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Title: STORM RUNOFF CHARACTERISTICS OF VARIOUS PLANT COMMUNITIES WITHIN THE OREGON RANGE VALIDATION AREA

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A sediment production and infiltration study was conducted within the Oregon Range Validation Project Work Area in east-central Oregon during the summers of 1977 and 1978. High intensity rainfall was simulated by using a Rocky Mountain Infiltrometer. This sprinkler-type infiltrometer closely approximates conditions associated with natural rainfall.

The basic ecological land unit for research purposes within the Validation Area is defined as the "Resource Unit". Resource units were derived in the Forest-Range Environmental Study (FRES) (USDA 1972) by categorizing the forest and range land into 34 ecosystems, four productivity levels, and three condition classes. Ten of the 34 ecosystems are found within the Validation Area.

Multiple range tests were used in order to compare data among resource units. Stepwise regression was used to evaluate the significance of vegetative cover, litter, and pavement on sediment production and infiltration.

Sediment values ranged from 1572 kg/ha in the Juniper ecosystem to 15 kg/ha in the Larch ecosystem. Significant differences in sediment production were noted among the majority of study areas. Mean infiltration rates ranged from 8.2 cm/hr in the Meadow ecosystem to 6.6 cm/hr in the Ponderosa pine ecosystem. Infiltration rates in the forested areas were more closely correlated with condition class than productivity class. Both condition class and productivity levels were correlated with filtration in the non-forested areas. Results of the Stepwise regression analysis indicated that vegetative cover, litter, and pavement were more closely correlated with potential sediment production than with infiltration rates.

Storm Runoff Characteristics Of Various Plant Communities
Within The Oregon Range Validation Area

by

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Ron Gaither

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STORM RUNOFF CHARACTERISTICS OF VARIOUS PLANT COMMUNITIES WITHIN THE OREGON RANGE VALIDATION AREA

INTRODUCTION

In compliance with Rangeland Resources Program requirements, this thesis is written in a style designed to accomodate a dual purpose. The bulk of the thesis is written in a "conventional theses" style. However, where the "RESULTS AND DISCUSSION" section would normally be found, a group of three chapters written in a "manuscript" style is present. This format is designed to serve the dual purposes of providing a complete compendium of literature, methods, and data while at the same time facilitating the arduous task of preparing the thesis for publication in a scientific journal. Because of this format, the reader is advised that some repitition in literature and methods is inevitable.

Many of our western rangelands are either in a condition far removed from their pristine state or are being rehabilitated to once again attain or surpass their original productivity. Grazing practices from mid to late 1800 into the early 1900's resulted in not only a reduction in range condition and productivity but also in the ability of many ranges to rehabilitate themselves.

The demand for red meat during this period in time enticed a number of people into the cattle and sheep industry. Domestic as well as foreign investors were exuberant at the thought of creating large fortunes with livestock. Cattle prices were high in the Eastern markets and men from almost every walk of life were eager to take their place in the livestock business. Unfortunately, the vast western grasslands were viewed by many of these investors as an unlimited resource to be exploited for their personal gain. Nearly every parcel of grazable land was stocked to its capacity and large numbers of animals foraged over ranges where half their number may have been too great a stress for the land.

Early settlers described the western and southwestern grasslands as covered knee-high with thick grass. Areas such as the short, mid, and tall grass prairies had evolved under grazing pressure from deer, elk, and countless numbers of bison. However, these animals were seldom concentrated in one location long enough for their grazing habits to adversely affect the range. Unlike the native herbivores, cattle and sheep were generally localized on ranges for long periods of time in order to utilize every bit of available forage. The intermountain-bunchgrass region did not evolve under the intensity of grazing as did grasslands east of the Rocky Mountains. Yet, livestock pressures on some sections of this region were even more severe than on other western ranges.

Gradually, thousands of cattle and sheep on overstocked ranges reduced the native vegetation and left many areas comparatively bare, except for shrub, forb, and grass remnants. Less valuable forage plants were then grazed more severely until they too were practically eliminated. Hungry animals searching for forage trampled the range, destroying plant roots and compacting the soil. Under these conditions, little was left to buffer the soil surface from the potentially destructive force of rainfall. The more compacted soil lost its ability to absorb significant quantities of water. Greater volumes of runoff produced under these conditions carried away the rich surface soil leaving clay subsoils exposed. Subsequently, many areas became dust bowls. For example, ranchers in Utah told of being able to count herds of sheep on the mountains by the number of dust clouds created from their trailing (Chapline 1929).

A severe decline in livestock numbers and herd productivity occurred in the 1890's due to a degradation of the range resource, coupled with a series of harsh winters. This spurred a request by a group of Texas cattlemen for the federal government's assistance in dealing with the problems of deteriorated range condition prevalent during that era. Studies conducted in the 1890's by Jared Smith and H.L. Bentley in West Texas and Frederick Colville in the Pacific Northwest were among the first in an attempt to understand the problems associated with livestock grazing on the open range (Stoddart, et al. 1975).

Rangelands represent a relatively fragile ecological system in that misuse may carry long-term consequences. Precipitation is characteristically low and variable in time and space. Many areas receive less than 25 cm (10 in) per year and are subject to high evaporational losses. By nature of the environmental medium, vegetation is usually sparse. Climate, particularly precipitation, and vegetation are important soil forming factors. Therefore, the soil in arid and semiarid regions is generally weakly developed. Topography in some areas may range from undulating to steep, and potential erosion problems may be compounded by a loss of vegetative cover on steep hillsides.

Livestock management to prevent excessive or inappropriate use of the range resource is an opportunity to conserve a valuable and limited commodity, water. Sound management practices can lead to the development and maintenance of favorable cover and soil conditions for storing precipitation where it falls. This, in turn, may reduce potential erosion, flood, and siltation problems resulting from excessive runoff while allowing for increases in forage production.

From the early history of grazing on marginal western rangelands until the passage of the Taylor Grazing Act in 1934, little had been accomplished with respect to the administration and regulation of grazing on these public lands. Management concerns of the early to mid 1900's were primarily directed toward existing conditions and there were no far-reaching policies designed to meet and anticipate future needs. Today the establishment and regulation of grazing on federal forest lands has greatly supplemented the capabilities of our grasslands. Clearcuts, reseeded skid trails and logging roads, and open forest stands are capable of producing large amounts of livestock forage. Under good management, clearcuts within a Douglas-fir forest may produce 1,100-1,300 kg/ha of forage (1,000-3,000 lb/ac) (USDA 1977). In comparison, herbage production under a closed canopy may only reach 56-168 kg/ha (50-150 lb/ac).

If we are to maintain and enhance our present standard of living we must manage our remaining natural resources more efficiently with both present and future demands in mind. With respect to livestock production, this involves an understanding of the mechanisms involved with producing and maintaining optimum amounts of forage. Adequate moisture is a primary factor in forage production. This study attempts to establish infiltration, runoff, and sediment production potentials of a variety of plant communities. These include not only open range areas such as sagebrush and grass communities but also a number of forested communities. Research for this thesis was conducted in conjunction with the Oregon Range and Related Resources Validation Area Project. Therefore, a knowledge of the Validation Project is mandatory before the objectives of this study can be fully defined.

Oregon Validation Project

The Oregon Range and Related Resources Validation Area Project was initiated to validate existing information and management practices in order to overcome inadequacies in our present knowledge of resource management. The Validation Work Area is located in east-central Oregon and covers a large portion of Grant County and smaller portions of surrounding Umatilla and Wheeler Counties (Fig. 1). The project is a cooperative venture and research areas were made available from both private sectors and government agencies (Table 1).

Goals of the Validation Project are to develop, acquire, assemble, and relate information which is needed to efficiently manage our range related resource base (Validation Team and Contributors 1976). An attempt will be made to answer questions raised by two complementary studies which relate to the effects of resource management decisions on the economy, society, and environment of resource-dependent areas. The studies are:

1. The Nation's Range Resources, A Forest-Range Environmental Study (FRES). Forest Service Research Report No. 19 (USDA 1972); and

2. The Oregon State University project entitled "Alternative for Growth in a Resource-Based Economy: A Pilot Area Study for Grant County, Oregon (Stages I and II)" (OSU 1975).

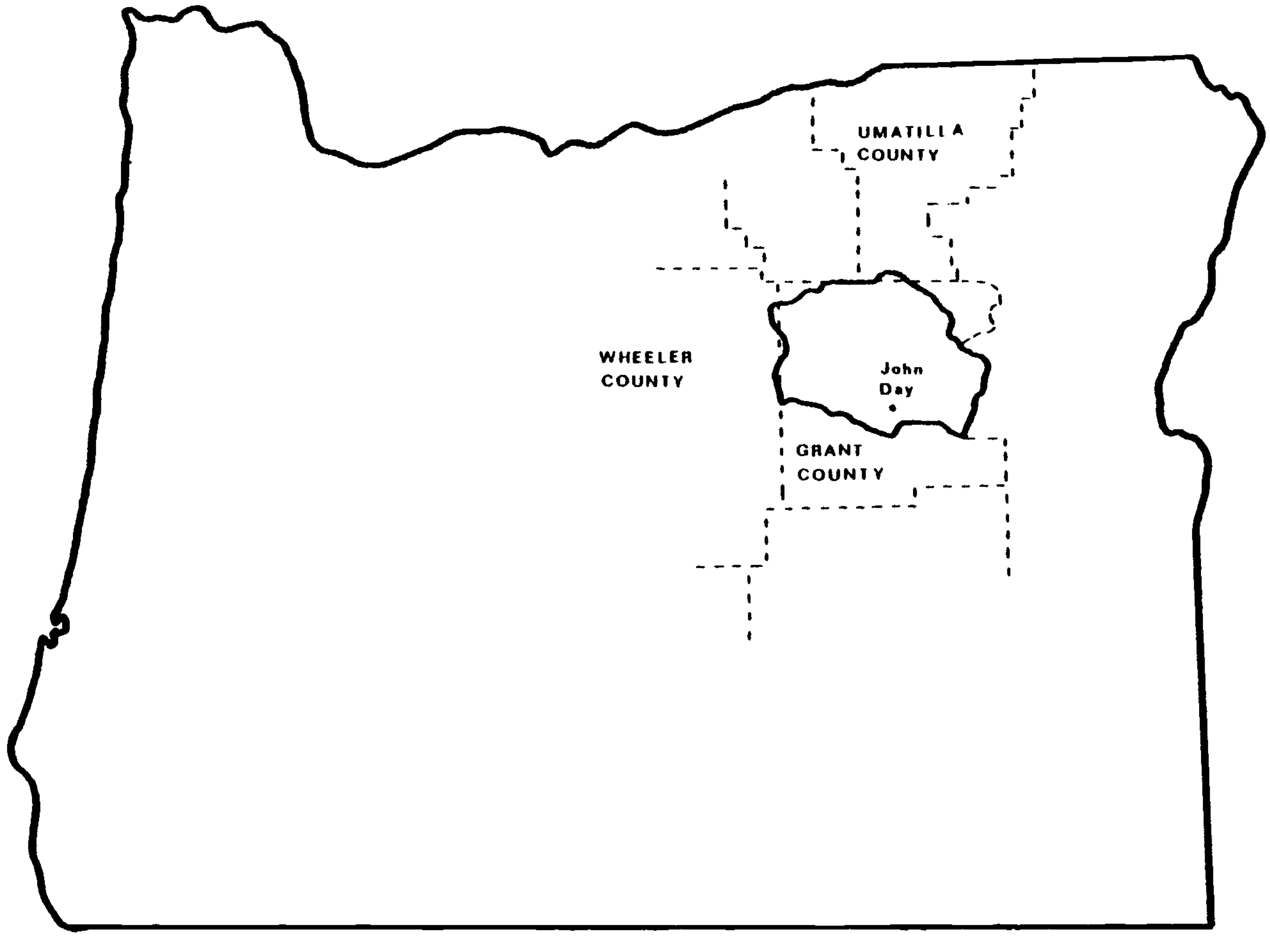

Figure 1. The Oregon Range and Related Resources Validation Project Work Area.

Table 1. Landowner distribution of the Validation Work Area.

Ownership	Hectares
Private	333,833
U.S. Forest Service	232,241
Bureau of Land Management	40,486
State of Oregon	2,639
National Park Service	2,550

The Forest-Range Environmental Study is primarily directed toward research of least-cost forage and rangeland management strategies. The Pilot Study is larger in scope in that practices are not prescribed and indirect effects are more comprehensively evaluated. The FRES has made use of hypothetical data and coefficients in order to develop alternative management strategies. The Validation Area is being used as a large-scale test site in order to confirm or adjust assumptions generated from the FRES.

A total of 23 monitored resource outputs are being investigated within the Validation Work Area (Appendix A-1). The resource outputs are being investigated with respect to their relationship with each of five different management strategies (Appendix A-2). The management strategies were defined to establish a link between range activities and the range resource in addition to simplifying the potential problem of large numbers of possible management strategies (USDA 1972). Strategies B through D consider multiple use as a constraint on the degree to which grazing can be emphasized. Strategy E is subject only to the stewardship of land and water resources.

The basic ecological land unit for research purposes within the Validation Area is defined as the "Resource Unit". Resource Units were derived in the Forest-Range Environmental Study by categorizing the forest and range land into 34 ecosystems, four productivity levels, and three condition classes. Productivity levels of forest ecosystems are based on volume of wood and condition classes are based on tree diameter (Appendix A-3). Productivity levels of juniper, sagebrush, grassland, and meadow ecosystems are based on pounds of forage per acre (Appendix A-4). Condition classes reflect the present plant composition relative to pristine conditions. Ratings of Good, Fair, or Poor are given, with Good representing the category nearest to pristine conditions. Ten of the 34 ecosystems identified and defined in the FRES occur within the Validation Work Area. Ecosystems are further refined into Resource Unit classifications. A description of each ecosystem with its corresponding Resource Unit classification is given in Appendix A-5. An example of the Resource Unit classification system is:

20-III-T

Where: 1. 20 is the Validation number indicating the Douglas-fir ecosystem.

2. III is the productivity level representing 50-84 cu. ft./ac./yr. of wood.

3. T is the condition class indicating stands with sawtimber having at least 50 percent of the trees above nine inches in diameter.

Forest and range management practices will be applied over a variety of land types and the effects of these practices will be monitored over time. The project was initiated in January, 1976 and is scheduled for completion on September 30, 1985. The result of the Validation project will be an accumulation of resource management data which have been tested and validated in a scientific manner. It is anticipated this information will be useful throughout much of the western United States in developing long-range resource management plans regarding public as well as private forest and range lands.

Objectives

The responsibility of this study to the Validation Project was to investigate storm runoff characteristics from a high intensity simulated rainstorm. This involved the establishment of infiltration, runoff, and sediment production potentials within a representative sample of resource units. Results of this study were to be applied toward:

1. Development of a theoretical runoff relationship between a high intensity rainstorm and a gentler, 2 day-2 year rainfall frequency.
2. Determination of potential soil loss from simulated rainstorms within designated resource units.
3. Identification of ground cover factors influencing infiltration and runoff potentials.
4. A comparison of resource units to identify those possessing similar storm runoff characteristics.

Simulated rainstorms were generated in resource units subject to various management strategies and contained within specified ecosystems.

STUDY AREA

Location

Research was conducted within the Validation Work Area in Grant County, Oregon. Grant County is situated in the Central Blue Mountains of east-central Oregon and lies between 44° and 45° north latitude and 118° and 120° west longitude. Studies were conducted in 14 locations representing 40 specific sites (Fig. 2).

Research areas within the Validation Work Area are designated by allotment and unit name or ownership name if located on private land. The 14 locations shown in Figure 2 represent research areas in which sampling was conducted. They are:

A. Brown Ranch - Roy Watkins Pasture

B. Monument Grazing Association - East Timber Basin

C. Donaldson Allotment - North Unit

D. Vaughn Ranch - Ferg and Sagebrush Units

E. Wilburn Ranch - Little Deer Creek Pasture

F. Wilburn Ranch - North Goldfish Pasture

G. Morgrass Grazing Association - Clarence Porter Unit

H. Morgrass Grazing Association - East Dustin Unit

I. Slide Creek Allotment - East Unit

J. Long Creek Allotment - Keeney-Clark Unit (Keeney Meadow), Hiyu Unit (Harper Meadow), and Hiyu Basin

K. Magone Lake

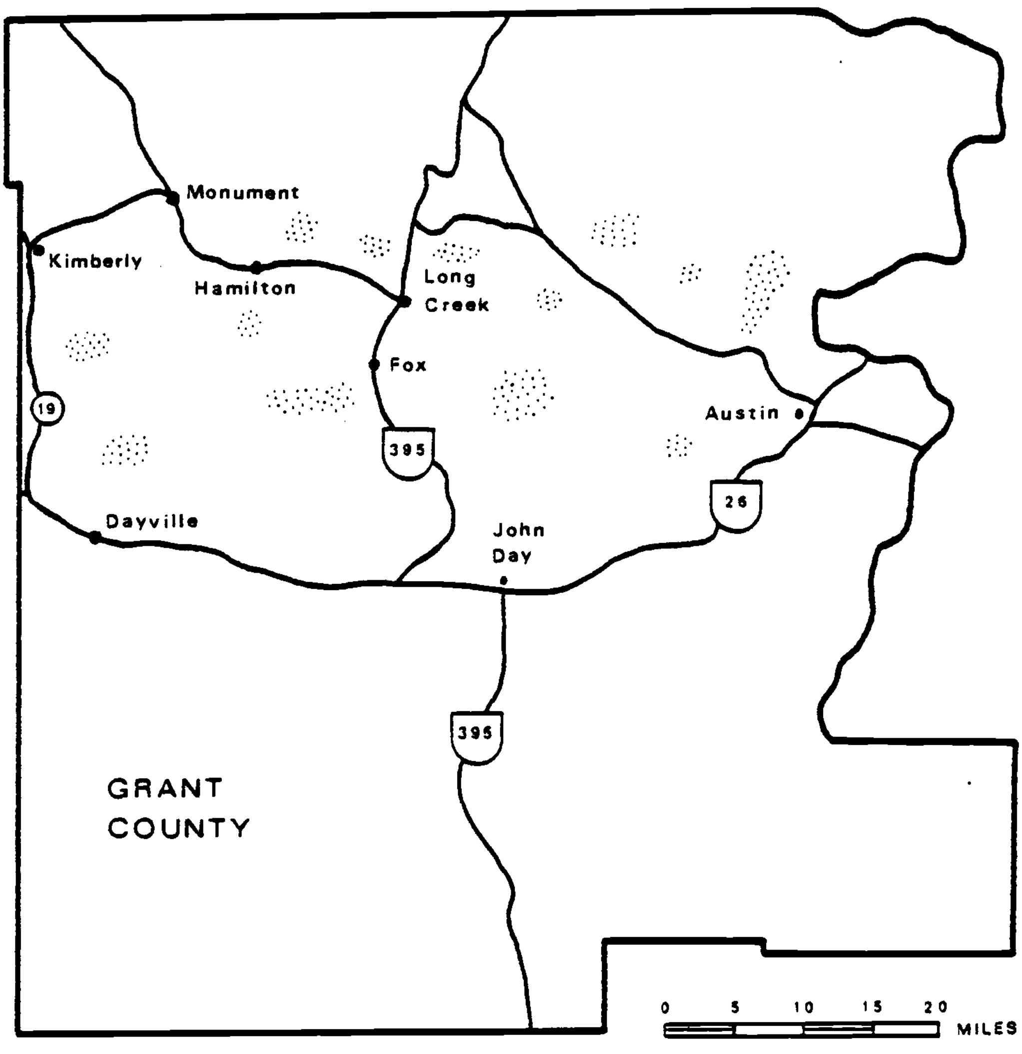

Figure 2. General location of hydrologic research areas within the Validation Work Area. (Dots represent general locations and not specific sites)

L. Upper Middle Fork Allotment - Deerhorn Unit

M. Upper Middle Fork Allotment - Upper Vinegar and Lower Vinegar Units and Blackeye Watershed.

N. Upper Middle Fork Allotment - Caribou Unit

O. Lower Middle Fork Allotment - Susanville Unit

Exact plot locations were delineated on aerial photographs which are on file at Validation headquarters.

Climate

Grant County is located in the Temperate Zone and has a climatic range from semi-arid to cold, sub-humid. Average winter temperature is 2.1^{o}C (35.8^{o}F). Average summer temperature is 19.2^{o}C (66.5^{o}F). Precipitation occurs primarily during the winter and spring months with significant amounts generally occurring through June. July marks the driest portion of the year followed by August and September. Although the summer months are relatively dry the area is subject to intense convective storms. On occasion they may lead to road wash-outs, crop damage, and structural damage to farm buildings as a result of local flooding.

Annual precipitation in the lower elevations is approximately 25 cm (10 in) and arrives primarily in the form of rain. Higher elevations may have annual precipitation up to 100 cm (40 in) primarily in the form of snow. Snow may persist in some areas throughout much of the year and may persist year-around at the highest elevations. Dependent upon elevation, the growing season may range between 80 and 180 days. Mean monthly temperature and precipitation values have been compiled for selected locations within the study area (Table 2).

Geology

The Validation Work Area is located in the John Day Drainage Basin. This area represents a borderland between the Columbia Plateau Province to the north and the Basin and Range Province to the south. The Aldrich and Strawberry Mountains form the southern boundary of the Work Area. Peak elevations extend from 2,130 m (6,988 ft) in the Aldrich Mountains to 2,755 m (9,038 ft) in the Strawberry Range. The eastern boundary is formed by the Greenhorn Mountains with a peak elevation at Vinegar Hill of 2,478 m (8,131 ft).

Topography is generally hilly or mountainous and the major streams are deeply entrenched. The North Fork, Middle Fork, and Main stem of the John Day River have their origins in the higher elevations of Greenhorn, Aldrich, and Strawberry Mountains. Drainage patterns are strongly controlled by orographic features of the area (Validation Team and Contributors 1976).

A wide variety of rock types are found throughout the area. These range from early Paleozoic sediments and late

Table 2. Mean monthly and mean annual temperature (T...°C) and precipitation (P...cm) data for Austin (1949-1978), John Day (1953-1978), Long Creek (1958-1978), Monument (1961-1978), and Dayville (1949-1978). (Climatological Data: Oregon 1949-1978).

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean An.
Austin	T	-5.6	-2.4	-0.2	4.3	8.4	12.6	16.8	15.7	11.3	5.9	0.2	-4.2	5.2
	P	7.47	4.75	5.26	3.42	4.45	3.51	1.45	1.98	2.41	3.58	6.07	7.82	52.17
John Day	T	-0.6	2.4	4.3	7.5	12.0	16.4	20.4	19.5	15.3	9.9	4.2	0.7	9.3
	P	3.40	1.98	2.46	3.25	4.04	3.38	1.12	2.18	1.88	2.67	3.51	3.58	33.45
Long Creek	T	-1.0	1.9	2.9	5.6	9.7	14.2	17.6	17.2	13.1	8.6	3.1	-0.4	7.7
	P	3.51	1.98	2.41	2.74	3.45	2.59	1.12	1.73	2.24	2.74	3.96	3.96	32.44
Monument	T	0.2	3.8	5.7	8.6	13.0	17.7	20.9	20.5	15.7	10.1	4.8	0.7	10.1
	P	3.86	2.01	2.54	3.00	3.05	2.95	1.22	1.70	1.83	2.34	4.04	4.11	32.64
Dayville	T	0.8	4.0	5.8	9.1	13.3	17.4	20.9	19.9	15.6	10.3	5.3	1.9	10.3
	P	3.35	2.16	2.62	2.44	4.06	2.92	1.04	1.22	1.27	2.26	3.02	3.43	29.79

Paleozoic metamorphics to late Tertiary volcanics. The oldest sedimentary and volcanic rocks in the area are found in the Greenhorn Mountains. Older sedimentary deposits are found primarily south of the John Day River and younger Tertiary volcanics occur primarily to the north. The John Day Fault forms an approximate boundary between these major rock types (Validation Team and Contributors 1976).

Soils and Vegetation

Six physiographic divisions are recognized in the John Day Basin (Valde and Scharback 1973). They are:

1. Columbia Basin outwash and lacustrine sediment plain.
2. Loess-mantled basalt plateau of the lower basin.
3. Alluvial fans and flood plains of the John Day Valley.
4. Low elevation semi-arid uplands.
5. Middle elevation sub-humid uplands.
6. High elevation forested uplands and open basins.

Of the six divisions, three are considered major physiographic areas of the John Day Basin (Validation Team and

Contributors 1976). They are: 1) alluvial fans and flood plains; 2) middle elevation uplands; and 3) high elevation uplands.

Soils of the alluvial fans and flood plains are primarily used for crops, hay or improved pasture. Those occurring on the alluvial fans vary from deep, well-drained loam or clay loam soils to deep, somewhat poorly drained alkali, silty, clay loam soils. Soils occurring on flood plains vary from deep, well-drained silty loam or sandy loam to poorly drained silty clay loams. The poorly drained silty clay loam soils are subject to periodic flooding.

Grass-shrub type vegetation dominates the medium elevation uplands. Soils of this area are derived primarily from Paleozoic sediments and Tertiary volcanics. Those occurring over sediments are moderately deep clayey soils. Those over basalt or tuff are silty, stony soils. Soils derived from ash or loess are moderately deep, silty clay loam and deep, ashy, silt loams.

Soils of the high elevation uplands support a predominately mixed conifer vegetation type. The most common soils encountered in the Blue Mountains are those derived from volcanic ash and basalt-andesite (Geist and Ehmer undated). These are the primary soils associated with coniferous forests of the high elevation uplands division (Carlson 1974).

Ash soils have a silt loam texture, weak structure, and generally overlay subsoils of varied origin. They often have a lower concentration of nutrients than basalt-andesite derived soils. However, they do possess a high water holding capacity and yield this water to plants quite readily. Basalt-andesite soils generally are coarser textured and their water holding capacity is lower compared to ash soils. The stronger structural characteristics of basalt-andesite soils give them more protection from erosive forces once a site has been disturbed. Ash soils are resistant to erosion under natural conditions, but are highly susceptible to displacement by mechanical means in both moist and dry conditions.

Fox Valley is the major open basin in the study area. It supports a grass-shrub and meadow type vegetation. Included soils are deep, well-drained, silty soils over old sediments and shallow to moderately deep clayey soils over tuff. Also found within the basin are black, poorly drained silty clay, silty clay loam, or alkali-affected silty clay loam soils formed from alluvium (Validation Team and Contributors 1976).

History of Land Use

Settlement of Grant County began in the early 1860's. Prior to this time protection from hostile Indians was so inadequate settlement was not inviting to prospectors or agriculturists. Gold was discovered near Canyon City in the early 1860's and migrations of prospectors from California and other parts of the west began to occur in 1862. By the end of 1862 the population of Grant County had risen to 4,000-5,000 people (West. Hist. Pub. Co. 1902).

The years from 1865 to 1878 were an alternating period of placer and quartz mining. As gold became more difficult to obtain, dredging operations were initiated. Dredging of the John Day River and some of its tributaries began in the late 1890's. Even today, many acres adjacent to the dredge sites are in a disturbed condition and incapable of supporting a natural vegetative cover.

Agricultural and horticultural resources of the county also began to develop during the period 1865 to 1878. Early settlers first believed the climate was too cold and severe for agriculture. Some people thought livestock could not be profitable even though there was "an abundance of bunchgrass covering each hill from base to crest and spreading out profusely over the valleys" (West. Hist. Pub. Co. 1902). It was soon realized these beliefs were unfounded. When the mining industry began to decline, the settlers turned their attention to the livestock industry.

Until 1882 stockmen dealt primarily in cattle and horses. Horse breeding was an early industry and some of the best horses in the state came from Grant County. Many of the cattle, horses, and sheep which crossed the Cascades during the early 1870's were taken to Wasco County, Grant County, and districts in northeast Oregon (Oliphant 1968). Large herds of cattle were located in Grant, Baker, Harney, and Malheur counties from the late 1870's to the early 1880's. The range soon became overcrowded and 30,000 head of cattle had to be driven from Grant County ranges to Harney and Malheur counties in the early 1880's. Cattle range began to deteriorate and during the mid 1880's large herds of cattle gave way to flocks of sheep. This change took place primarily because of a change in the condition of the range. In the mid 1880's an estimated 180,000 cattle, 15,000-20,000 horses, and 125,000-150,000 sheep were being grazed in Grant County (West. Hist. Pub. Co. 1902).

By the mid 1890's cattle range was shrinking rapidly due to overgrazing and the influx of sheep. During the late 1890's and early 1900's range wars had broken out between cattlemen and sheepmen. Cattlemen in Grant County were shooting sheep that were being driven in from Crook County. The Oregon range wars reached their height in 1904 and 1905. They were virtually ended by 1906 when the Federal Government began the practice of leasing grazing lands within its forest reserves (Oliphant 1968). Under this policy and the Taylor Grazing Act of 1934, range condition began to improve somewhat in eastern Oregon and other sections of the west. These policies provided for the orderly use, improvement, and development of public grazing lands.

The present population of Grant County is approximately 7,500, not much greater than it was in 1862 (Validation Team and Contributors 1976). The income of Grant County residents is generated largely from the sale and export of agricultural and timber products. This accounts for over 50 percent of total county income. The sale of livestock accounts for the greatest percentage of income derived from agricultural products. Mining is of minor importance in the overall economy. Mineral production is derived primarily from sand, gravel, and stone and varies considerably from year to year (Valde and Scharback 1973). Transportation links between Grant County and outside markets are poorly developed. Industrialization holds little promise for the county and future revenues will depend heavily upon natural resource products.

LITERATURE REVIEW

Infiltration and Runoff

Water is a primary limiting factor as regards production on many of our western rangelands. Activities which disturb the soil surface or vegetative composition and cover have the potential for reducing soil water intake, thereby reducing productivity which may be minimal at best. Water falling on bare soil tends to rapidly close the natural channels of percolation. Concentrating on the soil surface as runnoff, loss of sediments begins quickly. Vegetative cover tends to reduce the energy of rainfall by reducing rainfall velocity and by breaking the large drops into a fine spray which can then enter the soil without damage to the soil surface. Vegetation also plays an important role in augmenting evaporation and transpiration of moisture. Investigators have realized for many years the important associations between soil, vegetative cover, and hydrologic characteristics.

Influence of Soil

Blackburn and Skau (1974) studied infiltration rates and sediment production of 29 plant communities and soils in central and eastern Nevada. The highest infiltration rates and lowest sediment production occurred on sites with well-aggregated surface soils free of vesicular porosity. Infiltration was negatively related to vesicular horizons with the strength of the relationship dependent on vesicular horizon morphology. The researchers also found that substantially higher infiltration rates occurred on coppice dunes than on dune interspaces.

Allis and Kuhlman (1962) studied the effects of runoff and sediment yield on watersheds of different soil textures. Almost three times as much runoff was found to occur on fine-textured soils as from medium-textured soils. It was interesting to note that yearly seepage and evaporation was generally higher from the medium-textured soils.

Williams et al. (1972) used multiple regression analysis to determine relationships between vegetative and soil factors and infiltration rates and erosion from 550 infiltrometer plots at chained pinyon-juniper sites in Utah. Factors found to be most important in predicting infiltration rates were: 1) total porosity in the 0-3 inch layer of soil, 2) percent bare soil surface, 3) soil texture in the 0-3 inch layer of soil, and 4) crown cover.

Influence of Plant Cover

Studies at the Manti County watershed (subalpine rangeland) in central Utah showed that runoff varied inversely with the amount of total ground cover (Orr 1957). It has also been determined that water intake rate (infiltration), range condition class, and herbage production tended to vary together for a specific type of range site (USDA 1968). Meeuwig (1970), from a study conducted in northern Utah, reports that plant and litter cover was the most highly correlated variable with infiltration. This variable accounted for 73% of the variance in the amount of water retained by his study plots.

The ability to predict infiltration rates has been found to be variable. Conducting studies within a big sagebrush (Artemisia tridentata) area, Gifford (1972) reports the ability to predict infiltration rates using cover characteristics alone varies with time, both within a given storm event and on a seasonal basis. He further states that the relation of measured cover characteristics may help explain hydrologic behavior of a site at one time, yet be of little value at another time.

A form of soil cover oftentimes neglected is that produced by algae and other microflora. Loope and Gifford (1972), from a study in southeastern Utah on the effects of soil microfloral crusts on various hydrologic properties, found that sites with any degree of microfloral cover had significantly higher infiltration rates than areas with no lichen cover. Although there was a reduction in intrinsic permeability associated with a microfloral crust, it was not severe enough to affect infiltration at the soil-air interface.

Influence of Livestock

Two primary ways that grazing animals affect infiltration is the removal of protective plant cover and soil compaction. Both of these factors can significantly affect infiltration rates. Leithead (1959), conducting research in the Big Bend-Davis Mountain section of Texas, reports that runoff increases as range condition deteriorates. In this region a range site in good condition may have the capability of absorbing moisture 5-6 times faster than the same range in poor condition.

Rich and Reynolds (1963) studied the effects of grazing on chaparral lands in central Arizona with respect to runoff. They found that if no more than 40% of perennial grass production is removed at the end of the summer growing season, ground cover does not deteriorate and appears sufficient to maintain a stable soil. Presumably, grazing must be severe enough to reduce abundance of perennial grasses in order to lower infiltration and change runoff from a subsurface phenomena to a surface phenomena with accompanying increased erosion.

Rauzi and Hanson (1966), conducting water intake studies on three differentially grazed rangeland watersheds in South Dakota, found that infiltration rates were nearly linear with grazing intensity. Total water intake on lightly grazed watersheds was 2.5 times greater than on heavily grazed watersheds and 1.8 times greater than on moderately grazed watersheds. Heavy grazing resulted in soil compaction and significantly decreased pore spaces in the top four inches of soil when compared with light grazing. Data from this research indicated that storm characteristics are a dominant factor in the production of runoff from areas differentially grazed. Similar studies with similar results have been conducted by Rauzi and Smith (1973), Johnston (1962), Branson et al. (1962), and Tromble et al. (1974).

From grazing versus non-grazing studies in Colorado, Lusby (1970) reports that runoff on ungrazed watersheds was approximately 30% less than runoff from grazed watersheds. Ungrazed watersheds also averaged 45% less sediment than grazed watersheds. Data from this study indicated that within areas of similar physiography, runoff is directly related to percentage of bare soil. No mention was given of the grazing intensity used for this study. Hanson et al. (1970) conducted a similar study on the effects of grazing as regards runoff. Study areas in western South Dakota were subjected to light, moderate, and heavy grazing intensities. The greatest amounts of runoff were produced from the heavily grazed sites and the least amount of runoff was produced from the lightly grazed sites.

As the result of a study conducted in Colorado, Dunford (1949) reports that in practice it would appear that moderate grazing (33% herbage removal) is permissible on relatively gentle slopes. This of course depends on whether the resulting runoff loss does not cause a critical shortage of moisture for plant development. He further states that heavy grazing (57% herbage removal) is to be universally avoided. It should be noted that these grazing intensities are relative. What may be regarded as heavy grazing with respect to percent herbage removal in one plant community, may be considered moderate grazing in another plant community.

Influence of Range Improvement Practices

Gifford et al. (1970), working in southern Utah, found that areas subject to pinyon-juniper removal and then seeded to grass showed no consistent increase or decrease in infiltration rates or sediment production. Williams et al. (1969) had comparable results when conducting similar studies in central Utah.

Pinyon-juniper sites in which debris from chaining operations was windrowed has been shown by Gifford (1973) to result in 1.2-5.0 times more runoff as compared to a woodland control. Runoff from debris-in-place plots was equal to or less than that measured from the woodland control.

Plowing and seeding of a big sagebrush site in southern Utah resulted in a trend toward lowered infiltration rates (Gifford 1972). The greatest decline was recorded during the fall of the second year following treatment.

Following burning and grazing treatments of chained pinyon-juniper sites in southeastern Utah, Buckhouse and Gifford (1976) found that infiltration rates during certain time intervals were significantly lower as compared to a woodland control. A study conducted by Roundy et al. (1978) in a pinyon-juniper woodland in Nevada has shown that a loss in soil-protecting litter following prescribed burning results in decreased infiltration rates and increased sediment production. Infiltration rates on burned coppices were significantly lower than those on unburned coppices with the soil at field capacity. However, they were similar with the soil initially dry. Infiltration rates were generally similar for pinyon-juniper, sagebrush, and bitterbrush coppices. Shrub coppices generally had lower infiltration rates than tree coppices on unburned and burned areas.

A study conducted by Scott (1956) in California has shown a different effect on infiltration as a result of prescribed burning. The study was conducted in areas having a vegetative cover of pure and mixed stands of chamise, ceanothus, manzanita, oak and grass. His data indicated that the effect of burning and the presence of ash did not render the soil of the burned areas impervious to water.

On the contrary, burned areas reflected higher infiltration rates than did unburned areas.

Prescribed burning treatments conducted by Wright et al. (1970) in Texas showed that runoff, erosion losses, and water quality were unaffected on level areas. However, adverse effects lasted for 9 to 15 months on moderate slopes (8-20%) and for 15 to 30 or more months on steep slopes (37-60%).

METHODS

Equipment

Several models of sprinkler infiltrometers have been designed to establish or comparatively test infiltration, runoff, and sediment production potentials for a variety of ecological conditions. These devices differ primarily in plot size and rain drop characteristics (Nat. Acad. Sci. 1962). Wilm (1941) reported that results obtained with the Type F, Rocky Mountain, and North Fork sprinkler infiltrometers were comparable to each other, but were not comparable with data from other infiltrometer designs. Simulated rainfall for this study was generated with a Rocky Mountain infiltrometer (Fig. 3). This sprinkler type infiltrometer is particularly adapted to testing comparative infiltration-erosion rates and closely approximates conditions associated with natural rainfall (Dortignac 1951).

The sprinkler system employs three type F nozzles which are designed to provide a high intensity simulated rainfall. Water passes through a series of spacers and washers within each nozzle resulting in the formation of rain drops similar in size to those produced under natural conditions. A special flange located at the base of each nozzle acts to swirl the water as it passes through, thereby providing a relatively even distribution of rainfall.

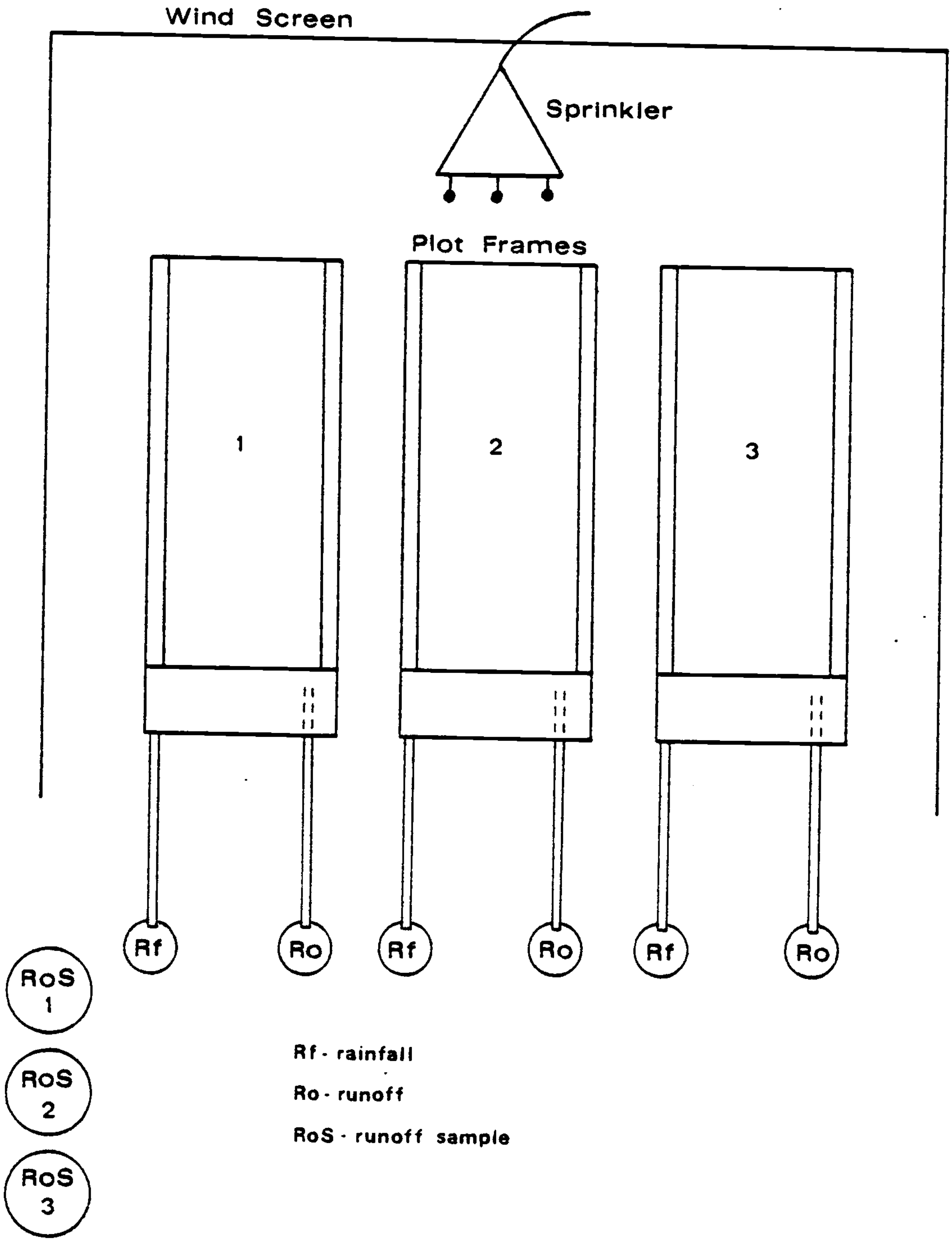

Figure 3. Diagrammatic representation of the Rocky Mountain Infiltrometer set-up.

In order to achieve runoff so that infiltration potentials could be determined, the infiltrometer was calibrated for a rainfall intensity of 10-13 cm/hr (4-5 in/hr).

When sampling within relatively open areas wind may adversely affect sprinkler performance. Drift can result in a highly variable rainfall application. A plastic wind screen was placed around the plot area to minimize wind disturbance. Plot locations were restricted to areas with slopes of 5% or less. This was done to minimize the effects of variable slope on runoff characteristics.

Plot frames consist of a rainfall frame and runoff frame. Dimensions of the runoff frame are 30.5 x 76.2 cm (1 x 2.5 ft) yielding a plot size of .23 square meter. A specially constructed slide hammer is used to drive run-off frames approximately 10 cm (4 in) into the ground. Rainfall frames are then placed over runoff frames. Rain-fall frames are designed with two collection troughs which are positioned along the outside perimeter of a runoff frame. The two collection troughs represent 1/6 of the runoff frame area.

A 1,900 liter (500 gallon) tank mounted on a 3/4 ton military trailer served as the water supply. Water was pumped to the sprinkler system through a series of 1.9 cm (.75 in) garden hose by means of a 6 1/2 hp gasoline engine and piston pump.

Field Procedures

Resource units in many of the study areas were identified by Validation personnel prior to initiation of data collection. Classifications in other areas were determined by "crosswalking" Blue Mountain plant community types (Hall 1973) to FRES resource units. Area maps of plant community types indicated productivity levels and condition classes. Therefore, a crosswalk consisted of establishing the corresponding FRES ecosystem using data provided by Validation headquarters.

Eighteen observations were made within each resource unit. Plots consisted of six randomly selected clusters comprised of three subplots per cluster. Cluster sampling provided practical and economical advantages (Steel and Torrie 1960). The sampling scheme allowed for the most efficient use of the sprinkler system. Rainfall was generated onto an area of approximately 1.4 m^2 (15 ft^2). This area was effectively used with three plot frames arranged approximately 6-10 cm (3-4 in) apart.

Prior to each field trial the soil was pre-wetted to ameliorate the affects of antecedent moisture. It was assumed this condition had been reached when water began to puddle within the plot frames.

Field trials were conducted over a 28 minute period. Rainfall and runoff were collected and measured at an initial three minute interval and at five minute intervals thereafter. Black plastic hose, attached to drain spouts built into the frames, channeled rainfall and runoff-sediment samples into six 2.9 l (.75 gal) buckets. Rainfall samples were discarded after measurement. Total rainfall for each subplot was obtained by multiplying measured values times six (rainfall frames represent 1/6 of plot frame area). Total volume was then converted to cm/hr and in/hr. Runoff-sediment samples were placed into three 7.6 l. (2 gal) buckets after measurement. Preceeding the 28 minute period, one .946 l (1 qt) sample was taken from each of the runoff-sediment containers. These samples were allowed to stand for approximately 48 hours in order for suspended sediments to settle. The clear water was decanted and the remaining slurry oven dried (105^{o}C). Sediment samples were then weighed (to the nearest .1 g), the jars washed, dried, and reweighed. Potential sediment production was determined from the difference in weight. Total runoff values for subplots were used in determining total sediment loss. A conversion factor of 43.06 was employed to convert grams of sediment to sediment production in kg/ha.

Percent ground cover for each subplot was determined by ocular estimation. Three categories of ground cover were considered: vegetation, litter, and pavement. The vegetation category included both live and standing dead plant material. Solid excreta from domestic and wild animals and plant litter were included in the litter category. In addition, percent bareground was recorded for each subplot.

Statistical Analysis

A comparison among mean infiltration rates and potential sediment production was made using three different multiple comparison tests. The three tests used were: 1) Student-Newman-Keul's (.05), 2) Duncan's Multiple Range Test (.05 and .01), and Least Significant Difference or LSD (.05 and .01). Three tests were used in order to note similarities for the purpose of general interest. Although results were almost identical for the majority of comparisons, the LSD was chosen for use in the interpretation of data. Student-Newman-Keul's and Duncan's Multiple Range Test are not exact tests when analyzing data from unequal sample sizes. Kramer (1956) devised an extension of multiple range tests that would apply to unequal sample sizes. However, this method has not been fully tested and is not totally acceptable to some statisticians.

Stepwise regression (Neter and Wasserman 1974) was used to determine the correlation between vegetative cover, litter, and pavement on potential sediment production and mean infiltration rates. This method computes a sequence of regression equations adding or deleting an independent variable at each step. Addition or deletion is dependent upon significance of the variable.

Potential Sediment Production Within Various Vegetative Communities

INTRODUCTION

Soil loss from accelerated erosion is a prime concern of land managers. This is particularly true for many of our western rangelands in which productivity may be inherently low. Associated with the nutrient loss as a result of eroded soil is the potential detrimental impact on the water resource as a whole. Increased sediment loads in streams and rivers may reduce the productivity of both aquatic flora and fauna. The "life-span" of reservoirs and stockwater ponds may be significantly reduced due to the input of excessive sediments. In addition, irrigation costs may increase due to the adverse effect of abrasive sediments on pumping equipment.

Erosion resulting from the action of water is one of the most common of geologic phenomena. Four factors and their interrelations are emphasized by Smith and Wischmeier (1963) as the basic influences on rate of rainfall erosion. They are:

1. Climate
2. Soil
3. Topography
4. Plant cover

Of the climatic effects on soil loss, rainfall is by far the most significant (Wischmeier 1959). Trimble and others (1958) found the problem of rill erosion on unprotected slopes, due to melting snow and rainfall, to be less severe under forest cover as compared to open land. Hanson et al. (1973) reported that sediment yields as they effect stockwater reservoirs, were related to soil texture. Meeuwig (1970) reported that organic matter content is the most important soil factor influencing soil erosion. Plant cover has also been shown to be a prime factor in influencing sediment production (Aldon and Garcia 1973, Meeuwig 1970).

The objective of this study was to determine and compare potential sediment production within and among 10 different ecosystems found within the Oregon Range Validation Project Work Area. The Validation Work Area is located in east-central Oregon. The basic ecological land unit for research purposes within the Validation Area is defined as the "Resource Unit". Resource units were derived in the Forest-Range Environmental Study (USDA 1972) by categorizing the forest and range land into ecosystems, each ecosystem in turn was further refined into one of four productivity levels, and one of three condition classes. The ten ecosystems found within the Validation Area are: 1) Douglas-fir (*Pseudotsuga menziesii*), 2) ponderosa pine (*Pinus ponderosa*), 3) fir-spruce (*Abies concolor*-*Picea englemannii*), 4) larch (*Larix occidentalis*), 5) lodgepole pine (*Pinus contorta*), 6) sagebrush (*Artemisia* spp.), 7) juniper (*Juniperus occidentalis*), 8) mountain grassland, 9) meadow, and 10) alpine. The ecosystems were refined into resource units by determining wood or forage volume as a measure of productivity and species composition, relative to climax, as a measure of condition.

A Rocky Mountain Infiltrometer was used to determine the potential sediment production of resource units found within the Validation Work Area. This sprinkler type infiltrometer is particularly adapted to testing comparative infiltration-erosion rates and closely approximates conditions associated with natural rainfall (Dortignac 1951). The infiltrometer was calibrated to produce a rainfall of approximately 13 cm/hr (5 in/hr).

Eighteen observations were made within each resource unit. Plots consisted of six randomly selected clusters comprised of three subplots per cluster. Cluster sampling provided practical and economical advantages (Steel and Torrie 1960). A comparison of potential sediment production was made using multiple comparison tests. Stepwise regression (Neter and Wasserman 1974) was used in order to determine the effects of vegetative cover, litter, and pavement on potential sediment production.

RESULTS and DISCUSSION

Sediment production potentials were established for 40 resource units representing each of the 10 ecosystems found within the Validation Work Area. Twenty-eight of the 40 were distinct resource units. In some instances equivalent resource units were sampled in order to establish a data base for allotments or units subject to differing management strategies. Sample distribution among ecosystems was variable due to physical limitations of the Rocky Mountain Infiltrometer and location of resource units. All possible resource unit combinations did not exist within the Validation Work Area. During the second summer of field work, opportunity existed for additional samples to be obtained for three previously sampled grassland resource units and one previously sampled ponderosa pine resource unit. In order to expand on those data bases, samples were pooled with previous data.

Variation in simulated rainfall was assumed to have no significant effect on sediment production. Mean rainfall for all samples ($n=44$) was 12.80 cm/hr (5.04 in/hr) with a standard deviation of 1.24 cm/hr (0.49 in/hr).

Large-scale resource management plans often consider a wide range of ecological features. Therefore, it was of interest to compare sediment production potentials for broad ecological classifications as well as the more ecologically refined resource units. Data from individual resource units were incorporated to form four groups of vegetation types based upon degree of ecological refinement. Group A, the group with the broadest ecological classification, had the following vegetation types:

1. Forest...resource units from the Douglas-fir, ponderosa pine, spruce-fir, larch, and lodgepole pine ecosystems.
2. Meadow-Grassland...resource units from the meadow and grassland ecosystems.
3. Shrub...resource units from the sagebrush (big sagebrush...*Artemisia tridentata* and low sagebrush...*Artemisia arbuscula*) and alpine (sub-alpine big sagebrush... *Artemisia tridentata* subspecies *vaseyana* for *spiciformis*) ecosystems.
4. Juniper...resource units from all climax and/or invaded ecosystems.

Group B represented an ecological refinement over Group A to the extent that the meadow and mountain grassland resource units were separated. The vegetation types were:

1. Meadow...resource units from the meadow ecosystem.
2. Forest...resource units from the Douglas-fir, ponderosa pine, spruce-fir, larch, and lodgepole pine ecosystems.

3. Grassland...resource units from the grassland ecosystem.
4. Shrub...resource units from the sagebrush and alpine ecosystems (same associated species as in Group A).
5. Juniper...resource units from all climax and/or invaded ecosystems.

Group C vegetation types are further refined in that the shrub component was separated into the alpine and low elevation brush types. The classification for Group C was as follows:

1. Meadow...resource units from the meadow ecosystem.
2. Forest...resource units from the Douglas-fir, ponderosa pine, larch, and lodgepole pine ecosystems.
3. Sub-alpine...resource units from the spruce-fir and alpine ecosystems.
4. Grassland...resource units from the grassland ecosystem.
5. Sagebrush...resource units from the sagebrush ecosystem.
6. Juniper...resource units from the juniper eco-ecosystem.

Group D was the most refined classification scheme that was used in this study. In this instance, resource units from each of the 10 ecosystems sampled were separated and compared. The vegetation types were composed of resource units from each of the following ecosystems:

1. Larch
2. Meadow
3. Lodgepole pine
4. Douglas-fir
5. Alpine
6. Ponderosa pine
7. Fir-spruce
8. Mountain grassland
9. Sagebrush
10. Juniper

Vegetation types of Groups A-C represent the broadest ecological classification in which sediment production potentials were compared. As would be expected with such a broad classification there was a wide range of sediment values for the various vegetation types (Table 3). However, results of the multiple comparison test indicated significant differences ($p < .05$) between the majority of vegetation types (Fig. 4-6 and Appendix B-1).

As the classification becomes more discrete the implications of considering a broad range of ecological features are apparent. Group B reveals a significant difference between sediment production potentials for mountain grassland and forest vegetation types, whereas Group A conceals this

Table 3. Mean, Range, and 95 percent Confidence Intervals for sediment production potentials (Kg/ha) within vegetation types of Groups A-C.

Group A

Veg. Type	n	Mean 1/	Min	Max	95% CI
Forest	114	104 a	0	1,488	64 - 146
Meadow-Grass	90	267 a	0	3,170	162 - 374
Shrub	36	903 b	0	3,874	537 - 1,268
Juniper	24	1,572 c	44	6,743	912 - 2,232

Group B

Veg. Type	n	Mean 1/	Min	Max	95% CI
Meadow	36	22 a	0	104	13 - 31
Forest	114	104 a	0	1,488	64 - 146
Grassland	54	431 b	2	3,170	266 - 596
Shrub	36	903 c	0	3,874	537 - 1,268
Juniper	24	1,572 d	44	6,743	912 - 2,232

Group C

Veg. Type	n	Mean 1/	Min	Max	95% CI
Meadow	36	22 a	0	104	13 - 31
Forest	102	92 a	0	1,460	55 - 128
Sub-alpine	24	178 ab	0	1,488	37 - 320
Grassland	54	431 b	2	3,170	266 - 596
Sagebrush	24	1,284 c	57	3,874	804 - 1,764
Juniper	24	1,572 c	44	6,743	912 - 2,232

1/ Different case letters indicate significant difference p .05.

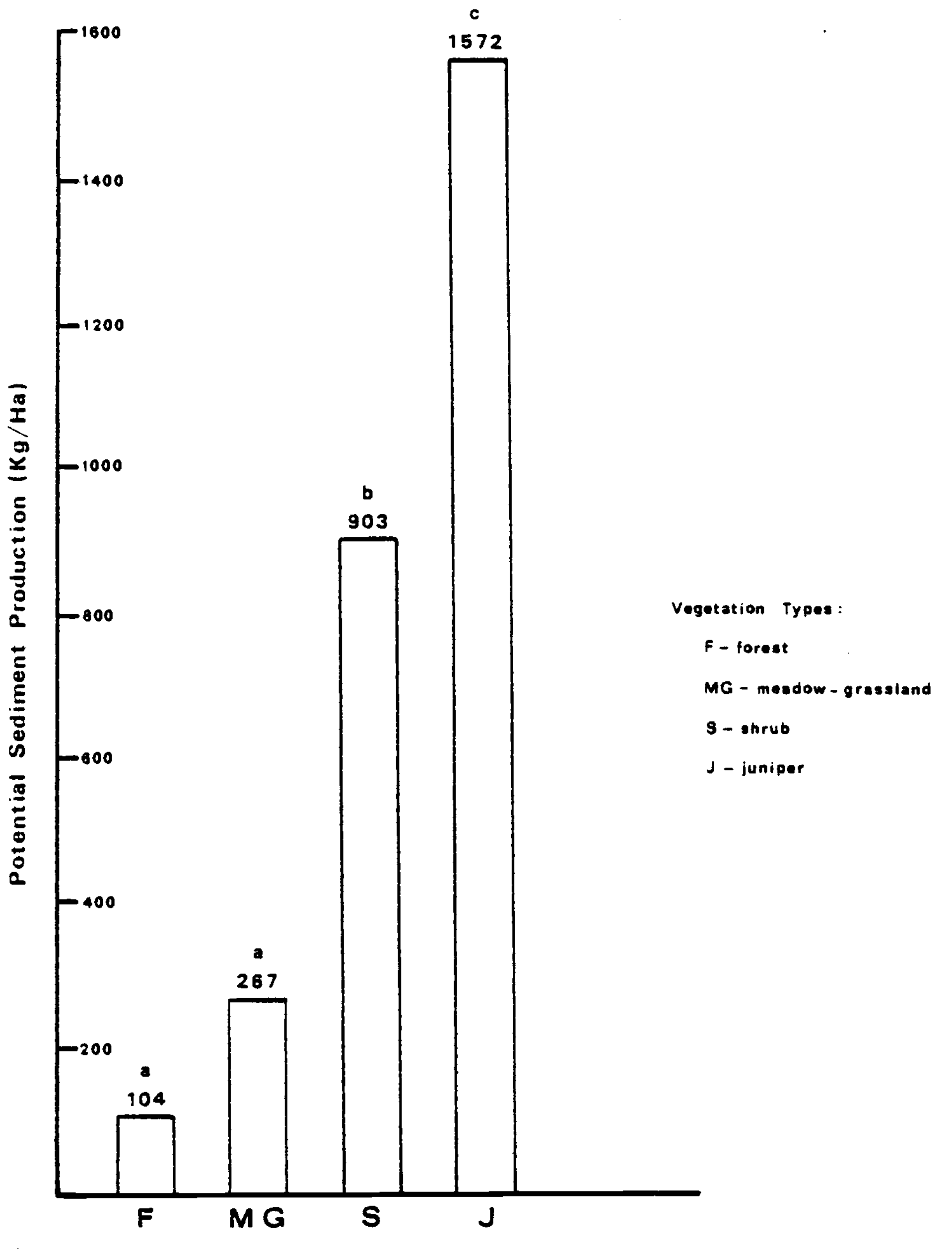

Figure 4. Potential sediment production of Group A vegetation types (different case letters indicate significant differences $p < .05$)

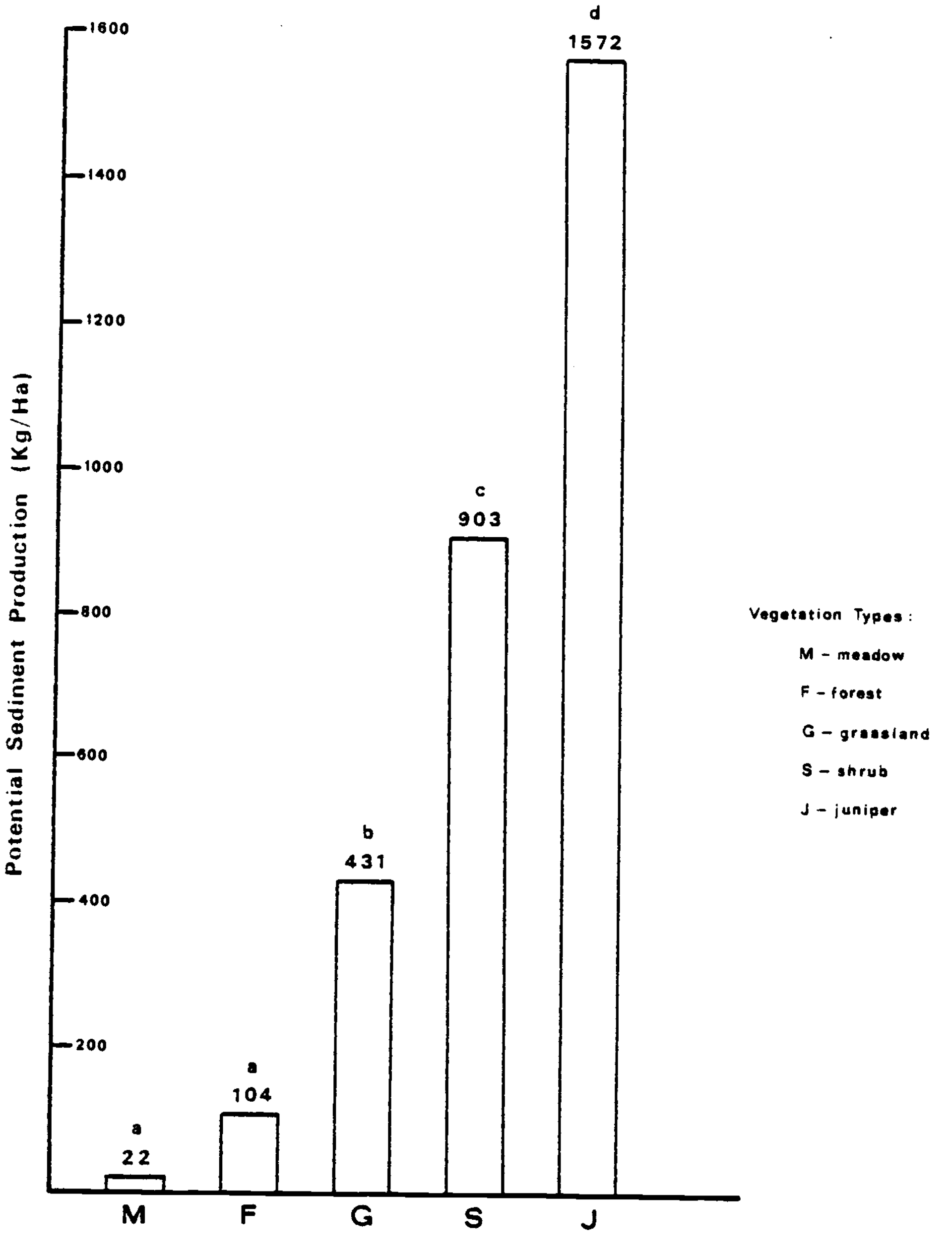

Figure 5. Potential sediment production of Group B vegetation types (different case letters indicate significant differences $p < .05$).

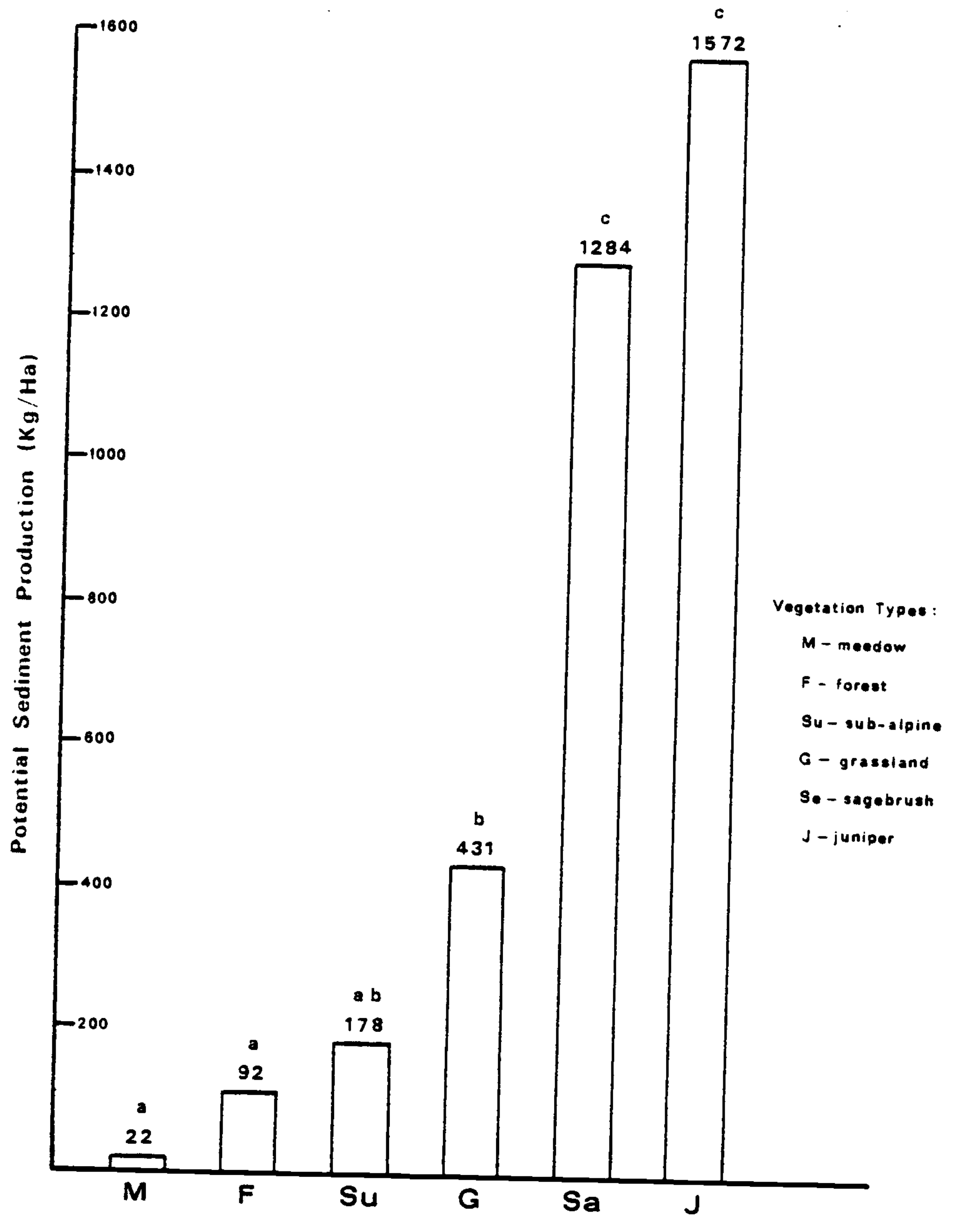

Figure 6. Potential sediment production of Group C vegetation types (different case letters indicate significant differences $p < .05$).

difference since mountain grassland and meadow vegetation types were considered as one type. Classifying sub-alpine big sagebrush (subspecies vaseyana form spiciformis) with the fir-spruce vegetation type for form an alpine vegetation type resulted in a significant difference between sagebrush types in Group C. These differences were even more apparent when a comparison is made among the 10 ecosystem categories (Fig. 7 and Appendix B-2). This further refinement indicates no significant difference ($p < .05$) in potential sediment production between forest ecosystems, with the exception of larch, and the grassland ecosystems. Although the multiple comparison test indicated significant differences ($p < .05$) between many of the ecosystems, there still remains a wide range of sediment values (Table 4).

Although gross ecological classifications may be useful for certain broad resource management plans, it is desirable for data to be pertinent to discrete classifications and therefore applicable to more specific resource planning. Multiple comparison tests were made on resource units within each of the 10 ecosystems in order to determine possible differences in sediment production potentials based on this classification (Table 5).

Resource units within the Douglas-fir ecosystems were generally minimal potential sediment producers. Mean potential sediment values ranged from 4-257 kg/ha (3-229 lb/ac) with an overall mean of 109 kg/ha (97 lb/ac). There

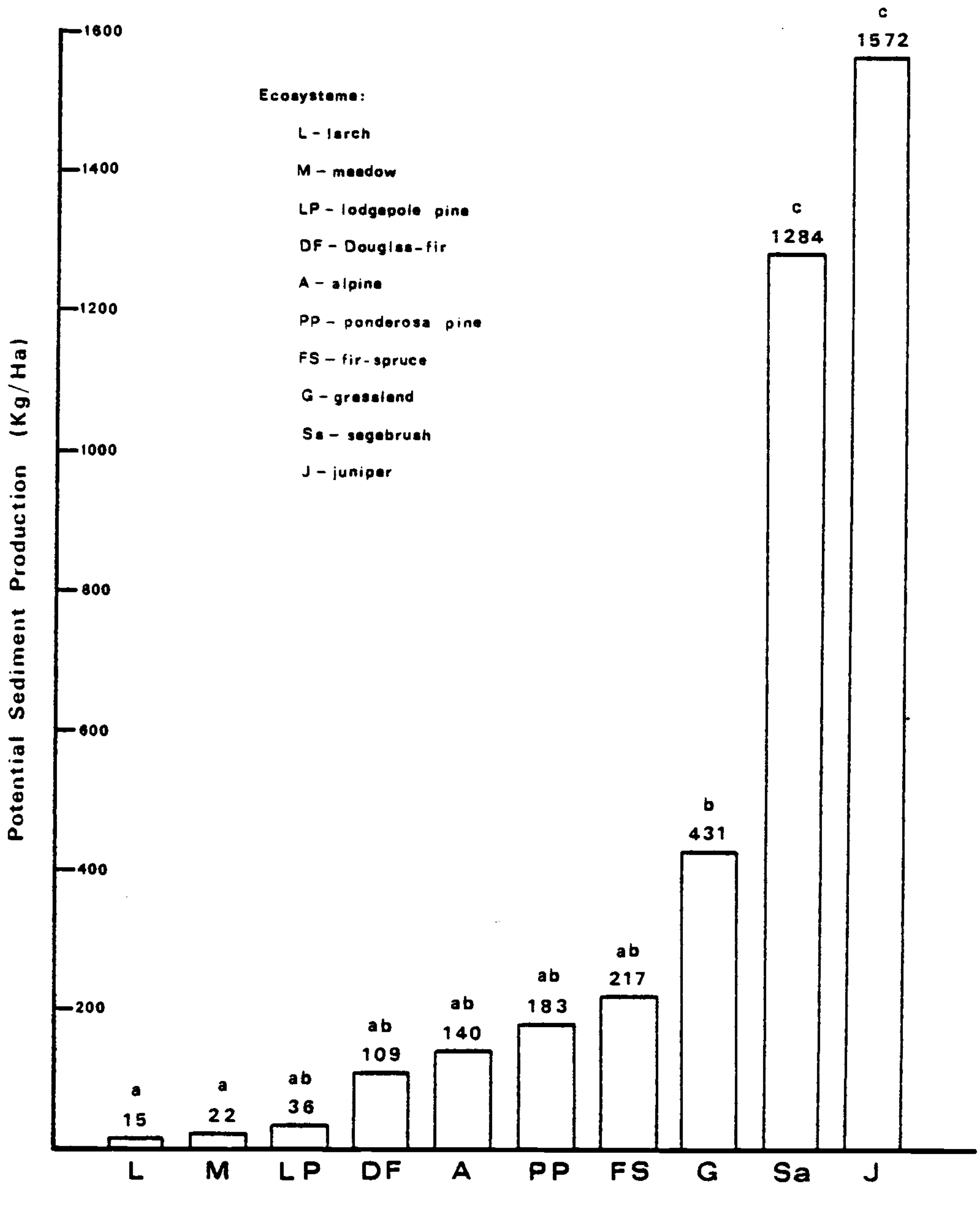

Figure 7. Potential sediment production of the 10 ecosystems studied (different case letters indicate significant differences $p < .05$).

Table 4. Mean, Range, and 95 percent Confidence Intervals for sediment production potentials (kg/ha) for the 10 FRES ecosystems.

Ecosystem	n	Mean[1/]	Min	Max	95% CI
Larch	24	15 a	0	55	8 - 22
Meadow	36	22 a	0	104	13 - 31
Lodgepole pine	12	36 ab	0	178	0 - 72
Douglas-fir	48	109 ab	0	1,460	44 - 175
Alpine	12	140 ab	0	746	0 - 289
Ponderosa pine	18	183 ab	0	856	79 - 289
Fir-Spruce	12	217 ab	2	1,488	0 - 479
Grassland	54	431 b	2	3,170	266 - 597
Sagebrush	24	1,284 c	57	3874	804 - 1,765
Juniper	24	1,572 c	44	6,743	912 - 2,232

1/ Different case letters indicate significant difference $p < .05$.

Table 5. Mean, Range, and 95 percent Confidence Intervals for sediment production potentials (kg/ha) for Resource Units (RU) within the 10 FRES ecosystems.

Douglas-fir

RU	n	Mean 1/	Min	Max	95% CI
20-III-P	6	4 a	0	15	0 - 10
20-III-T	6	20 a	0	40	4 - 36
20-IV-T	18	26 a	0	128	7 - 45
20-IV-P	18	257 b	24	1,460	98 - 417

Ponderosa pine

RU	n	Mean	Min	Max	95% CI
21-IV-P	18	183	0	856	79 - 289

Fir-Spruce

RU	n	Mean 1/	Min	Max	95% CI
23-IV-P	6	54 a	2	115	0 - 108
23-IV-T	6	380 a	25	1,488	0 - 962

Larch

RU	n	Mean 1/	Min	Max	95% CI
25-III-P	6	2 a	0	4	0 - 3
25-III-T	18	19 b	0	55	10 - 28

Lodgepole pine

RU	n	Mean	Min	Max	95% CI
26-IV-P	12	36	0	178	0 - 72

Sagebrush

RU	n	Mean 1/	Min	Max	95% CI
29-III-G	6	252 a	57	434	66 - 437
29-II-F	6	906 ab	521	1,325	612 - 1,198
29-IV-G	6	1,117 b	409	1,803	498 - 1,736
29-II-P	6	2,865 c	1,064	3,874	1,816 - 3,916

Table 5. (Continued)

Juniper

RU	n	Mean 1/	Min	Max	95% CI
35-III-P	12	609 a	44	1,768	285 - 932
35-I-F	6	1,746 a	482	3,103	711 - 2,780
35-IV-P	6	3,330 b	1,624	6,743	1,297 - 5,364

Grassland

RU	n	Mean 1/	Min	Max	95% CI
36-III-G	12	46 a	2	164	20 - 73
36-IV-P	6	250 ab	79	464	89 - 412
36-III-F	12	321 ab	29	661	189 - 454
36-III-P	12	718 b	80	3,170	145 - 1,290
36-IV-F	12	729 b	83	1,944	272 - 1,186

Meadow

RU	n	Mean	Min	Max	95% CI
37-III-P	6	4 a	0	15	0 - 11
37-I-P	6	6 a	0	19	0 - 13
37-II-F	12	13 a	0	47	1 - 26
37-III-F	12	49 b	24	104	34 - 66

Alpine

RU	n	Mean 1/*	Min	Max	95% CI
44-III-F	6	7 a	0	20	0 - 15
44-III-P	6	273 a	51	746	0 - 593

1/ Different case letters indicate significant difference p .05.

*Statistical difference $p < .06$.

were statistical differences between these resource units. With one exception these differences were manifested as decreases in potential sediment production as condition class changed from Pole to Timber ($p < .05$) and as productivity improved from class IV to class III ($p < .10$).

Three different location were sampled within the ponderosa pine ecosystem, however, they were all of the same resource unit classification. Although a multiple comparison test could not be made, this ecosystem also appears to be a relatively low potential sediment producer. The mean value for the resource unit sampled was 183 kg/ha (163 lb/ac). If the same trend was to follow, as with the Douglas-fir resource units, this value would be expected to decrease as condition class moved from Pole to Timber.

The fir-spruce resource units also produced relatively low amounts of potential sediment. Mean values ranged from 54-380 kg/ha (48-338 lb/ac) with an overall mean of 217 kg/ha (193 lb/ac). No differences were reflected between these resource units ($p < .05$), although the "F probability" value suggests that a difference would exist at the .20 level of testing. The insignificant difference may be due to the combined effect of a small sample size and a relatively high degree of variation among plots.

From a management perspective, potential sediment production from the larch resource units is negligible. Mean values ranged from 2-19 kg/ha (2-17 lb/ac) with an overall mean of 15 kg/ha (13 lb/ac). Although one could question the importance, there did exist a difference between the two resource units sampled. Unlike the trend associated with the Douglas-fir resource units, the larch resource units reflected an increase in potential sediment production as condition class changed from Pole to Timber. It is difficult to speculate on the reason for this. A difference in habitat type, soils, needle fall, or the uneven sample size could account for the discrepancy in trend.

Two locations were sampled within the lodgepole pine ecosystem, and these were of the same resource unit classification. As with the other forest-type ecosystems, the lodgepole pine resource unit also represents a minimal potential sediment production producer with a mean value of 36 kg/ha (32 lb/ac).

Potential sediment production was significantly greater in the sagebrush resource units as compared to the forest-type resource units. Mean values ranged from 252-2,865 kg/ha (224-2,550 lb/ac) with an overall mean of 1,284 kg/ha (1,143 lb/ac). There were differences (p .05) between sagebrush resource units. Changes in condition class are apparently more significant than changes in productivity class. Data indicated that potential sediment production decreased as condition class moved from Poor toward Fair and Good. Differences did exist between Poor and Fair and Poor and Good condition, but not between Fair and Good ($p < .05$).

On the average, juniper resource units were greater producers of potential sediment than resource units from any other ecosystem. A statistical difference did not exist between 35-III-P and 35-I-F, but did exist between these resource units and 35-IV-P ($p < .05$). A statistical difference existed between all these resource units at p .10. Mean potential sediment values ranged from 609-3,330 kg/ha (542-2,964 lb/ac) with an overall mean of 1,572 kg/ha (1,399 lb/ac). No statistical difference could be shown between Poor and Fair condition class ($p < .05$) and no apparent pattern existed among productivity levels. This could possibly be reflective of the classification scheme. Resource unit 35-I-F was actually a juniper-sagebrush community whereas the other resource units were juniper-bunchgrass communities. It is difficult to establish a potential trend when such communities are evaluated collectively under a common classification heading.

On a relative scale, resource units within the grassland ecosystem were moderate producers of potential sediment. Mean values ranged from 46-729 kg/ha (41-649 lb/ac) with an overall mean of 431 kg/ha (384 lb/ac). There was a significant difference between condition classes Good and Fair, Good and Poor, but not between Fair and Poor ($p < .05$). No significant differences were found between productivity classes III and IV ($p < .05$). Data would indicate that potential sediment production in these resource units is dependent on condition class when considering just these two variables and that a grassland in good condition is a minimal potential sediment producer.

Resource units within the meadow ecosystem were some of the least significant producers of potential sediment. Mean values ranged from 4-39 kg/ha (3-35 lb/ac) with an overall mean of 22 kg/ha (20 lb/ac). Data indicated that productivity class was more important in quantifying the erosional loss than was condition class. As condition class improved from class III toward classes II and I, potential sediment production decreased. These differences were significant between class III and the other two classes, but there were no apparent differences ($p < .05$) between classes II and I. It is speculated that with improved ecological condition, a greater biomass is present and therefore the soil surface is better protected.

Alpine resource units reflected a moderately low erosion potential. Mean sediment values ranged from 7-273 kg/ha (6-243 lb/ac) with an overall mean of 140 kg/ha (125 lb/ac). When comparing these resource units within the same productivity class it was noted that a difference existed between Fair and Poor condition class ($p < .10$). Data indicated that as the alpine resource units change from Poor to Fair, range condition potential sediment production decreases.

Stepwise regression was used to evaluate the relationships between vegetative cover, litter, and pavement on potential sediment production within each of the 10 ecosystems (Table 6). The three variables were most correlated in the alpine, lodgepole pine, ponderosa pine, and fir-spruce ecosystems. They were moderately correlated in the sagebrush, juniper, grassland, and larch ecosystem with the least correlation being reflected in the Douglas-fir and meadow ecosystems. Data did not indicate a precise trend for the effects of these variables on potential sediment production. There was variation as to which variable was first entered and which variables were significant. This would suggest that the significance of vegetative cover, litter, and pavement should be considered for a given plant community and cannot be used to expound potential sediment production for plant communities considered on a collective basis. This would also emphasize the key role that soil factors would have in determining potential erosion.

MANAGEMENT IMPLICATIONS

Data indicate that potential erosion problems are minimal for resource units within the larch, meadow, lodgepole pine, Douglas-fir, alpine, ponderosa pine, and fir-spruce ecosystems. This is, of course, considering the

Table 6. Coefficients of determination (r^2) for the effects of vegetative cover (V), litter (L), and pavement (P) on potential sediment production within each of the 10 FRES ecosystems (Stepwise Regression).

Douglas-fir		**Sagebrush**	
V	.08	V	.46
L	.23	P	.55
P	.25	L	.59
Ponderosa pine		**Juniper**	
V	.68	V	.32
L	.70	P	.52
P	.80	L	.53
Fir-Spruce		**Grassland**	
V	.13	V	.17
L	.29	L	.36
P	.73		
Larch		**Meadow**	
L	.06	L	.12
V	.43	P	.12
		V	.12
Lodgepole pine		**Alpine**	
V	.08	V	.23
L	.80	L	.51
		P	.90

absence of a severe or unusual disturbance to the vegetative composition and/or soil surface. Although of limited acreage, the Alpine areas are important sources of water to the John Day River system. A significant difference existed between Fair and Poor condition classes for the resource units within this ecosystem and would suggest that a severe disturbance in these areas could potentially have far-reaching impacts on the water resource. Resource units within the Grassland ecosystem would appear to be only moderate producers of potential sediment. However, a noticeable difference exists between grasslands in Good condition and grasslands in Fair and Poor condition with respect to erosion potential. A good condition grassland is a minimal producer of potential sediment. Resource units within the Sagebrush and Juniper ecosystems reflected the greatest potential problem. The majority of total precipitation in the study area occurs during the winter months in the form of snow. Precipitation in the form of rainfall occurs primarily during the summer months and is a result of convective storms of short duration and relatively high intensity. Periodically, storms occur during this time that may reach intensities of 10 cm/hr (4 in/hr) (Buckhouse, pers. com. 1980). It is during these times that the threat of potential erosion problems is the most prevalent. Most susceptible to this threat, would be resource units within the grassland, sagebrush, and juniper ecosystems. Greater attention should be given to these areas, particularly when considered for livestock use, when formulating and implementing various natural resource management strategies.

Mean Infiltration Rates Within

Various Vegetative Communities

INTRODUCTION

Water is a primary limiting factor as regards production on many of our western rangelands. Many of these areas are subject to low annual precipitation and high evaporational losses. Activities which disturb the soil surface or vegetative composition and cover, have the potential for reducing soil water intake, thereby reducing productivity which in some instances, may be minimal at best. A prime concern of land managers is to maintain or enhance those factors within managerial capabilities, which effect soil water intake and to identify those areas most susceptible to disturbance.

Blackburn and Skau (1974) studied infiltration rates and sediment production of 29 plant communities and soils in central and eastern Nevada. The highest infiltration rates occurred on sites with well-aggregated surface soils free of vesicular porosity. Williams et al. (1972) used multiple regression analysis to determine relationships between vegetative and soil factors and infiltration rates and erosion from 550 infiltrometer plots at chained pinyon-juniper sites in Utah. Factors found to be most important in predicting infiltration rates were: 1) total porosity in the 0-3 inch layer of soil, 2) percent bare soil surface, 3) soil texture in the 0-3 inch layer of soil, and 4) crown cover.

Water falling on bare soil tends to rapidly close the natural channels of percolation through the degradation of soil structure by raindrop impact. Studies at the Manti County watershed in central Utah showed that runoff varied inversely with the total amount of ground cover (Orr 1957). Vegetative cover tends to reduce the energy of rainfall by reducing rainfall velocity and by breaking the large drops into a fine spray which can then enter the soil without damage to the soil surface. Gifford (1972) reports the ability to predict infiltration rates using cover characteristics alone varies with time, both within a given storm event and on a seasonal basis. He further states that the relation of measured cover characteristics may help explain hydrologic behavior of a site at one time, yet be of little value at another time.

The objective of this study was to determine and compare infiltration rates within and among 10 different ecosystems found within the Oregon Range Validation Project Work Area. The Validation Work Area is located in east-central Oregon. The basic ecological land unit for research purposes within the Validation Area, is defined as the "Resource Unit". Resource units were derived in the Forest-Range Environmental Study (FRES) by categorizing the forest and range land into ecosystems, each ecosystem in turn was further refined into one of four productivity levels, and one of three condition classes (USDA 1972). The ten ecosystems found within the Validation Area are:

1) Douglas-fir (*Pseudotsuga menziesii*), 2) Ponderosa pine (*Pinus ponderosa*), 3) Fir-Spruce (*Abies concolor-Picea englemannii*), 4) Larch (*Larix occidentalis*), 5) Lodgepole pine (*Pinus contorta*), 6) Sagebrush (*Artemisia* spp.), 7) Juniper (*Juniperus occidentalis*), 8) Mountain Grassland, 9) Meadow, and 10) Alpine. These ecosystems were refined into resource units by determining wood or forage volume as a measure of productivity and species composition relative to climax as a measure of condition.

A Rocky Mountain Infiltrometer was used to determine infiltration rates of resource units found within the Validation Work Area. This sprinkler type infiltrometer is particularly adapted to testing comparative infiltration-erosion rates and closely approximates conditions associated with natural rainfall (Dortignac 1951). The infiltrometer was calibrated to produce a rainfall of approximately 13 cm/hr (5 in/hr).

Eighteen observations were made within each resource unit. Plots consisted of six randomly selected clusters comprised of three subplots per cluster. Cluster sampling provided practical and economical advantages (Steel and Torrie 1960). Multiple comparison tests were made in order to determine differences in infiltration rates among the different resource units. Stepwise regression (Neter and Wasserman 1974) was used to determine the significance of vegetative cover, litter, and pavement as regards infiltration.

RESULTS and DISCUSSION

Mean infiltration values were established for 40 resource units representing each of the 10 ecosystems found within the Validation Work Area. Twenty-eight of the 40 were distinct resource units. In some instances equivalent resource units were sampled in order to establish a data base for allotments or units subject to differing management strategies. Sample distribution among ecosystems was variable due to physical limitations of the Rocky Mountain Infiltrometer and location of resource units. In addition, all possible resource units did not exist within the Validation Work Area. During the second summer of field work, opportunity existed for additional samples to be obtained for three previously sampled grassland resource units and one previously sampled ponderosa pine resource unit. In order to expand on that data base, samples were pooled with previous data.

Variation in simulated rainfall was assumed to have no significant effect on infiltration values. Mean rainfall for all samples ($n=44$) was 12.80 cm/hr (5.04 in/hr) with a standard deviation of 1.24 cm/hr (0.49 in/hr).

Large-scale resource management plans often consider a wide range of ecological features. Therefore, it was of interest to compare mean infiltration values for broad ecological classifications as well as the more ecologically refined resource units. Data from individual resource units were incorporated to form four groups of vegetation types. Group A represents the broadest ecological classification, and was represented by the following vegetative types:

1. Forest...resource units from the Douglas-fir, ponderosa pine, fir-spruce, larch, and lodgepole pine ecosystems.
2. Meadow-Grassland...resource units from the meadow and grassland ecosystems.
3. Shrub...resource units from the sagebrush (big sagebrush...*Artemisia tridentata* and low sagebrush...*Artemisia arbuscula*) and alpine (mountain big sagebrush...*Artemisia tridentata* subspecies *vaseyana* form *spiciformis*) ecosystems.
4. Juniper...resource units from all climax and/or invaded ecosystems.

Group B represented an ecological refinement over Group A to the extent that the meadow and mountain grassland resource units were separated. The vegetation types were:

1. Meadow...resource units from the meadow ecosystem.
2. Forest...resource units from the Douglas-fir, ponderosa pine, fir-spruce, larch, and lodgepole pine ecosystems.
3. Grassland...resource units from the grassland ecosystem.
4. Shrub...resource units from the sagebrush and

alpine ecosystems (same associated species as in Group A.

5. Juniper...resource units from all climax and/or invaded ecosystems.

Group C vegetation types are further refined in that the shrub component was separated into the alpine and lower elevation brush types. The classification for Group C was as follows:

1. Meadow...resource units from the meadow ecosystem.
2. Forest...resource units from the Douglas-fir, ponderosa pine, larch, and lodgepole pine ecosystems.
3. Sub-alpine...resource units from the fir-spruce and alpine ecosystems.
4. Grassland...resource units from the grassland ecosystem.
5. Shrub...resource units from the sagebrush ecosystem.
6. Juniper...resource units from the juniper ecosystem.

Group D was the most refined classification used in this study. In this instance, resource units from each of the 10 ecosystems sampled were separated and compared. The vegetation types were composed of resource units from each of the following ecosystems:

1. Larch
2. Meadow
3. Lodgepole pine
4. Douglas-fir
5. Alpine
6. Ponderosa pine
7. Fir-spruce
8. Mountain grassland
9. Sagebrush
10. Juniper

Vegetation types of Groups A-C represent the broadest ecological classification in which mean infiltration rates were compared. Mead infiltration rates did not differ a great deal even though comparisons were made over a wide range of vegetation types (Table 7). Results of the multiple comparison tests did not indicate a significant difference ($p < .05$) between the majority of vegetation types (Figs. 8-10 and Appendix B-3).

A comparison of Group A vegetation types indicated no significant differences in mean infiltration rates between vegetation types. The implications of considering a broad range of ecological features for a given management plan are therefore apparent. Group B reveals a significant difference in mean infiltration rates between the juniper and meadow vegetation types, whereas in Group A this difference was concealed when grassland and meadow vegetation types

Table 7. Mean, Range, and 95 percent Confidence Intervals for infiltration rates (cm/hr) within vegetation types of Groups A-C.

Group I

Veg. Type	n	Mean[1/]	Min	Max	95% CI
Juniper	24	6.6 a	2.9	13.9	5.5 - 7.7
Shrub	36	7.3 a	4.0	11.5	6.7 - 8.0
Forest	114	7.6 a	2.3	14.2	7.1 - 8.2
Meadow-Grass	90	7.7 a	1.5	16.0	7.0 - 8.4

Group II

Veg. Type	n	Mean[1/]	Min	Max	95% CI
Juniper	24	6.6 a	2.9	13.9	5.5 - 7.7
Grassland	54	7.2 ab	2.7	12.0	6.5 - 7.9
Shrub	36	7.3 ab	4.0	11.5	6.6 - 8.0
Forest	114	7.6 ab	2.3	14.2	7.1 - 8.2
Meadow	36	8.2 b	1.5	8.4	6.9 - 9.8

Group C

Veg. Type	n	Mean	Min	Max	95% CI
Juniper	24	6.6 a	2.9	13.9	5.5 - 7.7
Sagebrush	24	7.0 ab	4.7	9.6	6.4 - 7.6
Grassland	54	7.2 ab	2.7	12.0	6.5 - 7.9
Sub-alpine	24	7.2 ab	2.5	13.8	5.8 - 8.5
Forest	102	7.8 ab	2.3	14.2	7.3 - 8.3
Meadow	36	8.4 b	1.5	16.0	6.9 - 9.8

[1/] Different case letters indicate significant difference $p < .05$.

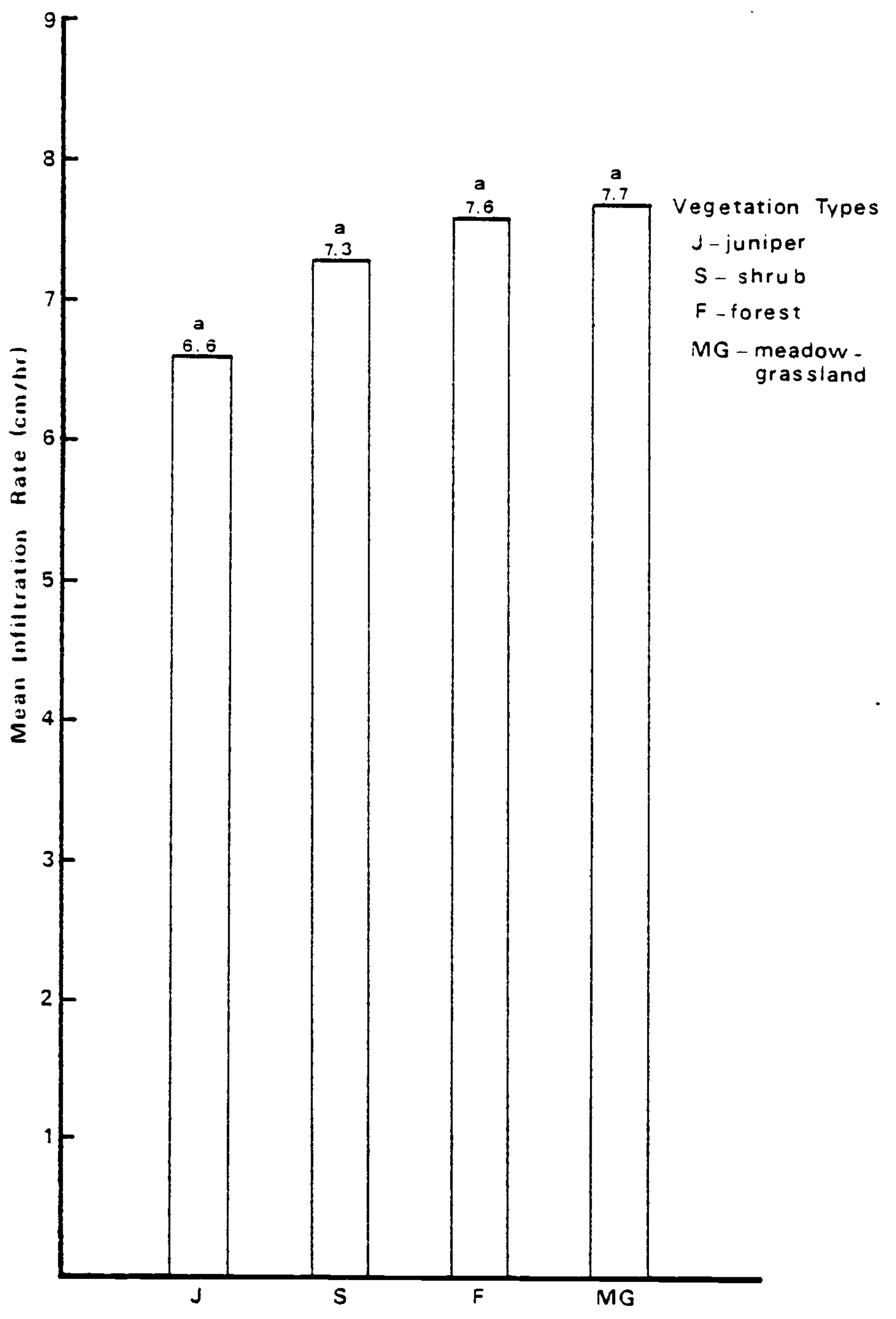

Figure 8. Mean infiltration rates of Group A vegetation types (different case letters indicate significant difference $p < .05$).

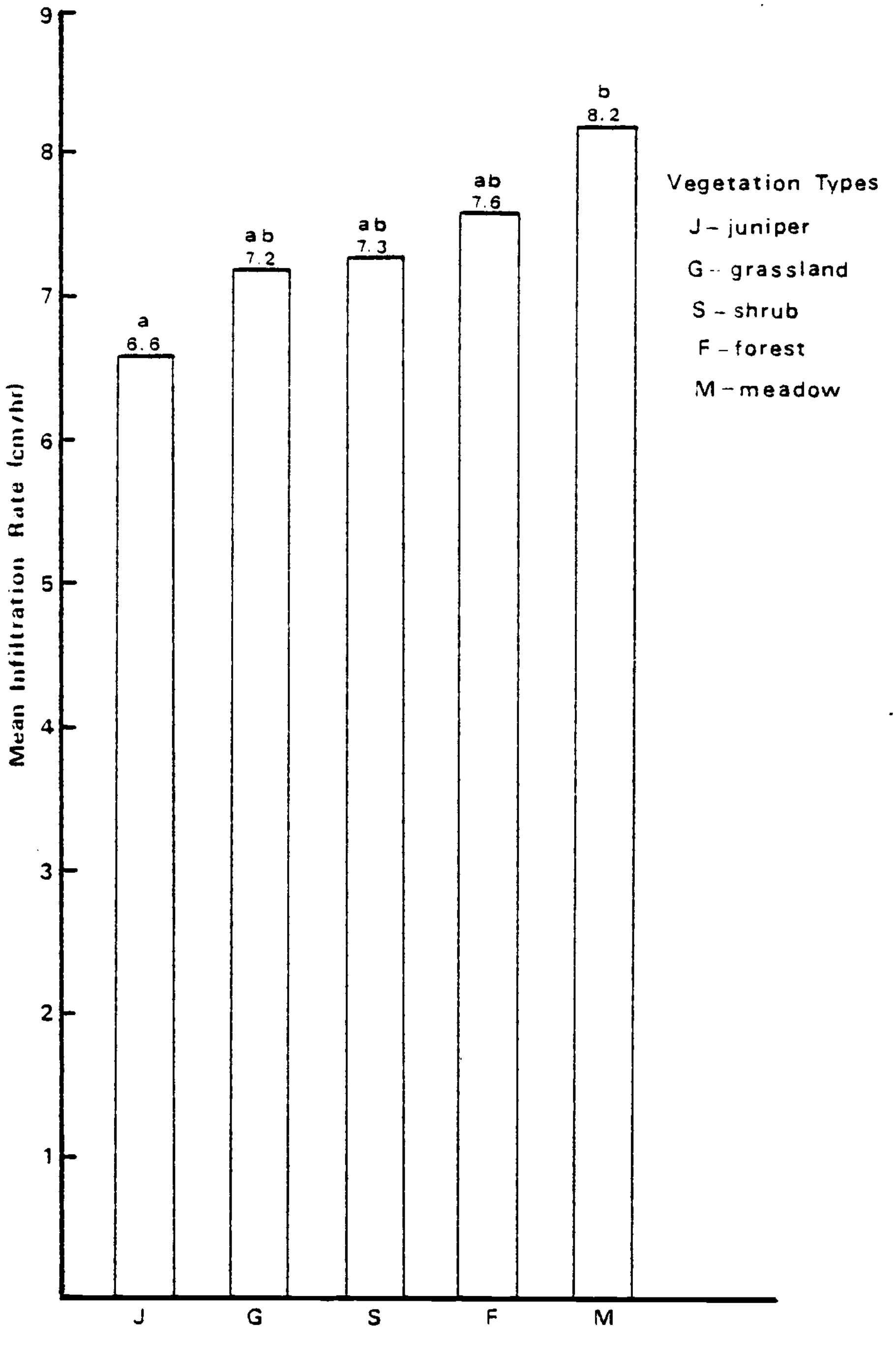

Figure 9. Mean infiltration rates of Group B vegetation types (different case letters indicate significant difference $p < .05$).

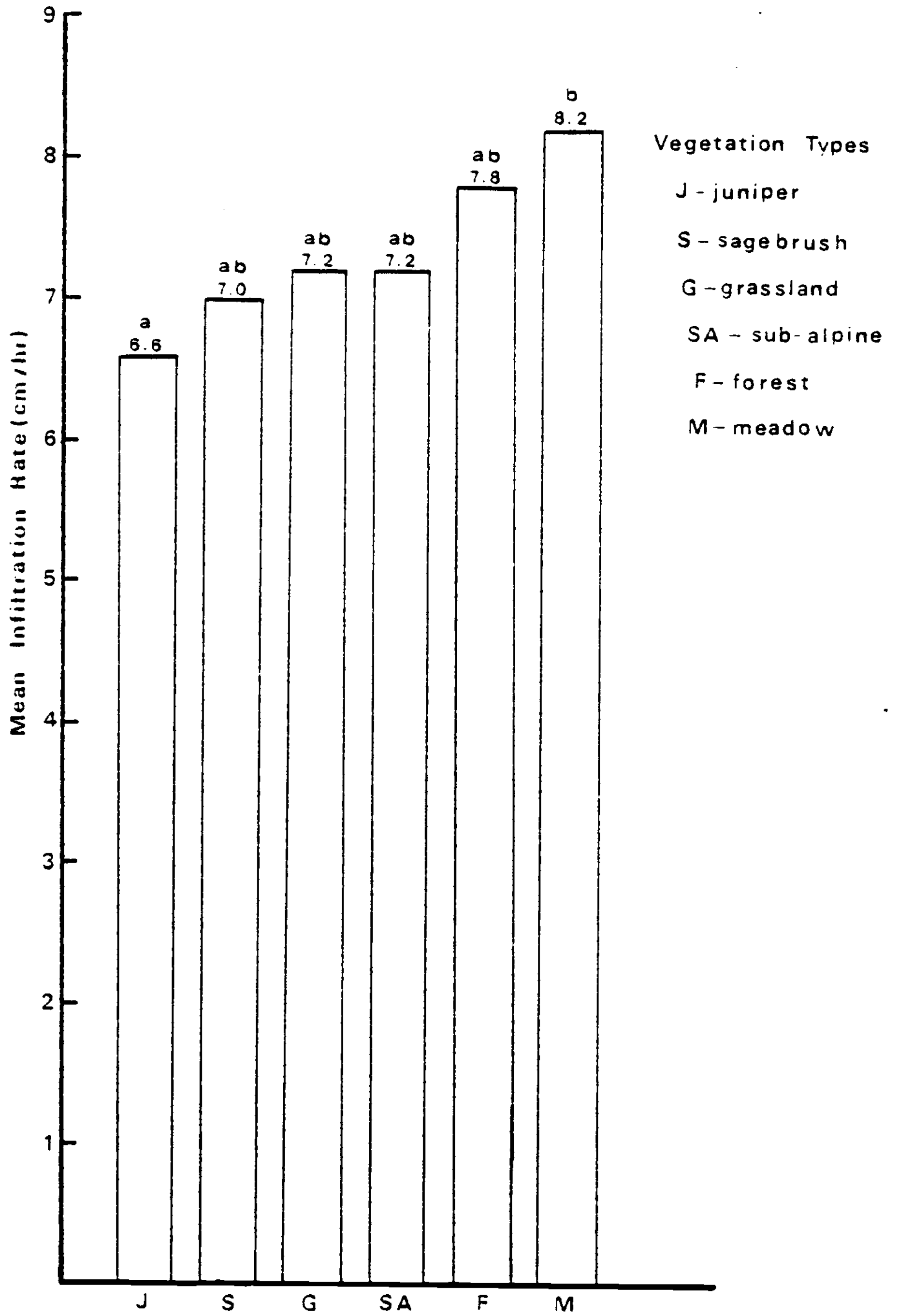

Figure 10. Mean infiltration rates of Group C vegetation types (different case letters indicate significant difference $p < .05$).

were considered as one type. Classifying sub-alpine big sagebrush (subspecies vaseyana form spiciformis) with the fir-spruce vegetation type to form a sub-alpine vegetation type did not result in additional significant differences between vegetation types in Group C. As the classification scheme becomes more discrete, as when a comparison was made among the 10 ecosystem categories, statistical differences became more apparent between vegetation types (Fig. 11 and Appendix B-4). Although the multiple comparison test indicated statistical differences ($p < .10$) between some of the ecosystems, there still remains a relatively narrow range in mean infiltration rates (Table 8).

Gross ecological classifications may be useful for certain broad resource management plans. However, it is desirable for data to be pertinent to discrete classifications and therefore applicable to more specific resource units within each of the 10 ecosystems in order to determine possible differences in mean infiltration rates based on this classification (Table 9).

Resource units within the Douglas-fir ecosystem had relatively high mean infiltration rates. Mean infiltration rates ranged from 6.6-9.7 cm/hr (2.6-3.8 in/hr) with an overall mean of 8.2 cm/hr (3.2 in/hr). There were statistical differences among these resource units although a trend based on productivity and condition class relative to infiltration rate could not be established. Multiple com-

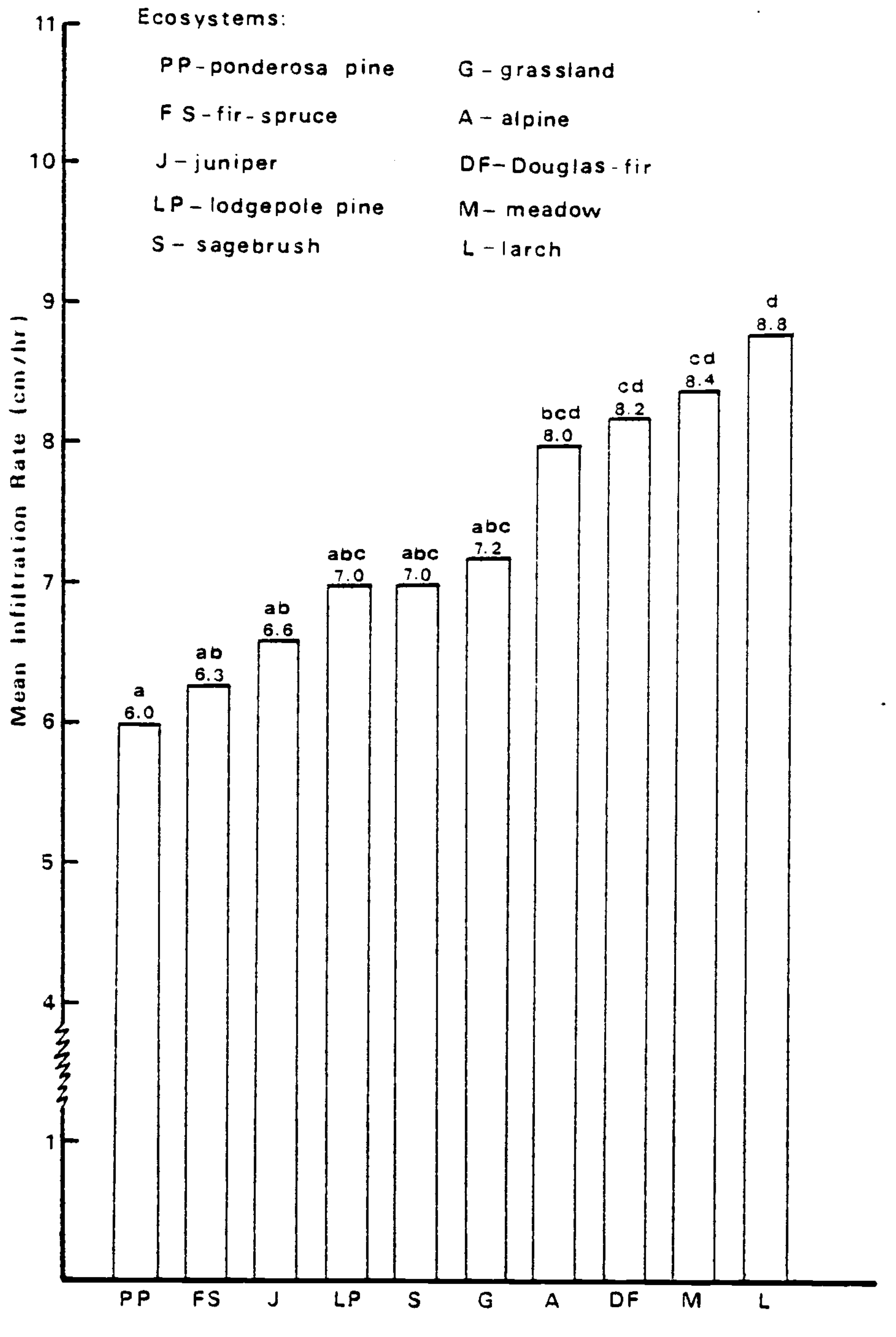

Figure 11. Mean infiltration rates of the 10 FRES ecosystems (different case letters indicate statistical difference $p < .10$).

Table 8. Mean, Range, and 95 percent Confidence Intervals for infiltration rates (cm/hr) for the 10 FRES ecosystems.

Ecosystem	n	Mean[1/]	Min	Max	95% CI
Ponderosa pine	18	6.0 a	3.6	10.6	5.1 - 7.0
Fir-Spruce	12	6.3 ab	2.5	13.8	4.0 - 8.6
Juniper	24	6.6 ab	2.9	13.9	5.5 - 7.7
Lodgepole pine	12	7.0 abc	5.0	10.0	5.9 - 8.1
Sagebrush	24	7.0 abc	4.7	9.6	6.4 - 7.6
Grassland	54	7.2 abc	2.7	12.0	6.5 - 7.9
Alpine	12	8.0 bcd	4.0	11.5	6.4 - 7.6
Douglas-fir	48	8.2 cd	2.3	14.1	7.5 - 8.9
Meadow	36	8.4 cd	1.5	16.0	6.9 - 9.8
Larch	24	8.8 d	3.4	14.2	7.4 - 10.2

[1/] Different case letters indicate statistical difference $p < .10$.

Table 9. Mean, Range, and 95 percent Confidence Intervals for infiltration rates (cm/hr) for resource units (RU) within the 10 FRES ecosystems.

Douglas-fir

RU	n	Mean 1/	Min	Max	95% CI
20-IV-P	18	6.6 a	2.3	9.0	5.8 - 7.5
20-III-T	6	7.8 ab	3.8	11.2	5.0 - 10.5
20-IV-T	18	9.3 b	4.6	14.1	8.1 - 10.5
20-III-P	6	9.7 b	7.7	11.0	8.4 - 11.0

Ponderosa pine

RU	n	Mean	Min	Max	95% CI
21-IV-P	18	6.0	3.6	10.6	5.1 - 7.0

Fir-Spruce

RU	n	Mean 1/	Min	Max	95% CI
23-IV-T	6	3.6 a	2.5	4.7	2.8 - 4.5
23-IV-P	6	9.0 b	4.8	13.8	5.6 - 12.4

Larch

RU	n	Mean 1/	Min	Max	95% CI
25-III-T	18	7.7 a	3.4	14.2	6.1 - 9.1
25-III-P	6	12.1 b	9.7	13.9	10.3 - 13.9

Lodgepole pine

RU	n	Mean	Min	Max	95% CI
26-IV-P	12	7.0	5.0	10.0	5.9 - 8.1

Sagebrush

RU	n	Mean 1/	Min	Max	95% CI
29-IV-G	6	6.1 a	5.4	7.3	5.3 - 6.8
29-II-P	6	6.6 ab	5.7	7.5	6.0 - 7.3
29-III-G	6	7.3 ab	4.7	9.1	5.4 - 9.2
29-II-F	6	8.0 b	5.8	9.6	6.6 - 9.3

Table 9. (Continued)

Juniper

RU	n	Mean 1/	Min	Max	95% CI
35-IV-P	6	4.2 a	2.9	7.0	2.6 - 5.8
35-III-P	12	7.3 a	5.0	13.9	5.7 - 9.0
35-I-F	6	7.5 b	5.9	11.2	5.5 - 9.6

Grassland

RU	n	Mean 1/	Min	Max	95% CI
36-IV-F	12	4.9 a	2.7	7.6	3.9 - 6.0
36-IV-P	6	6.2 ab	4.7	7.6	4.9 - 7.4
36-III-P	12	7.2 b	4.6	9.8	6.1 - 8.4
36-III-F	12	7.6 b	3.2	12.0	5.3 - 10.0
36-III-G	12	9.5 c	8.0	11.4	8.7 - 10.2

Meadow

RU	n	Mean 1/	Min	Max	95% CI
37-III-P	6	2.6 a	1.5	6.5	.6 - 4.6
37-I-P	6	8.0 b	5.0	11.1	5.9 - 10.2
37-III-F	12	8.1 b	4.7	11.2	6.4 - 9.8
37-II-F	12	11.6 c	4.9	16.0	8.9 - 14.4

Alpine

RU	n	Mean	Min	Max	95% CI
44-III-P	6	6.1 a	4.0	8.1	4.2 - 8.0
44-III-F	6	10.0 b	6.4	11.5	8.0 - 11.9

1/ Different case letters indicate significant difference $p < .05$.

parison tests did indicate a significant difference ($p < .05$) in mean infiltration rates based on condition class but not productivity class. This difference was manifested as a decrease in mean infiltration rate as condition class changed from Pole to Timber. This appears to be a function of the more open conditions associated with a mature forest.

Three different locations were sampled within the ponderosa pine ecosystem, however, they were all of the same resource unit classification. Although a multiple comparison test could not be made, this ecosystem reflected the lowest mean infiltration rate of any ecosystem sampled. The mean value for this resource unit was 6.0 cm/hr (2.4 in/hr). If the same trend were to follow as with the Douglas-fir resource units, the mean infiltration rate would be expected to decrease as condition class moved from Pole to Timber.

The fir-spruce resource units, as a whole, reflected relatively low mean infiltration rates. Values ranged from 3.6-9.0 cm/hr (1.4-3.5 in/hr) with an overall mean of 6.3 cm/hr (2.5 in/hr). A significant difference was shown between these resource units ($p < .05$). Mean infiltration rates decreased as condition class changed from Pole to Timber. This again may be a result of more open conditions associated with a mature forest.

Resource units within the larch ecosystem, as an average, reflected the highest infiltration rates of all study sites. Mean infiltration rates ranged from 7.7-12.1 cm/hr (3.0-4.8 in/hr) with an overall mean of 8.8 cm/hr (3.5 in/hr). There was a significant difference (p .05) between these two resource units. As with the Douglas-fir and fir-spruce resource units, mean infiltration rates decreased as condition class changed from Pole to Timber.

Two locations were sampled within the lodgepole pine ecosystem. However, they both were of the same resource unit classification. This resource unit reflected a moderate mean infiltration rate as compared to other resource units. The mean value was 7.0 cm/hr (2.8 in/hr). If the same trend were to follow, as with the other forest-type ecosystems, mean infiltration rate would be expected to decrease as condition class changed from Pole to Timber.

Sagebrush resource units also reflected moderate mean infiltration rates. Values ranged from 6.1-8.0 cm/hr (2.4-3.1 in/hr) with an overall mean of 7.0 cm/hr (2.8 in/hr). Although a significant difference ($p < .05$) existed between resource units, there was not a significant difference in the variables condition class and productivity class as they relate to mean infiltration rate.

Resource units within the juniper ecosystem reflected relatively low mean infiltration rates. Values ranged from 4.2-7.5 cm/hr (1.6-3.0 in/hr) with an overall mean of 6.6 cm/hr (2.6 in/hr). Significant differences ($p < .05$) existed between resource units. Data indicated that mean infiltration rates were better correlated with productivity class than condition class. A significant difference ($p < .05$) was noted between productivity classes I and III and productivity class IV. There was no difference between productivity classes I and III. Mean infiltration rates decreased as productivity decreased from I and III to IV. A significant difference did not exist between condition classes Poor and Fair.

Grassland resource units were found to have moderate mean infiltration rates as compared to resource units of other ecosystems. Mean infiltration rates ranged from 4.9-9.5 cm/hr (1.9-3.7 in/hr) with an overall mean of 7.2 cm/hr (2.8 in/hr). A significant difference ($p < .05$) existed among resource units. Data indicated that mean infiltration rates were influenced by both productivity class and condition class. There was a significant difference ($p < .05$) between productivity classes III and IV and condition classes Poor and Fair and condition class Good. A difference was not shown between condition classes Poor and Fair. Mean infiltration rates increased as productivity increased from IV to III and as condition class changed from Poor and/or Fair to Good, indicating the effect of additional biomass on the soil surface.

Meadow resource units were found to have some of the greatest mean infiltration values of any study area. Mean infiltration rates ranged from 2.6-11.6 cm/hr (1.0-4.6 in/hr) with an overall mean of 8.4 cm/hr (3.3 in/hr). A significant difference ($p < .05$) was found among productivity classes although a sequential trend could not be established. Data indicated that mean infiltration rates were dependent upon both condition class and productivity class. In general, as productivity increased and condition class changed from Poor to Fair, mean infiltration rates increased.

Resource units of the alpine ecosystem reflected moderately high mean infiltration rates. Values ranged from 6.1-10.0 cm/hr (2.4-3.9 in/hr) with an overall mean of 8.0 cm/hr (3.1 in/hr). There was a significant difference ($p < .05$) between these resource units. As in other ecosystems, mean infiltration rates increased as condition class changed from Poor to Fair.

Stepwise regression was used to evaluate the effects of vegetative cover, litter, and pavement on mean infiltration rates within each of the 10 ecosystems (Table 10). These variables were most correlated in the fir-spruce and alpine ecosystems. They were moderately correlated in the juniper, grassland, larch, meadow, sagebrush, and ponderosa pine ecosystems. The least correlation was reflected in the Douglas-fir and lodgepole pine ecosystems. Data did not indicate a trend for the effects of these variables on mean infiltration rates. There was variation as to which variable was entered first and which variables were significant. This would suggest that factors other than vegetative cover,

Table 10. Coefficients of determination (r^2) for the effects of vegetative cover (V), litter (L), and pavement (P) on mean infiltration rates within each of the 10 FRES ecosystems (Stepwise Regression).

Ecosystem	Variable	r^2
Douglas-fir	V	.01
	L	.05
	P	.05
Ponderosa pine	P	.12
	L	.12
	V	.16
Fir-Spruce	L	.42
	V	.50
	P	.62
Larch	V	.01
	L	.22
Lodgepole pine	L	.02
Sagebrush	V	.12
	P	.17
	L	.20
Juniper	V	.34
	L	.34
	P	.35
Grassland	L	.23
	P	.30
	V	.31
Meadow	V	.18
	P	.21
Alpine	V	.47
	P	.55
	L	.60

litter, and pavement have a key role in influencing infiltration rates within the majority of ecosystems studied.

MANAGEMENT IMPLICATIONS

Data indicated that condition class was generally more closely related to infiltration than was productivity class in the forested units. Mean infiltration rates tended to decrease as condition class changed from Pole to Timber. This is a particularly important factor in lieu of logging practices and the introduction of livestock into more open forests. Stepwise regression indicated that the effects of vegetative cover, litter, and rock pavement on mean infiltration rates were minimal within the forested resource units, with the exception of fir-spruce. This would suggest that soil factors may be a more dominant factor as regards infiltration within these areas. Resource units of the ponderosa pine and lodgepole pine ecosystems reflected some of the lowest infiltration rates of the forest-type ecosystems. Soil disturbing activities such as logging or grazing appear to be the most detrimental as regards mean infiltration rates in these areas.

A significant difference in mean infiltration rates of almost 4 cm/hr (1.5 in/hr) was noted between alpine resource units in Fair and Poor condition. The effects of vegetative cover, litter, and pavement were also more important in these resource units as compared to their effects in other areas. Considering the importance of these high elevation areas to the water resource, site disturbance may have a particularly high and long-term impact.

Data indicated that mean infiltration rates were more dependent upon productivity class than condition class within the juniper resource units. Mean infiltration rates decreased as productivity decreased from productivity classes I and III to IV. The effects of vegetative cover, litter, and pavement were also important, on a comparative basis, within these areas. This suggests the need for maintaining or enhancing adequate ground cover within these resource units in order to insure optimal mean infiltration rates.

Mean infiltration rates were shown to be correlated with both productivity class and condition class within the grassland and meadow resource units. This influence was particularly noticeable when comparing grassland ecosystems of low productivity and Poor condition class to areas of higher productivity and Good condition. Site disturbance, such as the effects of overgrazing, therefore, could have particularly adverse effects on soil water intake and retention.

Grant County is an area that receives a relatively low amount of annual precipitation. Optimal soil water intake and retention are necessary to insure a higher vegetative productivity for this natural resource based economy. It is therefore necessary to identify those areas most susceptible to disturbance so that proper management strategies may be implemented to insure their long-term productivity.

Comparing A High Intensity Simulated Rainfall To Storms Common Within The Validation Project Work Area

INTRODUCTION

When experimentally determining sediment production and infiltration potentials, it is necessary to produce simulated rainfall of an intensity that results in surface runoff. Dependent upon the location, the simulated rainfall will often be in excess of "normal" precipitation events. A Rocky Mountain infiltrometer (Dortignac 1951) was used to determine potential sediment production and infiltration rates related to a variety of plant communities found within the Oregon Range and Related Resources Validation Project Work Area. The infiltrometer was calibrated to produce a rainfall of approximately 13 cm/hr (5 in/hr). A precipitation event of this nature, particularly between September and May, is not common to the area. The majority of total precipitation in the Work Area occurs during the winter months in the form of snow (Validation Team and Contributors 1976). Summer months are generally hot and dry. Precipitation, primarily in the form of rainfall, is a result of periodic convective storms of short duration and relatively high intensity. A consideration of the study is to compare storms common to the area with simulated rainfall produced by the Rocky Mountain infiltrometer. It is of interest to determine whether or not "normal" precipitation events would be capable of producing storm runoff characteristics similar to high intensity simulated rainfall.

RESULTS and DISCUSSION

Infiltration curves were established for each of 10 ecosystems found within the Validation Work Area. Data were categorized as either forested or non-forested ecosystems. Forested ecosystems include the larch, Douglas-fir, lodgepole pine, fir-spruce, and ponderosa pine ecosystems (Fig. 12). Constant infiltration rates ranged from approximately 8.5 cm/hr (3.3 in/hr) in the larch ecosystem to approximately 5.5 cm/hr (2.2 in/hr) in the ponderosa pine ecosystem. Infiltration rates were assumed to reach a constant value after approximately 13-15 minutes of sample time. The shape of each infiltration curve and duration of sampling to reach constant value is similar to those of studies described by Branson and others (1972).

Non-forested ecosystems included the meadow, alpine, grassland, sagebrush, and juniper ecosystems (Fig. 13). Constant infiltration values ranged from approximately 7.5 cm/hr (3.0 in/hr) in the meadow ecosystem to approximately 6.0 cm/hr (2.4 in/hr) in the juniper ecosystem. Infiltration values of the non-forested ecosystems appear to be more related to each other than those of the forested ecosystems. A greater range in values was found to occur in association with the forested ecosystems.

Values of various storm intensities common to the study area were obtained from Climatological Handbook: Oregon (NOAA 1969) (Table 11). These values are related

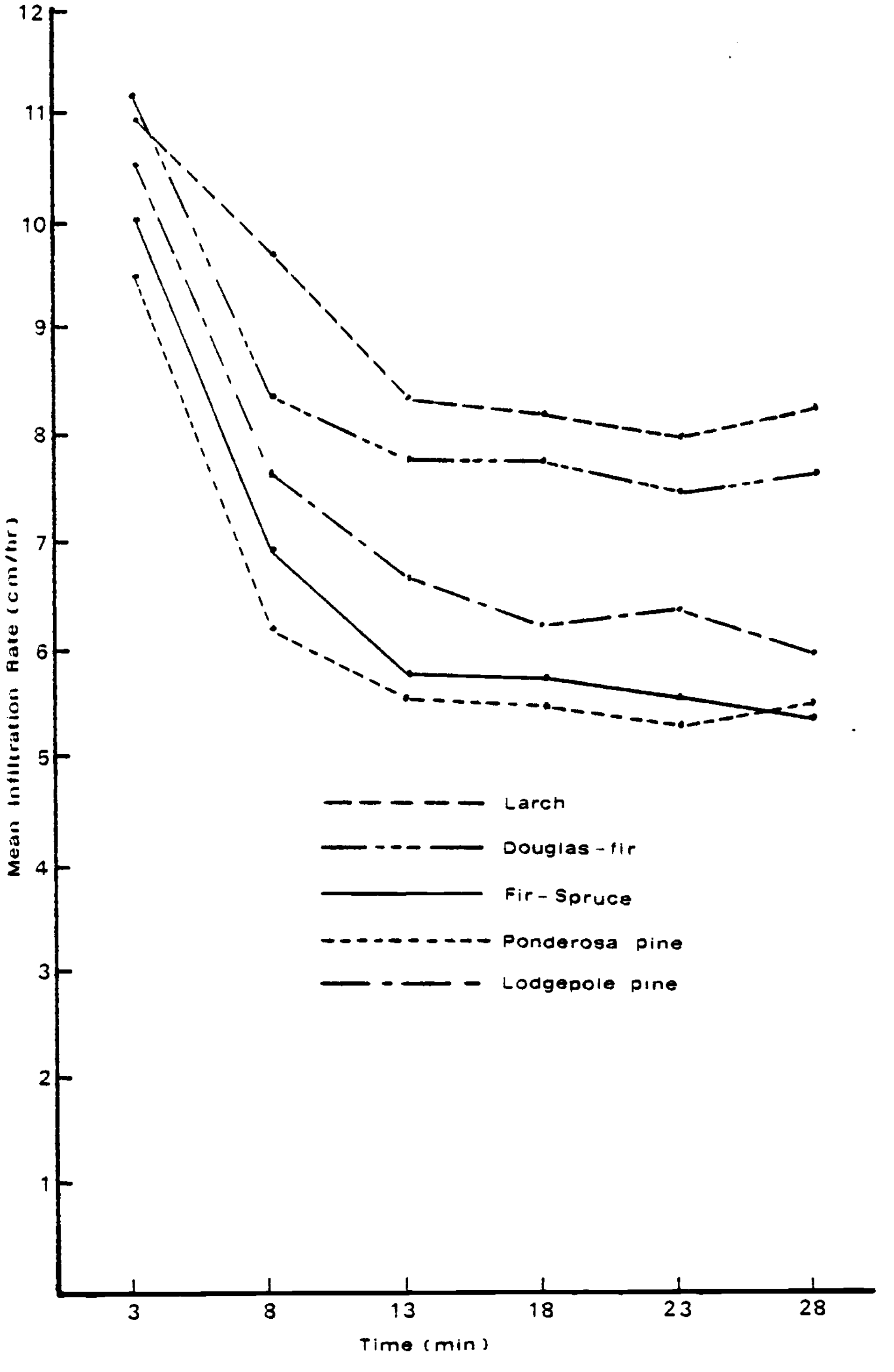

Figure 12. Mean infiltration rates of forested ecosystems.

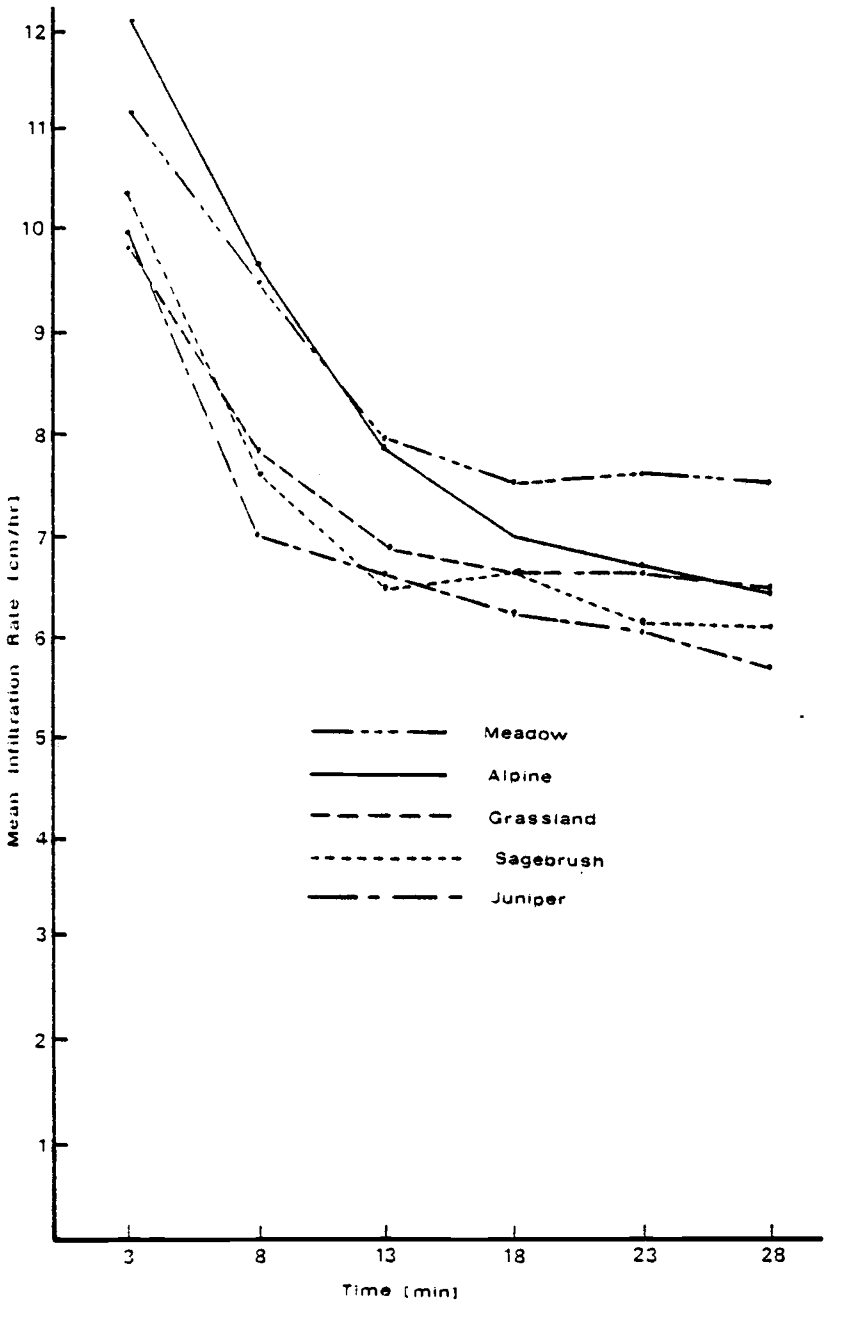

Figure 13. Mean infiltration rates of non-forested ecosystems.

Table 11. Return periods (RP) and durations (D) of various storms common to the Validation Project Work Area (Meteorology Committee 1969).

RP - D	in	cm	RP - D	in	cm
2yr - 30min	.30	.12	2yr - 24hr	1.00	.39
5yr - 30min	.50	.20	5yr - 24hr	1.50	.59
10yr - 30min	.60	.24	10yr - 24hr	1.60	.63
25yr - 30min	.80	.31	25yr - 24hr	2.00	.79
50yr - 30min	.80	.31	50yr - 24hr	2.00	.79
100yr - 30min	1.00	.39	100yr - 24hr	2.50	.98
2yr - 1hr	.40	.16	2yr - 2day	1.25	.49
5yr - 1hr	.60	.24	5yr - 2day	1.50	.59
10yr - 1hr	.80	.31	10yr - 2day	2.00	.79
25yr - 1hr	1.00	.39	25yr - 2day	2.20	.87
50yr - 1hr	1.00	.39	50yr - 2day	2.50	.98
100yr - 1hr	1.00	.39	100yr - 2day	2.75	1.08
2yr - 2hr	.50	.20	2yr - 4day	1.50	.59
5yr - 2hr	.75	.30	5yr - 4day	2.00	.79
10yr - 2hr	1.00	.39	10yr - 4day	2.20	.89
25yr - 2hr	1.00	.39	25yr - 4day	2.50	.98
50yr - 2hr	1.00	.39	50yr - 4day	2.75	1.08
100yr - 2hr	1.25	.49	100yr - 4day	3.00	1.18
2yr - 6hr	.75	.30	2yr - 7day	1.75	.69
5yr - 6hr	1.00	.39	5yr - 7day	2.00	.79
10yr - 6hr	1.25	.49	10yr - 7day	2.50	.98
25yr - 6hr	1.50	.59	25yr - 7day	3.00	1.18
50yr - 6hr	1.50	.59	50yr - 7day	3.00	1.18
100yr - 6hr	-	-	100yr - 7day	3.50	1.18
2yr - 12hr	1.00	.39	2yr - 10day	2.00	.79
5yr - 12hr	1.25	.49	5yr - 10day	2.50	.98
10yr - 12hr	1.50	.59	10yr - 10day	3.00	1.18
25yr - 12hr	1.60	.63	25yr - 10day	3.00	1.18
50yr - 12hr	1.75	.69	50yr- 10day	3.50	1.38
100yr - 12hr	2.00	.79	100yr - 10day	4.00	1.57

to return periods of 2, 5, 10, 25, 50, and 100 years. It should be noted that these data were obtained from a relatively sparse precipitation gage network and applied to a large area. As a result, precipitation values for various storms are general at best. Considering the oftentimes prohibitive costs of establishment and maintenance of a precipitation gage network, it is not uncommon to conduct hydrologic studies with data such as these. Such data are practical when considering large-scale management objectives.

Upon examination of Table 12, it is readily noted that no characteristic storms of this area would approach the constant infiltration rates established within the 10 ecosystems of the study area. For example, a 2yr - 2day storm with a precipitation value of .49 cm (1.25 in) had been considered "typical" of the study area. The average precipitation rate for a storm of this nature is .01 cm/hr (.03 in/hr). This amounts to little more than a 48 hour drizzle and is highly unlikely to occur in this portion of the state. If most of the precipitation of this storm were to occur within the first hour of the 2 day period, infiltration rates within the 10 ecosystems would still not be exceeded. The same conclusion is also reached when considering the effects of a 100yr - 2day storm or any other storm tabulated in Table 12.

MANAGEMENT IMPLICATIONS

From the foregoing discussion, it could be concluded that storms do not occur within the Validation Work Area that would exceed established infiltration rates. Therefore, problems as a result of flooding and sedimentation would not exist. However, in reality we know this not to be the case. High intensity, low frequency storms from relatively small convective cells are not altogether uncommon in this part of the state. Consider the summer of 1978. Several of these storm types occurred within the Hamilton, Monument, and Kimberly area of Grant County. Asphalt roads were washed-out in a number of places and at least one bridge incurred structural damage. Damage to private property included structural damage to homes and farm buildings and damage to field crops either in the form of wash-outs or heavy sedimentation.

It is evident that storms, usually less than an hour in total length, occur within the study area that do exceed infiltration rates of selected plant communities. Also evident is the fact that quantitative data for these storm types have yet to be established. Subjective estimates establish intensities for these convective storms to be of approximately 10 cm/hr (4 in/hr) with an associated return period of 75 years (Buckhouse, pers. com. 1980). Such an event, considered to be a 75yr, 1hr storm, would be potentially very erosive. Due to their timing, storms of this nature have the capacity to exceed established infiltration rates of various ecosystems and often result in flood related damages. Such a consideration underscores the need for forest and range management practices that tend to reduce detrimental effects to soil and vegetation or enhance stabilization and rehabilitation of soil and vegetation. It is doubtful that damages from high intensity convective storms can be altogether eliminated. However, it is possible that through proper timber harvesting and range management practices, potential flood damage may be reduced.

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APPENDICES

Appendix A-1. Monitored resource outputs within the Validation Project Area (Validation Team and Contributors 1976).

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1. Herbage and browse....tons per acre per year.
2. Livestock production....AUM's per acre.
3. Animal output value....dollars per acre.
4. Merchantable wood....cubic feet per acre per year.
5. Water quality.
6. Water yield....acre-feet per acre per year.
7. Storm runoff....inches per acre.
8. Stream sediment....tons per acre per year.
9. Soil stability....inches per acre per year.
10. Employment....manhours per acre per year.
11. Rare or endangered species....a qualitative evaluation based on population size of those rare or endangered species which are permanent, summer, or winter residents.
12. Non-game birds....a qualitative evaluation based on diversity of those species which are permanent, summer, or winter residents.
13. Carnivores and raptors....a qualitative estimation based on animal numbers of those species which are permanent, summer, or winter residents.
14. Air quality....a qualitative estimate based on atmospheric content of carbon and particulate matter.
15. Soil quality....a qualitative estimate based on fertility, structure, and drainage of the soil.
16. Depressed area impact....a qualitative assessment of the economic impact upon the residents of economically depressed areas.
17. Cultural heritage (resident)....a qualitative assessment of the impact on established way-of-life and local tradition.

Appendix A-1. (Continued)

18. Cultural heritage (non-resident)....a qualitative estimate of the impact upon an established tradition and way-of-life as viewed by a non-resident.

19. Beauty....a qualitative assessment of the aesthetic appeal of landscapes.

20. Hunting....a qualitative assessment of the impact on game animal numbers.

21. Fishing....a qualitative assessment of the impact on game fish populations.

22. Other outdoor recreation....a qualitative assessment based on visitor days per acre.

23. Flexibility for future management....a qualitative assessment of the ease with which management direction can be altered.

Appendix A-2. Management strategies implemented within the Validation Project Area (Validation Team and Contributors, 1976).

A. Environmental Management Without Livestock. Under this strategy livestock are excluded from the range by fencing, riding, public education, or by incentive payments. The environment is protected against natural and other disasters such as pest epidemics and wildfire. In addition, major past resource damage is corrected.

B. Environmental Management With Livestock. This management strategy allows livestock grazing within the present capacity of the range environment. Resource damage as a result of past overuse is corrected. Additional management practices are limited to those needed to maintain soil, water, timber, and wildlife resources in their present state. The goal is to attain livestock control. Livestock distribution is not a concern of this strategy.

C. Extensive Management of Environment and Livestock. Management systems and techniques such as fencing and water developments are applied where needed to obtain relatively uniform livestock distribution. The impacts on all major resources as may be affected by these practices are monitored. Maximization of livestock forage production by such practices as seeding is not

Appendix A-2. (Continued)

initiated under this strategy.

D. Intensive Management Of Environment and Livestock. The primary goal of this strategy is to maximize forage production within the constraints of maintaining the environment and providing multiple resource use. Vegetation control, seeding, and fertilization can be used to increase range productivity. Under this strategy advanced livestock management practices are common.

E. Environmental Management With Livestock Production Maximized. Practices are to be initiated which will maximize forage output and subsequently maximize livestock output. Under this strategy timber may be removed, however, soil, water, and wildlife resources may not be harmed. Public and private forest lands are excluded from this strategy.

Appendix A-3. Productivity levels and condition classes of forest ecosystems as applied by the Validation Project (Validation Team and Contributors 1976).

Productivity Level	Wood (cu ft/ac/yr)
I	120 +
II	85 - 119
III	50 - 84
IV	0 - 49

Condition Class

R - Regeneration or nonstocked.

P - Stands with seedlings and saplings or poles having trees up to approximately nine inches in diameter.

T - Stands with sawtimber having at least 50 percent of the trees above nine inches in diameter.

Appendix A-4. Productivity levels and condition classes of non-forested ecosystems as applied by the Validation Project (Validation Team and Contributors 1976).

	lbs/acre		Productivity Class
Sagebrush	1,750 -	250	I
	1,250	250	II
	750	250	III
	250	250	IV
Juniper	700 -	100	I
	500	100	II
	300	100	III
	100	100	IV
Mt. Grassland	2,625 -	375	I
	1,850	375	II
	1,125	375	III
	375	375	IV
Meadow	3,500 -	500	I
	2,500	500	II
	1,500	500	III
	500	500	IV

Condition Class

G - Good

F - Fair

P - Poor

Appendix A-5. FRES Ecosystems found within the Validation Work Area with their corresponding Validation number (Validation Team and Contributors 1976).

Douglas-Fir (20): This ecosystem can vary from almost a pure stand of Douglas-fir (*Pseudotsuga menziesii*) to a mixture of one or more of the following: grand fir (*Abies grandis*), ponderosa pine (*Pinus ponderosa*), lodgepole pine (*Pinus contorta*), and larch (*Larix occidentalis*). Englemann spruce (*Picea englemannii*) and sub-alpine fir (*Abies lasiocarpa*) may occur locally. Characteristic understory vegetation includes snowberry (*Symphoricarpos albus*), spirea (*Spirea betulifolia*), heartleaf arnica (*Arnica cordifolia*), elk sedge (*Carex geyeri*), and pinegrass (*Calamagrostis rubescens*). The Douglas-fir ecosystem occurs most frequently at the mid elevations.

Ponderosa Pine (21): The ponderosa pine ecosystem may vary from pure stands of ponderosa pine to combinations with other species. Douglas-fir is the most abundant associated species although grand fir, larch, and ledgepole pine may be common. Understory vegetation in pure stands of ponderosa pine may include curlleaf mahogany (*Cercocarpus ledifolius*), big sagebrush (*Artemisia tridentata*), bitterbrush (*Purshia tridentata*), Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Agropyron spicatum*), and Sandberg bluegrass (*Poa sandbergii*). In mixed stands the under-

Appendix A-5. (Continued)

story vegetation may include curlleaf mahogany, bitterbrush, snowberry, spirea, blue wildrye (Elymus glaucus), Kentucky bluegrass (Poa pratensis), pinegrass, and elk sedge. This ecosystem is commonly found at the lower elevations and on south facing slopes.

Fir-Spruce (23): Principal species found within this ecosystem are whitebark pine (Pinus albicaulis), sub-alpine fir, and Englemann spruce. Less common associates include white fir (Abies concolor), larch, and lodgepole pine. Understory vegetation may include alpine sagebrush (Artemisia tridentata subspecies vaseyana form spiciformis), big huckleberry (Vaccinium membranaceum), grouse huckleberry (Vaccinium scoparium), heartleaf arnica, white hawkweed (Hieracium albiflorum), mitella (Mitella stauropetala), squirreltail (Sitanion hystrix), needlegrass (Stipa spp.), and elk sedge. Pokeweed fleeceflower (Polygonum phytolaccaefolium) will dominate the ground vegetation where erosion has removed most of the A horizon. This ecosystem is restricted to the sub-alpine forest zone.

Larch (25): This ecosystem is considered seral to grand fir and Douglas-fir and will vary from a near pure stand of larch to a near pure stand of grand fir. Douglas-fir, lodgepole pine, Englemann spruce, and sub-alpine fir may be present in variable amounts. Understory vegetation

Appendix A-5. (Continued)

includes big huckleberry, grouse huckleberry, heartleaf arnica, twinflower (Linnaea borealis), and pinegrass. This ecosystem is more common at the upper elevations.

Lodgepole Pine (26): This species may occur in pure stands or in a mixture with Douglas-fir, Englemann spruce, larch, grand fir, and sub-alpine fir. Ground vegetation may include big huckleberry, grouse huckleberry, heartleaf arnica, and pinegrass. Englemann spruce and sub-alpine fir associations generally occur at the higher elevations.

Sagebrush (29): This ecosystem is characterized by one or more of the following species of sagebrush: big sagebrush, silver sagebrush (Artemisia cana), low sagebrush (Artemisia arbuscula), and stiff sagebrush (Artemisia rigida). Associated shrub species, dependent upon elevation and aspect, may include bitterbrush, rabbitbrush (Chrysothamnus spp.), wax currant (Ribes cereum), and snowberry. Stiff sagebrush is found on shallow, scabland soils and is indicative of a low productivity site. Big sagebrush occurs on a wide variety of sites including the most productive. Low sagebrush occurs on low to moderately low productivity sites and the less prevalent silver sagebrush is found on high and moderately high productivity sites. Understory vegetation may include balsamroot (Balsamorhiza spp.), yarrow (Achillea spp.), Idaho fescue,

Appendix A-5. (Continued)

prairie junegrass (Koleria cristata), wheatgrasses (Agropyron spp.), one spike oatgrass (Danthonia unispicata), and Sandberg bluegrass. A large portion of this ecosystem is in poor condition with an understory dominated by cheatgrass (Bromus tectorum).

Juniper (35): This ecosystem is characterized by the presence of western juniper (Juniperus occidentalis) which may vary from a dense to open to savanna stand. Understory vegetation may include big sagebrush, bitterbrush, rabbitbrush, a variety of forbs, bluebunch wheatgrass, Idaho fescue, and Sandberg bluegrass. Much of this ecosystem is also in poor condition with a dominant understory of cheatgrass.

Mountain Grassland (36): The mountain grassland ecosystem occurs over a wide range of topography and is characterized by three dominant grasses: bluebunch wheatgrass, Idaho fescue, and Sandberg bluegrass. Sandberg bluegrass tends to dominate the low productivity sites. Bluebunch wheatgrass and Idaho fescue become dominants as site productivity increases. Wheatgrass tends to dominate on south aspects and shallower soils and Idaho fescue tends to dominate on north aspects and deeper soils. Associated species are one spike oatgrass, bighead clover (Trifolium macrocephalum), and bisquitroots (Lomatium spp.) on scablands. Associated

Appendix A-5. (Continued)

species on the more productive sites are hawkweed (*Hieracium spp.*), lupine (*Lupinus spp.*), buckwheat (*Eriogonum heracleoides*), balsamroot, yarrow, squirreltail, needlegrass, and prairie junegrass. Occasional plants of big sagebrush, bitterbrush, gray rabbitbrush (*Chrysothamnus nauseosus*), snowberry, and wax currant may also occur. Much of this ecosystem is also in a deteriorated condition. Poor condition is characterized by one or more of the following species: sagebrush, rabbitbrush, tarweed (*Madia glomerata*), matchweed (*Gutierrezia sarothrae*), or cheatgrass.

Mountain Meadow (37): The mountain meadow ecosystem is divided into dry, moist, or wet meadows. A large portion of this ecosystem occurs along the major drainages and is primarily used as hay fields and improved pastures. It is also found in narrow bands along stream courses, small basins, and openings within the forest ecosystems. Large meadows are not common. The most productive forage sites occur within this ecosystem. Dominant vegetation in dry meadows include tufted hairgrass (*Deschampsia cespitosa*), Kentucky bluegrass, California oatgrass (*Danthonia californica*), and Idaho fescue. Dominants occurring in moist meadows are ovalhead sedge (*Carex microptera*), tufted hairgrass, redtop (*Agrostis diegoensis*), California oat-

Appendix A-5. (Continued)

grass, and Kentucky bluegrass. Wet meadow dominants include Nebraska sedge (Carex nebrascensis), ovalhead sedge, redtop, tufted hairgrass, and Nevada bluegrass (Poa nevadensis). Kentucky bluegrass now dominates many of the dry and moist meadow sites. Where deterioration has progressed further the vegetation is composed largely of annual and perennial forbs and invading shrubs such as sagebrush, rabbitbrush, and shrubby cinquefoil (Potentilla fruticosa).

Alpine (44): Four groups of plant dominants occur in this ecosystem: 1) elk sedge, Hood's sedge (Carex hoodii), and yarrow; 2) alpine fescue (Festuca brachyphylla), Ross sedge (Carex rossii), and yarrow; 3) alpine sagebrush, elk sedge, and yarrow; 4) pokeweed fleeceflower, sandwort (Arenaria capillaris), and broadleaf lupine (Lupinus latifolius). The last group of plant dominants occur on sites of severe soil erosion.

Appendix A-6. Descriptions of Blue Mountain plant communities studied within the Validation Area (Hall 1973).

Mixed Conifer - Pinegrass, Residual Soil (6CR)[1/]

Pseudotsuga menziesii-*Abies concolor*/*Calamagrostis rubescens*

Dominant Vegetation	% Cover
Douglas-fir (*Pseudotsuga menziesii*)	20-60 (0)[2/]
White fir (*Abies concolor*)	20-60 (0)
Ponderosa pine (*Pinus ponderosa*)	20-50 (0)
Snowberry (*Symphoricarpos albus*)	0-10
Heartleaf arnica (*Arnica cordifolia*)	5-20 (0)
Elk sedge (*Carex geyeri*)	20-40 (5)
Pinegrass	20-40 (80)

Soils are derived from such parent material as granite, tuff, and lavas or formed from alluvium or sedimentary deposits. Soil texture ranges from loamy sand to loam. Total soil depth is 61-122 centimeters (24-48 inches) with an effective depth of 25-86 centimeters (10-34 inches). These soils are susceptible to compaction when wet. Topography is undulating to steep and this community type may

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1/ Former code for Blue Mountain Mapping Types.

2/ Parentheses in this column denote exceptions.

Appendix A-6. (Continued)

be found on all aspects from elevations of 1,220-1,980 meters (4,000-6,500 feet). Increases in fir and decreases in ponderosa pine can be expected with increasing elevation and north aspects.

Good range condition is associated with a dominate ground vegetation of pinegrass and elk sedge. A dominate ground vegetation of heartleaf arnica and other herbs is indicative of poor range condition.

Mixed Conifer - Pinegrass, Ash Soils (6CA)

Pseudotsuga menziesii-Abies grandis/Calamagrostis rubescens

Dominant Vegetation	% Cover
Douglas-fir	20-40 (0) (60)
Grand fir (Abies grandis)	20-40 (0) (70)
Ponderosa pine	35-55 (0)
Larch (Larix occidentallis)	0-45
Spirea (Spirea betulifolia)	0-10 (20)
Heartleaf arnica	0-15 (30)
Elk sedge	0-20 (35)
Pinegrass	40-80 (20)

Soils are derived from volcanic ash overlying soil from any parent material common to this area. Texture is

Appendix A-6. (Continued)

fine loamy sand and structure ranges from weak to none. Total soil depth is 61-122 centimeters (24-48 inches) with exceptions of 152 centimeters (60 inches). Effective depth is 51-122 centimeters (20-48 inches) with exceptions of 152 centimeters. These soils are susceptible to wind erosion when exposed. Topography varies from undulating to steep and this community type can be found on all aspects from elevations of 1,220-1,830 meters (4,000-6,000 feet).

A dominant ground vegetation of pinegrass is associated with good range condition. Poor range condition is associated with a dominate ground cover of heartleaf arnica, western hawkweed (*Hieracium albertenum*), strawberry (*Fragaria virginiana*), and a near absence of pinegrass.

Ponderosa Pine - Douglas-Fir - Elk Sedge (6S)

Pinus ponderosa-Pseudotsuga menziesii/Carex geyeri

Dominant Vegetation	% Cover
Ponderosa pine	30-60 (15)
Douglas-fir	0-40
Mountain mahogany (*Cercocarpus ledifolius*)	0-30
Bitterbrush (*Purshia tridentata*)	0-20
Elk sedge	30-60 (80)

Appendix A-6. (Continued)

Soils are derived from lavas, granitics, and tuff. Texture is sandy to loamy and structure varies from weak to moderate. Total soil depth is 41-76 centimeters (16-30 inches) with exceptions of 25 centimeters (10 inches) and 102 centimeters (40 inches). Effective depth ranges from 25-51 centimeters (10-20 inches) with exceptions of 10 centimeters (4 inches) and 102 centimeters. These soils are subject to displacement under the impact of animals and there is some tendency to dry ravel on steep slopes. Topography is undulating to rough and this community type may be found on all aspects from elevations of 1,220-1,890 meters (4,000-6,2000 feet).

Mountain mahogany and bitterbrush are indicative of a poor productivity site for tree growth. A dominant ground vegetation of elk sedge typifies good range condition. Mountain mahogany and/or bitterbrush and some pinegrass may be present. A domination of litter, conspicuous lack of herbaceous vegetation, and a dense overstory inhibiting sedge production is indicative of poor range condition.

Appendix A-6. (Continued)

White Fir - Grouse Huckleberry (7WS)

Abies concolor/Vaccinium scoparium

Dominant Vegetation	% Cover
White fir	40-60 (80)
Douglas-fir	3-25 (40)
Larch	0-7 (30)
Grouse huckleberry	20-40 (50)
Pinegrass	5-40 (60)

Soils are derived from volvanic ash overlying subsoils formed from lavas, tuff, and granitic material. Texture is a fine loamy sand and structure ranges from weak to none. Total soil depth is 76-127 centimeters (30-50 inches) with exceptions of 152 centimeters (60 inches). Effective depth ranges from 61-122 centimeters (24-48 inches) with exceptions of 152 centimeters. These soils are susceptible to wind erosion when exposed. Grouse huckleberry is indicative of colder soils and cold air drainages at lower elevations. Clear cut areas may be subject to frost heaving. Topography varies from rolling to rough and this community type is found primarily on north aspects from elevations of 1,370-1,980 meters (4,500-6,500 feet).

Density and composition of understory vegetation is directly related to percent tree cover. White fir and grouse huckleberry, without a significant presence of sub-

Appendix A-6. (Continued)

alpine fir (*Abies lasiocarpa*) and big huckleberry (*Vaccinium membranaceum*), are key indicators of this community type.

White Fir - Big Huckleberry (7WM)

Abies concolor/Vaccinium membranaceum

Dominant Vegetation	% Cover
White fir	50-85 (5)
Douglas-fir	0-25 (40)
Larch	0-30 (40)
Ponderosa pine	0-20
Englemann spruce (*Picea englemannii*)	0-60
Big huckleberry	5-40 (80)

Soils are derived primarily from volcanic ash overlying subsoils derived from a variety of parent materials common to this area. Texture may range from fine loamy sand to loam and structure may vary from weak to none. Total soil depth is 91-152 centimeters (36-60 inches) with exceptions of 61 centimeters (24 inches) and 279 centimeters (110 inches). Effective depth ranges from 61-152 centimeters with exceptions of 36 centimeters (14 inches) and 254 centimeters (100 inches). These soils are susceptible to wind erosion when exposed. Characteristic topography is rolling to rough. This community type may be found on all aspects from elevations of 1,065-1,980 meters (3,500-6,500 feet). Increases in elevation are associated with decreases in ponderosa pine and Douglas-fir and increases in larch and Englemann spruce.

Lodgepole Pine - Grouse Huckleberry - Pinegrass (6LS)

Pinus contorta/Vaccinium scoparium/Calamagrostis rubescens

Dominant Vegetation	% Cover
Lodgepole pine	30-65
White fir	0-20
Grouse huckleberry	2-15 (0) (60)
Pinegrass	40-60 (20)

Soils are derived from volcanic ash overlying subsoils from any parent material common to this area. Soil texture is fine loamy sand and structure may range from weak to none. Total soil depth is 76-152 centimeters (30-60 inches) with an effective depth of 51-152 centimeters (20-60 inches). These soils are subject to wind erosion when exposed. Topography varies from undulating to steep. This community type is found primarily on north aspects from elevations of 1,220-1,830 meters (4,000-6,000 feet).

A dominant ground vegetation of pinegrass is indicative

Appendix A-6. (Continued)

of good range condition. Fir and lodgepole reproduction is also common. A wide variety of forbe such as strawberry, white hawkweed, and broadleaf lupine (*Lupinus latifolius*) with a dominance of grouse huckleberry is characteristic of poor range condition.

Lodgepole Pine - Grouse Huckleberry (7LS)

Pinus contorta/Vaccinium scoparium

Dominant Vegetation	% Cover
Lodgepole pine	30-60
Sub-alpine fir	0-40
Englemann spruce	0-20
Grouse huckleberry	15-50 (80)
Heartleaf arnica	0-8

Soils are primarily derived from volcanic ash overlying deep residual soils. Texture is fine loamy sand and structure may vary from weak to none. Total soil depth is 91-152 centimeters (36-60 inches) with exceptions of 61 centimeters (24 inches). Effective depth ranges from 51-152 centimeters (20-60 inches) with exceptions of 36 centimeters (14 inches). These soils are subject to wind erosion when exposed. Topography is rolling to steep. This community type is found on north aspects from eleva-

Appendix A-6. (Continued)

tions of 1,675-2,285 meters (5,500-7,500 feet).

Due to a lack of forage this community is not suited for livestock. Ground vegetation is dominated by grouse huckleberry and cover and diversity of herbaceous species is low.

Sub-Alpine Fir - Grouse Huckleberry (7AS)

Abies lasiocarpa/Vaccinium scoparium

Dominant Vegetation	% Cover
Sub-alpine fir	40-60 (15)
Englemann spruce	0-40
Grouse huckleberry	10-40 (60)

Soils are primarily derived from volcanic ash overlying residual soils. Texture is fine loamy sand and structure is weak to none. Total soil depth is 91-122 centimeters (36-48 inches) with exceptions of 61 centimeters (24 inches). Effective depth is 61-122 centimeters. These soils are susceptible to wind erosion when exposed and may be severely non-wettable. Topography varies from rolling to rough. This community type is found on northerly aspects from elevations of 1,830-2,285 meters (6,000-7,500 feet).

Sub-alpine fir and grouse huckleberry are indicative

Appendix A-6. (Continued)

of the coldest soils and climates of commercial forests. Due to a lack of forage this community type is not suitable for livestock.

Sub-Alpine Fir - Whitebark Pine - Sedge (7AP)

Abies lasiocarpa-Pinus albicaulis/Carex geyeri

Dominant Vegetation	% Cover
Sub-alpine fir	5-30
Whitebark pine	5-30
Elk sedge	40-80 (0)
Alpine sagebrush (*Artemisia tridentata* var. *vaseyana*) *Artemisia tridentata* ssp. *vaseyana* f. *spiciformis*	0-5
Sandwort (*Arenaria capillaris*)	0-10
Pokeweed fleeceflower (*Polygonum phytolaccaefolium*)	0-30
Needlegrass (*Stipa occidentalis*)	0-10

Soils are derived from either ash, lavas, tuff, granitics, or serpentine. Texture is sandy loam to loam and structure may vary from moderate to none. Total soil depth is 61-122 centimeters (24-48 inches) with an effective depth of 30-91 centimeters (12-36 inches). These soils are subject to erosion from high winds at exposed sites.

Appendix A-6. (Continued)

Characteristic topography is rolling to rough. This community type may be found on all aspects from elevations of 2,070-2,440 meters (6,800-8,000 feet).

Good range condition is typified by scattered whitebark pine and sub-alpine fir with a dominant ground vegetation of elk sedge. There may also be a scattering on alpine sagebrush. This condition is not common within this community type. Overgrazing has eliminated much of the elk sedge and lead to erosion of the A horizon. Where this has occurred pokeweek fleeceflower has become dominant. Sandwort may be present as a co-dominant under these conditions. Needlegrass, squirreltail (*Sitanion hystrix*), and alpine sagebrush are indicators of poor range condition on non-eroded sites.

This community type is classified as non-commercial forest. Revegetation is largely unsuccessful due to the cold soils and short growing season.

Alpine Sagebrush - Sedge (4TA)

Artemisia tridentatavar. vaseyana Artemisia tridentata ssp. *vaseyana* form *spiciformis/Carex geyeri*

Dominant Vegetation	% Cover
Alpine sagebrush	7-25 (40)
Elk sedge	40-60 (80)

Appendix A-6. (Continued)

Yarrow 1-5
(*Achillea millefolium*)

Soils are derived from lavas and granitics. Texture ranges from sandy loam to loam and structure varies from weak to moderate. Total soil depth is 51-91 centimeters (20-36 inches) with an effective depth of 18-55 centimeters (20-36 inches) with an effective depth of 18-58 centimeters (7-23 inches). Granitic soils are more susceptible to erosion and subsequent invasion of pokeweed fleeceflower. Lava soils are less prone to erosion and generally more productive. Topography is rolling to steep. This community type is found primarily on southerly aspects from elevations of 1,860-2,550 meters (6,100-8,200 feet).

Good range condition is typified by a dominant ground vegetation of elk sedge, occasional yarrow, and a moderate scattering of alpine sagebrush. Mountain mahogany may also be present. A dominance of pokeweed fleeceflower, phlox (*Phlox diffusa*), and sandwort are indicative of poor range condition on eroded sites. Poor range condition on non-eroded sites is indicated by a dominance of alpine sagebrush with some needlegrass, squirreltail, and phlox. Revegetation is generally unsuccessful due to cold soil conditions and a short growing season.

Appendix A-6. (Continued)

Dry Meadow (2D)

Dominant Vegetation	% Cover
Kentucky bluegrass (*Poa pratensis*)	40-80
Tufted hairgrass (*Deschampsia cespitosa*)	10-40 (60)
California oatgrass (*Danthonia californica*)	0-30

Soils are derived from alluvium. Texture ranges from loam to clay loam and structure varies from moderate to strong. Total soil depth is 51-152 centimeters (20-60 inches) with an effective depth of 51-152 centimeters. Topography is primarily flat to undulating. This community type may be found on all aspects from elevations of 760-1,980 meters (2,500-6,500 feet).

A key characteristic of this community type is the lack of a perched water table or freely available water within rooting distance throughout the growing season. Dry meadows are generally moist to wet in the spring and moderately to severely dry by fall.

Good condition dry meadows had not been identified in the Blue Mountains at the time of publication of the R6 Area Guide 3-1. Therefore, condition guides for this community type have not been established. Although Kentucky bluegrass is an introduced species it tolerates heavy grazing and serves as a good soil protector.

Appendix A-6. (Continued)

Moist Meadow (2M)

Dominant Vegetation	% Cover
Tufted hairgrass	20-60
Ovalhead sedge (*Carex microptera*)	0-40
California oatgrass	0-40
Kentucky bluegrass	0-40
Bentgrass (*Agrostis diegonensis*)	10-40

Soils are derived from alluvium. Texture ranges from loam to clay loam and structure is moderate to strong. Total soil depth is 51-152 centimeters (20-60 inches) with an effective depth of 51-127 centimeters (20-50 inches). Topography is generally flat to undulating. This community type may be found on all aspects from elevations of 760-1,980 meters (2,500-6,500 feet).

This community type is generally moist to wet during the spring and has freely available water within rooting distance throughout the growing season. Moist conditions in the early spring are usually a limitation to livestock turn-out. Prior to mid August the soil is sufficiently dry to support livestock without incurring trampling damage.

Good range condition is typified by a dominance of tufted hairgrass with various amounts of ovalhead sedge,

Appendix A-6. (Continued)

bentgrass, and California oatgrass. Kentucky bluegrass tends to become the dominant species as condition regresses. A dominance of false hellebore (*Veratrum californicum*) is indicative of poor range condition. Ovalhead sedge is an indication of more moist sites and California oatgrass indicates drier sites.

Wet Meadow (2W)

Dominant Vegetation	% Cover
Nebraska sedge (*Carex nebrascensis*)	50-90
Ovalhead sedge	20-50
Bentgrass	0-20

Soils are derived from alluvium or peat. Texture ranges from peat to loam to clay loam and structure may vary from none to moderate to strong. Total soil depth is 51-152 centimeters (20-60 inches) with an effective depth of 51-76 centimeters (20-30 inches). This community type may be found from elevations of 760-1,980 meters (2,500-6,500 feet).

Wet meadows remain wet at or near the soil surface throughout the growing season. Generally, the soil surface is too wet to support livestock. Soil damage from trampling may be incurred when this community type is graz-

Appendix A-6. (Continued)

ed by livestock.

Bunchgrass On Deep Soil, Gentle Slopes (1FD)

Agropyron spicatum-Festuca idahoensis

Dominant Vegetation	% Cover
Bluebunch wheatgrass	15-35
Idaho fescue	5-25
Sandberg bluegrass (*Poa sandbergii*)	10-20
Prairie junegrass (*Koleria cristata*)	5-15
Yarrow	1-6

Soils are derived from basic flow lavas and loess. Texture is sandy loam to loam and structure is moderate, blocky. Total soil depth is 38-114 centimeters (15-45 inches) with an effective depth of 18-76 centimeters (7-30 inches). The most productive soils are dark brown to black. Least productive soils are red to reddish light brown. Idaho fescue increases with darker soils. Topography is undulating to rolling. This community type may be found on all aspects from elevations of 1,065-1,525 meters (3,500-5,000 feet).

Good range condition is characterized by a dominance of bluebunch wheatgrass and/or Idaho fescue. Bluebunch

Appendix A-6. (Continued)

wheatgrass tends to dominate southerly aspects and Idaho fescue tends to dominate northerly aspects and deeper soils. Poor range condition is typified by increasing bare ground and a dominance of cheatgrass (Bromus tectorum) and Sandberg bluegrass. Yarrow, squirreltail, and needlegrass may also be present in varying amounts. The presence of prairie junegrass suggests waterlogging during the winter.

Bluegrass Scabland (1S)

Poa sandbergii Scabland

Dominant Vegetation	% Cover
Sandberg bluegrass	20-30
Onespike oatgrass (Danthonia unispicata)	0-20
Bighead clover (Trifolium macrocephalum)	0-20
Biscuitroots (Lomatium spp.)	2-6
Narrowleaf pussytoes (Antennaria stenophylla)	1-5
Serrated balsamroot (Balsamorhiza serrata)	2-8

Soils are derived from flow lavas. Texture is loam to sandy loam and structure is weak to moderate, subangular blocky. Total soil depth is 10-25 centimeters

Appendix A-6. (Continued)

(4-10 inches) with an effective depth of 8-20 centimeters (3-8 inches). Topography is undulating to rolling. This community type may be found on southerly aspects from elevations of 1,400-1,890 meters (4,200-6,200 feet). The presence of biscuitroots with varying amounts of dwarf squirreltail (Sitanion hystrix var. hordeoides) and the lack of yarrow and cheatgrass indicates scabland. This community type is subject to severe water saturation and frost heaving during the winter months.

Good range condition is characterized by a dominance of Sandberg bluegrass, some bare soil resulting from frost heaving, and caying amounts of moss. Poor range condition is indicated by a dominance of biscuitroots, narrowleaf pussytoes, and serrated balsamroot. There is also a tendency of increased amounts of bare soil and decreased amounts of moss. A natural gravel pavement, the result of frost heaving, tends to reduce wind erosion and prevent puddling on the soil surface.

Appendix A-6. (Continued)

Biscuit - Scabland (4R/4T, 1S/1FD)

Dominant Vegetation - Biscuit	% Cover
Big sagebrush (*Artemisia tridentata*)	0-15
Low Sagebrush (*Artemisia arbuscula*)	0-22
Bluebunch wheatgrass	15-35
Idaho fescue	5-25
Sandberg bluegrass	10-20
Yarrow	1-6

Dominant Vegetation - Scab	% Cover
Sandberg bluegrass	20-30
Onespike oatgrass	0-20
Bighead clover	0-20
Stiff sagebrush (*Artemisia rigida*)	0-20

Soils are derived from basic flow lavas. Texture is loam to clay loam and structure is moderate, blocky. Total soil depth of biscuit areas is 46-91 centimeters (18-36 inches) and effective depth is 25-76 centimeters (10-30 inches). Total soil depth of scab areas is 10-25 centimeters (4-10 inches) and effective depth is 8-20 centimeters (3-8 inches). Topography is undulating to rolling. This community type may be found on all aspects from elevations of 1,065-1,675 meters (3,500-5,500 feet).

Appendix A-6. (Continued)

Total productivity of this community type is generally limited to the proportion of biscuit area to scab area. Therefore, condition is best evaluated for the biscuit areas. Good range condition (biscuits) is typified by a dominance of bluebunch wheatgrass and Idaho fescus. Varying amounts of big sagebrush may also be common. A dominance of cheatgrass on the biscuits is indicative of poor range condition.

Big Sagebrush - Bunchgrass (4T)

Artemisia tridentata/Agropyron spicatum-Festuca idahoensis

Dominant Vegetation	% Cover
Big sagebrush	4-15 (25)
Bluebunch wheatgrass	5-45
Idaho fescue	0-40
Sandberg bluegrass	5-14
Prairie junegrass	1-8 (20)

Soils are derived from lavas, granitic material, or sedimentary deposits. Texture may range from sandy loam to loam to clay loam and structure is weak to moderate. Total soil depth is 61-122 centimeters (24-48 inches). Total soil depth is 61-122 centimeters (24-48 inches). Total depth of some sites may reach 152 centimeters

(60 inches). Effective soil depth is 46-76 centimeters (18-30 inches) with some sites having an effective depth to 114 centimeters (45 inches). Topography is undulating to steep. This community type may be found on all aspects from elevations of 1,065-1,770 feet). Granitic soils are subject to dry ravel and are also susceptible to displacement under livestock impact.

Good range condition is indicated by a dominance of bluebunch wheatgrass and Idaho fescue, occasional plants of big sagebrush, and the presence of yarrow. Bitterbrush may also be present in varying amounts. Bluebunch wheatgrass decreases and Idaho fescue increases with a change in aspect from south to north. A dominance of big sagebrush, Sandberg bluegrass, and cheatgrass is indicative of poor range condition.

Appendix A-6. (Continued)

Low Sagebrush - Bunchgrass (4A)

Artemisia arbuscula/Agropyron spicatum-Festuca idahoensis

Dominant Vegetation	% Cover
Low sagebrush	7-22 (2)
Bluebunch wheatgrass	0-50
Idaho fescue	0-40
Sandberg bluegrass	4-20 (28)
Yarrow	0-5

Soils are derived from basic and acidic lavas. Texture is sandy loam to loam with occasional clay loam and structure is weak to moderate. Total soil depth is 25-64 centimeters (10-25 inches) with an effective depth of 10-51 centimeters (4-20 inches). Topography is undulating to rolling. This community type may be found on all aspects from elevations of 1,220-1,890 meters (4,000-6,200 feet). There is a tendency for some winter moisture saturation and these soils may be subject to trampling damage from livestock in the early spring.

A dominance of bluebunch wheatgrass and Idaho fescue is characteristic of good range condition. A strong cover of grasses tends to hide the low sagebrush giving the impression of a continuous grassland. A dominance of low sagebrush, Sandberg bluegrass, and varying amounts of cheatgrass is indicative of poor range condition. Low

Appendix A-6. (Continued)

sagebrush is an indicator of a low productivity site.

Juniper - Big Sagebrush (9T)

Juniperus occidentalis/Artemisia tridentata

Dominant Vegetation	% Cover
Juniper	2 or more per acre
Big sagebrush	4-15 (26)
Bluebunch wheatgrass	5-45
Idaho fescue	0-40
Sandberg bluegrass	5-14
Prairie junegrass	1-8 (20)

Soils are derived from lavas, granitic material, or sedimantary deposits. Texture ranges from sandy loam to loam and occasionally clay loam. Structure is weak to moderate. Total soil depth is 61-76 centimeters (24-48 inches) with some sites having a total depth of 152 centimeters (60 inches). Effective depth is 46-76 centimeters (18-30 inches) with some sites having an effective depth of 114 centimeters (45 inches). Topography varies from undulating to steep. This community type may be found on all aspects from elevations of 1,065-1,770 meters (3,500-5,800 feet). Franitic soils are subject to displacement under livestock impact and are susceptible to dry ravel on

Appendix A-6. (Continued)

steep slopes.

Good range condition is indicated by a dominance of bluebunch wheatgrass and Idaho fescue, occasional plants of big sagebrush, and the presence of yarrow. Bitterbrush may also be present. A dominance of big sagebrush, Sandberg bluegrass, and cheatgrass is indicative of poor range condition.

Juniper - Bunchgrass (9B)

Juniperus occidentalis/Agropyron spicatum-Festuca idahoensis

Dominant Vegetation	% Cover
Juniper	2 or more per acre
Bluebunch wheatgrass	15-25
Idaho fescue	8-15
Sandberg bluegrass	18-28
Yarrow	1-5

Soils are derived from basic flow lavas. Texture is loam to silt loam and structure is moderate, blocky. Total soil depth is 20-36 centimeters (8-14 inches) with an effective depth of 15-25 centimeters (6-10 inches). Topography is undulating to steep. This community type may be found on all aspects from elevations of 1,065-1,675 meters (3,500-5,500 feet).

Appendix A-6. (Continued)

Good range condition is indicated by a dominance of bluebunch wheatgrass and Idaho fescue. Some bareground and erosion pavement may be evident. This community type represents the median between scabland on young, shallow soils and a good bunchgrass site on well developed soil. A dominance of Sandberg bluegrass and biscuitroots is indicative of poor range condition. Increasing cobble and lighter and redder surface soils are related to decreasing herbage production.

Appendix A-7. Blue Mountain Plant Communities (BMPC) found within each of the 10 FRES ecosystems.

Ecosystem	BMPC
Douglas-fir	Mixed Conifer-Pinegrass, Residual Soil
	Mixed Conifer-Pinegrass, Ash Soils
Ponderosa pine	Ponderosa pine-Douglas-fir-Elk Sedge
Fir-Spruce	Sub-Alpine Fir-Grouse Huckleberry
	Sub-Alpine Fir-Whitebark pine-Sedge
Larch	White Fir-Grouse Huckleberry
	White Fir-Big Huckleberry
Lodgepole pine	Lodgepole pine-Grouse Huckleberry-Pinegrass
	Lodgepole pine-Grouse Huckleberry
Sagebrush	Big Sagebrush-Bunchgrass
	Low Sagebrush-Bunchgrass
Juniper	Juniper-Big Sagebrush
	Juniper-Bunchgrass
Grassland	Bunchgrass On Deep Soil-Gentle Slopes
	Bluegrass Scabland
Meadow	Dry Meadow
	Moist Meadow
	Wet Meadow
Alpine	Alpine Sagebrush-Sedge

Appendix A-8. Sample sites by research area (RA), management strategy (MS), aerial photograph number (APN), and resource unit and field data identifier (RU-FDI).

RA: Brown Ranch - Roy Watkins Pasture

MS: current C; proposed D

APN: L6-87

RU-FDI: 29-III-G 14B

29-IV-G 15B

35-I-F 16B

RA: Monument Grazing Association - East Timber Basic

MS: current B; proposed D

APN: L11-175

RU-FDI: 20-IV-P 9A

21-IV-P 8A

35-IV-P 7A

RA: Donaldson Allotment - North Unit

MS: current C; proposed C

APN: L15-86

RU-FDI: 35-III-P 26B

RA: Vaughn Ranch - Ferg Unit

MS: current C; proposed D

APN: L21-120 (EWD4-10)

RU-FDI: 37-II-F 12A

37-III-F 10A

Appendix A-8. (Continued)

36-III-F 11A

20-IV-T 5A

25-III-P 6A

RA: Vaughn Ranch - Sagebrush Unit

MS: current D; proposed D

APN: L20-50

RU-FDI: 29-II-F 13A

29-II-P 14A

37-I-P 15A

RA: Wilburn Ranch - Little Deer Creek Pasture

MS: current B; proposed D

APN: L16-25

RU-FDI: 20-IV-P 3B

RA: Wilburn Ranch - North Goldfish Pasture

MS: current B; proposed C

APN: L16-22

RU-FDI: 29-IV-F 2B

RA: Morgrass Grazing Association - Clarence Porter Unit

MS: current B; proposed D

APN: L22-173

Appendix A-8. (Continued)

RU-FDI: 36-IV-F 2A-1B

37-II-F 1A

RA: Morgrass Grazing Association - East Dustin Unit

MS: current B; proposed D

APN: L24-35

RU-FDI: 36-III-G 4A-24B

36-IV-F 2A-1B

RA: Slide Creek Allotment - East Unit

MS: current B; proposed D

APN: L28-26

RU-FDI: 20-III-T 23B

RA: Long Creek Allotment - Keeney-Clark Unit (Keeney Meadow)

MS: current C; proposed D

APN: NA

RU-FDI: 26-IV-P 16A

RA: Long Creek Allotment - Hiyu Unit (Harper Meadow)

MS: current C; proposed D

APN: L28-19

RU-FDI: 37-III-F 22B

Appendix A-8. (Continued)

RA: Long Creek Allotment - Hiyu Basin

MS: current B; proposed D

APN: NA

RU-FDI: 20-IV-T 19A

RA: Magone Lake

MS: current A; proposed A

APN: L28-15

RU-FDI: 20-III-P 17A

25-III-T 18A

RA: Upper Middle Fork Allotment - Deerhorn Unit

MS: current B; proposed C

APN: L38-121

RU-FDI: 44-III-F 10B

RA: Upper Middle Fork Allotment - Upper Vinegar Unit

MS: current B; proposed B

APN: L39-185

RU-FDI: 20-IV-T 5B

35-III-P 4B

APN: L39-188

RU-FDI: 23-IV-T 20B

25-III-T 7B

Appendix A-8. (Continued)

APN: L39-190

RU-FDI: 23-IV-P 11B

APN: L40-199

RU-FDI: 20-IV-P 8B

RA: Upper Middle Fork Allotment - Lower Vinegar Unit

MS: current A; proposed C through D

APN: L40-204

RU-FDI: 37-III-P 12B

RA: Upper Middle Fork Allotment - Blackeye Watershed

MS: current A; proposed A

APN: L39-188

RU-FDI: 44-III-P 6B

RA: Upper Middle Fork Allotment - Caribou Unit

MS: current B; proposed B

APN: L38-117

RU-FDI: 21-IV-P 9B-21B

RA: Lower Middle Fork Allotment - Susanville Unit

MS: current B; proposed C

APN: L33-118

RU-FDI: 25-III-T 18B

Appendix A-8. (Continued)

<u>APN:</u> L34-73

<u>RU-FDI:</u> 26-IV-P 17B

<u>APN:</u> L39-189

<u>RU-FDI:</u> 36-IV-P 19B

Appendix B-1. Analysis of variance - Potential sediment production of Groups A-C vegetation types and the 10 FRES ecosystems.

Group A

Source	D.F.	F Ratio	F Prob.
Between Groups	3	36.95	.00
Within Groups	260		
Total	263		

Group B

Source	D.F.	F Ratio	F Prob.
Between Groups	4	30.33	.00
Within Groups	259		
Total	263		

Group C

Source	D.F.	F Ratio	F Prob.
Between Groups	5	31.37	.00
Within Groups	258		
Total	263		

Ecosystems

Source	D.F.	F Ratio	F Prob.
Between Ecosystems	9	17.32	.00
Within Ecosystems	254		
Total	263		

Appendix B-2. Analysis of variance - Potential sediment production for Resource Units (RU) within each of the 10 FRES ecosystems.

Douglas-fir

Source	D.F.	F Ratio	F Prob.
Between RU	3	5.26	.00
Within RU	44		
Total	47		

Fir-Spruce

Source	D.F.	F Ratio	F Prob.
Between RU	1	2.06	.18
Within RU	10		
Total	11		

Larch

Source	D.F.	F Ratio	F Prob.
Between RU	1	5.82	.02
Within RU	22		
Total	23		

Sagebrush

Source	D.F.	F Ratio	F Prob.
Between RU	3	20.51	.00
Within RU	20		
Total	23		

Juniper

Source	D.F.	F Ratio	F Prob.
Between RU	2	11.84	.00
Within RU	21		
Total	23		

Appendix B-2. (Continued)

Grassland

Source	D.F.	F Ratio	F Prob.
Between RU	4	3.35	.02
Within RU	49		
Total	53		

Meadow

Source	D.F.	F Ratio	F Prob.
Between RU	3	12.27	.00
Within RU	32		
Total	35		

Alpine

Source	D.F.	F Ratio	F Prob.
Between RU	1	4.59	.06
Within RU	10		
Total	11		

Appendix B-3. Analysis of variance - Mean infiltration values of Groups A-C vegetation types and the 10 FRES ecosystems.

Group A

Source	D.F.	F Ratio	F Prob.
Between Groups	3	.95	.41
Within Groups	260		
Total	263		

Group B

Source	D.F.	F Ratio	F Prob.
Between Groups	4	1.59	.18
Within Groups	259		
Total	263		

Group C

Source	D.F.	F Ratio	F Prob.
Between Groups	5	1.62	.16
Within Groups	258		
Total	263		

Ecosystems

Source	D.F.	F Ratio	F Prob.
Between Ecosystems	9	2.43	.01
Within Ecosystems	254		
Total	263		

Appendix B-4. Analysis of variance - Mean infiltration values for resource units (RU) within each of the 10 FRES ecosystems.

Douglas-fir

Source	D.F.	F Ratio	F Prob.
Between RU	3	6.22	.00
Within RU	44		
Total	47		

Fir-Spruce

Source	D.F.	F Ratio	F Prob.
Between RU	1	15.22	.00
Within RU	10		
Total	11		

Larch

Source	D.F.	F Ratio	F Prob.
Between RU	1	11.57	.00
Within RU	22		
Total	23		

Sagebrush

Source	D.F.	F Ratio	F Prob.
Between RU	3	2.78	.07
Within RU	20		
Total	23		

Juniper

Source	D.F.	F Ratio	F Prob.
Between RU	2	4.40	.02
Within RU	21		
Total	23		

Appendix B-4. (Continued)

Grassland

Source	D.F.	F Ratio	F Prob.
Between RU	4	6.79	.00
Within RU	49		
Total	53		

Meadow

Source	D.F.	F Ratio	F Prob.
Between RU	3	10.76	.00
Within RU	32		
Total	35		

Alpine

Source	D.F.	F Ratio	F Prob.
Between RU	1	13.84	.00
Within RU	10		
Total	11		