Technical and Physical Feasibility Fact Sheet

Alternative 1: Bosque Management

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1. Definition of Alternative

Restore Bosque habitat and manage vegetation in the Bosque to reduce evapotranspiration by selectively removing vegetation and promoting native plants.

2. Summary of the Alternative Analysis

The Middle Rio Grande Water Assembly (MRGWA) and the Mid-Region Council of Governments (MRCOG) is defining a water plan (MRGWP) to identify feasible strategies for enhancing water supply while reducing water demand. This plan will cover the Middle Rio Grande (MRG) planning region, which extends from the northern border of Sandoval County to the southern border of Valencia County. In this region, there are currently 13,290 acres of bosque (Coonrod, 2002). Most of this area contains cottonwood forests that have been heavily invaded by high water-using, non-native vegetation.

Removal of non-native vegetation combined with natural revegetation can restore the bosque to a cottonwood-saltgrass mosaic, resulting in water savings. Replanting generally is not a recommended restoration strategy in the planning region because of the existing cottonwood overstory. Conversely, in areas where the cottonwood overstory is absent, or where cottonwoods are dying or diseased, pole planting may be beneficial. A mosaic of isolated cottonwood forests, wetlands, and saltgrass meadows is the best strategy for minimizing depletions through bosque restoration.

In 1997, the action committee of the MRGWA identified water demand as five key depletions in the MRG water budget: evaporation, transpiration, municipal and industrial, groundwater recharge, and agricultural. Wherever vegetation is present, the first two depletions, evaporation and transpiration, are combined into evapotranspiration (ET). ET describes the process by which plants take water from the soil into their roots and transport water to the leaves, where water ultimately evaporates into the atmosphere. Because leaves are where evapotranspiration occurs, it is rightly believed that management of vegetation is a method for controlling water demand within the bosque.

The US Bureau of Reclamation (Reclamation) has pursued two methods for estimating ET in the planning region—the Blaney-Criddle estimation for the action committee's 1999 water budget, and more recently the ET Toolbox. In 1997, ET in the MRG was estimated by the Reclamation using the Blaney-Criddle method (Hansen et al., 1997). The Blaney-Criddle method relies upon monthly estimates of temperature and the number of daylight hours to estimate ET. More recently, ET in the MRG has been estimated by the Reclamation using the ET Toolbox, which uses a modified Penman formulation (Sammis et al., 1985). The Penman equation simulates evaporation from open water, estimating the amount of evaporation that results from solar energy (the energy available to evaporate water), vapor pressure deficit (the difference between actual atmospheric vapor pressure and the vapor pressure of saturated air at that temperature), and wind speed. The combination of these three terms determines potential ET, that is, the amount of water lost if there is an unlimited supply of water and no vegetation. To account for various types of vegetation, a crop coefficient curve is used to adjust potential ET into an estimate of actual ET.

In the ET Toolbox, crop coefficients for saltcedar and cottonwood were developed by Dr. Salim Bawazir from eddy covariance towers at the Bosque del Apache National Wildlife Refuge (http://www.usbr.gov/rsmg/nexrad/ ettoolbox.html). The towers at Bosque del Apache are located over a dense saltcedar stand and a seven-year-old cottonwood orchard. Wherever monospecific saltcedars occur, potential ET is converted to actual ET using the Bosque del Apache saltcedar crop coefficient; likewise, cottonwood forests are assigned the cottonwood orchard coefficient. Crop coefficients developed from the University of New Mexico's Bosque del Apache ET tower agree well with Dr. Bawazir's results. At other locations listed in the assumptions Exhibit 1A), crop coefficients show a great deal of spatial variability. Due to the inability of single-site crop coefficients to resemble natural variability in forest structure, resultant ET, and other physical and biological properties of the MRG bosque, this feasibility analysis will use the University of New Mexico (UNM) ET data and associated forest properties to predict the effects of restoration on the water budget.

The ET Toolbox is a work in progress in which crop coefficients and other parameters that are poorly understood could be estimated while providing a framework for later improving those "place-holder" variables. One such parameter is the crop coefficient for wetland, wet sand, and floodwater ET. While there is one scientific, peer-reviewed publication describing measurements of wetland ET, measurement of evaporation from wet sand and floodwater continues to evade the scientific community. Unfortunately, the basis of the wetland and marsh crop coefficients in the ET Toolbox are unavailable and thus beyond the scope of scientific review (Jensen, 1998). It is important to note that these crop coefficients provided suggest wetland ET is 15 percent greater than open water ET. This is physically impossible, for the physical structure of vegetation creates aerodynamic cavities that inhibit flux of water from the point of evaporation to free air. By creating pockets of slow moving air, the driving force for vapor flux known as vapor pressure deficit is decreased from pond surface to the free atmosphere, simultaneously decreasing wetland evaporation. In fact, the cottonwood site that floods every two years (Belen-Rio Communities) transpires less than the cottonwood site in the south valley of Albuquerque, which has not flooded in recent decades.

Most of the vegetation in the bosque is phreatophytic, meaning its roots are in contact with the water table. Because the plants always have their roots in contact with the water table, depth to the water table does not impact ET when the water table is within 3 meters of the soil surface (Horton et al., 2001). This is generally the case in the Middle Rio Grande (MRG), especially within the planning region defined below. At UNM, the hydrogeoecology group has been measuring depletions due to ET since 1999. This is done using state-of-the-art micrometeorological sensors mounted on towers above various characteristic bosque forest types, both native and non-native. This fact sheet describes the results from this research, focusing upon comparisons between cottonwood forests that have and have not been invaded by non-native species, primarily saltcedar (*Tamarix chinensis*) and Russian olive (*Elaeagnus angustifolia*). Both of these species have the ability to form dense, impenetrable thickets within cottonwood forests. It is with the resultant forest leaf area that we are most concerned. Results from saltcedar forests outside the planning region will provide a basis for predicting ET depletions due to future restoration efforts within the planning region.

Restoration efforts are well underway throughout the MRG, both within and outside the planning area. In general, this involves complete removal of the understory vegetation—saltcedar, Russian olive, willow (Goodding's and sandbar), and the herbaceous ground cover. Everything except cottonwood is rendered into mulch and removed from the site to decrease fire fuel load. When sites are burned, saltcedar often resprouts to higher ET rates than before—not only does removal of saltcedar decrease fire susceptibility, but saltcedars will not be present to benefit from fire. To avoid returning and removing re-sprouted volunteers, root rakes and root plows are used to pull out the near surface root crowns of the non-natives (Taylor, 2002). John Taylor has been leading the science of saltcedar removal at Bosque del Apache for many years, and he has developed these methods, which result in very low saltcedar recolonization rates following removal. Restoration efforts are underway to 1) decrease fire danger due to dense vegetation and excessive large woody debris and 2) reduce the water demand from bosque vegetation. This fact sheet details how these objectives are met by restoration of bosque habitat and maintenance of native bosque vegetation.

2.1 Historic and Current Conditions of the Middle Rio Grande Bosque

Acreage of bosque in the planning area has been provided by Dr. Julie Coonrod (Coonrod, 2002). Landsat 7 ETM+ data was visually inspected to roughly identify the presence of phreatophytes in a given pixel. The Landsat scenes that were used did not extend to the extreme northern terminus of the planning region (Figure 1-1). Based upon this satellite data, Sandoval County has 2,538 acres of bosque, Bernalillo County has 5,765 acres, and Valencia County has 4,990 acres. Thus, the total bosque area in the planning region is 13,293 acres.

Dominant native species along the MRG include the Rio Grande cottonwood (*Populus deltoides* subsp. *wislizennii*), Goodding's willow (*Salix gooddingii*), sandbar willow (*Salix exigua*), seepwillow (*Baccharis salicina*), yerba mansa (*Anemopsis californica*), saltgrass (*Distichlis spicata*), and screwbean mesquite (*Prosopis pubescens*). Historically, unrestricted meandering of the MRG created a rich mosaic of variously aged cottonwood stands, isolated understory areas, dry grasslands, and wetlands (Scurlock, 1998). There are already more than enough cottonwood trees within the planning area to support restoration to historical conditions.

In Figure 1-1, vegetation composition and cover characteristics at locations marked as Bosque Ecological Monitoring Project (BEMP) sites are described in Eichhorst et al. (2001). Locations marked as ET sites contain UNM's eddy covariance ET towers. The other two ET tower sites listed in the assumptions (Exhibit 1A) are located south of the planning area. The shading around the river represents the Middle Rio Grande bosque extent as of the 2000 Landsat data, which is abruptly cut off south of Cochiti. Over 75 percent of these sites, as described in the

BEMP progress report (Eichhorst et al., 2001) as well as in numerous aerial photographs, have a cottonwood overstory. Most of these trees are 30 to 50 years old and cottonwood has a maximal life expectancy of 100 years. While many of the trees will die within the next 30 years, it will take at least 40 to 50 years for the MRG within the planning area to reach cottonwood density equivalent to the late 1800s (Scurlock 1998).

Numerous exotic species have become established in the MRG bosque. Within the planning area, Russian olive (*Elaeagnus angustifolia*) and saltcedar (*Tamarix ramosissima*) often form dense thickets within cottonwood forests. In the sparse forests in Valencia county, the sometimes large gaps between cottonwoods are filled with a dense cover of Russian olive and saltcedar, rather than historically low water-using saltgrass meadows. Throughout all three counties, Russian olive also forms dense thickets beneath cottonwood forests and along riverbanks.

Establishment of riparian species is dependent upon seed production during a specific flow regime, where adequate germination sites are available for these wind-dispersed seeds to land. Inundation of bars and banks, followed by declining water table in these high light environments, generally promotes establishment in many of these highly specialized riparian species, including saltcedar, cottonwood, willow, and Russian olive (Shafroth et al, 1995; Auble and Scott, 1998, Mahoney and Rood 2002). Continued reproduction of riparian phreatophytic trees within forests and on terraces is limited to clonal resprouting.

Saltcedar germinates *en masse* on sand bars and islands, producing carpets of seedlings consisting of greater than 2,000 plants m^{-2}—a density that is three times higher than that of native species (Cleverly, 1999). During the first year following germination, aboveground growth of these seedlings is very slow. Small depositional floods occurring at the end of the first growing season bury and kill most saltcedar seedlings (Gladwin and Roelle, 1998; Cleverly, 1999). Furthermore, it has been shown that these small saltcedar seedlings are vulnerable to competitive exclusion by cottonwood (Sher et al 2000). Saltcedars have established quite well in the MRG region because they can colonize these sand bars throughout the growing season, while cottonwoods only produce seeds during a 3 to 4 week window of opportunity during the late spring. Whenever saltcedar seeds germinate outside that time period, they experience no competition from cottonwood seedlings.

The distinct advantage that allows saltcedar to invade native riparian forests is its stress tolerance (Busch and Smith, 1995; Cleverly et al, 1997). Saltcedar is highly halophytic, seeming to thrive under extremely saline conditions (Kleinkopf and Wallace, 1974). After surviving short- or long-term drought and salinity, saltcedar quickly recovers its high water use physiology. In fact, stress hardening in saltcedar opens opportunities for increased dominance of floodplain ecosystems and the resultant expanded water uptake for which they are capable." (Cleverly, in review.)

Russian olive and saltcedar grow in high density, producing numerous leaves and a high leaf area index (LAI). High LAI sites like these are associated with high ET (Table 1-1). Vegetation density in these invaded sites is high due to disruptions in natural flooding regimes because the channel-bound MRG no longer meanders. Without regular inundation and drawdown, cottonwoods do not regenerate, while non-native species become more vigorous with age. This high density of vegetation contributes to increased fire danger in the bosque, following which saltcedars regenerate from underground root crowns and Russian olives regenerate by seed.

Table 1-1 summarizes information about each site, showing the dominant community, interflood interval (IFI), season length, average April through November depth to groundwater, average daily growing season (ET > 0.75) ET, and the annual cumulative ET. Error estimates are standard error of the mean.

2.2 Future Conditions without Restoration/Management

Without vegetation management along the MRG, non-native species will continue to increase their dominance while cottonwoods and other native species will decline. There are three reasons for these shifts: (1) fire favors non-native species over cottonwoods, (2) Russian olive is one of the few species riparian species that does not require flood inundation for seedling establishment, and (3) cottonwoods begin to die after 80 to 100 years.

As dominance of non-native species increases, LAI will also increase. Continually increasing vegetation density will be associated with increased occurrence of bosque fires, creating an uncontrolled spiral of depletions and property damage. If all of the 13,290 acres of bosque habitat in the planning region were to increase water loss to the pre-restored South Valley of Albuquerque, depletions in the planning area would increase by up to 15,000 acre-feet.

Table 1-1. Summary Table

Site	Community	IFI	Season (days)	Depth (cm)	ET (cm/yr)	ET (mm/d)
1999 (normal spring, wet monsoon season):						
Sevilleta NWR	*T. chinensis* +	long	170	167 ± 0.1	74	3.4 ± 0.2
	Distichilus spicata					
Bosque del Apache NWR	*T. chinensis*	short	183	199 ± 0.3	122	5.4 ± 0.2
2000 (normal to dry spring, very dry monsoon season:						
Albuquerque	*P. deltoides* +	long	236	139 ± 0.1	123	5.2 ± 0.1
	T. chinensis, E. angustifolia					
Belen—Rio Communities	*P. deltoides* + natives	short	215	120 ± 0.1	98	4.6 ± 0.1
Sevilleta NWR	*T. chinensis* +	long	215	193 ± 0.1	76	3.5 ± 0.1
	Distichilus spicata					
Bosque del Apache NWR	*T. chinensis*	short	223	227 ± 0.1	111	5.0 ± 0.2
2001 (normal to wet spring, normal monsoon season):						
Albuquerque	*P. deltoides* +	long	233	138 ± 0.1	115	4.9 ± 0.1
	T. chinensis, E. angustifolia					
Belen—Rio Communities	*P. deltoides* + natives	short	236	131 ± 0.1	106	4.5 ± 0.1
Sevilleta NWR	*T. chinensis* +	long	192	198 ± 0.1	69	3.6 ± 0.1
	Distichilus spicata					
Bosque del Apache NWR	*T. chinensis*	short	214	223 ± 0.2	106	5.0 ± 0.2

Natives: Anemopsis californica (Yerba Mansa), Baccharis sp. (Seepwillow), Salix exigua (Coyote Willow), Equisetum sp. (Horsetail)

IIFI = Interflood interval cm/yr = Centimeters per year ET = Evapotranspiration mm/d = Millimeters per day
NWR = National Wildlife Refuge

2.3 Future Conditions with Understory Restoration/Management

Numerous restoration projects have been performed or are currently underway. Some of the projects south of the MRG planning region have had poor success due to poor planning; these projects did not include root crown removal. Success rates, indicated by failure of non-native species to re-establish, have improved since use of root crown removal or cut-stump applications of herbicide have become more common. The basis for projecting the future conditions with understory restoration and management will be drawn from in-progress projects that are occurring with in the planning region. These projects all take advantage of the findings of the Albuquerque overbank project and Bosque del Apache's pioneering efforts. Within the planning region, restoration and management projects are now underway in Sandoval County (Pueblo of Santa Ana and the U.S. Army Corps of Engineers [USACE]), Bernalillo County (the Middle Rio Grande Conservancy District [MRGCD], and the City of Albuquerque), and Valencia County (USACE).

The USACE projects in Santa Ana (Sandoval County) and Los Lunas (Valencia County) both include extensive modifications to surface water flow in addition to removal of non-native species. At Santa Ana, the Pueblo is placing in-stream gradient structures, thus creating habitat for the endangered silvery minnow. In Los Lunas, the USACE is cutting additional channels through the restoration site to mimic the success of the Albuquerque Overbank Project.

The Albuquerque Overbank Project (AOP) was an experiment performed by Dr. Cliff Crawford to test restoration of on-site hydrological processes as a method for creating self-managing native ecosystems. This small-scale study included removal of Russian olive and saltcedar thickets along the riverbank in association with placement of channels to facilitate establishment of native cottonwood and willow gallery forest.

Vegetation recovery at the AOP site followed a well-documented succession from initial establishment of sunflowers (most likely *Helianthus annuus* and *H. cilaris*), followed within a few short years by sandbar willow, Rio Grande cottonwood, and a few Russian olives. None of the vegetation that recurred on these experimental sandbars was planted; re-vegetation proceeded naturally under near-ideal conditions.

Considerably much less time has occurred since the implementation of the not-yet completed restoration project at Santa Ana Pueblo. Even less time has elapsed since the burgeoning restoration projects in the South Valley of Albuquerque and in Los Lunas. Some post-restoration infilling by Russian olive is possible in suitably cool and moist microclimates beneath the cottonwood canopy. Saltcedar, once root crowns are successfully removed, is slow to fill in following restoration because saltcedar establishes following inundation and drawdown as native species do. Replanting generally is not a recommended restoration strategy in the planning region because of the existing cottonwood overstory. Conversely, in areas where the cottonwood overstory is absent, or where it is needed to replace dying or diseased trees, pole planting may be beneficial. A mosaic of isolated cottonwood forests, wetlands, and saltgrass meadows is the best strategy for minimizing depletions through bosque restoration.

3. Alternative Evaluation

3.1 Technical Feasibility

Enabling New Technologies and Status

Two primary methods of non-native vegetation removal are being practiced in the MRG: herbicides and mechanical removal. Herbicide-based restoration is less expensive (approximately $180 per acre) but is generally not as successful as mechanical removal. Mechanical removal is more expensive (approximately $600 per acre), but use of root rakes, root plows, and other methods that extract the root crowns of Russian olive and saltcedar is much more successful after 5 to 10 years (Taylor, 2002). Mechanical removal is favored at sites where cottonwood trees are to be retained due to the toxic effect of general-use herbicides on cottonwoods. All restoration sites within the planning area contain cottonwood trees.

Infrastructure Development Requirements

This alternative action requires no infrastructure development. Contractors have already been identified through the numerous projects in the MRG.

Total Time to Implement

Complete implementation of this alternative will require at least 10 years and possibly up to 25 years. The City of Albuquerque has been restoring bosque habitat in the south valley of Albuquerque at a rapid rate since August 2002. This rapid restoration employs removal of understory vegetation without associated modifications to site hydrology. This project is working closely with the fuel reduction–restoration study by the MRGCD. The MRGCD's project began in 1999, actual restoration has begun in 2002, and the study will continue for 5 years. This project involves removal of non-native species, replanting of native species, and controlled burning of post-restoration sites. More hydrologically ambitious restoration projects, such as the Los Lunas project undertaken by the USACE, proceed much more slowly. However, the Los Lunas restoration project is more likely to succeed because it is modifying the on-site hydrology.

Such modifications improve the probability of native species establishments and increase leaching of salts from the vadose zone.

3.1.1 Physical and Hydrological Impacts

Effect on Water Demand

From a basin perspective, savings due to removal of riparian vegetation are interpreted as a decrease in water demand. In the water budget, restoration within the planning area is acknowledged as a reduction in water demand.

Effect on Water Supply (surface and ground water)

Because surface water and groundwater are immediately connected in the riparian corridor, change in ET is experienced directly as a change in surface water supply. Any impacts on the shallow alluvial aquifer are generally assumed to affect surface water supplies immediately. Therefore, restoration within the planning area is acknowledged as an increase in water supply of the same magnitude as the reduction in water demand.

Water Saved/Lost (consumption and depletions)

The total water savings due to restoration and management of all bosque habitats in the planning region is *13,900 acre-feet per year*, an average savings of 1.04 acre-feet per acre of restoration. This amount was estimated on a county-by-county basis, as described below.

LAI is an important factor in determining the effect of restoration projects upon the water budget. LAI preceding restoration is fairly well known throughout the planning region. LAI following restoration is being measured in some pilot projects, and is projected from the density of cottonwood at other sites and throughout the planning region. The change in ET is computed from the relationship between LAI and ET. Figure 1-2 shows the functional relationship between LAI and ET from monthly data taken during 2001. The equation represents the least squares regression line, and it was used to calculate the percent change in ET following a given change in LAI due to restoration activities. The LAI at the South Valley Albuquerque site following restoration activities is 2.5.

Sandoval County. The bosque community in Sandoval county consists of a narrow band of dense cottonwood forest (Figure 1-1). The Santa Ana Pueblo restoration forest is located upon a high terrace and contained a high-density Russian olive understory prior to vegetation removal. Sites like this throughout the county most likely have an unrestored LAI equivalent to the South Valley Albuquerque site, but the high density of cottonwoods sustained at this site limits the ET savings due to removal of non-native vegetation by 20 percent, from 3.9 acre-feet per acre to 3.1 acre-feet per acre restored. This represents a savings of 0.8 acre-feet per acre, and a total annual water savings of 2,030 acre-feet in Sandoval County.

Bernalillo County. The bosque community in Bernalillo County consists of a wider band of sparser cottonwood forests. A great deal of Russian olive and saltcedar exists between the cottonwoods and chokes the forest beneath the canopy. These sites, representing 80 percent of the bosque in Bernalillo County, are characterized by the South Valley ET site maintained by UNM and the AOP site (Eichhorst et al., 2001; Dahm et al., 2002). Since restoration efforts began at the South Valley site, LAI has declined from 3.5 to 2.5, creating a projected 25 percent decline in ET, from 3.9 acre-feet per acre to 2.9 acre-feet per acre. This is a water savings of one acre-foot per acre, and a total annual water savings of 4,612 acre-feet in 80 percent of Bernalillo County's bosque area.

Locations such as the Rio Grande Nature Center and Alameda account for 15 percent of the bosque in Bernalillo County. These sites maintain a savannah-like mosaic of cottonwood trees, open spaces, and non-native species (Eichhorst et al., 2001). Leaf production by cottonwoods at these sites has been steadily declining for over a decade (Molles et al., 1998). Low LAIs at these unfavorable sites limit the potential savings achieved by restoration and management. Under this alternative, sites as these would be transformed into forest mosaic savannahs, which would reduce ET by 13 percent, from 2.5 to 2.2 acre-feet per acre. This is a water savings of only 0.3 acre-feet per acre, and a total annual water savings of 259 acre-feet in 15 percent of Bernalillo County's bosque area. Restoration of sites such as these, which already have sparse vegetation, will not appreciably reduce vegetative water loss in Bernalillo County.

The remaining 5 percent of the bosque in Bernalillo County consists of constructed wetlands and wetland restoration projects. Typically, these wetlands are located near the river, where non-native species often grow very dense. ET from a wetland can be as much as 50 percent of the water lost from a dense cottonwood or saltcedar forest (Burba et al., 1999). Wetland restoration will reduce ET by 50 percent, from 3.6 acre-feet per acre to 1.8 acre-feet per acre. This is a water savings of 1.8 acre-feet per acre, and a total annual water savings of 519 acre-feet in 5 percent of Bernalillo County's bosque. The total water saved in Bernalillo County due to restoration is expected to be *5,390 acre-feet per year*.

Valencia County. Dominance of Valencia County by shrubs and non-native species is much greater than in the other two counties (Eichhorst et al., 2001). Large spaces beneath and between cottonwoods are taken up by Russian olive and saltcedar. Restoration at such sites would produce largely cottonwood savannahs—a patchwork of cottonwood copses, saltgrass meadows, and re-vegetated willow stands in the lower terraces. Restoration of these densely invaded cottonwood forests will reduce ET by 40 percent, from 3.3 acre-feet per acre to 2.0 acre-feet per acre. This is a water savings of 1.3 acre-feet per acre, and a total annual water savings in Valencia County of 6,487 acre-feet.

Impacts to Water Quality (and mitigations)

This alternative has a minor effect on water quality.

Most plants cannot tolerate saline soils and will exclude salt from entering the plant at the roots. If the soil is too saline, these intolerant plants will decrease evapotranspiration until they die from lack of water. Saltcedars, however, thrive on saline soils, taking up the salts and delivering them to the surface of their leaves. While saltcedar is known for its association with saline soils, soils are not salty due to the presence of saltcedar. Saltcedars cannot "create" saline soils—the salts must already be present in the system and the presence or absence of saltcedars has very little effect on water quality.

Russian olives are known to convert atmospheric nitrogen to nitrate; Russian olive roots act as hosts to nitrogen-fixing bacteria. The presence of Russian olive does impact water quality by increasing nitrate concentration in alluvial groundwater, but it is unknown exactly how much soil nitrate concentrations might change immediately following removal of Russian olives.

Watershed/Geologic Impacts

There are no known watershed/geologic impacts caused by this alternative action.

3.1.2 Environmental Impacts

Impact to Ecosystems

The intent of all restoration projects is to impact ecosystems for the better. The greater diversity of habitats generated by restoring a mosaic of forests, wetlands, and grasslands is expected to promote a greater diversity of organisms that can use the bosque.

Implications to Endangered Species

Decreasing depletions, which is the focus of this alternative, increases the probability that the river can remain wet. Any means of increasing surface water reliability provides better assurance that the endangered silvery minnow will survive in the MRG. While the endangered willow flycatcher has been found nesting in saltcedar, maintenance of sandbar willow communities does not affect the feasibility of bosque restoration. Sandbar willow is historically limited to wet banks at the river's edge (Scurlock, 1998), and such vegetative growth is consistent with the AOP restoration model.

3.2 Financial Feasibility

3.2.1 Initial Cost to Implement

Costs for the projects discussed in Section 2.3 are as follows:

- Los Lunas: Mark Horner, USACE, $20,000 per acre
- Albuquerque: Ondrea Hummel, City of Albuquerque
- Albuquerque: Sterling Grogan, MRGCD, $2,500 per acre, 450 acres
- Other estimates: John Taylor, Bosque del Apache National Wildlife Refuge, $180 to $1,000 per acre

Costs for pole planting are approximately $10 per tree with labor costs on the order of $10 per hour (Means, 1999). These costs can be reduced if volunteer labor is used to plant the poles. In some cases, poles may be available (such as from the Bosque del Apache) for no cost is volunteers cut and re-plant the poles.

3.2.2 Potential Funding Source

The sources shown in Table 1-2 have provided or currently are providing funding for bosque restoration:

Table 1-2. Funding Sources for Bosque Restoration

Source	Already Funded	County
U.S. Budget, Senator Pete Dominici	$ 75,000,000	Bernalillo
City of Albuquerque	unknown	Bernalillo
Middle Rio Grande Conservancy District	$ 1,500,000	All
Bosque Initiative	unknown	All
ESA Workgroup	unknown	All

3.2.3 Ongoing Cost for Operation and Maintenance

The cost of restoration provided by Taylor (2002) includes the ongoing cost for operation and maintenance for five years. The restoration projects from which these costs are estimated involved multiple years of minimal management. Maintenance costs in the planning region are likewise expected to be minimal, requiring mostly multiyear return visits by crews that exterminate isolated root sprouts and seedlings. Restoration of on-site hydrology (as with the AOP experiment and the nascent USACE projects) greatly reduces the ability of saltcedar to return following removal.

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