RUNOFF FROM NATURAL AND SIMULATED RAINFALL IN THE MULGA COMMUNITIES OF SOUTH WESTERN QUEENSLAND

A. J. Pressland* and J. K. Lehane

(Charleville Pastoral Laboratory, Queensland Department of Primary Industries, P.O. Box 282, Charleville, 4470.

** Present Address: School of Natural Resources, University of New England, Armidale, 2350)*

Abstract

Surface runoff in the mulga (*Acacia aneura* F. Muell.) lands of south western Queensland was recorded from small plots using both natural and artificial rainfall. Runoff was higher from the hard mulga and dissected residual land zones than from the soft mulga zone. Runoff was positively correlated with surface slope, soil bulk density and the fine sand component of the soil, and negatively correlated with plant dry matter, canopy cover and basal area, litter, and the coarse sand soil component. Emphasis is placed on the importance of maintaining adequate plant cover to reduce the deletarious consequences of surface soil and nutrient loss.

Introduction

The mulga (*Acacia aneura* F. Muell.) lands of Queensland may be classified as 1) Mulga Sand Plains 2) Soft Mulga 3) Hard Mulga and 4) Dissected Residuals (Dawson et al 1975). These authors state that the sand plains are stable, but the hard mulga and residuals are naturally unstable, and are made more so by misuse. Top feed has been reduced on the hard mulga and erosion of the soil surface has particularly occurred on those areas adjacent to more productive ones. Runoff is high on the residuals due to shallow soils and rocks, and steep slopes.

Although the soft mulga zone is stable in its natural state, mismanagement has lead to a reduction in ground cover, loss of soil, and an overall decrease in productivity. However, mulga regeneration on such areas is possible with sound management, and it is also possible the biomass of pasture may increase, although by which species is not clear.

It is generally agreed that water flow on the soil surface may be arrested to some degree by plant material (standing dry matter and litter), but it is increased through soil compaction by stock, and slope, among others. The work presented here was designed to study the effects of topographical, soil and plant variables on surface runoff in the soft mulga, hard mulga, and dissected residual land zones of south western Queensland. Preliminary results have been published previously (Pressland 1976a).

Materials and Methods

Two approaches were used in the measurement of runoff from small plots. Firstly, a number of permanent small runoff plots were installed from which surface runoff was collected and recorded following rain. Secondly, artificial rainfall was applied to small plots until a fixed quantity of runoff was recorded. The results from both methods were used to associate runoff with one or more topographical, soil, or vegetative features using correlation and regression analysis.

Permanent Runoff Plots

Twenty four micro-catchments were installed in the soft mulga zone under four densities of open mulga woodlands - 40, 160, 640 and 4000 trees ha^{-1} - as well as on areas cleared of mulga, both burnt and unburnt. A detailed site description was published previously (Pressland 1976b). The catchments were 2.4 m long and 1.2 m wide. At the down-slope side was a covered triangular concrete apron with an outlet hose leading to a 45 litre container. The plot walls were constructed of either galvanised iron or wood so that about 10 cm was below and 8 cm above ground level. The design was a modification of that described by Costin et al (1960). The soil was non cracking so walls 10 cm below ground level were considered adequate.

Runoff from each catchment was generally recorded following each fall of rain, although on a few occasions a number of events contributed to a single runoff recording. Rain was recorded from a rain-gauge placed within 10 m of the plot. Runoff was recorded from November 1972 to January 1974.

At the end of the period the soil and vegetative characteristics of the plots were measured. Soil bulk density in the 0 to 3 and 3 to 6 cm soil layers were estimated from five soil cores in each plot, except that in the five plots under 640 trees ha^{-1} bulk density of the 0 to 3, 3 to 4, and 4 to 7 cm soil depths were recorded. Soil strength was estimated from 20 readings with a soil penetrometer.

Basal area of the vegetation was recorded either from five line transects or direct measurement of the circumference of grass tussocks and forb stems with a flexible steel tape.

Canopy cover of the vegetation was estimated visually by two men working independently.

Standing dry matter was harvested two centimeters above ground level, dried in a forced draught oven and weighed.

Soil surface litter was swept off the ground surface and washed and dried before being weighed.

Surface slope over the area was less than one percent. Neither mulga tree density nor burning was included as a variable in the analysis.

Runoff from Artificial Rainfall

Two square frames one metre on side and 30 cm high were constructed from 6 mm armour plate steel. One side of one frame was equipped with four evenly spaced exit pipes 12.5 cm in diameter and situated 10 cm from the bottom. The second frame had a horizontal slit 6 mm wide cut along one side 10 cm from the bottom over which was welded a piece of 19 mm pipe on the outside of the frame. A Length of polyethelene pipe led from each exit to a 10 litre container which when filled from the 1 m^2 plot contained the equivalent of 10 mm of water.

Initially the frames were hammered into the ground to the level of the exit pipes, but because of rocks, in most instances it was necessary to dig a narrow trench into which the frame was fitted and the earth tamped tightly around. A hole was dug for the 10 litre container so water could gravitate into it from the enclosed surface.

Water was applied through a modified shower rose from a 1360 litre tank using a 4 hp Briggs and Stratton motor connected to an unmodified sheep jetting pump, of 38 mm inlet and 12.5 mm outlet. Rate of application was maintained as close as possible to 100 mm h^{-1}, although on a few occasions the rate fell to 85 mm h^{-1}. The shower rose was clamped into position 20 cm above ground level so a vertical stream of water was applied upwards which subsequently fell to the ground with a terminal velocity of 7.1 m sec^{-1}, similar to natural rainfall (Smith and Smith 1950). Water from either a household tank or a farm dam was used to minimise the effects of salts present in the more readily available bore water.

A galvanised pipe frame three metres square and three metres high and covered with canvas was erected around the plot to minimise the effects of wind. It was necessary to tie the frame down with guy ropes in gusty conditions.

Water was applied until the collection container was full or for 90 minutes whichever occurred first. The period of application was measured with a stopwatch. The application rate was checked at the start and completion of the run. Runoff was expressed either as a percentage of water applied, or as time taken for 10 mm of water to run off.

Sixteen sites were selected for runoff determination, 10 in the soft mulga zone, and three each in the hard mulga and dissected residual zones. At each site runoff from six plots was recorded. The position of each plot was selected so that a range of pasture biomass between least (usually none) and most was recorded.

At the completion of runoff recordings at each site, the following details of each plot were recorded:

1. Bulk density of the 0 - 3 and 3 - 6 cm soil depths were estimated from three samples using a 5 cm diameter core sampler.

2. Standing dry matter of vegetation was clipped as close to the ground as possible. The vegetation was oven dried and shaken to remove soil particles before being weighed. No attempt was made to separate living from dead material.

3. Surface litter (decaying vegetation, sticks and animal faeces etc.) was collected, oven dried and sieved to remove soil particles, separated into vegetation and faeces, and wood, and weighed.

4. The percentage ground surface covered by the base of plants (basal area %) was recorded as the length of plant base intercepts on six line transects across the plot, three parallel to each side of the plot. Where only a few plants were growing within the plot, the circumference of individual plant tussocks was recorded with a flexible steel tape.

In addition to the individual plot data, the surface slope of each site was recorded with a surveyor's theodolite and staff, and soil samples for mechanical analysis at each site were taken. Surface soil samples from within all plots at each site were thoroughly mixed. One hundred gram samples were taken and digested in a 5% hydrogen peroxide solution to remove the minimal organic matter. Coarse sand (2.0 - 0.2 mm) was separated by passing the soil suspension through a sieve, and the silt and clay fractions (0.02 - 0.002 mm and less than 0.002 mm respectively) were found by the hydrometer method. Fine sand (0.2 - 0.2 mm) was found by subtraction.

Runoff was recorded from soil which was air dry to a depth of at least 30 cm (determined visually), although runoff was collected from a few plots one day after the soil was wet to 30 cm.

Results

Permanent Runoff Plots

The soil and vegetation characteristics of the permanent runoff plots (Table 1) show the low vegetative biomass, basal area % and surface litter typical of the mulga understory. Soil bulk density is high ranging from 1.36 gcm^{-3} to 1.59 gcm^{-3} in the 0 - 3 cm layer, and from 1.47 gcm^{-3} to 1.57 gcm^{-3} in the 3 - 6 cm layer. The bulk density at depths of 3 - 4 and 4 - 7 cm of the plots under 640 trees ha^{-1} are in most cases much higher than those of the other plots.

The soil strength data were too variable (Table 2) to be used in the correlation analysis. Coefficients of variability (standard deviations %) as high as 73% were found within plots under dry soil conditions. Strength recordings on dry soil were more variable than those on wet soil.

TABLE 1

Vegetation and soil characteristics of natural rainfall plots

Plot		Plant Canopy Cover %	Basal area %*	Dry matter (g)	Litter (g)	Soil bulk density (g cm^{-3}) 0-3 cm	3-4 cm	4-7 cm	3-6 cm
cleared	1	73	1.7 (0.7)	1390	700	1.47 ± 0.05	NA	NA	1.50 ± 0.02
	2	77	3.2 (1.2)	1330	500	1.48 ± 0.06	NA	NA	1.50 ± 0.08
	3	95	2.6 (1.1)	1110	740	1.38 ± 0.07	NA	NA	1.48 ± 0.10
	4	80	1.5 (0.8)	910	580	1.48 ± 0.07	NA	NA	1.55 ± 0.05
40 trees ha^{-1}	1	83	1.5 (0.4)	1800	900	1.50 ± 0.10	NA	NA	1.55 ± 0.09
	2	77	1.3 (0.6)	550	1210	1.42 ± 0.05	NA	NA	1.48 ± 0.10
	3	87	3.6 (0.8)	1060	1220	1.47 ± 0.05	NA	NA	1.51 ± 0.13
	4	70	1.0 (0.3)	940	550	1.48 ± 0.04	NA	NA	1.50 ± 0.11
	5	95	3.2 (0.8)	1690	830	1.44 ± 0.08	NA	NA	1.50 ± 0.07
160 trees ha^{-1}	1	18	0.7 (0.5)	230	280	1.52 ± 0.06	NA	NA	1.54 ± 0.06
	2	90	2.3 (0.8)	930	580	1.53 ± 0.06	NA	NA	1.51 ± 0.15
	3	30	0.7 (0.3)	200	500	1.52 ± 0.07	NA	NA	1.57 ± 0.05
	4	100	3.2 (1.3)	2000	1230	1.43 ± 0.09	NA	NA	1.49 ± 0.09
640 trees ha^{-1}	1	33	1.2	110	740	1.48 ± 0.08	1.51 ± 0.15	1.62 ± 0.05	NA
	2	10	0	0	550	1.59 ± 0.09	1.65 ± 0.09	1.64 ± 0.05	NA
	3	25	0.1 (0.1)	120	1290	1.46 ± 0.01	1.65 ± 0.04	1.65 ± 0.09	NA
	4	33	0.4 (0.2)	100	490	1.39 ± 0.05	1.72 ± 0.13	1.69 ± 0.10	NA
	5	22	0.3 (0.3)	100	670	1.52 ± 0.08	1.72 ± 0.08	1.60 ± 0.09	NA
4000 trees ha^{-1}	1	**	0	0	870	1.41 ± 0.07	NA	NA	1.47 ± 0.05
	2	**	0	0	1140	1.46 ± 0.11	NA	NA	1.56 ± 0.06
	3	**	0	0	860	1.41 ± 0.05	NA	NA	1.50 ± 0.12
	4	**	0	0	650	1.43 ± 0.08	NA	NA	1.50 ± 0.11
cleared & fired	1	15	0.5 (0.5)	430	40	1.47 ± 0.10	NA	NA	1.58 ± 0.04
	2	<5	0.1	0	0	1.36 ± 0.06	NA	NA	1.47 ± 0.12

* standard errors in brackets   NA: not applicable

** these plots supported varying numbers of young trees

TABLE 2

Variability of dry soil strength of selected natural rainfall plots

Plot		Penetrometer reading* (kPa)	Standard deviation	Coefficient of variability (%)
cleared	1	6920	2960	43
	2	6100	3250	53
	3	5440	2670	49
	4	8940	3960	44
40 trees ha^{-1}	2	8870	2210	25
	3	8520	4320	51
	4	4620	1960	42
	5	6390	3340	52
160 trees ha^{-1}	2	7660	4680	61
640 trees ha^{-1}	1	4840	2380	49
	2	3350	2460	73
	3	7660	4680	61
4000 trees ha^{-1}	1	4810	3410	71
	2	11870	5210	44

*Mean of 20 readings

Runoff recorded from all plots following rain in excess of 10 mm is shown in Table 3. Runoff from some plots often exceeded the capacity of the container (45 litres), so it was necessary to use only those data which were complete in the correlation analysis. This lead to the analysis of data from only seven runoff periods. Litter and canopy cover were generally negatively correlated with runoff while basal area and dry matter were of lesser importance (Table 4).

Positive correlations between runoff and bulk density were found in most cases, but in only three instances was the correlation significant at $P<0.1$. In these three cases, the soil surface was wet from previous rain, and in two there was no associated significant correlation between runoff and vegetation characteristics (Table 4).

There is some evidence to suggest that correlations of vegetation parameters with runoff increased with rainfall aggregate. The absence of correlations between runoff and many of the plant/soil factors is probably due in part to the rain characteristics, particularly intensity, which although measured, was not relation to the runoff data in the analysis.

Artificial Rainfall Plots

The biomass of vegetation and litter was also low on the artificial rainfall plots, ranging from 0 to 1095 gm^{-2} and 0 to 760 gm^{-2} respectively. Wood litter on a few plots added up to 2800 gm^{-2} to the litter component. The biomass of both these components was greater on the soft mulga than hard mulga or dissected residuals. Plant basal area was also higher on the soft mulga (up to 21%), than on the hard mulga or residuals (up to 2.6%).

The degree of slope ranged from 0 to 5.7%, the lowest on the soft mulga and the highest being on the dissected residuals.

Bulk density of the soil was higher on the hard mulga and residuals than the soft mulga. Bulk density in the former zones were 1.73 (SD 0.15) and 1.73 (SD 0.12) gcm^{-3} respectively in the 0 - 3 cm and 3 - 6 cm depths, compared with 1.56 (SD 0.10) and 1.56 (SD 0.11) gcm^{-3} respectively in the soft mulga zone.

Fine sand fraction of the soil was higher in the hard mulga and residuals than the soft mulga (75%, SD 4%, compared with 70%, SD 7%), but the reverse was the case for the coarse sand component (12%, SD 4% compared with 20%, SD 6%).

Higher correlations between runoff and the topographical, soil and plant parameters were found under the artificial rainfall study than the natural rainfall one. As the correlations obtained when runoff was expressed as runoff % and time were similar, only the former are discussed. Runoff % was positively correlated with bulk density in the 0 - 3 cm soil profile ($P<0.01$), fine sand % ($P<0.01$), fine sand % ($P<0.01$) and slope % ($P<0.01$), and negatively correlated with dry matter ($P<0.01$), litter other than wood ($P<0.01$), dry matter + other litter ($P<0.01$), dry matter + wood ($P<0.05$), basal area % ($P<0.01$), and the coarse sand fraction of the soil ($P<0.01$) (Table 5).

TABLE 3

Runoff from natural rainfall plots at selected recording dates (litres)

Date	Plot	9/11/72	27/11/72	29/11/72	8/12/72	27/1/73	12/2/73	18/2/73	20/2/73	1/5/73	9/7/73	21/7/73	17/8/73+	2/10/73	9/10/73	19/10/73	27/10/73	8/11/73	24/11/73	14/12/73	10/1/74	14/1/74	31/4/74
Precipitation (mm)		13.5	102	19.5	10.3	22	82	165	42	40	32	38	38	19	34	22	18	20	48	26.6	71.2	54	64
Cleared	1	22.8	*	11.4	20.5	*	*	*	*	*	4.6	27	18.2	25	41	25	4.6	0.1	34.1	27	2.3	29.6	6.8
	2	4.6	6.8	2.3	6.8	3.4	13.7	*	45	6.8	0.1	4.6	0.1	0	0.1	0.1	0.1	0.1	2.3	20.5	10	14	13.5
	3	0	8	0	4.6	0.1	45	>91	29.6	9.1	0.1	0.1	0.1	0	0.1	0.1	0	0	4.6	2.3	0.1	6.8	0.1
	4	0	*	2.3	NA	33	*	>91	30**	*	0.1	0	0	0	0.1	2.3	0	0.1	13.7	6.8	3.5	33	9.1
40 trees ha^{-1}	1	0	22.8	0.1	0.1	21	*	*	*	29.6	4.6	4.6	1.1	2.3	9.1	2.3	4.6	0.1	0.1	14	5	14	0
	2	4.6	*	4.6	4.6	2.3	*	*	*	31.9	0.1	18.2	4.6	13.7	5	10	6.8	1.1	9.1	25	13.7	22.8	9
	3	4.6	NA	2.3	2.3	34.1	2.3	0.5	*	0.1	0.1	2.3	0.1	0	0.1	1.1	0.1	0.1	13.7	17	8	13.7	4.6
	4	0	4.6	0.5	0.1	2.3	4.6	11.4	0.1	4.6	0.1	2.3	1.1	0	0.1	0.1	0.1	0.1	9.0	3.0	3.5	11.4	2.3
	5	27	*	0.5	4.6	8.0	6.8	43.2	*	*	2.3	31.9	13.7	19	2.3	34.1	1.1	2.3	23.5	36.4	27	*	34.1
160 trees ha^{-1}	1	20.5	*	11.4	22.8	*	*	*	*	*	4.6	*	25	27	*	*	19	0.1	41	45	43.2	*	*
	2	4.6	*	2.3	4.6	18.2	4.6	*	*	18	4.6	9.1	15.9	0	41	27	4.6	0.1	4.6	30.5	22.8	*	34.1
	3	0	*	1.1	1.1	25	45	*	*	36.4	2.3	4.6	4.6	4.6	4.6	27	2.3	1.1	31.9	29.6	41	*	15.9
	4	0	4.6	0	0	1.1	4.6	25	45	0	0	0	0	0	0.1	0	0	0	2.3	4.6	2.3	4.6	5
540 trees ha^{-1}	1	0	11.4	0	0	22.8	*	*	45	*	0.1	18.2	0.1	0	2.3	2.3	0.1	0	15.9	4.6	9.1	*	31.9
	2	9.1	37	27	NA	28	*	*	*	NA	0.1	36.4	8	0	34.1	18.2	0.1	0	25	11.4	20.5	*	38.7
	3	0	NA	0	0	2.3	*	NA	45	13.7	0	0.1	0.1	17	0.1	0.1	0.1	0	2.3	25	5	NA	14
	4	2.3	45	0	0	14	45	*	12	45	0.1	2.3	0.1	4.6	15	2.3	0	0	22.8	25	5	45	0.1
	5	4.6	*	0.5	2.3	23.5	45	*	36.4	45	0.1	31.9	9.1	10	28	18.2	0	0.1	45	29.6	16	45	27
4000 trees ha^{-1}	1	0	*	0	0	3.4	*	*	*	18.2	0	0.1	0	0	18.2	2.3	0	0	0	27	6.8	45	22
	2	4.6	*	4.6	2.3	11.2	*	*	*	18.2	2.3	9.1	11.4	9.1	19	20.5	5	1.1	4.6	14	9.1	*	43.2
	3	2.3	9.1	0	1.1	6.8	45	*	20.6	15	0	4.6	3.4	0	18.2	9.1	0.1	0.1	25.5	12	2.3	29.6	14
	4	2.3	*	0.1	0.1	12	45	*	*	4.6	0	2.3	0.1	3.4	11.4	2.3	0.1	0.1	18	6.8	9.1	*	15.9
Cleared + fired	1	NA	*	NA	NA	NA	NA	*	45	9.1	0.1	22.8	4.6	2.3	1.1	0.1	1.1	0	*	21	41	45	*
	2	NA	*	NA	NA	NA	NA	*	45	36.4	4.6	NA	9.1	6.8	0.1	4.6	3.4	3.4	*	14	43.2	38.7	6.8

*exceeded 45 litre storage capacity ** collection tin upset; probably > than this

+ 15 mm 9/8/73; 7 mm 13/8/73; 16 mm 17/8/73 NA: not available

TABLE 4

Correlation coefficients between runoff and various soil/plant parameters for seven rainfall events

Rain (mm)	Date	Vegetation Characteristics Canopy cover	Basal area	Dry matter	Litter	Soil bulk density 0-3 cm	3-6 cm
22	27/ 1/73	-0.57**	-0.43+	-0.33	-0.76**	-0.02	-0.06
22	19/10/73	-0.27	-0.26	-0.24	-0.32	0.43+	-0.03
34	9/10/73	-0.28	-0.24	-0.22	-0.27	0.47*	0.13
38	21/ 7/73	-0.49*	-0.41+	-0.38	-0.42+	0.36	0.04
48	24/11/73	-0.67**	-0.55*	-0.48*	-0.75**	-0.14	0.06
64	31/ 1/74	-0.51*	-0.37	-0.38+	-0.54*	0.43+	0.15
71	10/ 1/74	-0.63**	-0.52*	-0.52*	-0.73**	0.21	-0.03
Overall		-0.61**	-0.50*	-0.45*	-0.69**	0.29	0.05

Significance is shown by:
+ $P<0.1$
* $P<0.5$
** $P<0.01$

The correlations of most interest are those of runoff % with soil bulk density and percentage sand, plant litter, dry matter and basal area %, and slope %.

The multiple regression analysis indicates that the functions which can be used most satisfactorily for runoff prediction in this semi-arid environment are the soil bulk density and the fine sand and silt fractions of the soil, plant dry matter and basal area, and litter. The relationship with the highest R^2 value and the smallest number of variables (indicated by the C.P. Statistic) is shown in Table 6, together with the relevant significance tests.

Discussion

Both methods of studying the effect of topographical, soil and plant parameters on runoff yielded similar results. The probability of runoff occurring is higher on soils of high bulk density, and ones containing a large percentage of fine sand and silt, than on soils of low bulk density, and ones containing a lower percentage of fine sand but an increased amount of coarse sand; plant litter and standing plant material suppress runoff, and areas of high plant basal area possesses lower runoff tendencies.

However, surface slope may have a marked effect on these generalities. There was no correlation between slope and quantity of dry matter upon it, but litter (apart from wood) was negatively correlated with slope. In other words, the greater the slope the less the litter. Observations show that surface litter is greater on areas of low slope and at the base of ridges or slopes. The lack of correlation between plant dry matter and basal area, and degree of slope, indicates that runoff is not likely to be reduced by improving the body of herbage growing on ridges in mulga country - areas which have a notoriously high runoff potential (Dawson and Boyland 1974). Rather, soil surface bulk density and slope % will tend to dictate the runoff potential of the hard mulga and dissected residual zones. It is therefore most unlikely that stock management on such areas will succeed either in improving pasture basal area and biomass or reducing runoff.

However, it is probably that stock management to maintain a basal cover of about 3% on the lower slopes and flats will result in less surface water movement and greater infiltration of rain water into the soil. The removal of standing plant biomass and litter through extended periods of over-grazing by domestic stock and wildlife (including insects), or by fire, will tend to increase runoff and together with increased wind and water erosion - particularly on the hard mulga land zones and dissected residual land zones - will inevitably lead to poorer conditions for germination and establishment of plants (Condon et al 1967). In particular, surface soil moisture, organic carbon, and nitrogen will be considerably reduced. Under such conditions, major changes to the soil surface conditions will be necessary to encourage increased soil water availability and thus plant growth. Ripping, ploughing and pitting are mechanical methods available to the grazier but in the present state of the rural sector, it is unlikely that such techniques are financially feasible even if the manpower is available.

TABLE 5

Correlation coefficient between runoff % recorded from artificial rainfall and the independent variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Bulk density 0-3 cm	1.00												
2 " " 3-6 cm	0.73	1.00											
3 Dry matter	-0.15	-0.04	-1.00										
4 Wood litter	-0.10	-0.13	-0.01	1.00									
5 Other litter	-0.44	-0.20	0.20	-0.05	1.00								
6 (3+5)	-0.16	-0.13	0.51	0.86	0.06	1.00							
7 (3+4)	-0.35	-0.14	0.84	-0.04	0.71	0.40	1.00						
8 Basal area %	-0.39	-0.28	0.59	0.14	0.20	0.43	0.54	1.00					
9 Slope %	-0.06	-0.11	0.06	0.18	-0.34	0.19	-0.15	-0.10	1.00				
10 Soil clay %	0.37	0.35	-0.22	-0.03	-0.30	-0.14	-0.33	-0.12	-0.05	1.00			
11 " silt %	-0.14	-0.37	-0.11	0.07	0.15	<0.01	<-0.01	<-0.01	-0.20	-0.03	1.00		
12 " coarse sand %	-0.40	-0.40	0.19	0.08	0.10	0.17	0.20	0.34	-0.19	-0.21	0.00	1.00	
13 " fine sand %	0.34	0.36	-0.14	-0.07	-0.09	-0.13	-0.16	-0.31	0.27	0.03	-0.12	-0.97	1.00
Runoff %	0.33	0.07	-0.44	<0.00	-0.41	-0.23	-0.55	-0.60	0.32	0.07	0.15	-0.34	0.34

Values to be exceeded for significance at $P<0.05$: 0.22
$P<0.01$: 0.29

TABLE 6

Regression coefficients and significance tests of the best "compromise" equation relating runoff percent to plot variables

Variable	Regression Coefficient	S.E. of Coefficient	T
BD03	29.0825	13.2852	2.19 *
BD36	-23.7548	13.3896	1.77
DM+other litter	- 0.0161	0.0060	2.67 **
Basal area %	- 1.6716	0.4010	4.17 **
Slope %	1.9545	0.6607	2.96 **
Silt %	2.4024	1.1829	2.03 *
Fine sand %	0.3352	0.2020	1.66
B(0)	5.3041	20.2825	

$R^2 = 0.56$

R^2 (adjusted) = 0.53

C.P. statistic = 6.18

Analysis of Variance

Source of variation	DF	Sum of squares	Mean squares	Variance ratio
Regression	7	15356.2	2193.74	16.352 **
Residual	89	11940.2	134.159	

It is inevitable though that some deterioration of mulga landscapes will occur - if not from the extended periods of drought common in the mulga regions, then from the continuance, through financial necessity, of maintaining too many animals on too small an area for too long.

The multi-regression analysis showed that only 56% of the variation in runoff from the artificial rainfall plots could be accounted for by the physical variables measured, leaving 44% unexplained. Some of this may have been due to irregularity of the rate of water application (85 to 100 mm h^{-1}). However, as even 85 mm h^{-1} is high, it is not considered probable. Surface roughness, presence of rocks, and type of ground cover (e.g. tussock grasses compared with prostrate broad leafed herbs) may be important additional factors. Notes were taken on these factors, but they were considered to be too subjective to be incorporated in the correlation analysis. The inclusion of a grazing intensity factor may have also increased the percentage of explained variability in runoff, although Rauzi and Smith (1973), working in the rangelands of the U.S.A., found that the grazing intensity of cattle had no significant effect on water infiltration into some sandy soils. They did however, find that infiltration on other loam soils was greater under low (0.6 beasts h^{-1}) to moderate (0.8 beasts ha^{-1}) stocking than under heavy (1.4 beasts ha^{-1}) stocking.

Acknowledgements

Mr. C. Palmer and Mr. R. G. McIntyre provided able assistance in the field. The statistical analysis of the artificial rainfall results was carried out by officers of Biometry Branch, Department of Primary Industries, Brisbane. Finance for the study was provided by the Australian Wool Corporation.

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