

RESEARCH WORK UNIT DESCRIPTION Ref: FSM 4070	1. Number FS-RM-4652	2. Station Rocky Mountain Research Station
	3. Unit Location Albuquerque, New Mexico	
4. Research Work Unit Title Understanding Disturbance Interactions and Effects for Restoring and Sustaining Ecological Conditions, Biotic Components, and Ecosystem Services in the Middle Rio Grande Basin.		
5. Project Leader (Name and address) Deborah M. Finch, Rocky Mountain Research Station, 333 Broadway SE, Suite 115, Albuquerque, NM 87102		
6. Area of Research Applicability New Mexico, Colorado, Texas, Mexico		7. Estimated Duration 5 years
7. Justification and Problem Selection		

Middle Rio Grande Basin (MRGB) arid ecosystems have evolved under human influence and changing climates for at least 12,000 years. Since 1540, the Basin has experienced increasing anthropogenic changes, including human population growth, introduction of new plant and animal species, cultural and socioeconomic changes in land and water use, and environmental degradation. To maintain the health and diversity of native grasslands, shrublands, woodlands, and forests in the overall Basin, new knowledge is needed that will help sustain human populations and resources in the space- and resource-limited environments along the Middle Rio Grande and within its basin watersheds. To accommodate environmental change, landowners and stakeholders - including federal, state, municipal, tribal, and private entities - must develop a holistic and conceptual understanding of the history, ecology, and responses of ecosystems and how to sustain them over time. Such an understanding is dependent on the creation, synthesis, modeling, and transfer of research knowledge that describes 1) the functional processes, structural components, and interactions of ecological systems, in the context of extreme climate variability, changing human needs and priorities, changing environments, and expected population growth, and 2) methods and approaches for restoring these processes, components and interactions when they change beyond desired goals and expectations for natural resource uses and values.

Fluctuations in the functional health and productivity of the Basin's arid and semiarid ecosystems are largely driven by interactive changes in water availability and climate. Water supply and factors that limit water, especially drought, in turn govern human occupancy patterns, land and resource uses, ecosystem and habitat structures, plant and animal community composition, and species distributions in the Southwest. Some of the most significant environmental conflicts in the Basin result over competing

Signature	Title	Date
Recommended:	Program Manager for Research	
	Assistant to Staff Director	
	Staff Director	
Approved:	Station Director	
Concurred:	Deputy Chief for Research	

demands for water. For example, increasing the availability of surface water needed for survival by endangered species such as the Rio Grande Silvery Minnow or Southwestern Willow Flycatcher is likely to substantially reduce water supply for irrigators, urban communities, pueblos, and recreationists in the Basin.

In the arid Southwest, long-term drought results in drying of soils, streams, and vegetation, producing environmental conditions that can lead to a chain reaction of additional disturbances and problems stretching over forested watersheds to floodplain bottomlands, farmlands, and human centers. These can be witnessed as:

- demographic shifts in plant and animal species,
- accumulations of salt concentrations in soils and water,
- reductions in surface and ground water supplies
- loss of forage and habitat for wildlife and livestock,
- invasions by alien plant species that can adjust to dry sites
- pest and virus outbreaks (e.g., bark beetle, hantavirus, prairie dog plague)
- population reduction, endangerment and local extinction of native species,
- catastrophic wildfires and related watershed problems
- land desertification and habitat fragmentation
- loss of human livelihoods
- reduced resources and ecosystem services for human use
- changes in social, cultural and economic stability

Current approaches for restoring Basin ecosystems in the wake of short-term and long-term disturbances typically triggered by drought are often based on a limited understanding of the underlying conditions and reasons that led to the problem(s). Consequently, quick-fix solutions are frequently cobbled together without consideration of the full array of interactive factors that could undermine restoration goals. In particular, drought, overgrazing, and fire exclusion are three major interacting factors that have resulted in degraded upland ecosystems in the MRGB. Research is needed on historic and current ecosystem responses to these major perturbations as well as responses to other less acknowledged perturbations such as fuel removal, land use, and plant or bark beetle invasions, to clarify how such responses influence dynamics, stability, productivity, biological diversity, and sustainability of upland ecosystems (Problem 1).

Human populations have concentrated along the river valleys of the Rio Grande Basin at least since the 12th century, and today, a continuous corridor of transportation and communication links contemporary urban environments along the main stem of the Rio Grande. The Rio Grande has long been a source of drinking water, travel pathways, fuelwood, food supply, community concentration, and recreation for human populations. Livestock were introduced upon the arrival of European settlers in the 16th century. Europeans built water diversion structures, cleared riparian vegetation, planted non-native species, and constructed dwellings and villages in the Rio Grande bosques. Dams, groundwater pumping, agricultural developments, and urban centers along the main river valleys have impacted the nature, extent, distribution, and regenerative health of floodplain bosques. Exotic plant species such as Russian olive and salt cedar have invaded most river systems in the Basin, potentially reducing water availability, outcompeting native plant species, increasing fuel loads and fire risk, forming barriers for animal and human travel. Habitats of fish and wildlife species have been substantially altered and reduced in area by lack of flooding, diversion of surface water, spread and maturation of invasive plants, and increasing frequency and impact of riparian fires. Pollutants and introduction of exotic salmonids

and bullfrogs have eliminated native fisheries along the Rio Grande, endangering some fish species by isolating them in headwater streams or in remnant pockets along the river itself.

In the mid-1980's, a Bosque Biological Management Plan was prepared under the direction of the U.S. Fish and Wildlife Service to identify methods of maintaining and restoring the riparian woodland "bosque". In the late 1990's, additional river agencies and cooperators in and around Albuquerque formed a congressionally-charged partnership called the Middle Rio Grande Endangered Species Act Collaborative Program focused on understanding and restoring habitats, ecosystem processes such as overbank flooding, and instream flow for the endangered Rio Grande Silver Minnow and the endangered Southwestern Willow Flycatcher. These programs have sparked enormous community and public interest and support for research, monitoring, and restoration of bosque ecosystems, recovering endangered species, and sustaining the unique water-driven biological wealth of the Middle Rio Grande. The Collaborative Forest Restoration Program managed by USDA Forest Service's Southwest Region has offered competitive grants to state and private groups to reduce bosque fuel loads, develop wood products from invasive plants, and manage urban forests along the river. To contribute to these multi-agency efforts, RWU 4652 will determine responses of physical and biological ecosystem components, including native and non-native plant and animal species, to management practices focused on reducing fire risk, controlling invasive plants, and restoring ecosystem function along the Middle Rio Grande and its tributaries. Also, RWU 4652 will evaluate restoration effectiveness in sustaining biological diversity and societal needs, and evaluate the basis, extent, and problems associated with human uses and allocations of resources along the Middle Rio Grande (**Problem 2**).

Studies on many of the individual questions posed in Problem 1 and 2 have already been conducted by Basin scientists from a range of research institutions, but existing information has not been summarized or synthesized into a coherent package digestible by land management decision-makers. Many scientists are currently working on these questions in the Basin but their results and products are often distributed to a limited number of scientists or may not be ready to be published or distributed to the land management community. Scientists can be challenged to deliver their information in multiple forms through forums such as workshops, symposia and models for use by a broad range of user groups. An assessment is needed of existing information that will be useful in guiding land management and restoration in the MRGB. Therefore, RWU 4652 proposes to develop state-of-the-art publications, synthetic documents, regional assessments, symposia and proceedings, databases, computer programs, or other science-based products that will be useful for sustaining natural resources and human populations in the MRGB (**Problem 3**).

8. APPROACH TO PROBLEM SOLUTIONS:

Chief Bosworth challenged the Forest Service to "...focus on entire ecosystems...and take an ecosystem-based, landscape-scale approach to management", while at the same time recognizing the societal context for these ecosystems (Bartuska 2004. *Frontiers in Ecology and the Environment* 2: 339). RWU 4652 is unusual in its approach in that research is identified through a competitive Request for Proposal process. Proposals to this program are most often successful when submitted by a team of investigators who use an integrated, interdisciplinary, landscape-level approach to address research questions related to ecosystem management problems.

Problem areas addressed by the Middle Rio Grande Ecosystem Management Unit address

several of the national Forest Service Strategic Program Areas (SPAs) (http://www.fs.fed.us/rm/main/strategic_program_areas.html) led by teams of Washington Office and Station personnel. Relevant proposals to problem areas relate strongly to five SPAs: 1) Resource Management and Use, 2) Wildland Fire and Fuels, 3) Invasives, 4) Water and Air, and 5) Wildlife and Fish. Problem areas are also linked to the focus areas of the 2003 RMRS Strategic Framework (http://www.fs.fed.us/rm/main/strategic_plan.html). The RMRS Strategic Framework identifies 6 focus areas for research that are relevant in helping to solve land management problems and challenges in the Rocky Mountain and Intermountain states: 1) Changing Ecosystems, 2) Conflicting Values, 3) Wildland Fire, 4) Healthy Environments, 5) Wildlife and Fish Habitats, and 6) Communicating with Our Stakeholders. Relevant proposals also tap into other major research strategies and priorities within or appropriate for the MRGB such as:

- New Mexico Forest and Watershed Plan (<http://www.nmforestry.com>),
- NM Forest and Watershed Restoration Institute (<http://www.fs.fed.us/r3/partnerships/plans>),
- National Fire Plan (<http://www.fireplan.gov/>),
- Southwest Strategy (<http://www.swstrategy.org/>),
- National Invasive Species Management Plan (<http://www.invasivespecies.gov/council/nmp.shtml>)
- Bosque Biological Management Plan (<http://mrgbi.fws.gov/>),
- Habitat Restoration Plan for the Middle Rio Grande (http://mrgesacp.fws.gov/pdf/Habitat_Restoration_Plan.pdf),
- Sevilleta Long Term Ecological Research Plan (<http://sev.lternet.edu>) and
- National Ecological Observatory Network (<http://www.neoninc.org>).

Problem 1. Drought, overgrazing, and fire exclusion are three major interacting factors that have resulted in degraded upland terrestrial and river ecosystems in the MRGB. Research is needed on ecosystem responses in upland watershed(s) to these major historic and current perturbations as well as responses to other less acknowledged perturbations such as fuel removal, climate change, and plant or bark beetle invasions, to clarify how such responses influence dynamics, stability, productivity, biological diversity, and sustainability of upland ecosystems. Xx SY/yr.

The uplands of the MRGB are composed of Chihuahuan desert scrub, Desert, Plains and Montane grasslands, Piñon-juniper, Coniferous and Mixed woodland communities, and their associated river systems. Historic and contemporary perturbations caused by factors such as climate, grazing, fire reduction, periods of severe drought, and past and present human activities have led to changes in vegetative cover, soil stability, and ecosystem processes such nutrient cycling. These, in turn, affect habitat of associated aquatic and terrestrial wildlife species.

Studies to evaluate methods for restoring processes and interactions interrupted by disturbances will also be conducted. Research issues must be considered within the context of human activity. Can elements be restated to address outcomes vs evaluating?

Element 1. Develop Knowledge About the Relationships Between Drought, Bark Beetle Outbreaks and Pinyon Mortality. Piñon-juniper woodlands are a major component of upland watersheds. Perturbations to these woodlands will have important consequences for the management of the region. A major consequence of drought is an increase in the frequency of outbreaks of pests that colonize either under dead trees or in inter-canopies. Long-term drought coupled with bark beetle infestations increase the risk of catastrophic fire and soil erosion in piñon-juniper woodlands in managed areas, and in property that adjoins these areas. Research will be conducted on the influence of a mega-drought on bark beetle populations in pinyon woodland sites at the Sevilleta National Wildlife Refuge, at Bandelier National Park, and on the Cibola National Forest. Studies will provide managers with a greater understanding of how these biotic and abiotic disturbances affect piñon-juniper woodland ecosystems. (Proposal awarded to Northern Arizona University (Lead Investigator Neil Cobb) and Paulette Ford, RM-4351).

Element 2. Improve Understanding of the Ecological Interactions and Consequences of Drought, Tree Thinning, and Grazing for Use in Restoring Ecosystems. The combined influences of drought, tree thinning, fuel removal, grazing and restoration on fire-return intervals and tree mortality are not well understood in the arid Southwest. This lack of information limits the range of options available to land managers for sustaining forest and woodland health. Further research is needed to understand the implications of changes in stand density via drought-related mortality and restoration thinning on forest productivity. Tree-ring research to evaluate whether drought-related pinyon mortality results in ecosystem-level effects analogous to thinning or fire will be conducted at the Sevilleta Long Term Ecological Research Site and on National Forests. Fire, both natural and anthropogenic, has been a common occurrence in upland watershed ecosystems during the past 9,000 years. But fine fuel removal, through extensive domestic and wild ungulate grazing, coupled with active fire suppression efforts have modified fire return cycles, resulting in a need for management strategies aimed at providing sustainable resource use for wildlife and domesticated livestock. Additionally, research at Valles Caldera National Preserve will explore the interactive effects of fire and grazing on multiple aspects of watershed-level community dynamics, including plant community composition, plant and soil nutrient dynamics, soil erosion, terrestrial arthropod communities, stream water quality, and aquatic macroinvertebrate and fish communities. These data will provide managers with an overall picture of positive and negative effects of using prescribed fire and livestock grazing for ecosystem conservation, fuels reduction, and sustainable management of fish and wildlife populations. (1. Proposal by Valles Caldera Trust (Lead Investigator Bob Parmenter) in cooperation with Rosemary Pendleton, RM-4351, Carol Raish, RM-4351, and Paulette Ford, RM-4351. 2. Proposal by Los Alamos National Lab (P.I. Neal McDowell) in cooperation with Mike Ryan, RMRS, and Will Pockman, UNM).

Element 3. Develop Information for Managing the Consequences of Biological Invasions. Managers are increasingly concerned about the presence, expansion, and difficulty in controlling noxious and invasive weeds and woody plants. Biological invasions disrupt natural ecosystems, posing negative consequences for both ecological and socioeconomic systems. Invasive species displace desirable native species, reduce the quality of wildlife habitat, damage sensitive watershed areas, and increase erosion, resulting in decreases in water quality. As native

vegetation becomes displaced, alterations in ecosystem processes occur including nutrient cycling and decomposition rates. The degree to which a community is susceptible to invasion varies through time, and invasion events are commonly episodic. Research will be completed and new research proposed through RWU 4652's competitive awards process that address factors affecting the susceptibility of upland plant communities, as well as effective control measures and vegetation management practices. Information on the basic biology of newly emerging and established invasive weeds can provide insights into mechanisms for prevention and control of infestations. (Proposals awarded to New Mexico State University and University of Arizona in cooperation with Rosemary and Burt Pendleton, RM-4351).

Element 4. Develop Information for Resolving the Social Issues Related to Drought, Fire, Invasions, and Grazing. Ongoing and new cultural dimensions research is needed to assess and evaluate the human/cultural component of major, emerging upland ecosystem issues. These include responses to drought, grazing by both domesticated and wild herbivores, wildfire and the effects of fire exclusion, and land fragmentation resulting in habitat loss and perturbations to watershed function. Understanding human concerns and responses to drought-related problems, such as invasions of drought-tolerant weeds and shrubs, tree mortality, bark beetle infestations, and potentially increased fire danger, is of considerable importance, as is an understanding of how various human groups view wildfire risk and fuels reduction treatments designed to reduce that risk. Human attitudes on these topics directly affect the ability of land managers to carry out programs to mitigate drought-related impacts. In addition, continued research on evaluating the social, cultural, and economic role and importance of livestock grazing to Basin families and communities can be crucial to understanding cultural perceptions and attitudes concerning wildlife, TES protection, and species reintroduction. Finally, the human aspect of threats to upland Basin ecosystems posed by increasing land fragmentation, resulting from growing populations, development, and urbanization, requires clarification and further research to develop a Basin-wide response to this growing threat. Research will be proposed using RWU 4652's competitive awards process to address these sociocultural topics. (No proposals funded as yet).

Cooperators: USDA Forest Service Rocky Mountain Research Station, USDA Forest Service Region 3, Cibola National Forest, Santa Fe National Forest, Carson National Forest, Bandelier National Monument, Northern Arizona University Merriam-Powell Center for Environmental Research, University of New Mexico: Museum of Southwestern Biology. University of New Mexico; Sevilleta Long Term Ecological Research Project, New Mexico State University, University of Arizona, Valles Caldera Trust, United States Geological Survey, Highlands University, Tetratex, Inc., Geometronics Lab., Los Alamos National Lab, and the Sevilleta National Wildlife Refuge. Cooperators associated with the proposed projects include the Middle Rio Grande Conservancy District, the Bureau of Land Management, and the cities of Albuquerque, Bernalillo, and Socorro. Other cooperative relationships might also be developed.

Accomplishments planned during the next 5 years:

- Determine ecosystem responses in upland watershed(s) to current perturbations caused by drought and bark beetle attacks and clarify how such responses influence dynamics, stability, and productivity of upland ecosystems in relation to watershed capability. Responses will involve a comparison of ecosystem characteristics (vegetation stand

structure and diversity, arthropod and small mammal community structures) in areas of significant piñon-juniper mortality and comparable unaffected areas.

- Assess the change in stand structure of piñon-juniper woodlands in areas of high mortality throughout the MRGB.
- Incorporate USFS-Forest Health Monitoring data and verify the extent of piñon-juniper woodland drought-related mortality throughout MRGB uplands.
- Establish experiments and study sites at Valles Caldera that will provide data on the interactions of prescribed fire and the grazing activities of elk and livestock. Ecosystem responses studied will include vegetative composition and cover, nutrient cycling, litter decomposition, soil erosion, elk and cattle foraging behavior, terrestrial arthropod populations, stream water quality, fish populations, and aquatic macroinvertebrates. Data collected will include one year pre-burn and 4 years post-burn data, with a prescribed fire scheduled for 2005.
- Complete study on the use of fire as a management tool for controlling yellow starthistle in SW New Mexico.
- Meet with weed specialists in Arizona and New Mexico to determine the most pressing needs in weed research and prepare a suitable grant proposal(s) to be submitted to RWU 4652 and to CSREES.
- Determine the cultural, social, and economic importance of livestock ownership to the primarily Hispanic families and communities who are grazing permittees on the Carson and Santa Fe National Forests. Clarify if/how livestock ownership is used to maintain Hispanic cultural heritage and tradition in the region. Explore if/how livestock ownership affects cultural perceptions and attitudes concerning wildlife, TES protection, and species reintroduction.
- Develop a proposal to conduct research gathering information on public knowledge, views, and preferences concerning upland vegetation restoration and management tools, including prescribed fire, mechanical removal, and use of herbicides, in the MRGB communities of Albuquerque, Bernalillo, and Socorro. Information would be provided to Middle Basin land management agencies to assist in gathering support for upland restoration projects designed to mitigate the effects of drought and reduce the risk of wildfire.
- Develop a proposal to conduct research on the cause, extent, and effects of land fragmentation in the MRGB uplands surrounding the communities of Albuquerque, Bernalillo, and Socorro. Determine the effect of using agricultural land as a means of maintaining open space and wildlife habitat in areas surrounding the targeted communities. Explore the effects of the potential loss of agricultural land to open space and habitat maintenance.

Planned outcomes (outputs) within the next 5 years:

- Establishment of paired high- and low-mortality pinyon-juniper study plots in the northern, central, and southern ranges of the MRGB.
- Publication of a station GTR “An Assessment of Current and Historic Drought and Bark Beetle Interactions in Pinyon-Juniper Woodlands of the MRGB.”

- Production of an Arcmap project detailing impact and extent of piñon mortality throughout range of piñon. This product will be a statistically valid document for long-term monitoring purposes, and it will also serve local managers who need this tool to prioritize management such as fuel treatments, individual tree protection.
- Completion of and publication of M.S. thesis from Northern Arizona University on arthropod community response to drought and bark beetle perturbations in pinyon-juniper woodlands of Arizona and New Mexico.
- Completion of and publication of M.S. thesis from the University of Arizona on an investigation of community-based and integrated yellow starthistle management in southwestern New Mexico.
- Establishment of burned and control research sites in two paired watersheds at Valles Caldera. Site establishment includes the installation of all appropriate instrumentation. Conduct prescribed fire at Valles Caldera burn site and post pre- and post-fire data sets on the VCNP and RMRS websites.
- Complete data collection and analysis from questionnaires and personal interviews conducted with grazing permittees on the Carson and Santa Fe National Forests.
- Provide information to land management agencies concerning the role and importance of livestock management to grazing permittees on the Carson and Santa Fe National Forests in order to enhance agency/community relations and improve land management project acceptance through greater cultural understanding and sensitivity.
- Publish a General Technical Report on the role and importance of livestock management to grazing permittees on the Carson and Santa Fe National Forests.
- Prepare and submit a proposal for FY2006 for a project examining public knowledge, views, and preferences concerning upland vegetation restoration and management tools, including prescribed fire, mechanical removal, and use of herbicides, in the communities of Albuquerque, Bernalillo, and Socorro.
- Prepare and submit a proposal for FY2006 for a project examining the cause, extent, and effects of land fragmentation in the uplands of the MRGB surrounding the communities of Albuquerque, Bernalillo, and Socorro.
- Prepare and submit annual reports for ongoing and expired joint ventures and other agreements.
- Publication in peer-reviewed journals of manuscripts associated with current and completed research projects, including yellow starthistle, drought and bark beetle infestations, Valles Caldera fire and grazing interaction, and the ranching project.
- Presentations at local and national conferences including the Ecological Society of America annual meeting, the Annual Sevilleta LTER Research Conference, and other appropriate meetings.

PROBLEM 2. Determine responses of physical and biological ecosystem components, including water quantity and native and non-native plant and animal species, to management practices focused on reducing fire risk, controlling invasive plants, and restoring ecosystem function along the Middle Rio Grande and its tributaries. Evaluate the effectiveness of restoration methods in sustaining biological diversity and societal needs, and evaluate the basis, extent, and problems associated with human uses and allocations of resources along the Middle Rio Grande.

Watershed perturbations, whether natural or anthropogenic, have direct and sometimes-detrimental effects on ecosystem function, soil stability, habitat structure, and populations of terrestrial and aquatic flora and fauna of rivers and streams. Natural perturbations such as long-term drought can affect not only the quantity of water available for human uses, but also riparian plant reproduction and growth and aquatic habitat for fish and other aquatic organisms. Disturbances can also reduce the quality of runoff and downstream water thereby degrading aquatic and terrestrial habitat quality. Research is needed to evaluate effects of drought, watershed perturbations, and water limitations on river and stream ecosystems, aquatic and riparian biota, and endangered fish and wildlife.

Element 1. Improve Understanding of the Effects of Disturbances on Aquatic Habitats and Fish Populations for Use in Mitigating Effects and Restoring Ecosystems. When drought problems in the Southwest interact with environmental changes caused by exotic plant invasions, habitat fragmentation, or land management practices, aquatic and riparian environments typically deteriorate, resulting in shifts and reductions in native habitats and ecosystem types, emergence and spread of undesirable invasive plants, increased fire risk, increased plant and fish mortality, wildlife losses and emigration, and reduced recreational value. During drought periods and even at other times, management of invasive species, livestock, and fuel loads on aridlands within the MRGB can have ecological costs and benefits that need to be accounted for by decision-makers. Livestock grazing practices can be used to improve range conditions when managed appropriately but research is needed to determine what amount and kinds of grazing are appropriate for sustaining biological diversity and productivity of aquatic and riparian species. Likewise, research is needed to determine what approaches and amounts of river and watershed restoration -- whether to reduce fuels, remove invasive plants, or mitigate other problems -- will lead to sustainable and productive environments. To address some of these questions, research was initiated in 2006 to evaluate responses of fish and other aquatic organisms to grazing by cattle and elk, and to prescribed fire, and to interactions of fire and grazing. Control sites, livestock- elk exclosure sites, and grazed and ungrazed sites treated with prescribed fire were established for this study at the Valles Caldera National Preserve. (Proposal awarded to New Mexico State University (Lead Investigators Colleen Caldwell and Bob Dubey) in cooperation with the Valles Caldera Trust and RWU-4652..

Element 2. Improve Understanding of the Effects of Removal of Bosque Invasive Species and Fuels on Ecosystems and Terrestrial Animals for Use in Sustaining Biological Diversity. The Middle Rio Grande supports the most extensive, remaining gallery of cottonwood forest (*Populus deltoides* subspecies *wislizeni*) in the southwest. In the past century, humans have dramatically altered the vegetative structure and composition of the bosque through damming, channelization, irrigation, urbanization, and restoration. Much of the previous extent of the bosque has been converted for agricultural or urban use, and the remaining bosque primarily exists between levee roads paralleling the river. In the 20th century, engineers dammed and channelized the river to reduce the frequency and severity of flooding and to facilitate agriculture and water management. As a result, many natural processes in the bosque ecosystem have been disrupted or altered. For example, spring floods historically scoured forests of woody debris and deposited new sediments on which cottonwood seedlings germinated. The absence of spring flood events has reduced recruitment in cottonwood populations and allowed invading plants, such as saltcedar (*Tamarix ramosissima*) and Russian olive (*Elaeagnus angustifolia*), to establish on sites formerly available to cottonwood. The quantities of woody debris in many areas of the bosque have also increased substantially due the lack of scouring floods.

Accumulation of these woody debris, combined with dense stands of saltcedar and Russian olive in the understory, lead to fuel loadings capable of supporting catastrophic wildfires. Land managers require basic and applied information to understand historic and current conditions, processes, and communities of the bosque, to identify desired future conditions and restoration goals, and to effectively use of management tools (herbicide, chaining, etc.) to achieve these goals and conditions. For many years, agencies have been actively managing riverside bosque with herbicide, prescribed fire, chaining, ripping, and other mechanical manipulations. Managers lack information on the long-term impacts of these activities on riparian ecosystems (biodiversity, flora and fauna, ecosystem function, hydrologic cycles, etc.) and the effectiveness of these tools at achieving management goals (e.g. restoring cottonwood forests, reducing fire risk, removing fuels, increasing ground water recharge, recovering endangered species, protecting biodiversity, etc.). To begin to address these questions, research was initiated in 2000 and will continue through 2010 to evaluate responses and interactions of water, soils, plants, and animals to removal of understory invasive species such as Tamarisk and Russian olive from cottonwood bosque. These invasive species are associated with high fuel loads and fire risk and inaction would lead to loss of cottonwoods and many other native plants through wildfire. However, ecological costs and benefits of removal need to be quantified. Proposal awarded to RMRS and University of New Mexico (UNM) (Lead Investigators Deborah Finch and Alice Chung-MacCoubrey, RM-4351, David Merritt, RM Stream Team, and Mike Campana, UNM.

Element 3. Develop Information to Aid in Resolving Social Concerns in Managing Limited Resources in Urban-Wildland Ecosystems. Social concerns about the integrity and use of urban-wildland environments such as the Middle Rio Grande urban forests are becoming increasingly pronounced as growth and its concomitant impact on water supply continue in Albuquerque, Bernalillo, Rio Rancho and Socorro. Managers require information and a better understanding of public knowledge, views, and preferences concerning water supply, riparian urban forests, bosque restoration and management tools. Understanding human uses of, needs for, and responses to ground and surface water, urban bosque, and urban-wildland open space is important. The social costs and benefits of urban forest restoration using released flooding, removal of invasives and fuels, and restructuring of channels need to be quantified. Restoring riparian and aquatic systems can result in new opportunities for human uses but may also be misunderstood in relation to impacts on water availability. Misunderstandings related to competition for or protection of limited resources can result in backlash from urban and rural publics, recreationists, and private landowners. Research is needed to increase understanding of the social implications of water and urban forest use and management. (No proposals awarded as yet).

Cooperators

USFS Stream System Technology Center, Santa Fe National Forest, Colorado State University, University of New Mexico, New Mexico State University, Middle Rio Grande Conservancy District, Bosque del Apache National Wildlife Refuge, Sevilleta National Wildlife Refuge, City of Albuquerque, NM Division of Forestry, USDA Joint Fire Sciences Program, National Fire Plan, U.S. Fish and Wildlife Service, NRCS Plant Materials Center, USFS State & Private Forestry, NMSU Extension Program, University of Oklahoma, Interstate Stream Commission, Valles Caldera Trust, other Research Work Units, and Cities of Bernalillo and Socorro. Other cooperative relationships might also be developed.

Planned accomplishments for the next 5 years:

- Analyze plant community data to discern differences in community composition between experimental treatments (two treatments and the control) after accounting for differences in abiotic attributes of sites.
- Shed light on the factors that influence the establishment (and/or re-establishment) of native and non-native plants from site to site and treatment to treatment.
- Determine if removal of invasive woody plants reduces the magnitude of diurnal fluctuations of groundwater levels.
- Compare transpiration in cottonwood forests with and without invasive saltcedar understories to identify potential water savings from vegetation removal efforts.
- Collect at least three years of post-treatment data on birds, bats, reptiles, amphibian, vegetation, and water at fuels-reduction sites on the Middle Rio Grande.
- Quantify the types of changes in the plant community, (e.g. species diversity, composition, and abundance) that occur in the first 3 years after treatments
- Identify how treatments differ in their effectiveness in 1) suppressing invasive plants (based on amount of resprouting) and 2) reducing fire risk (based on fuel loads).
- Describe the effects of fuels treatments on species composition, relative abundance, and productivity of herpetofaunal communities of the Middle Rio Grande bosque.
- Describe bat communities that use the Middle Rio Grande bosque, bat activity patterns, factors that influence the use of bosque for foraging and roosting, and the effects of different fuels reduction treatments on bat activity.
- Identify effects of fuels and invasive species treatments on bird populations and productivity, species richness, relative abundance, and reproductive success at restoration sites of the Middle Rio Grande bosque.
- Complete manuscript preparation of bird migrant responses to native and invasive plant habitats along the Middle Rio Grande.
- Implement a study to determine population responses of fish and aquatic organisms to grazing by livestock and elk in stream reaches with and without exclosures at the Valles Caldera National Preserve.
- Develop a proposal to conduct research gathering information on public knowledge, views, and preferences in the MRGB communities of Albuquerque, Bernalillo, and Socorro concerning riparian vegetation restoration and management tools, including prescribed fire, mechanical removal, and use of herbicides. Information would be provided to Middle Basin land management agencies to assist in gathering support for bosque restoration projects designed to mitigate the effects of drought and reduce the risk of wildfire.
- Develop a proposal to conduct research on the cause, extent, and effects of land fragmentation in the MRGB surrounding the communities of Albuquerque, Bernalillo, and Socorro. Determine the effect of using agricultural land as a means of maintaining open space and wildlife habitat in areas surrounding the targeted communities. Explore the effects of the potential loss of agricultural land to open space and riparian habitat maintenance.
- Analyze algal community structure in the Middle Rio Grande to distinguish the effect of fire on algal dominance.

Planned outcomes within the next 5 years:

- Synthesize research progress and preliminary results from different investigators working collaboratively on the Fuels Reduction Project and submit reports to agency cooperators.
- Publications in peer-reviewed journals, general technical reports, and other research outlets on topics listed in planned accomplishments.

- Completion and publication of a PhD dissertation on biology, ecology, and management of herpetological communities in the Middle Rio Grande bosque (Department of Biology, University of New Mexico).
- Completion and publication of a PhD dissertation on the diet, food/habitat requirements, and management of the Rio Grande Silvery Minnow (Department of Biology, University of New Mexico).
- Completion and publication of a PhD dissertation and 1 or more papers on bird migration in relation to native and invasive plant habitats (Department of Biology, University of New Mexico).
- Completion and publication of a Ph.D. dissertation and 1 or more papers on Rio Grande Cutthroat Trout ecology, distribution, and exposure to whirling disease in New Mexico.
- Oral and poster presentations of research results will be given at local and national professional meetings, such as North American Bat Symposium, The Wildlife Society national and local meetings, Southwestern Association of Naturalists, Ecological Society of America, and Ornithological Societies of North America.
- Consult with and provide guidance on controlling exotic plants and reducing fuel loads to agencies managing lands along the Middle Rio Grande.
- Prepare and submit a proposal for FY2006 for a project examining public knowledge, views, and preferences in the communities of Albuquerque, Bernalillo, and Socorro concerning riparian vegetation restoration and management tools, including prescribed fire, mechanical removal, and use of herbicides.
- Prepare and submit a proposal for FY2006 for a project examining the cause, extent, and effects of habitat fragmentation and loss of agricultural land in the MRGB surrounding the communities of Albuquerque, Bernalillo, and Socorro.

Problem 3. Develop state-of-the-art publications, synthetic documents, regional assessments, symposia and proceedings, databases, computer programs, or other science-based products that will be useful for sustaining natural resources and human populations in the MRGB. Report progress of RWU 4652 studies on an annual basis to increase accessibility of information to Basin users.

Approaches and documents produced under Problem 3 will range in purpose, scope, and theme and will be based on a wide range of possible proposals submitted to the program. The goal is to provide general information and products on MRGB ecosystems that will be easily accessible and quickly available to Basin users.

Cooperators

Bureau of Land Management, Forest Service Southwest Regional Office, Carson, Cibola, and Santa Fe National Forest, U.S. Fish and Wildlife Service, State agencies, New Mexico State University Extension Service, University of New Mexico, and Northern Arizona University.

Planned accomplishments for the next 5 years:

- A symposium will be hosted by RWU 4652 with the intent of summarizing a variety of Basin environmental research for use by a broad diversity of users.
- An annual meeting to report progress of studies funded by RWU 4652 will be hosted, and investigators will be asked to prepare and present powerpoint presentations. Progress reports from individual studies funded by RWU 4652 will be distributed to users as they are made available.

- To ensure that studies and assessments funded by RWU 4652 will be of critical value to users, a review board will be established to evaluate and rate proposals using criteria identified in an Annual Request for Proposals.
- Summarize user needs and priorities for research and report 5-year progress of the program in a summary volume.
- Host show-me field trips on a periodic basis to demonstrate the scope and value of RWU 4652 research and to get information quickly into the hands of users.
- Fund special assessments, models, and state-of-the art publications on high priority Basin topics using a competitive awards process.

Planned outcomes within the next 5 years:

- A proceedings of Basin research will be published in the RMRS Proceedings series.
- Proposals to RWU 4652 will be awarded competitively on an annual basis, resulting in multiple agreements with research institutions.
- A five-year progress report of RWU 4652 research will be produced as a book or General Technical Report.
- Results of funded proposals for assessments, state-of-the-art papers, and synthetic documents will be published in journals and other peer-reviewed outlets. Future topics will be identified through the proposal awards process.

FY06 BUDGET WITH MATCHING FUNDS DEFINED

Six proposals were funded in FY2006. Some multi-year proposals were first funded in FY2005 and are expected to continue through FY2007. Assuming flat annual R&D budgets, the RWU 4652 allocation of funds for FY07, FY08, FY09, and FY10 are projected to be similar to FY06 but will depend on the actual proposals awarded each year. Proposals are usually funded for a period of three years and can be extended. It is estimated that allocations will be renewed annually for 2-3 years with opportunities for new proposals in FY08.

The FY06 Proposals were used to estimate annual budgets by Strategic Program Areas (Table 1). In FY06, \$40,859 was used to support administrative and corporate costs and \$322,141 was the amount available for spending. This information was then smoothed to project approximate proportions of the base budget allocation to each SPA (Table 2).

Table 1. Breakout of Budget by Strategic Program Area (SPA) and Activity in FY06.

		RWU 4652
SPA	Activities	\$322,141
Water and Air R&D Resource	Air & Water Ecosystem Processes	\$11,000
	Air & Fire Interaction	-
	Climate Variability & Air/Water Pollution	-
	Science Based Management Tools	-
	Forest & Range Ecocsystems	\$76,000

Mgmt & Use R&D	Develop Forest & Range Mgmt Technologies & Apps	\$20,000
	Develop & Deliver Forest & Range Goods & Svcs	
Recreation R&D	Core Recreation Science	-
	Recreation Planning & Monitoring R&D	-
	Recreation Mgmt Research	-
Fish and Wildlife R&D	Sustaining Species & Ecosystems	\$12,000
	Public Use Effects	-
	Manage for Terrestrial & Aquatic Habitats	\$30,800
	Evaluate Outcomes of Land & Water Uses & Natrl Disturbances	\$44,000
Wildland Fire and Fuels R&D	Core Fire Science	-
	Ecological and Environmental Fire Science	\$85,000
	Develop and Deliver Tools and Knowledge	-
	Social Fire Science	-
	Integrated Fire and Fuels Management Research	\$13,341
Resource Data and Analysis	Conduct Resource Inventory	-
	Periodic Resource Assessments	-
	Quantitative Analysis & Techniques	-
Invasive Species R&D	Predict and Prevent Introductions	-
	Detect, Respond and Eradicate IS Introductions	-
	Manage & Mitigate Established IS Infestations	\$30,000
	Restore & Maintain Ecosystems Degraded by IS	-

Table 2. Proportion of Annual Budget Allocation by SPA.

Water and Air	10%
Resource Management and Use	25%
Recreation	0
Fish and Wildlife	20%
Wildland Fire and Fuels	20%
Resource Date and Analysis	0
Invasive Species	10%
Administration and Operations	15%

FUTURE FUNDING NEEDS

In 2005 RWU 4652 received 16 proposals to conduct MRGB Research, and in 2006, the unit received 15 proposals, 3 of which were renewal proposals. The total amount of proposal requests to RWU 4652 greatly exceeded (4X) the amount of annual funds allocated to the program. Funding to 4 of 5 RMRS Ecosystem Management Units has declined since 2000. RWU 4652's budget decreased from a high of \$416K in 2000 to \$363K in 2006 owing to R&D budget reductions.

To address the full range of research needed in the Basin, as indexed by this RWUD, and by proposals and comments at the 2005 Technical Assistance Visit (TAV), consideration should be given to increase funds for this program in out-year budgets. With a \$100,000 increase in funds, greater attention can be focused on research to address emerging social and cultural conflicts. With a \$200,000 increase in funds, the program can devote more attention to the development of synthetic products and assessments requested by stakeholders. With a \$300,000 increase in funds, the program can develop landscape and Basin-wide imagery using remote-sensing and satellite technology to depict geographical and temporal models of biological invasions and tree mortality associated with problems like fire and drought.