Ecohydrology of Pinyon and Juniper Woodlands

Purpose

This factsheet is an abbreviated version of the ecohydrology section of the book ***The Ecology, History, Ecohydrology, and Management of Pinyon and Juniper Woodlands in the Great Basin and Northern Colorado Plateau of the Western U.S.*** by Richard Miller and others. The book is a thorough review of the current knowledge of pinyon and juniper ecosystems, both persistent and newly expanded woodlands. This factsheet provides just highlights—the full text draws from a large volume of research on semi-arid woodlands with reviews and citations from hundreds of sources.

Complex Ecohydrologic Systems

Throughout much of the semi-arid intermountain region, pinyon and juniper are expanding into sagebrush ecosystems and infilling into persistent woodlands. Tree expansion and infill can result in reduced understory vegetation, increased connectivity of bare ground, and amplified runoff and soil loss.

The changes occurring throughout pinyon and juniper woodlands pose important ecohydrologic ramifications for plant communities. These aren't simple systems. The broad variety of climate, soils, topography, and plant composition and structure in pinyon and juniper woodlands result in a wide range of hydrologic function.

Woodlands can be generally classified as either "resource conserving" or "non-conserving" (figs. 1 and 2). Resource conserving communities have ample vegetation and groundcover to limit runoff and soil loss, promoting ecohydrologic resilience. Non-conserving or "leaky" communities typically have extensive bare ground connectivity, which promotes runoff and soil loss. Woodlands between these two endpoints may transition from one state to another following disturbance or drought events which can change the amount and structure of surface cover.

Potential for Recovery to Resource Conserving

The likelihood to remain or return to resource conserving woodland is closely linked to an area's soils, climate, and topography. Increased frequency of droughts and heavy fuel-loads increase the threat of high-severity wildfires, which also have significant adverse impacts on ecohydrological process. Initial ecohydrologic and erosion impacts of tree reduction by fire, mechanical treatments, or drought depend on the degree to which the vegetation and ground cover structure are altered, the initial conditions of the site, and the ecological site attributes such as soils and plant species present.

Figure 1. *Phase II sites, such as this one on the Modoc Plateau in northeastern California, still maintain an intact understory and are resource conserving. As trees continue to fill in, however, the understory declines, increasing bare ground and converting the site to non-resource conserving. (Photo by Rick Miller, Oregon State University.)*

Figure 2. *Phase III sites, with depleted herbaceous vegetation, declining shrub canopy, and high level of bare ground, are non-resource conserving. The high amount and connectivity of bare ground limits water capture, resulting in increased runoff, sediment loss and loss of nutrients. (Schell Creek Mountains, eastern Nevada. Photo by Rick Miller, Oregon State University.)*

In rain to snow-dominated climate regimes, plot and hillslope-scale studies suggest that burning commonly increases the risk of runoff and soil erosion-generating events by reducing surface cover structure and increasing connectivity of bare ground. This risk is likely greatest for sites commonly subjected to intense summer thunderstorms. Risk declines over time with recovery of vegetation and ground cover, commonly within five years.

Research literature spanning the Great Basin and northern Colorado Plateau indicates that mechanical tree removal treatments can initially improve infiltration and limit hillslope runoff and erosion if tree debris is sufficiently distributed into bare patches and in contact with the soil surface. Runoff directly beneath tree canopy areas in pinyon and juniper woodlands is often limited relative to that of the intercanopy between trees due to precipitation interception and water storage in the canopy and litter layers. In contrast, runoff generated in bare interspaces on woodlands is the primary source for runoff accumulation downslope unless captured by nearby vegetated or litter-covered patches. Historic and recent research on drought-related vegetation transitions have documented marked changes in ecohydrologic function that facilitate site degradation.

These studies highlight the need to identify sites approaching a tipping point and management practices that increase resilience ahead of drought, fire, beetle infestations, invasive weeds, and other disturbance events. When ecological site characteristics are considered, and the appropriate vegetation treatments are applied, successful tree-reduction treatments on woodland-encroached sagebrush rangelands can improve vegetation structure and ecohydrologic function. Improved ecohydrologic function on these landscapes further enhances the vegetation and ground cover structure and improves ecosystem resistance and resilience to invasive plants and disturbances.

Tree Removal and Groundwater Availability

Historical and current literature is inconclusive about tree-removal impacts on groundwater availability. Studies conducted in the Great Basin and Colorado Plateau indicate tree removal can increase soil water along a hillslope over a broad range of annual precipitation. However, the additional amount of available water typically declines in the first four years after tree removal. The literature suggests the annual precipitation requirement for such enhancements in available soil water with tree reductions likely occurs at ranges from 8 to 16 inches for predominately cold-season precipitation regions in the Great Basin. In the Southwest, very limited work would suggest 16 inches or more is required to see a response in soil water. The literature is also inconclusive regarding tree reduction impacts on streamflow.

Great Basin studies indicate tree reduction can affect patterns of snow accumulation and melt and in doing so, influence the timing of streamflow. Other studies from the Great Basin suggest tree reductions may have little impact on streamflow but can temporarily increase groundwater. Literature on impacts of tree removal treatments to increase streamflow for the southern Colorado Plateau and southwestern U.S. have reported mixed results, and there is no clear indication that tree removal in pinyon and juniper woodlands on sites with rain-dominated precipitation regimes will foster long-term increases in streamflow. Recent studies of drought-induced tree die-off in woodlands and forests of the Colorado Plateau have reported reductions to no change in streamflow.

To date, there is little evidence that drought related changes to vegetation in pinyon and juniper woodlands significantly alter ground water availability or subsurface flow at the annual time scale, particularly for the rainfall-dominated southwestern U.S. In the Great Basin and northwestern Colorado Plateau, large-scale die-offs have not been reported and therefore ecohydrologic impacts of drought cannot be assessed for those regions.

Figure 3. *Placing downed pinyon and juniper trees on the intercanopy had no immediate beneficial impact on runoff and erosion rates at multiple woodland sites in the Great Basin. In those studies, runoff tended to route through downed trees. However, nine years following treatment, runoff and erosion from overland flow were greatly reduced. (Photo courtesy of Northwest Watershed Research Center, USDA Agricultural Research Service, Boise, Idaho.)*

More

To see references, specific details and a discussion of many other topics, see the full text of the book available **HERE**. Refer to section four for a synthesis of the research available on ecohydrology of pinyon and juniper woodlands.