

Minimizing Post-Fire Erosion Using Rainwater Harvesting Practices



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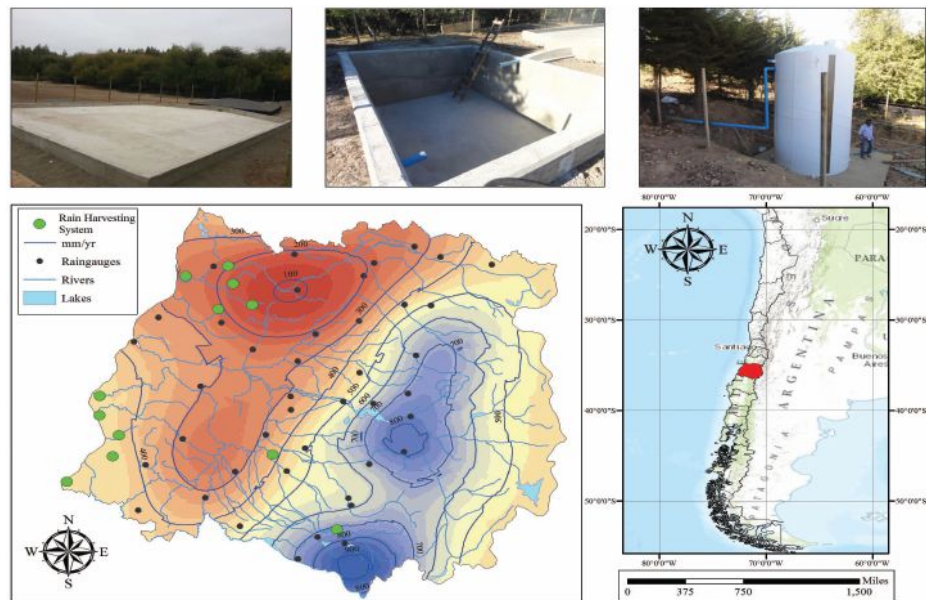
The authors present research conducted in Chile showing how rainwater harvesting can reduce costs associated with firefighting. They encourage foresters, land managers and firefighting-related decision-makers all over the world to more strongly consider this idea when developing policies and strategies to fight wildfires and to minimize the erosion that follows.

Fire is a natural occurrence in a significant portion of forest ecosystems in parts of North America, South America, Europe, Australia, Africa and the Mediterranean region. These fires usually are uncontrolled wildfires in areas of ignitable vegetation, but they also can be prescribed fires set for vegetation management purposes.

The four major natural causes of wildfire ignitions are lightning, volcanic eruptions, sparks from rockfalls and spontaneous combustion. Among the most common human-induced sources of wildfires are escaped prescribed fires, arson, unextinguished campfires, trash fires, cigarette butts, equipment sparks and power line arcs.

Though wildfires can lead to tremendous rates of soil erosion, they also have several beneficial effects on natural areas. Plants in ecosystems that are susceptible to wildfires often survive through adaptation processes that include physical protection against heat, increased growth after a wildfire event and production of flammable materials that stimulate fire and may diminish competition.

This means that some plant species actually depend on the effects of fire for growth and reproduction. An example is ponderosa pine (*Pinus ponderosa*), which can survive the passage of frequent low-severity wildfires thanks to a number of fire-resistant adaptations, such as thick bark, a deep



These photos show rainwater harvesting systems that were installed in Central Chile next to forest plantations to store water for domestic supply, irrigation, grazing and later on, for helicopter-based firefighting purposes. The color-map represents the spatial distribution of the minimum annual precipitation (mm) for T=100 years.



Constructed stock watering tank in the Apache-Sitgreaves National Forest, Arizona. Photo courtesy Arizona Game and Fish Department

root system, thick pine needles, etc. This and many other fire-tolerant forest species compete with other trees for nutrients, water and light, thus controlling the establishment of competing species while providing good conditions for their own seeds to germinate.

Causes and Costs

The establishment of forest plantations using fire-adapted species such as conifers has created a serious problem for land managers. Those species are more pre-disposed to fires due to the release of dry needles on the ground, which increases the likelihood of ignition by lightning.

Due to the large quantities of fine material that those species can drop every year (a few metric tons per hectare), wildfires in forest plantations are among the most destructive disturbances in the forestry industry. Just in the western United States alone, hundreds of thousands of hectares of land forested with these species are eroded every year as a consequence of wildfires. For instance, it is estimated that 3.52 M ha are burned annually within the United States alone. Wildfires across the western United States have been increasing in size and frequency over the past decades, and this tendency is expected to continue as the global climate keeps warming up, resulting in more severe and frequent draughts. Additionally, similar patterns have been documented in many other countries, such as Chile.

Activities such as prevention, detection, suppression and rehabilitation (reforestation) are considered the most important adaptation actions that can be taken to mitigate negative impacts of wildfires. In relation to this, the total costs of wildfires have been estimated to be between U.S. \$2,964 ha-1 and U.S. \$3,952 ha-1 (accounts for timber, property loss, prevention, suppression, erosion control, tourism, trade and

health). Most of the time, wildfire suppression costs range from two percent to ten percent of the total wildfire cost.

Despite its high costs per hour of operation, wildfire suppression using water bucket-based helicopters is still one of the most common techniques employed. The helicopters' performance on fire suppression is a function of the distance between the fire and the nearest body of water. When bodies of water are too far from the fire, water trucks usually go to the nearest safe location to fill portable tanks supplying water for the helicopters. The tanks constantly are being refilled in preparation for the helicopters' next trip.

Saving Time and Money

Because of the inherent inefficiency of the scenario described with the water trucks and the constant re-filling of water tanks, twelve rainwater harvesting systems were installed next to forest plantations in central Chile to supply water for domestic, irrigation and grazing purposes. The consumption per capita per day (per family group) was calculated to determine the users' demands, which fluctuated between 30,000 and 70,000 L for the dry season (October through March).

With these figures in mind, forty-three rain gauges were used to calculate the minimum annual accumulation (mm) associated with different return periods ($T = 2, 5, 10, 25, 50$ and 100 years) using the Gumbel's Probability Density Function (PDF). Both the demands and minimum accumulation were used to design the catchment areas. Geomembrane and cement were used to build the impervious surface of each catchment, and water was stored in tanks made of polyethylene, polyvinyl chloride (flex-tanks), fiberglass and concrete (See Figure 1).

After three years of monitoring, the conclusion is that rainwater harvesting systems represent an exceptional opportunity for minimizing firefighting costs in forestry-developed countries such as Chile or the United States.

These simple and relatively economic systems can be installed on clear, flat and sloped areas located next to forest plantations, such as firebreaks, a common fire prevention management practice. With a proper firebreak network design and the installation of an optimum rainwater harvesting systems network, helicopter-based

firefighting could be much more effective. Water would be available in-situ, eliminating the need to fly back and forth to the nearest body of water or to the location where water truck tanks are, which is a function of the road network within and/or around the plantation. The harvested rainwater also could be used by firefighters with long hoses connected to those cisterns located uphill from the fire.

Though there is some experience in the U.S. with rainwater harvesting for structural firefighting, the use of rainwater harvesting systems for wildland firefighting purposes is variable depending on climate and region. It is a common practice in semi-arid areas of the Intermountain West, Great Plains and Southwest where stock watering tanks have been established due to the lack of perennial surface water flow (See Figure 2). Rainwater harvesting is not a common practice in more humid regions, such as the Pacific Northwest, where most streams are perennial.

Rainwater harvesting is widely recognized as having tremendous potential for saving monetary and forest resources, private property and human lives. The authors suggest using GIS-based approaches to identify potential rainwater harvesting systems sites. Additionally, future research should focus on quantifying the economic and environmental impacts of these systems to minimize the cost/benefit ratio of firefighting.

As a conclusion, the authors encourage the world's foresters, land managers and firefighting-related decision-makers to consider this emerging idea among their fire suppression policies and strategies to minimize the area eroded during the rainy season following wildfires. 

**NOTE: This article was adapted from the article titled "Using Rainwater Harvesting Techniques for Firefighting on Forest Plantations" that appeared in the Journal of Tropical Forest Science 27(1):1 1-2 written by Garcia-Chevesich, P. R. Valdes, D. Neary and R. Pizarro in 2015. Garcia-Chevesich and R. Valdes are with the Department of Hydrology and Water Resources, University of Arizona; D. Neary is with the U.S. Forest Service, Rocky Mountain Research Station; and R. Pizarro is with the Faculty of Forest Engineering, University of Talca.*