RECLAMATION Managing Water in the West

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The Knowledge Stream
Research Update

Testing Nitrogen Fertilizer to Help Restore Mature Cottonwood Trees

Determining if fertilizing cottonwood trees might help restore lost productivity in dryland riverine ecosystems

Bottom Line

This research project examined the hypothesis that mature cottonwood trees are generally limited by the amount of nitrogen in the soil. However, no effect or trend from fertilizing with nitrogen was detected on either river studied.

Better, Faster, Cheaper

A greater understanding of the role nitrogen plays in dryland riparian systems will help water resource managers adaptively manage restoration projects more effectively.

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Problem

Riverine forests in the world's semiarid and arid regions (drylands) are threatened by flow regime changes linked to river regulation, increasing human demands for water, and climate change. Restoring lost riparian forest productivity is a common management goal in dryland riverine ecosystems. If nutrient deficiency is a factor in how many trees can grow in an area, then mature trees at these sites may be especially sensitive to nutrient supplement in sandy or coarse alluvium areas where soil nutrients, particularly nitrogen, are sparse.

In the Western United States, cottonwoods (*Populus fremontii*) dominate many dryland river ecosystems. Cottonwoods provide habitat for many organisms, including threatened and endangered species. The stress that flow alterations cause in these trees is well documented, but managing resilience to reduced water availability requires understanding other potential stressors, such as low soil nutrient concentrations.

Study and Results

This Reclamation Science and Technology Program research project studied two areas in Colorado—one along the Green River in the Browns Park National Wildlife Refuge and the other along the Yampa River in the Deerlodge Park at Dinosaur National Monument. These rivers originate in the Rocky Mountains and are characterized by a snowmelt-driven spring flood. Study trees from multiple locations on each floodplain were systematically selected, with the intention of having two sets of trees at each subsite, matched by size, to serve as treatment and control groups. In 1999, one tree in each pair received granular urea at the rate of 20 grams of nitrogen per square meter.

If cottonwood growth is limited by lower levels of nitrogen in the soil, then radial growth would increase in response to fertilization. To quantify this expected increase, this work:

- Calculated a ratio (R_G) of the 1999 - 2001 cumulative growth increment (the three growing seasons after fertilization) to the 1996 - 1998 cumulative growth increment (the three growing seasons before fertilization) for each tree. Comparing R_G values circumvented the potential problem of variation among trees in their radial growth rates as each tree effectively served as its own control.
- Compared related growth during the 3-year (1999 - 2001) post-fertilization period to a 10-year pre-fertilization period. This addressed the potentially confounding effects from size and spatial variability in a different manner, and included fertilized and unfertilized trees excluded from the growth ratio analysis because they lacked a matching tree for pairing.

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Cottonwoods along the Green River, Colorado.

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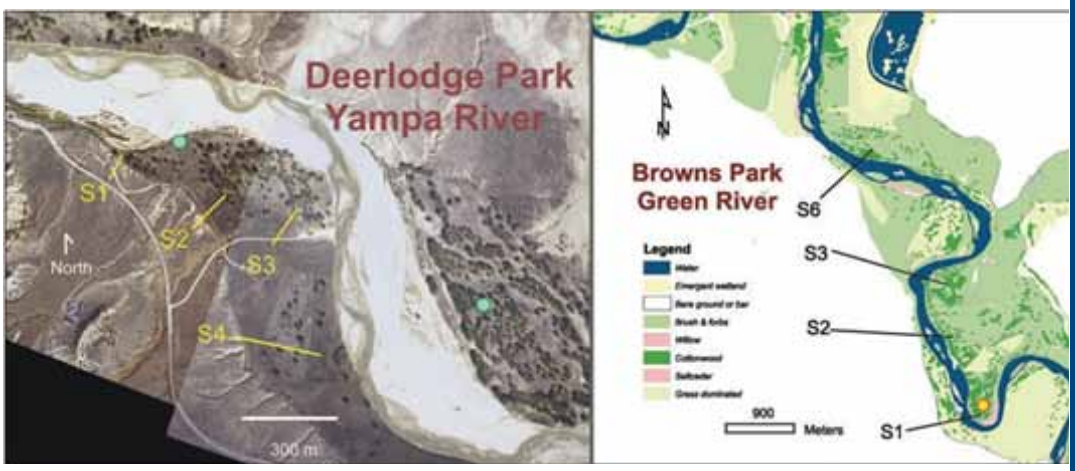

Locations of the subsites containing the study trees at the Deerlodge Park (DLP) (Yampa River) and Browns Park (BP) (Green River), Colorado, study areas. Flow in the Yampa River is from right to left; the Green River flow is from left to right. The two dots at DLP and single dot at BP are locations where microclimates and ground water levels were monitored.

Cottonwoods at both sites showed strong variation in annual increments, reflecting year-to-year variation in environmental conditions. However, no effect from nitrogen fertilization was detected in either site. Also, no effect was detected when examining the radial growth of trees at either site, based on growth during the 10-year period prior to the date of fertilization to standardize subsequent growth. The failure to find a fertilization effect on radial growth was surprising and can be interpreted several ways:

- Growth of mature cottonwood trees is not limited by nitrogen levels in the soil.
- Trees are limited of nitrogen, but the fertilizer dose was too small or the application needed to be repeated in multiple years to elicit the expected response.
- The response might have been in an unmeasured way, such as root biomass or reproductive output.
- Other mechanisms, such as precipitation, restricted nitrogen uptake by trees.

In summary, these data suggest, but do not conclusively show, that mature cottonwood trees are not limited by the amount of nitrogen in the soil at the study sites.

Implications for Best Management Practices

Restoring dryland riverine forest productivity lost as a result of reduced soil water availability, or increasing resilience of established restoration tree plantings to water stress in dryland riparian areas through nitrogen fertilization, needs further study.

Until future studies reveal general patterns, local testing for soil nutrient constraints on tree productivity is needed to inform water resource managers about the efficacy of fertilization as a means to enhancing productivity of degraded dryland riparian forest.

Future Plans

Before dismissing fertilization as a practical management option to increase cottonwood productivity in degraded systems, or to enhance resilience in dryland riparian ecosystems, additional testing using different application rates is warranted. Positive confirmation of adequate soil nitrogen at these and other dryland riparian sites would bolster the argument that flow management is necessary and sufficient to achieve high levels of productivity in degraded desert riverine cottonwoods.

"While this study did not show that the availability of nitrogen in the soil increases cottonwood growth, it provides guidance for best management practices."

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Collaborators

- **U.S. Geological Survey**
- **Rubenstein School of Environment and Natural Resources, University of Vermont**
- **Department of Ecosystem Science and Sustainability, Colorado State University**
- **Natural Resource Ecology Laboratory, Colorado State University**

More Information

www.usbr.gov/research/projects/detail.cfm?id=15

Andersen, D.C., E.C. Adair, S.M. Nelson, and D. Binkley. 2014. *Can Nitrogen Fertilization Aid Restoration of Mature Tree Productivity in Degraded Dryland Riverine Ecosystems?* Restoration Ecology. DOI:10.111/rec. 12104.