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THE MONSOONAL NORTH OF WESTERN AUSTRALIA.

BY

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The Monsoonal North of Western Australia.

K. M. DURACK.

SECTION I.—A survey of the environment and its relation to comparable climatic types.
SECTION II.—The open range, its problems and improvement.
SECTION III.—The Carlton Reach Experimental Area: Findings 1942 to 1945.

SECTION I.—CLIMATE.

A certain amount is known about the geography of the Kimberleys; sufficient possibly to form a working basis for development if aspects of topography, geological structure, soil characteristics and flora were the only concern of geographical understanding. However, of equal if not greater importance is the nature of the climate, which is in itself a vital consideration in determining the trend of rural development. What confusion exists as regards the potential value of the northern section of our continent, largely hinges on an inadequate or sometimes misleading interpretation of the climate.

The area under review may be classed as having a tropical, monsoonal climate of light rainfall. In monsoonal lands the influence of moisture laden winds from the ocean flowing inland towards a region of low pressure, caused by rising air above a greatly heated land mass, provides a markedly seasonal rainfall with annual precipitations varying from as much as 500 inches in the region of coastal mountains to less than five inches for inland centres.

The suitability of the country for white settlement is a perennial question for debate. Outside opinion on the whole seems satisfied that the climate offers a serious challenge to the prospects of settlement owing to its unattractive and likely unhealthy nature.

It is interesting to note that practically all residents of the area would not agree with such claims. Though conceding the point that conditions are trying for a certain period of the year most would contend that on the contrary the climate offers a particularly urgent and unreasoning attraction. Besides, they would be quick to discard the suggestion that the country is unhealthy. Nevertheless, a holiday south is looked forward to, not so much as an escape from the rigour of the climate which after a period of mental adjustment hardly enters the consciousness of a northern resident, but as a means of escaping for a time the far more serious rigour of an isolated existence, often quite devoid of all the amenities of civilisation, which man has come to regard as so important.

It is very likely a fact, that man is not capable of exerting his maximum output of muscular energy during six months of the northern year. It must be remembered, however, that we are living in a mechanised age where it is seldom necessary for humans to work their bodies at full pressure for more than very short intervals. What disability there may be present in this respect, which applies to animals as well as man should not hamper efficient development in the modern sense.

Straightout sickness among the white population is a rare occurance. The area is quite free from the many serious tropical diseases and malaria need hardly be considered. The suggested unhealthy nature of the climate if such has any foundation must therefore be due to subtler influences than infection.

Presumably our North is considered unhealthy because of a rather false comparison with the equatorial regions of the world which have perhaps rightly been described as "regions of debilitation." Here owing to the absence of sea-

sonal change, in an area which is continually fairly hot and humid, it has been found that the white man experiences great difficultiy in recuperating from a state of ill health which may have been brought about by any cause—accident, unsatisfactory diet or infection. In order to regain full health and vigour a change of climate is more or less essential. On the other hand under light rainfall monsoonal conditions there should be sufficient seasonal change within each year to allow for the continued healthy existence of white settlers. What evidence there is from those already resident in the North supports this claim.

Strictly speaking from a Geographer's point of view we are dealing with a transitional climatic type—transitional between what is classed "tropical savanna" and "low latitude steppe." It is important to understand this fact and so realise that it is rather easy to approach any question of development with either an optimistic or pessimistic bias, depending upon whether the country is classified as belonging wholly to the former or wholly to the latter category. While we still have to deal with unknown factors there is always likely to be contention between two factions each of which is capable of proving with figures, no less than words, the serious disabilities on the one hand or the very great potentialities on the other. The only hope of reaching a final, truthful interpretation lies in research directed towards accurate local understanding and correlation on a world basis.

The following brief account of four comparable climatic regions is included in the hope that it may be a small but useful contribution to a study which in the writer's opinion is of vital importance in relation to any policy of development in North Australia.

1. INDIA.

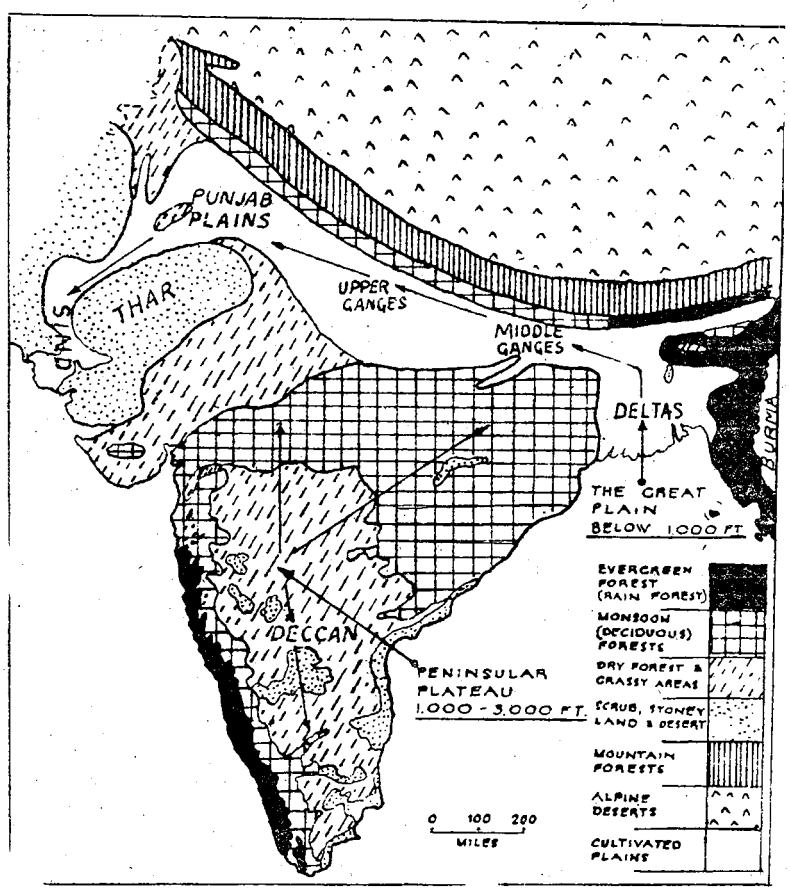
Practically the whole of India is classed by geographers as a "tropical monsoonal" country, yet strangely enough nowhere within its boundaries do we find any extensive areas of true grass land. Even the areas of low rainfall which would superficially appear directly comparable with our northern grass lands carry a low, open thorn forest vegetation with grass occupying a subsidiary part in the flora. To quote from L. D. Stamp:—

> The natural vegetation of India is essentially forest and even the desert tracts are really very dry types of forest. Patches of grass land occur interrupting the monsoon forests on the hills and much of the open thorn forest has a carpet of grass but otherwise grass land is not characteristic of India.

For thousands of years India has been essentially an agricultural region The general trend of modern endeavour still leads to a system of agricultural land use.

Few people realise the importance and scope of irrigation works in India especially throughout the great northern plain which extends for more than 2,000 miles across the northern section of the sub-continent. In the Punjab alone, 13 million acres are irrigated. This is but a small portion of the total irrigated area which amounts to more than 63 million acres, or something like a sixth of the whole cultivated area.

Recently large engineering works in the form of canals and dams have been undertaken which yearly bring fresh areas within the irrigation network. Under the Lloyd Barrage scheme of the Indus River in the Sind, nearly 7½ million acres are to be irrigated. As someone has pointed out, India adds an Egypt to her land every year and no one takes any notice.



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[L. Dudley Stump, "A.S.I.A."]

In relation to our own irrigation project which pales beside such enterprise India may be looked upon as the store house of agricultural knowledge in fields which could possibly concern us vitally. A list of their main crops might not be out of place.

Food.	Oil.	Fibre.	Spices, etc.
Rice	Linseed	Cotton	Chillies
Wheat	Sesamum	Jute	Pepper
Barley	Rape and mustard	Hemp	Ginger
Millet	Ground nuts	Kapok	Nutmegs
Maize	Coconut		Cloves
Gram	Castor		Opium
Sugar			Indigo
			Coffee
			Tea
			Tobacco

Besides, fruits of practically every description, especially sub-tropical and tropical varieties.

2. SOUTH AMERICA.

South America possesses two areas which are comparable with monsoonal North Australia:—

(a) The Llanos of Venezuela and Columbia.

(b) The North Eastern section of Brazil.

(a) *The Llanos.*—The Llanos or low lands of the Orinoco River possess an almost unparalleled grassland area covering 200,000 sq. miles. It lies within a tropical environment having a more than moderate rainfall—40-80 inches. The area is essentially a vast grass covered plain which suggests the nature of the climate—heavy summer rains and absolute winter drought. The country is most interesting in that it presents a picture of an environment that many would wish upon our monsoonal North, simply a bountiful seasonal rainfall and on the other hand an environment that many seem to imagine our North really does possess in the form of general climatic disabilities.

Economically, industry in the Llanos, which is at present almost wholly restricted to the rearing of cattle and horses, has lagged behind other parts of South America. After a study of the area it is fairly easy to imagine why Stock suffer severely from plagues and pests, the likelihood of flood together with the normal hazard of swamp and bog renders the area almost unmanageable and inaccessible in the wet season. Grasses, reacting to the bountiful rain rapidly reach a state of development too coarse and unpalatable for efficient utilisation by stock and once dry may be considered even less useful. The climate and low-lying nature of the country provides ideal conditions for malaria and other fevers which are common so that it appears an unsatisfactory habitat for man. To such factors must be added the country's stormy political heritage. Despite such obvious disabilities the area apparently carries a fairly large population, at least when compared with Australian standards.

Under improved conditions the grasses La India and Yaragua are recognised to be of great value and reference has been made to the use of alfalfa in an effort to overcome the severe nutritional stress of the annual drought. If it is correct that the Llanos can grow alfalfa satisfactorily a study of its reaction in such comparable and likely more rigorous environment could very possibly provide us with considerable enlightenment.

(b) *North Eastern Brazil.*—In North Eastern Brazil there is an area which may be looked upon as an island, within an otherwise almost wholly humid tropical region characterised by uncertainty of rainfall and partial aridity, a land of violent storms, floods and droughts to which Brazilians have given the name "Job of the North." In considering this environment it must be remembered that when not suffering from drought the area receives what could be almost looked upon as abundant rain, so that between periods of denuding, desiccation and torrential downpours, presenting ideal conditions for erosion, this section of Brazil is sorely tried.

In times of drought the populace is forced to evacuate the stricken region. In one instance forty-five thousand people left the "Sertao" in the State of Ceara. To overcome water shortage the Brazilian Government has instituted a programme of water conservation in the form of reservoirs, which seem to be similar to the famous "tanks" of India.

For the above reasons and also because of a peculiar climatic trick which causes the rainy season to occur in autumn rather than summer, so that no rain falls during the hottest period of the year, the area is not directly comparable with our North, but does provide a most interesting field for fruitful comparative study.

The country may be divided into several distinct regions predetermining any programme of land use. Firstly, the comparatively well watered coast lands of limited extent—the "Matta," which is characterised by agricultural enterprise. Secondly, as we proceed inland the "Caatinga" possessing a rather typical arid type of vegetation within which cacti are prominent and thirdly the "Sertao," a land of brush wood and grasses extending to the upland regions of greater rainfall reliability. Here we find the greatest development of pastoral enterprise. Despite obvious shortcomings such pastoral activities are extensive in scope. It is estimated that there are four million cattle of the Zebu type and over 3,000,000 goats in Brazil's north-eastern States (excluding Bahia).

The following is an interesting quotation from a writer referring to this area:—

> Cattle rearing is organised on large scale lines on great estates, each of which is largely self sufficing as to food supplies in ordinary times. Attached to these estates are small colonies of permanent settlers called "Moradores," whose business it is to cultivate the food crops for the whole patriarchal community . . . The cattle roam at large and the small areas under crops are fenced in.

(*Vide* Land Utilisation Prospective, in the "Kimberley Project," by L. J. H. Teakle. *Journal Dept. Agric.*, Dec., 1944.)

Together with the main ranching undertakings there are three subsidiary industries.

(1) Cotton culture, in regard to which it is said that the annual type is only grown in favoured districts, whereas a drought resistant tree variety becomes prominent in less favoured areas.

(2) Producton of Carnaúba wax from the Carnaúba Palm, a drought resistant tree growing wild over extensive areas of the Sertaos and Caatingas. The wax is obtained from young leaves. Fruit and pith provide food, the stem timber and leaves are used for roofing purposes.

(3) Rubber production. Two types of rubber producing plants are native to the area, viz., (a) the Manicoba plant, *Manihot glaviovii*, producing what is known as Ceará Rubber, and (b) the Mangabeira Tree, *Hancornia speciosa*.

Once again it is of interest to point out that there is a body of opinion which when dealing with the subject of our Northern environment lays much stress on:—

(a) The unreliability of the rainfall and possible drought.

(b) The likelihood of floods.

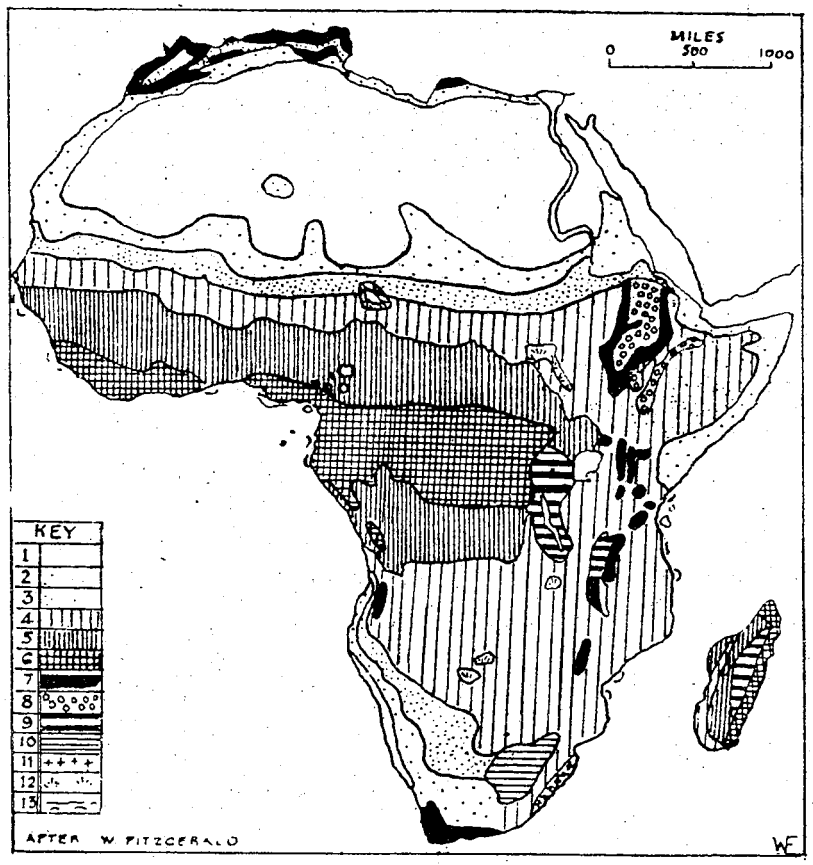
(c) The damaging effect of torrential downpours.

(d) The imagined disability of great heat and evaporation in summer as a factor in limiting the growth of plants.

It would appear that their arguments would fit the outlook of north-eastern Brazil much more closely than that of our Northern Area. This does not mean that we are without some of these disabilities or that we should in any way pass them off as unimportant, but it does not mean that in approaching the subject it is necessary to keep all aspects in perspective. It is here claimed that in relation to at least monsoonal North-West Australia they are not so important as some would suggest.

3. AFRICA.

One might suppose that large sections of Africa would be comparable in more than a superficial way. However, after interpolating the factors climate, vegetation, topography, latitude and rainfall, our search is narrowed down to an area which by happy coincidence is almost the direct mirror image of Northern and particularly North-Western Australia, namely the Western Sudan.



1, Desert. 2, Semi-desert with small scanty bush. 3, Dry grassland with acacia. 4, Savanna. 5, Park savanna. 6, Rain forest of Guinea, Congo and Madagascar. 7, Mediterranean and cape forest and thicket, East African highland forest. 8, High plateau grasslands of Abyssinia. 9, High plateau grasslands of Equatorial East Africa and of Madagascar. 10, High veld. 11, Palm belt of Natal. 12, Marsh. 13, Mangrove.

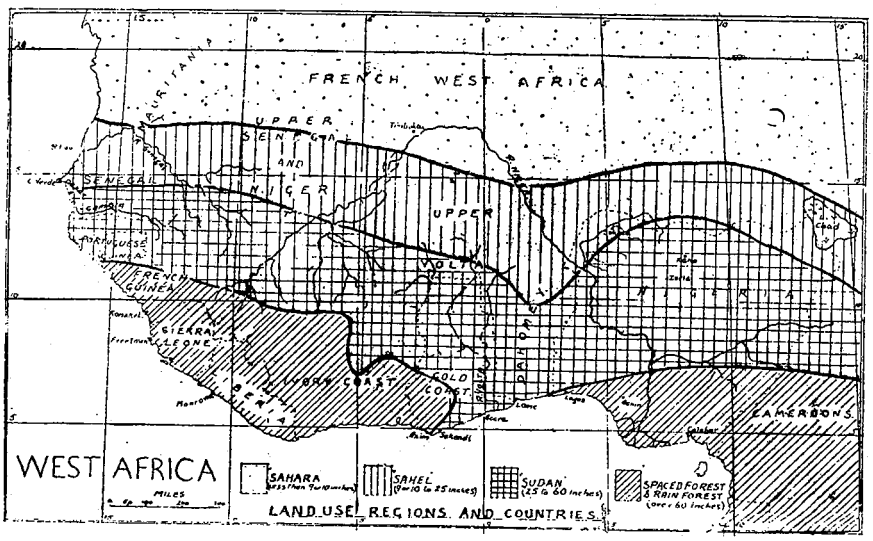
The French recognise several land use regions within their large colonial territory of French West Africa. Three regions of most significance to us are:—

(1) The Sahara, a region almost wholly unmitigated desert with a fringe of semi desert on its southern border.

(2) The Sahel, an area of dry Savanna merging into the Sahara region on its northern boundary. Over the whole area rainfall does not exceed 25 in.

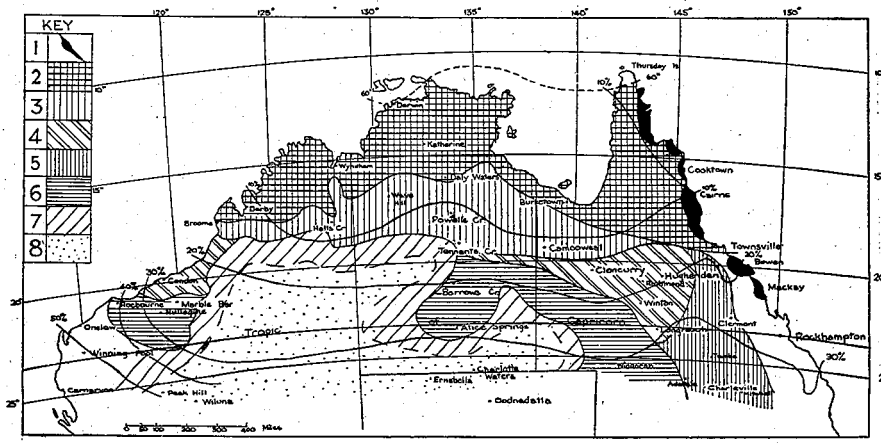
(3) The Sudan, tall grass wooded savanna with a rainfall of between 25 and 60 in.

The above land use regions together with the area of spaced forest and equatorial forest, 60-160 in. rainfall, have been charted on a map of West Africa and their boundaries extended outside French territory. Further, comparable regions have been indicated on a map of Northern Australia.



It is interesting to note that apparently the greatest agricultural development in French West Africa has taken place within the Sahel and about the low rainfall boundary of the Sudan. Soil types (refer soil map) and the peculiar requirements of the exceedingly important crops, ground nuts and millet may be responsible. It has been stated that up to recent years ground nuts contributed more than half of the outgoing commerce of French West Africa.

When we consider the soils and topography of North Australia (refer map) it is reasonable to suppose that as appears to be the case in French West Africa, large scale developments in monsoonal North Australia will follow the boundary between the Australian counterpart of the Sahel and Sudan, with more extensive use being made of the former, if only as a controlled pastoral undertaking.



1, Rain forest, humid, 10-12 months' effective rainfall. 2, Sudan (open forest, savanna woodland ranges), semi-humid, 4-6 months' effective rainfall, 25 in. to 60 in. summer seasonal rains. 3 and 4, Sahel (savanna woodland and savanna principally), sub-humid, 2-4 months' effective rainfall [less in the DeGrey, Anna Plains and Sturt Creek areas]—(3) North Sahel, not more than 15 per cent. of rainfall during winter months, fairly reliable rainfall; (4) South Sahel, above 15 per cent. of rainfall during winter months, unreliable rainfall. 5, Queensland, Central Western (open forest, acacia scrub, savanna), semi-humid, 4-8 months' effective rainfall, effective inter-seasonal rains, unreliable rainfall. 6 (a) Ashburton, Fortescue (dry steppe and ranges); (b) Alice Springs (mulga, saltbush, spinifex, sandhills, parkland and ranges); (c) Queensland Far Western (grassland, open forest, "channel country," mulga, spinifex sandhills and ranges); semi-arid, low rainfall, very unreliable, effective inter-seasonal rains. 7 and 8, Sahara. (7) Desert margins; (8) Desert, arid.

Note.—Lines indicate the percentages of the precipitation falling in the six "winter" months, April to September.

This map has been arranged for comparison with a West African interpretation of land use regions.

The Australian Sudan-Sahel boundary in accord with the French definition follows the 25 in. isohyet. Such line could be expected to have true significance as a critical land-use boundary for North Australia in that agriculture restricted to short season monsoonal crops should be just possible, within suitable areas, where the rainfall exceeds 25 in.

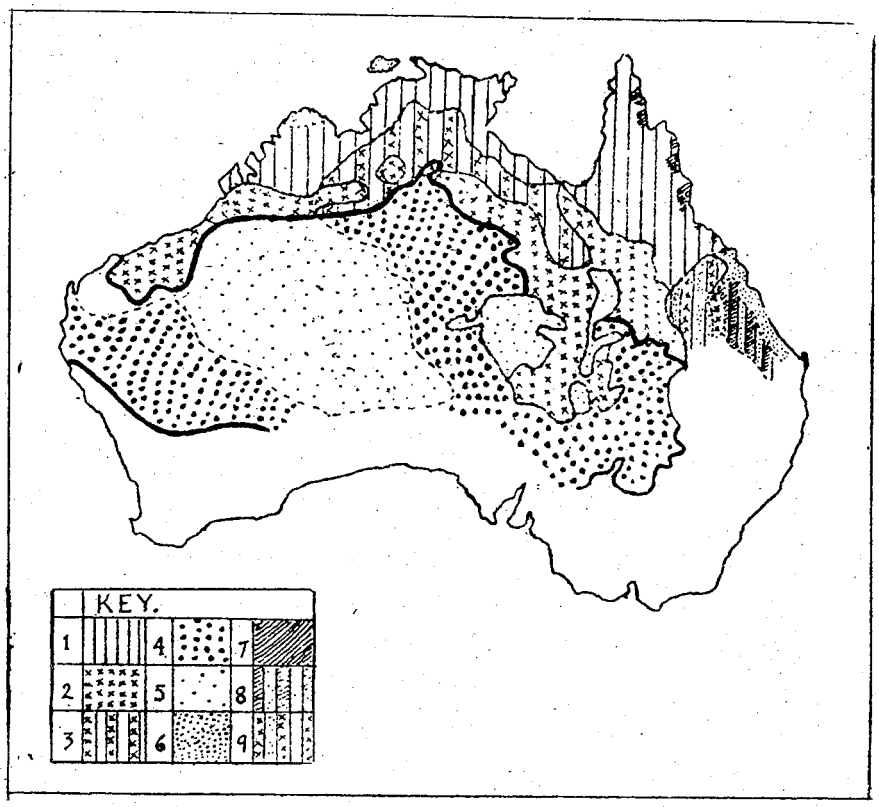
For Australia the mapping of a Sahel-Sahara boundary presents certain complications owing to the intrusion of areas which, mainly because of differences in the rainfall regime, cannot be considered as part of the Sahel.

These areas of intrusion into somewhat higher latitudes, receive a considerable percentage of their rainfall during winter months. When not suffering from drought they possess a grazing value in advance of the more northern pastoral areas in the Sahel. An adequate understanding of the factors involved is of vital importance to the future development of the Fitzroy, Ord, Victoria River and Barkly Tableland districts.

In Queensland, particularly, the Sahel, when considered as a whole, tends to lose significance as an area of strictly summer seasonal rain. At Cloncurry for example June has received effective rainfall as frequently as March. It therefore seems advisable to introduce a distinction between a Northern "True" Sahel and a Southern Sahel which receives effective winter rains in a number of years. The far eastern boundary of the latter subdivision has been made to correspond with the isochrone of four months' seasonal duration, and the southern boundary in Western Australia follows the limits of the spinifex plain country (brown soils of light texture).

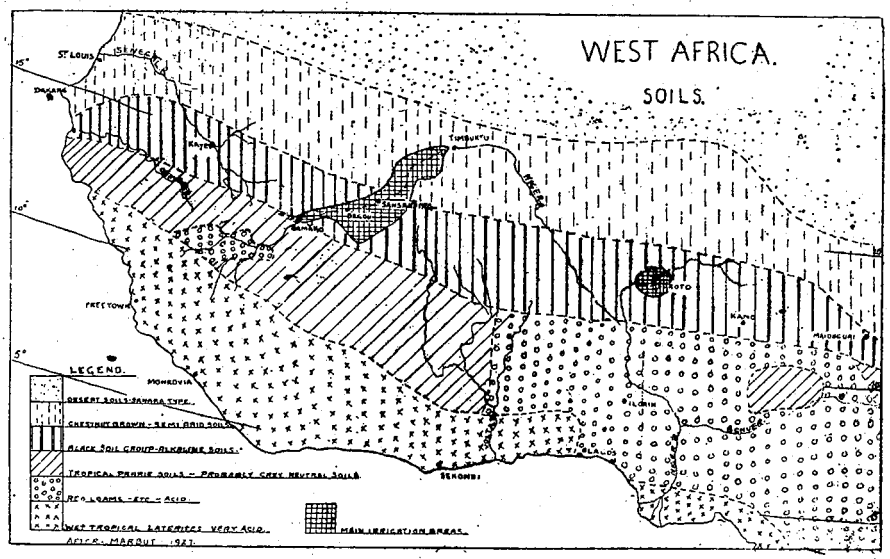
A study of the pastoral situation in the Queensland Central Western District, characterised by a comparatively equable distribution of a low rainfall throughout most of the year, has direct bearing on the problems of the Sahel so typically represented in the Kimberleys.

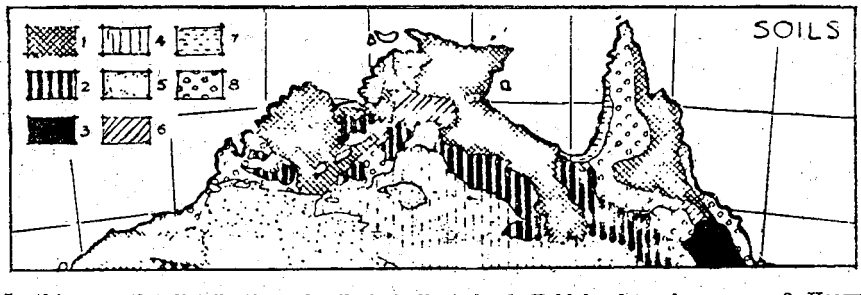
In compiling the map, use has been made of the work of Elizabeth F. Lawrence, C. A. Gardner, J. A. Prescott, A. McTaggart, A. G. Lowndes and H. H. Finlayson.



1, Park savanna. 2, Savanna; grassland with few trees. 3, Mixed park savanna and savanna. 4, Dry grassland and acacia mulga. 5, Desert grasses. 6, Spaced forest. 7, Dense forest. 8, Mixed spaced and dense forest. 9, Mixed spaced forest and grassland. The thick line separates the realm of the eucalypts from that of acacias which prefer dry country.

[*Map courtesy Dr. J. Gentilly.*]





In this map the distribution of soils is indicated:—1, Tablelands and ranges. 2, Heavy textured brown soils carrying open grasslands. 3, Black earths, including modified black soils carrying brigalow scrubs. 4, Soils of the desert and semi-desert other than sandhill country. 5, Desert sandhills carrying Triodia. 6, Red soils, including the red loams of the Atherton Tableland. 7, Low-lying coastal plains with heavy soils subject to flooding. 8, Sandy and stony soils, including brown soils carrying low-tree savannas and inland and coastal podsols associated with savanna woodlands and heaths.

(After Prescott.)

Reference to a world rainfall variability map shows that our monsoonal North and West Africa are fairly comparable for this vital aspect. Though West Africa, as Prescott has clearly demonstrated, has a more reliable rainfall it must be recognised that monsoonal North-West Australia does not suffer any great disability in this respect. The area may be classed as having an assured rainfall quite adequate for pastoral needs with careful management. Droughts are not a factor to be reckoned with. (Refer experimental findings.)

The French have commenced to develop a large irrigation scheme which will eventually cover nearly eight million acres in the middle Niger basin between Bamako and Timbuctoo, thus controlling to a large extent the flooding which occurs annually below Segou, where the river slowly works its way through an intricate network of channels and lakes eighty miles wide, in some years inundating an area of thirty thousand square miles.

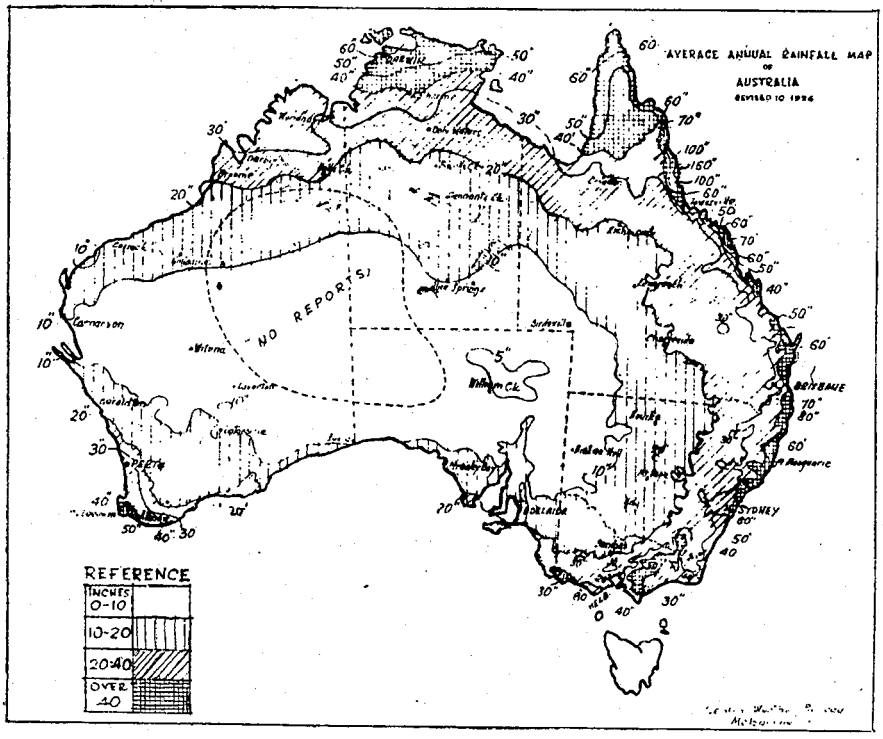
Up to the present time cotton culture has occupied almost exclusive attention. Fitzgerald points out that prior to French penetration the area was self supporting under a system of multi-culture but latterly owing to an insistent emphasis on the production of cotton tending towards an unsatisfactory system of mono-culture, large quantities of rice and other foodstuffs have to be imported annually for local consumption.

Pastoral industry in the Sudan appears very primitive and fades in significance besides what is essentially agricultural occupation. To quote from Fitzgerald, "when estimating the potential resources of the Western Sudan one should not overlook the undoubted future that is offered to a ranching industry of vast dimensions, comparable that is to say, with the great stock industry of the Argentine Pampas and the Australian Downs."

When concern is expressed about the encroaching Sahara, and an apparent process of gradual desiccation of the grass lands, one wonders whether West Africa, approaching pastoral expansion, might learn from us the dangers of vast uncontrolled ranching industries in return for what we could well learn from her in the form of agricultural technique.

Before leaving the West African scene it may be of interest to note that the Shea tree, *Butyro-spermum Parkii,* with its important product, Shea butter, might well find a home in Kimberley.

Other tropical areas in Africa, particularly the eastern states south of the Equator, although in no way directly comparable, provide an interesting field for study, especially in relation to grass land management and animal husbandry under improved conditions.



As far as the writer knows there are no areas comparable to our North using irrigation for pasture development, so that a knowledge of grassland development under naturally humid tropical conditions is the next best field of study when considering this likely important phase of our northern development.

It is comforting to learn that the results of our own experimental work small as they may be, closely follow the general conception of profitable and healthy land use in a humid tropic environment. It seems that as far as pastures are concerned their problems are our problems but that luckily we being in a position to regulate precisely the all important factor, water, as well as possessing for six months a comparatively dry atmosphere, should be in a much better position to overcome those problems. The mere fact that we should be able to grow lucerne satisfactorily simplifies the whole outlook. (Refer experimental findings.)

4. AUSTRALIA.

Perhaps one of the most significant experimental results of the last three years has been the indication that the research findings of the sub-tropical parts of Australia, as regards grassland management and improvement, will be fairly applicable within our thoroughly tropical monsoonal environment. In fact it seems that we can even go as far as to say that under irrigated conditions our prevailing northern environment, for plant growth more closely approaches that of Lawes in Southern Queensland than that of Townsville and like areas in the North.

This means that not only may a study of Queensland sub-tropical rural conditions help us considerably, but also, that we may call on the knowledge of the sub-tropical southern States of the U.S.A. and the Argentine.

It must be stressed, however, that these humid sub-tropical regions only become comparable when we accept the possibility of overcoming the prevailing sub-humid conditions of our North through irrigation.

Anyone familiar with Mediterranean climatic conditions (generally recognised as the nearest possible approach to an ideal living environment) would find it somewhat difficult to adjust his outlook to tropical monsoonal conditions. It may therefore be useful to list some important features which the South-West and far North-West of Australia have in common.

(1) Each is subject to a rather low rainfall, ranging from about 40 to 10 inches, so that there is in the Mediterranean area and is likely to be in the monsoonal area, a characteristic zoning of land use from the coast inland.

(2) The reliability of the rainfall is roughly comparable in each case. In as much as rainfall reliability figures provide a useful index for the success of agriculture, it must be pointed out that although agriculture may be considered safe within the Southern area where rainfalls are considerably less than 20 inches for the northern area agriculture could, it seems, only be contemplated where the rainfall exceeds 25 inches.

(3) Both areas have a strictly seasonal rainfall as opposed to the inter-seasonal rain of most subtropical regions and the more or less continual rain of Equatorial regions. The seasonal rainy season implies an extensive period of drought. Each carries a natural vegetation peculiarly adapted to withstand such period of stress.

Because of such common exigencies of climate irrigation if possible should be of great importance to the economic development of both areas.

We may likewise list some important differences:—

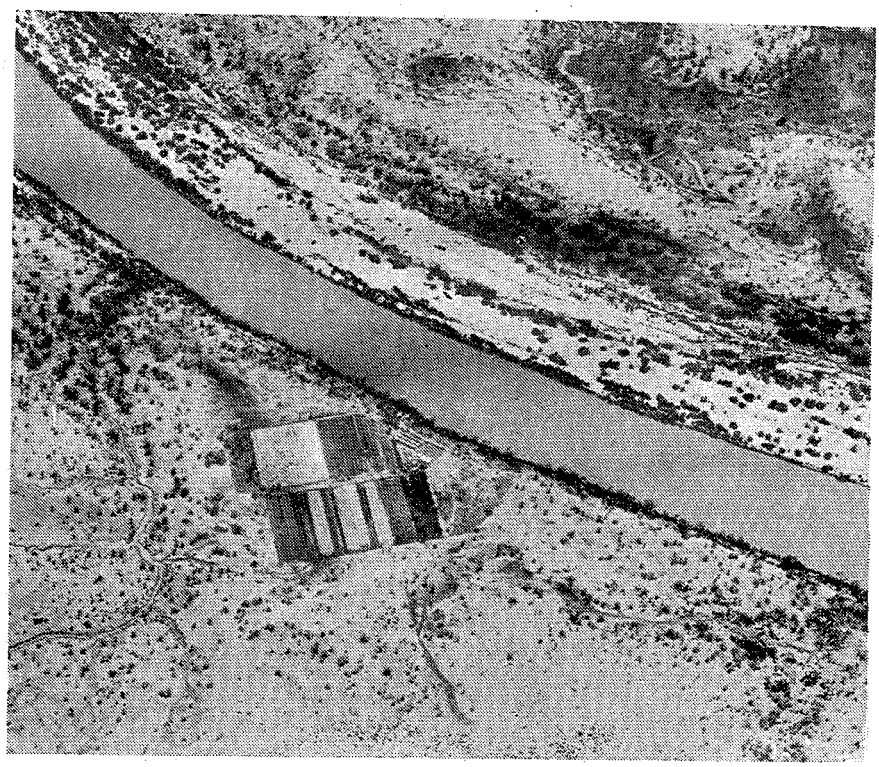
(1) The South-West receives the bulk of its rain in winter. The monsoonal North-West receives its rainfall in summer.

(2) The length of the wet season is shorter for the North. The ideal growing conditions present during the monsoonal wet season could be expected to narrow down any relative disability in this respect.

(3) The rainfall per wet day is considerably greater under northern conditions. In a summer rainfall area this can hardly be considered undesirable, as light showers unless immediately following substantial falls would be of little value. Besides, monsoonal crops seem well adapted to take full advantage of isolated heavy bouts of rain.

(4) A winter rainfall does not favour the growth of grass so that until extensive research somewhat overcame this disability of Mediterranean areas

they were pre-eminently agricultural lands. On the other hand summer rains favour abundant development of grass pre-eminently therefore the North is and is likely to remain a pastoral proposition. In its natural state the latter stands as a greater asset than the former.



Aerial photo. of Experimental Plots—December, 1944.

SECTION II.—THE OPEN RANGE.

The pastoral industry throughout Australia's light rainfall areas has up to the present conformed to the simple pattern of extensive open range management. It has been a system of exploiting the natural grassland and herbage resources of the continent for what they are immediately worth.

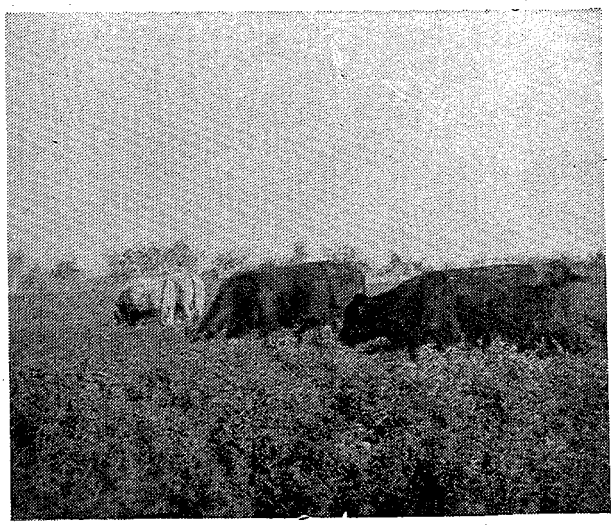
The provision of water to make such grazing land fully available has been one greatly important aspect of improvement; considerably more important than the only other recognised essential of improvement, fences and yards for stock control.

This system has been applied throughout the whole continent regardless of the peculiar conditions and needs of widely differing districts. It has almost up to the present worked remarkably well, so much so that it is more or less looked upon as the only feasible method of pastoral exploitation. Now, however, there ore obvious signs throughout the entire hinterland that such a policy of land utilisation will not work indefinitely, simply because the natural fodder

resources are not a stable and unchanging asset, but one peculiarly responsive to treatment; which is expressed in a now rather obvious law:—

> Uncontrolled stocking on a sufficient scale to satisfy man's economic demands leads eventually to denudation and final pasture destruction through erosion.

We are at the present entering a new era of land appraisement, in which it is beginning to be realised that Australia's out-back needs classifying into at least three regions. Firstly, marginal stocking areas of lasting difficulty Secondly, potentially valuable areas which however are subject to drought and so require delicate handling. Thirdly, areas of assured rainfall which should respond through careful management and the application of research to become lasting assets of great national significance.



Stock in Lucerne Pasture—Ord River.

Such a like arrangement is the first vital step in recognising that for the future successful continuance of the vast stock raising industry of Australia the accent needs to be on pasture control as well as stock control.

In the writer's opinion, after nearly ten years of close observation and three years of experiment, monsoonal North Australia falls into the third catagory. With good sense in stocking and ordered research for pasture and stock improvement there seems no reason why it should not become one of the most prosperous and stable cattle rearing centres of Australia. With the provision of irrigation it should rank in capabilities if not in extent among the greatest beef producing centres of the world, quite apart from any subsidiary industries which irrigation would make possble.

The realisation of this goal will largely depend on the extent to which we are capable of appreciating fully the controllable limitations rather than the immediate productive value of the land. It would therefore appear important to review very briefly certain problems which confront the pastoral industry as

it stands at the moment, and also point out certain observed facts with regard to the effects of roughly sixty years of open range grazing management on the natural grasslands of the country.

At the end of the wet season in Kimberley and the adjoining areas of the Territory there is what could be casually looked upon as an over abundance of feed. Much of it will, however, be coarse and unpalatable and probably by August all pasture will be below maintenance in terms of protein, phosphate and vitamin content. (Research in similar latitudes indicates that by far the major problem confronting an animal relying solely on natural grass to fulfil its needs, is that of protein deficiency.)

Towards the end of the dry season cattle are of necessity concentrated around permanent waters. Feed in the vicinity is likely to become extremely scarce, so that they have not only to cope with nutritional shortcomings but also straight out starvation.

The first rains can only be expected to aggravate the situation by further leaching what feed is available and by imposing on stock a severe muscular strain through their often futile efforts at "storm chasing."

Unless immediate seasonal conditions are extremely favourable, the bulk of the herd remains concentrated along river frontages or around bores. Feed has little chance of coming away in the face of such stocking; a state of affairs which is serious in October, may well be prolonged until the end of December. It is only after December that the expected incidence of the rainfall becomes much more favourable and full relief is certain.

Under these conditions there is a tendency for the effective season to become shorter and shorter as the years progress and frontages deteriorate until claimed by a sparse weed flora which is not sufficient to prevent final desolation through erosion.

The situation varies from year to year and the intensity of the trouble will vary also with the type of country concerned. The fact, however, that we are confronted with a man-made problem of serious and ever increasing proportions cannot be denied.

It must be recognised that improvement does not entirely depend on the expedient of providing water as a means of bringing fresh country into use or by the provision of fencing and yards to facilitate the handling of stock, as there is no limit to the amount of country that can be eventually ruined if we do not know exactly the laws governing the existence of the very life blood of the industry—the natural grassland.

As a result of the existing policy of management there is evidence to show that a process of grassland deterioration has occurred; continuance of such a policy must eventually lead to the time when it will no longer be possible to rear stock on a profitable basis.

Grassland research is urgently needed to determine the limits within which pastures may be maintained indefinitely at an appropriate level of productivity, and also to investigate thoroughly the feasibility of improving that standard of productivity with due regard to the essential nutritional needs of the grazing animal.

At the moment we can but say that all evidence, observational and experimental, which is available points to the fact that such research would be extremely fruitful; that there is a definite possibility of vastly improving the present carrying capacity of the district.

The attached chart is submitted as a contribution towards the study of grassland associations in relation to stocking practice. It may be looked upon as a survey of pasture succession, progressive or retrogressive, operative under large scale grazing in Kimberley with particular reference to the Ivanhoe area.

The succession ranges from the highest expression of grassland under the natural environment, namely the likely state of the grassland in the pre-stocking era, to bare ground which has become a feature of frontage areas in the immediate vicinity of watering places. The process may be regarded as a reversible one dependent on fluctuations in stocking or particular conditions of stock management. The whole indicated system hinges, as it were, about the region classified as the lowest expression of grassland consisting of annual grasses of a very ephemeral type. It may be divided into two distinct phases:—

(i) The herbage phase—indicating marginal grazing conditions.

(ii) The grassland phase—indicating safe grazing conditions.

The estimated usefulness of the varying associations has been indicated. It will be noted that the higher expressions of grassland do not necessarly mean a better quality pasture, this is particularly true for red soil areas. However, it appears that the climax grass association of black soil may be recognised as a most satisfactory pasture, namely, the blue, Mitchell and Flinders grass country of much renown. It may be said that only island areas now retain this particularly useful combination of grass types.

SECTION III.—CARLTON REACH EXPERIMENTAL AREA, EAST KIMBERLEY.

PRINCIPAL FINDINGS, EXPERIMENTAL AND OBSERVATIONAL, 1942 TO 1945.

PART I.—IRRIGATED PASTURE—PERMANENT AND SEMI-PERMANENT.

1. The prospects of obtaining a permanent highly productive pasture are good. Permanent being in the sense of a five or six year ley. Such statement at the moment, is wholly dependent on the fact that lucerne under certain conditions will persist as a mixture with grass. Sufficient time has not yet elapsed for definite conclusions to be reached, but we do know enough to assure excellent results, well into the third grazing year, from a paspalum/lucerne or rhodes/lucerne pasture. A uniform carrying capacity of two beasts to the acre could be expected.

2. It can be stated almost categorically that irrigated pasture requires a suitable mixture of grass and legume for continued satisfactory production.

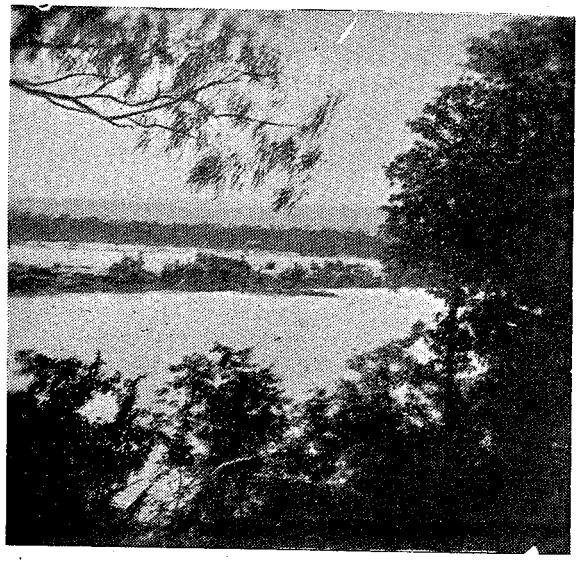
3. This does not mean that in the final analysis pure grass swards would have no place in a mixed farming economy. With due regard to the problem involved, straight out grass pasture, irrigated and looked upon as a semi-permanent ley of one or two years duration, should, owing to comparative ease of establishment, find ample scope for recognition as a profitable undertaking.

4. Simply considered however, it must be recognised that returns from a pure grass sward will be remarkably low after a very few months. Lack of available nitrogen here certainly plays a major role.

Pasture Components.

5. Lucerne is likely to be of great importance in any development project concerned with irrigation. Certain problems have arisen with regard to its healthy persistence, especially where it is considered as a pure grazing stand. Evidence indicates that we may reasonably hope for satisfactory control of such problems through relatively simple management practice.

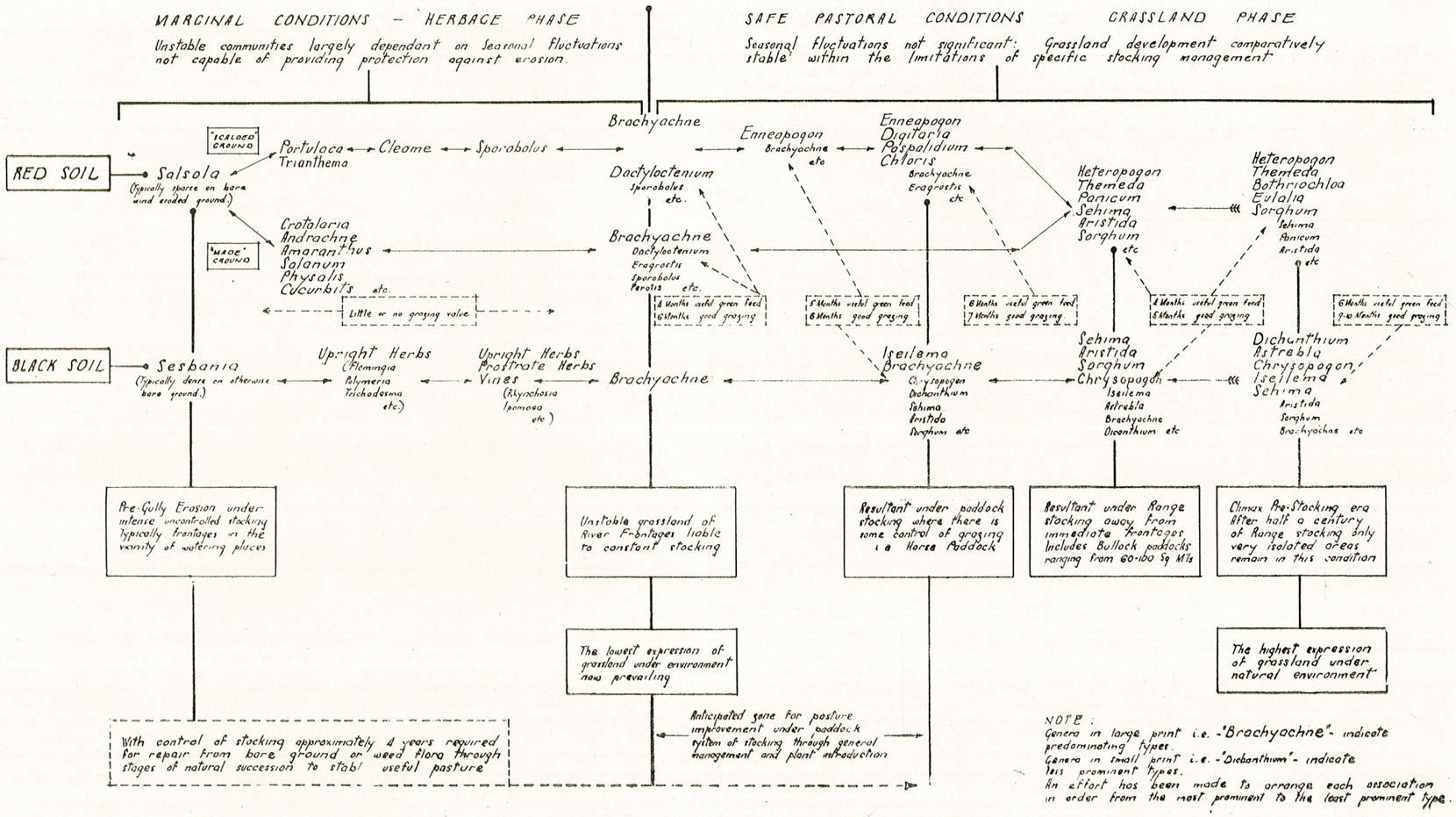
6. Tropical grasses in general when functioning as perennials, tend to lie dormant during the winter months. Further, grasses with a low water requirement will not tolerate a continually moist environment. Thus, the grass fraction of permanent pasture (which for the time being at least, must be looked upon as a grass-lucerne mixture) is restricted to types which, firstly, other factors being equal, are capable of a long productive period within each season; secondly, can stand permanently moist conditions, and thirdly, by reason of their growth habit will allow lucerne ample scope for satisfactory development. (Grasses which tend to develop large tussocks are not suitable.)



The Ord River at the New Experimental Site.

7. Three examples that fulfill the above requirements are Paspalum, Para grass and Rhodes grass. The latter being exceedingly aggressive it its early growth, can only be considered as a candidate when introduced sparingly to a lucerne stand after it has become established. In each case the essential process is the same, with the grass fraction coming into prominence only after lucerne has made considerable headway without competition. Subsequent management must be directed towards retaining good conditions for the growth of lucerne. Rather frequent and thorough renovation becomes important, as also heavy waterings at long intervals rather than light waterings at short intervals.

8. In the case of semi-permanent pasture, as defined earlier, grasses which develop rapidly come into prominence. Among many of potential value, Rhodes the Guinea grasses are likely to be of outstanding importance.



PASTURE SUCCESSION CHART.

	Common Names:
Salsola	Roly poly.
Sesbania	Pea bush.
Portulaca	Pig weed.
Sporobolus	Fairy grass.
Brachyachne	Native couch.
Dactyloctenium	Button grass.
Eragrostis	Love grass.
Perotis	Comet grass.
Enneapogon	Nigger head.
Chloris	Windmill grass.
Iseilema	Flinders grass.
Chrysopogon	Turnover grass.
Dichanthium	Blue grass.
Sehima	White grass.
Aristida	Feather top or wind grass.
Sorghum	Sugar grass.
Heteropogon	Bunch spear grass.
Themeda	Kangaroo grass.
Astrebla	Mitchell grass.
Bothriochloa	Blue grass.
Eulalia	Brown top.

9. The need for legume admixture in this type of pasture is important. A number of essentially tropical legumes have been grown successfully as pure stands. Work in this field has not been sufficient to justify any statements as to whether promising types could cope with the competition of a vigorous grass stand. *Phaseolus lathyroides,* an annual and *Stylosanthes guiannensis,* a perennial, may prove very useful. Besides, pigeon pea, a perennial peanut, and even cow pea have some potential value.

Irrigation Technique.

10. The Border System, Level Check or Contour Check methods of irrigation are necessary for pasture layout. Furrow irrigation of pastures is impracticable because of:—

(i) The deep unchanging profile of the soil.

(ii) The essential humus-less nature of such tropical soils, which compact with watering and trampling to a limiting degree.

11. In experiments to date, the Border System has been almost exclusively used. Borders six chains long and 22 feet wide have proved quite satisfactory.

Water Requirements of Pasture.

12. Experience so far indicates that we may expect the irrigation season to last from Mid-April to Mid-December. Although further information is necessary, it seems that for optimum and lasting returns watering will be necessary at three weekly intervals throughout the greater part of the season.

13. No serious work with regard to the water requirements of pastures has been carried out. It is rather obvious that irrigation practice to date has been generally in excess of plant requirements. Now that we have some knowledge of the likely reaction of various plants to the environment, it is possible to attack this question in some detail. It is nevertheless, reasonable to suppose, that other factors being equal, the ratio of water applied to resultant growth is well within economic bounds. General management in the nature of renovation and regulating the recovery period between grazings will be most important factors influencing effective utilisation of irrigations.

PART II.—NATURAL PASTURE.

14. The improvement of natural pasture has been the subject of some experiment and careful observation, as a result of which, although much more work is required before final judgment can be passed, it is possible to suggest as follows:—

Irrigation of Natural Pastures.

15. The concept of extending the growth period of natural pasturage by irrigation must be approached with caution, and as an ameliorative measure such no doubt costly arrangement, should not be necessary and could be most harmful.

16. It is extremely doubtful whether the natural grass species available would respond to much more moisture than the rainfall already provides. Experience indicates that where at least the river alluvial soil is irrigated, in its natural conditions, there is, if such irrigation is carried out as a normal practice a rapid reversion from grass land to wasteland, carrying immediately all the perennial weeds of the district to the exclusion of grass.

17. Apart from the fact that we have been able to observe, after the first waterings, green feed where normally none would exist, little has been gained to offset a much greater future loss. A problem in fertility also becomes evident which could be as much responsible for pasture failure as the relative moisture toleration of different plant species.

18. The mere fact of watering seems a straightforward and simple procedure, but it sets in motion a complicated mechanism of change. It therefore appears that pasture, when irrigated, is subject to the limitations and requirements of a much altered internal environment and that the premise "more water means more profitable growth" does not necessarily follow.

Sufficiency of the Rainfall.

19. Other factors being reasonable the natural rainfall is always sufficient for the abundant development of natural grass types. This it appears can be taken as axiomatic, and such assertion could well be operative over a much wider belt of country than the Ivanhoe district and its immediate surroundings. It follows, that if grass is not plentiful on areas of recognised grazing potential, it must be due to factors other than the rainfall.

Grazing Potential of Seasonal Pasture.

20. Seasonal pasture is here taken to mean any forage species or combination of species endemic or introduced growing entirely under natural rainfall conditions.

Within the experimental area, observation has shown that rotationally grazed seasonal grass pasture is capable of very high production over an extended period within each growing season, but that even though dealing with the natural rainfall, production is limited to fertility. To make full use of the productive power of suitable grasses and the moisture available, the fertility status of the soil needs to be raised. The introduction of a vigorously growing edible legume could be expected to both expand the possibilities of production and greatly enhance the value of the feed, especially during the dry months, (Unfortunately it is not yet possible to even suggest a likely suitable legume.)

21. The fertility of the soil should be quite adequate however, for the requirements of any extensive grazing concern.

Grasses Suitable for Seasonal Pasture.

22. For the improvement of seasonal pasture the following grasses can be immediately looked upon as worth encouraging:—

A. For so called red soil areas:
   - i. Buffel grass.
   - ii. Birdwood grass.
   - iii. Blue panic grass (*Panicum antidotale*).
   - iv. Digitaria species.

B. For so called black soil areas:
   - i. Blue grasses (especially *Diclanthium sericeum*).
   - ii. Mitchell grasses (especially *Astrebla lappacea*).
   - iii. Flinders grasses.
   - iv. Chrysopogon species.

The Prospects of Improving Natural Pasture.

23. Summing up the present outlook for the improvement of natural pastures, it may be said that we can go far towards greatly relieving the annual nutritional stress by simply insuring that pastures can take full advantage of a quite sufficient rainfall. The prospects of further improving the situation through plant introduction and/or plant reinstatement, together with the provision of home grown concentrates, should be agriculturally possible and we might dare to hope economically sound.

24. Comprehensive research in this field directed towards general agronomic aspects should be relatively straightforward and amply justified.

PART III.—FARM CROPS.

25. Efforts in respect to the growing of farm crops have mainly been directed towards ascertaining the nature of the habitat involved and gaining some idea of necessary cultural practices.

Crop Types Under Trial.

26. The crops used for such preliminary investigation have been summer growing types such as grain sorghums, Sudan grass, millet, maize, cow pea, pigeon pea, peanut, bombara ground nut, cotton, rosella and soya bean. With the exception of soya bean all have proved that they are thoroughly suited to the prevailing soil and climatic conditions. Grain sorghums are outstandingly successful. It may be well to note that rice has not been tried. It should be admirably suitable as a crop for "black soil" areas.

The Climate in Relation to Crop Production.

27. When the moisture factor is regarded as a constant, climate is suitable for at least the vigorous vegetative growth of summer growing crops throughout the year. Unless considered as purely forage propositions however, successful yield of the final product (grain, fruit or fibre), will depend on the peculiar conditions prevailing at the time the crop is approaching maturity. Thus maize in the tasseling stage would be seriously affected by the hot dry blasts of October. Again much loss from a number of causes could be expected if cotton was to mature during November or somewhat later. The same would apply to peanuts or sorghum.

28. Generally where crops are to be grown for their end product, seeding time would lie between December and May.

Cropping Under Natural Rainfall Conditions.

29. There is considerable, yet not conclusive evidence to support the contention that the natural rainfall is quite adequate for the healthy development of the more typical short season monsoonal crops. Which means in the final analysis that provided adequate cultural steps are taken, seasonal variability of rainfall, rainfall intensity and intra-seasonal drought are not of limiting consequence, and that the amount of precipitation and length of growing season are within bounds; despite the fact that such meteorological data when tabulated may seem hopeless.

30. We may say that agriculture entirely dependent on the rainfall could be successful as a subsidiary undertaking where the annual rainfall exceeds 25 inches, making possible the production of hay, grain, both cereal and pulse, and what may be vitally important for seasonal temperate vegetable culture, a satisfactory green manure crop.

Crop Production Under Varying Soil Types.

31. Crop production has been attempted on three soil types:

i. River alluvial or levee soil.

ii. Heavy, so called black soil.

iii. Light, so called sandy soil.

32. Results from the levee soil indicate that initially thorough preparation and later frequent cultivation throughout the growth period is essential for satisfactory returns. We have also been able to record strikingly better results from crops following irrigated pasture than from those grown on virgin ground.

33. Limited evidence from black soil indicated that initial thorough preparation and subsequent cultivation is not so essential for success and that such soil tends to exhibit a greater natural fertility than the levee soil.

34. Finally our initial dealings with sandy soil show that it is essentially poor with very restricted usefulness.

Irrigation of Crops.

35. Little work has been carried out as regards the large scale irrigation of crops. However, there is evidence to show that the amount of water required under a system of furrow irrigation would be directly comparable with the optimum moisture requirements of similar crops under rain grown conditions, provided, and this is certainly essential when dealing with levee soils—cultivation is considered a necessary complement of watering.

Factors Limiting Crop Productivity.

36. When considering the prospects of crop culture whether irrigated or not, during the summer and early autumn, that is between December and May, we are forced to face the fact that the grasshopper will be a most serious limiting factor, rendering successful results rather precarious. The grasshopper must be controlled.

37. Further factors limiting crop productivity are firstly, the chemical fertility of the soil and secondly of even greater significance, the physical structure of the soil.

38. There is every reason to believe that a healthy alteration between cropping and pasture would adequately deal with the latter factors without imposing any economic strain.

39. Agronomically we could expect the concept of "semi-permanent" pasture as a function of mixed farming, to fulfil a variety of needs. Needs which are obvious for so called red soils even in their virgin state. Needs which would, it is thought, become apparent over the black soil areas within a short period if simple cropping be the rule.

40. Viewing but one aspect of the situation, a short term grass pasture could be looked upon as essentially a drain crop to precede cotton culture, or on the other hand a short term pure lucerne pasture could be looked upon as a

storage proposition to precede an arable rotation involving crops with a higher nitrogen requirement. The question is, however, more complex, in as much as both types of pasture would be of greater value in improving the soil structure and maintaining that structure.

41. It seems that within this tropic environment we would have to choose between a fertility conserving programme, involving a pasture-crop rotation supporting a varied stable economy or, the result of continued cropping for even a few years, a structureless dust or pug, subject to erosion, incapable of absorbing an adequate amount of moisture or air, resisting root penetration and quite dependent on the application of artificial fertiliser for any results.

PART IV.—VEGETABLE CULTURE.

42. Some work has been carried out in connection with vegetable production. Cultural aspects of this activity follow the same general pattern as for farm crops already discussed.

43. When production is considered on the scale of the home gardener or small market gardener, it is felt, because of the scope for intensive management as regards manuring and rotation, that a "garden area" could be kept in constant crop production.

44. Large scale vegetable culture with possibly no great scope for rotation, should for reasons already enumerated be considered as a function of mixed farming.

45. Owing to insects and likely unfavourable climatic conditions, early vegetable planting must be from seedlings reared in insect proof frames arranged in a somewhat shaded position. Later in the season considerable success could result from the direct planting of seed into permanent positions.

46. Satisfactory results can be assured by watering not more often than once a week. Under existing soil conditions, where the watering of short crop rows is frequent, it appears that some modification of the orthodox furrow method of irrigation is required. Better results have been obtained from the direct application of water to the plant than through watering by means of furrows at the side of the plant.

Suitability of Vegetable Crops Under Trial.

47. The following analysis gives some idea of the possible scope of activity:—

I. Outstandingly suitable with a wide range of production:
Sweet potato, pumpkin, tomato, Chinese cabbage, goyda bean, snake bean, watermelon.

II. Outstandingly suitable for growth during autumn, winter and early spring:
Onions, cabbage, beetroot, silver beet, turnip, kohlrabi, green peas, cucumber, rockmelon, sweet corn, carrot and culinary herbs.

III. Requiring special cultural stimulus for success with a rather restricted season:
Lettuce, cauliflower and celery.

48. There is no reason to suppose that sufficient vegetables of quite a varied and healthful order should not be available throughout the year. Tomatoes, a most acceptable vegetable, could with special attention remain in season

between late June and January. January to May could be considered lean months with at least the following to be called on:—Sweet potato, snake bean goyda bean, Chinese cabbage, bugle pumpkin (all suitable for production during this period), together with onions and pumpkins out of store.

PART V.—FRUIT CULTURE.

49. Little work has been carried out with regard to fruit culture. It seems that we are only in a position to say that papayas and bananas may be grown successfully and with ease. Pineapples, tried in a very restricted way have not flourished. It may be that, for their successful culture under our particular conditions, special means of reducing the prevailing alkalinity of the soil would have to be adopted. The application of sulphur could possibly be a means to this end. An effort is being made to grow passion fruit. With special attention plants have survived their first summer; they should grow vigorously and produce fruit with the onset of cooler weather.

50. Probably the scope of fruit culture will be quite restricted to tropical and semi-tropical types. A list of those which should be quite adaptable to our conditions follow:—

(i) The citrus fruits.
(ii) Banana and plantain.
(iii) Papaya.
(iv) Custard apple.
(v) Mango.
(vi) Pineapple.

These have already proved their suitability in gardens of the Kimberleys and Territory.

(vii) Avocado.
(viii) Granadilla.
(ix) Monstera deliciosa.
(x) Passion fruit.

51. Concern is often expressed as to the suitability of citrus fruits, because of their susceptibility to white ant attack. Control would be necessary, but it is hardly conceivable that such would not prove thoroughly effective, especially when we think in terms of a well planned and carefully prepared orchard rather than the odd tree in a garden corner.

PART VI.—FERTILISER EXPERIMENTS.

52. Manurial trials have been instituted at various times throughout our investigations.

53. In the original layout a replicated experiment involving the three manures, blood and bone, sulphate of ammonia and superphosphate, together with control areas receiving no treatment, yielded no positive result whatever. The resultant growth was comparable in all cases, even and vigorous.

54. Superphosphate was looked upon as the most likely immediate manurial requirement, as a general practice therefore, most of the area in the course of establishment was arranged to fit the requirements of a simple experiment. One third of the various pastures received no treatment, another third received 1 cwt. of superphosphate per acre and the final third 2 cwt. of superphosphate per acre.

55. Results showed that superphosphate did stimulate the growth of pastures in a minor degree, with nothing to justify any further claims.

56. As time progressed it became very obvious that all pure grass swards were suffering from a serious deficiency. The fact that grass when intimately mixed with lucerne was very much more productive, together with other observations, provided the clue which lead us to the conclusion that the major factor operating against the continued satisfactory maintenance of yield, when dealing with irrigated grass pasture, was simply a lack of available nitrogen. Subsequent evidence has fully supported this finding and further lead us to the proposition, that permanent pasture demands legume admixture.

57. It is not at the moment expected that direct manurial treatment with nitrogenous fertilisers would be economically feasible. It is felt, however, that the normal fertility of the soil could, with adequate cultural practices, be raised to a point where semi-permanent irrigated grass swards would become a profitable undertaking.

58. Lack of nitrogen leads to a host of related troubles, the most spectacular being the rapid failure of paspalum through "grass grub" attack once a certain stage of deterioration has been reached.

59. So far it appears that lucerne will not react to manurial stimulus. Where lucerne is not suffering from disease, there is nothing to indicate that it is not thoroughly catered for in all its requirements. Where disease is rampant, application of superphosphate, blood and bone, potash, and sulphate of ammonia, together with minor elements, alone and in combination have as yet had no observable effect.

60. Blood and bone has given good results in vegetable production.

61. Up to the present we have asked our farm crops to grow without manurial treatment. Results have been quite satisfactory, with nitrogen alone showing up as a factor worthy of immediate attention.

62. Summing up, we may say that at least during the first years of intensive exploitation the soil presents no serious limitations. Lack of available nitrogen and an attendant problem, lack of humus, is quite understandable within a tropic environment and should be adequately catered for without direct applications of fertiliser. It can be noted that lucerne-grass mixtures which have as yet received no manure are, after three years, among the few remaining highly productive areas.

FERTILISER EXPERIMENT, NOVEMBER, 1944.
Irrigated Grass Pasture.

Treatment. Fertiliser and Rate.	*Yield—Lb. green material per acre.		
	Paspalum (*Paspalum dilatatum*)	Molasses grass (*Melinis minutiflora*)	Rhodes grass (*Chloris gayana*)
No manure	2,722	3,932	3,932
P2	3,026	....	....
K1	2,722	....	....
N1	5,596	6,806	12,100
N2	11,344	17,242	19,965
N2 P1, K1	8,167	....	....
N1, P1, K1	6,352	....	15,881
N1, P2	....	6,050	14,520

P2	Superphosphate 2 cwt. per acre.
K1	Sulphate of potash 1 cwt. per acre.
N1	Sulphate of ammonia 1 cwt. per acre.
N2	Sulphate of ammonia 2 cwt. per acre.

*Yields taken 5½ weeks after application of manures.

PART VII.—ENTOMOLOGICAL ASPECTS.

64. Innumerable pests, grubs, caterpillars, moths, thrips, aphis, jassid hoppers, termites, ants, grasshoppers, crickets, weevils, beetles, mealy bugs and no doubt many others may be regarded as potential enemies, together with stock pests, principally the buffalo fly and the tick. However, only three have been present to date in sufficient concentration to defy simple control measures and shed any gloom on the prospects of economic development.

65. The first is a jassid leaf hopper, which in one year only, inflicted very severe damage on lucerne during a full month of spring. The second is the buffalo fly. Between January and the end of April it is a source of extreme irritation to both cattle and horses and is responsible for serious loss of condition during the height of attack. It may be noted that buffalo fly traps have proved effective. For a small undertaking, typically a dairy farm and as an adjunct to stables or horse paddock traps would be essential at least until such time as future research can suggest a more direct means of control. The third is the grasshopper for which considerable concern has already been expressed. It, in its various forms, is a devastating menace to all cultivated vegetation, banana and pineapple no less than grass and lucerne.

66. Grasshopper control has been the subject of much investigation throughout the world. Although thorough local study of the problem is essential, it is thought that many of the findings of outside research would have direct application.

PART VIII.—PATHOLOGICAL ASPECTS.

67. Except in the case of lucerne and to a very minor extent in the case of papayas and tomatoes, disease has to date, not operated against the full development of plants.

68. A diseased condition which is responsible for widespread damage to lucerne stands during their second year of production, closely resembles what is considered a virus infection, known in other parts of Australia as "little leaf," "bunchy top" or "witches broom."

69. Such names are quite suggestive of the main symptoms. The bunched shoots much reduced in size are sickly in colour, with the minute leaves of seriously effected plants, often distorted by curling.

70. The same general symptoms have been noted in certain other cultivated Legumes (pigeon pea, peanut and *centrosema pubescens*) and native plants (Cleome, Physalis, Crotalaria, and Rhynchosia).

71. Observations of significance are:—

I. The disease does not kill quickly.

II. There is a marked tendency for affected plants to recover during the ideal growing conditions of winter and early spring.

III. Areas receiving what could be termed an excess of water do not suffer as readily as areas receiving less water.

IV. The months November and December seem to favour a rapid spread of disease and plant mortality is high during this period.

V. Pure lucerne stands suffer very much more seriously than mixed grass and lucerne pasture.

VI. Lucerne grown in rows three feet apart was the first area to show symptoms and finally collapse.

The fact that this disease is of considerable economic importance cannot be denied, but at the same time we must admit that lucerne is capable of remarkable returns before the onset of the disease and that at least another year can be added to its very satisfactory existence, provided it is combined with a suitable grass—that is if the evidence we have before us is in any way a true indication. Further, there is yet no reason or supposing that the life of lucerne where associated with grass could not be prolonged indefinitely.

72. Lucerne it is felt will remain the major introduction for irrigated pasture. We have seen that although its maximum response is restricted to the late autumn, winter and spring months, it can produce heavily throughout every month of the year. Through its efforts we have produced a pasture capable of carrying 2½ beasts to the acre during the full twelve months; grass alone without specialised attention could not be expected to carry much more than half a beast to the acre.

73. *A comparative analysis*:

(A) Rhodes grass—Pure stand one year to two years old.
7-8 grazings per year.
0.8 beasts per acre carrying capacity.

(B) Lucerne—Pure stand one year to two years old.
10 grazings per year.
2.2 beasts per acre carrying capacity.

(C) Mixed pasture—stand one year to two years old.
Grass plus lucerne—one quarter of area a pure grass stand.
10 grazings per year.
1.75 beasts per acre carrying capacity.

(D) Mixed pasture—stand one year to two years old.
Grass plus lucerne.
10 grazings per year.
2.5 beasts per acre carrying capacity.

74. Perhaps extended research may be necessary before we will be able to take full advantage of lucerne's remarkable ability, perhaps on the other hand the solution of problems might prove quite a simple matter. Whatever the case lucerne can and must be saved for the area.

75. It is possible to suggest the following as a basis for experimental operations directed towards overcoming disease in lucerne.

I. The extent to which stooking practice may be responsible for upsetting the physiological processes of the lucerne plant.

II. The extent to which stock trampling may be responsible for direct damage to crowns.

III. Whether climatic factors are basically significant. (A study of the comparative environments at or near ground level in:—

(a) Lucerne under row conditions.

(b) Lucerne as a pure stand.

(c) Lucerne as a mixture with grass; could possibly lead to enlightening conclusions.)

IV. To what extent any established findings in the case of I, II, and III may be offset by management technique or mixture with a suitable grass.

V. Response of varying strains to the environment, besides Hunter River and Peruvian which are at the moment outstanding.

VI. The growth response from locally produced seed with a view to subsequent selection.

VII. Nutritional requirements

76. It will be noted that here we have gone into some detail and it may be asked why other sections have been confined to broader outline with no lengthy recommendations for analytical research?

77. The answer is twofold. Firstly, we cannot say else than that we have but touched the fringe of our essentially exploratory task and secondly, if we may be excused from what might be termed over-optimism, that questions other than a disease in lucerne, and the grasshopper menace, have not taken as yet and we trust never will take the form of obstacles that cannot be successfully by-passed if not entirely solved.

CONCLUSION.

78. Above all preliminary investigations have shown that, the particular climatic belt with which we have to deal is indeed a poor "mining proposition," that haphazard and/or casually transported cultural methods will result certainly in failure. Although the principles of agriculture apply equally for a temperate or tropical environment the successful application of the larger concept of agriculture in general is a matter of local understanding.

79. It has been said that "A question has meaning only when it is possible to find operations by which an answer can be given." It is so with the question of developing the North—operations must be found by which an answer can be given.

80. With such in view we may conclude with an all embracing recommendation:—

That a research station be established to ascertain the scope of economic land utilisation and settlement in the Kimberleys and adjoining districts of Northern Australia.

By Authority: WILLIAM H. WYATT, Government Printer, Perth.