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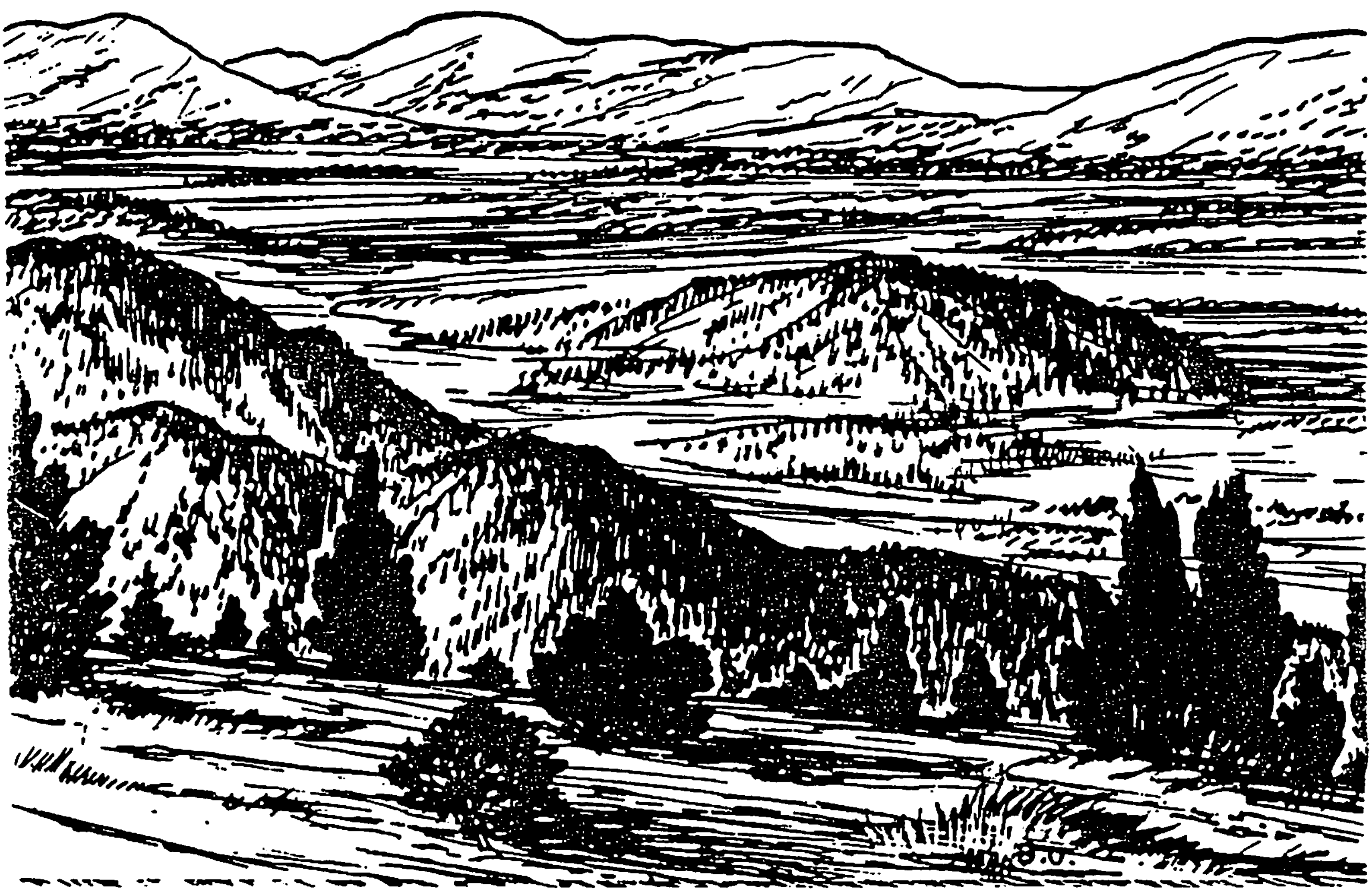

Proceedings—Pinyon-Juniper Conference

Reno, NV, January 13-16, 1986

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RICHARD L. EVERETT, Project Leader, Intermountain Research Station, Forest Service, U.S. Department of Agriculture

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PRESENT AND FUTURE EROSION PREDICTION TOOLS FOR USE IN PINYON-JUNIPER COMMUNITIES

Kenneth G. Renard

ABSTRACT: Although most of the erosion prediction technology currently used in the United States was developed from research on cultivated agriculture, the physics of the process are such that, with appropriate parameter adjustment, the technology can be transferred to other areas and land use types with appropriate caution. The primary erosion processes in the pinyon-juniper ecological areas, as in other areas, are those associated with raindrop splash erosion and erosion due to the shear of water moving over the land surface. Most models used for most erosion prediction consider erosion in interrill areas, in rills, and in concentrated flow or stream channel areas. Current technology for such prediction involves the Universal Soil Loss Equation, which lumps the processes of rill, interrill erosion, and sediment transport. The paper discusses some recent modifications and improvements to this technology. Also discussed is the effort to develop second generation erosion prediction technology which is physically based, and includes a hydrologic component to provide the runoff estimates required for estimating sediment detachment, transport and deposition at upland sites. The replacement technology is designed to operate on personal computers or small minicomputers, simulates on a storm basis, and aggregates to obtain monthly and annual soil loss values.

INTRODUCTION

Erosion continues to be a problem for conservationists and environmental planners in the United States. Concerns associated with soil erosion involve the offsite pollution consequences of sediment deposition in streams and reservoirs (and adsorbed chemicals associated with such erosion) and the loss in productivity of the soil resource (soil pedon) (Crosson 1984; Follett and Stewart 1985; American Society of Agricultural Engineers 1984). Erosion concerns are not only restricted to those historically called sheet and rill erosion, but also include the erosion associated with concentration of runoff which leads to gully formation, arroyo enlargement and, associated with it, restriction of access to land areas by domestic grazing animals.

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Kenneth G. Renard is a Research Hydraulic Engineer, Aridland Watershed Management Research Unit, Agricultural Research Service, U.S. Department of Agriculture, 2000 E. Allen Road, Tucson, AZ 85719.

PINYON-JUNIPER EROSION CONTROL

Pinyon-juniper acreage, currently estimated at 80 million acres (Sauerwein 1984), is increasing. One must consider the erosion from such an area in a geologic sense, as well as the impact of grazing, vegetation control, and grazing management. Unfortunately, the technology for erosion assessment is weak, whereas, in many instances, the erosion rates and downstream sediment damage are excessive.

Sauerwein (1984), in commenting about management of pinyon-juniper communities, stated, "When a pinyon-juniper forest becomes overcrowded, ecosystem efficiency breaks down. Some part of the system fails. Often, the first to go is the grass and forb understory. Next is the organic surface. Then surface erosion begins, and the overstory suffers. The entire site continues to degrade to a level that nature can maintain. This is not a desirable alternative to good management.

Pinyon and juniper generally grow on shallow stony, or rocky, soils. Maintenance of the soil and organic matter is critical. Even the loss of the organic surface can be disastrous. Retention of the duff layer under pinyon trees is also important."

Although one might argue with the implication that erosion increases as the stand becomes overcrowded (Patric 1985) (e.g., a complete stand would be expected to absorb most of the impact energy of raindrops and increase precipitation interception), the disappearance of the understory would result in more bare soil, which may accelerate erosion. Experiments have indicated that organic matter is important in the erosion process, and that erosion would be expected to increase with decreasing understory and organic matter.

The soil erosion measurements made by Sampson and Weyl (1918) on overgrazed rangelands were among the earliest erosion experiments in the U.S. These studies and research by Chapline (1929) illustrated how grazing and erosion affected soil fertility and the soil water-holding capacity. Unfortunately, these early experiments were not continued, nor were similar experiments performed on pinyon-juniper. Concern for the ecological health of rangelands grew with the general environmental awareness that developed during the late 1960's and 70's, and detrimental erosion was again recognized on rangeland. As a consequence, management plans for rangelands had to consider how management alternatives might affect erosion. Since research had provided little information on rangeland erosion and in pinyon-juniper ecosystems specifically, technology developed for croplands was adapted to the rangeland problem. Because of the uncertainty and lack of data, many questions arose. The Universal Soil Loss Equation (USLE) (Wischmeier and Smith 1978), which has been successfully used on cropland, was adapted to estimate erosion on rangeland (Renard and Foster 1985).

The USLE (Wischmeier and Smith 1965, 1978) is:

$$A = R \times K \times L \times S \times C \times P \quad \text{where:} \qquad (1)$$

A is the estimated average annual erosion rate per unit of area computed by multiplying values for the other six factors. It is an estimate of the average annual sheet and rill erosion from rainstorms on upland areas, and it does not include erosion from gullies or streambanks, snowmelt erosion, or wind erosion. It does include eroded sediment that may subsequently be deposited on the toe of slopes and at other places before runoff reaches streams or reservoirs.

R is the rainfall and runoff erosivity factor for a specific location, usually expressed as average annual erosion index units.

K is the soil erodibility factor for a specific soil horizon, expressed as soil loss per unit of area per unit of R for a unit plot (a unit plot is 72.6 feet long, with a uniform 9% slope maintained in continuous fallow with tillage, when necessary, to break surface crusts and to control weeds). These dimensions were selected because the 1/100 ac erosion research plots used in early erosion work in the U.S. were 72.6 feet long, and had slopes near 9%. Continuous fallow was selected as a base because no cropping system is common to all agricultural areas, and soil loss from any other plot condition would be influenced by residual and current crop and management effects that vary from one location to another.

L is the dimensionless slope-length factor (not the actual slope length) expressed as the ratio of soil loss from a given slope length to that from a 72.6 foot length under the same conditions.

S is the dimensionless slope-steepness factor (not the actual slope steepness) expressed as the ratio of soil loss from a given slope steepness to that from a 9% slope under the same conditions.

C is the dimensionless cover and management, or cropping-management, factor expressed as a ratio of soil loss from the condition of interest to that from tilled continuous fallow.

P is the dimensionless supporting erosion-control practice factor expressed as a ratio of the soil loss with practices such as contouring, strip cropping, or terracing to that with farming up and down the slope.

The term 'universal' in the USLE was given to the equation to assist users who were accustomed to previous equations that applied to very specific regions in contrast to the USLE, which applied, initially in 1965, to all of the U.S. east of the Rocky Mountains, and to the 1978 revision, which applies to all of the United States. Wischmeier (1972) explained, "The name 'universal' soil-loss equation originated as a means of distinguishing this prediction from the highly regionalized models that preceded it. None of its factors utilizes a reference point that has direct geographic orientation. In the sense of the intended functions of the equation's six factors, the model should have universal validity. However, its application is limited to states and countries where information is available for local evaluations of the equation's individual factors." This statement then provides a key element for use of the technology on rangeland (and pinyon-juniper communities). Although the USLE is sometimes referred to as being a 'Midwest' equation, it is much more broadly based. The 48 locations used in the original data base are reasonably well distributed across locations east of the Rocky Mountains. Data from these 48 locations were principally used to determine the effects of soil, topography, cover, and management on erosion. More than 180 locations were used to develop the rainfall erosivity factor, including numerous locations in the western United States. Admittedly, the technology used to develop the erosivity does not adequately consider conditions encountered with orographic precipitation problems, snowmelt, and rain on frozen or thawing soil.

In the early 70's, interest evolved for applying the USLE to noncropland applications such as construction sites and undisturbed land, including rangelands. Since an extensive data base was not available for these applications, Wischmeier (1975) developed the subfactor method to estimate values for the cover management (C) factor. The subfactor method uses relationships for canopy, ground cover, and the "within" soil effects to estimate a composite C value. This development allowed the use of data collected from more basic studies to be used in the USLE. Recognizing the need for data, scientists began erosion experiments on rangeland to develop USLE parameter values, and to evaluate the performance of the USLE on rangelands.

Renard and Foster (1985) discussed the basis of the individual factors of the USLE and the background behind factor development and application for rangelands. They also cited recent research that supported the application of the USLE for rangelands.

Recent discussions regarding the use of the USLE (and the estimates it leads to on rangelands) as an indicator of the condition of the rangeland resource has resulted in increased discussion of the USLE. The U.S. Department of Agriculture (USDA), which uses the USLE as a planning mechanism in its conservation assistance programs, has been subjected to considerable criticism (Schuster 1984; Renard 1984). The issue of using the USLE on rangelands remains unresolved, but more importantly, the use of the USLE for erosion assessment in pinyon-juniper remains a distinct problem.

PROBLEMS OF USING THE USLE WITH PINYON-JUNIPER COMMUNITIES

Many opponents of the USLE cite that it does not work, because it was not developed for rangeland conditions. The data to support this contention are not available. If such a data base were available, improved USLE factor values or alternate technology could be developed.

There are some significant problems associated with attempting to use the USLE in pinyon-juniper (P-J) communities, including:

(1) Although Hortonian overland flow probably occurs during intense storms, runoff usually occurs as a partial area phenomena.

(2) The rainfall-runoff erosivity factor considers precipitation in the form of rain; yet much of the runoff and erosion in P-J areas is associated with snowmelt, frozen soil, and rain on snow.

(3) The cover-management factor was developed for a more uniform cover than that encountered in P-J areas.

(4) The soil erodibility term in the worst condition, historically, is that associated with a fallow-tilled soil. Tillage activities are not normally encountered in P-J communities.

(5) Recent research indicates the LS factor, presented in Agriculture Handbook 537, may be incorrect for the steep slopes such as are often encountered on P-J sites.

Further discussion on these problems seems warranted.

Partial Area Runoff

Most pinyon-juniper communities have highly variable runoff conditions with little or no runoff originating, except in the open areas between individual trees, especially if the grass density is reduced or almost nonexistent in the openings. Often the soil surface under trees contains an extensive amount of organic matter and a soil profile with a well developed A-horizon having relatively high infiltration rates relative to that in open areas. Such conditions result because the tree canopy successfully absorbs the impact energy of thunderstorms and therefore reduces erosion potential. The net effect may show that beneath a pinyon-juniper canopy, the topography will be higher (the profile deeper) than in open areas. Thus on a single storm event, runoff from the area beneath a tree can be much less as a percentage of the precipitation than in open areas.

Rainfall-Runoff Erosivity

Isoerodent maps (maps of equal annual R values) in the Basin and Range topography which dominate the western United States, and especially pinyon-juniper areas, were developed from power functions relating the average annual value of erosivity to the 2-year frequency rainfall depth expected in a 6-hour duration (P_{2-6}). This P_{2-6} value has been developed and mapped in the western United States, state by state, considering a number of topographic and orographic factors. Despite the efforts that have gone into these developments, there are problems, because there is a preponderance of gage locations in mountain valleys. Furthermore, the technology does not consider the erosivity associated with melting snow, freeze-thaw soil conditions, and rain on snow. Research indicates most erosion (except from channels) occurs from thunderstorm rainfall events, except in the snowmelt-dominated conditions such as the Pacific Northwest winter wheat farming areas of the Palouse (McCool and George 1983). Snow drifting and differential melting in pinyon-juniper vegetation-dominated areas could be a problem requiring special investigation.

Cover-Management Factor

Table 1 presents some values of C for use in the USLE which is reproduced from Agriculture Handbook 537. Of concern to the range scientist or conservationist is how such a table can be used with the heterogeneous conditions of a pinyon-juniper community. Obviously, the lower portion of the table applies for conditions where the raindrops are intercepted by the canopy and then reform and fall at less than terminal velocity.

An alternative to the above approach involves the subfactor technology developed by Dissmeyer and Foster (1981), and also reported by Dissmeyer with examples for forest (1982a) and rangeland (1982b) conditions. Such a subfactor approach is being proposed for use in a revision of Handbook 537 currently underway, as will be discussed subsequently.

Soil Erodibility

The soil erodibility nomograph, presented in Agriculture Handbook 537, was developed from experimental data from many soils in areas east of the Rocky Mountains. Unfortunately, cultivation is not a normal treatment used on rangeland soils, and was one of the conditions involved in the C factor and K factor evaluations/calibrations. Most experimental erosion work in the noncultivated areas of the West has assumed the nomograph is applicable.

A question that arises, and is often applicable in soils encountered on pinyon-juniper vegetation complexes, involves the treatment of coarse fragments in the soil profile. The nomograph assumes that particles larger than 2.0 mm are ignored in the particle-size distribution. Such coarse fragments in the soil profile affect the soil in two ways: the porosity and, in turn, infiltration; and coarse fragments can lead to the formation of an erosion pavement residual at the soil surface as fine particles erode away. Current recommendations are that erosion pavement surface cover be considered as part of the cover-management term (Farrell and Neff 1982; Simanton and others 1984), and the impact on infiltration be accommodated in the nomograph.

Table 1.--Factor C for permanent pasture, range-grazed forest land, and idle land[1] (Wischmeier and Smith 1978)

Vegetative canopy: Type and height[2]	Vegetative canopy: Percent cover[3]	Cover that contact the soil surface: Type[4]	Percent ground cover: 0	20	40	60	80	95+
No appreciable canopy		G	0.45	0.20	0.10	0.042	0.013	0.003
		W	.45	.24	.15	.091	.043	.011
Tall grass, weeds, short brush with average drop fall height of 20 in	25	G	.36	.17	.09	.038	.013	.003
		W	.36	.20	.13	.083	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.076	.039	.011
	75	G	.17	.10	.06	.032	.011	.003
		W	.17	.12	.09	.068	.038	.011
Appreciable brush or bushes with average drop fall height of 6 1/2 ft	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.087	.042	.011
	50	G	.34	.16	.08	.038	.012	.003
		W	.34	.19	.13	.082	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.078	.040	.011
Trees, but no appreciable low brush. Average drop fall height of 13 ft[5]	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.089	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.087	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.084	.041	.011

[1]The listed C values assume that the vegetation and mulch are randomly distributed over the entire area.

[2]Canopy height is measured as the average fall height of water drops falling from the canopy to the ground. Canopy effect is inversely proportional to drop fall height, and is negligible if fall height exceeds 33 ft.

[3]Portion of total-area surface that would be hidden from view by canopy in a vertical projection (a bird's-eye view).

[4]G: cover at surface is grass, grasslike plants, decaying compacted duff, or litter. Grass includes, as cover at the surface, parts which interfere with water flow, and are in contact with the soil during a rainstorm. The height of these parts depends on variety of grass.
W: cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface) or undecayed residues, or both.

[5]Multiply values by 0.7 for a grazed forest where organic matter has built up in the topsoil under permanent woodland conditions.

Slope Length-Steepness

Recent research has indicated that the LS factor from Handbook 537 produces values that are too large for steep slopes. The exponential relationship used in the original work was obtained for slopes less than about 20%, and the extrapolation then leads to overestimation. Recent analysis, using additional data and analytical solutions of a physically based model, led to the material contained in table 2, which is now recommended for use on rangelands or other consolidated soil conditions where there is a low ratio of rill to interrill erosion. Care must also be taken in rangeland conditions to ensure that slope lengths are not selected to be excessively long. The raised profile associated with litter and soil beneath pinyon-juniper canopies, and the eroded areas between trees, would indicate slope lengths seldom exceed 200 feet at slopes greater than 10%.

FUTURE USLE WORK

An effort is currently underway to revise the USLE to incorporate recent research results. Most significant in such work is the development of an algorithm to enable computing the cover-management factor (C) using some equations which quantify the subfactor approach.

The procedure is very similar to that presented by Dissmeyer (1982a and b) and Dissmeyer and Foster (1981) for forestland in the southeastern United

Table 2.--Values for topographic factor, LS, for rangeland and other consolidated soil conditions with cover (low rill to interrill erosion -- applicable to thawing soil where both interrill and rill erosion are significant)

Percent	Slope Length (feet)											
Slope	15.	25.	50.	75.	100.	150.	200.	250.	300.	400.	600.	800.
0.2	0.046	0.046	0.047	0.047	0.047	0.048	0.048	0.048	0.048	0.049	0.049	0.049
0.5	0.072	0.073	0.076	0.077	0.078	0.080	0.081	0.081	0.082	0.083	0.085	0.086
1.0	0.112	0.117	0.123	0.127	0.130	0.135	0.138	0.140	0.142	0.146	0.151	0.154
2.0	0.182	0.196	0.216	0.228	0.237	0.251	0.261	0.269	0.276	0.287	0.304	0.316
3.0	0.245	0.269	0.305	0.329	0.347	0.373	0.394	0.410	0.424	0.447	0.481	0.507
4.0	0.302	0.338	0.393	0.430	0.458	0.500	0.533	0.560	0.583	0.621	0.678	0.723
5.0	0.355	0.403	0.480	0.531	0.570	0.631	0.678	0.717	0.750	0.806	0.892	0.958
6.0	0.406	0.467	0.565	0.632	0.684	0.764	0.827	0.880	0.925	1.001	1.119	1.212
8.0	0.499	0.586	0.730	0.830	0.909	1.034	1.132	1.215	1.287	1.410	1.603	1.756
10.0	0.670	0.801	1.020	1.175	1.299	1.496	1.653	1.787	1.904	2.105	2.425	2.680
12.0	0.831	1.006	1.304	1.518	1.690	1.967	2.191	2.382	2.550	2.840	3.305	3.681
14.0	0.983	1.203	1.583	1.859	2.083	2.445	2.740	2.993	3.217	3.605	4.232	4.742
16.0	1.129	1.394	1.857	2.197	2.475	2.927	3.297	3.615	3.899	4.392	5.194	5.850
20.0	1.404	1.761	2.393	2.864	2.253	3.893	4.422	4.881	5.291	6.010	7.192	8.169
25.0	1.726	2.194	3.039	3.677	4.210	5.093	5.831	6.475	7.054	8.076	9.771	11.185
30.0	2.026	2.604	3.658	4.463	5.139	6.271	7.221	8.056	8.810	10.145	12.378	14.254
40.0	2.571	3.354	4.809	5.937	6.895	8.514	9.887	11.104	12.208	14.178	17.505	20.329
50.0	3.049	4.017	5.840	7.269	8.490	10.567	12.342	13.922	15.362	17.943	22.333	26.085

Unpublished information from McCool and Foster 1985.

States, and now used elsewhere. The cover-management factor proposed for rangeland is (J. M. Laflen, USDA-ARS, Ames, IA personal communication, 1984):

$$C = (PLU)\ (PC)\ (SC)\ (SR) \qquad (2)$$

where PLU is a prior land use subfactor; PC is a plant canopy subfactor; SC is a surface cover subfactor, and SR is a surface roughness subfactor. The individual subfactors can be obtained as follows:

$$PLU = 0.45\ EXP(-.012\ RS) \qquad (3)$$

where RS is the mass of roots and residue (kilograms/hectare/millimeter of depth) in the surface 100 millimeters of soil. At present, there are no adjustments in this subfactor to account for differences in grazing intensity. However, the coefficient 0.45 does express the long-term consolidation effects occurring on rangeland due to grazing. Other grazing effects, such as reduced canopy cover, different surface cover, or roughness changes, are reflected in other subfactors.

If the rangeland is tilled, the PLU is assumed as:

$$PLU = (1 - 0.08\ Y)\ EXP(-.012\ RS) \qquad (4)$$

where Y = years since disturbance by tillage; $Y \leq 7$ years.

The relationship of plant canopy to soil erosion was taken from Wischmeier and Smith (1978) and given as:

$$PC = 1 - FC(EXP(-\ 0.34H)) \qquad (5)$$

where FC is the fraction of the land surface covered by canopy, and H is the average canopy height (meters).

Surface cover creates small dams where runoff is temporarily ponded and eroded sediment may be deposited. The surface cover factor is expressed as:

$$SC = EXP(-3.5M) \qquad (6)$$

where M is the fraction of the land surface covered by nonerodible material such as litter, rock, and growing vegetation.

Surface roughness influences soil erosion by reducing runoff volume and velocity, and by ponding surface runoff to cause sediment deposition. The roughness of a surface is expressed as the standard deviation among heights along the surface perpendicular to the slope. The algorithm used to compute the subfactor is:

$$SR = EXP\left[-.026(RB-6)\left(1-EXP(-.035RS)\right)\right] \qquad (7)$$

where RB is surface roughness, and RS is as defined earlier. Tables and pictures for estimating RB are given in the document to assist the user in selecting the appropriate value for the condition being considered.

COMPUTER-ASSISTED EROSION TECHNOLOGY

If computer technology had been available in the 1940 to early 1960 period in any way comparable to that available today, current erosion prediction methods might more closely resemble the Ellison (1947) theory than the empirical form of the USLE. The USLE and its predecessors were structured for ease of use, and to assist planning activities such as the USDA Soil Conservation Service needs for specific farm, ranch, and field conservation programs. The Agricultural Research Service has recently initiated a multilocation and multidiscipline project to develop technology to replace the USLE.

USLE Replacement Technology

Although technology that is physically based has been reported in scientific literature (Foster and Meyer 1972; Simons and others 1977; Negev 1967; Huggins and Monke 1966; Foster and others 1980), all suffer from insufficient validation/experiments to provide parameter values to use a priori. Only the CREAMS model (Foster and others 1980) has received wide interest in USDA; yet even it suffers, because it requires considerable effort to develop input information. It is also relatively expensive to operate, although it has recently been run on personal computers.

The Water Erosion Prediction Project (WEPP), as the USLE replacement project is known, has set a number of conditions and constraints for the model as follows:

(1) Operate on a personal computer;

(2) have a climate-generating routine to simulate storm inputs on at least a daily basis;

(3) have a physically based hydrology routine to provide spatially variable runoff;

(4) have erosion routines for soil detachment and transport by raindrop impact and overland flow for both interrill and rill areas;

(5) have a concentrated flow erosion subroutine;

(6) route sediment for the size distributions as they erode;

(7) include sediment deposition in ponded areas, vegetated areas, and/or at changes in the energy grade line;

(8) consider a variety of topographic forms;

(9) sum soil loss over various time periods as the total of individual storm period soil loss;

(10) be capable of considering conditions for many types of land use (agricultural, urban, disturbed, rangeland, and forest land), and

(11) be "user friendly" so that estimates can be made with minimal effort, and that user errors in parameter estimation are minimized.

The effort, expected to take up to 5 years, is now well underway, and is expected to be applicable to both cultivated and rangeland. Of interest will be whether it will be able to handle the partial area runoff problem regularly encountered on pinyon-juniper areas, and whether it will adequately handle the snowmelt and rain on frozen soil problem. Unless the model can address these problems, additional technology will be required beyond this effort to assist with the pinyon-juniper erosion assessment problem.

DISCUSSION

The hydrology portion of the WEPP project has the important task of considering both temporal and spatial variability in infiltration characteristics. Whereas many hydrology models have used the runoff curve number model of the Soil Conservation Service, USDA (1972), it's anticipated that the current effort will utilize some of the recent progress in quantification of the parameters in the Green-Ampt infiltration relationship with soil properties and management factors such as Rawls and others (1983) have presented. When used with the kinematic flow equations and the use of cascading planes, hydrologic refinement can be accommodated to provide temporal and spatial variability including such topographic modifications as those associated with grassed waterways, ponds, and channels.

The sediment transport and yield part of the model might well be approached using the 1978 development of Shirley and Lane, where they expressed interrill erosion rate (E_I) as a function of rainfall excess rate (R):

$$E_I = K_I R \tag{8}$$

and rill erosion rate (E_R) as:

$$E_R = K_R(Bh^a - q_s) \tag{9}$$

where K_I, K_R and B are respectively interrill coefficient and rill coefficient. The depth (h) exponent (a) is usually assumed equal to the exponent in the kinematic flow equation (reflecting the conditions for laminar or turbulent flow) and q_s is sediment discharge per unit width of the plane.

Using the kinematic flow equations and equations 8 and 9, Shirley and Lane (1978) derived a sediment yield equation by integrating, with respect to time, the sediment continuity equation

$$\frac{\partial(ch)}{\partial t} + \frac{\partial q_s}{\partial x} = E_I + E_R \tag{10}$$

to produce a sediment yield equation as a function of position on the plane. The resulting equation for sediment yield per unit width of the plane, $Q_s(x)$, as a resultant of constant and uniform rainfall excess is

$$Q_s(x) = Q(x)\ [\frac{B}{K} + (K_I - \frac{B}{K})(\frac{1 - e^{-K_R x}}{K_R x})] \tag{11}$$

where Q(x) is runoff volume per unit width of the plane, and the other variables are described earlier. Equation 11 expresses the influence of slope length (x) on sediment yield in overland flow.

Experiments will be required, if such a series of algorithms are selected, to evaluate K_I, K_R and B for the many management and soil conditions for which the model might be used. Data are already available to permit many such evaluations from rainfall simulator experiments at the many locations where erosion experiments have been conducted. For pinyon-juniper areas, experimental data will be difficult to obtain with simulators on plots. As an alternative, small natural watersheds may be required so that individual plants will be contained completely within the experimental boundaries.

The WEPP project will also address the commonly encountered problem of sediment transport in concentrated flow areas. Thus, the technology should be applicable to more complicated topographic features, and will be applicable to estimates of sediment yield, rather than the material eroded from a small landscape element, such as was the case with the USLE.

SUMMARY

Erosion experiments in pinyon-juniper communities have not been conducted like they were on improved agronomic cropland. The spatial variability of the plant canopy poses difficulties when plots of the 12 x 72.6 foot size such as were used for the USLE technology are used. Mature pinyon-juniper plants are often difficult to locate within such a plot and certainly, the root system would be expected to extend well beyond the plot edges. Similarly, drop reformation, following interception by the canopy, might well fall outside the plot boundary. Thus it is difficult to apply USLE technology or even to use rainfall simulators to measure infiltration and erosion from a pinyon-juniper community.

To estimate erosion from a pinyon-juniper plant community, the best approach may be to use current analytical technology such as is being proposed in the USLE revision, which uses a subfactor approach for the estimation of the cover-management factor in the USLE. Better yet, the replacement technology (WEPP) being developed using physically based algorithms and the computing/simulation technology of digital computers offers a more realistic approach to erosion estimation. Of greatest concern, however, is that experiments will be required to provide data on erosion rates from some pinyon-juniper communities so that model parameters may be optimized with data which can then be used for apriori applications.

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