PRODUCTIVITY OF *ERAGROSTIS ERIOPODA* IN A MULGA COMMUNITY

M. A. Ross* and C. Lendon*

ABSTRACT

Temporal and spatial factors affecting the productivity of Eragrostis eriopoda *in a groved stand of mulga have been examined. Relative productivity of different phases in the grove/intergrove system is examined and differences attributed to water distribution between phases.*

A simple simulation model of the course of Eragrostis *biomass with time, as affected by rainfall, growth, and grazing is presented.*

INTRODUCTION

Primary productivity is the fixation of solar energy as plant material. In the arid zone solar energy is rarely limiting, so the dynamics of productivity are more usefully related to the most important limiting factors, plant material and soil moisture.

Heavy rainfall is infrequent and the soil moisture is rapidly extracted, so that most periods of available soil moisture are discrete events. Perennial understorey species respond rapidly to rainfall but the germination requirement of annual species delays their response and their composition varies greatly with the season and duration of rainfall events.

Where grazing during the growing period is negligible, estimates of peak standing biomass produced in response to a given rainfall,indicate the maximum productivity of the community.

Measurement of peak standing biomass of the understorey of a dead mulga grove near Alice Springs was reported by Perry (1970). In response to 144 mm of rainfall in the preceding three months, 2454 kg/ha of grass and forbs was produced on a site ungrazed by domestic stock.

Where communities are grazed during the growing period, productivity becomes a more dynamic concept with the level of biomass itself affecting productivity relative to potential productivity. When the growth rate is reduced the proportion of moisture used in transpiration is also reduced relative to that lost through soil surface evaporation or drainage from the profile.

THE LOCATION

The experiments reported in this paper were done on Kunoth Paddock, Hamilton Downs Station, 40 km north-west of Alice Springs, N.T. The paddock is 15,300 ha in area and consists of gently sloping alluvial plains and fans on the northern flanks of the Macdonnell Ranges. Fifty-three per cent of the area is mulga country on stable plains classified by Perry *et al.* (1962) into two land systems, *viz* Bushy Park and Boen.

The soils of both land systems are mainly gradational red-earths with surface textures ranging from loamy sands to sandy clay loams and becoming finer-textured at depth.

On Boen land systems the mulga trees are aggregated in groves varying from 20 to 400 metres long and 5 to 40 metres wide, few if any trees occurring on intergroves.

Mulga groves are run-on areas favourable for plant growth, and commonly support drought-tolerant perennial grasses and shrubs, particularly on the margins.

---

* CSIRO Rangelands Research Unit, Alice Springs Field Centre, Alice Sprints, N.T., Australia.

Typical species are *Eragrostis eriopoda, Danthonia bipartita, Thyridolepis mitchelliana, Eremophila gilesii, Eremophila latrobei.* The run-off intergrove supports less dense stands of plants.

Kunoth paddock receives an annual rainfall of about 250 mm. Pan evaporation in Alice Springs ranges from 10.6 mm/day in December to 3.1 mm/day in June. At Alice Springs the mean maximum screen temperature for the hottest month is 35.2°C, suggesting that high temperature is unlikely to inhibit growth of *Eragrostis eriopoda* which has a temperature optimum of 42°C (Ross, unpublished data).

EXPERIMENTAL

Two types of experiment are reported in this paper. In the first, growth curves of *Eragrostis eriopoda* were defined in a variety of field situations in response to 2 rainfall events. In the second, the growth curve of *E. eriopoda* was determined along with simultaneous measurements of soil moisture. Data from this experiment were used to construct a simple mathematical model of plant growth.

Community productivity estimates

Method

Five phases, representing different sections of the grove/intergrove pattern were selected as follows:

(A) A depression on the upslope margin of a grove.
(B) Similar to A on a different grove.
(C) Downslope margin of the same grove as A.
(D) Similar to C, with a high density of *Eremophila gilesii.*
(E) Intergrove area.

Biomass estimation

Periodic weight estimates were taken, using a double sampling technique whereby each major species was visually estimated in blocks of one m^2 fixed quadrats which had been stratified on the basis of biomass. Fifty quadrats were estimated in each of phases A to D and 200 in phase E. Up to 20 additional quadrats of each major species were visually estimated then clipped to obtain dry weights of individual species. Observer calibration curves were constructed from the clipped plot data and used to transform visual estimates.

Results

Curves in Fig. 1 represent the course of *Eragrostis eriopoda* biomass production in the absence of grazing by domestic stock. Initial growth occurred in response to 44 mm of rain falling between 17th and 21st November 1971. A second growth period occurred after 186 mm fell between the 1st and 5th March 1972. Interpolations of curves between points for the dry period prior to March rain are hypothetical.

Discussion

The response of *Eragrostis eriopoda* to 44 mm of rain falling during the third week in November is illustrated by the first growth period in Fig. 1. In Phase A, free from mulga competition and supporting a high level of biomass, 683 kg/ha dry matter were produced during the growth period. Plants in Phase B, also a favoured area, started from a low level and produced 210 kg/ha. Phase D, showed a growth pattern similar to A and B but produced only 31 kg/ha, perhaps partly due to competition from *Eremophila.* The intergrove areas, represented by Phase E, apparently received

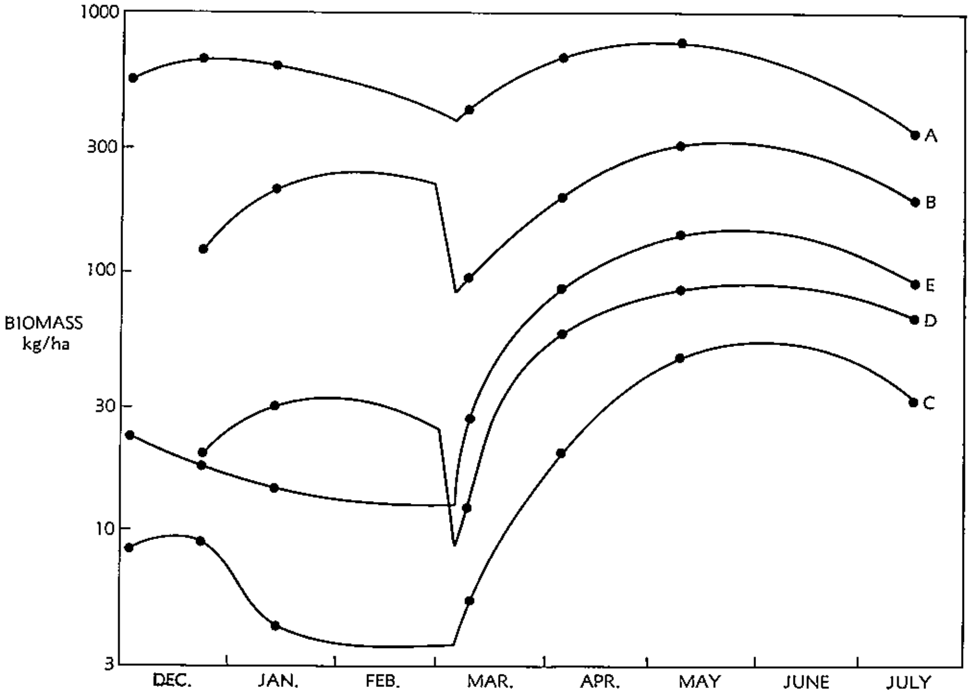

FIGURE 1
The course of biomass of *Eragrostis eriopoda* with time following rain in November, 1971 and March, 1972. A, B, C, D, and E curves are explained in the text.

negligible infiltration from the November rainfall which promoted plant decomposition rather than growth. Phase C, on the lower side of a grove, behaved similarly to E.

The response of *Eragrostis eriopoda* to the March rainfall was similar for all phases. Such similarity suggests that, in general, plant density was well matched to the amount of moisture available at each site, and that moisture lasted for about the same period in each phase. However phases supporting low initial biomass grew faster than those of higher biomass and attained peaks much higher than those of the first growth period. The higher observed growth rates in the less favoured areas may have been due to more moisture available per unit of plant density than the more favoured areas. This suggestion is supported by the fact that the peak biomass occurred earliest in the favoured areas and latest in the lower producing phases.

Plant productivity and soil moisture extraction

Method

An area of *Eragrostis eriopoda,* near the previous site and typical of local mulga lands was flooded with approximately 150 mm of water in August after mowing to 1 cm high. Plant biomass and soil moisture measurements were made periodically.

Biomass was estimated on 25 two metre square vegetated plots by the double sampling technique described above, using 32 plots to obtain the calibration relationship.

A neutron moisture meter was used to determine soil moisture in 9 vegetated plots and 5 plots from which vegetation was removed. Readings were made at 10 cm intervals to 80 cm and 20 cm intervals to 140 cm. Regression coefficients of volumetric soil moisture on neutron counts did not differ significantly between depths, even as shallow as 10 cm.

Evaporation was measured on automatically-recording Class A pans, situated 6 km and 10 km from the site.

During the growth period a number of kangaroos broke the enclosing fence and quickly and uniformly grazed the vegetation to 6 kg/ha. Growth continued to November when soil water was recharged by rainfall and when the whole area was mown again.

The Model

From the initial values of plant biomass, soil water content, and the daily value of pan evaporation, the growth of plants and the loss of water from the soil were calculated for one day by relationships derived from the experimental data.

1. The growth rate of *Eragrostis eriopoda* was related to the available soil moisture, biomass and pan evaporation and was fitted by the quadratic expression:

$$\triangle B = 0.9 + 2.11 \times 10^{-4} \times (M \times B \times Ep) + 2.26 \times 10^{-9} \times (M \times B \times Ep)^2$$

where $\triangle B$ is the change in biomass (B) in kg/ha/day.

M is the moisture content of the 0-140 cm soil profile less 205 mm which is the level of soil moisture at which growth ceases.

Ep is Class A pan evaporation in mm/day.

2. The rate of total moisture loss from the soil is made up of a transpiration component related to changes in biomass and a soil evaporation component estimated as a function of time and the degree of vegetation cover. It was assumed that biomass of 1000 kg/ha gives a complete canopy and prevents soil evaporation.

$$E = \frac{\triangle B + 0.51}{15} + Eb\,(1 - B \times 10^{-3})$$

and $$Eb = 5.71 - 2.33 \log (t) + 0.24 \log (t)^2$$

where E is evapotranspiration loss in mm/day.

Eb is the evaporation from bare soil in mm/day.

t is time from initial recharge in days.

After calculating the daily change, biomass and soil water content were adjusted to their new values which became input levels for the next day together with another daily evaporation figure. A computer programme was written to handle the calculations. During the course of the simulation the biomass was reduced at the appropriate times to reflect the mowing and grazing treatments and the soil water content increased according to amount of recharge after each of 3 rainfalls.

Results

The biomass of *Eragrostis eriopoda* and the total soil moisture content are plotted against time from irrigation in Figs. 2a and 2b respectively, in which points are observed values and lines are drawn from the daily values calculated in the model. The occurrences of mowing, grazing and soil water recharge are shown also.

Discussion

The simulation exercise with an unvalidated model shows that data from a number of growing periods provide relationships which reproduce individual growth curves. The climatic component of plant growth was satisfied by pan evaporation, an abstract parameter which conveniently integrates the influences of solar radiation, wind speed and above ground temperature and humidity. The over-estimation of

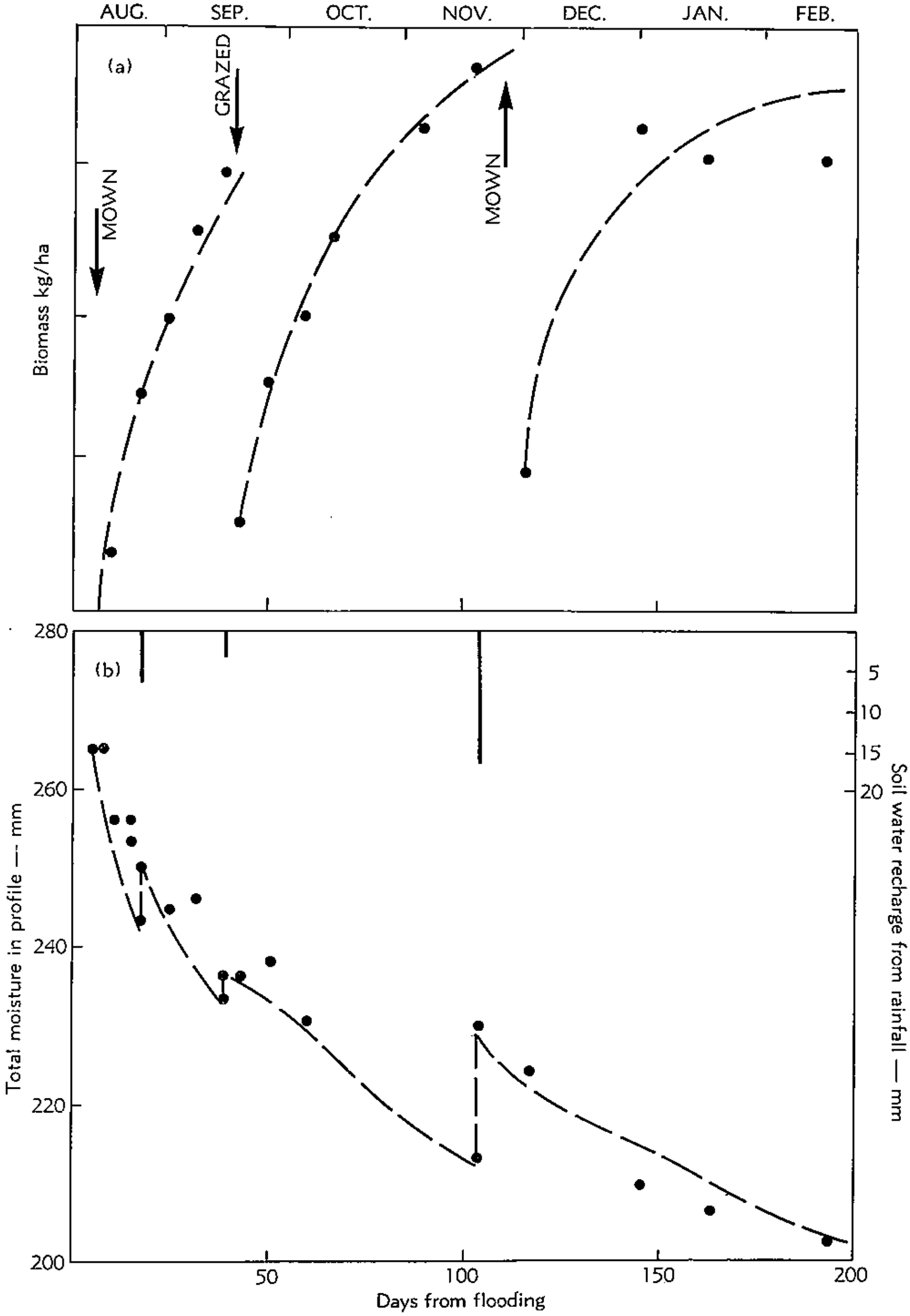

FIGURE 2a
The course of biomass of *Eragrostis eriopoda* with time from flooding, mowing and grazing, both as observed (.) and simulated (- - -).

FIGURE 2b
The course of total moisture in the soil profile with time from flooding and rainfall, both as observed (.) and simulated (- - -). Bars represent soil moisture recharge following rainfall.

biomass by the model in the January-February period (see Fig. 2a) probably relates to an under-estimation of evapotranspiration rate at that time giving higher moisture contents than actually observed (see Fig. 2b). The error is likely to be in the soil evaporation component where the over-simple rate function was based on observed evaporation from artificially bared plots, the best data available at the time of writing.

CONCLUSIONS

The productivity of *Eragrostis eriopoda* was examined in its ecosystem context from which the interaction between site (phase) and rainfall can be attributed to water flow between the phases influencing the amount of water entering the soil. Analysis of data on soil water contents at the various phases following rain will elucidate further the differences in productivity.

The growth of *Eragrostis eriopoda* was reproduced using a simple water budget model. Discrepancies between observed and computed biomass and soil water contents suggest that functions used to calculate soil evaporation rate need revision.

ACKNOWLEDGEMENTS

The authors wish to acknowledge with thanks, Messrs J. M. Edwards and A. R. Johns for their technical assistance, and to Mr R. W. Millington for supplying meterological data.

We also thank Messrs R. N. D. Millar and T. W. Prior of Hamilton Downs Station for their extensive co-operation.

REFERENCES

Perry, R. A. (1970). The effects on grass and browse production of various treatments on a mulga community in central Australia. Proceedings of the XI International Grassland Congress. University of Queensland Press, St Lucia, p. 63.

Perry, R. A., Mabbutt, J. A., Litchfield, W. H., and Quinlan, T. (1962). Land Systems of the Alice Springs Area. CSIRO Land Research, Series 6: 20.