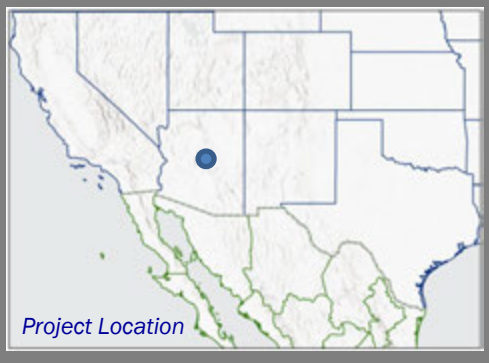
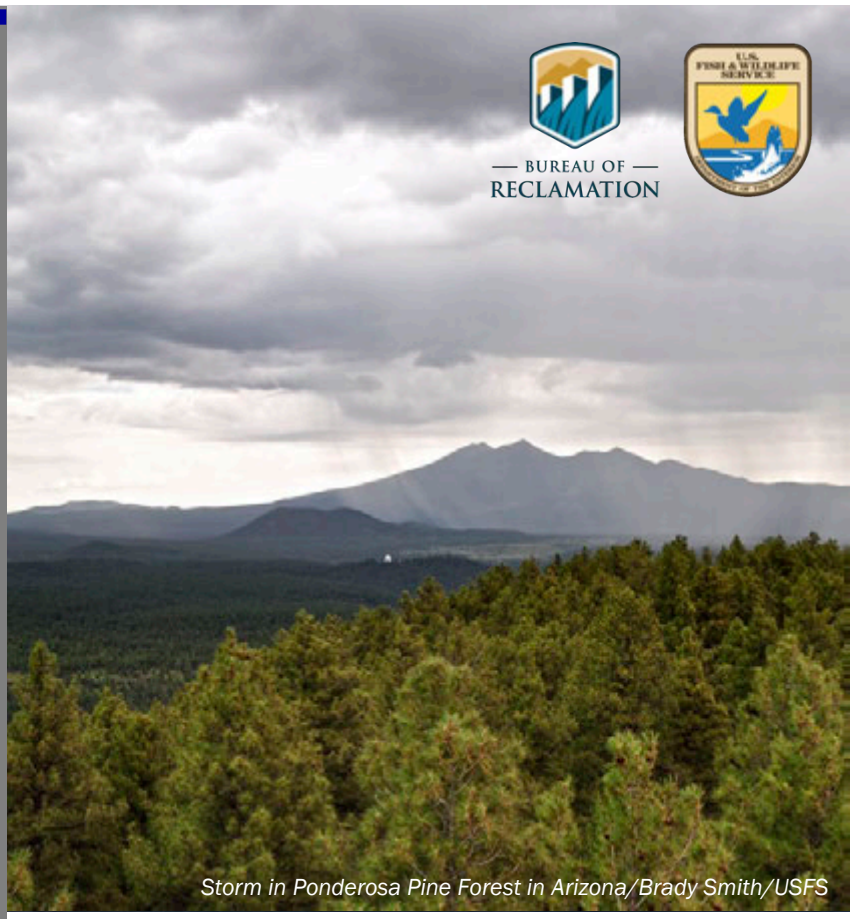
ACTIONABLE SCIENCE

Climate Change and Management Effects on Water Yield from Ponderosa Pine Forests

The Nature Conservancy Arizona

Human and ecological communities alike depend on mountain forests for water supply in water-limited regions. The Salt River with its tributary Verde River is the largest source of renewable water in Arizona and provides up to 40% of the municipal water supply for the Phoenix metropolitan area. A century of fire suppression has resulted in dramatic changes to forest conditions in ponderosa pine forests in Arizona. This study explored how changing forest conditions coupled with inter-annual variation in precipitation explained the 20th century trends in streamflow magnitudes and timing in the Salt River watershed.





Storm in Ponderosa Pine Forest in Arizona/Brady Smith/USFS

KEY ISSUES ADDRESSED

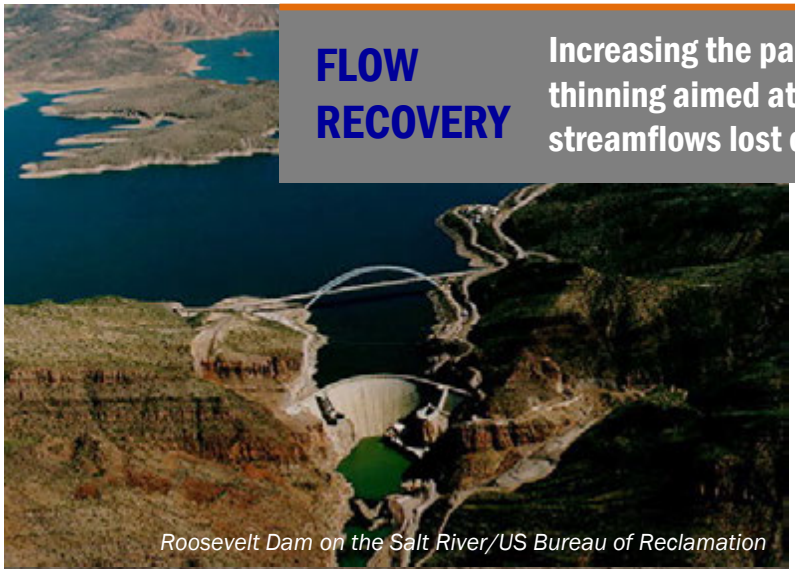
Streamflow in central Arizona is greatly influenced by inter-annual variability in precipitation but also may be impacted by a legacy of fire suppression that has resulted in high-density forests. Several large-scale forest restoration programs are underway across the Southwest, including the Four Forest Restoration Initiative. These restoration programs have diverse goals, including re-establishing natural forest densities and fire regimes, decreasing the risk of catastrophic wildfire, and improving habitat conditions for wildlife. Water yield from forest may also increase due to reduced water use by trees. Research is needed to assess the potential for large-scale forest restoration to recover streamflow that supports wildlife as well as human communities downstream.

PROJECT GOALS

- Evaluate trends and relationships among forest density, climate, and streamflow in the Salt River Watershed in the 20th century
- Inform forest restoration and water management in the region

FLOW RECOVERY

Increasing the pace and scale of prescribed fire and mechanical thinning aimed at reducing forest density may help recover streamflows lost during the early to mid-20th century.



Roosevelt Dam on the Salt River/US Bureau of Reclamation

PROJECT HIGHLIGHTS

Forest Condition Assessments: Using various data sources, researchers qualitatively assessed changes in forest conditions and fire during the 20th century. Historical measurements of ponderosa pine canopy cover, density and basal cover were obtained from sites in northern Arizona and the Southwest. Historical logging estimates were derived from timber inventory and sales from the White Mountain Apache Reservation, USFS Alpine Ranger District, and Pleasant Valley Ranger District. Current estimates of forest basal area, canopy cover, and density were summarized from plots from the USFS Inventory and Analysis program within the Salt River watershed. Records of prescribed fires and wildfires were also gathered for the watershed.

Climate and Streamflow Data: Monthly total precipitation and monthly mean temperature values were obtained from the McNary cooperative weather station. Monthly streamflow data from 1914-2012 were gathered from the U.S. Geological Survey Salt River stream gage in Roosevelt, Arizona.

Flow Trends: Researchers used linear regression models to account for climate variation, then time trends of the model residuals were evaluated to assess the influence of changing forest condition. To evaluate how the timing of spring flows has changed, time trends in the date at which 50% of the cumulative annual streamflow occurred were calculated. This is an estimation of peak spring snowmelt.

LESSONS LEARNED

Ponderosa forest densities increased at least 10-fold in the 20th century, with some evidence that most of this change occurred in the 1st half of the century. This increase is attributed to suppression of wildfire. Analysis indicated that after accounting for climate variation, annual and monthly flows in the Salt River declined by 8-29% from 1914-1963 as ponderosa pine forest densities increased. Summer and fall streamflow declined by 37-56%.

Flow declines reversed mid-century when spring and annual flows increased by 10-31% from 1964-2012, possibly resulting from large-scale wildfires and/or large rain-on-snow winter events. Spring flows during this period occurred earlier, coinciding with winter and spring temperatures increasing by 1-2 Celsius.

Restoration practices including prescribed burning and mechanical thinning, designed to reduce wildfire risks, could also potentially recover seasonal flows by reducing forest density at large scales.

NEXT STEPS

- Evaluate the impact of the two largest wildfires in state history, the Rodeo-Chediski (2002) and Wallow (2011), on annual streamflow
- Compare the influence of snowmelt versus large rain-on-snow events on annual streamflow
- Use results of this and other studies to help land and water managers sustain water supplies and forest health in a changing climate

PROJECT RESOURCES

For more information on this project, contact Marcos Robles: mrobles@tnc.org

For additional project resources and case studies, scan the QR code below or visit the CCAST website: WWW.DESERTLCC.ORG/RESOURCE/CCAST

Smoke From Fire on Coconino National Forest/Brady Smith/USFS

Lead Author: Briana Becerra, University of New Mexico, March 2020.
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