Control Tamarisk and Monitor Vegetation at Backcountry Seeps, Springs and Tributaries in Grand Canyon National Park

Northern Arizona University / National Park Service
Colorado Plateau Cooperative Ecosystem Studies Unit
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ABSTRACT

This project supported the continuation and further development of Grand Canyon National Park's tamarisk (*Tamarix ramosissima* and *T. aphylla*) management project, which focuses on tamarisk control and vegetation monitoring at backcountry seeps, springs and tributaries outside of the main Colorado River corridor. These non-corridor areas represent some of the nation's best examples of relatively intact desert riparian and wetland systems. The primary objective of this task agreement was to ensure a well-designed system of data collection and monitoring was in place prior to expansion and continuation of the large-scale management project. The key official for the NPS was Lori Makarick, Grand Canyon National Park (GRCA) Backcountry Vegetation Program Manager. The Principal Investigator (PI) for Northern Arizona University (NAU) was Mike Kearsley, Biologist, and the Co-PI was Thomas Sisk, Environmental Scientist. GRCA and NAU staff worked together to re-evaluate the control and monitoring methods used in Phase I project areas, develop a new long-term monitoring program for the project, develop new data collection and management protocols, develop an overall work plan for Phase II project areas, and continue project implementation and outreach efforts.

All of the task agreement goals and objectives were met, and many were exceeded, during the implementation of this agreement. A user-friendly, complete, and well-designed was developed and is now in use on a weekly basis by GRCA's vegetation program staff. The database allows for entry and storage of all of the program's data and has thoughtfully constructed query and report functions. Field crews conducted two river trips and two backpacking trips during which they controlled 99,515 tamarisk trees, removing 14.53 acres of tamarisk cover from 925 gross infested acres. They also removed 49,196 individuals of other highly invasive plant species from the project areas. Volunteers donated 1780 hours to this project, for a matching contribution of $31,150 to this National Park Service project. The primary PI, Mike Kearsley, designed an effective and efficient long-term, integrated resource monitoring system, which is compatible with the methodology used for vegetation monitoring efforts within GRCA. Following preliminary data collection, Mike completed preliminary statistical analyses to refine the data exports and data collection methodology. For the public outreach component, project leaders produced and distributed one site bulletin, two educational brochures, one poster, and several articles. The PI and NPS key official gave one joint presentation on the results of this task agreement.

Often, the focus of projects is the on the ground work, which in this case was the number of tamarisk trees removed and acres cleared. As this project grew and expanded, the coordinator noted the increasing importance of data management and long-term monitoring components. The NPS Cooperative Conservation Initiative (CCI) funding that covered the costs of this Task Agreement allowed for the development of very solid monitoring, education and data management components. These further increase the long-term success of the project and provide important NPS matching funds to a primarily state funded project. The products and deliverables generated through this task agreement are invaluable to project management and success and will be made available to other NPS units and partners.

INTRODUCTION

This project supported the continuation and further development of Grand Canyon National Park's tamarisk (*Tamarix ramosissima* and *T. aphylla*) management project. The project focused on tamarisk control and vegetation monitoring at backcountry seeps, springs and tributaries outside of the main Colorado River corridor where tamarisk is dominant and has an extensive range. These non-corridor areas represent some of the nation's best examples of relatively intact desert riparian and wetland systems.

Tamarisk's threats to native ecosystems and natural processes are well known and documented in current scientific literature, and the recent encroachment of tamarisk into Grand Canyon National Park (GRCA) tributaries poses a significant threat to the integrity of the natural ecosystems and plant communities that the National Park Service (NPS) is committed to preserving. NPS Management Policies (2006) 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." 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. The removal of tamarisk from the park's tributaries provides this protection, ensures that park managers are meeting policy directives, and allows native plant communities to recover.

The park's tamarisk management program began in the fall of 2000 with the installation of a monitoring system in about 25% of the project areas. Park staff then prepared an Environmental Assessment / Assessment of Effect (EA/AEF) for the project. The tamarisk control work began in 2002 and when this project was initiated, crews had completed in 70 of the park's side canyons, tributaries, and river corridor springs, which combined are considered Phase I of the project. Crews had removed over 90,000 individual tamarisk trees from the park's inner canyon areas, and based on preliminary data analysis, the project was very successful.

The primary objective of this task agreement was to ensure a well-designed system of data collection and monitoring was in place prior to expansion and continuation of the large-scale management project. The key official for the NPS was Lori Makarick, GRCA Backcountry Vegetation Program Manager. The Principal Investigator (PI) for Northern Arizona University (NAU) was Mike Kearsley, Biologist, and the Co-PI was Thomas Sisk, Environmental Scientist. GRCA and NAU staff worked together to re-evaluate the control and monitoring methods used in Phase I project areas, develop a new long-term monitoring program for the project, develop new data collection and management protocols, develop an overall work plan for Phase II project areas, and continue project implementation and outreach efforts.

METHODS

This project created a partnership between the GRCA's vegetation management staff and NAU staff who have been working on terrestrial monitoring in the inner canyon (Mike Kearsley) and invasive plant management in the southwest (Thomas Sisk). The partnership opened lines of communication between local scientists and the enthusiastic and energetic community within NAU, helping to ensure continuation of this project into the future. The project also promoted stewardship and conservation through the expansion of a successful volunteer program and partnerships and the production of educational material. Tamarisk removal protects native plant communities, restores native habitats, and promotes public support of GRCA management actions. This project enhanced the Park's vegetation and GIS databases through the inventorying, mapping, and monitoring of native and exotic plant species. This project also formalized the link between the vegetation monitoring that is currently occurring in the main river corridor and the new monitoring efforts in the Park's tributaries and side canyons.

This project included work in the broad categories of data management, project monitoring, and public outreach, as specified in the task agreement. For report organization, the anticipated results at project initiation are listed under each of the broad categories, and the same format is used in the results section.

I. Data management and project implementation

A. **Database Design -** Design of more efficient and user-friendly data collection protocols and an associated database (integrated into ArcGIS), allowing project data to be readily shared with other agencies and organizations;
B. **Tamarisk Control** - Control of more than 15,000 individual tamarisk trees (tamarisk control on more than 500 acres); and,
C. **Volunteer Donation** - Donation of over 2,000 volunteer hours to this project.

II. Project monitoring

A. **Monitoring Design** - Design and preliminary implementation of a more effective and efficient long-term, integrated resource monitoring system that includes a minimum of vegetation transects, photopoints, GPS data collection, and associated database design;
B. **Monitoring Review** - Review of the new monitoring system design following initial data collection and analysis in October and November; and
C. **Final Monitoring Protocol Development** - Development of final integrated resource monitoring protocols and associated database for this large-scale project.

III. Public outreach

A. **Educational Material** - Preparation of education material including a site bulletin about the project and a summary in the form of a link on the park's website;
B. **Article** - Submittal of an article for publication in local and nationwide news media;
C. **Poster** - Creation of a poster for future presentations; and
D. **Presentations -** Presentation of preliminary project results and new protocols and procedures to GRCA and NAU staff.

RESULTS

Throughout the span of this task agreement, Mike Kearsley and Lori Makarick maintained consistent contact and developed a great working relationship, which is an under-appreciated outcome of CESU task agreements. Due to contracting delays at GRCA and challenges with the database component, the duo had to request several no cost extensions to the task agreement, which were always completed in a very timely manner by Nancy Skinner. Both contributors completed all of the assigned tasks in the statement of work included in the project Scope of Work (Appendix A). Despite time delays along the way, the overall results of this task agreement exceeded expectations.

I. Data management and project implementation

A. Database Design

This is the most important component of the overall project and has been invaluable to the project as a whole. The first draft of the database design was completed by Lawrence Walters, who spent several days with Lori Makarick discussing the various components and linkages. Lawrence developed the overall database and then went through nearly a dozen revisions and modifications. Lawrence also imported all of the project data that had been stored in MSExcel and MSWord formats, in addition to the data that was in a very basic MSAccess format.

The database is in MSAccess software and is constructed so that there are two primary files: the *grca.mdb* file contains the physical structure of the database and the user interface and the *grca data.mdb* file contains the data itself. As the *grca.mdb* file is opened, it automatically links to the data file. The database structure allows for several versions of the database to be in use at the same time or stored in different locations, and then each of the versions can be replicated with the master version. This set up has been extremely useful and has worked out well. The database contains dozens of tables and queries, which were thoughtfully designed to allow for easy linkage to Geographic Information System (GIS) software and produce reports in a wide variety of formats. The early efforts focused on the exotic control, monitoring and volunteer data components.

After Lawrence's first version of the database, Rachel Stanton was hired to make modifications to some of the components to assist with the export and analysis of the various monitoring components. This was extremely challenging due to the fact that the overall database structure is very complex, and Lawrence did not provide a detailed write-up regarding the structure and linkages. Overall, Rachel did a great job under pressure to make the necessary changes prior to the May 2005 report deadline. Nicole Tancreto also assisted with the database design, focusing on the report exports, which are really well-designed and truly facilitate the preparation of reports and the analysis of data. Refer to Appendix D for examples of reports produced by the database.

The database contains the following six major components: Exotics, Vegetation Monitoring, Vegetation Collection, Volunteers, Species Management and Photos. As the database is opened, the first switchboard allows the user to select the component they wish to work with (Figure 1). For each category, there are options for data entry and then a separate list for report production. The report features have revolutionized the manner in which annual reports are prepared. These features were created in consultation with Lori Makarick, who has been responsible for report production for the park's Vegetation Program for several years. Her wealth of experience with the various NPS databases allowed for the very careful construction of the report features. Refer to Appendix C for database report examples. An electronic copy of the database is included with this report; however, the photographs are not included as they increase the size of the database beyond the capacity of a compact disk. When reviewing the photograph component, errors stating that the file is unavailable will occur.

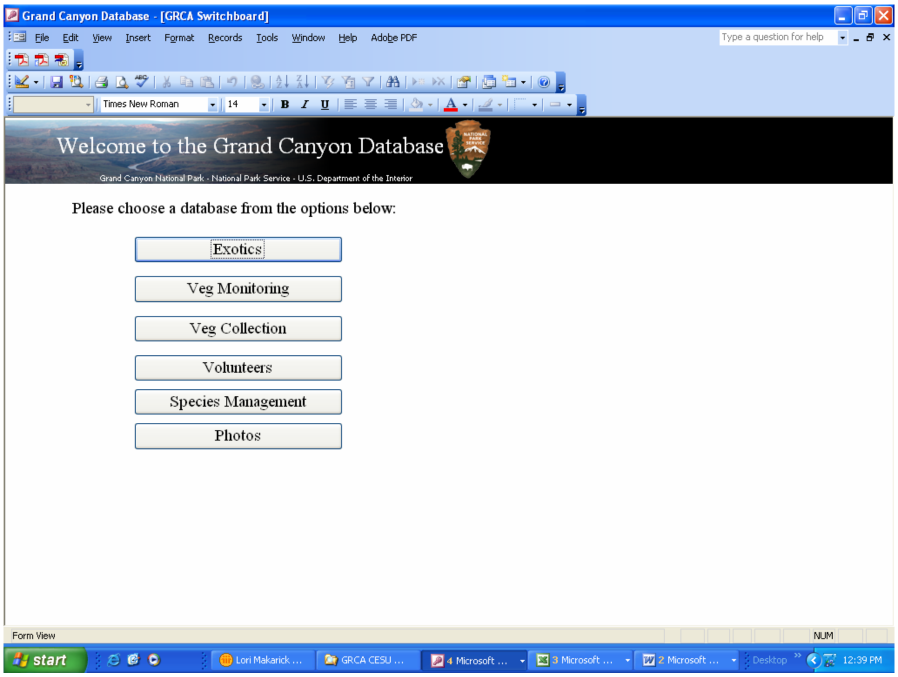

Figure 1. Database entry switchboard displaying the major components included in the overall database.

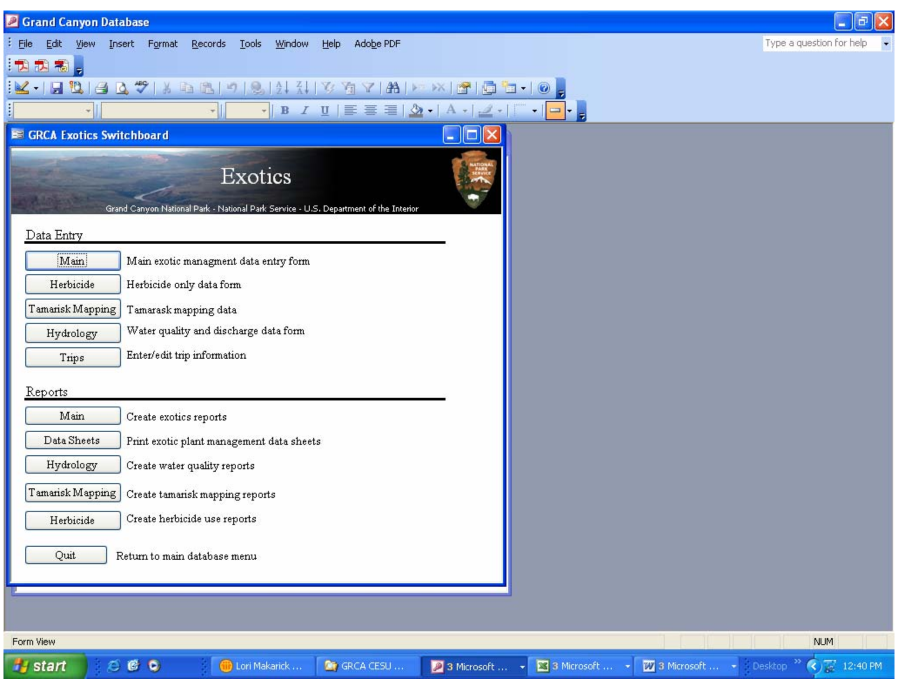

Figure 2. Exotics switchboard displaying the data entry and report components.

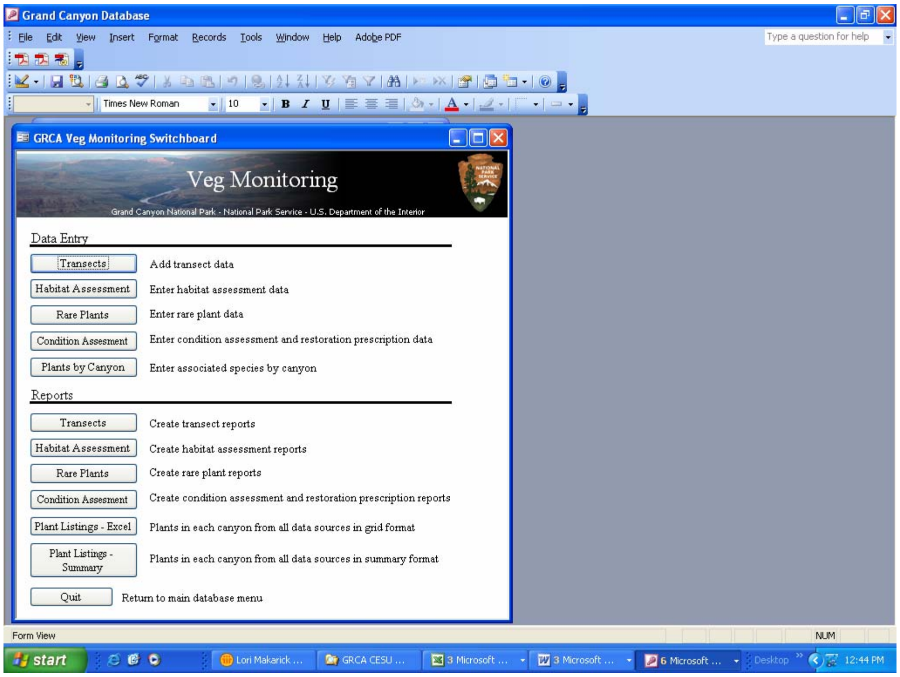

Figure 3. Vegetation Monitoring switchboard displaying the data entry and report components.

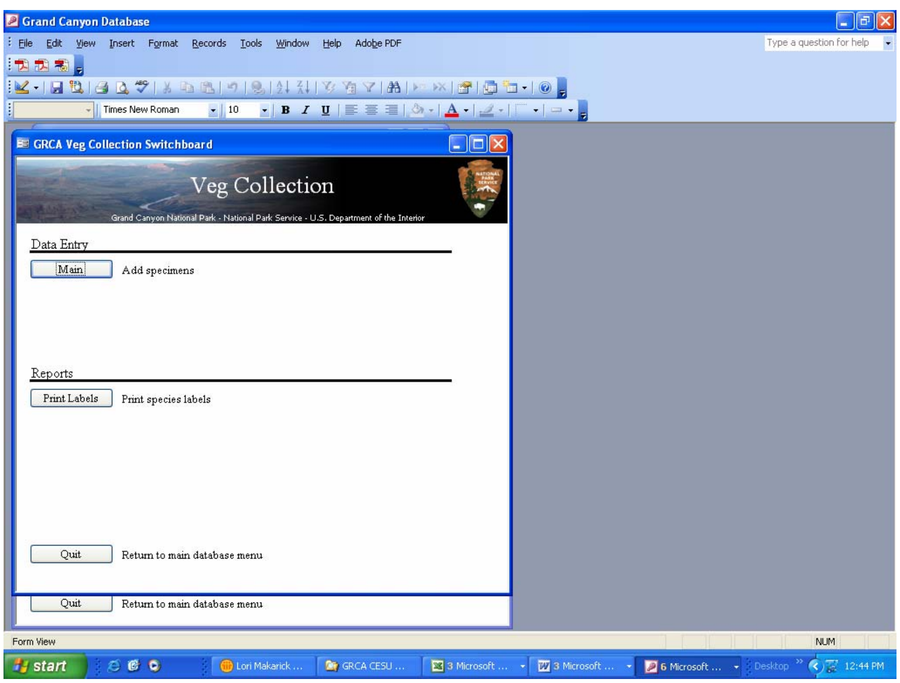

Figure 4. Vegetation Collection switchboard displaying the data entry and report components.

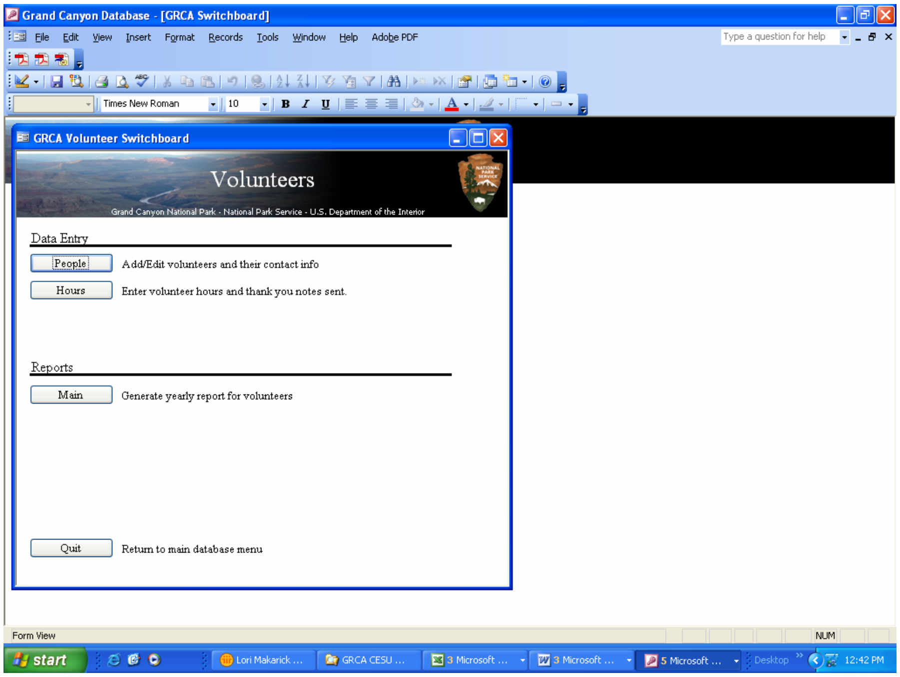

Figure 5. Volunteer switchboard displaying the data entry and report components.

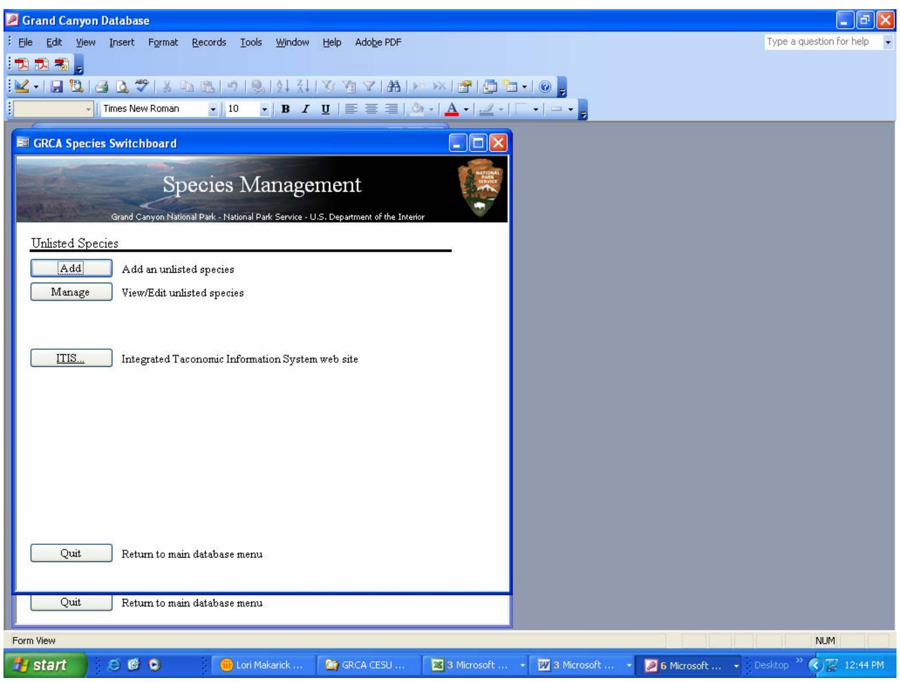

Figure 6. Species Management switchboard displaying the data entry and report components.

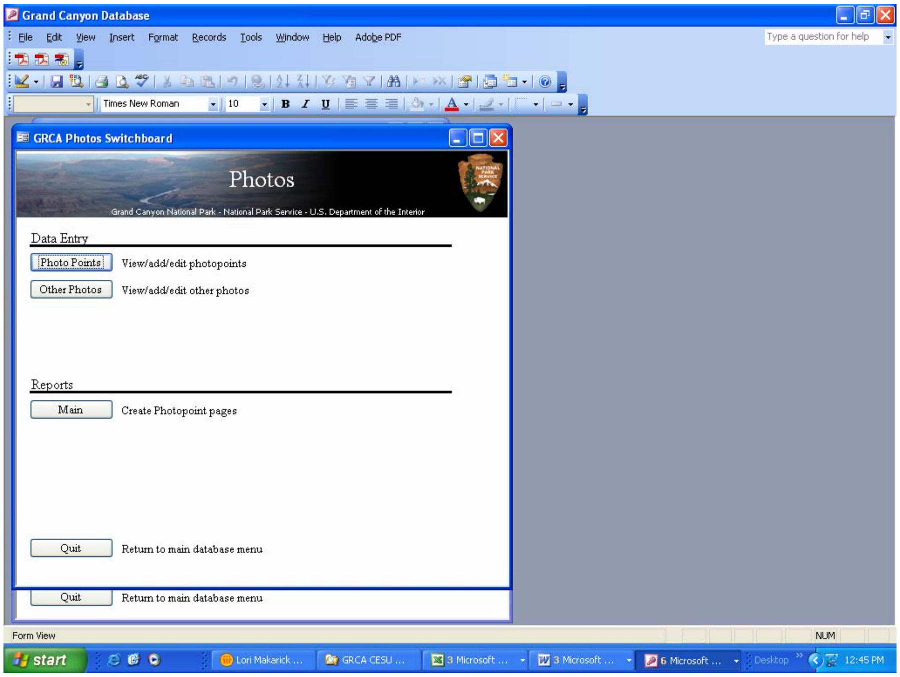

Figure 7. Photos switchboard displaying the data entry and report components.

A few of the database features truly stand out and have proven extremely useful for field work. The exotics report feature creates a field sheet that contains all of the site information for the specific site. Prior to returning to a side canyon or specific area of the park, the data manager can print these reports, and then the field crews merely need to record the control data and do not have to re-write all of the site specific information. The photo reports are perhaps the most useful component of the database. As the data manager enters the photopoint information in to the database, the database automatically names the photo. The file name includes the photopoint name, view number and date. The database creates a folder for each overall project area (i.e. canyon name) and then subfolders within that folder that correspond to the various type of photopoints places (i.e. exotics control, tamarisk mapping, rare plant monitoring, campsite rehabilitation). The report feature prints four photographs per page, including the UTM information, bearing, and descriptions, which are invaluable for photodocumentation. Prior to this, the storage of photographs was very problematic, as was preparation of the photographs for re-photography. Another time-saving feature of the database is that herbarium specimens are generated automatically.

The database design and development has focused on the areas of the overall Vegetation Program that are critical to this project. However, during the design, all of the various components of GRCA's Vegetation Program were included. Some of the components (e.g. species management, condition assessment and rare plant monitoring) remain under development and require additional funds to complete.

B. Tamarisk Control

During the fall of 2004 and the spring of 2005, crew leaders completed tamarisk management work in the park's remote backcountry areas. During this time period, crew leaders supervised two river trips and two backpacking trips.

The first river trip occurred from September 29 to October 16, 2004. Colorado River and Trails Expeditions (CRATE) based in Fredonia, Arizona outfitted the trip and assisted with the project work. The crew focused on tamarisk control and monitoring in project areas from Lees Ferry at Colorado River Mile (CRM) 0 to Phantom Ranch at CRM 88. On this trip, small crews installed vegetation transects along Nankoweap and Unkar Creeks, while the remainder of the trip participants removed tamarisk from those project areas.

The second river trip took place from February 17 to March 6, 2005. Diamond River Adventures based in Page, Arizona outfitted the trip through the Colorado River Fund (CRF) support. NPS Exotic Plant Management Team (EPMT) members from Lake Mead National Recreation Area served as additional crew members on the trip in addition to four volunteers. The crew focused on tamarisk control in project areas from Phantom Ranch at CRM 88 to Diamond Creek CRM 226.

Crews coordinated and supervised two backpacking trips to the Bright Angel Creek drainage. During these trips, the crews backpacked in and out on the South Kaibab trail and based out of the bunkhouse at Phantom Ranch. The trip leaders organized all of the meals and purchased the food prior to the trip. The trip leaders also recruited, oriented, trained and supervised the volunteers. Both trips were very successful, with all of the project participants expressing a desire to assist with the tamarisk removal work again in the future. On these trips, the crews also removed highly invasive data palm (*Phoenix dactylifera*) trees from the Phantom Ranch area.

The initial estimate of tamarisk removal that would be completed under this task agreement was greatly underestimated at 15,000 trees. With funding from this task agreement, crews removed 99,515 tamarisk trees, including 57,459 seedlings, 32,569 saplings and 9,487 mature trees (Table 1). In total, 14.53 acres of actual tamarisk canopy were removed from over 925 gross infested acres.

The two primary control methods used were pulling, which was used to remove 40% of the trees, and the cut stump method, which was used to remove just over 50% of the trees. Crews use the pulling method (i.e. manual removal) to remove tamarisk seedlings in washes, streambeds, and non-sensitive areas. Workers used geology picks and shovels to loosen the soil surrounding the plants and then removed the entire root system, or at least to below the root crown. Crews use the cut stump method on larger trees. With this method, workers cut the tree trunks near ground level with handsaws and then spray the cut surface with herbicide, which is transported through the tree's phloem into the roots. Crews used Garlon® 4 and Tahoe® 4E in a mixture of 25% with 75% methylated soybean oil (MOC) or JLB oil, or Pathfinder, a pre-mixed version of the same mixture. They used Garlon® 3a mixed with 50% water in treatment areas in close proximity to water. The herbicide application tool was a 32-ounce stainless steel sprayer, pressurized with bicycle pumps. These sprayers are virtually indestructible, easy to repair in the field, and are light and well suited for the backcountry conditions the Grand Canyon offers.

Pesticide certification is not required for the application of any of these herbicides; however, park vegetation staff adopted the policy of having trained and certified applicators on site during application. During these trips, the project leader and all field crew leaders had 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 and rules outlined in the safety plan for the project. Rubber gloves, long sleeve shirts, long pants, and eye protection were part of the PPE necessary for this project. All project participants reviewed the job hazard analyses (JHAs) for exotic plant removal and herbicide application.

Project participants 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 pack mules, 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. On backpacking trips, herbicide containers are carried only by crew leaders in heavy duty plastic dry bags which are strapped to the outside of backpacks.

In addition to tamarisk control, crews also removed 49,196 individuals of other highly invasive plant species during the implementation of this project (Table 2). The species included Sahara mustard (*Brassica tournefortii*), Russian olive (*Elaeagnus angustifolia*), horehound (*Marrubium vulgare*), date palm (*Phoenix dactylifera*), Himalaya blackberry (*Rubus discolor*), Ravenna grass (*Saccharum ravennae*), Russian thistle (*Salsola tragus*), sowthistles (*Sonchus* spp.), and woolly mullein (*Verbascum thapsus*). Some of these species were located within tamarisk project areas, while others were pro-actively removed from the Colorado River corridor to minimize the chance of spread into the park’s side canyons, seeps and springs. The vast majority (99.6%) of these plants were manually removed, with only Russian olive requiring herbicide treatment.

Table 1. Tamarisk Control Data

Canyon Name	Seedlings	Saplings	Mature	# Plants	Pulled	Combo	Girdle	Basal Bark	Cut Stump
Forster Canyon	0	0	2	2	0	0	0	0	2
102.5 Mile Wash	0	0	2	2	0	0	0	0	2
121.5 Mile Creek R	0	0	8	8	0	0	0	0	8
126 Mile Wash	0	0	2	2	0	0	0	0	2
128 Mile Creek	1184	225	252	1661	1070	0	0	40	551
133 Mile Creek	8	40	70	118	6	0	0	0	112
142 Mile Spring	0	0	8	8	0	0	0	0	8
148 Spring	0	3	38	41	6	1	0	6	28
152 Spring	76	34	26	136	84	0	24	0	28
1st Redbud Alcove	0	0	4	4	0	0	0	0	4
212.7 Mile Wash	0	1	0	1	0	0	0	0	1

Canyon Name	Seedlings	Saplings	Mature	# Plants	Pulled	Combo	Girdle	Basal Bark	Cut Stump
214 Mile Creek	2	64	20	86	6	0	0	0	80
36.5 Mile Wash	0	0	5	5	0	0	0	0	5
75 Mile Creek	0	20	4	24	14	0	0	0	10
85 Mile Spring	2	6	2	10	2	0	0	4	4
94 Mile Canyon	82	880	520	1482	150	0	0	0	1332
Basalt Canyon	8154	68	32	8254	8188	0	0	2	64
Bedrock Canyon	298	761	483	1542	182	0	0	0	1360
Bessie's Camp Creek	0	10	23	33	4	2	0	0	27
Bighorn Wash	0	38	28	66	0	0	0	0	66
Blacktail Canyon	246	172	14	432	252	0	0	6	174
Boucher Creek	3857	4208	529	8594	1981	0	0	1470	5143
Bright Angel Campground	193	608	210	1011	12	0	82	917	0
Bright Angel Creek	9675	7300	622	17597	5751	0	1	263	11582
Buckfarm Canyon	0	6	2	8	0	0	0	0	8
Carbon Creek	3	99	345	447	10	0	20	0	417
Clear Creek	7	8	7	22	12	3	0	0	7
Colorado River Corridor	448	27	64	539	428	0	0	0	111
Cove Canyon	11	3	3	17	11	0	0	0	6
Cove Canyon - Lower	12	20	4	36	12	0	0	0	24
Cove Canyon - Upper	18	2	10	30	18	0	0	0	12
Cranberry Canyon	0	42	14	56	0	0	0	0	56
Elves Chasm	459	36	63	558	459	0	0	0	99
Fern Glen Canyon	146	0	3	149	149	0	0	0	0
Forster Canyon	22	110	40	172	0	0	0	0	172
Fossil Canyon	14	20	14	48	12	0	0	0	36
Galloway Canyon	1308	949	791	3048	702	4	0	22	2320
Garden Creek	0	0	9	9	4	0	0	0	5
Garnet Canyon	2	92	43	137	7	0	0	0	130
Hakatai Canyon	16	108	58	182	16	0	0	0	166
Hermit Creek	3870	1456	574	5900	3740	0	0	0	2160
Hotauta Canyon	2	11	58	71	2	0	0	0	69
Kwagunt Creek	960	1608	770	3338	334	2	18	74	2910
Last Chance Spring	326	149	14	489	302	0	0	0	187
Lava Chuar Canyon	658	1798	956	3412	275	0	6	462	2669
Ledges Spring	127	120	40	287	121	0	0	0	166
Matkatamiba Canyon	1201	478	4	1683	1616	0	0	0	67
Monument Creek	14316	7588	567	22471	4921	0	0	6002	11548
Monument Spring	100	0	0	100	100	0	0	0	0
Nankoweap Creek	372	609	486	1467	165				1302
North Canyon	384	2	17	403	385	0	0	0	18
Pipe Creek	223	478	620	1321	214	0	0	41	1066
Rider Canyon	35	15	0	50	50	0	0	0	0
Ruby Canyon	0	1	30	31	0	0	0	0	31
Saddle Canyon	18	144	1	163	71	0	0	0	92

Canyon Name	Seedlings	Saplings	Mature	# Plants	Pulled	Combo	Girdle	Basal Bark	Cut Stump
Salt Creek	22	10	2	34	4	0	0	0	30
Serpentine Canyon	4	114	90	208	4	0	0	0	204
Slimey Tick Canyon	1933	188	16	2137	2045	0	0	0	92
Soap Creek	14	22	14	50	0	0	0	0	50
South Bass	0	4	0	4	4	0	0	0	0
Specter Chasm	638	74	68	780	640	0	0	0	140
Stairway Canyon	217	260	58	535	243	0	0	13	279
Stone Creek	2935	286	8	3229	2318	0	0	0	911
Tatahatso Beach	0	0	1	1	0	0	0	0	1
Tatahatso Wash	0	0	1	1	0	0	0	0	1
Trinity Canyon	3	15	7	25	3	0	0	0	22
Trinity Creek	3	15	7	25	3	0	0	0	22
Tuckup Canyon	1614	66	8	1688	1678	0	0	0	10
Tuna Creek	486	695	186	1367	62	10	0	28	1267
Unkar Creek	723	387	386	1496	466	1	0	2	1027
Upper Redbud	18	4	58	80	18	0	0	0	62
Vishnu Creek	14	12	66	92	12	0	0	0	80
TOTAL:	57459	32569	9487	99515	39344	23	151	9352	50645

Table 2. Other Invasive Plant Species Control Data

Canyon Name	Species Code	# Plants	Pulled	Combo	Girdle	Basal Bark	Cut Stump
Colorado River Corridor	BRATOU	629	629	0	0	0	0
Garden Creek	BRATOU	1	1	0	0	0	0
Lee's Ferry	BRATOU	37738	37738	0	0	0	0
Saddle Canyon	BRATOU	43	43	0	0	0	0
Colorado River Corridor	ELAANG	56	0	0	1	0	55
Lee's Ferry	ELAANG	19	0	0	0	0	19
Paria Beach	ELAANG	1	0	0	0	0	1
Paria River	ELAANG	113	0	0	0	0	113
Bright Angel trail	MARVUL	136	136	0	0	0	0
Garden Creek	MARVUL	938	938	0	0	0	0
South Kaibab Trail	MARVUL	240	240	0	0	0	0
Bright Angel Campground	PHODAC	2	2	0	0	0	0
Bright Angel Creek	PHODAC	1	1	0	0	0	0
Garden Creek	PHODAC	2	2	0	0	0	0
Garden Creek	RUBDIS	7157	7140	0	0	0	17
Colorado River Corridor	SACRAV	56	53	0	0	0	3
Lee's Ferry	SACRAV	1	1	0	0	0	0
Trinity Canyon	SALTRA	1	1	0	0	0	0
Colorado River Corridor	SONASP	10	10	0	0	0	0
Bright Angel Creek	VERTHA	4	4	0	0	0	0
Garden Creek	VERTHA	1998	1998	0	0	0	0
	TOTALS	**49146**	**48937**	**0**	**1**	**0**	**208**

C. Volunteer Donation

Volunteers are crucial to this project's success and accomplishments. Volunteers donated a total of 1,780 hours to the tamarisk and invasive species management portion of this project from the fall of 2004 through the spring of 2005 (Table 3), just under the initial estimate of 2,000 hours. These hours are valued at $17.50 per hour according to NPS guidelines, for a total matching contribution to the management portion of this project of $31,150. The passionate volunteers carried heavy packs for long distances, sawed tamarisk trees from dawn to dusk, clawed their way through barbed camelthorn and razor-like Ravenna grass leaves, and gathered site-specific data that enhances the overall knowledge about the park's most remote areas. For many people, the backpacking and river trip experiences are life-changing and many of the program's volunteers repeatedly return, each time with more passion for the work, the canyon, the park, and the NPS. This level of support translates directly into an enhanced visitor experience, increased awareness of NPS mission and goals, and augmented knowledge of natural resource management issues. When combined, amplified support for the NPS in general and an increased sense of stewardship for GRCA resources are major beneficial results of the project work.

Table 3. Volunteer Hours Contributed

First Name	Last Name	Start Date	End Date	Hours	Trip Category
Ashleigh	Furrow	11/10/2004	11/16/2004	70	Tamarisk Backpacking
CanEx Guides		3/28/2005	3/31/2005	30	Exotics River
Dave	Gentempo	11/10/2004	11/16/2004	65	Tamarisk Backpacking
Donaig	Gaiser	10/26/2004	11/16/2004	60	Tamarisk Backpacking
Eleanor	Curran	10/1/2004	10/10/2004	108	Tamarisk River
Ellen	Wyoming	2/21/2005	3/6/2005	140	Tamarisk River
Frank	Bruno	10/1/2004	10/4/2005	35	Tamarisk Backpacking
GC Hikers		10/20/2004	10/21/2004	82	IG Exotics
Gillian	Edward	2/21/2005	3/6/2005	140	Tamarisk River
Hernan	Abreu	2/16/2005	3/6/2005	30	Tamarisk River
Hillary	Hudson	11/10/2004	11/16/2004	60	Tamarisk Backpacking
Jim	Hasbargen	11/10/2004	11/16/2004	70	Tamarisk Backpacking
Joe	Welke	10/26/2004	10/29/2004	59	Tamarisk Backpacking
Joseph	Welke	10/26/2004	10/29/2004	50	Tamarisk Backpacking
Kari	Malen	2/17/2005	2/21/2005	30	Exotics River
Kari	Malen	2/17/2005	2/21/2005	20	Rare, Native and Exotic Inventory
Kari	Malen	2/17/2005	2/21/2005	10	Tamarisk River
Kassy	Theobold	2/17/2005	2/21/2005	20	Exotics River
Kassy	Theobold	2/17/2005	2/21/2005	20	Rare, Native and Exotic Inventory
Larry	Chaney	10/1/2004	10/10/2004	103	Tamarisk River
Loren	Bell	2/21/2005	3/6/2005	160	Tamarisk River
Maria	O'Sullivan	10/1/2004	10/16/2004	163	Tamarisk River
Melissa	Guy	2/21/2005	3/6/2005	140	Tamarisk River
Micheal	Wolcott	10/26/2004	10/29/2004	50	Tamarisk Backpacking
Samuel	Denham	2/17/2005	2/21/2005	5	Rare, Native and Exotic Inventory
Stephen	Gaiser	11/10/2004	11/16/2004	60	Tamarisk Backpacking

TOTAL HOURS:	1920

II. Project monitoring

A. Monitoring Design

The primary goal for this project component was to design an effective and efficient long-term, integrated resource monitoring system. At minimum, the system would contain vegetation transects, photopoints, and GPS data collection, all included in the database design development. Mike Kearsley met with Lori Makarick on several occasions to discuss the objectives of the tamarisk monitoring project and the various components of the overall design. The primary objective of the monitoring portion of the project is to monitor the success of the tamarisk removal through pre- and post-removal vegetation monitoring. The overall design should help to answer the following questions:

- How successful is removing tamarisk from seeps, springs and tributaries in reducing the colonization of tamarisk in these areas?
- How much and to what extent do native plant communities recover and benefit from this removal?
- Will wildlife and hydrological resources benefit from the removal of tamarisk?

A secondary goal was to ensure that the monitoring design for this project was compatible with that used for Colorado River Corridor vegetation monitoring plots. To accomplish both of these goals, Mike Kearsley completed a thorough review of the recent and historic vegetation plot designs used by the Grand Canyon Monitoring and Research Center (GCMRC). Mike selected plot size and methodology that were compatible with GCMRC plots. He also incorporated the Phase I transect methodology (i.e. point intercept) so that there would be compatibility with the 2000-2004 data. The initial design is included in the May 2005 Monitoring Report for Phase II-a of the AWPF project entitled "Management & Control of Tamarisk and Other Invasive Vegetation at Backcountry Seeps, Springs and Tributaries in Grand Canyon National Park (Makarick and Watters, 2005). The final, slightly altered, design is included in the May 2006 Monitoring Report (Makarick and Watters, 2006) for Phase II-b. The remainder of this section is excerpted and slightly modified from the May 2006 Monitoring Report.

The design includes paired 50m line transects running parallel to the drainage channel, with one placed approximately in the middle of a treatment area and a reference transect in a nearby area with similar substrate and aspect in which little or no tamarisk occurs. The overall goal is to have 1-3 transect pairs per selected project area. Crews record data at 0.5 m intervals along the transect, cover within 3m radius circles, and total vegetation volume measurements. Each transect is considered a sampling unit and will be compared to themselves as well as the untreated pair to detect change in vegetation cover. The transect datasheet is included as Appendix B along with the protocols for the field crews.

The point intercept method characterizes substrates and documents the major plant species present along the transect lines. Crews use a 0.75cm diameter, 2m tall rod to take a reading every 0.5m along the 50m transect, providing 100 points per line transect. They note the species identity of all live plants in contact with the pole and also characterize ground cover substrate in one of nine categories (Table 4).

Table 4. Ground Cover Substrate Categories

Category	Description
Bare soil	<0.1 mm (smaller than sand)
Sand	0.1 - 2mm
Gravel	2 mm – 6.4 cm
Cobble	6.4 cm – 19 cm
Stone	19 - 61 cm
Boulder	> 61cm
Bedrock	Solid rock surface, non-boulder
Litter (duff)	Dead plant material < 3cm diameter
Coarse woody debris	Dead wood 3-10 cm diameter
Woody debris structure	Woody material > 10 cm in depth and width

In future data analyses, we will sum the number of points recorded for each category (vegetation, substrate and debris) across all points and divide by 100 to calculate a percentage value for each type. The number of points covered by each species present will be converted to a percentage vegetative cover for all species present on the transect, allowing for determination of overall ground cover including vegetation.

In order to further describe the composition of plant species present along the transects, crews collect ground cover and vegetation cover data on all plant species present in a 3m radius circle at five points along the transect (5m, 15m, 25m, 35m, and 45 m). Field staff record vegetative cover for all species present in a cylinder from the ground surface to the sky, including the categories of moss, lichen, and microbiotic soil crust. To minimize observer biases and increase the speed of the surveys, crews record cover in seven broad cover classes (Table 5). Because points on the transect are not independent of each other, cover scale values will be converted to the mid-point of the class ranges and averaged before being analyzed so that there is only a single value for each species recorded on the transect.

Table 5. Cover Classes

Class	Cover Range
0	0%
1	<1%
2	1-5%
3	5-10%
4	10-25%
5	25% - 50%
6	50% - 75%
7	> 75%

In order to understand how the vegetation recorded in the cover data is distributed vertically at each point; crews record the three-dimensional structure, measured as total vegetation volume (TVV). At the center of each circle, a survey rod is held vertically and the number of 10cm segments in each meter above the ground with contacts with live vegetation was recorded. If a species occurs more than once in a given 10cm segment, it is only counted once. The TVV measure for a particular point is the count of all 10cm increments occupied over that point. The TVV measures at each point will be summed to generate a transect measure, since individual points on the same transect cannot be considered independent for statistical purposes.

Because tamarisk removal is likely to have effects on surface water hydrology, hydrological and soil sampling are also included in the design. The hydrology measurements include discharge, pH, air and water temperature, and salinity at or near transect locations. Soil measurements are taken at five points along the vegetation transects (5m, 15m, 25m, 35m, 45m) using a Hanna Instruments® probe to measure soil pH and electroconductivity (EC). At each point, a person mixes two parts de-ionized water with one part topsoil to make a slurry solution into which they submerge the probe three times and record each reading.

Photopoints are installed in association with each transect, exotic species control area, and hydrology point. At each photopoint location, the site leader records a compass bearing, UTM reading, camera height, site description, and photopoint description. Photographs are taken prior to tamarisk control, immediately following tamarisk removal, and then again during final project monitoring.

B. Monitoring Review

The best way to determine the effectiveness of protocols is to implement them in a limited number of project areas and then review the results and make any required revisions. The first test of the monitoring protocols was in October 2004 in two project areas: Nankoweap Creek and Unkar Creek. Suzanne Rhodes, who had experience reading GCMRC vegetation plots, was hired as the primary lead on that portion of the project. At each site, a variety of crew members rotated with Suzanne so that numerous people gained exposure to the methodology and were able to provide input to the project leaders. The crews installed three pairs of transects along Nankoweap Creek and two pairs along Unkar Creek.

C. Final Monitoring Protocol Development

During the October 2004 field work, the field crews took detailed notes about the protocols and the project forms. Lori Makarick and Mike Kearsley reviewed the suggestions and made revisions to the overall design to improve on the ease of the transect installation. They revised the data forms and wrote very straightforward instructions to the crews in an effort to improve the data collection process. The transect datasheet along with the protocols for the field crews are included in Appendix B.

Crews incorrectly recorded the TVV readings by counting the total number of times each species touched the pole within the 10cm section. During the May 2005 transect installation, crews took the incorrect readings in order to match the October 2004 transect methodology, and then also recorded the TVV measurements the proper way. This remedied the problem but required a revision to the database to accommodate the supplemental data.

The initial monitoring plan called for recording observational wildlife data in the project areas and taking pellet counts in standard 1/100-acre permanent circular plots at the beginning and end of each vegetation transect line. The plan was to remove the deer and bighorn pellet groups at the initial transect establishment, and then conduct pellet group counts in each subsequent monitoring period. The plan also called for the establishment of comparison plots on similar physiographic and vegetative features in nearby areas to provide an index to differential use of treated and untreated areas. The initial plan also called for having an avifauna point count location established adjacent to the transect line to determine species richness and relative abundance, paired with a point count location in a similar untreated area. The component was substantially revised after the first monitoring trip. Due to the vegetation density along many of the transects and their locations in or very near drainage channels, bighorn and deer pellets were not found. While these species do utilize these areas, the greater use appeared to be in the river corridor, and for bighorn, higher up on the slopes in the side canyons. The bird counts were removed from the design due to the logistical challenge they created and the lack of funds to fully account for the required wildlife crews. The installation and reading of the vegetation transects occurs throughout the day, but the bird counts would have to be completed between 5am and 10am. On a typical day, perhaps only one transect would be installed by the end of the avifauna sampling window, which just made this component not feasible. Rather than retaining these components, the project managers decided to only record observational data, including the date, the project area name, the species, and the activity.

Statistical Analyses

To further review the monitoring design, Mike Kearsley analyzed the suite of project data collected from 2005-2006, which is the most complete data set. The review helped to refine the monitoring components of the database, which will be very useful for future analyses Mike, Lori and the database designer developed the various queries required to export the transect data for analysis. The queries export the data into a MSExcel format, which is readily imported into various statistical packages.

To test for differences between control and tamarisk transects, and to look for changes between 2005 and 2006, data on total vegetative cover and species richness from the vegetation 2005 and 2006 cover surveys (3m radius plots) were analyzed with a split-plot analysis of variance analogous to a repeated measures design. Cover class data were converted to cover values by substituting the midpoint of the range for each cover class value (e.g., class 2 = 5 – 10% cover became 7.5% cover), and values for each species were averaged across all five sample points on the transect (5m, 15m, 25m, 35m, 45m). Species richness data were taken from the averaged cover data (i.e. species were not counted only once from all five sample points).

For the analysis, transects were nested within canyons and treated as a random effect. Canyon, year and transect type were fixed effects, and a transect type x year interaction term was added to the model. The latter term would test for differences in the behavior of control and tamarisk removal transects over time. Because the interaction term was statistically significant in the analysis of cover data ($F_{(1,17)} = 5.81$, $p < 0.05$), the trends in the two transect types were analyzed separately for the effects of the canyon and year terms in a similar design with only canyon, year, and transect nested within canyon as factors. The interaction term was not statistically significant in the analysis of plant species richness data, so only the overall analysis was performed.

Data from only the initial point intercept surveys (either 2005 or 2006) along each transect were analyzed with a 2-way analysis of variance to compare cover estimates from the two transect types as a check to ensure that both transect types had similar starting conditions. For each species encountered along the transect, the number of the 100 points at which it was detected was used as a percent cover along that transect. For each transect, the sum of the individual species cover estimates was used as the transect total cover estimate. These numbers were analyzed using canyon and transect type as factors. The number of contacts of tamarisk in each transect were analyzed in the same way as a check on the distinctness of the two transect types.

To compare the species composition of the two transect types, an analysis of similarity (ANOSIM; Clarke 1993) was performed on the point-intercept data. This method begins by converting the species-in-plots data to a list of all pairwise compositional dissimilarities between all transects, measured as the Bray-Curtis dissimilarity. The dissimilarities are ranked, smallest to largest, and the average of the within-group dissimilarities is subtracted from the average of the between-group dissimilarities. This number is normalized so that the test statistic, R, can vary between +1 (all between-group > all within group) and -1 (all within-group > all between group), although for all practical purposes, it varies from 0 to 1 and strong patterns show up as values above 0.15. The statistical significance of patterns are assessed by 1000 Monte Carlo simulations in which R is calculated from random assignments of samples to groups, and the likelihood of the result with real data is the proportion of these random runs with greater values of R than that calculated from field data.

To determine if control and tamarisk transects had similar vertical vegetation structure, data from the first Total Vegetation Volume (TVV; Mills et al 1991) surveys along transects were analyzed with a 2-way analysis of variance. Contacts by all species at all five points were summed within each transect to generate a single TVV measure per transect. These data were analyzed in an unbalanced 2-way ANOVA with canyon and transect type as factors. To assess whether TVV was distributed within the canopy in similar ways, we performed a second 2-way ANOVA on the proportion of all TVV hits which came from the first meter above the ground. Each transect's proportion of low TVV was arcsine-squareroot transformed before being analyzed.

To determine whether vegetation compositional differences between transects were affecting soil quality, the soil pH and electroconductivity (EC) data from tamarisk and control transects were compared with paired t-tests. The three pH values taken at each of the five sample points were averaged, and the five average values were averaged to give a mean pH reading for the transect. Transect types were averaged within canyons, producing nine paired observations of pH and nine paired observations of EC. Data on EC were log – transformed before the analysis due to the extreme skewness of the data.

To assess whether tamarisk and other vegetation were growing in soils of different depths, soil probe depth data from the canyons where it was taken were compared with a paired t-test. Data were averaged across all five points and these transect values were averaged within transect type for each canyon.

Statistical Results

The overall analysis of cover data from the 3m radius circular plots showed no difference between transect types (Table 6), but the interaction between transect type and year was significant (i.e. the two types behaved differently between 2005 and 2006). When the tamarisk transects were analyzed separately, canyons were significantly different from one another, and cover in 2006 was approximately 35% lower (66% vs. 33%) than in 2005 (Table 7, Figure 8). Cover in 3m radius plots in control transects did not change significantly between 2005 and 2006 (Table 8, Figure 8), and total cover did not differ between canyons. Species richness in the 3m radius plots did not differ by transect type or canyons, nor was there a statistically significant interaction between transect types and year, but there was a drop of approximately 8% between 2005 and 2006 (Table 9, Figure 9).

The point intercept data from the first surveys of the transects confirmed that control and tamarisk transects had equivalent amounts of cover at establishment (Table 10, Figure 10). Transect types did not differ statistically in the total number of contacts over the 100 points sampled (126 for tamarisk, 122 for control). Tamarisk represented approximately 30% of the contacts on the tamarisk transects (38 of 126). On control transects, they were replaced by mesquite (*Prosopis glandulosa*), jimmyweed (*Isocoma acradenia*), baccharis (*Baccharis* spp.), acacia (*Acacia greggii*) and saltbush (*Atriplex canescens*), depending on which part of the canyon you were in. The ANOSIM analysis confirmed this difference in species composition between transect types (ANOSIM $R = 0.676$, $p < 0.001$), and an examination of an ordination of the data (Figure 11) showed a consistent gradient of composition from upstream to downstream sites.

Total vegetation volume in the pre-treatment surveys did not differ between transect types (Table 11, Figure 12), indicating that the structure of the two types were similar as well. TVV did not differ canyons either (Table 11). The vertical distribution of foliage and branches did not differ between the two transect types either, based on the proportion of TVV hits below 1 meter (Table 12), although it was approximately 15% denser in the low segments of control transects (88% vs. 77%). Canyons did differ in terms of low vegetation structure (Table 12).

Control and tamarisk transects had very similar levels of soil pH, according to our paired comparison (Figure 6; $t_{(8)} = -0.331$, n.s.). Although a Levene test revealed that the control transects had more variable values for pH ($F_{(1,16)} = 5.27$, $p < 0.05$), the paired test was based on the control – tamarisk difference, which was normally distributed. The EC data analysis showed that the tamarisk transects had much higher levels of dissolved ions (Figure 14; $t_{(8)} = -3.12$, $p < 0.01$). EC values averaged 812 in tamarisk transects vs. 294 in control transects. Soil depths did not differ statistically between control and tamarisk transects ($t_{(3)} = -0.389$, n.s.).

In general, the statistical analyses showed that the methodology and plot sizes were adequate to answer the questions address in the monitoring plan. The big change in the circular plot data between 2005 and 2006 was the loss of tamarisk cover, which is obviously due to the tamarisk removal. But both transects lost cover in 2006, and the tamarisk transects lost more than the average drop in total cover (~35%). Most of the rest of the loss was from the lack of annual bromes on the transects in 2006, which was a very dry winter and spring.

Table 6. ANOVA table – 3m radius plots, cover, all transects

ANOVA table for analysis of all cover data from 3m radius plots. Because Transect are the error for the Canyon term, the effects are shrunk and not included in this table.				
Source	DF	SS	F	probability
Transect Type	1, 17	27.09	0.138	n.s.
Canyon	3, 4	3784	6.409	n.s.
Transect (Canyon)	4, 17	311	*	*
Year	1, 17	3131	15.909	$p < 0.001$
Transect Type x Year	1, 17	1144	5.814	$p < 0.025$

Table 7. ANOVA table – 3m radius plots, cover, tamarisk transects

ANOVA table for analysis of cover data from 3m radius plots in tamarisk transects. Because Transect are the error for the Canyon term, the effects are shrunk and not included in this table.				
Source	DF	SS	F	probability
Canyon	3, 4	4325	14.04	$p < 0.05$
Transect (Canyon)	4, 7	410	*	*
Year	1, 7	4702	24.65	$p < 0.05$

Table 8. ANOVA table – 3m radius plots, cover, control transects

ANOVA table for analysis of cover data from 3m radius plots in control transects. Because Transect are the error for the Canyon term, the effects are shrunk and not included in this table.				
Source	DF	SS	F	probability
Canyon	3, 6	503	0.89	n.s.
Transect (Canyon)	2, 5	410	*	*
Year	1, 5	4702	1.45	n.s.

Table 9. ANOVA table – 3m radius plots, species richness, all transects

ANOVA table for analysis of all richness data from 3m radius plots. Because Transect are the error for the Canyon term, the effects are shrunk and not included in this table.				
Source	DF	SS	F	probability
Transect Type	1, 17	3	0.450	n.s.
Canyon	3, 4	983	5.912	n.s.
Transect (Canyon)	4, 17	10	*	*
Year	1, 17	481	8.680	$p < 0.001$
Transect Type x Year	1, 17	0.10	0.002	n.s.

Table 10. ANOVA table – point intercept

ANOVA table for analysis of data from point-intercept surveys in all transects.				
Source	DF	SS	F	probability
Canyon	3, 9	7980	1.08	n.s.
Transect Type	1, 9	42.01	0.02	n.s.

Table 11. ANOVA table – total vegetation volume

ANOVA table for analysis of data from Total Vegetation Volume surveys in all transects.				
Source	DF	SS	F	probability
Canyon	3, 9	2379	1.24	n.s.
Transect Type	1, 9	161	0.25	n.s.

Table 12. ANOVA table – total vegetation volume below 1m

ANOVA table for analysis of data on proportion of TVV below 1m from the ground in all transects.				
Source	DF	SS	F	probability
Canyon	3, 9	0.393	6.97	$p < 0.05$
Transect Type	1, 9	0.034	1.82	n.s.

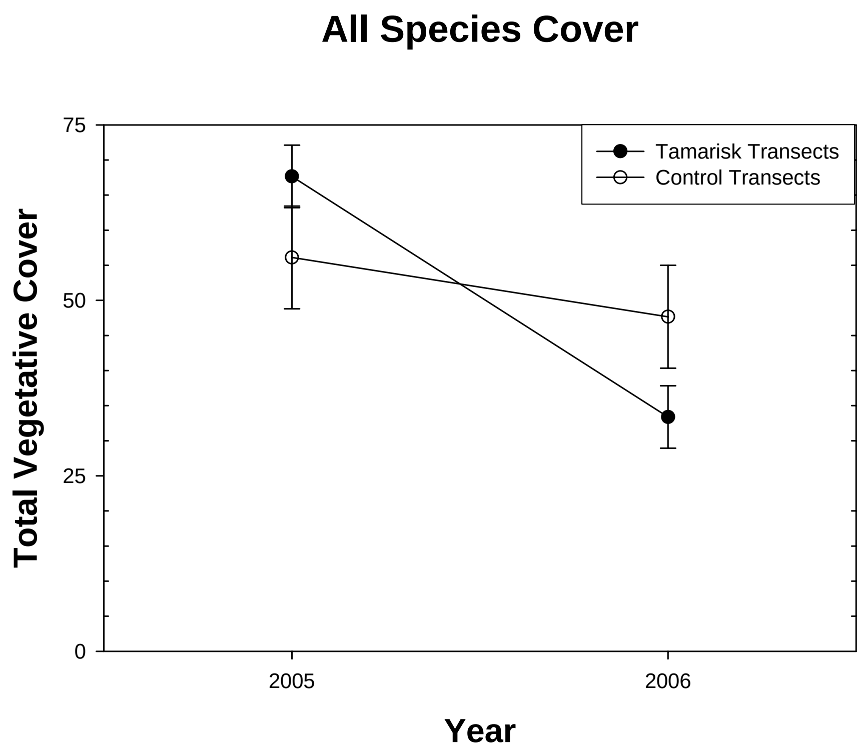

Figure 8. Cover data from 3m radius plots in control and tamarisk transects.

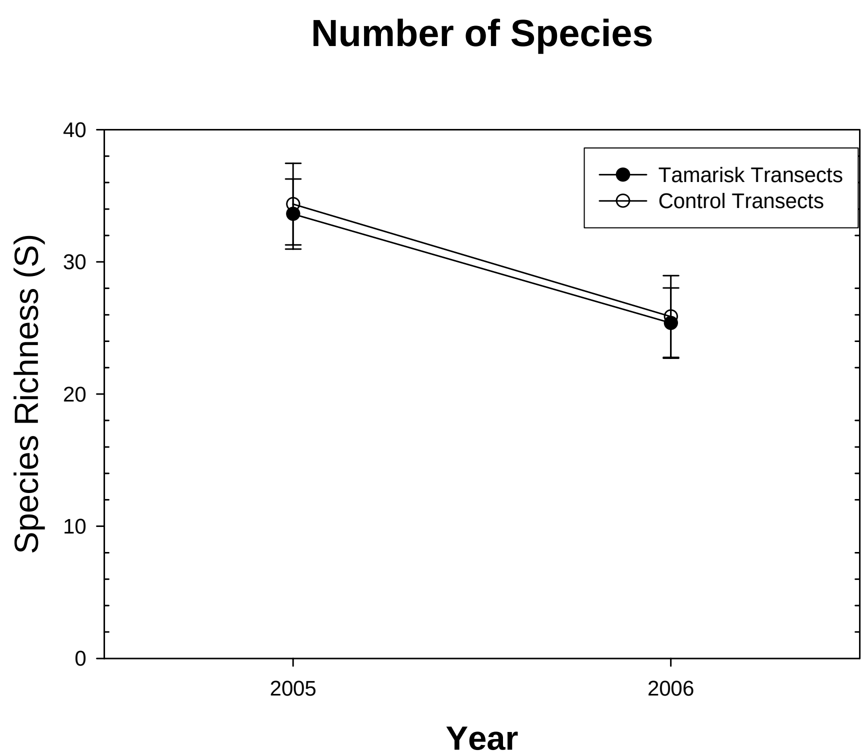

Figure 9. Species richness in the 3m radius plots in 2005 and 2006.

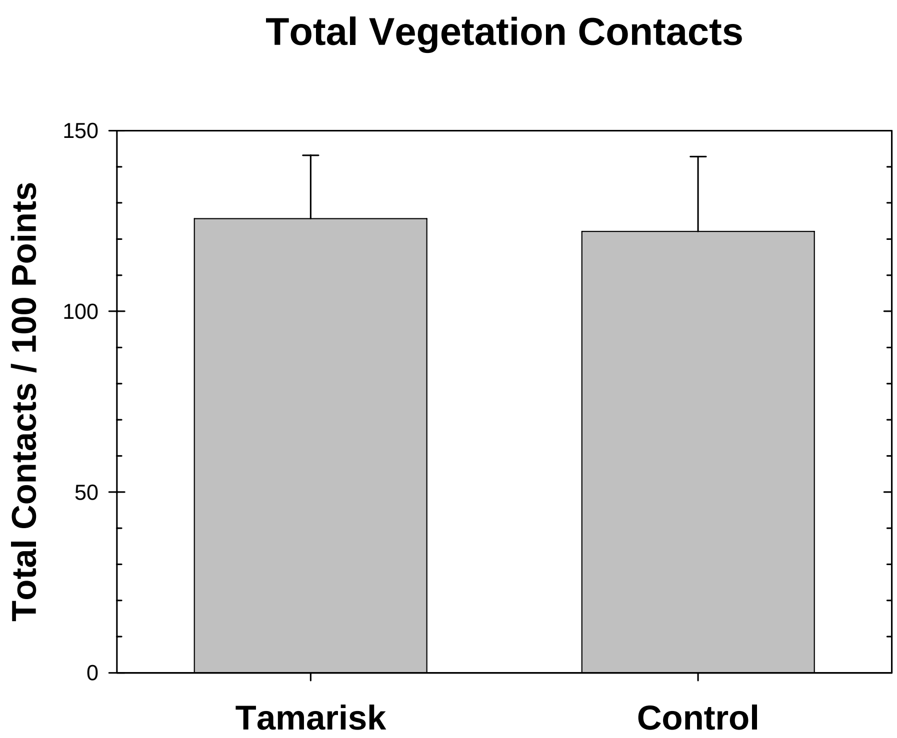

Figure 10. Total contacts per 100 points in the point-intercept data do not differ between control and tamarisk transects

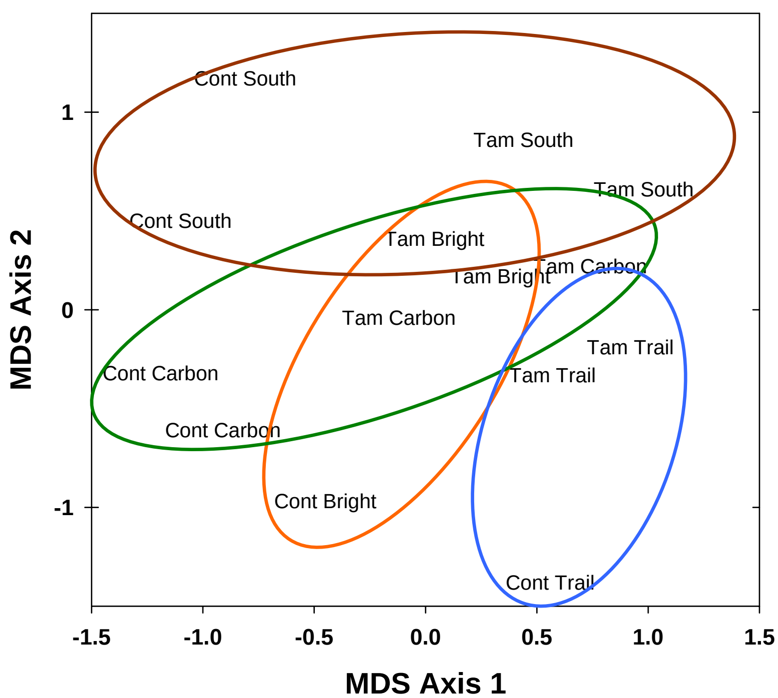

Figure 11. MDS ordination of compositional data from the point-intercept transects showing the distinctness of the two transect types (upper right = tamarisk, lower and left = control) and a gradient of composition from upper canyon to lower canyon (top to bottom).

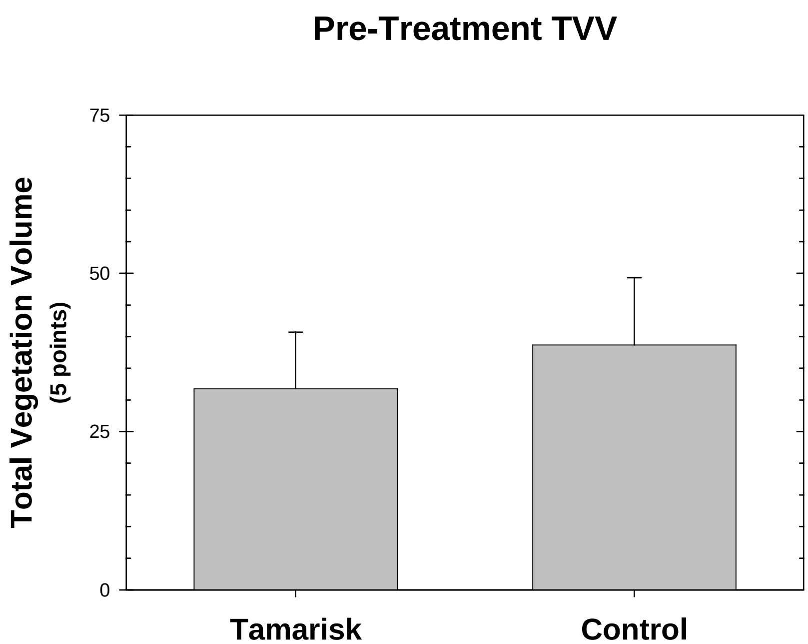

Figure 12. Total Vegetation Volume data from tamarisk and control transects showing no statistical difference between transects before treatment.

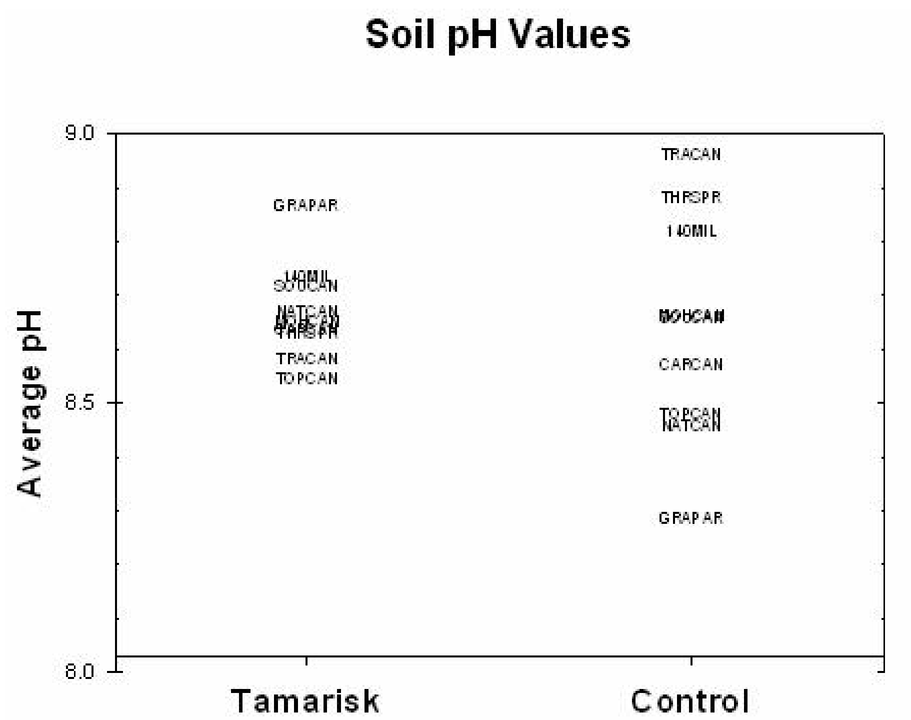

Figure 13. Soil pH values from tamarisk and control transects showing no statistical difference between them. Symbols are abbreviations for the canyon names.

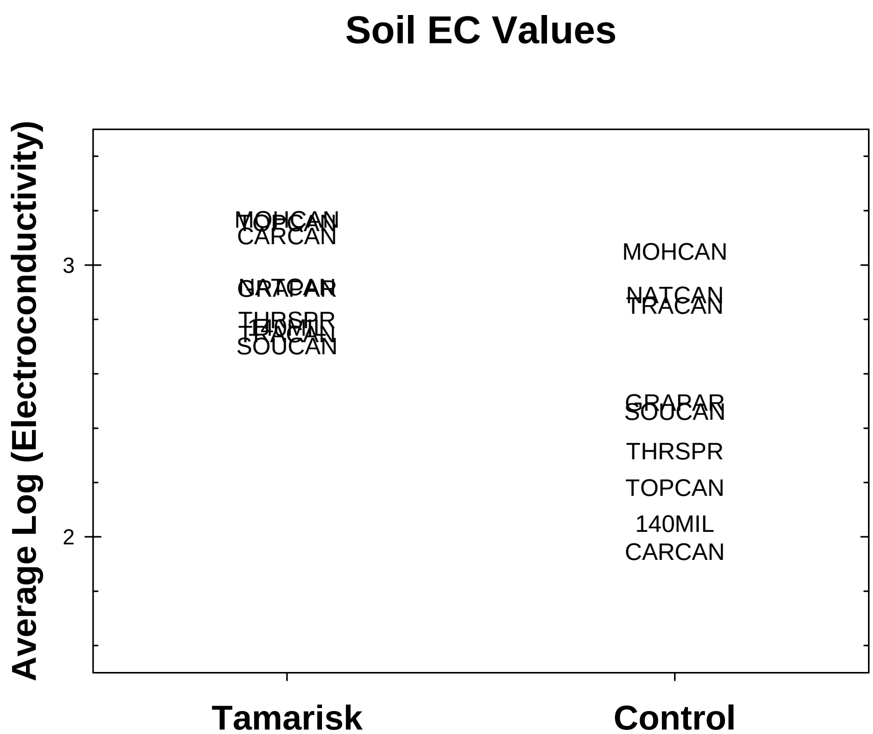

Figure 14. Soil EC, expressed as log10(EC), from tamarisk and control transects showing much higher levels of ions in the tamarisk transects soil.

III. Public outreach

A. Educational Material

Dr. Tom Sisk assisted with the recruitment of an NAU student for this portion of the project review. Pamela Edwards was selected for the position. Pam has a great background in environmental studies and quite a bit of interpretive experience, including previous work at GRCA. She did an excellent job with the production of the educational material. Pam completed the following tasks:

- Reviewed and edited GRCA site bulletin
- Researched the highest priority plant species and prepared text for the brochure entitled “Fight the Invasion!”
- Researched the highest priority plant species and prepared text for the educational pamphlet entitled “Invasive Plant Species Observation”

These materials are valuable teaching tools and are a wonderful method of getting information to the general public. The Arizona Water Protection Fund (AWPF), Grand Canyon National Park Foundation (GCNPF), and GRCA paid for the design and printing of the educational materials. Scanned copies of these bulletins are included in Appendix E and hard copies are also provided with the final report.

B. Articles

Over the course of this task agreement, GRCA and GCNPF issued several press releases, with a focus on generating and maintaining support for the project. In addition, several articles have appeared in local and national media. A few examples are included in Appendix F and more examples are available upon request.

C. Poster

Kate Watters, the primary field coordinator for this project created a poster that can be used for future presentations. The poster is currently being used to provide project information to the general public and is available for viewing at the park's backcountry office. The poster will be continually revised to include the most up-to-date project information. The poster can be readily edited and altered to serve as a more detailed poster for scientific conferences and more formal presentation. A copy of the poster is included as Appendix F.

D. Presentations

Lori Makarick has given numerous presentations about this project to GRCA staff, other agencies and organizations, a wide variety of non-profit groups, and the general public. Mike Kearsley and Lori Makarick gave a joint presentation on September 19, 2006 entitled "Tamarisk Control and Monitoring at Backcountry Seeps, Springs and Streams" at the Colorado Plateau Natural Resource Management Meeting. In addition to a variety of staff from Colorado Plateau parks, meeting participants included Mike Soukup, NPS Associate Director for Natural Resource Stewardship and Science, and Bob Moon, IMR Associate Regional Director. A handout version of the presentation is included as Appendix G.

DISCUSSION

Grand Canyon National Park's Tamarisk Management and Tributary Restoration Project was initiated in 2000 with funding from AWPF, administered in partnership with the Grand Canyon Wildlands Councils (GCWC). The results from the first few years of the tamarisk project helped to refine the control methods and monitoring protocols for this project. The NPS has an affirmative responsibility to protect and preserve the resources located within its units and 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 2006). This project continued to verify that the control of tamarisk and other invasive plant species in the park's side canyons and tributaries is feasible and should be undertaken.

Often, the focus of projects is the on the ground work, which in this case was the number of tamarisk trees removed and acres cleared. As with many projects, there was very little funding for data management and long-term monitoring. As this project grew and expanded, the coordinator noted the increasing importance of these components and sought supplemental funding. The NPS Cooperative Conservation Initiative (CCI) funding that covered the costs of this Task Agreement allowed for the development of very solid monitoring, education and data management components. These further increase the long-term success of the project and provide important NPS matching funds to a primarily state funded project. The products and deliverables generated through this task agreement are invaluable to project management and success and will be made available to other NPS units and partners. The partnerships developed between GRCA, NAU, GCNPF, and AWPF during this project have been integral to the success of the project.

LITERATURE CITED

Clarke, KR. 1993. Non-parametric multivariate analyses of changes in community structure. Aust. J. Ecol. 18, 117-143.

Makarick, LJ and K Watters. 2005. May 2006 Monitoring Report for: Management & Control of Tamarisk and Other Invasive Vegetation at Backcountry Seeps, Springs and Tributaries in Grand Canyon National Park (First Year of Phase II of Comprehensive Project). Unpublished report for Arizona Water Protection Fund, Contract Number 05-131WPF. 14 pages plus appendices.

Makarick, LJ and K Watters. 2006. May 2006 Monitoring Report for: Management & Control of Tamarisk and Other Invasive Vegetation at Backcountry Seeps, Springs and Tributaries in Grand Canyon National Park (First Year of Phase II of Comprehensive Project). Unpublished report for Arizona Water Protection Fund, Contract Number 06-138WPF. 14 pages plus appendices

Mills, GS, Dunning, JB, and Bates, JM. 1991. The relationship between breeding bird density and vegetation volume. Wilson Bull. 103(3), 468-479.

National Park Service. 2006. National Park Service Management Policies. Washington, DC: U.S. Department of the Interior.

ACKNOWLEDGEMENTS

The National Park Service's Cooperative Conservation Initiative provided generous support for this project in an effort to promote stewardship and protect resources. Nancy Skinner with the Colorado Plateau CESU provided guidance with the development of the initial task agreement and continual support throughout the term of the agreement. Tom Sisk facilitated the educational component. Sally Evans served as the NAU budget lead. The Arizona Water Protection Fund (AWPF) provided long-term matching support for this work, and Reuben Téran, AWPF Project Manager, provided consistent positive support for the vast majority of the Tamarisk Management and Tributary Restoration Project. Deborah Tuck, Bob Newtson, Jackie Clark, and Terra Crampton (all with GCNPF) contributed to the success of this work through their preparation and administration of APWF grants. Kate Watters held all the pieces together as the field crew coordinator for GRCA's Backcountry Vegetation Program. Kim Fawcett served as the critical link as she managed all of the program data. We also gratefully acknowledge the work of the following staff who were directly involved with the implementation of this task agreement: Loren Bell, Maggie Drechsler, Pamela Edwards, Alicyn Gitlin, Kari Malen,

Suzanna Rhodes, Rachel Stanton, Nicole Tancreto, Steve Till, and Lawrence Walters. We continue to be amazed with and thankful for the commitment and dedication of the project volunteers.

APPENDIX A – Task Agreement

Cooperative Ecosystem Studies Unit **Cooperative Agreement Modification**		
FUNDING AGENCY: **National Park Service**		
MODIFICATION NO.: **[CESU info only]**	COOPERATIVE AGREEMENT NO.: **H1200040002**	FUNDING AMOUNT: $ **35,000**
INVESTIGATORS' Contact Information: Primary PI Mike Kearsley, Department of Biological Sciences, NAU (928)523-5005 / Co-PI Thomas Sisk, Associate Professor, Environmental Sciences, NAU, (928) 523-7423 / Lori Makarick, Inner Canyon Vegetation Program Manager, GRCA (928)226-0165		
PROJECT TITLE: **Control Tamarisk and Monitor Vegetation at Backcountry Seeps, Springs and Tributaries in Grand Canyon National Park**		
EFFECTIVE DATES**: Start Date August 29, 2004 / End Date March 31, 2005**		
PROJECT ABSTRACT: This project will support the continuation and further development of Grand Canyon National Park (GRCA)'s tamarisk (*Tamarix ramosissima* and *T. aphylla*) management project, which focuses on tamarisk control and vegetation monitoring at inner canyon seeps, springs and tributaries, considered some of the nation's best examples of relatively intact desert riparian and wetland systems. This specific project will begin to move the Park's tamarisk management program into Phase II, which includes over 100 new project areas and the routine monitoring and treatment of the remaining tamarisk trees in Phase I project areas. Tamarisk's threats to native ecosystems and natural processes are well known and documented, and the management of this species outside of the Colorado River corridor (where it is a dominant species with extensive range) is the focus of this park wide program and a vegetation management priority. Prior to continuation of this large scale project, Park biologists and Northern Arizona University staff will re-evaluate the control and monitoring methods used in Phase I (based on the report completed by GRCA's Inner Canyon Vegetation Program Manager), develop a new long-term monitoring program for the project, develop new data collection and management protocols, develop an overall work plan for Phase II project areas, and begin project implementation.		

Agency Representative:	**Agency Administration Representative**	**Investigator:**	**Partner Admin. Contact:**
Ron Hiebert, NPS Research Coordinator CPCESU Northern Arizona University P.O. Box 5765 Flagstaff, AZ 86011-5765 Tel: (928) 523-0877 Fax: (928) 520-8223 Ron.Hiebert@nau.edu	Lynell Wright Budget Analyst Intermountain Region – Budget & Finance P.O. Box 25287 12795 W. Alameda Parkway Denver, CO 80225-0287 Tel: (303) 969-2654 Fax: (303) 969-2794 Lynell_Wright@nps.gov	Mike Kearsley Department of Biological Sciences Northern Arizona University, Box 5640 Flagstaff, AZ 86011-5640 Tel: (928)523-5005 Mike.Kearsley@nau.edu	Wilma Ennenga, Director Office of Grant and Contract Services Northern Arizona University P.O. Box 4130 Flagstaff, AZ 86011-4130 Tel: (928) 523-8319 Fax: (928) 523-1075 winnie.ennenga@nau.edu

List of Key Words: Protocols / Reference Materials, Surveys / Inventory and Monitoring, Exotic Vegetation, Riparian Habitats, Revegetation / Restoration (herbicide control, fertilizer)

Key Official from National Park - Include contact information @ Specific Park or NPS Office:
Lori J. Makarick
Inner Canyon Vegetation Program Manager
Grand Canyon National Park
823 N. San Francisco Street, Suite B
Flagstaff, AZ 86001
(928)226-0165

SCOPE OF WORK
Requisition Number: R8213040071

Project Title: Control Tamarisk and Monitor Vegetation at Backcountry Seeps, Springs and Tributaries in Grand Canyon National Park

This agreement by and between the National Park Service (NPS) and Northern Arizona University (NAU) is issued against the Colorado Plateau Cooperative Ecosystem Studies Unit (CPCESU) Cooperative Agreement Number H1200040002, for the purpose of mutual assistance in conducting a project entitled "Control Tamarisk and Monitor Vegetation at Backcountry Seeps, Springs, and Tributaries in Grand Canyon National Park."

BACKGROUND AND OBJECTIVES
This project will support the continuation and further development of Grand Canyon National Park (GRCA)'s tamarisk (*Tamarix ramosissima* and *T. aphylla*) management project. The project focuses on tamarisk control and vegetation monitoring at inner canyon seeps, springs and tributaries, areas outside the main Colorado River corridor (where it is a dominant species with extensive range). These areas are considered some of the nation's best examples of relatively intact desert riparian and wetland systems.

Tamarisk's threats to native ecosystems and natural processes are well known and documented in current scientific literature, and the recent encroachment of tamarisk into GRCA tributaries poses a significant threat to the integrity of the natural ecosystems and plant communities that the NPS is committed to preserving. NPS management policies (2001) 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". 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. The removal of tamarisk from the park's tributaries will provide this protection, ensure that park managers are meeting policy directives, and allow native plant communities to recover.

The park's management program began in the fall of 2000 with the installation of a monitoring system in about 25% of the project areas. Park staff then prepared an Environmental Assessment / Assessment of Effect (EA/AEF) for the project. The tamarisk control work began in 2002 and to date crews have completed work in 70 of the park's side canyons, tributaries, and river corridor springs. Crews have removed over 90,000 individual tamarisk trees from the park's inner canyon areas, and based on preliminary data analysis, the project has been very successful. Prior to continuation of this large-scale management project, park staff members want to ensure that well-designed data collection and monitoring protocols are in place.

GRCA biologists and Northern Arizona University (NAU) staff will re-evaluate the control and monitoring methods used in Phase I project areas, develop a new long-term monitoring program for the project, develop new data collection and management protocols, develop an overall work plan for Phase II project areas, and continue project implementation and outreach efforts. Public and non-profit organization support for project implementation has been high; outreach and education, which are significant components of the project and have been since the initial planning stages, will continue as the project moves into the next stage.

We anticipate the following results from this partnership:

D. Design of more efficient and user-friendly data collection protocols and an associated database (integrated into ARCGIS), allowing project data to be readily shared with other agencies and organizations;

E. Design and preliminary implementation of a more effective and efficient long-term, integrated resource monitoring system that includes a minimum of vegetation transects, photopoints, GPS data collection, and associated database design;

F. Review of the new monitoring system design following initial data collection and analysis in October and November;
G. Development of final integrated resource monitoring protocols and associated database for this large-scale project;
H. Preparation of education material including a site bulletin about the project and a summary in the form of a link on the park's website;
I. Submittal of an article for publication in local and nationwide news media;
J. Creation of a poster for future presentations;
K. Presentation of preliminary project results and new protocols and procedures to GRCA and NAU staff;
L. Control of more than 15,000 individual tamarisk trees (tamarisk control on more than 500 acres); and
M. Donation of over 2,000 volunteer hours to this project.

This project will create a partnership between the park's vegetation management staff and NAU staff who have been working on terrestrial monitoring in the inner canyon (Mike Kearsley) and invasive plant management in the southwest (Thomas Sisk). The partnership will create open lines of communication between local scientists and the enthusiastic and energetic community within NAU, helping to ensure continuation of this project into the future. The project will also promote stewardship and conservation through the expansion of a successful volunteer program and partnerships, and the production of educational material. Tamarisk removal will protect native plant communities, restore native habitats, and ensure that a publicly supported 3 year program is continued. This project will enhance the Park's vegetation and GIS databases through the inventorying, mapping, and monitoring of native and exotic plant species. This project will also begin to formalize a link between the vegetation monitoring that is currently occurring in the main river corridor and the new monitoring efforts in the Park's tributaries and side canyons.

STATEMENT OF WORK

The NPS will:

A. Provide three copies of the required permits for this project including the Grand Canyon National Park (GRCA)-approved administrative permits for river and backpacking trips, and the already approved research permit which will remain under Lori Makarick's name in the Investigator's Annual Report (IAR) database. Ms. Makarick will be responsible for inputting project data into the IAR system.

B. Provide three copies of the already approved and signed compliance documents for this project including the Environmental Assessment / Assessment of Effect (EA/AEF) and the Finding of No Significant Impact (FONSI).

C. Provide three copies the pre-approved river trip itineraries for the two fall 2004 river trips.

D. Provide three copies of the monitoring and management data and the reports for Phase I of the tamarisk management project.

E. Provide one overall project coordinator and key official to serve as the liaison for the duration of this project. At this time, the official is Lori J. Makarick, the park's Inner Canyon Vegetation Program Manager. Ms. Makarick will be responsible for selecting an alternate person and providing that person' contact name and information to the CESU Coordinator and the Principal and Co-Investigators should she be unable to assume the duties and responsibilities.

F. Provide workman's compensation coverage for all project volunteers through the Volunteer in Park's program, and will ensure that all proper volunteer paperwork is signed and in the proper files prior to implementing any fieldwork. NAU staff will assist with the recruitment process, but the park will retain the right to make final volunteer selections.

G. Furnish all of the necessary tools, supplies, and equipment to complete the tamarisk management and project monitoring field work.

H. Schedule and provide initial project orientation and training to all NAU staff involved in the project.

I. Prepare a park-approved safety plan and job hazard analyses for all project related work.

J. Through a separate contract, provide the boats, licensed river guides, and all food for two 18-day fall 2004 river trips.

K. With the NAU staff, co-write and submit a minimum of one article for publication in local and nationwide news media.

L. Schedule a presentation about the project for GRCA upper-level management staff.

M. Provide position recruitment information to NAU investigators.

NAU will:

A. In cooperation with the NPS key official, design of a more efficient and user-friendly data collection protocols and associated database (integrated into ARCGIS), allowing project data to be readily shared with other agencies and organizations.

B. In cooperation with the NPS key official, design a more effective and efficient long-term, integrated resource monitoring system that includes a minimum of vegetation transects, photopoints, GPS data collection, and associated database design.

C. Review the new monitoring system design following initial data collection and analysis in October and November and develop final integrated resource monitoring protocols and associated databases for this large-scale project.

D. Prepare education material including a site bulletin about the project and a project summary in the form of a link on the park's website.

E. With the NPS key official, co-write and submit a minimum of one article for publication in local and nationwide news media.

F. Create a poster for future presentations.

G. Present preliminary project results and new protocols and procedures to GRCA and NAU staff.

H. Provide one person to serve as the field lead for the project monitoring efforts.

I. Provide one person in October and two in November to serve as the field leaders for the tamarisk control efforts on the river; these people must have or acquire Arizona pesticide applicator's licenses.

J. Provide one person to serve as the field lead for the tamarisk control efforts through backpacking trips; this person must have or acquire Arizona pesticide applicator's license.

K. Provide one person to serve as the database design and data manager for this project.

L. Provide the food and camping equipment for backpacking trips.

M. Provide GIS control and monitoring layers and a final project map to NPS key official upon completion of this project.

STATEMENT OF NPS SUBSTANTIAL INVOLVEMENT

There has been substantial NPS involvement in the preparation for this partnership. To date, the NPS has completed the necessary compliance, obtained the river and research permits, designed standardized volunteer recruitment protocols, and prepared the safety plan and job hazard analyses. In addition, NPS managers have already completed the majority of the logistics for the two fall 2004 river trip, including the approved trip itineraries. The NPS has taken the lead on ensuring that this partnership includes the foremost experts at NAU, and the key official, Ms. Lori Makarick, will continue to have an active role in the implementation of this project. This partnership will create a new network of experts and support for this project, and will also ensure that the most up-to-date scientific input is included into park management plans.

TERM OF AGREEMENT

This Task Agreement is effective on August 29, 2004 and will extend through March 31, 2005.

KEY OFFICIALS

A. For the NPS

Lori J. Makarick
Inner Canyon Vegetation Program Manager
Grand Canyon National Park Science Center
823 N. San Francisco Street, Suite B
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(928)226-0165
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B. For NAU

Principal Investigator:
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Thomas Sisk
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Thomas.Sisk@nau.edu

AWARD OR PAYMENT

NPS will provide funding to NAU in an amount not to exceed $35,000. The chargeable appropriations for this Task Agreement are:

8213-0494-SCH	$35,000

PRODUCTS, DELIVERABLES AND SCHEDULE

The earliest this project will be initiated is August 29, 2004. The latest that this project will be initiated is September 20, 2004.

The data and reports from Phase I and all of the associated permits will be transferred from the NPS key official to NAU investigators by August 29, 2004.

The preliminary monitoring design will be due on September 23, 2004.

The data collection protocols and associated database will be due on September 23, 2004.

A short progress report on the field control efforts will be due on December 15, 2004. A copy of all field notes and labeled digital photographs will also be due on this date.

The final integrated resource monitoring protocols, control and monitoring databases, project map, and data summaries will be due on January 30, 2005. The NPS key official will be responsible for entering project data into the IAR system.

The education material, project poster, and draft article will be due on January 30, 2005.

The draft final report for this project will be due on February 20, 2005.

The final report will be due on March 20, 2005.

This project will be complete and all funds expended by March 31, 2005.

The Principal Investigator will prepare a brief report abstract suitable for public distribution, along with four hard copies and an electronic version (in PDF file format) of the final report with two copies mailed to the NPS Research Coordinator, CPCESU, NAU, P.O. Box 5765, Flagstaff, AZ 86011-5765 and two copies mailed to the NPS Key Official, Ms. Lori Makarick, 823 N. San Francisco St., Suite B., Flagstaff, AZ 86023.

BUDGET
The NPS and NAU will not provide office space, computers, or computer software for the NAU hired employees working on this project.
Refer to draft budget in separate MSExcel File entitled CESU GRCANAU Tamarisk Budget.

FINAL NO COST EXTENSION LETTER

August 10, 2006

Lori Makarick
Grand Canyon National Park Science Center
823 North San Francisco, Suite B
Flagstaff, AZ 86001-3265

Dear Lori;

I'm writing to request another No Cost Extension for our tamarisk removal and monitoring project ("Control Tamarisk and Monitor Vegetation at Backcountry Seeps, Springs and Tributaries in Grand Canyon National Park"; Cooperative Agreement # H1200040002, Task Agreement NAU-171-J8213040071). The database design is about 80% complete, but we are still working on the final design phase with the remaining funds. The second year's monitoring data and analyses are about 80% complete, but I feel that additional time would result in a much better report and project. Below are the changes we will need to the project timetable; the original dates and dates from the schedule we revised in November 2004, February 2005, June 2005, and November 2006 are crossed out and the new, requested dates are in bold.

Please don't hesitate to contact me if you need to discuss this.

Mike Kearsley

PRODUCTS, DELIVERABLES AND SCHEDULE

The earliest this project will be initiated is August 29, 2004. The latest that this project will be initiated is September 20, 2004. Completed

The data and reports from Phase I and all of the associated permits will be transferred from the NPS key official to NAU investigators by August 29, 2004. Completed

The preliminary monitoring design will be due on September 23, 2004. Completed

The data collection protocols and associated database (old) will be due on September 23, 2004. Completed

A short progress report on the field control efforts will be due on ~~December 15, 2004~~ ~~April 1, 2005~~ ~~June 1, 2005~~ ~~September 30, 2005~~ ~~January 31, 2006~~ **March 31, 2007.** A copy of all field notes and labeled digital photographs will also be due on this date.

The final integrated resource monitoring protocols, control and monitoring databases, project map, and data summaries will be due on ~~January 30, 2005~~ ~~April 1, 2005~~ ~~June 1, 2005~~ ~~October 30, 2005~~ ~~July 15, 2006~~ **March 31, 2007.** The NPS key official will be responsible for entering project data into the IAR system on the annual reporting date.

The education material (completed), project poster, and draft article will be due on ~~January 30, 2005~~ ~~February 28, 2005~~ ~~April 30, 2005~~ ~~September 30, 2005~~ ~~June 30, 2006~~ **March 31, 2007.**

The draft final report for this project will be due on ~~February 20, 2005~~ ~~April 8, 2005~~ ~~June 15, 2005~~ ~~November 15, 2005~~ ~~July 15, 2006~~ **March 31, 2007**.

The final report will be due on ~~March 20, 2005~~ ~~April 30, 2005~~ ~~July 15, 2005~~ ~~December 9, 2005~~ ~~August 15, 2006~~ **June 30, 2007**.

This project will be complete and all funds expended by ~~March 31, 2005~~ ~~May 1, 2005~~ ~~July 15, 2005~~ ~~December 31, 2005~~ ~~September 30, 2006~~ **September 30, 2007**.

APPENDIX B – Monitoring Data Forms and Protocols

Grand Canyon Tamarisk Vegetation Transect Data Spring 2006

Canyon Name: Transect # A=tamarisk area B=reference	Date:	Recorder: Reader:	Weather Notes:	
Transect Start Point Information:	Easting	Northing	GPS Accuracy Elevation	Pre-tamarisk removal
Transect End Point Information:	Easting	Northing	GPS Accuracy Elevation	Post-tamarisk removal
Transect General Description:				Bearing: _________° Geological Layer Information:

Location Description: ____(e.g. Kwagunt 1)
River Mile ________ River Side? **R L** Revisit? **Y N**

Additional Location Details:

____
____
____
____

Dominant Plant Species:

____
____

Associated Plant Species:____
____
____
____
____
____

**Include only species not hit on the transect here!*

Habitat type______________________________ Land form: ______________________

Surface water within 25m? **Y N** Circle one: seep spring stream pothole river

Slope (degrees): ____________ ° Aspect (0-360): _______________ Light exposure: open full-shade partial-shade

Soil moisture: dry moist saturated standing water Surface rocks: ______________________

Soil type: sand loamy sand sandy loam silt loam loam sandy clay loam silty clay loam clay loam sandy clay clay silty clay

DESCRIPTION KEYS

SURFACE ROCKS:

Basalt	**Conglomerate**
Limestone	**Shale**
Sandstone	**Granite**
Mudstone	**Other**

LANDFORM:

Rockpile: uplands composed primarily of jointed and efoliating granitic outcrops
Drainage channel: bottom not side slope of a drainage confined by banks or a canyon
Valley Bottom Fill: usually level places
Side Slope: side of drainage channel
Lower Slope: lower better watered portion of a slope
Mid Slope: central portion of a slope
Upper Slope: the upper driest portion of a slope
Interfluve: the area between small drainage channels
Ridge: high ground between two opposing slopes
Slick rock: large exposed expanses of bedrock
Terrace: level or gently sloping shelf perched on a slope, often caused by down-cutting rivers
Mesa: level or gently sloping ground surrounded on 3 or more sides by steep down slopes and capped
Butte: similar to a mesa, except with a top that does not have a flat configuration
Cliff: very steep rock slopes
Talus: unsorted material resulting from mass wasting of steep mountain slopes
Sand Dune/Sand Sheet: large accumulations of sand, may be stable or unstable (moving)
Plateau: flat area of great extent and elevation; specifically an extensive land region; considerably elevated (more than 100 meters) above adjacent lower-lying terrain

SOIL TAXONOMY:

1. Place soil in hand, remove pebbles, and add water very slowly, until it has the potential to have the consistency of putty. Add more soil or water as needed.
   a. If the soil does not remain in a ball, circle "**sand**"
2. If the soil remains in a ball, squeeze the ball between your thumb and forefinger, attempting to make a ribbon of uniform thickness and width pushing up and over your forefinger until it breaks from its own weight.
   a. If no ribbon is formed, record "**loamy sand**"
3. If ribbon forms but breaks before it is 2.5 cm, rub the soil between fingers.
   a. If very gritty, record "**sandy loam**"
   b. If very smooth, record "**silt loam**"
   c. If neither gritty or smooth, record "**loam**"
4. If ribbon breaks between 2.5 and 5 cm, rub the soil between fingers.
   a. If very gritty, record "**sandy clay loam**"
   b. If very smooth, record "**silty clay loam**"
   c. If neither gritty or smooth, record "**clay loam**"
5. If ribbon breaks when it is >5 cm, rub the soil between fingers.
   a. If very gritty, record "**sandy clay**"
   b. If very smooth, record "**clay**"
   c. If neither gritty or smooth, record "**silty clay**"

HABITAT TYPES: Adapted from Brown et al. (1998)

Habitat Type	Description
Subalpine conifer forest	Engelmann spruce-alpine fir, bristlecone pine-limber pine
Mixed conifer	Douglas and white fir, ponderosa pine, aspen
Ponderosa pine forest	ponderosa pine, Gambel oak, white fir
Great Basin montane scrub	oak-scrub, mountain mahogany, brittlebush, serviceberry
Great Basin conifer woodland	pinyon-juniper series
Great Basin desertscrub	sagebrush, blackbrush, rabbitbrush, winterfat, saltbrush
Mojave desertscrub	creosote, blackbrush, mesquite, saltbush
Alpine/subalpine grassland	bunchgrass (AZ fescue) and sedge-forb-grass association
Semi-desert grassland	grama grass-scrub (*Bouteloua/Pleuraphis*), mixed shrub
Interior wetlands	Cattail, rushes, sedges, willows
Riparian	cottonwood-willow, mixed deciduous broadleaf

Canyon Name: Transect #: **A**=tamarisk area **B**=reference Date:

Daubenmire Scale Cover Data from 50m Transects

Species	**5**	**Age**	**15**	**Age**	**25**	**Age**	**35**	**Age**	**45**	**Age**	**Species**	**5 m**	**Age**	**15**	**Age**	**25m**	**Age**	**35**	**Age**	**45m**	**Age**
Bare soil																					
Sand																					
Gravel																					
Cobble																					
Stone																					
Boulder																					
Bedrock																					
Litter (duff)																					
Coarse woody																					
Woody debris																					
Crypto																					
Moss																					
Lichen																					

Cover Scale: **0** = None present **1** = <1% **2** = 1 – 5 % **3** = 5 – 10 % **4** = 10 – 25 % **5** = 25 – 50 % **6** = 50 – 75 % **7** = 75 – 100 %

Age: For the previous readings, note **S**=Seedling, **P**=Sapling, **M**=Mature or combination for all tree species

Canyon Name: Transect #: **A**=tamarisk area **B**=reference Date:

VEGETATION STRUCTURE *Imagine a 20 cm wide cylinder that exists around your pole. For each height category (e.g., 1-2 meters), record each plant species that enters the cylinder and the number of cylindrical decimeter sections that the species occurs in. Since each height category only has 10 dm sections the maximum # of hits per category is 10.*

Point / Height	< 1.0 meter		1 – 2 meters		2 – 3 meters		3 – 4 meter		4 - 5	
	Species Code	# of hits	Species Code	# of hits	Species Code	# of hits	Species Code	# of hits	Species Code	# of hits
5m										
15m										
25m										
35m										
45m										

Soil pH and EC Data for Transects						
Point	**Reading #1**		**Reading #2**		**Reading #3**	
	pH	**EC**	**pH**	**EC**	**pH**	**EC**
5 m						
15 m						
25 m						
35 m						
45 m						

For soil readings, move leaf litter aside and take a small amount of topsoil. Mix 2 parts DI or distilled water with 1 part soil to make a slurry (you only need a small amount). Obtain 3 readings for pH and EC. Rinse probe with DI or distilled water between samples.

Substrate Categories:

Ground cover substrate classes used along transects	
Category	Description
Bare soil	<0.1 mm (smaller than sand)
Sand	0.1 - 2mm
Gravel	2 mm – 6.4 cm
Cobble	6.4 cm – 19 cm
Stone	19 - 61 cm
Boulder	> 61cm
Bedrock	Solid rock surface, non-boulder
Litter (duff)	Dead plant material < 3cm diameter
Coarse woody debris	Dead wood 3-10 cm diameter
Woody debris structure	Woody material > 10 cm in depth and width

Point Intercept Data Canyon Name: Transect #: **A**=tamarisk area **B**=reference Date:

|----------GROUND COVER CATEGORIES-------------| | ----------PLANT SPECIES----------|

Data Point	Bare Soil	Sand	Gravel	Cobble	Stone	Boulder	Bedrock	Litter (duff)	Coarse woody	Woody debris	Plant																								
0.5																																			
1																																			
1.5																																			
2																																			
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	Ground Cover Categories											Plant Species																							
Data Point	Bare Soil	Sand	Gravel	Cobble	Stone	Boulder	Bedrock	Litter (duff)	Coarse woody	Woody debris	Plant																								
25																																			
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Grand Canyon/AWPF Tamarisk Transect Monitoring Protocols

Quantitative Monitoring

The standard transect length will be 50m, with one transect placed approximately in the middle of a treatment area and one in a nearby area with similar substrate and aspect in which no tamarisk occurs. Both transect lines will run parallel to the drainage channel. There will be 1-3 transect pairs per selected project area. Point intercept, cover within 3m- radius circles, and total vegetation volume measurements will be recorded. Transects should be oriented with the 0 or start at upstream.

Environmental site Information

Do a good job describing the site and directions to the site for someone that will be returning without you. Include major landmarks in your description and put those in the photopoints.
Aspect is recorded as the slope of the drainage and flow of the water. This should probably be pretty close to the bearing of the transect.
Slope-take at least 3 and as many as 5 measurements (at the same time as soil perhaps, at 5, 15, 25, 35, 45) then average them.

Daubenmire Scale in 3m radius

In order to further describe the composition of plant species present along the transects, we will collect ground cover and vegetation cover data on all plant species present in a 3m- radius circle at five points along the transect (5m, 15m, 25m, 35m, and 45 m). We will record vegetative cover for all species present in a cylinder from the ground surface to the sky. We will also include the categories of moss, lichen, and microbiotic soil crust. To minimize observer biases and increase the speed of the surveys, we will record cover in seven broad cover classes. Because points on the transect are not independent of each other, cover scale values will be converted to the mid-point of the class ranges and averaged before being analyzed so that there is only a single value for each species recorded on the transect. Ground cover substrate categories can total more than 100%. Identify plants to species when possible, within a reasonable time frame to expedite the process. Identify plants to genus when characteristics are not available, (i.e. lacking mature seed in Cryptantha plants will be listed as sp.)

Litter is considered dead plant material less than 3 cm in diameter. Dead plant material connected to a LIVING perennial plant is considered a live plant and should be recorded as such. Dead annual plants from the previous year can be specified to genus and species if they can be easily identified on site.

Calculating cover classes for sand versus bare soil can be tricky if there is a combination of sand and soil. For soil types of sandy loam and loamy sand, sandy clay loam and sandy clay assume 50% is sand and 50% is soil.

Aging is only done for trees. The age class is based on height/diameter same as for tamarisk age class. Seedling-single stem under 1 m tall. Sapling-over 2 m tall but largest trunk is under 5 cm in diameter. Mature-Largest trunk is over 5 cm in diameter. A tree is a woody plant having one well-defined trunk at least two inches in diameter, a height class of at least 10 feet, and a somewhat definitely formed crown of foliage. Coyote willow is a shrub and Acacia and tamarisk are trees.

Vegetation Structure
In order to understand how the vegetation recorded in the cover data is distributed vertically at each point, we will also record the three-dimensional structure, measured as total vegetation volume (TVV: Mills et al. 1991). At the center of each circle, a survey rod will be held vertically and the number of 10cm (or 1 decimeter) segments in each meter sections above the ground with contacts with live vegetation will be recorded. Imagine a 20 cm wide cylinder around the pole. For each height category (e.g. 1-2 m) record each plant species that enters the cylinder and the number of cylindrical decimeter sections that the species occurs in. If there are more than one species present in a given tenth-meter increment, we will only count it once. So the maximum # of occurrences per height category is 10. The TVV measure for a particular point is the count of all tenth-meter increments occupied over that point. The TVV measures at each point will be summed to generate a transect measure, since individual points on the same transect cannot be considered independent for statistical purposes. If two or more species occur at one point also record total number of segments that are vacant. Do not include dead plant material.

Because we sampled the vegetation structure slightly differently in 2005 due to a misunderstanding of the protocols, we now read both an old and a new category. New being the correct way described above, and the old way includes a count of every plant part, dead or alive that hit a segment, many times more than 10 counts.

Point Intercept
The point intercept method will be used to characterize substrates and document the major plant species present along the transect lines. We will use a 0.75cm diameter, 2m tall point and take a reading every 0.5m along the 50m transect, providing 100 points per transect. We will note the species identity of all live plants in contact with the pole and also characterize ground cover substrate in one of nine categories (including plant). To read, stand on the left and read the pole on the right facing downstream from 0 point or beginning of transect.

The installation of transects in 25% of the 35 project areas will provide an adequate measure of the change in cover. Since this monitoring plan aims to detect change in vegetative cover over time, each transect will be compared to itself and its pair in future years. In Phase I of this project, crews installed transects in 25% of the total project areas and the data were sufficient to determine the vegetation cover changes.

Soil Survey
Take soil sample from within the 3 meter releve, near the point on the meter tape, but not exactly at the point on the meter tape line where the point intercept data will be sampled. For soil readings, mix 2 parts DI or distilled water with 1 part soil to make a slurry. Shake sample in DI water for 30 seconds and then let sample settle for 1 minute before taking reading with probe. Obtain 3 readings for pH and EC. Rinse probe with DI or distilled water between samples.

Qualitative monitoring

Photopoints
Each transect should have photopoints installed at both transect start and end points. Photopoints should be named Bright Angel T1A Start, Bright Angel T1A End, etc. View A is the view of the

photopoint (in this case the Transect Start point, showing a picture of a person at the photopoint. We encourage you to take multiple views of the photopoint in order to help others relocate the start as precisely as possible. View B, C and D would be photos of the photopoint taken from yet a different angle.

- Before you take any pictures at the site, write the canyon name, transect # and label it start or end with the date on the dry erase board and then TAKE A PHOTO OF IT!!. This will help with labeling and organizing the photographs following the trip since the person will know that the series of photos following that "location photo" are of the site listed on the sheet. You have absolutely no idea how invaluable this is until you have hundreds of photos to label.
- The photopoint name should be the name of the Transect (i.e. Bright Angel T1A Start) plus specify whether it is start or end.
- Keep in mind that there may be more than one view (i.e. different bearings) from the same photopoint – those views would be labeled 1, 2, etc. in the view # column. View A is always a photo of the person at the photopoint.
- Please take a photo of a person at the transect start or end to help relocate it – this is the reference photo, denoted by an "A" in the view column (Bright Angel T1A Start View A would be a photo of a person standing at the beginning of that transect. Add different views (B, C, D) of photos taken from other angles to best describe the start of the transect. Photos of the rocks where the transect tape start is lying can be indispensable for those relocating, especially if you weren't there!
- For the description of photopoint – please be as detailed as possible, keeping in mind to include key site characteristics that are of a permanent nature (e.g. rocks, large trees). Please describe the color, size of any boulder / rock you might be on or near. Just saying "rock in middle of creek" is not enough. Be VERY detailed if you cannot get a GPS reading – and if you can define the point in relation to something visible on a GIS layer or another point, we should be able to place it on a map.
- For the view from photopoint – please also be detailed about what you are looking at and describe what you are seeing (e.g. river in lower left corner, trail obliteration doing up sand dune).
- Please remember the following for your descriptions: "Creek Right" is on the right as you are heading down the creek – just like on the river.
- Keep in mind that this work will become part of the Park's files and archives – your work will be used by future Park managers and resource specialists.

APPENDIX C – Database Report Examples

TAMARISK MAPPING REPORT EXAMPLE

Canyon/Park	**140 Mile L**	River mile:	140 L
Location description:	140 Mile 1	Date:	5/10/2006

	Start point	End point
Easting:	359410	359332
Northing:	4029266	4028872
GPS Accuracy (m):	7	13
Elevation (m):	590	595

Site description: This site begins at the canyon mouth and goes 500m up canyon to the large muav patios.

Site access: The site ends above 2 dry falls of muav that must be detoured on creek right. There are many large boulders to scramble around in this section.

Tamarisk distribution: Tamarisk are all concentrated near the canyon mouth and stop about 150m up the canyon. The section is dry above.

Tamarisk numbers: Seedlings: 200 Saplings: 8 Mature: 38

Tamarisk control: This is just one approx. 50m stretch of dense tamarisk thicket - half of a day with a 6 person team.

Associated species: Acacia greggii Gray, Adiantum capillus-veneris L., Agrostis stolonifera L., Andropogon glomeratus (Walt.) B.S.P., Artemisia ludoviciana Nutt., Baccharis salicifolia (Ruiz & Pavón) Pers., Bernardia incana Morton, Brickellia longifolia S. Wats., Cladium californicum (S. Wats.) O'Neill, Epipactis gigantea Dougl. ex Hook., Parietaria hespera Hinton, Polypogon monspeliensis (L.) Desf., Typha latifolia L.

Canyon/Park	**140 Mile L**	River mile:	140 L
Location description:	140 Mile 2	Date:	5/10/2006

	Start point	End point
Easting:	359332	359517
Northing:	4028872	4028274
GPS Accuracy (m):	13	10
Elevation (m):	595	597

Site description: This site ends at the first fork in 140 mile canyon. The left (east) fork is the main one from here on, and the west fork the lesser. RV checked out the smaller fork and Kevin and Steve checked out the East fork.
NOTE: Delete Baccharis from associates.

Site access: Once you are above the dry falls of section 1, it is an easy walk with some boulders to scramble around.

Tamarisk distribution: None

Tamarisk numbers: Seedlings: 0 Saplings: 0 Mature:

Tamarisk control: None.

Associated species: Acacia greggii Gray, Acourtia wrightii (Gray) Reveal & King, Baccharis spp., Brickellia longifolia S. Wats., Bromus rubens L., Bromus spp., Cercis Occidentalis, Datura wrightii Regel, Opuntia spp., Rhus trilobata Nutt.

HABITAT ASSESSMENT REPORT EXAMPLE

Canyon/Park Area:	**140 Mile L**			River mile:	140 L
Location description:	140 Mile 1			Date:	5/10/2006
	Start point	End point			
Easting	359410	359333			
Northing	4029266	4028870			
GPS accuracy (m)	7	13			
Surface water within		Surface water type:	seep		
Soil moisture:	dry	Surface rocks:	shale		
Associated species:	Adiantum capillus-veneris L., Agrostis stolonifera L., Andropogon glomeratus (Walt.) B.S.P., Artemisia ludoviciana Nutt., Baccharis salicifolia (Ruiz & Pavón) Pers., Bernardia incana Morton, Brickellia longifolia S. Wats., Cladium californicum (S. Wats.) O'Neill, Epipactis gigantea Dougl. ex Hook., Parietaria hespera Hinton, Polypogon monspeliensis (L.) Desf.,				
Dominant species:	Acacia greggii Gray				
Habitat type:	Great Basin desert scrub				
Vegetation density:	Low	Average height of vegetation	2.5		
Tamarisk estimate:	Low				
Other info:	There are 2 large waterfalls at the upper end of this section.				
SWIFL determination:	Not Suitable or Potential Southwestern Willow Flycatcher Habitat				

Canyon/Park Area:	**140 Mile L**			River mile:	140 L
Location description:	140 Mile 1st West Fork			Date:	5/10/2006
	Start point	End point			
Easting	359507	359308			
Northing	4028427	4027913			
GPS accuracy (m)	10	7			
Surface water within		Surface water type:			
Soil moisture:	dry	Surface rocks:	limestone		
Associated species:	Bromus spp., Opuntia spp.				
Dominant species:	Acacia greggii Gray, Baccharis spp.				
Habitat type:	Great Basin desert scrub				
Vegetation density:	Low	Average height of vegetation	2		
Tamarisk estimate:	None				
Other info:					
SWIFL determination:	Not Suitable or Potential Southwestern Willow Flycatcher Habitat				

HYDROLOGY REPORT EXAMPLE

Date of Survey: 5/10/2006 Time Measurements Began: 12:55 Observer: FH Frank Hays

Canyon Name: 140 Mile L Location Description: 140 L Hydro 1

Measurement Location Details: At the top of the larger pool the seeps flow in a single channel for about 1.5m between an upper pool (1.5mx2.3m) and a short pourover about 1 meter into a larger pool (4mx10m).

UTM Easting: 359410 UTM Northing: 4029266 GPS Accuracy (m): 7

Type of Water Feature: stream Light Exposure: open

Elevation (m):577 Slope (degrees): 40 Aspect: 296

Soil Type:

Weather: clear, light wind

Weather over previous 3 days: partly cloudy, gusty winds, warm days, and cool nights

Current Temperature Air: 31 C Water: 25 C

Description of Water Source: Series of seeps coming out of Tapeats sandstones combine into one channel that connects the pools described above. A 1.5m long channel flows to pourover into larger pool.

Water Quality Measurements

Last Calibration--------> **Date:** 5/10/2006 **Time:** 13:45

Meter Reading #	**1**	**2**	**3**	**Average**
Water Temp (C)	26.3	26	25.9	26.1
pH	8.22	8.22	8.22	8.2
EC (mS)	852	846	850	849.3
TDS (ppm)	425	419	423	422.3

Water Quantity Measurements

Discharge Type: Float

Average Discharge (m3/sec): 148.7068953956

Additional Comments/Information

PHOTOGRAPHY REPORT EXAMPLE

PP 140 Mile 1

Photopoints printed on:
Tuesday, January 09, 2007

RM: 140 RS: L

Easting: 359419 Northing: 4029254 Height: 5'04

Photopoint Description: PP is a redwall limestone boulder in the middle of the drainage (2x1x3m) located just at the point where you enter the drainage from the beach. This is just below the BA shale ledge on creek right.

View # 1 Bearing: 162

10/4/2006 1:36 PM Post Treatment

Looking upstream - postwork.

View # 2 Bearing: 270

10/4/2006 1:38 PM Post Treatment

Looking downstream - postwork.

10/4/2006 10:55 AM Pre Treatment

Looking upstream at the greatest point of tamarisk infestation.

10/4/2006 10:57 AM Pre Treatment

Looking downstream at a pool of water and tamarisk on creek left.

PP 140 Mile 1

Photopoints printed on:
Tuesday, January 09, 2007

RM: 140 RS: L

Easting: 359419 Northing: 4029254 Height: 5'04

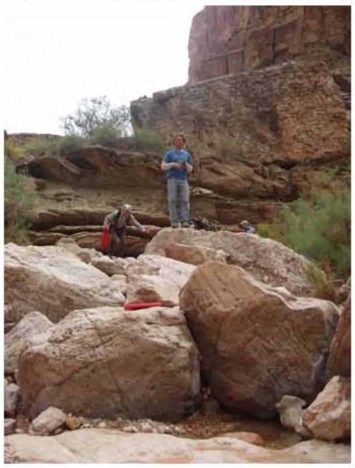
Photopoint Description: PP is a redwall limestone boulder in the middle of the drainage (2x1x3m) located just at the point where you enter the drainage from the beach. This is just below the BA shale ledge on creek right.

View # A

Bearing: 106

10/4/2006 10:51 AM Pre Treatment

Steve at photopoint. Taken from 10m downstream of photopoint looking upstream.



PHOTOPOINT SUMMARY EXAMPLE

Location Description	View #	Date	Time	Bearing	Camera Ht.	Vert. or Horiz.	Easting	Northing	Accur.	Photopoint Description	View
140 Mile T1B Start	1	5/10/2006	13:44	42	5'5 "	V	359461	4029160	9	T1B start.	T1B start. Looking down transect tape.
140 Mile T1A End 140 Mile T1A End	A	5/10/2006	13:10	84	5'5 "	V	359430	4029267	7	140 mile T1A End.	Middle of the streambed, looking at the photpoint at stream right. T1A endpoint at Pam's feet.
140 Mile T1B End	2	5/10/2006	14:10	328	5'5 "	V	359426	4029176		T1B End.	T1B end. Looking downstream toward creek left.
140 Mile T1A End 140 Mile T1A End	1	5/10/2006	13:20	275	5'5 "	V	359430	4029267	7	140 mile T1A End.	T1A End. Looking downstream from photopoint.
140 Mile T1B End	C	5/10/2006	14:00	136	5'5 "	V	359426	4029176		T1B End.	Just stream left of T1B end. Close up of T1B end point.
140 Mile T1B Start	2	5/10/2006	13:48	164	5'5 "	V	359461	4029160	9	T1B start.	T1B start. Looking upstream to stream right through some Acacias.
140 Mile T1B End	1	5/10/2006	14:00	229	5'5 "	V	359426	4029176		T1B End.	T1B End. Looking upstream along transect tape.
140 Mile T1B Start	A	5/10/2006	13:40	176	5'5 "	V	359461	4029160	9	T1B start.	6m directly below photopoint on stream right. T1B start with Amy in the photo.
140 Mile T1A Start	B	5/10/2006	12:52	166	5'6 "	V	359439	4029214	7	Start of T1A	Looking at photopoint from the stream. Right skyline is in the background. Pam at photpoint.
140 Mile T1B Start	B	5/10/2006	13:41	162	5'5 "	V	359461	4029160	9	T1B start.	In stream bed looking upstream at photopoint. T1B start with Amy by the start.
140 Mile T1B End	B	5/10/2006	13:55	136	5'5 "	V	359426	4029176		T1B End.	In stream bed looking to creek right T1B end point.
140 Mile T1B End	A	5/10/2006	13:49	53	5'5 "	V	359426	4029176		T1B End.	On creek right of tape looking downstream at T1B end.
140 Mile T1A Start	2	5/10/2006	13:30	223	5'5 "	V	359439	4029214	7	Start of T1A	The start of T1A, looking upstream along the transect tape.
140 Mile T1A End 140 Mile T1A End	2	5/10/2006	13:20	188	5'5 "	V	359430	4029267	7	140 mile T1A End.	T1A end. Looking upstream along transect tape.
140 Mile T1A Start	1	5/10/2006	13:05	0	5'5 "	V	359439	4029214	7	Start of T1A	The start of Mile 140 T1A. Looking down the transect tape at TAMRAM and boulder.

EXOTIC CONTROL EXAMPLE *(for site revisits)*

Grand Canyon National Park, Inner Canyon Exotic Plant Management Data

☐ Check if same as previous site ☐ Check after entered in database

Date of survey: ______ Observers: ______

Canyon Name: 140 Mile L Location Description 140 Mile 1

River Mile: 140.0 River Side: L Revisit? Yes

UTM Easting 359380 UTM Northing 4029275

Species Code: TAMRA Habitat Type: Riparian Landform: Drainage channel-bottom not side slope of a drainage confined b

Surface Water within 25m? ☑ Surface Water Type: stream Elevation 591 m

Slope: 5 degrees Aspect: 302 Light Exposure: partial-shade

Soil Moisture: moist Surface Rocks: shale

Soil Type: sandy loam

Associated Species

ADICAP ANDGLO BACEMO BRILON CLACAL PLEJAM PLUSER SALEXI
TYPSPP

%Cover* ______ Area Cover* ______ *Use SWEMP Code Infested Area (m2): ______ Gross Infested Area (m2): 5000

# of Plants: ______ # of Seedheads/Plant: ______ Treatment* ______ *Use SWEMP Code

Plants Flowering ______ % Plants Fruiting ______ % Vegetative State ______ % *This row should total 100%*

Herbicide Used? **Y N** Herbicide Type ______ Herbicide Mix ______ *Record in herbicide use log*

For TREES: Seedlings # ______ Saplings # ______ Mature # ______

Control Method: Pulled ______ Combo cut/girdle ______ Girdle ______ Basal bark ______ Cut stump ______

Control notes/comments: ______

Site notes/comments

SWEMP CODES

% Cover of Species (in survey area): T≤1%, L=1-5%, M=5-25%, H=25-100%

Area Coverage (Acreage): A≤0.01, B=0.1-1, C=1-5, D>5

Treatement: A=No Action, D=Mechanical, E=Chemical

SWEMP CONVERSION CHEAT SHEE

AREA COVER sq m	**T** sq m	**L** sq m	**M** sq m	**H** sq m
A<=400	≤4	4-20	20-100	100-400
B=400-4050	≤40	40-200	200-1000	1000-4050
C=4050-20200	≤200	200-1000	1000-5050	5050-20200
D>20200				

VEGETATION COLLECTION SPECIMEN LABEL EXAMPLE

PLANTS of Arizona
Grand Canyon National Park Vegetation Inventory

Apiaceae

Apium graveolens L.

USA. .Coconino County. NPS. Grand Canyon N.P.. - Colorado River Corridor Riparian. This is right at the river's edge, in very moist soil. This is about 700m above 50 Mile camp.

UTM: NAD83 12S 421515E 4022822N
Elev: 856m

Associated Species: Salix exigua Nutt., Saccharum ravennae (L.) L., Plantago lanceolata L., Tamarix ramosissima Ledeb., Baccharis salicifolia (Ruiz & Pavón) Pers., Agrostis stolonifera L.

Collector: Lori Makarick 8/27/2006

With:

APPENDIX D – Project Monitoring Examples

(From May 2006 AWPF Report – displays one transect area only)

Appendix E - Monitoring Transect Data

Canyon/Park Area: 140 Mile L River mile: 140 L

Transect Name: 140 Mile L 1 Type: Tamarisk area

	Start point		End point
Easting:	359439	Easting:	359430
Northing:	4029217	Northing:	4029267
GPS accuracy (m):	7	GPS accuracy (m):	8
Bearing:	0	Elevation (m):	
Aspect (0-360):	350	Slope (degrees):	8

Transect description: Take the trail from pull in above the drainage and drop into drainage start point is just about 50m up canyon from where trail drops in on the west side of a 3x3m limestone boulder. The line goes under a SUV sixe boulder from 10-12m. At 31.6m the tape pivots to 340 degrees on a 1.5x1.2m gray boulder so that we could get a full 50m line in. The end is right in a BA shelf ~1.2m tall right in a vertical crack. There was a deep pool from 35-38m on tape, with dried algae around the edges. There is water from 35.8-36.2 on tape. Many small seedlings in this area. General location is about 300m from river.

Geological layer: Bright Angel Shale

Habitat type: Riparian

Dominant species: Acacia greggii Gray, Brickellia longifolia S. Wats., Tamarix ramosissima Ledeb.

Associated species: Camissonia multijuga (S. Wats.) Raven, Datura wrightii Regel, Eriogonum spp., Gnaphalium chilense, Pluchea sericea (Nutt.) Coville, Thymophylla pentachaeta (DC.) Small

Surface water within 25 m? ☑ Surface water type: Surface rocks: limestone cobbles

Landform: Drainage channel Light exposure: open

Soil type: sand Soil moisture: dry

Canyon/Park Area: 140 Mile L River mile: 140 L

Transect Name: 140 Mile L 1 Type: Tamarisk area

Date: 5/10/2006 Revisit? ☐ Pre-tamarisk removal

Recorder: Lori Makarick Reader: Mike Kearsley

Weather: Samll wispy clouds-5%, sunny, 28.7 C

Point Intercept Transect (50m)

Ground Cover	% Cover
Bedrock	6
Boulder	21
Cobble	10
Gravel	26
Litter (duff)	18
Sand	11
Stone	9

Species	% Cover
Acacia greggii Gray	3
Algae spp	7
Brickellia longifolia S. Wats.	12
Bromus rubens L.	1
Funastrum cynanchoides (Dcne.) Schlechter	3
Tamarix ramosissima Ledeb.	32
Water	3
Water	

Daubenmire Scale Cover Data

Ground Cover	5m	15m	25m	35m	45m
Stone	10-25%	5-10%	1-5%	<1%	5-10%
Gravel	25-50%	5-10%	10-25%	25-50%	10-25%
Coarse woody debris	1-5%	1-5%	1-5%	1-5%	<1%
Bare Soil	<0%	<0%	<0%	<0%	
Bedrock	1-5%	5-10%	<0%	<0%	1-5%
Sand	1-5%	<1%	5-10%	5-10%	5-10%
Litter (duff)	5-10%	5-10%	10-25%	<1%	1-5%
Cobble	10-25%	<1%	5-10%	5-10%	5-10%
Boulder	5-10%	10-25%	25-50%	5-10%	1-5%
Woody debris structure	<0%	<0%	<0%	<0%	<0%

Species	5m	Age	15m	Age	25m	Age	35m	Age	45m	Age
Acacia greggii Gray	<1%		25-50%	M	<1%		<1%		<1%	
Algae spp							5-10%			
Artemisia ludoviciana Nutt.	<1%		<1%						<1%	
Baccharis emoryi Gray	<1%		<0%		1-5%					
Baccharis salicifolia (Ruiz & Pavón) Pers.							<1%			
Brickellia longifolia S. Wats.	5-10%		<1%		1-5%				5-10%	
Bromus rubens L.	<1%		<1%				<1%		<1%	
Cryptantha spp.	<1%									
Cryptobiotic soil	<0%		<0%		<0%		<0%		<0%	
Funastrum cynanchoides (Dcne.) Schlechter			5-10%		1-5%					
Hedeoma nana (Torr.) Briq.									<1%	

Lepidium lasiocarpum Nutt. var. lasiocarpum	<1%		<1%				<1%			
Mimulus guttatus DC.							<1%			
Moss MOSS SPP	<0%		<0%		<0%		<0%		<0%	
Nicotiana obtusifolia Mertens & Galeotti var. obtusifolia			1-5%						<1%	
Parietaria hespera Hinton									<1%	
Polypogon monspeliensis (L.) Desf.									<1%	
Porophyllum gracile Benth.	<1%		<0%							
Sporobolus spp.	<1%		<1%						<1%	
Stylocline micropoides Gray	<1%									
Tamarix ramosissima Ledeb.	10-25%	M	25-50%	S+M	25-50%	M	1-5%	S+M	5-10%	S+M
Typha spp.							<1%			
Vulpia octoflora	<1%									
Water Water							5-10%			

Vegetation Structure Data - Old

Point	Species	≤1m	1-2m	2-3m	3-4m	4-5
5	Brickellia longifolia S. Wats.	12				
15	Tamarix ramosissima Ledeb.	13	9			

Vegetation Structure Data - New

Point	Species	≤1m	1-2m	2-3m	3-4m	4-5m
5	Brickellia longifolia S. Wats.	2				
15	Acacia greggii Gray					
15	Tamarix ramosissima Ledeb.	4	4			
45	Acacia greggii Gray	1				

Soil Data

	Reading 1		Reading 2		Reading 3		Average	
Point	pH	EC	pH	EC	pH	EC	pH	EC
5	8.46	977	9.37	863	8.37	990	8.73	943
15	8.49	1055	8.49	1060	8.48	1067	8.49	1061
25	8.96	104	8.92	104	8.91	106	8.93	105
35	8.85	381	8.85	384	8.84	389	8.85	385
45	8.64	1764	8.69	1756	8.7	1760	8.68	1760

Canyon/Park Area: 140 Mile L River mile: 140 L

Transect Name: 140 Mile L 1 Type: Reference

	Start point		End point
Easting:	359411	Easting:	359426
Northing:	4029160	Northing:	4029176
GPS accuracy (m):	9.1	GPS accuracy (m):	
Bearing:	19	Elevation (m):	
Aspect (0-360):	0	Slope (degrees):	10

Transect description: Transect start is located ~75m upstream of T1A on creek R in the first big acacia grove. Car-sized boulders block the main channel of the drainage around the 10m mark of the transect forcing you to traverse to creek R to get to the start. The start is located at the base of a 2x2.5 wide limestone boulder flanked by acacias. Just upstream a sheer B.A. shale ledge enters the drainage on creek L.

Geological layer: muave limestone

Habitat type: Riparian Mojave desert scrub

Dominant species: Acacia greggii Gray, Brickellia longifolia S. Wats., Isocoma acradenia (Greene) Greene

Associated species: Adiantum capillus-veneris L., Aloysia wrightii Heller ex Abrams, Camissonia walkeri (A. Nels.) Raven, Datura wrightii Regel, Echinocereus triglochidiatus Engelm., Encelia resinosa var. resinosa, Ferocactus cylindraceus (Engelm.) Orcutt var. cylindraceus, Fraxinus anomala Torr. ex S. Wats., Galium stellatum Kellogg, Lycium pallidum Miers, Nicotiana obtusifolia Mertens & Galeotti, Perityle congesta (M.E. Jones) Shinners, Sonchus asper (L.) Hill, Stanleya pinnata (Pursh) Britt.

Surface water within 25 m? ☐ Surface water type: Surface rocks: limestone

Landform: Drainage channel Light exposure: open

Soil type: sandy loam Soil moisture: dry

Canyon/Park Area: 140 Mile L River mile: 140 L

Transect Name: 140 Mile L 1 Type: Reference

Date: 5/10/2006 Revisit? ☐ Pre-tamarisk removal

Recorder: Kate Watters Reader: Lisa Hahn

Weather: Breezy, sunny, clear and ~ 90F

Point Intercept Transect (50m)

Ground Cover	% Cover
Bedrock	2
Boulder	20
Cobble	16
Gravel	10
Litter (duff)	19
Plant	1
Sand	17
Stone	15

Species	% Cover
Acacia greggii Gray	19
Brickellia longifolia S. Wats.	6
Bromus rubens L.	2
Gutierrezia sarothrae (Pursh) Britt. & Rusby	1
Stephanomeria pauciflora (Torr.) A. Nels.	1

Daubenmire Scale Cover Data

Ground Cover	5m	15m	25m	35m	45m
Boulder	10-25%	10-25%	10-25%	5-10%	25-50%
Stone	5-10%	5-10%	10-25%	10-25%	25-50%
Litter (duff)	10-25%	1-5%	1-5%	5-10%	1-5%
Woody debris structure	<0%	<0%	<0%	<0%	<0%
Gravel	10-25%	50-75%	5-10%	5-10%	5-10%
Cobble	5-10%	10-25%	10-25%	25-50%	10-25%
Sand	1-5%	5-10%	25-50%	10-25%	5-10%
Bedrock	10-25%	<0%	<0%	50-75%	<0%
Coarse woody debris	<1%	<1%	<1%	1-5%	<1%
Bare Soil	<1%	<1%	5-10%	1-5%	1-5%

Species	5m	Age	15m	Age	25m	Age	35m	Age	45m	Age
Acacia greggii Gray	50-75%	M	<1%	S+M	25-50%	S+M	50-75%	S+M	1-5%	S+P
Aloysia wrightii Heller ex Abrams										
Artemisia ludoviciana Nutt.	<1%						1-5%			
Aster species									<1%	
Brickellia longifolia S. Wats.			1-5%		1-5%		5-10%		10-25%	
Bromus rubens L.	1-5%				<1%		<1%		<1%	
Bromus tectorum L.							<1%			
Camissonia walkeri (A. Nels.) Raven							<1%		<1%	
Cryptantha spp.									<1%	
Cryptobiotic soil	1-5%		<0%		<1%		<1%			
Datura wrightii Regel							<1%		1-5%	

Ephedra fasciculata A. Nels.	<1%					
Eriogonum inflatum Torr. & Frém.					<1%	
Erodium cicutarium (L.) L'Hér. ex Ait.					<1%	
Fraxinus anomala Torr. ex S. Wats.					<1%	S
Grass spp	<1%					
Gutierrezia sarothrae (Pursh) Britt. & Rusby	<1%			<1%	<1%	
Hedeoma nana (Torr.) Briq.					<1%	
Isocoma acradenia (Greene) Greene				1-5%	1-5%	
Lepidium lasiocarpum Nutt. var. lasiocarpum		<1%	<1%	<1%		
Lepidium spp.		<1%				
Lichen sp.	<1%					
Maurandella antirrhiniflora (Humb. & Bonpl. ex Willd.) Rothm.		1-5%				
Moss MOSS SPP						
Muhlenbergia porteri Scribn. ex Beal					<1%	
Parietaria hespera Hinton		<1%	<1%	<1%	<1%	
Plantago patagonica Jacq.				<1%		
Poa fendleriana (Steud.) Vasey	<1%				<1%	
Porophyllum gracile Benth.	<1%					
Sporobolus spp.				<1%		
Stanleya pinnata (Pursh) Britt.			<1%			
Stephanomeria pauciflora (Torr.) A. Nels.	<1%			1-5%	1-5%	
Thymophylla pentachaeta (DC.) Small var. belenidium (DC.) Strother				<1%		

Vegetation Structure Data - Old

Point	Species	<1m	1-2m	2-3m	3-4m	4-5
5	Acacia greggii Gray	2	2	2	1	1
35	Acacia greggii Gray				3	1

Vegetation Structure Data - New

Point	Species	<1m	1-2m	2-3m	3-4m	4-5m
5	Acacia greggii Gray					2
5	Bromus rubens L.	1				
35	Acacia greggii Gray					1
35	Isocoma acradenia (Greene) Greene	1				

Soil Data

	Reading 1		Reading 2		Reading 3		Average	
Point	pH	EC	pH	EC	pH	EC	pH	EC
5	8.87	211	8.87	200	8.87	199	8.87	203
15	8.94	97	8.94	94	8.92	99	8.93	97

APPENDIX E – Educational Materials

A success!

The Tamarisk Management and Tributary Restoration Program is one example of the park's aggressive efforts to control invaders. Tamarisk, established along the Colorado River and up tributary canyons, is succumbing to efforts aimed at controlling its spread in the park's side canyons. Program managers have accomplished an almost complete elimination of tamarisk in treated areas and native plants are returning. This successful program was made possible with the help of dedicated volunteers and NPS partners, including the Grand Canyon National Park Foundation, the Grand Canyon Wildlands Council and the Arizona Water Protection Fund.

Join in the fight.

Become a volunteer with Grand Canyon's Vegetation Program; go to www.volunteer.gov/gov or www.gcnpf.org for more information.

Give native vegetation a break. Stay on trails and do not disturb the soil.

Learn to recognize invasive species where you live and what you can do to help control their spread.

We all have an integral role to play in protecting our public lands and preserving our world s biodiversity.

The Grand Canyon National Park Foundation works to build the ethic of stewardship for Grand Canyon through private philanthropy, volunteer leadership, and public outreach. Donations to the Foundation support projects that protect and preserve the Canyon's irreplaceable natural, cultural, and historic resources while enhancing the visitor experience.

625 NORTH BEAVER STREET FLAGSTAFF, AZ 86001 PH 928.774.1760
FX 928.774.1240 www.gcnpf.org

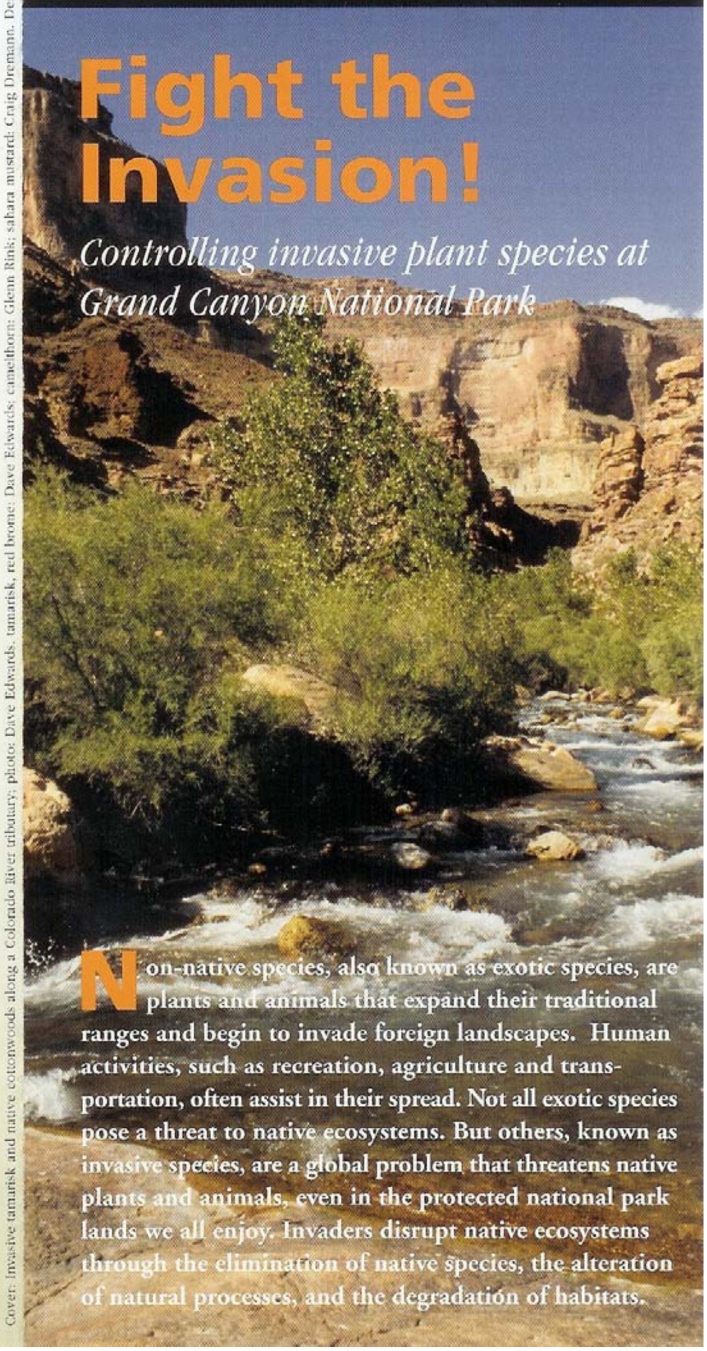
The Arizona Water Protection Fund Commission has funded a portion of this brochure. The views presented are the Grantee's and do not necessarily represent those of the Commission, the State, or the Arizona Department of Water Resources.

August 2005

Cover: Invasive tamarisk and native cottonwoods along a Colorado River tributary; photo: Dave Edwards. tamarisk, red brome: Dave Edwards; camelthorn: Glenn Rink; sahara mustard: Craig Dremann. Design: Mary Beath

National Park Service
U.S. Department of the Interior

Grand Canyon National Park
Arizona



Fight the Invasion!

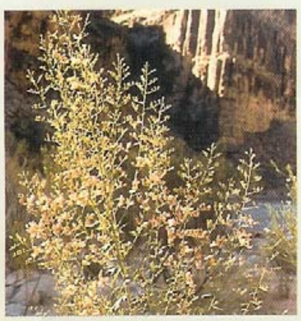
Controlling invasive plant species at Grand Canyon National Park

Non-native species, also known as exotic species, are plants and animals that expand their traditional ranges and begin to invade foreign landscapes. Human activities, such as recreation, agriculture and transportation, often assist in their spread. Not all exotic species pose a threat to native ecosystems. But others, known as invasive species, are a global problem that threatens native plants and animals, even in the protected national park lands we all enjoy. Invaders disrupt native ecosystems through the elimination of native species, the alteration of natural processes, and the degradation of habitats.

THE SIX LEAST WANTED!

These invasive plants may have interesting traits, but they severely threaten Grand Canyon's native species. Here are a few of the park's most troublesome invaders:

Tamarisk *(Tamarix ramosissima)*, a Eurasian tree also known as salt cedar, quickly crowds out native plants, such as willow and cottonwood trees. Once established, tamarisk trees make it tough for native plants to grow—by adding salt to the soil and producing a very thick layer of duff below the trees.



Camelthorn *(Alhagi maurorum)*, a Eurasian shrub, has roots that can reach a depth of 45 feet, stealing precious ground water from native plants and taking over limited beaches along the Colorado River corridor.

Growing in early spring, the Eurasian plant **Sahara mustard** *(Brassica tournefortii)* can quickly reach a height of more than three feet, out competing native wildflowers. It is rapidly spreading along the Colorado River.

Ravenna grass, *(Saccharum ravennae)*, a Eurasian grass found along the river in the park, forms clumps that can grow to ten feet tall and six feet wide. It is highly competitive and provides little habitat for native wildlife.

Cheatgrass *(Bromus tectorum)* and **red brome** *(Bromus rubens)*, are Eurasian grasses now widespread in Grand Canyon. They can increase fire frequency and disrupt the growth of native grasses and forbs. Red brome is shown below.

Which invaders are successful?

Not all non-native species are a problem. Of the 170 exotic plant species found at Grand Canyon, 60 are "target" species because of the threats they pose to native plants and animals. The characteristics of a successful invader include:

Habitat generalists can survive in a variety of environmental conditions, such as wide temperature ranges.

Rapid reproducers have abundant seed production or can spread across a large area via their stems or roots.

Habitat modifiers may alter their environments, such as soil conditions, making habitats inhospitable for native plants.

Can we stop the invasion?

With exotic species comprising about 10 percent of Grand Canyon's total vegetation, the National Park Service (NPS) is getting tough with invaders. In addition to focusing on "target" species, resource managers are working hard at protecting areas rich in native species and backcountry regions where controlling the invaders is still possible.

NATIONAL PARK SERVICE
U.S. DEPARTMENT OF THE INTERIOR

GRAND CANYON NATIONAL PARK
ARIZONA

Invasive Plant Species Observation

You can make a difference! Of the more than 170 exotic plant species found in Grand Canyon National Park, about 60 are "target" species because of the threats they pose to native plants, animals, and ecosystems. You can help the National Park Service control these invaders by documenting how many invasive plants you see and exactly where they are located. With help from you we can compile information and quickly respond to sites infested with these plants. Please contact the park's Backcountry Vegetation Program Manager for additional paperwork and training if you are willing to help manually remove these plants. Even skilled botanists can confuse these exotic plants with some of our well-loved, native species, so we want to make sure you have the necessary information to help us with this battle.

Early identification is one of our strongest tools in fighting the invasion! Visitors to Grand Canyon play an integral role in protecting our national park from invasive species. The National Park Service thanks you for your voluntary participation in this program and your interest in protecting native plants and animals. Please use the format below when gathering information. If you are not sure of a plant's name or status, take a picture and send it along with your collected data.

Send your postcard and any pictures to:

Grand Canyon National Park / Backcountry Vegetation Program Manager
823 North San Francisco, Suite B / Flagstaff, AZ 86001-3265
phone (928) 226-0165 fax (928) 226-0170 / email: Lori_Makarick@nps.gov

SAMPLE REPLY POSTCARD

Please note the following when you see an invasive plant species.

Date of observation ____________________

Name of plant species ____________ # of individuals at the site ________

Location (the more precise you can be, the easier it will be for us to find the site)

River mile ________ River right or left ________ Name of camp or side canyon ________

Descriptive place name al ong a trail? ________ GPS coordinates and datum ________

Did you take any action ? Yes No

If yes, did you pull the plants? Yes No How many did you pull? ________

Was the plant flowering? Yes No

If there was more than one plant of the same species, what percent were flowering? ________ %

Were there ripe seeds on the plant? Yes No

Did it appear that some of the seeds had already dropped? Yes No

Comments

Camelthorn *(Alhagi maurorum)*

Camelthorn, a member of the pea family, is native to the Mediterranean and Asia. It was accidentally introduced into the United States in 1915 via contaminated alfalfa seed, but is now found throughout Arizona and in 34 other states.

Identifying characteristics

- Shrub, 1-4 feet tall, intricately branched, with yellow-tipped spines
- Leaves small, alternate, wedge-shaped, with hairy undersides
- Flowers pink to magenta, on upper part of branches
- Seedpods slender, spine-tipped, brown to maroon

PHOTOS: GLENN RINK

Top: mature plant; bottom: flowers.

Why is this plant a threat?

Camelthorn is notorious for taking over Grand Canyon's already limited beaches. Its hardy roots and stems can reach a depth of 45 feet and extend more than 24 feet from the plant, giving it plenty of reserves to survive during hard times. The extensive underground system allows it to spread rapidly, tap into the groundwater, and steal nutrients and moisture from native vegetation.

Management of camelthorn

Currently, the only tributary camelthorn grows in is the Little Colorado River (LCR), but it thrives along the main river corridor from the confluence downstream. In order to curtail the empire it is creating, park biologists need to know immediately if this species is found in other side canyons or anywhere upstream of the LCR. Due to its widespread distribution in the river corridor, current control efforts focus on just a few sites, including Unkar Delta and Crystal Camp. Park staff and volunteers pull camelthorn from these sites several times a year, keeping count of the number of plants pulled each time to see if this method will control this species. If you are interested in pulling camelthorn at these sites, please contact the park's Backcountry Vegetation Program Manager before heading into the field to get the latest information on the project.

Date palm *(Phoenix dactylifera)*

PHOTO: NPS

Mature plant.

Originally from North Africa and the Middle East, date palms were first brought to the United States in the mid-18th century by Jesuit and Franciscan missionaries. Today most date palms in Arizona, California and Nevada grow in landscaped settings, with some renegades escaping into the wild.

Identifying characteristics

- Medium-sized tree, 10-40 feet tall, with woody sheaths on trunk
- Leaves to 20 feet long, blue-green, clustered, leaflets folded lengthwise
- Flowers white, clustered, fragrant
- Fruits known as dates, dark-brown to yellowish-brown when they are ripe

Why is this plant a threat?

The easily identified date palm reproduces from seeds and roots, tending to form dense stands. This invader uses vast quantities of water. Date palms have been known to dry up precious desert springs relied on by wildlife, native plants, and humans.

Management of date palm

Before 2004, only a small number of date palms grew in Grand Canyon. Recently, vegetation managers noticed the number of palm trees increasing and even found trees with fruit and viable seed near Phantom Ranch. Knowing that humans and animals could potentially spread the seed far and wide, park biologists took action. Crews labored to remove the trees with shovels and small saws and then meticulously re-contoured the sites to minimize the ground disturbance. Any new date palms will be removed from the park, so please let us know if you see these trees.

Perennial pepperweed *(Lepidium latifolium)*

PHOTO: ©BARRY RICE/THE NATURE CONSERVANCY PHOTO: NPS

Top: mature plants; bottom: leaves.

Originally from Eurasia, perennial pepperweed may have been accidentally introduced to North America via contaminated sugar beet seed at the turn of the 20th century. It is now found throughout coastal New England and in all states west of the Rocky Mountains.

Identifying characteristics

- Perennial herb, 3-8 feet tall, forming dense stands
- Leaves alternate around stem, green to gray-green, waxy, with toothed edges
- Flowers white, with 4 petals, clustered at the branch tips
- Plants appear as a rosette for the first few weeks in early spring

There are 2 native pepperweeds in the Inner Canyon: mountain pepperweed (*L. montanum*) and bush pepperweed (*L. fremontii*). Bush pepperweed is more common at higher elevations, while mountain pepperweed grows in abundance in the river corridor. Look for toothed margins on broad leaves of perennial pepperweed and its more showy and open flowering stalk.

Why is this plant a threat?

Once established, perennial pepperweed forms dense stands that make it difficult for native plants to survive. Its ability to bring salts from deep in the soil to the surface and the copious litter it produces further limits native plant germination and survival. Each perennial pepperweed plant can produce thousands of seeds. New plants can also grow from small pieces of broken rootstock. It flourishes in a wide variety of habitats, even on relatively dry sites, making it suitable to creep into the park's side canyons.

Management of perennial pepperweed

This plant is only known to occur in the river corridor, but the number of populations is increasing every year. At this time, park biologists are mapping populations and determining the best strategy for control. Please record any sites in the Inner Canyon where you see this species.

Ravenna grass *(Saccharum ravennae)*
Pampus grass *(Cortaderia spp.)*

Ravenna grass is a large bunchgrass from Eurasia and pampus grass is an even larger bunchgrass from South America. Both were originally imported as ornamentals, but have escaped into natural areas, thriving and adapting to the arid Southwest.

PHOTO: NPS

Top: Ravenna grass with seedhead; bottom: pampus grass seedhead.

Identifying characteristics of Ravenna grass:

- Perennial bunchgrass, to more than 6 feet tall and wide
- Leaves have the following characteristics:
  - very fine, short hairs along blade with long, dense visible hairs clustered at the base
  - v-shaped when viewed in cross-section, white vein running along the underside from tip to base
  - edges have serrated teeth that will grab the skin if rubbed from tip to base
  - turn tan-brown, often with red streaks, curl as they dry
- Flower stalks to 12 feet, with silvery, plume-like seed clusters

Pampus grass is even larger than Ravenna grass—up to 9 feet tall with very long leaf blades. The flowering stalk appears more feathery, delicate, and white, up to 15 feet tall.

Why are these plants a threat?

Highly competitive with the ability to produce large numbers of wind-dispersed seeds, both bunchgrasses rapidly colonize riparian habitats, displacing native plants. Both currently occur only in the Colorado River corridor, with pampus grass found only at a few locations. Ravenna grass has been found on upper, drier terraces, indicating that it could be expanding its range within the park.

Management of ravenna and pampus grasses

Ravenna grass has been the target of an ongoing control program since the early 1990s, with voluteers removing more than 20,000 individual plants between Lees Ferry and Diamond Creek. Only a few pampus grass plants have been found in the park, and those were immediately removed. Annual surveys locate any new plants, which are removed prior to seed set. It is critical to the program's success for more people to be able to identify these plants! We need to know where these plants are so we can focus our control efforts each fall. Please send in your information!

PHOTO: J. SCOTT PETERSON

Mature Russian olive tree.

Russian olive *(Elaeagnus angustifolia)*

Originally from Eurasia, Russian olive was brought to North America during colonial times as a much-loved ornamental tree. Used for erosion control and as a windbreak, it is still sold today in many nurseries. If you have traveled in the Southwest, you have seen this tree.

Identifying characteristics

- Tree to 45 feet tall, with a dark brown, deeply furrowed trunk
- Branches smooth, reddish brown, with long thorns
- Leaves narrow, 2-3 inches long, silvery-green
- Flowers creamy yellow, in clusters, highly aromatic

Why is this plant a threat?

Russian olive aggressively invades riparian habitats and, once established, provides inferior wildlife habitat compared to native trees. Like other invasive species, Russian olive uses copious amounts of water. Its thorny thickets can make camping and hiking along waterways a challenge.

PHOTO: PAUL WRAY

Russian olive flowers and leaves.

Management of Russian olive

Only a limited number of Russian olive trees have been found within the park. Park biologists have removed them due to their aggressive nature; however, more may be out there. The earlier we locate these trees, the easier they will be to control. Please scan the shorelines as you are floating down the river—look for the silvery hue. From a distance, buffalo berry (*Sheperdia rotundifolia*) and young netleaf hackberry (*Celtis laevigata* var. *reticulata*) resemble Russian olive trees, so get closer and look at the leaves before filling out the site description postcard!

PHOTO: NPS

PHOTO: MARY ELLEN HARTE

Top: mature plant; bottom: seedling.

Russian thistle *(Salsola tragus)*

Russian thistle first arrived in North America from Eurasia in 1873 through contaminated flaxseed. Commonly known as "tumbleweed," mature plants pull free from the soil and blow away, spreading their seeds across the land.

Identifying characteristics

- Shrub, 1-4 feet tall, very branched and round
- Stems with distinct reddish stripes when young
- Leaves alternate, linear, fleshy when young
- Flowers small, papery, without petals with 5 pink to greenish white sepals

Why is this plant a threat?

Since the late 1800s botanists have been concerned with the ability of Russian thistle to dominate disturbed soil in drought conditions. One plant can produce up to 250,000 seeds, increasing this species' ability to spread and dominate. It can cause allergies in humans. This plant can crowd out native plants and also impact recreation, overgrowing beaches prized for camping.

Management of Russian thistle

Until very recently, Russian thistle was relatively uncommon in the park's Inner Canyon. However, this plant can now be seen on virtually every beach and in many side canyons. Volunteers and biologists manually remove the young plants before they produce seed. The plants are left on site to dry. Each site requires several visits since the seed can remain viable for several years. This is a plant we could use help pulling, so please contact the park's Backcountry Vegetation Program Manager if you are interested in lending a hand.

Sahara mustard *(Brassica tournefortii)*


Sahara mustard basal rosette.

Sahara mustard is native to Mediterranean areas, thriving in the broad desert belt from northwestern Africa to the Saudi Arabian peninsula, preferring sandy and gravelly soils. Fully adapted to arid regions, the southwestern U.S. reminds this plant of home, allowing it to settle in and feel very comfortable. It spread exponentially during the moist spring of 2005—earning it the nickname "tsunami mustard."

Identifying characteristics

- Annual or biennial herb, to 4 feet tall and 3 feet wide
- Basal leaves deeply lobed, with rounded tips
- Stem leaves small, linear, with stiff hairs
- Flowers dull yellow with 4 petals


PHOTO: MARY ELLEN HARTE
Tumble mustard.

Two other similar mustards occur in Grand Canyon: London rocket (*Sisymbrium irio)* and tumble mustard *(S. altissimum*). London rocket usually only grows to 2 feet tall, with more slender, curved upright seedpods than Sahara mustard. Tumble mustard is common throughout the U.S., growing to about 3 feet tall. Its leaves are reduced and more linear toward the top of the plant, but the seed pod can grow to 5 inches long, even longer than that of Sahara mustard.

Why is this plant a threat?

Sahara mustard sprouts earlier than most native plants and its enormous basal leaves can smother surrounding plants and rob them of early spring moisture. It also coats its seeds with a sticky gel, helping them to cling to animals and catch a ride. As these giants die back in early spring, their large, dry bodies act like tumbleweeds, acrobatically rolling across the landscape, spreading seed far and wide and providing tinder for future fires.


PHOTO: NPS
London rocket.

Management of Sahara mustard

Sahara mustard is found in great numbers in both Glen Canyon and Lake Mead National Recreation Areas, surrounding Grand Canyon and poising itself for an advance. Park biologists and volunteers began an aggressive control program in the spring of 2004, with a primary focus on the Lees Ferry area. We now need all the help we can get to start searching for this plant in the river corridor and side canyons.

Sowthistles *(Sonchus* spp.*)*

Originally from Europe and Asia, sowthistles are now widely distributed throughout the United States. Three species of sowthistles grow in Grand Canyon: common sowthistle (*Sonchus oleraceus)*, spiny sowthistle (*Sonchus asper*), and perennial sowthistle (*Sonchus arvensis*). These species prosper in moist soils along rivers and springs. Flowerheads appear very similar to common dandelion.


PHOTO: JAMES H. MILLER
Perennial sowthistle flower/seedhead.


PHOTO: CHRIS EVANS
Common sowthistle.

Identifying characteristics for all 3 species:

- Plants about 1-6 feet tall but begin life as a small rosette
- Stems and leaves exude a milky sap when broken
- Yellow flowers mature into fluffy, dandelion-like seed heads

Common and spiny sowthistle characteristics:

- An erect and unbranched stem
- Alternately-arranged, bluish-green, hairless, toothed leaves

Spiny sowthistle characteristics:

- Leaves are much more prickly than those of common sowthistle

Perennial sowthistle characteristics:

- A smooth, unbranched lower stem, but a branched upper stem
- Alternately-arranged, shiny, green leaves
- Upper leaves smaller and fewer than lower leaves

Why are these plants a threat?

Sowthistles can displace native vegetation by invading disturbed and undisturbed sites. All species have seeds the wind can carry great distances, aiding their ability to spread. Usually you find hundreds of sowthistles growing at a site, not just a handful.

Management of sowthistles

Once you get a search image for these species, you start to see them everywhere. Current control focuses only at seeps, springs and side canyons in the Inner Canyon because these plants are so widespread in the river corridor. We need information about where they are in the side canyons. How widespread are they beyond the river corridor? How many plants are found in each location? You can help us get this information!


PHOTO: CHRIS EVANS
Spiny sowthistle.

Tamarisk *(Tamarix ramosissima)*


PHOTOS: NPS
Top: mature tree; bottom: flowers.

Originally from Eurasia, settlers introduced tamarisk into the western United States in the early 19th century. It was used as both an ornamental tree and for erosion control along riversides and in fields. It reached Grand Canyon during the early 1930s, but did not become a dominant plant along the Colorado River until after completion of Glen Canyon Dam in 1963.

Identifying characteristics

- Deciduous shrub or small tree, 12-15 feet tall, often forming dense thickets
- Leaves are alternate, gray-green, scaly
- Flowers are pink to white, appearing nearly year round
- Young branches and saplings have smooth, reddish-brown bark

Why is this plant a threat?

Tamarisk forms dense stands that usurp water and can quickly crowd out native vegetation such as willow and cottonwood trees. Once established, tamarisk trees create dense piles of leaf litter below their canopy, making it tough for native plant seedlings to establish. This litter also increases salt levels in the soils, making it difficult for native plants to survive.

Management of tamarisk

Although tamarisk is well-established along the Colorado River corridor, it is succumbing to efforts aimed at controlling its spread in Grand Canyon's side canyons. Through the Tamarisk Management and Tributary Restoration Program, staff and volunteers use herbicides and hand saws to fight this persistent invader. This ongoing project, which began in fall 2002, has resulted in a 99 percent reduction of tamarisk coverage in treated areas and native plants are returning and thriving. We need help mapping and pulling tamarisk seedlings in select side canyons, so please let us know if you are interested in joining the team.

Tree of heaven *(Ailanthus altissima)*

PHOTO: NPS

PHOTO: JAMES H. MILLER

Top: mature plant; bottom: leaves.

Native to China, tree of heaven was introduced to the United States in the late 18th century, moving west during the California gold rush. Today, it can be found in 42 states from Maine to Florida and west to California, often in dense patches with few other native plants.

Identifying characteristics

- Deciduous tree to 80 feet tall and 6 feet wide
- Bark light gray, cracked, and branches gray, smooth and glossy
- Leaves large, compound, 1-4 feet long, leaflets to 7 inches long
- Flowers small, greenish-yellow, with 5 petals, appearing from April to June
- All parts of the tree emit a strong, offensive odor
- Fruit flat, papery, wing-shaped, with twisted tips

Why is this plant a threat?

Tree of heaven spreads rapidly, often forming dense thickets and displacing native vegetation. It can grow from seed but most often spreads through its well-developed rhizomes and roots. It outcompetes native plants by releasing toxins that inhibit the growth of other plants.

Management of tree of heaven

This aggressive tree has only been found at one location within the park, less than a mile up Kanab Creek from the river. It was quickly removed the same year a boatman informed park biologists about it. It is very likely that there are more tree of heaven in the park, which is why your help is needed. Please learn to identify this tree and notify park biologists if and where you find one.

The Grand Canyon National Park Foundation works to build the ethic of stewardship for Grand Canyon through private philanthropy, volunteer leadership, and public outreach. Donations to the Foundation support projects that protect and preserve the Canyon's irreplaceable natural, cultural, and historic resources while enhancing the visitor experience.

625 North Beaver Street Flagstaff, AZ 86001 ph 928.774.1760 fx 928.774.1240 www.gcnpf.org

The Arizona Water Protection Fund Commission has funded a portion of this brochure. The views presented are the Grantee's and do not necessarily represent those of the Commission, the State, or the Arizona Department of Water Resources.

FEBRUARY 2004

Grand Canyon

National Park Service
U.S. Department of the Interior

Grand Canyon National Park
Arizona

Tamarisk Management and Tributary Restoration

Tamarisk (on left) growing near a water source

Tamarisk (Tamarix ramosissima), also known as salt cedar, is a highly invasive plant native to Eurasia. Introduced to the U.S. in the 19th century as an erosion control agent, tamarisk has since spread throughout the West, causing major changes to natural environments. Tamarisk reached the Grand Canyon area during the early 1930s, becoming a dominant riparian zone species along the Colorado River following completion of Glen Canyon Dam in 1963. Despite the dominance of tamarisk in the river corridor, the tributaries and side canyons of the Colorado River, and the seeps and springs within Grand Canyon National Park, are among the most pristine watersheds and desert riparian habitat remaining in the United States. The encroachment of tamarisk into these tributaries now poses a significant threat to the integrity of natural ecosystems within the Park.

Why is tamarisk undesirable?

Although wildlife species use this plant for shelter, food, or nesting habitat, and people rely on it for shade, tamarisk threatens the park's native ecosystems. A large mature tree is capable of producing close to a million seeds, which are dispersed by wind and water, making tamarisk an aggressive invader. Tamarisk spreads quickly in riparian areas and often develops into monoculture stands, which lower water tables. Dense thickets of tamarisk trees crowd out native vegetation, reduce suitable wildlife habitat, increase fire frequency and negatively affect the hydrology of riparian areas. National Park Service policies call for managing non-native species "if control is prudent and feasible, and the exotic species interferes with natural processes and the perpetuation of natural features, native species, or natural habitats." Tamarisk in side canyons and tributaries of the Colorado River meets these criteria. The Tamarisk Management and Tributary Restoration project seeks 1) to prevent further loss or degradation of the existing native flora and fauna and 2) to restore more natural conditions, thereby protecting the park's riparian areas, some of the nation's last intact examples of these rare desert ecosystems.

Project history and methods

Through a public review process, called an Environmental Assessment / Assessment of Effect, park management evaluated the impacts to natural, cultural and wilderness resources, and solicited public comments. Through this process the environmentally preferred alternative was selected, and includes the control of tamarisk in side canyons, tributaries, developed areas, and springs above the pre-dam water level of the Colorado River.

Crews remove tamarisk through a combination of mechanical and chemical controls, allowing for native vegetation to recover. The size of the plant usually dictates how it is removed. Methods include pulling, cutting to stump level, or girdling it to leave the dead tree standing for wildlife habitat. The combination of hand tools and herbicide ensures maximum effectiveness with minimum impact to visitors and the environment. The particular method used is specific to each site and determined by the restoration biologist or on-site project leader.

Project update

Phase I of the project, supported by the Arizona Water Protection Fund (AWPF), the Colorado River Fund (CRF), the Grand Canyon National Park Foundation (GCNPF), the Grand Canyon Wildlands Council (GWC), and the NPS began in 2002 with 63 side canyons. The AWPF provided funding for the NPS and GCNPF to expand this project into 35 additional side canyons during 2005-06 (Phase IIa), and another 30 side canyons during 2006-07 (Phase IIb). Some Phase IIb project areas lie on Hualapai Tribal lands, and combined NPS and Hualapai crews work cooperatively in these areas.

To date, crews have completed work in 130 project areas, removing more than 250,000 tamarisk trees from over 5,000 acres of the park's inner canyon. Only 12% of the initially controlled trees require follow-up treatment.

Prior to project implementation, biologists assess areas for potential habitat of the endangered southwestern willow flycatcher and install long-term monitoring components. The monitoring includes 35 vegetation transects and more than 1000 fixed photo points. Post treatment assessment of vegetation transects in 2004, showed a 99% reduction of tamarisk cover and an increase in the presence of native plants. Park biologists will continue to monitor project areas for 5-10 years.

Upcoming work

From September 2006 through March 2007, crews will be working in side canyons along the Colorado River. Crews will be spending several weeks at Phantom Ranch and Cottonwood Campground to complete tamarisk removal along Bright Angel Creek. They will also be conducting backpacking trips into more remote tributaries.
For project reports and the Environmental Assessment/Assessment of Effect for this work please refer to the park's webpage: www.nps.gov/grca

If you would like additional information about this project, please contact the park's Backcountry Vegetation Program Manager and Project Coordinator at: Lori_Makarick@nps.gov

If you would like to volunteer to help with this effort, please contact Terra Crampton at the Grand Canyon National Park Foundation, (928)774-1760, or terra@gcnpf.org

Or visit www.gcvoluteers.org

Special thanks

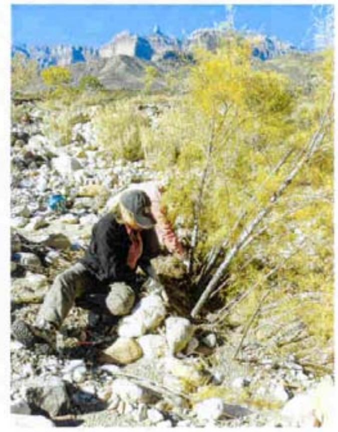
The tamarisk management project is extremely labor intensive and time consuming. The enormous progress made over the last six years is largely due to the hard work of volunteers who have collectively donated more nearly 30,000 hours of their time to this project. We thank all of the individual volunteers for making this project a success!

NOTICE

Tamarisk control work is ongoing from September-March each year. As you visit portions of the Inner Canyon, you will notice cut stumps and you may encounter work crews. In addition to removing smaller trees with hand tools, certified herbicide applicators selectively spray the herbicide Garlon, which is low in toxicity, directly onto the cut stumps and not into creek or water sources. If you are in area while crews are working or 1-2 days after the work is completed, you may notice a varnish odor from the oil mixed with the herbicide.

APPENDIX F – Project Press Examples

THE GRAND CANYON NEEDS YOUR HELP!
Tamarisk Backpacking Project



Grand Canyon National Park is looking for motivated, enthusiastic individuals to work as short-term volunteers with the Park's Backcounty Vegetation Program!

One of the most significant threats to global biodiversity is the invasion of exotic plants. Tamarisk (*Tamarix ramosissima*), commonly known as salt cedar, is an invasive exotic tree that grows in dense stands along rivers and streams in the western United States. Tamarisk, introduced to the U.S. in the 19th century as an erosion control agent, rapidly spread and established throughout the West and caused major changes to natural environments. These prolific non-native trees displace native vegetation, create conditions that are inhospitable for the germination of native plant seeds, impact wildlife abundance, and increase fire frequency.

The spread of tamarisk has gone beyond the river corridor of the Grand Canyon and poses a significant threat to tributaries and springs that remain as some of the last examples of pristine riparian habitat in the desert southwest. This encroachment not only threatens native vegetation communities but also wildlife that depends upon these sources of water. Luckily, you can help!

September 2006 marks the beginning our fifth year of the Tamarisk Management and Tributary Restoration Project. To date, volunteer crews have removed over 200,000 tamarisk trees from over 100 side canyons. Volunteers are critical to making this project a success and have donated over 20,000 hours, kneeling beneath dense canopies with hand saws in action. Does this sound like fun to you? At this point in the project, we are reaching remote areas via backpacking on 4-8 day trips. The work is hard and the days are long, but the sense of community and accomplishment are great.

Volunteer Requirements:
Ability to...

- live in remote areas with few amenities where inclement weather is possible.
- work extended schedules with long work days.
- maintain a positive attitude in a group setting for extended periods of time.
- backpack with a load of 50 pounds or more over rough terrain.

For more information or to sign up for a trip contact Terra Crampton at:
terra@gcnpf.org (928) 774-1760 or visit our website: www.gcvolunteers.com

INVASIVE WEED AWARENESS COALITION (IWAC)

Taking Back The Grand Canyon from Tamarisk (Saltcedar) Infestation

Removing saltcedar in the Grand Canyon.

Grand Canyon National Park has some of the nation's last remaining native desert riparian ecosystems. The side canyons and tributaries that line the Colorado River are especially valuable to hundreds of wildlife species. Since the 1930s, when tamarisk (*Tamarix ramosissima*), more commonly referred to as saltcedar, reached the Grand Canyon area and started growing densely along the river's slopes, this precious ecosystem has been jeopardized.

The National Park Service has been managing saltcedar in Grand Canyon National Park since 2002.

Challenge:

Saltcedar, a non-native shrub from Asia and Africa, is a highly aggressive invasive species. The average saltcedar tree produces 600,000 seeds, and one acre of living saltcedar trees consumes 977,553 gallons of water per year. Because saltcedar has been growing in Grand Canyon National Park for more than 70 years, it has impacted water availability in side canyons and tributaries to the Colorado River, as well as crowded out native riparian plant species, such as willow and cottonwood.

Solution:

In 2000, the Grand Canyon Park Service staff conducted an environmental assessment to evaluate the impact of saltcedar in the park. The assessment revealed the devastation of saltcedar on the biodiversity in the area, which led to a tamarisk management and tributary restoration project. The Arizona Water Protection Fund Commission funded all or a portion of this project. Work crews comprised of staff and volunteers began monitoring saltcedar infestation locations and levels. In 2002, teams began removing saltcedar through a combination of mechanical and chemical means, including manual removal and various single-plant targeted herbicide application methods. The labor-intensive work continues today from September to March every year, thanks to the efforts of hundreds of volunteers from all over the country.

One acre of living saltcedar trees consumes 977,553 gallons of water per year.

Result:

Since beginning the saltcedar management effort, Grand Canyon staff and volunteers have removed 119,498 seedlings, 42,892 saplings and 13,294 mature plants, for a grand total of 175,684 removed saltcedar trees and a 99 percent reduction of saltcedar coverage in the project areas. The staff also closely monitors any impact to other vegetation, wildlife, water or soil in the area. Preliminary results show a resurgence of native plant species. Using the saltcedar removal project as a model for future projects, Grand Canyon staff has begun controlling other invasive exotic species within the main Colorado River Corridor. They hope to manage these infestations before they spread into the adjoining side canyons.

NIWAW
NATIONAL INVASIVE WEED AWARENESS WEEK

Learn More:
Lori Makarick
(928) 226-0165
Lori_Makarick@nps.gov

NIWAW Information:
Gina Ramos, Bureau of Land Management (BLM)
(202) 452-5084
gina_ramos@blm.gov

Lee Van Wychen, Ph.D.
National and Regional Weed Science Societies
(202) 408-5388
lee.vanwychen@weedscienceorgs.com

To learn from other success stories, visit www.weedcenter.org and www.nawma.org
For more weeds information, visit www.blm.gov

Put In > NEWS

Canoe & Kayak
July 2006

Botanical Warfare

A diligent crew of volunteers is battling invasive tamarisk trees on the Colorado.

> **THE RAFTS ARE UNLOADED,** camp is set up, and a group of river-runners walk up one of the Grand Canyon's spectacular side canyons. This isn't just another crew going for a hike, however. These are tamarisk hunters, and they are bent on eliminating *Tamarisk ramosissima*—the dreaded invader of western desert rivers.

Tamarisk trees were introduced to America from the Mediterranean in the mid-1800s. The species flourished in its new home, and now river corridors throughout the Southwest are choked with the invasive trees. Tamarisk trees increase ground salinity, inhibit the growth of native species, displace wildlife, and siphon precious springs. In short, the tamarisk is a nightmare.

Fortunately, the tamarisk is on its way out. Twice a year, the National Park Service rallies several volunteers for a raft trip in The Ditch. The participants raft between camps, then hike to previously identified tamarisk groves and attack the trees with hatchet, ax, and saw.

Before signing up, one should know that these trips are no paid vacations. They are done mostly in winter, and long, cold river days are followed with brutal physical work. Tamarisk trunks must first be dug out from beneath compacted flood debris, and then cut with handsaws. The exposed stumps are painted with herbicide to inhibit regrowth.

The NPS chose Garlon as an effective but low-impact herbicide. It is absorbed by the stumps and kills tamarisk roots, but goes no farther. Without the herbicide treatment, the resilient trees resprout rapidly, and all the saw work is for naught.

So far, native plants have recolonized treated areas, and springs that were nearly sucked dry by tamarisks are returning to historical flows. —*Tyler Williams*

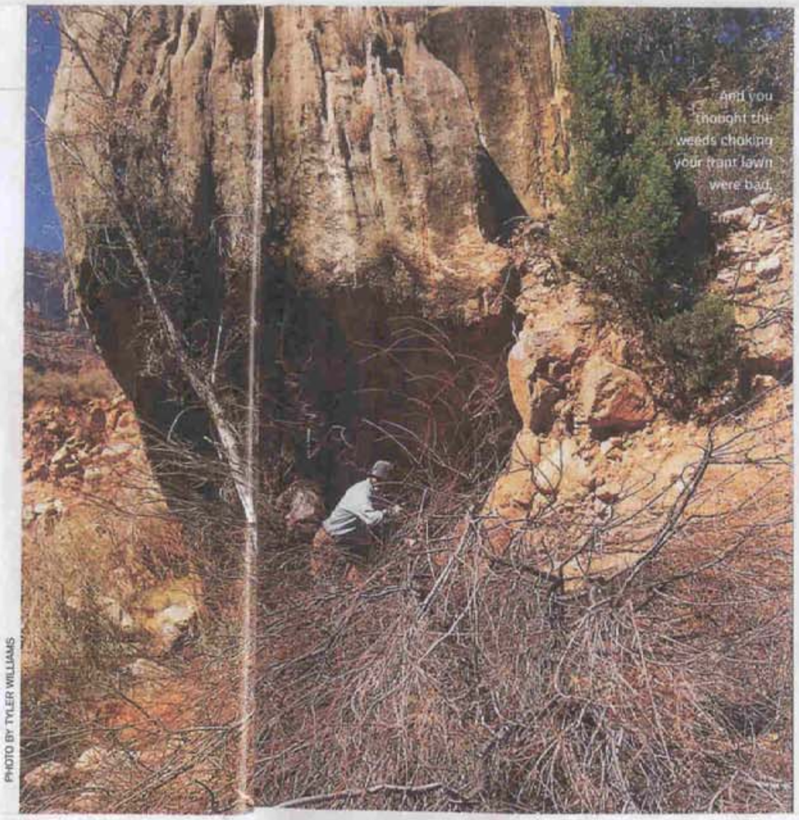


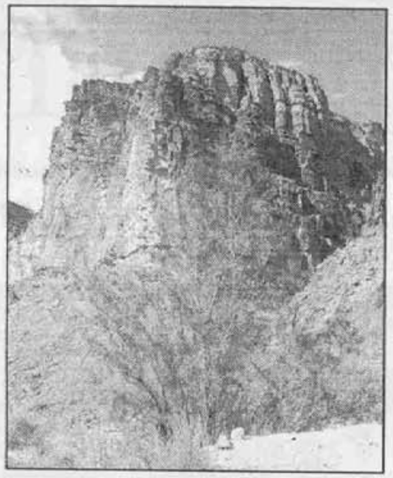
PHOTO BY TYLER WILLIAMS

And you thought the weeds choking your front lawn were bad.

Grand Canyon Nation Park - the Guide

Park News

Controlling an Invader



As you travel throughout the Southwest, you will likely see a small, many-branched tree with feathery, drooping leaves—the tamarisk (*Tamarix ramosissima*) or salt cedar. Introduced in the 19th century as an erosion control agent and for ornamental purposes, the highly invasive tamarisk spread throughout the West, causing major changes to natural environments. This exotic species reached the Grand Canyon area in the 1930s, but only became dominant along the Colorado River following completion of Glen Canyon Dam in 1963.

Although people and wildlife species use this plant for shelter, food, or nesting habitat, tamarisk threatens the park's native ecosystems. An average tree produces about 600,000 seeds (a mature tree may develop more than 250 million seeds), which wind and water disperse widely. Tamarisk roots can reach depths of more than 100 feet (30 m), outcompeting many native species. As tamarisk invades the beaches and side canyons of the park, it crowds out native vegetation, displaces wildlife, usurps valuable water, and leads to ecosystem-level changes.

National Park Service policies call for managing exotic (or nonnative) species "if control is prudent and feasible, and the exotic species interferes with natural processes and the perpetuation of natural features, native species, or natural habitats." The Tamarisk Management and Tributary Restoration project seeks to prevent further loss or degradation of the existing native flora and fauna and restore more natural conditions to protect the park's riparian areas.

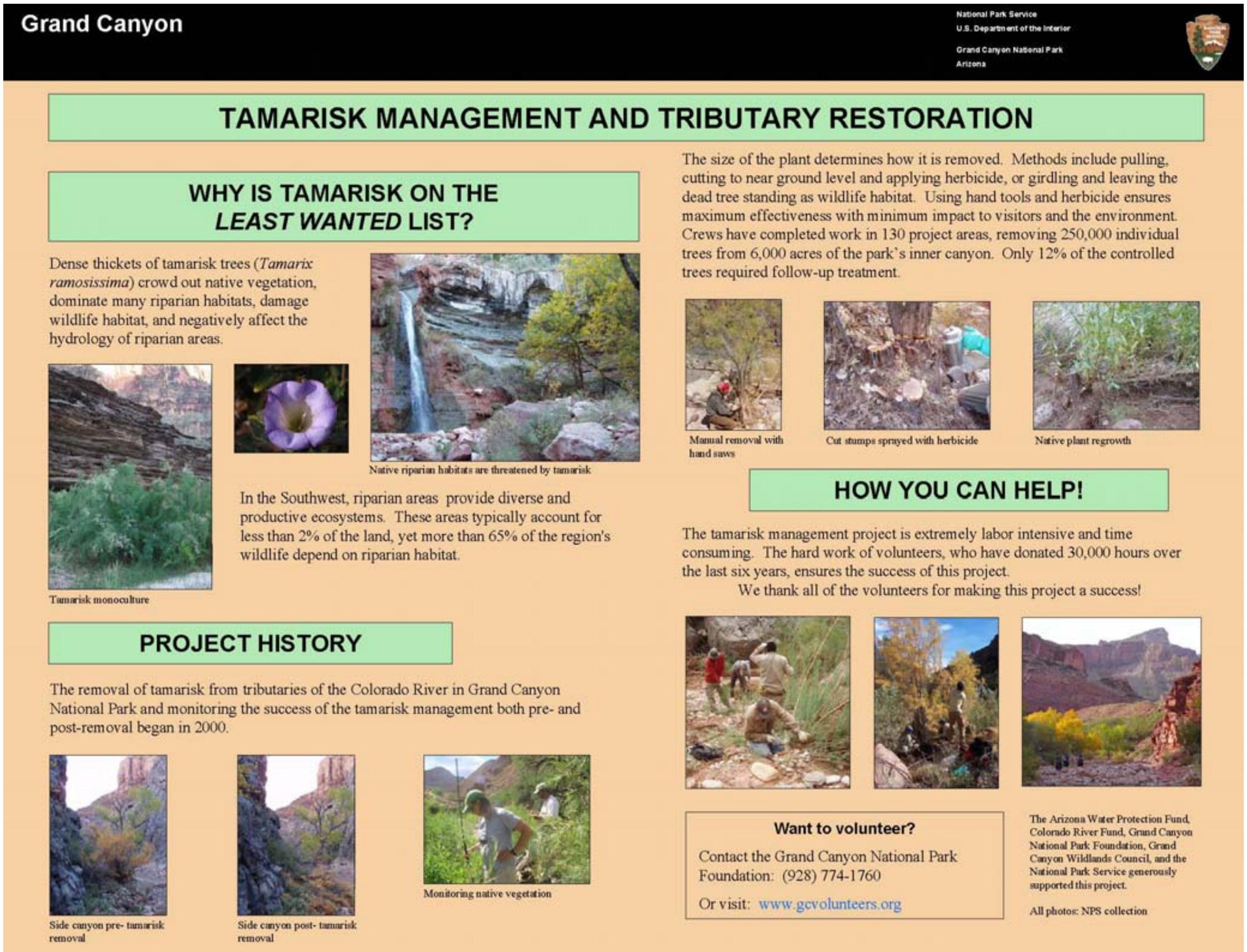
Through a public review process, the park evaluated the beneficial and adverse impacts of a tamarisk management project to natural, cultural, and wilderness resources. Environmentally acceptable actions include mechanical (hand-pulling or cutting) and chemical control of tamarisk in side canyons, tributaries, developed areas, and springs.

Control efforts began in 2002 with support from the Arizona Water Protection Fund, the Colorado River Fund, the Grand Canyon National Park Foundation, the Grand Canyon Wildlands Council, and the National Park Service. To date, crews have completed work in nearly 100 project areas, removing in excess of 180,000 tamarisk trees from more than 5,000 acres. Only seven percent of the initially controlled trees required follow-up treatment. This ongoing project has resulted in a 99 percent reduction of tamarisk in treated areas. Native plants are returning and thriving.

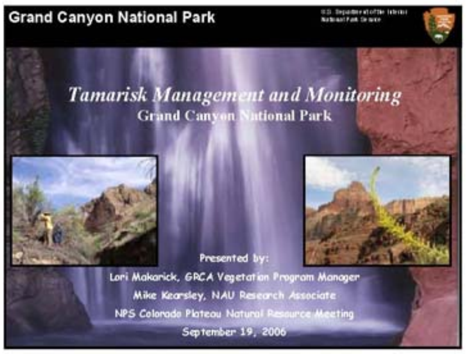
Enormous progress has been made over the past three years with the hard work and dedication of volunteers. The National Park Service thanks all of the volunteers and welcomes new folks to the team. If you are interested in volunteering at Grand Canyon National Park visit www.volunteer.gov/gov or www.gcvolunteers.org. Find the volunteer description and apply online.

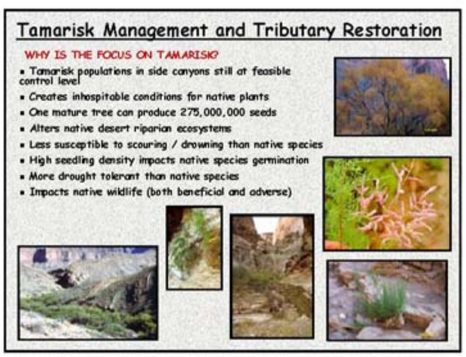
For more detailed project information, refer to the compliance documents and project reports posted on the park's webpage www.nps.gov/grca.

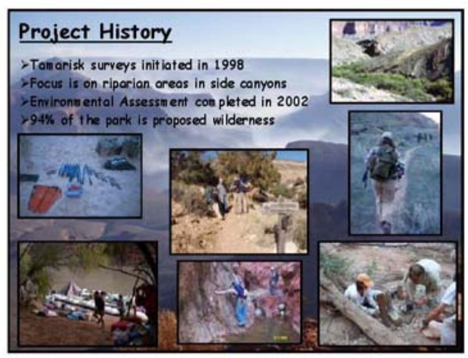
APPENDIX G – Project Poster

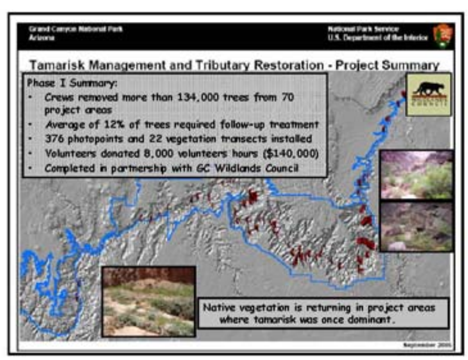


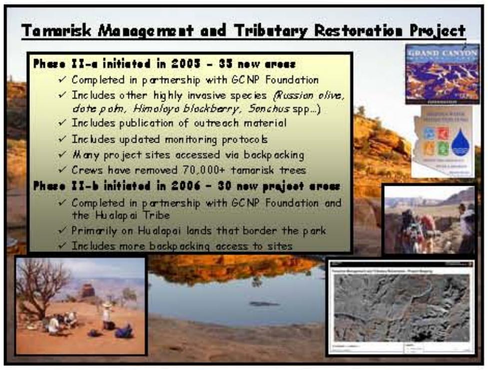
APPENDIX H – Presentation Examples





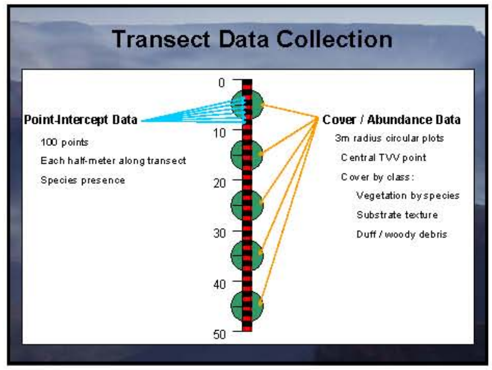


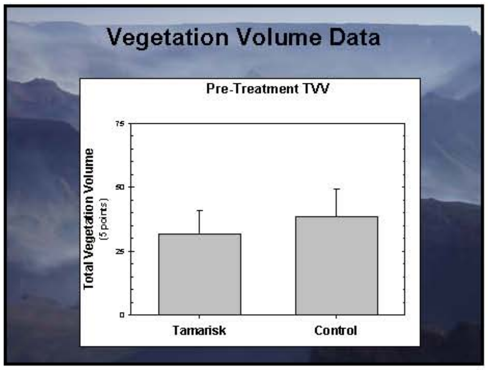


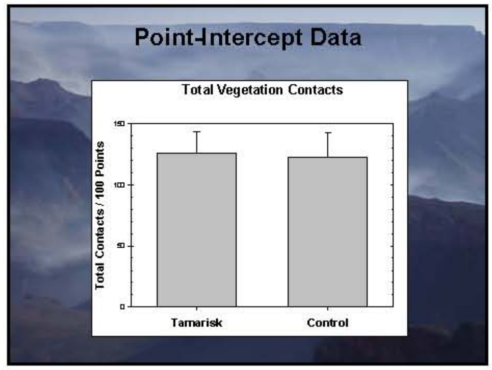

Tamarisk Management and Tributary Restoration Project
Phase II-a initiated in 2005 – 35 new areas
✓ Completed in partnership with GCNP Foundation
✓ Includes other highly invasive species (Russian olive, date palm, Himalaya blackberry, Sonchus spp…)
✓ Includes publication of outreach material
✓ Includes updated monitoring protocols
✓ Many project sites accessed via backpacking
✓ Crews have removed 70,000+ tamarisk trees
Phase II-b initiated in 2006 – 30 new project areas
✓ Completed in partnership with GCNP Foundation and the Hualapai Tribe
✓ Primarily on Hualapai lands that border the park
✓ Includes more backpacking access to sites
GRAND CANYON


Project Area Inventory
Jane's globemallow
Sphaeralcea janeae
dark-throat shooting star
Dodecatheon pulchellum ssp. pulchellum
paleface
Hibiscus denudatus

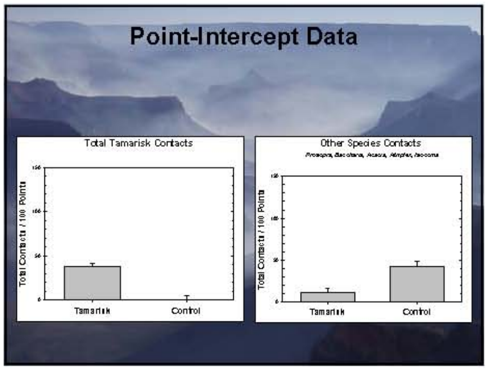

Project Monitoring
Vegetation transects installed in 20% of project areas
➢Point Intercept
➢Vegetation Structure
➢Additional Vegetation Cover & Substrate Data
➢Soil Data
➢Hydrological Data
➢Wildlife Observations
➢Additional Site Data
➢Photopoints

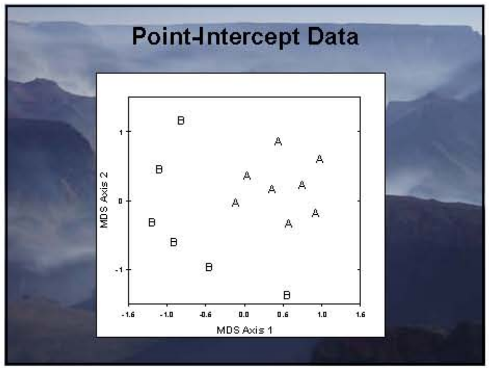

Transect Data Collection
Point-Intercept Data
100 points
Each half-meter along transect
Species presence
0
10
20
30
40
50
Cover / Abundance Data
3m radius circular plots
Central TVV point
Cover by class:
Vegetation by species
Substrate texture
Duff / woody debris

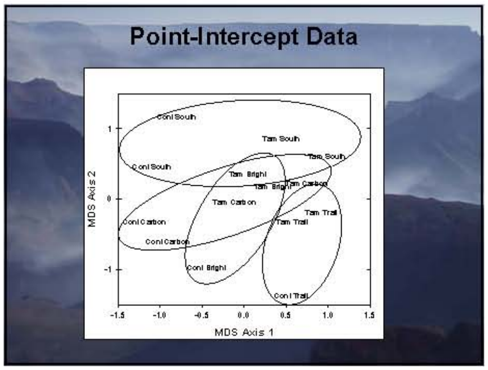

Vegetation Volume Data
Pre-Treatment TVV
Total Vegetation Volume
(5 points)
0
25
50
75
Tamarisk
Control

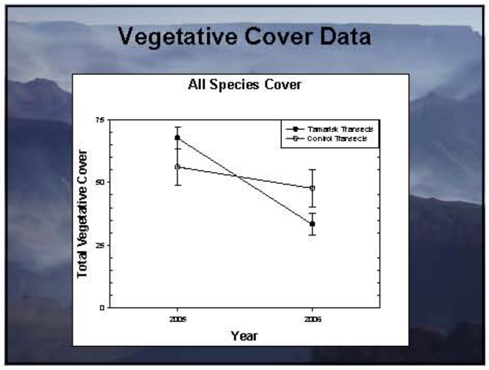

Point-Intercept Data
Total Vegetation Contacts
Total Contacts / 100 Points
0
50
100
150
Tamarisk
Control

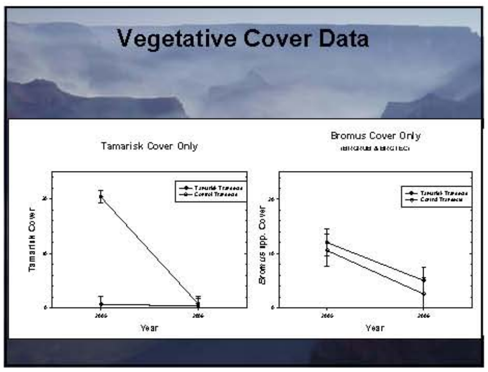
2

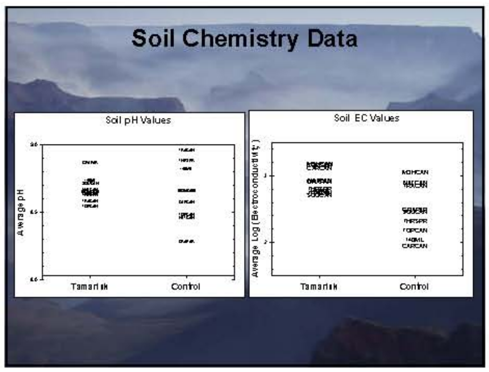

Point-Intercept Data
Total Tamarisk Contacts
Total Contacts / 100 Points
Tamarisk
Control
Other Species Contacts
Total Contacts / 100 Points
Tamarisk
Control


Point-Intercept Data
MDS Axis 2
MDS Axis 1


Point-Intercept Data
MDS Axis 2
MDS Axis 1

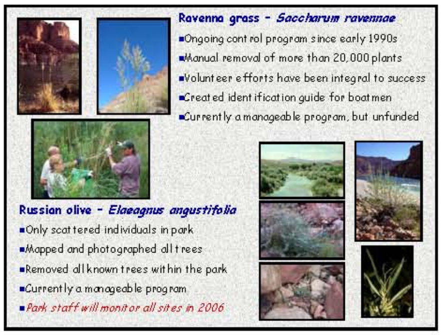

Vegetative Cover Data
All Species Cover
Tamarisk Transects
Control Transects
Total Vegetative Cover
Year

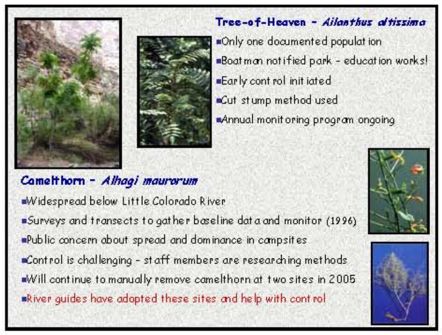

Vegetative Cover Data
Tamarisk Cover Only
Tamarisk Cover
Year
Bromus Cover Only
Bromus spp. Cover
Year


Soil Chemistry Data
Soil pH Values
Average pH
Tamarisk
Control
Soil EC Values
Tamarisk
Control

3

GRCA Backcountry Invasive Plant Management Update for Staff
August 22, 2006

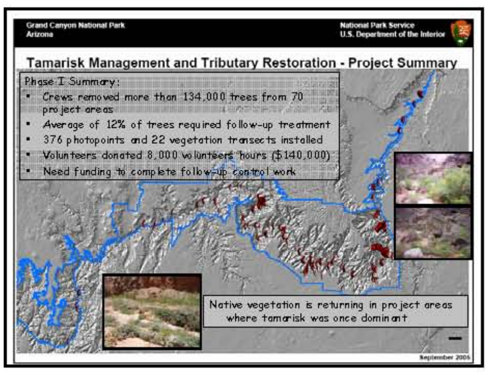




1


Tamarisk Management and Tributary Restoration
What is being done to control tamarisk in Grand Canyon National Park?
➢Tamarisk surveys initiated in 1998
➢Environmental Assessment completed in 2002
➢Project divided into 3 distinct phases
➢First 6 years primarily funded by the Arizona Water Protection Fund
➢Focus is on riparian areas in side canyons


94% of Park is proposed wilderness


Grand Canyon National Park
Arizona
National Park Service
U.S. Department of the Interior
Tamarisk Management and Tributary Restoration - Project Summary
Phase I Summary:
• Crews removed more than 134,000 trees from 70 project areas
• Average of 12% of trees required follow-up treatment
• 376 photopoints and 22 vegetation transects installed
• Volunteers donated 8,000 volunteers hours ($140,000)
• Need funding to complete follow-up control work
Native vegetation is returning in project areas where tamarisk was once dominant
September 2005


Tamarisk Management and Tributary Restoration Project
Phase II-a initiated in 2005 – 35 new areas
✓ Completed in partnership with GCNP Foundation
✓ Includes other highly invasive species (Russian olive, date palm, Himalaya blackberry, Sonchus spp…)
✓ Includes publication of outreach material
✓ Includes updated monitoring protocols
✓ Control trips scheduled through December 2006
✓ Many project sites accessed via backpacking
✓ Crews have removed 60,000+ tamarisk trees
Phase II-b initiated in 2006 – 30 new project areas
✓ Completed in partnership with GCNP Foundation and the Hualapai Tribe
GRAND CANYON


Project Monitoring
We install vegetation transects in 25% of project areas
➢ Point Intercept
➢ Vegetation Structure
➢ Additional Vegetation Cover & Ground Cover Data
➢ Soil Data
➢ Hydrological and Wildlife Data Collection
We install photopoints in ALL project areas


Plant species inventories are completed in each project area
Jane's globemallow
Sphaeralcea janeae
dark-throat shooting star
Dodecatheon pulchellum ssp. pulchellum
paleface
Hibiscus denudatus

2