Effects of woody vegetation removal on groundwater recharge in the Carrizo-Wilcox aquifer

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Abstract: The Carrizo-Wilcox aquifer is an important source of water for agricultural and municipal needs across approximately 60 counties in Texas. As use of the aquifer increases and managers look for methods to increase recharge rates, understanding the effects of woody vegetation removal on recharge is becoming more important. However, surprisingly little research has been done to quantify the impacts of such actions on recharge. This project will investigate the impacts of woody vegetation removal from the recharge zone of the Carrizo-Wilcox aquifer on downward fluxes of vadose zone soil moisture in a replicated field experiment. Given the difficulties associated with quantifying recharge in semi-arid systems such as this one, we employ multiple indirect methods across the experiment, validated by an intensive instrumentation effort. The proposed research will provide quantitative information needed by the groundwater conservation districts and landowners throughout the region.

Statement of Critical Regional Water Problems: The Carrizo-Wilcox aquifer supplies water for agricultural, livestock and municipal uses in many counties in southern Texas. As for other aquifers in Texas, population increases have lead to greater demand for water from the Carrizo-Wilcox aquifer, especially as urban centers see increasing demands on existing water sources (e.g., the San Antonio and the Edwards Aquifer). Landowners and natural resource and conservation managers are increasingly being asked to maximize the production and sustainability of multiple environmental services in this management area. If sustainable land use is to occur, quantitative knowledge of the linkages between ecosystem change, recharge and groundwater quality is imperative (Scanlon et al. 2005). Likewise, understanding vegetation and soil dynamics is a critical component of understanding recharge.

Nature, Scope, and Objectives of the Research: Understanding the effects of vegetation on groundwater recharge is important in areas such as the Winter Garden

Groundwater Conservation District where vegetation is being managed for various outcomes and by different means. Some of the current research suggests that there could be positive impacts on deep drainage by vegetation manipulation (Moore et al. 2010), while other research indicates removal of woody vegetation would have little if any effect on recharge (Seyfried et al. 2005). A study by Scanlon et al. (2005) argues that rangelands have essentially not had any recharge since the beginning of the Holocene. The same study showed that when native untilled, grassland and shrublands in arid and semi-arid environments were converted to non-irrigated agriculture, water tables increased. This change in land cover suggests potential for removal of woody vegetation to have a positive impact on recharge. When looking at recharge across arid and semi-arid areas in the western United States, Seyfried et al. (2005) found that deep drainage may not be occurring even beyond the root zone where measurements indicate an upward soil water potential gradient. Both Seyfried and Scanlon highlight the importance of considering the plant soil-system when drawing conclusions regarding vegetative effects on recharge.

Rangelands across Texas are subject to a variety of management practices and are managed for a variety of reasons. Some land is managed to improve grazing for cattle, while some is managed to improve bird or deer habitat for hunting. Increasingly, managers are explicitly engaged in activities to improve aquifer recharge. There is currently discussion of offering land owners credits for water “saved” by removal of woody vegetation. In consideration of all of the reasons why vegetation is being removed and to what degree, it is important to understand what the impacts are on groundwater. At this time, there is very little scientific information for the Carrizo-Wilcox region to support decisions about removal of vegetation and its subsequent effects on groundwater. Even less is known about the role of soil type or texture on the effects of vegetation removals.

Our primary objective is to enhance the interpretation of planned indirect estimates of aquifer recharge in a large, manipulative field experiment through targeted direct measurements of moisture flux below the root zone. We have established a large, replicated experiment in the southwestern recharge zone of the Carrizo-Wilcox aquifer. In this experiment we are removing woody vegetation using three commonly-applied mechanical and chemical techniques, as well as evaluating their interaction with cool-season fires and how these techniques interact with soil texture. The techniques used for removal of woody vegetation span the range of impacts associated with common brush removal techniques from no impact (control plots) to moderate mortality (roller chopping) to near 100% mortality of woody species (chainsaw plus herbicide of all woody stems).Roller chopping involves a large water filled cylinder (Tandem Aerator; Lawson Manufacturing, Kissimmee, FL) with teeth being rolled by a tractor over the vegetation. Cut stump is a method where chainsaws are used to remove all of the woody vegetation. Once cut, an herbicide (Remedy; Dow AgroSciences, Indianapolis, IN)is applied to stump. Of the 54 total plots (mechanically/chemically treated and control), half will be randomly assigned to a cool season fire treatment. Soils maps from the region were used to determine locations for plots (approx. 0.10 hectare) and include three general classes of soil textures: sandy loam, clay loam, and loamy sand to sand.

Quantifying recharge in these semi-arid systems is difficult and the application of multiple techniques increases the reliability of recharge estimates (Scanlon et al. 2002).We will be making assessments of water movement from volumetric water content measurements, soil texture, chloride, and stable isotopes (δ^2H and δ^{18}O) throughout the soil profile. Chloride profiles provide a long-term history of recharge for the area. To allow an assessment of shorter-term responses, soil moisture stable isotope ratios will be analyzed. The combination of chloride concentration profiles and stable isotope data will provide critically important information about recharge. However, given the uncertainties associated with each method, it is important to implement multiple techniques for quantifying recharge due to increase reliability of the estimates (Scanlon et al. 2002).

We therefore propose here to enhance our understanding of recharge significantly by directly quantifying recharge using "Gee-type" passive capillary lysimeters and comparing those observations to estimates made using the above-described indirect methods. Recharge rates are especially difficult to predict in semi-arid regions and the reliability of estimates is quite variable (Scanlon et al. 2002).Our current approach is to estimate recharge indirectly with three methods (soil chloride, soil water isotopes, and water balance) across the experiment. Here we propose to enhance our ability to understand the recharge dynamics by directly quantifying recharge in a subset of plots using so-called "drain gauges" or passive capillary lysimeters. With additional funding from USGS we will make direct measurements of soil moisture flux below the rooting zone in three replicate control plots.

Results Expected from this Project: The proposed project will yield current recharge rate estimates under existing brush-dominated conditions and allow comparisons to be made with indirect methods for estimating recharge. Recharge rates associated with various brush removal techniques will also be estimated. The comparison of this information is critical to the evaluation of land management decisions and their effects on a regionally-important groundwater resource. This project will allow us to assess methodologies for indirectly estimating recharge and significantly enhance our ability to determine how brush control techniques interact with soil characteristics to affect aquifer recharge. We will also produce peer-reviewed publications based on our findings and provide timely project reports to relevant land and water managers (e.g., the Wintergarden Groundwater Conservation District).

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