Quantifying Ground-Water Savings Achieved by Salt-Cedar Control Measures: A Demonstration Project

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Introduction

Consumption of ground water by phreatophytes in riparian corridors is thought to be one factor responsible for stream-flow reductions in western Kansas and elsewhere. Extensive phreatophyte-control measures, primarily focusing on invasive species such as salt cedar (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*), are being considered in response to concerns about the impact of phreatophytes on surface- and ground-water resources. At present, there is no generally accepted means of quantifying the ground-water savings that might be gained through these control measures. Micrometeorological methods are often not appropriate for this application because their fetch requirements are too large for narrow riparian corridors. Recently, an approach based on diurnal fluctuations in the water table, which was originally proposed by White (1932), has been shown to have potential for quantifying ground-water consumption by phreatophytes (Loheide et al., in press). A demonstration project is underway to examine the utility of this method for assessing ground-water savings achieved through phreatophyte-control measures.

Field Site

This project is being carried out at the Ashland Research Site, which is located in a region of salt-cedar infestation along the Cimarron River in southwestern Kansas (Figure 1). The site has been subdivided into four areas of approximately four hectares each in which different salt-cedar control measures will be applied (Figure 2). Plot 1 will not undergo treatment so that data unaffected by control measures can be obtained. Plots 2-4 will be mowed and chemically treated, mowed only, and mowed and burned, respectively. Two wells have been placed in each of Plots 1-3 in the vicinity of the most common phreatophyte communities at the site. All wells are screened across the water table. Figures 3a and 3b displays photos of wells in Plot 1 and Plot 2, respectively.

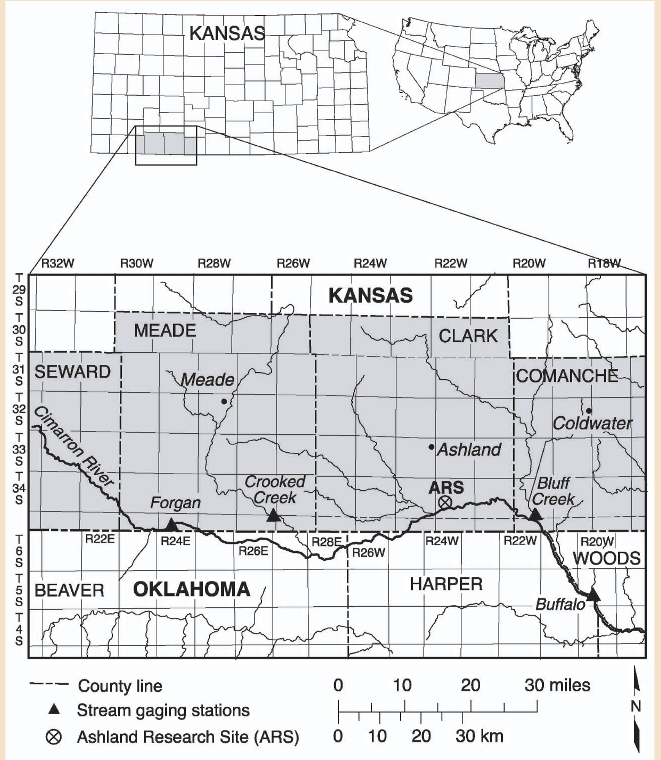

Figure 1

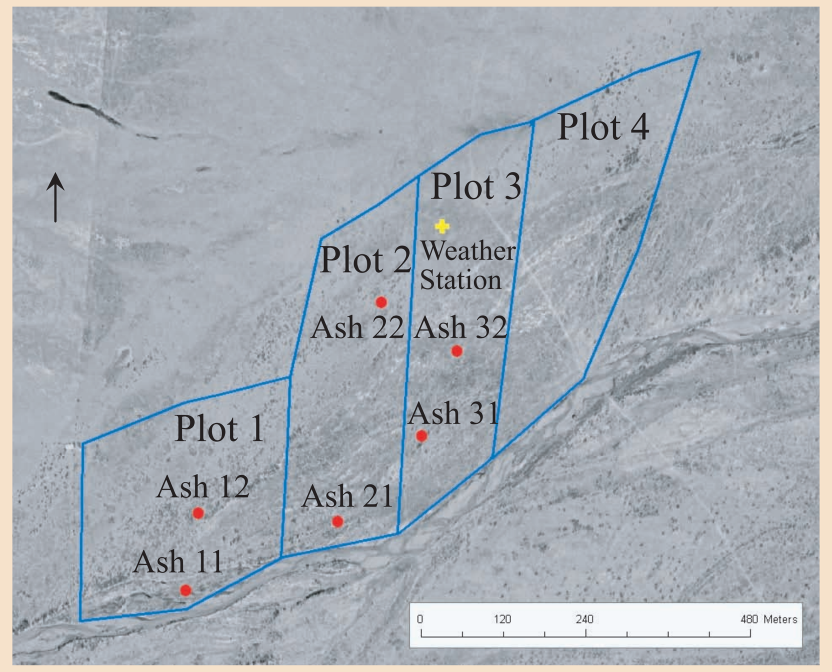

Figure 2

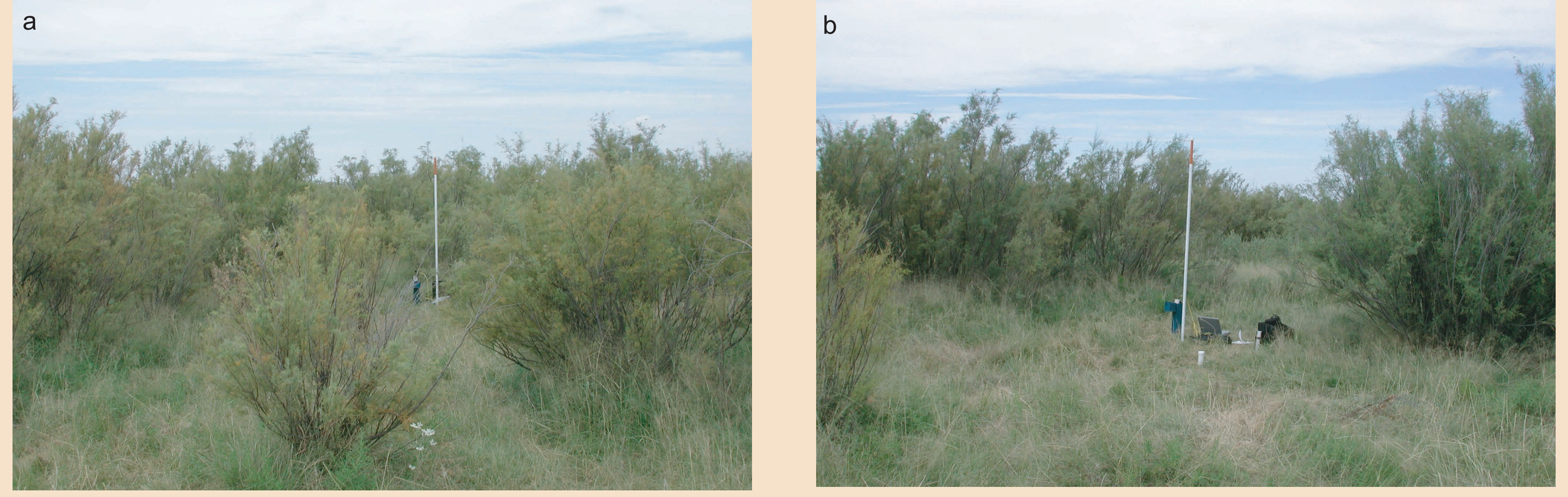

Figure 3 – a) Well Ash11 (Plot 1) in stand of salt cedar; pole is 2.54 m in height; b) Well Ash22 (Plot 2) amidst most vigorous growth of salt cedar at site; pole is 2.59 m in height, short PVC tube in foreground is neutron-probe access tube (photos taken 8/31/04).

Monitoring Equipment

Wells are equipped with submersible pressure sensors that record absolute pressure every 15 mins. An absolute-pressure sensor measures the pressure exerted both by the height of the overlying column of water in the well and by the atmosphere. The atmospheric pressure component must therefore be removed using data from a barometer on site. Figure 4 displays records from a transducer prior to and after the barometric pressure correction. Manual measurements of water levels are taken periodically to assess the performance of the pressure transducers. A neutron access tube has been emplaced adjacent to each well so that water content in the vadose zone can also be monitored. Changes in water-content profiles will be used to estimate specific yield, a critical parameter in the proposed methodology (McKay et al., 2004). A weather station has also been installed to monitor meteorological conditions and provide reference ET_0 estimates.

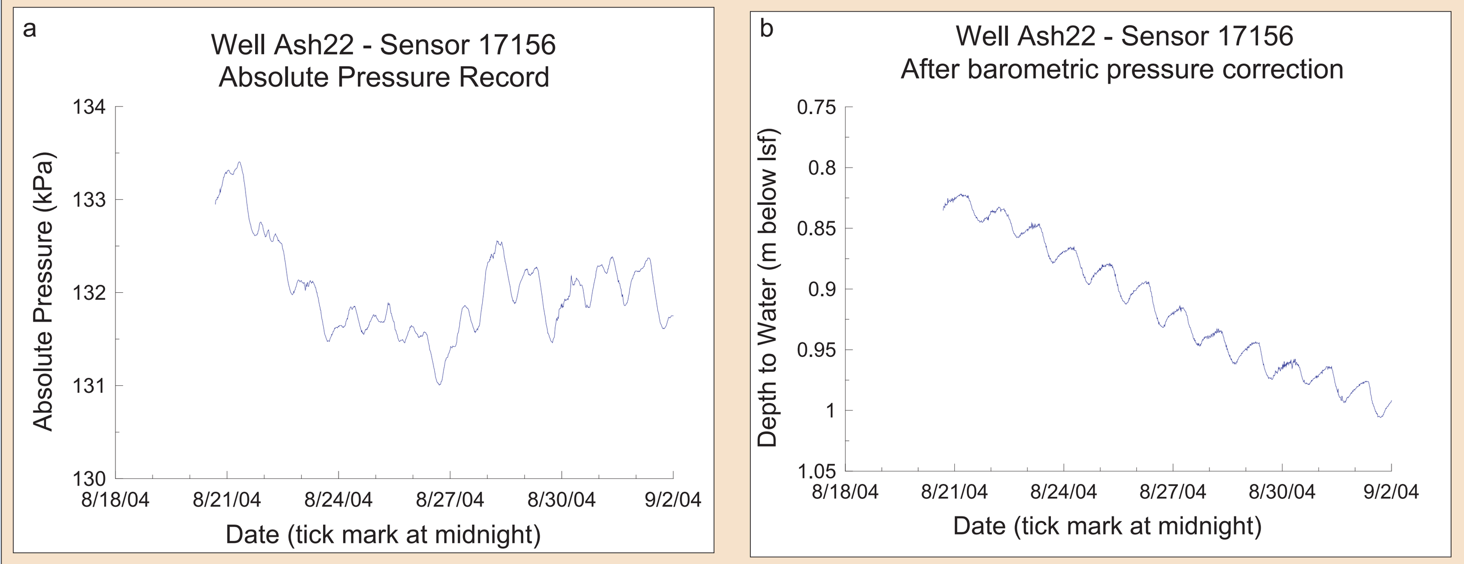

Figure 4 – a) Absolute pressure measured with sensor in Ash22; b) Depth to water at well Ash22 calculated after atmospheric pressure component is removed.

Estimation of Ground-Water Consumption

Ground-water consumption by phreatophytes will be estimated using a method first proposed by White (1932). This method is illustrated in Figure 5. A recent simulation study (Loheide et al., 2005) has shown that the White method can provide reasonable (within 10-20%) estimates of ground-water consumption by phreatophytes in sand and gravel units. The shallow subsurface at the Ashland Research Site consists primarily of fine to medium sand, so the White method should provide reasonable estimates of the changes in ground-water consumption associated with treatment at the site.

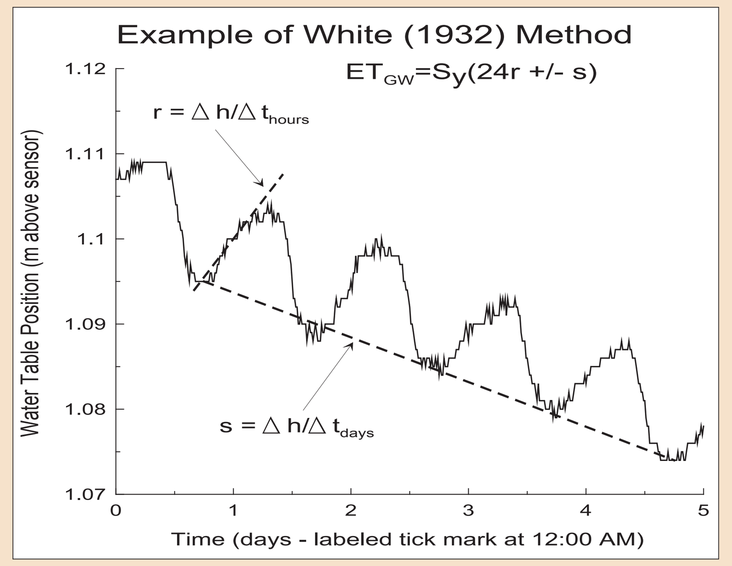

Figure 5 – Example application of the White method. Groundwater consumption by phreatophytes (ET_{GW}) is estimated from the overnight recovery (r), the multi-day trend (s) in the water table, and the readily available specific yield (S_y).

Project Phases

Phase 1 – August 2004 – March 2005 – Pre-Treatment Monitoring
The focus of this phase was to collect water-level data prior to treatment in order to establish a relationship between data from wells in Plot 1 and those in the plots undergoing treatment. This phase has been completed.

Phase 2 – March 2005 – June 2005 – Sequential Treatment
During this period, Plots 2-4 will be mowed in a series of stages. In the first stage, which was completed in March, the three plots were cleared except for circles about each well of approx. 60-70 m in diameter. Figures 6a-b are distant and close-up views, respectively, of the circle remaining around well Ash22. During the month of June, the circles will be gradually reduced in size until complete removal at the end of the month.

Phase 3 – After June 2005 – Post-Treatment Monitoring
Monitoring of water levels will continue for two to three years to assess the changes in ground-water consumption by vegetation through time.

Figure 6 – Distant (a) and close-up (b) views of circle about well Ash22 after first stage of cutting in March of 2005 (photos taken 3/31/05).

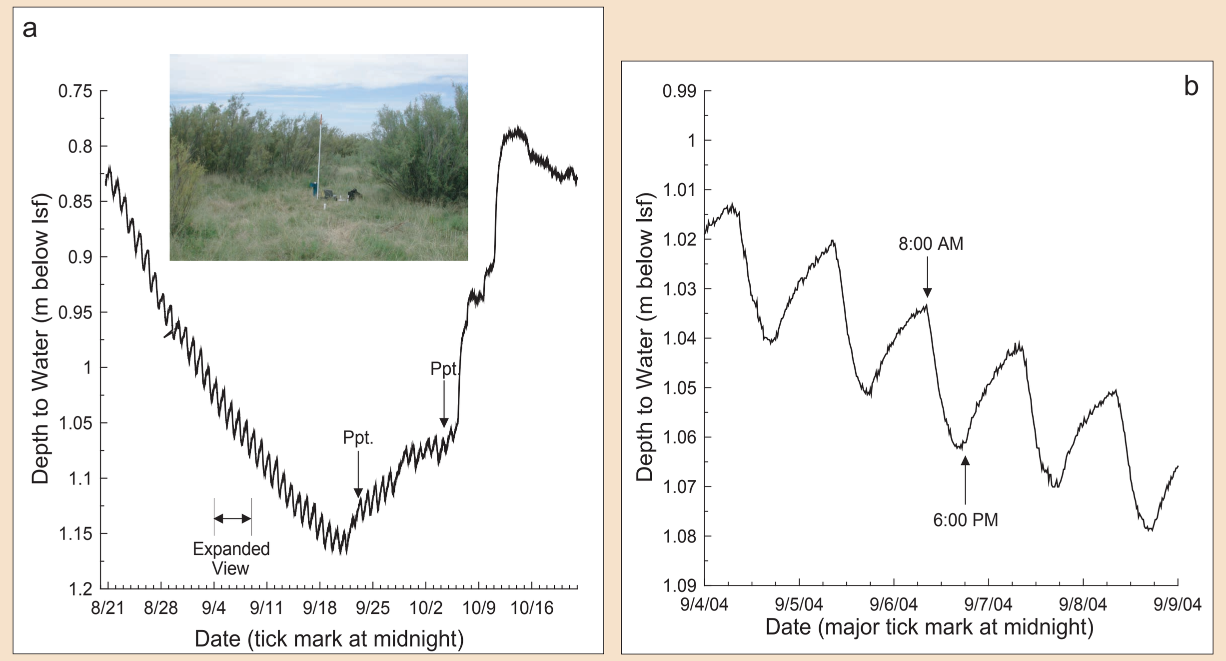

Figure 7 – Depth to water recorded at well Ash22 : a) 8/20/04 to 10/22/04. Rises in the water table after 9/21 are primarily due to rises in the stage of the Cimarron River produced by seasonal decreases in upstream irrigation pumping and plant water use, and by upstream precipitation (only the two precipitation events marked on the figure occurred at the site during this period and neither exceeded a total of 0.01 m); b) Expanded view for a five-day period in early September of 2004.

Results

Wells were emplaced in mid-August of 2004 and pressure sensors were installed shortly thereafter. Water-level data collected prior to treatment clearly indicate that the water-table fluctuations display a pattern similar to that of plant water uptake (Figures 7a-b), and that the pattern of water-table fluctuations between wells in Plot 1 (the undisturbed area) and Plots 2-3 are quite similar (Figures 7a and 8). The relation between variations in plant water uptake and in water-table position has recently been demonstrated using multi-day suites of meteorological, water-table, and sapflow data from a sister site in central Kansas (Butler et al., in prep). The pre-treatment data also show that the magnitude of the water-table fluctuations at the Ashland Research Site is highly dependent on the apparent vitality of the phreatophyte community in the vicinity of each well (Figures 7a and 9). Thus, we expect that the water-level data collected after treatment in Plots 2-3 will be dramatically different from that collected in the undisturbed Plot 1. That comparison, in conjunction with specific yield estimates obtained from the neutron logging, should enable quantification of reductions in ground-water consumption produced by treatment. Initial estimates of those reductions should be obtained by late summer of 2005.

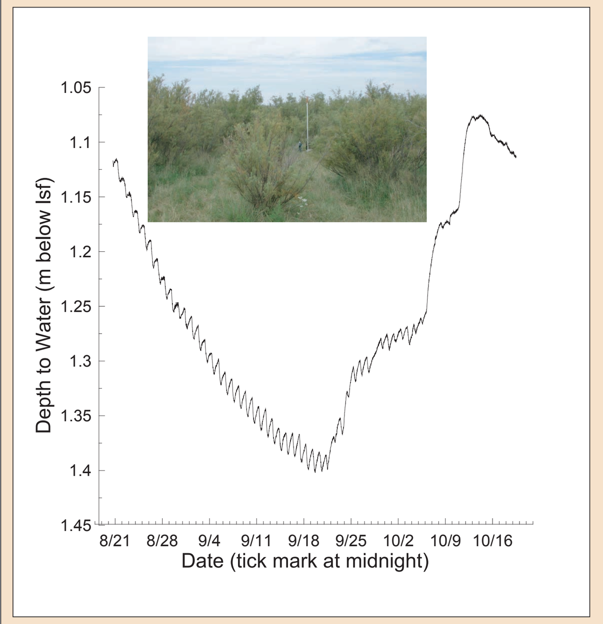

Figure 8 – Depth to water at Ash11 in Plot 1

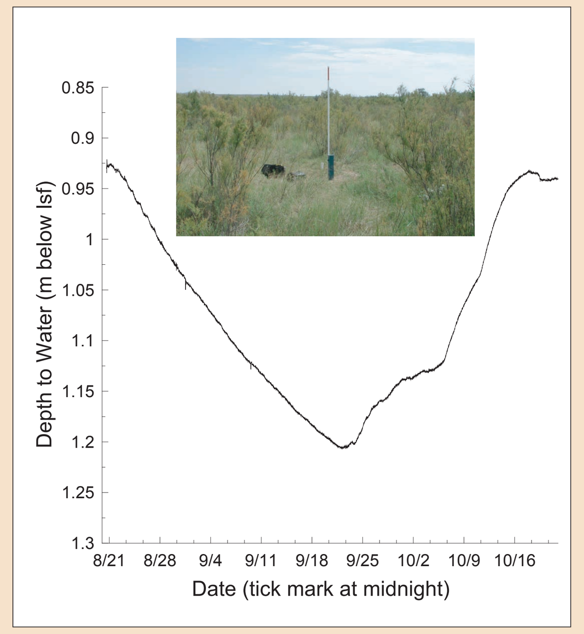

Figure 9 – Depth to water at Ash32 in Plot 3. Inset photo (8/31/04) shows location of well in stand of small salt cedars; pole is 2.51 m in height, short PVC tube in left rear is neutron-probe access tube (salt cedars the same age as in Figure 7a; see Figure 7a caption for further details regarding post-9/21 increases in water level).

ACKNOWLEDGMENTS

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