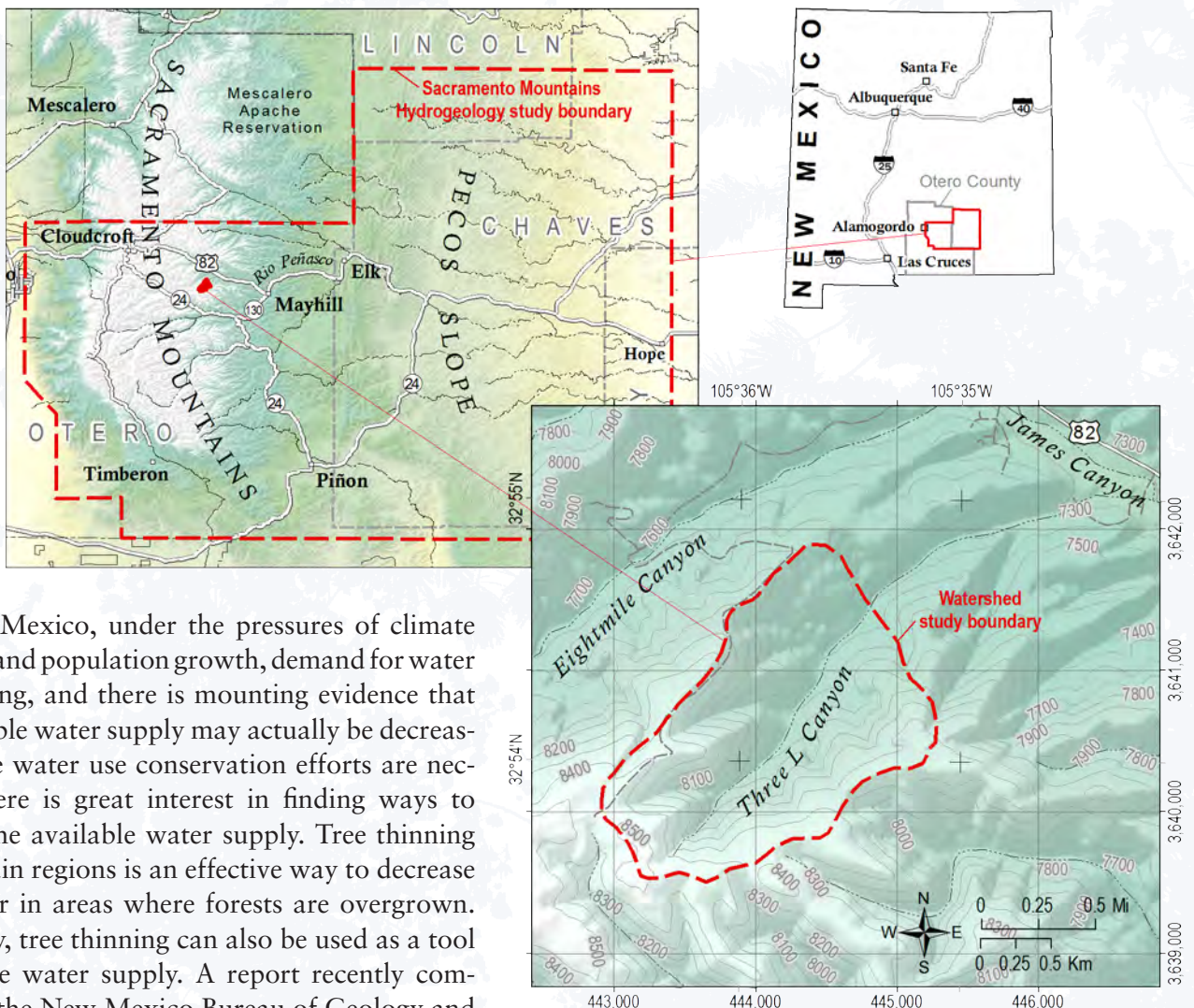


Sacramento Mountains Watershed Study Summary and Results

October 2015



In New Mexico, under the pressures of climate change and population growth, demand for water is increasing, and there is mounting evidence that the available water supply may actually be decreasing. While water use conservation efforts are necessary, there is great interest in finding ways to increase the available water supply. Tree thinning in mountain regions is an effective way to decrease fire danger in areas where forests are overgrown. Potentially, tree thinning can also be used as a tool to increase water supply. A report recently completed by the New Mexico Bureau of Geology and Mineral Resources describes a watershed study to address tree thinning in the Sacramento Mountains. This study focused on the effects of tree thinning on the hydrologic system, specifically on the potential to increase groundwater and surface water availability in the Sacramento Mountains.

The Sacramento Mountains watershed study took place in Three L Canyon, which is along James Canyon between Cloudcroft and Mayhill, New Mexico. This study took place during and after a regional study of the Sacramento Mountains hydrogeology, outlined in red on image top left.

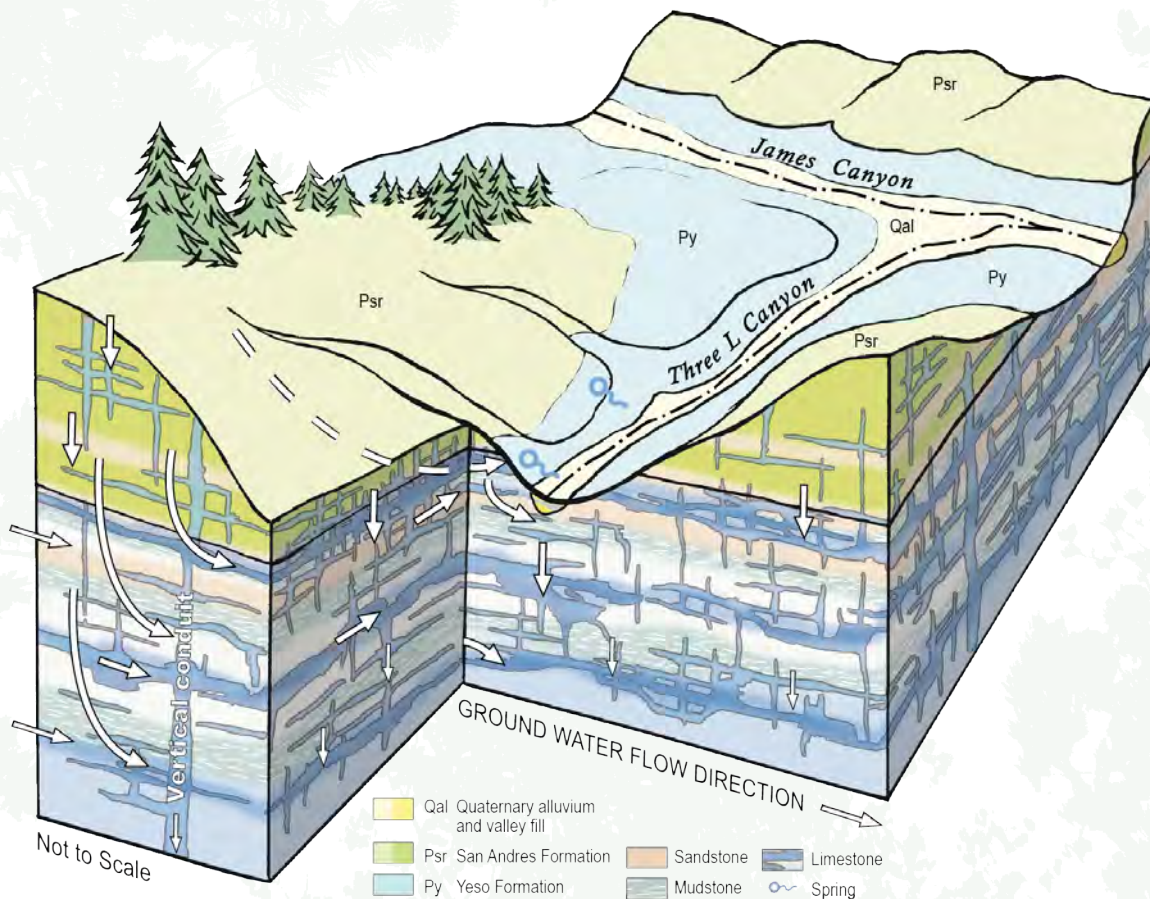
Around the world, studies related to tree thinning over the last 50 or so years have shown that the increase in stream flow and water availability mainly depends on climate, tree species composition, and the relative change in forest density. However, the measured hydrologic responses to tree thinning are highly variable and largely site specific.

The Sacramento Mountains, located in southeastern New Mexico, are the primary recharge area for adjacent regional aquifers, including the Roswell Artesian Basin aquifer, which supplies water to one of the most productive agricultural areas in the state. In the Sacramento Mountains, average annual precipitation is relatively high (up to 26 inches per year), and soils are relatively thin (average one foot thick). Precipitation at elevations above approximately 7800 feet recharges localized perched aquifers and moves down gradient to the east through the high mountain aquifer system. Previous work by the New Mexico Bureau of Geology and Mineral Resources (see websites listed), helped to characterize this aquifer system. The aquifer system has multiple layers of perched aquifers formed in fractured and dissolved carbonate (i.e. karst/caves

in limestone). The perched aquifers are connected by mountain streams and extensive fractures in this carbonate bedrock.

The watershed study took place on private property in Three L Canyon, a second order watershed along James Canyon. The study area includes approximately 800 acres and ranges in elevation from 7700 feet in the valley bottom to 8800 feet on the ridge top. Before thinning, tree densities ranged from twenty-eight to over one thousand trees per acre and consisted of mixed conifer, dominated by Douglas-fir. Four experimental 300 x 300 foot plot pairs, where one plot per pair was thinned and the other served as an un-thinned control plot, were used to investigate the effects of tree thinning on the local soil water balance. Outside of the plots, trees were thinned in a large portion of the watershed between 2011 and 2013. Tree densities were reduced by 20–30% on average with some areas having tree densities reduced to a much larger degree.

Challenging aspects of this study include the absence of a perennial stream, which for similar studies, serves as the main metric to determine an increase



Conceptual hydrogeologic model of Three L Canyon. The multiple layers of perched aquifers in fractured/dissolved carbonate bedrock are shown, with complexity of interconnection between aquifers and springs indicated by arrows.



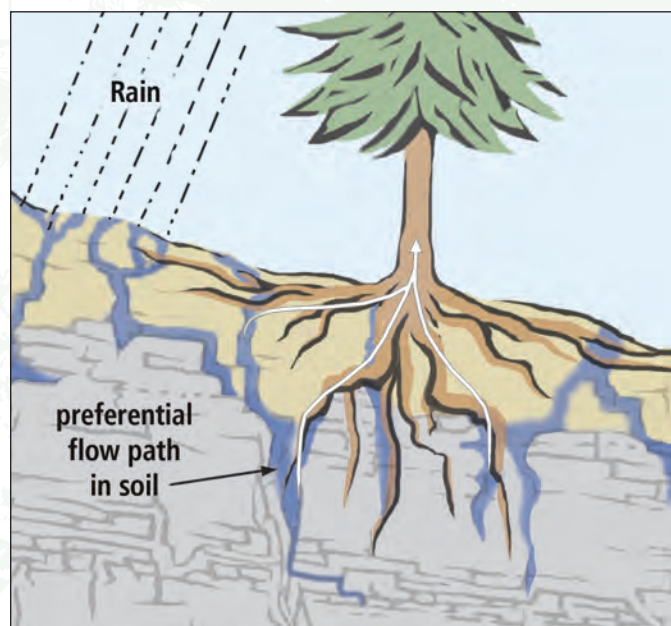
Before and after thinning photos. The photo above shows an area that was not thinned, while the photo below is an area that was thinned recently using mechanical mastication treatment.

in water yield. In the 2–4 years since tree thinning, the monitoring of groundwater levels and spring discharge showed no hydrologic response. This lack of hydrologic response to tree thinning is primarily due to the complex nature of the underlying fractured, karstic aquifer system. Therefore, to assess the effects of tree thinning on the local hydrologic system, we took a closer look at the small-scale system.

In this watershed study, we analyzed the different components of the soil water balance to assess the specific hydrologic responses to tree thinning. Components of the soil water balance begin with precipitation. As rain or snow reaches the land surface, it is partitioned into several different components of the soil water balance. Some water runs off (runoff), while the rest infiltrates into the soil. Water that evaporates or is extracted by tree roots is called evapotranspiration (ET). Water that percolates through the soil can potentially

recharge the aquifer system. In this watershed study, many instruments, including weather stations, rain gauges, and soil moisture sensors were installed to help examine each soil water balance component and how it changes due to tree thinning.

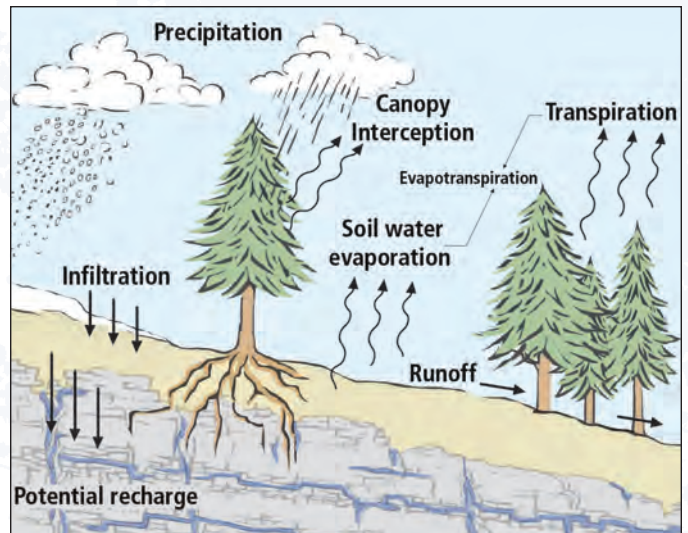
Our results show that canopy interception, which is the water that is captured by leaves and stems that subsequently evaporates, decreased dramatically when a significant portion of trees were removed. This decrease in canopy interception resulted in a very significant increase in the amount of water that was able to reach the land surface to contribute to the soil water balance. Surface runoff is extremely small in the study area (<10% of total rainfall) and was not affected by tree thinning. Net ET rates were shown to significantly decrease due to tree thinning. Soil moisture was higher in thinned areas because of the increase in the amount of water that reached the ground, with a decrease in ET. Interestingly, the soil was able to effectively store most of this ‘extra’ water, resulting in only small possible increases to the amount of water flowing through the soil matrix to the underlying fractured bedrock. Stable isotope analyses of soil water and water extracted from trees showed strong evidence of preferential flow paths, by which summer monsoon precipitation moved very quickly through the soil. Examples of preferential



Preferential flow paths exist in the soils and bedrock in the Sacramento Mountains watershed study area. These flow paths identified in this study area can provide an important mechanism for precipitation and soil water to recharge the aquifer.

flow paths in this region include large connected pores in the soil (macropores) or fractures in the underlying limestone bedrock. Thinning trees in this region likely results in more water moving through these preferential flow paths into to underlying fractured bedrock and perched aquifers. Additionally, a decrease of tree roots in the fractured limestone, due to thinning, will decrease the amount of water extracted from the root zone in the bedrock, resulting in more water that can potentially recharge the groundwater system.

The complicated hydrologic system composed of multiple perched aquifers made it difficult to quantify changes in groundwater supply as a result of thinning trees. Also, due to the lack of a perennial stream in the study area, we were not able to witness changes in surface water availability. While these two features would be ideal results to show as effects of tree thinning, our findings do suggest that there is likely an overall increase in potential recharge to the region due to tree thinning in the Sacramento Mountains. Within the recharge area of the southern Sacramento Mountains, at elevations above approximately 7800 feet, thinning of trees should promote increases in soil moisture, reduced evapotranspiration, and increased overall amount of precipitation to reach the land surface. Despite the fact that we did not quantify changes in water availability, these results suggest that tree thinning will likely promote increases in potential recharge, as well as many other added forest health benefits.



For a soil water balance, the only input is precipitation that reaches the surface. A significant amount of rain may be lost as canopy interception. Outputs include runoff, evapotranspiration (soil evaporation and uptake by vegetation), and potential recharge that moves downward past the soil column. Water is stored in the soil.

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geoinfo.nmt.edu/resources/water/amp/projects/SM_watershed_study.html
geoinfo.nmt.edu/resources/water/amp/projects/Southern_Sacramentos.html



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