JUNIPER AND WATERSHEDS

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SUMMARY

Western juniper encroachment into shrub-steppe communities can have a significant effect on the water cycle. Sites where juniper encroachment fosters biomass concentration at the tree with increasing amounts of bare ground in the interspaces become drier from decreased infiltration of precipitation into the soil profile and increased surface flows, which quickly carry water off-site. Sites also become drier with increasing juniper dominance because of interception and evaporation, gully erosion, and a lowering of the capillary fringe associated with influent ground-water systems and desert streams. High transpiration rates can also occur on a site as an evergreen species encroaches onto a seasonal growth species' original habitat.

Role of Organics

In watershed management, the key phrase is "the soil's ability to capture, store and beneficially release water". This phrase has been bandied about since Hugh Barrett coined the phrase and I began to popularize it some 15 years ago. The phrase works because it reminds one of infiltration (capture), nutrient and water recycling (storage), and water quality in terms of regimen, erosion/sedimentation, bacterial relationships, nutrient fate, and water temperatures (beneficial release). But how does this relate specifically to juniper woodlands?

Watersheds may provide certain properties associated with water quality, but to do so it all begins with the "capture" part of this formula. Infiltration is defined as the movement of water across the air-soil interface, in other words, water moving from the atmosphere into the soil. This movement is influenced by a number of geologic, biotic, and abiotic factors.

Most textbooks suggest that these factors are soil texture, soil structure, slope, frost conditions, antecedent moisture relationships, soil colloids, and organisms. It is appropriate to note that while these biophysical parameters create the boundaries for the amount of water which can infiltrate at any given site, they all are ameliorated by the addition or removal of organics. Soil texture will not be changed in terms of its abiotic features given the addition of organics, but the distribution of those soil particles will be. Addition of organics will effectively increase pore space in any given soil textural class. Soil structure is defined by the development of "peds" within the soil profile. For all intents and purposes, organics are the "glue" which holds peds together and promotes their formation. Slope will be ameliorated at the microsite level by the retention/detention storage capacity of vegetation present on the surface, hence effectively holding precipitation in contact with the soil longer and enhancing its chance of infiltrating. Frost forms more quickly and freezes harder under conditions of bare ground, and as a consequence lowers infiltration rates. Vegetation is extremely valuable in absorbing incoming short-wave radiation and re-emitting long-wave radiation which slows or even prevents the formation of frost at the ground, leaving the soil more open to infiltration. Bone dry soils may actually repel raindrops when they finally do fall. If there is some residual soil moisture remaining, however, that will not be the case. Vegetation and incorporated soil organics are extremely valuable in conserving soil moisture and delaying evaporative soil moisture losses. Soil colloids are essentially the relationships of organic chemistry valence. Organics foster valence relationships which are conducive to open soils capable of increased infiltration. Finally, textbooks address the value of organisms in enhancing infiltration rates. These organisms are everything from earthworms to vegetation.

While it is clear that there are several biophysical features that limit infiltration, it is equally clear that under any given set of ecological conditions, standing vegetation, litter and duff at the soil surface, and incorporated organics within the soil profile ameliorate these limits and encourage infiltration as the organic component increases. It is also true that as organics are lost or unevenly distributed this enhancement of infiltration is lost.

Why Worry About Infiltration?

In a water budget, an arithmetic equation can be created:

$$P = I - SRO +/- S$$

Precipitation (P) equals infiltration (I) minus surface runoff (SRO) plus/minus any changes in surface storage (S).

To encourage subsurface storage of precipitation water and nutrient cycling, infiltration should be enhanced and surface runoff decreased. Decreasing surface runoff has the additional benefit of reducing the kinetic energy of the overland flows so that erosion and its subsequent decrease in soil production and fertility is minimized.

From a managerial point of view, anything that encourages the "capture" of precipitation (infiltration) is very positive. Not only will the water now be available for "storage" in the soil profile with its ultimate discharge as seeps, springs, transpiration through plants ("beneficial release") but also, the negative effects of rapid runoff with high kinetic energies and high potential for soil erosion, are reduced. Infiltration is the key to site productivity and function, and vegetation and its resulting organic component is the key to infiltration.

How Watersheds Relate to Juniper Sites

Western juniper (*Juniperus occidentalis*) is an extremely interesting and complex species: its adaptability and fluidity make it challenging and risky to stereotype. Several studies have been dedicated to understanding the ecology, form, function, and limits of this species. Since it has the ability to grow on a variety of soil types, under remarkable elevational and climatic extremes and aspect orientations - from scabland ridge tops to riparian bottoms - from alluvial fans to outwashes of snow cornices - in dry sagebrush sites well up into the coniferous zone- what is known about juniper may often seem disjunct and even contradictory. The species is, however, competitive over a wide variety of habitat types.

The growth patterns of juniper as it encroaches beyond its original, fire-restricting sites, demonstrates its competitive abilities. After evaluating the vegetation patterns with encroaching and maturing juniper, one notices that the on-site organic relationships change. The total biomass may not decrease, but the distribution of it does. Organics are now located in the tree itself. The remarkable and tenacious root system of the tree, coupled with its evergreen nature and ability to photosynthesize year-long, enable it to out-compete most native perennial grass, forb, shrub, and other tree species which have a definite dormant period. As the juniper tree out-competes its neighboring species and sequesters nutrients unto itself, the ground between trees becomes increasingly devoid of vegetation. This paucity of vegetation leaves those interspace sites vulnerable to splash impact of raindrops; to migration of fines to the surface, which in turn dry to hydrophobic "mud crusts"; to decreased infiltration into the soil profile; to increased surface runoff and, therefore, to higher kinetic energies capable of eroding the A and B soil horizons where most nutrient cycling takes place and where the most productive soil exists. Rill and gully erosion is common in these denuded interspace sites, causing further decline in site productivity to the extent that existing ecological states are overcome and ecological transitions to different, less productive, new states are created.

Oregon Plant Community Relationships

Infiltration work has been conducted over the years 1988-1992. Infiltration and sediment potentials have been recorded on ten Oregon ecosystems. Particularly the *Juniperus occidentalis* sites have consistently low infiltration rates, indicating high surface runoff flows, high kinetic energies, and therefore high erosion potentials (Buckhouse and Gaither 1982). In addition, encroached juniper sites with their low interspace vegetation cover have exponentially higher sediment/erosion potentials than do sites with greater ground cover resulting from more uniformly dispersed vegetation (Gaither and Buckhouse 1983).

Efforts by Eddleman, Miller, and other researchers in the last several years have refined much of the ecologic amplitudes of this species. The relationships between juniper and transpiration, evaporation, interception, soils, reproduction, plant community, and wildlife habitat has been studied and carefully documented. Yet the basic relationships of the watershed hold on sites where juniper encroachment fosters biomass concentration at the tree with increasing amounts of bare ground in the interspaces. These sites become drier from decreased infiltration of precipitation into the soil profile and increased surface flows which quickly carry water off-site. Sites also become drier with increasing juniper dominance from interception and evaporation, gully erosion, and a lowering of the capillary fringe associated with influent ground water systems and desert streams and high transpiration rates by an evergreen species encroached onto a seasonal growth species' original habitat. The removal of juniper trees on a mountain, big-sagebrush, Thurber-needlegrass site increased the length of the growing season for the herbaceous understory 6 weeks compared to adjacent uncut woodlands (Bates et al. 1999).

Solutions and Cautions

Since the fire regime which controlled juniper in presettlement times has been lengthened, it seems that the obvious solution to encroached juniper would be the reintroduction of fire. Some caution is advised. First, it may not be possible to ignite fires in mature stands where most, if not all, of the understory, fine fuels have been out-competed and lost. Next, even if a fire could carry, caution needs to be used on existing fuel loads. At the tree locations, where biomass is concentrated, hotter fires are probable. Compelling research exists that at soil surface temperatures between 300 and 600° F the colloidal relationships of the organic valence chemistry will change for the worst, creating hydrophobic soils which will not infiltrate at all. In Oregon, considerable effort has been expended to cut juniper trees then scatter limbs to create retention-detention microsites for watershed and herbaceous seed establishment, with an eye to reintroduction of fire somewhere down the line. Ideally, a wait of several years (perhaps as many as a dozen) should occur before reintroducing fire because she/he is well advised to have granted ample time for the herbaceous vegetation to establish prior to subjecting it to the disturbance of fire, ample time for nutrient cycling of the juniper needles and small twigs to occur, and time for the residual juniper seed source, lying in the soil, to have germinated and therefore be susceptible to the fire. All of these are watershed-based concepts with the goal of mimicking nature and the ground cover vegetation relationships which result in functional infiltration rates of the limited precipitation which falls on these semi-arid environments of the Great Basin.

LITERATURE REVIEW

Bates, J.D., R.F. Miller, and T.J. Svejcar. 1999. Understory dynamics in cut and uncut western juniper woodlands. Journal of Range Management. 52:(in press)

Buckhouse, J.C. and R.E. Gaither. 1982. Potential sediment production within vegetative communities in Oregon's Blue Mountains. Journal Soil and Water Conservation. 37:120-122.

Gaither, R.E. and J.C. Buckhouse. 1983. Infiltration rates of various vegetative communities within the Blue Mountains of Oregon. Journal of Range Management. 36:58-60.

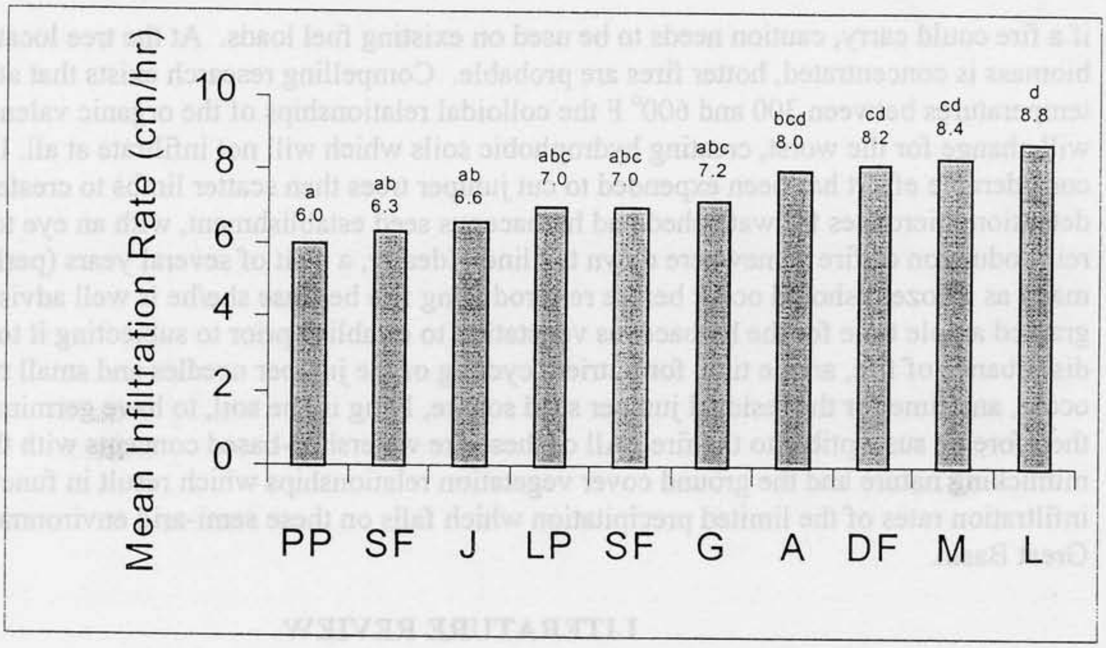

Figure 1. Mean infiltration rates of 10 ecosystems (different lower case letters indicate statistical difference P<0.10). Ecosystems: PP - ponderosa pine, SF - spruce-fir, J - juniper, LP - lodgepole pine, S - sagebrush, G - grassland, A - alpine, DF - Douglas fir, M - meadow, L - larch.

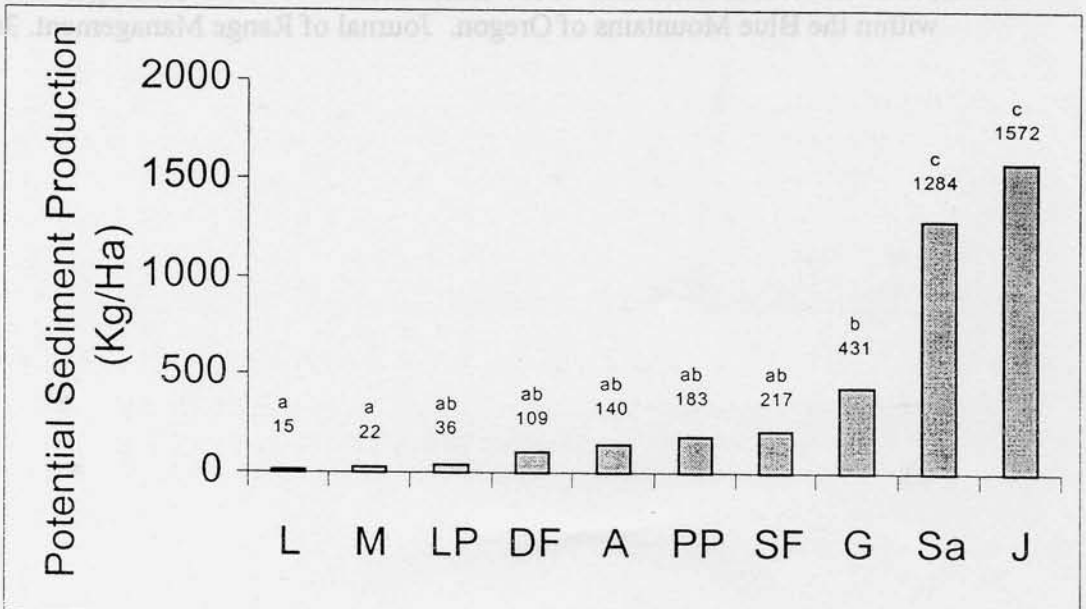

Figure 2. Potential sediment production in 10 Blue Mountain ecosystems. Different lower case letters indicate differences in statistical significance (P<0.10) Ecosystems: L - larch, M - meadow, LP - lodgepole pine, DF - Douglas fir, A - alpine, PP - ponderosa pine, SF - spruce-fir, G - grassland, Sa - sagebrush, J - juniper.