

USING RAINWATER HARVESTING TECHNIQUES FOR FIREFIGHTING IN FOREST PLANTATIONS

P Garcia-Chevesich¹, R Valdes-Pineda¹, D Neary² & R Pizarro^{3,*}

¹Department of Hydrology and Water Resources, University of Arizona, 1133 E James E Rogers Way, J W Harshbarger Bldg Rm 122, PO Box 210011, Tucson, AZ 85721-0011, USA

²US Forest Service, Rocky Mountain Research Station, 2500 South Pine Knoll Drive, Flagstaff, AZ 86001, USA

³Faculty of Forest Engineering, University of Talca, Camino Lircay S/N, Talca, Chile; rpizarro@utalca.cl

Fire is a natural component of forest ecosystems in parts of North America, South America, Europe, Australia, Africa and the Mediterranean region. These fires are usually uncontrolled wildfires in areas of ignitable vegetation but can also be prescribed fires set for vegetation management purposes. Wildfires are commonly characterised based on cause of ignition, physical properties (e.g. propagation rate), fuel material and weather conditions. 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, equipment sparks and power line arcs.

Wildfires can cause widespread damages to property and human life; however, they also have several beneficial effects on natural areas. Plants in ecosystems that are susceptible to wildfires often survive through adaptations processes that include physical protection against heat, increased growth after a wildfire event and flammable materials that stimulate fire and may diminish competition. This means that some plant species depend on effects of fire for growth and reproduction. An example is *Eucalyptus* spp. which contain flammable oils that stimulate fire and have hard leaves able to resist heat and drought, ensuring their dominance over less fire-tolerant species. Another example is of ponderosa pine (*Pinus ponderosa*), which can survive the passage of frequent low-severity wildfires thanks to a number of fire-resistant adaptations (e.g. thick bark, deep root system, thick pine needles). These fire-tolerant forest species compete with other trees for nutrients, water and light by encouraging low-severity, periodic fires, thus controlling the establishment

of competing species while providing good conditions for their own seeds to germinate.

The establishment of forest plantations using fire-adapted species such as many conifers has created a serious problem for land managers because these species are more predisposed to fires due to the release of dry needles on the ground, which increases the likelihood of being ignited by lightning. Due to the large quantities of fine material (needles) that these species can drop every year (a few metric tonnes 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 burned and destroyed every year by wildfires. For instance, it is estimated that 2.95 Mha are burned annually within the United States during the past decade and it is clear that wildfires across the west portion of the country have been increasing in size and frequency over the past decades. This tendency is expected to continue as global climate keeps warming up, resulting in more severe and frequent draughts.

Activities such as prevention, detection, suppression and rehabilitation (reforestation) are considered the most important adaptation actions that can be applied to mitigate negative impacts of wildfires. Based on several studies, Howard (2014) suggested that most of the time wildfires suppression costs range from 2 to 10% of the total wildfire cost. Despite its elevated costs per hour of operation, wildfire suppression using water bucket-based helicopters is still one of the most common techniques to suppress wildfires. Their performance in 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, normally, the procedure calls for the use of water trucks which are driven

to the nearest safe location to fill portable tanks to supply water for helicopters. These tanks are constantly refilled in preparation for the helicopter's next trip.

Due of the above situation, 12 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 with the purpose of defining users' demands, fluctuating between 30,000 and 70,000 L in the dry season (October through March). 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.

After three years, conclusion has been reached that the systems represent an exceptional opportunity for minimising firefighting costs in forestry-developed countries. These simple and relatively economic systems can be installed on clear, flat and sloped areas located next to forest plantations such as firebreak, a common fire prevention management practice. With proper firebreak network design and installation of an optimum rainwater harvesting system network, helicopter-based firefighting could be much more effective because water would be available in-situ, as opposed to flying back and forth to the nearest body of water or to the location where water truck flex-tanks are, which is a function of the road network within and/or around the plantation. The harvested rainwater could be also used by firefighters with long hoses connected to those cisterns located uphill from the fire.

Though there is some experience in the USA 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 south-west where stock watering tanks have been established due to lack of perennial surface water flow. Rainwater harvesting is not a common practice in more humid regions such as the Pacific north-west where most streams are perennial. It is recognised as having tremendous potential

for saving monetary and forest resources as well as private property and human lives.

The authors suggest using GIS-based approaches to identify potential rainwater harvesting system sites. Additionally, future research should focus on quantifying the economic and environmental impacts of these systems to minimise the cost/benefit ratio of firefighting. As a conclusion, we encourage all foresters, land managers and firefighting-related decision-makers to consider this emerging idea among their fire suppression policies and strategies. From simple earthworks to embank and store storm runoff during rainy seasons, as practised in the USA, to underground and surface water tanks to store runoff generated from impervious catchment areas, as we've been experiencing in Chile, the potential of rainwater to improve firefighting efficiency is of epic proportions. Indeed, the first response, or the first few helicopter trips, is the most important variable to suppress wildfire because it is then when the perimeter of the fire is the smallest. Having a source of water to combat wildfires in or next to the plantation would maximise the effectiveness of helicopters, saving millions of dollars worth of forest resources and firefighting costs.

REFERENCES

- HOWARD P. 2014. *Flammable Planet: Wildfires and the Social Cost of Carbon. The Cost of Carbon Project. Environmental Defend Fund. Natural Resource Defense Council.* [Http://costofcarbon.org/files/Flammable_Planet_Wildfires_and_Social_Cost_of_Carbon.pdf](http://costofcarbon.org/files/Flammable_Planet_Wildfires_and_Social_Cost_of_Carbon.pdf)

Pablo Garcia-Chevesich is an expert in hydrology, soil erosion/sediment processes and control, land reclamation, and climate change mitigation from the natural resources management perspective. Pablo Garcia-Chevesich teaches courses in the above topics in the US, Europe and South America, and is constantly involved in scientific and development project in several countries. He is an active committee member for the International Development and the SOIL (Save Our International Land) programmes of the International Erosion Control Association and the US Ambassador for the International Sediment Initiative of UNESCO.