Rocky Mountain Research Station

Rocky Mountain Riparian Digest

Chief Kimbell and Forest Service Priorities

Libby Creek, Wyoming creates a riparian zone in Medicine Bow National Forest. By permission M. D. Marcus. Inset: USDA Forest Service Chief Gail Kimbell. By permission USDA FS.

USDA Forest Service Chief Gail Kimbell speaks with enthusiasm when she talks about the environmental and recreational importance of our nation's forests. In her presentations to scientists, journalists, and stakeholders, she focuses their attention on sustainable forest management and three Forest Service priorities: climate change, water, and reconnecting people with nature.

Without directly mentioning riparian areas, the greenbelts of vegetation that follow the paths of rivers and streams, Kimbell is also making others aware of the effects of climate change, water quality and availability, and conservation attitudes on these vitally important habitats. Kimbell tells her audience that we are already seeing the effects of climate change on our forests and the riparian habitats contained within them.

One result of warmer winters is less snow and snowmelt water the following spring. Elevated temperatures, that allow both native and invasive insects to survive through the winter months, are another outcome of unseasonably warm winters. These weather-related changes kill trees and provide the fuel that increases the frequency and intensity of forest fires.

This lethal combination–invasive plants, dead trees, and intense fires–makes riparian habitats less able to retain and purify runoff water, provide shade to the adjoining rivers and streams, and support diverse plant and animal communities. Therefore, climate-related changes not only damage riparian habitats but also impair their ability to replenish and purify our fresh water supplies and support diverse native plant and animal communities.

In the Rocky Mountain Region, which includes many semi-arid and arid zones, water availability and water quality is of utmost importance. Riparian ecosystems occupy less than two percent of the total western landscape. However, riparian areas contribute water and other resources to more than 50 percent of regional wildlife species and play a significant role in meeting the freshwater needs of people who live in or near arid and semi-arid environments.

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Protecting Our Riparian Habitats: The Big Picture

As Forest Service Chief Gail Kimbell often states, "Water issues, climate change, and the loss of a connection to nature, especially for kids," are Forest Service priorities. Creating and conserving sustainable riparian habitats is an important aspect of meeting these challenges.

The term "riparian," derived from the Latin word "ripa," or riverbank, refers to the land on either side of any body of water. The "green strips" of vegetation that follow the paths of rivers and streams are perhaps the best examples of what scientists, land managers, and foresters call riparian habitats. While it is sometimes difficult to notice riparian habitats from the ground, it is easy to see them in high-altitude photographs. Most scientists consider riparian habitats as "transitional" zones between aquatic and terrestrial ecosystems.

Riparian habitats are environmentally important because they link water ecosystems to adjoining terrestrial ecosystems such as forests and grasslands. Riparian areas facilitate the movement of nutrients, yet at the same time slow the transfer of materials such as sediment between water and the land. These areas are also the principle source of the woody debris that helps stabilize stream channels and provides protective habitats for aquatic invertebrates and fish.

In the mountainous western US, most riparian habitats extend many miles along the uninterrupted length of narrow streams and rivers. While western riparian zones may be no more than a few feet wide, low-elevation midwestern and eastern riparian areas are often many miles from side to side.

Subtle interactions between water and the land produce riparian zones. Because of the intimate relationship between water and land, riparian habitats are sensitive indicators of natural and man-made disturbances to the water, land, and to the entire riparian water supply system, or watershed. This inherent sensitivity allows the Forest Service to use riparian habitats as indicators of entire watershed conditions.

Factors such as local climate, water flow, and nutrient supply create unique riparian habitats. In addition to these factors, Forest Service researchers have identified other features, such as distinctive soil characteristics, that help riparian zones protect and replenish water supplies and support diverse plant and wildlife communities.

Effective forest management includes the riparian areas within larger forest habitats. To make this process more efficient, the Forest Service is developing a set of riparian classification and monitoring practices. Forest Service researchers will use these standardized methods to record and evaluate local, regional, and national riparian habitat characteristics.

According to a recent National Research Council review article, riparian areas perform three categories of essential and intertwined ecological functions. Perhaps the most important category involves the storage of surface and subsurface water and the subsequent trapping of soil sediments. The storage and slow release of water into streams reduces the potential for downstream damage such as streambank erosion caused by heavy rain, snowmelt, and other causes of flooding. The slow release of water also sustains aquatic habitats during drier periods such as those that often occur during the late summer and early fall.

Related to the storage of surface and subsurface water is the trapping

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Riparian habitats link water ecosystems to adjoining forests and grasslands. By permission Janet Yagoda Shagam, PhD, Rhizotech, Albuquerque, NM.

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Reconnecting people with nature is another Forest Service priority area. Taking the lead from former Forest Chief Bosworth, Kimbell is an active proponent of the More Kids in the Woods program that funds meaningful "hands-on" outdoor activities for children. The goals of this program are to get children outdoors and to cultivate the next generation of conservation leadership.

The Rocky Mountain Research Station is already addressing Forest Service priorities. Scientists throughout the Station are actively engaged in research that ranges from large-scale riparian threat assessments to determining the biological indicators of successful riparian restoration and management practices.

The Rocky Mountain Research Station is also doing its part to get more children outdoors and connected to nature. Recently, two RMRS More Kids in the Woods proposals received Forest Service funding. These are the American Indian Math and Science Camp held at Flathead Lake, Montana and a field day at the Sevilleta National Wildlife Refuge, in Socorro County, New Mexico. Nationwide, 24 projects, out of 250 submitted proposals, received funding in 2007. ■

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and storage of sediment. Preventing sediments from reaching aquatic environments both reduces erosion and water turbidity and preserves sustainable habitats for fish and other aquatic animals.

The second category of riparian activity is preventing contaminants, such as the fertilizer sometimes contained in runoff water, from entering and polluting the adjoining river or stream. Slowing the flow of runoff water allows for purification within riparian soils. This biological remediation reduces the need for more expensive remediation tactics.

The third critical category of riparian activity concerns the support of aquatic and terrestrial habitat diversity. Numerous bird and fish species are dependent on riparian habitats for entire or significant portions of their life cycles. In addition to animals, many species of amphibians, reptiles, and arthropods – the aquatic insects that birds and fish eat – require healthy riparian habitats to complete their life cycles.

Riparian habitats have a direct and significant effect on both the production and quality of our fresh water supplies. National Forest System (NFS) lands contribute nearly 20 percent of the nation's water supply. In the relatively arid western states, NFS lands produce over 50 percent of the region's water supply. The total economic value of high-quality fresh water flowing from NFS lands exceeds $7.2 billion annually. The long-term sustainability of this important economic and recreational resource depends on attentive monitoring and ongoing restoration and conservation efforts.

Nearly 75 percent of our nation's outdoor recreation – including fishing, hiking, and viewing wildlife – takes place within one-quarter mile of streams or other bodies of water. Each year, more than 46 million people visit the National Forests to fish. Supporting fishing interests, while producing over $2 billion in expenditures, also provides 51,000 jobs and generates more than $264 million in federal taxes. As Forest Service Chief Kimbell often mentions, establishing personal connections to our nation's forests helps us appreciate their biological and aesthetic importance and encourages conservancy.

The ultimate effects of climate variability on riparian habitats and their associated NFS watersheds are largely unknown at this time. In some parts of the United States, changes in regional weather patterns may influence the frequency, severity, and duration of drought and other extreme weather events such as hurricanes and tornadoes. In other parts of the nation, regional climate change may affect the timing, and the amount of rain or snow. Ultimately, modifications in precipitation patterns may cause a spectrum of damaging effects. This makes protecting riparian habitats and their associated watersheds currently at-risk for events such as fire and floods especially important. In the long term, climate change may reduce riparian water quality, diminish riparian plant, animal, and fish diversity, and lower the economic value and quality of life that riparian habitats provide. ■

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Social and Economic Value of Riparian Environments

Riparian areas commonly represent only a small percentage of a landscape, but typically are more structurally diverse and more productive in plant and animal biomass than adjacent upland areas. Yet, this small percentage of land area provides many benefits to society. These benefits, however, are not generally accounted for in market transactions. One exception to this appears to be private property values. Studies in both Arizona and Oregon found that proximity to a stream corridor increased the value of vacant land in residential areas by as much as 10 to 27 percent.

Economic valuation of riparian ecosystems is complicated by the fact that these areas are characterized by multiple and intertwined ecological roles that provide benefits to society known as ecosystem services. For example, riparian vegetation both provides habitat for fish and birds and helps capture sediments. A review of published research on the valuation of freshwater ecosystems from 1971 to 1997 (30 studies) found that most studies focused on a specific indicator of water quality such as water clarity. While these studies have demonstrated that these ecosystems have value, particularly non-use value, they only provide partial benefit estimates because they are based on an incomplete list of potentially important ecosystem services.

One group of riparian nonmarket ecosystem services is related to wildlife and fish habitat. Riparian areas supply food, cover, and water for a broad diversity of animals, and serve as migration routes and forest connectors between habitats for a variety of wildlife, particularly ungulates and birds. Riparian ecosystems generally are characterized by increased structural diversity of vegetation compared to surrounding plant communities. In addition, their linear shape gives riparian zones a lengthy edge with adjacent plant communities. Both structural diversity and edge are important wildlife habitat characteristics. In the arid Southwest, riparian habitats support higher species richness and densities of wildlife than any other desert habitat. Riparian areas of western rangelands provide food, water, shade, and cover for fish and wildlife. Recreation is only one aspect of the value of wildlife and fish, but it alone is substantial. More than half of all US adults hunt, fish, birdwatch, or photograph wildlife. US fishing-

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related expenditures alone totaled more than $37 billion in 1996.

In addition to providing wildlife habitat, riparian areas provide other very valuable ecosystem services as well. Riparian (streamside) forests act as "living filters" that intercept and absorb sediments, and store and transform excess nutrients and pollutants carried in runoff from adjacent lands. These excess nutrients and pollutants include salts, sediments, organic wastes, pesticides, and other pollutants running into our streams and, ultimately, our drinking water. Riparian areas can reduce the nitrogen concentration in water runoff and floodwater by up to 90 percent and reduce the phosphorous concentration by as much as 50 percent. Excess nitrogen and phosphorous, both substances that compose animal wastes, manufactured fertilizers, and other commonly encountered compounds, promote the overgrowth of algae and undesirable weeds.

The economic worth of these living filters in improving water quality is difficult if not impossible to measure. The fact that the US spends more than $2 billion annually for clean water initiatives is an indicator of the value of clean water.

Another major role of the riparian zone is to dissipate stream energies and decrease the extent of soil erosion associated with high flows. This, in turn, permits sediments to deposit and continue development of the alluvial valley floor. Alluvial riparian zones also function as shallow aquifers that recharge at high flows and drain at low flows. This interaction between surface flows and groundwater storage results in moderation of high flows and enhanced or prolonged base flows. These prolonged base flows are valuable for water use during low flows, such as irrigation, instream flows for fisheries, boating, and delivery to downstream users.

One of the challenges to realizing the values of riparian areas is the loss of functioning riparian areas that has occurred over time. As an illustration of the magnitude, the US Fish and Wildlife Service estimates that 70 percent of the natural riparian communities in the US had been lost by 1981, much of it on private land. On National Forest lands, the Forest Service is responsible for maintaining and enhancing riparian areas. Agency policies protect riparian habitat by restricting timber harvest and prescribed burning within riparian buffers, limiting grazing by domestic animals in riparian areas, improving road stream crossings, limiting construction of new roads adjacent to riparian zones, and removing existing roads that are in or adjacent to riparian areas. Roads and road crossings are often problematic sources of stream sediments.

While restricting vegetation treatments such as timber cutting and prescribed burning in riparian areas and adjacent buffers does protect these areas in the short run, ecologists are beginning to question the wisdom of this policy over the longer term. Studies of disturbance history of forested riparian areas are providing evidence that fires visited riparian zones adjacent to upland, fire-adapted ecosystems. These fires rejuvenated riparian areas by reducing less diverse coniferous vegetation and promoting more ecologically diverse deciduous vegetation, such as willows and cottonwood. Periodic fire or disturbances that mimic fire may be needed to maintain the vitality of riparian habitats in the long run. ■

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A City of Albuquerque Waste Water Treatment Center technician testing outflow water to the Rio Grande. By permission Janet Yagoda Shagam, PhD, RhizoTech, Albuquerque, New Mexico.

The fact that the US spends more than $2 billion annually for clean water initiatives is an indicator of the value of clean water.

- **Brinson, M.M., B.L. Swift, R.C. Plantico, and J.S. Barclay. 1981. "Riparian ecosystems: Their ecology and status." US Fish and Wildlife Service Report, OBS-81/17.**
- **Manci, K.M. 1989. "Riparian ecosystem creation and restoration: A literature summary." US Fish and Wildlife Service Biological Report, 89(20):1-59.**
- **Netusi, N.R. 2006. "Economic valuation of riparian corridors and upland wildlife habitat in an urban watershed." *Journal of Contemporary Water Research & Education,* 134: 39-45.**

Climate Change, Riparian Sustainability, and the Great Basin Ecosystem Management Research Unit

Climate change, often a front-page news item, is a phrase easier to say than to define. Few are aware of the far-reaching temporal and spatial considerations associated with that term.

Many people have the impression that climate change is a new phenomenon caused entirely by human activities such as burning fossil fuels. While it is true the human footprint makes the "climate pendulum" swing further and faster, it is becoming increasingly clear that the combined effects of historic and recent climate change processes shape environmental responses to human-influenced and natural disturbances.

Dr Jeanne Chambers, a research ecologist with the Great Basin Ecology Laboratory located in Reno, Nevada defines climate change as "the variation in the Earth's global climate or in regional climates over time." She goes on to say that "Climate change involves alterations in the variability or average state of the atmosphere over durations ranging from decades to millions of years. External forces including variations in sunlight intensity and, more recently, human activities can cause these atmospheric changes."

This year marks the 15th year of funding for the Great Basin Ecosystem Management Project for Restoring and Maintaining Sustainable Riparian Ecosystems (Great Basin EMR Unit). Initiated by the USDA Forest Service Ecosystem Management Projects in 1993, and managed by the RMRS, this interdisciplinary research effort is revealing the complex relationship between long-term climate change patterns and the spectrum of biological and physical factors that influence stream processes and, over the long-term, determine stream and riparian ecosystem sustainability.

In addition to Forest Service funding, the Great Basin EMR Unit receives financial support from the Environmental Protection Agency and the Stream Systems Technology Center, and receives administrative assistance from the University of Nevada – Reno.

The Great Basin, a 200,000 square-mile region comprised mostly of north-west trending mountain ranges, separated by intermountain basins, covers most of Nevada, nearly half of Utah, and portions of California, Idaho, Oregon, and Wyoming. The Great Basin EMR Unit focuses on the small upland watersheds in the central Great Basin that typify the types of watersheds that occur on National Forest lands in the region.

Great Basin riparian zones, encompassing less than two percent of the total landscape, support a rich biodiversity by providing water and habitat for common and endangered plant and animal species and a variety of migrating birds. Great Basin riparian zones also provide forage for livestock, water for municipal and agricultural use, and are popular recreation destinations. Many Great Basin riparian habitats are highly degraded and more than half are in poor ecological condition. Much of the degradation is the outcome of human influences such as livestock grazing, mining, recreation, and valley floor roads.

Great Basin EMR Unit findings reveal that a combination of historic and recent climate change processes also influence riparian ecological conditions and sustainability. According to EMR Unit team leader Chambers, a mid-Holocene drought that occurred more than 2000 years ago continues to affect how Great Basin watersheds and riparian areas react to natural and human disturbances.

In reminiscing about the beginnings of the Great Basin EMR Unit, Chambers says, "We realized that to develop effective management and restoration approaches, we needed to acquire a basic understanding of the factors that cause ongoing Great Basin streambed incision [down cutting] and riparian ecosystem degradation."

Their solution was to take a process-based approach to understanding the biological and physical factors that influence stream

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Mark Your Calendar for this Event!

Save September 9-11, 2008 for the Great Plains Riparian Forest Summit that will take place in Sioux Falls, South Dakota. The summit will explore a range of topics to help participants consider riparian restoration in terms of community and scientific issues. Sessions will include presentations on local politics, funding sources, community outreach, water use and quality, stream hydrology, streambank stabilization, and wildlife damage management.

Sponsored by the USDA National Agroforestry Center, the USDA Natural Resources Conservation Service, and forestry agencies throughout the Plains states, this summit will be of interest to researchers who study Great Plains habitats, planners who manage riparian areas, on-the-ground riparian managers, policy makers involved in conservation-related issues, and the public who may either own or are curious about riparian habitats.

For more summit information, schedule of events, and registration details, please visit:
http://www.unl.edu/nac/Riparian_Summit.htm

incision and ultimately affect riparian sustainability. Chambers describes their strategy by saying, "In many cases we try to develop solutions from a single snapshot when what we really need is something like time-lapsed photography."

Taking a process-based approach required an interdisciplinary team that included paleoecologists, plant ecologists, hydrologists, geomorphologists, and biogeochemists from a variety of government organizations and academic institutions. As Chambers relates, "Communicating with this group of enthusiastic researchers was interesting. Ecologists tend to think in terms of one to 50 years while geomorphologists and the other physical scientists consider relevant time scales as extending beyond hundreds or even thousands of years." As it turned out, their focus on the mid- to late Holocene (last 11,500 years), the post-settlement period (the years since 1860), and the present (the past 10 years) helped the research team dissect the linkages between historic climate change events, current watershed and stream processes, and their combined effects on watersheds and riparian ecosystems.

The first studies conducted by Great Basin EMR Unit researchers reconstructed the vegetation and geomorphic histories of the watersheds. Using carbon-14 to date plant remains and charcoal found in stream embankments and in ancient and modern woodrat middens gave researchers the means to correlate changes in the distribution of plant species to climate-related watershed and stream system alterations.

Active stream incision through a meadow ecosystem in Cottonwood Canyon. By permission Jeanne Chambers, PhD, Great Basin Ecology Laboratory, Reno, Nevada.

Their results show that during the early to mid-Holocene (11,500 to 5500 years ago) the total number of plant species found in woodrat middens remained constant. Later, the cool and wet climate associated with the Neoglacial period (4500 to 2500 years ago) caused a reduction in arid plants and, in mid-to-low elevations, an increase in trees. A severe drought (2500 to 1300 years ago) decreased the number of plant species by more than 50 percent, caused a regional decline in woodland trees and, not unexpectedly, increased the predominance of desert shrub vegetation.

Looking at the effects of comparatively recent climate change events on plant diversity revealed similar patterns. Plant diversity increased during the Medieval Warm Period (1300 to 900 years ago) and reached a peak 550 to 150 years ago during the Little Ice Age — a period characterized by cooler and wetter conditions and the spread of piñon and juniper trees throughout the area.

The most recent period, the past 150 years, shows the plant diversity changes expected with trends toward an increasingly dry climate and the impacts of European settlers on the region. Excessive livestock grazing caused a cascade of environmental disturbances that included expansion of woodlands and invasion of exotic plant species.

Correlating the climate-driven changes in Great Basin riparian plant communities to climate-related watershed geomorphic changes provided the clues that helped Great Basin EMR Unit researchers understand the processes that drive long-term riparian sustainability. The cool and wet Neoglacial period had relatively low hillside erosion and the streams were relatively stable as indicated by analysis of the soil layers deposited on valley floors. The ensuing drought created predominantly arid plant communities and resulted in the movement of fine-textured soils from the hillsides. The net result of hillside erosion was the deposition of sediments on valley floors – to depths of one meter or more – and the expansion of side-valley alluvial fans in the watersheds. As a result, stream systems are sediment limited, and ever since the Post-Neoglacial drought, have a natural tendency to incise.

The most recent episode of streambed incision began about 400 years ago and predates European settlement of the region around 1860. Over the past 150 years, human-caused disturbances, including overgrazing by livestock, water diversions, and especially roads on the valley bottoms, have increased both the rate and magnitude of streambed downcutting. The consequences of ongoing stream incision include isolation of the streams from their floodplains, changes in stream channel pattern and form, and a decrease in water tables. In total, streambed downcutting reduces the amount of water available to support aquatic and riparian ecosystems.

Great Basin EMR Unit researchers are quick to point out that Great Basin watersheds differ in their sensitivity to climate change and natural and

...this interdisciplinary research effort is revealing the complex relationship between long-term climate change patterns and the spectrum of biological and physical factors that influence stream processes...

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human disturbances. While some watersheds are highly sensitive to small disturbances, others maintain a balance between runoff and sediment deposition. Also, within individual watersheds, incision processes are not uniformly distributed along stream channels. The variability in watershed responses to disturbance and the magnitude of the resulting riparian habitat changes indicate that environmental scientists need to base riparian management and restoration practices on an understanding of current biological and physical processes rather than historical conditions.

To meet applied management and restoration needs, Great Basin EMR Unit researchers assessed watershed sensitivity to human influences and natural disturbances by correlating various geologic, geomorphic, and vegetation features with the tendency for streambed downcutting. This ambitious undertaking revealed four watershed sensitivity levels that range from very high to low. The practical outcome of their work is a broadly-applicable assessment tool that can help environmental professionals design site-specific and lasting, rather than stop-gap, riparian management and restoration strategies. ■

■ ***Great Basin riparian ecosystems: Ecology, management and restoration.*** **2004. Edited by Chambers, J.C., and J.A. Miller. Island Press, Washington, D.C. Chambers, JC.**

■ **Chambers, J.C. 2000. "Great Basin Research and Management Project: Restoring and maintaining riparian ecosystem integrity." USDA Forest Service Proceeding, RMRS-P-17.**

Camp Stimulates Kids' Interest in Science

RMRS has joined hands with the Confederated Salish and Kootenai Tribe to promote science and math education for students on the reservation. Each summer, sixth-graders have an opportunity to attend the week-long American Indian Science and Math (AIMS) Camp held at Flathead Lake, Montana, on the reservation. Since 1997, RMRS has co-sponsored the camp through its civil rights funding with Salish-Kootenai College. Corwin Clairmont, vice president of Salish-Kootenai College, is program director, and Dr Elaine Kennedy Sutherland, RMRS Research Biological Scientist, is the Station coordinator. AIMS is part of the USDA Forest Service More Kids in the Woods program. "The camp assists a young person to achieve and do better in his schooling. The camp is free of charge and open to everyone who wants to come. We don't discriminate in terms of grades or behavior," Clairmont said. Seventy students attended the 2007 AIMS Camp.

Sutherland described the camp as "learning by doing" instead of listening to lectures. Campers hike, swim, fish, and learn about plants and animals and their Native American culture. "The tribe has six different stations that the students rotate through," Clairmont said. At the natural resources station, the kids learned to calculate the amount of water going through a canal. They also set up camp in the wilderness and learn preparedness and survival skills. Presenters from Fairchild Air Force Base taught the students how to read maps and use compasses. "We do know we have had several students who have gone on to work in forestry or natural resources," Clairmont said.

Sutherland and Forest Service ecologist Jane Kapler Smith taught the campers about fire behavior. The children learned that oxygen, fuel, and a source of ignition – known as the fire triangle – are necessary for starting a fire. Sutherland demonstrated how fires could ignite and spread by showing them her Match Stick Forest. "I have wooden matches that I place in a board with holes in a grid pattern," she explained. "I demonstrate how fires can ignite more easily if the trees are close together or are on a steep slope."

Sutherland also saw an opportunity to add value to the children's experience by purchasing some equipment for on-the-ground restoration work. "The wildlife manager of the Salish-Kootenai Tribe was restoring some agricultural land to wetland status," Sutherland said. "He needed some plants to place along the edge. It occurred to me that a good project for the kids would be to buy the plants so the kids could place them in the ground. The Forest Service awarded us the funds to buy the plants."

Supervisory Research Biologist Elaine Kennedy Sutherland teaches AIMS campers about fire ecology with her Match Stick Forest. By permission Salish-Kootenai College.

Clairmont said the camp also emphasizes respect among the students. "I think it has helped our community with relations between Indians and non-Indians. We reinforce getting along and we reinforce respect," he said. About a quarter of those who attend are non-native children. Sutherland said she hopes RMRS can apply for funding for the camp again this year. "Many kids live in town and don't get to go camping or out into natural settings," she said. ■

Remote Sensing – An Important Riparian Research Tool

In the mid-19th century, the invention of photography changed our view of the world when cameras attached to kites, carrier pigeons, and hot air balloons allowed people to see the landscape from above without having to climb a mountain. Today, we use a variety of distance, or remote, sensing techniques to retrieve information from afar.

Photographic imagery still plays an important role in helping us understand our environment. However, in addition to photographs of objects, scientists use specialized sensors to detect physical and chemical information such as temperature, water flow, and salinity. Combining and connecting spatial imagery, such as the location of a river, to attributed information, such as river-water temperature, is proving to be a powerful tool in helping us understand riparian habitats.

Remote sensing allows us to collect field data over long time frames and very broad geographic spans, and download it to office or laboratory computers. Ways to gather data from remote locations include sensors attached to weather balloons, airplanes, and satellites, and sensors contained within field instruments such as water-flow gauges and temperature loggers.

Forest Service scientists often use satellite-based sensors to receive data from inaccessible locations such as forest fires or to gather information over large geographical areas such as the Rio Grande valley. These sensors can detect, measure, and record the light energy absorbed by or reflected from specific geographic, geologic, hydrologic, or biological features. Because emitted infrared radiation is a stand-in, or surrogate, measure for heat, scientists use this information to plot differences in temperature over entire lakes, deserts, or tree-covered regions.

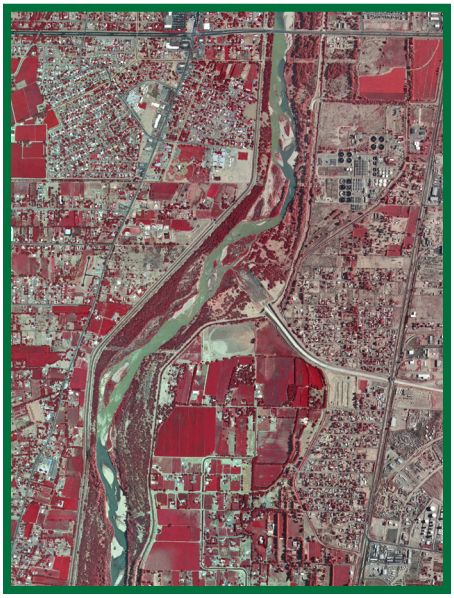
For example, measuring the reflected light associated with plant chlorophyll is a surrogate measure for the number of plants in a given area. Forest Service researchers use remote chlorophyll measurements to assess the tree cover in a riparian zone without having to count trees. Software that combines and maps various data sets makes it possible to correlate the relationship between temperature and tree cover to a particular location and helps reveal the big picture in the context of many small details.

Many Rocky Mountain Riparian Digest articles describe research that takes advantage of various remote sensing technologies such as the Global Positioning (GPS) and Geographic Information (GIS) Systems. GPS is a satellite-based navigation network composed of at least 24 satellites. GPS uses latitude, longitude, and altitude measurements and extremely precise clocks to map the position of stationary objects and track moving subjects. RMRS researchers use GPS for tasks that may range from mapping the location of invasive plant infestations to tracking grazing animals.

A GIS is a computer-based system that connects spatial data, information linked to a physical location, to descriptive data. Using computational methods to associate GPS-mapped locations to descriptive attributes such as temperature, water flow, soil permeability, or plant cover, may reveal information that would be otherwise difficult to see.

RMRS scientists use GIS to assess the effects of roads, weather events, climate change, invasive species, and fire on riparian sustainability. By combining remote-sensing information received from NASA satellites and other sources, they hope to discover the combination of factors that threaten riparian habitats. This makes the GIS a powerful analytical tool to help researchers prioritize risk factors, make realistic threats assessments, and design effective restoration strategies. ■

RMRS researchers use GPS for tasks that may range from mapping the location of invasive plant infestations to tracking grazing animals.



This false-colored infrared image shows areas of vegetation along the Rio Grande and throughout the southern portions of Albuquerque, New Mexico. By permission USDA, Natural Resources Management Gateway.

Remote sensing satellite photographs aren't just for scientists. Anyone who has access to the Internet can download images. Use the links below to see what the earth or your own neighborhood looks like from above:

- **http://earthobservatory.nasa.gov/**
- **http://asterweb.jpl.nasa.gov/index.asp**
- **http://www.loc.gov/rr/geogmap/guide/gmillapa.html**

Early Warning Detection Systems for Threats to Western Riverine Ecosystems

When you think about it, protecting our wildlands from environmental threats such as fire, loss of species, urban development, and homogenization of river dynamics by dams is similar to how we gauge and protect our personal health. We respond to a high cholesterol report by improving our diet and getting more exercise. We measure these and other health-related landmarks because research shows that doing so gives us the opportunity to intervene and frequently prevent medical emergencies.

Responses to environmental events such as floods and fires are often stopgap measures that neither address the source of the problem nor reduce the likelihood of repeated occurrences. Similar to the blood tests that help prevent heart disease, environmental assessment tools provide the ability to predict, detect, and evaluate environmental threats to public and private wildlands.

In 2003, Representative Greg Waldon and Senator Ron Wyden of Oregon presented Congress, the Department of Agriculture, and the Forest Service with a proposal for a comprehensive Environmental Threat Assessment Center (ETAC). What made their plan unique was an emphasis on taking an integrated, rather than a piecemeal, approach to wildlands sustainability.

Two years later, congressional action created two threat assessment centers – the Western Wildland Environmental Threat Assessment Center (WWETAC) in Prineville, Oregon (Pacific Northwest Research Station) and the Eastern Forest Environmental Threat Assessment Center (EFETAC) located in Asheville, North Carolina (Southern Research Station). The Pacific Northwest Research Station, with joint funding from three Forest Service branches – Research and Development, National Forest System, and State and Private Forestry – administers the program.

The ETACs take advantage of new technologies to retrieve and analyze data. Rather than relying predominantly on field studies, ETACs use geospatial and information management methods such as remote sensing and computer-based modeling and decision-making systems to detect, prioritize, and map imminent threats to ecological systems.

Combining remote sensing data with computer-based modeling analysis allows scientists and policymakers to consider the combined and interacting effects of overgrazing and road construction, and many other activities and biological processes, on a variety of site-related sustainability factors such as water quality.

The main focus of the ETACs is to provide researchers, policymakers, and the public with the tools to support well-founded land protection, remediation, and restoration decisions. Having a repertoire of resources will help researchers take advantage of what we already know about western wildlands environmental threats and reveal topics that require further research. This information, available in a user-friendly format, will also support well-founded land management strategies.

The RMRS is taking an active role in developing the riparian portion of the Western Wildland threats assessment program. Dr David Merritt (Stream Systems Technology Center; National Watershed, Fish, and Air Program; Fort Collins, Colorado) and collaborators Dr David Theobald (Warner College of Natural Science, Colorado State University) and John Norman (Research Associate, Warner College, Colorado State University) are constructing an interactive riparian threats assessment map. Dr Dan Neary (Air, Water and Aquatics Science Program; Flagstaff, Arizona), with the assistance of postdoctoral researchers and Northern Arizona University students, is assembling an extensive annotated bibliography.

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Growing New Riparian Researchers

Similar to many other RMRS researchers, Dr Victoria Saab finds time in her busy day to collaborate with university scientists. Saab, a research wildlife biologist with the Wildlife and Terrestrial Ecosystems program in Bozeman, Montana, is also an Ecology Department affiliate at Montana State University (MSU). Saab says her relationship with the Ecology Department is fun because it gives her the chance to discuss papers and "chew over" new ideas with peers and graduate students.

Recently, Saab, an expert on the effects of grazing on plant and animal communities, participated as a thesis co-advisor to MSU graduate student Karen Newlon. With the guidance of her departmental thesis advisor, Professor Jay Rotella, Newlon studied the demography of Lewis's woodpecker at the Pioneer Mountain Ranch (Lava Lake Land and Livestock) located in Butte and Blaine counties, Idaho. The goal of Newlon's research was to identify the grazing management strategy best compatible with local riparian breeding bird communities.

Saab remarks that working with graduate students is yet another benefit of Forest Service scientists collaborating with local universities: "I find the experience personally satisfying because I get to see students bloom as they learn more in their graduate program and I am excited when they discover that their applied research can solve real problems."

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Using geospatial resources such as the National Land Cover Data Set (NLCDS) and US Geological Survey maps, Merritt, Theobald, and Norman are compiling and mapping a spectrum of landcover features that includes satellite views of roads, dams, and other man-made objects, and landscape features, such as mountains and valley floors, that might affect riparian zones adjacent to and influenced by streams and rivers. NLCDS images, with a spatial resolution of 30 meters, also enable us to see cities and smaller communities in the context of the surrounding landscape. The end product will be an interactive map of the western US where users click on a sub-watershed to discover the spectrum of local and distant threats affecting that riparian area.

Theobald compares the Western Riparian Threats Assessment (WRTA) program to a blueprint to help locate threatened riparian zones and describe the causes for and relative degree of threat. In addition to environmental threats such as fire and erosion, the WRTA also takes into consideration how parking lots, housing developments, recreational trails, dams and water diversions, and community demographic features may have immediate or eventual effects on riparian-related issues such as water availability and quality, biodiversity, endangered species, invasive plants, and increased fire risk. And similar to a cost-benefit analysis, the WRTA identifies the riparian sites that are more resistant to human impact. This feature will help community developers balance riparian sustainability with the pressures of community growth.

You can find preliminary information about the Western Riparian Threats Assessment at http://www.nrel.colostate.edu/~davet/wrta.html. Merritt, Theobald, and Norman are aiming for a late spring (2008) launch date for the completed product.

The annotated bibliography makes a perfect complement to the WRTA. Once users identify threatened areas, they can make use of the annotated bibliography to discover what we already know about specific riparian problems. As Neary aptly states, "having a good handle on what research has been done improves our ability to make good land-use and land-management decisions without having to reinvent the wheel."

A draft version of the annotated bibliography is already available on the RMRS website at http://www.rmrs.nau.edu/awa/ripthreatbib/. Here, site visitors can view over 400 references, alphabetized by author, and an accompanying abstract. Covering a span of nearly 70 years of riparian-related research, the bibliography contains information on topics that range from human impacts on Rio Grande Valley riparian ecosystems and the effects of cattle grazing on nesting birds to plant tolerance to increased soil salinity and the stream management strategies used to protect water quality.

Though eager to have this information available to the public, Neary emphasizes that this website is a work in progress. He expects that eventually there will be close to 1000 references and that site visitors will access information either by author or by riparian threat categories such as insects, drought, and water diversions.

The ecological and economic importance of riparian habitats is disproportionately large in comparison to their small landscape footprint. Riparian zones provide water and habitat for plants, fish, and other animals. Western communities depend on functional riparian habitats for ecosystem services such as providing fresh water, recreation, and as a welcomed respite from often hot and dry weather. However, conveying the fundamental roles that rivers and riparian areas play in our lives is a challenging undertaking.

In addition to alteration of natural flow regimes, loss of species diversity, urbanization, over-grazing and invasive species, Merritt also includes

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City of Albuquerque workers removing bosque invasive species. By permission Forest Service RMRS, Albuquerque Lab, New Mexico.

- **Obedzinski, R.A., C.G. Shaw, and D.G. Neary. 2001. "Declining woody vegetation in riparian ecosystems of the western United States." *Western Journal of Applied Forestry,* Vol. 16 (4), pp. 169-181.**
- **Poff, N.L., J.D. Oldern, D.M. Merritt, and D.M. Pepin. April, 3, 2007. "Homogenization of regional river dynamics by dams and global biodiversity implications." Proceedings of the National Academy of Science, Vol. 104 (14) pp. 5732-5737.**
- **Theobald, D.M. 2007. *GIS Concepts and ArcGIS Methods (v9.2).* Conservation Planning Technologies, http://www.consplan.com.**

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a lack of appreciation of rivers by society in his list of significant riparian threats: "People need to see how rivers provide innumerable free ecosystem services that directly affect them. People should also realize that their actions may influence river health as well." Though acknowledging that attitudes are difficult to program into an interactive map, Merritt says, "We can't possibly appreciate or value something that as a society we do not understand. So, perhaps, educating people about the multiple services river and riparian ecosystems provide to human society for free is the easiest way to avoid future threats." ■

Keeping a Watchful Eye on Invasive Plants

The public, as well as the RMRS, can play an important role in helping to protect our riparian habitats from invasive plants. It is important to become familiar with local invasive species so you can recognize them throughout the year. Be sure to report the locations of any invasive plants you might see while visiting a riparian area to your local Forest Service or weed management associations. It is also important to keep all vehicles, pets, and livestock out of weed patches. Seeds attached to tires, vehicle undercarriages, and to animal fur and feet travel! For the same reason, remove any seeds you might see attached to your own shoes and clothing. ■

They look pretty enough, but Bull Thistle is an invasive plant that takes advantage of disturbed conditions such as those caused by forest fires. By permission Peter Landres, PhD.

Middle Rio Grande – Risk, Probability, and Riparian Fires

On June 24, 2003, Albuquerque residents, including the City's mayor, who live along the Rio Grande had to evacuate their homes when an urban forest fire burned out of control. While many people assume forest fires occur more often in rural areas, an ongoing RMRS-funded study shows that close proximity to roads and population centers increases the probability of a fire occurring in a riparian forest.

For the past three years, principle investigator Deborah Finch, PhD (Research Wildlife Biologist, RMRS Albuquerque Laboratory), and colleagues from New Mexico State University and the University of Oklahoma have been investigating burned sites along the middle Rio Grande – from Cochiti Dam to Elephant Butte - to see how plant and animal communities respond to and recover from fire. Recently, they have added another component to their study.

New Mexico State University graduate student, Justin Fitch, is using a Geographic Information System (GIS) to link data that includes such things as the types and numbers of plants and animals and the presence of woody debris to locations along the middle Rio Grande corridor. RMRS hired Fitch through the Student Temporary

...close proximity to roads and population centers increases the probability of a fire occurring in a riparian forest.

Employment Program using Middle Rio Grande Ecosystem Management Research Unit (MRG EMRU) funds. Deborah Finch leads the MRG EMRU. The result of Justin Fitch's efforts will be an easily-interpreted map showing the relative risk that disturbances such as fire impose on specific riparian ecosystem components such as native plants and vertebrates (see map, page 12). The GIS study will also reveal locations within the 254 square kilometer (97 square mile) study site where wildfires are most likely to occur.

Fitch, using GIS data and classification and regression tree (CART) analysis, shows areas of low,

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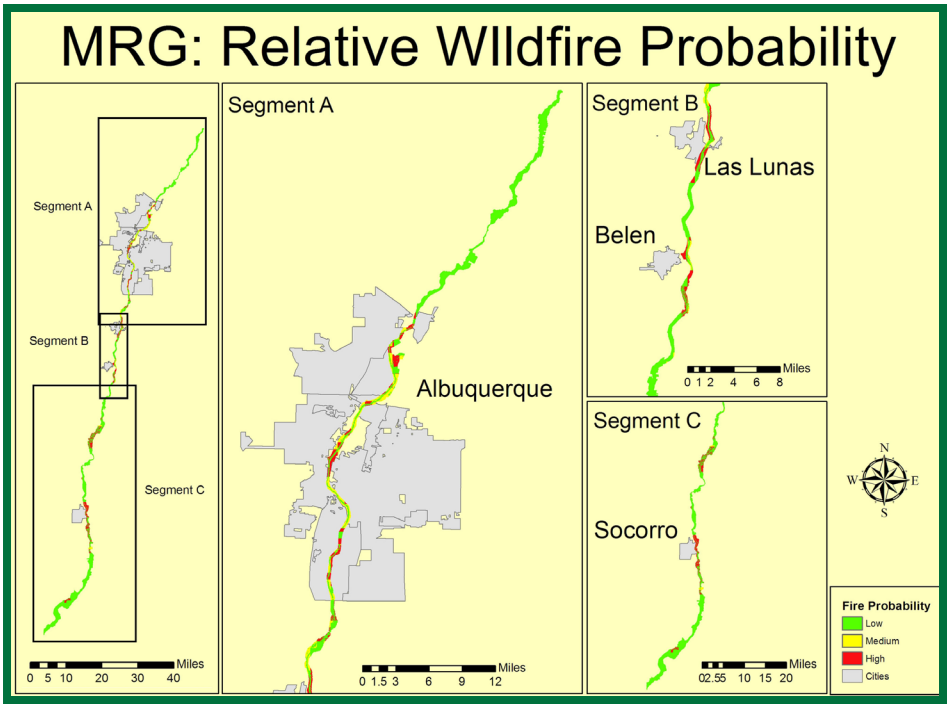
An urban forest fire along the middle Rio Grande. By permission Chief Bobby Halton, Albuquerque Fire Department.



GIS mapping and classification and regression tree analysis (CART) showing relative risk for wildfire along the Middle Rio Grande (MRG). By permission Justin Fitch, New Mexico State University.

Indicator Species in Riparian Areas

The presence of birds and amphibians in a riparian area is a biological sign of ecosystem health. These animals are indicator species because they are among the first groups to show the effects of changes to their habitat, thus indicating the quality of their environment. Dr Vicki Saab and Karen Newlon have studied bird populations, while Dr Steve Corn has monitored amphibians to determine the health of riparian areas in the Intermountain West.

Saab, a Forest Service research wild life biologist, and Newlon, a Montana State University Department of Ecology graduate student, examined the effects of sheep and cattle grazing on birds and vegetation in aspen riparian woodlands. They conducted their study at Lava Lake Ranch in Idaho from 2002 to 2004. One objective of their research was to determine how grazing cattle and sheep affect vegetation in aspen woodlands and how those changes influence breeding birds. Newlon found that measuring the amount of bare ground and woody stems enabled her to best differentiate between cattle- and sheep-grazed sites. Her data showed that cattle-grazed sites had more bare ground, less herbaceous cover, and lower willow and aspen tree densities than sheep-grazed sites. Her findings correlated with fewer birds selecting cattle-grazed areas to nest.

Some species, such as House Wrens, were an exception to the patterns observed in the bird community as a whole. House Wrens were more frequently found in areas grazed by cattle, possibly because they breed in a variety of habitats and often select nest sites with an open understory. Other species followed the pattern for the bird community as a group – Yellow Warblers, Warbling Vireos, Song Sparrows, and Lazuli Buntings. Saab and Newlon believe these birds were more often found in areas grazed by sheep because sheep grazing retained more ground cover than cattle-grazed areas. Lazuli Buntings nest in shrubs, whereas Song Sparrows nest on or near the ground under vegetation that provides cover for their nests. Yellow Warblers and Warbling Vireos nest in the canopy or in shrubs and have higher populations in areas where sheep graze.

Another research objective was to

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medium, and high probability for wildfire along the middle Rio Grande corridor. While CART analysis shows that 77 percent of the study site is of low probability for fire, 23 percent of the area contains medium-to-high fire probability regions. Fitch clarifies these findings by saying, "This map doesn't tell why fires are more likely to occur at one place or another – just that, based on historical data, there is a higher or lower probability for it to happen."

Looking at the map, it is easy to see that most areas of medium and high relative probability for riparian wildfires are located within or near middle Rio Grande cities and towns. It will take further analysis to discover the combination of factors that increase the likelihood that fires may occur here.

Project leader Finch, in describing her pleasure in discovering the level of local interest and cooperation, says, "People do love the river. When they see it unravel, they ask questions and want to know how they can help." Studies such as these both help researchers understand the interplay between environmental disturbances, such as fire, and riparian sustainability and recovery and provide easily accessible information to landowners, environmental organizations, and the public. ■

Dr Vicki Saab has studied the effects of sheep and cattle grazing on birds and vegetation in aspen riparian woodlands. By permission USDA Forest Service.

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evaluate how grazing influenced the reproductive biology of the Lewis's Woodpecker. The Lewis's Woodpecker is unique among woodpecker species because it is an aerial insectivore – it catches insects while in flight. The birds' primary habitats are burned and riparian forests. The birds have high nest success – survival of nestlings – in burned forests because they place their nests in cavities located in stands of dead trees, or "snags." The release of nutrients after a burn results in an abundance of flying insects for the birds to eat. Furthermore, many nest predators such as snakes and small mammals move out of the area after a fire.

Saab said she and Newlon wanted to determine whether the Lewis's Woodpeckers also have high nest success in riparian areas. Like the burned forests, riparian habitats also offer a great abundance of insects for the birds to feast on. Nearly all aspen trees contain fungi that make their wood soft and easy to hollow out. Unlike most woodpeckers, the Lewis's Woodpecker does not have the strong musculature in its head needed for carving nests in hard wood. The birds find it easier to enlarge cavities for nesting in soft aspens as well as in snags. Saab and Newlon found that Lewis's Woodpeckers successfully produced young in riparian aspen woodlands. "Aspen riparian woodlands are rare in the Intermountain West and are valuable in terms of biodiversity relative to other habitats of interior western North America. Ecologists are particularly concerned about riparian woodlands because they are declining and it's not clear why. There are theories that it may be due to climate change or to fire suppression," Saab added.

Saab and Newlon's research helped Lava Lake land managers make informed decisions about cattle and sheep grazing. In addition to the academic significance of Newlon's work, these results supported the management changes that Lava Lake implemented to sustain their riparian holdings. Now, Lava Lake no longer allows cattle to graze in aspen riparian woodlands. Sources of funding for the study include the Rocky Mountain Research Station, Bureau of Land Management in Idaho, Idaho Department of Fish and Game, Idaho Chapter of the Nature Conservancy, Lava Lake Land and Livestock Company, and the North American Bluebird Society.

Amphibians such as frogs are also indicators of riparian health. Corn, a US Geological Survey research zoologist at the Northern Rocky Mountain Science Center and Aldo Leopold Wilderness Research Institute in Missoula, Montana, and cooperators are monitoring long-term distribution of amphibians in Rocky Mountain National Park (NP), Glacier NP, Yellowstone NP, and Grand Teton NP. According to Corn, frog populations have declined in Rocky Mountain NP and in the southern Rockies because of infection by the fungus, Batrachochytrium dendrobatidis, which appears to kill amphibians. "The fungus seems to be spreading in waves in the tropics – eastern Australia, Central America, and northern South America," he said. The fungus is affecting Mountain Yellow-legged frogs in the Sierra Nevada

Dr Steve Corn is researching why amphibian populations have declined more in Colorado than in regions further north. By permission Erin Muths, USGS.

in California; boreal toads in Colorado, New Mexico, and Wyoming; and Wyoming toads. The fungus has also appeared in Montana, but does not seem to have affected populations in Montana as it has in Colorado.

Corn and colleagues at Idaho State University and the USGS Fort Collins Science Center are studying why frog and toad populations are declining more in Colorado than in northwest Wyoming and Colorado. Corn suggested the species may differ in how they react to the pathogen. Other possible explanations may be that the fungus is more virulent in Colorado than in regions further north, or that climate change is involved.

Warmer temperatures have been hypothesized to promote the growth of the fungus in the tropics. Corn said that climate change will influence conservation of amphibians worldwide. "In the Rockies, amphibian life will be affected by climate change. Amphibians breed when snow melts. Because they are breeding earlier now, they may be exposed to potentially more extreme weather events, such as spring blizzards," Corn explained. When snow pack is reduced, vernal ponds – temporary pools of water created by

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Good Science Makes Good Business Sense

Teaming good business practices with good science is a winning combination at Lava Lake Land and Livestock (Lava Lake) of Hailey, Idaho. Founded by Brian and Kathleen Bean in 1999, this livestock company produces organic, grass-fed lamb in an environmentally conscientious manner.

From the very beginning of their venture, Lava Lake collaborated with the Salmon-Challis and Sawtooth National Forests and the RMRS — as well as other county, state, federal, academic and community organizations — to survey and identify areas in need of restoration within their nearly 850,000-acre operating area.

There are several reasons why riparian habitats were of special interest to Lava Lake and their collaborators: the majority of riparian wildlife species depend on these complex habitats for their survival and because riparian zones are vulnerable to damage from over-use by livestock. In addition, because riparian areas are somewhat moist compared to the surrounding sagebrush uplands, they respond relatively quickly to improved land management.

Overgrazing occurs when too many plant-eating animals such as cows or sheep stay too long in one location. The Lava Lake surveys showed that riparian overgrazing by livestock had caused streambank erosion, and a shift in plant communities towards more grasses, upland vegetation, more invasive plants and fewer willows and sedges. Surveys also showed that a variety of wildlife made their homes along the stream corridors and sagebrush expanses where Lava Lake livestock grazed. Lava Lake, wanting to make the habitat even better for wildlife, consulted with scientists to determine how to increase wildlife diversity while at the same time using these areas for sheep grazing.

Poor land management practices caused streambank incisement–Fish Creek, October 2001. By permission Lava Lake Land and Livestock, Hailey, Idaho.

In 2002, Lava Lake invited Montana State University graduate student Karen Newlon and her Forest Service mentor and thesis co-advisor, Vicky Saab, PhD to survey and study riparian bird populations. In addition to providing needed baseline information to support Lava Lake riparian restoration and conservation efforts, Newlon and Saab's work also helps clarify the relationship between plant and bird diversity and the health of riparian ecosystems. A practical outcome of their research may be the ability to use bird population measurements to evaluate riparian restoration efforts.

Ultimately, preventing overgrazing and the deterioration of riparian habitats requires careful livestock management. Tess O'Sullivan, Lava Lake Manager of Conservation Science Programs, reports that, because of their partnership with the Forest Service, Lava Lake shepherds now use GPS to track nearly 6000 ewes and their lambs as they travel and graze over remote mountain and high desert rangelands.

In 2006, in recognition of their commitment and innovative approach to land stewardship, the Sawtooth National Forest presented Lava Lake with two prestigious Forest Service awards. The Sawtooth National Forest's Award for Conservation Excellence is an annual award given in recognition of land proj-

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snowmelt and spring rains – may not last long enough for tadpoles to metamorphose into frogs. Corn pointed out that climate change is complex and may produce some beneficial effects for northern amphibians that tend to increase their populations in warmer, wetter conditions. "It is difficult to make general statements," he said. For example, wildfires are expected to increase in most climate models, but after large fires in Glacier NP in 2001 and 2003, Columbia Spotted Frogs and Long-toed Salamanders did not decline and boreal toads underwent a brief population explosion. The small, young tadpoles of the Rocky Mountain Tailed Frog, however, did not do well following the fires as their populations were reduced in riparian areas that burned.

A national program – the Amphibian Research and Monitoring Initiative – which the US Geological Survey has funded since 2000, supports the study. The National Park Service supports some of the researchers on the project. "Most of what we're oriented toward is understanding the relation of amphibians to a montane environment and understanding how we can maintain them over a long period of time," Corn said. ■

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ects and programs demonstrating outstanding contributions to conservation excellence. In presenting the award to Lava Lake, Sawtooth supervisor Ruth Monahan stated, "They are very effective at applying the art and science of resource management. All of us have learned from the many projects they have championed. Most importantly, they are good stewards of the public lands where they graze sheep."

Presenter of the first Intermountain Region's Regional Forester awards, Deputy Regional Forester for Resources Jack Troyer had similar words of praise. In presenting the Stewardship Award for Natural Resources to Lava Lake, Troyer stated, "We are very fortunate in this Region to work with a number of outstanding livestock operators. Lava Lake Land and Livestock is a true leader, exemplifying ecological sensitivity in their livestock management operations as well as conservation and restoration of rangeland ecosystems. They are creative, innovative, heavily involved in research, they value and seek out the human dimension as it relates to their operations, and are willing cooperators with state and federal agencies."

Fish Creek shows the effects of good management practices – September 2003. By permission Lava Lake Land and Livestock, Hailey, Idaho.

Lava Lake is committed to continuing their relationship with scientific researchers and to riparian conservation and protection. One example of this is the Lava Lake Conservation Research Fund. Established in 2004 by the Lava Lake Foundation for Science and Conservation, the fund supports research by graduate students, university researchers, and independent scientists on topics that will have a direct and positive conservation impact on sagebrush steppe and montane ecosystems in the West. "Our goal," says Tess O'Sullivan, "is that each scientist's work will build on the research that was done in prior years. Newlon and Saab have the distinct honor of having been our first research team. We hope many scientists will continue the tradition." ■

RMRS Exhibits Research at Bosque del Apache

Each November, thousands of wintering sandhill cranes flock to Bosque del Apache National Wildlife Refuge – a cottonwood riparian forest along the Rio Grande – near Socorro, New Mexico. During the 2007 Festival of the Cranes, which attracted birdwatchers from across the US, RMRS showcased their study of wildfires and wildlife habitat at a poster session at the Refuge Visitor Center. "Most of our Rocky Mountain Research Station meetings and outreach tools are to fellow scientists and managers, and consequently, we have fewer opportunities to reach the public than agencies without a research mission. Thus, we look for opportunities like this, piggybacking on Festival of the Cranes, to get the word out to the public," said Deborah Finch, RMRS supervisory wildlife biologist.

Birdwatchers ambled into the visitor center to browse the gift shop and buy bottled water before heading out to the Refuge to view and photograph the cranes and other avian species. A few wandered by the attractively-designed posters displaying color photographs, and paused to learn more about efforts to preserve the area. Representatives from the Forest Service and other agencies welcomed the inquisitive visitors and answered their questions about the bosque, or the riparian forest bordering the Rio Grande.

Since 2000, RMRS has examined the effects of reducing exotic plants such as saltcedar, or tamarisk, and Russian olive, on bird species diversity and their abundance in the middle Rio Grande Valley. Finch and David Hawksworth, Technician, RMRS Albuquerque, presented a poster showing that increases in the amount of combustible wood associated with these exotics has increased risk for riparian fires along the bosque. MRG EMRU, Joint Fire Sciences Program, and other sources fund this research. Hawksworth said the study has evaluated the relationships among groundwater, exotic and native plants, dead wood, and animals. Researchers are conducting their investigation using three blocks of study sites at locations ranging from urban Albuquerque to the Refuge. Each block contains a control site where the bosque receives no treatment and invasive species continue to grow, a controlled burn site, a mulched site, and a fourth site replanted with native vegetation. Finch and Hawksworth's goal is to provide decision support

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information to managers for reducing the risk of bosque wildfires. They also want to preserve cottonwoods and other native plants, control the spread of exotic woody shrubs, and conserve water quality and availability.

Finch and Hawksworth found that fewer mid-story nesting bird species – those that use shrubs for nesting – such as Spotted Towhees and Blue Grosbeaks – remained in the cleared areas. In contrast, clearing did not affect canopy nesters such as Summer Tanagers, Western Wood Pewees, and Cooper's Hawks. A preliminary conclusion of their study is that exotic shrub removal may reduce the risk, severity, and frequency of wildfires in the bosque and thus improve the chances for successful regeneration of cottonwoods and willows. "Once we complete the study, we'll be able to recommend how best to clear invasive plants and have the least negative effect on wildlife," Hawksworth said.

According to another RMRS poster, biologists expect that four out of six lizard species will become more abundant or present in the cleared areas. "Open habitat is generally available in riparian areas not overrun by non-natives and it may simply be that the lizards we studied prefer habitats with areas open to some sunlight. Lizards are ectothermic (cold-blooded) and are inextricably linked to their environment," said RMRS postdoctoral wildlife biologist Heather Bateman. Biologists can use lizards as indicators of changes in their riparian habitats. "By understanding how restoration activities affect wildlife, land managers can balance management objectives, like removing non-native plants, with other considerations, such as providing important wildlife habitat," Bateman added.

Christian Gunning, a graduate student in the University of New Mexico Water Resource Program (WRP), along with WRP Director Bruce Thomson and Finch, presented a poster about their study of groundwater hydrology at Bosque del Apache. RMRS Albuquerque Lab sponsored their work. They examined the river flow and groundwater level and found that groundwater tends to follow the river closely.

RMRS and the University of Oklahoma presented the results of their collaboration on a study of mortality rates and seed production of cottonwoods and saltcedar to determine the effects of wildfire on their populations in the bosque. Their research indicated that saltcedar is better adapted to survive wildfire than cottonwood. Cottonwood had higher mortality rates than saltcedar at most study sites and did not produce seeds until at least six years after a fire. Ultimately, wildfire could promote the spread of the non-native saltcedar in the bosque while reducing the cover of the native cottonwood. "Managers can use our results to understand site differences in saltcedar and cottonwood responses after wildfire, to understand the rapidity of saltcedar succession, and to understand the need, at some burn sites, to take action promptly to prevent saltcedar from returning or invading the site after fire," Finch said. "Managers can also use the information to better understand the need to proactively restore sites through fuel reduction to prevent fires from occurring in the first place."

Visitors who viewed the posters learned a little more about the riparian environment and the research that managers use to protect the bosque. "We'd like people to know we're trying to do something to preserve the birds and other wildlife and their habitat," Hawksworth said. ■

Firefighters battled the bosque fire in Albuquerque in June 2004. By permission USDA Forest Service.

Invasive Plant Species Versus the Rocky Mountain Research Station

They look innocent enough. Some are even pretty - but, without question, the spread of invasive or exotic plants that displace or destroy native species causes costly environmental damage. According to the Forest Service, invasive weeds already cover 133 million acres in the US, and expand their range at the rate of about 1.7 million acres per year. Dr David Pimentel, a Cornell University researcher, reports that invasive species, including invasive animals and pathogens as well as plants, cost the public approximately $137 billion per year.

A combination of biological features helps invasive plants spread and quickly adapt to new habitats. Many invasive plants produce large numbers of seeds that can spread efficiently by wind, water, and animals. In addition to seeds, some invasive plants can establish new plants from roots. This means that pulling weeds or mowing weeds may actually worsen the problem if some of the root mass remains in the soil. Having extensive root systems, that may reach 20

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feet deep or more, makes invasive plants better able to tolerate drought, poor soil, and fire.

In riparian habitats, exotic plants reduce the diversity of plant and animal communities, consume large amounts of water, contribute to increasing soil salinity, and produce the fuel that in combination with the effects of climate change helps increase fire frequency and intensity. These changes also reduce the economic value of riparian habitats by making them less attractive for recreational activities such as hiking, boating, fishing, and bird watching.

RMRS is taking an active role in both preventing the spread of invasive plants to riparian habitats and managing invasive plants in areas of established growth. In the West, watershed headwaters are often located within National Forest wilderness areas. Therefore, monitoring and managing exotic plants upstream is an effective way to prevent their spread throughout the watershed and the adjoining riparian habitats.

Dr Peter Landres, a Leopold Institute research ecologist, monitors wilderness areas for invasive plants. With the help of contracted research technicians from the University of Montana, Landres uses GIS mapping to locate areas that contain invasive plants. This information helps Landres and other RMRS scientists learn how invasive plants spread, as well as identify locations that require remediation.

Much to everyone's surprise, Canada thistle, a plant that commonly invades disturbed areas such as those found by roadsides and pastures and croplands, is invading the Anaconda-Pintler Wilderness located in southwestern Montana. Research Technician Courtney Hall wonders if elk, in the process of wandering the many miles that separate disturbed logging areas from backcountry streams, are transporting seed on their hooves and coat. While an intriguing idea, research is necessary to determine if this hypothesis has merit.

A lack of natural enemies is one of many factors that help invasive plants overrun new habitats. Therefore, outsmarting invasive plants is another tactic scientists use to control their spread. Dr Jack Butler, a RMRS research ecologist located in Rapid City, South Dakota, studies the ability of black and brown flea beetles – imported natural enemies – to control the spread of leafy spurge in the Great Northern Plains.

In addition to a semi-arid continental climate with long cold winters and a variable summer season, the Great Northern Plains also includes upland drainage systems and ephemeral streams. In the course of looking at ways to restore riparian vegetation following successful spurge control, Butler found that the establishment of black flea beetles, more so than brown flea beetles, occurred on a wide variety of grassland and shrubland sites. Butler says that while black flea beetles are an effective management strategy for Great Northern Plains ephemeral streams, this might not be the case for the shaded riparian forest habitats, especially sites with sandy soils. His statement points to the importance of understanding the interplay of subtle riparian habitat characteristics before attempting invasive plant management or remediation.

Black flea beetles eat leafy spurge leaves and reduce leafy spurge dominance under a variety of field conditions. By permission of the Agricultural Research Service and Animal and Plant Health Inspection Service.

Invasive plants also include invasive trees. Examples of invasive trees commonly encountered in Rocky Mountain riparian habitats are the Russian olive, Siberian elm, and the salt cedar or tamarisk. These scrubby trees, in addition to producing dense monocultures, also fuel intense fires.

Salt cedar, prevalent throughout Rocky Mountain riparian habitats, is a notable problem along the Rio Grande where dams prevent seasonal flooding. These trees, in addition to consuming large amounts of water, increase soil salinity. The combination of reduced water and changes in soil chemistry contributes to making these riparian habitats less able to support native plant species.

Salt cedar management practices include treating cut tree stumps with herbicides, aerial herbicide treatments, and bulldozing. However, managing the spread of salt cedar comes with an interesting complication – the endangered Southwestern Willow Flycatcher, a riparian bird that now

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breeds in salt cedar dominated sites.

Many government agencies, including the Forest Service, are working on salt cedar management while also taking into consideration the Southwestern Willow Flycatcher. A recently published Forest Service Proceedings describes a successful project involving monotypic salt cedar infestations along the Rio Grande in Socorro, Sierra, and Doña Ana counties in New Mexico. Using helicopters equipped with GPS units, the Socorro Soil and Water Conservation District made a quarter-mile buffer zone around Southwestern Willow Flycatcher nesting sites. This strategy enabled them to remove salt cedar from nearly 8000 acres while also preserving Southwestern Willow Flycatcher nesting sites.

While eradicating invasive plants might be a desired goal, most agree that, because of the biological features that help invasive plants spread and quickly adapt to new habitats, invasive plant management is a more realistic target. Overall, invasive plant management strategies such as pulling weeds, herbicide treatments, and public education allows the RMRS to maintain healthy riparian habitats at an affordable cost. ■

- **Invasive and Noxious Plants. USDA National Resources Conservation Service. http://plants.usda.gov/java/noxiousDriver. On this site, you can find invasive plant listings by state.**
- **Stowe, Nyleen Troxel. 2006. "Aerial Treatment of Salt Cedar within Threatened and Endangered Species Habitat – A Success Story." USDA Forest Service Proceeding, RMRS-P-42CD.**

Pulling Weeds in Montana's Protected Wilderness Areas

For Laurie Ashley, a Wilderness Institute Program Coordinator at the University of Montana and instructor for the University's Wilderness and Civilization program, environmental stewardship and pulling weeds go hand-in-hand. Each summer, Ashley recruits volunteers to participate in a summer-season Wilderness Institute Citizen Science Program. This program, funded in part by the Aldo Leopold Wilderness Research Institute, exemplifies the benefits of collaborations between citizen groups and RMRS scientists. Peter Landres, an Aldo Leopold Institute research ecologist, is a Wilderness Institute science advisor.

In 2006, 67 citizen volunteers helped map over 1300 weed infestation sites, representing 20 different weed species in four wilderness areas. Before venturing into the wilderness, citizen volunteers receive backcountry travel, noxious weed identification, mapping, and remediation training. Because knowing the location of noxious and invasive plants is important to the Forest Service that manages nearly 3.5 million acres of designated wilderness in Montana, volunteers map plant locations using GIS units and data dictionaries. These data points allow Forest Service researchers to monitor the movement of noxious and invasive plants and identify areas for further observation or remediation studies.

The GIS and GPS information is especially important to Forest Service riparian researchers, as the presence of invasive plants can indicate other ecological stresses such as reductions in natural flooding and over-grazing by livestock. Once established, invasive plants can have far-reaching detrimental effects that may include reductions in plant and animal diversity, streambank and hillside erosion, and impairments in the ability of riparian soils to clean runoff water before it enters an adjoining creek or stream. In a sense, Institute Citizen Scientists are an "on-the ground" early warning system that helps spot threats to riparian and other wilderness area ecosystems.

Once out in the wilderness, program volunteers, in the company of two Wilderness Institute field leaders, focus their attention on finding any of the 27 plants on the Montana noxious plant list as well as many other invasive plant species that tend to overrun disturbed environments. Accord-

In 2006, 67 citizen volunteers used GPS and GIS to map over 1300 weed infestation sites, representing 20 different weed species in four wilderness areas. By permission Laura Ashley, University of Montana.

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ing to Ashley, the predominant riparian culprits are Canada thistle (*Cirsium arvense*), oxeye daisy (*Chrysanthemum leucanthemum*), common tansy (*Tanacetum vulgare*), orange hawkweed (*Hieracium aurantiacum*), tall buttercup (*Ranunculus acris*), bull thistle (*Cirsium vulgare*), and spotted knapweed (*Centaurea maculosa*). With the exception of bull thistle, all are on the Montana noxious weed list.

Ashley reports that many Citizen Science Program participants are University of Montana students, faculty, and staff. However, she also says that many volunteers are truly community citizens.

You can learn more about the Wilderness Institute, the Citizen Science Program, and other institute programs at www.cfc.umt.edu/wi.

Volunteers must be at least 18 years old to participate in the program.

Citizen volunteers spend anywhere from one to six days in the field mapping the locations of noxious and invasive weed infestations. Although volunteers usually do not cover more than six miles a day, these are not leisurely hikes in the woods. "Volunteers put in a hard day's work," Ashley acknowledges.

Remediation often means "pulling weeds." Mindful of not creating conditions that will worsen infestations, volunteers bag and remove any weeds likely to produce and drop seeds, and replant disturbed areas with native seed.

Even though volunteers may balk at pulling weeds in their own yard, exit surveys show that almost 90 percent of program participants are interested in volunteering again. Nearly all of the participants agreed with the survey statement, "The experience made them feel more connected to the Wilderness Area where they worked."

Their responses help us appreciate the long-term importance of Wilderness Institute-sponsored opportunities for the University community and interested citizens alike. In addition to the Citizen Science Program, the Wilderness Institute provides a spectrum of wilderness-related workshops, public lectures, for-credit courses and distance education programs. Without question, these programs demonstrate the Wilderness Institute's commitment to their mission statement–"to further the understanding of wilderness and its stewardship through education, research, and service." ■

Fire and the Healthy Riparian Ecosystem

Cottonwood trees, willows, and Gambel's oak grow in the streambed of Tajique Creek in the Cibola National Forest in the Manzano Mountains near Tajique, New Mexico. But the streambed is dry on this sunny day in October. "This used to be a perennial stream," said Dr Darin Law. "But now it's an ephemeral stream – it only runs part of the year and then dries up."

Law, a postdoctoral range ecologist for RMRS in Albuquerque, is in the Manzano Mountains researching how fire may influence mountain streams. Dr Deborah Finch, supervisory wildlife biologist at RMRS, is co-investigator and is funding the study through the Forest Service's National Fire Plan. "Our hypothesis is that when fires burned on a regular interval, they kept the vegetation and groundwater in balance. Historically, riparian zones and groundwater may have been dependent on fire. If so, that may be one of the reasons that some streams dried up," Law said.

Finch explained how this work will help the Forest Service to better manage the resource. "The value of this research," she said, "is that it identifies factors–burns–and stressors–lack of fire–that influence healthy riparian vegetation and stream ecosystems that can be potentially addressed through management, for example, the use of upland prescribed fire, to restore streams, wildlife, and fish habitat, or endangered species habitats. Riparian ecosystems provide high value to biological diversity, and their loss due to drought, fire suppression, invasive species, etcetera reduces biological diversity and could potentially jeopardize some species. Prolonged drought and global warming may influence these trends, given projections about global warming impact on southwestern environments."

Fires in the area historically were low intensity and low severity, meaning they did not burn at extremely high temperatures or over a long period. Since fire usually occurred every 15 to 25 years in the ponderosa pine zone, not a lot of vegetation accumulated between burns. As a result, the burns were always low severity. "Now that we've eliminated fire, we have thick growth and the woods have become unhealthy, diseased, overgrown, and too thick," Law said. "Prescribed fires have to be very well planned because they potentially can be high in severity and intensity until a more natural fire return interval [low severity and low intensity] is achieved."

According to Law, geology, soils, and climate are factors that also affect groundwater. Non-fractured bedrock can prevent water from seeping into the ground. The texture of soil layers also affects how much water is absorbed. A sandy soil has little water-holding capacity, so the rain percolates through the ground into the water table. Heavier soils hold more moisture. If rain falls on a clay soil, not as much water will seep into the water table.

The loss of vegetation resulting from fire causes erosion and increased

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water runoff. Water is also lost due to runoff during intense summer monsoon rains. "Riparian areas are very dependent on snow. Snow melts slowly and the soil can take in more water than during a monsoon," Law explained. But if the snow sublimates – vaporizes without going to a liquid stage – it evaporates before being absorbed into the ground. With fewer trees and vegetation to serve as wind blocks, wind speeds increase after a burn and cause more evaporation and sublimation. Evaporation also occurs in fire-blackened soils because the black absorbs sunlight and thereby causes the soil to heat more quickly.

At Tajique Creek, Law noticed two dead cottonwoods standing in the streambed. "Are the upland trees removing the water that would have been used by these cottonwoods? We know they are pumping water out of the ground," he commented. Law is investigating and comparing the water tables to each other in three fire-stricken areas – these are the sites of the Sedgwick Fire of 2003, the Tajique Fire that occurred 21 years ago, and an area that has not burned in about 80 years. Most of the growth since the Tajique area burned has been Gambel's oak. The few ponderosa pines that have regenerated are small and about 7 to 10 years old.

Law measured the groundwater at a well he had placed near a willow. "The soil is pretty wet at the bottom of the well, but the water table has dropped since the beginning of the year. The high soil water might be supporting the willow after the groundwater drops," he said. He then clamped a handheld leaf porometer onto a Gambel's oak leaf to measure stomatal conductance – the rate at which water vapor is conducted through tiny pores known as stomates in the plant's leaves. From the conductance and other temperature and humidity measurements, Law calculates the transpiration rate – the amount of water the plant has lost through the leaf. "From the transpiration rate, we can measure the plant's water use efficiency," Law explained. He measured the conductance of five leaves to obtain an average stomatal conductance for the Gambel's oak. "Comparing conductance, transpiration, and water use efficiency of Gambel's oak in the upland with the streambed may help us understand water use that could support riparian vegetation such as the willows and the cottonwoods," he said.

Dr Darin Law uses a leaf porometer to measure the water use efficiency of a Gambel's oak. By permission Helen L. Huntley.

Preliminary results indicate shallower groundwater, or closer to the soil surface, in the most recent burns. Law also measures upland vegetation cover to correlate with water table levels and observes species diversity in the three burn areas. "Sedgwick has the most diversity, Tajique the second most, and the 80-year burn has the least diversity. That is what we expected," he said.

Law enjoys the fieldwork, the statistics, and data analysis in his work. "It's exciting to put the pieces of the puzzle together," he said. "Research helps us better manage our resources. In this line of work, we're not so much trying to improve on Mother Nature as we are trying to understand Mother Nature – to understand why species coexist, why they live where they do, how they relate to their environment – to provide knowledge and understanding to better aid life." ■

Fire, Woody Debris, and the Habitable Stream

Naturally-occurring disturbances such as fire and the accumulation of large wood in stream channels can create healthier streams with a diversity of habitats. However, human interventions such as removing wood from streams and fire suppression can impair the ecosystem. Large woody debris – fallen trees and logs of at least 10 cm in diameter and 2 m in length – are important to the development of habitat for fish and, ultimately, plants and animals along the stream. The number of years between fires in the riparian forest may also influence habitat development. Forest Service Research Biologist Dr Elaine Kennedy Sutherland and Research Fishery Biologist Dr Michael Young (RMRS, Missoula, Montana) are studying how fire and its frequency affect a stream and the habitat it provides.

"From an aquatic perspective, large wood is critical to the organization and complexity of a stream channel," Young said. Large woody debris that falls into the channel slows the movement of the water and allows the deposition of sediment. The wood impedes water flow, thus forming a pool. A waterfall cascades over the wood to a plunge pool below. The complexity of the streambed attracts fish that find the wood a source of shade and refuge from predators. A channel that provides a diversity of habitats can harbor stable and diverse populations of fish. Young pointed out that the size of the wood and the size or amount of sediment also influences the complexity of stream habitat.

Woody debris in a stream can affect habitat for tens or hundreds of years. About one hundred years ago

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in some parts of the intermountain west, railroad builders removed large wood from streams so that the channels could serve as conduits to float railroad ties to construction sites. "Those streams are still recovering," Young said. "When we alter a stream, we affect how it behaves for the foreseeable future as well as for centuries."

Removing large wood is not the only way humans have affected natural ecosystem processes in riparian zones. Young and Sutherland are studying how low- and high-intensity fires affect riparian areas, streambeds, and fish habitat. By analyzing tree rings for fire scars, Sutherland can determine when burns occurred over past centuries. "The pattern of fire and the distribution of large wood is far more complex than previously understood," Sutherland said. "There's much more fire occurring in riparian zones than previously thought. This is an important factor in determining a fire management plan for the entire watershed. The research will help land managers determine the places where fire should be suppressed and locations where burns help restore ecological processes. This information was previously unknown." She pointed out that low-intensity fires might stimulate the growth of shrubs and other understory that can be important wildlife habitat.

Young said that land managers have established buffer zones for logging and have therefore excluded fire in many riparian areas despite the fact that fire can contribute to the overall health of those ecosystems. The goal of Young's research is to determine how fire has influenced stream channels and the habitats those channels provide. The study also gives land managers a plan for monitoring large wood in streams.

Forest Service scientists study how fire influences stream channels and the habitats those channels provide. By permission USDA Forest Service.

Young and Sutherland have been conducting their study since 2001 in twelve 10,000-acre research plots located in the Bitterroot and Lolo National Forests in Montana. Young said the most exciting part of his research is the "Aha!" flashes. "Those moments can happen at the computer or out in the field, but they are few and far between," he added. "I regard our understanding of the natural world as a portrait. I want to leave that portrait for future generations and add color to the artist's palette and add depth of appreciation for what's out there." Sutherland said she wants her work "to add understanding of long-term ecological processes to forest management; it will help fulfill the Forest Service's original directive to do 'the greatest good for the greatest number in the long run.'" She said she saw a career in science as interesting and creative work. "I had the example of my sister who is a microbial geneticist. I've always been interested in the outdoors and trees," she added. Young attributes his career choice to being born with a healthy curiosity. "My parents made sure I spent a lot of time outdoors. Since I was 14, I knew this was what I wanted to do," he said. ■

River wildlife, fish, and habitat facts for the US:

- **Fully 80% of all vertebrate wildlife in the Southwest depends on riparian areas for at least half of their life.**
- **Of the 1200 species listed as threatened or endangered, 50% depend on rivers and streams.**
- **At least 123 freshwater species became extinct during the 20th century. These include 79 invertebrates, 40 fishes, and 4 amphibians. Freshwater animals are disappearing five times faster than land animals.**

Cicadas and the Middle Rio Grande Bosque: Timing is Everything

Just like a memory of a childhood television show, the word "cicada" makes many people hear the theme song associated with the hot and dry southwestern summers. The cicada's music is also a good reminder of the fundamental role these insects play in shaping the ecological character of the Rio Grande riparian habitat.

The Rio Grande, New Mexico's major waterway, extends nearly 2000 miles from Colorado to the Gulf of Mexico. The river, running the full length of the state of New Mexico, passes through high mountainous regions, valleys, and plains. The terms upper, middle, and lower Rio Grande correspond to the northern, central, and southern portions of the river.

The middle Rio Grande region begins at Cochiti Dam, located approximately 50 miles north of Albuquerque, and ends near San Acacia – a small farming community about 50 miles south of Albuquerque. This 100-mile stretch of the river includes high desert range and farmlands, extensive flood plains, numerous state and federal nature preserves, and high-density urban and industrial areas. According to the latest US Census Bureau estimates, over 700,000 people, or close to 35 percent of the population of the entire state of New Mexico, live near or along the middle Rio Grande.

For the past 80 years, there have been ongoing efforts to reduce the flooding that results from spring snowmelts and summer rains in this developed and urbanized stretch of the river. Starting in the 1930s, the combined effects of levees and jetty jacks reduced river water flow velocity – and thereby increased sediment deposition, strengthened river embankments, straightened the river channel, and raised the relative elevation of the floodplain. Since 1973, Cochiti Dam, the tenth-largest earth-filled dam in the United States, has eliminated flooding by controlling the release of water to the river channel. While this change is an improvement for the people who live or farm near the Rio Grande, the loss of cyclic flooding has profound consequences for a riparian ecosystem long adapted to a regime of seasonal flooding.

The riparian area along the middle Rio Grande, called the bosque by locals, was once populated by tall and stately cottonwood (*Populus* spp.) and Gooding's willow (*Salix*) trees. Native understory shrubs include coyote willow (*Salix exigua*), seep willow (*Baccharis glutinosa*), and false indigo (*Amorpha fruiticosa*). Reductions in water flow and soil saturation have killed many mature cottonwoods and have reduced cottonwood reseeding. Reduced water availability has also produced the ecological changes that encourage the growth of drought- and fire-tolerant invasive plant species.

Shrubby trees, such as salt cedar (*Tamarix ramosissma*) and the silver Russian olive (*Elaeagnus angustifolia*), now grow in place of the cottonwoods and willows. These and other drought-resistant plants have replaced a relatively open understory with a dense thicket.

A combination of factors put the bosque at high risk for frequent and intense fires. Some of these risk factors include large amounts of fuel wood from dead and dying cottonwood trees, a dense understory composed of highly flammable plants, and the many people who use the area for hiking, bird watching, and other recreational activities.

The shift from flooding to wildfire, in addition to affecting native riparian species, has caused a cascade of interrelated events that may permanently alter the structure and function of the bosque ecosystem. Deborah Finch, PhD, a RMRS research wildlife biologist with the Albuquerque Laboratory, and associates from the University of Oklahoma are interested in the long-term effects of wildfires on riparian habitats. Their research efforts, in addition to showing how wildfires alter riparian ecosystems, are helping them develop well-founded riparian restoration and management strategies.

Finch and her colleagues, Max Smith (Oklahoma Biological Survey, Department of Zoology, University of Oklahoma) and Jeffrey Kelly (Assistant Professor of Zoology, University of Oklahoma), are taking an interesting approach to this important and complex problem by looking at the relationship between riparian wildfires, cottonwood tree density, and the mid-summer emergence of cicadas.

Cicadas play an important role in shaping the Rio Grande riparian habitat. By permission Max Smith, Oklahoma Biological Survey, University of Oklahoma.

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A combination of MRG EMRU and Forest Service National Fire Plan funds, granted to Finch, supported a research joint venture agreement with the University of Oklahoma to pay for Smith's work.

The middle Rio Grande bosque is home to the cicada *Tibicen dealbatus*. Each year, *T. dealbatus* nymphs, after living three to five years underground, emerge from the soil, transform into winged adults, reproduce, and die a few weeks later. The mid-summer emergence of *T. dealbatus* transports water and nitrogen to aboveground communities and supplies food to secondary consumers such as breeding birds. Research indicates that some riparian birds select their breeding sites based on characteristics associated with large numbers of cicadas.

Smith, at the time a graduate student at the University of Oklahoma, correlated the emergence of cicadas in burned and unburned areas to such factors as soil temperature and vegetation. Expecting that fire might "cook" underground cicada nymphs, Smith was surprised to find that cicadas did emerge from burned sites. He also noticed that cicadas in burned sites emerged earlier in the summer than those living in unburned plots. Further analysis allowed the research team to correlate his observation to reduced shade and increased soil temperature caused by dead or burnt cottonwood trees.

It took another season of fieldwork before Smith could explain why cicadas surfaced from recently burned plots. His big eureka moment came, Smith says, when "I noticed cicadas did not emerge from sites burned more than five years ago. It was then that I realized fire influences the time of emergence and not their time underground."

In fire-burned and artificially-warmed sites, cicadas tended to appear in June and early July rather than mid-July to early August. This few weeks' difference in timing means that nymph emergence no longer coincides with the nesting of Yellow-billed Cuckoos and other riparian birds. Researchers speculate that this change in emergence timing, by affecting the availability of food, may ultimately affect the success of riparian nesting birds.

Cottonwood trees are fundamental to the cicada lifecycle. After mating, female *T. dealbatus* fly into cottonwood trees and slit and insert their eggs into small-diameter branches. A few weeks later, the nymphs hatch, fall to the ground, and burrow into the soil where they feed on tree root sap. In the case of burned trees, researchers believe the nymphs receive nourishment from the roots of resprouting cottonwoods.

Max Smith in the field. By permission Max Smith, University of Oklahoma.

Smith, Kelly, and Finch show the number of emerging cicadas per square meter plot increases with cottonwood tree canopy coverage and decreases with the distance between trees. Their work also shows that approximately 20 meters between trees is the spacing that provides sufficient cicada egg-laying sites and the shade needed to maintain the soil temperature. They estimate that, after a fire, it will take nearly 10 years to reestablish the cottonwood forest.

These findings translate into recommendations for successful bosque land management. In the most general sense, preventing wildfires helps preserve the native riparian habitat and thereby ensures that cicadas emerge at times and densities that benefit the birds and other animals that eat them. It is also important to replace aging cottonwood trees with seedlings and to space them no more than 20 meters apart. When wildfires do occur, as the result of human activity or natural causes, it is essential to restore the cottonwood canopy lost to fire by encouraging the growth of cottonwood resprouts. Failure to encourage cottonwood recovery and regrowth will ultimately lead to the loss of *T. dealbatus* from burned sites. The discovery that the number of cottonwood trees influences both the density and timing of cicada emergence shows the importance of cottonwood trees to maintaining the bosque habitat.

In combination, the levees and dams used to control flooding and the impacts of agriculture and urban development have confined the Rio Grande bosque to narrow bands of riparian forest made up of old and dying cottonwood trees. Therefore, protecting what remains of the Rio Grande bosque becomes especially important so that each summer we can look forward to hearing the cicada theme song in this ecologically important habitat. ■

- **Albuquerque Bosque Restoration Projects: http://www.bosquerevive.com/**
- **Middle Rio Grande Bosque Initiative: http://www.fws.gov/southwest/mrgbi/**
- **Middle Rio Grande Conservancy District: http://www.mrgcd.com**
- **Smith, D.M., J.F. Kelly, and D.M. Finch. 2006. "Cicada emergence in Southwestern riparian forest: Influences of wild fire and vegetation composition."** ***Ecological Applications,*** **Vol. 16(4), pp. 1608-1618.**

Watershed Restoration and Post-Fire Regrowth

When the western portion of the Little Granite Creek watershed in western Wyoming burned in 2000, the fire provided an opportunity for Forest Service researchers to study stream and riparian post-fire recovery processes. Although fire is an important natural disturbance in many ecosystems, scientists have a limited understanding of the behavior properties and history of fire in many riparian areas of the western US including how riparian vegetation responds to a burn.

Kate Dwire, RMRS Research Riparian Ecologist, is studying the post-fire regrowth of riparian shrubs in the Little Granite Creek drainage. "Along riparian transects, we tallied every shrub and measured their height and width," Dwire said. "We found good regrowth on some of the shrubs. Our general knowledge is that riparian vegetation comes back strong after fire, but we don't know the rates of recovery or the responses of individual species. Most vegetation in the western US is fire-adapted to some extent." Following the 2000 burn, most shrubs re-sprouted within one to three years and grew quickly, partly because they received plenty of sunlight. However, shrubs in the most severely burned portions of the watershed were either killed or did not resprout for another four to five years. Severe fire, which burns hot enough to kill root crowns and other subsurface regenerative tissue can hinder or delay the regrowth of woody vegetation.

Dwire pointed out that grazing on grasses and browsing on shrubs and trees by native ungulates (hoofed animals such as elk) and livestock impacts the recovery of post-fire riparian vegetation. Her research showed that animals browsed re-sprouting shrubs heavily and slowed growth for several species of willows and other riparian shrubs. Riparian vegetation provides shade for streams, offers nesting habitat, and contributes to stream bank stability and channel form. Following fire, these functions cannot resume until riparian shrubs grow back and increase in both numbers and size. To promote the recovery of streams and riparian areas following wildfire, Dwire's results suggest, managers should consider excluding livestock from recently burned areas until riparian shrub species have reached a target height or volume. Knowledge of post-fire recovery rates for key riparian shrubs also helps managers decide where to focus restoration and rehabilitation efforts along streams.

Dwire and her colleagues are also interested in how fire affects channel processes, sediment dynamics, and the input of large wood to streams. Large wood is important to streams because it partially controls the routing of water and sediments, and creates and maintains pools and other aquatic habitat.

Past research shows that pulses of large wood may enter streams following wildfire, but input rates differ with forest type and watershed conditions. In burned portions of the Little Granite Creek watershed, scientists observed that more wood entered the stream in 2007 than previous years and that most contributions came directly from the streamside areas. These results demonstrate that some fire-related processes continue for years, and highlight the value of tracking post-fire changes over time.

Dwire, interested in the multi-faceted role of fire in riparian areas, envisions a long-term involvement with this particular aspect of her research. "Fire is an important natural disturbance that influences many ecosystem processes over both short- and long-term scales," Dwire said. "Riparian plant species may burn differently than surrounding vegetation during a wildfire and respond differently after a burn, but they have evolved within the context of fire, just like upland species." ■

About the New RMRS Director

On January 7, 2008, George "Sam" Foster became the new Director of the Forest Service's Rocky Mountain Research Station. Foster follows Dave Cleaves who accepted a position as the Forest Service's Associate Deputy Chief for Research and Development in the Agency's Washington, DC headquarters.

Foster received a BS degree in forest management and a MS in forest genetics and silviculture from the University of Tennessee, and a PhD in forest genetics and silviculture from Oregon State University.

The new RMRS Director brings a rich and diverse background to the RMRS that includes applied and basic research as well as management and administration in industrial, governmental, and academic institutions. A well respected researcher, Foster has authored over 75 research articles and book chapters, and is a senior executive fellow with the Kennedy School of Governments, Harvard University.

In collaboration with the RMRS Leadership Team, Foster has devised a short list of focal point issues that are critical to the Station's success. Their efforts resulted in five high-priority items: (1) put into practice "Science First" to highlight Station scientific accomplishments; (2) complete the Chief's Review that focuses on restructuring, safety, and strategic science focal areas; (3) update the 2003 Strategic Framework with input from Station employees and stakeholders; (4) implement Station's new staffing plans and work processes; and (5) build strong internal and external partnerships to help achieve the Station's and Agency's missions and goals.■

Rocky Mountain Research Station