Ecological Restoration Institute

***Fact Sheet**: Modeling Aquifer Response to Large-scale Restoration Treatments and Climate Change*

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NORTHERN ARIZONA UNIVERSITY

Ecological Restoration Institute

Interpretive Model of Regional Semi-arid Aquifer Responses to Large-scale Forest Restoration Treatments and Climate Change

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INTRODUCTION

The Four Forest Restoration Initiative (4FRI) is a collaborative effort to restore ponderosa pine ecosystems and reduce the threat of catastrophic wildfires throughout four National Forests along the Mogollon Rim in northern Arizona. To assess how this landscape-scale forest restoration project and future climate projections will affect groundwater recharge to regional aquifer systems that impact springs and streams along the Mogollon Rim, an adaptation of the Northern Arizona Regional Groundwater-Flow Model (NARGFM) was used. The modeling objectives were to:

- Simulate changes in groundwater recharge from landscape change and changing climatic conditions;
- Assess the impacts that these changes may have on the groundwater budget (recharge, discharge, and storage) of northern Arizona, with a focus on the Verde Valley groundwater catchment area and associated tributaries;
- Deliver the results to regional water users, managers, and stakeholders so the results may be used to inform water management strategies in the study area.

METHODS

A set of relatively novel methods were used for estimating changes in recharge from forest restoration treatments and climate change. The NARGFM groundwater model is not able to model variations in surface vegetation or precipitation. Therefore, a change in groundwater recharge was the model input data used to represent these changes. Changes in groundwater recharge were estimated as proportionately similar to changes in surface water discharge for given changes in tree basal area, which are known from findings the Beaver Creek Experimental Watersheds. All other NARGFM parameters, including pumping and evapotranspiration (ET), were kept at the same values used for the last NARGFM stress-period (a period of time during which all model stresses, such as groundwater pumping or variations in recharge, remain constant) of the published model, or the years 2000–2005. Scenarios were created to estimate recharge and discharge conditions into the future. These scenarios included:

- A baseline scenario from the period of record 1971–2000, which due to the lack of restoration treatments simulates future recharge conditions absent forest restoration treatments and climate change;
- Three scenarios that simulate 4FRI treatments effects combined with precipitation estimated from the mean, mean +1 standard deviation, and mean -1 standard deviation of the Intergovernmental Panel on Climate Change (IPCC) emission scenarios A1B (some increase in renewable energy), A2 (continued current level of fossil fuel use), and B1 (dramatic increase in renewable energy and decrease in fossil fuel use).

Changes in recharge from 4FRI treatments and precipitation projections were simulated by applying recharge -change factors to the recharge parameters built into the published NARGFM.

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Research Findings

Over a 10-year period of forest restoration treatments, a 2.8% increase (23,000 acre-feet) in recharge to one adjacent groundwater basin (the Verde Valley sub-basin) was estimated compared to conditions that existed from 2000–2005. However, this increase in recharge was assumed to quickly decline after treatment due to regrowth of vegetation and forest underbrush and their associated increased evapotranspiration. Furthermore, predicted groundwater recharge increases were masked by decreases in water levels, stream baseflow, and groundwater storage (see Figures 1 and 2 below) resulting from surface water diversions and groundwater pumping. These results show that there is an imbalance between water supply and demand in this regional, semi-arid aquifer. They also reveal that current groundwater pumping practices may not be sustainable into the far future and that comprehensive action should be taken to minimize this water budget imbalance.

Management Implications

If groundwater outflow exceeds groundwater inflow, a decrease in well water levels, stream baseflow, and groundwater storage may occur. Because both natural and human communities depend on these resources to survive, a reduction in these supplies will present a problem for both communities. Some problems may include decreased discharge at springs, change of streams from perennial to ephemeral conditions, increased depth to and fluctuations of the water table, and increased average annual depth to saturated soils. These impacts may reduce native vegetative diversity and abundance and increase the abundance of non-native "weedy" species such as tamarisk. These changes in vegetation may change the structure and resiliency of native fish, bird, mammal, herpetofauna, and invertebrate populations along the Verde River. These potential problems can also impact human communities that depend on groundwater and surface water in the area. The consequences of unsustainable groundwater pumping rates are that there will be an imbalance between water supply and demand, which may result in a significant amount of unmet demands for water users across the region. While landscape-scale forest restoration treatments are expected to cause a temporary increase in groundwater recharge, depending on climate conditions, this will do little to offset the long-term trend of regional groundwater depletion.

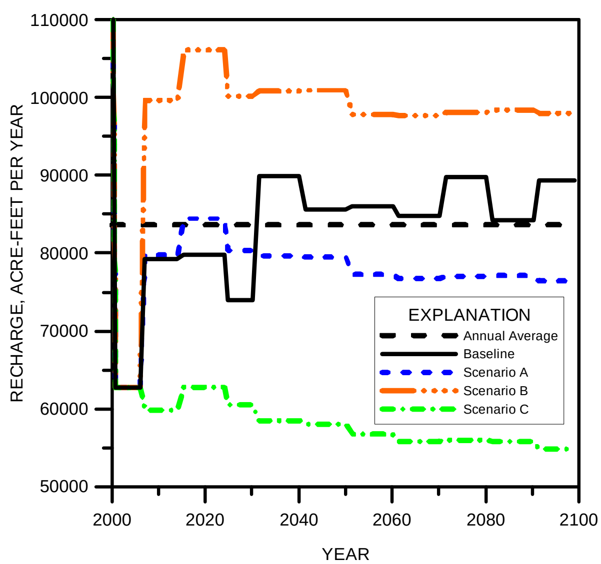

Figure 1. Changes in groundwater recharge in the Verde Valley sub-basin by scenario. Values are clipped to the years 2000–2100 to highlight differences between climate scenarios, baseline and historical scenarios, and 4FRI treatment effects.

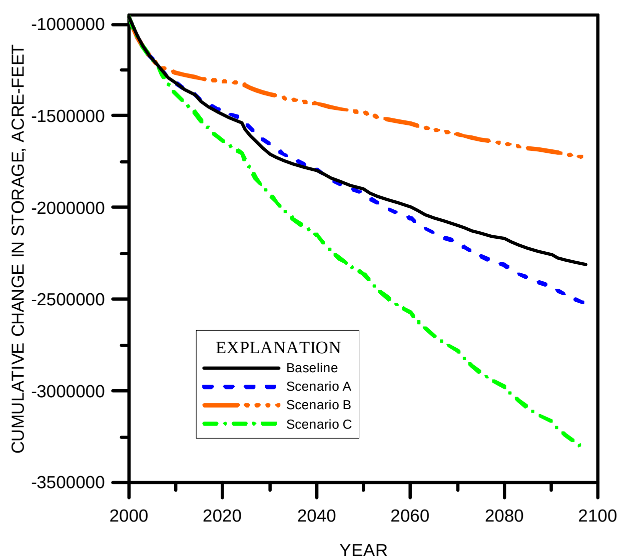

Figure 2. Changes in groundwater storage, by IPCC climate scenario, for the Verde Valley sub-basin clipped to the years 2000–2100.

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