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THE CLIMATIC POTENTIAL FOR BEEF CATTLE PRODUCTION IN TROPICAL AUSTRALIA: PART IV—VARIATION IN SEASONAL AND ANNUAL PRODUCTIVITY

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SUMMARY

In Part II liveweight loss in the dry season was found in most years to be closely related to cumulative 'dry weeks'; extraordinary weight loss occurred in the dry season in years in which there were a low number of 'growth weeks' in the previous green season. Annual liveweight gain was related to the total number of 'green weeks'. In this paper the geographic variation in these three agro-climatic parameters is described using a network of 77 stations across northern Australia, and the year-to-year variability is examined for eight representative stations.

Variation in dry season severity was greater than variation in green season productivity (growth weeks). Median 'dry weeks' in the dry season varied from 29 to nil over the area. 'Green weeks' in the dry season as a result of winter rain is an important phenomenon in a relatively small part of the area, but in this area year-to-year variability is extremely high.

It is concluded that the objectives of the study, to extend existing agro-climatic methodology to interface with cattle production and to use this in surveying the climatic potential for this form of land use over the entire tropical region of Australia, were achieved to the extent that the existing animal production data allow.

INTRODUCTION

In Part I (McCown *et al.*, 1981) the liveweight changes of cattle grazing tropical grass pastures were related to simple agro-climatic parameters derived from standard meteorological data. Variation in the quality of forage was estimated by classifying each week as a 'green week' or a 'dry week' on the basis of the value of the pasture growth index for that week. The variation in quantity of forage produced was estimated by integrating the growth index for all weeks in the green season and

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expressing the sum as the equivalent number of weeks with growth index = 1 ('growth week'). These variables accounted for substantial portions of variation in dry season liveweight losses and net annual gains at three stations in Queensland. This paper describes the geographic and temporal variation in these variables for grass pastures in northern Australia, adding a further dimension to the improved assessment of this important production resource presented in Part III.

METHODS AND DATA

The methods used were described by McCown (1980–81) and McCown *et al.* (1981). Briefly, a weekly growth index was calculated using standard weather data and simple soil water balance and temperature–growth models. When output was compared with cattle liveweight trends, it was found that cattle gained weight when the growth index exceeded 0·1; such weeks were termed 'green weeks' and the main period of gain, the 'green season'. Weeks in which the growth index <0·1 were termed 'dry weeks' and the non-productive season, the 'dry season'.

A sum of the weekly index values in the green season provides an estimate of the season's productivity. If g_i is the value of the growth index during the ith of n green weeks, the cumulative number of 'growth weeks', n_g, is given by $n_g = \sum_i^n g_i$, and corresponds to n_g weeks when $g_i = 1{\cdot}0$.

The set of climatological data was described by McCown (1981). These consisted of rainfall records from 77 stations for an average duration of 35 years. Temperature records were available from 53 of the 77 stations and evaporation from 20; temperature and evaporation were estimated by interpolation for the remainder of the stations.

RESULTS AND DISCUSSION

Growth weeks during the green season

The geographic variation in median growth weeks is shown in Fig. 1. The area of highest values is the north-east of Cape York Peninsula. This area has the highest rainfall during this period (McCown, 1980–81, Fig. 1), the lowest potential evaporation (E_0) (Anon., 1968), and the highest average daily temperatures. In the north-west the greatest number of growth weeks occur on the coast around Darwin. In both cases, growth weeks decline along a transect inland corresponding with decreasing rainfall and increasing E_0, and lower temperatures.

In a previous paper (McCown 1981), eight stations from different geographic areas were used to compare year-to-year variability. The same sample of stations is used in Fig. 2 to compare variability in growth weeks. For six of the stations, the

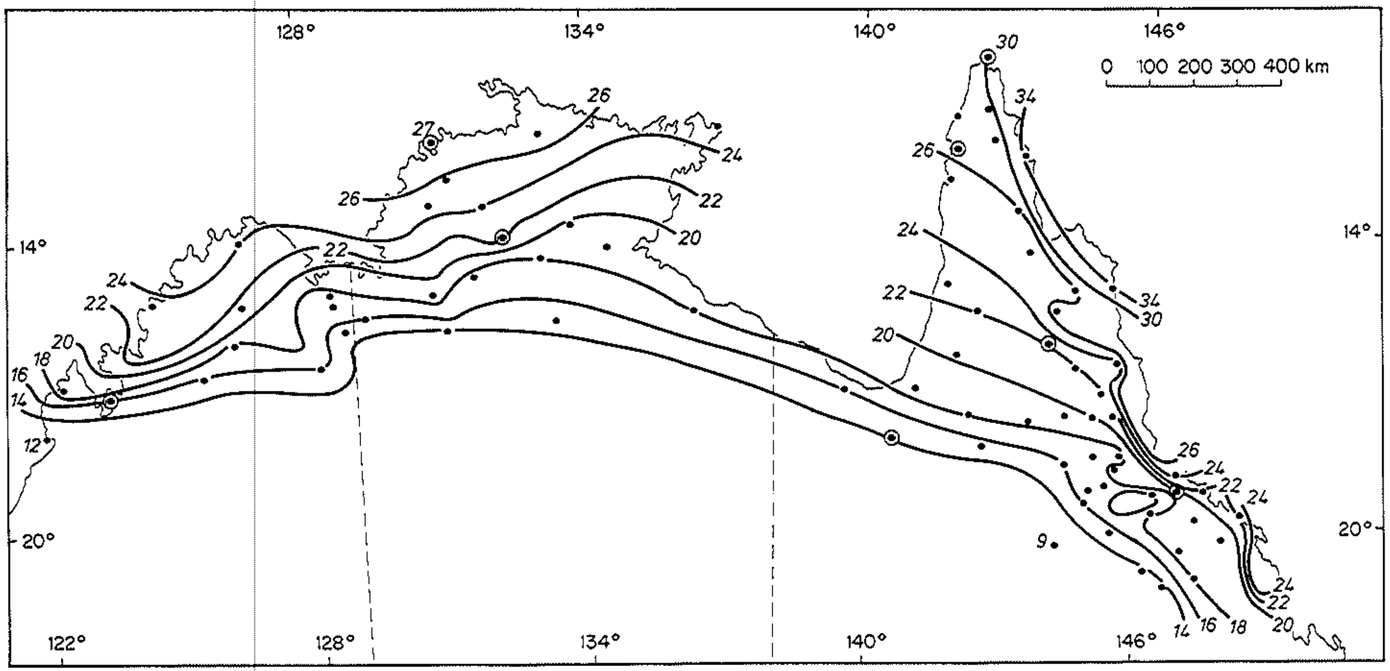

Fig. 1. Map of median growth weeks (circled points denote stations for which year-to-year variability is described in Fig. 2).

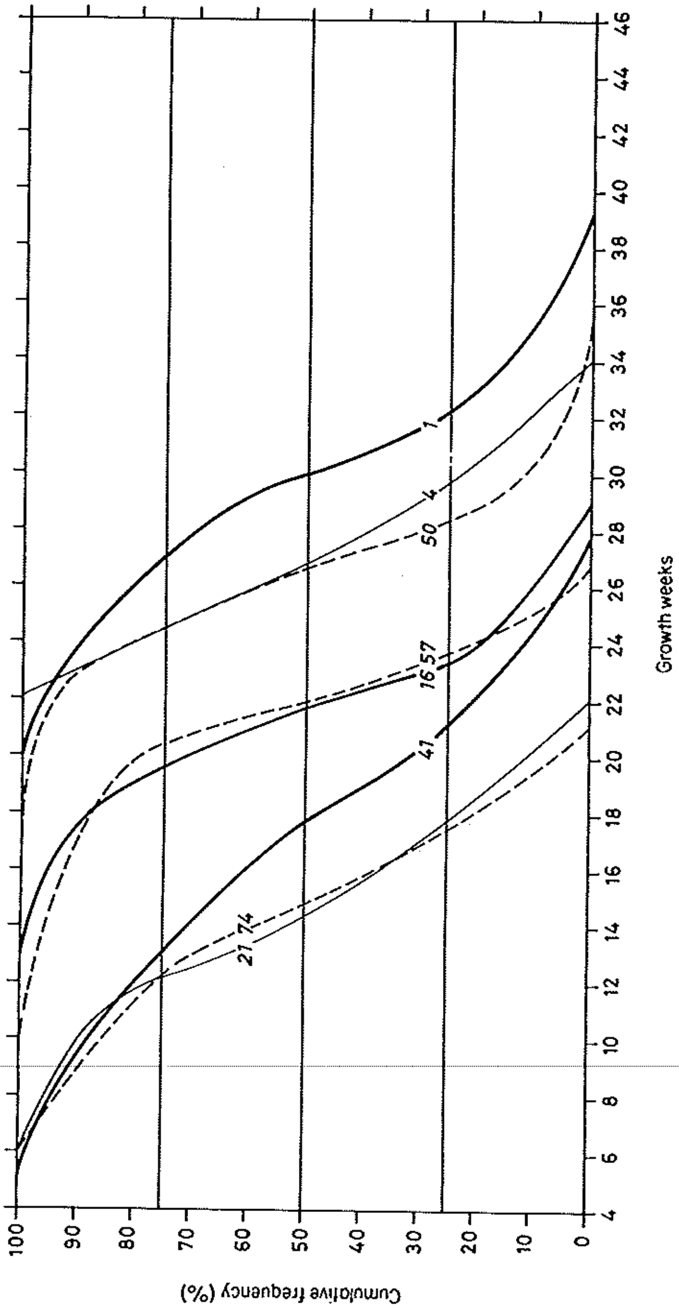

Fig. 2. Cumulative frequency distribution of growth weeks for Cape York (1), Weipa (4), Wrotham Park (16), Donor's Hill (21), Woodstock (41), Darwin (50), Katherine (57) and Derby (74).

relative differences among stations in frequency distributions are similar to those of the duration of the green season (McCown, 1981); very close similarities exist between Darwin (Station No. 50) and Weipa (4), Katherine (57) and Wrotham Park (16), and between Derby (74) and Donor's Hill (21); the relative differences between the medians of the pairs is also much the same. However, in the cases of Cape York (1) and Woodstock (41) the medians are much lower relative to the other stations and the dispersion about the medians is much less than in the case of green season duration.

McCown *et al.* (1981) found that in the area represented by Woodstock (41) at normal stocking densities, catastrophic weight losses of steers occurred in the dry season in years when the number of growth weeks in the green season is less than 10; in the industry, such years more importantly result in catastrophic mortalities of cows and calves. From Fig. 2, it can be seen that such an event occurs at Woodstock, one year in 10, a frequency made more tolerable to date by the availability of government drought relief assistance. Similar analysis of other stations is not possible because of lack of animal data. The lower variability of other stations suggests, however, that such 'droughts' would be less frequent.

The dry season

Although, in general, the dry season is deficient in green feed and cattle lose weight, in some places and years it may include substantial periods of green feed availability and liveweight gains. McCown *et al.* (1981) found that liveweight loss during the dry season was closely related to the number of dry weeks in the dry season. The southeastern portion of the area of study receives the most winter rainfall, but year-to-year variation is extremely high, and in many years no useful falls occur. For this reason, geographic variation is most usefully described by the frequency of occurrence of the more important events; Fig. 3 shows the upper quartile of green weeks in the dry season. Although most of the area has no more than 4 green weeks in the wettest 25 % of dry seasons, the southeast can expect 6–10 green weeks in those seasons. The value of winter rainfall is, however, much reduced if new growth is frosted and, as shown in Fig. 3, the incidence of frost is greatest in the south-east.

The geographic variation in median number of dry weeks is shown in Fig. 4. The isopleths are similar in orientation to those of duration of the green season (McCown, 1981), and for stations with minimal winter rain, values are complementary to green season duration.

With regard to the year-to-year variability of dry weeks, the pronounced skewing of the distributions for Wrotham Park (16) and Donor's Hill (21) toward low values and of Cape York (1) toward high ones is notable (Fig. 5). Although frequency distributions of Wrotham Park and Donor's Hill were similar to those of Katherine (57) and Derby (74) respectively over approximately the lower three quartiles, they

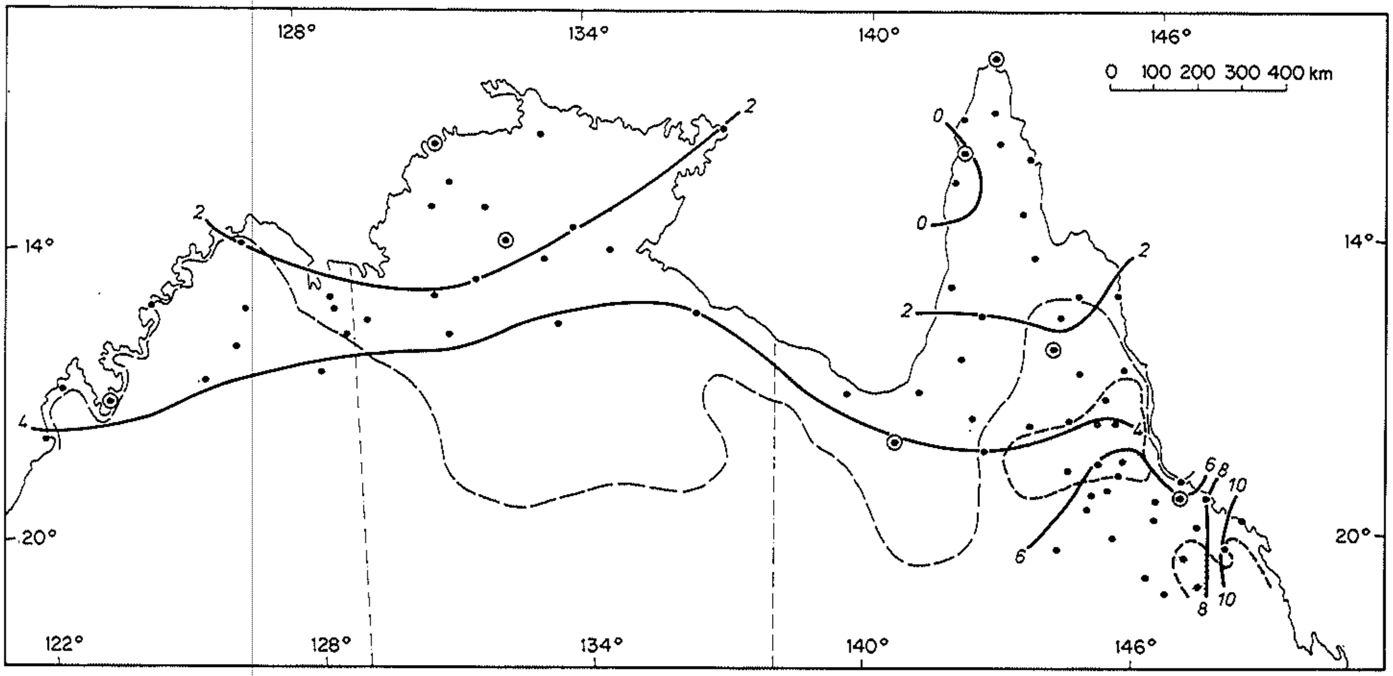

Fig. 3. Map of upper quartile of green weeks in the dry season (light dashed line denotes northern limit of frost, high areas with an average date of first frost of June 30 $\pm$ 2 weeks are indicated by heavy dashed lines).

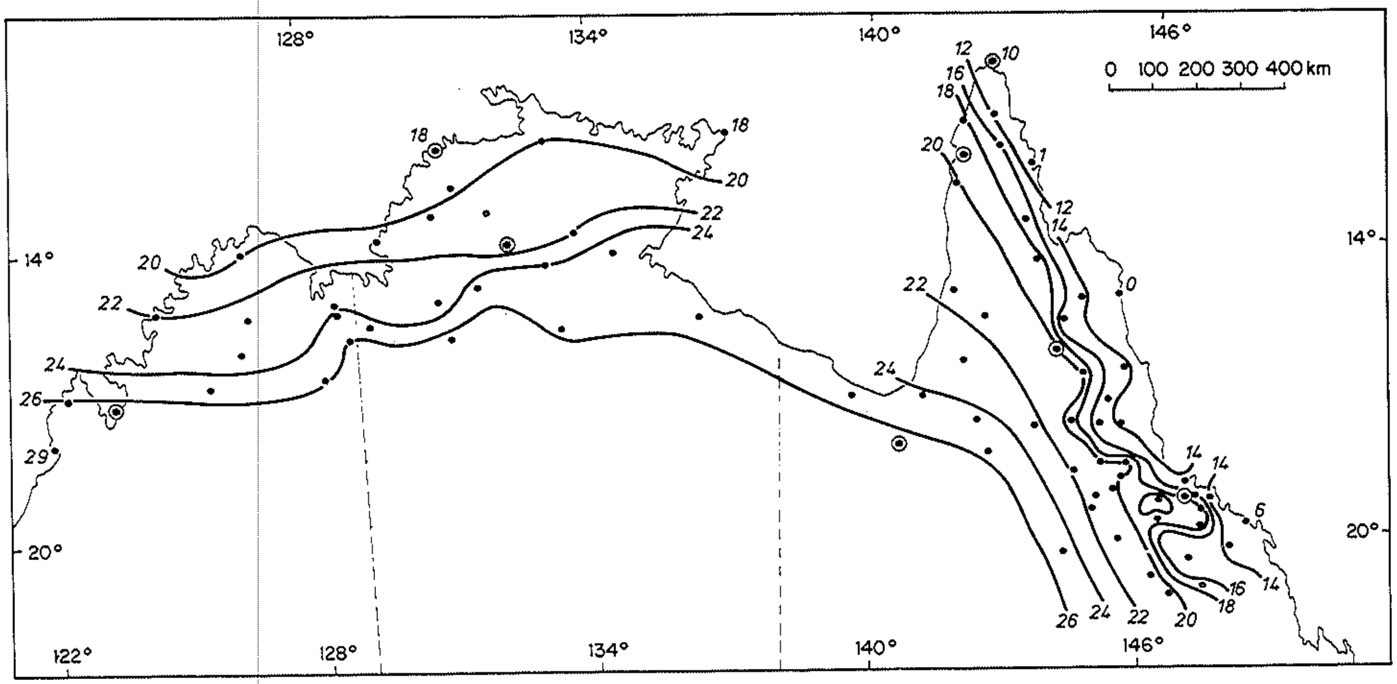

Fig. 4. Map of median dry weeks in the dry season.

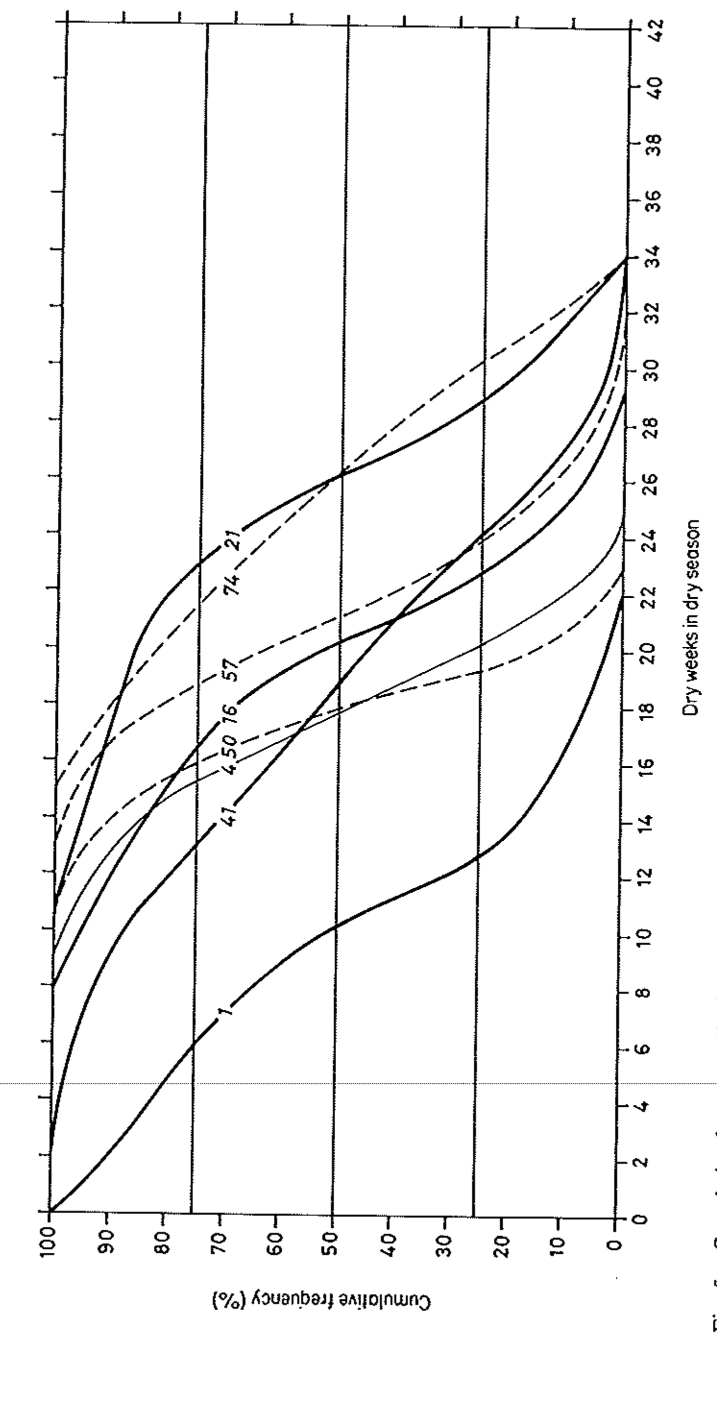

Fig. 5. Cumulative frequency distribution of dry weeks in the dry season for Cape York (1), Weipa (4), Wrotham Park (16), Donor's Hill (21), Woodstock (41), Darwin (50), Katherine (57) and Derby (74).

deviated markedly over the upper quartile. For Wrotham Park, the incidence of fewer than normal dry weeks in the dry season was due mainly to late cessation of the previous green season, sometimes combined with an early start to the following green season; the occurrence of green weeks within the dry season was not important. In the case of Donor's Hill, the reduction in number of dry weeks was due mainly to late cessation of the previous green season, followed closely by green weeks due to winter rainfall. The higher than normal frequency of high numbers of dry weeks for Cape York was attributable equally to early cessation and late starts to green seasons.

Annual green weeks

Annual liveweight gain of beef cattle is closely related to the total green weeks for the year (McCown *et al.*, 1981); Fig. 6 is a map of this parameter. Although the median values are complementary to those for dry weeks in the dry season (Fig. 4), the frequency distributions are not. The skewing, so pronounced in Fig. 5 for Stations 1, 16, and 21, is much reduced in Fig. 7. The explanation is probably that green seasons and dry seasons adjacent in time are not constrained to fall within a 52-week period. Unexpected numbers of short (or long) dry seasons occurred at these three stations for the various reasons noted above. 'Compensation' apparently occurred in subtle ways and not by drastic changes in the length of the adjacent season.

As with the variables previously discussed, dispersion about the median total green weeks is similar for stations with similar median values, with the notable exception of Woodstock (41). This station has a median green season duration one week shorter than Katherine (57), but due to the incidence of winter rainfall the median annual green weeks is three greater than Katherine and only one less than Darwin (50) and Weipa (4). It is, however, the degree of variation about the median that is so remarkable. One year in 10 Woodstock is among the worst of the sample stations; however, in five years in 10, this station has as many, or more, green weeks than all but the much wetter area around Cape York (1). It would seem that although production in this region is extraordinarily unpredictable and catastrophies relatively frequent, the probability of having a good year is sufficiently high to more than compensate.

The interquartile range has been used to stratify the year-to-year variability in annual green weeks for the entire area (Fig. 6, insert). Although median annual green weeks in eastern Queensland exceed those anywhere in the north-west, in general, reliability is less in Queensland. The area with the interquartile range of 12–16 in the Burdekin River basin is by far the most variable climate in the Australian tropical region. This figure suggests that the eight sample stations used throughout this study for detailed comparisons have provided adequate representation of the major strata.

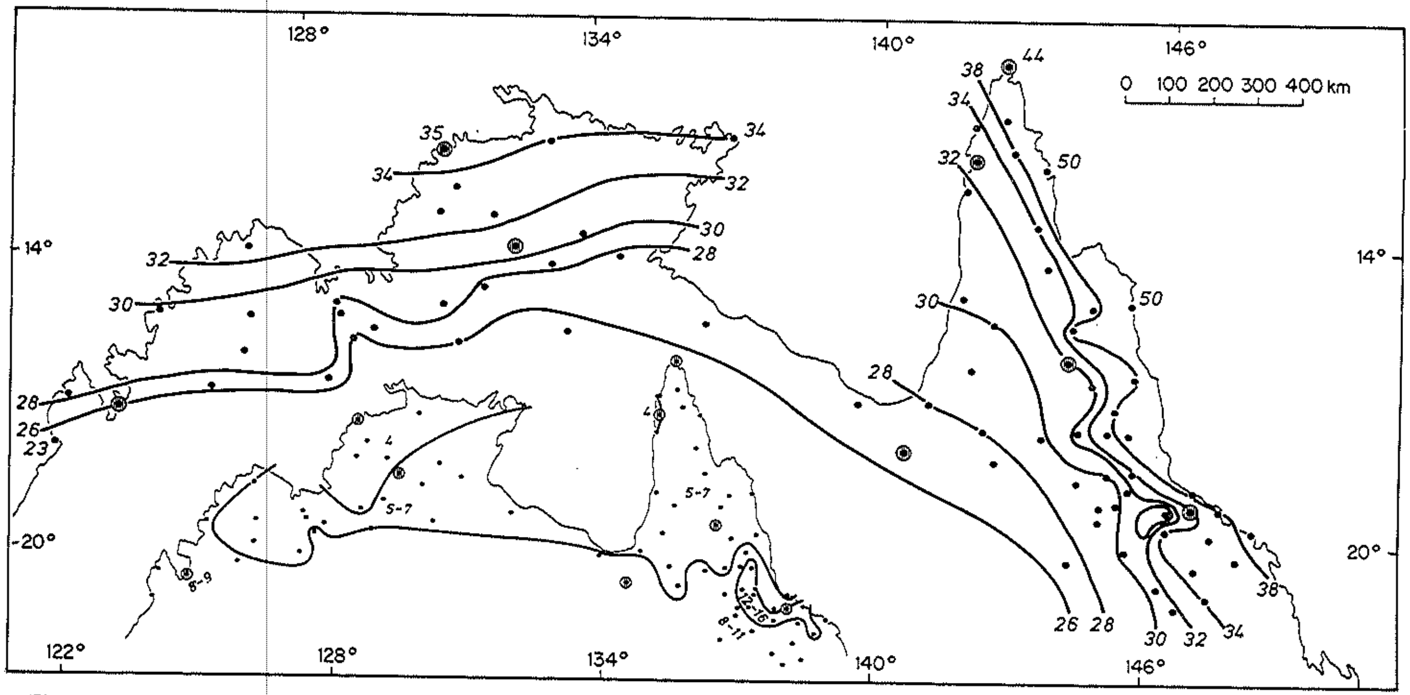

Fig. 6. Map of median annual green weeks (sum of green season + those in following dry season). Insert shows zones of differing classes of the inter-quartile range.

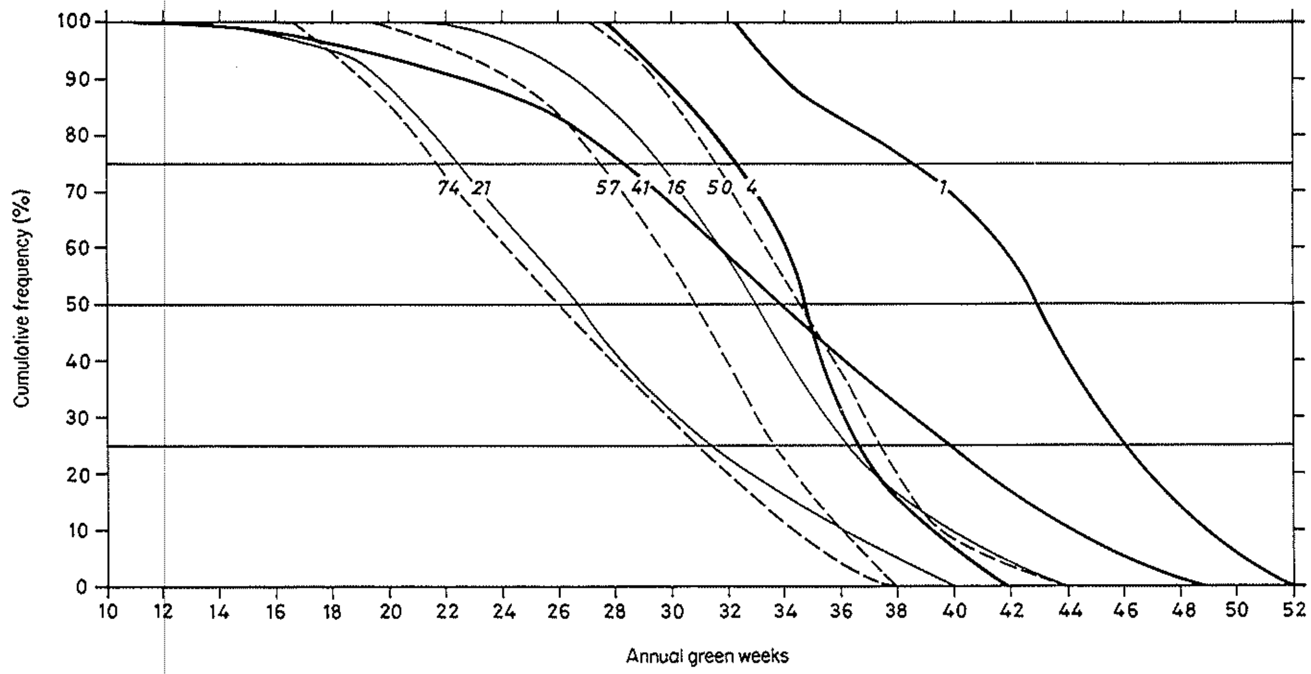

Fig. 7. Cumulative frequency distribution of annual green weeks for Cape York (1), Weipa (4), Wrotham Park (16), Donor's Hill (21), Woodstock (41), Darwin (50), Katherine (57) and Derby (74).

GENERAL DISCUSSION

The land area considered in this study is approximately 100 million ha, and in 1975 carried 5·7 million cattle (Winter, 1978). The aim of this exercise was to provide an improved assessment of the potential for beef production in the region. While recognising that climate is only one of the important physical resources concerned, the present study of the climate of the region is of special relevance due to the very close linkage of cattle performance and weather on native grass pastures (McCown 1980–81; Fig. 3) and the great predominance of this pasture vegetation in the industry now and for the foreseeable future.

This present study is the first to attempt calibration of agro-climatic models using animal production data in the tropics; it is submitted that the relationships presented in Parts I and II demonstrate that the approach is satisfactory for survey purposes. The actual contribution to the survey of northern Australia, however, is limited due to insufficient suitable animal data. Based on the data sets from Swan's Lagoon and Kangaroo Hills (McCown *et al.*, 1981), it would be possible to describe climatic variation in the Burdekin Basin in terms of liveweight change. This would be most reliable for assessment of variation among years, but the fact that regressions between the two stations did not differ significantly confers confidence in extending the results geographically within this restricted area, delineated in Fig. 6, insert. Three data sets served to identify the key independent variables whose variation throughout the region was then described, on the assumption that their relations to animal performance elsewhere would be similar. Although the limited animal data from Katherine supported that extrapolation (McCown *et al.*, 1981), a satisfactory test awaits further research data. Unfortunately, the prospect of the collection of such data is dimmed by recent cuts in funding of agricultural production research in Australia and the tendency of researchers to focus attention on improved pastures rather than native pastures.

The information on year-to-year variability presented for the eight representative stations exists for all 77 stations. Publication of this is planned eventually, but information for specific stations is available upon request from the author.

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