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THE CLIMATIC POTENTIAL FOR BEEF CATTLE PRODUCTION IN TROPICAL AUSTRALIA: PART III—VARIATION IN THE COMMENCEMENT, CESSATION AND DURATION OF THE GREEN SEASON†

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SUMMARY

Part I demonstrated a method for deriving from standard meteorological data a 'green season' and a 'dry season' which correspond to the main periods of liveweight gain and loss respectively of cattle on native grass pastures. This paper describes (a) the geographic variation in the incidence and duration of the green season utilising a network of 77 stations in tropical Australia, and (b) the year-to-year variability for eight of these stations. Variability in the date of commencement of the green season (the termination of the dry season) differed among stations, with ranges as low as 11 weeks and as high as 20. Differences of up to 16 weeks in the median duration of the green season between stations occurred within the study area, while the range of variation from year to year at a station was as low as 13 weeks and as high as 34. Results are compared with those of previous descriptions. Difficulties imposed on management by climatic variability are discussed.

INTRODUCTION

In tropical wet–dry environments cattle normally gain weight during the rainy season and lose weight during the dry season. A method for predicting the periods of liveweight gain and loss of grazing cattle was described in Part I (McCown, 1981). Simple models, requiring only standard meteorological data as input, were used to derive a pasture growth index. Using data from 15 grazing experiments at 7 locations, weekly values of this growth index were related to monthly changes in

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cattle weights. The start of the main weight gain period could be reliably predicted for a wide range of pasture types; the cessation of gain could be predicted with grass pastures, although not for pastures containing appreciable amounts of legumes. The aim of this paper is to describe the geographical and temporal variation in the dates of the start and cessation and in the duration of the productive season of grass pastures in tropical Australia, providing an improved assessment of this major production resource.

METHODS AND DATA

The methods used were described fully in Part I (McCown, 1981). A growth index (GI) was calculated as a product of a moisture index, derived using a simple water balance model, and a temperature index for standard 7-day periods. Weeks with $GI > 0{\cdot}1$ qualified as a 'green week', those with $GI < 0{\cdot}1$ as a 'dry week'. The 'green season' began with an eight-week period in which three of the first four and six of the eight weeks were green weeks; the first week of such a period was GOWK. Cattle weight gains were detectable 2–5 weeks from GOWK. STOPWK was defined as the first of two consecutive 'dry weeks', and marked the cessation of the 'green season' and the start of the 'dry season'.

Seventy-seven stations (Fig. 1; listed in Appendix) were selected to describe the main geographic variation of the region. In general, stations with more than 30 years rainfall records were used, but in areas of sparse habitation stations with as few as 11 complete years were included. Meteorological data for model input consisted of weekly rainfall, weekly evaporation, and weekly average of daily maximum and minimum temperatures. Average daily temperature was estimated as (maximum + minimum)/2. Evaporation data consisted of a mixture of Class A pan and Australian tank; conversion was made using the relationship, tank = 0·85 pan. Not all stations in the study recorded all parameters (see Appendix); sufficient data to provide reliable monthly means were available for only 20 stations for evaporation and 53 stations for temperature. Where necessary, evaporation was estimated from maps of estimated monthly means of Australian tank (Anon., 1968). Weekly values from these and from mean monthly maximum and minimum temperatures were obtained by an objective interpolation method used by Fitzpatrick & Nix (1970). Where temperature records were non-existent, either data from a nearby station or interpolations from two nearby stations were used.

In the water balance model soil water storage capacity was assumed to be 150 mm for all stations and maximum evapotranspiration was assumed to be 0·75 of Australian tank evaporation throughout the year.

Presentation of the variation among years for each station is not attempted here; instead frequency distributions for eight stations representing different geographic areas are compared. These stations are circled in Fig. 1: Cape York (1), Weipa (4),

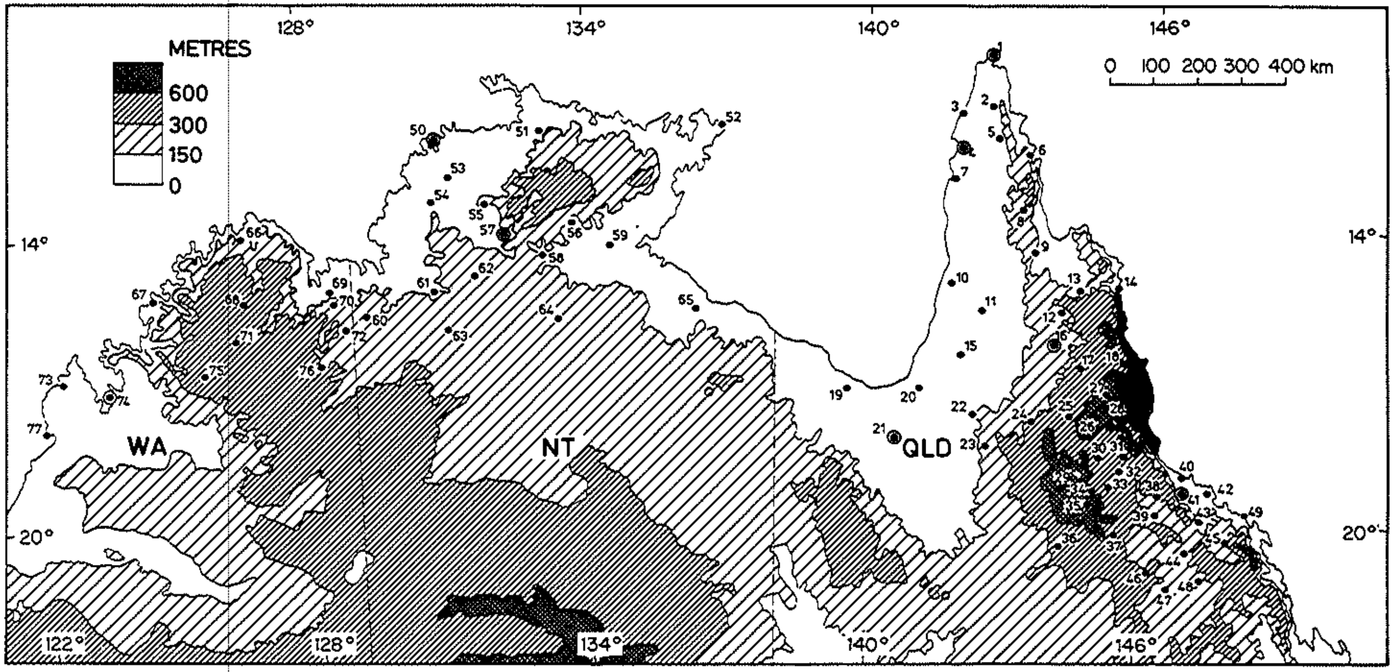

Fig. 1. Location of stations included in survey (station numbers identified in Appendix). Circled points denote stations for which year-to-year variability is described; darkest shaded area excluded from survey.

Wrotham Park combined with Walsh River (16), Woodstock combined with CSIRO's Landsdown Research Station (41), Donor's Hill (21), Darwin (50), Katherine (57) and Derby (74).

RESULTS

Date of commencement of the green season (GOWK)

Geographic variation in GOWK is shown in Fig. 2. Since this event is due entirely to renewed soil water supply, its pattern can be expected to reflect patterns in rain bearing influences. The earliest median GOWK dates occur in the north-west around Darwin (Station No. 50) and on the northwestern tip of Cape York Peninsula around Weipa (4). These areas are the first to experience thunderstorm activities with the onset of the monsoonal stream from the north-west (Gentilli, 1971). Median GOWK for most of the region falls in November.

The variation from year to year is large by contrast (Fig. 3). The range among years at the least variable location (Darwin, 50) is greater than the range of the median date among locations (Fig. 2). The frequency distribution about the median is similar for Darwin (50), Weipa (4), Katherine (5) and Wrotham Park (16) with a range of 9–11 weeks; Derby (74), although generally having late starts, has a frequency distribution strongly skewed toward early starts. The other three stations are considerably more variable, with ranges of 14 weeks for Cape York (1), 16 for Donor's Hill (21) and 20 for Woodstock (41); the range for Woodstock encompasses the range of values for all other stations. The extreme uncertainty about the timing of this crucial 'drought-breaking' event is a major managerial problem. Knowledge of the 'near-latest' probable commencement date provides some constraint to the uncertainty. From Fig. 4, the date by which the green season will have commenced in nine out of ten years can be obtained for any station.

Date of cessation of the green season (STOPWK)

While the transition from dry season to green season is normally abrupt, that from green season to dry season is gradual (McCown, 1981). Furthermore, the climatic factors influencing this process exert their influence according to a more general coastal-continental pattern than those at the initiation of the green season (Fig. 5). The isopleths are similar in orientation to those of both rainfall and potential evaporation for this period (Anon., 1968).

In general, low temperature plays a very secondary role to water supply in terminating the green season. In areas of higher elevation there is more chance of low temperatures checking growth before the soil dries out; these are also the most frost-prone areas. The limit of frost and two areas of higher elevation (Fig. 1) with an average first-frost date of June 30 $\pm$ 2 weeks, are shown in Fig. 5 (drawn after Foley, 1945). For most of the frost areas, the median date of STOPWK occurs well prior to

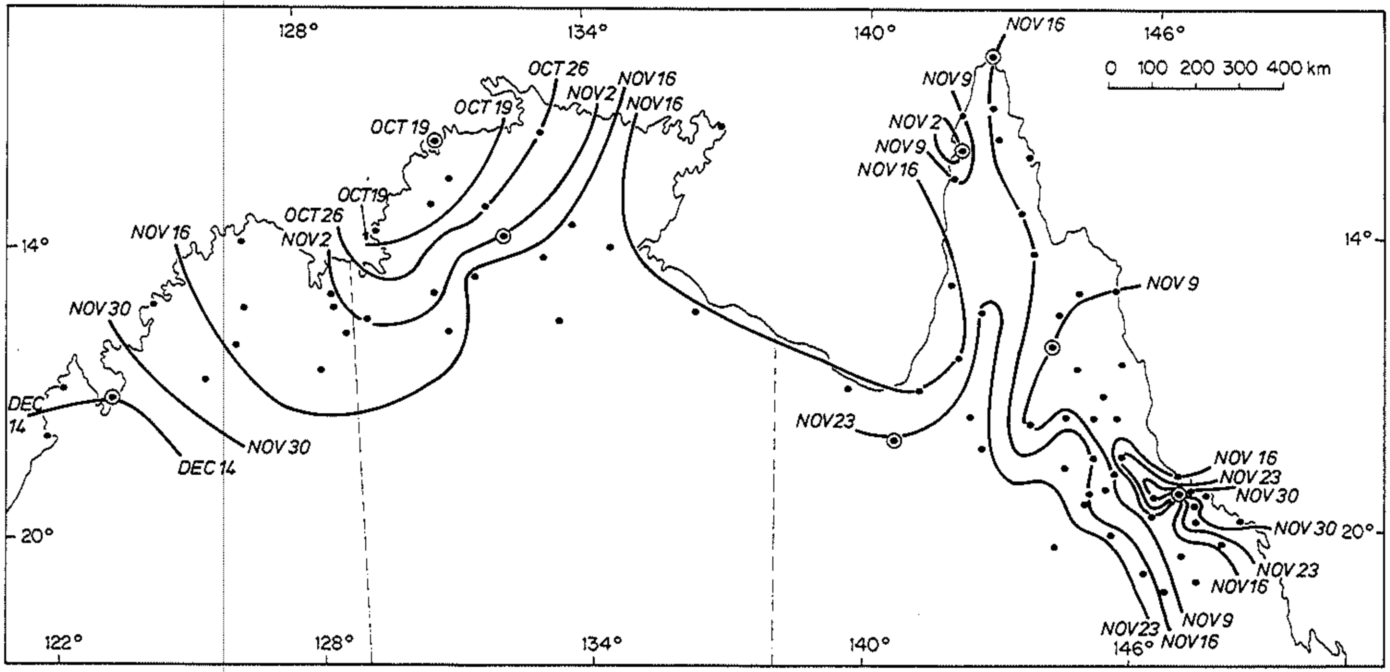

Fig. 2. Map of median date of commencement of green season (GOWK).

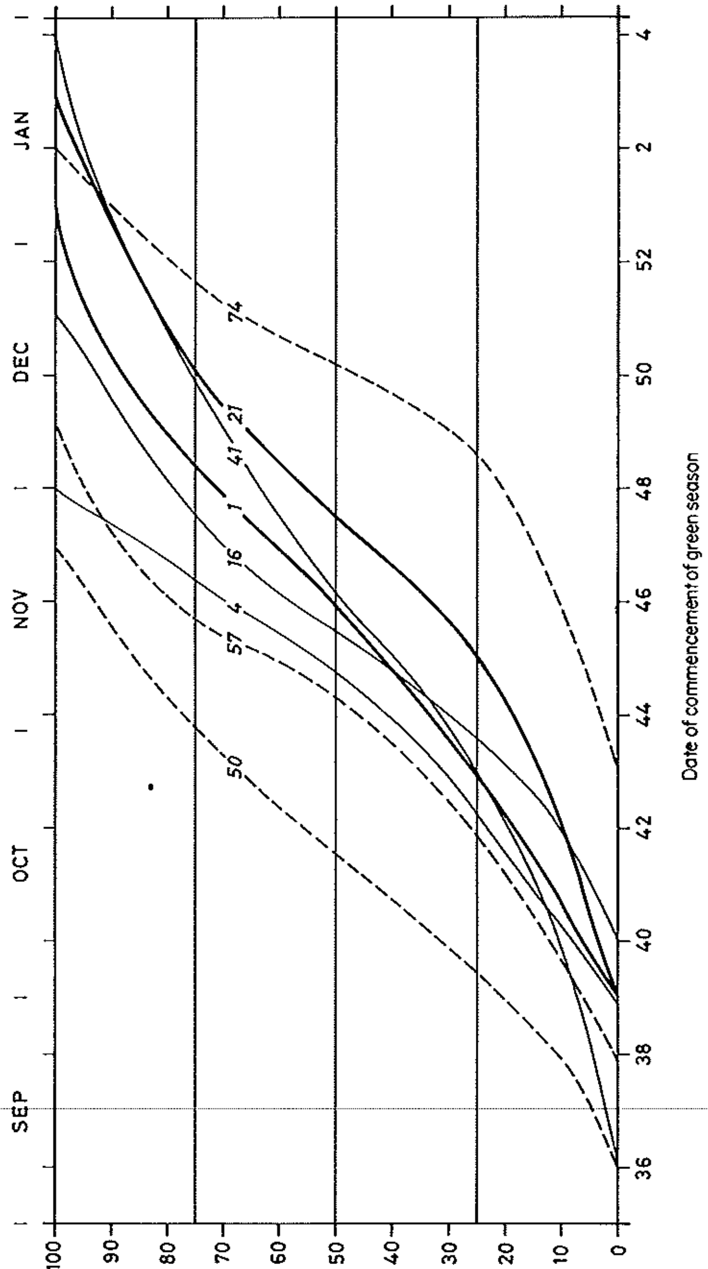

Fig. 3. Cumulative frequency distribution of date of commencement of green season (GOWK) for Cape York (1), Weipa (4), Wrotham Park (16), Donor's Hill (23), Woodstock (41), Darwin (50), Katherine (57) and Derby (74).

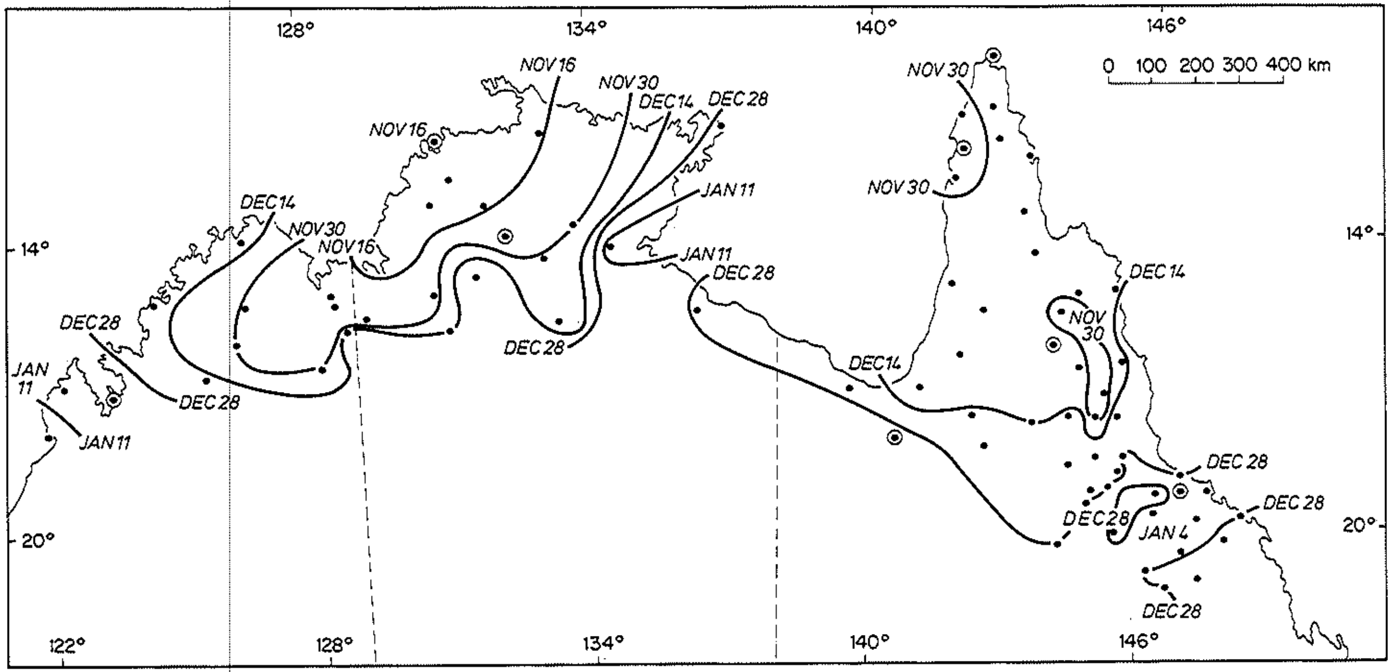

Fig. 4. Map of earliest date by which the green season can be expected to commence in 9 years out of 10.

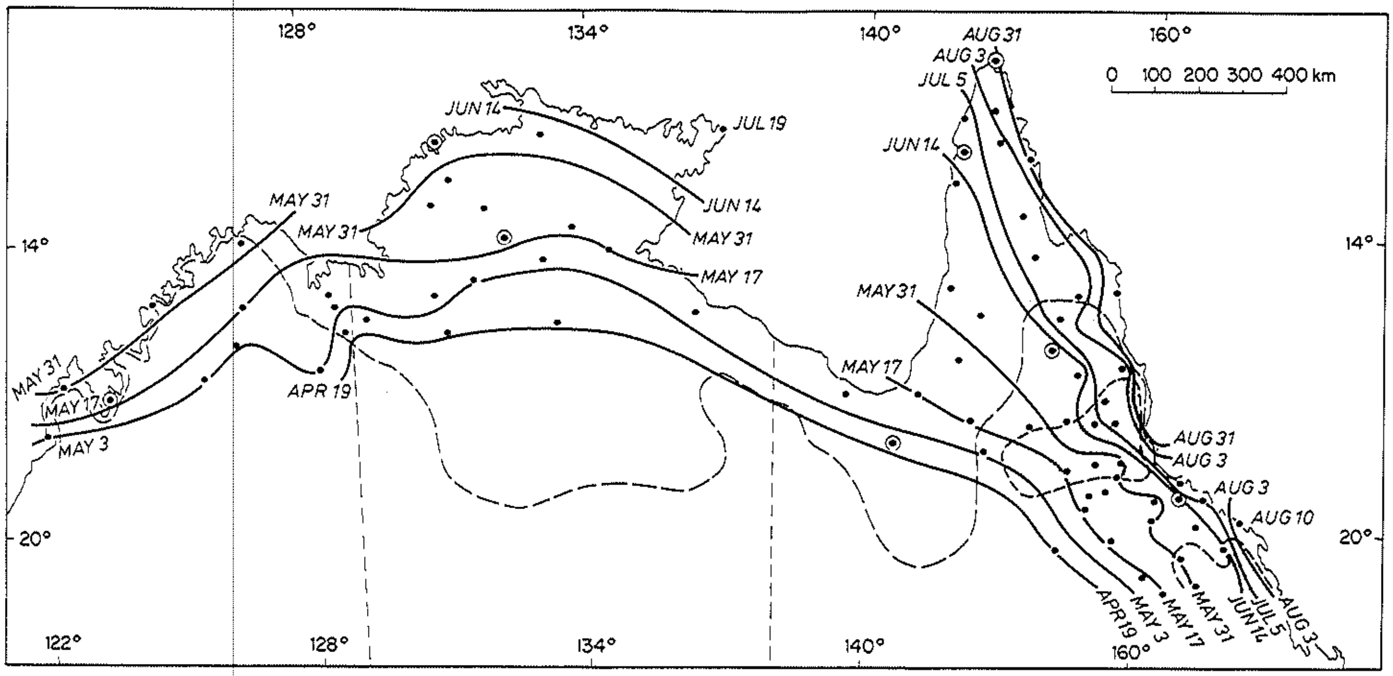

Fig. 5. Map of median date of cessation of green season (STOPWK). Dashed line denotes northern limit of frost; stippled areas denote high altitude areas with an average date of first frost of June 30 ± 2 weeks.

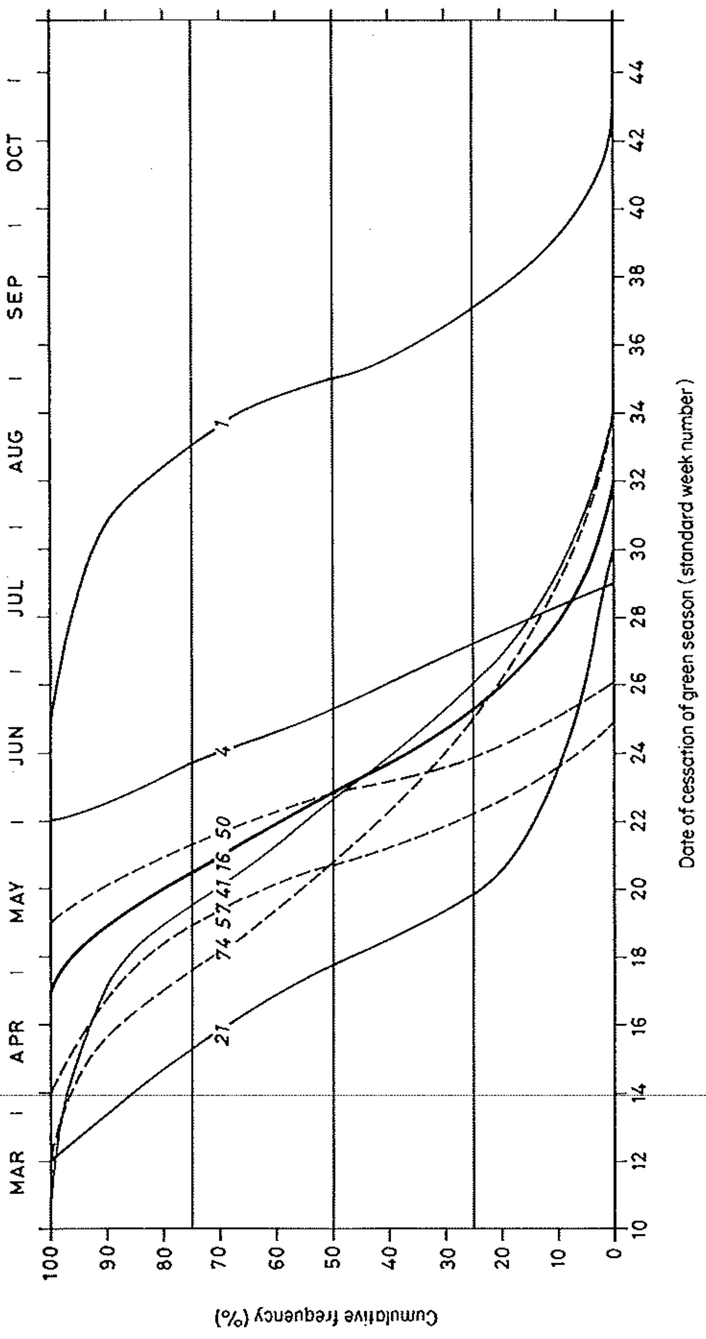

Fig. 6. Cumulative frequency distribution of date of cessation of green season (STOPWK) for Cape York (1), Weipa (4), Wrotham Park (16), Donor's Hill (21), Woodstock (41), Darwin (50), Katherine (57) and Derby (74).

June, suggesting that instances of the green season being cut short by frost would be rare. Eastern portions of the two higher areas, however, have median STOPWK dates sufficiently late to suggest that frosts may frequently truncate the green season.

Year-to-year variability in STOPWK for the sample of representative stations is shown in Fig. 6. Major differences exist between a group consisting of Darwin (50), Weipa (4), and Katherine (57) with low variability and the highly variable Derby (74) and Woodstock (41). Donor's Hill (21), while having generally the earliest cessation date, has a frequency curve skewed toward late cessation dates.

Duration of the green season

It is clear that the median length of green season (Fig. 7), is associated with proximity to the east coast in Queensland, the north-west coast in the Northern Territory, and the northern coast in Western Australia. Although the sample of stations was chosen mainly on the basis of geographic representation, similarities in season length emerge between Darwin (50) and Weipa (4); Katherine (57) and Wrotham Park (16); and between Derby (74) and Donor's Hill (21).

The similarities between these pairs of stations extend to variation among years (Fig. 8). Woodstock has a median similar to Katherine (57) and Wrotham Park (16), but has a range of 34 weeks which encompasses the range of all other stations combined, with the exception of the upper quartile of Cape York (1). Cape York (1), although having the longest green seasons, is also highly variable.

DISCUSSION

In a climate with a long and variable non-productive season, an obvious early step in agricultural resources assessment is description of the variation in the timing and duration of the productive season. Miles (1947) described these aspects of the pastoral growing season for north-eastern Australia. Using a ratio of precipitation to mean temperature, a month was classified as 'wet' or 'dry' using a ratio value identified from field observations to discriminate between months in which plants grew and those in which they did not. The resultant pastoral growing season lengths are less than half those of green season duration (Fig. 7). Clearly, on grass pastures with normal stocking rates, the main cattle gain period is much longer than the period when the plant is growing actively.

The distinction between 'active growth' periods and 'useful growth' periods was made by Fitzpatrick (1965) and Slatyer (1970). Slatyer described the period of useful pasture growth as representing 'the summation of several periods of growth, but also including varying periods of pasture activity. It is, therefore, essentially a total period during which a "green pick" is available for stock rather than one in which a high growth can be expected'. His estimates of commencement date and duration of this extended period of useful growth are compared with those of the present study in Table 1. Slatyer's commencement dates were 4–8 weeks later; his season duration

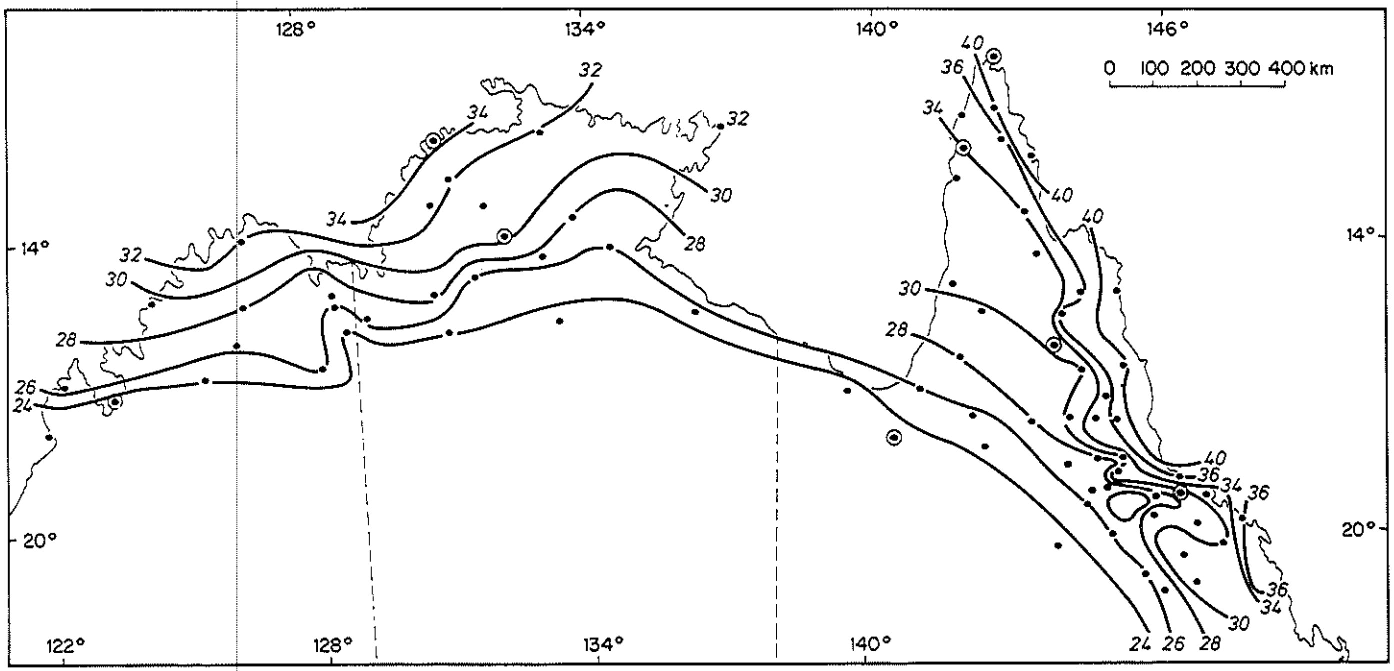

Fig. 7. Map of median duration of green season.

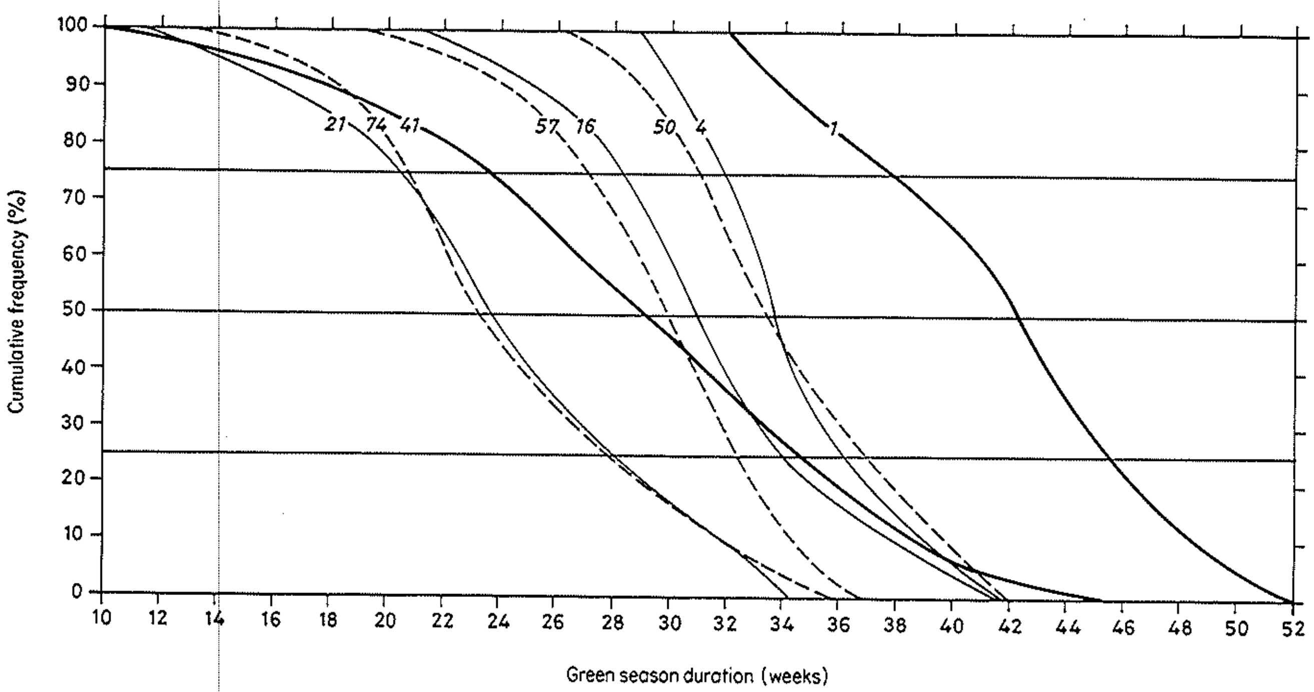

Fig. 8. Cumulative frequency distribution of green season duration for Cape York (1), Weipa (4), Wrotham Park (16), Donor's Hill (21), Woodstock (41), Darwin (50), Katherine (57) and Derby (74).

TABLE 1

A COMPARISON OF ESTIMATES OF THE COMMENCEMENT AND DURATION OF THE PRODUCTIVE SEASON FOR SEVERAL STATIONS MADE BY SLAYTER (1970) WITH THOSE OF THE PRESENT STUDY

Name	Station No.	Commencement date			Duration (weeks)			Difference adjusted for SWSC[a] difference
		Slatyer (1970)	*Present study*	*Difference (weeks)*	*Slatyer (1970)*	*Present study*	*Difference (weeks)*	
Daly River	54	Nov. 23	Oct. 12	6	25	33	8	6
Katherine	57	Nov. 30	Nov. 2	4	22	30	8	6
Willeroo	62	Dec. 21	Nov. 23	4	18	26	8	6
Victoria River Downs	63	Jan. 1	Nov. 9	8	15	24	9	7
Turkey Creek	76	Dec. 28	Nov. 2	8	15	26	11	9

[a] Soil water storage capacity: Slatyer (1970), SWSC = 100 mm; present study, SWSC = 150 mm.

was 8–11 weeks shorter. When adjustment is made for the difference in assumed soil water storage capacity, difference in duration is attributable almost entirely to differences in commencement dates.

The criterion used by these earlier workers for commencement of the season was attainment of an amount of soil water storage that coincided with 'significant' growth of pasture (Fitzpatrick, 1965). Their error of estimation is due firstly to the fact that cattle on dry pasture vegetation can change from a state of weight loss to weight gain after production of small amounts of green feed following moderate falls of rain, as evidenced in Part I (McCown, 1981). M. J. Playne and R. L. McCown (unpublished) found that steers which lost $> 1\,\mathrm{kg\,day^{-1}}$ for the two weeks prior to 40 mm rainfall, gained $0{\cdot}8\,\mathrm{kg\,day^{-1}}$ during the six weeks following this rain. A second cause of error was due to their reliance on soil water storage as the independent variable driving plant growth. This ignores the efficiency of sequential small rainfalls in producing important amounts of green feed without appreciably influencing the soil water term in the model, a problem avoided in the present study by using an evapotranspiration-based independent variable.

The description of climate in this study has been calibrated and interpreted in terms of animal production. However, since the independent variable is defined in terms of plant growth there is reason to expect that the climatic descriptions may be useful to those concerned with pasture plant introduction, evaluation, and improvement in this region. The survey cited above by Miles (1947) was conducted specifically to serve this research activity in Queensland. In addition to expanding the geographic scope, it is submitted that the green season, as defined here, and its complement, the dry season, may be more relevant to pasture plant adaptation in this climate than the active growth criterion of Miles.

The uncertainties as to when the green season will begin and how long it will last in any given year are severe constraints on animal production. Mating (and calving) should be timed to synchronise maximum nutritional demands by cows and calves with the period of highest quality pasture. The most important determinant of conception date is the date of green season commencement (Churchwood, 1965). Not only is this beyond the control of a manager, but it varies so greatly from year to year that it cannot be anticipated within limits of many weeks over much of this region (Figs. 2 and 3). It is not surprising, therefore, that the efficacy of controlled mating has been questioned (Churchwood, 1965; Donaldson *et al.*, 1967). The methods used in this study should provide an effective means of evaluating the consequences of breeding management alternatives for different areas.

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APPENDIX

Number of years of rainfall data and the source of evaporation and temperature averages used in the simulation of pasture growth regimes. 'Pan' or 'tank' indicate existing records; '(T)' indicates estimates made using monthly maps of Australian tank (Anon. 1968); numeral is station code (McCown, 1980–81) of nearby donor station. With temperature, no entry indicates that data exist; a single station name or code number indicates source of data; in the case of two donors, estimates obtained by interpolation.

Station number	*Station name*	*Duration rain data (Years)*	*Evaporation data source*	*Temperature data source*
1	Cape York	34	2	
2	McDonnell	33	Pan	
3	Mapoon	29	4	
4	Weipa	24	Pan	
5	Moreton	36	2	
6	Iron Range	14	(T)	
7	Aurukun	34	4	4
8	Coen	40	Mt. Croll pan	
9	Musgrave	33	8	
10	Mitchell River	34	(T)	
11	Dunbar	32	(T)	10
12	Palmerville	41	Pan	
13	Laura	34	(T)	Fairview
14	Cooktown	36	(T)	
15	Van Rook	32	(T)	10, 20
16	Wrotham Park (Walsh)	34	(T)	12, 25
17	Chillagoe	30	(T)	18
18	Mareeba	34	Tank	
19	Burketown	40	Pan	
20	Normanton	34	Pan	
21	Donor's Hill	47	(T)	
22	Croydon	33	Pan	
23	Esmeralda	29	(T)	22, 24
24	Georgetown	34	Pan	
25	Mt. Surprise	60	Pan	
26	Meadowbank	14	(T)	25
27	Mt. Garnet	33	18	18, 25
28	Cashmere	29	(T)	18, 25
29	Lyndhurst	35	(T)	25, 39
30	Greenvale	42	(T)	25, 39

Station number	*Station name*	*Duration rain data (Years)*	*Evaporation data source*	*Temperature data source*
31	Kangaroo Hills	59	(T)	
32	Clarke River	31	(T)	39
33	Maryvale	34	(T)	39
34	Wandovale	28	(T)	39
35	Cargoon	33	(T)	36, 39
36	Hughenden	64	Pan	
37	Pentland	30	Pan	36, 39
38	Dotswood	30	(T)	39
39	Charters Towers	39	(T)	
40	Townsville	40	Pan	
41	Woodstock	72	(T)	
42	Ayr	40	Pan	
43	Woodhouse	35	(T)	Millaroo
44	Mt. McConnell	39	Mt. Coolon pan	48
45	Collinsville	35	Pan	
46	Mirtna	59	(T)	39, Clermont
47	Bulliwalla	61	(T)	39, Clermont
48	Mt. Coolon	19	Pan	
49	Bowen	44	Pan	
50	Darwin	34	(T)	
51	Oenpelli	27	(T)	
52	Gove (Yirkalla)	30	(T)	
53	Adelaide River	25	(T)	Milton Springs
54	Daly River Mission	11	Douglas Pan	Douglas
55	Pine Creek	35	(T)	
56	Mountain Valley	13	(T)	57, 59
57	Katherine	34	(T)	
58	Mataranka	14	(T)	Larrimah
59	Roper River	29	(T)	
60	Newry	33	(T)	Kununurra
61	Timber Creek	30	(T)	
62	Willeroo	30	(T)	57, 63
63	Victoria River Downs	33	(T)	
64	Daly Waters	25	(T)	
65	Borroloola	33		
66	Kalumburu	34	(T)	Pago Mission
67	Kunmunya	25	(T)	MB
68	Drysdale River	21	(T)	Mitchell Plateau
69	Carlton Hill	29	(T)	Kununurra
70	Ivanhoe	30	(T)	Kununurra
71	Gibb River	35	(T)	76, 68
72	Argyle Downs	38	(T)	70, 76
73	Beagle Bay	29	(T)	Cape Leveque
74	Derby	29	(T)	
75	Mt. House	31	(T)	71, Fitzroy Crossing
76	Turkey Creek	41	(T)	
77	Broome	30	(T)	