# Hydrology of Crested Wheatgrass Seedings

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ABSTRACT: Ungrazed crested wheatgrass seedings may intercept from 7 to 22 percent of the annual precipitation. Infiltration rates following seeding are not particularly impacted on coarse-textured soils characteristic of pinyon-juniper sites but on medium-textured soils (and especially if plowing is involved) a reduction in infiltration rates may occur. Seeded sites exhibit large variability in both time and space in terms of measured infiltration rates. Soil water is usually increased through seeding former pinyon-juniper and sagebrush sites. Sediment is the primary water quality problem on seeded areas; chemical water quality is usually good.

## INTRODUCTION

During the past several decades many thousands of acres of crested wheatgrass (Agropyron cristatum or A. desertorum) have been seeded on western rangelands. The hydrologic impacts of these seedings have not been well documented, but changes in infiltration, soil water recharge, evapotranspiration and perhaps even groundwater recharge might be expected, with the absolute magnitude of such changes being a function of specific site characteristics. The objective of this paper is to briefly review hydrologic studies which relate to crested wheatgrass seedings as a starting point for those who may want to explore the topic in greater detail.

## HYDROLOGY OF CRESTED WHEATGRASS SEEDINGS

### Interception

Interception involves wetting of various segments of a plant community (live vegetal material, litter, rock) and the eventual loss of that water through evaporation. Precipitation that eventually reaches the mineral soil surface is called throughfall. Though interception studies on crested wheatgrass seedings are lacking, interception values for several grass species have been tabulated by Branson et al. (1981), with values ranging from .01 to .51 cm on a per-storm basis. Interception characteristics of pinyon (Pinus spp.), juniper (Juniperus spp.), and sagebrush (Artemisia spp.), plants commonly occurring in crested wheatgrass seedings, have been outlined by Gifford (1975a) and Sturges (1979).

Calculations by Gifford (1975b) for an ungrazed seeding in southeastern Utah indicate that from 12 to 22 percent of the annual precipitation may be lost to interception, depending on pinyon-juniper debris disposal techniques. Similar calculations for a site in southwestern Utah indicated a potential loss of from 7 to 18 percent of the annual precipitation.

### Infiltration

Infiltration studies on crested wheatgrass seedings have been reported by several researchers. Blackburn and Skau (1974) and Blackburn (1973) found little change in infiltration rates several years after seeding on several sites in Nevada.

Rather extensive studies have been made in Utah regarding surface soil infiltration rates on seeded pinyon-juniper sites (Williams et al. 1969 and 1972, Gifford et al. 1970, Loope and Gifford 1972, Buckhouse and Gifford 1976b, Busby and Gifford 1981). In essence, these studies have shown that infiltration and interrill erosion rates on chained and seeded sites were not particularly affected by the treatment practice. If impacts occur they are most pronounced on sites where debris has been windrowed (lots of mechanical disturbance), and the impact is probably slightly negative.

Near Blanding in southeastern Utah, part of an observed reduction in infiltration rates on a chained (windrowed) and seeded treatment appeared related to destruction of cryptogamic soil crusts (Loope and Gifford 1972). However, the reduction apparently is not permanent, because total

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protection (no grazing by domestic livestock) of the same windrowed and seeded site for a period of six years was sufficient for recovery of infiltration rates (but not the cryptogamic cover) (Buckhouse and Gifford 1976b).

Infiltration studies on a plowed and seeded silty loam big sagebrush (Artemisia tridentata) site in southern Idaho have shown that there was a significant decline in infiltration rates over a 2- or 3-year period (Gifford 1972, Gifford and Busby 1974, Gifford 1982a). Grazing did not cause a further reduction in infiltration rates beyond that caused by the plowing, but did appear to eliminate seasonal trends and recovery to pre-plowing rates appeared impossible as long as grazing continued. Gifford and Skau (1967) also found that plowing prior to seeding reduced infiltration rates on two sites in Eastgate Basin, Nevada.

Little is known regarding seasonal and yearly infiltration rate trends on seeded sites, but rather dramatic changes with time were reported for an ungrazed site in southeastern Utah (Gifford 1979). Grazing appears to reduce the temporal variability of infiltration. Springer and Gifford (1980) discuss the use of a normal or log-normal distribution for describing measured infiltration rates on a seeded site in southern Idaho.

Spatial variability studies of infiltration rates as a function of three seasons, two different instruments (sprinkling rainfall simulator and double-ring infiltrometer), and two grazing intensities were conducted by Achouri and Gifford (1984) and Merzougui and Gifford (manuscript submitted) on a seeded site near Eureka, Utah. Use of autocorrelograms and semi-variograms on a two-meter grid spacing showed a complete lack of variance structure among measured infiltration rates regardless of treatment. Spring infiltration rates were significantly higher than summer or fall rates; moderate grazing reduced infiltration rates by a factor of three over an ungrazed area protected for over 20 years; and the rainfall simulator gave significantly lower infiltration rates (by a factor of 2 to 3) than rates measured with a double-ring infiltrometer.

Coefficients for use in Philip's infiltration equation have been derived for a number of seeded sites in the western U.S. by Jaynes and Gifford (1981). Applicability of Kostiakov's, Horton's and Philip's infiltration equations to the representation of plant community infiltration rates has been examined by Gifford (1976). Relationships between steady-state infiltration velocities as measured with double-ring and rainfall simulation devices, along with the influence of antecedent plot moisture ("wet" vs "dry") have been presented by Aboulabbes et al. (1985).

Factors influencing infiltration.--Williams et al. (1972), Gifford (1972), Blackburn (1973), Gifford and Skau (1967), Gifford and Busby (1974), and Busby and Gifford (1981) have all studied various site factors which influence infiltration rates. Busby and Gifford (1981) found 21 different variables that explained significant amounts of variation in infiltration rates on seeded sites. However, none of the variables proved consistently useful for explaining variation in infiltration on all vegetation-conversion/grazing-condition combinations studied. Their results are typical of results obtained in the other studies.

Results presented by Blackburn (1973) in Nevada are similar in that the importance of measured site factors in predicting infiltration rates varied from one watershed to another. In general the rate at which water entered the soil profile was governed mainly by the extent and morphology of the surface soil horizon in interspace areas between plants. The influence of cover on infiltration was highly variable. Hessary and Gifford (1979) point out that seeding does not guarantee an increase in plant cover over that originally present.

The relationship of selected rangeland vegetation characteristics and soil physical properties to various infiltration coefficients in Kostiakov's, Horton's, and Philip's infiltration equations was studied on 13 seeded pinyon-juniper sites in Utah (Gifford 1978). Based on an analysis of data pooled over 12 of the 13 sites, it appeared that coefficients in Kostiakov's equation were related more to vegetation factors, while coefficients in Philip's equation were more related to soil factors. The single coefficient in Horton's equation was somewhat intermediate, representing both vegetation and soil influences. It was concluded that perhaps changes in use or intensities of use could be detected through changes encountered in infiltration coefficients, with emphasis on either vegetation or soil factors or both, depending on the equation or model used.

Published literature (Gifford 1982a, Busby and Gifford 1981, Buckhouse and Gifford 1976b) has indicated that grazing does affect infiltration rates on seeded sites. Impact of burning on infiltration rates is apparently related to site characteristics (Roundy et al. 1978, Buckhouse and Gifford 1976b). The effects of incremental surface soil depths on infiltration rates, erosion, chemical water quality, plant production, transpiration ratios, and nitrogen mineralization rates have been studied on a seeded area in southeastern Utah (Lyons and Gifford 1980a,b).

Soil Water Studies

Soil water studies described by Gifford and Shaw (1973) and Gifford (1982b) indicate that pinyon-juniper sites cleared and seeded to crested wheatgrass almost always develop greater soil water contents. The same is often true on big sagebrush sites (Hull and Klomp 1974). Grazing had little impact on soil water patterns on a seeded site in southeastern Utah, but burning of pinyon-juniper debris on another seeded area increased soil water beginning the second year (Gifford 1982b).

Seeding of crested wheatgrass in conjunction with contour furrowing has been very successful in Montana. This treatment combination increased total water infiltration and soil water content (Branson et al. 1962, Soiseth et al. 1979). Similar treatments on marine shales in Utah were less successful (Wein and West 1971).

Bleak and Keller (1973) found that water requirements of several Agropyrons and Elymus junceus averaged from 429 to 823 ml water/g dry matter, depending on harvest date. Black (1968), Power and Alessi (1970) and Williams et al. (1979)

have all shown that water use efficiencies of crested wheatgrass can be improved through application of nitrogen fertilizer.

## WATER BUDGETS

Even though evapotranspiration approximates precipitation on many crested wheatgrass seedings, the only published approximate annual water budgets are those of Gifford (1975b) for two sites in southern Utah. His calculations indicated that most of the 250 mm annual precipitation falling on each treatment was lost through evapotranspiration, with much of the balance lost through interception.

### Runoff

Other than rainfall simulator studies already described there has been only one runoff study utilizing natural rainfall on seeded crested wheatgrass ranges. In Utah, Gifford (1973) found during a five-year study that runoff from .04-hectare runoff plots on seeded pinyon-juniper sites (chained-with-windrowing) yielded 1.2 to 5 times more water during a runoff event than similar woodland plots. Runoff from seeded debris-in-place plots was equal to or less than that measured from natural woodland for all storms. On these particular sites (perhaps 250 mm annual precipitation) all runoff results from high intensity convectional thunderstorms during the approximate period June 15 to September 15. Results from this study indicate strongly that debris-disposal techniques are the key to minimizing runoff from seeded pinyon-juniper sites. Because infiltration rates are only slightly affected by chaining and seeding activities (at least on sites in Utah and perhaps also in Nevada), the runoff differences are apparently the result of debris and depressions left from uprooting trees which simply hold water on site until it has the opportunity to infiltrate.

### Water Quality

Sediment is the most important water quality parameter associated with seeded crested wheatgrass stands. Studies of 28 seeded sites throughout central and southern Utah have shown that point measures of interrill erosion are, for the most part, not increased by chaining and seeding activities (Williams et al. 1969, Gifford et al. 1970, Buckhouse and Gifford 1976b, Busby and Gifford 1981). Based on a smaller sample, the same appears true in Nevada (Blackburn 1973).

Data from .04-hectare runoff plots in Utah are in agreement with the above with regard to seedings on chained pinyon-juniper sites (debris-in-place treatments). But on debris-windrowed treatments, 1.6 to 6 times more sediment can be expected from the windrowed areas than from the adjacent woodland when runoff exceeds about 0.1 cm (Gifford 1973).

Gifford and Busby (1974) noted an increased potential for interrill erosion following plowing and seeding on a site in southern Idaho.

Factors Influencing Erosion.--Factors influencing erosion on seeded crested wheatgrass sites have been identified in a very general way. Though numerous sites have been studied (Gifford and Skau 1967, Williams et al. 1972, Blackburn 1973, Gifford and Busby 1974, Busby and Gifford 1981), factors that influence interrill erosion are so variable from one geographic location to another that no consistent relation has been found. No studies have been published that deal with both rill and interrill erosion.

Other Water Quality Parameters.--Buckhouse and Gifford (1976a) collected baseline water quality data from three treatments (including two seeded areas) during one field season on a pinyon-juniper study site in southeastern Utah. This was followed by another season of sampling where secondary treatments were imposed, consisting of controlled burning of a seeded debris-in-place site and livestock grazing of a seeded debris-windrowed site. A Rocky Mountain infiltrometer was used to create simulated, high intensity rainstorms on the area. Results of the study indicated that potential public health hazards of livestock grazing of seeded crested wheatgrass range on gentle slopes are minimal. As for nutrient release following burning, significantly increased amounts of phosphorus and potassium were measured season long in overland flow on the chained and seeded with debris-left-in-place site. No significant changes were detected in calcium, sodium, or nitrate-nitrogen contents in the runoff due to differences in land treatment.

Lyons and Gifford (1980a) found that as surface soils were removed on a seeded site in both southeastern and southwestern Utah that potassium concentrations in runoff waters decreased with soil depth, but phosphorus concentrations did not.

## SUMMARY

Hydrologic features of crested wheatgrass seedings have been briefly reviewed with respect to interception, infiltration, soil water, runoff, and water quality. Most of the available literature concentrates on the impacts of seeding on infiltration rates and interrill erosion. In this regard, it would appear that hydrology of former pinyon-juniper sites has been only slightly affected by seeding, the main effect being an increase in soil water. The same is probably true on former big sagebrush sites. Plowing with seeding may significantly reduce infiltration rates on medium textured soils.

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