Effects of Fuel Reduction and Exotic Plant Removal on Vertebrates, Vegetation and Water Resources in the Middle Rio Grande, New Mexico

Final Report to the Joint Fire Sciences Program
Prepared by the USFS Rocky Mountain Research Station






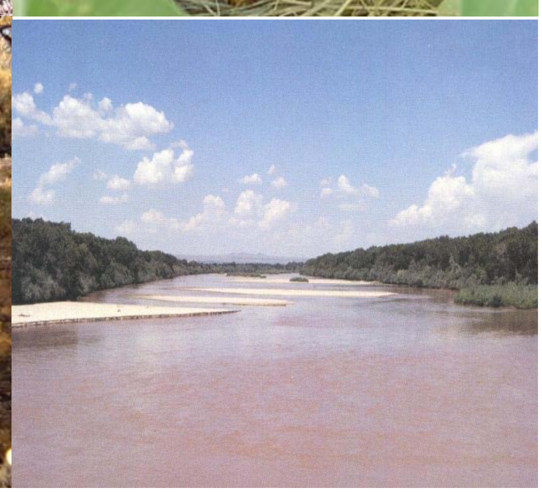

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TABLE OF CONTENTS

PROPOSAL TO JOINT FIRE SCIENCE PROGRAM: RFP 2001-1. **April 16, 2001**

Project Title: Effects of Fuels-Reduction and Exotic Plant Removal on Vertebrates, Vegetation, and Water Resources in Southwestern Riparian Ecosystems.

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ABSTRACT. Fuel reduction treatments are needed in southwestern riparian ecosystems. The middle Rio Grande riparian bosque (woodland) in Sandoval, Bernallilo, Valencia, and Socorro Counties, New Mexico, is a prime example of a system where fuel reduction is needed to prevent further spread of wildfire in southwestern riparian woodlands, and to reduce risks of fire damage for residents of Albuquerque, Socorro, Belen, Isleta, Sandia, Cochiti, and surrounding rural areas. Dead and downed wood and exotic woody plants comprise fuels leading to high bosque fire risk. Research will identify fuels-reduction practices that will simultaneously preserve cottonwoods and other native plants, reduce wild fire risk via fuels removal, control spread of exotic woody shrubs, and have positive or neutral impacts on wildlife species. Three treatments will be compared: 1) Mechanical removal of dead and down wood and exotic plants, 2) Partial mechanical removal of dead, down, and exotics followed by light prescribed fire, 3) Mechanical removal of dead, downed, and exotics followed by revegetation with native plants. Our proposed study evaluates treatment effectiveness at 16 sites over 4 counties by monitoring water quantity, soil salinity, habitat structure, plant reproductive response, and bird, bat, and herptile populations. This study addresses Task 3 of the RFP *"Within the matrix of land management practices, determine the cumulative effects of fuels manipulation/reduction methods…."* Specifically we target Element 1 of Task 3, *"address fuels treatment impacts on wildlife populations and habitat structure, hydrology, soils, ecosystem health, or other environmental variables at a landscape or regional level."*

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INTRODUCTION

Project Justification

We propose to monitor vegetation, bird, bat, reptile, and amphibian, and hydrological responses to 3 fuels removal treatments in the middle Rio Grande bosque (woodland). A Memorandum of Understanding (MOU) that defines collaboration among federal, state, and municipal agencies and specifies organizational roles, authorities and contacts has been signed by all parties. This study is conducted under the auspices of the Middle Rio Grande Ecosystem Management Research Program (http://www.fs.fed.us/rm/albuq) which is managed by the Rocky Mountain Research Station's Albuquerque Laboratory in collaboration with University of New Mexico, Cibola and Santa Fe National Forests, U.S. Fish and Wildlife Service's Southwest Region, Bureau of Reclamation, City of Albuquerque, and New Mexico Energy, Minerals and Natural Resources Department.

Removal of fuels in the form of dead and downed wood and exotic invasive woody plants is needed in southwerstern riparian ecosystems. A prime example o fthis need is the middle Rio Grande bosque, where fuel reduction would : 1) prevent further spread of catastrophic wildfire, 2) control escalating costs and labor of bosque firefighting, 3) reduce risks of fire damage for residents of Albuquerque, Socorro, and Belen, and surrounding rural areas, and 4) preserve native riparian plant and animal communities. Exotic salt cedar (*Tamarix ramosissima*) and Russian olive (*Elaeagnus angustifolia*) as well as dead and down wood are fuels that have led to increased fire frequency and risk on the middle Rio Grande (Stuever 1997). Several agencies have engaged in local case-by-case actions to reduce bosque fuels and control exotics, and share their results at Middle Rio Grande Bosque Consortium (MRGBC) meetings.

Treatments that remove invasive woody shrubs from southwestern riparian ecosystems, however, have unknown consequences for wildlife species, including sensitive, threatened, and endangered vertebrate species known to inhabit Rio Grande woodlands. Comparing wildlife, vegetation, and abiotic responses to a variety of treatment types is essential for determining which treatments are least ecologically costly and most advantageous in reducing fire risk while sustaining biological diversity, sensitive species populations, and ecosystem functioning.

Objectives

We propose to study responses of vegetation, birds, bats, herptiles, and hydrology to fuel removal treatments in middle Rio Grande woodlands having cottonwood overstories and high fuel loadings of dead wood and exotic woody shrubs and trees. Research is directed toward identifying best fuels-reduction and exotic plant removal practices that will simultaneously 1) preserve cottonwoods and other native trees and shrubs, 2) reduce catastrophic fire risk via control of exotic plants, and 3) have positive or least-negative impacts on native wildlife species. Each treatment was designed to attain fuel-loading levels estimated to avert catastrophic fire risk. Three treatment types were determined: 1) Mechanical removal of dead and down wood and exotic plants (cut stumps of exotics treated with herbicide), 2) Partial mechanical removal of dead, down, and exotics (herbicide) followed by prescribed fire, and 3) Mechanical removal of dead, downed, and exotics (herbicides) followed by revegetation with native understory plant species such as New Mexico olive, coyote willow, seep willow, wolfberry, and saltbush.

Background

Exotic and Native Plant Issues

Replacement of native vegetation by exotic plant species, particularly those that are highly flammable such as Tamarisk, has increased fire frequency in southwestern riparian ecosystems (Southwestern Willow Flycatcher Recovery Team (SWFRT), 2000. Native tree species inhabiting the middle Rio Grande such as Rio Grande cottonwood (*Populus deltoides* subsp. *wislizeni*) and Fremont cottonwood (*P. fremontii*) are not fire-adapted and thus cannot resist fire damage or respond with regenerative resilience to fires (Abrams 1986, Adams et al. 1982, Busch 1995). The probability of fire is enhanced by river regulation because of the propensity for flammable biomass to accumulate on regulated, flood-suppressed rivers such as the Rio Grande (Busch 1995, Shafroth 1999).

Dewatering of rivers and flood suppression increases the frequency and intensity of fires by increasing the amount, distribution, and flammability of surface fuels (Ellis et al. 1998). Reduced base flows, lowered water tables, and less frequent inundation can cause plants to lose water content, and cause mortality of stems or whole plants. Stress-related accumulation of dead and senescent woody material is a primary factor contributing to fire increase in riparian systems (Busch 1995, Busch and Smith 1995). Dewatering also facilitates the replacement of broad-leaved riparian vegetation by more drought-tolerant species such as tamarisk (Smith et al. 1998).

Tamarisk plants have many stems and high rates of stem mortality, resulting in an accumulation of dense, dry dead branches. Large amounts of litter, including dead branches and the small, needle-like leaves, are caught in the branches, enhancing its flammability. Fallen leaves of the native broadleaf trees (e.g., *Populus* spp. and *Salix* spp.) decay quickly relative to tamarisk, thus reducing the relative fuel loading (SWFRT 2000). Anderson et al. (1977) noted that 21 of the 25 tamarisk stands they studied had burned in the prior 15 years. When dense tamarisk stands burn, the fires are often intense and fast moving. For example, during just 3 years, recent fires totaled 1,000 ha of riparian habitat along the Lower Colorado River – a substantial amount considering only about 6,200 ha of suitable bird habitat currently exists along this river (U.S. Bureau of Reclamation 1999), down from 36,000 ha in 1983 (SWFRT 2000).

Brothers (1984) attributed increased frequency of fires along the Owens River to increased human use of riparian areas. Wisenborn (1996) reported that wildfires in tamarisk were increasingly common owing to increased population densities along rivers. Increased fires in desert uplands also may contribute to riparian fire increase. Grazing-adapted, exotic annual plants spread fire more readily than native annuals and have become established in southwestern deserts and grasslands (Brooks 1995), contributing to increased loads of dry, fine fuels and heightened ignition rates.

Bird, Bat, and Herptile Issues

Numerous Neotropical migratory bird species are ranked as management priorities by Partners in Flight (PIF), a national consortium of government and private groups that supports bird conservation. New Mexico PIF identifies restoration and protection of riparian habitats as an essential step in conserving Neotropical migrants, several species' populations of which are reported by Breeding Bird Surveys to be declining. Mid-story and canopy-nesting Neotropical migrants that could be affected by catastrophic fire include the Yellow-billed Cuckoo, a bird species repeatedly petitioned by environmental groups to be federally-listed as Threatened or Endangered (see *positive finding to list*, 1999 Federal Register). Short-distance migrants such as Spotted Towhee and Song Sparrow may also respond numerically to treatments that remove midstory habitat structure. Some ground and shrub-nesting Neotropical migrants that could be potentially affected by removal of exotic plants or downed wood include Black-chinned Hummingbird, Common Yellowthroat, Yellow Warbler, Yellow-breasted Chat, Lucy's Warbler, Summer Tanager, and Blue Grosbeak.

Removal of standing snags and mature exotic woody plants could conceivably have either positive or negative effects on canopy-nesting and canopy-foraging migrants such as Black-headed Grosbeaks, Summer Tanager, Yellow-billed Cuckoo, Western Wood Pewee by opening the canopy and removing perch sites. Such treatments may also alter quantity and composition of food supplies (e.g., foliage arthropods, bark beetles), but without research, it is impossible to know whether consequences for birds would be positive or negative. Removal of dead wood, especially standing snags, to reduce fuels may eliminate critical nest sites and foraging substrates for cavity-nesting birds such as woodpeckers, Bewick's Wren, Ash-throated Flycatcher, and Violet-green Swallow.

New Mexico supports up to 26 species of bats, of which 2 are federally endangered and 13 are federal Species of Concern (former USFWS Category 2 candidate species). The high degree of bat species diversity in the Southwest is reflected by the occurrence of over half of the known North American bat species in New Mexico and Arizona. The federal status of over half of New Mexico's bat fauna indicate that bat populations in the state may be threatened or need to be more thoroughly evaluated.

Along the middle Rio Grande, riparian forests and open water are commonly used by many bat species for feeding, roosting, and commuting. Despite their importance in ecosystems as the primary nocturnal predators of insects, bats have been paid very little attention historically by researchers or managers. Thus it is not known how bat communities and activities have been altered in response to nonnative plant invasions, fragmentation of riparian forests, agriculture, urbanization, or other anthropogenic changes along the middle Rio Grande. Given the current federal status of many bat species in New Mexico, it is critical to understand the impact of land management activities on bat populations. Changes caused to cottonwood forest structure and composition by removal of understory invasive plants and dead wood will likely impact the use of these forests by bats. These impacts must be identified, evaluated, and weighed against the merits of invasive plant control and fuels reduction. The objective of the bat component of this project will be to determine and compare the effects of various exotic plant removal treatments on bat activity in and use of mature cottonwood forests with high understory fuel loadings

The objective of the herpetofauna component of this project is to determine the effects of invasive plant removal treatments on species richness and relative abundance of herpetofauna in mature cottonwood forests with high densities of salt cedar and Russian olive and high fuel loadings. We focus on herptiles, particularly ground-dwelling reptiles, because they are a diverse taxonomic group in the Southwest whose local presence and distribution in the bosque may be influenced by retention or clearing of low vegetation cover and dead wood. From these findings, we will develop recommendations to mitigate the impacts of exotic plant control on herpetofaunal communities.

MATERIALS AND METHODS

Collaborative Arrangements

This study is conducted in coordination with Middle Rio Grande Conservancy District (MRGCD, a state-managed irrigation district), New Mexico State Forestry (NMSF), City of Albuquerque Open Space (ALBQ), Bosque del Apache National Wildlife Refuge (BNWR), Bureau of Indian Affairs (BIA), Pueblo of Cochiti, and Natural Resources Conservation Service (NRCS). Representatives from these organizations serve as regular members of the "Bosque Fuel-Reduction Team" which has been meeting monthly since January 2000 to coordinate treatment plans, NEPA processes, grant-writing, field tours, access, letters of agreement, MOU, and authorizations for this research project. Other cooperators include U.S. Fish and Wildlife Service (hosted a NEPA-writing workshop for the team), Bosque Improvement Group (sponsoring mechanical treatments); Albuquerque Corps of Engineers, U.S. Forest Service Southwest Region, Bureau of Land Management, Save our Bosque Task Force, and Tree New Mexico.

Study sites are located on lands managed by MRGCD, the City, BNWR, and Pueblo of Cochiti. These land-managing agencies are financing and arranging manual labor to clear exotic vegetation, apply herbicides, implement prescribed fires, prepare documents in compliance with regulatory requirements, and permit access to sites. NRCS will implement the revegetation component of treatments. NMSF will supervise and coordinate Inmate Work Crews to clear vegetation at MRGCD sites, BIA will arrange internal crews to remove fuels at Cochiti, and Bosque del Apache will remove fuels using personnel from the U.S. Fish and Wildlife Service. A Memorandum of Understanding (MOU) between the RMRS, land-owning entities, and NRCS Plant Materials Center (PMC) clarifies organizational roles, authorities, and contacts and is enclosed as an appendix. A separate agreement between RMRS, BIA, and Pueblo of Cochiti is being prepared which is similar in scope. The Counsel and Governor of Cochiti voted to approve the project on pueblo property in August, 2000.

Site Selection

Sites were selected in winter and spring of 2000 by using maps to find habitat patches of sufficient size, visiting each to evaluate habitat structure, plant species composition, and fuel loads (Table 1). Livestock are excluded from sites although cattle occasionally trespass at two locations.

Table 1. Study sites that meet site-selection criteria (> 20 ha, high fuel loads). Block 1 refers to Bernallilo Co, Block 2 Valencia Co., and Block 3, Socorro Co.

Block	Land Manager	Location	Site #	Ha	Location Description
1	Albq,MRGCD,NMSP	South Valley	1	28	S Rio Bravo-N I25 W
1	Albq,MRGCD,NMSP	South Valley	2	30	S Rio Bravo-N I25 W
1	Albq,MRGCD,NMSP	South Valley	3	23	S Rio Bravo-N I25 W
1	Albq,MRGCD,NMSP	South Valley	4	25	S Rio Bravo-N I25 E
2	MRGCD	Bosque Farms	1	25	N NM6 S Isleta Pueblo E
2	MRGCD	Los Lunas	1	48	S NM6 S Los Lunas W
2	MRGCD	Los Lunas	2	46	S NM6 S Los Lunas W

2	MRGCD	Bernardo	1	40	N US60 E Bernado Rfge W
3	MRGCD	Bernardo	2	40	N US60 E Bernado Rfge W
3	BLM,MRGCD	Lemitar	1	33	E of river South of Lemitar
3	USFWS	Bosque del Apache	1	31	Management Unit 7
3	USFWS	Bosque del Apache	2	20	East of willow Deck
4	Cochiti Pueblo	Below Cochiti Dam	1	22	W of Rio 0.2 mi S on NM22
4	Cochiti Pueblo	Below Cochiti Dam	2	25	W of Rio 1 mi S on NM22
4	Cochiti Pueblo	Below Cochiti Dam	3	23	W of Rio 2.1 mi S on NM22
4	Cochiti Pueblo	Below Cochiti Dam	4	28	W of Rio 3.3 mi S on NM22

To find enough sites for this research, plots were established across multiple ownerships. Treatments will be applied by cooperating agencies. To conduct 3 treatments, 16 plots have been selected for monitoring purposes (Fig 1.). There will be 4 replicates of each treatment to ensure statistical power. To summarize, total number of plots will equal 4 replicates x 3 treatments + 4 controls = 16 plots. One replicate of each treatment will be located in each of 4 blocks. These blocks (Cochiti, north, middle, and south) each sample a geographically distinct reach of the middle Rio Grande. Each plot must be in habitat patches $\geq$ 20 ha to ensure accurate sample sizes and monitoring goals for mobile bats and birds. Treatment plots may be adjacent to each other (with habitat buffers between plots) in patches that are large enough to have two or more plots.

Treatments. Treatments will be applied after two seasons of data collection. Fuel loads at sites are in the process of being measured by New Mexico State Forestry (NMSF), and costs of treatments will be based on tons/acre of fuels. Cost estimates for removing (cutting) all dead and down wood and exotics range in the Rio Grande bosque (NMSF pers. comm.) from $141/ha for 10 ha to $264/ha for 26 ha depending on tonnes/ha (tons/acre) of fuel loads at a site. Estimates include directed (non-aerial) basal application of Garlon 4 to cut stumps of woody exotics by licensed applicators. Garlon 4 is a selective herbicide proven effective in treating salt cedar and Russian olive with little or no impact on desirable plants or water (Parker and Williamson 1996). U.S. Fish and Wildlife Service (USWFS) and BIA fire crews will implement prescribed fires at sites designated for fire follow-up treatments. Two fire sites are on MRGCD (irrigation district) land and will be implemented under pre-arranged MOUs between MRGCD and U.S. Fish and Wildlife Service. The estimate for revegetation is $70,000/site of which $20,000 will be funded through NRCS partnerships and the remainder financed through this proposal and/or by land-owning agencies and funding organizations such as but not limited to U.S. Fish and Wildlife Service's Bosque Improvement Group, U.S. Forest Service, Southwest Region's State and Private Forestry, and Albuquerque Corps of Engineers.

Fuel Loading and Removal. Trained crews supervised by NMSF, BIA, and BNWR will remove dead, down, and exotic woody plants according to fuel-loading targets and treatment types that meet estimated levels necessary to avert fire risk (Wicklund 1999). Selected bosque sites in need of treatment have fuels ranging from 360-450 tonnes/ha (160-200 tons/ac). Prescriptions to avert catastrophic fire risk range from 11 to 68/tonnes/ha (5-30 tons/ac) depending on type and depth of fuel. A range of 5-8 snags/ha will be retained. Fuel loading will be determined in tons/acre by NMSF using the Handbook for Inventorying Downed Woody

Material by James K. Brown (USDA-FS GTR-INT-16, 1994). The handbook provides a detailed description of how to inventory fuels using the Planer Intercept Method. This method involves sampling data planes placed throughout the sample area with dead, down, and exotic woody material being counted and measured. Volume is estimated; then weight is calculated from volume by applying estimates of specific gravity of woody material sampled.

A randomized block design will be used to treat sites, with 4 sites in each of 4 reaches. Treatments will be applied in winter and early spring, prior to May when wildlife sampling begins, and when conditions are safe (e.g., damp soils) for controlled burning. We estimate that it may take two years to implement all treatments. Treatments will be completed the same year within blocks to control for the impacts of random temporal variation. Treatments will be selected randomly by site. Modifications in treatment sites may be needed to meet revegetation requirements and to mitigate public concerns about prescribed fires.

<u>Prescribed Fire.</u> A Prescribed Burn Plan has been developed by qualified agency personnel, and the prescription will be applied to each of the 4 burn sites. To ensure consistency in meeting research fire specifications at each site, Fire and Forestry Supervisor Cal Pino, Bureau of Indian Affairs and Fire Officer Jim Sullivan, U.S. Fish and Wildlife Service have agreed to jointly oversee implementation of fire prescriptions. Funding for prescribed fire projects have been requested by agency fire personnel through normal agency avenues. Resources such as crews, equipment, consultations for implementing fires and mechanically removing hazardous fuels will be shared as authorized under existing MOUs and Joint Powers Agreements. Burning will be preceded by mechanical reduction of 75% of fuels. Objectives of mechanical clearing done in conjunction with fire are to remove live exotics, remove ladder fuels, and to ensure discontinuous distribution of fuels. A specific goal of low-intensity prescribed fire in this context is to open soil surfaces to encourage seeding, suckering, and growth of native plants in the absence of exotics. Our test is to determine if prescribed fire enhances the ability of native plants to re-seed after exotics have been removed. We also hope to determine whether fire can sometimes be used in place of revegetation (which is much more expensive) to return a site to a native understory. To protect live native trees, all fuels will be removed in a circle around them.

Site-specific prescription guidelines are addressed in the Fire Burn Plan with details describing work to be accomplished and methods used. To apply prescribed burning in the bosque, weather and fuel conditions must meet specific criteria (see below) for the project to be successful. Because cottonwood and willow stands have low tolerance to intense heat from fire and because the presence of salt cedar produces fire volatility, precise burning conditions are required so that fire does not damage the residual stand or escape containment.

A major objective is to remove dead, down and duffy material without building up too much heat in and around residual stands and not allowing fire to ignite ladder fuels and move into crowns of residual stands. Burning will be accomplished during the dormant season between November and early March when live fuel moistures are very low (25 – 50%). Air temperatures in the range of 35 to 60 degrees will be targeted. Relative humidity should be in the high range (50 to 100% for piles, 40 to 60% for broadcast burns), winds should be in low (0 to 10 mph), soil moisture should be high with light snow cover being beneficial when burning piles.

Since there will be a large amount of smoldering and creeping fire behavior during the 24 to 48 hours after ignition due to the hard wood duff and slash, we will emphasize burning when there is a 50% chance of measurable precipitation within the 2- 4 day period following the burn (either pile or broadcast). Patrols will be arranged on a daily basis.

Revegetation. Local ecotype shrub vegetation will be planted by Natural Resources Conservation Service (NRCS) on 4 of the 20-ha treatment plots. Because the Rio Grande Valley receives less than 20 cm of annual moisture, the vegetation will be installed as dormant 4.5 m pole cuttings or as containerized transplants with 74 cm rootstock. This vegetation will be planted in holes that have been augured to the capillary fringe of the water table. Subsequently, the plants should not require any irrigation treatments, which is normally required for one-gallon transplants to obtain satisfactory survival. To adequately reach subsurface moisture, the relatively short 75 cm rootstock will be limited to planting near the river. The 4.5 m cuttings can be planted randomly within the plots.

The NRCS Los Lunas Plant Material Center (PMC) has determined in previous studies that the common Rio Grande riparian shrub species *Amorpha fruticosa* and *Baccharis glutinosa* can be field-established as dormant pole cuttings. The PMC has local collections of both species in farm production. The Rio Grande riparian shrub species *Lycium spp.* and *Forestiera neomexicana* are grown in 10-cm diameter tubes, 75 cm in length, to produce long root systems that can reach subsurface moisture after transplanting. Both species produce fleshy fruit that are readily consumed by many wildlife species including birds.

For enhancement of vegetation establishment, both soil salinity and depth to water table measurements will be taken on each of the 20-ha study plots. Each plot will be divided into quadrants. A well will be installed in the approximate center of each quadrant to monitor the water table depth. A composite sample of 30 soil samples taken from a 15 – 25 cm depth will be collected in each quadrant and measured for electrical conductivity to estimate total soil salts. Extreme salty and dry areas will not be planted.

The PMC will contribute $20,000/year of in-kind services of plant materials and personnel hours towards this project. This will include the 75 cm tube transplant (@$20/unit), 4.5 m pole cuttings (@$8/unit), and personnel hours (@$250/day). The PMC has the equipment and experience to install shallow monitoring wells and measure soil salinity.

Monitoring Methods

Soils, Hydrology, and Weather. Soils, hydrology and weather are basic environmental parameters that dictate the types of ecosystems found in the Rio Grande Bosque. The treatments proposed in this study could alter conditions in these ecosystems and consequently the habitats of animal and plant species that live there. To determine the effects of the treatments in this study on these environmental parameters, a subset of factors that are vital to animal and plant species will be measured and monitored. The factors are depth to water below the soil surface, the salinity of surface soils, precipitation and air temperature.

Water is critical to the growth and development of all plant species. The primary sources of water for plants growing in the bosque are precipitation, ground water and surface water. Water flowing in the Rio Grande is the primary source of surface water. River water is also the primary source of ground water recharge for areas along the bosque due to the porous nature of the soils and subsurface materials. Water levels in the river are regulated by human-operated dams and generally only vary seasonally.

Contact with a permanent water source is critical to many riparian plant species for germination, early growth years and/or throughout their lives. Rapid changes in the depth to water can kill existing plants and/or create unfavorable conditions for new plants. Therefore it is necessary that we determine the effects our treatments could have on the depth to water in our project areas. To accomplish this, we will monitor the depth to water below the soil surface in 2" (5 cm) diameter piezometers. Each of the 16 study sites will be subdivided into 4 quadrants and one piezometer will be installed in the center of each quadrant. A total of 60 piezometers will be installed for the entire study. The depth to water in each piezometer will be measured and recorded monthly.

Precipitation that falls directly on the bosque in concert with the surface and ground water helps fulfill the needs of the plants and animal species when delivered within regular cycles and quantities. One tipping bucket recording rain gage will be installed at each of the 16 sites to monitor precipitation over the life of the study. Precipitation data will be collected and checked monthly.

Air temperature can influence the amount and location of activities by birds and mammals. Our treatments will affect the amount of shaded and exposed areas, and potentially the temperatures in those areas. Therefore the temperature in one exposed area and one shaded area at each of the 16 sites will be monitored with recording thermometers concealed in weatherproof shields. A total of 32 thermometers will be installed for the study. The data will be collected and summarized monthly.

The amount of salinity in surface soils can adversely affect established and new plants. One treatment is to revegetate selected sites with native plant species. Extensive revegetation work done by the NRCS in New Mexico has demonstrated that high salinity levels in surface soils will reduce the success rate of new plantings. Therefore, salinity level of the surface soils will be sampled at each site. Using the piezometer quadrants, 30 randomly spaced soil samples will be collected from the upper soil surface (15-25 mm below the soil surface). An electrical conductivity measure of the combined samples will be taken to estimate total soil salts. A total of 60 composite samples will be collected and sampled. Revegetation of extremely salty soils will be avoided. Salinity will be sampled prior to treatments. Soil salinity will be sampled again 5 years after treatment.

Vegetation Sampling. A reduction in the amount of woody vegetation from treatment application will result in open space available for establishment and recolonization by native and exotic species. Questions specific to vegetation responses are: 1) what plant community, including what species diversity and composition, will be in place 1-5 yrs post treatment, and 2) will all treatments result in the same plant community? To answer these questions, 1-m square subplots will be established within larger 0.04 ha plots at the plot center and midway along each of the 4 cardinal-direction radii. A minimum of 10 subplots will be sampled at each site. Within the subplots, density and cover of all vascular plant species will be recorded.

To assess changes in bird habitat in relation to treatments, vegetation structure at each site will be characterized by using 0.04 ha circular plots (James and Shugart 1970). One plot will be centered on each bird point count location. Random plots and avian nest sites will also be sampled and used to characterize the vegetation surrounding nests in relation to random habitat availability. In each plot the number of woody stems of each species will be counted by diameter-at-breast height size classes before and after treatment. After treatment, health of remaining woody vegetation will be assessed by estimating percentage of live, standing dead, and dead and down biomass. Ground cover that contacts a vertical rod will be recorded at 25 points spaced at 20 cm intervals along each of 4 radii of the sampling plot. The radii will be oriented in the cardinal directions. All grasses and herbs will be recorded to species where possible. Ground cover diversity will be estimated at 2 m intervals along each radii by counting the number of times vegetation hits a vertical rod in a series of 1 dm height categories. Foliage diversity of shrubs and trees will be estimated by counting the number of times foliage hits a vertical rod in 2 m height categories. Canopy closure will be measured with a densiometer at the point center and the end of each radii.

Vegetation surveys for herptile and bat studies will include variables that assess the degree of ground clutter/cover for herptiles, obstructions to bat flight below the canopy, and availability of snags and damaged trees for bat roosts.

Bird Sampling. Breeding birds will be monitored by a crew of 6 persons from 15 May through 15 July at all study sites. Approximately half of their time will be spent counting birds, searching for nests, and monitoring nests and behavior. The remaining half of the time will be spent measuring vegetation, mist netting, and monitoring hydrologic conditions. USFWS has issued permits to RMRS to survey southwestern willow flycatchers in the bosque. Sites occupied by breeding flycatchers will not be included in the study in accordance with guidance in the draft flycatcher recovery plan.

Generally, our count methods follow the recommendations of Bibby et al. (1992). Point-count stations will be placed at a density of 1 per 4 ha. Birds will be counted at each site 4-5 times per season. During each count, all birds seen or heard will be recorded at each point for 8 minutes. Each counter will be trained to estimate and record distances in meters. Each site will be searched for nests on 4-5 occasions during between 15 May and 15 July. The contents of accessible nests will also be checked regularly. The location of each nest will be recorded via global positioning system (GPS).

Bat Sampling. To identify impacts of treatments on summer activity levels of bats, relative changes in bat activity at each site will be quantified. One to two years of pretreatment data will identify the inherent differences in bat activity between control and treatment sites due to site differences. Treatment effects will be identified as significant changes in the magnitude of these differences.

From night to night, bat activity depends on weather conditions, moon phase, insect activity, and other factors. To reduce this temporal variation, the multiple sites in a block will be monitored simultaneously in a single night. One block will be monitored per night, and each block will be monitored once per week from June 5 through September 1. The order of sampling each week will be randomized. Thus each site will be monitored 12-13 nights per season. Three bat-monitoring stations will be established per site. All monitoring stations will have their GPS locations recorded, will be marked with flags, and will be reused each year. On the night a site is to be monitored, automated echolocation-monitoring devices will be set up at the stations and activated just prior to dusk. Bat activity will be reflected by an index of abundance (IA) which is the total number of passes recorded in a night. A pass is defined as a sequence of $\geq$ 1 echolocation pulses with < 1 s between sequential pulses.

To determine whether prey abundance is correlated with changes in bat activity, the relative abundances of moths, beetles, and chironomids, the primary prey of many bat species, will be evaluated pre- and post-treatment. Arthropods will be collected in blacklight traps placed near acoustical monitoring stations on the same nights as monitoring. Moths and beetles will be sorted into size classes, and dry weight of each size class will be determined.

Reptiles and Amphibians. To identify impacts of treatments on reptile and amphibians, species richness and relative abundance will be quantified at each of the sites prior to and post-treatment. The direction and magnitude of changes on treatment sites will be compared to the control sites. Other factors that will be included to explain potential variation include block and year. To evaluate species richness and relative abundance, reptiles and amphibians on each site will be trapped with three drift fence arrays. Arrays will be placed randomly within the site and at least 25m from the periphery. Sites at each block will be trapped for 1 day per week from 1 May through 1 September. Each drift fence array will consist of three silt erosion fences with 2 pitfalls and 2 funnels per fence. Each fence will be 7.5 m long, will start 7.5 m from a central point, and will be positioned at an angle of 60 degrees from the other fences. For each day of trapping, we will record site number, array number, date, time, collector's name, species caught, which trap, snout-vent length, total length, mass, sex, and age. The cumulative number of species captured over one season will be tallied to determine species richness at a site. Each year's relative abundance will be reflected by a trapping rate (e.g. numbers per trap night).

Data Analyses

Analysis of variance with a randomized block design will be used to evaluate effects of treatments on wildlife numbers, vegetation variables, and avian nesting success. Power analyses to determine influence of variability among sites within blocks, within sites, and over time will be applied to ensure adequate sample sizes of wildlife data. Modifications of numbers of bat detectors, bird point counts, and habitat samples per site will be made during the first pre-treatment year, if power analyses dictate revisions in sampling design. Exploratory specialized sampling that varies number of bat detectors/site will be conducted to determine adequate number of bat samples.

PROJECT DURATION

We established sites in 2000 and tested monitoring methods in May-September 2000. A minimum of 2 years of pre-treatment monitoring (Years 2001-02) of birds, bats, herptiles, and hydrology will be followed by 2 years of treatment (2002-03) and at least 3 years of post-treatment sampling (2004-07) to determine short-term effects on flora, fauna, and hydrology. Sampling of flora and fauna will be conducted each year from May 15 to September 30. Hydrological and weather monitoring will be continuous through each year. To evaluate long-term efficacy and impacts of treatments, monitoring will continue to be conducted in 5-year intervals. For the purposes of this budget request, we seek funding for Fiscal Years 2001-2004 (3 calendar years starting Summer 2001).

BUDGET

Treatment costs will be sponsored by FWS, BIA, MRGCD, and ALBQ. NRCS PMC partners will contribute $20,000/yr for revegetation. ALBQ is also supplying $5,000/year for equipment purchases. RMRS requests the following funds/year:

Year	Cooperators**	RMRS	JFSP
Year One*	$50,300	$164,395	$111,680
Year Two*	$136,071	$142,162	$121,390
Year Three*	$55,300	$156,753	$122,665
Total All Yrs	**$241,671**	**$463,310**	**$355,735**

*A more detailed budget breakout is included in the Appendix.
**NMSF estimates costs for mechanically clearing 240 Ha at $33,739 to $60,771. Prescribed fires will be sponsored by USFWS and BIA with assistance from other agencies.

DELIVERABLES

The first annual progress report will be delivered electronically and via hard copy by December 30, 2001, followed by annual reports December 30, 2002 and 2003, and a final report by September 30, 2004. Results will be published in peer-reviewed outlets such as *Forest Ecology and Management*, *Restoration Ecology*, and *Ecological Applications*. We envision at least 8 publications, 4 in natural resources journal, and the remainder in specialty journals focused on plants, animals, and water. Upon completion of the project (i.e., years 2001-2007), we will host a conference to report synthesized results and results by specialty (e.g., vegetation, soils/water, bats, birds, and herptiles) and conduct open site visits to illustrate results.

TECHNOLOGY TRANSFER

Demonstration Sites. Our research blocks are designated as "demonstration sites", and as such will be used on an annual and *ad-hoc* basis to host field tours for those seeking solutions for reducing fuels and removing exotic woody plants from riparian sites in the Western United States. Target audiences include rural landowners in Sandoval, Valencia and Socorro Counties as well as urban residents and managers in Bernallilo County. These landowners include federal, state, tribal and private entities. For example, almost half of the 18 Pueblos in New Mexico are located along the Rio Grande and can benefit greatly from information transferred from this project. Congressional representatives and media representatives will be regularly invited on field tours, and public demonstrations will be announced in the Albuquerque Journal and the Albuquerque Tribune.

Training Workshops. Training workshops will be hosted annually by a combination of collaborating agencies and researchers to demonstrate methods for removing fuels, controlling exotics, measuring fuel loads, setting fire prescriptions, revegetating sites with native plants, alternative restoration methods, monitoring wildlife populations, estimating treatment costs, and writing grants to obtain treatment funds. Workshops will include presentations of research results and visits to demonstration sites.

Meetings and Tours. Information and guidelines will be transferred to MOU cooperators during monthly project meetings and to other managers via consultations, oral presentations at agency locations, professional meetings and symposia, and via Powerpoint presentations and RMRS technical reports.

WebSites and Newsletters. Preliminary and published results will be posted on the RMRS' web site (http://www.fs.fed.us/rm/albuq) and linked to cooperators' websites including but not limited to NMSF: (http://www.emnrd.state.nm.us), ALBQ (http://www.cabq.gov), BNWR (http://southwest.fws.gov/refuges/newmex/bosque.html), and BIA (http://www.doi.gov/bureau-indian-affairs.html). Results will also be publicized in the RMRS monthly newsletter and in its quarterly "Publication Announcement" series. Products will be advertised and summarized in the quarterly MRGBC Newsletter, and in the City of Albuquerque's Open Space newsletter. Research findings will be presented at the Bosque Consortium's annual conference, at regular meetings of Bosque Improvement Group and Rio Caucus, and via "Basin Net", an internet mail list service for Rio Grande/Rio Bravo Basin users.

Rotating Posters. One or more posters will be prepared that describe methodology, treatment sites, collaboration, and research results. These will be rotated to workplaces identified by our fuels reduction team, or at request.

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5. Brothers, T.S. 1984. Pp. 75-84 *in* California riparian systems: Ecology, conservation, and productive management. UC Press, Berkeley, CA.
6. Brooks, M.L. 1995. Environ. Manage. 19:65-74.
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10. Parker, D. & M. Williamson. 1996. USDA FS, SW Region, Albuquerque, NM.
11. Shafroth, P. 1999. Ph.D. Dissertation, Arizona State Univ., Tempe, AZ.
12. James, F.C. and Shugart Jr., H.H., 1970. Audubon Field Notes 24:727-736.
13. Smith, S.D., D.A. Devitt, A. Sala, J.R. Cleverly, & D.E. Busch. 1998. Wetlands 18:687-696.
14. SWFRT. 2000. Draft Recovery Plan. USFWS, SW Region, Albuquerque, NM.
15. Stuever, M.C. 1997. M.S. Thesis, Univ. New Mexico, Albuquerque.
16. U.S. Bureau of Reclamation. 1997. L. Colorado Reg. Off., Boulder City, NV.
17. Wicklund, C. 1999. Prescription guide for the Rio Grande Bosque. NM State Forestry, Santa Fe, NM.
17. Wiesenborn, W.D. 1996. Salt Cedar Management Workshop, June 12, 1996. BOR, Boulder City, NV.

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Curriculum Vitae

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Education:
Ph.D. Zoology, Range Minor, University of Wyoming, Laramie, 1987.
M.S. Zoology and Physiology, Arizona State University, Tempe, 1981.
B.S. Wildlife Mgmt, Range Minor, Humboldt State University, Arcata, CA, 1978.

Professional Experience (Permanent Positions):
1993-Present. Project Leader, GS-14. USDA FS, Rocky Mtn Res. Stn. Albuquerque, NM.
1992-93. Research Wildlife Biologist, GS-13. USDA FS, Rocky Mtn.Forest and Range Exp. Sta., Flagstaff, AZ.
1991-92. Neotropical Migrant Program Coordinator, GS-13. USDA FS, Forest Environment Research, Washington, DC.
1986-90. Res. Wildlife Biol, GS-12-13. USDA FS, Rocky Mtn. Forest & Range Exp. Sta., Laramie, WY.
1981-86. Res.Wildlife Biologist, GS-9-11. Rocky Mtn. For. & Range Exp.Sta., Laramie, WY.
1978-81. Res. Wildlife Biologist, GS-5-7. Rocky Mtn. Forest & Range Exp. Sta., Tempe, AZ.

Narrative Biography: I have been a research biologist employed by the Rocky Mountain Forest and Range Experiment Station since 1978. My research interests include ecosystem restoration using prescribed fire, exotic plant removal, and grazing adjustments; riparian and grassland ecology and health; avian reproductive ecology and habitat relationships; invasive and exotic plants; community ecology; threatened, endangered and sensitive species; and technology transfer. I currently lead two interdisciplinary programs of research on wildlife habitat relationships, biological diversity, and ecosystem sustainability, evaluating vertebrate and plant responses to range, fire, and restoration management, habitat manipulation, and climate change. I manage a Middle Rio Grande Ecosystem unit, and a Southwest Grasslands and Riparian unit.

Selected Grants and Contracts

$74,600 Grant, 1992-93 for Mexican Intern Program. Tropical Forestry Program, USFS.
$73,000 Contract, 1991. Forest fragmentation study. Funded by Region 4, USFS.
$105,000 Grant, 1994-96. Rapid Assessment of BioDiversity, Michoacan, Mexico. LOI, Mexico-U.S. Research, Washington, DC.
$400,000/yr Grant, 1994-present. Rio Grande Basin Program. F.S. Research.,Washington, DC.
$66,000. 1996-97. Southwestern Willow Flycatcher Migration. Bureau of Reclamation..
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$45,000. 1996. Songbirds of Ponderosa Pine. U.S. For. Serv., SW Region, Albuquerque, NM.

$25,000. 1997. Cryptogam crusts on RNAs in NM. U.S. Forest Service, Washington, D.C.
$450,000. 1998-2001. Grazing assessment in the Southwest. U.S. Forest Service, SW Region.
$167,000. 1999-2001. Southwestern willow flycatcher surveys. U.S. Air Force.
$42,000. 2000. Neotropical Migratory Bird Studies. National Fish and Wildlife Foundation.
$200,000. 2000. Evaluating ecosystem responses to grassland fires. National Fire Plan, U.S.F.S.
$500,000. 2000. Monitoring fire effects in riparian ecosystems. National Fire Plan, U.S.F.S.

Peer-reviewed Publications: Last Four Years

Kelly, J.F. and **D.M. Finch**. *In press*. Effects of sampling design on age ratios of migrants captured at stopover sites. Condor.

Finch, D.M., and S.H. Stoleson. 2000. Ecology and Conservation of the Southwestern Willow Flycatcher. RMRS-GTR-xx (in press). Ogden, UT: Rocky Mountain Research Station.

Beissinger, S. R., J. M. Reed, J. M. Wunderle, Jr., S. K. Robinson, and **D. M. Finch**. 2000. Report of the AOU Conservation Committee on the Partners in Flight species prioritization plan. Auk 117:549-561.

Franzreb, K., **D. Finch**, P. Wood, & D. Capen. 2000. Management strategies for the conservation of forest birds. 17 p. Strategies for Bird Conservation. Cornell Univ, Ithaca, NY.

Thompson, F. R. III, **D. M. Finch**, J. R. Probst, G. D. Gaines, and D. S. Dobkin. 2000. Multi-resource and multi-scale approaches for meeting the challenge of managing multiple species. 13 pp. Strategies for Bird Conservation. Cornell University, Ithaca, NY.

Finch, D.M. and W. Yong. 2000. Landbird migration in riparian habitats of the Middle Rio Grande: A case study. Studies in Avian Biology 20: 88-98.

Stoleson, S. H., and **D. M. Finch**. 1999. Unusual nest sites for southwestern willow flycatchers. Wilson Bulletin 111: 574-575

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Finch, D. M. 1999. Recovering southwestern willow flycatcher populations will benefit riparian health. Trans. 64th No. Am. Wildl. And Natur. Resour. Conf: 275-291.

Finch, D.M., J.C. Whitney, J.F. Kelly, and S.R. Loftin. 1999. Rio Grande Ecosystems: Linking Land, Water, and People. Rocky Mtn. Res. Stn. Proceedings RMRS-P-7. 245 pp.

Kelly, J. F., R. Smith**, D. M. Finch**, F.R. Moore, W. Yong. 1999. Effects of summer biogeography on the stopover abundance of Wood Warblers. Condor 101:76-85.

Yong, W., **D. M. Finch**, F.R. Moore, and **J.F. Kelly**. 1998. Stopover ecology and habitat use of migratory Wilson's Warblers. Auk 115:829-842.

Kelly, J. F. and **D. M. Finch**. 1998. Using stable isotopes to track migrant songbirds. Trends in Ecology and Evolution 13:48-49.

Garcia, S., **D.M. Finch**, and G. Chavez Leon. 1998. Patterns of forest use and endemism in resident bird communities of north-central Michoacan, Mexico. For. Ecol. & Manage. 110:151-171.

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Yong, W. and **D.M. Finch**. 1997. Migration of the willow flycatcher along the middle Rio Grande. Wilson Bulletin 109:253-26.

Shaw, D.W. and **D.M. Finch**, eds. 1996. Desired future conditions for Southwestern riparian ecosystems. Rocky Mtn. For. & Range Exp. Sta. GTR-RM-272. 359 pp.

Curriculum Vitae

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Research Interests

Mammalian habitat use, resource requirements, effects of habitat alteration, competition, reproductive ecology, physiology and nutrition. Taxa of interest: bats, herps, sciurids, and carnivores.

Education

Doctor of Philosophy (Biology) 2001 (expected)
University of New Mexico, Department of Biology. Dissertation: Maternity roosting habits of *Myotis thysanodes*, *M. volans*, and *M. evotis* in pinyon-juniper woodlands and ponderosa pine forests of central New Mexico.

Master of Science (Fisheries and Wildlife Sciences) 1993
Virginia Polytechnic Institute and State University, Dept. of Fisheries and Wildlife Sciences. Thesis: Effects of tannins on protein digestibility and detoxification activity in gray squirrels (*Sciurus carolinensis).*

Bachelor of Science (Biochemistry) 1988
Highest Honors. Rutgers University, Cook College, Department of Biochemistry.

Professional Experience

1994 - present Research Wildlife Biologist
USFS Rocky Mountain Research Station, Albuquerque, NM.
1995 - present Ph.D Graduate Student
University of New Mexico, Department of Biology, Albuquerque, NM.
1993 - 1994 Wildlife Nutrition Lab Technician
Smithsonian Institution, National Zoo, Dept. Zoological Research, Washington, D.C.
1991 - 1993 M.S. Graduate Student and Research Assistant
Virginia Tech, Department of Fisheries and Wildlife Sciences, Blacksburg, VA.
1991 Wildlife Biologist Trainee- Coop. Ed program
Wallowa-Whitman National Forest, Wallowa Valley Ranger District, Enterprise, OR.

1990 Wildlife Biologist - Spotted Owl Research
Oregon State University Coop. Wildlife Research Unit, Dept. Fisheries and Wildlife, Corvallis, OR.

Professional Experience (cont'd)

1988 - 1990 Senior Biochemistry Lab Technician
Robert Wood Johnson Medical School, Department of Pathology, Piscataway, NJ.

1988 North Atlantic Rightwhale Research Assistant
New England Aquarium, Edgerton Research Laboratory, Boston, MA.

Publications

Chung-MacCoubrey, A. L. 1999. Maternity roosts of bats at the Bosque del Apache National Wildlife Refuge: a preliminary report. Pp. 187-190 *in* D. M. Finch, J. C. Whitney, J. F. Kelly, and S. R. Loftin, eds. Rio Grande Ecosystems: Linking land, water, and people. Toward a sustainable future for the Middle Rio Grande Basin. June 2-5, 1998. Albuquerque, NM. Proc. RMRS P-7. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mtn. Res. Stn. 245p.

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Education

Ph.D. in Watershed Management and Soil Science, University of Arizona, Tucson, AZ, 1989.
M.S. in Watershed Management and Soil Science, University of Arizona, Tucson, AZ, 1985.
B.S. in Forest Management, Rutgers University, New Brunswick, NJ, 1974.

Professional Experiences

8/96 - Now Research Hydrologist, Rocky Mountain Research Station, Albuquerque, NM.
1/92 – 7/96 Research Soil Scientist, Rocky Mountain Research Station, Flagstaff, AZ.
6/89 – 12/92 Research Soil Scientist, Rocky Mountain Research Station, Tempe, AZ.
5/84 – 7/89 Watershed Research Assistant, University of Arizona, Tucson, AZ.
8/86 – 5/88 Computer Lab Teaching Assistant, University of Arizona, Tucson, AZ.
8/82 – 4/84 Watershed Research Assistant, University of Arizona, Tucson, AZ.
2/82 – 5/82 Forestry/Soil Conservation Consultant, USAID/Niger, Niamey, Niger (West Africa).
8/77 – 1/82 Project Director/Research Forester, The Research Institute, Strategies for Responsible Development, University of Dayton, Niamey, Niger.
4/77 – 7/77 Forestry and Administrative Consultant, Catholic Relief Services, Niamey, Niger.
10/76 - 3/77 Forestry Consultant, Research Institute, Strategies for Responsible Development, University of Dayton, Dayton, OH and Niamey, Niger.
6/74 – 9/76 Forester, Peace Corps/Niger Waters and Forest Service, Niamey, Niger.
7/71 – 8/72 Natural. Resources Counselor, Boy Scouts of America, Plainfield, NJ.
8/70 – 5/74 Forestry Assistant, Rutgers the State University, New Brunswick, NJ.

Publications

Jemison, R. and A. Edwards. 2000. Roads, riparian, restoration. In: Beschta, R. and P.J. Wigington, Jr. *eds.* Riparian ecology and management in multi-land use watersheds: AWRA specialty conference proceedings: 2000 August 27-31, Portland, OR. AWRA-TPS-002, Middleberg, VA.

Jemison, R. and C. Raish *eds*. *In Press*. Livestock management in the American southwest: ecology, society and economics. Elsevier Science. The Netherlands. 597p.

Kruse, W. and **R. Jemison.** *In Press*. Grazing systems of the southwest. Chapter 3, Pp. 27-52. In: Jemison, R. and C. Raish, *eds*. Livestock management in the American southwest: ecology, society and economics. Elsevier Science. The Netherlands. 597p.

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Jr., C.B. Edminster, M.C. Dillion, and K.L. Mora, *tech. eds*. Land stewardship in the 21st century: the contributions of watershed management: 2000 March 13-16, Tucson, AZ. Proc. RMRS-P-13. Ft. Collins, CO. USDA Forest Service, Rocky Mountain Research Station. 438p.

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Pawelek, D., **R. Jemison**, and D. Neary. 1999. A constructed wet meadow model for forested lands in the southwest. Pp. 97-99. In: Finch, D., J. Whitney, J. Kelly, and S. Loftin, *eds*. Rio Grande ecosystems: linking land, water, and people. 1998 June 2-5; Albuquerque, NM. Proceedings RMRS-P-7. Ogden, UT. USDA Forest Service, Rocky Mountain Research Station. 245p.

Jemison, R. 1998. A model for constructed wet meadows on forest land in the southwest. Pp.113-114. In: Water at the confluence of science, law, and public policy. Proceedings of the 11th annual symposium of the Arizona Hydrological Society, September 24-26-, 1998. Tucson, AZ 251p.

Jemison, R., D.G. Neary, and D. Pawelek. 1997. Re-engineering forest roads to enhance riparian ecosystems in the Zuni mountains of New Mexico. Pp. 803-808. In: Wang, S.S.Y., E.J. Langendoen, and F.D. Shields Jr. *eds.* Management of landscapes disturbed by channel incision, The University of Mississippi, Oxford, MS, May 19-23, 1997. Proceedings. 1134p.

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Tellman B. and **R. Jemison.** 1995. Riparian/wetland research expertise directory: Arizona, Colorado, Nevada, New Mexico, and Utah. Ft. Collins, CO. Rocky Mountain Research Station. 269p.

Fox. D., **R. Jemison,** D.U. Potter, H.M. Valett, and R. Watts. 1995. Geology, climate, land and water. Chapter 4. Pp. 52-79. In: Finch, D.M. and J.A. Tainter *tech eds*. Ecology, Diversity, and Sustainability of the Middle Rio Grande Basin. Gen. Tech. Rep. RM-GTR-268. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 186p.

Jemison, R. 1995. An ecosystem management strategy for sycamore creek watershed in south-central, Arizona. Proceedings of the 39th annual meeting of the Arizona-Nevada Academy of Sciences, April 22, 1995. Flagstaff, AZ.

Dunn, W. and **R. Jemison**. 1995. Foraging partnerships abroad: the sister forest program. Journal for Forestry 93:28-31.

Jemison, R. 1993. Associations between riparian ecosystem parameters in Happy Valley, Arizona. Pp. 233-239. In: Riparian management: common threads and shared interests. Albuquerque, NM. February 4-6, 1993. Gen. Tech rep. RM-GTR-RM-226. Ft. Collins, CO. USDA Forest Service, Rocky Mountain Research Station. 419p.

Baker, M.B., Jr. and **R. Jemison**. 1991. Soil Loss -- Key to understanding site productivity. In: Proceedings: 36th annual New Mexico water conference. Las Cruces, NM, November 7-8, 1991. New Mexico Water Resources Institute, Las Cruces, NM. WRRI Report No. 265, p. 71-76.

Jemison, R. 1989. Conditions that define a riparian zone in southeastern Arizona. PhD. dissertation. University of Arizona, Tucson, AZ. 62p.

Professional Affiliations

Arizona Hydrological Society
Arizona-Nevada Academy of Science
Arizona Riparian Council
International Society of Tropical Foresters
New Mexico Riparian Council
Society of Range Management
Soil and Water Conservation Society
World Association of Soil & Water Conservation

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Curriculum Vitae
USDA Forest Service, Rocky Mountain Research Station,
333 Broadway SE, Albuquerque NM, 87102-3497
Phone: 505-724-3676, email:jfkelly@fs.fed.us

Education

Ph.D. in Zoology, Colorado State University, 1996
M.S. in Zoology, Oklahoma State University, 1991
B.S. in Wildlife Management, University of Maine, 1987

Experience

8/98 - Present **Postdoctoral Research Wildlife Biologist,** Rocky Mountain Research Station and **Research Assistant Professor,** Department of Biology, Univ. of New Mexico
2/97 - 8/98 **Visiting Scientist** at Rocky Mountain Research Station, Albuquerque, NM
6/96 - 8/96 **Instructor,** Dept. of Biology, Colorado State University
8/91 - 5/96 **Teaching Assistant**, Dept. of Biology, Colorado State University
5/91 - 8/91 **Research Associate**, University of Montana, Missoula, MT
4/89 - 5/91 **Research Assistant**, Oklahoma State University, Stillwater OK
6/87 - 4/89 **Wildlife Technician**, U.S. Fish & Wildl. Serv., Volcano HI
6/86 - 8/86 **Volunteer**, U.S. Fish and Wildlife Service, Anchorage, AK 99503

Research Support 1999-2000

2000 - Are golf courses, hotspots for biodiversity in the desert southwest? J.F. Kelly et al. National Fish and Wildlife Foundation. 3yrs -$86,400
2000 - Using stable isotopes to link breeding, wintering and migratory populations of Southwestern Willow Flycatchers. USDA, Forest Service, Rocky Mountain Research Station J.F. Kelly et al. $13,140
2000 - Effects of grazing on habitat use by wintering grassland birds on the Sevilleta NWR. USDA, Forest Service, Rocky Mountain Research Station. J.F. Kelly et al. $ 11,520
2000 - Habitat use by grassland songbirds relative to grazing management, New Mexico Department of Game and Fish. J.F. Kelly, et al. $3,000
2000 - Migration and winter habitat use by grassland birds of the Sevilleta NWR, U.S. Fish and Wildlife Service, A.B. Montoya, R. Meyer, and J.F. Kelly. $10,280.
1999 - Use of stable hydrogen isotopes for tracking migrant songbirds, USDA, Forest Service, Rocky Mountain Research Station. J.F. Kelly et al. $12,500
1999 - Effects of grazing on habitat use by wintering grassland birds on the Sevilleta NWR, USDA, Forest Service, Rocky Mountain Research Station, J.F. Kelly et al. $14,000

Professional Activities

Local organizing committee member - 2001 Cooper Ornithological Society Meeting
Organizing a grassland bird symposium - 2001 Cooper Ornithological Society Meeting
Member of the Restoration Ecology Working Group of the Wildlife Society
American Ornithologists= Union - Conservation Committee Member - 1997-2001
Manuscripts Reviewed for *Ecology, Auk, Condor, Journal of Wildlife Management, American Midland Naturalist, Wilson Bulletin*
Proposal Review for the Center for Field Studies
1993-1994 - President, Colloquium In Life Sciences, Colorado State University
1992-1993 - Treasurer, Colloquium in Life Sciences, Colorado State University
1990-1991 - Graduate Student Representative, Dept. of Zoology, Oklahoma State Univ.

<u>Publications (1996-2000)</u>

Schooley, R.L., B. T. Bestelmeyer, and **J.F. Kelly**. 2000. Influence of small-scale disturbances by kangaroo-rats on Chihuahuan Desert ant communities. Oecologia 125:142-149.

Kelly, J.F. and D.M. Finch. 2000. Effects of sampling design on age ratios of migrants captured at stopover sites. Condor 102:699-702.

Kelly, J. F., D. M. Finch, and W. Yong. 2000. Vegetative associations of wood warblers migrating along the Middle Rio Grande Valley, New Mexico. Southwestern Naturalist 45:159-168.

Cartron, J-L, **J.F. Kelly**, and J. H. Brown. 2000. Relationships among clutch size, body size and latitude: sorting out the paradox in strigid owls. Oikos 90:381-390.

Brown, J. H., E. J. Bedrick, S. K. M. Ernest, J-L. E. Cartron, and **J. F. Kelly**. *In Press*. Constraints on negative relationships: mathematical causes and ecological consequences. In (M. Taper, L. Subhash and N. Lewin-Koh eds.) *The Nature of Scientific Evidence*. Univ. of Chicago Press.

Kelly, J.F. 2000. Stable isotopes of carbon and nitrogen in the study of avian and mammalian trophic ecology. Canadian Journal of Zoology 78:1-27.

Kelly, J.F. 1999. [Review of] *Population Limitation in Birds* by Ian Newton. Auk 116:866-868.

Kelly, J. F., R. Smith, D. M. Finch, F.R. Moore, W. Yong. 1999. Effects of summer biogeography on the stopover abundance of Wood Warblers. Condor 101:76-85.

Yong, W., D. M. Finch, F.R. Moore, and **J.F. Kelly**. 1998. Stopover ecology and habitat use of migratory Wilson=s Warblers. Auk 115:829-842.

Kelly, J. F. 1998. Latitudinal variation in sex ratios of Belted Kingfishers. Journal of Field Ornithology 69:386-390.

Kelly, J. F. and D. M. Finch. 1998. Using stable isotopes to track migrant songbirds. trends in Ecology and Evolution 13:48-49.

Kelly, J. F. 1998. Behavior and energy intake of Belted Kingfishers in winter. Journal of Field Ornithology 69:75-84.

Kelly, J. F. and B. Van Horne. 1997. Effects of supplemental food on timing of nest-initiation in Belted Kingfishers. Ecology 78:2504-2511.

Kelly, J. F. and B. Van Horne. 1997. Effects of scale-dependent variation in ice cover on the distribution of wintering Belted Kingfishers. Ecography 20:506-512.
Shields, S. J. and **J. F. Kelly.** 1997. Nest-site selection by Belted Kingfishers in Colorado. American Midland Naturalist. 137:401-403.
Kelly, J.F. 1996. Effects of substrate on prey use by Belted Kingfishers: an experimental test of the prey abundance-availability assumption. Canadian Journal of Zoology. 74:693-697.

<u>Technical Reports, Symposia, and Proceedings</u>

Periman, R. And **J.F. Kelly**. 2000. Historical survey of Willow Flycatcher habitat in the Southwest. Pages 25-42 *in* (Finch, D.M., and S.H. Stoleson, eds.) Ecology and Conservation of the Southwestern Willow Flycatcher. RMRS-GTR-60. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station
Finch, D.M., **J.F. Kelly**, and J-L., E. Cartron. 2000. Migration and Winter Ecology. Pages 71-82 *in* (Finch, D.M., and S.H. Stoleson, eds.) Ecology and Conservation of the Southwestern Willow Flycatcher. RMRS-GTR-60. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station
Finch, D. M., J. W. Whitney, **J. F. Kelly**, and S. R. Loftin. Technical editors . 1999. Rio Grande ecosystems: linking land, water, and people. 1998, June 2-5 Albuquerque, NM. RMRS-P-7. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
Kelly, J. F. and D. M. Finch. 1999. Use of saltcedar vegetation by landbirds migrating through the Bosque del Apache National Wildlife Refuge. Pages 222-231 *in* (Finch, D.M., J. W. Whitney, J. F. Kelly, and S. R. Loftin. eds.) Rio Grande ecosystems: linking land, water, and people. 1998, June 2-5 Albuquerque, NM. RMRS-P-7. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
Finch, D. M. and **J. F. Kelly**. 1999. Status and migration of the Southwestern Willow Flycatcher in New Mexico. Pages 197-203 *in* (Finch, D. M., J. W. Whitney, J. F. Kelly, and S. R. Loftin. eds.) Rio Grande ecosystems: linking land, water, and people. 1998, June 2-5 Albuquerque, NM. RMRS-P-7. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
Delay, L.S., D.M. Finch, S. Brantley, R. Fagerlund, M.D. Means, and **J.F. Kelly**. 1999. Arthropods of native and exotic vegetation and their association with Willow Flycatchers and Wilson=s Warblers. Pages 216-221 *in* (Finch, D. M., J. W. Whitney, J. F. Kelly, and S. R. Loftin. eds.) Rio Grande ecosystems: linking land, water, and people. 1998, June 2-5 Albuquerque, NM. RMRS-P-7. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

CURRICULUM VITAE
BURTON PENDLETON
Research Ecologist
Rocky Mountain Research Station,
333 broadway SE, Albuquerque, NM 87102

Degrees and Professional History:

B.S., Brigham Young University, 1976, Botany
M.S., Brigham Young University, 1980, Botany/Ecology
Ph.D., Wayne State University, 1990, Biology/Evolution, Systematics and Ecology

Adjunct Assistant Research Professor, Brigham Young University, 1990-present.
Research Ecologist GS-408-11, Rocky Mountain Research Station, USDA FS, 1990-1994.
Research Ecologist GS-408-12, Rocky Mountain Research Station, USDA FS, 1994-present.
Instructor (Genetics), Utah Valley State College, 1995-1996.

Professional Affiliations:

Ecological Society of America, member, 2000.
Botanical Society of America, member, 1986-present.
Society for Range Management, member, 1991-1996.
Society of the Sigma Xi, 1982, 1990.
Canyon Country Ecological Research Site, Rocky Mountain Station technical representative, 1999-present

Areas of Research Interest: Plant reproductive ecology; plant community ecology; plant recruitment and establishment in arid ecosystems.

Research Grants (last 4 years):

09-Feb-96; Benefit of Microphytic Crust Inoculation and Arbuscular Mycorrhizal Fungi on Productivity of VAM-dependent Forbs; R. L. Pendleton and B. K. Pendleton, USDA FS Intermountain Research Station, Shrub Sciences Laboratory; $28,212; one year; U.S. Army Corps of Engineers, Construction Engineering Research Laboratory.

21-April-97; Microphytic Crust Biology: Evaluation of Algal Inoculation Effectiveness; R. L. Pendleton and B. K. Pendleton, USDA FS Intermountain Research Station, Shrub Sciences Laboratory, $9,000; one year; U.S. Army Corps of Engineers, Construction Engineering Research Laboratory.

09-Sept-98; Microphytic Crust Biology: Effect of Alginate Carrier on Plant Survival;

R. L. Pendleton and B. K. Pendleton, USDA FS Intermountain Research Station, Shrub Sciences Laboratory, $9,000; one year; U.S. Army Corps of Engineers, Construction Engineering Research Laboratory.

Refereed Journal Publications (last 4 years):

Pendleton, B. K., and R. L. Pendleton. 1998. Pollination biology of *Coleogyne ramosissima* (Rosaceae). Southwestern Naturalist 43:376-380.

Buttars, S. M, L. L. St. Clair, J. R. Johansen, J. C. Sray, M. C. Payne, B. L. Webb, R. E. Terry, B. K. Pendleton, and S. D. Warren. 1998. Pelletized cynobacterial soil amendments: laboratory testing for survival, escapability, and nitrogen fixation. Arid Soil Research and Rehabilitation 12:165-178.

Other Publications (last 4 years):

Pendleton, R. L., B. K. Pendleton, and S. D. Warren. 1999. Response of blackbrush (*Coleogyne ramosissima*) seedlings to inoculation with arbuscular mycorrhizal fungi. p. 245-251 *in* E.D. McArthur, W. K. Ostler, C. L. Wambolt, comps. Proceedings: shrubland ecotones; 1998 August 12-14; Ephraim, UT. Proc. RMRS-P-11. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Pendleton, R. L., B. K. Pendleton, S. D. Warren and G. L. Howard. 2000. Response of blackbrush seedlings to dual inoculation with arbuscular mycorrhizal fungi and microbiotic soil crust organisms. Champaign, IL: U.S. Army Corps of Engineers, Construction Engineering and Research Laboratory.

Pendleton, B. K. In press. Coleogyne. *In*: Seeds of Woody Plants in the United States, 2nd ed. U.S. Department of Agriculture, Forest Service. Agriculture handbook.

CURRICULUM VITAE

ROSEMARY L. PENDLETON

Research Ecologist,
Rocky Mountain Research Station
333 Broadway SE, Albuquerque, NM 87102

Degrees and Professional History:

B.S., Brigham Young University, 1978, Botany
M.S., Brigham Young University, 1980, Range Science
Ph.D., Wayne State University, 1986, Biology/Plant Ecology

Research Ecologist GS-408-9, Intermountain Research Station, USDA FS, 1985-1986.
Research Ecologist GS-408-11, Intermountain Research Station, USDA FS, 1986-1990.
Research Ecologist GS-408-12, Rocky Mountain Research Station, USDA FS, 1990-present.
Adjunct Assistant Research Professor, Brigham Young University, 1986-present.

Professional Affiliations:

Ecological Society of America, member, 2000.
Botanical Society of America, member, 1986-present.
Society for Range Management, member, 1986 to 1996; Councilor, Utah Section, 1990-1991; Information and Education Committee member and chair, Utah Section, 1987-1989; Utah Range Camp Planning Committee, 1990; Workshop Co-Chair, Summer Meeting and Tour, Utah Section, 1992.
Phi Kappa Phi, 1978-1983.

Areas of Research Interest: Plant reproductive biology and establishment ecology; plant-soil relations; ecology of vesicular-arbuscular mycorrhizae.

Research Grants (last 4 years):

09-Feb-96; Benefit of Microphytic Crust Inoculation and Arbuscular Mycorrhizal Fungi on Productivity of VAM-dependent Forbs; R. L. Pendleton and B. K. Pendleton, USDA FS Intermountain Research Station, Shrub Sciences Laboratory; $28,212; one year; U.S. Army Corps of Engineers, Construction Engineering Research Laboratory.

21-April-97; Microphytic Crust Biology: Evaluation of Algal Inoculation Effectiveness; R. L. Pendleton and B. K. Pendleton, USDA FS Intermountain Research Station, Shrub Sciences Laboratory, $9,000; one year; U.S. Army Corps of Engineers, Construction Engineering Research Laboratory.

09-Sept-98; Microphytic Crust Biology: Effect of Alginate Carrier on Plant Survival; R. L. Pendleton and B. K. Pendleton, USDA FS Intermountain Research Station, Shrub Sciences Laboratory, $9,000; one year; U.S. Army Corps of Engineers, Construction Engineering Research Laboratory.

Refereed Journal Publications (last 4 years):

Pendleton, B. K., and R. L. Pendleton. 1998. Pollination biology of *Coleogyne ramosissima*. Southwestern Naturalist 43:376-380.

Tarkalson, D. D., R. L. Pendleton, V. D. Jolley, C. W. Robbins, and R. E. Terry. 1998. Preparing and staining mycorrhizal structures in dry bean, sweet corn, and wheat using a block digester. Communications in Soil Science and Plant Analysis 29:2263-2268.

Pendleton, R. L., D. C. Freeman, E. D. McArthur, and S. C. Sanderson. 2000. Gender specialization in heterodichogamous *Grayia brandegei* (Chenopodiaceae): evidence for an alternative pathway to dioecy. American Journal of Botany 87:508-516.

Meyer, S. E., and R. L. Pendleton. In press. Genetic regulation of seed dormancy in *Purshia tridentata* (Rosaceae). Annals of Botany.

Pendleton, R. L. In press. Pre-inoculation with an arbuscular mycorrhizal fungus affects male reproductive output of buffalo gourd. International Journal of Plant Science.

Other Publications (last 4 years):

Pendleton, R. L., S. D. Nelson, and R. L. Rodriguez. 1996. Do soil factors determine the distribution of spineless hopsage? p. 205-209 *in* J.R. Barrow, E.D. McArthur, R.E. Sosebee, and R.J. Tausch, eds., Proceedings: shrubland ecosystem dynamics in a changing environment. U.S. Department of Agriculture, Forest Service, Intermountain Research Station General Technical Report INT-GTR-338, Ogden, UT.

Pendleton, R. L., and S. D. Warren. 1996. The effects of cryptobiotic soil crusts and VA mycorrhizal inoculation on growth and nutrient content of five rangeland plant species. p. 436-437. In: N.E. West (ed.), Rangelands in a sustainable biosphere - proceedings of the Fifth International Rangeland Congress. 1995 July 23-28; Salt Lake City, UT. Denver, CO: Society for Range Management.

Pendleton, R. L., B. K. Pendleton, and S. D. Warren. 1999. Response of

blackbrush (*Coleogyne ramosissima*) seedlings to inoculation with arbuscular mycorrhizal fungi. p. 245-251 *in* E.D. McArthur, W.K. Ostler, C.L. Wambolt, comps. Proceedings: shrubland ecotones; 1998 August 12-14; Ephraim, UT. Proc. RMRS-P-11. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 299 p.

Pendleton, R. L., B. K. Pendleton, S. D. Warren and G. L. Howard. 2000. Response of blackbrush seedlings to dual inoculation with arbuscular mycorrhizal fungi and microbiotic soil crust organisms. Champaign, IL: U.S. Army Corps of Engineers, Construction Engineering and Research Laboratory.

Leidolf, A., M. L. Wolfe, and R. L. Pendleton. 2000. Bird Communities of Gambel Oak: a descriptive analysis. General Technical Report RMRS-GTR-48. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 30 p.

COLLABORATIVE AND/OR SUBCONTRACTUAL ARRANGEMENTS

An interagency agreement between two USDA agencies will be used to transfer funds from U.S. Forest Service RMRS to NRCS Los Lunas Plant Materials Center (PMC) to complete revegetation work identified in this proposal. Local ecotype shrub vegetation will be planted by NRCS on 4 of the 20-ha treatment plots. Greg Fenchel is our NRCS contact and his CV is enclosed. Because the Rio Grande Valley receives less than 20 cm of annual moisture, the vegetation will be installed as dormant 4.5 m pole cuttings or as containerized transplants with 74 cm rootstock. This vegetation will be planted in holes that have been augured to the capillary fringe of the water table. Subsequently, the plants should not require any irrigation treatments, which is normally required for one-gallon transplants to obtain satisfactory survival. To adequately reach subsurface moisture, the relatively short 75 cm rootstock will be limited to planting near the river. The 4.5 m cuttings can be planted randomly within the plots.

PMC has determined in previous studies that the common Rio Grande riparian shrub species *Amorpha fruticosa* and *Baccharis glutinosa* can be field-established as dormant pole cuttings. The PMC has local collections of both species in farm production. The Rio Grande riparian shrub species *Lycium spp.* and *Forestiera neomexicana* are grown in 10-cm diameter tubes, 75 cm in length, to produce long root systems that can reach subsurface moisture after transplanting.

For enhancement of vegetation establishment, both soil salinity and depth to water table measurements will be taken on each of the 20-ha study plots. Each plot will be divided into quadrants. A well will be installed in the approximate center of each quadrant to monitor the water table depth. A composite sample of 30 soil samples taken from a 15 – 25 cm depth will be collected in each quadrant and measured for electrical conductivity to estimate total soil salts. Extreme salty and dry areas will not be planted. The PMC will contribute $20,000 of in-kind services of plant materials and personnel hours towards this project. This will include the 75 cm tube transplant (@$20/unit), 4.5 m pole cuttings (@$8/unit), and personnel hours (@$250/day). The PMC has the equipment and experience to install shallow monitoring wells and measure soil salinity.

COLLABORATOR RESUMES

Greg Fenchel

Received a B.S. degree in Range Management (1980) and a M.S. in Natural Resources with emphasis in Soil Science (1985) from Humboldt State University in California. While attending college, worked seasonally for the Bureau of Land Management as a Range Technician in Nevada and Wyoming. Also worked seasonally for AMFAC Nurseries in California as a student intern learning commercial horticulture production.

Has been employed by the USDA Natural Resources Conservation Service Plant Materials program since 1985, and subsequently worked at three Plant Material Centers: Colorado, Texas, and New Mexico. Duties have included all PMC activities, from farm maintenance to field study and evaluation. Current duties include promoting New Mexico's PMC program to potential cooperators for generating new resources. Areas of expertise include reclamation of disturbed lands such as surface coal mines, riparian areas, and range lands.

Greg Fenchel's Personal Publications include:

Restoration of Riparian Areas on Minelands Using Native Vegetation, presented at the Colorado Riparian Association October 5-7, 1995, Alamosa Colorado.

Overview of Riparian Restoration in New Mexico, presented at the International Erosion Control Association February 15-18, 1994, Reno Nevada.

Effects of Topsoil Dressing over Mine Spoil on Establishment of Vegetation at San Juan Mine, Northwestern New Mexico, presented at the eighth National Meeting ASSMR May 14-15, 1991, Durango, Colorado.

Establishment and Propagation Techniques For Cottonwood and Black Willows For Use in Southwestern Riparian Restoration, Presented at the Western Region Riparian Resource Management Workshop, May 8-11, 1989, Billings, Montana.

The Distribution of Marine Wind-Borne Sodium, Calcium, and Magnesium and it's Effect on Forage Nutrition in the Arcata Bottom and Mad River Area, Presented at International SRM meeting February 8, 1988 in Orlando, Florida.

Charles P. Wicklund,

I received my BS-Forestry from Northern Arizona University in 1965. I served two years in the Army with a one-year tour in Vietnam including the 68 TET offensive. Upon return went to work for private industry in forestry and lumber manufacturing.

The State of New Mexico, Forestry Division, has employed me since 1992. I have worked as Fire Management Officer on the Capitan District, and in fire and timber on the Socorro District. I was the Timber Management Officer on the Bernalillo District and participated in numerous bosque fires while in Bernalillo. When Legislation was passed to establish the Inmate Work Camp program in Los Lunas, I became the first IWC Camp Supervisor.

I transferred to Santa Fe as the Inmate Work Camp Program Manager. It was during this time that I became one of the authors of the "Prescription Guide to the Rio Grande Bosque". I have continued to update the guide over the past two years. I'm now the Forest Management Officer for the State of New Mexico. Presently, I'm working on a photo guide to help determine fuel loading in tons per acre of dead and down material in the bosque. This guide will allow land managers to identify and prioritize areas for hazardous fuel reduction.

Yasmeen Najmi
415 11th Street, NW, Albuquerque NM 87102

(505) 242-2085

Candidate for Masters Degree in Community and Regional Planning - Natural Resource Planning Emphasis, University of New Mexico. Professional Project title: *The Middle Rio Grande Conservancy District and Bosque Management: A Framework and Approach for Restoration Projects*. Expected graduation in May 2000.

Other Education: State University of New York at Buffalo, BA in Political Science, 1990
Experience:

February 2000 – Present

Assistant Planner and Reclamation Reform Act Coordinator
Middle Rio Grande Conservancy District (MRGCD), Albuquerque NM
Develops the Bosque Management Master Plan and coordinates the planning process for 30,000 acres of riparian forest within the MRGCD. Coordinates planning, management and monitoring of bosque rehabilitation and fire management projects and associated endangered species issues. Develops programs, projects and policies with MRGCD staff and other entities and agencies. Serves as the MRGCD's Reclamation Reform Act Administrator and Land Sales Coordinator.

October 1997 – February 2000

Planning Intern
Middle Rio Grande Conservancy District, Albuquerque NM
Developed a Conceptual Bosque Management Master Plan for review and outlined a planning process for 30,000 acres of riparian forest within the MRGCD. Coordinated planning, management and monitoring of bosque rehabilitation and fire management projects and associated endangered species issues. Developed programs, projects and policies with MRGCD staff and other entities and agencies.

October 1996- March 1997

Research Assistant, National Parks Conservation Association
Southwest Regional Office, Albuquerque, NM
Reviewed and commented on management plans and Environmental Impact Statements from the National Park Service (NPS) and other agencies pertaining to the operation of NPS units. Formulated a draft scenic byway proposal for highways accessing the Grand Canyon's South Rim. Developed position papers to address management concerns in NPS units in the Southwestern United States.

September 1994 - **August 1996**
Recreation Technician (GS-5) and AmeriCorps National Service Volunteer
Bureau of Land Management, Taos Field Office, Taos NM
Assisted a bi-state planning team in developing a Coordinated Management Plan and Environmental Impact Statement for 90 miles of the Rio Grande Corridor in Colorado and New Mexico. Compiled recreation data and developed use projections and trends to support plan alternatives. Designed and implemented a river recreation monitoring program.

Ondrea C. Linderoth-Hummel

4720 Plume NW
Albuquerque, NM 87120
(505) 898- 8390

EDUCATION

University of New Mexico; Albuquerque, NM; PhD Graduate Program: January 1998-Present;
Florida Institute of Technology, Melbourne, FL; **MS Biological Sciences: 1994**
Keuka College, Keuka Park, NY; **BA Biology: 1992**

WORK EXPERIENCE

City of Albuquerque, Open Space; 3615 Los Picaros Rd. SE; Albuquerque, New Mexico, 87105
Supervisor: Matt Schmader, (505)873-6620
***Program Manager*, March 1999 to present**

- Oversee daily functions of Resource Management and Visitor Services Section including facility management, planning, environmental education and biological monitoring
- Oversee management of Open Space Visitor Center including implementation of Visitor Center plan
- Supervise 15 employees; review documentation, projects, etc. developed by staff
- Perform evaluations of natural and cultural resources on Open Space lands for planning and management
- Perform biological and cultural resource inventories, damage assessments, make management recommendations
- Create environmental documentation displaying management and monitoring data; coordinate with academic and scientific community
- Point of contact for all projects conducted on Open Space lands; maintain database of projects
- Implement existing management plans and review present conditions prior to implementation; pursue funding
- Maintain familiarity with City of Albuquerque Open Space Network (currently 28,000 acres) and all projects taking place on these lands
- Develop interpretive displays, brochures and newsletters to educate public of the Open Space Program
- Develop Resource Management Plans, Master Plans, or Site Plans for new properties as dictated in the *Major Public Open Space Facility Plan*; facilitate public participation
- Develop and implement wetland and riparian restoration projects on Open Space lands

City of Albuquerque, Open Space; 3615 Los Picaros Rd. SE; Albuquerque, New Mexico, 87105
Supervisor: Matt Schmader, (505)873-6620
Natural Resource Planner/Biologist, July 1995 – March 1999

- Oversee daily planning and biological monitoring programs
- Supervise three employees
- Perform evaluations of natural and cultural resources of Open Space lands for planning and management purposes

U.S. Fish and Wildlife Service; P.O. Box 2676; Vero Beach, Florida 32961

Supervisor: Craig Johnson, (407)562-3909
***Fish and Wildlife Biologist*, January 1995 to June 1995**

- Conducted field investigations and literature reviews to collect data on fish and wildlife resources
- Predicted probable impacts of proposed development projects on fish and wildlife resources
- Reported probable impacts to U.S. Army Corps of Engineers through permit review process
- Participated in local monitoring projects including water, sediment and habitat quality of the Indian River Lagoon and adjoining Atlantic Ocean system

PROFESSIONAL DEVELOPMENT AND SKILLS

- Received training certification in:
  - Public Speaking
  - Advanced Public Speaking

- ➢ Supervisor Training
- ➢ Train the Trainer Academy
- ➢ Meeting Facilitation Training
- ➢ Introduction to GIS/Intermediate GIS

- Computer skills include Windows 95/98, WordPerfect 6.0-8.0, Office 1998/2000: Microsoft Word, MS PowerPoint, MS Excel, MS Publisher; Adobe- PageMaker, Reader/Distiller, PhotoShop LE, Illustrator; Corel Photo, HP Desk scan, Netscape, Internet Explorer, Beginning skills in Arc: Arc Info, Arc Plot, Arced it

PUBLICATIONS

"Seagrass Coverage and Diversity Changes due to Mosquito Impoundment Influences in Selected Impoundments in the North Indian River Lagoon, Brevard County, Florida" **1994. Unpublished Master's Thesis, Florida Institute of Technology.**

"San Antonio Oxbow Biological Management Plan" **1997. City of Albuquerque, Open Space Div.**

"Candelaria Farm Preserve Management Plan" Draft, 1998. City of Albuquerque, Open Space Div.

"Analysis of the Groundwater Monitoring Program in the Rio Grande Valley State Park, January 1996 through December 1997" 1998. E. Cordova and O. Linderoth.

"Restoration Efforts in the Rio Grande Valley State Park, Albuquerque, NM" 1998. Rio Grande Ecosystem Conference Proceedings

"Las Huertas Creek Watershed Management Plan" 1998. UNM Watershed Management Planning class.

"The Riparian Zone" Newsletter of the New Mexico Riparian Council. Design layout and **Co-Editor**

"Open Space News" Newsletter of Open Space Division/Open Space Alliance**. Editor**

Rio Grande Valley State Park Trail Map, Sandia Foothills Trail Map
Government 16 Shows: What is Open Space?, Managing the Bosque, Prairie Dogs in Open Space, Open Space Visitor Center, Fuel Reduction in the Bosque

PRESENTATIONS

- ♦ **"Balancing Public Amenities with Natural Resource Protection"** 1997. New Mexico Parks and Recreation Association Conference
- ♦ **"Management of the Rio Grande Valley State Park, Albuquerque, NM"** 1998. New Mexico Riparian Council Conference
- ♦ **"Volunteerism in the Rio Grande Valley State Park, Albuquerque, NM"** 1998. Partnerships for the Future Conference
- ♦ **"Restoration Efforts in the Rio Grande Valley State Park, Albuquerque, NM"** 1998. Poster presentation. Rio Grande Ecosystems: Linking Land, Water and People Conference

PROFESSIONAL AFFILIATIONS

New Mexico Riparian Council, **President**, October 1999 – October 2000.
Open Space Alliance. **Board Member, Project Committee Chair,** October 1998 to Present.

New Mexico Recreation and Parks Association. 1997 Conference Planning Team.
Rio Grande/Rio Bravo Basin Coalition
New Mexico Mountain Biking Club
New Mexico Volunteers for the Outdoors
Ecological Society of America

HONORS

International Who's Who of Professionals. November 1997.

Annual Employee Appreciation Award, Open Sp

JOHN P. TAYLOR
U.S. Fish and Wildlife Service
P.O. Box 1246
Socorro, New Mexico 87801
PH: (505) 835-1828
FX: (505) 835-0314
EM: John_P_Taylor@fws.gov

Education and Work Experience

B.S. Wildlife Science, New Mexico State University, 1980
M.S. Wildlife Management, Texas Tech University, 2000

1976-1978 *Range Aid: Jornada Experimental Range USDA/NMSU, Jornada, N.M.*
I conducted range evaluation and utilization surveys. I was involved in ranch maintenance and cattle management.

1978 *Biological Aid: Crab Orchard National Wildlife Refuge, ILL.*
1979 *Biological Aid: Sherburne National Wildlife Refuge, MN.*
I conducted wildlife censusing and waterfowl management programs. I participated in prairie restoration activities including plantation timber logging and prescribed burning.

1981 *Asst. Refuge Manager: Minnesota Valley National Wildlife Refuge, MN.*
1982 *Asst. Refuge Manager: Litchfield Wetland Management District, MN.*
I planned and developed newly created portions of the refuge/district which included wetland, riparian, and prairie restoration programs. I coordinated biological studies including grassland evaluation, satellite wetland characteristics and waterfowl breeding response.

1983-1985 *Refuge Manager: Culebra National Wildlife Refuge, Puerto Rico*
I managed a 1500 acre refuge consisting of islands and beaches for 12 species of seabirds and 4 species of endangered sea turtles. I developed seabird monitoring programs and analyzed population structures and

trends. I developed habitat improvement programs which arrested population declines. I initiated sea turtle nesting surveys on 8 area beaches which resulted in the recognition of a significant unique leatherback turtle nesting population.

1986-present Wildlife Biologist, Bosque del Apache National Wildlife Refuge, N.M.
I am responsible for migratory bird management, wetland management, riparian management, water management, and research and monitoring on the 57,000 acre Bosque del Apache WNR. I frequently work outside refuge boundaries serving as a regional consultant for these management activities throughout the Middle Rio Grande corridor of new Mexico extending from Cochiti Pueblo to El Paso, Texas. I serve on regional management committees involved with migratory bird management and riparian management and I am the field representative for the North American Waterfowl and Wetlands Office reviewing wetland conservation initiatives in the Rio Grande corridor and in the Interior Highlands of Mexico. Involvement in these activities has allowed the formation of close contacts with American, Canadian, and Mexican biologists assessing our management actions on bird movements regionally and internationally through marking and resighting program research.

Responsibilities for migratory bird management include assuring habitat needs for light geese, sandhill cranes, other waterfowl, waterbirds, shorebirds, and migratory passerine species are met. Winter bird management activities involving cranes and waterfowl are considered among the most intensive in the world, maximizing a limited wetland and cropland habitat base for high numbers of birds. Other aquatic bird species management centers on expanding waterbird rookery and feeding habitats and maximizing quality migratory shorebird habitats.

Responsibilities for wetland management involve refining recognized moist soil management practices regionally for use by other area managers. Through intensive management practices, wetland food production and habitat needs are expanding for wetland dependent wildlife. Migratory bird use has increased 5 fold since initiation of intensive management practices. Our wetland management system is now considered a model for use regionally. I conduct research programs focusing on wetland food plant production techniques.
Responsibilities for riparian management center on the maintenance and restoration of the cottonwood/willow dominated forest on the refuge. I coordinate research and monitoring programs on the refuge dealing with the effects of seasonal flooding on flora and fauna. I coordinate riparian restoration programs both on and off the refuge dealing with exotic flora control, revegetation, and natural forest regeneration using flood management.

Peer Reviewed Publications:

Taylor, J.P. and R.E. Kirby. 1990. Experimental dispersal of wintering snow geese and Ross' geese. Wildlife Society Bulletin. 18:312-319.

Sheets, K.R., Taylor, J.P., and J.M.H. Hendrickx. 1994. Rapid salinity mapping by electromagnetic induction for determining riparian restoration potential. Restoration Ecology. 2:242-246.

Post, D.M., Taylor, J.P., Kitchell, J.F., Olson, M.H., Schindler, D.E., and B.R. Herwig. 1998. The role of migratory waterfowl as nutrient vectors in a managed wetland. Conservation Biology. 12:910-920.

Taylor, J.P. and K.C. McDaniel. 1998. Restoration of saltcedar infested floodplains on the Bosque del Apache national wildlife refuge. Weed Technology. 12:345-352.

Taylor, J.P. and K.C. McDaniel. 1998. Riparian management on the Bosque del Apache national wildlife refuge. New Mexico Journal of Science. 38:219-232.

Taylor, J.P., Wester, D.B., and L.M. Smith. 1999. Soil disturbance, flood management, and riparian woody plant establishment in the Rio Grande Floodplain. Wetlands. 19:372-382.

Armstrong, W.T., Meeres, K.M., Kerbes, R.H., Boyd, W.S., Silveira, J.G., Taylor, J.P., and B. Turner. 1999. Routes and timing of migration of lesser snow geese from the Western Canadian Arctic and Wrangel Island, Russia, 1987-1992. Pages 75-88 in R.H. Kerbes, K.M. Meeres, and J.E. Hines, editors. Dirtribution, survival, and numbers of lesser snow geese of the Western Canadian Arctic and Wrangel Island, Russia. Occasional Paper Number 98. Canadian Wildlife Service, Ottawa, Ontario, Canada.

Hines, J.E., Baranyuk, V.V., Turner, B., Boyd, W.S., Silveira, J.G., Taylor, J.P., Barry, S.J., Meeres, K.M., Kerbes, R.H., and W.T. Armstrong. 1999. Autumn and winter distribution of less snow geese from the Western Canadian Arctic and Wrangel Island, Russia, 1953-1992. Pages 39-74 in R.H. Kerbes, K.M. Meeres, and J.E. Hines, editors. Dirtribution, survival, and numbers of lesser snow geese of the Western Canadian Arctic and Wrangel Island, Russia. Occasional Paper Number 98. Canadian Wildlife Service, Ottawa, Ontario, Canada.

Hines, J.E., Wiebe, M.O., Barry, S.J., Baranyuk, V.V., Taylor, J.P., McKelvey, R., Johnson, S.R., and R.H. Kerbes. 1999. Survival rates of lesser snow geese in the Pacific and Western Central flyways, 1953-1989. Pages 89-110 in R.H. Kerbes, K.M. Meeres, and J.E. Hines, editors. Dirtribution, survival, and numbers of lesser snow geese of the Western Canadian Arctic and Wrangel Island, Russia. Occasional Paper Number 98. Canadian Wildlife Service, Ottawa, Ontario, Canada.

RESUME

Jim Sullivan

District Fuels Specialist
West Texas/New Mexico Fire District
U.S. Fish and Wildlife Service
P.O. Box 7
Roswell, New Mexico 88202
Phone: 505-622-6755 ext. 22
Fax: 505-627-9414
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EDUCATION

B.S. 1978 - Environmental Resource Management, Arizona State University

EXPERIENCE

US Forest Service - 1974-1983, 1985-1986, Tonto National Forest
- 1986-1988, Coconino National Forest
- 1993-1994, Olympic National Forest

US Park Service - 1989-1991, Grand Canyon National Park
- 1991-1992, Yosemite National Park
- 1995-1996, Guadalupe Mountains National Park

US Fish and Wildlife Service - 1998-2000, Bitter Lake National Wildlife Refuge

The Nature Conservancy - 1984, Muleshoe Ranch Preserve

Jim has been involved in fire suppression and fire management for over 25 years, since initiating Grand Canyon as a pilot Park for the Western Region Fire Monitoring program, he has been actively involved in fire effects monitoring.

RICHARD SCHWAB

POSITION: Regional Assistant Fire Management Officer

ADDRESS: Bureau of Indian Affairs
Southwest Regional Office
P.O. Box 26567
Albuquerque, New Mexico 87125
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Richardschwab@bia.gov

DUTIES:

- Assists in the preparation, review, and updating of the Regional and Agency Fire Management Planning Analysis (FMPA). Insures that program expenditures and staffing are in compliance and consistent with approved FMPA budgets.
- Assists in the development and negotiation of cooperative fire agreements within the Area with various Federal, Tribal, State, and private fire management agencies and organizations.
- Assists in conducting activity reviews and technical assistance trips to Agency units to evaluate compliance with policies, objectives, standards, and overall effectiveness of operations. Provides technical assistance in the solution of specific local problems. Recommends changes in operational procedures to increase effectiveness and efficiency of operations, and to provide technical assistance in the solution of specific local problems. Recommends changes in operation procedures to increase effectiveness or to correct practices in violation of established regulations or procedures.
- Coordinates studies in such areas as fire prevention, fire behavior, fire spread, fire effects, resistance factors, fire retardant, fuels, weather and related fire management factors. Works with research personnel in the development and trial of new methods and approaches for fire management activities.
- Provides assistance and guidance in the planning, implementation, and oversight of incidental Burned Area Emergency Rehabilitation (BAER) activities within the Area.
- Makes on-the-ground reviews of suppression activity effectiveness on large fires. Assists in the planning and direction of administrative studies designed to analyze the effectiveness of new methods of combating wildfire and participates in the evaluation of new fire fighting equipment.
- Represents supervisor and Area Office on designated local, regional, and/or national interagency fire management committees and/or task groups.
- Assists with the completion of all required correspondence including but not limited to project proposals and accomplishment reports related to the fire program.

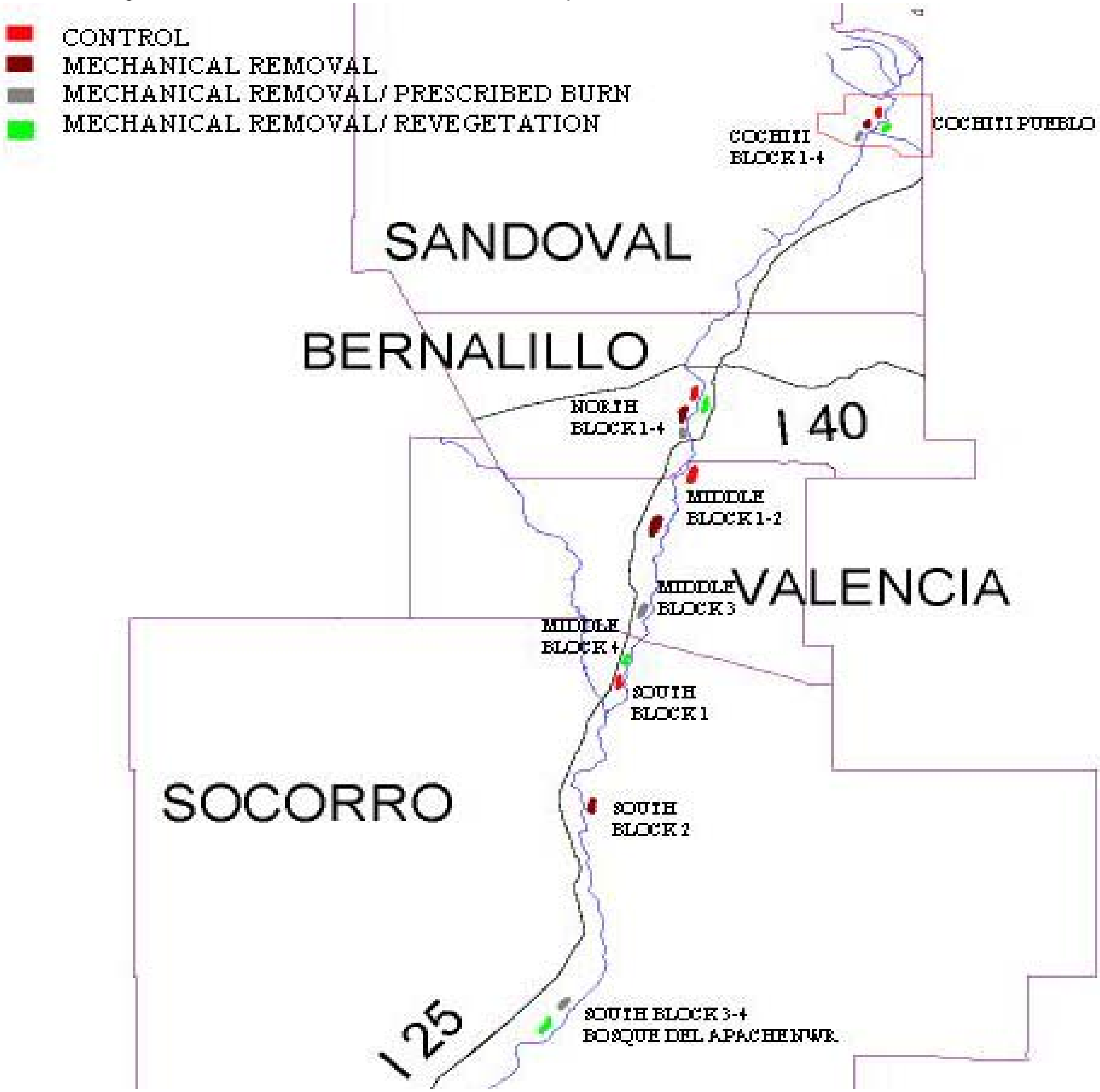
EDUCATION: Bachelor of Science Degree, Northern Arizona University, May 1981

APPENDIX

Detailed Budget	**Cooperators**	**RMRS**	**JFSP**
Year One			
P.I. Salaries (in-kind)	0	$137,395	0
Field Crew Housing	$5,000	0	0
Field Technician Salaries	0	22,000	$42,020
Bat research equipment	$5,000	0	$ 5,000
Herp research equipment	0	$2,500	$ 2,500
Bird & day-arthropod equipment	0	0	$ 3,250
Vegetation sampling equipment	0	0	$ 5,000
Arthropod collection at night	0	0	$ 2,000
Hydrology, soil, weather gear & labor	0	0	$12,360
GSA Vehicle rental (two)	0	$2000	$ 4,000
Travel/Per Diem	0	0	$ 6,000
Miscellaneous office supplies/software	$300	$500	$ 500
Revegetation Equipment	0	0	$16,700
SubTotal	**$10,300**	**$164,395**	**$99,330**
Indirect Costs 12%	0	0	$12,350
Total	**$10,300**	**$164,395**	**$111,680**
Year Two			
P.I. Salaries (in kind)	0	$114,774	$28,107
Field Crew Housing	$5,000	$0	0
Field Technician Salaries	0	$24,888	$43,701
Arthopod Specialist – All ID work	0	0	$ 6,000
Sampling Equipment	$5,000	0	$ 1,500
GSA Vehicle rental (two)	0	$2,000	$ 4,000
Travel/Per Diem	0	0	$ 6,500
Miscellaneous office supplies/software	$300	$500	$ 500
Revegetation Treatment	$20,000	0	$16,700
SubTotal	**$30,500**	**$142,162**	**$107,008**
Indirect Costs 12%	0	0	$ 14,382
Total	**$30,500**	**$142,162**	**$121,390**
Year Three			
P.I. Salaries (in kind)	0	$119,365	$29,231
Field Crew Housing	$5,000	$0	0
Field Technician Salaries	0	$24,888	$43,701
Arthopod Specialist	0	0	$ 6,000
Sampling Equipment	$5,000	0	$ 1,500
GSA Vehicle rental (two)	0	$2,000	$ 4,000
Travel/Per Diem	0	0	$ 6,500
Miscellaneous office supplies/software	$300	$500	$ 500

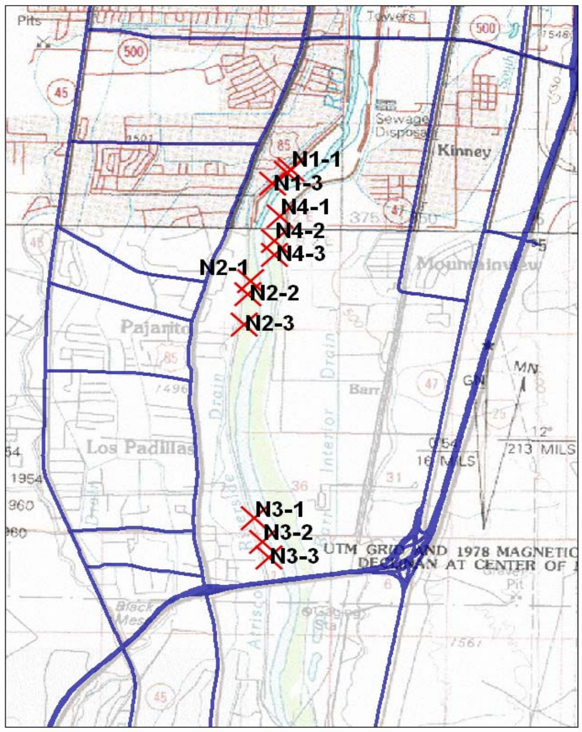
Revegetation Treatment	0	0	$16,700
Publication Costs	0	$10,000	0
SubTotal	**$15,300**	**$156,753**	**$108,132**
Indirect Costs 12%	0	0	$ 14,533
Total	**$15,300**	**$156,753**	**$122,665**

Figure 1. Locations of the fuel reduction study sites in the middle Rio Grande



Response of Groundwater Levels and Temperatures to Mechanical Removal of Invasive Plants

Rocky Mountain Research Station
Middle Rio Grande Fuels Reduction Study
Progress through December 2005



2005 Progress Report Presented to Rocky Mountain Research Station, Albuquerque, New Mexico

March 2006
University of New Mexico
Water Resources Program (WRP)
Joint Venture Agreement with USDA Forest Service

Principal Investigator: Dr. Michael Campana, Director, WRP
Technical Advisor: Dr. Roy Jemison, Regional Hydrologist, NFS
WRP Graduate Students: Christian LeJeune[1], Christian Gunning[2], Lynda Price[3]

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Introduction

The following provides a summary of progress through December 2005 on the hydrological portion of the Middle Rio Grande Fuels Reduction Project (FRS). The primary goals of the study are to: 1) validate and prepare data for further analysis by merging the data files into Microsoft Excel compatible Comma Separated Value (CSV), one file per well, to facilitate data sharing amongst researchers, 2) characterize the response of groundwater levels and temperatures to the three types of treatments performed at each site, and 3) link the dataset to regional spatial data such as soil maps and to time-series data such as river discharge, precipitation, surface temperature, and humidity.

Tasks completed to date that address the above goals include: 1) collection of groundwater data from data loggers, 2) maintenance of wells and data loggers, 3) creation of an ArcGIS document containing well locations and topographical area maps for future integration of spatial data, 4) merging of all North site data files into time-stamped Microsoft Excel compatible Comma Separated Value (CSV) files, one file per well, 5) preliminary validation and analysis of the North Block, Site 1, Well C (N1C) control site data, and 6) preliminary visualization of regional precipitation and river discharge records.

Overview of Project Data

Pre-existing Site Tables, including:

- Coordinates of wells
- Timelines of sampling, treatment progress, and other events effecting sites along with actions taken
- Ecological site descriptions performed by Forest Service staff, including soil profile and topology surveys

Logger Data Files, including:

- Logger descriptions
- Distance from well Top of Casing (TOC) to data logger
- Groundwater levels and temperatures at 15-minute sample intervals
- All times in UTC+6
- Groundwater levels above sensor and/or from top of well-casings (to be validated)
- Conversion to time-stamped Microsoft Excel-compatible Comma Separated Value (CSV) files
- CSV file merging and labeling, one file per well

Regional Data:

- ArcGIS base map created using Regional Geographic Information System (RGIS) data (see http://rgis.unm.edu/data_entry.cfm)
    - Locations of each well added to base map
    - RGIS topographic and regional road map layers added to base map

- Regional precipitation and temperature monthly averages obtained from the Desert Research Institute's Western Regional Climate Center (see http://www.wrcc.dri.edu/summary/climsmnm.html)
- Rio Grande discharge monthly averages obtained from the United States Geological Survey (see http://waterdata.usgs.gov/nwis)
- Soil data obtained from the Natural Resource Conservation Service (NRCS) (see http://soildatamart.nrcs.usda.gov/)

Methods

Three uniform blocks (North, Middle, and South) were selected to serve as replicates for proposed treatments (see Table 1). Within each block, four sites were selected to be treated and monitored. A randomized block design was created to assign the three treatments plus a control to each of the four sites within each block.

Table 1. Summary of Treatment Sites.

Block	Site	Area (ha)	Groundwater Sampling Started	Treatment Type	Dates of Treatments Performed	Treatments Completed as of 2005
NORTH	North 1	16.07	5/1/2000	Control Site	Control Site	None-Control site
NORTH	North 2	18.33	5/1/2000	Re-vegetation with Native Vegetation	2002-Nov./2003-Nov.	Cut, Chip, Herbicide
NORTH	North 3	17.03	5/1/2000	Mechanical Removal and Chipping	2003-Apr./2004/Apr.	Cut, Chip, Herbicide, Firewood
NORTH	North 4	23.43	5/1/2000	Controlled Burn	2002-Nov./2003-Apr.	Cut, Pile, Herbicide, Firewood
MIDDLE	Middle 1	19.41	5/1/2000	Mechanical Removal and Chipping	2002-Nov./2004-Mar.	Cut, Chip, Herbicide, Firewood
MIDDLE	Middle 2	29.17	5/1/2000	Controlled Burn	2004-Oct./2004-Dec.	Cut, Chip, Herbicide, Firewood
MIDDLE	Middle 3	13.21	5/1/2000	Re-vegetation with Native Vegetation	2004-Apr.	Cut, Chip, Herbicide, Firewood
MIDDLE	Middle 7	35.00	5/1/2000	Control Site	Control Site	None-Control site
SOUTH	South 1	28.87	5/1/2000	Control Site	Control Site	None-Control site
SOUTH	South 2	15.54	5/1/2000	Re-vegetation with Native Vegetation	2003-Feb./2003-Apr.	Cut, Pile, Herbicide, Firewood
SOUTH	South 3	26.71	5/1/2000	Controlled Burn	2002-Nov./2003-Feb.	Cut, Pile, Firewood, Herbicide
SOUTH	South 4	15.45	5/1/2000	Mechanical Removal and Chipping	2002-Nov./2003-Feb.	Cut, Chip, Herbicide, Firewood
						Updated: March 2006

Two groundwater observation wells were installed at each of the 12 study sites two years prior to treatment. Each well consists of a two inch diameter, five foot long, perforated stainless-steel well point driven into the saturated zone. Each well extends three feet above the soil surface via a two inch diameter galvanized pipe that is fitted with a locking cap.

Each well was fitted with an In-Situ MiniTroll data logger to monitor changes in groundwater before, during, and after treatments. Loggers measure the groundwater level at every site via an internal pressure transducer and measure the temperature at one of two wells at each site. Measurements are taken every 15 minutes.

Data are collected regularly from loggers using a handheld computer. The data files are downloaded to a PC and converted in bulk to time-stamped CSV files using In-Situ's AutoCSV utility (see http://www.in-situ.com/In-Situ/Downloads/Downloads_Software.html). Preliminary inspection was conducted using Microsoft Excel. CSV preprocessing was conducted using sed (see http://www.gnu.org/software/sed/) and vim (see http://www.vim.org/). Further processing of the CSV files, including merging, validation, and visualization, was conducted using the R open source statistical analysis package (see http://www.r-project.org/). All data were processed using a reference time zone of UTC+6. Future consideration will be given to accurately aligning time series with respect to time zone.

Existing site tables of well coordinates were first converted into the ArcGIS-compatible DBF format using Microsoft Excel. The resulting files were then imported into an ArcGIS base map of New Mexico obtained from RGIS. Topographical area maps were obtained and imported in the MrSid format.

Progress

As of now, removal treatments have been completed in their proposed sites. Monitoring well data collection is still ongoing to determine the effects of these treatments on selected ecosystem parameters. Currently, data from the North sites have been collected up to December 2005 and the Middle and South sites have data up to August 2005.

All data files from the North site have been merged into one time-stamped CSV file per well. Preliminary inspection reveals several gaps in the record, in addition to numerous outliers. Well C of the North Control Site (N1C) proved to be a high-quality record and is visualized here as an example (see Figure 1). Date ranges and summary statistics for the N1C record are also included (see Table 2).

Table 2. Analysis of North 1 Control C Groundwater.

Record Begins: 6/21/2001 13:58
Record Ends: 2/25/2006 13:44

	Temperature, C	Depth above Logger (cm)
Minimum	10.40	40.99
1st Quarter	12.76	54.85
Median	15.79	60.33
Mean	15.20	63.48
3rd Quarter	17.28	67.06
Maximum	19.15	159.34
Total Samples	158660.00	158660.00
Standard Deviation	2.57	15.62

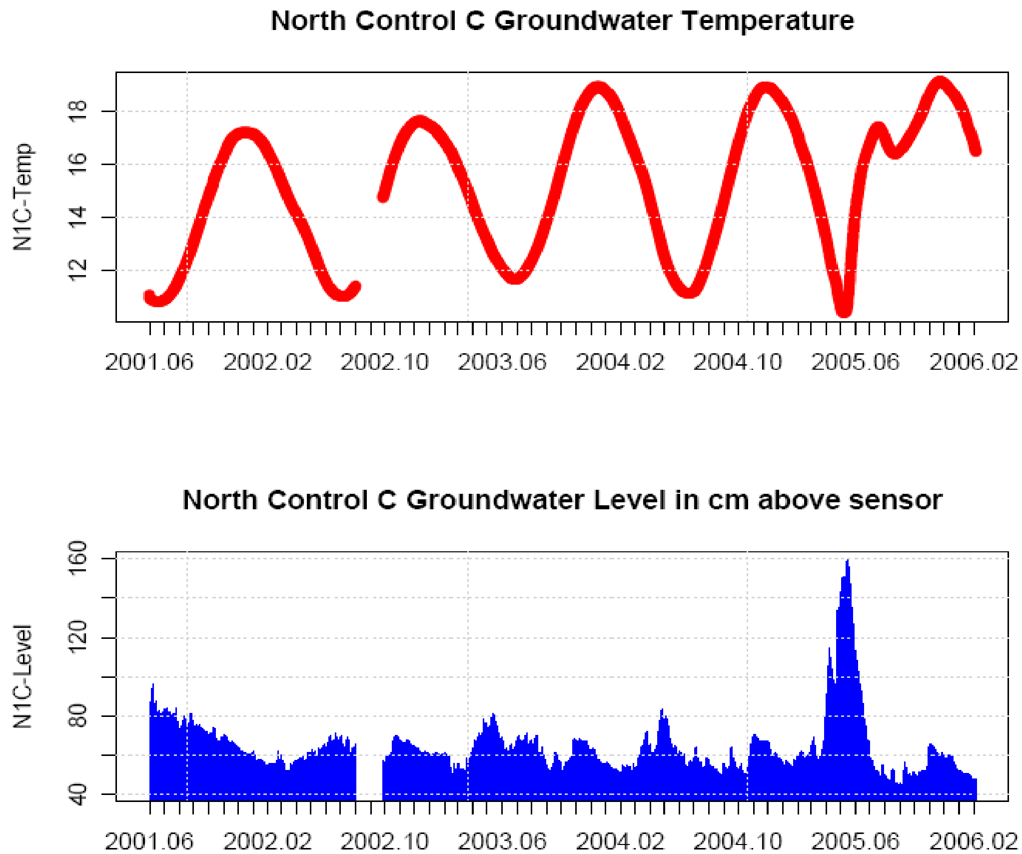

Figure 1. North 1 Well C (N1C) – Control Groundwater Temperatures and Groundwater Levels.

Most notable in the N1C record, aside from seasonal periodicity, is the strong groundwater level spike in early 2005. An aperiodic temperature anomaly clearly coincides with this spike. The other North records showed similar events.

Other variables investigated include annual precipitation data and monthly annual streamflow data. Direct precipitation is an important water source for plants in the Rio Grande Bosque. However, it does not contribute largely to the groundwater levels in areas where it falls (Finch et al. 2002). Figures 2 and 3 summarize the precipitation recorded near the northern and southern limits of the study areas.

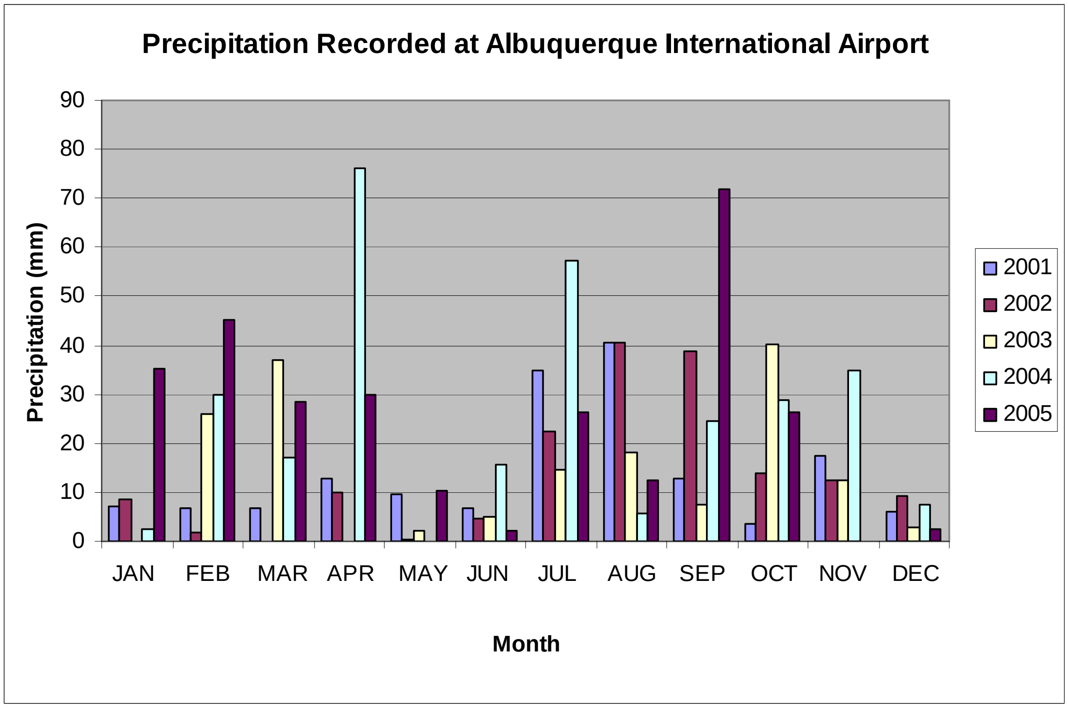

Figure 2. Precipitation Recorded at Albuquerque International Airport (Western Regional Climate Center 2006).

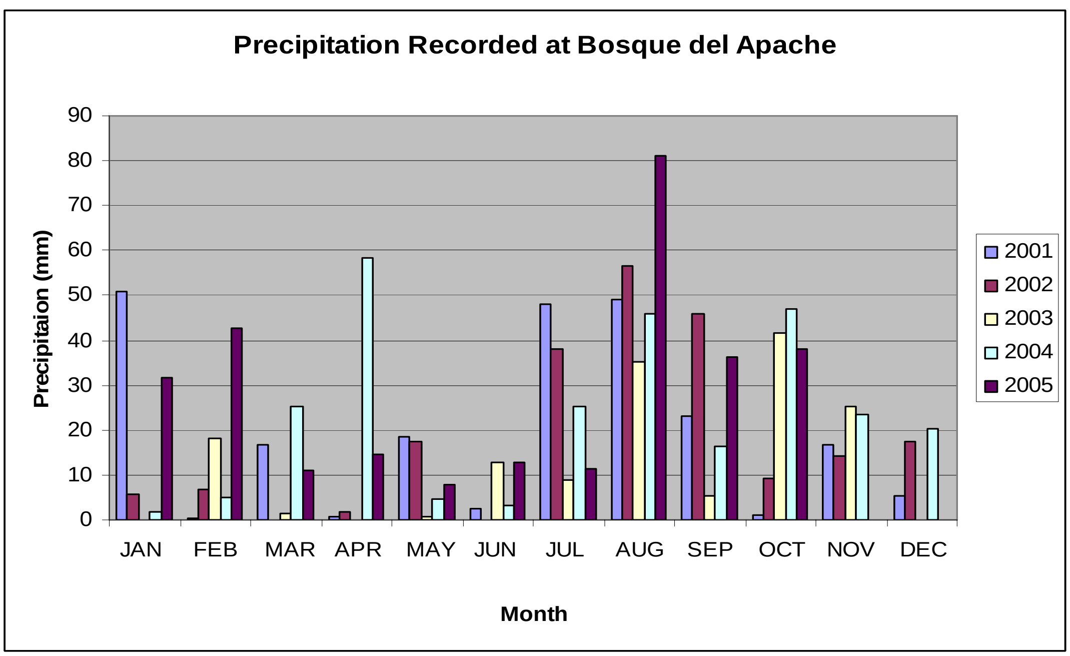

Figure 3. Precipitation Recorded at Bosque del Apache (Western Regional Climate Center 2006).

A primary source of groundwater in the Bosque is water that percolates into the ground from the river and canals that pass through the Bosque (Finch et al. 2004). Figure 4 illustrates monthly average streamflow measured from a USGS gage on the Rio Grande near Albuquerque.

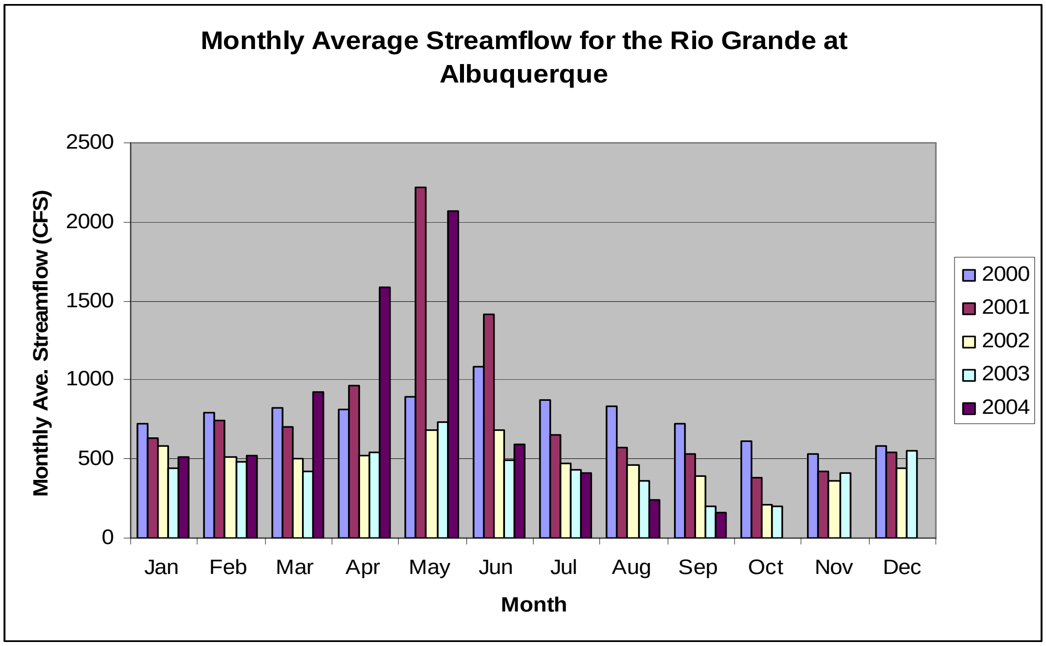

Figure 4. Rio Grande streamflow measured USGS gage 08330000 (U.S. Geological Survey 2006).

Precipitation and river discharge source files are obtained or converted into, from their respective sources, as time-stamped CSV files, and can be aligned with the time-stamped well CSV files for further visualization and analysis using R.

Future Work to be Performed

As we continue to make progress with the hydrological portion of the Fuels Reduction Study (FRS), we have determined the following points to be part of future work that will assist in a more complete understanding of how groundwater levels are potentially affected by the three treatments performed at each site. These points are by no means exhaustive, but provide a template for future work to be executed:

- Survey wellhead elevations and, if feasible, link to local benchmarks to establish wellhead height above mean sea level (msl)
- Complete merging of data into time-stamped CSV files, one per well
- Validation of data, including identification of outliers and gaps
- Work with the RMRS statistician to conduct robust statistical analysis, including inter-site and inter-block ANOVA of groundwater temperatures and levels
- Investigate correlation of groundwater levels with Rio Grande discharge and regional precipitation rates

- Link treatment location, type, and timeline to hydrological data using time-stamped CSV files
- Link other FRS time-series data such as ground surface temperature and relative humidity to hydrological data using time-stamped CSV files
- Link other FRS spatial data such as soil profiles and topology to hydrological data using ArcGIS
- Continuation of preparation of an annual report as required of the Joint Venture Agreement with the University of New Mexico WRP, and the RMRS

By investigating correlations among treatment type, groundwater levels and temperatures, and regional spatial and hydrological data, we hope to reveal the influence of the various treatment types on local processes such as evapotranspiration rates, stream-groundwater coupling, and infiltration of precipitation in the Middle Rio Grande Bosque. If a complete analysis reveals substantial changes in groundwater rates at the study sites, then recommendations for future Bosque land and water management could be made at the appropriate time. The results of this study could be applicable to similar southwestern United States regional riparian area studies to develop sound research strategies to mitigate the long-term reversal of current trends of riparian ecosystem degradation.

Literature Cited

Finch, D.M., J.M. Galloway, M.D. Means, D.L. Hawksworth, 2002. Progress report for Middle Rio Grande fuels reduction study 2000-2002. Rocky Mountain Research Station-Albuquerque, New Mexico. Rocky Mountain Research Station, Albuquerque Report, NM.

Finch, D.M., R. Jemison, A. Chung-MacCoubry, J. Galloway, H. Bateman, D. Hawksworth, 2004. Middle Rio Grande Fuels Reduction Study 2004 Annual Report. Rocky Mountain Research Station- Albuquerque, New Mexico. Rocky Mountain Research Station, Albuquerque Report, NM.

U.S. Geological Survey, 2006. Real-Time Data for New Mexico. Water Resources of New Mexico. (http://nwis.waterdata.usgs.gov/nm/nwis/rt)

Western Regional Climate Center, 2006. New Mexico Climate Summaries. Desert Research Institute. Reno, NV. (http://www.wrcc.dri.edu/summary/climsmnm.html)

Response of riparian vegetation to mechanical removal of invasive plants, RMRS Middle Rio Grande Fuels Reduction Study (FRS): Progress to date

2005 Progress Report presented to Rocky Mountain Research Station, Albuquerque, NM

March, 2006

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Introduction

The following provides a brief summary of progress to date on the vegetation portion of the Middle Rio Grande Fuels reduction project. The overarching goals of vegetation monitoring and analyses are to: 1) characterize responses of herbaceous and woody vegetation to fuels reduction treatments in the context of site landscape and environmental characteristics and land-use history, 2) monitor re-sprouts of treated exotic species in fuels reduction treatments, and 3) monitor transplant success (survival) in replanted sites. Our vegetation evaluations consider each fuel reduction treatment and control at the North, Middle and South sites. A secondary component of this project was evaluation of the efficacy of ETGages™ as a means of estimating evapotranspiration in a range of cover types along the MRG.

Specific tasks completed in 2005 towards meeting the above goals include, 1) completion of ground cover and litter measurements, 2) monitoring and removal of climate sensing instruments, 3) monitoring of exotic resprouts and survival of planted native species, 4) assembly of a GIS (geo)database for geomorphic/landscape analysis, 5) completion of the field components of monitoring of ETGages, and relative humidity and air temperature instruments at associated researchers' eddy covariance towers and sap flux stations along the Middle Rio Grande, and 6) preliminary analysis of ecological data.

Integrated Project Progress Overview

The following provides a brief overview of study methods, current results and preliminary findings.

Task 1 – Description of Vegetation Patterns

<u>Placing sites and treatments in a landscape context</u>

Current treatment, historical land use, and landscape/environmental setting all interact to create the ecological dynamics of MRG riverine ecosystems. Extensive vegetation surveys in experimental treatment plots initiated in 2004 and completed in 2005 form our baseline vegetation data set (Merritt and Johnson 2005). These data are being used to track site succession following fuels reduction treatments relative to untreated control plots. Since treatment blocks span a latitudinal gradient and blocked plots possess differing geomorphic positions and land use histories, the first phase of our analyses concerns quantification of site differences and similarities within and among experimental blocks. Using these analyses in conjunction with a Geographic Information System (GIS) data, we are seeking to understand how these historical and landscape factors affect vegetation dynamics and response to experimental treatment.

To this end, we reviewed published reports, historic accounts, and data sources regarding the chronology of water development and vegetation change along the Rio Grande River. We also obtained digital orthographically-corrected aerial photographs and other available GIS data of the entire study reach and examined valley attributes, fluvial landscape, and current structure of the dominant woody vegetation at the sites. In our final analyses, we will use this information to statistically partition ecological variation into its component parts to evaluate the results of fuels reduction treatments after accounting for inherent site differences.

Summary of Vegetation Analyses

What follows is a brief synopsis of preliminary vegetation analyses to date. These analyses explore the broad vegetation characteristics and patterns occurring in the study region and lay the necessary groundwork for future statistical modeling and time-series analysis. Here, we are particularly concerned with describing inter-site and inter-block differences in species richness, composition, and associated environmental factors, and initial responses to fuels reduction treatments.

These data were obtained in our 2004 and 2005 surveys, during which we gathered vegetation data from all nine study sites.

Species Richness in Control and Fuels Reduction Treatments

In total, 99 vascular plant species were identified in our vegetation surveys, 40 percent of which were exotic, introduced plants. We compared plant species richness, species composition, and environmental characteristics of the sites.

Irrespective of experimental block, average *plot-level* (2x2 m^2) herbaceous *species richness* was highest in the control sites followed by fuels reduction plus revegetation ("Fuels Red-Veg") and fuels reduction only ("Fuels Red"), respectively (Figure 1). This result was expected since data were obtained the first growing season after the intensive site alteration that is part of fuels reduction treatments. Similarly, we also found significant differences in *species composition* between treatment and control sites, however, most species in control sites are still represented at treatments sites, indicating that there is a high likelihood of re-colonization and establishment of species richness at the treated sites.

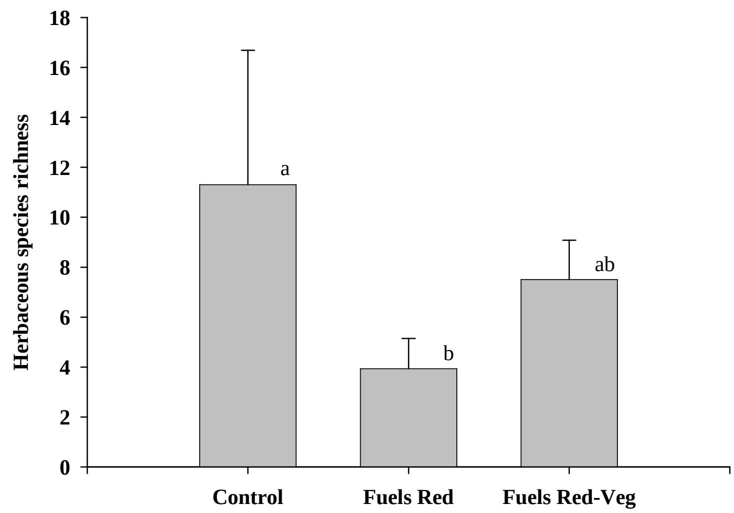

Figure 1. Mean (+/-1 standard error) herbaceous species richness at the plot level in control, fuels reduction, and fuels reduction-revegetation treatments. Different inset letters indicate significant ($p < 0.05$) differences in means from Tukey's test following analysis of variance.

Site-level species richness was calculated by first accounting for differences in sampling intensity and site size. These calibrated species richness values were generated by first fitting sample-based species accumulation curves to the plot-level species data from each site. The curves were generated by randomly entering samples from a site (without replacement) and plotting new species added to the list with each added sample. These randomizations were repeated 50 times to generate species accumulation curves and to estimate standard deviations. We conducted the randomizations using the Bootstrap Method. We then compared richness for similar numbers of plots sampled to account for species-area relationships. These calibrated species richness values were used to compare the *site-level* species richness between sites within blocks and between treatments.

Site-level species richness calculated from species-areas curves is shown in Figure 2. The richest sites were the fuels reduction-revegetation treatment in the North block and the control in the south block. The three most species poor sites were the fuels reduction treatments in the North and South Blocks and the fuels reduction-revegetation site in the Middle block. These results suggest that inherent differences in species richness exist among sites within blocks as well as among the blocks themselves.

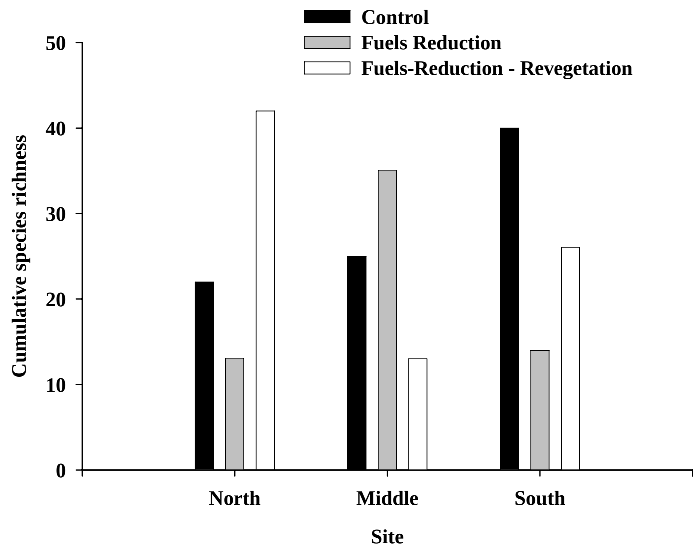

Figure 2. Site-level differences in cumulative species richness by site and treatment. Cumulative richness was calculated using species accumulation curves.

Aggregating *site-level* species richness data by treatment showed that in the year following fuels reduction treatment there were no detectable differences in species richness between treatments and controls (Fig. 3). This result is, of course, confounded by inter-block differences in species richness, however, it does suggest that fuels reduction treatments do not have an unduly severe affect on species richness (at least in the short term). Future vegetation analyses will parse out the portion of variation caused by inter-block differences, to provide a better understanding of the specific effects of fuels reduction treatments, regardless of regional trends.

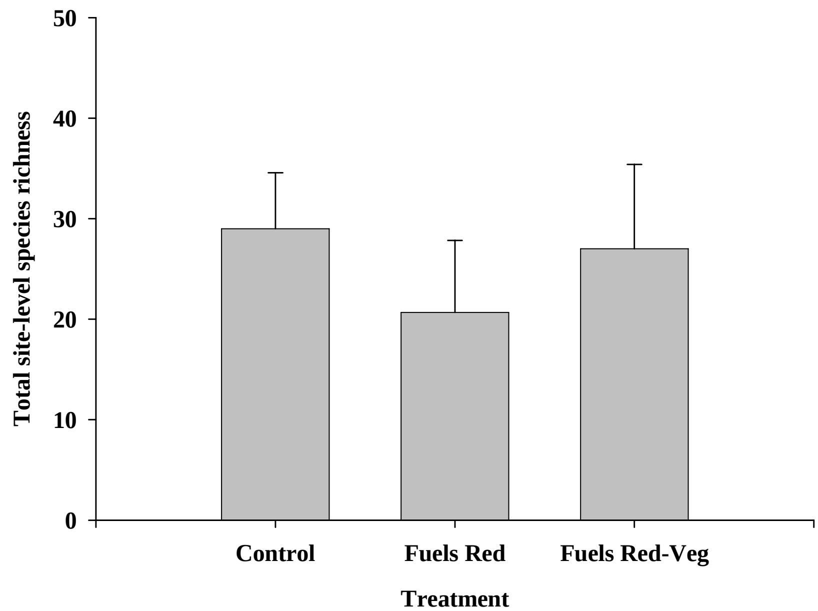

Figure 3. Mean (+/-1 standard error) cumulative species richness by treatment. There were no significant differences in species richness between treatments (ANOVA: $p > 0.05$).

Comparison of Species Composition in Control and Fuels Reduction Treatments

We conducted analysis of similarity (ANOSIM) to test for differences in species composition between fuels reduction treatments and control sites in the first year following treatment. These analyses were conducted on data aggregated by transect. The ANOSIM procedure is initiated by constructing a Bray-Curtis similarity matrix for all pairwise comparisons of transects. Bray-Curtis similarity index incorporates shared species abundances between transects and calculates similarity ranging from 0 (no shared species) to complete similarity 100 (same species in the same proportions). ANOSIM tests the null hypothesis of no difference between factors (treatments) by calculating an R statistic. R of 0 indicates that the average similarity of transects within treatments is no different than the average similarity of transects between treatments; R = 1 indicates that the similarity of transects within the treatments are considerably higher than between treatments. The closer R is to 1 the stronger the compositional differences between factors. ANOSIM is then conducted on 999 random assignments of transects to each of the factor (treatment) levels. The number of times that the R calculated for randomly assigned transects exceeds that for the actual data is used to calculate a p-value (proportion of Rs higher by chance).

The first ANOSIM tested for vegetation differences between blocks. The hypothesis of no vegetation differences between the blocks was rejected (Global R = 0.25, p = 0.001) and all pairwise differences were significant. Thus, from a vegetation standpoint, blocks were not true replicates and aggregating data by treatment was inappropriate for this type of analysis. All remaining analyses were conducted to test for differences between treatments within each block.

In the North block, there were significant differences between treatments (R = 0.30, p = 0.016). The control was marginally different from the fuels reduction–revegetation treatment (R = 0.20, p = 0.056), but not significantly different from the fuels reduction only treatment (R = 0.21, p = 0.079). The biggest difference in vegetation between North treatments was between the fuels reduction and fuels reduction–revegetation treatment (R = 0.65, p = 0.008).

At the Middle site there were also significant differences between treatments (Global R = 0.31, p = 0.005). All treatments differed significantly: control and fuels reduction only (R = 0.42, p = 0.016), control and fuels reduction–revegetation treatment (R = 0.43, p = 0.024), and fuels reduction and fuels reduction–revegetation treatment (R = 0.23, p = 0.063).

All treatments at the South block were likewise significantly different (Global R = 0.64, p = 0.001). All pairwise comparisons between treatments were significantly different: control and fuels reduction (R = 0.41, p = 0.024), control and fuels reduction–revegetation treatment (R = 0.56, p = 0.005), and fuels reduction and fuels reduction–revegetation treatment (R = 0.99, p = 0.029).

After performing ANOSIM, we then tested for the influence of each species on dissimilarity between factors by performing similarity percentage analysis (SIMPER). SIMPER provides the subset of all species that contribute to 90% of the total measured differences between treatments. This provides the subset of the whole species list that best discriminates between (or are sensitive to) the treatments. Species driving the differences between the control and treatments at the North sites included *Acroptilon repens*, *Anemopsis californica*, and *Parthenocissus quinquefolia*, which were all more abundant in the control than in the treated sites. *Muhlenbergia aperifolia*, *Ailanthus altissima*, and *Ipomoea leptophylla* were among those species that were more abundant in the treated sites compared to the control in the North block.

In the Middle block *Panicum obtusum, Muhlenbergia aperifolia*, *Sporobolus airoides*, *Distichlis spicata*, *Ratibida tagetes*, *Elymus elymoides*, *Chamaesyce serpyllifolia*, and *Apocynum androsaemifolium* collectively explained 73% of the difference in species composition between the control and fuels reduction treatment; all were more abundant in the control. *Anemopsis californica* was markedly more abundant in the treated sites than in the control. In the South block *Chloris* spp., *Ipomoea leptophylla*, *Gutierrezia sarothrae*, *Senecio riddellii*, *Sphaeralcea* spp., *Muhlenbergia asperifolia*, and *Aristida purpurea* var. *longiseta* collectively explained 71% of the distinction between plant communities between the control and treatments, all being abundant in the control but absent or sparse in the treatments. Species in the treatments but not the control in the South block include *Anemopsis californica, Amaranthus hybridus*, *Sisymbrium altissimum, Panicum obtusum*, and *Helianthus ciliaris.*

Factors Influencing Herbaceous Vegetation

Documenting patterns of herbaceous vegetation is fundamental to understanding the ecological effects of fuel reduction treatments. Herbaceous species populations tend to be much more immediately responsive to environmental change, including alteration of canopy structure, than long-lived woody species. As such, patterns in herbaceous species abundance can be particularly informative indicators of short-term changes in ecosystems.

Our initial statistical analyses are focused on characterizing “baseline” conditions in control sites and determining the primary factors influencing herbaceous species composition under “natural” conditions. Redundancy Analysis (RDA) was used to visualize patterns in control site herbaceous vegetation and relate them to environmental factors. RDA uses a reciprocal averaging algorithm to order samples (e.g., plots, transects, or sites) according to similarities or differences in their species compositions. RDA then constrains site scores to be linear combinations of environmental variables. This procedure is analogous to multiple regression of site scores on environmental variables.

The end result of this analysis is a RDA diagram in which proximity of sample points in the diagram implies similarity in vegetation and environmental characteristics. Vectors in the diagram indicate the maximum direction of change for that factor. The order of sites relative to any given vector provides a ranking of the site with regard to that environmental factor. The further from the origin a site is in the direction a vector is pointing, the greater the value for the environmental factor (stronger positive association). The converse applies to sites oriented in the direction of the vector tail. The relative lengths of the vectors indicate the strength of the correlation between vegetation and that environmental factor.

Figure 4 is the RDA diagram of samples (plots) from control sites for which soil chemistry data were available. Environmental factors included in this analysis were chosen on the basis of a step-wise forward selection process using Monte Carlo permutations to test for significance. All included factors had significance (p) values lower than 0.05. As is evident from the diagram (Fig. 4), differences in soil factors (P, NO_3, Ca, and Clay), ground cover/litter (total ground cover, fine wood litter, and leaf depth*leaf cover), and exotic woody cover were all strongly associated with control site vegetation.

It is unclear how fuels reduction treatments could affect soil chemistry, however, such treatments without question have a strong effect on exotic woody cover and ground cover/litter composition. Field observations suggest that in treated sites, on-site chipping of cut exotics and mulching with those chips has a marked affect on herbaceous vegetation cover. We noted that in areas with a deep and/or continuous mulch of chips vegetation cover and to a lesser degree species richness appeared suppressed compared to non-mulched areas of the same site.

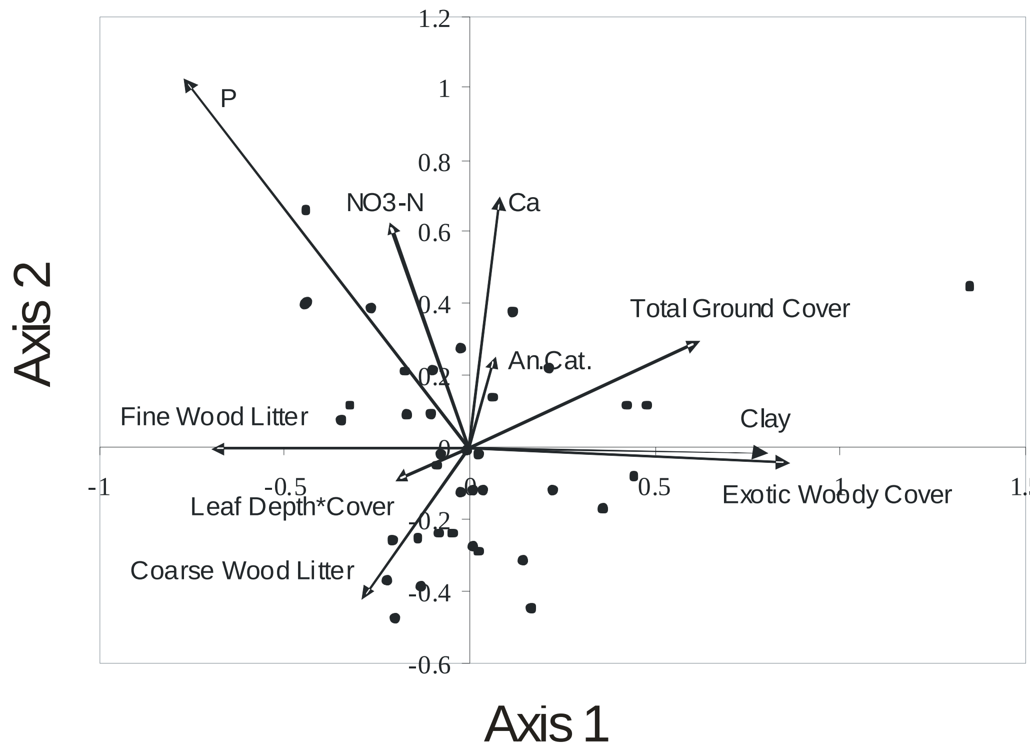

Figure 5. RDA diagram of plots in control sites possessing soil data. Points indicate sample location. These have been left unlabled for clarity. An.Cat. Is the anion/cation ratio. See text for additional details.

Our analyses of treatment site vegetation dynamics encompass many facets, but one of our primary foci at this point is investigating how chip mulch affects herbaceous vegetation. The process of fuels reduction essentially obliterates all surface components of the herb layer. Thus, in our modeling we assume that herbaceous species abundance was essentially zero at t_0 in 2003. Our data collected during 2004 – 2005 is representative of the initial successional state of treatment sites (t_1).

As part of our exploratory research on the t_1 herbaceous data, we assembled bar graphs of herbaceous species richness and total cover versus chip depth and percent cover (Fig. 5). These charts include the aggregation of data from all treatment sites and all blocks, thus considerable natural variation is included. Despite the inclusion of such natural variation, this analysis was informative. Plots show a gradual decrease in species richness and a marked decrease in herbaceous coverage with increasing chip depth. In both cases, the increase in vegetation parameters in the deepest chip class resulted from a just a few unusually well vegetated plots at site M3. It is also interesting to note that the vast majority of species cover and diversity arose from plants with predominately stoloniferous, vegetative growth such as *Anemopsis californica, Muhlenbergia asperifolia*, and *Distichilis spicata*.

The extent of chipping appears to have less of an effect on herbaceous vegetation than chip depth, although there could be a slight tendency for herbaceous vegetation cover to be reduced by increased extent of chips (Fig. 5). We speculate that chip

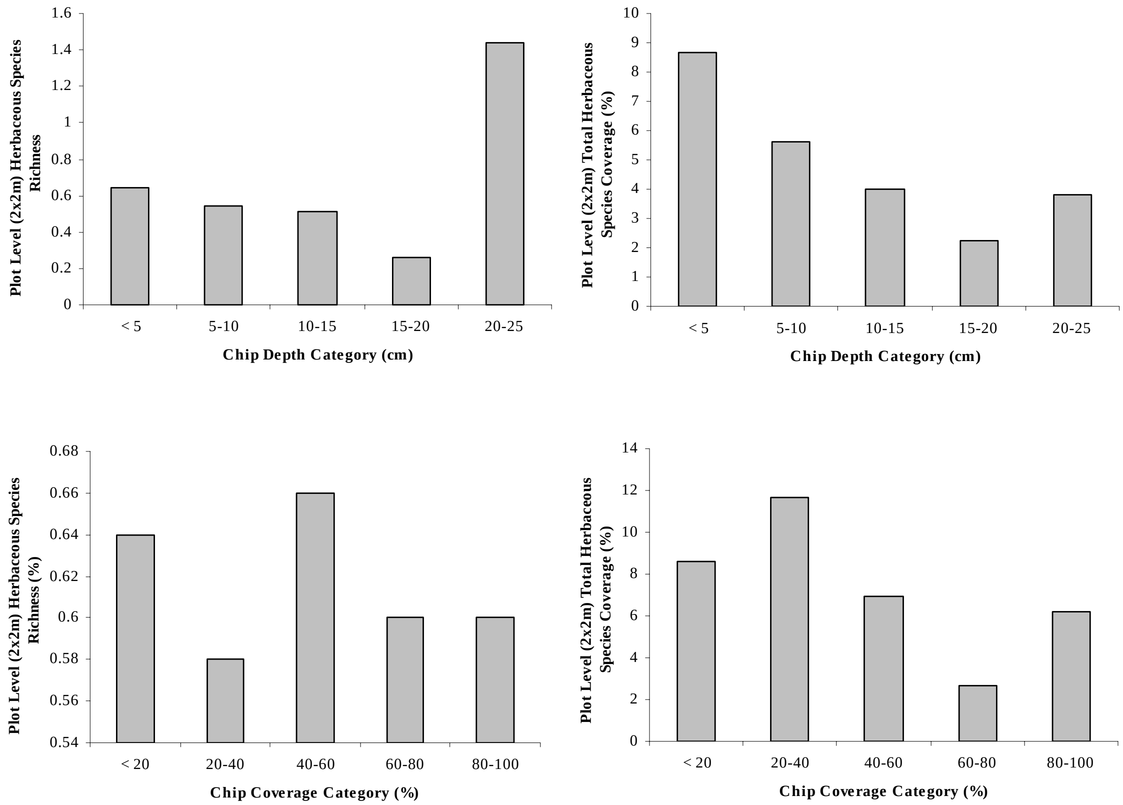

Figure 6. Bars graphs relating herbaceous species richness and cover to wood chip depth and percent cover. Data are aggregated from all treatment sites.

coverage does not appreciably retard herbaceous species, and that any apparent reduction results from the inter-correlation of chip coverage and depth (i.e., areas with a high coverage of chips also tend to be those with greater chip depths).

<u>2006 Vegetation Evaluation Goals</u>

The approximately two thousand vegetation plots established by Merritt and Johnson in 2004 will be re-inventoried in 2006 to characterize short-term successional trends in herbaceous and woody plant species composition. Linkages between plant community dynamics and physical site characteristics (including patterns of chipped fuel application and disturbance associated with equipment access roads) will be used to provide recommendations for conducting fuels reduction activities to enhance rapid recovery of plant communities. These data will be evaluated in the context of the historical landscape-scale analysis of the MRG following the 2006 inventories.

Task 2: Monitoring of re-sprouting and re-growth of treated exotic trees and shrubs and survivorship of transplanted native species.

Resprouts

A total of 837 cut stems of non-native woody species were evaluated for resprouting at the treated sites (North 2, North 3, Middle 1, Middle 3, South 2, and South 4). These resprouts were measured along transects established for the vegetation inventories. Russian olive (*Elaeagnus angustifolia*), tamarisk (*Tamarix ramosissima*), Siberian elm (*Ulmus pumila*), and mulberry (*Morus alba*) resprouts were inventoried along the transects.

The overall resprout rate for the 837 stems measured was 16%. Resprout rate was highest for Siberian elm (50%) and lowest for Russian olive (3%). *Tamarix* and *Morus* each had resprout rates of 18% (Fig. 4).

The *fuels reduction treatment was effective in reducing exotic species at the fuels reduction sites*; mortality rate was 84% across all exotic species treated. These results suggest that Siberian elm is least sensitive to treatments, and perhaps should receive more intensive removal efforts during future fuels reduction treatments.

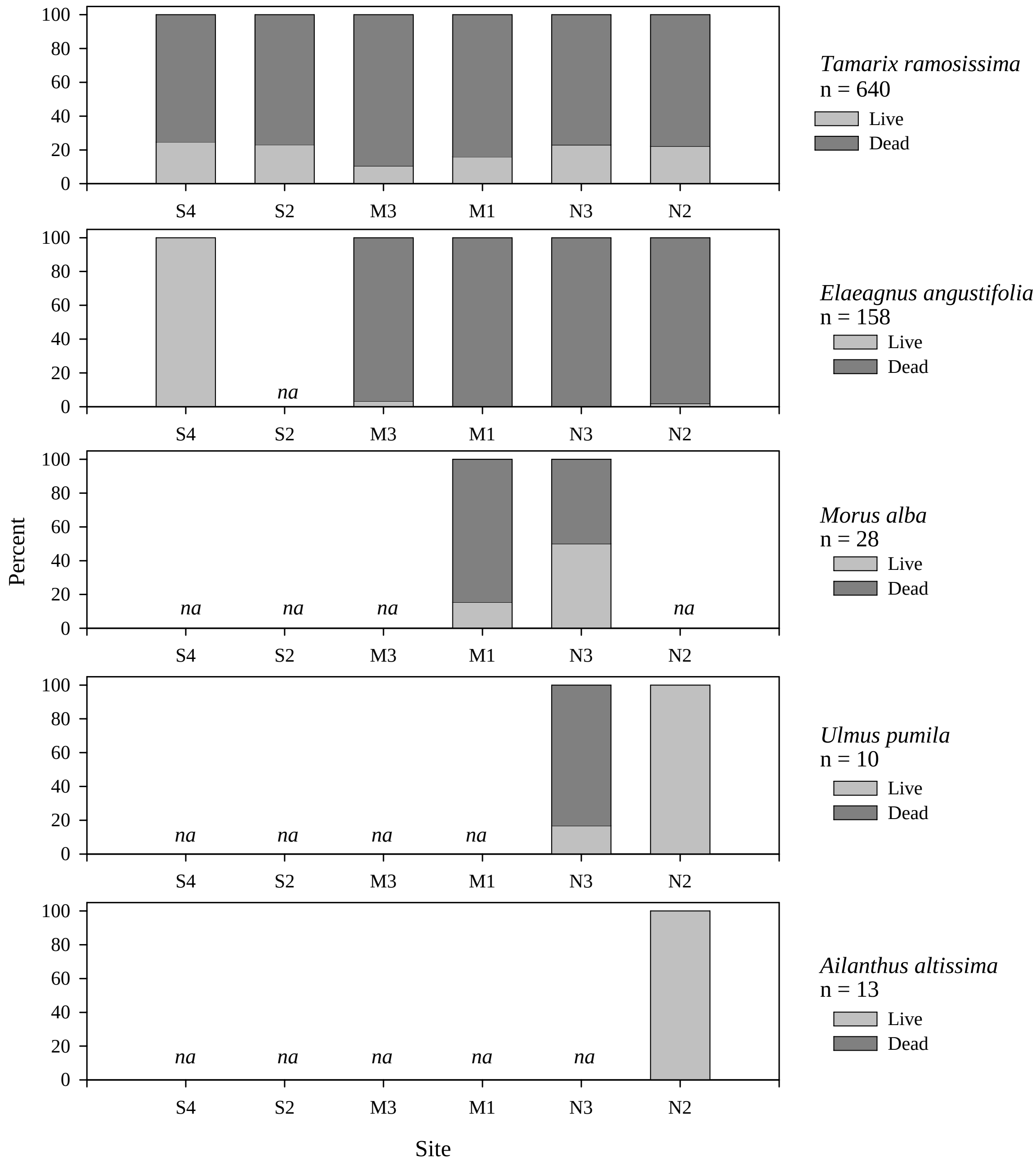

Figure 4. Resprout mortality at the treated fuels reduction sites along the Middle Rio Grande. The mortality rate of the 837 resprouts sampled was 84%.

Transplant survival

We measured survival of transplants at each of the cleared and revegetated sites. Species sampled included *Amorpha fruticosa*, *Baccharis salicina*, *Forestiera pubescens*, *Lycium pallidum*, *Prosopis pubescens*, *Rhus trilobata*, and *Ribes aureum*. Survival of transplants ranged from 60-100% at the three sites (185 individuals were measured). Mortality rate was highest for skunkbrush (*Rhus trilobata*) in the North block (40% mortality), mesquite (*Prosopis pubescens*) in the Middle block (30% mortality), and for wolfberry (*Lycium pallidum*) in the South block (8% mortality). The primary cause of mortality for all species appeared to be drought stress and desiccation.

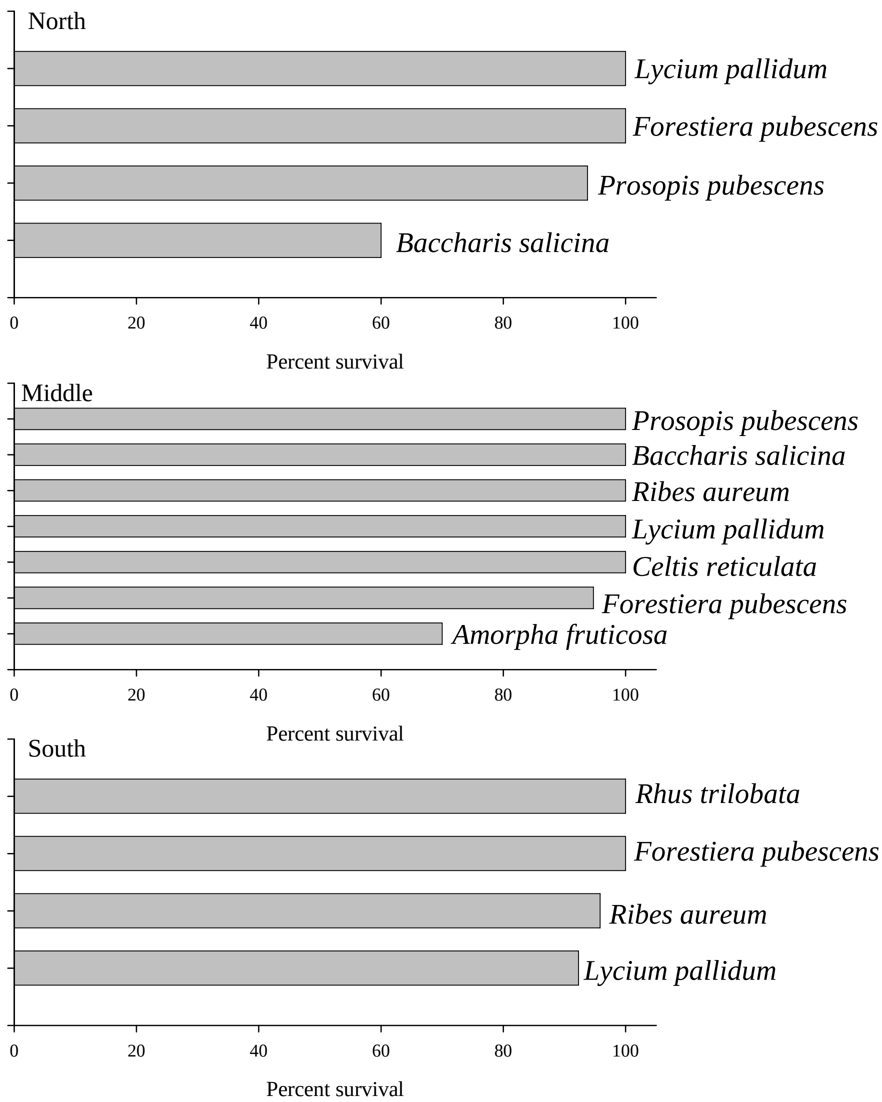

Figure 5. Survival rate of transplanted saplings of several native plants in the fuels reduction-revegetation treatments.

Task 3: Continued monitoring of ETGages, relative humidity, and air temperature at eddy covariance towers and sap flux stations.

ET gages were established this year at seven sites and data were gathered from June through September. We also gathered relative humidity and temperature data. These data will be compared to ET measured at each of the eddy covariance towers established by University of New Mexico.

BOSQUE RESTORATION EFFECTS ON BATS AND HERPETOFAUNA

Final Report to Joint Fire Sciences Program (also submitted to Middle Rio Grande Bosque Initiative, Middle Rio Grande Conservancy District, and other cooperators)

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METHODS

Bat Activity Monitoring

Activity of bats at each site was monitored using Anabat detection systems before and after treatments occurred. Three monitoring stations were installed a random distance to the north of each herp array. Selected station locations were sometimes located in deep brush and dense stands of trees. At each station, we selected an orientation (1-360 degrees) for the bat detector such that microphones were not immediately obstructed by vegetation and could pick up the calls of bats flying by without interference. Monitoring station locations were recorded with GPS, and the same stations and detector orientations were reused each year. From night to night, bat activity depends on weather conditions, moon phase, insect activity, and other factors. To reduce variation in bat activity among sites due to these factors, the four sites in each block were monitored simultaneously. One block was monitored per night, and each block was monitored once per week, and the order of sampling each week was randomized. We monitored bat activity from June through August and attempted to achieve 12 nights of monitoring per site per season.

To monitor bat activity, ultrasonic detection systems (Anabats) were set up and activated just prior to dusk. Monitoring devices were positioned on posts such that they set 1 m above the ground. From 2001-2002, Anabats were angled at 45 degrees above the horizontal and were connected through Anabat ZCAIM units to laptop computers powered by portable batteries. Anabat ZCAIM units convert analog signals from the bat detector into digital signals to the computer. Because these systems were extremely prone to periodic failure, field crews monitored the systems throughout the night and bat calls were also recorded to a backup device (Sony minidisc recorders). From 2003-2005, we took advantage of new and more reliable technology that permitted storage of bat call data on compact flash cards. Thus, we replaced the ZCAIM/laptop recording systems with Compact Flash ZCAIMs. Since field crews no longer monitored the units at night, Anabats were also placed within PVC housings to protect the units from rain. To prevent rain from entering and damaging sensitive microphones, Anabats were oriented 45 degrees below the horizontal. Microphones were oriented to receive audio data reflected off flat, Lexan surfaces.

Call data were transferred from laptop computers nightly and from compact flash cards weekly. After data was transferred to an office computer, a technician examined each call file using Analook software. The technician kept all files that contained at least 2 bat calls (a sequence of > 1 echolocation pulses with < 1 s between sequential pulses). All other files containing 1 bat call or extraneous noise (insects, etc.) were discarded. Consistency in call file interpretation among technicians was achieved by thorough training and standardization of method. Bat activity was defined as the total minutes during which qualified calls were recorded during the official monitoring period each night. The official monitoring period started at 15 minutes past official sunset and continued for the next 4.5 hours.

Treatment effects on bat activity

To identify impacts of treatments on summer activity levels of bats, we compared relative changes in bat activity at control and treated sites. At the completion of field season 2005, we had two years of post-mechanical treatment data at most study sites. Using data from pre-treatment years (2001-2002) and post-treatment years (2004-2005), we calculated average minutes of activity per night for pre- and post-treatment periods at each monitoring station. We then used General Linear Model- Repeated Measured Analysis to compare pre- and post-treatment bat activity at treated and control sites. We also used linear regression to identify habitat structure variables that correlate with bat activity.

Herpetofaunal sampling

To sample reptiles and amphibians, we installed three drift fence arrays per site. Arrays were placed randomly within the site and at least 25m from the periphery. Each drift fence array consisted of three silt erosion fences with 2 pitfalls and 2 funnels per fence. Each fence was 6m long, started 7.5 m from a central point, and was positioned at an angle of 60 degrees from the other fences. The location of each trap site was recorded by GPS, marked with flagging, and revisited each year. Traps were open continuously from June to mid September each year, and arrays were checked for animals 3 days per week.

For each animal captured, we recorded species, snout-vent length, vent-to-tail length, mass, sex, and age. We uniquely marked lizards, but not amphibians or snakes. Hatchlings were also marked to evaluate reproductive success and survival probability before and after treatment.
To evaluate how herpetofaunal species responded to restoration treatments we first characterized bosque habitat in terms of its vegetation. Then we correlated herpetofaunal occurrence or relative abundance with these vegetation characteristics.

Vegetation changes at herp arrays

Using 15 variables from the 50 m ground cover transects and 4 m radius plots at each array (before and after treatment), we used a principal components analysis (PCA) to detect differences among arrays based on vegetation variables. Variables entered into the analysis included type and percent ground cover, percent overstory cover, number of dead branches and debris, number and size of native and non-native trees, and number of shrubs. To determine how restoration treatments altered bosque vegetation, we compared pre- and post-treatment factor scores using paired t-tests.

Lizard response to treatments

Most herpetofaunal captures were lizards (nearly 85% out of over 16,000 captures), and we examined the six most common lizard species. To evaluate how restoration treatments impacted lizards, we correlated species' occurrences and abundances with vegetation factor scores derived from the PCA. For three lizard species that were not ubiquitous throughout the study, we used a logistic regression analysis to determine which factor scores best predicted lizard species presence. We used a backward elimination procedure that eliminated variables with $P>0.25$ (Hosmer and Lemeshow 2000). To correlate relative species abundance with vegetation characteristics, we used a backward stepwise regression to identify significant vegetation factor scores. For the 3 species that were not ubiquitous at all our study sites, we conducted the regression analysis with data only from sites where the species occurred.

Amphibian response to treatments

Similar to analyses used to evaluate lizard species, we correlated amphibian species' presence and relative abundance with vegetation factor scores from the PCA. Two spadefoot toad species, Couch's Spadefoot toad (*Scaphiopus couchii*) and New Mexico spadefoot toad (*Spea multiplicata*) were combined to represent amphibians in the family Pelobatidae. Spadefoot toads were only present at 27 of 72 arrays (from before and after treatment), and therefore occurrence was analyzed using a logistic regression analysis. Three toad species, Woodhouse's toad (*Bufo woodhousii*), Great Plains toad (*B. cognatus*), and Red-spotted toad (*B. punctatus*) were combined to represent amphibians in the family Bufonidae. Toads were common throughout the study and therefore abundance was analyzed using a stepwise regression.

Amphibian response to flooding
In 2005, an unexpected experiment occurred when two of 12 study sites flooded for the first time during the Fuels Project. We noted duration and degree of flooding at these sites and compared post-flood capture rates of toads in 2005 with capture rates from previous years at these sites. Many toads were identified to genus only (*Bufo* spp.) because they were too small (<30mm) for individual species identification.

RESULTS

Treatment effects on bat activity
We had two seasons of pre-treatment (2001-2002) and post-treatment year (2004-2005) data for all monitoring stations except Middle 7. Because Middle 7 was introduced in 2002 to replace our unintentionally burned control site at Middle 4, we had only one season of pre-treatment data for monitoring stations at Middle 7. In pre-treatment years, we achieved fewer nights of monitoring than desired due to weather and equipment difficulties. Frequent night-time showers in 2001 and 2002 often necessitated that we bring in equipment prematurely, and thus several nights were not sampled successfully (for the full 4.5 hour period). In 2001, we achieved only 4-8 nights of sampling per station, and in 2002, we achieved 8-11 nights of sampling per station. However, drier weather and equipment improvements allowed us to successfully achieve 9-14 nights of sampling per summer in 2004-2005.

Results of GLM-Repeated Measures Analysis indicate overall bat activity was different between pre- and post-treatment years (i.e. significant time effect; Table 1). This time effect was not different between blocks (nonsignificant 'time*block' interaction). The significant interaction between time and assigned (control vs. treated site) indicates that bat activity was affected by invasive plant treatments. This interaction indicates that activity on treated sites increased to a greater degree in post-treatment years than activity on control sites (Figure 1). Thus, our analyses suggest that removal of exotic trees and woody fuels has had a positive effect on the use of sites by bats.

A significant block effect indicates that bat activity was different among North, Middle, and South blocks (Table 2). In pre- and post-treatment years, bat activity was higher on sites in the South block (Fig. 2). We used stepwise linear regression to determine if habitat structure variables from pre-treatment vegetation surveys (canopy cover, canopy height, midstory clutter, tree basal area, and exotic stem density) could explain the variation in bat activity among sites (pre-treatment years). Percent canopy cover was inversely related to bat activity among sites and explained 50.2% of the variation. Sites in South block had lower canopy cover values and higher levels of bat activity than North and Middle blocks. Lower levels of canopy cover likely reflect more open, less cluttered sites. This openness may improve the accessibility of the site to bat species with wider variety of flight styles. For example, more open sites may be more accessible to fast-flying species such as the Mexican free-tailed bat (*Tadarida brasiliensis*) whereas denser, more cluttered sites may only be accessible to more maneuverable species such as the Arizona myotis (*Myotis occultus*).

Table 1. Results of within-subjects contrasts of GLM-Repeated Measures Analysis comparing interactions between time period (pre- vs. post-treatment), block (North, Middle, South), and assigned (treated vs. control site).

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	4049.306	1	4049.306	15.494	.000
TIME * BLOCK	Linear	732.009	2	366.004	1.400	.261
TIME * ASSIGNED	**Linear**	**1660.756**	**1**	**1660.756**	**6.355**	**.017**
Error(TIME)	Linear	8363.019	32	261.344		

Fig. 1. Minutes of bat activity per night on control and treated sites during pre-treatment (2001-2002) and post-treatment (2004-2005) periods.

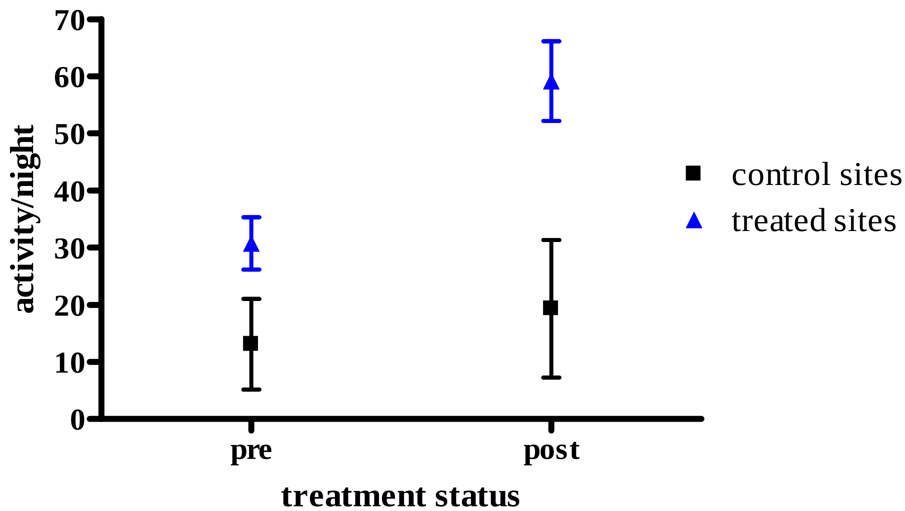


Table 2. Results of between-subjects tests from GLM-Repeated Measures Analysis comparing bat activity at control and treated sites during pre-treatment (2001-2002) and post-treatment (2004-2005) periods.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	50452.436	1	50452.436	31.226	.000
BLOCK	**28588.496**	**2**	**14294.248**	**8.847**	**.001**
ASSIGNED	11149.601	1	11149.601	6.901	.013
Error	51703.065	32	1615.721		

Fig. 2. Average minutes of bat activity per night for each study block during pre-treatment (2001-2002) and post-treatment (2004-2005) periods.

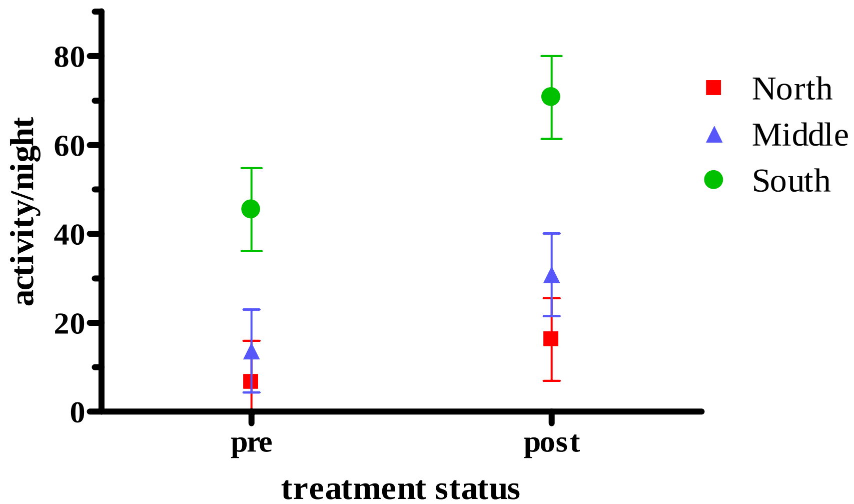


Table 3. Results of stepwise linear regression between habitat structure variables and average minutes of bat activity per night (for the pre-treatment period at all sites).

Model	Coefficient	Std. Error	t	Sig.
Constant	192.898	52.807	3.653	.004
Canopy Closure (%)	**-1.941**	**.611**	**-3.175**	**.010**

Herpetofaunal communities of the Middle Rio Grande Bosque

Historical Information on the Herpetofaunal Community

The Middle Rio Grande supports the most extensive, remaining gallery of cottonwood forest (*Populus deltoides wislizeni*) in the southwest (Hink and Ohmart 1984). This forest, or bosque, hosts a rich assemblage of vertebrates, particularly birds (Hink and Ohmart 1984). Several studies have focused on arthropod, bird, and mammal communities of the Middle Rio Grande bosque; however information on the herpetofaunal community is limited. A list of expected species may be assembled from recent studies, historic and museum records, and habitat associations from Degenhardt and others (1996). Because there are no studies of amphibians and reptiles in the bosque prior to channelization and damming of the river, it is difficult to characterize the herpetofaunal community of native, undisturbed cottonwood forest. More recently, Hink and Ohmart (1984) characterized herpetofauna associated with riparian vegetation of the Middle Rio Grande based on results of their pitfall surveys, museum records, and other field observations. Stuart and others (1995) reported herpetofauna captured at two sites within the Bosque del Apache National Wildlife Refuge (BDANWR) near Socorro, NM. Several studies have examined the lizard communities of desert riparian areas in Arizona. However, data from these studies are not comparable to Middle Rio Grande bosque because mesquite (*Prosopis velutina*) was the major overstory tree/shrub in the Arizona study areas, and cottonwood

(*Populus fremontii*) and willow (*Salix gooddingii*) had only a scattered or occasional presence (Vitt and others 1981; Jakle and Gatz 1985; Jones and Glinski 1985; Szaro and Belfit 1986).

Based on available literature, cottonwood forests and associated habitats of the Middle Rio Grande (including ditches, canals, ponds, sandbars, and drier peripheral riparian habitats) are used by at least 50 reptile and amphibian species. Species that were captured (Hink and Ohmart 1984; Stuart and others 1995) and species with other types of records in the Middle Rio Grande bosque (Hink and Ohmart 1984; Degenhardt and others 1996; Bailey and others 2001) are listed in table 1. The Eastern Fence Lizard (*Sceloporus undulatus*), New Mexico Whiptail (*Aspidoscelis neomexicana*, formerly genus *Cnemidophorus* from Reeder and others 2002), and Woodhouse's Toad (*Bufo woodhousii*) were frequently captured from Española to Socorro, NM (Hink and Ohmart 1984). Fifteen other species of lizards, snakes, amphibians, and turtles were captured infrequently, at a limited number of locations, or both (Hink and Ohmart 1984; Table 1). An additional 23 species of reptiles and amphibians were occasionally sighted or otherwise documented in the Middle Rio Grande Valley (Hink and Ohmart 1984; Table 1). In two mixed stands of mature cottonwood and saltcedar at BDANWR, Stuart and others (1995) detected 8 amphibian and reptile species (Table 1).

Most of the species captured are typically associated with upland habitats (for example, desert grasslands, shrublands, and arroyos) rather than mesic riparian forest (Degenhardt and others 1996). Hence, capture rates were highest in open vegetation types with sandy soils and sparse ground cover and lowest in stands with dense understories (Hink and Ohmart 1984). Species captured more frequently in open, sandy habitats with sparse vegetation (for example, open stands of intermediate aged cottonwoods) included Eastern Fence Lizards, New Mexico Whiptails, Chihuahuan Spotted Whiptails (*A. exsanguis*), Woodhouse's Toads, Great Plains Toads (*Bufo cognatus*), and Plains Spadefoots (*Spea bombifrons*; Hink and Ohmart 1984). However, Great Plains Skinks (*Eumeces obsoletus*) were captured frequently in stands with densely vegetated understories.

Species associated with wetter habitats within the bosque (for example, near permanent water) included Gartersnakes (*Thamnophis* spp.), Spiny Softshell Turtles (*Apalone spinifera*), Tiger Salamanders (*Ambystoma tigrinum*), Western Chorus Frogs (*Pseudacris triseriata*), and American Bullfrogs (*Rana catesbeiana*; Hink and Ohmart 1984). Although once abundant in the bosque, Northern Leopard Frogs (*Rana pipiens*) were rarely captured by Hink and Ohmart (1984) and are considered extirpated from Bernalillo, Socorro, and Sierra counties (Applegarth 1983; Bailey and others 2001). The absence or low numbers of these species captured likely reflect the loss of suitable wetland habitat along the river. From 1935 to 1989, surface area covered by wet meadows, marshes, and ponds declined by 73% along 250 miles of Middle Rio Grande floodplain (Roelle and Hagenbuck 1995).

Herpetofaunal Community of the Fuels Reduction Project

From 2000-2005, we documented 9 amphibian, 11 lizard, and 13 snake species. We captured 2,355 amphibians, and *Bufo woodhousii* (Woodhouse toad) was the most common. We captured 13,728 lizards (8,174 individuals). *Sceloporus undulatus* (Eastern fence lizard), *Aspidoscelis neomexicana* (New Mexico whiptail), and *A. exsanguis* (Chihuahuan spotted whiptail) were the most common lizards. We captured 152 snakes, and *Lampropeltis getula* (common kingsnake) was the most common. Few aquatic or moist habitat species are represented. We did not document several species that were listed in Table 1 (2 amphibian, 6 lizard, and 3 snake species), likely because we did not use the variety of sampling techniques employed in the other studies and we sampled only in mature cottonwood forest. Similar to previous studies, the majority of species we captured were upland species. For example, the New Mexico Whiptail is typically associated with open, sparse vegetation (Christiansen and others 1971).

Table 1. Species list of herpetofauna observed or captured in the Middle Rio Grande bosque and associated habitats (including ditches, canals, ponds, sandbars, and drier peripheral riparian habitat). Reference codes are as follows: HC = captures by Hink and Ohmart (1984), HM = museum records and other observations reported in Hink and Ohmart (1984) Appendix 2, D = habitat associations from Degenhardt and others (1996), B = Bailey and others (2001), S = captures by Stuart and others at BDANWR (1995).

Taxa	**Scientific Name**	**Common Name**	**REFERENCE**
Amphibians	*Ambystoma tigrinum*	Tiger Salamander	HC, D, B, S
	Bufo cognatus	Great Plains Toad	HC, D, B
	Bufo punctatus	Red-spotted Toad	HM
	Bufo woodhousii	Woodhouse's Toad	HC, D, B, S
	Pseudacris triseriata	Western Chorus Frog	HC, D, B
	Rana blairi	Plains Leopard Frog	B
	Rana catesbeiana	American Bullfrog	HC, D
	Rana pipiens	Northern Leopard Frog	HM, D, B
	Scaphiopus couchii	Couch's Spadefoot	HM, D, B
	Spea bombifrons	Plains Spadefoot	HC, B
	Spea multiplicata stagnalis	New Mexico Spadefoot	HM, D, B
Turtles	*Apalone spinifera*	Spiny Softshell Turtle	HC, D, B
	Chelydra serpentina serpentina	Eastern Snapping Turtle	D
	Chrysemys picta	Painted Turtle	HM, D, B
	Terrapene ornata	Ornate Box Turtle	HM, D, B
	Trachemys gaigeae gaigeae	Big Bend Slider	D, B
	Trachemys scripta elegans	Red-eared Slider	D
Lizards	*Aspidoscelis exsanguis*	Chihuahuan Spotted Whiptail	HC, D, S
	Aspidoscelis inornata	Little Striped Whiptail	HC, D, S
	Aspidoscelis neomexicana	New Mexico Whiptail	HC, D
	Aspidoscelis tesselata	Common Checkered Whiptail	HM, D
	Aspidoscelis tigris	Tiger Whiptail	HM
	Aspidoscelis uniparens	Desert Grassland Whiptail	HM, D, S
	Aspidoscelis velox	Plateau Striped Whiptail	HC
	Cophosaurus texanus	Greater Earless Lizard	D
	Crotaphytus collaris	Eastern Collared Lizard	D
	Eumeces obsoletus	Great Plains Skink	HC, D, B
	Holbrookia maculata	Common Lesser Earless Lizard	HC
	Phrynosoma hernandesi	Greater Short-horned Lizard	HM
	Phrynosoma modestum	Round-tailed Horned Lizard	HC, D

	Sceloporus magister	Desert Spiny Lizard	HM, D, B
	Sceloporus undulatus	Eastern Fence Lizard	HC, D, S
	Urosaurus ornatus	Ornate Tree Lizard	D
	Uta stansburiana	Common Side-blotched Lizard	HC, D
Snakes	*Arizona elegans*	Glossy Snake	HC
	Coluber constrictor	Eastern Racer	HM, D, B
	Crotalus atrox	Western Diamond-backed Rattlesnake	HM, B
	Crotalus viridis	Prairie Rattlesnake	HM, B
	Heterodon nasicus	Western Hog-nosed Snake	HM
	Lampropeltis getula	Common Kingsnake	HM, D, B, S
	Leptotyphlops dissectus	New Mexico Threadsnake	D, B
	Masticophis flagellum	Coachwhip	HM, B
	Pituophis catenifer	Gophersnake	HM, D, B
	Rhinocheilus lecontei	Long-nosed Snake	HM
	Sistrurus catenatus	Massasauga	HM
	Tantilla nigriceps	Plains Black-headed Snake	HM, B, S
	Thamnophis cyrtopsis	Black-necked Gartersnake	HM, D, B
	Thamnophis elegans	Terrestrial Gartersnake	D, B
	Thamnophis marcianus	Checkered Gartersnake	HM, D, B
	Thamnophis sirtalis	Common Gartersnake	HC, D, B

Table 2. Species list of herpetofauna captured in the Middle Rio Grande bosque (2000 to 2005), ordered within taxa by total number of captures.

Scientific name	Common name	2000	2001	2002	2003	2004	2005	Grand Total
Amphibians								
Bufo woodhousii	Woodhouse's Toad	89	190	293	45	136	472	1225
Bufo cognatus	Great Plains Toad	6	5	6	41	3	88	149
Scaphiopus couchii	Couch's Spadefoot	1	21	12	6	22	17	79
Spea multiplicata	New Mexico Spadefoot	1	9	1	2	7	5	25
Rana catesbiana	American Bullfrog		2					2
Spea bombifrons	Plains Spadefoot	2						2
Bufo punctatus	Red Spotted Toad						1	1
Pseudacris triseriata	Western Chorus Frog		1					1
Ambystoma tigrinum	Tiger Salamander		2				2	4
Turtles								
Trionyx spinifera	Spiny Softshell Turtle				1			1
Lizards								
Sceloporus undulatus	Eastern Fence Lizard	315	908	809	723	869	908	4532
Aspidoscelis neomexicanus	New Mexico Whiptail	227	843	681	818	583	455	3607
Aspidoscelis exsanguis	Chihuahuan Spotted Whiptail	263	846	428	496	514	551	3098
Aspidoscelis uniparens	Desert Grassland Whiptail	250	446	180	263	236	140	1515
Eumeces obsoletus	Great Plains Skink	45	147	91	114	156	174	727
Sceloporus magister	Desert Spiny Lizard		29	18	26	13	19	105
Uta stansburiana	Common Side-blotched Lizard	3	2	13	17	7	11	53
Aspidoscelis tigris	Tiger Whiptail	7	16	4	2	1	3	33
Aspidoscelis tesselatus	Common Checkered Whiptail		1	9	2	5	9	26

Aspidoscelis inornatus	Little Striped Whiptail			1			3	4
Phrynosoma cornutum	Texas Horned Lizard		1					1
Snakes								
Lampropeltis getula	Common Kingsnake	5	11	1	7	8	10	42
Pituophis catenifer	Gophersnake	1	5		9	5	10	30
Tantilla nigriceps	Plains Black-headed Snake	2	3		2	6	6	19
Thamnophis sirtalis	Common Gartersnake	2	5		1	3	4	15
Heterodon nasicus	Western Hog-nosed Snake	2	3	1	3	2	2	13
Crotalus viridis	Prairie Rattlesnake				1	6	1	8
Crotalus atrox	Western Diamond-backed Rattlesnake					1	5	6
Masticophis flagellum	Coachwhip		1	1	1	2		5
Thamnophis marcianus	Checkered Gartersnake		1		3			4
Arizona elegans	Glossy Snake				1	1		2
Leptotyphlops dulcis	New Mexico Threadsnake	1					1	2
Thamnophis elegans	Terrestrial Gartersnake	2						2
Rhinocheilus lecontei	Long-nosed Snake		1					1

Lizard response to restoration activities

Bosque vegetation

By conducting a PCA analysis of 15 vegetation variables (Table 1), we identified five factors that best explained the difference among arrays before and after treatment. Based on the correlation matrix (Table 2), sites with high Factor 1 scores have a more dense and woody environment, and sites with high Factor 2 scores have a more open understory.

Results from a paired-t test (table 3) showed that restoration treatments did alter the bosque vegetation. Before treatment, sites had a more dense and woody environment characterized by more non-native trees, dead branches, and little bare ground (Factor 1, table 2) compared to after treatment. After treatment, sites had a more open understory environment compared to before treatment. Factor scores were not significantly different in control sites before treatment compared to after treatment (table 3).

Correlating species presence or abundance with vegetation characteristics

Lizard species were correlated with factor scores associated with post-treatment conditions. Two species, Desert Grassland whiptail (*A. uniparens*) and Chihuahuan Spotted whiptail (*A. exsanguis*), were positively correlated with Factor 2 (tables 4 and 5). Four species, Great Plains skink (*Eumeces obsoletus*), Side-blotched lizard (*Uta stansburiana*), and Eastern Fence lizard (*Sceloporus undulatus*) were negatively correlated with Factor 1 (tables 4 and 5).

Table 1. Vegetation measured at each array before and after restoration treatments.

Variable	Method
percent bare ground	50 m transects
percent wood chips ground cover	50 m transects
percent forbs and grass ground cover	50 m transects
percent litter cover	50 m transects
depth of litter	50 m transects

percent woody debris ground cover	50 m transects
number of dead branches, sm diam.	4 m radius plots
number of dead branches, lg diam.	4 m radius plots
number of shrubs	4 m radius plots
number of exotic trees	4 m radius plots
average Cottonwood diameter	4 m radius plots
average Russian olive diameter	4 m radius plots
average saltcedar diameter	4 m radius plots
canopy cover	2 readings per array
basal area	1 reading with prism

Table 2. Correlation matrix for 2 of 5 factors resulting from PCA analysis of 15 vegetation variables around herp arrays. Major variables that influence factor scores are in bold.

Vegetation variables	Factor 1	Factor 2
% bare ground	**-0.562**	-0.108
% wood chips	-0.348	0.268
% forbs and grass	-0.451	-0.041
% litter cover	**0.718**	-0.337
% litter depth	0.290	0.202
% woody debris ground coverage	0.494	**0.725**
No. dead branches, sm diam.	**0.700**	0.243
No. dead branches, lg diam.	**0.638**	0.484
shrub count	-0.301	0.104
exotic trees	0.477	**-0.648**
Cottonwood diameter	0.093	-0.328
Russian olive diameter	0.449	-0.334
saltcedar diameter	**0.561**	-0.432
canopy cover	0.366	-0.072
basal area	0.408	0.219

Table 3. Results of paired t-tests comparing vegetation factor scores at arrays before and after treatment.

	treated sites (n=27)				control sites (n=9)			
	mean (pre)	mean (post)	*t*	P	mean (pre)	mean (post)	*t*	P
Factor 1	0.383	-0.504	7.23	**<0.001***	0.230	0.130	0.24	0.819
Factor 2	-0.510	0.650	-4.47	**0.001***	-0.396	-0.027	-2.08	0.071
Factor 3	-0.074	0.094	-0.74	0.468	0.004	-0.063	0.23	0.825
Factor 4	0.294	-0.270	2.08	**0.048***	-0.130	0.064	-0.55	0.599
Factor 5	-0.265	-0.226	-0.21	0.838	0.802	0.667	0.233	0.822

Table 4. Results of logistic regressions predicting the presence of lizard species from vegetation factor scores. Classification accuracies of models are in parentheses.

Species	Pos. or Neg. Correlation	Vegetation factor	Factor description	P value
Desert Grassland whiptail	+	Factor 2	open understory	P<0.001
	-	Factor 3	mature	(73.6%)
Side-blotched lizard	-	Factor 1	dense & woody	P<0.001
	+	Factor 5	litter cover	(90.3%)
Eastern Fence lizard	-	Factor 1	dense & woody	P=0.001
(*Sceloporus undulatus)*				(75.0%)

Table 5. Results of linear regression predicting lizard species abundance from vegetation factor scores.

Species	Pos. or Neg. Correlation	Vegetation factor	Factor description	P value R squared value
Desert Grassland whiptail		model not significant		
New Mexico whiptail		model not significant		
Chihuahuan Spotted whiptail	+	Factor 2	open understory	P=0.001, R-sq.=0.176
Great Plains skink	-	Factor 1	dense & woody	P=0.009, R-sq.=0.127
	+	Factor 3	mature	
Side-blotched lizard	-	Factor 1	dense & woody	P=0.021. R-sq.=0.462
Eastern Fence lizard	-	Factor 1	dense & woody	P<0.001, R-sq=0.339
	+	Factor 3	mature	
	+	Factor 4	plant cover	

Amphibian response to treatments

Spadefoot toads (Family Pelobatidae) were predicted to be absent at sites with high Factor 1 scores (dense, woody environments) and to be present at sites with higher Factor 4 scores (more plant ground cover; Table 6). Relative abundances of spadefoot toads and true toads (Family Bufonidae) were negatively correlated with sites with high Factor 1 scores (dense, woody environments; Table 7).

Table 6. Results of logistic regression predicting the presence of spadefoot toads from vegetation factor scores. Classification accuracy is in parenthesis.

Correlation	Vegetation factor		P value
-	Factor 1	dense, woody	P=0.002
-	Factor 3	mature	(66.7%)
+	Factor 4	plant ground cvr	

Table 7. Results of regressions correlating relative abundance of spadefoot toads and true toads with vegetation factor scores.

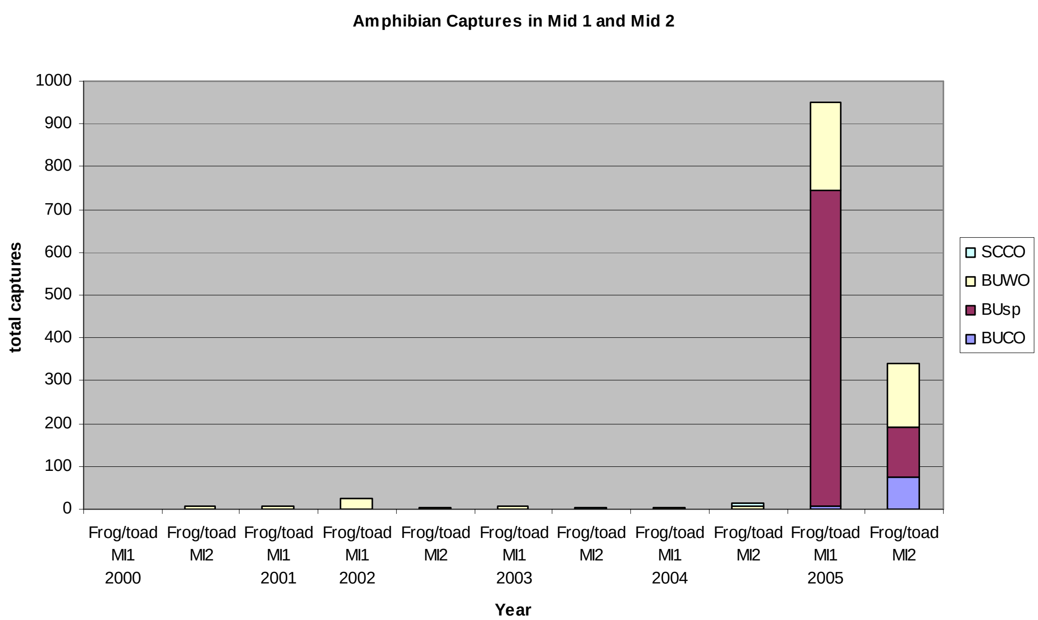
Family	Correlation	Vegetation factor		P value
Spadefoot toads	-	Factor 1	dense, woody	P=0.010, R-sq. = 0.228
True toads	-	Factor 1	dense, woody	P=0.005, R-sq. = 0.108

Amphibian response to flooding

Middle 1 and Middle 2 are north and south, respectively, of the city of Los Lunas in Valencia County. In 2005, flooding of these sites was a consequence of heavy winter snowpack (record-breaking levels) being melted by high spring temperatures. This runoff swelled local reservoirs to capacity and increased the amount of in stream flow during May. These 2 study sites likely began to flood in early April. Sites were sufficiently dry to open herp arrays by the fourth week of June. Middle 1 experienced higher water levels than Middle 2. We observed Middle 1 to be one to three feet underwater, with water in the riparian area continuous with water in the main channel of the Rio Grande. We observed a current moving downstream through the cottonwood stand. Middle 2, however, was flooded by rising ground water instead of overbank flow. We observed standing water and saturated soils in Middle 2. High water tables were evident; groundwater would flow into buckets as we bailed water from our belowground pitfall traps.

After this flood event in 2005, we captured more toads at these two sites (Middle 1 and Middle 2) than toad captures from all previous years and sites combined (Figure 3). Temporary pools in these sites contained eggs and tadpoles of *Bufo cognatus* and *B. woodhousei*. The day following some heavy rains, we captured over 500 toads (*Bufo* spp.) in traps at these 2 sites. Metamorphs made up the majority of captures. These toadlets were approximately 25 mm (snout-vent length).

Figure 3. Total number of toad captures in study sites Middle 1 and 2 from 2000 to 2005. These sites flooded during the spring of 2005.



SUMMARY

Due to significant interannual and interblock variation in capture rates and variation in the timing of treatments among sites, pre- vs. post-treatment comparisons of the herpetofaunal community are not easily performed. By investigating species' correlations with habitat variables, we can infer the effects of restoration treatments on herpetofaunal populations. Overall, five of the six most common lizard species and both amphibian groups occurred in or were more abundant in sites with post-treatment vegetation characteristics. Therefore, restoration treatments appear to alter the habitat in a way that would allow lizard species to persist or to be abundant.

There are also species-specific responses to restoration activities. For example, both Great Plains skinks and Side-blotched lizards were negatively correlated with dense, woody environments, but skinks were positively correlated with sites with a more mature cottonwood environment whereas Side-blotched lizards were positively correlated with sites with more plant ground cover (grass and herb).

None of the lizard species in New Mexico are true riparian species, nor are they strongly dependent on aquatic or wet habitats typically found in riparian systems. For example, the New Mexico Whiptail is typically associated with open, sparse vegetation (Christiansen et al. 1971). Chihuahuan Spotted whiptails, while associated with mesic habitats, are typically found in pinyon-juniper woodland and grassland habitat (Degenhardt et al. 1996). Not surprisingly, these species increase when habitats are modified to reduce woody ground cover and create a more open understory (i.e. conditions resembling upland habitats). Riparian areas typically have much higher plant and animal diversity compared to upland habitats (Stevens et al. 1977; Farley et al. 1994; Maisonneuve and Rioux 2001), and upland lizard species may be drawn to riparian areas due to their abundant food supplies.

Future analyses will allow us to explore the mechanisms explaining changes in lizard species abundance. By evaluating the proportion of adults and hatchlings in experimental sites compared to control sites before and after treatments, we will determine if lizard abundance is increasing due to increased reproductive effort. If reproductive effort has not changed, then perhaps lizards are moving into restored habitats through immigration.

All amphibian species found in the bosque require either temporary or permanent water sources to lay eggs and for tadpole development (Degenhardt et al. 1994). Therefore mechanisms explaining amphibian responses are likely to be different than those explaining lizard responses. As seen from captures in summer 2005, flooded sites had nearly 45 times as many toads as seen in any other season since the project began in 2000. Although amphibian habitat associations showed that true toads and spadefoot toads were negatively correlated with habitat features found in pre-treatment sites, it seems that for *Bufo* species, they respond much greater to the presences of temporary pools. Therefore changes in amphibian abundance may be due to factors other than restoration activity.

Overall, restoration treatments appear to be a beneficial or at least, nondamaging, to the existing herpetofauna of the Middle Rio Grande bosque. However, amphibian species would benefit from land managers incorporating spring flood events as part of their restoration efforts.

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BIRD SPECIES AND DENSITIES IN RELATION TO FUEL REMOVAL TREATMENTS

Final Report to
Joint Fire Sciences Program
(also submitted to Middle Rio Grande Bosque Initiative, Middle Rio Grande Conservancy District, and other cooperators)

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INTRODUCTION

The objective of the ornithological component of this bosque fuel removal project is to determine the effects of invasive plant removal treatments (i.e., fuel treatments) on species richness and relative abundance of birds. Our twelve study sites are located in mature cottonwood forests along the Middle Rio Grande. Each site initially had high fuel loads comprised of high densities of Tamarisk (*Tamarix ramosissima)*, Russian olive (*Elaeagnus angustifolia*), other exotic woody plants, and dead and down wood and debris. Sites with high invasive plant densities were designated as high risk locations for wildfire. We focus on birds, particularly in relation to four nesting guilds, because they are a highly visible and recreational taxonomic group in the Southwest whose local presence and distribution in the bosque may be influenced by retention or clearing of shrubs, small trees and dead wood. From these findings, we will develop recommendations to mitigate the impacts of exotic plant control on bird communities.

Numerous Neotropical migratory bird species are ranked as management priorities by Partners in Flight (PIF), a national consortium of government and private groups that supports bird conservation. New Mexico PIF identifies restoration and protection of riparian habitats as an essential step in conserving Neotropical migrants, several species' populations of which are reported by Breeding Bird Surveys to be declining. Mid-story and canopy-nesting Neotropical migrants that could be affected by habitat disturbances such as catastrophic fire or restoration by removal of mid-story plants include the Yellow-billed Cuckoo (see Appendix for scientific names of bird species), a bird species repeatedly petitioned by environmental groups to be federally-listed as Threatened or Endangered (see *positive finding to list*, 1999 Federal Register). Short-distance migrants such as Spotted Towhee may also respond numerically to treatments that remove midstory or ground layer habitat structure. Some Neotropical migrants that nest in shrubs and small trees could be potentially affected by removal of exotic plants or downed wood. These include such species as Mourning Dove, Black-chinned Hummingbird, Black-headed Grosbeak, Yellow-breasted Chat, Lucy's Warbler, Blue Grosbeak, and the endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*).
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Removal of standing snags and mature exotic woody plants could conceivably have either positive or negative effects on canopy-nesting and canopy-foraging migrants such as Summer Tanager and Western Wood Pewee by opening the canopy and removing perch sites. Such treatments may also alter quantity and composition of food supplies (e.g., foliage arthropods, bark beetles), but without research, it is impossible to know whether consequences for birds would be positive or negative. Removal of dead wood, especially standing snags, to reduce fuels may eliminate critical nest sites and foraging substrates for cavity-nesting birds such as woodpeckers, Bewick's Wren, Ash-throated Flycatcher, and Violet-green Swallow. Aerial foraging cavity-nesting species may also benefit, however, from reduced clutter in their foraging space.

METHODS

Breeding Bird Point Counts

At each study site, we established generally eight point count stations along a north to south gradient based on global positioning system (GPS) coordinates. Only two sites do not have the standard number of point count stations; North 3 (7) and South 2 (5). All stations were positioned 150 meters apart and the majority are 75 meters from boundary edges. There is one point count station per 2.5 hectares.

Generally, our point count methods follow Bibby and others (1992). All points are sampled an average of five times per season, with each transect surveyed in a north-south direction, alternating direction each session. A round of counts for all sites were completed before beginning a new session. Point counts were performed every other week during each breeding season (05 May to 25 July, approximately). During each count, the observer at each point recorded all birds seen or heard for 8 minutes. Detection mode (heard, seen), sex, relative age of bird, and distance from point (m) were also recorded. Each transect was surveyed by 3-5 different individuals over the course of each of each season to standardize observer bias (Verner 1985). We used program DISTANCE to convert number of point count detections to density estimates (number of birds per hectare) (Buckland et al. 2001). Because the majority of detections were of singing males, we assume that densities estimated by DISTANCE are an underestimate of the true (unknown) densities but are comparable across time and space.

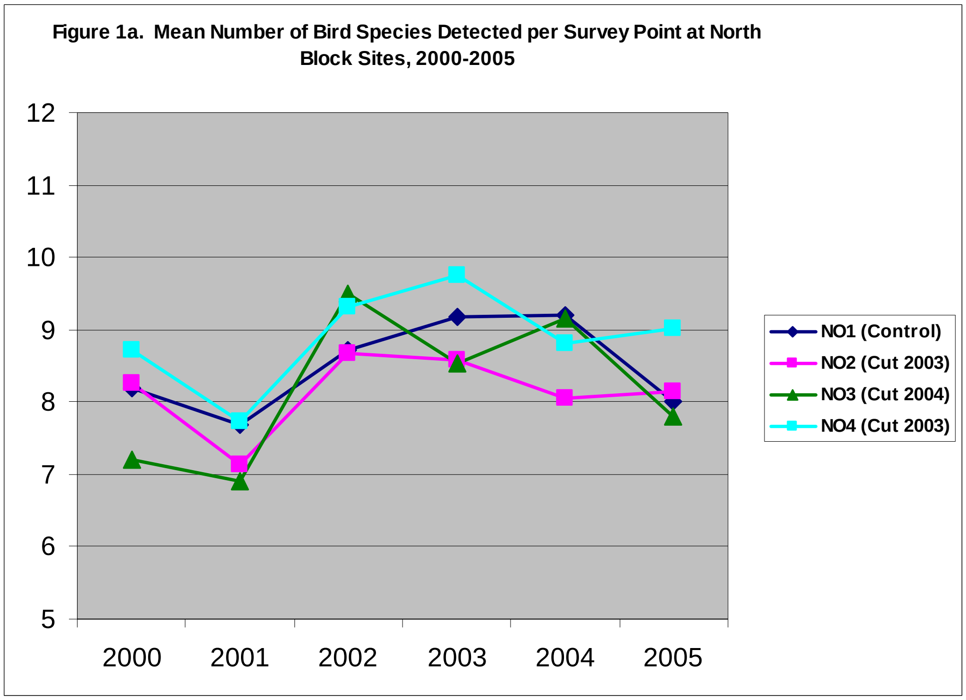
We used General Linear Mixed Model (GLMM) Analysis with Repeated Measures to determine effects and interactions of treatment type ("Trt": control versus treatment) and phase of study ("Period": pre-treatment versus post-treatment phases) on mean number of bird species and number of birds per species or per nesting guild. For the purposes of this report, we pooled sites with different treatments (mechanical removal with garlon herbicide application (MRHA), MRHA followed by fire, and MRHA followed by revegetation) into one category referred to as "treatment". The pre-treatment phase was defined as as a 3-year period consisting of years 2000, 2001, and 2002, and the post-treatment phase was defined as a 2-year period comprised of years 2004 and 2005. Data from 2003 were excluded because treatments were conducted in this year. Some data from the Middle Block of sites were also excluded because of treatments. Because two more years of post-treatment monitoring are planned, we used a $P \leq 0.10$ rather than the traditional $P \leq 0.05$ to detect treatment effects (i.e., interactions of Trt x Period) for individual species.

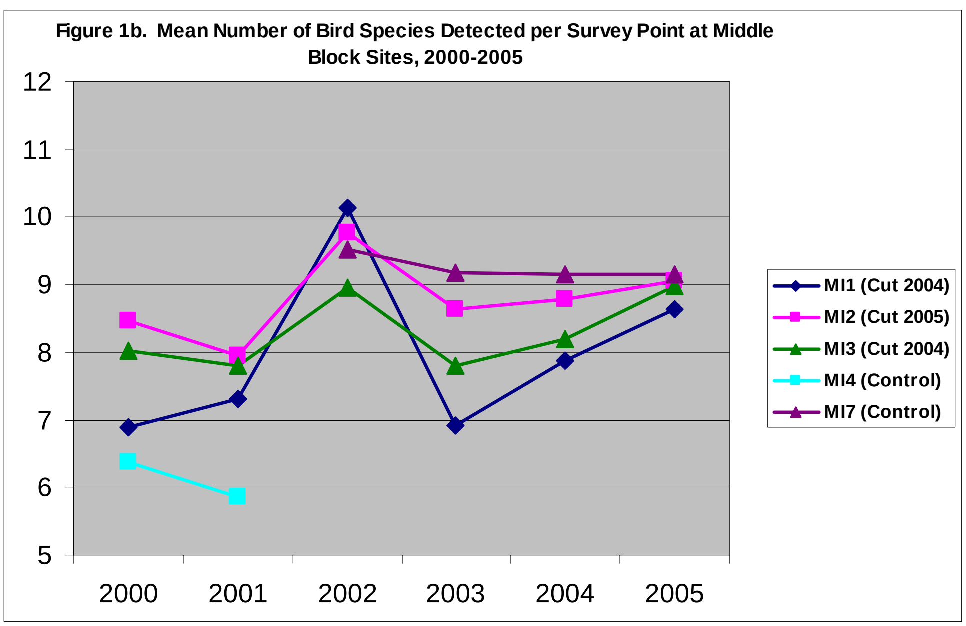
RESULTS

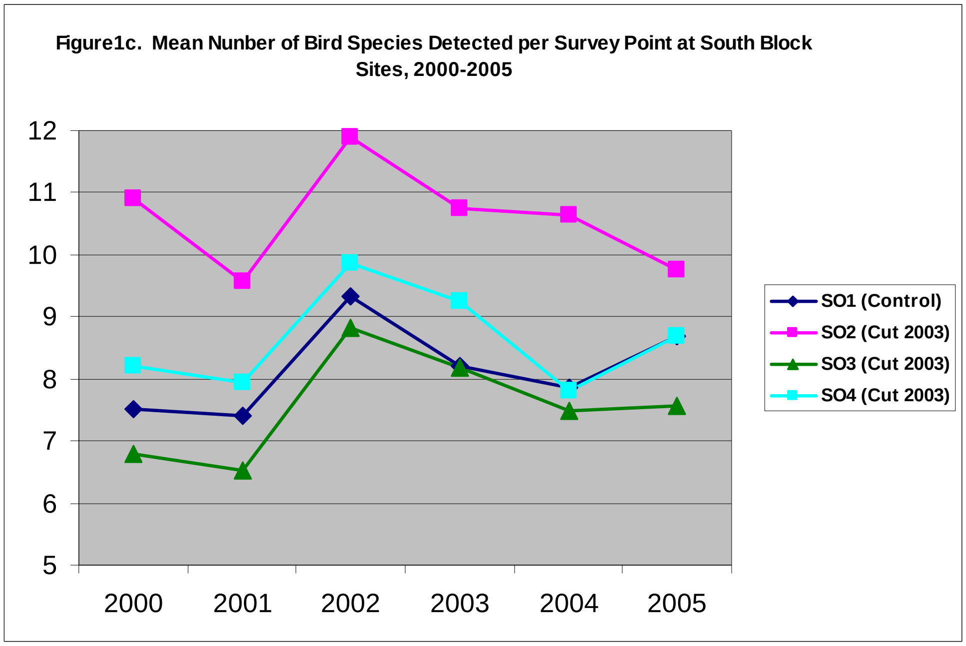
Mean Number of Bird Species

The total number of bird species detected during point counts over the duration of the study was 132. Mean number of bird speces/point (Figure 1a, b, c.) fluctuated between 2001 to 2005. Results of GLMM-Repeated Measures Analysis revealed that number of species/point, when pooled by treatment type (Trt: control versus treatment) and Period (pre- and post-treatment) did not significantly differ between treatment and control sites ($F = 0.55$, $P = 0.4870$) and between pre- and post-treatment periods ($F = 0.73$ and $P = 0.4246$). The interaction between Trt and

Period was also non-significant ($F = 0.08$, $P = 0.7813$), signifying that mean number of species detected at point count stations did not change in response to removal of fuels and invasive plants.







Annual Bird Densities by Guild.

<u>Species Classifications by Guild</u>

Removal of invasive plants and woody debris has the potential to change availability of nest substrates and nesting habitat. Bird species that select specific nest substrates may be positively or negatively affected by alteration of specific habitat layers. We classified annual densities of bird species into four general nesting guilds: Ground Shrub, Mid-Story, Canopy, and Cavity (Table 2) and used GLMM Repeated Measures Analysis to detect potential guild responses to treatment. We truncated point count distances at 100 m to exclude species heard or seen off sites (e.g, in adjacent fields) or observed flying over without stopping. Because 2003 was a treatment year, data from this year were not included in analyses. Middle block was still under treatment in 2004, so this block was excluded from 2004 data.

Table 2. Classification of Common Bird Species by Guild.

Ground Shrub	**Mid-Story**	**Canopy**	**Cavity**
Mallard	Mourning Dove	Cooper’s Hawk	American Kestrel
Ring-necked Pheasant	Black-chinned Hummingbird	Swainson’s Hawk	Ladder-backed Woodpecker
Wild Turkey	Black-billed Magpie	Great Horned Owl	Downy Woodpecker
Gambel’s Quail	American Robin	Western Wood-Pewee	Hairy Woodpecker
Killdeer	Phainopepla	Western Kingbird	Northern Flicker

Yellow-billed Cuckoo	Black-headed Grosbeak	American Crow	Ash-throated Flycatcher
Greater Roadrunner	Lesser Goldfinch	Common Raven	Black-capped Chickadee
Verdin		Bushtit	White-breasted Nuthatch
Gray Catbird		Summer Tanager	Bewick's Wren
Yellow-breasted Chat		Bullock's Oriole	European Starling
Spotted Towhee		House Finch	Lucy's Warbler
Blue Grosbeak			
Lazuli Bunting			
Indigo Bunting			

Ground-Shrub Species

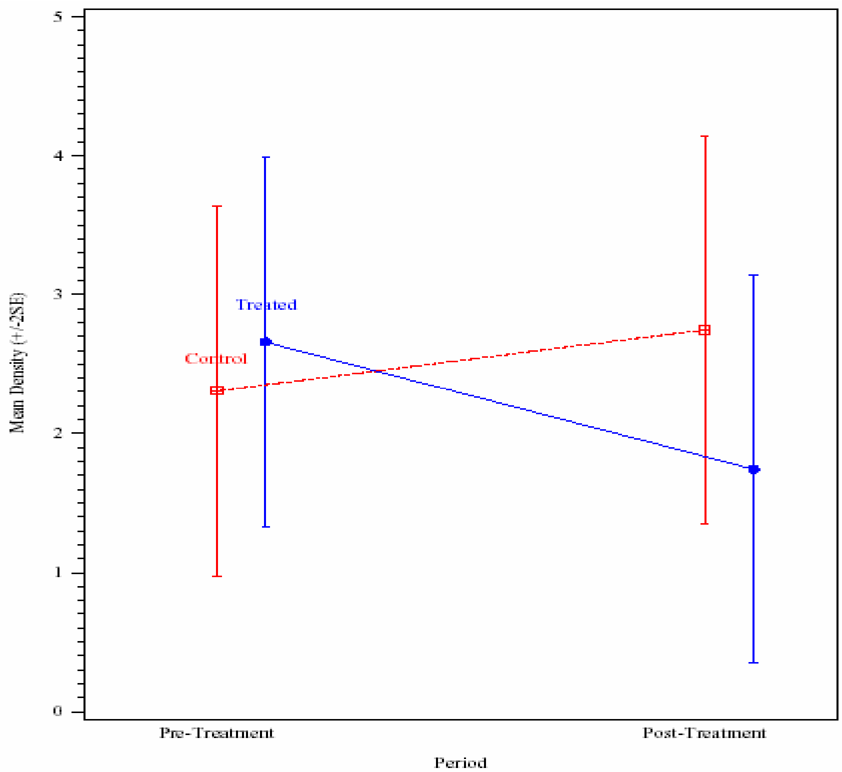
Results of GLMM-Repeated Measures Analysis for ground-shrub nesting species indicate annual bird densities/HA did not significantly differ between treatment and control sites and between pre- and post-treatment periods (Table 4). The interaction between Trt and Period was also non-significant, meaning that abundances of ground-shrub birds did not change over time or between control versus treated sites. This lack of interaction suggests that ground-shrub bird densities were not affected by removal of invasive plants/fuels, at least in the short term (but Figure 1 suggests trends that could become significant if continued into the future). This lack of effect is contrary to what we had predicted (Finch et al. 2005). We had expected populations of ground- and shrub-nesting birds to decrease in response to removal of exotic vegetation and woody debris in the low shrub layer. Over the long term or with additional post-treatment years, effects on population trends for species nesting in this layer may become more visible.

Table 3. Results of General Linear Mixed Model (GLMM) Analysis with Repeated Measures of annual bird densities for ground-shrub nesters comparing effects and interactions between Period (pre- vs. post-treatment) and Trt (treated vs. control site).

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Trt	1	6	0.23	0.6502
Period	1	6	0.12	0.7389
Trt*Period	1	6	0.99	0.3591

Least Squares Means							
Effect	**Trt**	**Period**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Trt*Period	Control	Post-Trt	2.7464	0.6968	6	3.94	0.0076
Trt*Period	Control	Pre-Trt	2.3073	0.6648	6	3.47	0.0133
Trt*Period	Treated	Post-Trt	1.7448	0.6968	6	2.50	0.0463
Trt*Period	Treated	Pre-Trt	2.6602	0.6648	6	4.00	0.0071

Figure 1. Breeding densities (#birds/HA) of ground-shrub nesters at pooled control and treatment sites during pre- and post-treatment periods.



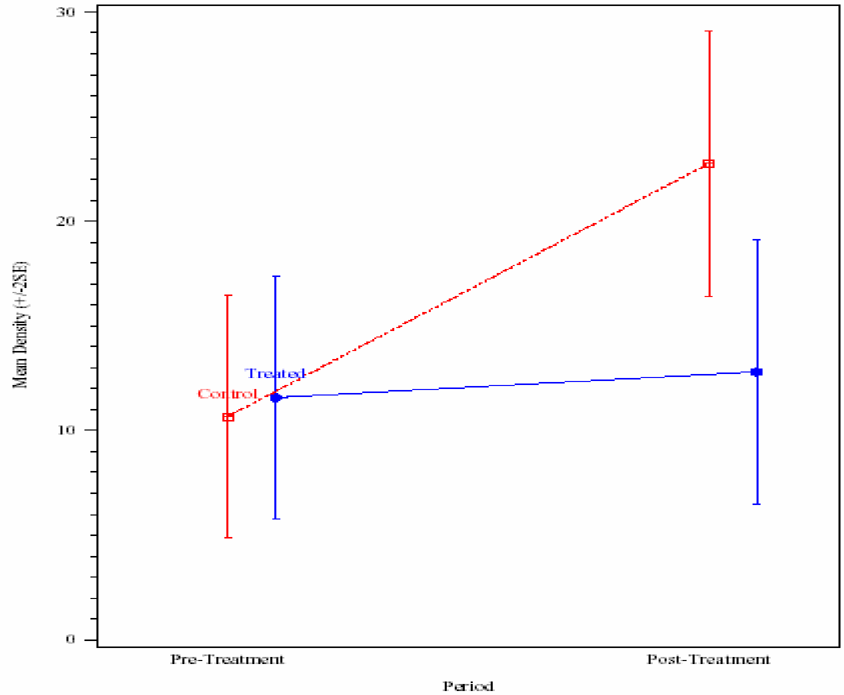
Results of GLMM-Repeated Measures Analysis for mid-story species indicate annual bird densities differed between treatment and control sites (i.e., significant Trt effect) and between pre- and post-treatment phases (i.e., significant Period effect) (Table 3a). The interaction between Trt and Period was also significant, meaning that mid-story bird abundance changed over time but the extent or direction of this change was different at control versus treated sites (Table 3b). This interaction indicates that mid-story bird densities were affected by removal of invasive plants/fuels. Annual densities of mid-story birds on control sites increased substantially in 2004-2005 but this increasing trend was suppressed on treated sites during this post-treatment period (Figure 2). Thus, our analyses suggest that removal of exotic trees and woody fuels suppressed the local abundances of mid-story species.

Tables 4. Results of General Linear Mixed Model (GLMM) Analysis with Repeated Measures of annual bird densities for the mid-story nest guild comparing effects and interactions between Period (pre- vs. post-treatment) and Trt (treated vs. control site).

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Trt	1	6	8.74	0.0254
Period	1	6	16.90	0.0063
Trt*Period	1	6	11.65	0.0143

Least Squares Means							
Effect	Trt	Period	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt*Period	Control	Post-Trt	22.7619	3.1703	6	7.18	0.0004
Trt*Period	Control	Pre-Trt	10.6636	2.8902	6	3.69	0.0102
Trt*Period	Treated	Post-Trt	12.7992	3.1703	6	4.04	0.0068
Trt*Period	Treated	Pre-Trt	11.5759	2.8902	6	4.01	0.0071

Figure 2. Breeding bird densities (# birds/HA) of mid-story species at pooled control and treatment sites during pre- and post-treatment periods.



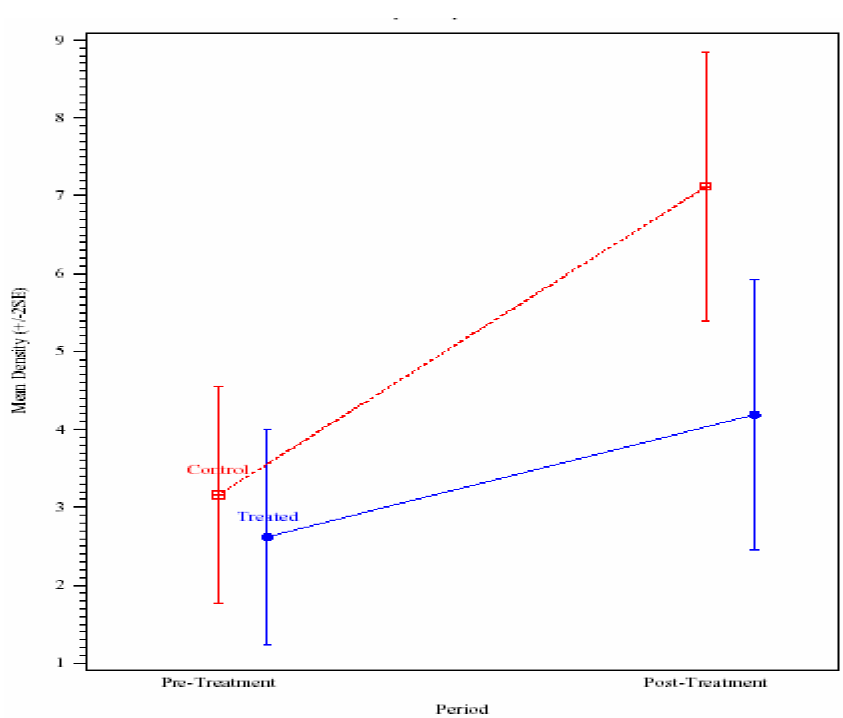
Results of GLMM-Repeated Measures Analysis for cavity-nesting species indicate annual bird densities were almost significantly different between treatment and control sites (i.e., Trt Effect: $0.10 < P > 0.05$) and were significantly different between pre- and post-treatment phases (i.e., significant Period effect) (Table 5). The interaction between Trt and Period, however, was not significant, meaning that densities of cavity nesters changed over time but the extent and direction of this change was similar at control versus treated sites. This lack of interaction suggests that densities of cavity nesters were not immediately affected by removal of invasive plants in the understory. Annual densities of cavity-nesters on both control and treated sites increased substantially from the 2000-2002 period to the 2004-2005 period (Figure 3). Thus, our analyses suggest that overall densities of the cavity-nesting group increased over the duration of the study, but this increase was probably not in response to the removal of exotic trees and fuel loads. In other words, cavity-nesters were not noticeably benefited by exotic tree removal at least in the short term. Also, the exotic woody species present on our study sites have stems with diameters too small for cavities, and therefore, nest site availability for cavity-nesters may not be detrimentally reduced by exotic tree removal. In the long term, cavity nesters may benefit from exotic tree removal if competition between exotics and native cavity trees is reduced such that that cavity trees are preserved and sustained.

Table 5. Results of General Linear Mixed Model (GLMM) Analysis with Repeated Measures of annual bird densities for cavity nesters comparing effects and interactions between Period (pre- vs. post-treatment) and Trt (treated vs. control site).

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Trt	1	6	5.03	0.0662
Period	1	6	12.09	0.0132
Trt*Period	1	6	2.26	0.1837

Least Squares Means							
Effect	Trt	Period	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt*Period	Control	Post-Trt	7.1156	0.8648	6	8.23	0.0002
Trt*Period	Control	Pre-Trt	3.1599	0.6947	6	4.55	0.0039
Trt*Period	Treated	Post-Trt	4.1864	0.8648	6	4.84	0.0029
Trt*Period	Treated	Pre-Trt	2.6176	0.6947	6	3.77	0.0093

Figure 3. Breeding densities (# birds/HA) of cavity-nesters at pooled control and treatment sites during pre- and post-treatment periods.



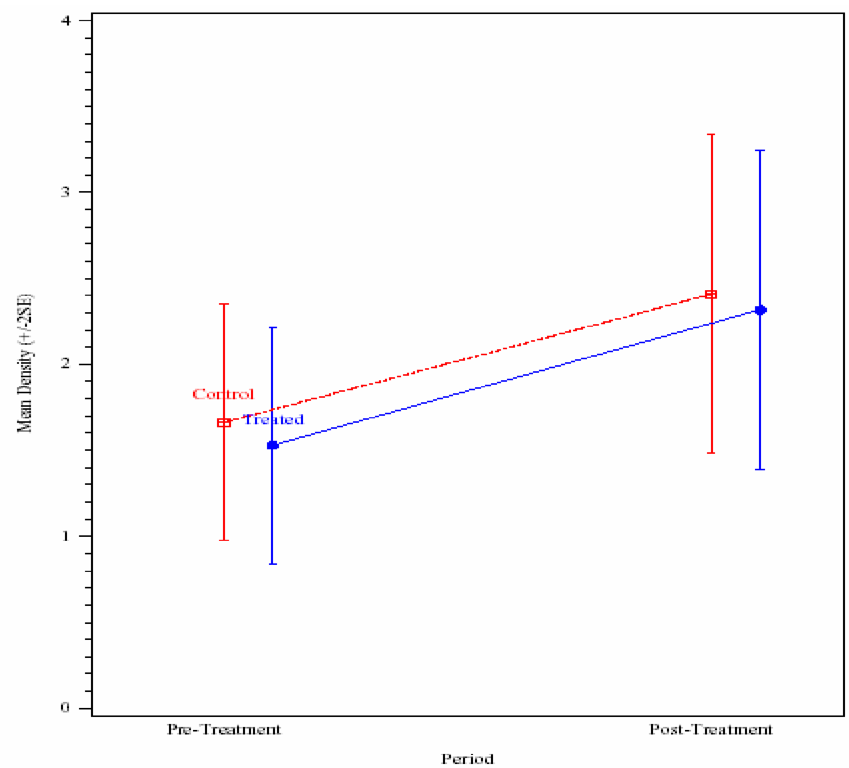
Results of GLMM-Repeated Measures Analysis for canopy-nesting species indicate annual bird densities did not significantly differ between treatment and control sites and between pre- and post-treatment periods (Table 6). The interaction between Trt and Period was also non-significant, meaning that overall abundances of canopy birds did not greatly change over time or between control versus treated sites. This lack of interaction indicates that canopy bird densities were not apparently affected by removal of invasive plants/fuels, at least in the short term. This lack of effect is contrary to what we had predicted (Finch et al. 2005). We had expected populations of canopy-nesting birds to respond positively (e.g., like bat activity) to reductions in "clutter" from removal of exotic vegetation and woody debris. There was a tendency toward increasing populations over time (Figure 4), and over the long term, interactions between effects of time and treatment may become more apparent for this guild.

Table 6. Results of General Linear Mixed Model (GLMM) Analysis with Repeated Measures of annual bird densities for canopy nesters comparing effects and interactions between Period (pre- vs. post-treatment) and Trt (treated vs. control site).

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Trt	1	6	0.08	0.7912
Period	1	6	3.51	0.1100
Trt*Period	1	6	0.00	0.9616

Least Squares Means							
Effect	Trt	Period	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt*Period	Control	Post-Trt	2.4083	0.4636	6	5.19	0.0020
Trt*Period	Control	Pre-Trt	1.6617	0.3437	6	4.83	0.0029
Trt*Period	Treated	Post-Trt	2.3162	0.4636	6	5.00	0.0025
Trt*Period	Treated	Pre-Trt	1.5285	0.3437	6	4.45	0.0043

Figure 4. Breeding densities (# birds/HA) of canopy-nesters at pooled control and treatment sites during pre- and post-treatment periods.



Variation in Pooled Densities of Individual Species

Black-chinned Hummingbird was consistently the most abundant species observed each year. Other common species detected each year during point count surveys are listed in Table 7. A full list of all species detected over the duration of the study is provided in the Appendix.

We selected 13 species to conduct in-depth analyses of density estimates over time (pre- and post-treatment), space (block), and treatment type (Trt: Control, Treated). To convert point count detections to density estimates using Program DISTANCE, we first pooled count data across sites and years to produce densities by block, treatment type and period (Table 7). We refer to these estimates as "pooled densities" to distinguish them from later analyses of "annual densities". We were able to evaluate more species using pooled densities than annual densities because sample sizes did not constrain tests. With the exception of Spotted Towhee,

Table 7. Density estimates (birds/HA) ±SE of 13 bird species at control and treated sites in North, Middle, and South blocks during the pre- and post-treatment periods.

Key: DENS. = Density. SE= Standard Error. *=sample size too small for analysis.**

Species	Trt	North Pre DENS.	SE	North Post DENS.	SE	Middle Pre DENS.	SE	Middle Post DENS.	SE	South Pre DENS.	SE	South Post DENS.	SE
Spotted Towhee	Treated	1.778	0.203	0.725	0.075	1.133	0.101	0.340	0.071	1.770	0.170	0.871	0.103
	Control	1.050	0.134	1.169	0.209	1.349	0.188	1.529	0.189	0.996	0.175	0.454	0.095
Yellow-Breasted Chat	Treated	0.228	0.039	0.103	0.037	0.207	0.033	0.098	0.021	0.650	0.090	0.428	0.078
	Control	0.131	0.030	0.246	0.057	0.043	0.016	0.121	0.052	0.283	0.050	0.132	0.049
Bewick's Wren	Treated	1.095	0.070	0.801	0.090	0.506	0.058	0.191	0.024	1.170	0.145	1.041	0.123
	Control	1.541	0.342	2.625	0.402	1.386	0.204	1.405	0.304	0.697	0.144	0.708	0.125
Blue Grosbeak	Treated	0.357	0.074	0.212	0.037	0.403	0.056	0.466	0.087	0.475	0.050	0.679	0.084
	Control	0.315	0.072	0.379	0.104	0.468	0.189	1.159	0.472	1.109	0.124	0.969	0.169
Black-Headed Grosbeak	Treated	1.332	0.066	1.446	0.167	1.041	0.077	0.547	0.070	0.706	0.066	0.605	0.078
	Control	0.852	0.106	1.341	0.163	1.228	0.131	2.140	0.447	1.719	0.148	0.986	0.135
Black-Chinned Hummingbird	Treated	15.079	0.796	14.349	0.912	12.978	0.754	11.868	1.152	3.733	0.634	6.577	1.407
	Control	11.510	1.119	28.888	3.285	17.433	1.307	19.034	1.941	6.396	0.502	9.590	1.620
Ash-throated Flycatcher	Treated	0.305	0.047	0.599	0.074	0.934	0.172	1.480	0.172	0.974	0.104	1.612	0.137
	Control	0.335	0.270	0.657	0.421	1.557	0.348	2.617	0.617	1.770	0.270	2.293	0.421
Black-capped Chickadee	Treated	0.450	0.095	0.602	0.132	0.741	0.099	0.234	0.065	***	***	***	***
	Control	1.076	0.224	1.269	0.290	0.507	0.148	0.525	0.174	***	***	***	***
Brown-Headed Cowbird	Treated	0.409	0.062	0.287	0.042	0.653	0.071	0.711	0.131	1.244	0.150	0.561	0.083
	Control	0.325	0.079	0.352	0.085	0.891	0.196	1.268	0.272	1.711	0.257	1.364	0.264
Mourning Dove	Treated	0.315	0.039	0.401	0.067	0.330	0.039	0.434	0.064	0.514	0.044	0.613	0.041
	Control	0.212	0.057	0.168	0.053	0.862	0.124	1.240	0.261	0.544	0.100	2.073	0.385
Summer Tanager	Treated	0.480	0.051	0.963	0.129	0.449	0.053	0.651	0.095	0.796	0.087	1.117	0.195
	Control	0.417	0.086	0.905	0.177	0.884	0.196	1.498	0.358	0.624	0.106	0.489	0.092
White-breasted Nuthatch	Treated	0.330	0.056	0.636	0.058	0.348	0.063	0.431	0.061	0.143	0.045	0.297	0.056
	Control	0.770	0.199	1.541	0.401	0.512	0.080	0.886	0.188	0.096	0.026	0.263	0.083
Western Wood-Pewee	Treated	0.310	0.055	0.612	0.089	0.136	0.039	0.311	0.065	0.172	0.035	0.070	0.013
	Control	0.145	0.039	0.121	0.042	0.145	0.054	***	***	0.583	0.136	0.143	0.049

truncating detection distances did not result in substantial changes in analytical results of individual species so we used all observations to estimate pooled densities.

Pooled densities of only one species, Ash-throated Flycatcher, differed between treatment and control sites ($P < 0.0213$) and between pre- and post-treatment periods ($P < 0.0199$) but Trt x Period interactions were not significant. Pooled flycatcher densities demonstrated parallel increases on treatments over time, suggesting that they responded positively to unidentified factors (e.g., food supply, winter habitat quality) which varied similarly over time, either at both control and treated sites or perhaps at wintering sites.

At $P < .10$, pooled densities of Spotted Towhee differed between pre- and post-treatment periods ($P < 0.0586$), and significant interactions between Trt and Period ($P < 0.0988$) suggested that towhees decreased after treatment on treated sites but increased on control sites during the same period. These effects were more marked (Trt x Period: $P < 0.025$) when truncated count distances were used to estimate towhee densities. These results suggest that towhee densities were negatively affected by removal of invasives and fuel loads. Density increases at control sites suggest that towhees may have emigrated from treated areas (not just our sites) in 2004-2005 in search of denser, uncleared understories.

Pooled Brown-headed Cowbird and White-breasted Nuthatch densities showed Period effects (at $P < 0.10$), but interactions with Trt were absent, suggesting that removal of invasive trees did not explain temporal density changes in the short term. Species exhibiting Trt effects (at $P < 0.10$) were Black-chinned Hummingbird, White-breasted Nuthatch, and Blue Grosbeak, but interactions with Period were not significant. This means that pooled densities of these species differed at control and treatment sites in the pre-treatment period as well as in the post-treatment period and were likely not influenced by clearing of invasive fuels in either period (but see tests of annual hummingbird densities).

Variation in Annual Densities of Individual Species

We selected a subset of six species with sufficient detections in each year (2000, 2001, 2002, 2004, 2005) of each block to conduct GLMM Repeated Measures Analysis of “annual densities” sorting by Trt, Block, Period, and Year. Comparing annual densities may reveal trends that were masked by pooling densities. Data from 2003 were excluded because this was a treatment year and data from middle block 2004 were excluded because of differences in site within block treatment times. These common species were Black-chinned Hummingbird, Mourning Dove, Ash-throated Flycatcher, Bewick’s Wren, Black-headed Grosbeak, and Spotted Towhee. Individuals of these species were usually detected within 100 m of the count station rather than flying overhead or heard or seen off the site, and therefore we did not deem it necessary to truncate detection distances when converting count data to densities.

We used $P \leq 0.10$ to detect effects of treatments, time, and interactions between time and treatments on bird abundances. A generous Type I error level was applied with the intent to reduce the likelihood of failing to detect differences in annual densities. We believe this is wise at this stage, given that three years of post-treatment data are not yet available for use in detecting differences and therefore, we consider our analyses preliminary.

Results of GLMM-Repeated Measures Analysis indicate annual bird densities differed between treatment and control sites (i.e., significant Trt effect) for only 1 of the 6 tested species, Black-headed Grosbeak (Table 8). Annual bird densities varied between pre- and post-treatment phases (i.e., significant Period effect) for 3 species, Ash-throated Flycatcher, Mourning Dove, and Black-chinned Hummingbird. The interaction between Trt and Period was significant for annual densities of 4 of 6 species, Mourning Dove, Black-chinned Hummingbird, Spotted Towhee, and Black-headed Grosbeak, meaning that bird yearly abundances changed between pre- and post-treatment periods but the extent or direction of this change was different at control versus treated sites. Three of the species, Black-chinned Hummingbird, Mourning Dove, and Black-headed Grosbeak, are mid-story nesters, and the fourth species, Spotted Towhee, is a ground-shrub nester. These interaction effects suggest that densities of species that typically use the lower two-thirds of the vertical habitat space were affected by removal of invasive plants/fuels. This is consistent with results of GLMM analysis of mid-story guild densities. Annual densities of all four species on control sites increased substantially from the pre-treatment period to the post-treatment period but this trend was dampened or reversed on treated sites. Thus, our analyses suggest that removal of exotic trees and woody fuels suppressed the local abundances of selected species.

Table 8. Results of General Linear Mixed Model (GLMM) Analysis with Repeated Measures of annual bird densities for selected species comparing fixed effects and interactions between Period (pre- vs. post-treatment) and Trt (treated vs. control site). Detection distances were not truncated. P < 0.10 are highlighted in red.

Species	**Trt**		**Period**		**Trt x Period**	
	F value	*P*	*F value*	*P*	*F value*	*P*
Ash-throated Flycatcher	2.44	0.169	19.61	0.004	0.53	0.495
Bewick's Wren	2.19	0.190	0.37	0.567	1.80	0.228
Mourning Dove	2.34	0.180	3.79	0.099	3.91	0.095
Black-chinned Hummingbird	2.03	0.204	4.90	0.069	4.49	0.078
Spotted Towhee	0.04	0.576	1.02	0.352	5.32	0.061
Black-headed Grosbeak	7.21	0.036	1.84	0.224	4.37	0.082

CONCLUSION

Mean number of bird species per point did not appear to change in response to removal of invasives and fuels, suggesting that the contribution of bird species richness to the biological diversity of this system was not substantially altered by treatment. However, bird densities of the mid-story nest guild showed declining trends. Bird densities of the ground-shrub, cavity and canopy guilds were not affected by treatments. In evaluations of individual bird species, we found that annual densities of three mid-story species, Mourning Dove, Black-chinned Hummingbird and Black-headed Grosbeak, and one ground-shrub species, Spotted Towhee were reduced in response to treatment effects. Tamarisk and Russian olive are small trees that dominate the mid-story biomass of our study sites. Removal of these two invasive plant species reduces the availability of nesting and foraging substrates for bird species that use the mid-story layer of habitat. Therefore, effects on bird species using this layer are predictable. Based on the mid-story guild response, we speculate that populations of rarer mid-story species such as Yellow-billed Cuckoo and Southwestern Willow Flycatcher will respond similarly and negatively to removal of invasive woody plants in riparian woodlands of the Southwest.

Overall bird densities of the cavity-nesting guild increased over time at both control and treated sites. A cavity-nesting species, Ash-throated Flycatcher, substantially increased in the period following treatments. While the flycatcher increase was not directly explained by removal of invasives, it can also be said that this treatment was not harmful to this species. Reduced vegetation clutter in the mid-story and canopy layers following treatment may actually improve foraging navigability for this flycatcher species.

We regard these results as preliminary. Two more years of post-treatment sampling are scheduled. We view the data from these additional sampling years as essential for determining treatment effects. For the purposes of this final report, however, we suggest a few recommendations.

1. To retain the full diversity of a wide range of bird species and to reduce effects on sensitive and endangered species, we recommend replanting of native woody plants at treated sites after removal of woody species such as Tamarisk and Russian olive.
2. We do not recommend removal of invasives at sites occupied by sensitive or endangered bird species except as identified in recovery plans.
3. Where removal of invasives is necessitated to reduce fire risk, we suggest that treatments be staged over a period of years and in small patches to allow birds to adapt to habitat changes over time.
4. Treatments should be scheduled during the non-breeding season of birds whenever possible. Birds are disturbed by noise and can vacate nests and territories in response to disturbance during the breeding season.
5. Prior to treatments, surveys should be conducted for threatened and endangered bird species, and decisions to treat sites should be adjusted according to survey results.
6. If sites are at risk of wildfire, select and restore sites with high fuel loads and in close proximity to urban areas first.

Our results and recommendations apply to sites with cottonwood overstories and are not intended to guide decision-making for sites having monotypic stands of invasives.

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APPENDIX

Birds Detected on Point Count Surveys, 2000-2005

Common Name	Scientific Name
Waterfowl	**Anatidae**
Canada Goose	Branta canadensis
Wood Duck	Aix sponsa
Gadwall	Anas strepera
Mallard	Anas platyrhynchos
Northern Shoveler	Anas clypeata
Northern Pintail	Anas acuta
Green-winged Teal	Anas crecca
Pheasant and Turkey	**Phasianidae**
Ring-necked Pheasant	Phasianus colchicus
Wild Turkey	Meleagris gallopavo
Quail	**Odontophoridae**
Gambel's Quail	Callipepla gambelii
Grebes	**Podicipedidae**
Pied-billed Grebe	Podilymbus podiceps
Pelicans	**Pelecanidae**
American White Pelican	Pelecanus erythrorhynchos
Cormorants	**Phalacrocoracidae**
Neotropic Cormorant	Phalacrocorax brasilianus
Double-crested Cormorant	Phalacrocorax auritus
Herons and Egrets	**Ardeidae**
Great Blue Heron	Ardea herodias

Great Egret	Ardea alba
Snowy Egret	Egretta thula
Cattle Egret	Bubulcus ibis
Green Heron	Butorides virescens
Black-crowned Night-Heron	Nycticorax nycticorax
Ibises	**Threskiornithidae**
White-faced Ibis	Plegadis chihi
Vultures	**Cathartidae**
Turkey Vulture	Cathartes aura
Osprey, Kites and Hawks	**Accipitridae**
Osprey	Pandion haliaetus
Mississippi Kite	Ictinia mississippiensis
Cooper's Hawk	Accipiter cooperii
Swainson's Hawk	Buteo swainsonii
Red-tailed Hawk	Buteo jamaicensis
Ferruginous Hawk	Buteo regalis
Falcons	**Falconidae**
American Kestrel	Falco sparverius
Rails and Coots	**Rallidae**
Common Moorhen	Gallinula chloropus
American Coot	Fulica americana
Virginia Rail	Rallus limicola
Plovers	**Charadriidae**
Killdeer	Charadrius vociferus
Stilt and Avocet	**Recurvirostridae**
Black-necked Stilt	Himantopus mexicanus
American Avocet	Recurvirostra americana
Sandpipers	**Scolopacidae**
Greater Yellowlegs	Tringa melanoleuca
Spotted Sandpiper	Actitis macularius
Long-billed Curlew	Numenius americanus
Wilson's Snipe	Gallinago delicata
Gulls	**Laridae**
Ring-billed Gull	Larus delawarensis
Pigeons and Doves	**Columbidae**
Rock Pigeon	Columba livia
White-winged Dove	Zenaida asiatica
Mourning Dove	Zenaida macroura
Cuckoos and Roadrunner	**Cuculidae**
Yellow-billed Cuckoo	Coccyzus americanus
Greater Roadrunner	Geococcyx californicus
Typical Owls	**Strigidae**
Western Screech-Owl	Megascops kennicotti
Great Horned Owl	Bubo virginianus
Nightjars	**Caprimulgidae**
Lesser Nighthawk	Chordeiles acutipennis
Common Nighthawk	Chordeiles minor
Hummingbirds	**Trochilidae**
Black-chinned Hummingbird	Archilochus alexandrinus
Broad-tailed Hummingbird	Selasphorus platycercus
Rufous Hummingbird	Selasphorus rufus
Kingfishers	**Alcedinidae**
Belted Kingfisher	Ceryle alcyon
Woodpeckers	**Picidae**
Lewis's Woodpecker	Melanerpes lewis
Ladder-backed Woodpecker	Picoides scalaris

Downy Woodpecker	Picoides pubescens
Hairy Woodpecker	Picoides villosus
Northern Flicker	Colaptes auratus
Flycatchers	**Tyrannidae**
Olive-sided Flycatcher	Contopus cooperi
Western Wood-Pewee	Contopus sordidulus
Willow Flycatcher	Empidonax traillii
Dusky Flycatcher	Empidonax oberholseri
Cordilleran Flycatcher	Empidonax occidentalis
Black Phoebe	Sayornis nigricans
Say's Phoebe	Sayornis saya
Ash-throated Flycatcher	Myiarchus cinerascens
Western Kingbird	Tyrannus verticalis
Vireos	**Vireonidae**
White-eyed Vireo	Vireo griseus
Plumbeous Vireo	Vireo plumbeus
Cassin's Vireo	Vireo cassinii
Warbling Vireo	Vireo gilvus
Red-eyed Vireo	Vireo olivaceus
Jays, Magpies, Crows and Ravens	**Corvidae**
Western Scrub-Jay	Aphelocoma californica
Pinyon Jay	Gymnorhinus cyanocephalus
Black-billed Magpie	Pica hudsonia
American Crow	Corvus brachyrhynchos
Chihuahuan Raven	Corvus cryptoleucus
Common Raven	Corvus corax
Swallows	**Hirundinidae**
Violet-green Swallow	Tachycineta thalassina
Northern Rough-winged Swallow	Stelgidopteryx serripennis
Bank Swallow	Riparia riparia
Cliff Swallow	Petrochelidon pyrrhonota
Barn Swallow	Hirundo rustica
Chickadees	**Paridae**
Black-capped Chickadee	Poecile atricapillus
Mountain Chickadee	Poecile gambeli
Verdin	**Remizidae**
Verdin	Auriparus flaviceps
Bushtit	**Aegithalidae**
Bushtit	Psaltriparus minimus
Nuthatches	**Sittidae**
White-breasted Nuthatch	Sitta carolinensis
Creeper	**Certhiidae**
Brown Creeper	Certhia americana
Wrens	**Troglodytidae**
Bewick's Wren	Thryomanes bewickii
House Wren	Troglodytes aedon
Marsh Wren	Cistothorus palustris
Kinglets	**Regulidae**
Ruby-crowned Kinglet	Regulus calendula
Gnatcatchers	**Sylviidae**
Blue-gray Gnatcatcher	Polioptila caerulea
Bluebirds, Thrushes and Robins	**Turdidae**
Eastern Bluebird	Sialia sialis
Swainson's Thrush	Catharus ustulatus
Hermit Thrush	Catharus guttatus
American Robin	Turdus migratorius

Thrashers	**Mimidae**
Gray Catbird	Dumetella carolinensis
Northern Mockingbird	Mimus polyglottos
Starling	**Sturnidae**
European Starling	Sturnus vulgaris
Waxwings	**Bombycillidae**
Cedar Waxwing	Bombycilla cedrorum
Silky-flycatcher	**Ptilogonatidae**
Phainopepla	Phainopepla nitens
Warblers	**Parulidae**
Orange-crowned Warbler	Vermivora celata
Virginia's Warbler	Vermivora virginiae
Lucy's Warbler	Vermivora luciae
Yellow Warbler	Dendroica petechia
Yellow-rumped Warbler	Dendroica coronata
Black-throated Gray Warbler	Dendroica nigrescens
Black-and-white Warbler	Mniotilta varia
American Redstart	Setophaga ruticilla
Prothonotary Warbler	Protonotaria citrea
Ovenbird	Seiurus auricapilla
Northern Waterthrush	Seiurus noveboracensis
Kentucky Warbler	Oporornis formosus
MacGillivray's Warbler	Oporornis tolmei
Common Yellowthroat	Geothlypis trichas
Hooded Warbler	Wilsonia citrina
Wilson's Warbler	Wilsonia pusilla
Yellow-breasted Chat	Icteria virens
Tanagers	**Thraupidae**
Summer Tanager	Piranga rubra
Western Tanager	Piranga ludoviciana
Towhees and Sparrows	**Emberizidae**
Spotted Towhee	Pipilo maculatus
Chipping Sparrow	Spizella passerina
Lark Sparrow	Chondestes grammacus
White-crowned Sparrow	Zonotrichia leucophrys
Cardinals, Grosbeaks and Buntings	**Cardinalidae**
Northern Cardinal	Cardinalis cardinalis
Rose-breasted Grosbeak	Pheucticus ludovicianus
Black-headed Grosbeak	Pheucticus melanocephalus
Blue Grosbeak	Passerina caerulea
Lazuli Bunting	Passerina amoena
Indigo Bunting	Passerina cyanea
Blackbirds, Meadowlarks and Orioles	**Icteridae**
Red-winged Blackbird	Agelaius phoeniceus
Eastern Meadowlark	Sturnella magna
Western Meadowlark	Sturnella neglecta
Yellow-headed Blackbird	Xanthocephalus xanthocephalus
Brewer's Blackbird	Euphagus cyanocephalus
Common Grackle	Quiscalus quiscula
Great-tailed Grackle	Quiscalus mexicanus
Brown-headed Cowbird	Molothrus ater
Bullock's Oriole	Icterus bullockii
Finches	**Fringillidae**
House Finch	Carpodacus mexicanus
Pine Siskin	Carduelis pinus
Lesser Goldfinch	Carduelis psaltria

American Goldfinch	Carduelis tristis
Evening Grosbeak	Coccothraustes vespertinus
Weaver Finches	**Passeridae**
House Sparrow	Passer domesticus