Infiltrometer Studies on Treated vs. Untreated Pinyon-Juniper Sites in Central Utah[1]

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Highlight

Based on data from small-plot studies utilizing high intensity simulated rainfall, conversion of pinyon–juniper stands to grassland in central Utah has not necessarily increased infiltration rates or always reduced sediment yields from a given point on treated areas. Of 14 sites studied, two sites indicated improved infiltration rates and two sites indicated decreased infiltration rates on treated as compared with nearby untreated areas; two sites had significantly less sediment from treated areas compared to nearby untreated areas.

Estudios con el Infiltrometro en Sitios de Pino–Enebro (*Pinus juniperus*) Tratados y no Tratados en la Parte Central de Utah

Resumen[2]

Basado en los datos de los estudios realizados en pequeñas parcelas utilizando una alta intensidad de precipitación simulada, la conversión de sitios de pino–enebro a zacatales en la parte central de Utah no necesariamente ocasionó aumento en las tazas de infiltración u ocasionó reducción en las producciones de sedimentos de un punto dado en las áreas tratadas. De 14 sitios estudiados, 2 sitios indicaron mejora en las tazas de infiltración y 2 sitios indicaron reducción en dichas tazas, en los tratamientos comparados con áreas cercanas sin tratar; 2 sitios tuvieron enforma significativa menos sedimentos en los tratamientos comparados con áreas próximas sin tratar.

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The conversion (by chaining, dozing, etc.) of pinyon–juniper (*Pinus edulis* Engelm., *Pinus monophylla* Torr. and Frem. - *Juniperus* spp.) woodland environments to seeded grassland is not uncommon in many sectors of western United States. Such programs have been underway during the past 10 to 15 years. Though much of this effort has been directed toward increasing range forage production, increasingly more emphasis is being placed on watershed value and soil protection aspects of such land management techniques.

Little information is available concerning watershed management implications of pinyon–juniper conversions. Studies in the southwestern U.S. have tentatively shown that clearing of pinyon–juniper results in no increase in water yield (Brown, 1965; Collings and Myrick, 1966). Soil moisture studies under cleared and natural stands (Skau, 1964) have provided similar findings.

Surface hydrology of treated areas may be influenced by cabling pinyon–juniper. Skau (1961) reported that pits created by cabling and debris left on the ground help reduce the amount of surface waterflow. The pits, at the base of uprooted trees, left an average water storage capacity of 0.18 inch/acre.

The objective of this study was to gather preliminary information concerning infiltration rates and sediment production at a given point from several converted (and nearby untreated) pinyon–juniper sites in central Utah.

Methods

A Rocky Mountain infiltrometer (Dortignac, 1951) was utilized to simulate high intensity (three in/hr or greater) rainfall on plots approximately 2.5 ft^2 in size. Fourteen treated and 14 nearby untreated pinyon–juniper sites were sampled with a total of 225 infiltrometer plots near Price and Eureka, Utah during the summer of 1967. Tables 1 and 2 give a brief description of each site.

All plots were pre-wet a minimum of 3 hours before infiltrometer runs began. Runoff was measured at selected time intervals during each infiltrometer run. Simulated rainfall was applied to

Table 1. Brief description of study sites near Price, Utah.

Project	Date seeded[1]	Percent cover[2]		Average production in 1965[3] (dry lb/acre)	Grazing history
		Untreated	Treated		
1. West Huntington Double chained, debris in place.	1961	0	2–41	420	Limited winter and spring use by cattle prior to treatment. No grazing since treatment.
2. Pinnacle Bench Double chained, debris in place	1962	2–24	11–24	770	Winter and spring use by sheep prior to treatment. Winter use by sheep and spring use by cattle after treatment.
3. Horse Canyon Double chained, debris in place.	1963	0–4	0–29	570	Winter and spring use by sheep prior to treatment. No grazing since treatment.
4. Coal Creek Double-chained, debris in place	1964	0	7–16	530	Spring-fall use by cattle and sheep prior to treatment. Limited use by cattle since treatment.
5. Wood Hill Double chained, debris in place.	1966	0–22	0–27	New	Winter-spring use by sheep prior to treatment. No grazing since treatment.

[1] Seeded primarily to crested wheatgrass at 6 to 11 lbs/acre in fall unless otherwise indicated.
[2] Percent plant cover on infiltrometer plots (excludes canopy coverage of pinyon-juniper on untreated plots).
[3] Represents seeded area only.

Table 2. Brief description of study sites near Eureka, Utah.

Project	Date seeded[1]	Percent cover[2]		Average production in 1965[3] (dry lb/acre)	Grazing history
		Untreated	Treated		
1. Boulter Chained and windrowed.	1957	0	1–33	920	Common use (sheep and cattle) during spring and summer prior to treatment. After treatment and 3 years rest, 1000 sheep during May of each year.
2. Loftgreen Chained and windrowed.	1962	0	6–17	Unknown	Fall-spring use by sheep before and after treatment.
3. Black Rock Canyon Chained and windrowed.	1964	0	7–22	Unknown	Winter use by sheep prior to treatment.
4. Onaqui Chained, debris in place.	1963	0–5	0–21	Unknown	Winter use by sheep prior to and following treatment.
5. Government Creek Area					
Location #1 Chained, debris in place	1966	0–16	4–12	New	Summer use by cattle prior to treatment.
Location #2 Chained, most debris burned.	1960	0–6	6–20	720	Summer use by cattle prior to and following treatment.
Location #3 Chained, debris in place.	1965	0–6	0–14	New	Summer use by cattle prior to treatment.
Location #4 Chained, debris in place.	1960	0–5	0–17	360	Summer use by cattle prior to and following treatment.
Location #5 Chained, part with debris in place. Windrowed.	1962	0–5	2–21	Unknown	Summer use by cattle prior to and following treatment.

[1] Seeded primarily to crested wheatgrass at 6 to 9 lbs/acre in the fall unless otherwise indicated.
[2] Percent plant cover on infiltrometer plots (excludes canopy coverage of pinyon-juniper on untreated plots).
[3] Represents seeded area only.

Table 3. Mean infiltration rates (in./hr.) during specified time intervals on various pinyon-juniper sites near Price, Utah.

Site[1]	Time interval (minutes) 3–4	4–5	5–6	6–7	7–8	8–13	13–18	18–23
Pinnacle Bench								
T (Treated)	2.2	2.2	2.2	2.0	1.8	1.5	1.5	1.5
U (Untreated)	2.7	2.4	2.4	2.1	2.2	1.9	2.0	2.0
Pinnacle Bench								
T[2]	1.5	1.4	1.4	1.2	1.3	1.3	1.3	1.4
U	2.7*	2.4**	2.4*	2.1**	2.2**	1.9*	2.0**	2.0*
Coal Creek								
T	3.3	2.8	2.8	2.6	2.4	2.4	2.1	2.0
U	3.0	2.6	2.5	2.7	2.6	2.2	2.0	2.0
Horse Canyon								
T	1.9	1.8	1.7	1.8	1.6	1.3	1.3	1.2
U	1.7	2.8	1.5	1.4	1.3	1.2	1.1	1.1
Wood Hill								
T	2.3	2.3	2.1	2.0	1.8	1.6	1.7	1.7
I	2.2	2.2	1.8	1.8	1.8	1.7	1.6	1.6
West Huntington								
T	2.6	2.4	2.4	2.4	2.3	2.1	2.0	1.9
U	2.8	2.5	2.1	2.2	2.1	2.2	1.9	1.9

* Significantly larger at 0.05 level than other value in pair.
** Significantly larger at 0.01 level than other value in pair
[1] See Table 1 for brief description of sites.
[2] Burned portion only.

each plot until a constant runoff rate was reached (generally 25 minutes were sufficient).

Sediment was measured by collecting total runoff plus sediment from each plot, mixing thoroughly, and finally obtaining a 1-quart sample. The water was then evaporated off, sediment oven-dried, and sample weights converted to tons per acre. The use of a small plot prohibits full expression of the sometimes turbulent activity associated with overland flow; sediment yields should, therefore, be interpreted accordingly.

Soils at study sites were derived from colluvium, alluvium, and residuum of mainly sedimentary rock (Eureka area) and sandstones and shales (Price area). Those soils common to the pinyon–juniper type in both areas may be categorized into three orders: Entisols (suborder Ortherts), Aridisols (suborder Argids and Orthids), and Mollisols (suborders Xerolls and Ustolls) (Isaacson, 1966).

Results and Discussion

Sites near Price, Utah

Table 3 shows mean infiltration rates (in/hr) during specified time intervals and Fig. 1 denotes relative differences in sediment production from treated and untreated conditions on five pinyon–juniper sites studied near Price, Utah. As noted from Table 1, age of treatment varied from 1 to 6 years.

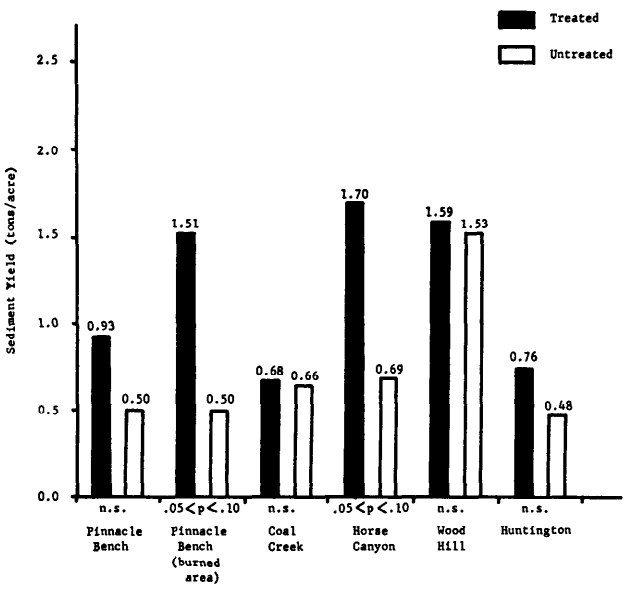

FIG. 1. Sediment yields from five pinyon–juniper sites near Price, Utah. ("n.s." indicates no significant difference between treated and untreated.)

Pinnacle Bench.—No significant differences in infiltration rates are indicated between treated and untreated conditions during any time interval (item one, Table 3). However, means shown for the treated area include data from a portion of the project which was burned following chaining. Means from the burned area alone are given as item two in Table 3. In this instance, infiltration rates on the burned area were significantly less throughout the infiltrometer runs than were rates on the untreated portions. Whether this represents a soil wettability problem is not known.

As shown in Fig. 1, there were no significant differences (.05 level of probability) in sediment yields between chained and untreated or between chained (burned) and untreated at the Pinnacle Bench site.

Coal Creek, Horse Canyon, Wood Hill, West Huntington.—No significant differences between treated and untreated conditions are indicated for either infiltration rates (Table 3) or sediment yields (Fig. 1). At the West Huntington site, the following four exclosures were within the treated area: (1) Everything excluded, (2) rabbits only, (3) deer only, and (4) deer and rabbits only. There were no significant differences between any of the exclosures and untreated conditions with respect to infiltration rates and sediment production.

Sites near Eureka, Utah

Table 4 shows mean infiltration rates during specified time intervals and Fig. 2 denotes relative differences in sediment production from treated and untreated conditions on nine sites near Eureka, Utah.

Table 4. Mean infiltration rates (in./hr.) during specified time intervals on various pinyon-juniper sites near Eureka, Utah.

Site[1]	Time interval (minutes) 3–4	4–5	5–6	6–7	7–8	8–13	13–18	18–23
Loftgreen								
T (Treated)	2.2	2.1	2.1	2.0	2.1	1.7*	1.6*	1.5*
U (Untreated)	1.6	1.6	1.5	1.6	1.6	1.0	0.9	0.9
Black Rock Canyon								
T	1.6	1.5	1.3	1.2	1.2	1.1	1.0	0.9
U	2.0	2.0	2.0*	2.0**	2.0**	1.4	1.4	1.4*
Boulter								
T	1.4	1.3	1.2	1.2	1.2	1.1	1.1	1.0
U	1.5	1.5	1.4	1.4	1.6	1.3	1.4	1.2
Gov't Creek								
Job #1								
T	1.3	1.0	0.7	0.7	0.6	0.6	0.4	0.4
U	1.1	0.8	1.1	1.1	1.0	1.0*	0.9*	0.8*
Job #2								
T	1.5	1.2	1.1	1.3	1.1	0.8	0.6	0.7
U	1.4	1.1	1.2	1.0	1.4	1.0	0.9	0.7
Job #3								
T	1.3	1.1	1.2	1.1	1.0	0.6	0.7	0.6
U	1.2	1.1	1.3	1.1	0.9	1.0	0.9	0.8
Job #4								
T	2.8	2.7	2.3	2.1	2.4	1.7	1.6	1.6
U	2.4	2.6	2.3	2.0	2.0	1.6	1.6	1.7
Job #5								
T	2.4	2.1	2.2	2.1	2.1	1.4	1.5	1.4
U	2.4	2.4	2.3	2.0	2.0	1.6	1.6	1.7
Onaqui								
T	3.9*	3.4	2.8	2.8	2.8	2.0	2.0	1.9
U	1.7	1.9	2.0	1.9	2.0	1.4	1.3	1.3

[1] See Table 2 for brief description of sites.
* Significantly larger at 5% level than other value in pair.
** Significantly larger at 1% level than other value in pair.

Loftgreen.—Infiltration rates were significantly greater on the treated area after approximately 8 minutes of simulated rainfall. There were no differences between treated and untreated areas with respect to sediment yield.

Black Rock Canyon.—In contrast to the Loftgreen site, infiltration rates were significantly greater on the untreated area after approximately 5 minutes of simulated rainfall. There were, however, no significant differences in sediment yields between treated and untreated areas.

Gov't Creek Job #1.—As with the Black Rock Canyon site, infiltration rates were significantly greater on the untreated area after about 8 minutes of simulated rainfall. There were no significant differences in sediment yield, however.

Boulter, Gov't Creek Jobs #2, 3, 4, and 5.—No significant differences in infiltration rates between treated and untreated conditions are indicated. As for sediment yields, Fig. 2 shows that significantly less sediment was collected from the treated area (as compared to untreated) on the Gov't Creek Job #5.

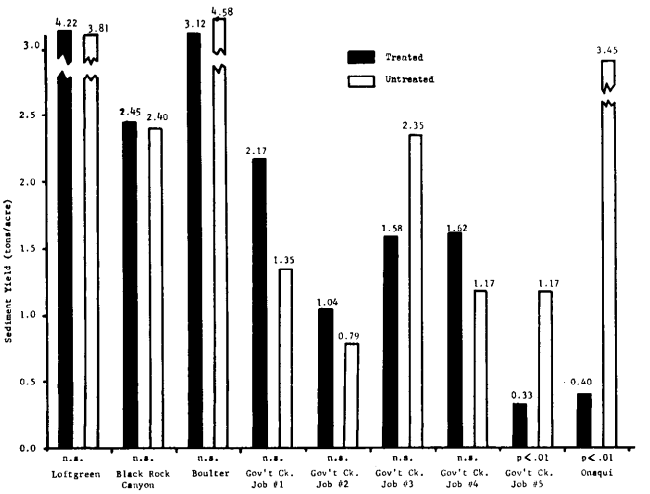

FIG. 2. Sediment yields from nine pinyon–juniper sites near Eureka, Utah. ("n.s." indicates no significant difference between treated and untreated.)

Onaqui.—Mean infiltration rates were from 0.6 to 2.2 in/hr greater on the treated area during all phases of the infiltrometer runs. However, due to variability among plots within the treated area, only the infiltration rates during the 3- to 4-minute time increment were significantly different. The treated area, in conjunction with higher infiltration rates, also had significantly less sediment production, as shown in Fig. 2.

Conclusions

Infiltration and sediment data collected with a Rocky Mountain Infiltrometer at several sites in central Utah indicate that conversion of pinyon–juniper cover to grassland has not necessarily increased infiltration rates or always reduced sediment yields at a given point on such lands. Of 14 sites studied (burned portion of Pinnacle Bench excluded), two indicated increased infiltration rates on treated areas and two indicated decreased infiltration rates on treated areas. There were no significant differences between treated and untreated at the remaining sites. As for sediment yields, two sites indicated significantly less sediment from treated areas as compared to nearby untreated. Sediment yields were similar from treated and untreated areas at the remaining sites.

It is difficult to successfully evaluate the influence of standing trees or pinyon–juniper debris on runoff and sediment production through the use of small plots. In addition, it is impossible to evaluate the influence of a seeding on the "time" factor in infiltration. This time factor (simply the length of time a given area is allowed to absorb a given amount of water) is important because cover on the

soil surface acts as a barrier to overland flow. Rate and quantity of runoff may, therefore, be decreased, not because of increased absorptive capabilities of the surface soil profile but because the water has more time to infiltrate.

This study was designed to detect obvious improvement or deterioration of certain watershed values as the result of conversion of pinyon–juniper. Other studies currently underway will evaluate the influence of conversion treatments through use of 0.1-acre runoff plots and eventually small watersheds.

LITERATURE CITED

BROWN, H. E. 1965. Preliminary results of cabling Utah juniper, Beaver Creek Watershed Evaluation Project. *In* Proceedings, 9th Annual Arizona Watershed Symposium, Tempe, Arizona, Sept. 22, p. 16–21.

COLLINGS, M. R., AND R. M. MYRICK. 1966. Effects of juniper and pinyon eradication on streamflow from Corduroy Creek Basin, Arizona. U.S. Geol. Surv. Prof. Paper 491-B. 12 p.

ISAACSON, H. E. 1966. Description of ecological provinces within the study area. *In* Management Alternatives for Pinyon–Juniper Woodlands, Part A, Utah Agric. Expt. Sta. Unnumbered Publ., p. 27–54.

SKAU, C. M. 1961. Some hydrologic influences of cabling juniper. U.S. Forest Service, Rocky Mt. Forest & Range Expt. Sta. Res. Note 62. 2 p.

SKAU, C. M. 1964. Soil moisture storage under natural and cleared stands of alligator and Utah juniper in northern Arizona. U.S. Forest Service, Rocky Mt. Forest & Range Expt. Sta. Res. Note RM-24. 3 p.