LAND-BASED WATER CONSERVATION & WATER YIELD PRACTICES IN REGION L: MONITORING STRATEGIES

SUBMITTED TO
REGION L
SOUTH CENTRAL TEXAS REGIONAL WATER PLANNING GROUP
BY

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ABSTRACT

The goal of the monitoring program is to determine the amount, if any, of additional recharge and/or streamflow results from managing woody plants. An effective monitoring program would need to include multiple measurements at several different scales. Monitoring approaches include remote sensing, watershed comparisons, small catchment studies, micrometeorological towers and soil moisture measurements. For the Region L area we recommend the following: (1) incorporate and apply the large scale remote sensing technology across the Region L area; (2) in each of the target areas have a network of evaptranspiration (ET) towers in treated and untreated locations; (3) in the Carrizo-Wilcox area, complement ET tower measurements with detailed monitoring of soil moisture in treated and untreated areas: and (4) in the Guadalupe Watershed monitor spring flow in as many locations in treated and untreated areas (ET towers would be in the same areas).

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We have determined that there are three distinct areas within Region L that offer the most potential for increased streamflow through management of woody plants. These include (1) the Carrizo-Wilcox aquifer recharge zone with special emphasis in Dimmit and Zavala Counties (2) the Edwards aquifer recharge zone in Uvalde, Medina, Bexar, Comal and Hays Counties, and (3) the Guadalupe River watershed above Canyon Lake including Comal and Kendall counties. Each of the areas are different and have a distinct regional hydrology that must be taken into account in developing monitoring protocols that are aimed at evaluating the hydrological effect of brush control.

There are two major recharge zones within the Region L Area—the Carrizo-Wilcox and the Edwards Aquifer. As noted above the recharge zones and the aquifers that they supply are very different in character. The Edwards Aquifer is a karst system and as such is very dynamic and capable of very rapid recharge as well as discharge. It is a renewable groundwater resource meaning that recharge is roughly equivalent to discharge, including groundwater pumping. Recharge occurs largely within stream channels that traverse the recharge zone. There is likely some distributed recharge outside of the stream channels but as of yet there have been no reliable estimates of how important distributed recharge may be.

The Carrizo-Wilcox aquifer, by contrast, is not a renewable aquifer and recharge is lower than ground water pumping, with the result being that groundwater levels are declining. Recharge occurs where the Carrizo Sands and Wilcox formation are exposed at the surface. Soils are quite sandy and infiltration rates are high (little runoff). Water that moves beyond the rooting zone is available for recharge.

The third area that we have identified as having a potential for augmenting water supply through brush control is the area of the Guadalupe Watershed above Canyon Lake. The presence of Canyon Lake affords the opportunity for storing any additional water that may result from land management activities.

The goal of this report to lay out some potential strategies and techniques that may be employed for determining the extent to which, if any, water supply is augmented through brush management. Because each area is so distinct, a different suite of monitoring protocols will be required for each.

POTENTIAL MONITORING STRATEGIES

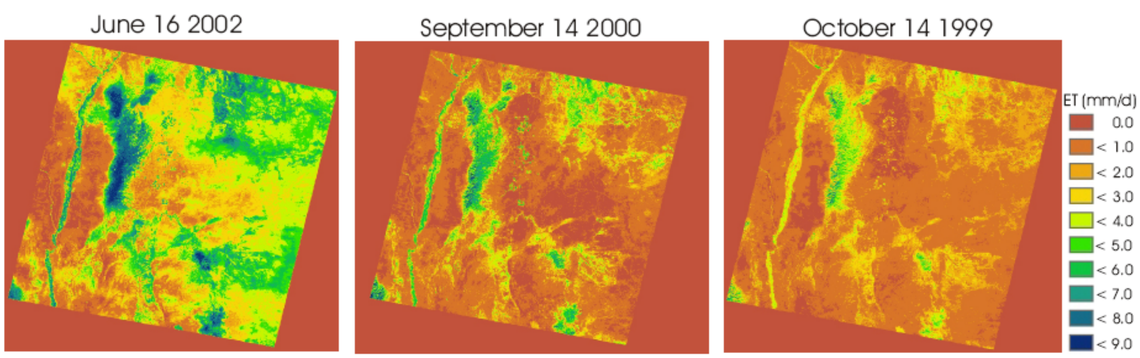
The fundamental challenge posed is that of determining how much, if any, additional water has resulted from particular land management practices. This requires determining both how much recharge (or streamflow) occurs AND whether or not it is higher than would have been in the absence of the land management practice. The variability of climate often makes this a difficult and time consuming proposition. In addition, in order to determine if there is a difference we have to be able to make a comparison of different treatments either in time or space.

Regional scale

Remote sensing

Emerging technology now exits for estimating evapotranspiration using remote sensing imagery. This is relatively new technology but there is the potential to map evapotranspiration across very large areas within Region L and relating evapotranspiration rates to vegetation cover (the presence or absence of woody plant cover). This approach could potentially allow for a comprehensive evaluation of the potential for releasing more groundwater recharge through shrub control. Specifically, tracking evapotranspiration rates across several years could answer specific questions such as (1) can shrub clearing lead to enhanced recharge (2) where would shrub clearing be most effective (3) would the effect be the same or different for wet and dry years.

The technique has been successfully applied in New Mexico. An example from the Rio Grande Valley in New Mexico is presented below (Hong and Hendrickx, 2006). This example provides a nice illustration of the spatial and temporal resolution that is possible.



Challenge: This technique is still experimental and would require implementation and evaluation by remote sensing experts

Application Area: This technique could be effectively applied in each of the three target areas

Intermediate scale (100-10000 km^2)

Large Watershed Studies

Watershed experiments in which streamflow is continuously monitored in one or more watersheds offer the potential of assessing land management practices. These kinds of experiments have been conducted in many settings, with considerable success(Bosch and Hewlett, 1982; Stednick, 1996). However, there are significant challenges in successfully completing such experiments. A typical approach is using a pair of watersheds where one is treated and the other is not. For these kinds of experiments to work, considerable time is required (years), both to insure that the watersheds are comparable and also having sufficient time after implementation of the treatment. Another approach is that of using a single watershed and implementing the treatment after several years of monitoring. The effectiveness of the North Concho shrub control project has recently been evaluated using this kind of approach (Wilcox et al. 2008). Similarly, Trimble et al. (1987) used long term streamflow records to demonstrate that streamflows in Tennessee have been diminished because of expanding forests.

Challenge: Time and expense. Large watershed studies require significant time and resources to be successfully implemented

Application Area: Guadalupe River above Canyon Lake.

Field Scale

At smaller scales more detailed measurements of water fluxes can be measured and several approaches are available, both of which have advantages and disadvantages

Evapotranspiration Micrometeorology Towers

The technology is now available to directly measure evapotranspiration over areas the size of a football field using instrumentation that is mounted on towers. The most common approach for doing this relies on the Eddy Covariance technique. Similarly, the Bowen Ratio approach has been applied with some success. Direct measurements of evapotranspiration at the field scale can provide estimates of water savings resulting from vegetation management. These techniques have been used with good success for assessing the effects of vegetation on the water cycle (Dugas *et al.*, 1998; Dugas and Mayeux, 1991; Scott *et al.*, 2003) and for best results these measurements should be complemented by field measurements of surface runoff.

Challenge: Operation of evapotranspiration towers require skilled technicians and good data management systems.

Application Area: All areas

Small catchments experiments

Monitoring runoff and springflow at the scale of a few acres can provide insight as to the effects of vegetation manipulation. The same logic ideas and constraints apply as for the very large watershed scale studies discussed above. Small catchment studies have been done with some success in the Edwards Plateau in evaluating the effect of vegetation management (Huang *et al.*, 2006; Wilcox *et al.*, 2005).

Challenge: As with the large watershed studies, catchment experiments required many years of observation. In addition, it can be very difficult to find suitable catchments for paired experiments.
Application Area: Guadalupe River above Canyon Lake.

Plot Scale

Monitoring water in the vadose zone

One of the best ways of determining the influence of plants on recharge is that of making detailed measurements soil water both within and below the plant root zone. Ideally measurements would be made repeatedly in both time and space. The technology is available for continuous monitoring of soils moisture and a variety of techniques and approaches are available. This approach has been used with great success including several studies in South Texas (Weltz and Blackburn, 1995; Moore *et al.*, 2008)

Challenge: Soil monitoring is difficult if not impossible in the Edwards Plateau region because of shallow, rocky soils.

Application Area: Carrizo-Wilcox recharge zone.

Plant level measurements of transpiration and interception

Woody plants affect the water cycle because they transpire water and they also intercept rainwater—both of which are very important. Transpiration and interception by shrubs can be directly measured and there are examples of this kind of work in the Edwards Plateau and south Texas (Owens *et al.*, 2006; Owens, 1996; Owens and Schreibe, 1992).

Challenge: Tree level measurements can be made but it is often difficult to determine what they mean on a landscape scale

Application Area: all areas

RECOMMENDATIONS

Each of the target areas are different and each pose opportunities and challenges in terms of monitoring.

Recommendation 1: Incorporate and apply the large scale remote sensing technology across the Region L area. In addition to addressing the effectiveness of the brush management program, it will provide very useful regional information related to water resources

Recommendation 2: In each of the target areas have at a network of ET towers in treated and untreated locations. These measurements should be complemented by monitoring of surface runoff so that recharge could be estimated by difference.

Recommendation 3: In the Carrizo-Wilcox area, complement ET tower measurements with detailed monitoring of soil moisture in treated and untreated areas

Recommendation 4: In the Guadalupe Watershed monitor spring flow as many locations in treated and untreated areas (ET towers would be in the same areas).

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