Infiltration Rates and Sediment Production of Selected Plant Communities in Nevada

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Highlight: *Infiltration rates and sediment production of 29 plant communities and soils on five rangeland watersheds were studied in central and eastern Nevada. Three inches per hour of simulated rainfall was applied to soil initially dry and to soil initially at field capacity. Infiltration rates and sediment production for the various plant communities and soils varied considerably within and between watersheds. Highest infiltration rates and lowest sediment production occurred on sites with well-aggregated surface soils free of vesicular porosity.*

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Effective management of rangeland watersheds in the Great Basin depends largely on the plant cover and infiltration rates of associated soils to control sediment production and peak floods from intense summer thundershowers. Few studies are available for the Great Basin (Jager, 1972; Gifford and Coltharp, 1972; Gifford et al., 1970; Gifford and Tew, 1969; Gifford and Skau, 1967; Woodward, 1943). Related studies stress the importance of plant cover type in other western regions (Branson et al., 1970 and 1965; Brown, 1965; Box, 1961; Rowe and Reimann, 1961; Rauzi and Zingg, 1956).

This study reports results of infiltration and sediment production for a broad range of plant communities occurring in Nevada.

Methods

Twenty-eight study sites were selected within the watersheds (Table 1). Nine sites were located within the Duckwater Watershed, six within the Coils Creek Watershed, six within the Steptoe Watershed, and seven within the Pine and Mathews Canyon Watersheds. Study sites were selected for their accessibility, repetition over large areas in the Great Basin, and vegetation and soil properties. Each site was located on a typical area with a different plant community and/or soil.

A water application rate of 3 inches per hour for a duration of ½ hour was applied to two antecedent moisture conditions: soil surface horizon initially air dry and soil surface horizon initially at field capacity. There were six replications for each treatment, except for some sites at Duckwater where eight were used. For all variable plots, six replications were used for dune interspace and six for coppice dunes.

Data were subjected to analysis of variance to compare infiltration rates and sediment production by treatment for each watershed.

In the Great Basin, summer thunderstorms usually occur on dry

Table 1. Study sites description.

Watershed	Location	Elevation	Climate	Geology and soils	Dominant vegetation
Duckwater	30 airline miles south and east of Eureka, mostly in White Pine County, Nevada. Site: 100 square miles Blackburn et al. (1968)	Highest peak is around 7,300 ft and the basin outlet is 4,800 ft	Annual precipitation 7.8 to 13.7 inches, mostly as snow. Temperature at the lower elevations ranges from a low of −34°F to a high of 99°F with a mean annual temperature of 43°F	Volcanics and sedimentaries, i.e., tuff, basalt, andesites and limestone. Aridisols, and Entisols, i.e., Torrifluvents, Durorthids, Haplargids, Durargids and Natragids	Black sagebrush (*Artemisia nova*) Big sagebrush (*Artemisia tridentata*) Shadscale (*Atriplex confertifolia*) Winterfat (*Eurota lanata*) Green rabbitbrush (*Chrysothamnus viscidiflorus*) Utah juniper (*Juniperus osteosperma*) Singleleaf pinyon (*Pinus monophylla*)
Coils Creek	32 airline miles northwest of Eureka in Eureka County, Nevada. Site: 48 square miles Blackburn et al. (1969a)	Highest peak is around 8,400 ft and the basin outlet is 6,500 ft	Annual precipitation 8.8 to 14.8 inches, mostly as snow. Temperature ranges from a low of −26°F to a high of 110°F with a mean annual temperature of 47°F	Volcanics and sedimentaries, i.e., basalt, shale, sandstone and limestone. Entisols and Aridisols or Mollisols, i.e., Torriorthents, Camborthids, Haplustolls, Haploxerolls, Durixerolls, and Argixerolls	Low sagebrush (*Artemisia arbuscula*) Big sagebrush Snowberry (*Symphori carpos longiflorus*) Utah juniper Singleleaf pinyon Sandberg bluegrass (*Poa secunda*) Bluebunch wheatgrass (*Agropyron spicatum*) Woolly wyethia (*Wyethia mollis*) Squirreltail (*Sitanion hystrix*) Arrowleaf balsamroot (*Balsamorhiza sagittata*) Diffused phlox (*Phlox diffusa*)
Steptoe	24 airline miles southeast of Ely in White Pine County, Nevada. Site: 45 square miles Heinze et al. (1966)	Highest peak is around 9,081 ft and the basin outlet is 7,100 ft	Annual precipitation is 12 inches, mostly as snow. Temperature ranges from a low of −26°F to a high of 97°F with a mean annual temperature of 44°F	Limestone. Aridisols or Mollisols, i.e., Camborthids, Haplargids, Durargids, and Argixerolls	Big sagebrush Bitterbrush (*Purshia tridentata*) Utah juniper Singleleaf pinyon Bluebunch wheatgrass Crested wheatgrass (*Agropyron desertorum*)
Pine and Mathews Canyon	18 airline miles southeast of Caliente in Lincoln County, Nevada. Site: 66 square miles Blackburn et al. (1969b)	Highest peak is around 6,700 ft and the basin outlets are approximately 5,600 ft	Annual precipitation 11.9 to 21.8 inches mostly as snow during winter or rain in late summer. Temperature of the basins range from a low of 0°F to a high of 101°F with a mean annual temperature of 50°F	Volcanics and old lake bed sediments, i.e., andesite, tuff, ignibrite, tuffaceous clay, sand and silt. Aridisols or Mollisols with a few Entisols, i.e., Torriorthents, Durargids, Haplargids, Argixerolls, and Haploxerolls	Big sagebrush Black sagebrush Rubber rabbitbrush (*Chrysothamnus nauseosus*) Serviceberry (*Amelanchier alnifolia*) Utah juniper Singleleaf pinyon Intermediate wheatgrass (*Agropyron intermedium*) Squirreltail

soil, although some occur on soil that is at or near field capacity. A 3-inch per hour storm was used to simulate the exceptional thunderstorm and to assure that maximum site infiltration rate was exceeded, under both moisture conditions.

The infiltrometer and methods of application are described by Blackburn et al. (1974).

Basically, infiltration was defined for any point in time as the difference between total water applied and total runoff. Two types of runoff plots were used: 3 by 3-foot and variable. Regular plots were situated so the same mean percent coppice dune that occurred on the site also occurred in the plot. Coppice dune is the area of accumulation of litter and soil under shrubs and bunch grasses. Variable plots were located to contain approximately 100% dune interspace area or coppice dune area. Variable plots were used only on sites that demonstrated obvious dune interspace and coppice dune differences.

Sediment production was determined from a 900-ml runoff sample and other sediment trapped in the collection apparatus. Suspended sediment was allowed to settle in the laboratory and the water was drained off. Samples were then oven dried, weighed, and converted to sediment in tons per acre.

Results

Highest infiltration rates and lowest sediment production were observed in the Steptoe Watershed. Conversely, the lowest infiltration rate and highest sediment production were found in the Duckwater Watershed. Infiltration rates were lower and sediment production higher when the soil was initially at field capacity. Highest infiltration rates and lowest sediment production occurred in the coppice dunes; the opposite was true for the dune interspace areas regardless of plant community or soil (Table 2). Throughout the study, $P = 0.05$ was accepted as significant.

Infiltration

Duckwater Watershed.

Infiltration rates were significantly higher ($P = 0.05$) for the singleleaf pinyon/Utah juniper and black sagebrush communities than for all other communities except black sagebrush and big sagebrush/green rabbitbrush. Conversely, the lowest infiltration rates were in the winterfat community. Infiltration rates in the winterfat community were significantly lower than those in all other communities except shadscale.

Coils Creek Watershed.

The snowberry/big sagebrush/bluebunch wheatgrass/woolly wyethia community had the highest infiltration rate, and it was significantly higher than those of all other units except big sagebrush/bluebunch wheatgrass/arrowleaf balsamroot community. Lowest infiltration rates occurred in the low sagebrush/Sandberg bluegrass/squirreltail community.

Steptoe Watershed.

Singleleaf pinyon/Utah juniper community consistently had the lowest infiltration rates, and this rate was significantly lower than all other communities except crested wheatgrass (seeded big sagebrush/bluebunch wheatgrass site), initially dry. Infiltration rates for communities plowed and seeded to crested wheatgrass were not

Table 2. Mean infiltration rate (inches/hr) and sediment production (tons/acre) for the plant communities in each watershed.[a]

	Infiltration rate		Sediment production	
Watershed and plant community	Dry[b]	Field capacity[b]	Dry[b]	Field capacity[b]
Duckwater				
Singleleaf pinyon/Utah juniper	2.85[a]	2.79	0.003	0.003
Black sagebrush	2.70[ab]	2.05[a]	0.140[bc]	0.266[ab]
Big sagebrush/green rabbitbrush	2.40[bc]	1.52[ab]	0.642[a]	0.666[a]
Big sagebrush	2.16[cd]	1.42[b]	0.262[abc]	0.359[a]
Black sagebrush/shadscale	2.10[cd]	1.49[b]	0.386[abc]	0.508[a]
Shadscale/winterfat	1.98[cd]	1.58[b]	0.235[abc]	0.243[ab]
Utah juniper	1.97[de]	1.71[b]	0.122[c]	0.071[b]
Shadscale	1.75[e]	1.26[bc]	0.594[ab]	0.673[a]
Winterfat	1.38	0.87[c]	0.552[ab]	0.522[a]
Coils Creek				
Snowberry/big sagebrush/bluebunch wheatgrass/woolly wyethia	2.68[a]	2.39[a]	0.22[c]	0.32
Big sagebrush/bluebunch wheatgrass/arrowleaf balsamroot	2.60[ab]	2.36[a]	0.25[bc]	0.37[c]
Singleleaf pinyon/Utah juniper/low sagebrush/Sandberg bluegrass	2.42[b]	1.87[b]	0.42[abc]	0.62[bc]
Low sagebrush/Sandberg bluegrass	2.40[b]	1.82[b]	0.63[a]	1.25[a]
Big sagebrush/Sandberg bluegrass/diffused phlox	2.39[b]	1.73[b]	0.38[bc]	0.87[ab]
Low sagebrush/Sandberg bluegrass / squirreltail	1.97	1.62[b]	0.48[ab]	0.58[bc]
Steptoe				
Big sagebrush/bluebunch wheatgrass	2.87[a]	2.41[a]	0.14[a]	0.13[abc]
Crested wheatgrass (seeded big sagebrush/bluebunch wheatgrass site)	2.82[a]	2.47[a]	0.07[ab]	0.21[abc]
Big sagebrush/bitterbrush/bluebunch wheatgrass	2.82[a]	2.35[a]	0.08[ab]	0.36[ab]
Big sagebrush	2.78[a]	2.69[a]	0.01[b]	0.07[c]
Crested wheatgrass (seeded big sagebrush site)	2.69[ab]	2.23[a]	0.04[ab]	0.09[bc]
Singleleaf pinyon/Utah juniper	2.55[b]	1.79	0.20[a]	0.52[a]
Pine and Mathews Canyon				
Black sagebrush/intermediate wheatgrass	2.84[a]	2.31[a]	0.04[a]	0.23[a]
Utah juniper	2.54[ab]	1.97[ab]	0.05[a]	0.16[ab]
Big sagebrush/crested wheatgrass	2.50[ab]	2.05[a]	0.22[a]	0.35[a]
Utah juniper/crested wheatgrass	2.46[ab]	2.38[a]	0.06[a]	0.02[c]
Singleleaf pinyon/Utah juniper/black sagebrush/serviceberry	2.41[ab]	2.14[a]	0.38[a]	0.54[a]
Utah juniper/big sagebrush/squirreltail	2.21[b]	1.95[ab]	0.04[a]	0.03[bc]
Big sagebrush/rubber rabbitbrush	2.09[b]	1.29[b]	0.40[a]	0.45[a]

[a]Means followed by the same letter are not significantly different (0.05) as determined by Duncan's multiple range test. All comparisons are made within column and within watershed.

[b]Antecedent moisture condition.

significantly different from rates of their undisturbed counterparts.

Pine and Mathews Canyon Watersheds.

Black sagebrush/intermediate wheatgrass and Utah juniper/crested wheatgrass communities exhibited the highest infiltration rates. Big sagebrush/rubber rabbitbrush communities had the lowest infiltration rate, and this rate was significantly lower than for black sagebrush/intermediate wheatgrass, Utah juniper/crested wheatgrass, singleleaf pinyon/Utah juniper/black sagebrush/serviceberry and its railed and seeded counterpart (big sagebrush/crested wheatgrass), field capacity.

Sediment Production

Duckwater Watershed.

Largest quantities of sediment came from the big sagebrush/green rabbitbrush, shadscale, and winterfat communities and the smallest quantities from Utah juniper and singleleaf pinyon/Utah juniper communities. Sediment production from the singleleaf pinyon/Utah juniper community was significantly smaller than for other communities sampled.

Coils Creek Watershed.

Largest quantities of sediment were produced from the low sagebrush/Sandberg bluegrass and low sagebrush/Sandberg bluegrass/squirreltail communities. Smallest quantities of sediment came from big sagebrush/bluebunch wheatgrass/arrowleaf balsamroot and snowberry/big sagebrush/bluebunch wheatgrass/woolly wyethia community. Sediment production was significantly smaller than for low sagebrush/Sandberg bluegrass and low sagebrush/Sandberg bluegrass/squirreltail communities, soil initially dry.

Steptoe Watershed.

Singleleaf pinyon/Utah juniper community consistently produced more sediment than other sampled communities. Least sediment came from big sagebrush and crested wheatgrass (seeded big sagebrush site) communities. Communities that had been plowed and seeded to crested wheatgrss showed no significant difference nor trend in sediment production from their unseeded counterparts.

Pine and Mathews Canyon Watersheds.

Big sagebrush/rubber rabbitbrush and singleleaf pinyon/Utah juniper/black sagebrush/serviceberry communities produced the largest quantities of sediment. Lowest sediment production communities were Utah juniper/crested wheatgrass, black sagebrush/intermediate wheatgrass, and Utah juniper/big sagebrush/squirreltail. Communities railed and seeded or chained and seeded (big sagebrush/crested wheatgrass, black sagebrush/intermediate wheatgrass and Utah juniper/crested wheatgrass) showed no significant difference in sediment production from their unseeded counterparts (big sagebrush/rubber rabbitbrush, singleleaf pinyon/Utah juniper/black sagebrush/serviceberry, and Utah juniper/squirreltail). However, the trend was for larger quantities of sediment from untreated sites.

Discussion

Substantially higher infiltration rates and sediment production were observed on coppice dunes than on dune interspace areas. Thus, the extent and morphology of the dune interspace surface soil essentially control infiltration rates of the various soils. Dune interspace areas with a vesicular surface horizon have a lower percent carbon, a higher pH, a higher bulk density, a higher percent silt, and shallower surface horizon than the coppice dunes. Structure in the dune interspace areas is massive or platy as compared to granular in coppice dunes. Infiltration rates are negatively related to vesicular horizons. The strength of this relationship is dependent on vesicular horizon morphology (Blackburn, 1973). These surficial vesicular horizons develop in arid and semiarid areas of sparse vegetation cover (Volk and Gyeger, 1970) and tend to increase with the removal of herbaceous vegetation in the interspace area by overgrazing. More specifically, soils involved in vesicular development are classified as Aridisols, Torrifluvents, or Torriorthents. These vesicular horizons are very unstable when nearly saturated (Miller, 1971), which accounts for the absence of vesicular porosity in the better aggregated coppice dunes and dune interspace soils. This unstableness also accounts for the larger sediment production from dune interspace areas and from soils that are initially at field capacity. The surface soil reaches saturation quicker on soils initially at field capacity, thus the time required to erode dispersed soil particles in longer.

Infiltration rates and sediment production for the various plant communities and soils varied considerably within and between watersheds. Soils in the Steptoe Watershed generally had the highest infiltration rates and lowest sediment production. The Duckwater Watershed soils generally exhibited the lowest infiltration rates and hightest sediment production. However, the variation was high among plant communities; for example, in the Duckwater Watershed the singleleaf pinyon/Utah juniper community had the hightest infiltration rate and the winterfat community the lowest rate of all sites studied.

The two plant communities in Steptoe Watershed that were plowed and drilled to crested wheatgrass showed no significant ($P = 0.05$) difference nor apparent trend in infiltration rates or sediment production as compared with their untreated counterparts. Three plant communities, however, at Pine and Mathews Canyon Watersheds that were railed and seeded or chained and seeded showed a trend of higher infiltration rates and lower sediment production for treated sites as compared to untreated counterparts. Of the three treated communities only the older treatment that had been railed and seeded in 1954 showed a significantly higher infiltration rate than its untreated counterpart. These results indicate that time is required for a vegetation conversion treatment to significantly affect infiltration rates. If dune interspace soil surface is well aggregated and free of a vesicular horizon before treatment, a significantly larger infiltration rate or significantly lower sediment production for the treated site may never be realized.

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