Joint Fire Science Program
Fire Science Brief
RESEARCH SUPPORTING SOUND DECISIONS

By applying treatments, the team worked to restore New Mexico's Middle Rio Grande bosque, the most extensive, remaining cottonwood forest in the Southwest. Photo by USDA Forest Service.

Pentimento: Fuels Reduction and Restoration in the Bosque of the Middle Rio Grande

Summary

The Middle Rio Grande of New Mexico is the most extensive, remaining bosque, or cottonwood forest in the southwest. Alterations caused by humans—damming and channeling the river, controlling floods, and planting non-native trees—have disrupted the cycles of the earlier ecosystem. Without periodic flooding, native cottonwoods cannot regenerate. Invasive exotic plants such as Tamarisk, also known as salt cedar, and Russian olive have filled in the gaps and open spaces, increased fuel loads, and continue to replace native trees and shrubs after wildfires. Cottonwoods, not a fire-adapted species, are now at risk from wildfire and replacement by invasive plants.

An array of fuel treatments applied to study sites reduced invasive woody plants in the bosque. Resprout rates for exotic trees were low overall. Survival rates of transplanted native plant species were high. Restoration had various effects on birds, animals, amphibians, and reptiles of the bosque. Species that prefer a more open, less-cluttered habitat benefited, and their numbers increased. Species that prefer a closed, shrubbier habitat altered by invasives declined.

Key Findings

- Treatments reduced fuel loads, which will save native trees not adapted to fire from burning in fire.
- Treatments, such as deep mulch, reduced the ability of invasive plants to regrow.
- 60-100% of native transplants survived in treatment areas.
- Bird, animal, amphibian, and reptile species that use less cluttered, more open habitat benefited from treatment; species that relied on pretreatment, dense habitat declined.

We are in a continual process of reworking the ecosystems of our planet. The compositions we have produced on our landscape canvas have ranged from inelegant to deleterious. Such is the picture of the Middle Rio Grande of New Mexico, the most extensive, remaining bosque, or cottonwood forest in the southwest. Many of the forms produced by our earlier vision have disrupted natural processes and allowed highly flammable exotic plants to replace native trees that are not fire-adapted. The unintended consequence of our work is a landscape prone to fires that destroy forests. A pentimento is an alteration in a painting, an area repainted to remove forms or rework earlier ones. A pentimento, when discovered by the viewer, reveals the artist changed his mind about the composition. Like the great artists while in the process of creation, we now view our works with a different eye. Deborah Finch, team leader with the USDA Forest Service's Rocky Mountain Research Station, has looked at our creation in the bosque, and offers techniques to restore the elements of a more harmonious composition.

The picture: a landscape of unsuitable forms, patterns, and proportions

The picture begins with a river. The Rio Grande had been a flood river, often pouring water over its banks during the late spring and early summer as snow in the upper watersheds melted. Floodwater washed away dead and downed trees and branches, and dispersed the seeds of native plants. Settlers, opposed to severe and frequent flooding, introduced a number of elements to change the picture: dams to control the river, making it a reservoir rather than free-flowing; channels to deliver convenient water for agriculture; and plants to control erosion and to stabilize banks. Salt cedar and Russian olive, imported and planted for these reasons, spread into the bosque and became a dominant element, changing the composition of the landscape. Floodwaters, confined for the most part to the river's channel, no longer inundate the land. Native species that rely on water passing over the land to regenerate have declined. Dead wood accumulates, dense stands of invasive woody plants thrive in the gaps left vacant by native plants, and a composition of increased fuel loads is prime for fires.

Testing the perspective

Experience helps us imagine myriad concerns when we think about removing undesirable components in an ecosystem. How do you eliminate invasive species, such as salt cedar and Russian olive, without creating more damage? Finch and her team of scientists, in collaboration with the Middle Rio Grande Conservancy District, U.S. Fish & Wildlife Service Bosque del Apache, the city of Albuquerque, and the USDA Forest Service Rocky Mountain Research Station, set out to find answers to that question and others. Beginning in 2000, Finch and her cooperators set up 12 experimental units along the river to test the effects of three treatments. The scientists were searching for the most effective way of reducing fuels and exotic species, while limiting damages to cottonwood and other native trees and shrubs, to wildlife, to plants, and to water resources in the Middle Rio Grande bosque. Albuquerque Block (North), Los Lunas-Bernardo Block (Middle), and Lemintar-Bosque del Apache Block (South) each contained three treatments and a control site. The scientists selected these sites, spread over 90 miles, based on the following criteria: landowners reported high fuel loads; the vegetation was relatively homogenous and at least 50 acres; the plant community consisted of a cottonwood overstory with an understory of native and exotic woody plants; road access was available; landowners allowed

Cutting and piling exotic plants gave native species some breathing room.

access and treatments; and grazing, vehicles, and other uses had generally not disturbed these sites.

The scientists, in cooperation with landowners, arrayed on their palette a trio of treatments: mechanical removal of dead, downed, and exotic woody plants, and treatment with garlon herbicide; partial mechanical removal of dead, downed, and woody exotics, and treatment with herbicide followed by light, prescribed fire; mechanical removal of dead, downed, and woody exotics, and treatment with herbicide, followed by revegetation with native plants.

A fourth component to craft the study included a control, where no treatment was applied. To remove the unwanted elements of salt cedar and other woody exotics from the picture, Finch and her colleagues used a multilayered technique with a variety of tools. Contractors were hired to cut the tree canopy with chainsaws, immediately applying herbicide to each cut stump with a low volume backpack sprayer. They chipped trunks and branches and stems on site with trailer-mounted chippers, or hauled the pieces in pickup trucks and front-end loaders to an access road where the public could gather the firewood. This alteration of the landscape picture, a pentimento delivered to restore an earlier composition, gives the viewer a potent work.

Restoring the structure—a different picture emerges

To understand a complex work of composite images on a canvas hanging in a gallery, or on treatment sites established on the land, the viewer finds it helpful to explore individual elements.

The Plants

Although plot-level species richness is suppressed, site-level richness is similar between control and treated sites.

Restoration treatments altered the bosque. Before treatments, sites had dense stands of non-native trees, dead branches, and little bare ground. After treatment, sites had gaps between the understory plants. Bosque sites needing treatment had fuels ranging from 160–200 tons per acre. The scientists determined that 5–30 tons of fuel per acre, depending on type and depth of fuel, would need to be treated to reduce the risk of fire. The treatments the team applied created this aspect in the new picture of the plant community: invasive woody plants were reduced. Mulch, created by chipping the destroyed exotic plants on-site and applied to some treatment areas, made it difficult for the unwanted herbaceous plants to regrow. Deep mulch was the most effective at this. Downsides to mulch were that it suppressed growth of native plants, not just invasive plants, and could carry a fire.

The scientists evaluated the resprouting rates of 837 stems of the non-native woody species they had cut on the treated sites, and found the overall rate was 16%. Resprout rate was highest for Siberian elm at 50%, and lowest for Russian olive at 3%. Tamarisk and mulberry each had resprout rates of 18%. The scientists found Siberian elm was the least sensitive to treatments and should receive more intensive removal efforts.

The scientists also found that 60%–100% of their transplants survived at the treatment sites. The highest number of plant deaths was skunkbrush in the North block at 40%, mesquite transplants in the Middle block at 30%, and wolfberry in the South block at 8%. The main cause of death for all species appeared to be drought stress and drying.

Treatments were successful in reducing invasive woody plants and in decreasing fuel loads. This, the scientists believe, will save desirable trees from burning as would happen in a fuel-loaded landscape consumed by fire.

On treatment sites, people and equipment compacted soils.

The Soil

Trucks, equipment, and humans can compact soils during the removal of unwanted plants. Clays and silty soils are more easily compacted than sandy soils, and wet more than dry. Changes on treatment sites in the Bosque, the scientists found, were usually increases in soil compaction and less soil moisture after treatment.

The Reptiles and Amphibians

Herpetologists on Finch's team did not have a picture of the reptile and amphibian members before settlement. The scientists knew reptiles and amphibians are an important part of the native, undisturbed cottonwood forest both as food and as feeders. To understand the current picture, the team monitored populations, before and after restoration treatments, using trapping and mark-recapture techniques. Because of their low turnout at capture locations, snakes and amphibians were not marked. What the scientists found was a plethora of lizards—85% of the over 16,000 captures—and because of this, the scientists used only the six most common lizard species in their analyses.

Most of the species captured, they found, are typically associated with desert grasslands, shrublands, and arroyos—upland habitats. Four common lizard species increased in numbers after restoration, possibly owing to fewer trees and less downed wood, a restored bosque that

Chihuan Spotted Lizard.

resembles the preferred habitats of those species. These lizards may use the bosque for food since riparian areas typically have higher plant and animal diversity than upland habitats. None of the lizard species in New Mexico are true riparian species, nor are they strongly dependent on wet habitats typically found in riparian areas. The scientists saw a different picture with amphibians. After flooding in the summer of 2005, scientists captured at flooded sites 45 times as many toads as in any other season since the project began. Observing that for some amphibian species, their life cycles benefit from temporary pools, Finch's team considered these changes in amphibian abundance might be due to factors other than the team's efforts. Natural cycles of rain and water, inundation and pooling could give a boost. "Amphibian species would benefit from land managers incorporating spring flood events as part of their restoration efforts," team member Heather Bateman, a postdoc with Finch, offers.

Reducing canopy clutter revealed bats liked it better.

The Bats

Despite their importance in ecosystems as the primary nocturnal feeders on insects, bats have received little attention by researchers or managers. Using Anabat detection systems, the scientists monitored three stations that they sometimes placed in deep brush and dense stands of trees. As bat activity varies from night to night, depending on weather, moon phase, insect activity, and other factors, the team monitored the sites simultaneously, from June through August, starting at 15 minutes past official sunset and continuing for the next 4½ hours.

In assessing the responses of these study subjects, the team's bat expert, Alice Chung-MacCoubrey, determined that when it comes to the post-treatment landscape, bats like it better. They found the lesser the canopy cover the greater the levels of bat activity. Lower levels of canopy cover meant less cluttered sites, which allowed bat species with a wider variety of flight styles to use these areas. Fast-flying species such as the Mexican free-tailed bat could use the more open sites, whereas denser, more cluttered sites might only be accessible to more maneuverable species such as the Arizona myotis.

Counting on the birds to reveal their preferences required monitoring of different species, sites, and habitats.

The Birds

Partners in Flight (PIF), a national consortium of government and private groups that support bird conservation, ranks numerous neotropical migratory bird species as management priorities. Because of these goals, New Mexico PIF considers restoration of riparian habitats essential. In the bosque landscape, Finch and her colleagues looked at bird species of four nesting types: ground shrub, mid-story, canopy, and cavity. They began by counting birds, seen or heard, at eight count stations situated at roughly one per 6 acres. They sampled each count station around five times per season, every other week during each breeding season. Because the majority of birds detected were singing males, the scientists assumed the densities they estimated were less than actual numbers. Observers detected 132 bird species over the duration of the study while measuring the effects of treatment type (control versus experimental), and phase of study (pre-treatment versus post-treatment) on the birds. The scientists then selected six species they had detected a sufficient number of times to measure annual densities. These common species were Black-chinned Hummingbird, Mourning Dove, Ash-throated Flycatcher, Bewick's Wren, Black-headed Grosbeak, and Spotted Towhee.

Finch and her team saw various elements emerge in the reworked landscape. Removal of invasive plants in the understory did not immediately affect cavity-nesters, nor did removal noticeably benefit them: the trunks of non-native trees have circumferences that are too small for cavities. The scientists speculate that in the long term though, removing exotic trees may benefit cavity nesters by reducing the competition native cavity-producing trees face, and allowing native trees to thrive. Removal of invasive plants also seemed to have little impact on canopy-nesting birds, though the researchers thought tree dwellers would respond positively to less plant clutter, as the bats had. Removing invasive plants had the greatest impact on species that use the lower two-thirds of the vertical habitat, and the numbers of Black-chinned Hummingbird, Mourning Dove, Black-headed Grosbeak (mid-story nesters), and Spotted Towhee (ground shrub nesters) declined. The pre-treatment scene of the study sites contained Tamarisk and Russian olive, small trees growing lush in the mid-story. Removing these two invasive plant species reduced nesting and foraging opportunities for birds that use this area of habitat.

When planning treatments, land managers should consider the parts as they look at the full picture. Removal of exotic woody plants on the basis of fire risk is warranted along traffic corridors and human population centers, Finch offers. Removal of these species will also reduce the risk of fire that destroys cottonwoods and other native trees that offer nest, hole and roost sites, and food resources to birds and bats. Averting fire that promotes the spread of non-native plants will help preserve native plants. To ease the transition for some bird, animal, amphibian, and reptile species, Finch encourages land managers to include replanting with native shrubs to replace the non-native plants cleared from the lower and mid-understory. By considering Finch's understanding of restoration techniques for the riparian cottonwood forest, land managers can rework the composition of forms and features we have made on our landscape scene. A more fitting picture gives us a new appreciation of the landscape before us.

Management Implications

- To retain the full diversity of a wide range of species and to reduce effects on sensitive and endangered species in sites with cottonwood overstories, replant with native woody plants in restored sites.
- 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.
- Where removal of invasive plants is necessary to reduce fire risk, stage treatments over a period of years and in small patches to allow animals to adapt to habitat changes over time.
- Treatments should be scheduled during the non-breeding season of birds and reptiles and amphibians whenever possible.
- Plan restoration activities during the dry season to avoid compacting soils. If treatments must be made during the summer monsoon and winter rainy seasons, set a wait period following rain to avoid compacting soils.
- If sites are at risk of wildfire, select and restore sites with high fuel loads that are close to urban areas first.

Further Information: Publications and Web Resources

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Scientist Profile

Deborah M. Finch is Supervisory Research Wildlife Biologist, Leader of the Middle Rio Grande Ecosystem Management Research Unit, and Director's Representative of the Albuquerque, New Mexico Office of the USDA Forest Service's Rocky Mountain Research Station. Finch has research interests in restoration of river and grassland ecosystems and associated native species, management of invasive species, and understanding the effects of wildfire, fuel management practices, and habitat restoration on native plants and animals.

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Manager's Viewpoint
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Bosque Restoration: A Manager's Perspective

Written By: Lara Durán

Purpose of this opinion piece
Manager's Viewpoint is an opinion piece written by a fire or land manager based on information in a JFSP final report and other supporting documents. This is our way of helping managers interpret science findings. If readers have differing viewpoints, we encourage further dialogue through additional opinions. Please contact Tim Swedberg to submit input (timothy_swedberg@nifc.blm.gov). Our intent is to start conversations about what works and what doesn't.

Background
Southwestern riparian habitats are sensitive ecosystems subject to a variety of ecological problems. Exotic invasive plants are replacing native plants and cottonwoods and increasing fire frequency, rate of spread, and severity, especially along regulated and flood-suppressed rivers. Water regulation and flood suppression allows for the unnatural build-up of surface fuels and exotic woody invasive plants, and causes flood-adapted native plants to decline. This fuel build-up increases fire risk, and threatens native plants, bats, birds, reptiles, and amphibians, who are not adapted to fire and cannot respond or regenerate. Loss of native plants to exotic invasive species and uncharacteristic fire not only degrades habitat, but also threatens bank stability and hydrologic function.

Techniques used to eliminate exotic woody plants, reduce fire frequency, increase native plants, and benefit native wildlife species are sorely needed. Techniques are additionally needed to reduce fire hazard to adjacent wildland urban interfaces, reduce fire severity, and lower suppression costs. Lastly, the effects of the proposed treatments on abiotic riparian factors, native flora and fauna, especially listed species, are unknown.

Applications by Land Managers
This extensive and in-depth study provides southwestern riparian land managers with a plethora of urgently needed data and recommendations to reduce fuel loads, fire hazard, and maintain or improve wildlife habitat and riparian integrity. The problems with exotic woody species along Southwestern riparian corridors were well documented and discussed. Native tree species inhabiting the middle Rio Grande such as Rio Grande cottonwood (Populus deltoids subsp. wislizeni) and Fremont cottonwood (P. fremontii) are not fire-adapted and thus cannot resist fire damage or respond with regenerative resilience to fires (Busch 1995). Few studies, however, were conducted prior to this, and none as extensive. The success of this project is not only attested to in the results, but also in the exhaustive partnerships that were required and created to pull it off. The research project clearly demonstrated the reality of the complexities surrounding fuel reduction and restoration of riparian habitats in the southwest as it stresses the

importance of the partnerships of many land management agencies due to the intermingled jurisdictions that are likely to exist.

The prescription and details about the use of prescribed fire will be very useful for managers wanting to replicate the study and effects. Few research studies provide these kinds of details, which are extremely important to land managers who want to use prescribed fire, but need to find the right burning conditions for complex situations.

Most managers will probably desire further explanation and detail about the mechanical fuel reduction prescriptions and methods used. More information about the tools used, the desired vegetation structure, and resulting conditions would be very useful to understand the extent of the treatment. This is especially the case for any studies that implement chipping or mastication as a biomass treatment, because managers are pressured to use these tools for economic reasons, yet very few scientific studies have documented the effects from different depths and spread covers.

Fire and fuels managers will be very interested to know which, if any, of these treatments would be the most effective for managing the fuels themselves. In addition, managers need to know the period of time these treatments would be effective and approximately when maintenance treatments would be recommended. Greater discussion about the effects of weather conditions and the resulting threat of fire to species of concern and their habitat is needed.

Access to Data and Technology Transfer

The study captured a variety of information about the effects of treatment to bats, herpetofauna, and Neotropical migratory birds and other resource areas. Through the JFSP website managers have access to the majority of data that was compiled during the study which should be beneficial to future planning and research efforts.

- Response of groundwater levels and temperatures to mechanical removal of invasive plants
- Response of riparian vegetation to mechanical removal of invasive plants, RMRS Middle Rio Grande Fuels Reduction Study (FRS): progress to date
- Bosque restoration effects on bats and herpetofauna and Part 2
- Bird species and densities in relation to fuel removal treatments

Additionally a technical report is available that captures impacts to bird populations from various fuel treatments.

- Finch, Deborah M. Finch, and D. Hawksworth. 2006. Monitoring Bird Populations in Relation to Fuel Loads and Fuel Treatments in Riparian Woodlands with Tamarisk and Russian Olive Understories. USDA Forest Service Proceedings RMRS-P-42CD.

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She earned a BA in Ecology from the University of Colorado at Boulder where she earned a National Science Foundation grant for undergraduate research in alpine plant development. She was a Wildlife and Plant Ecology Research Assistant at the University of Colorado, contributing to long-term studies on ponderosa pine, Abert squirrels, dwarf mistletoe, elk, American marten, and yucca plants. Since then, she's completed graduate courses in wildlife and plant ecology, law, and administration. She is interested in disturbance ecology and the effects to wildlife.

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