

Forest Change and Water Balance: *Investigating Forest Restoration Treatment Effects on Soil Water Storage, Evapotranspiration, Groundwater Recharge and Surface Water Discharge*

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PURPOSE AND NEED

Previous watershed experiments in ponderosa pine forests of the Southwest have investigated how changes in forest cover affect surface water runoff. However, those treatment prescriptions differed from forest restoration treatments and the water balance as a whole was not addressed. Therefore, there is a need to research restoration treatment effects

on evapotranspiration, soil water storage, and groundwater recharge as well as surface water runoff. By understanding the water, mass and energy balance of hydrologic processes in restored forests (Figure 1), adaptive management plans for the Four Forest Restoration Initiative, or 4FRI, can be shaped to promote a forest that is more resilient to climate variability, thereby safeguarding habitat for many dependent species.

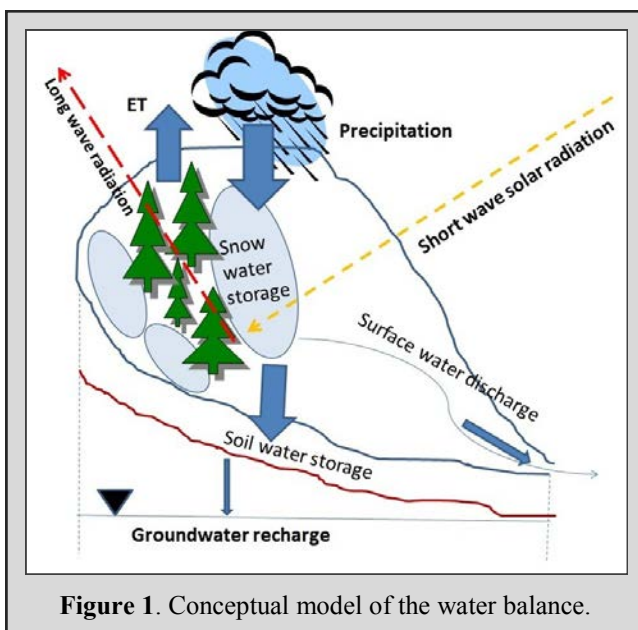


Figure 1. Conceptual model of the water balance.

DESIGN

Paired watersheds, which compare treated “experimental” and untreated “control” watersheds, are standard practice for evaluating hydrologic effects of forest management practices. They require years of pretreatment and post-treatment data to draw conclusions. The size of watersheds may vary between studies, but it is best to have consistent watershed sizes within a single study to reduce extraneous sources of variability. A single untreated watershed can serve as the control for several treated watersheds with which it is paired.

Multiple pairs with relatively consistent characteristics (similar elevation, aspect, topography, geology, etc.) are preferred for determining the significance of findings across the landscape. Three control and nine experimental watersheds are proposed for the first analysis area for the 4FRI paired watershed study. Six watersheds are within the Sycamore Canyon watershed on Kaibab National Forest; and six watersheds are in the Walnut Creek watershed (or more specifically the Lake Mary watershed) on Coconino National Forest (Figure 2, page 2). Most of these watersheds are between 700 and 1,000 acres, are all in predominantly ponderosa pine forest, and all have basalt or basalt and volcanic surficial geology (Table 1, page 2).

In contrast to earlier experimental watersheds in Arizona, the treatments are not designed to affect surface water yield. Instead, the paired watershed study works within the context of the treatment prescriptions selected for multiple objectives of 4FRI. This study proposes to evaluate changes in water, mass, and energy balance in forest restoration prescriptions of low, medium, and high-intensity treatments and various degrees of change in basal area and forest structure. One hypothesis of the study is that a 30% to 70% decrease in basal area will elicit the greatest water balance response in terms of decreased evapotranspiration and increased soil water storage, groundwater recharge, and surface water discharge.

The Ecological Restoration Institute is dedicated to the restoration of fire-adapted forests and woodlands. ERI provides services that support the social and economic vitality of communities that depend on forests and the natural resources and ecosystem services they provide. Our efforts focus on science-based research of ecological and socio-economic issues related to restoration as well as support for on-the-ground treatments, outreach and education.

All watersheds will be instrumented to measure precipitation, weather, soil moisture, snow water equivalence, evapotranspiration, surface water discharge, water quality, and recharge through chloride mass balance.

Data collection will include a seven-year pre-treatment period, followed by initial mechanical thinning and burn treatments. This will be followed by a 21-year post-treatment data collection period. The post-treatment period will include follow-up burn treatments in seven-year intervals. Researchers will monitor hydrological effects from a fire regime that resembles a more natural fire return interval, something that hasn't been done before. Data will be statistically analyzed and used in models to better understand hydrologic processes in restored ponderosa pine forest.

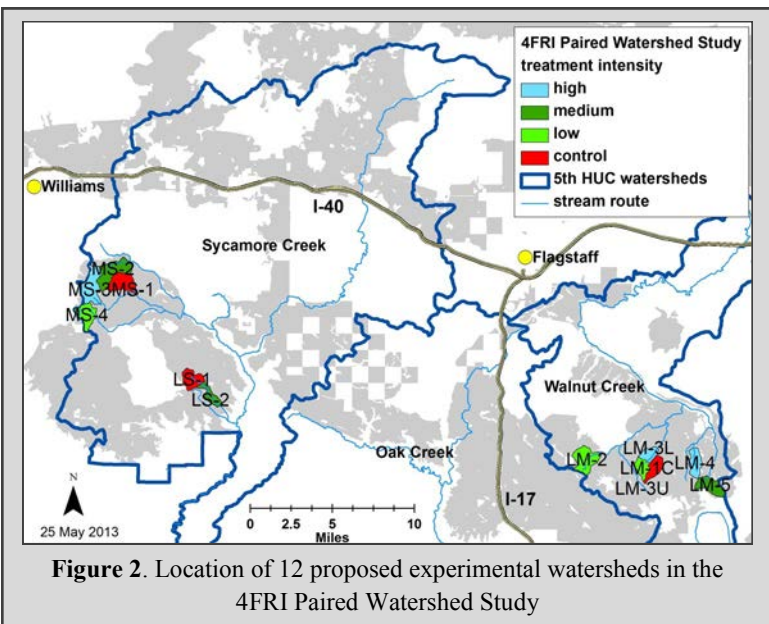


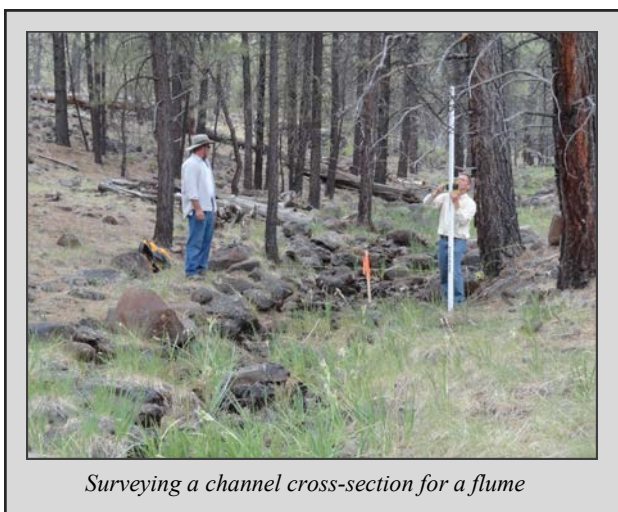
Figure 2. Location of 12 proposed experimental watersheds in the 4FRI Paired Watershed Study

Table 1. 4FRI Paired Watershed Study watershed properties

Watershed ID	MS-1	MS-2	MS-3	MS-4	LS-1	LS-2	LM-1C	LM-2	LM-3U	LM-3L	LM-4	LM-5
acres	980	1312	1235	809	752	505	624	1161	504	455	722	799
lowest elevation	6749	6788	7037	7044	6499	6375	7054	7165	7142	7077	6923	7018
highest elevation	7365	7365	7415	7789	6824	6548	7356	7684	7339	7188	7247	7238
aspect	ESE	ENE	S & SE	NE & SE	SE	SE	NE	NE	NE	NE	N	N
parent material	basalt	basalt	basalt	basalt	basalt	basalt	basalt	basalt	basalt	basalt	basalt	basalt
treatment intensity	control	medium	high	low	control	medium	control	low	low	high	high	medium

INTEGRATED RESEARCH

The 4FRI Paired Watershed Study is part of a network of forest restoration research activities that build on a long history of forest research in the Southwest. In the vicinity of the paired watershed study are other forest restoration study sites including the Fort Valley Experimental Forest (which includes the Gus Pearson Natural Area), Fire and Fire Surrogate Study sites (part of a nation-wide network of study sites), the Centennial Forest, and numerous current and past study sites investigated by Northern Arizona University's biology, forestry, geology, and environmental science graduate students. The Fort Valley Experimental Forest has extensive forest ecology data dating back to 1906. The Beaver Creek Experimental Watersheds, while using hazardous fuel reduction treatments that are not considered restoration treatments, nevertheless inform much of what is known about the hydrologic response to forest treatments in Arizona. Other experimental watersheds in the eastern half of 4FRI, including Workman Creek, Willow Creek, Thomas Creek, and Castle Creek, similarly provided insights that can be built on as restoration treatments and associated research progresses eastward.



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