
<i>Larrea tridentata</i>	creosotebush																				x	x					x
<i>Lepidium fremontii</i>	desert alyssum										x									x							
<i>Lepidium latifolium</i>	perennial pepperweed	up																									
<i>Lepidium montanum</i>	peppergrass																									x	
<i>Lepidium sp.</i>										x (annual native)			x														x
<i>Lycium andersonii</i>	wolfberry, anderson thornbush																x	x		x							
<i>Lycium fremontii</i>	Fremont thornbush										x																
<i>Lycium pallidum</i>	rabbit thorn																x										
<i>Lycium sp.</i>	wolfberry species																										x
<i>Machaeranthera pinnatifida</i> var. <i>goodingii</i>	spiny goldenweed	up	x	x			x		x	x							x									x	
<i>Malacothrix californica</i> var. <i>glabrata</i>	desert dandelion																				x						
<i>Mammillaria tetrancistra</i>	Corky-seed fishhook													x	x	x	x										
<i>Maurandella antirrhiniflora</i>	twining snapdragon, blue snapdragon vine		x	x					x	x							x	x						x			x
<i>Melilotus albus</i>	white sweet clover					x														x							
<i>Mentzelia puberula</i>	rough stemmed blazing star		x																								
<i>Mentzelia tricuspidis</i>	shiny-leaved blazing star																x									x	
<i>Mimulus cardinalis</i>	scarlet monkeyflower									x																	x
<i>Mirabilis multiflora</i>	Colorado four o'clock																	x			x	x					
<i>Muhlenbergia asperifolia</i>	scratch grass			x	x	x	x						x	x	x	x	x	x	x							x	x
<i>Muhlenbergia microsperma</i>	little seed muhly		x																								
<i>Muhlenbergia texanus</i>						x																					
<i>Nasturtium officinale</i>	water cress																			x							
<i>Nicotiana trigonophylla</i>	desert tobacco								x	x			x				x	x			x					x	x
<i>Nolina microcarpa</i>	beargrass				x								x					x		x						x	x
<i>Oenothera caespitosa</i>	evening primrose																				x	x					
<i>Oenothera elata</i> ssp. <i>hookeri</i>	hooker evening primrose				x																						
<i>Oenothera pallida</i>	pale evening primrose																										
<i>Opuntia basilaris</i>	beavertail cactus										x																
<i>Opuntia basilaris</i> var. <i>longiaerolata</i>	beavertail species	up																									
<i>Opuntia erinacea</i> var. <i>utahensis</i>	mojave prickly pear, grizzly bear cactus	up																									
<i>Opuntia phaeacantha</i>	desert prickly pear, engelmann prickly pear		up		x								x	x			x	x		x				x			x
<i>Opuntia phaeacantha</i> var. <i>major</i>	Desert prickly pear, Engelmann prickly pear																							x			
<i>Opuntia polyacantha</i>	plains prickly pear												x													x	

Appendix F-4

Scientific Name	Common Name	Soap	North	Hakatai	Bighorn Wash	85 Mile Spring	Last Chance	Tatahato	1st Redbud	2nd Redbud	Bert	Saddle	94 Mile	Kwagunt	Lava Chuar	Clear Creek	Garnet (cholla)	Stone Creek	Boucher	Kanab	209	Hell's Hollow	Waltenberg	Malgosa	Cranberry	Specter	Cove
Opuntia sp.	prickly pear species			x													x						x		x		
Oxalis albicans	wood sorrel																										
Panicum sp.	panic grass species								x																		
Parietaria hespera	pellitory		x																							x	x
Pellaea truncata	spiny cliffbrake																x										
Perityle congesta	rock daisy						x																				x
Perityle emoryi	emory rock daisy														x												x
Petrophyton caespitosum	mat rockspirea										x						x										x
Peucephyllum schottii	pigmy cedar																									x	
Phacelia crenulata	notch-leaf scorpion-weed	up															x										
Phacelia crenulata var. angustifolia		up																									
Phacelia sp.	phacelia species												x	x	x	x	x	x	x	x						x	x
Pholistoma auritum var. arizonae	Arizona fiesta flower																x	x		x							
Phragmites australis	giant common reed																	x									
Physalis crassifolia	yellow nightshade groundcherry																					x					
Physalis hederifolia var. fendleri	Fendler groundcherry						x																				
Physalis hederifolia	ivy leaf groundcherry																									x	x
Plantago major	common plantain						x											x									
Plantago ovata	woolly plantain, inland plantain	x											x	x													x
Pleuraphis jamesii	galleta				x																				x	x	x
Pluchea sericea	arrowweed												x					x			x						
Poa fendleriana	mutton grass					x												x									
Polypogon monspeliensis	rabbitfoot grass				x	x				x																	x
Polypogon viridis	beardless rabbitsfoot grass					x																					x
Populus fremontii	fremont cottonwood				x									x	x			x		x							
Porophyllum gracile	pore-leaf, odora			x									x				x	x				x			x	x	x
Prosopis glandulosa	honey mesquite			x						x	x	x		x	x							x					x
Psilostrophe taetina	woolly paperflower																							x			
Psilostrophe sp.	paperflower species																										x
Ptelea trifoliata	pale hoptree		x																								
Purshia mexicana	cliffrose													x										x			
Quercus turbinella	shrub live oak													x													
Rafinesquia neomexicana	desert chicory																	x		x	x						
Rhamnus betulaeifolia	birchleaf buckthorn										x							x									
Rhus glabra	Smooth sumac												x					x									
Rhus trilobata	squaw bush																	x						x			
Rhus trilobata var. simplicifolia	singleleaf skunkbush			x	x					x																	
Salix exigua	coyote willow				x						x			x	x	x		x		x							
Salix goodingii	gooding willow				x																						
Salsola tragus	russian thistle	x																									x
Schizachyrium scoparium var. scoparium	little bluestem						x																				

Appendix F-5

Scientific Name	Common Name	Soap	North	Hakatai	Bighorn Wash	85 Mile Spring	Last Chance	Tatahato	1st Redbud	2nd Redbud	Bert	Saddle	94 Mile	Kwagunt	Lava Chuar	Clear Creek	Garnet	Stone Creek	Boucher	Kanab	209	Hell's Hollow	Waltenberg	Malgosa	Cranberry	Specter	Cove
<i>Senna covesii</i>	Cove's cassia												x														
<i>Setaria verticillata</i>	bur bristlegrass																										x
<i>Shepherdia rotundifolia</i>	round-leaf buffalo berry				x																			x			
<i>Silene antirrhina</i>	sleepy catchfly																								x		
<i>Solanum americanum</i>	american nightshade																										x
<i>Solanum nigrum</i>	black nightshade																										x
<i>Solidago altissima</i>	tall goldenrod									x																	
<i>Solidago occidentalis</i>											x																
<i>Solidago sp.</i>	goldenrod species				x				x																x		
<i>Sonchus asper</i>	spiny-leaved sow thistle			x	x					x																x	x
<i>Sphaeralcea ambigua</i>	desert mallow	up								x					x		x	x		x							
	gooseberry/leaf globe mallow																										
<i>Sphaeralcea grossularifolia</i>	mallow																x										
<i>Sphaeralcea parvifolia</i>	littleleaf globe mallow																x					x					x
<i>Sphaeralcea sp.</i>	globe mallow species												x									x			x	x	
<i>Sporobolus airoides</i>	alkali sacaton	x											x														
<i>Sporobolus contractus</i>	spike dropseed			x													x	x			x						
<i>Sporobolus cryptandrus</i>	sand dropseed																x								x	x	
<i>Sporobolus flexuosus</i>	mesa dropseed						x										x										
<i>Sporobolus sp.</i>	dropseed species				x								x				x						x				
	prince's plume, desert plume	up	x					x	x	x	x			x	x					x						x	x
<i>Stephanomeria pauciflora</i>	desert straw	up	x				x		x	x		x	x				x							x	x	x	x
<i>Stephanomeria tenuifolia</i>	wire lettuce												x														
<i>Streptanthella longirostris</i>	long beaked twist flwr													x	x					x	x						
<i>Tamarix ramosissima (gone from most canyons)</i>	tamarisk, salt cedar	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
<i>Thamnosma montana</i>	turpentine broom													x	x	x		x					x				
<i>Thelypodium integrifolium ssp. longicarpum</i>	thelypodium										x															x	x
<i>Thelypodium sp.</i>			x	x																							
<i>Thymophylla pentachaeta var. pentachaeta</i>	fetid Marigold								x				x				x	x	x					x			x
<i>Thymophylla pentachaeta var. belanidium</i>			x																								
<i>Tidestromia lanuginosa</i>	woolly tidestromia																	x									
<i>Tiquilia latior</i>	hispid coldenia	up								x																	x
<i>Trixis californica</i>	trixis			x									x				x										
<i>Typha domingensis</i>	cattail														x		x	x	x								
<i>Typha latifolia</i>	broadleaf cattail								x																		
<i>Typha sp.</i>	cattail species																										
<i>Vulpia octiflora</i>	six-weeks fescue	up	x										x				x									x	x
<i>Xylorhiza tortifolia</i>	mohave aster	up							x																		x
<i>Yucca angustissima</i>	fine leaf yucca												x														
<i>Yucca baccata</i>	banana yucca									x		x	x	x	x					x							
<i>Yucca elata</i>	Soaptree yucca	up	up						x				x														
<i>Zannichellia palustris</i>	common poolmat																										x
<i>Ziziphus obtusifolia var. obtusifolia</i>	greythorn												x									x					x

Appendix F-6

Appendix F: Plant Species List for Selected Canyons

Canyon: Soap Canyon

Genus / Species / Authority	Common Names
<i>Achnatherum hymenoides</i> (Roemer & J.A. Schultes) Barkworth	indian ricegrass
<i>Allionia incarnata</i> L.	trailing four o'clock
<i>Artemisia filifolia</i> Torr.	sand sagebrush
<i>Artemisia ludoviciana</i> Nutt.	Louisiana sage
<i>Atriplex canescens</i> (Pursh) Nutt.	four wing saltbush
<i>Atriplex obovata</i> Moq.	saltbush
<i>Brickellia longifolia</i> S. Wats.	longleaf brickellbush
<i>Bromus rubens</i> L.	foxtail chess, red brome
<i>Camissonia multijuga</i> (S. Wats.) Raven	camissonia, frost-stem suncup
<i>Chrysothamnus nauseosus</i> (Pall.) Britton	rabbitbrush
<i>Cirsium</i> sp. (unknown not exotic)	
<i>Datura wrightii</i> Regel	sacred datura
<i>Encelia resinifera</i> Gray	white brittlebush
<i>Ephedra</i> sp. (use when unknown)	
<i>Eriogonum inflatum</i> Torr. & Frém.	desert trumpet
<i>Hesperostipa speciosa</i>	
<i>Lepidium latifolium</i> L.	perennial pepperweed
<i>Machaeranthera pinnatifida</i> var. <i>goodingii</i> (A. Nels.) B.L. Turner & Hartman	spiny goldenweed
<i>Opuntia basilaris</i> var. <i>longiaerolata</i>	
<i>Opuntia erinacea</i> Engelm. & Bigelow ex Engelm. var. <i>utahensis</i> (Engelm.) L. Benson	mojave prickly pear, grizzly bear cactus
<i>Phacelia crenulata</i> Torr. ex S. Wats.	notch-leaf scorpion-weed
<i>Phacelia crenulata</i> var. <i>angustifolia</i>	
<i>Plantago ovata</i> Forsk.	woolly plantain, inland plantain
<i>Salsola tragus</i> L.; <i>Salsola iberica</i> Sennen & Pau.	russian thistle
<i>Sphaeralcea ambigua</i> Gray	desert mallow
<i>Sporobolus airoides</i> (Torr.) Torr.	alkali sacaton
<i>Stanleya pinnata</i> (Pursh) Britt.	prince's plume, desert plume
<i>Stephanomeria pauciflora</i> (Torr) A. Nels	desert straw
<i>Tiquilia latior</i> (I.M. Johnston) A. Richards.	hispid coldenia
<i>Vulpia octoflora</i> (Walt.) Rydb.	six-weeks fescue
<i>Xylorhiza tortifolia</i> (Torr. & Gray) Greene	mohave aster
<i>Yucca elata</i> (Engelm.) Engelm.	Soaptree yucca

Canyon: North Canyon

Appendix G

Plant Lists for Canyons with Transects

Canyon: Soap Canyon

Genus / Species / Authority	Common Names
<i>Achnatherum hymenoides</i> (Roemer & J.A. Schultes) Barkworth	indian ricegrass
<i>Allionia incarnata</i> L.	trailing four o'clock
<i>Artemisia filifolia</i> Torr.	sand sagebrush
<i>Artemisia ludoviciana</i> Nutt.	Louisiana sage
<i>Atriplex canescens</i> (Pursh) Nutt.	four wing saltbush
<i>Atriplex obovata</i> Moq.	saltbush
<i>Brickellia longifolia</i> S. Wats.	longleaf brickellbush
<i>Bromus rubens</i> L.	foxtail chess, red brome
<i>Camissonia multijuga</i> (S. Wats.) Raven	camissonia, frost-stem suncup
<i>Chrysothamnus nauseosus</i> (Pall.) Britton	rabbitbrush
<i>Cirsium</i> sp. (unknown not exotic)	
<i>Datura wrightii</i> Regel	sacred datura
<i>Encelia resinifera</i> Gray	white brittlebush
<i>Ephedra</i> sp. (use when unknown)	
<i>Eriogonum inflatum</i> Torr. & Frém.	desert trumpet
<i>Lepidium latifolium</i> L.	perennial pepperweed
<i>Machaeranthera pinnatifida</i> var. <i>gooddingii</i> (A. Nels.) B.L. Turner & Hartman	spiny goldenweed
<i>Opuntia basilaris</i> var. <i>longiaerolata</i>	
<i>Opuntia erinacea</i> Engelm. & Bigelow ex Engelm. var. <i>utahensis</i> (Engelm.) L. Benson	mojave prickly pear, grizzly bear cactus
<i>Phacelia crenulata</i> Torr. ex S. Wats.	notch-leaf scorpion-weed
<i>Phacelia crenulata</i> var. <i>angustifolia</i>	
<i>Plantago ovata</i> Forsk.	woolly plantain, inland plantain
<i>Salsola tragus</i> L.	russian thistle
<i>Sphaeralcea ambigua</i> Gray	desert mallow
<i>Sporobolus airoides</i> (Torr.) Torr.	alkali sacaton
<i>Stanleya pinnata</i> (Pursh) Britt.	prince's plume, desert plume
<i>Stephanomeria pauciflora</i> (Torr) A. Nels	desert straw
<i>Tiquilia latior</i> (I.M. Johnston) A. Richards.	hispid coldenia
<i>Vulpia octoflora</i> (Walt.) Rydb.	six-weeks fescue
<i>Xylorhiza tortifolia</i> (Torr. & Gray) Greene	mohave aster
<i>Yucca elata</i> (Engelm.) Engelm.	Soaptree yucca

Canyon: Lava Chuar Canyon

Genus / Species / Authority	Common Names
<i>Acacia greggii</i> Gray	catclaw acacia
<i>Adiantum capillus-veneris</i> L.	maidenhair fern
<i>Agave utahensis</i> Engelm.	century plant
<i>Aristida arizonica</i> Vasey	Arizona three awn
<i>Artemisia ludoviciana</i> Nutt.	Louisiana sage
<i>Astragalus</i> sp. (use when unknown)	
<i>Baccharis salicifolia</i> (Ruiz & Pavón) Pers.	baccharis, seep willow
<i>Bothriochloa barbinodis</i> (Lag.) Herter	cane bluestem
<i>Brickellia longifolia</i> S. Wats.	longleaf brickellbush
<i>Bromus rubens</i> L.	foxtail chess, red brome
<i>Camissonia speculicola</i> (Raven) Raven	Kaibab suncup
<i>Chaenactis stevioides</i> Hook. & Arn.	Steve's dusty maiden
<i>Cladium californicum</i> (S. Wats.) O'Neill	sawgrass
<i>Cryptantha capitata</i> (Eastw.) I.M. Johnston	capitate catseye
<i>Dasyochloa pulchella</i> (Kunth) Willd. ex Rydb.	fluff grass
<i>Descurainia pinnata</i> (Walt.) Britt.	yellow tansy mustard
<i>Encelia farinosa</i> Gray ex Torr.	white brittlebush
<i>Equisetum ×ferrissii</i> Clute (pro sp.)	horsetail
<i>Eriogonum deflexum</i> Torr.	skeleton weed
<i>Erodium cicutarium</i> (L.) L'Hér. ex Ait.	filaree, stork's bill
<i>Fallugia paradoxa</i> (D. Don) Endl. ex Torr.	apache plume
<i>Galium stellatum</i> Kellogg	desert bedstraw
<i>Imperata brevifolia</i> Vasey	satintail
<i>Juniperus osteosperma</i> (Torr.) Little	utah juniper
<i>Mammillaria tetrancistra</i> Engelm.	Corky-seed fishhook
<i>Muhlenbergia asperifolia</i> (Nees & Meyen ex Trin.) Parodi	scratch grass
<i>Oenothera pallida</i> Lindl.	pale evening primrose
<i>Perityle emoryi</i> Torr.	emory rock daisy
<i>Phacelia</i> sp. (use when unknown)	
<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	giant common reed
<i>Populus fremontii</i> S. Wats.	fremont cottonwood

Canyon: Lava Chuar Canyon continued

Genus / Species / Authority	Common Names
<i>Prosopis glandulosa</i> Torr.	honey mesquite
<i>Salix exigua</i> Nutt.	coyote willow
<i>Sphaeralcea ambigua</i> Gray	desert mallow
<i>Stanleya pinnata</i> (Pursh) Britt.	prince's plume, desert plume
<i>Streptanthella longirostris</i> (S. Wats.) Rydb.	long beaked twist flwr
<i>Tamarix ramosissima</i> Ledeb.	tamarisk, salt cedar
<i>Thamnosma montana</i> Torr. & Frém.	turpentine broom
<i>Typha domingensis</i> Pers.	cattail
<i>Yucca baccata</i> Torr.	banana yucca

Canyon: Waltenberg Canyon

Genus / Species / Authority	Common Names
<i>Acacia greggii</i> Gray	catclaw acacia
<i>Agave utahensis</i> var. <i>utahensis</i> Engelm.	Utah agave
<i>Aristida arizonica</i> Vasey	Arizona three awn
<i>Brickellia longifolia</i> S. Wats.	longleaf brickellbush
<i>Datura wrightii</i> Regel	sacred datura
<i>Encelia farinosa</i> Gray ex Torr.	white brittlebush
<i>Eucnide urens</i> (Parry ex Gray) Parry	rock nettle, sting bush
<i>Funastrum cynanchoides</i> (Dcne.) Schlechter ssp. <i>cynanchoides</i>	climbing milkweed
<i>Opuntia phaeacantha</i> Engelm.	desert prickly pear, engelmann prickly pear
<i>Sporobolus</i> sp.	

Canyon: Garnet Canyon

Genus / Species / Authority	Common Names
<i>Abronia elliptica</i> A. Nels.	sand verbena
<i>Acacia greggii</i> Gray	catclaw acacia
<i>Achnatherum speciosum</i> (Trin. & Rupr.) Barkworth	
<i>Acourtia wrightii</i> (Gray) Reveal & King	brownfoot
<i>Agave utahensis</i> Engelm.	century plant
<i>Amsinckia menziesii</i> (Lehm.) A. Nels. & J.F. Macbr. var. <i>intermedia</i> (Fisch & C.A. Mey.) Ganders	coast fiddleneck
<i>Anemone tuberosa</i> Rydb.	desert windflower, anemone
<i>Aristida adscensionis</i> L.	six-weeks three-awn
<i>Aristida arizonica</i> Vasey	Arizona three awn
<i>Artemisia ludoviciana</i> Nutt.	Louisiana sage
<i>Baccharis salicifolia</i> (Ruiz & Pavón) Pers.	baccharis, seep willow
<i>Bebbia juncea</i> (Benth.) Greene var. <i>aspera</i> Greene	chuckwalla's delight
<i>Bothriochloa barbinodis</i> (Lag.) Herter	cane bluestem
<i>Brickellia atractyloides</i> Gray	spiny brickellbush
<i>Brickellia longifolia</i> S. Wats.	longleaf brickellbush
<i>Bromus rubens</i> L.	foxtail chess, red brome
<i>Bromus tectorum</i> L.	cheatgrass, downy chess
<i>Camissonia speculicola</i> (Raven) Raven	Kaibab suncup
<i>Chenopodium</i> sp.	
<i>Cirsium neomexicanum</i> Gray	New Mexico thistle
<i>Cryptantha capitata</i> (Eastw.) I.M. Johnston	capitate catseye
<i>Cylindropuntia whipplei</i> Engelm. & Bigelow	whipple cholla
<i>Dasyochloa pulchella</i> (Kunth) Willd. ex Rydb.	fluff grass
<i>Descurainia</i> sp.	
<i>Draba cuneifolia</i> Nutt. ex Torr. & Gray	whitlow grass
<i>Echinocactus polycephalus</i> Engelm. & Bigelow	barrel cactus, cottontop
<i>Echinocactus polycephalus</i> var. <i>polycephalus</i> Engelm. & Bigel	multi-headed barrel cactus, cottontop
<i>Echinocereus engelmannii</i> (Parry ex Engelm.) Lem.	englemann hedgehog
<i>Echinocereus triglochidiatus</i> Engelm.	claretcup cactus
<i>Encelia farinosa</i> Gray ex Torr.	white brittlebush
<i>Ephedra nevadensis</i> S. Wats.	Nevada mormon tea
<i>Ephedra</i> sp. (use when unknown)	
<i>Ephedra torreyana</i> S. Wats.	torrey mormon tea, torrey joint-fir
<i>Equisetum ×ferrissii</i> Clute (pro sp.)	horsetail
<i>Eriogonum deflexum</i> Torr.	skeleton weed
<i>Eriogonum inflatum</i> Torr. & Frém.	desert trumpet

Canyon: Garnet Canyon continued

Genus / Species / Authority	Common Names
<i>Erodium cicutarium</i> (L.) L'Hér. ex Ait.	filaree, stork's bill
<i>Eucnide urens</i> (Parry ex Gray) Parry	rock nettle, sting bush
<i>Ferocactus cylindraceus</i> (Engelm.) Orcutt var. <i>cylindraceus</i>	California barrel cactus
<i>Ferocactus cylindraceus</i> (Engelm.) Orcutt var. <i>eastwoodiae</i> (L. Benson)	yellow-spined barrel
<i>Festuca</i> sp.	
<i>Galium stellatum</i> Kellogg	desert bedstraw
<i>Gutierrezia sarothrae</i> (Pursh) Britt. & Rusby	broom snakeweed
<i>Hedeoma oblongifolia</i> (Gray) Heller	mock pennyroyal
<i>Isocoma</i> sp.	
<i>Lycium andersonii</i> Gray	wolfberry, anderson thornbush
<i>Lycium pallidum</i> Miers	rabbit thorn
<i>Machaeranthera pinnatifida</i> var. <i>gooddingii</i> (A. Nels.) B.L. Turner & Hartman	spiny goldenweed
<i>Mammillaria tetrancistra</i> Engelm.	Corky-seed fishhook
<i>Maurandella antirrhiniflora</i> (Humb. & Bonpl. ex Willd.) Rothm.	twining snapdragon, blue snapdragon vine
<i>Mentzelia tricuspis</i> Gray	shiny-leaved blazing star
<i>Muhlenbergia asperifolia</i> (Nees & Meyen ex Trin.) Parodi	scratch grass
<i>Nicotiana trigonophylla</i> Dunal	desert tobacco
<i>Oenothera pallida</i> Lindl.	pale evening primrose
<i>Opuntia phaeacantha</i> Engelm.	desert prickly pear, engelmann prickly pear
<i>Opuntia</i> sp. (cholla)	
<i>Pellaea truncata</i> Goodding	spiny cliffbrake
<i>Petrophyton caespitosum</i> (Nutt.) Rydb.	mat rockspirea
<i>Phacelia crenulata</i> Torr. ex S. Wats.	notch-leaf scorpion-weed
<i>Phacelia</i> sp. (use when unknown)	
<i>Pholistoma auritum</i> var. <i>Arizona</i>	Arizona fiesta flower
<i>Pleuraphis jamesii</i> Torr.	galleta
<i>Porophyllum gracile</i> Benth.	pore-leaf, odora
<i>Sphaeralcea ambigua</i> Gray	desert mallow
<i>Sphaeralcea grossulariifolia</i> (Hook. & Arn.) Rydb.	gooseberryleaf globe mallow
<i>Sphaeralcea parvifolia</i> A. Nels.	littleleaf globe mallow
<i>Sporobolus contractus</i> A.S. Hitchc.	spike dropseed
<i>Sporobolus cryptandrus</i> (Torr.) Gray	sand dropseed
<i>Sporobolus flexuosus</i> (Thurb. ex Vasey) Rydb.	mesa dropseed

Canyon: Garnet Canyon continued

Genus / Species / Authority	Common Names
Sporobolus sp.	
Stephanomeria pauciflora (Torr) A. Nels	desert straw
Tamarix ramosissima Ledeb.	tamarisk, salt cedar
Thymophylla pentachaeta var. pentachaeta (DC.) Small	fetid Marigold
Tidestromia lanuginosa (Nutt.) Standl.	woolly tidestromia
Trixis californica Kellogg	trixis
Typha domingensis Pers.	cattail
Vulpia octoflora (Walt.) Rydb.	six-weeks fescue

Canyon: Bighorn Wash

Genus / Species / Authority	Common Names
<i>Acacia greggii</i> Gray	catclaw acacia
<i>Agave utahensis</i> Engelm.	century plant
<i>Agrostis semiverticillata</i>	
<i>Andropogon glomeratus</i> (Walt.) B.S.P.	bushy beardgrass
<i>Aristida adscensionis</i> L.	six-weeks three-awn
<i>Astragalus</i> sp. (use when unknown)	
<i>Baccharis emoryi</i> Gray	Emory baccharis
<i>Baccharis salicifolia</i> (Ruiz & Pavón) Pers.	baccharis, seep willow
<i>Bothriochloa barbinodis</i> (Lag.) Herter	cane bluestem
<i>Brickellia longifolia</i> S. Wats.	longleaf brickellbush
<i>Bromus rubens</i> L.	foxtail chess, red brome
<i>Cladium californicum</i> (S. Wats.) O'Neill	sawgrass
<i>Echinocereus engelmannii</i> (Parry ex Engelm.) Lem.	englemann hedgehog
<i>Eleocharis</i> sp.	
<i>Encelia farinosa</i> Gray ex Torr.	white brittlebush
<i>Ephedra</i> sp. (use when unknown)	
<i>Equisetum ×ferrissii</i> Clute (pro sp.)	horsetail
<i>Eriogonum inflatum</i> Torr. & Frém.	desert trumpet
<i>Ferocactus cylindraceus</i> (Engelm.) Orcutt var. <i>cylindraceus</i>	California barrel cactus
<i>Galium stellatum</i> Kellogg	desert bedstraw
<i>Gutierrezia sarothrae</i> (Pursh) Britt. & Rusby	broom snakeweed
<i>Imperata brevifolia</i> Vasey	satintail
<i>Isocoma pluriflora</i> (Torr. & Gray) Greene	jimmyweed
<i>Muhlenbergia asperifolia</i> (Nees & Meyen ex Trin.) Parodi	scratch grass
<i>Nolina microcarpa</i> S. Wats.	beargrass
<i>Oenothera elata</i> ssp. <i>hookeri</i> (Torr. & Gray) W. Dietr. & W.L. Wagner	hooker evening primrose
<i>Opuntia phaeacantha</i> Engelm.	desert prickly pear, englemann prickly pear
<i>Pleuraphis jamesii</i> Torr.	galleta
<i>Polypogon monspeliensis</i> (L.) Desf.	rabbitfoot grass
<i>Populus fremontii</i> S. Wats.	fremont cottonwood
<i>Rhus trilobata</i> Nutt. var. <i>simplicifolia</i>	
<i>Salix exigua</i> Nutt.	coyote willow
<i>Salix gooddingii</i> Ball	gooding willow
<i>Shepherdia rotundifolia</i> Parry	round-leaf buffalo berry
<i>Solidago</i> sp. (use when unknown)	
<i>Sonchus asper</i> (L.) Hill	spiny-leaved sowthistle
<i>Sporobolus</i> sp.	

Canyon: Last Chance

Genus / Species / Authority	Common Names
<i>Acacia greggii</i> Gray	catclaw acacia
<i>Adiantum capillus-veneris</i> L.	maidenhair fern
<i>Aristida arizonica</i> Vasey	Arizona three awn
<i>Artemisia ludoviciana</i> Nutt.	Louisiana sage
<i>Baccharis salicifolia</i> (Ruiz & Pavón) Pers.	baccharis, seep willow
<i>Baccharis sergiloides</i> Gray	waterweed
<i>Bebbia juncea</i> (Benth.) Greene var. <i>aspera</i> Greene	chuckwalla's delight
<i>Brickellia longifolia</i> S. Wats.	longleaf brickellbush
<i>Bromus rubens</i> L.	foxtail chess, red brome
<i>Camissonia multijuga</i> (S. Wats.) Raven	camissonia, frost-stem suncup
<i>Conyza canadensis</i> (L.) Cronq.	horseweed
<i>Datura wrightii</i> Regel	sacred datura
<i>Echinocereus engelmannii</i> (Parry ex Engelm.) Lem.	englemann hedgehog
<i>Encelia farinosa</i> Gray ex Torr.	white brittlebush
<i>Gnaphalium wrightii</i> Gray	cudweed
<i>Gutierrezia sarothrae</i> (Pursh) Britt. & Rusby	broom snakeweed
<i>Juncus balticus</i> Willd.	wire rush
<i>Juncus torreyi</i> Coville	rush
<i>Machaeranthera pinnatifida</i> var. <i>gooddingii</i> (A. Nels.) B.L. Turner & Hartman	spiny goldenweed
<i>Muhlenbergia asperifolia</i> (Nees & Meyen ex Trin.) Parodi	scratch grass
<i>Perityle congesta</i> (M.E. Jones) Shinnars	rock daisy
<i>Physalis hederifolia</i> Gray var. <i>fendleri</i> (Gray) Cronq.	Fendler groundcherry
<i>Plantago major</i> L.	common plantain
<i>Schizachyrium scoparium</i> (Michx.) Nash var. <i>scoparium</i>	little bluestem
<i>Sporobolus flexuosus</i> (Thurb. ex Vasey) Rydb.	mesa dropseed
<i>Stephanomeria pauciflora</i> (Torr) A. Nels	desert straw

Canyon: Cranberry Canyon

Genus / Species / Authority	Common Names
<i>Acacia greggii</i> Gray	catclaw acacia
<i>Andropogon glomeratus</i> (Walt.) B.S.P.	bushy beardgrass
<i>Aristida arizonica</i> Vasey	Arizona three awn
<i>Atriplex</i> sp.	
<i>Baccharis salicifolia</i> (Ruiz & Pavón) Pers.	baccharis, seep willow
<i>Baccharis sergiloides</i> Gray	waterweed
<i>Bebbia juncea</i> (Benth.) Greene var. <i>aspera</i> Greene	chuckwalla's delight
<i>Bothriochloa barbinodis</i> (Lag.) Herter	cane bluestem
<i>Camissonia multijuga</i> (S. Wats.) Raven	camissonia, frost-stem suncup
<i>Cladium californicum</i> (S. Wats.) O'Neill	sawgrass
<i>Datura wrightii</i> Regel	sacred datura
<i>Encelia farinosa</i> Gray ex Torr.	white brittlebush
<i>Funastrum cynanchoides</i> (Dcne.) Schlechter ssp. <i>cynanchoides</i>	climbing milkweed
<i>Gutierrezia sarothrae</i> (Pursh) Britt. & Rusby	broom snakeweed
<i>Imperata brevifolia</i> Vasey	satintail
<i>Pleuraphis jamesii</i> Torr.	galleta
<i>Porophyllum gracile</i> Benth.	pore-leaf, odora
<i>Solidago velutina</i>	
<i>Sphaeralcea</i> sp.	
<i>Sporobolus cryptandrus</i> (Torr.) Gray	sand dropseed
<i>Stephanomeria pauciflora</i> (Torr) A. Nels	desert straw
<i>Typha</i> sp.	

Canyon: Specter Chasm

Genus / Species / Authority	Common Names
<i>Acacia greggii</i> Gray	catclaw acacia
<i>Agave utahensis</i> Engelm. var. <i>kaibabensis</i> (McKelvey) Breitung	century plant
<i>Ambrosia dumosa</i> (Gray) Payne	white bursage
<i>Aristida adscensionis</i> L.	six-weeks three-awn
<i>Aristida arizonica</i> Vasey	Arizona three awn
<i>Astragalus praelongus</i> Sheldon	
<i>Baccharis sergiloides</i> Gray	waterweed
<i>Bebbia juncea</i> (Benth.) Greene var. <i>aspera</i> Greene	chuckwalla's delight
<i>Bothriochloa barbinodis</i> (Lag.) Herter	cane bluestem
<i>Brickellia atractyloides</i> Gray	spiny brickellbush
<i>Brickellia longifolia</i> S. Wats.	longleaf brickellbush
<i>Camissonia multijuga</i> (S. Wats.) Raven	camissonia, frost-stem suncup
<i>Cryptantha pterocarya</i> (Torr.) Greene	wing nut cryptantha
<i>Dasyochloa pulchella</i> (Kunth) Willd. ex Rydb.	fluff grass
<i>Echinocactus polycephalus</i> var. <i>polycephalus</i> Engelm. & Bigel	multi-headed barrel cactus, cottontop
<i>Encelia farinosa</i> Gray ex Torr.	white brittlebush
<i>Encelia resinifera</i> Gray	white brittlebush
<i>Ephedra</i> sp. (use when unknown)	
<i>Eriogonum deflexum</i> Torr.	skeleton weed
<i>Erodium cicutarium</i> (L.) L'Hér. ex Ait.	filaree, stork's bill
<i>Escobaria grahamii</i> Engelm. var. <i>grahamii</i>	pincushion cactus, arizona fishhook
<i>Eucnide urens</i> (Parry ex Gray) Parry	rock nettle, sting bush
<i>Ferocactus cylindraceus</i> (Engelm.) Orcutt var. <i>cylindraceus</i>	California barrel cactus
<i>Galium stellatum</i> Kellogg	desert bedstraw
<i>Gutierrezia sarothrae</i> (Pursh) Britt. & Rusby	broom snakeweed
<i>Hedeoma oblongifolia</i> (Gray) Heller	mock pennyroyal
<i>Isocoma acradenia</i> (Greene) Greene	alkali goldenbush
<i>Lepidium montanum</i> Nutt.	peppergrass
<i>Machaeranthera pinnatifida</i> var. <i>gooddingii</i> (A. Nels.) B.L. Turner & Hartman	spiny goldenweed
<i>Mentzelia tricuspis</i> Gray	shiny-leaved blazing star
<i>Muhlenbergia asperifolia</i> (Nees & Meyen ex Trin.) Parodi	scratch grass
<i>Nicotiana trigonophylla</i> Dunal	desert tobacco

Canyon: Specter Chasm continued

Genus / Species / Authority	Common Names
<i>Nolina microcarpa</i> S. Wats.	beargrass
<i>Opuntia polyacantha</i> Haw.	plains prickly pear
<i>Opuntia</i> sp.	
<i>Parietaria hespera</i> Hinton	pellitory
<i>Peucephyllum schottii</i> Gray	pigmy cedar
<i>Phacelia crenulata</i> Torr. ex S. Wats.	notch-leaf scorpion-weed
<i>Physalis hederifolia</i> Gray	ivy leaf groundcherry
<i>Pleuraphis jamesii</i> Torr.	galleta
<i>Porophyllum gracile</i> Benth.	pore-leaf, odora
<i>Silene antirrhina</i> L.	sleepy catchfly
<i>Sonchus asper</i> (L.) Hill	spiny-leaved sow thistle
<i>Sphaeralcea</i> sp.	
<i>Stanleya pinnata</i> (Pursh) Britt.	prince's plume, desert plume
<i>Stephanomeria pauciflora</i> (Torr) A. Nels	desert straw
<i>Thelypodium integrifolium</i> (Nutt.) Endl. ex Walp. ssp. <i>longicarpum</i> Al-Shehbaz	thelypodium
<i>Vulpia octoflora</i> (Walt.) Rydb.	six-weeks fescue

Canyon: Cove Canyon

Genus / Species / Authority	Common Names
<i>Acacia greggii</i> Gray	catclaw acacia
<i>Adenophyllum porophylloides</i> (Gray) Strother	San Felipe Dyssodia
<i>Allionia incarnata</i> L.	trailing four o'clock
<i>Anulocaulis leiosolenus</i> (Torr.) Standl. var. <i>leiosolenus</i>	ringstem
<i>Aquilegia chrysantha</i> Gray	golden columbine
<i>Aristida adscensionis</i> L.	six-weeks three-awn
<i>Aristida arizonica</i> Vasey	Arizona three awn
<i>Artemisia ludoviciana</i> Nutt.	Louisiana sage
<i>Astragalus praelongus</i> Sheldon	
<i>Baccharis salicifolia</i> (Ruiz & Pavón) Pers.	baccharis, seep willow
<i>Baccharis sarothroides</i> Gray	broom baccharis
<i>Baileya multiradiata</i> Harvey & Gray ex Gray	desert marigold
<i>Bebbia juncea</i> (Benth.) Greene var. <i>aspera</i> Greene	chuckwalla's delight
<i>Bothriochloa saccharoides</i> (Sw.) Rydb.	silver beardgrass
<i>Brickellia longifolia</i> S. Wats.	longleaf brickellbush
<i>Bromus diandrus</i> Roth	ripgut grass
<i>Bromus rubens</i> L.	foxtail chess, red brome
<i>Camissonia multijuga</i> (S. Wats.) Raven	camissonia, frost-stem suncup
<i>Conyza canadensis</i> (L.) Cronq.	horseweed
<i>Cryptantha</i> sp. (use when unknown)	
<i>Dasyochloa pulchella</i> (Kunth) Willd. ex Rydb.	fluff grass
<i>Descurainia</i> sp.	
<i>Encelia farinosa</i> Gray ex Torr.	white brittlebush
<i>Ephedra</i> sp. (use when unknown)	
<i>Epipactis gigantea</i> Dougl. ex Hook.	giant helleborine
<i>Eriogonum inflatum</i> Torr. & Frém.	desert trumpet
<i>Eucnide urens</i> (Parry ex Gray) Parry	rock nettle, sting bush
<i>Flaveria macdougalii</i> Theroux, Pinkava & Keil	macdougal's flaveria
<i>Funastrum cynanchoides</i> (Dcne.) Schlechter ssp. <i>cynanchoides</i>	climbing milkweed
<i>Gutierrezia sarothrae</i> (Pursh) Britt. & Rusby	broom snakeweed
<i>Hedeoma oblongifolia</i> (Gray) Heller	mock pennyroyal
<i>Hesperodoria salicina</i> (Blake) Nesom	burroweed
<i>Isocoma acradenia</i> (Greene) Greene	alkali goldenbush
<i>Larrea tridentata</i> (Sessé & Moc. ex DC.) Coville	creosotebush
<i>Lepidium</i> sp.	
<i>Lycium</i> sp.	

Canyon: Cove Canyon continued

Genus / Species / Authority	Common Names
<i>Maurandella antirrhiniflora</i> (Humb. & Bonpl. ex Willd.) Rothm.	twining snapdragon, blue snapdragon vine
<i>Mimulus cardinalis</i> Dougl. ex Benth.	scarlet monkeyflower
<i>Muhlenbergia asperifolia</i> (Nees & Meyen ex Trin.) Parodi	scratch grass
<i>Nicotiana trigonophylla</i> Dunal	desert tobacco
<i>Nolina microcarpa</i> S. Wats.	beargrass
<i>Opuntia phaeacantha</i> Engelm.	desert prickly pear, engelmann prickly pear
<i>Parietaria hespera</i> Hinton	pellitory
<i>Perityle congesta</i> (M.E. Jones) Shinnery	rock daisy
<i>Perityle emoryi</i> Torr.	emory rock daisy
<i>Petrophyton caespitosum</i> (Nutt.) Rydb.	mat rockspirea
<i>Phacelia</i> sp. (use when unknown)	
<i>Physalis hederifolia</i> Gray	ivy leaf groundcherry
<i>Plantago ovata</i> Forsk.	woolly plantain, inland plantain
<i>Pleuraphis jamesii</i> Torr.	galleta
<i>Polypogon monspeliensis</i> (L.) Desf.	rabbitfoot grass
<i>Polypogon viridis</i> (Gouan) Breistr.	beardless rabbitsfoot grass
<i>Porophyllum gracile</i> Benth.	pore-leaf, odora
<i>Prosopis glandulosa</i> Torr.	honey mesquite
<i>Psilostrophe</i> sp.	
<i>Salsola tragus</i> L.; <i>Salsola iberica</i> Sennen & Pau.	russian thistle
<i>Setaria verticillata</i> (L.) Beauv.	bur bristlegrass
<i>Solanum americanum</i> P. Mill.	american nightshade
<i>Solanum</i> sp.	
<i>Sonchus asper</i> (L.) Hill	spiny-leaved sow thistle
<i>Sphaeralcea parvifolia</i> A. Nels.	littleleaf globe mallow
<i>Sporobolus cryptandrus</i> (Torr.) Gray	sand dropseed
<i>Stanleya pinnata</i> (Pursh) Britt.	prince's plume, desert plume
<i>Stephanomeria pauciflora</i> (Torr) A. Nels	desert straw
<i>Thelypodium integrifolium</i> (Nutt.) Endl. ex Walp. ssp. <i>longicarpum</i> Al-Shehbaz	thelypodium
<i>Thymophylla pentachaeta</i> var. <i>pentachaeta</i> (DC.) Small	fetid Marigold
<i>Tiquilia latior</i> (I.M. Johnston) A. Richards.	hispid coldenia
<i>Vulpia octoflora</i> (Walt.) Rydb.	six-weeks fescue
<i>Xylorhiza tortifolia</i> (Torr. & Gray) Greene	mohave aster
<i>Zannichellia palustris</i> L.	common poolmat
<i>Ziziphus obtusifolia</i> (Hook. ex Torr. & Gray) Gray var. <i>obtusifolia</i>	greythorn

APPENDIX H

Tamarisk Eradication and Restoration of 63 Tributaries

Project Press and Articles

If you are interested in obtaining the information contained
in this appendix, please contact:

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APPENDIX I

Tamarisk Eradication and Restoration of 63 Tributaries

Project Implementation Map

If you are interested in obtaining the information contained
in this appendix, please contact:

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