Panel Discussion: Can Vegetation Management Increase Water Yield from Forest and Rangeland Watersheds?

Panel Moderator

Lee MacDonald, Colorado State University

Lee MacDonald is professor emeritus and a senior research scientist at Colorado State University. His academic training includes a BS in human biology from Stanford, an MS in resource ecology from the University of Michigan, and a PhD in forest hydrology from the University of California at Berkeley. He did a post-doc at the University of Washington, was a hydrologist for the U.S. Forest Service, and has worked as a consultant. From 1990 to 2012 he was a professor of land use hydrology in the Watershed Science Program, and he has advised more than 40 graduate students and published more than 50 peer-reviewed articles, monographs, and book chapters. His research focusses on how changes in land use and vegetation affect runoff, erosion, and sediment yields, particularly in forested areas, with special emphasis on the effects of fires, roads, and timber harvest. He also has taught and published on cumulative watershed effects, hillslope and wetland hydrology, forest management effects on stream channels, and erosion in steep agricultural areas. The bulk of his work has been in the western U.S., but he has worked and traveled in more than 60 countries on all seven continents, and given dozens of invited workshops and lectures throughout the U.S., Europe, Asia, and the Pacific. He also was appointed to a National Academy of Sciences panel to assess the hydrologic effects of a changing forest landscape. In his current positions he is leading research projects, advising graduate students, consulting, and directing a long-term curriculum development project in Vietnam. More details and links to his publications and student theses can be found on his web site http://www.nrel.colostate.edu/macdonald-lab/.

Changing Snowmelt Runoff

Dagmar Llewellyn, Bureau of Reclamation

Dagmar Llewellyn has served as a hydrologist at the Bureau of Reclamation office in Albuquerque since 2010. At Reclamation, she coordinates projects related to the projection of the impacts of climate change, and to building of resilience to resulting changes in our watersheds and water supply. She provides her expertise to endangered species and other environmental compliance in the Rio Grande Basin, as well as to research and outreach efforts related to water supply and demand challenges in the Rio Grande basin. Prior to employment at Reclamation, she worked for 22 years at S.S. Papadopulos & Associates, a firm that specializes in quantitative analysis of groundwater and surface water, in its Washington DC office, and as the manager of the firm's Albuquerque office. She is an adjunct faculty at the University of New Mexico, where she has taught hydrogeology in the Civil Engineering Department, and New Mexico Water Management at the Law School, and served on Master's Thesis committees.

New Mexico is experiencing significant changes to the accumulation and melt of our mountain snowpacks (Figure 1), and therefore, the usable water supply available to us from this source. These changes include:

- **Temperatures that have been steadily increasing**, and which are projected to continue to increase (Figure 2 and Figure 3). These continuing temperature increases are leading to:
  - More precipitation falling as rain rather than snow, leading to higher winter runoff, earlier spring melt-off of the snow that does accumulate, and decreasing ability to store water in mountain snowpacks into the summer.
  - More losses through evaporation and transpiration of the snowmelt as it works its way down from the mountain to the locations that we use it.
  - More demand for water at each point along the system, which decreases the magnitude of the spring snowmelt peak.

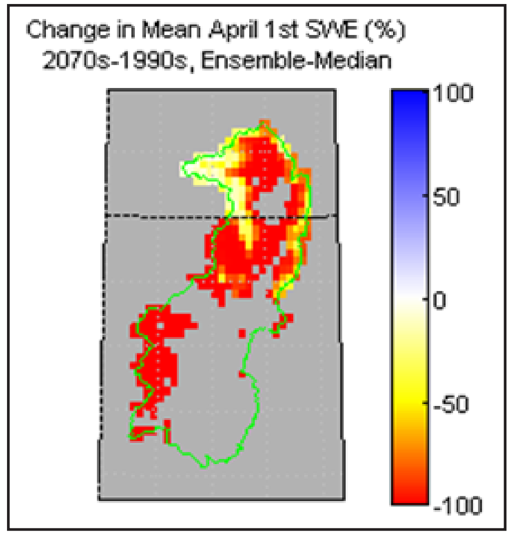


Figure 1. Future climate: basin-distributed snow (2070s).

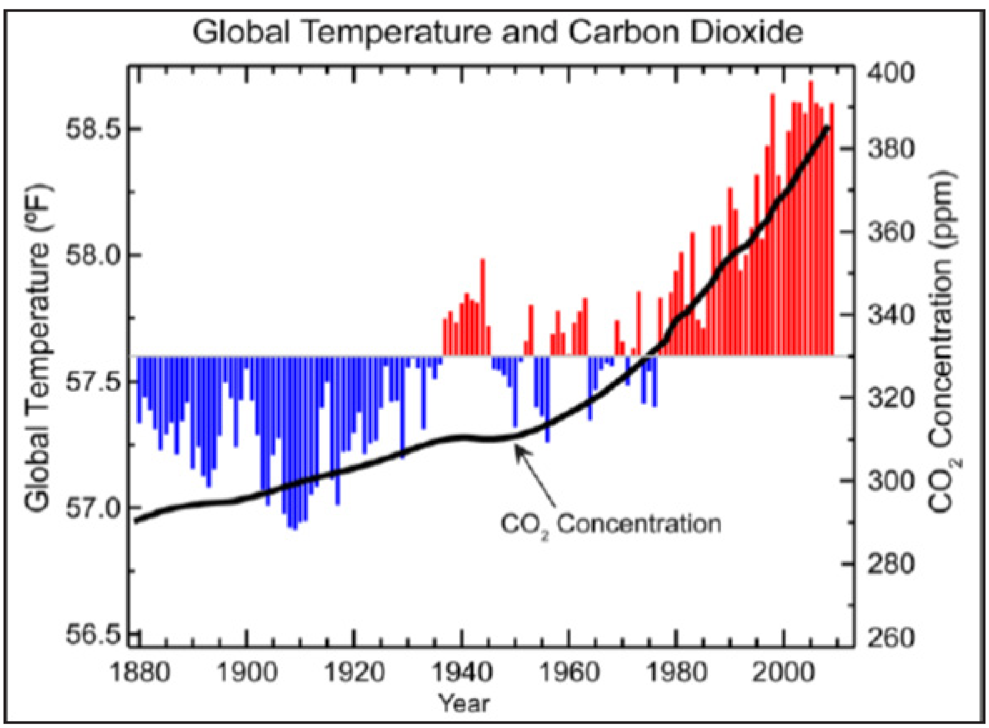


Figure 2. Temperatures that have been steadily increasing, and are projected to continue to increase.

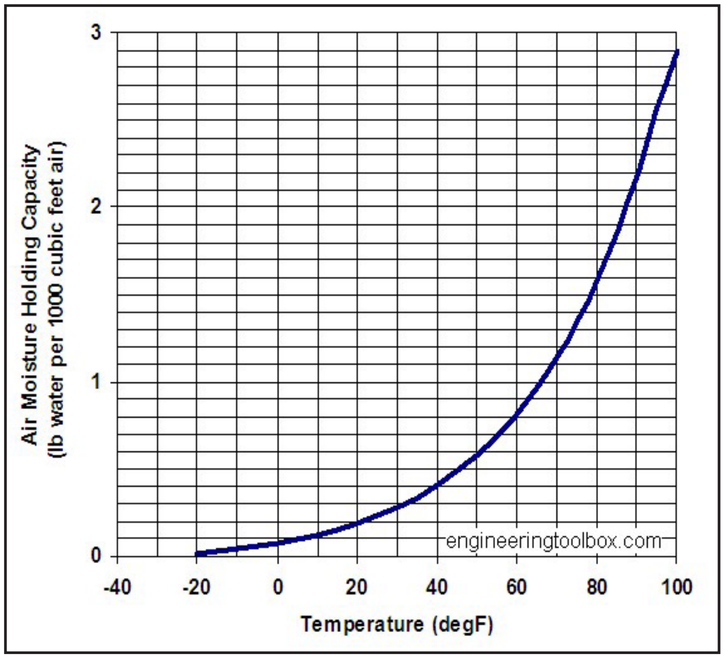


Figure 3. Exponential relationship between air temperature and water-holding capactiy.

- **Decreasing health of our mountain forests** and their ability to accumulate and maintain winter snowpacks (Figure 4). Causes and impacts of these changes include:
  - A history of fire suppression that has led to overgrowth of forests. These denser forests intercept more snow as it falls, therefore decreasing snowpack accumulation.
  - Decreasing soil moisture, and increasing vapor-pressure deficits for our forests, that result from increasing temperatures. These stressors are decreasing forest health and making trees vulnerable to bark beetle and other infestations
  - Increasing risk of catastrophic wildfire (Figure 5). The forest stresses and overgrowth described above significantly increase the potential for catastrophic wildfire. Post-fire, mountain slopes are subject to increased erosion and debris flows, which may clog streams and rivers and inhibit their ability to convey the snowmelt runoff. They may even bury infrastructure such as diversion structures, and inhibit their function.
- **Increasing dust accumulation on our snowpack** (Figure 6): Land use practices such as over-grazing, in combination with increasing temperatures and decreasing soil moisture, is leading to increased vulnerability of soils to erosion from spring winds, which has been leading to greater falls of dust on snow. This dust decreases albedo (reflectivity) and leads to greater sublimation and earlier melting of snow.

Figure 4. Decreasing health of our mountain forests and their ability to accumulate and maintain winter snowpacks.

Figure 5. Increasing risk of catastrophic wildfire.

Figure 6. Increasing dust accumulation on our snowpack.

Santa Fe Paired Basin Study

Amy Lewis, Hydrologist

Amy Lewis earned a master's degree in hydrology from New Mexico Tech in 1985 and has over 30 years of expertise evaluating water resource data, as both a public servant for the New Mexico Environment Department, Office of the State Engineer, and City of Santa Fe and as a private consultant, including her own hydrologic consulting business beginning in 2002. Amy developed an interest in forest restoration and the impacts on the hydrologic water budget while working as the City of Santa Fe Hydrologist. In 2008, she began managing the Santa Fe Paired Basin study funded by the New Mexico Interstate Stream Commission to monitor the changes in water budgets following forest thinning and maintenance burns.

The Santa Fe Watershed Paired Basin study, funded by NM Interstate Stream Commission, is monitoring the water budget components in response to ongoing forest treatments. Over the past eight years of the relatively dry period, stream flow and evapotranspiration appear to be decreasing in the treated basin with respect to an untreated basin but recharge may be increasing. A series of wet years, particularly in a significant snow pack, may show different results.

Figure 1. Introduction.

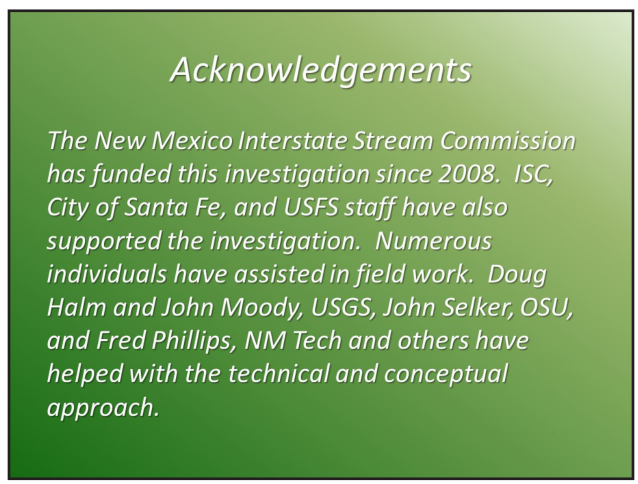


Figure 2. Acknowledgements.

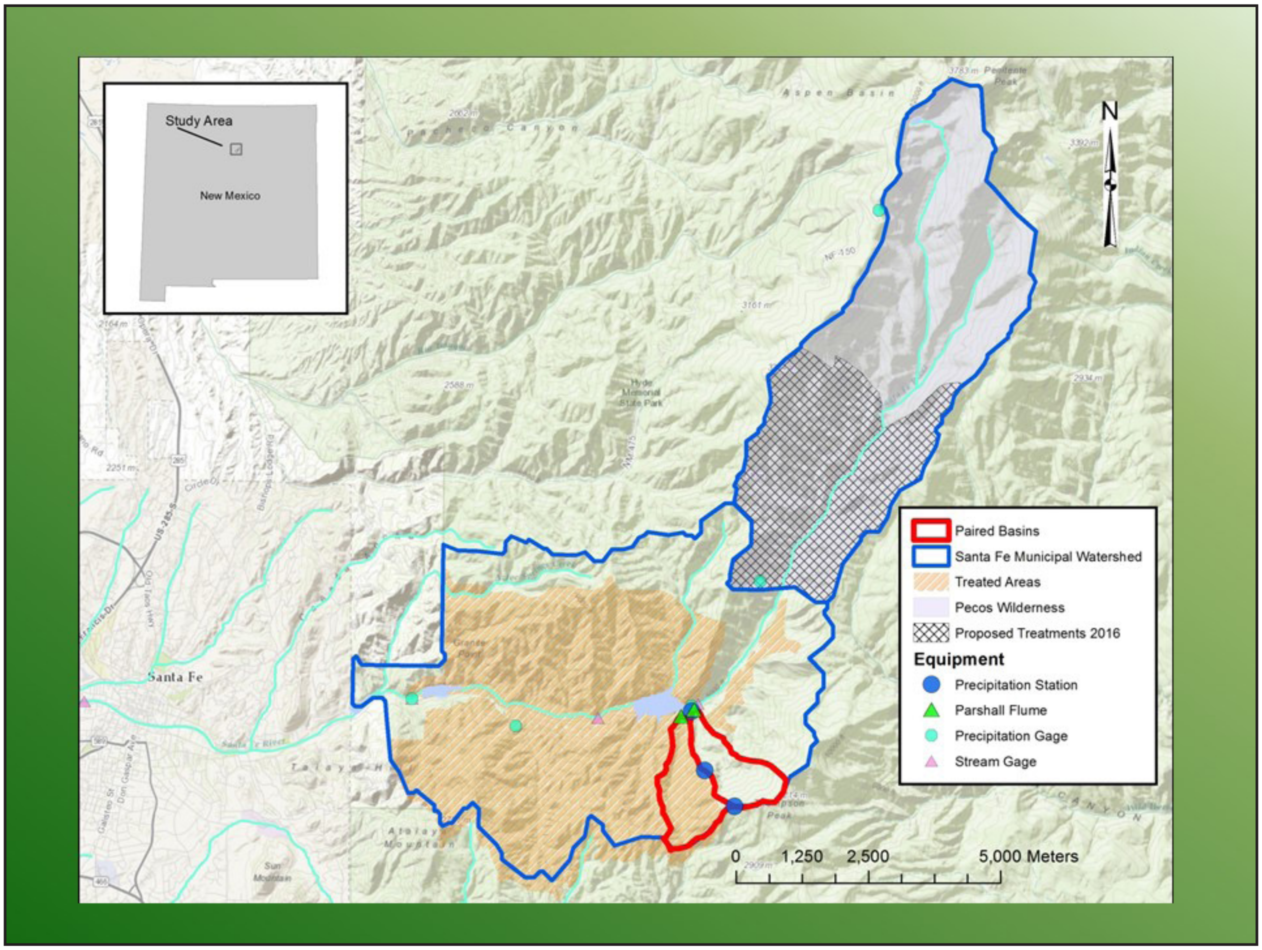


Figure 3. Santa Fe River supplies up to 40% of the City of Santa Fe's water supply, or about 5000 ac-ft/yr. The watershed is about 17,000 acres with the headwaters up at 12,000 feet. Water is stored in two reservoirs (McClure & Nichols-4,000 ac-ft of storage). The paired basins are each about 400 acres, one was treated in 2004 and 2010, and the other is untreated.

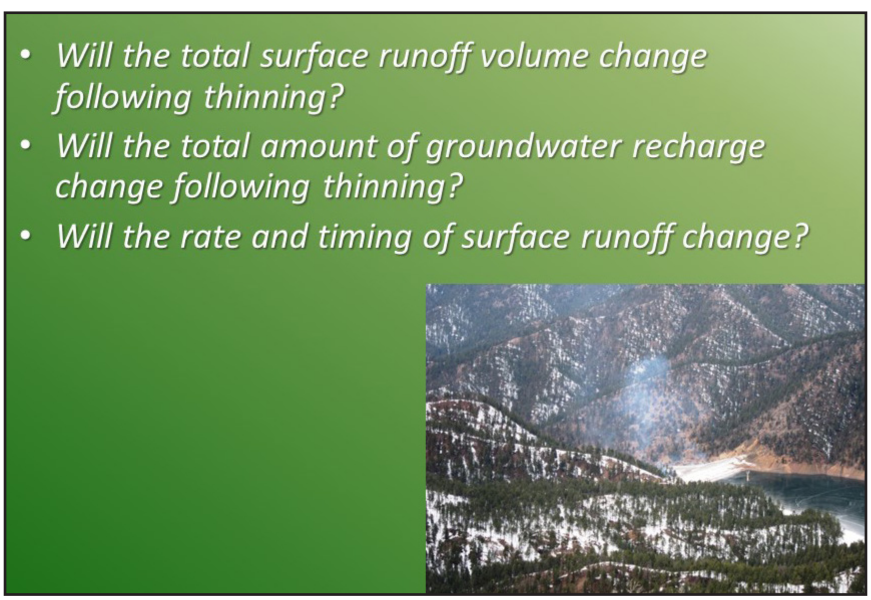


Figure 4. Specific questions.

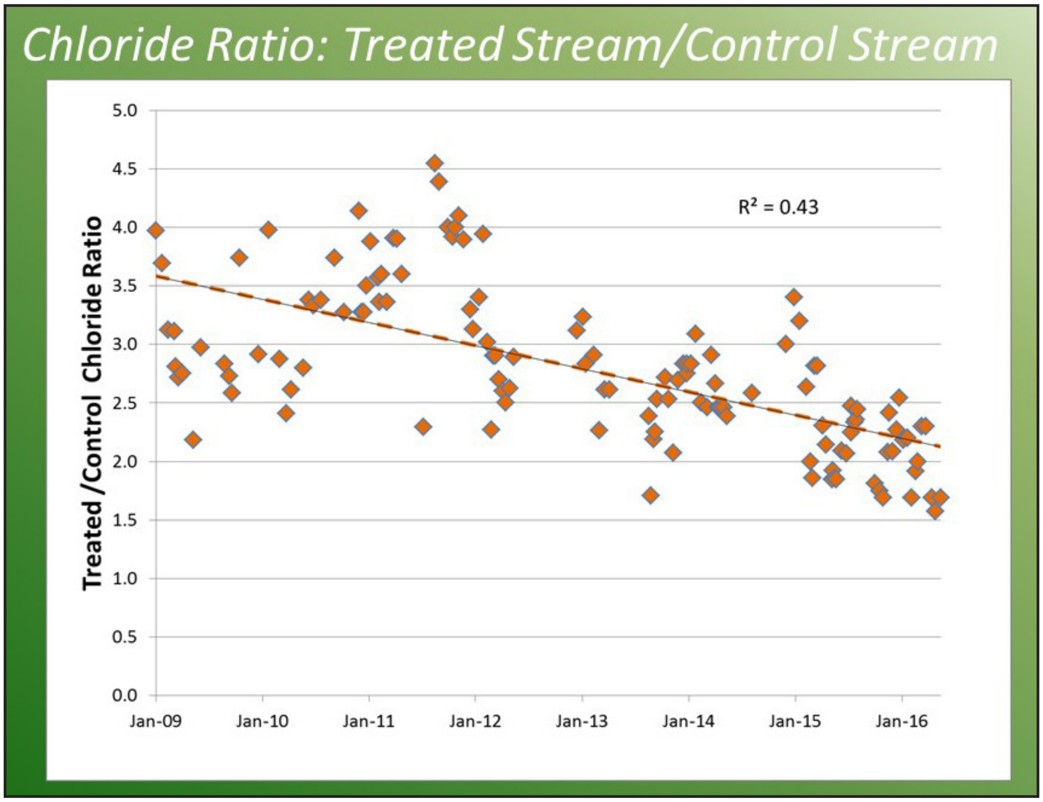


Figure 5. The chloride ratio was 3 to 1 from a sample collected in 1995, thus the forest treatments are not the cause of the higher ET in the treated basin. The historic higher ET may possibly be due to the greater area of west-facing slope in the treated basin. Although the R^2 is not impressive, the ratio appears to be declining, which would suggest a lower rate of ET in the treated basin as compared to the control.

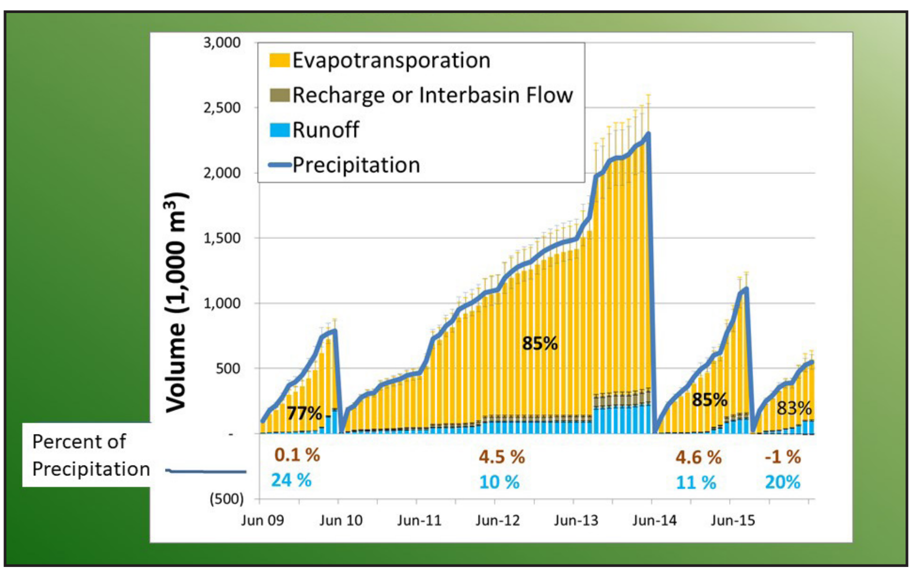


Figure 6. Cumulative water budget control basin. Now looking at the results of our water budgets based on the four integration periods defined by the chloride mass balance. The change in storage is not shown here, but it is less than 0.5%. ET ranges from 76 to 85% and runoff is 10 to 24% of precipitation. Recharge is between 0 and 5%. A value which is within the expected range for mountain front recharge.

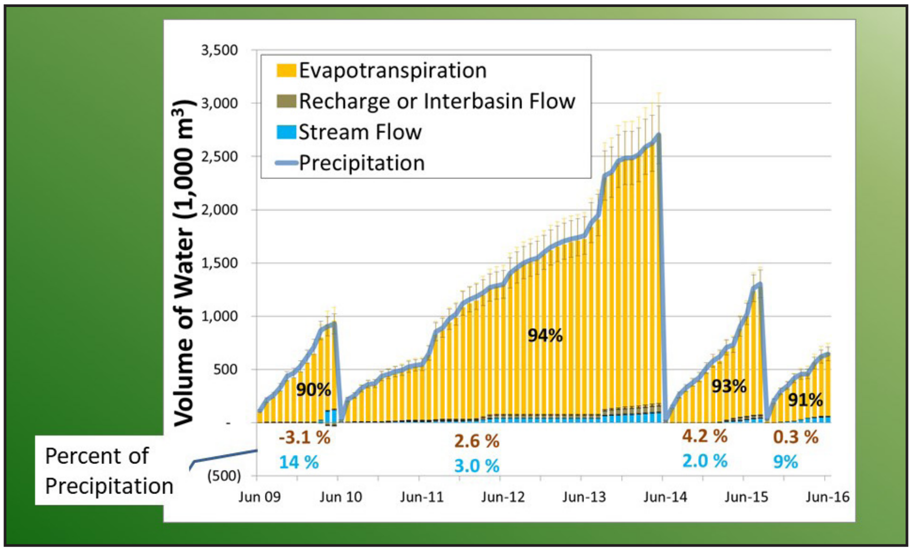


Figure 7. Cumulative water budget treated basin. ET is greater in the treated basin, ranging from 90 to 94%, with runoff between 2 and 14% of precipitation. Recharge estimates ranges from 0 to 4.7% of precipitation.

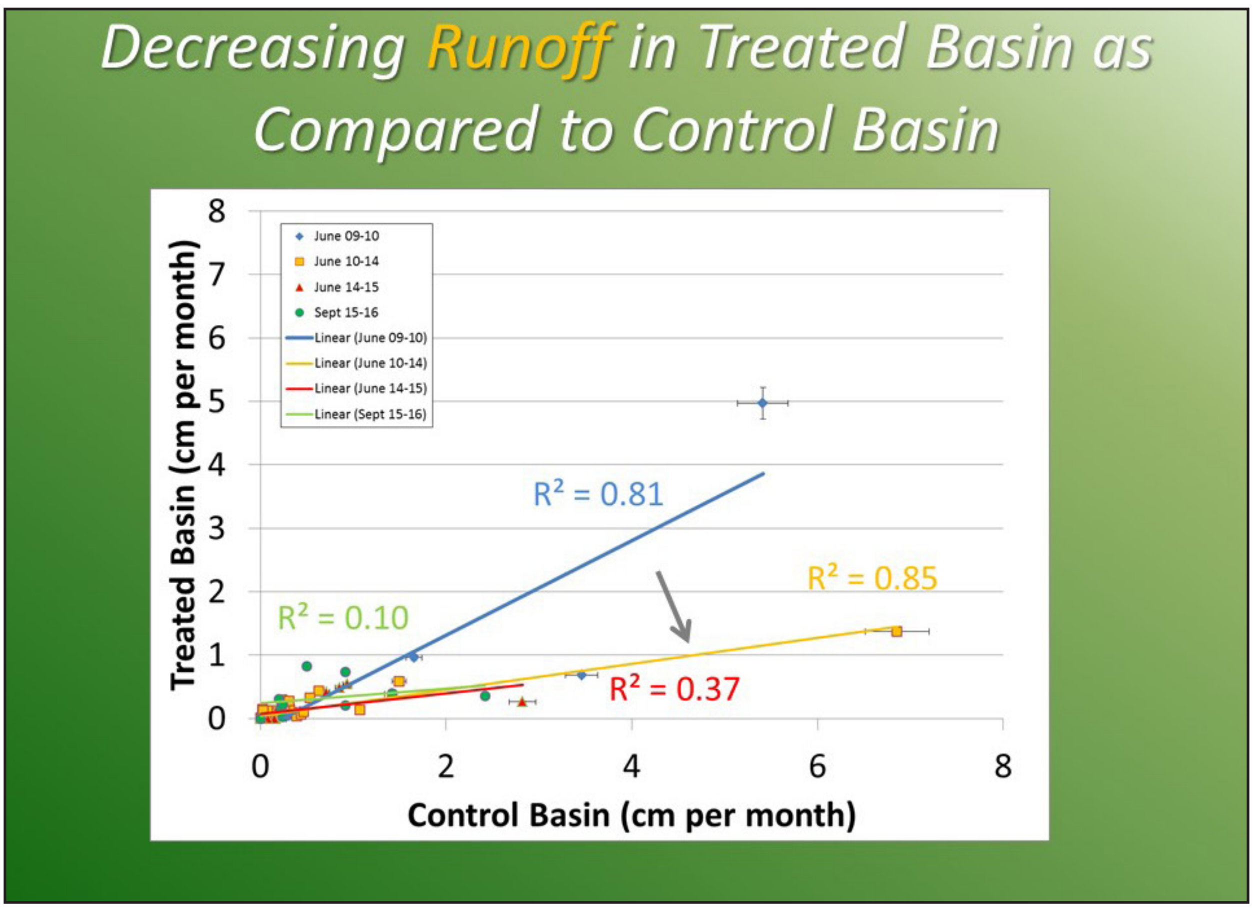


Figure 8. Looking at the monthly rate of stream flow based on the monthly water budget graphs, see how the monthly flows in the three periods compare. Stream flow appears to be trending downward from the first integration period to the last. This is consistent with our mean-monthly flow cross plot of before and after treatments.

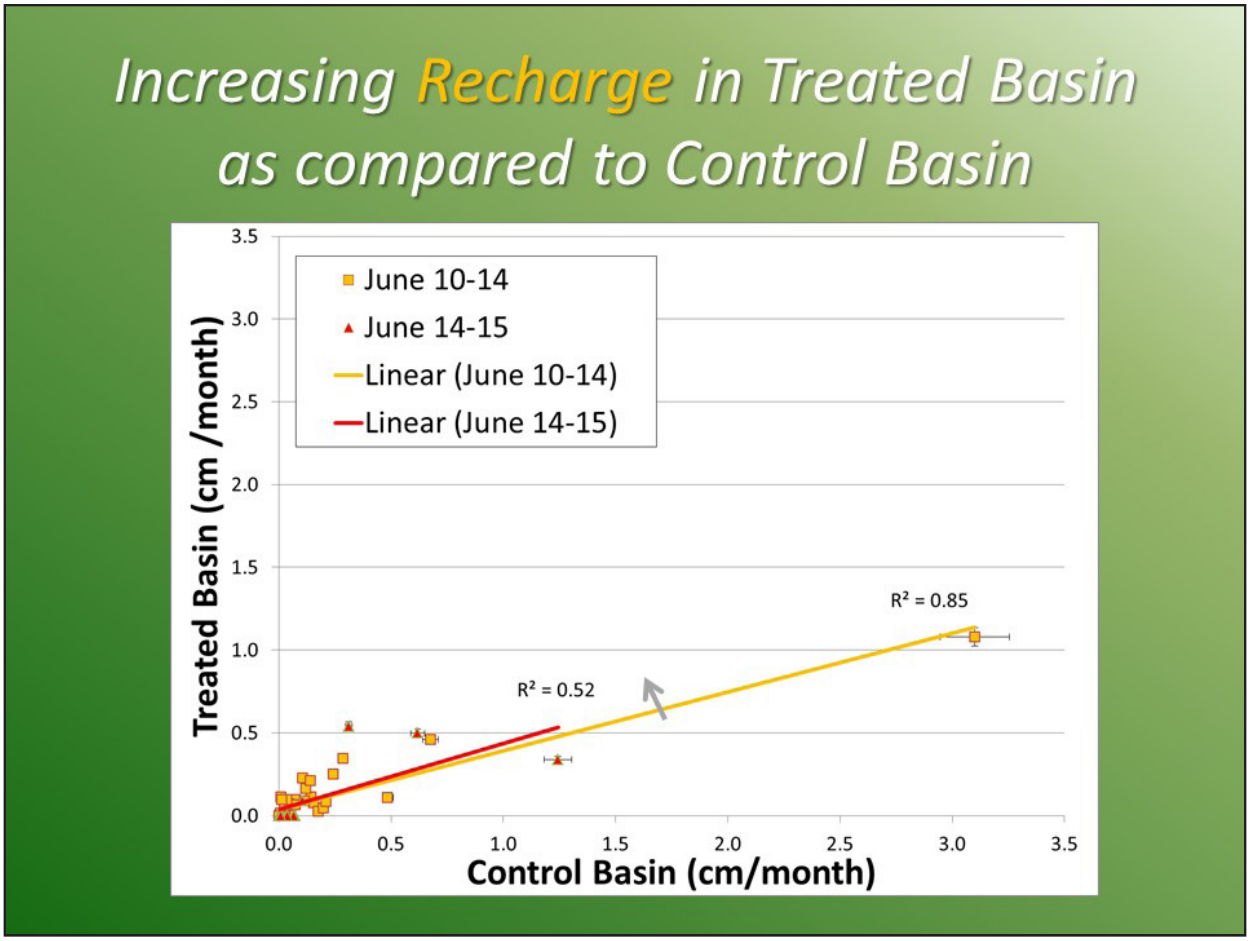


Figure 9. Preliminary results suggest that recharge appears to be doing the opposite, increasing with time in the treated basin as compared to the control basin. This is consistent with the conceptual understanding of increased groundcover - slower runoff, and increased time for recharge to occur.

Conclusions

Parameter	Treated vs Control	Basis
ET	Decreasing	Chloride ratio appears to be declining
Runoff	Decreasing?	Flow in treated basin is progressively less with each of the dry integration periods, but a series of wet years are needed to confirm
Recharge	No change-Increasing?	Cross plot of T v C monthly recharge slightly higher
Storm Runoff	Intensity Decreasing	Based on storm response pre and post-treatment

Figure 10. Conclusion. Surface runoff volume appears to decrease following thinning, but the period of investigation is a very dry period. Groundwater recharge appears to increase following thinning and maintenance burns with resulting increase in groundcover. The intensity of storm flows are reduced following thinning and increase in groundcover.

Collaborative Forest Management Project in New Mexico

Kent Reid, New Mexico Highlands University

Kent Reid moved to New Mexico in 1996, and worked here and internationally as a consulting forester before going to work for the NM Forest and Watershed Restoration Institute (FWRI) in 2007. He currently is Director of FWRI, located at Highlands University in Las Vegas. Kent has degrees from North Carolina State, Colorado State, and Clemson, and has worked for Weyerhaeuser, the Peace Corps, the University of Missouri, Auburn, Virginia Tech, and Cornell.

New Mexico Landscape Assessment Tool
Joe Zebrowski, New Mexico Highlands University
New Mexico Forest and Watershed Restoration Institute

What is the Landscape Assessment Tool?

- Displays and summarizes landscape characteristics from multiple geographic databases
- User friendly interface
- Curated "One-stop" for locating and viewing information
- A concept (based in reality)

Table 1. Criteria, Description, and Score.

Criteria		Description	Score	
Watershed Condition Class Framework (USFS)		Watershed condition is the state of the physical and biological characteristics and processes within a watershed that affect the soil and hydrologic functions supporting aquatic ecosystems. http://www.fs.fed.us/sites/default/files/Watershed_Condition_Framework.pdf	Functioning Properly Functioning at Risk Impaired Function	81% 19% 0%
Water Sources (NMED)		Location of drinking water sources. From NMED, Jan 2014, via The Nature Conservancy.	GU GW SW	53 GW
Priority Landscapes Composite (NMSF)		New Mexico State Forestry has created a draft of priority landscapes to show areas where we would like to focus future projects based on a spatial analysis of mitigated threats and benefits to be achieved from Forestry projects. This dataset is meant to be a guideline, and a starting point for deciding where to focus funds on the ground. http://allaboutwatersheds.org/groups/fwhcg/public/new-mexico-state-forestry-draft-priority-landscapes-overview-of-data-and-methods-utilized	Low Priority Medium/Low Priority Medium Priority Medium/High Priority High Priority	Medium Priority
State Forestry Action Plan (NMSF) http://www.emnrd.state.nm.us/SFD/statewideassessment.html	Development Potential (Risk)	This data layer emphasizes areas that are projected to experience increased housing development in the next 30 years. This layer will be used in the State Strategy and Response plan to help emphasize areas which will conserve working forests.	0 1 3 5	0
	Forest Health	Forest Health Risk: This data layer identifies areas that make a forest area more susceptible to insect and disease outbreaks. This layer will be used in the State Strategy and Response plan to help prioritize areas where management of threats to forest health is most needed.	Low Low/Medium Medium Medium/High High	Medium
	Water Quality and Supply	This data layer identifies watersheds important for supplying sustainable water supply along with the potential risks to supplying clean water. This layer will be used in the State Strategy and Response Plan to help emphasize areas which will enhance public benefit from forested areas.	1 2 3 4 5	3
	Fire Risk	This data layer identifies areas with a relatively high risk of destructive wildfire. The intent of this layer is to identify areas where forest management is most likely to reduce the risk of wildfire damage (or reduce the impact of wildfire on natural resources, and human infrastructure and development). This layer has been developed for the State Strategy and Response Plan to help prioritize areas which will minimize potential and reduce impact of wildfire.	Low Low/Medium Medium Medium/High High	3
Debris Flow (TNC)		Combined classification of probability and volume of a post wildfire debris flow from the Nature Conservancy, 2016.	0 1 2 3 4 5 6 7 8	2.3
Wildfire Hazard Potential – 2014 (USFS)		Relative potential for wildfire that would be difficult for suppression to contain. Areas mapped with higher wildfire potential values represent fuels with a higher probability of experiencing torching, crowning, and other forms of extreme fire behavior under conducive weather conditions, based primarily	1: Very Low 2: Low 3: Moderate 4: High	

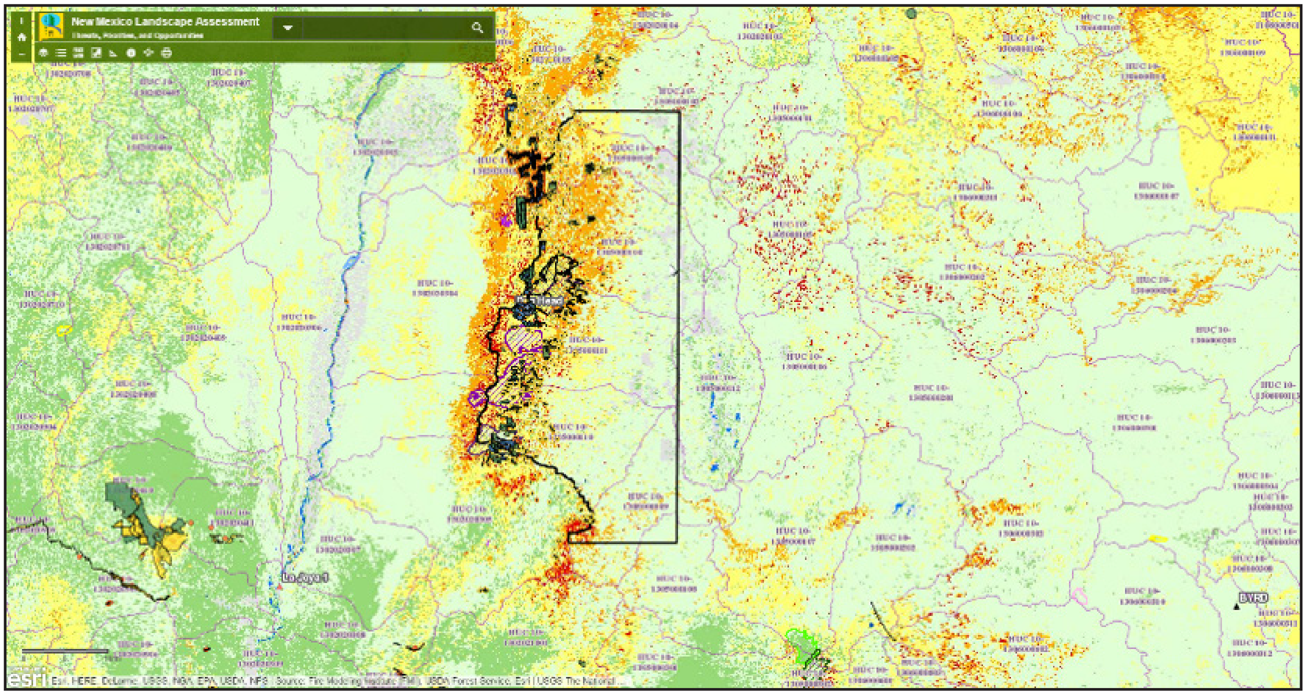


Figure 1. First draft of concept: http://arcg.is/2dmkmiY.

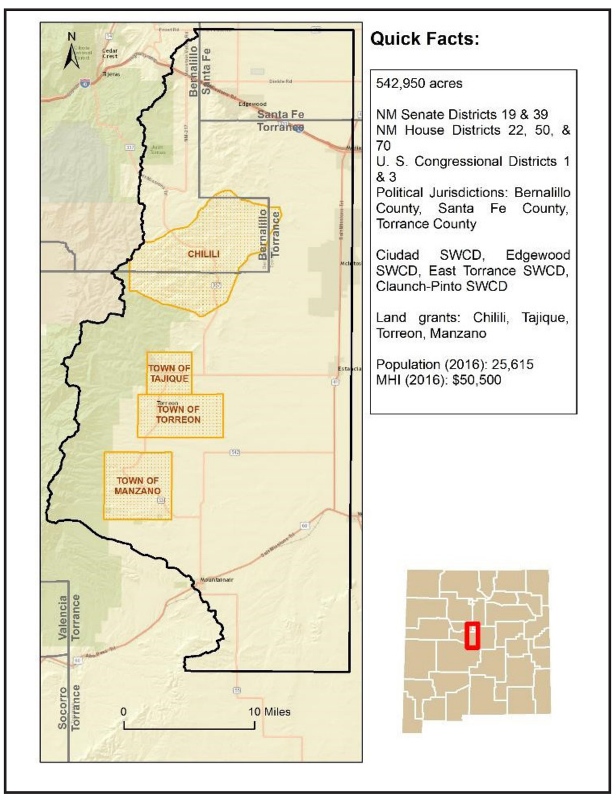


Figure 2. Western Estancia basin landscape.

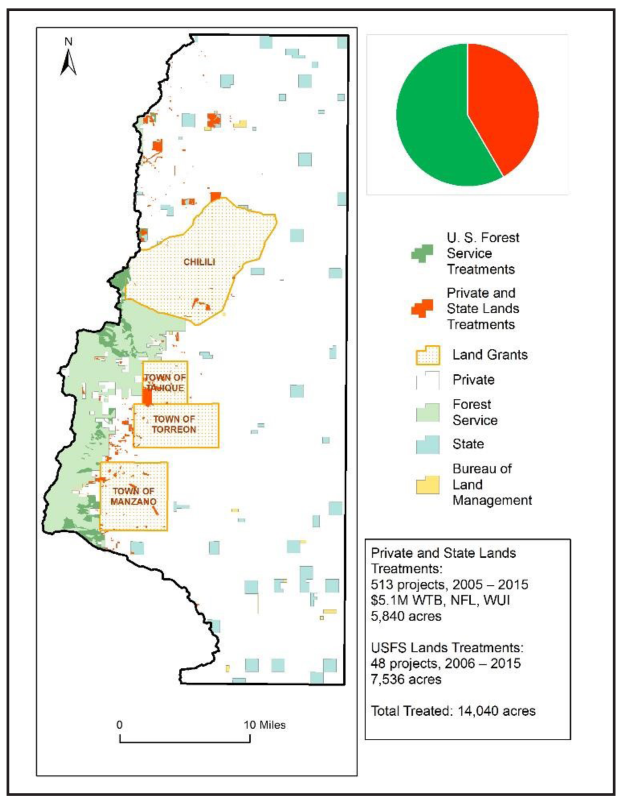


Figure 3. Treatments.

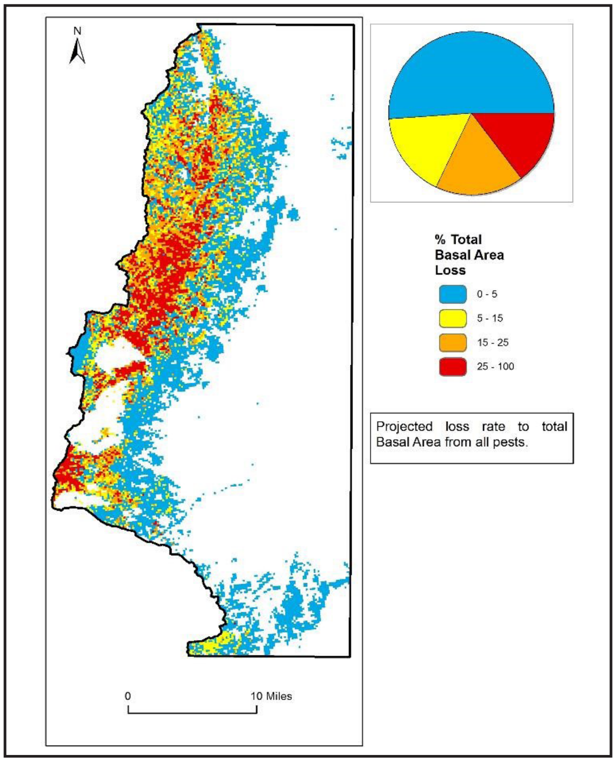


Figure 4. Fifteen year (2013-2017) projected risk from forest insect and diseases.

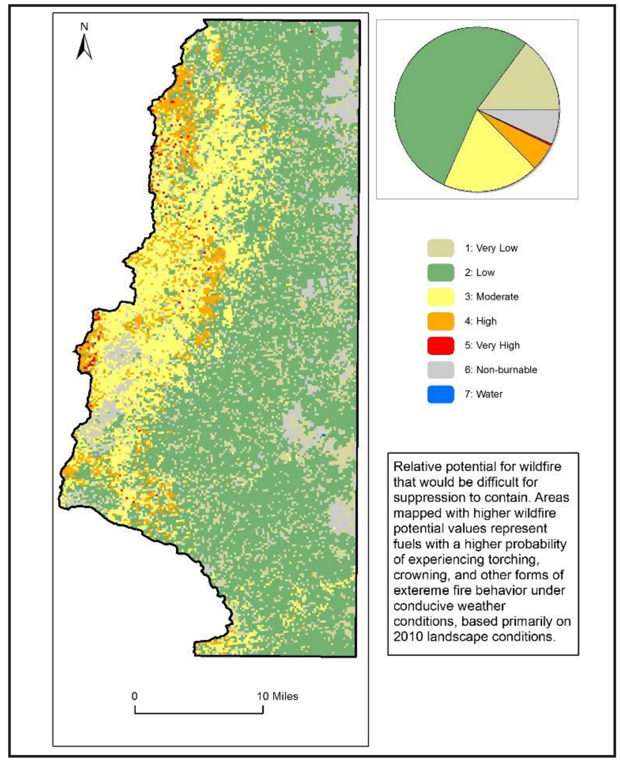


Figure 5. Wildfire hazard potential.

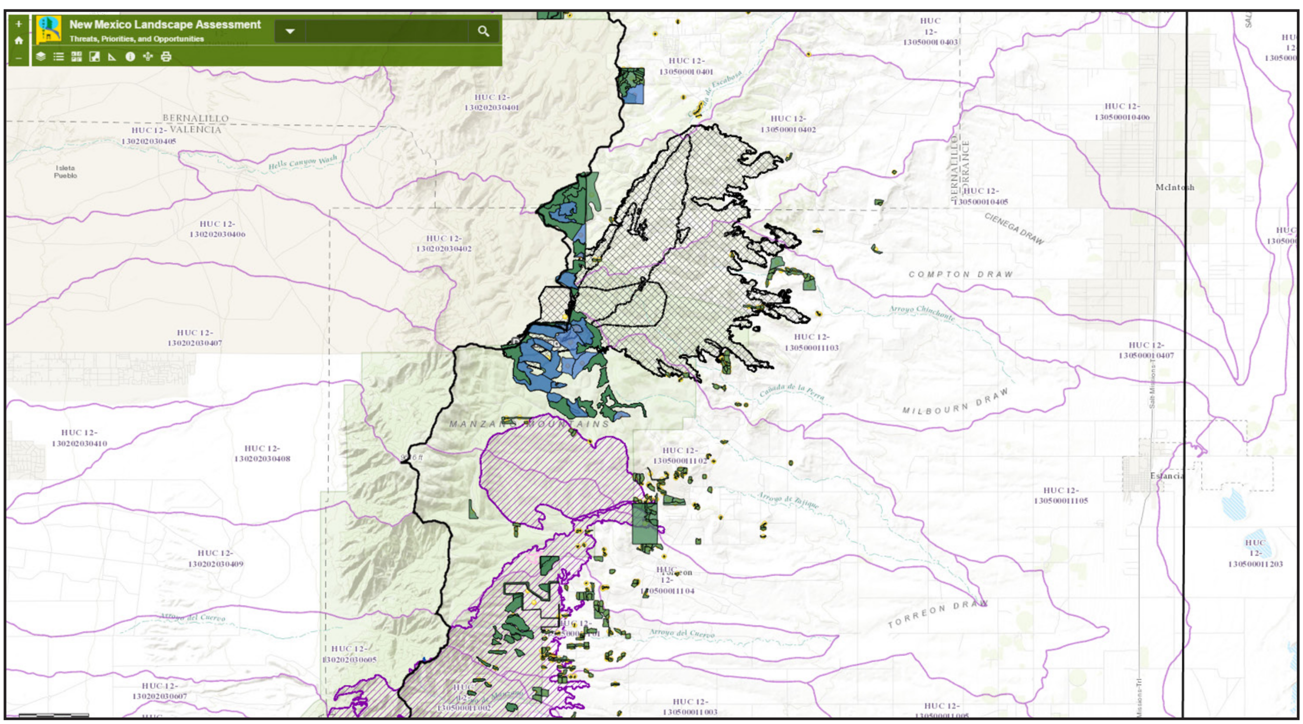


Figure 6. New Mexico landscape assessment - threats, priorities, and opportunities.

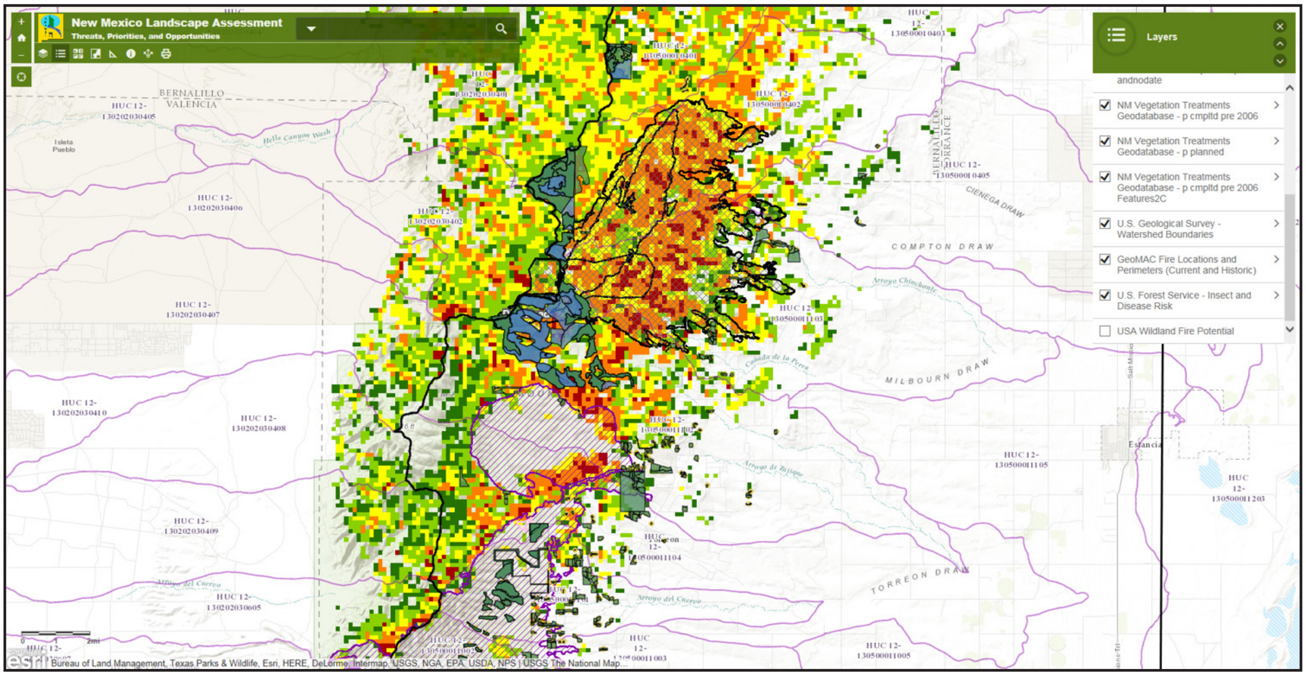


Figure 7. Bug and rot risk (USFS) with layers.

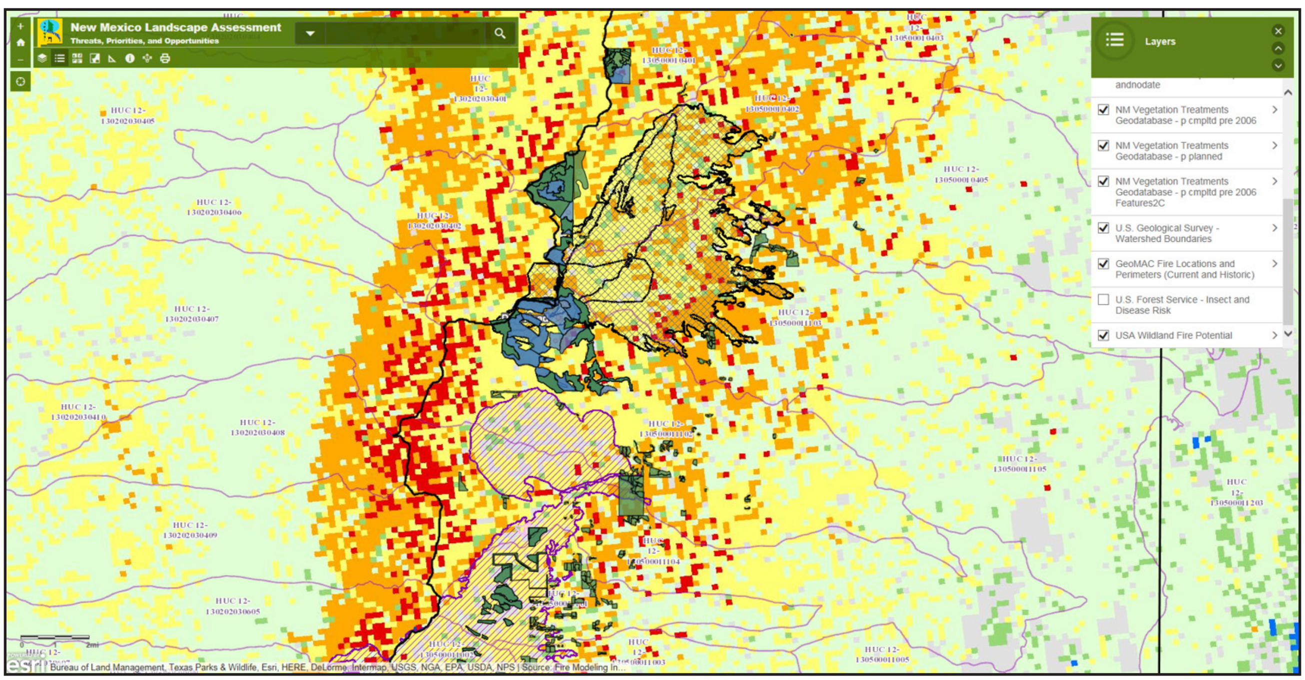


Figure 8. Wildland fire potential (USFS) with layers.

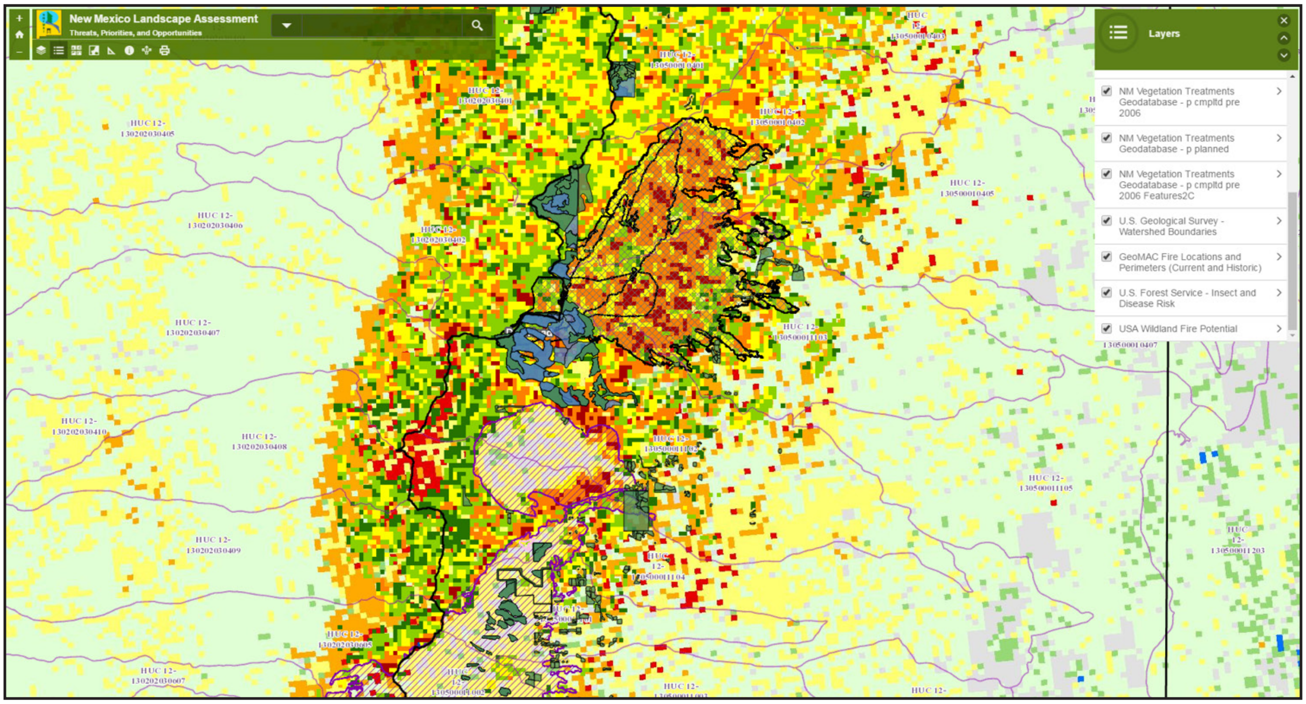
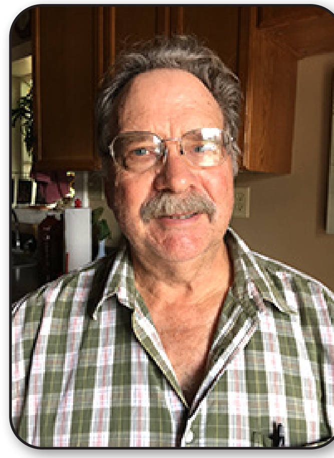


Figure 9. First draft of concept with layers.

Gila/San Francisco Watershed Restoration Project—Lessons Learned

Alex Thal, Southwest Center for Resource Analysis
Ralph Pope, Southwest Native Ecosystems Management



Alexander J. Thal is director and owner of the Southwest Center for Resource Analysis and previously was a professor at WNMU, working extensively with local, state, tribal, and federal governments in various types of policy and economic legal analyses in natural resources. For over 45 years, he worked with local governments in the US, Alberta, Canada, and in Viet Nam, evaluating and developing natural resources and environmental projects, plans, and policies. He has worked with the US Forest Service, Bureau of Land Management, Bureau of Indian Affairs, Navajo Nation, San Carlos Apache Tribe, Bureau of Reclamation, US Fish & Wildlife Services, Natural Resources Conservation Service, and local conservation districts. Alex's own research efforts have contributed to successful federal, local, and state decisions with a focus on incorporating local land users into resource decisions. He has conducted numerous socioeconomic impact analyses, cost/ benefit analyses, risk assessments, and distributional impact analyses in all aspects of natural resources including water/watershed, wildlife, rangeland, forestry, and wildfires. Alex received a BS in forest recreation from Northern Arizona Univ, an MS in community planning from Arizona State University, and a PhD in natural resource law and economics from the University of Buffalo. He was a Captain in the USMC and received the Bronze Star for rural development accomplishments in Vietnam.

Can Vegetative Management Increase Water?

For the San Francisco Watershed, the question shouldn't be "Can Vegetation Management Increase Water Yield from Forest and Rangeland Watersheds?" Rather: How much will major changes in vegetation, due to large wildfires, adversely impact downstream communities and the users of water (Figure 1)? We cannot increase the amount of water that enters a watershed, but through treatment, or, events like wildfires, the timing, rate, and quality of water that comes off a watershed and flows downstream can be significantly altered.

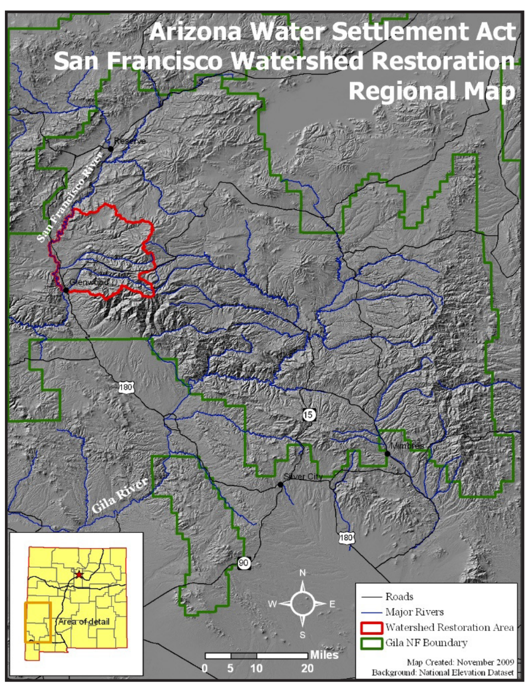


Figure 1. Arizona Water Settlement Act,
San Francisco Watershed Resoration Regional Map.

San Francisco Watershed Restoration Project

This is a unique watershed project that integrates upland vegetative restoration with community ditch/acequias restoration. The project seeks to mitigate the effects to at-risk agricultural assets due to the impaired upland watershed that was severely altered by catastrophic wildfires. It also seeks to improve the irrigation systems along the San Francisco River, where the impacts on water supply and quality from the Whitewater Baldy (WWB) fire are most deleterious (Figure 2).

The goal of the project is to extend the water supply to longer periods in streams and to enhance water quality through the improvement of conditions over a significant portion of the San Francisco watershed. It includes improving herbaceous ground cover and streambank stability, thus improving infiltration and the watershed's water storage capability.

Monitoring, measurement, and work all go hand-in-hand. We may not know until a catastrophic event occurs the magnitude of wildfire effects. This is especially true if there is little or no monitoring of upland watershed conditions, like what was proposed here. With close monitoring and efforts to re-establish the vegetative communities found in the upland watershed, we could possibility reduce the magnitude of future catastrophic events.

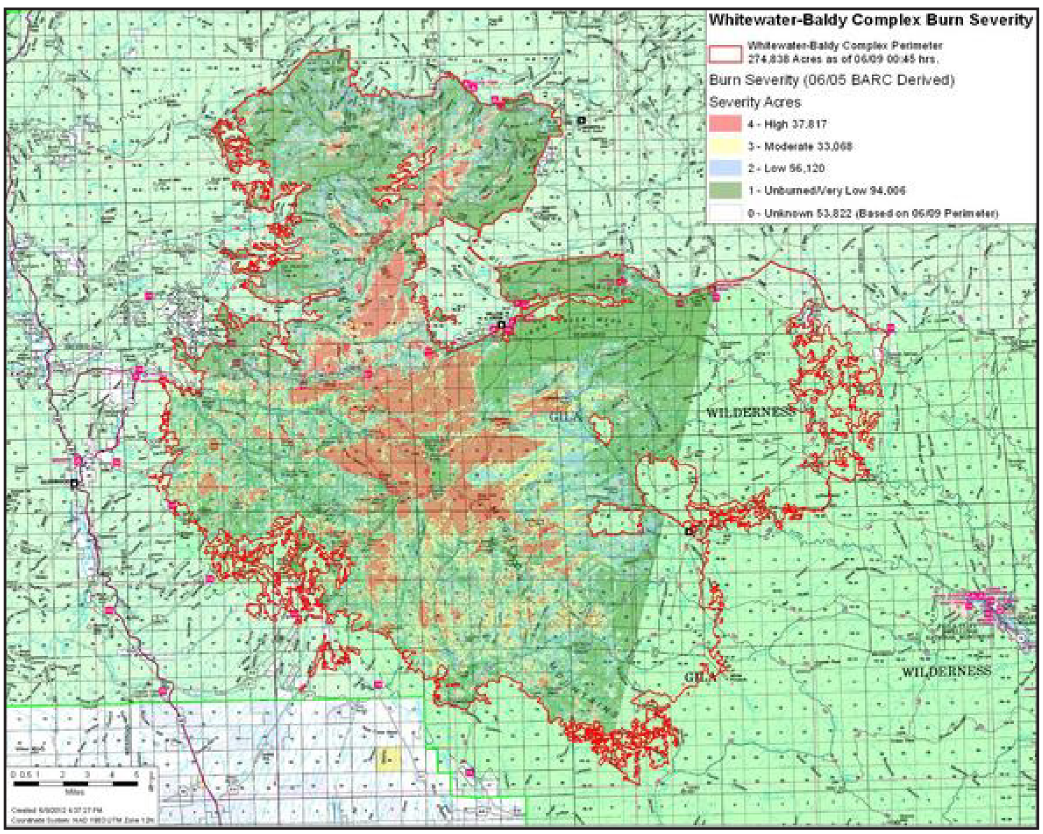


Figure 2. Whitewater-Baldy catastrophic wildfire.

Project Status – An Expression of Community Needs and Aspirations

Some vegetation management and community ditch restorations are taking place in the watershed. One irrigation system rehabilitation project was funded by the New Mexico Interstate Stream Commission (ISC) at the cost of $500k (Figure 3).

However, community concerns continue as expressed by the project community liaison who lives under the threat of catastrophic events in Glenwood:

I guess something is better than nothing. Still the threat to diversion infrastructure from the WWB fire remains, so it is indeed a shame that apparently no mitigation for southern Catron County water rights holders was included in the funding. - Jo Anne

Many individuals still believe there is a real need to monitor and, where possible, mitigate impaired upland watershed conditions that are the result of the major wildfires. Some individuals have expressed a need to address the dramatic changes in the upland watershed due to the Whitewater-Baldy wildfire as well as the need for restoration of the community ditch/acequias.

Much of the Gila National Forest watersheds has been damaged, and will have significant effects on irrigation systems and other downstream users.

It appears that the U.S. Forest Service is letting things run their natural course without looking to do any significant mitigation of the wildfire effects. If erosion continues to degrade key stream channels and the vegetative communities, it is felt "that is just the way things happen."

With millions in funding that was potentially available for restoration of the upland watershed and that could have put hundreds of local people to work on ways to sustain the productivity of thousands of acres of once very productive land, we can't imagine what the Catron County Commission and the ISC saw that made them table or scrap the watershed restoration component of this project.

With that said, we believe that the connectivity between the upland watershed and the downstream use of water will be the major issue in the Gila/San Francisco Watershed for years to come.

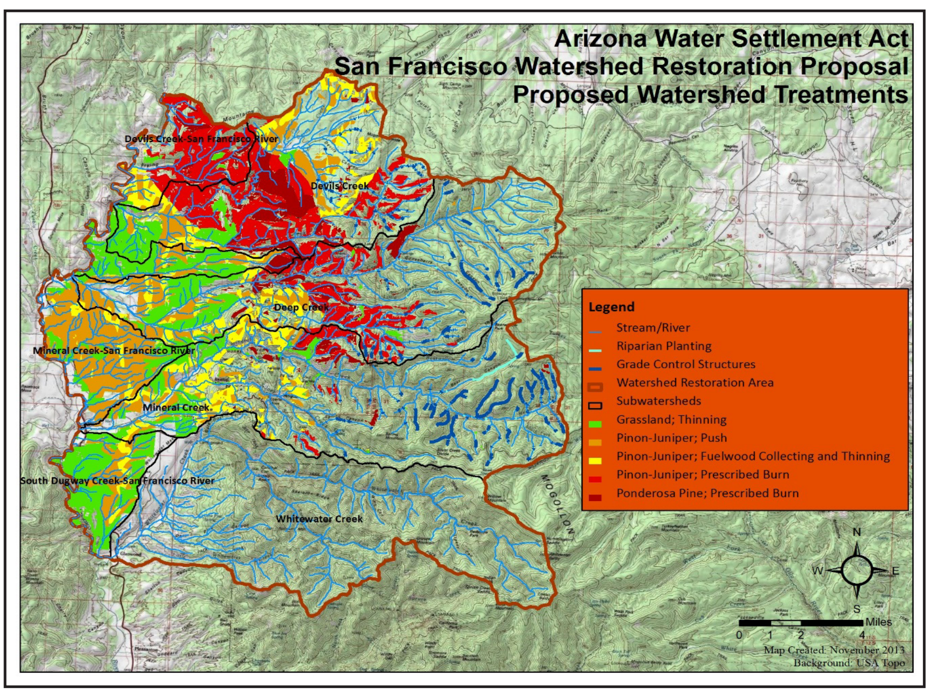


Figure 3. Arizona Water Settlement Act, San Francisco Watershed Restoration Proposal, Proposed Watershed Treatments.