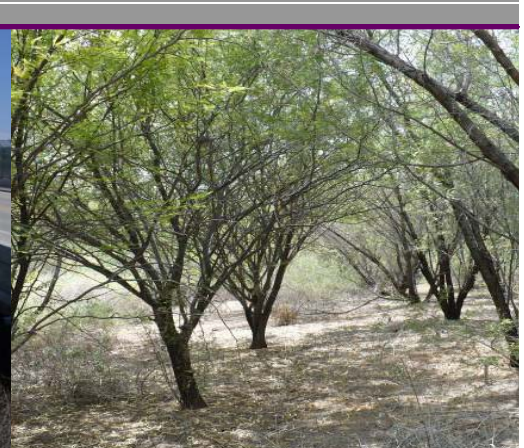
Determination of Section 404 Permit and Habitat Mitigation Requirements

Final Report 589
September 2012





Arizona Department of Transportation
Research Center

DETERMINATION OF SECTION 404 PERMIT AND HABITAT MITIGATION REQUIREMENTS

Final Report 589
September 2012

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16. Abstract

The Arizona Department of Transportation (ADOT) is committed to developing habitat, mitigation, monitoring, and maintenance plans that replace the loss of the functions and values of an area and are self-sustaining, thereby providing long-term compensation for habitat adversely affected by ADOT construction activities. This study focuses on identifying administrative and biological criteria that are important to the success or failure of mitigation and/or restoration projects and developing recommendations from these criteria. Files on ADOT and non-ADOT riparian habitat restoration and mitigation projects were obtained from several sources and were reviewed for project applicability to the study goals. Thirty-four sites were selected for further analysis. In addition, employees from the Corps and ADOT were interviewed to gain a realistic perspective. A review of project files, associated site data sheets, and analysis of the interview results yielded mitigation practices and a variety of administrative and biological problems commonly associated with restoration projects in Arizona. More specifically, the problems are associated with ADOT mitigation projects for which Clean Water Act Section 404 permits are involved. Recommendations based on analysis of these problems, review of applicable peer-reviewed literature, and research team expertise, are offered in this report to aid future ADOT projects and all future restoration projects in Arizona, regardless of the agency or organization undertaking the restoration of riparian areas.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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LIST OF ACRONYMS

ADOT	Arizona Department of Transportation
ADWR	Arizona Department of Water Resources
AGFD	Arizona Game and Fish Department
DEC	district environmental coordinator
EPA	Environmental Protection Agency
EPG	Environmental Planning Group
FHWA	Federal Highway Administration
FCDMC	Flood Control District of Maricopa County
MP	milepost
NEPA	National Environmental Policy Act
NGO	non-governmental organization
NWP	nationwide permit
PVC	polyvinyl chloride
SR	state route
TI	traffic interchange

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EXECUTIVE SUMMARY

Using current U.S. Army Corps of Engineers (Corps) guidelines as the backdrop, this study focuses on determining administrative processes and biological factors that are important to the success or failure of land restoration and disturbance mitigation projects. Data were collected by identifying past or ongoing projects of the Arizona Department of Transportation (ADOT) and other agencies that have habitat restoration or disturbance mitigation components, conducting site visits as needed, and interviewing Corps project managers and ADOT employees who work with mitigation projects. The data were used to assess the condition of mitigation plantings at these projects and from this analysis, to identify factors important to the success or failure of such projects.

ADOT and the Federal Highway Administration (FHWA) are committed to mitigating the ecological impact of ADOT construction on an area. They do this by executing plans that provide for the replacement of lost habitat with plants that will be self-sustaining in the long run. ADOT has concluded that its projects too often fail to meet the planting success criteria contained in the mitigation requirements of Corps' Clean Water Act, Section 404, permits. When these requirements are not initially met, the replantings and extension of monitoring periods needed to do so create time and cost burdens for ADOT, the FHWA, and Arizona taxpayers. ADOT and the FHWA have concluded that research is needed to ensure that mitigation developed for future ADOT projects meets the criteria required by the Corps.

Methods

Files on ADOT and non-ADOT habitat restoration and land disturbance mitigation projects were obtained from the Corps; internal EcoPlan Associates, Inc. (EcoPlan) project files; the University of Arizona Water Resources Research Center; and the Arizona Department of Water Resources (ADWR). The files were reviewed to determine project goals, the level of available detail such as planting plans and follow-up monitoring reports, and overall file completeness. Researchers selected 34 projects for detailed study: 19 ADOT projects, four projects from the Flood Control District of Maricopa County (Flood Control District), and 11 restoration projects undertaken by private entities or non-governmental organizations (NGOs). Of these 34 projects, 23 were selected for further evaluation through site visits by EcoPlan biologists. Eleven of the sites visited were ADOT project sites, four were Flood Control District sites, and eight were private or NGO sites. Researchers used information in the file and field observations to make an overall determination of each project's success.

One-on-one interviews with select Corps and ADOT employees provided important insights into the causes of success or failure of mitigation projects. Researchers obtained firsthand knowledge from individuals who are, or should be, involved in the mitigation process. ADOT employees were interviewed using a standardized set of questions to facilitate comparison and analysis of responses.

Results

A review of project files, site visit observations, and associated site visit data sheets and photo logs yielded seven common mitigation practices:

- Planting stock collected at the site.
- Planting nursery stock.
- Planting stock raised in tall pots.
- Testing the soil before planting.
- Replacing dead trees on a regular basis.
- Salvaging and transplanting saguaros.
- Seeding or hydroseeding.

These practices have varying levels of success.

The project file review and associated site visits also yielded a list of problems that occurred during the mitigation projects, although these did not always lead to failure. Many of the projects had multiple problems, which increased their potential to fail. The problems were divided into two main categories: administrative processes and biological factors. Some problems, such as unmaintained irrigation, were classified as both.

Administrative process problems were:

- Failure to monitor mitigation plantings.
- Failure to inspect the irrigation system.
- Premature removal of irrigation systems.
- Not initiating or not completing the planned mitigation work.
- Mitigation monitors who lacked monitoring experience.
- Disconnects in project knowledge and follow-through caused by staff turnover.
- Overplanting.
- Not irrigating.
- Not using a reference plot to create mitigation or planting plans.
- Revising mitigation plans due to an unsuccessful original plan.

Biological factor problems were:

- Direct damage to the planted vegetation from wildlife, cattle, or both.
- Wildlife damage to irrigation lines.
- Transplant shock.
- Drought stress.
- Insect and pest damage.
- Invasion of the project site by tamarisk or other invasive plants.
- Root-bound nursery plants.
- Parasitic infestation by mistletoe.
- Improper handling of tall-pot container trees prior to planting.
- Natural events such as flooding and fire.

Results of the interviews with Corps and ADOT employees were subjective and variable, so those data were analyzed in a slightly different manner from the other data. Comments were categorized as either administrative process or biological factor, with the following subcategories added to clarify the results:

Administrative processes:

- In-lieu fees and other off-site mitigation.
- Responsible parties.
- Staffing and training.
- Other agency involvement.
- Mitigation plans and monitoring.

Biological factors:

- Planting.
- Seeding.

ADOT employees were split between opposition and support for in-lieu fees: Five respondents opposed and eight favored use of in-lieu fees as a mitigation method. Most interviewees agreed that ADOT should designate a staff position responsible for developing mitigation plans and monitoring their completion from project beginning through final acceptance by the Corps. Employees most commonly suggested the ADOT district environmental coordinator (DEC) as the responsible position.

The issue of staffing and training came up tangentially during some of the interviews, where it was noted that there is an overall need for dedicated, local personnel who are involved with each project and for increased cross-training among all employees so everyone understands all of the components of a project, including mitigation work. Interviewees indicated that mitigation and planting plans should be developed by someone with experience in desert ecology, not by someone whose experience is limited to urban landscaping only.

According to interviewees, working with multiple agencies on one project can be difficult because of differing goals and priorities, making mitigation less likely to succeed. Three interviewees suggested that the Corps be involved in the process from the beginning to ensure everyone agrees on a mitigation plan's goals and success criteria.

Five ADOT employees indicated that mitigation plans and monitoring need to have specific success criteria; three said plans should be site-specific. Five ADOT employees said that monitoring should be conducted by consultants; three said these consultants should have a minimum of two or three years of experience.

Biological factors were fairly wide ranging, but the most commonly stated problems were issues with irrigation, seasonality, and animal damage to plantings. Many ADOT interviewees were unfamiliar with using tall-pot plantings to minimize irrigation needs. Time of planting was another concern because mitigation plans are often based on the construction schedule rather than the biological schedule of plants.

The interviews with Corps employees only covered administrative process issues and yielded many of the same responses as the ADOT employee interviews. However, the Corps project managers in general favored the use of in-lieu fees. Five project managers mentioned problems obtaining permittee compliance with mitigation requirements of Section 404 permits, including monitoring and reporting. Mitigation plans often lack required information. One project manager saw insufficient monitoring and compliance as one of the biggest problems. Another said that ADOT's chain of responsibility is not strong enough and does not hold contractors sufficiently responsible for their actions or inactions.

Discussion

Though many problems were identified, inefficiency was frequently noted by ADOT and Corps interviewees. For example, mitigation plans that are not based on desert ecology and local conditions ultimately fail and require replanting and extended monitoring. This causes additional expense for ADOT, the contractor, or both.

Another problem they noted was inadequate planning, monitoring, and maintenance of the irrigation system, and seasonal adjustment of the frequency and duration of supplemental water. Failure of the irrigation system or application of insufficient depth and frequency of supplemental water most often results in failure of the mitigation plantings.

In some cases, disconnects occur when projects transition between employees or departments, making it difficult to follow the progress of mitigation and maintain oversight of the contractor.

Clear objectives, specific measures of success, and a clearly defined monitoring plan detailed in the mitigation plan are key to project success. Replacement ratios should be based on site-specific characteristics and the use of multiple reference plots. Cooperation with the Corps and other agencies in the early phases of the project will ensure that all agencies understand the objectives and success criteria of a mitigation project. A qualified ADOT employee or consultant should develop mitigation plans; plan implementation should include biological timing considerations.

If no viable on-site or nearby off-site opportunities exist for compensatory mitigation, in-lieu fees should be considered. The Corps rule regarding mitigation, "Compensatory Mitigation for Losses of Aquatic Resources," which became effective June 9, 2008, encourages the use of in-lieu fees over permittee-responsible mitigation. According to Corps managers, in-lieu fees may especially be appropriate for linear projects where the impacts are small and occur within the right of way.

Recommendations

A partial list of recommendations that were developed based on the data analysis is given below. A complete list of recommendations is given in Chapter 5.

Administrative processes:

- Enlist an ADOT employee or consultant with a clear understanding of natural environments and a background in landscape ecological design, landscape ecological restoration, plant biology, or restoration ecology to develop and monitor land disturbance mitigation plans.
- Create mitigation plans that outline clear performance objectives with specific success criteria and a monitoring plan that defines the quantitative data needed to determine success.
- Designate an ADOT staff position responsible for following all mitigation projects—from initial development through implementation, monitoring, and final acceptance by the Corps—to ensure that each project has met success criteria. All employees in that position should have a similar understanding of their responsibilities and receive training, if warranted.

Biological factors:

- Provide exclusionary fencing or other plant protection around each planting or planting site in areas prone to wildlife or cattle damage.
- Ensure irrigation lines are regularly monitored and maintained.
- Irrigate plantings for at least two years to ensure adequate root system development.
- Monitor plantings for at least five years, as required by the Corps—two years during irrigation and three years after irrigation ceases.
- Turn off irrigation only if the site is meeting or exceeding the required success criteria.

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CHAPTER 1. INTRODUCTION

ADOT's mission is to provide products and services for a safe, efficient, cost-effective transportation system that links Arizona to the global economy, promotes economic prosperity, and demonstrates respect for Arizona's environment and quality of life. Fulfilling this mission sometimes entails unavoidable impacts to jurisdictional Waters of the United States (Waters). In keeping with the Clean Water Act, these impacts must be mitigated according to direction from the Corps and the Environmental Protection Agency (EPA).

ADOT is committed to developing and implementing mitigation plans that provide long-term compensation for habitat adversely affected by its construction activities. The mitigation must be self-sustaining in perpetuity. To ensure that mitigation strategies developed for future ADOT projects meet these goals, research and subsequent analysis are needed. Any mitigation plan ADOT develops and adopts must further the Corps' goal of no net loss of Waters while remaining cost-effective.

ADOT has concluded that its projects too often fail to meet the planting success criteria of the mitigation requirements of the Corps' Clean Water Act, Section 404, permits. These permits typically require replacing plants (usually trees) that are damaged or removed as a result of a construction project at a 3:1 ratio. The permits usually require that the planted trees have an 80 percent success rate five years after being planted and a minimum of two years after supplemental watering sources have been removed. When these criteria are not met, the consequent replantings and extensions of mandated monitoring periods create substantial time and cost burdens for both ADOT and Arizona taxpayers.

Plantings can fail for many reasons. Site conditions may be inappropriate, a site may not be properly prepared, or planting stock may have been improperly handled before planting. The supplemental water required to establish plantings may not be provided in the quantity, frequency, or length of time needed for plants to establish adequate root systems that enable long-term survival without irrigation. Also, typical planting success criteria required by the Corps permit may be unattainable. The planting densities and survival percentage required in many Corps permits at the end of a typical three- to five-year monitoring period frequently cannot be met because the required plant densities are too high to be sustainable without long-term irrigation. Even with favorable rainfall conditions, a substantial number of plants die when supplemental watering is stopped and success criteria may not be met. In the current long-term drought, the required survival rate for excessively dense plantings is even more difficult to achieve.

The April 19, 2004, Corps' Los Angeles District mitigation guidelines are an example of provisions that do not specify mitigation requirements, but instead direct applicants to propose realistic success criteria. To date, ADOT has not successfully proposed criteria different from the Corps' typical guidelines because adequate documentation to support different, more locally based benchmarks is unavailable. Research and subsequent analysis are needed. Realistic success criteria developed from permit history of Arizona projects, local experience and knowledge, and published literature would benefit the Corps as well as ADOT.

The requirements for compensatory mitigation are contained in Corps guidance memos and federal rules. Final rule "Compensatory Mitigation for Losses of Aquatic Resources," as published in the *Federal Register* April 10, 2008, became effective June 9, 2008 (EPA 2008). The rule revises and consolidates existing Corps regulations and guidance to establish equivalent standards for all types of compensatory mitigation, including permittee-responsible on-site and off-site mitigation, in-lieu fees, and mitigation banks. The rule encourages using mitigation banks and in-lieu fee programs instead of permittee-responsible mitigation in which the permittee retains direct responsibility for implementing, monitoring, and ensuring the success of mitigation. The Corps now prefers mitigation bank credits for compensatory mitigation; in-lieu fee program credits are second; and permittee-responsible mitigation is the least-preferred choice.

The rule sets a minimum monitoring period of five years for all types of mitigation. The content and level of detail for monitoring reports are to match a project's scope. Reports for projects with small impacts to Waters will presumably require less detail.

Restoration projects have increased in the Southwest over the past 20 years in an attempt to mitigate the effects of human activity (Follstad Shah et al. 2007). This study reviews restoration projects as well as Section 404 mitigation projects. According to Follstad Shah et al. (2007), the greatest number of restoration projects in the National River Restoration Science Synthesis database for the Southwest was in Arizona. This finding and the associated amount of data on restoration practices that was collected suggest that it is important for all restoration practitioners to have studies that focus on improving the success of such projects in Arizona.

ADOT hired EcoPlan to research mitigation practices and develop recommendations for future mitigation and restoration projects. To identify mitigation practices that are successful and those that need improvement, this study focuses on the following areas:

- Identification of projects over the past three to 10 years that involved, or ongoing projects that will involve, a habitat restoration or Section 404 mitigation component.
- Opinions of Corps project managers and ADOT employees who work most closely with mitigation projects.
- Assessment of the conditions of any mitigation plantings associated with the projects that were required to meet the Section 404 permit habitat restoration mitigation requirements.
- Determination of administrative processes and biological factors that are important to the success or failure of mitigation or restoration plantings.

CHAPTER 2. METHODS

SITE VISITS

The Corps, EcoPlan, the University of Arizona Water Resources Research Center, and the ADWR provided files about ADOT and non-ADOT habitat restoration and land disturbance mitigation projects. The files were reviewed to determine project goals; the level of available data such as mitigation plans, planting plans, and monitoring reports; and overall file completeness. Thirty-four projects were selected for detailed study: 19 ADOT projects, four Flood Control District projects, and 11 restoration projects undertaken by private entities or NGOs. Twenty-three projects with goals and actions that were determined to be valuable to this assessment but had insufficient postplanting information to determine project failure or success were selected for site visits: 11 ADOT projects, four Flood Control District projects, and eight private or NGO projects. The four Flood Control District sites were specifically selected to further determine the level of success or failure of tall-pot plantings. The remaining 19 sites used seeding, container plants, or a combination of seeding, container plants, and tall-pot plants.

EcoPlan biologists conducted the site visits. Before visiting a project site, they reviewed details of restoration activities and any preliminary results or observations available in the project file. At each site (with the exception of the tall-pot sites), they made general observations about the area, noting the overall level of ground, understory, and overstory cover, and identifying plant species, focusing specifically on the species that were planted or seeded, if known. For each species, they observed the relative dominance, health, and presence of planted individuals compared with natural recruitment. The biologists noted any signs of erosion, flood activity, or damage to the site from animals or recreational use to identify potential outside sources of plant failure or stress. After the site visits, the biologists determined the overall project success based on the information available in the file and field observations.

Because the tall-pot sites did not lend themselves to gathering the same types of data as other sites, EcoPlan limited its observations to the overall success of the site, site photos, and possible reasons for success or failure of mitigation.

INTERVIEWS

EcoPlan interviewed employees from the Corps and ADOT to obtain firsthand knowledge of the success or failure of practical mitigation practices and overall agency processes. An effort was made to interview employees involved at every stage of the ADOT project process, including project managers in the Corps' Arizona office and ADOT Environmental Planning Group (EPG) senior reviewers and biologists, DECs, development engineers, resident engineers, Natural Resource Management Group project managers, maintenance engineers, and maintenance superintendents.

EcoPlan interviewed the Corps project managers in January and February 2008. One Corps project manager was the ADOT liaison, who normally handled all ADOT projects;

another had primary responsibility for managing the Corps in-lieu fee program in Arizona. The other project managers had experience with many projects that are quite different from ADOT projects, such as dams and master-planned communities, which involve private developers as well as public agencies. However, all Corps project managers administered projects that include linear features, such as roads and sewer lines, which cross Waters in a manner similar to many ADOT projects. The managers' comments therefore reflected experience with different kinds of projects and applicants, including linear projects.

With the exception of the ADOT liaison, project managers in the Corps' Arizona office had approximately five to 22 years of experience, with an average of about 15 years. Individual ADOT liaisons had stayed in the position for years. Project managers were asked to describe key components of successful and unsuccessful project mitigation efforts based on their experience. Preferences for types of mitigation (for example, on-site replacement vs. in-lieu fee) were also discussed.

EcoPlan researchers asked ADOT employees a standard set of questions organized under two main categories that influence project success: administrative processes and biological factors. Interviewees were queried regarding the success or failure of specific on-the-ground practices, their experience with and assessment of the practice of using in-lieu fees, their experience with current ADOT processes and suggestions for improvement based on these experiences, and the success or failure of specific planting types and practices. Employees were also asked to cite specific project examples to support their responses.

Thirty-five of the 52 people selected for interviewing were actually interviewed. Interview questions were answered based on interviewee experience. Not every interviewee answered every question; instead, many interviewees only answered questions dealing with topics with which they had experience. An additional four employees declined to be interviewed because they had only recently been hired by ADOT and were inexperienced in the subject matter. The remaining 13 employees did not respond to attempts to contact them. However, at least one person was interviewed from each key area.

CHAPTER 3. RESULTS

PROJECT FILE REVIEW AND SITE VISITS

This section presents the mitigation practices along with the administrative and biological problems that were noted during the data collection portion of this study. The majority of the projects had multiple problems and may be referenced in more than one subsection.

To illustrate specific mitigation practices and/or problems, a select number of case studies have been included at the end of this report. Because each case study may illustrate more than one mitigation practice or problem, it may be referred to in more than one subsection.

Mitigation Practices

Thirty-four habitat restoration and/or mitigation projects were selected for detailed study; EcoPlan biologists visited 23 sites. Figure 1 shows the number of projects that used various common mitigation practices. The total number of projects and successful projects are depicted for each mitigation practice. For example, five projects used planting stock that was collected on-site, but only two succeeded. It is important to emphasize that the data reported in Figure 1 are conservative because there was no standard reporting form for the projects reviewed, and many of the practices may have been employed but not reported. Seven mitigation practices are discussed.

Tall-Pot Plantings

Most desert plants have a deep taproot. Traditional planting containers cannot accommodate this taproot, which requires uninterrupted development when growing, making the plants difficult to propagate. The tall-pot method uses a 30-inch section of 6-inch-diameter PVC pipe. Plants are grown in tall pots for approximately one year, then transplanted into holes (dug with a power auger) that correspond to the depth and diameter of the pots. If the water table is shallow, the tall-pot plants may not require supplemental irrigation; otherwise, supplemental irrigation may be needed.

The tall-pot method has been successfully used in various locations in the deserts of California, such as in the Joshua Tree National Monument; however, it is a relatively new method of planting in Arizona, where it has had varying degrees of success. Only one of the six projects analyzed could be verified as being successful to date. However, on three of the sites—the Red Mountain Freeway, State Route (SR) 87 to US 60 site; the Flood Control District North Inlet Channel site; and the Chicken Ranch site—the tall-pot plants were planted too recently to draw any conclusions.

In Riparian Restoration on the San Xavier Indian Reservation, the tall-pot plants were left in the pots in direct sunlight for an extended period before planting. Excessive heat buildup in the planting tube killed many of the trees (see the Biological Mitigation Problems section in this chapter).

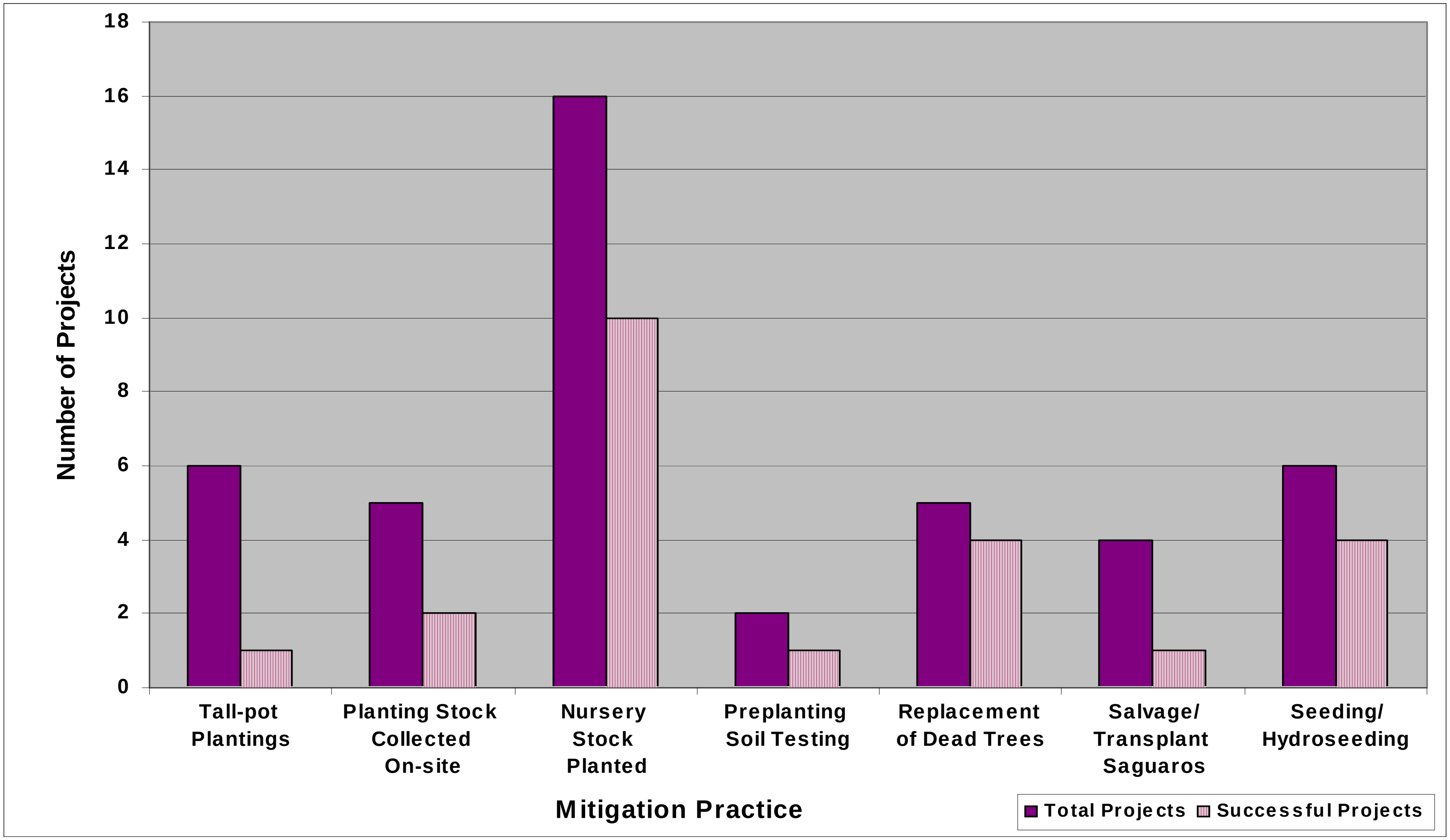


Figure 1. Mitigation Practices. Total number of projects and number of successful projects that incorporated each mitigation practice. Projects may be listed in multiple categories.

Invasive species have negatively affected several of the tall-pot planting sites. Invasive species took over the Flood Control District Chandler Heights site and it failed. Tall-pot planting sites, like other types of sites, should receive routine maintenance, including removing invasive weeds within the drip line of the planted trees and replacing unhealthy or dead trees as soon as they are detected.

Planting Stock Collected On-Site

Many growers involved in revegetation have noted—and it was observed in this study—that volunteer plants do better than nursery-grown plants at the same site even though they do not get supplemental watering. Possible reasons for this are nursery plants may be genetically different from volunteers that are locally adapted to the planting site; nursery plants may be conditioned to a potted existence and may not acclimate well to the barren soil and other extreme conditions of a mitigation site; and nursery plants, especially larger ones, may be root-bound and never overcome that condition.

To take advantage of local adaptation and avoid problems associated with nursery stock that might have been obtained from hundreds of miles away, several projects have collected seed or cuttings and later used them for mitigation or revegetation (Paschke, Redente, and Brown 2003; Anderson, Russell, and Ohmart 2004). In this study, only two of five projects that used planting stock grown on-site were successful. There are many reasons such projects might not be successful, as discussed in the Administrative Process Mitigation Problems section and the Biological Mitigation Problems section in this chapter. Case Study 1 is a synopsis of a restoration project that collected and propagated planting stock on-site.

Nursery Stock Planted

Many of the project files reviewed did not specify the origin of the plantings used. In all cases where tall-pot plantings, seeding, or on-site propagation was not specified, it was assumed that nursery stock was used.

Over half (10 of 16) of the projects that used nursery stock resulted in successful mitigation and restoration. SR 51, Bell Road to Pima Loop 101 Freeway planted more than 2000 nursery trees (1672 mesquite [*Prosopis velutina*]; 209 paloverde [*Cercidium microphyllum*]; and 209 ironwood [*Olneya tesota*]). Despite a number of problems in the first year following planting, after three years the overall survival rate was almost 94 percent.

Several problems have been associated with using nursery stock: Nursery plants are not as well-adapted to local conditions as plants collected or propagated on-site; nursery plants are often root-bound; and nursery plants taken directly from the greenhouse and planted in the field may experience transplant shock (see the Transplant Shock section in this chapter).

SR 87, MP 201–MP 202.5 is an example of an unsuccessful project that used nursery stock. The project's failure may not be completely associated with the use of nursery stock because it had a number of other problems, including overplanting, lack of monitoring, and failure to maintain the irrigation system (see the Administrative Process Mitigation Problems section in this chapter).

Preplanting Soil Testing

Soil testing before planting is not commonly done—it was reported in only two projects—but it may be a valuable tool for mitigation and revegetation (Amezketa and de Valle de Lersundi 2008). Researchers at the Glen-Grand Canyon Riparian Restoration Project planned to measure soil type, electroconductivity, and water table depth, and then use these data to determine where to plant. This project largely failed because supplemental water was discontinued; but survival was good near the perennial Colorado River, presumably an area with a high water table.

The 'Ahakhav Tribal Preserve (Case Study 1) measured soil type, pH, salinity, and water table depth to determine anticipated success at each site. Soil testing before planting, especially measurement of water table depth, probably contributed to the success of this restoration project.

Murder Camp Wash is an ADOT mitigation project located on State Route (SR) 78 near the New Mexico border. Project construction resulted in the loss of suitable planting soils. Essentially, most of the topsoil at the project site was removed during the construction of a low water crossing, leaving behind rocky soils that probably contributed to the failure of the early mitigation plantings. However, once the replacement plantings received sufficient water (by hand watering), survival increased dramatically.

Replacement of Dead or Unhealthy Trees

ADOT's *Standard Specifications for Road and Bridge Construction* states that "all dead or unhealthy plant stock shall be removed and replaced ..." (ADOT 2008, 807). Based on this specification, the replacement of dead or unhealthy trees or shrubs during a mitigation and revegetation project is probably more common than is indicated by the data (only five cases in more than 30 projects). In the Partnership for Riparian Restoration in NE Pima County revegetation project, many of the original plantings, which were obtained from a nursery, were root-bound and eventually had to be replaced. The replacement trees were grown from seeds collected on-site, which was an opportunity afforded by the long-term nature of this project. The replacement plantings were much more successful than the original plantings.

The original mitigation plan for Murder Camp Wash was unsuccessful for a variety of reasons, including trees being planted in dry, shallow, and rocky soil, and problematic and unreliable irrigation. Planted trees included 50 sycamore *(Platanus wrightii)*, 40 velvet ash *(Fraxinus pennsylvanica* spp. *velutina)*, and 12 netleaf hackberry *(Celtis reticulata)*. An additional 25 trees were planted after one year. To accommodate poor survival, the Corps agreed to several modifications to the mitigation plan, including reducing the survival rate to less than 50 percent of the original number of trees planted and counting all volunteer trees toward the success criteria. Ultimately, while the overall number of surviving trees is sufficient, the number of sycamores is far below the mitigation plan success criteria.

Salvaged/Transplanted Saguaros

The Arizona Department of Agriculture has declared the saguaro *(Carnegiea gigantea)* a Highly Safeguarded Protected Native Plant. Saguaros are valuable in terms of aesthetics because they are symbolic of the desert Southwest and they are important wildlife habitat. They are commonly salvaged and transplanted when they are associated with development projects such as road construction, as illustrated in Case Study 2. As long as sufficient supplemental water is provided and support is provided to prevent leaning, these transplants are usually successful.

Seeding/Hydroseeding

For most ADOT construction projects, seeding is required postconstruction for mitigation and erosion control. This seeding may be done in combination with landscape or mitigation plantings. Hydroseeding uses a slurry of seed and mulch that is sprayed over prepared ground in a uniform layer. The mulch helps maintain the moisture in the seed and seedlings and is thought to result in faster germination and better erosion control. Certain tree seeds may be too large for use with a hydroseeder without damaging the seed. In these cases, it may be necessary to spread tree seed by hand.

Ligurta Wash is a seeding-only project on Interstate 8 (I-8) near Yuma; no supplemental plantings were included. A native herb, shrub, and tree seed mixture was applied without any supplemental irrigation. Shrub germination and survival either from the seed mix or from nearby seed sources were fairly successful given the area. However, most of the shrubs showed signs of drought stress at the site visit. No trees that might have germinated as a result of this seeding application were observed.

SR 89A, Cornville Road to Sedona (Case Study 3) used hydroseeding to propagate mesquite and acacia. Supplemental irrigation was provided but was discontinued within the first year, and most seedlings died.

SR 87 North of Rye was a successful seeding project. The site, in the median of SR 87, was hydroseeded approximately 15 years ago with mesquite, shrubs, and forbs. The site is unique because the original plan had been to waste excess material, but instead the excess was used for contouring. The ground was ripped 12 inches deep, which is much deeper than usual but perhaps should be considered as a requirement when ripping areas to be hydroseeded. Survival, even among the mesquite, was good.

Administrative Process Mitigation Problems

Figure 2 shows the number of projects that experienced various common administrative process problems. Some of these problems (for example, failure to monitor) can be classified as both administrative process and biological problems. The total number of projects and successful projects are depicted for each mitigation problem. For example, unmaintained irrigation occurred in four projects, and only one of these projects was successful. It is important to emphasize that the data reported in Figure 2 are conservative. Because there was no standard reporting form for the projects reviewed, many of the mitigation problems may have occurred but were not reported.

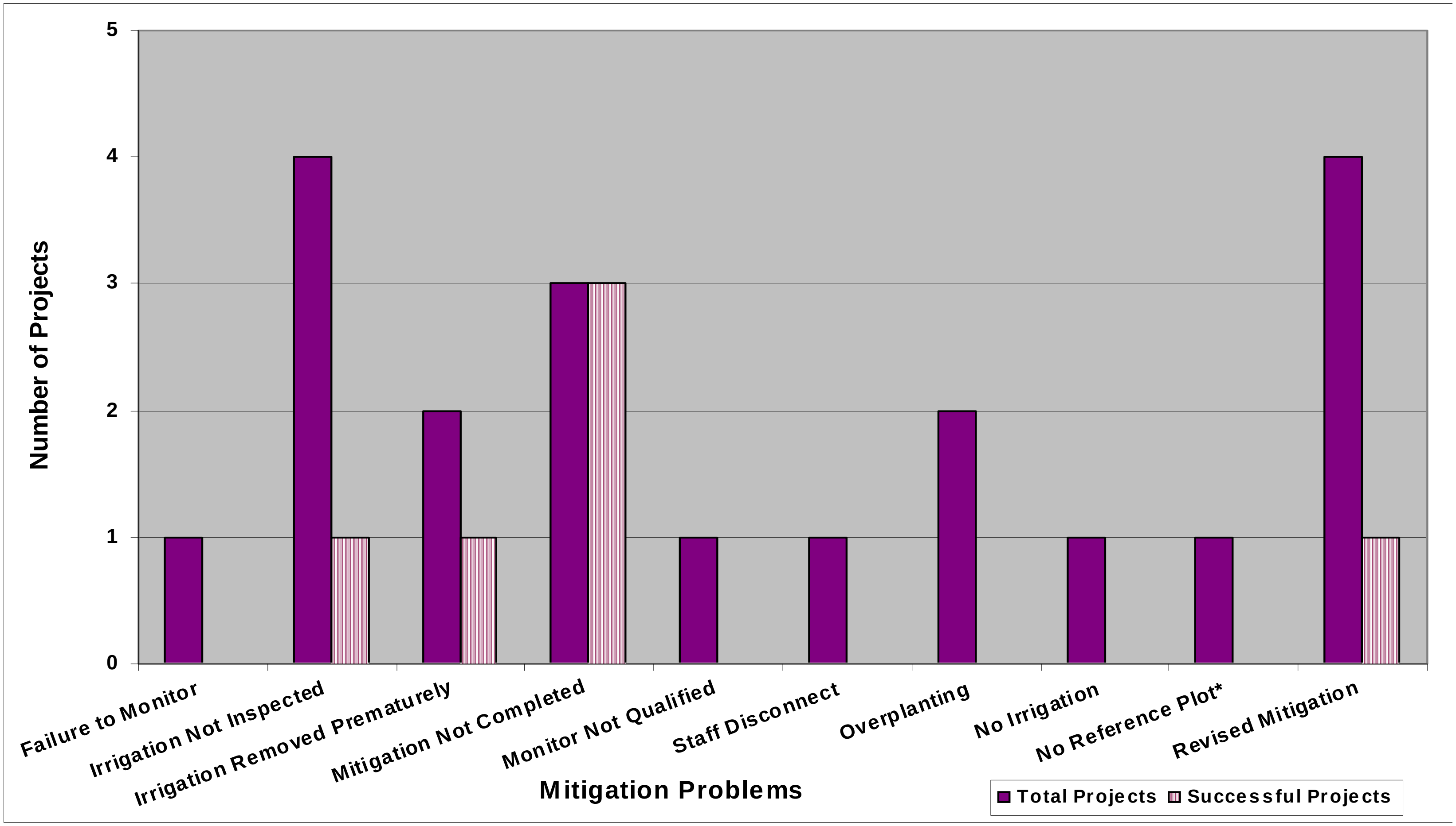
Ten administrative process problems are discussed in the following sections: failure to monitor mitigation plantings, failure to inspect irrigation, irrigation removed prematurely, mitigation not completed, mitigation monitor not qualified, staff turnover, overplanting, no irrigation, no reference plot, and revised mitigation.

Failure to Monitor Mitigation Plantings

SR 87, MP 201–MP 202.5 is an example of a project with insufficient monitoring. The original mitigation plan called for 350 trees to be planted in three wash corridors. When EcoPlan visited the site, most of these plants were dead, stressed, or could not be located, partly as a result of a lack of monitoring. Subsequent versions of the mitigation plan called for a more realistic number of trees to be planted and included trees and cacti planted in upland areas. Eventually, the survival criteria for the plan were achieved.

One way to ensure that the required level of monitoring is performed would be to designate a job position (probably at the ADOT district level) that would be in charge of following all projects through the mitigation and monitoring stages. To be effective, all employees in this position would need to have a similar understanding of their responsibilities and receive the necessary training, if warranted. This individual would coordinate with the biological monitor conducting the on-site monitoring, if applicable.

The irrigation monitoring should be done by the irrigation contractor as frequently as is needed to avoid problems. This monitoring would be in addition to the quarterly or monthly monitoring performed by the biological monitor. Biological monitors should, as part of their scope of work during site visits, ensure that the plants are receiving adequate water and that the system is in good repair. Any deficiencies should be noted in the monitoring report to ADOT.



* The number of projects in this category is likely underestimated. Many project files did not have sufficient information to determine if a reference plot was used.

Figure 2. Administrative Process Mitigation Problems. Total number of projects and number of successful projects experiencing each type of administrative process mitigation problem. Projects may be listed in multiple categories.

Failure to Inspect Irrigation or Irrigation Removed Prematurely

One common mitigation problem is the failure to inspect the irrigation system frequently enough. Irrigation systems should be tested every 60 to 90 days and should include stress flushing, checking emitter ends, and ensuring that the PVC piping remains covered. For example, irrigation lines placed above ground in times of drought and/or in areas where wildlife have access tend to be chewed on to obtain water. Frequent maintenance of these lines is required to ensure water is delivered to the plants. If possible, irrigation lines should be buried to prevent this problem, and individual emitters should not be placed on the ends of drip lines. If individual emitters are used and chewed off, the line is completely open. If buried emitter hubs are used and the drip line is chewed, it will continue to drip.

Unreliable irrigation was found at four projects, only one of which was successful. As mentioned previously, problematic and unreliable irrigation resulted in a lack of water and contributed to the failure of mitigation plantings at Murder Camp Wash. In another project, Riparian Restoration on the San Xavier Indian Reservation, an irrigation malfunction that lasted only two weeks resulted in more than 10 percent mortality of the affected trees.

Another project where the failure to monitor the irrigation system likely contributed greatly to the initial failure of the mitigation plantings is SR 87, MP 201–MP 202.5. In this case, an EcoPlan biologist found damaged and disconnected irrigation lines. Many of the plantings had therefore not received water for a while.

One possible solution to ensure that the irrigation system remains in good repair, is adequately inspected, and that the planted material remains healthy would be to require a separate bond for the mitigation component of the construction project. The primary contractor's bond would be returned once construction was completed and approved by ADOT. However, ADOT would retain the mitigation bond until the survivorship requirements were met and the project was accepted by the Corps.

In two projects, the irrigation system was removed before the mitigation plants had become established, resulting in widespread mortality and failure of the original plantings. I-10 (Fort Grant TI) had recurring problems with its irrigation system over the two-year monitoring period. Nevertheless, the mitigation was largely successful, most likely because dead plants were replaced as they were discovered. The other project, SR 89A, Cornville Road to Sedona (Case Study 3), used hydroseeding and mitigation plantings in two locations: Dry Creek and Spring Creek. At the Spring Creek location, irrigation water was terminated and the irrigation system was removed in the first year by the landscape/irrigation contractor before a dedicated biological monitor was contracted to monitor the sites. As a result, the hydroseeding and plantings failed. The project was eventually successful, but only after the irrigation system was reinstalled, irrigation was resumed, and new trees were planted.

To prevent this problem, ADOT, the landscape/irrigation contractor, and the biological monitor should coordinate to ensure that the irrigation system remains in place and in good repair for the required period. The landscape/irrigation contractor should also completely understand the requirements of the mitigation plan. The landscape/irrigation contractor should be required to monitor the irrigation system frequently enough to detect any problems with the system before any plant mortality occurs. During the summer months in desert areas, this should be at least weekly. ADOT should retain the services of a biological monitor or an ADOT employee should monitor at the required intervals (at least quarterly) once the plantings are in place. Along with assessing the health and growth rates of the planted vegetation during site visits, the monitor should note whether the irrigation system is in place and working properly. ADOT could require that the irrigation system remain in place and in working order until it authorizes in writing the irrigation contractor to end irrigation and remove the system. It is important that all parties realize that early removal of the irrigation system puts the success of the mitigation plantings at risk.

Mitigation Not Completed

Construction occurred and a mitigation plan was developed but not implemented at three projects. Because of natural recruitment, these areas revegetated, but only because there was perennial or intermittent water on-site, as illustrated in SR 75, Gila River Bridge #311 (Case Study 4). If the mitigation plan had been implemented, a much larger area would have been restored to preconstruction functions and values.

To ensure that mitigation is completed, a district-level staff position should be charged with following all projects through mitigation, monitoring, and ultimate acceptance by the Corps. All employees in that position should have a similar understanding of their responsibilities and should receive adequate training, if warranted.

In summary, ADOT must take a stronger oversight role in the preparation and implementation of the required mitigation plans and supervision of subcontractors responsible for them.

The first monitoring report should document as-built conditions, including a thorough assessment of mitigation that actually occurred, the limits of the mitigation area, species and number of individuals planted compared with plantings required in the mitigation plan, and irrigation information.

Mitigation Monitor Not Qualified

Monitoring is often performed by someone other than a qualified biologist, resulting in improper, inconsistent data collection that is not useful to the Corps or other agencies and that could contribute to project failure. For example, in SR 89A, Cornville Road to Sedona (Case Study 3), the irrigation system was prematurely removed, resulting in the loss of most of the initial plantings and seedlings. The landscape contractor for the construction project was initially tasked with monitoring the mitigation sites. However, the contractor was not familiar with the mitigation requirements and the monitoring requirements of the mitigation plan. As a result, the contractor did not obtain the appropriate information required in the monitoring reports. A qualified biologist was eventually contracted to conduct the monitoring, but the site was already failing by that time.

Monitoring should be performed only by a qualified biologist with at least two years of experience who thoroughly understands the mitigation plan and Corps guidance and rules regarding mitigation. The monitor can be an ADOT employee or a qualified consultant. Monitoring techniques should be quantitative, repeatable, and clearly defined in the mitigation plan. Site monitoring should be conducted at least quarterly and for at least five years as required by the Corps.

Staff Turnover

Mitigation projects may fail because turnover among ADOT staff or consultant staff results in a lack of project knowledge or follow-through on key project components. In Riparian Restoration on the San Xavier Indian Reservation, turnover in the groundskeeper position caused a disconnect in knowledge. The current groundskeeper was not in place when plantings occurred and was unaware of the locations of all the plantings.

Another practical problem with monitoring occurred when the tags that identified the monitored trees were lost. The tags were attached to the wire baskets around the plant and not to the plant itself. The baskets were removed as the plants matured, and the tags were lost. (Monitoring tags, if used, should be placed on a conspicuous location on the tree that will still be able to be located as the tree density and height increases. Tree tags should not be attached with wire around a trunk or main branch of the tree. If tree tags are lost, they should be promptly replaced.)

To preserve project knowledge, all project information, including the mitigation plans, planting plans, and monitoring reports, should be kept in at least one location with the original Corps permit that includes any special conditions of the permit. The ADOT employee responsible for following through on mitigation plans should keep these records.

Overplanting

Mitigation plans often call for planting more trees than the area can support in the long term without supplemental irrigation, resulting in mortality and ultimately the failure of the mitigation plan. This scenario occurred in SR 87, MP 201–MP 202.5, where the mitigation plan was revised several times to accommodate low survival and to include plantings in upland areas outside the washes that were originally included in the plan. In this case, replacement ratios seemed to be higher than would ideally be demanded, instead of being based on naturally occurring tree densities. Several relatively small sites received mitigation plantings. The numbers of plants required in these areas greatly exceeded what was found naturally. Overplanting can also result when too many trees are planted near stands of naturally occurring trees, as was the case in Peck Canyon Bridges (Case Study 5).

To avoid the negative effects of overplanting, the percentage of intentional overplanting to meet survivorship requirements must be determined on a site-by-site basis. One way to accomplish this is by using reference plots—areas adjacent to the planting site that are surveyed to obtain natural species' composition and density—to assist in creating the mitigation plan (see the Revised Mitigation section in this chapter). As dead or severely stressed trees are detected during the monitoring site visits, they should be replaced immediately so that at the end of the irrigation period, 100 percent of the trees will be alive. This assists in ensuring that after three years without water, the required survivorship percentage (usually 80 percent) will be met.

No Irrigation

Sometimes seeding-only projects are planted without supplemental irrigation, such as at Ligurta Wash. The seed mix included herbaceous vegetation, shrubs, and trees. At the site visit, there was no evidence of tree survival, and though herb and shrub survival was relatively good, surviving shrubs appeared drought-stressed.

In the desert Southwest, seeding without irrigation is only successful if it is timed to occur with natural precipitation, either prior to the sometimes rainy winter season or in the summer monsoon season. Given the unpredictable nature of precipitation in Arizona, it would be best to provide any mitigation plantings with supplemental irrigation at least until the plants are well-established.

No Reference Plot

SR 87, MP 201–MP 202.5 did not use reference plots, which contributed to overplanting and led to several revisions of the mitigation plan. This scenario is probably much more common than reported here because many projects did not report whether a reference plot was used. Reference plots are vital to developing a mitigation plan, to determining appropriate replacement ratios for the site, and to justifying those ratios to the Corps and other agencies.

Revised Mitigation

When mitigation plans are unsuccessful, they are often revised (with Corps approval) to make success achievable, such as in Case Study 3. Required survivorship percentages may be reduced, additional plantings are most often done, and sometimes natural recruitment is counted toward survival of the plantings (for example, Murder Camp Wash). Revised mitigation plans allow many projects that would otherwise be unsuccessful to move forward and eventually achieve at least some measure of success, though at a high cost temporally and economically.

Biological Mitigation Problems

Figure 3 shows the number of projects that experienced some common biological problems. The total number of projects and the number of successful projects are depicted for each mitigation problem. For example, animal damage occurred on eight projects, and only four of these projects were successful. It is important to emphasize that the data reported in Figure 3 are conservative. Because there was no standard reporting form for the projects reviewed, many of the mitigation problems may have occurred at these sites but were not reported.

Twelve biological problems are discussed in this section: animal damage, flooding, animal damage to irrigation lines, transplant shock, drought stress, insects and pests, tamarisk, invasive species, root-bound nursery plants, mistletoe, heat-damaged roots in tall-pot plantings, and fire. The following biological problems are also considered administrative process problems and were discussed previously: overplanting, failure to monitor, unmaintained irrigation, no irrigation, no reference plot, and revised mitigation.

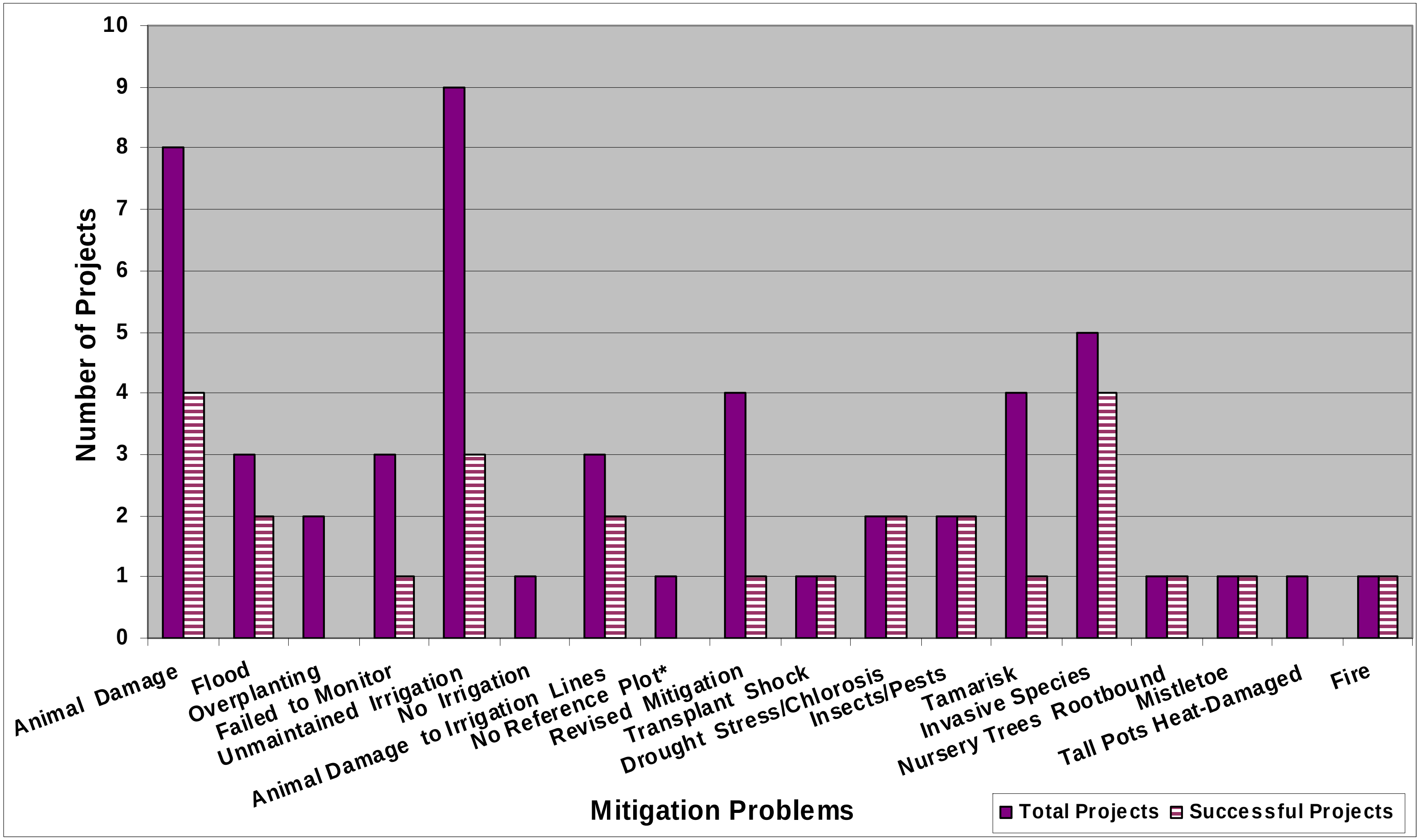
Animal Damage

Animal damage to mitigation plantings is common and was reported in eight of the 34 projects. Browsing by domestic herbivores, such as cattle, and native herbivores, such as deer and elk, can damage mitigation plantings. Beavers and other small rodents that chew on the trunks and main branches of planted trees can also damage them. Planted trees are particularly vulnerable to animal damage because of their vigorous new growth and because they are often planted at high densities. Animal damage on these trees is more pronounced because of their small size. Small trees planted at high densities are also susceptible to trampling by large mammals.

Several methods can be used to prevent animal damage to mitigation plantings, including placing plastic tree sleeves over small trees; placing wire cages around the trunks of larger trees to prevent beavers from cutting them down or other rodents from girdling them; fencing the planting areas to exclude large mammals; trapping and removing small mammals, such as gophers and voles, from the planting area; and implementing various biological controls. In some cases, a combination of these techniques is necessary for the same project.

Flooding

To take advantage of favorable groundwater conditions, plantings are often placed in floodplains and sometimes even in floodways. Unfortunately, flooding often negatively impacts small trees, as illustrated in Case Study 5, Peck Canyon Bridges. Many trees are uprooted and removed by floodwaters, and many other trees are buried by debris carried by the flood. Inundation also causes tree mortality, which may occur when plantings are grown in artificial basins associated with development projects such as with SR 51, Bell



* The number of projects in this category is likely underestimated. Many project files did not have sufficient information to determine if a reference plot was used.

Figure 3. Biological Mitigation Problems. Total number of projects and number of successful projects experiencing each type of biological mitigation problem. Projects may be listed in multiple categories.

Road to Pima Loop 101 Freeway. At this site, 85 trees (25 mesquite, 25 paloverde, and 35 ironwood) were killed by flooding or had suffered significant damage because of the amount of water retained in the basin during an unseasonably wet winter.

To avoid damage by floods, plants should not be placed in the floodway of a stream, river, or wash. If possible, plantings should be restricted to the overbank and upland areas of a site. Also, riparian species that have a relatively low resistance coefficient, such as coyote willow *(Salix exigua)*, cottonwood, and Goodding's willow *(Salix gooddingii)*, should be used for areas that may be prone to flooding but should not be planted in areas prone to scour.

Animal Damage to Irrigation Lines

Irrigation pipe is commonly placed above ground to make it accessible for maintenance and repairs. Unfortunately, this makes the irrigation line more accessible to animals that chew through the pipe to obtain water. Damage to main lines can prevent the irrigation of hundreds of trees, resulting in considerable mortality, especially if the leaks go undetected during hot, dry periods. Animal damage to irrigation lines was reported in three projects and likely occurred in others. To control animal-chewing damage on the North Simpson Site Riparian Restoration project, dead snags were erected at several locations to attract raptors that hunted the rodents, which achieved some success.

Animal-chewing damage can become a serious problem when plants and irrigation systems aren't monitored frequently enough for the conditions. These systems should be frequently maintained or placed underground to ensure that water is delivered to the plants. In areas where limited supplies of water are available to wildlife, a simple watering guzzler could be constructed away from the irrigation lines to provide water and possibly discourage wildlife from chewing on irrigation lines.

Transplant Shock

Transplant shock occurs when plants are taken from a controlled environment and planted in a natural environment, often resulting in nutrient or water stress. It can also occur when the established root system within a planting pot is disturbed during transplanting. Transplant shock is common in mitigation plantings and was noted in SR 51, Bell Road to Pima Loop 101 Freeway, where more than 2000 trees were planted in a basin created by freeway construction.

The adverse effects of transplant shock may be lessened if potted plants are brought to a protected area of the planting site for a few weeks and allowed to acclimate to site conditions before being planted. Planting should occur during the cooler times of the day and not during the stressful summer months in desert areas of the state. The irrigation system should be operational before planting begins, and supplemental water should be provided to transplants as soon as possible after planting.

Drought Stress

Drought stress occurs when plants receive insufficient water because the irrigation system is set improperly and does not run often enough or long enough, or the irrigation system fails. In severe cases of drought stress, plants' leaves turn yellow and are shed. This condition, which can be mistaken for chlorosis (which is caused by nutrient deficiency), was noted in SR 51, Bell Road to Pima Loop 101 Freeway and Rio Salado Habitat Restoration Project. When given supplemental irrigation, most of the plants recovered from drought stress.

Drought stress can be avoided by providing sufficient water, watering at an appropriate rate for long durations to ensure deep watering, and regular maintenance of the irrigation system.

Insects and Pests

Insects may become a problem in mitigation plantings because the trees are often genetically similar, increasing the chances that susceptible trees may be colonized by the same species of insect herbivore. In fact, if the plants were propagated from cuttings, they may be genetically identical. Insect infestations are often associated with plant water or nutrient stress, both of which can be found in mitigation plantings. Insect damage was noted in SR 51, Bell Road to Pima Loop 101 Freeway and 'Ahakhav Tribal Preserve (Case Study 1). In both cases, the plants were doing well despite the insect infestations.

In general, the presence of insects in plantings in normal densities is probably not a concern. However, an infestation of insects such as spider mites or tent caterpillars on young plants in high densities is a cause for concern, especially during high-stress months. If infestations are detected, an aggressive eradication program should start. The presence of insects on older, established plants is usually not a reason for concern in and of itself. Insect damage may, however, indicate that the plants are stressed or in otherwise poor health.

Tamarisk

Tamarisk, also known as saltcedar (*Tamarix* spp.), was introduced to the southwestern United States in the early 1900s to stabilize irrigation canals and control erosion on elevated railroad lines. It quickly escaped cultivation and today occupies thousands of acres of land, especially riparian habitats. Tamarisk is both drought- and salt-tolerant, is able to outcompete native cottonwoods and willows in disturbed habitats, and is thought to use more water than native vegetation (Briggs 1996, 39-42).

Generally, tamarisk is removed from mitigation or restoration sites before planting, though several projects reported that tamarisk had recolonized planting sites. For example, workers at the Glen and Grand Canyon Riparian Restoration Project attempted to improve bird habitat by replacing tamarisk with native vegetation. However, the tamarisk re-established itself within the mitigation area, undoubtedly due to the presence of nearby tamarisk stands that acted as a seed source. Also, in SR 75, Gila River Bridge #311 (Case Study 3), natural colonization of the mitigation area included numerous large tamarisk shrubs.

Tamarisk is difficult to eradicate. Burning a site is initially somewhat effective, but this method also kills the mitigation plants. Tamarisk seems to thrive and come back in even higher densities after a fire. Prolonged inundation kills tamarisk, but prolonged flooding would also kill many of the native mitigation plants. The best method is mechanical clearing and grubbing, followed by treating the stumps with a systemic herbicide to prevent resprouting and to kill the entire root system.

Simply removing tamarisk does not usually ensure that native species will become established or that they can even be grown in those areas. If tamarisk has been present for any amount of time, the soil in those areas may be too saline to allow native trees, which have a relatively low tolerance to salt, to become established. If native riparian or upland species are to be planted in locations that formerly supported stands of tamarisk, the soil's salinity should be tested. If the salinity is outside the tolerances of the desired species, soil amendments may have to be applied, the salt may have to be flushed out of the soil by natural or man-made flooding, or the soil may have to be replaced with soil whose salinity is within the level of tolerance of the desired species.

Tamarisk removal may not always be desirable. Increased water yield may not always result, and the potential for successful revegetation is not assured (Shafroth et al. 2005). Because many riparian birds use tamarisk as habitat, projects that remove tamarisk but do not replace it with high-quality native riparian habitat may ultimately reduce net riparian habitat value, especially for birds (Sogge, Sferra, and Paxton 2008). However, even if the tamarisk is replaced with native habitat, the temporal losses experienced until the new vegetation can support the local species needs to be considered.

Invasive Species

Several non-native plants besides tamarisk are a problem for mitigation and restoration plantings. Competition with these fast-growing weeds is a particular problem when the planted trees are small and just becoming established. Invasive species were a problem on at least five of the 34 projects that were reviewed. In Partnership for Riparian Restoration in NE Pima County, the entire floodplain where most of the plantings occurred was dominated by carelessweed *(Amaranthus palmeri)* and prickly Russian thistle *(Salsola tragus).* Only the tops of the planted trees were visible above the weeds. These two species and others have created serious problems at another southern Arizona site, Bingham Cienega Natural Preserve Restoration. Other common invasive species at the North Simpson Site Riparian Restoration project include Johnsongrass *(Sorghum halepense)*, Bermudagrass *(Cynodon dactylon),* and giant reed *(Arundo donax).*

Control of invasive species is notoriously difficult. Systemic herbicides are sometimes used, but these can damage mitigation and restoration plants. The field of carelessweed at the Partnership for Riparian Restoration in NE Pima County site is regularly mowed, but this technique puts the restoration plantings at risk. The best technique may be to mechanically remove invasive species, either by hand or with tools such as hoes and shovels, or with mechanized equipment in an open area. But all of these methods are labor-intensive.

Root-Bound Nursery Plants

Many greenhouse or nursery plants are grown too long in pots without being transplanted or planted in the field. This results in their roots encircling the inside of the pot—a condition known as being root bound. Many root-bound plants never recover—their roots continue to grow in a circle, and they are unable to obtain sufficient water to survive. This condition is undoubtedly common in plants grown for mitigation planting, but it was reported in only one project, Partnership for Riparian Conservation in NE Pima County. Here, the project manager began growing his own trees from the seed of trees in the area as replacements for the dead and underperforming trees.

Taking on the role of tree propagation is probably the best solution to the problem of root-bound plants. However, if this is not feasible, the appropriate ADOT employee or consultant should be on-site when mitigation vegetation is planted to inspect each plant as it is removed from the pot and either reject any that appear to be root-bound or, at the very least, require that the root balls be sliced to free up the roots. The landscape contractor should be made aware of this possibility before bidding on the project.

Mistletoe

Mistletoe in mitigation and restoration plantings was noted in one project, ‘Ahakhav Tribal Preserve (Case Study 1). Though mistletoe is a plant parasite that is sometimes associated with plant stress, the observer noted that the infested mesquite trees in this study did not appear stressed.

Heat-Damaged Roots in Tall-Pot Plantings

Tall pots are an increasingly popular method of propagating plants for mitigation and restoration projects (see the Planting Stock Collected On-Site section in this chapter). A potential downside to the tall-pot method was noted in Riparian Restoration on the San Xavier Indian Reservation. Planting was conducted from June to September. The black containers heated up considerably during this time, even though the plants were placed under shade. According to notes from the ADWR files, the roots in long, narrow tall-pot containers were particularly prone to heat damage; this heating had the potential to “cook” the roots of the plant before it was planted, thus effectively killing the plant before it was put in the ground. Mortality from this heating effect was observed in several tall-pot plants during the planting period.

Fire

One project, Bingham Cienega Natural Preserve Restoration, has experienced periodic fire since its inception in 1998. The fires have not affected most of the wetland vegetation except Fremont cottonwood *(Populus fremontii)* and Goodding's willow *(Salix gooddingii)* along the edges of marsh areas; these plantings have been unsuccessful because of the fires. In general, riparian vegetation is not fire-adapted, and fire should be avoided in most mitigation and restoration projects.

INTERVIEWS

This section presents the results of interviews with Corps project managers and ADOT employees in August and September 2008. The information obtained during these interviews is based on the experience and knowledge of these staff members and provide valuable, realistic perspective. The comments and suggestions offered during the interviews were carefully considered and contributed to the recommendations given in Chapter 5.

These interviews yielded generally similar comments, although more topics were investigated during the ADOT interviews than the Corps interviews. Comments are presented according to the two main categories (administrative process and biological factors) and the following subcategories: in-lieu fees, responsible parties, staffing and training, other agency involvement, mitigation plans and monitoring, planting, and seeding. The Corps interviews section does not include the planting and seeding subcategories. Table 1 summarizes the key points of these interviews.

Table 1. Comments from ADOT Interviews.

Key Points	Number of Interviewees
Administrative Process	
In-Lieu Fees and Other Off-Site Mitigation	
In-lieu fees should not be used because benefits don't stay in the same watershed as impacts.	5
In-lieu fees should be used as close to the location of impact as possible.	5
ADOT should initiate mitigation banks as a replacement for in-lieu fees.	1
In-lieu fees encourage developers to just pay the money because it's easier than doing the restoration work.	1
In-lieu fees are practical, efficient, and provide habitat in the most effective areas by individuals with knowledge of restoration techniques.	8
On-site mitigation rather than in-lieu fees should be used in unique waters or on federal lands.	2

Table 1. Comments from ADOT Interviews.

Key Points	Number of Interviewees
Responsible Parties	
The DECs should be involved in project implementation because they are with a project from the beginning.	12
The resident engineer should be responsible for mitigation success.	8
Mitigation and monitoring are successful because the Corps requires them to be successful.	1
The contractor should be held economically responsible for mitigation failure.	6
The DECs should be given more authority to ensure that mitigation is addressed by the resident engineer.	5
An ADOT team should be responsible for the success of mitigation.	3
There has been inadequate ADOT oversight and no clear chain of command. The contractors were left in charge of mitigation, and it has not been clear who at ADOT is responsible for mitigation.	2
If ADOT enforces contractor obligations, then the current system works.	3
Staffing and Training	
ADOT should have several environmental engineers on staff.	1
Local, dedicated personnel is the key for successful mitigation and survivorship.	2
Knowledgeable National Environmental Policy Act (NEPA) planners are needed to carry restoration needs to the engineers, who don't always understand practical issues such as temporal plant losses, and ensure planting needs are included.	1
ADOT has sufficient personnel, but training and awareness are needed, specifically regarding mitigation and monitoring.	6
Landscape architects need to be willing to listen to different ideas on species and irrigation issues.	1
ADOT should have restoration ecologists develop and/or review restoration plans. Landscape architects do not always have the proper background to understand desert ecology.	1
Sometimes ADOT [employees] do not pay attention to smaller projects because they believe that in the big scheme of things, smaller projects don't matter.	4
The contractor should have someone local to do regular irrigation checks and for rapid maintenance response.	1
The EPG needs to focus on a teamwork approach. Personnel should be cross-trained so there is a broad understanding of the issues and areas of concern.	3

Table 1. Comments from ADOT Interviews.

Key Points	Number of Interviewees
Other Agency Involvement	
Upfront negotiations are needed with the Corps regarding replacement ratios based on local conditions.	1
The state wildlife agency should be involved because of its experience and vested interest in successful mitigation and restoration projects.	1
Working with multiple agencies can be difficult because of differing goals and expectations; competing goals lead to a low assurance of success.	1
Nationwide permits (NWPs) are not written for the Southwest or dry washes; projects should meet intent rather than the letter of the NWP.	1
The Corps should provide flexibility and understanding about the unique situation in the Southwest.	1
The Corps should monitor projects regularly because it can enforce [them].	1
For local government projects, responsibility should not pass to the local jurisdiction too early.	1
Mitigation Plans and Monitoring	
Current plans are based on straight lines; plans should try to simulate the natural environment and avoid straight lines.	1
ADOT should contract mitigation monitoring through a consultant.	5
Restoration plans, planting, and monitoring should be site-specific. Arizona has 14 biozones, and there should be a general plan for each that can be tweaked as necessary for specific projects within each biozone. [Note: Arizona has 12 biozones.]	8
Mitigation and planting plans should be more specific, with clearer success criteria.	5
A centralized clearinghouse is needed for all project information, especially mitigation, that contains information from beginning to end.	1
Mitigation, monitoring, and reporting should be better tracked (permit).	2
Monitoring consultants should have at least two or three years of experience and biologically sound methodologies.	3
Monitoring reports should be more detailed and include more background information; reports get lost, and having key information on each report would be useful.	1
Monitoring should include more quantitative data gathering; visual assessment/“eyeballing it” is not sufficient.	1

Table 1. Comments from ADOT Interviews.

Key Points	Number of Interviewees
Topsoil should be saved and replaced in ADOT projects, except areas with invasive species issues.	2
Other	
Currently, there is inadequate control over contractor choice; contractors with the lowest bid are awarded the contracts; a request for proposal system would allow contractors to be selected based on qualifications and past performance rather than lowest bid.	2
A better handoff system is needed between construction and maintenance.	5
A tall-pot nursery pilot program to test cost-effectiveness would be good.	1
Biological Comments	
Planting	
Browsing from cattle and animal damage causes problems; exclusionary fencing is needed around the entire area, not just individual trees.	2
Implementation of mitigation and/or plantings should be based on biology, not the construction schedule; planting should not be performed during the dry season.	9
There is inadequate follow-up on mitigation projects.	2
Reports are not always completed, or if completed, they are not read and followed up on by appropriate individuals; need better follow-through.	2
Consultants are not tagging plants as required, so success monitoring is hard.	1
Plantings should be in place so that they are not destroyed in a large rainfall event; consideration needs to be given in the planting plans to the anticipated flows in a planting area.	2
Contractors should perform frequent and timely inspections of irrigation lines.	5
Tall-pot plantings should not be used statewide; they would not work in certain areas.	1
Tall pots without irrigation is a good idea as long as you know depth to groundwater.	2
ADOT should partner with entities (such as cities) to carry out replanting responsibilities.	1
Including seeding with native tree species could offset planting casualties.	2
Salvaged plants should be used more often; they tend to be successful if a plan is in place prior to salvaging.	1
We need guidelines for monitoring salvaged plants.	1

Table 1. Comments from ADOT Interviews.

Key Points	Number of Interviewees
Pole plantings work if done at the right time and get into the water table.	2
Irrigation systems should be computerized so they can send an alert when line or pump problems occur.	1
Irrigation of plantings should be a more formal program.	1
Lack of irrigation is not a problem; animal damage and drought are bigger problems; irrigation will get done because it is part of the mitigation plan.	2
Seeding	
Seeding should be based on seasonality.	4
Millings are dumped and compacted on shoulders, and then these areas have to be seeded even though there's little to no growth after this process. Compacted millings are not a planting medium conducive to plant growth.	1
There is inadequate follow-up after hydroseeding.	1
Seeding with native trees is a good option; recommend including native tree species for seeding projects in all areas of the state.	2
Monitoring methods to determine success should be transparent and available upon request.	1
Focus should be on the growth success of desirable vegetation, not weeds.	1
The ADOT Roadside Development section should be sure to include native species for the specific area when seeding.	2

ADOT Interviews

Administrative Processes

In-Lieu Fees and Other Off-Site Mitigation. ADOT employees had differing opinions about in-lieu fees. Five respondents did not support in-lieu fees because mitigation often does not remain in the impacted watershed. Eight respondents supported the in-lieu fee process because it is more efficient, mitigation is more likely to occur in suitable areas, and mitigation is more likely to be implemented by individuals with knowledge of restoration techniques. For example, an ADOT project in the Yuma District affected the endangered flat-tailed horned lizard (*Phrynosoma mcallii*). Rather than mitigate for the effects on-site where there was little to no suitable habitat, the project used in-lieu fees to preserve or enhance habitat for that lizard at a more suitable site in southern California. The benefit to the overall lizard population was greater than would have occurred with on-site mitigation.

Five ADOT employees said that if on-site mitigation is not practical, in-lieu fees should be distributed to benefit an area close to the project area, preferably within the same watershed. One ADOT employee suggested that a mitigation bank system would be effective for ADOT projects.

When asked if there were any circumstances in which in-lieu fees would not be appropriate, most interviewees could not think of any. However, two ADOT employees said that projects in unique waters or on federal land should mitigate impacts on-site whenever possible.

Responsible Parties. Two ADOT responders noted that historically, ADOT oversight of contractors has been inadequate. ADOT employees also said that ADOT needs to hold contractors more accountable for their actions or lack thereof. Three ADOT interviewees reported that when ADOT enforces contractor responsibilities such as irrigation checks, the current system of management works. Contractor neglect extends the monitoring period or replanting mitigation, which is both inefficient and a waste of economic resources. Therefore, a better system for contractor oversight is needed. The most common solution, suggested by six ADOT interviewees, was to change the contractor bond system so that the contractor is held financially responsible for mitigation failure over a longer term. Another suggestion from two of the respondents was to change how contractors are awarded a contract. Currently, contractors with the lowest bid are awarded the contracts. A system that chooses contractors based on qualifications and past successes rather than solely on the lowest bid would likely improve mitigation success.

Along with the oversight issue, ADOT employees noted that no clear chain of command was in place to determine who in the district office would be in charge of mitigation. When asked who should be responsible for ensuring that mitigation and monitoring occur as planned, 12 ADOT interviewees said that the recently created DEC position is the appropriate choice. Most ADOT personnel said the DEC position, which is perceived to be involved with a project from its inception through completion of monitoring, should be responsible for ensuring mitigation and monitoring success. The second most frequent choice (eight respondents) was the resident engineer. A third idea suggested by three ADOT interviewees was a team of ADOT personnel, including the DEC and employees from the Natural Resource Management Group.

Staffing and Training. This topic was not a direct interview question but the issue arose in a few interviews. Because this subject was not discussed with all interviewees, the number of responses will not be presented; instead, a review of the problems and solutions recommended by ADOT interviewees follows.

The availability and training of ADOT staff was raised tangentially when employees were discussing responsible parties, mitigation and planting plan development, and project follow-through and monitoring. ADOT interviewees suggested that although ADOT has sufficient personnel for adequate follow-through on projects, training and awareness are needed, especially in mitigation and monitoring practices. The EPG needs to focus on a teamwork approach. Personnel should be cross-trained so all employees understand the broader picture of a project, recognize valid concerns and issues, and can recognize how all the pieces fit together. ADOT employees also said that project follow-through seems to break down when a project switches from Construction Division to Maintenance, and they suggested a better handoff system between the two divisions.

ADOT employees also said that knowledgeable NEPA planners are needed to transmit the restoration needs to the engineers. Mitigation and restoration issues and needs should be supported throughout the development process, but engineers don't always have the background to understand this aspect of design and development or to understand concepts such as temporal plant losses. Planting designs are often developed by landscape architects who do not necessarily have the proper background to understand desert ecology and what is sustainable in a natural system. Employees suggested ADOT use restoration ecologists to develop planting plans because they have the background and training to develop a sustainable plan that is more likely to succeed. One interviewee also commented that current planting plans are often based on straight lines, which do not look natural. A restoration ecologist would be more likely to simulate the natural environment and avoid straight lines. Another suggestion was to have environmental engineers on staff during the development stage.

The likelihood for long-term success of mitigation efforts is increased if ADOT and/or its contractors have dedicated personnel locally. The presence of someone in the area who can easily check irrigation lines and plant survivorship, or respond quickly to a crisis that threatens mitigation success is important. Whether ADOT personnel or contractors are checking on the mitigation site frequently, ADOT personnel need to follow through on the project to the end regardless of project size. Some respondents said that smaller projects get ignored in favor of big projects because the small projects "don't matter" in the larger scheme of things.

Other Agency Involvement. One ADOT interviewee mentioned that working with multiple agencies on one project can be difficult due to differing goals and priorities. When so many interests are competing, mitigation success is less likely. No example was given, though a conversation with a private party currently in the midst of a large mitigation project yielded the same comment. One ADOT interviewee recommended that ADOT involve the state wildlife agency in mitigation planning because of its years of experience and vested interest in the success of mitigation and restoration projects.

Three ADOT respondents discussed the responsibilities of the Corps in the mitigation process. One interviewee said that ADOT should have upfront negotiations with the Corps to determine appropriate replacement ratios on a site-by-site basis. A one-size-fits-all replacement ratio will not work because individual site conditions vary greatly across the state. One ADOT respondent noted that NWPs were not written with the Southwest or ephemeral washes in mind; therefore, the Corps should be flexible and understanding about meeting the conditions of a NWP and focus on meeting the intent rather than the letter of the NWP. The final comment regarding Corps involvement was a suggestion that the Corps become more involved in monitoring each project because it, as the regulatory agency, has the power to enforce the Section 404 permit.

Mitigation Plans and Monitoring. Five ADOT respondents said that mitigation and planting plans need to have specific success criteria, which many plans currently lack.

Three ADOT interviewees emphasized that restoration and monitoring plans should be site-specific because Arizona has 12 biozones. Two associated problems were raised. First, one general plan will not work for Arizona. For example, a mitigation plan for Yuma will not work in Payson, and vice versa. Therefore, restoration plans should be developed on a more specific level. Second, developing restoration plans takes time, which most projects cannot afford. ADOT interviewees suggested a general mitigation plan be created for each biozone in Arizona that can then be quickly adjusted for specific projects. Having a base plan will reduce the time required to develop a restoration and mitigation plan.

Five ADOT respondents also said that ADOT should hire consultants to perform the mitigation monitoring. Three interviewees said these consultants should have a minimum of two or three years of restoration mitigation field experience, and monitoring should be biologically sound. One respondent said monitoring should be more quantitatively based, using accepted data-gathering practices, and such methods should be transparent.

As mentioned earlier in the Staffing and Training section, follow-through is sometimes an issue with mitigation projects, partly because of employee turnover but also because reports are not always read by the appropriate person. One employee suggested that monitoring reports have more detail and include more background information. Reports get lost or do not get passed on during project transfers; therefore, all monitoring reports should repeat the key information. Three interviewees said project and mitigation information needs better organization. For example, a centralized clearinghouse for all project information, including mitigation, should be maintained so the information can be easily accessed even if responsibility for the project changes before the project is completed. Employees also suggested better tracking of mitigation, monitoring, and reporting.

Biological Factors

Planting. Issues discussed about planting were fairly wide-ranging—from irrigation to planting areas to browsing damage. The most common topics were water and seasonality. Nine respondents discussed the importance of seasonality when planning plantings. Often planting timing is based on the construction schedule rather than plant biology, leading to mitigation failure. For example, if a project ends in a dry time, such as May or June, the plantings, already stressed by the transplanting process, are unlikely to survive. These interviewees emphasized that the implementation of mitigation plantings should be based on biology, not the construction schedule.

Water is almost always a major limiting factor when establishing plants in Arizona. Ten of the comments in this section addressed water availability—either naturally or through irrigation. Only two of the 40 total comments in this section stated that the lack of irrigation is not a main problem, and that because it is part of the mitigation plan, it will get done. The majority of the interviewees said a lack of irrigation line monitoring or other failures in the irrigation system are frequent problems. Five ADOT respondents said that the contractor needs to perform frequent and appropriately timed inspections of irrigation lines. As discussed in the Staffing and Training section of this chapter, mitigation is more likely to succeed if the contractor has someone locally who can inspect project sites regularly and quickly repair irrigation systems.

Planting methods exist that theoretically need minimal to no irrigation. Two methods—pole plantings, which are generally used for trees such as cottonwoods and willows, and tall-pot plantings, which are propagated in narrow tubes to increase the length of the taproot at planting—were discussed during the ADOT interviews. Two interviewees said pole plantings work if they are done in the right season and are placed so that they are at the water table from the very beginning. Two ADOT interviewees agreed that tall-pot plantings can be used without irrigation as long as the depth to groundwater is known and the taproot can reach it. However, one interviewee acknowledged that tall-pot plantings would not work universally across the state but should be used on a site-specific basis.

One interviewee said that although irrigation would be needed, salvaged plants should be used more often on mitigation sites. Because they are local stock and proven to be adapted to conditions at the project site, they tend to be successful if a specific mitigation and monitoring plan is in place before salvaging. However, the interviewee said guidelines are needed for monitoring salvaged plants.

Other general planting recommendations were to seed with native tree species in addition to planting trees to offset planting casualties, and to design planting plans so plantings would not be destroyed during a heavy rainfall. Planting plans should consider the anticipated flows within a planting area, keep the plantings out of the active flow channel, and consider exclusionary fencing around an entire mitigation area to prevent browsing or other animal damage. Finally, employees recommended that ADOT partner more frequently with other entities such as city governments to replant areas as it did with the Red Mountain Park site in Mesa.

Seeding. While the focus of the interviews was on physical plantings, many of the interviewees had more experience with seeding. Recommendations regarding seeding are included in this report because many of the comments apply to plantings as well.

The most common comment regarding seeding was seasonality: Four ADOT interviewees said seeding should be based on seasonality rather than on the construction schedule. Seeding immediately following construction is usually done for erosion control, but many interviewees said there is no benefit to laying seed that is either eaten by birds or sits for months before conditions are right for growth. Millings that are dumped and compacted on the shoulders of a road are required to be seeded even though there is little to no germination of seeds on this type of compacted substrate.

As has been previously discussed with plantings and mitigation plans, the seeding mix should include plants that are native to the area and are likely to successfully establish cover, including native tree species. The focus of seeding establishment, even for erosion control, should be the germination and survival of desirable native vegetation, not weeds. Monitoring of establishment success should be transparent, and monitoring methods should be available upon request.

Corps Interviews

Administrative Processes

In-Lieu Fees and Other Off-Site Mitigation. Of the five project managers who commented on in-lieu fees, three advocated the use of in-lieu fees or mitigation banks to satisfy compensatory mitigation requirements for projects, particularly projects with small impacts to jurisdictional Waters. A fourth project manager indicated that he had become more willing to accept in-lieu fees in the last few years after the program was revised to tighten legal requirements so that true compensation was more likely to occur; however, in his opinion, the full effect of in-lieu fee programs in Arizona was not yet known because these programs were still relatively new. Two project managers noted that permittees seem to prefer using in-lieu fees to satisfy mitigation requirements because of the certainty of being done with permit requirements upfront, including the need to hire consultants to monitor a site for years.

When discussing compensatory mitigation for linear projects, one project manager said that the 2004 Corps mitigation guidance was designed to address relatively large mitigation sites and was not suitable for the typical linear ADOT project that involves a number of small impacts at different sites. This same project manager said that road right of way was not the appropriate place to try to compensate for habitat lost within right of way. Instead, it made more sense to limit on-site mitigation within the right of way to site stabilization, including seeding but not planting, and provide compensatory mitigation for habitat impacts off-site through in-lieu fees or a mitigation bank. This project manager suggested that ADOT could create several mitigation banks in different parts of the state to be used to diminish the impacts of ADOT projects anticipated to impact relatively large amounts of Waters.

Responsible Parties. Five project managers said there are problems with obtaining permittee compliance with compensatory mitigation requirements of Corps permits, including monitoring and reporting requirements. One project manager said that the key to monitoring success was to have a conscientious permittee who actively tracked mitigation progress and took action when changes were needed. Another said noncompliance was not as common with “repeat permit customers” such as public agencies and municipalities as it was with one-time permittees.

One project manager noted that ADOT does not have a strong enough chain of responsibility because there is no evidence of follow-through from the time the permit is issued to the time the project is constructed and completed. ADOT hires one consultant firm during the design phase to assist in the permitting process, including preparation of the mitigation plan. When the project enters the construction phase—sometimes years later—the same consultant is not hired to follow through with mitigation installation and monitoring. No one at ADOT seems to be responsible for ensuring that compensatory mitigation is done and done properly, particularly in projects with a long time between permit issuance and project construction.

The project manager said that if design changes in the field during construction affected design or implementation of the mitigation plan authorized in the Corps permit, the Corps was not being notified to obtain authorization for a modified plan. The manager also said that ADOT does not seem to hold its contractors sufficiently responsible for their actions or lack of actions. In one example, contractor neglect apparently caused plants to die. The area had to be replanted and the monitoring period extended, yet ADOT apparently did not fine or penalize the contractor for these avoidable project costs.

Staffing and Training. Two project managers noted that the Corps does not have sufficient staff to inspect construction or mitigation sites on a semiregular basis and therefore relies on permittees and their consultants for site inspections and reporting.

Three project managers said mitigation plans have included plants that are not native to the area or are unsuitable for site conditions. One project manager said that sometimes the plant material is too large—24-inch pots are fine for landscaping purposes, but smaller plants are more likely to survive long term without irrigation.

Other Agency Involvement. When asked if there was a constructive role that ADOT could take if there were no existing in-lieu fee projects in an area where ADOT construction projects were proposed, the project manager primarily responsible for the in-lieu fees program in the Corps' Arizona office said the Arizona Game and Fish Department (AGFD) has an existing memorandum of agreement with the Corps that covers the entire state, so project locations are limited only by the locations that the AGFD proposes for suitable projects. If ADOT had a need for an in-lieu fee project in areas where the AGFD did not already have projects, ADOT might encourage AGFD field managers to develop proposals for in-lieu fee projects in those areas.

Mitigation Plans and Monitoring. One project manager said mitigation plans are often incomplete, leading to repeated requests by the Corps for the missing information. As mentioned earlier, another project manager said the 2004 Corps mitigation guidance was designed to address large mitigation projects and may be unsuitable for the typical linear ADOT project that involves a number of small impacts at a given site. A third project manager said that in addition to providing compensatory mitigation for impacts, mitigation plans require avoiding and minimizing impacts to jurisdictional Waters as much as possible.

One project manager saw insufficient monitoring and compliance as one of the biggest problems and said that some permittees take advantage of the Corps' lack of staffing for monitoring compliance. On-site mitigation adjacent to residential areas is another concern. According to two Corps project managers, residents do not always want to abide by the requirements of the Corps permit or restrictive covenants. Problems with compliance result when residents prune trees that block their views, cut down vegetation they feel is a fire hazard, allow unleashed dogs to run through the site, or set fires.

The Corps also noted that design changes in the field during construction are not always passed on to the Corps.

CHAPTER 4. DISCUSSION

This section presents the results of the project file review and site visits. It also includes comments and suggestions from the interviews that, in association with a review of the literature and knowledge of the research team, seem most relevant and have the potential to increase the success of future projects.

Inefficiency in the administrative process and biological categories was observed in the projects reviewed for site visits and noted by ADOT and Corps interviewees. The complexity of mitigation and revegetation projects along with the size and complexity of the agencies involved contributes to this inefficiency. Strategic changes can improve the efficiency temporally and economically.

Irrigation issues created one area of inefficiency—because of incorrect placement, early withdrawal, maintenance issues resulting from lack of contractor follow-up, or a lack of ADOT oversight of the contractor. In arid Southwest riparian areas, water is the limiting factor that controls species composition (National Research Council 2002; Anderson, Russell, and Ohmart 2004). Stromberg, Tiller, and Richter (1996) show that species distribution in southern Arizona is associated with depth to groundwater. Irrigation to planted species, especially in areas where depth to groundwater has not been determined or in areas with a low water table, is critical until they are able to gather sufficient water on their own. In many cases, the contractor uses a manual irrigation system, which may not operate on a regular, timely basis or for the necessary length of time, leading to plant failure. Using automatic irrigation timing systems would reduce the concerns associated with manual watering and would ensure that irrigation occurred on a regulated basis. Solar-powered emitter controllers can be used in areas where power sources are unavailable.

The system of irrigation should depend on the species and its method of gathering water. For a wet riparian species such as willow or cottonwood, which needs access to the water table, the irrigation timing and amount should encourage deep root growth. Other species develop shallow, widespread root systems that enable them to effectively and immediately use any precipitation that falls. Irrigation emitters should be placed an adequate distance from the base of the plant to promote adequate root growth. Unless there is a sufficient source of water at the site to enable the plantings to survive without supplemental irrigation (a rare situation in Arizona), irrigation placement, timing, and quantity are keys to successful mitigation.

Insufficient maintenance of the irrigation system was commonly reported. Regular maintenance and system checks should be enforced to ensure that irrigation problems do not limit a project’s success. Another consideration, based on discussions with interviewees, the technical review committee, and the internal research team, is to alter the current contractor bonding system, which could increase the likelihood of mitigation success.

Staff turnover at ADOT, project transition between departments, insufficient training of personnel, or inadequate project organization can impede the progress of mitigation and oversight of the contractor during mitigation implementation or establishment periods. The current bonding system does not provide a financial incentive for the contractor to ensure long-term mitigation establishment success. Creating an additional bond or a separate bond specifically for the irrigation system and mitigation plantings would provide an incentive for the contractor to more carefully monitor irrigation system effectiveness and change other practices that may put the bond in jeopardy. It would also provide ADOT with a solid enforcement tool, which is currently lacking.

Project transition, either within a department or across departments, can cause a disconnect in ADOT oversight that can interfere with the mitigation's success. If mitigation practices specific to a site are not fully detailed or project documentation is incomplete, the new project manager may not know what the measure of mitigation success should be. Specifying one staff position in ADOT to follow the mitigation aspect of a project from design to Corps acceptance of establishment would provide a valuable link between the previous project manager and the current project manager. This position would retain a copy of all documentation regarding the mitigation and would be familiar with the specifics of each site to prevent disconnects during transition.

Most interviewees said the DEC was the most appropriate person for this responsibility, and the research team concurs, provided there is a standard understanding of the role and responsibility of this position in reviewing mitigation plans and tracking implementation and results. The first monitoring report following planting should document as-built conditions, including a thorough assessment of mitigation that actually occurred, the limits of the mitigation area, species and number of individuals planted compared to required plantings specified in the mitigation plan, planting locations, irrigation system information, and other pertinent information that would aid future project managers or DECs in supervising mitigation establishment.

Good mitigation planning is vital to the success of a project as is having clear objectives, specific measures of success, and a clear monitoring plan that will provide data on those measures (Kondolf et al. 2007). The Corps, as the permitting agency, is involved in determining an appropriate replacement ratio and planting scheme. The agency has specific guidance for mitigation projects under Section 404 of the Clean Water Act that should be incorporated into mitigation plans. A rule on mitigation was issued by the Corps in April 2008 and became effective in June 2008 (EPA 2008). The Corps also determines when the mitigation is accepted as complete as specified in the permit and any associated documentation for the site, such as mitigation plans. Replacement ratios should be determined based on site-specific characteristics and multiple reference plots in related areas because they capture the inherent variation and are more likely to provide a representative source of standards to determine mitigation success (Ruiz-Jaen and Aide 2005). Cooperation with the Corps and any other agencies with a stake in the project area during the early phases of project planning will ensure that all agencies agree about the objectives and success criteria of a mitigation project.

Mitigation plans should be based on at least one, but preferably multiple, reference plots; should be site-specific; and should include a specific plan to monitor the success of the project. Because of Arizona's large variation in biozones, a one-size-fits-all plan is not effective. Not only do plans need to adapt to each geographical zone, but within each of these zones, plans need to vary based on the status of the impacted wash (ephemeral, intermittent, or perennial); the nature of the adjacent area (rural vs. urban); and the level of prior disturbance. The mitigation plan should be developed, in cooperation with the Corps and other applicable agencies, by a consultant with a clear understanding of natural environments and with a background in biology or restoration ecology. This could include landscape architects with a background in, or adequate experience with, restoration of natural environments. Landscape architects with purely urban landscaping experience should not be considered qualified to develop a mitigation plan because the requirements, distribution, and needs of species when restoring a natural riparian area are quite different from the average urban landscape.

While developing the mitigation plan, it is important to verify that the desired plants are available in local nurseries. Following mitigation plan implementation, a qualified consultant with a background in biology should monitor the project. Monitoring reports should be submitted to the ADOT project manager, the DEC, the Corps, and any other agency involved in the project. Under the 2008 rule from the Corps, all mitigation must be monitored for a minimum of five years. Monitoring detail depends on the scope and should be determined on a project-specific basis.

Seasonality was a concern in mitigation plan implementation. Often with transportation projects, on-site mitigation plans are implemented after construction rather than during the season conducive to planting success, which can lead to mitigation failures.

In off-site mitigation, in-lieu fees may be appropriate. According to the Corps project managers, these may especially be appropriate for linear projects where the impacts are small and occur within the right of way. In-lieu fees can also be an efficient and practical alternative or companion to on-site mitigation. The 2008 Corps mitigation rule encourages the use of mitigation banks and in-lieu fee programs over permittee-responsible mitigation in which the permittee retains direct responsibility for seeing that mitigation is implemented, monitored, and successful. Under this rule, existing in-lieu fee programs may continue to operate under the terms of their existing instrument (the legal document for the establishment, operation, and use of an in-lieu fee program) for two years, and the Corps may grant an extension for up to three additional years. Any revisions made to an existing in-lieu fee program instrument as well as all new in-lieu fee instruments must be consistent with the rule. The Corps has estimated that decisions regarding the establishment of mitigation banks and in-lieu programs would be made within approximately 225 days of federal agency review time, but the amount of time required to prepare the documentation as well as actual review times are not yet known.

Under the Corps' 2008 rule, mitigation bank credits are the preferred form of compensatory mitigation, in-lieu fee program credits are second, and permittee-responsible mitigation is the least-preferred choice. Mitigation banks would be more likely to keep the benefits of mitigation within the same watershed as the impacts—the preferred result of any off-site mitigation. Currently no mitigation banks are set up in Arizona; the Corps has approved 10 in-lieu fee recipient organizations in Arizona and one in California.

CHAPTER 5. RECOMMENDATIONS

This chapter provides a list of recommendations for addressing administrative process and biological issues in mitigation projects.

ADMINISTRATIVE PROCESSES

- **Enlist an ADOT employee or consultant with a clear understanding of natural environments and a background in landscape ecological design, landscape ecological restoration, plant biology, or restoration ecology to develop and monitor land disturbance mitigation plans.** Findings from the interviews and project file reviews indicate that mitigation plans are more likely to succeed and to be in line with the objective of restoring an area to a more natural aspect when created by someone with a background in natural resources. Landscape architects who do not have natural habitat replacement experience and whose experience is limited to urban landscape planning should not be considered qualified to develop a mitigation plan because the needs for a mitigation plan are different from the average urban landscape. ADOT should require mitigation designers and installation supervisors to attend a class on ecologically sound mitigation practices prior to involvement on mitigation projects.
- **Outline clear performance objectives in the mitigation plans with specific success criteria and a monitoring plan that defines quantitative data needed to determine success.** Viable mitigation planning and supportive data are keys to realistic assessments of project success. Projects often have unspecified objectives that make it difficult to judge success, particularly if success is gauged by “eyeballing it,” as is sometimes done. Clear objectives, transparent methods, and quantitative data will not only provide more convincing signs of project success, they also will aid future efforts to determine which mitigation practices work and which should be refined or discarded.
- **Designate an ADOT staff position in each district to be responsible for following all mitigation projects—from initial development through implementation, monitoring, and final acceptance by the Corps—to ensure that each project has met success criteria. Ensure that the employees in those positions have a similar understanding of their responsibilities and receive training, if warranted.** Many of the administrative process problems noted from the file review and interviews, such as lack of follow-through and lack of ADOT oversight, could be resolved with this suggestion. The research team recommends using the DECs for this position, assuming all DECs would have a standard understanding of their roles and responsibilities.

- **Ensure corresponding planting plans are prepared jointly by a qualified landscape architect and the individual charged with the development of the mitigation plan.** To ensure that planting plans for a specific project agree with the requirements laid out in the mitigation plan, the landscape architect and the individual who developed the original mitigation plan should coordinate closely during design of the planting plan.
- **Brief the landscape and irrigation contractors and the biological monitor once the mitigation plantings are in place to ensure that the contractors understand the requirements of the mitigation plan.** The review of the project files and interview results indicated that disconnects occur when projects change hands or departments. This disconnect may also occur when a new contractor comes on board or when a new phase of the project is beginning. In some cases, the landscape and irrigation contractors may not even be aware of the mitigation plan requirements. Arranging a meeting between the monitor and the landscape and irrigation contractors will ensure that everyone has a common understanding of their responsibilities as detailed in the mitigation plan.
- **Keep copies of all project information, including the entire mitigation plan, planting plans, and monitoring reports, in at least one location. The ADOT position charged with the follow-through of the mitigation plan should keep all of this information.** ADOT interviews and project reviews, including some non-ADOT projects, indicate that a disconnect often occurs when projects transition between employees, whether from staff turnover or from normal project transitions between departments. The DEC, who is involved in the project from the beginning, can act as a resource for recovering plans or reports that may not have made the transition to the new project manager, an EPG employee, or other involved party.
- **Monitor the mitigation site at least quarterly after the mitigation vegetation or seeding has been placed.** ADOT interviewees and the site reviews emphasized the importance of using a qualified biological monitor with at least two or three years of mitigation monitoring experience. Annual monitoring is not frequent enough to catch and/or prevent potential issues from becoming large-scale problems biologically and economically. A massive die-out of plantings could easily occur within a year and not be detected. Quarterly or more frequent monitoring is much more likely to detect plant stress or potential catalysts for stress before they become large-scale problems, reducing the economic and biological toll of mass plant replacement.
- **Prepare monitoring reports for each monitoring site visit and submit them to the designated ADOT position.** Monitoring reports should be prepared in a timely manner after each monitoring visit and submitted to the ADOT employee who stores all of the records. The research team suggests using the DEC position for this purpose. All parties involved with the project should read the report and act accordingly.
- **Submit monitoring reports to the Corps promptly after each site visit.** During the interviews, Corps project managers noted that insufficient monitoring occurs and that some permittees take advantage of the low Corps staffing for monitoring compliance. In many cases, permittees have to be reminded to submit the

monitoring reports. Monitoring reports should be submitted in a timely manner following each site visit, unless otherwise directed by the Corps project manager.

- **In the first monitoring report, document as-built conditions and record whether the on-site conditions accurately reflect the requirement contained in the mitigation plan.** At a minimum, the first monitoring report should include the limits of the mitigation area, species and number of individuals planted compared with the required plantings in the mitigation plan, planting locations, irrigation system information, and any other pertinent information. As discussed previously, transitions can cause a disconnect in project knowledge. The new project manager may only know what the mitigation plan specified and may not have the information explaining what was actually done on-site. Including this information in the first monitoring report will clarify the project status for all involved parties and will provide a valuable, clear, and concise source of information following a transition.
- **Create a separate contractor bond for the mitigation project that will be held until mitigation survivorship requirements are met and the project is accepted by the Corps.** Irrigation problems and failure to replace dead trees are frequent causes of mitigation failure. Keeping a bond until the mitigation is accepted by the Corps will create an economic incentive and will encourage the contractor to perform regular irrigation maintenance checks, repair problems promptly, and replace dead trees so the survivorship requirement is met and the bond recovered.
- **Require landscape or irrigation contractors to regularly inspect irrigation systems and submit irrigation monitoring reports to ADOT.** Monitoring reports allow ADOT to evaluate the current status and long-term trends in a project area. Requiring irrigation monitoring reports from the contractor or subcontractor will ensure that irrigation monitoring occurs on a regular basis and will keep ADOT informed of any need for maintenance, the potential for stressed plants, and the failure of mitigation plantings or seeding.
- **Specify in mitigation plans that irrigation may not be discontinued until authorized in writing from ADOT.** Irrigation was discontinued prematurely in at least two projects, leading to severe plant stress and/or failure of the mitigation project. Requiring written authorization in the mitigation plan, which becomes part of the enforceable Section 404 permit, gives ADOT the power to ensure that irrigation occurs until plantings have established a sufficient root system to continue growing following irrigation withdrawal. The irrigation system should remain in place for the entire five-year monitoring period in case irrigation water needs to be turned on after the initial termination.
- **Consider using in-lieu fees for projects where viable on-site or nearby off-site mitigation opportunities do not exist.** According to the 2008 Corps rule, the Corps now considers mitigation bank credits as the preferred form of compensatory mitigation; in-lieu fee program credits are second; and permittee-responsible mitigation is the least-preferred choice. Because Arizona currently has no mitigation banks, the use of in-lieu fees for compensatory mitigation should be considered whenever viable on-site or nearby off-site mitigation opportunities do not exist.

- **Discuss creating mitigation banks to use for compensatory mitigation with the Corps.** Mitigation banks would ensure that the benefits of mitigation would stay within the same watershed as the impacts, which was of prime concern to several ADOT interviewees.
- **Work with the Corps to obtain its support on using reference densities to assign plant replacement ratios instead of using arbitrary ratios that may not be based on sound biology.** Overplanting was an issue on several projects. Mitigation plans often call for planting more trees than can be supported without irrigation in the long-term, ultimately leading to mitigation failure. The number of plantings should be based on what is naturally occurring in the greater project area, as determined by surveying multiple reference plots.

BIOLOGICAL FACTORS

- **Provide exclusionary fencing or other plant protection around each planting or planting site in areas prone to wildlife or cattle damage.** The method of exclusionary fencing or protection will depend on cost and the source of concern at a particular site (such as cattle or elk browsing and beaver damage). The project file reviews have made it clear that every project should include a consideration of the animals present, the potential damage from these animals, and a solution to aid the successful establishment of vegetation.
- **Ensure that irrigation lines are regularly monitored and maintained.** Irrigation monitoring is necessary not only to identify mechanical and environmental problems and clogs, but also for leaks due to animal damage. Rodents or other animals often chew through the irrigation lines, chew off emitters, or chew into DriWater cartons to reach the water. This damage can be catastrophic to mitigation plantings unless the problem is resolved quickly.
- **Irrigate plantings for at least two years to ensure adequate root system development.** Once the irrigation plan has been developed and implemented, irrigation should continue for at least two years to ensure that the root systems are developed and self-sustaining. Irrigation systems were removed prematurely in at least two projects, leading to more dead plants that had to be replaced or the mass replacement of the plantings and the irrigation system.
- **Monitor plantings for at least five years, as required by the Corps—two years during irrigation and three years after irrigation ceases.** Irrigation should occur for at least two years. Following removal of irrigation, monitoring should continue for three years to ensure that the plantings are not stressed from the removal of irrigation and that their root systems are sufficiently developed to sustain them throughout periods of varying precipitation without outside aid.
- **Turn off irrigation only if the site is meeting or exceeding the required success criteria. Once irrigation ceases, dead and unhealthy trees should not be replaced.** It is important to ensure that the survivorship requirement is met before removing irrigation to avoid replacing dead and unhealthy trees after supplemental watering has been discontinued. In fact, it would be preferable to have the site exceed the required survivorship percentage before removing irrigation to allow for some mortality afterward. At the end of irrigation, dead and unhealthy trees should not be replaced because they are unlikely to establish

without a period of supplemental watering. As a matter of practice, new trees should not be planted during the last three months prior to the end of irrigation.

- **If possible, completely exclude cattle from mitigation sites. If cattle must have access to or through the site for watering or movement, work with the allotment permittee or private landowner to provide fenced access through the site.** Cattle can wreak havoc on a mitigation site, especially in riparian areas. They may trample seedlings; slough the bank as they try to reach water and uproot new plantings; or engage in intense browsing of young plantings, stripping young trees of their leaves and severely stunting their growth, which potentially leads to tree mortality. If cattle need to access the project area, exclusionary fencing should be used to protect the young plantings from grazing. ADOT should work with the allotment permittee or landowner to ensure that their needs are met while protecting the plantings until they are large enough that the majority of the canopy is out of the reach of grazing cattle.
- **Select an appropriate spatial irrigation arrangement and plan appropriate timing and quantity of irrigation, depending on species planted and seasonality.** An irrigation plan should be created for each project. Plans may differ based on the type of species planted; for example, quantity and timing of irrigation depend on whether the irrigation needs to encourage deep root growth or lateral root growth. For tall-pot plantings, each tree should have a well to gather rainwater. Irrigation plans should consider spatial effectiveness in distributing the water. While planning irrigation schematics, ADOT should consider alternatives to prevent animal damage such as using emitter and underground irrigation lines.
- **Replace dead and unhealthy trees identified during the site visits in a timely manner after each site visit.** Replacing dead and unhealthy trees promptly allows the replacement trees to take advantage of the irrigation for as long as possible. The longer the plantings have access to irrigation during the two-year period, the greater their chance of survival once irrigation is removed. This makes attaining the survivorship requirement easier because waiting to do a mass replanting toward the end of the irrigation period would likely necessitate an extension of the irrigation period and, therefore, an extension of the overall monitoring period. If mass replantings are conducted toward the end of the irrigation period without extending that period, the majority of those replantings could fail because their roots have not developed sufficiently to sustain the plant.
- **Do not terminate irrigation during the summer months in desert areas of the state. If irrigation is scheduled to be shut off in the summer months, planting should be postponed until the cooler fall months.** The dry, hot days of summer in the desert are a stressful time even for well-established plants. The success and survival of mitigation plantings following end of irrigation are more likely if water is shut off after the summer months. Removing irrigation forces the plants to rely on their developing root system to obtain whatever water is available, and it causes less stress on them if this is done in the cooler months.

- **Do not use individual emitters at the ends of the irrigation tubing. All irrigation lines should be buried, if possible, and emitter hubs used to regulate the flow rate.** In many projects, animal damage to irrigation lines is a major source of irrigation failure. If lines are above ground, they are more likely to be chewed by animals to obtain water. Burying the lines will lend some protection. Even if lines are buried, animals may chew off the emitter heads to obtain water. If this happens and an individual emitter was used, the line will send a steady stream of water, flooding the area and causing erosion and other problems. Using emitter hubs would resolve this problem because even if animals chew off the end of a line, the flow is controlled from a buried hub, and the line will continue to only send out water at the regulated rate.
- **Consider areas likely to be affected by flooding or inundation when planting trees and shrubs.** Flood flows destroyed vegetation in several projects examined for this study, resulting in the need for replanting. Designers should consider low flow and flood channels when creating planting plans. For example, trees and shrubs should be planted outside of scour areas, such as along the inside curve of the drainage where the current is slowest, in deposition areas, or in areas with natural barriers such as large logs or boulders too large to be moved by calculated flows. Planting trees and shrubs on the downstream side of existing vegetation would also provide some protection against flows. If plantings will occur in areas that could be inundated, designers should choose species that can withstand the anticipated periods of inundation.
- **Consider seasonality and biozone when planning planting and seeding mix and schedule.** Seeding and planting following the vegetation's biological schedule, instead of the construction schedule of the transportation project, will most likely yield successful establishment.
- **Use mechanical methods to create hollows or depressions where seeds can lodge and rainwater can collect.** Because seeding often occurs based on the construction schedule rather than biological seasonality, seeds often get blown away or eaten by animals before conditions are right for germination. In conjunction with considering seasonality and the biozone, creating microtopographical variations may encourage the development of conditions conducive to germination.
- **Rip areas to be seeded or hydroseeded to a depth of at least 10 inches and preferably 12 inches.** One of the projects reviewed, SR 87 North of Rye, ripped the soil to 12 inches before seeding and had great success and species establishment. Ripping the soil creates microtopography that aids seed germination. It is important to rip the soil deep enough to provide the seeds with a growing medium that facilitates root development. Shallow ripping may not break through the hardpan associated with many soils in Arizona.
- **Use multiple reference plots in a late successional stage to determine an appropriate planting density.** Tree mortality is associated with many factors, one of which is the replacement ratio. Often, these replacement ratios are high to accommodate expected losses following planting. However, areas planted too densely result in an unhealthy level of competition, increasing mortality or

stunting growth in the long term. Using multiple reference plots and selecting reference plots that are in a later successional stage will help determine the density a site can sustain in perpetuity without long-term supplemental water.

- **Use native species found in the immediate vicinity for mitigation plantings.** Using multiple reference plots can help determine an appropriate planting density and will aid the selection of species appropriate to plant in the project area. These reference plots should be nearby and similar to the project area prior to construction, unless the project area had an invasive species problem. Selecting species that are found in the immediate vicinity and planting those species at the project site will increase the likelihood for success. Whenever possible, use local genetic stock because there may be subtle adaptations that allow the species to survive in a particular area.
- **Perform preplanting soil testing if soil conditions are a concern.** High salinity soils, low water tables, and inappropriate soil texture or water holding capacity can impact the survival of plantings. For example, if the site has a rocky topsoil, has saltcedar stands that are likely to raise soil salinity, or is near an ephemeral or intermittent drainage with an unknown water table depth—preplanting soil testing will help determine the appropriate species for planting and the appropriate locations for each. Such detailed knowledge of soil conditions will aid the immediate survival and long-term establishment of mitigation plantings.
- **Select healthy nursery plants that are not root-bound.** In the project file review and site visits, some of the nursery-grown plants had become root bound, which greatly affected their ability to grow and survive.
- **If invasive species removal is necessary, include funds to remove the invasive species from ADOT-controlled areas adjacent to the project site as well.** If there are seed sources adjacent to the project area, the project area is likely to quickly become populated with the invasive species after planting, even if all invasive species are removed from the immediate project area. Removing invasive species in the adjacent areas will remove nearby seed sources and decrease the likelihood that invasive species will overrun the site.
- **Include the periodic removal of invasive species in maintenance.** Many invasive species have competitive advantages that will aid their establishment over the more desirable native species. If invasive species such as saltcedar are not removed as a regular maintenance procedure, over time the invasive species will overrun the planted species. When removing saltcedar, the root or stump should be treated with an appropriate systemic herbicide. Invasive annuals should be removed before they flower to prevent the spread of seeds.
- **If using tall-pot plantings, use DriWater cartons to assist with water retention; create a defined well just beyond the drip line to assist in gathering and retaining rainwater; and place plantings according to established and proven planting protocols.** Tall-pot plantings are gaining support in Arizona, and in some areas it may be possible to use them without supplemental irrigation. However, if irrigation is not going to be used, DriWater cartons should be used and a rainwater well should be created to aid water retention. Regardless of the type of planting, water is still a major factor in ensuring successful establishment,

and all appropriate aid should be given to ensure that tall-pot plantings will not need to be replaced due to drought stress.

- **Preserve topsoil, which contains native seed, and place it over the site when construction is completed to assist in revegetation through natural recruitment.** Whenever possible, it is preferable to use local genetic stock for revegetation, whether through local cuttings and propagation or through local seed collection. Local seed collection rarely occurs because it is not financially feasible. Saving topsoil and replacing it, however, can easily be done on-site during construction, and it aids the revegetation effort because it already contains native seed of local stock.
- **If tamarisk eradication and replacement with native species is a component of a mitigation plan, test soil salinity to ensure it is not too saline to support the desired mitigation species.** Tamarisk, or saltcedar, is an invasive riparian species that often outcompetes native species because of its long seeding period and higher drought and salt tolerance. Saltcedar excretes excess salt through its leaves; the salt then drops onto the soil below and raises the soil salinity. Because of this biological adaptation, an area that has had a stand of saltcedar may have higher soil salinity than many native riparian species can tolerate. In these cases, soil salinity testing should be done to avoid high mortality and possible replanting.

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APPENDIX

CASE STUDIES

Case Study 1

‘Ahakhav Tribal Preserve

Location: Parker, La Paz County, Arizona, off of Rodeo Road

Mitigation Implementation Date: 1997

Project Description: This project dredged historic river channels and planted native riparian vegetation over 100 acres (split into two 50-acre sites) adjacent to aquatic or wetland habitat along the Colorado River. Researchers also completed avian and terrestrial wildlife surveys as part of this project to evaluate the impacts of the planted vegetation on wildlife density and diversity.

Mitigation/Restoration Plan: From EcoPlan’s site visit, it is apparent that some mitigation activities occurred; however, it is not known if all the described activities took place. This project was not completed to mitigate impacts to jurisdictional Waters, but instead was a channel dredging and habitat restoration project. Before planting, two soil samples per acre were to be taken to test soil type, pH, salinity, and water table depth to determine anticipated success at each site. Plantings were to be obtained by starting local cuttings of willow and cottonwood in 1-gallon pots. Seeds or seedlings of mesquite, salt bush, and wolfberry were to be obtained locally and propagated in a nursery. The ‘Ahakhav Tribal Preserve Nursery was to be started on-site for this project. Prior to planting, the vegetation was to be cleared, with the exception of native trees; planting holes were to be augered to 8 feet or to the water table; and an above-ground drip irrigation system was to be installed. Planted trees were to receive 8 gallons of water per tree per day, five days a week, for 18 weeks.

Large trees such as cottonwoods were to be planted on 20-foot centers, willows and mesquite trees on 15-foot centers, and patches of shrubs on 10-foot centers. Fertilizer was to be added if necessary. Cottonwood and willow were not to be planted where depth to groundwater was greater than 8 feet. Dead trees were to be replaced, and weeding was to occur as necessary during the irrigation period.

Monitoring Plan: A few weekly monitoring reports indicate that some monitoring occurred; however, it is unknown whether all the described monitoring took place or if it occurred over the specified time frame. Nineteen percent of planted trees, including a minimum of 30 of each planted species, were to be monitored weekly immediately following planting and throughout the first growing season. Height and canopy diameter was to be measured with ground cover and foliage volume calculated from those measurements. Growth was to be compared with soil measurements in the specific planting area. Occasional monitoring was to occur for an additional 10 years, though the frequency of monitoring was not specified. After three years, 95 percent survival was anticipated.

Results: Approximately 17 percent of cottonwood, willow, and mesquite were in poor health or dead in September 1998. Mammal and insect damage were the main contributing factors to the poor health and mortality. Deer and rabbit browsing and chewing by beavers caused damage to the cottonwood and willow trees, and insects damaged the screwbean and honey mesquite trees. The irrigation did not start until several days after planting. The problems associated with the irrigation lines included a burst line that went unnoticed for several days after the irrigation was turned on and the irrigators not properly understanding their assigned inspection areas. Fencing to prevent browsing damage was recommended in the weekly monitoring reports. No further monitoring or baseline information was available.

Site Visit Observations: EcoPlan conducted a site visit on July 25, 2008. Approximately 5 percent of the revegetation area was surveyed on foot, and the edges of much of the remaining area were surveyed by car to look for conspicuous problem areas. Mistletoe was frequently sighted on mesquite trees within the surveyed area but did not appear to cause stress. Along the riverfront, a dense barrier of coyote willow *(Salix exigua),* various shrubs, and phragmites (8 to 10 feet tall) were flourishing. This area of vegetation showed dense natural recruitment, mostly through cloning of coyote willow. Mesquite trees were common farther from the river channel, and willows and cottonwoods were more common close to the river channel. The trees were planted so evenly that in many areas, it created a park-like setting (Figure 4) whereas in other areas, recruitment has created a more natural setting with denser cover (Figure 5). Ground cover throughout the area was sparse, with scattered grasses, forbs, and debris from trees and shrubs. Understory cover varied from low to high. In the park-like areas, understory cover was low, while other areas had such high shrub density that it was difficult to traverse the area. Canopy cover was generally moderate to high. In the park-like areas, the canopies covered more area, so the amount of cover provided by fewer trees was still high compared with areas of higher tree and shrub densities. Some seedling cottonwoods and willows were observed, indicating that natural recruitment was occurring.

Conclusions: This habitat restoration project was successful, probably because of the presence of perennial water and supplemental irrigation. Preplanting soil testing and depth-to-groundwater testing were also unique features of this restoration project that aided site selection and contributed to the success. Due to this testing, planting occurred in areas where the depth to water table was within 8 feet and where soil salinity and pH readings were within the tolerances of the species planted. The irrigation was monitored frequently and adjusted as necessary during the first growing season.

Figure 4. Evenly Spaced Plantings at the Northern End of the 'Ahakhav Tribal Preserve Project Site.

Figure 5. Dense Cover Behind the 'Ahakhav Tribal Preserve Nursery.

Case Study 2

Covered Wells, Why–Tucson Highway (SR 86)

Location: Why–Tucson Highway (SR 86), Milepost (MP) 91.49 to MP 92.07

Mitigation Implementation Date: Unknown

Project Description: Highway profile reconstruction

Mitigation/Restoration Plan: From EcoPlan's site visit, it is apparent that some mitigation activities occurred; however, it is not known whether all described activities took place. Saguaros in the disturbed area were to be salvaged and replanted. According to the plan, 295 15-gallon trees—37 blue paloverde *(Parkinsonia florida),* 159 desert ironwood *(Olneya tesota),* and 99 velvet mesquite *(Prosopis velutina)*—and 99 saguaros—22 0.5- to 6-foot saguaros, 57 6- to 12-foot saguaros, 18 12- to 20-foot saguaros, and two 20-foot saguaros—were to be planted. Seeding was to occur over 11 acres. Irrigation was the contractor's responsibility.

Monitoring Plan: Information about the monitoring plan was not available. Monitoring did occur, however, the project team was unable to review the monitoring reports.

Results: According to ADOT correspondence, more than 89 saguaros were salvaged and replanted. No other information was available.

Site Visit: EcoPlan conducted a site visit on August 12, 2008. A drive-by overview of the area found numerous apparently healthy transplanted saguaros and 3- to 8-foot-tall blue paloverde, ironwood, and velvet mesquite trees growing abundantly throughout much of the mitigation area (Figures 6 and 7). The remnants of an extensive irrigation system were observed. Though many saguaros, particularly smaller individuals, survived and appeared healthy, the dried remains of several other, mostly larger specimens, suggest that some died as a result of dehydration.

Transplanted saguaros must establish a new root system and take in water faster than they transpire stored water to survive. Young saguaros can more easily sustain themselves with a re-establishing root system, but larger individuals often transpire faster than the recovering root system can take in water. Several leaning saguaros were observed at the site visit, which suggests that sufficient support was not provided long enough.

Though a few dead trees were observed, far more appeared to be growing and reproducing. Recruitment from reproducing planted trees was high, with abundant young blue paloverde, mesquite, and ironwood trees and perennial species from the surrounding Sonoran desertscrub, including creosote bush *(Larrea tridentata),* whitethorn acacia (*Acacia constricta),* wolfberry *(Lycium berlandieri),* desert (*Senna armata*), and sweetbush (*Bebbia juncea*).

The only area where survival and growth of planted trees was low was on the rockiest soils of ridges and slopes east of Quijotoa Wash.

Conclusions: Clearly supplemental irrigation was provided to saguaros and nursery-grown trees for some period following their planting. Given their high survivorship, the mitigation effort was successful. Many blue paloverde and mesquite trees bore seed pods, and recruitment was high. Plants apparently incorporated within the reseeding mix, such as brittlebush, desert marigold, galleta grass, and purple three-awn, are thriving. Recruitment of perennial shrub species from the surrounding Sonoran desertscrub community also appeared to be high.

Figure 6. Relocated Saguaros at the Western End of the Covered Wells, Why–Tucson Highway (SR 86) Project Site.

Figure 7. An Actively Growing Saguaro Near the Irrigation Tube at the Covered Wells, Why–Tucson Highway (SR 86) Project Site.

Case Study 3

SR 89A, Cornville Road to Sedona, Arizona

Location: SR 89A from MP 357.57 to MP 369.55, just east of Verde Village, Yavapai County, Arizona

Mitigation Implementation Date: 2003

Project Description: Road construction and construction of two bridges at Spring Creek and Dry Creek

Mitigation/Restoration Plan: Disturbed areas were to be hydroseeded with an approved mesquite and acacia seed mix in late spring or early summer, timing the hydroseed application to coincide with cool air temperatures and high seasonal precipitation. Three to six months after hydroseeding, the contractor was required to ensure seedling success by using Supertube tree shelters where necessary to protect individual mesquite and acacia seedlings.

For Waters permanently impacted by construction, the plan called for three mitigation components. The first component was on-site and in-kind container plantings at Spring Creek and Dry Creek. Mitigation was to consist of planting xeric riparian vegetation at a ratio of 1:1. Additional trees (20 percent) were also to be planted to ensure 100 percent of the trees were surviving at the end of two consecutive years after discontinuing supplemental water. Trees were to be planted in clusters of four to eight to maximize benefits as wildlife habitat. Wire baskets were required to be installed around the trees to protect them from animals, and supplemental water was to be provided for the first year (once a month during the cool season and twice a month during the warm season). The plan called for 17 mesquite (*Prosopis* sp.) and 46 desert willow *(Chilopsis linearis)* to be planted at Spring Creek, with 14 mesquite and 38 desert willow needed to survive to achieve 100 percent success. At Dry Creek, three sycamore (*Platanus* sp.), four ash (*Fraxinus* sp.), and three desert willow were to be planted, with two sycamore, three ash, and two desert willow needed to survive to achieve 100 percent success.

The second component was on-site enhancement. The pavement was to be removed where the existing SR 89A was to be abandoned, and the area regraded and revegetated. From MP 367.2 to MP 367.5, the area was to be revegetated using hydroseeding and salvaged native mesquite and pinyon pine (*Pinus* sp.) (29 salvaged trees total). The area from MP 367.8 to MP 367.9 was to be revegetated using hydroseeding and salvaged mesquite (11 trees). From MP 368.5 to MP 369.3, a fill area created by construction was to be hydroseeded and planted with salvaged mesquite, pinyon pine, and juniper (*Juniperus* sp.) (131 salvaged trees). Supplemental water was to be provided to salvaged plants for two years.

Off-site enhancement was the third component of the mitigation and was to consist of restoring Dumas Ditch on the Crescent Moon Ranch to provide water for a three- to four-acre basin that supports cottonwood (*Populus* sp.) and sycamore trees.

The project files indicate that some of these activities occurred; however, it is not known whether all activities took place.

Survivorship Requirements: For the hydroseeded area, a 50 percent survival rate of mesquite and acacia was required after three years. For trees planted at Spring Creek and Dry Creek, a 100 percent survival rate was required for two consecutive years after discontinuing supplemental water. For salvaged trees, a 100 percent survival rate was required after two years of being replanted. In later monitoring reports, however, ADOT changed the required survivorship rate to 80 percent.

Monitoring Plan: Growth measurements for trees were to be monitored quarterly for the first year and twice a year for the second and third year if supplemental watering was discontinued. If watering continued, monitoring would occur every three months. Plant density for mesquite and acacia (at the hydroseeded locations) was to be monitored twice a year for three years. Salvaged plants were to be monitored twice a year for two years. Dead trees were to be replaced in kind. Photo records were to be taken quarterly for the first year and annually for the second and third years. Reports were to be submitted to the Corps annually for three years. No monitoring was required for the off-site portion.

Results: Mitigation plantings and hydroseeding for acacia and mesquite at Spring Creek were largely unsuccessful in 2003. A large number of dead trees were found and the irrigation system had been prematurely removed. At Dry Creek, the majority of the trees were healthy, with only three Arizona sycamore needing to be replaced. There were no signs of mesquite or acacia germination from the hydroseed. The hydroseeding for acacia and mesquite was declared unsuccessful by the end of 2003. The monitoring plots were eliminated, and additional containerized trees were planted at both sites. Monitoring at the three revegetated portions of the previous SR 89A roadbed indicated that survivorship was close to 100 percent, and the trees appeared healthy.

In early 2004, the Spring Creek site was cleared of all non-native vegetation, the irrigation system was reinstalled, 40 additional trees were planted to replace the dead trees and to compensate for the failed hydroseeding, and the three-year monitoring period was restarted. At Dry Creek, the majority of the trees were healthy, with some additional plantings added to compensate for the failure of the hydroseeding and to replace dead trees. The three obliterated areas of abandoned SR 89A still exhibited a high percentage of survivorship. In 2004, supplemental water was terminated for the plantings along the alignment of the obliterated SR 89A corridor and at the Dry Creek site because of the overall health of the sites and the growth measurements taken at Dry Creek (Figures 8 and 9).

By 2005, Dry Creek and the sites along the obliterated SR 89A corridor had met their survivorship requirements, and monitoring was terminated. Monitoring at Spring Creek indicated that vegetation at the site was flourishing, and supplemental watering at Spring Creek was terminated. By the end of 2006, Spring Creek had met its survivorship requirements, and monitoring was terminated.

Conclusions: Monitoring was completed as planned. Irrigation was removed prematurely, leading to the death or stress of many trees. Hydroseeding for acacia and mesquite was unsuccessful. Some of the plants were destroyed by cattle.

Because of the initial failure of one of the three mitigation sites, additional costs were incurred to replant the site, reinstall the irrigation system, and extend the original monitoring period by three years.

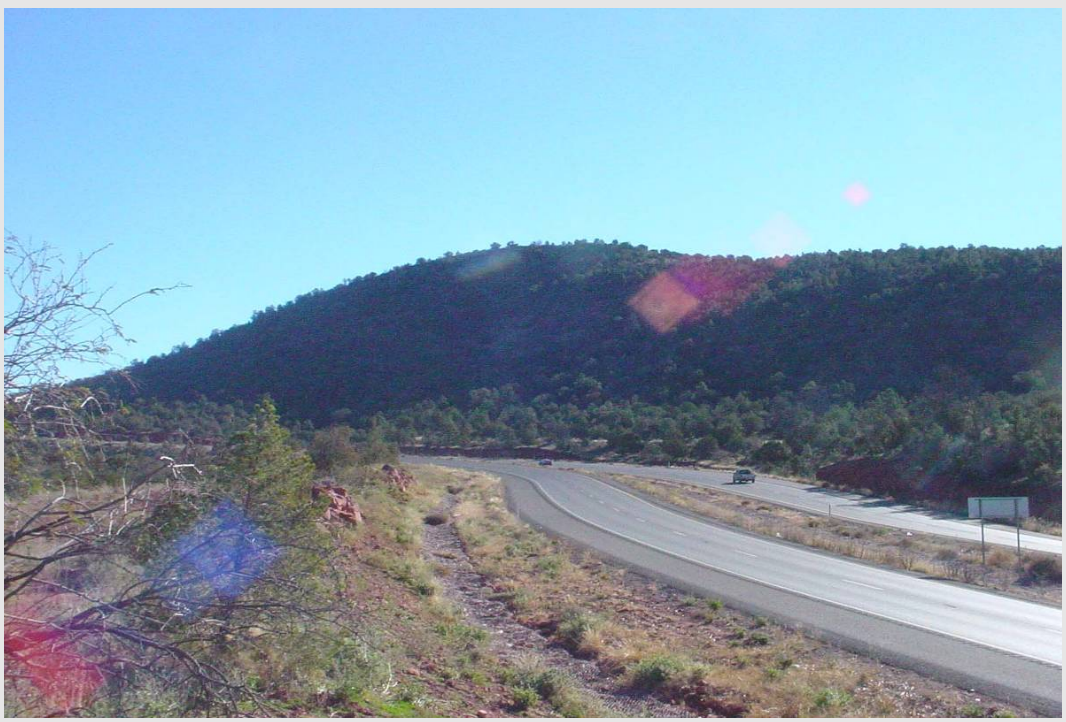

Figure 8. Revegetated Area Adjacent to and West of the SR 89A, Cornville Road to Sedona Project Site (Facing North).

Figure 9. Revegetated Area Adjacent to and West of the SR 89A, Cornville Road to Sedona Project Site (Facing South).

Case Study 4

SR 75, Gila River Bridge #311

Location: SR 75, MP 378.9 to MP 379.4, approximately a quarter-mile northeast of the town of Duncan, Greenlee County, Arizona

Mitigation Implementation Date: Unknown

Project Description: Bridge replacement project

Mitigation/Restoration Plan: From the site visit, EcoPlan believes that mitigation did not occur as planned. Mitigation was to occur on more than 0.67 acre of impacted riparian habitat, including on-site and in-kind mitigation, with a 1:1 replacement ratio. Riparian vegetation, including 81 Goodding's willow *(Salix gooddingii),* 36 Fremont cottonwood *(Populus fremontii),* and 25 coyote willow *(Salix exigua)* pole cuttings collected from the Gila River bank, was to be planted near the project area. To ensure pole cutting establishment, contractors were to divide the mitigation area into three zones, with varying planting density. Supplemental water was to be provided to a portion of the revegetated area for the first year. Trees were to be watered twice a month during the dry summer season of May to September and once a month during the cool winter season of October to April. Trees were to be planted when dormant and when the groundwater table was high and stream flow was not at a high-flow stage.

Monitoring Plan: Because mitigation did not occur, monitoring likely did not occur. The site was to be maintained and monitored for three years after the end of construction. Monitoring was to be done on an annual basis.

Survivorship Requirements: The original plan prepared in February 2000 set a survival requirement of approximately 80 percent of the planted trees after three years. If monitoring indicated less than 80 percent survivorship, additional planting was required. In the July 2000 modified plan, ADOT changed this requirement to 100 percent survivorship after three years.

Results: Information was unavailable.

Site Visit: EcoPlan conducted a site visit on August 19, 2008. No pole plantings appeared to have been planted on the site (Figure 10). However, naturally recruited willow (*Salix* sp.), mesquite (*Prosopis* sp.), and tamarisk (*Tamarix* sp.) make the mitigation area appear healthier than before construction (Figure 11). There was evidence of postproject all-terrain vehicle use in the floodplain. There were no trees growing higher in the floodplain.

Conclusions: No conclusions can be drawn about the effectiveness of mitigation practices on this site because mitigation did not occur. However, riparian vegetation was developing in patches through natural recruitment near the river, likely due to the presence of perennial water.

Figure 10. The 40-Foot-Wide Mitigation Strip Along the West Side of the SR 75, Gila River Bridge #311 Project Site.

Figure 11. Dense, Naturally Recruited Riparian Trees Along the West Side of the SR 75, Gila River Bridge #311 Project Site.

Case Study 5

Peck Canyon Bridges

Location: Peck Canyon, Interstate 19 (I-19), 12.9 miles north of Nogales, Arizona

Mitigation Implementation Date: 2001

Project Description: Scour protection

Mitigation/Restoration Plan: A review of the monitoring reports indicated that activities occurred as planned. Natural revegetation was to be allowed in the disturbed areas. Salvaged pole plantings of cottonwood were to be planted north and south of bridge construction.

Monitoring Plan: From a review of the project files, it is apparent that monitoring occurred as required. The site was to be monitored one week, one month, three months, six months, and nine months after construction and then yearly for a minimum of two years.

Survivorship Requirements: The plan required replacing 41 removed cottonwoods with 41 surviving pole plantings at the end of the two-year monitoring period.

Results: Survival of cottonwood pole plantings in areas where cattle were excluded met or exceeded the survivorship requirements. Areas where cattle were not excluded had a single-digit percentage of survival. Of the 129 cottonwood pole plantings, only 41 were alive at the end of the monitoring period.

Site Visit: EcoPlan conducted a site visit on August 7, 2008. Several individuals and small groups of cottonwood trees from 12 to 25 feet tall were growing within the mitigation area between the west frontage road and I-19, in the median between the I-19 traffic lanes, and east of I-19, providing moderate to abundant canopy coverage. The majority of these trees were individuals avoided during project construction. Three surviving mitigation pole plantings were found between the west frontage road bridge and I-19. These trees were 12 to 18 feet tall and appeared healthy, with substantial trunks and numerous lesser branches off the main trunk. Two dead stumps were located in this area along with a dead but leafed-out pole planting about 10 feet tall that had fallen as a result of recent flooding. Two other surviving pole plantings were found east of I-19 next to living trees avoided during construction. These plantings supported about 3 feet of growth and appeared to have been browsed intensely by cattle until recently.

Conclusions: This mitigation effort appears to have largely failed. Only five of the 41 pole plantings that survived the two-year monitoring period remain. Flooding along Peck Canyon seems to be the main reason that few trees remain in the area between the west frontage road bridge and I-19. The force of floodwaters removed all but the largest of the pole plantings (Figures 12 and 13). However, this flood-related thinning appears to have been a normal course of events.

Pole plantings were planted in patches to simulate the growth pattern of groups of cottonwoods growing in the area at the time of construction. Since then, flooding has removed all but the largest of the naturally growing cottonwoods in each patch so that only individuals and small groups of larger trees remain, rather than patches of cottonwood.

Heavy flooding is largely out of the control of mitigation specialists who are trying to re-establish a seminatural vegetation community in a riparian area. Some suggestions to mitigate the effects of flooding include avoiding planting directly in the floodway; using natural barriers such as rocks and trees as velocity dissipaters to block the force of floodwaters; and planting along the inside curve of the drainage, where the current is slowest.

Another factor in low survivorship of pole plantings is cattle browsing. Before flooding, most plantings between the west frontage road bridge and I-19 (where there was no cattle access) survived the two-year monitoring period. However, most plantings east of I-19 were heavily browsed and few survived. The two surviving pole plantings east of I-19 showed the effects of browsing and supported only minimal growth of thin, low branches still within easy reach of cattle. These individuals probably continue to survive because cattle are not currently grazing in the area.

Browsing by cattle is especially destructive to low vegetation. One suggestion to mitigate the effect of browsing is to install exclusionary fencing to protect the plantings while not excluding cattle from watering areas or travel corridors to which they may legally be entitled.

Mitigation for this project called for a significant percentage of the pole plantings to be planted east of I-19. At the time of construction, there was already abundant growth of young cottonwood trees along the Peck Canyon drainage east of I-19. To accommodate additional plantings within suitable habitat, it was necessary to plant immediately adjacent to existing young trees, increasing the size of existing patches. Even with overgrazing by cattle in this area, additional plantings only contributed to the excessive numbers of trees already present. To avoid this problem, the percentage of overplanting to meet survivorship requirements must be determined on a site-by-site basis. Avoidance of trees and other vegetation outside the construction footprint may do more to restore a project area than planting additional vegetation.

Figure 12. Pole Planting Knocked Down by Flooding at Peck Canyon Bridges Project Site, Between the Frontage Road and the I-19 Bridges.

Figure 13. Growing and Dead Pole Plantings Downstream at the Peck Canyon Bridges Project Site.