Lessons Learned in Calibrating and Monitoring a Paired Watershed Study in Oregon's High Desert

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Abstract

The use of the paired watershed approach has been used extensively in forested ecosystems as a way of determining impacts of management activities on water yield. These studies have suggested that a minimum of 17 in of annual precipitation is needed in order to measure water yield as a result of vegetative manipulation. Because of this assumption, this approach has had limited use in rangeland settings. In 1994, the Camp Creek Paired Watershed Study was initiated to determine if juniper removal had any impact on hydrological processes. Two watersheds, Mays and Jensen (each approximately 260 acres in size) were identified for the purpose of calibrating, monitoring and analyzing the effects of juniper removal. The watersheds are located in the Camp Creek watershed, a tributary of the Crooked River, upper Deschutes River Basin. Continuous recording flumes, channel morphology, hillslope erosion, and a variety of geomorphological parameters were installed and analyzed to determine how alike and how different the two watersheds were from each other. In 2003, springs were developed to measure flow, weather stations were established onsite, and soil moisture and soil temperature probes were installed. Shallow wells were placed at the bottom of each watershed to monitor changes in near-surface groundwater.

Cell phone access, radio, and satellite telemetry were explored for ease of remote monitoring. Satellite telemetry and use of the Internet were selected because they allowed for continuous monitoring, sensor monitoring, and ease of data acquisition and analysis. The practicality of this approach makes long-term monitoring of landscapes feasible.

Keywords: paired watersheds, monitoring, geomorphology, western juniper, erosion processes.

Introduction

The purpose of this study was to use two similar watersheds in the western juniper zone to quantify and understand changes that are hypothesized to take place due to vegetation-type conversion. This project is a two-phased project. Phase one (1993–2003) included the instrumentation and calibration of the paired watersheds, whereas phase two encompasses the treatment and follow-up analyses. The first phase involved providing the watershed hydrology description and analysis of the two basins based on vegetation, soils, topography, geology, channel morphology, streamflow, local climate, and erosional processes. The calibration period, which was a continuation of the first phase, involved continued data collection for a period of approximately ten years (1994–2003), at which time one of the watersheds was treated and the other acted as a control based on the calibration period. Phase two began when Mays watershed was treated, providing for post-treatment data analysis.

Western juniper (*Juniperus occidentalis*) stands were modified in the treatment watershed in order to shift the vegetation structure from a juniper-dominated to a shrub/grass-dominated system. During the fall of 2005, all post-Euro-American established, western junipers were felled. Old growth (pre-European established trees) were left with the intent of mimicking natural conditions. Downed woody material should provide safe sites for grass seedling establishment as well as promote

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the capture of sediment and minimize temperature extremes at the soil surface. This conversion of vegetation type should assist in the function of the water cycle by providing a more uniform and stable environment for capture, storage, and beneficial release of water (Buckhouse 1999). By converting the understory from bare ground to a grass and shrub cover, the site should retain moisture more readily and release the moisture into the system on a more stable and sustained basis.

During the calibration period, monitoring has quantified differences in streamflow quality and quantity. Differences in water quality were studied indirectly as a function of hillslope erosional processes and changes in channel geomorphology. The hillslope erosion was analyzed by evaluating the changes in vegetation versus bare soil composition, distribution and density, and soil status relative to increased or decreased erosion. Erosion and sedimentation were analyzed by studying changes in channel morphology in the primary channel of each watershed. Differences in streamflow quantity focused primarily on water yield within each watershed and comparisons between the two watersheds.

The vegetation conversion portion of this project focuses on the conversion of a western juniper overstory with relatively high percentages of bare ground interspaces to a grass/shrub system with minimal bare ground. One of the primary differences expected is a change in the distribution of biomass over the watersheds (Bates et al. 1999). Biomass distribution in western juniper-dominated systems tends to be elevated above the ground and moves toward patchiness of vegetative cover with larger concentrations of bare soil. The soil portion of phase two of the study will focus on whether or not the forces of erosion are stronger in the western juniper-dominated system (control) as compared to the treated system.

Project Location

The study area is located in central Oregon approximately 80 km southeast of Prineville and approximately 40 km northeast of Brothers along U.S. Highway 20.

Lessons Learned

Often the lessons learned in the setting up of a study are as important as the study itself. One of the key points that came into play during the setup phase of this study was "keep it simple." An example of "keeping it simple" was the use of sandbags as barriers against seepage at the front of the flume-approach. Although the sandbags are probably the most basic method for stabilizing this area (as compared to cold-patch asphalt, visquien plastic, metal shields, and geo-textile materials), they proved to be the most functional. Another example would be the sedimentation rods and cross-section plots used to determine erodible properties of soil scour and deposition on the hillslopes and in the main channels.

As technology improved over the life of the study, the focus also changed. During the early years of the study, the data loggers would breakdown causing large gaps in channel flow data collection (Deboodt 2008). During this time, the only way of knowing whether the devices were functioning was to be onsite to download the data and check. With the installation of the satellite communication technology, sensors could be checked weekly with the simple ease of logging onto the Internet and going to the website to see that data were being collected. Sensors not working could be identified and repairs scheduled with the supporting agencies. Even with this newfound capability, the necessity for regular field visits was never eliminated.

Flume Setup and Placement

The first step in the flume placement and selection was the reconnaissance of the area to be evaluated. This included selection of channel locations having low (2–4 percent) gradients, good access, and appropriate channel geometry. Flume placement was also critical, in that the study-area size was dependent on the flume location. Proper channel gradient is essential for maintaining accuracy of flume measurements (Grant 1992). For every 1 percent increase in slope greater than 2 percent gradient, there is a relative loss of accuracy of up to 5 percent in the stage measurement. Proper channel geometry was emphasized in order to allow for ease of flume placement and greater flume stability. Flumes and channels were matched according to depth and width, since poor fitting requires excess soil removal and (or) fill and can make the flume vulnerable to washouts. Using sandbags allowed for increased flexibility of flume placement (Figure 1).

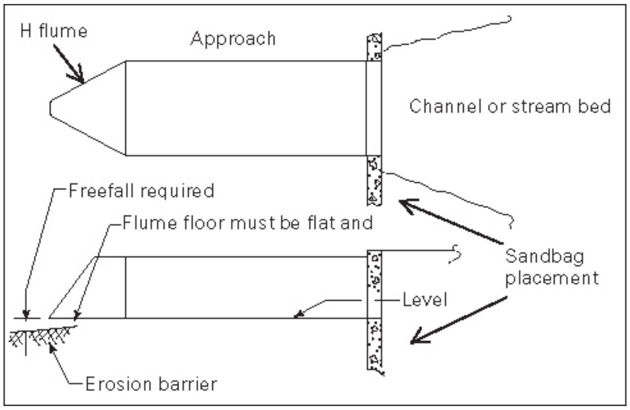


Figure 1. Flume schematic showing placement of sandbags.

Spring Flow

Throughout the pre-treatment period, two springs (one in each watershed) were identified. Flow had never been recorded and in conversations with the person who is both the landowner and Bureau of Land Management (BLM) permittee, the springs had been identified as seasonal at best. That is, each spring only flowed during spring snowmelt periods and provided no flows from mid-summer through the winter. In the fall of 2003, permission was received from the Prineville BLM District and the private landowner to improve the two springs and install spring boxes and pipe so that water could be collected and measured. A private contractor was hired to excavate and install the appropriate materials.

Well Development

In 1995, a series of shallow wells were placed at the bottom of each watershed near the flume (5 wells per watershed). Well depth varied between 0.9 and 8.2 m. The collection of well data was sporadic and incomplete but freestanding water in at least one of the deeper wells in each watershed was recorded sometime during the year.

In the fall of 2003, U.S. Department of Agriculture (USDA) Forest Service personnel from the Ochoco National Forest provided the expertise and drilling equipment to install 6 groundwater wells per watershed (Deboodt 2008). A Simco© track portable drilling rig was equipped with a 5-in auger drill bit. Wells were drilled to a maximum potential depth of 8.2 m (27 ft). These wells have provided more complete data because of their placement and depth. Water is present in these multiple wells throughout the year.

Soil Moisture and Soil Temperature

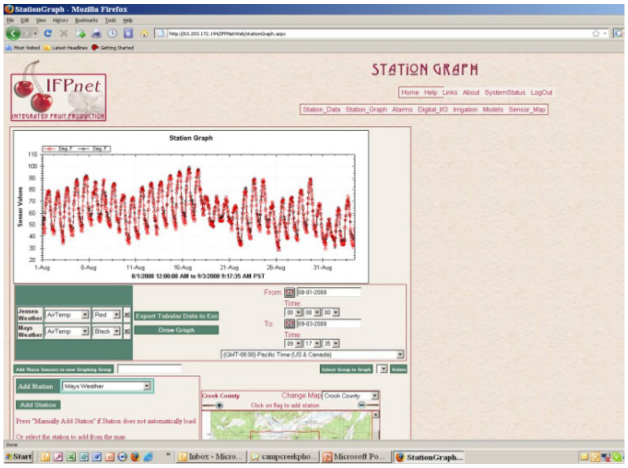
According to Hibbert (1983) and Wilcox (1994) (as referenced in Deboodt 2008), soil moisture may often be the only measurable hydrologic response following vegetation conversion in semiarid watersheds. Although this was not the case in this study, the soil moisture data has proven to be very insightful as to the hydrologic function of these watersheds. In May 2005, soil moisture probes were placed in two locations within each watershed with each site containing 3 separate stations and each station containing 3 probes at different depths. At each station a trench was dug, exposing a 1-m profile of the soil. Holes were drilled in the trench wall at depths of 0.2, 0.45, and 0.76 m. The holes were drilled using a 16-mm drill bit, making a hole slightly larger than the probes. The hole was drilled slightly larger to allow for good probe-to-soil contact with minimal soil disturbance. Increased soil disturbance around the probe increases probe reading stabilization (Deboodt 2008). The soil moisture data provided insight on how the precipitation moves through the system seasonally, annually, and by each individual event.

Offsite Data Collection

Because the Paired Watershed Project is located approximately 65 mi southeast of Prineville, OR, it became evident that taking regularly timed data was critical in understanding the hydrological processes that were occurring at the site. Channel flow data were being recorded every 10 min, but there would be times that the data logger would quit working and data would be lost. Traveling to the site daily or weekly was not possible, so an effort was made to find a system that was compatible with the sensors installed. Remote access provided a means of accessing data and, when possible, provided a way to monitor the function of the equipment so that it could be determined, in real time, if sensors were working or not, which allowed for timely maintenance and repair.

Prior to choosing a system, several were reviewed that included cellular phone connections and radio, as well as combinations of radio, cellular phone, and satellite radio (Deboodt 2008). Due to the remoteness of the site and topography, there was no cellular signal near any of the monitoring sites. Radio access was limited and required licensing and locating sites for towers, as well as getting through the permitting process. A combination of short distance radio (monitoring site to ridge top) and cellular phone was also evaluated. Vegetation (trees) limited signal quality, and the cellular phone was limited to analog technology. Cellular phone companies in central Oregon at the time were abandoning analog technology in favor of digital. Working with Automata, Inc., satellite radios provided the solution. In 2004, automated weather stations were installed in both watersheds.

Each weather station is powered by a 12-volt battery that is continuously charged by onsite solar panels. The weather stations were constructed to allow for easy maintenance of all of the components. The tower was constructed with a pivoting point that allows for ease in lowering the top to the ground for access and maintenance of the elevated sensors (Deboodt 2008). The only requirement of this system was an unobstructed view of the sky so that the radios could communicate with the orbiting satellites (Automata, Inc. 2005). The satellite radio allowed access to all sensors daily, each on its own schedule. Satellite radios require no repeaters and each radio was separate and transmitted data through the satellite to a data server. Data were accessed through the Internet website http://ifpnet.com (Figure 2).



Press "Manually Add Station" if Station does not automatically load

Or select the station to add from the map

Figure 2. Webpage showing satellite generated data.

Data are currently accessible via the Internet 24 hrs a day. If there is a break in a line or a problem with a sensor or batteries, the system red flags the site, warning that there is a problem. This is a much improved approach compared with showing up onsite every other month to find that the batteries had died or a sensor had been disconnected sometime during the prior two months.

Conclusion

The intent at the beginning of this project was to keep it simple and applicable yet plan for the future. Planning for the future required researching the latest technological opportunities and evaluating their place in this type of study. The latest technology soon became outdated but still provided a firm foundation. As technology became more accessible and practical, it made sense to bring it onboard and broaden the opportunities of the project. The installment of the weather stations and associated sensors has made a dramatic difference in the month-to-month management of the project.

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References

Automata, Inc. 2005. Service Manual. Automata Inc.

Bates, J., R. Miller, and T. Svejcar. 1999. Plant succession in cut juniper woodlands: 1991–1998. In Range Field Day 1999: Progress Report Juniper Woodlands: History, Ecology, and Management. pp. 30–43. Oregon State University, Eastern Oregon Agricultural Research Center, Special Report 1002, Corvallis, OR.

Buckhouse, J.C. 1999. Juniper and watersheds. In Range Field Day 1999: Progress Report Juniper Woodlands: History, Ecology, and Management. pp. 25–28. Oregon State University, Eastern Oregon Agricultural Research Center, Special Report 1002, Corvallis, OR.

Deboodt, T.L. 2008. Watershed Response to Western Juniper Control. Oregon State University. Ph.D. dissertation. Corvallis, OR. 156 p.

Grant, D.M. 1992. Isco Open Channel Flow Measurement Handbook (3rd ed.). Isco Inc., Lincoln, NE.