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BASAL AREA, DRY WEIGHT AND SIZE DISTRIBUTION OF INDIVIDUAL PLANTS OF SOME RANGELAND GRASSES.

by

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A number of different criteria have been used to determine the response of rangeland to management and as an index of range condition (Parker, 1954). The most common methods involve estimates of the weight of herbage per unit area (Brown,1954) and/or species composition by weight (Pechanec and Pickford, 1937), or by basal area/cover (Roberts etal, 1976). The dry matter produced by individual plants of certain grasses in the rangelands of the Northern Tablelands of New South Wales has also been observed to respond to management and may be a useful criterion for such studies. However, most of the available techniques for estimating weight use 'quadrats' of various shapes and sizes and emphasize production per unit area. Such data often mask much information on the response of individual species to manipulation and on the process of changes in species composition. Furthermore, changes in the dry matter production per plant of key species (Sampson, 1952) may be a sensitive indicator of changes in range condition.

Work with individual plants has been hampered by the lack of effective means of standardizing plant weights for comparative purposes. Measurement of the basal area of individual plants would appear appropriate in this respect. However, measurement techniques such as Pearse (1935) and Vose (1956) suffer from the limitation that they assume that plant bases are regular in outline and that all within the outline of a plant base so defined is actually basal area. In reality, the measure consists of the cross-sectional area of both live and dead stems, as well as the area of airspace at the plane of harvest. The relative proportion of live stems, dead stems and airspace can vary tremendously from plant to plant and from species to species. Therefore, any device for estimating the cross-sectional area of only live stems must have an integrative capability as well as some precision in estimation. Observation of clipped plant bases through a transparent grid overlay appeared to fulfill these requirements.

This paper reports on laboratory and field studies on the measurement of basal area of individual grass plants, its relationship to the dry weight of green leaves of these plants and some possible applications of these measures to range condition and trend assessment.

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LABORATORY STUDIES

The laboratory work was designed to validate procedures for the use of transparent grid overlays. In these studies, thirty artificial plant bases of different sizes, four grid overlays of different dimensions and two methods of estimating area were examined.

Materials and Methods:

a) Grid Overlay Construction:

Transparent grid overlays of dimensions 10, 5, 3, and 2 mm were made by each of two processes:

1) etching fine lines on a sheet of two millimetre thick perspex; black or blue chinagraph pencil being used to enhance the visibility of the lines. A rigid durable grid resulted which was liable to fog up in the field in humid conditions.

2) photocopying graph paper onto acetate transparency sheets. A rapidly made, low cost and flexible grid. However, the photocopying process reduces the grid dimensions, particularly at the edges of a large transparency.

For this reason, only the perspex grids were used in the validation study.

b) Artificial Plant Bases:

Artificial plant bases were made by clustering, but not overlapping, adhesive black paper discs of 3.5, 2.0 and 1.0 mm diameter on paper to create ten 'bases' with each size of disc, each with a different basal area. The thirty clusters were intended to represent transverse sections of clipped grass plants of different species (using discs of different diameter) and of different basal areas (using different numbers of a particular size of disc). Field observations suggested the disc sizes employed and the range in basal area used for the validation procedures.

c) Area Estimates:

Two estimation methods were employed:

1) a count of the total number of grid cells estimated to be filled by the area of black paper discs, integrating part filled cells by eye;

2) a count of only those grid cells for which the paper discs occuppied more than half the area of a cell.

These estimates are henceforth referred to as filled-cell and half-cell methods respectively.

The two estimates of disc area were then compared with the actual area of discs for each artificial plant base. Regressions and correlation coefficients were calculated for each size of disc and grid and for each estimation method.

Results and Discussion:

The half cell method tended to underestimate area and appeared limited in field applications to species with large stems (Table 1). For these reasons it was abandoned.

In general, as disc size decreased, so the filled cell method tended to overestimate disc area, irrespective of grid size, as shown by the increase in slope (Table 1). Yet the relationship between estimated and actual area remained close irrespective of disc size. This suggests that for species with quite small stems (approximately 1.0 mm diameter) it is advisable to use a small grid. In other cases, larger grids can be selected depending on the basal area of the plants to be measured rather than the stem diameter.

TABLE 1

Results of a test of two methods of estimating 'basal' area using 10.0, 5.0, 3.0 and 2.0 mm perspex grids on thirty artificial plant bases constructed from clusters of black paper discs of 3.5, 2.0 and 1.0 mm diameter

Disc Diameter (mm)	Grid Size (mm)	Estimation Method[1]	Relationship between Est (estimated) and Act (actual) Area	Correlation Coefficient 'r'
3.5	10	a	Est = 0.0238 + 1.0049 Act	0.999
3.5	5	a	Est = - 0.1017 + 1.0484 Act	0.998
3.5	3	a	Est = - 0.0359 + 0.8756 Act	0.999
3.5	2	a	Est = - 0.1071 + 0.9336 Act	0.996
2.0	10	a	Est = 0.0497 + 1.0103 Act	0.971
2.0	5	a	Est = 0.0197 + 1.0417 Act	0.964
2.0	3	a	Est = 0.0493 + 0.9705 Act	0.939
2.0	2	a	Est = - 0.0522 + 1.4267 Act	0.966
1.0	10	a	Est = 0.0306 + 1.2678 Act	0.777
1.0	5	a	Est = 0.0023 + 1.4779 Act	0.940
1.0	3	a	Est = - 0.0076 + 1.4399 Act	0.966
1.0	2	a	Est = 0.0018 + 1.2466 Act	0.993
3.5	10	b	Est = 0.2377 + 0.5959 Act	0.829
3.5	5	b	Est = - 0.3320 + 1.0631 Act	0.963
3.5	3	b	Est = 0.2459 + 0.5374 Act	0.900
3.5	2	b	Est = - 0.1225 + 0.5640 Act	0.938
2.0	10	b	Est = 0.1076 + 1.5532 Act	0.044
2.0	5	b	Est = - 0.1309 + 0.7284 Act	0.597
2.0	3	b	Est = - 0.0039 + 0.2396 Act	0.361
2.0	2	b	Est = 0.0191 + 0.6083 Act	0.875
1.0		b	Est = [2]	

[1] a = filled cell method
b = half cell method

[2] By definition and with the grid sizes listed, this method must fail.

FIELD STUDIES

Initially, field studies were intended to develop a method for the estimation of basal area and the dry matter yield per unit basal area of different species. The procedure below was adopted after much trial and error and use in the field by undergraduate students. The final procedure was used to establish the relationship between basal area (as measured with a transparent grid overlay) and the dry weight of green leaf blades of plants of different grass species growing at different sites at more or less the same point in time.

Methods:

Twenty plants, representing the range in plant size of a species at a site, were clipped as low to the ground as possible. Grid overlays were placed, etched side down, on either the clipped plant base or on an inverted hand-held clump of the tops, trimmed square with shears. Estimates of basal area were made with a 5 mm grid to the nearest quarter of a filled grid cell and expressed as a count of filled cells. Tops were bagged, labelled with the basal area estimate and transported to the laboratory in sealed plastic bags. The material was then sorted and dead matter, flowering culms and sheathing leaf bases discarded. Only those blades green for greater than half their length were dried at 85°C for twenty-four hours, then weighed. This is the value described as leaf weight.

One hundred plants of seven selected species were sampled at random at different sites for the frequency distribution of different basal areas.

Species examined included Aristida spp, Bothriochloa macra (Steud.) S.T. Blake, Chloris truncata R.Br., Cymbopogon refractus (R.Br.) A.Camus, Danthonia spp, Eleusine tristachya (Lam.) Lam., Eragrostis spp, Eulalia fulva (R.Br.) O. Kuntze, Panicum effusum (R.Br.), Poa sieberana Spreng var. sieberana, Sorghum leiocladum (Hack.) C.E.Hubbard, Sporobolus elongatus R.Br., Stipa variabilis sensa lato and Themeda australis (R.Br.) Stapf..

Results and Discussion:

Leaf Weight / Basal Area Relationships:

Species with a tufted or tussocky habit consistently showed useful and significant (r 0.80), though different, straight line relationships between leaf weight and basal area (Fig. 1). Many of these species such as C. refractus, S. leiocladum and T. australis were probavly components of Tableland pristine communities and decrease under grazing (Norton, 1971). Figure 1 also indicates that these species are characterized by far more available forage per unit basal area than many of the increasers/invaders that are now present day dominants eg. B. macra. Species whose growth habit changes in response to management, such as B. macra, C. truncata, E. tristachya and P. effusum,were generally inconsistent in both the nature and significance of the leaf weight/ basal area relationship. The relationship is also poor with species whose leaves are cauline rather than basal; eg. A. ramosa. This suggests that changes in leaf weight per unit basal area of these sorts of species is not particularly sensitive to management and that such species could prove poor key species.

However, from Figure 1 a change in the slope of the straight line describing some of the more useful weight/basal area relationships appears to be a function of rate of fertilizer, grazing pressure or range condition. It could also be a function of time and provide a measure of growth and defoliation of a species. As regards fertilizer and grazing it remains for the value of this observation to be further examined. In terms of range condition, the weight/basal area relationship of plants of Danthonia with a fairly wide ecological amplitude (Scott, pers. comm.), were recorded at sites subjectively assessed by the authors as being in poor, fair, good and excellent condition (Fig. 2). An apparently strong relationship exists between leaf weight per unit basal area of this species and condition. However, any further inference is limited by the subjectivity of our assessment of condition. The trend of the results can be expressed in another way (Fig. 3), which suggests that this species is an increaser (Dyksterhuis, 1958) that may in fact reflect the trend in condition of the range. Quite possibly a whole family of such curves exists for other tufted species that are common to sites in different condition. These species would appear to be ideal key species.

Size Distribution of Grass Plants:

Although the plants in Figure 2 were not selected at random, the data suggested that as well as differences in weight per unit basal area, the frequency distribution of basal area itself seemed to reflect range condition. To investigate this further, 100 randomly selected plants of Themeda australis were clipped at each of three different sites and the basal area of each plant measured with a 5 mm transparent grid overlay. Figure 4 shows differences in size distribution of the T. australis populations associated with differences in grazing pressure and presumably range condition.

If the size-age relationships for each species and site were known, it might be possible to analyse the population structures in terms of what changes are occurring and what changes are likely in response to a particular manipulation. Rabotonov (1969) has distinguished invasion, normal and regressive types of coenopopulations according to their 'age spectra' and Kershaw (1973) has indicated that ...." in general terms there exists a direct relationship between age, performance and competitive ability, potentially, for most if not all perennial plants". However, quantitative in situ assessment of the age of individual grass plants remains a problem (Kershaw, 1962). The major difficulty seems to be that the rate of increase of basal area of any one species is probably dependent on seasonal conditions as well as soil fertility, grazing pressure and other condition related factors.

However, the frequency distribution of the basal area (age(?)) of 100 plants of six species growing at 3 different sites were examined as a further assessment of the possibilities of the concept. Three quite different frequency distributions are evident (Fig. 5). Assuming age to be proportional to basal area, the nature of the frequency distributions of S. leiocladum and C. refractus suggest a stable population of long lived individuals; A. ramosa and E. brownii, a young and invading population, and B. macra and S. elongatus a population of short-lived individuals with a rapid turnover. If these suggestions are true, a change in the frequency distribution of the basal area of a key species would appear to indicate a change in trend.

CONCLUSIONS

A simple measure of the basal area of individual plants of a number of grasses has, through various applications generated a host of new hypotheses on the selection of key species and assessment of condition and trend in perennial grass pastures. A great deal of supplementary work is necessary to assess the true value of the notions presented in this paper and for those interested to pursue the many avenues, guidelines for field use of the transparent grid technique for measuring basal area, are presented:

1. Although twenty plants of a species were examined in the study reported here, as few as five plants have been found to provide significant linear relationships between leaf weight and basal area of some species in certain cases.
2. With this technique it is advisable to check and review estimates of basal area against black disc standards both before and during a program of basal area measurement.
3. The individual plant referred to can consist of either a discrete tuft of grass or a number of vegetative stems of a large tuft. Either way, the technique appears to work well.
4. The inclusion of the cross-sectional area of flowering culms in the basal area estimate invariably weakened the left weight/basal area relationship and it was difficult to distinguish, and so visually separate, what was a flowering culm from a vegetative stem in a clipped plant base. For this reason, the hand held estimate is to be preferred. Alternatively, coupling species in the vegetative phase would give better correlations.

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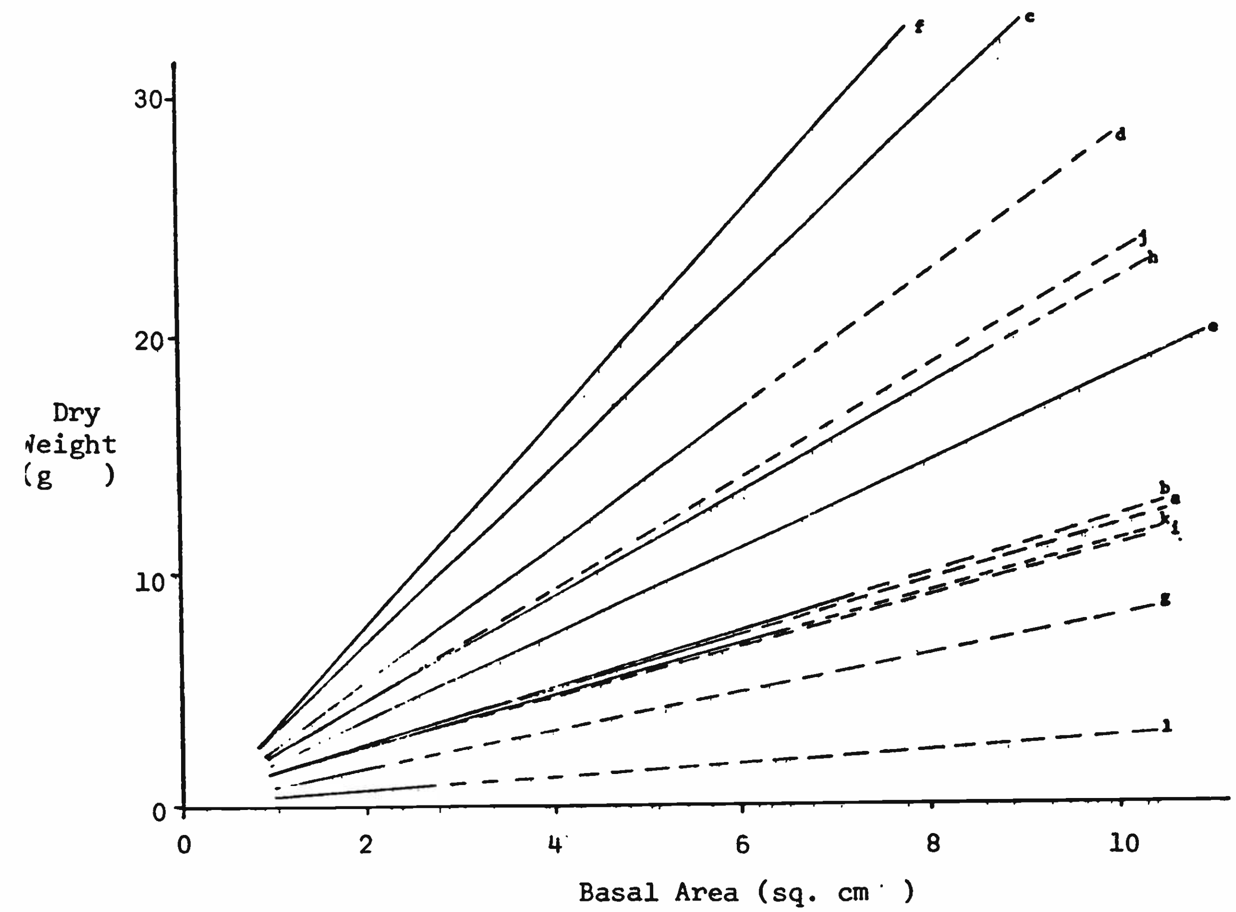

FIGURE 1: Relationships between leaf weight and basal area of individual plants of different grasses growing at different sites:

a) T. australis, traprock, continuous light grazing (r = 0.966)
b) " , " , grazing excluded for 2.5 years (r = 0.947)
c) " , " , road verge, occasional light grazing (r = 0.944)
d) " , " , " " , " " " (r = 0.973)
e) S. leiocladum, " , continuous light grazing (r = 0.960)
f) " , " , road verge, occasional light grazing (r = 0.959)
g) P. effusum, " , grazing excluded for 2.5 years (r = 0.812)
h) C. refractus, " , road verge, occasional light grazing (r = 0.947)
i) S. elongatus, " , grazing excluded for 2.5 years (r = 0.904)
j) " , granite, cultivated, 70 kg Starter 18[R]/ha (r = 0.990)
k) B. macra, traprock, grazing excluded for 2.5 years (r = 0.865)
l) " , " , heavily grazed (r = 0.375)

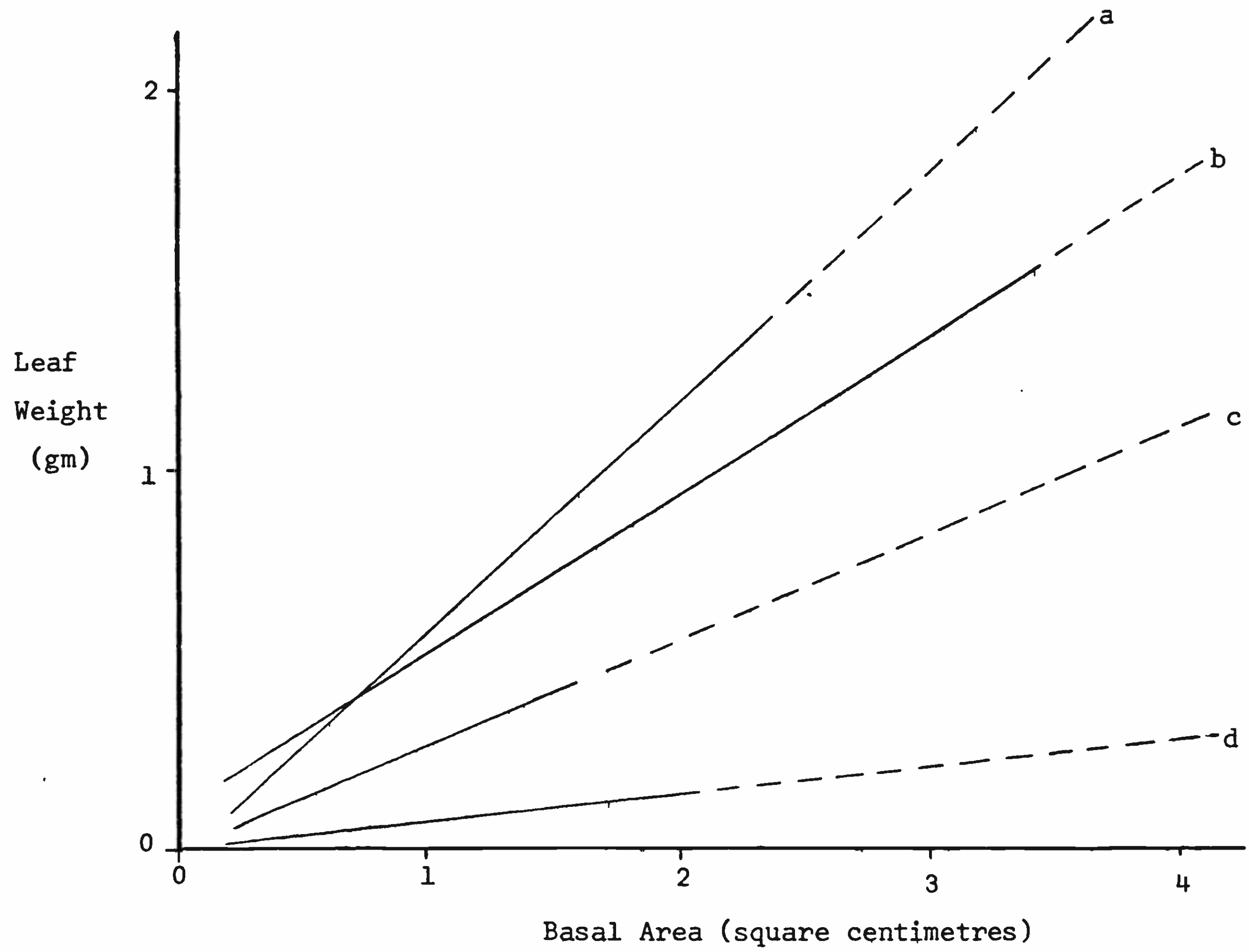

FIGURE 2: Relationship between dry-weight of leaves and basal area of Danthonia [illegible] at sites subjectively assessed to be in different condition:
a) 'good' condition, b) 'excellent' condition, c) 'fair' condition, d) 'poor' condition.

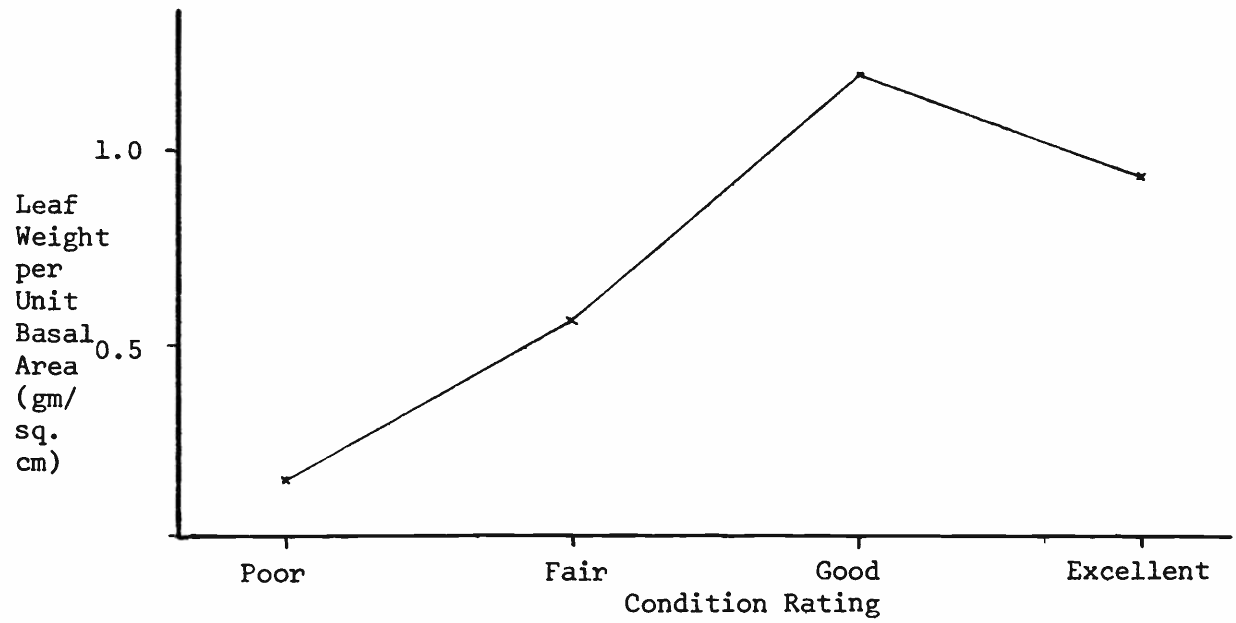

FIGURE 3: Suggested relationships between a subjective assessment of condition and leaf weight per unit basal area of Danthonia ____________.

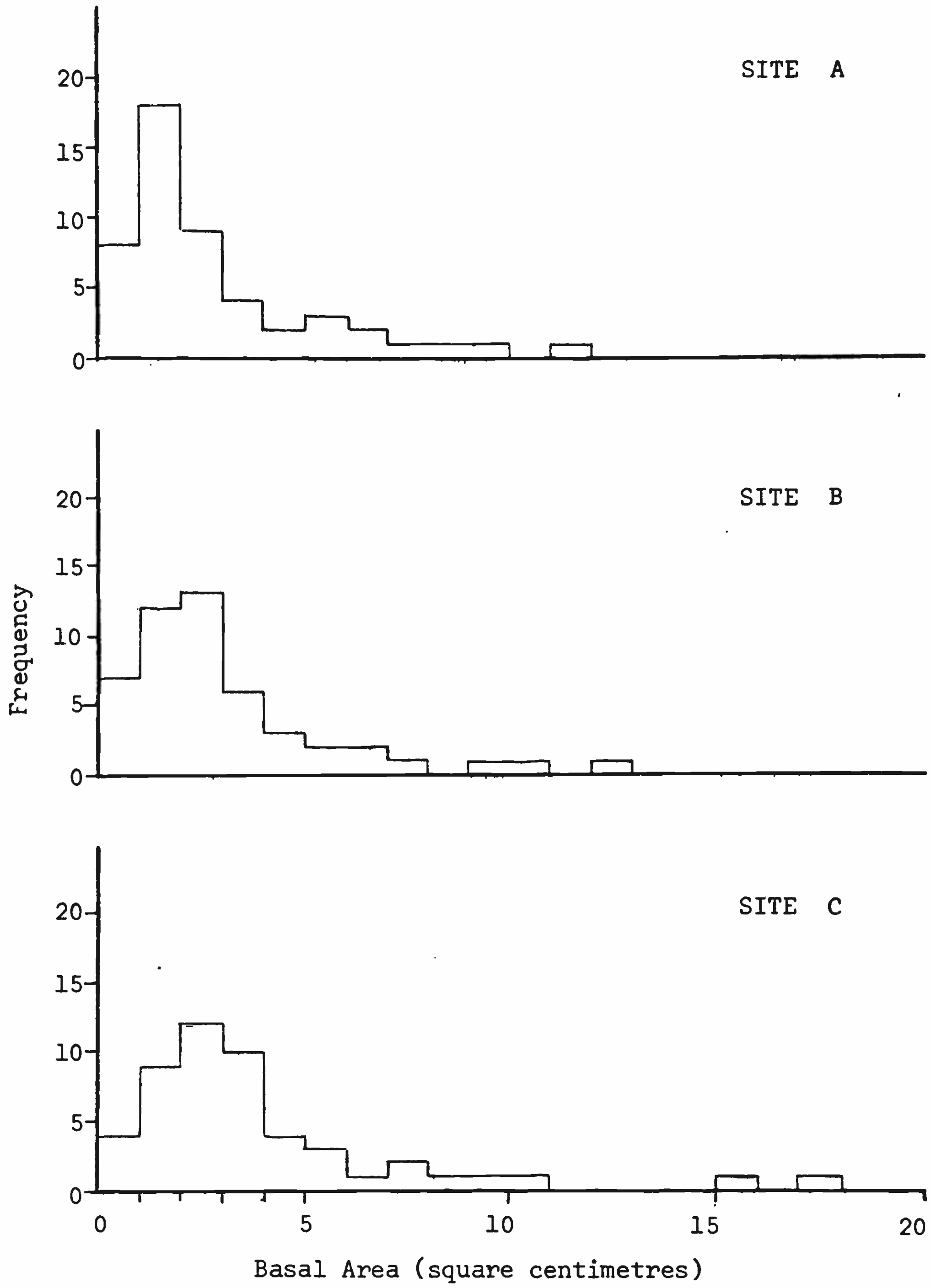

Figure 4: Frequency distribution of the basal area of *Themeda australis* plants recorded at three different sites:

a) continuous light grazing, 'fair' condition

b) adjacent to (a), but grazing excluded for the last 2.5 years; 'good' condition

c) road verge, occasional light grazing, 'excellent' condition

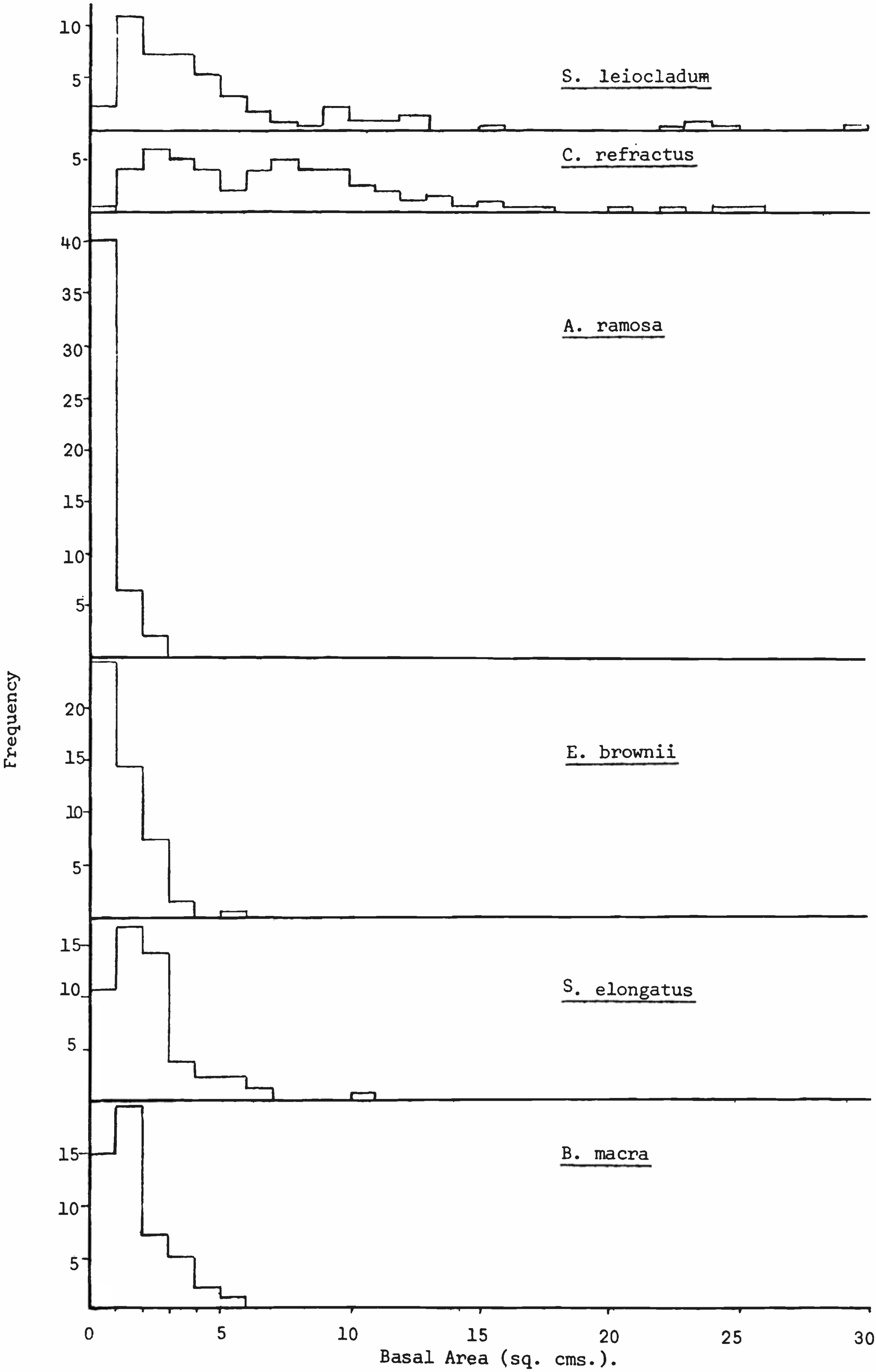

FIGURE 5: Frequency distribution of the basal area of different species.