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## Soil potential for groundnut production at Kununurra, Western Australia : report of a survey conducted in January 1979

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## SOIL POTENTIAL FOR GROUNDNUT PRODUCTION AT KUNUNURRA, WESTERN AUSTRALIA

Report of a survey conducted in January 1979

# **SOIL POTENTIAL FOR GROUNDNUT PRODUCTION AT KUNUNURRA, WESTERN AUSTRALIA**

**Report of a survey conducted in January 1979**

by J. C. Dixon and R. J. Petheram  
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Manuscript received November, 1979

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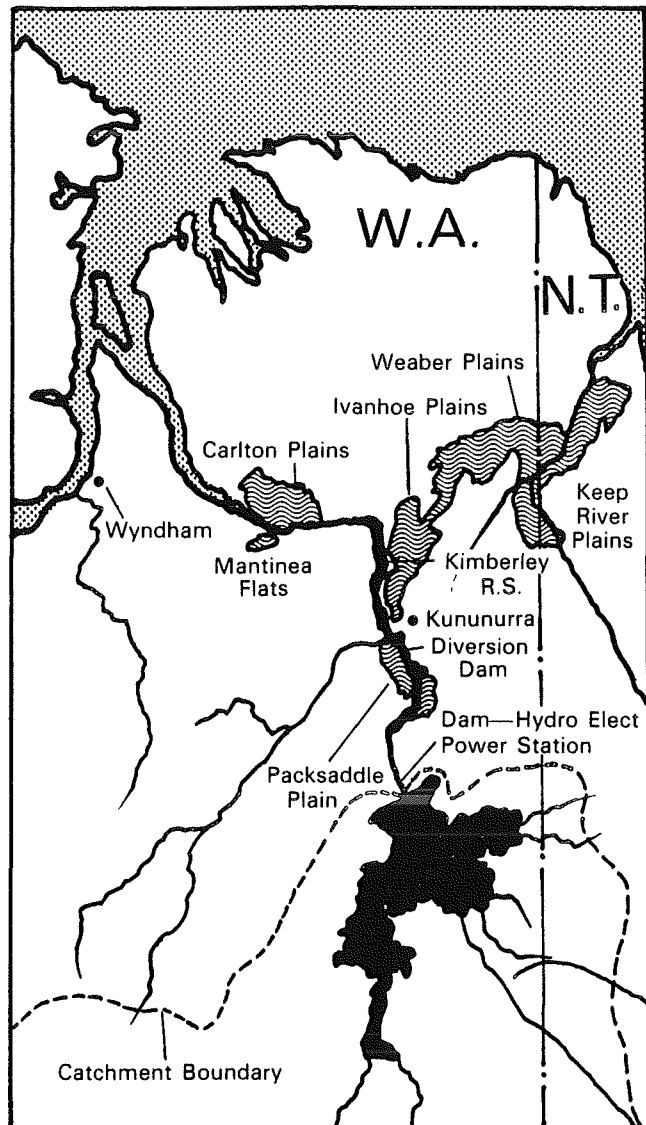
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**TECHNICAL BULLETIN No. 50, MARCH 1979  
DEPARTMENT OF AGRICULTURE OF WESTERN AUSTRALIA**

Location map for Kununurra and Ord River area.  
Distance from Kununurra to Wyndham = 50 km



## INTRODUCTION

Production of groundnuts in trials on irrigated Cockatoo Sands near Kununurra have been sufficiently encouraging for a soil survey to be requested of three small areas possibly suitable for commercial release. It was anticipated that between 1 000 and 1 200 ha would be necessary in the immediate future for development of five farms for groundnut production. The survey was begun in November 1978 to:

- classify the sand soil types.
- determine the potential of these types for groundnut production.
- examine possible relationships between soils and vegetation to be used when selecting land for groundnut production.

At this stage of research the soil requirements for groundnuts appear straight forward, although further research may allow finer definition. The requirements are:

- proximity to a suitable, economic irrigation water supply.

- topsoil textures of sands, loamy sands or clay sands.
- subsoil texture of loams.
- slopes of less than 2 per cent to prevent erosion of the highly erosive soil types.
- working areas of between 40 and 50 hectares.
- absence of a high water table during the wet season.
- uniform soil types for each farm with regard to soil texture, available moisture, infiltration rate, surface and subsurface drainage.

Although some comment on the suitability of the soils for groundnut production were also requested, final selection of areas for this land use will additionally depend on engineering and economic considerations as well as agronomic constraints.

## PREVIOUS SURVEY WORK

Van Cuylenberg (Unpublished and undated, probably 1977) conducted a brief survey of the area now being used for groundnut research. He defined eight land units, and the four soil families below. Some soils he described have been retained as type examples in this survey.

- (i) Cockatoo Family
- (ii) Pago Family
- (iii) Elliot Family
- (iv) Cullen Family

A CSIRO worker (R. Gunn, unpublished draft report made available by the Lands and Surveys Department about July 1978) conducted a brief survey of areas south of the Cotton Gin and along Cave Paintings Road and retained the concept of Cockatoo Sands as being deep red sands. This is adhered to in the current report, although phases of Cockatoo Sand are defined. Pago was a deep yellow sand and Cullen was a greyish sand merging into a mottled yellow sand. All soils were under a woodland of *Eucalyptus tetrodonta* and *E. miniata*.

## SURVEY METHOD

Survey work was completed in January because it enabled the soils to be observed during the wet season. This illustrated two important characteristics; the first a perched water table in an area that would have otherwise been designated country without any limitations, the second the high erosivity of the sands and the need for erosion control works on many areas.

The survey area was broken into three regions (see figure and maps):

- (1) Between the crop sprayers air strip and Kununurra town and between

the sandstone ranges on the east and the black soil plains to the west.

- (2) From the crop sprayers air strip running north east to Steeple Peak, and between the sandstone ranges and the black soil plains.
- (3) To the south east of Kununurra townsite.

Region 1 was sampled on a regular grid with one site per 4 ha; region 2 on a regular grid, with one site per 8 ha; region 3 on the basis of photo pattern at approximately one



site per 100 ha. Each "sampling" constituted a full profile and vegetation description.

Colour aerial photography (1978) at 1:20 000 was used for interpretative purposes and black and white prints taken from the colour negatives served as base maps. Maps have

been drawn from uncontrolled mosaics at 1:20 000.

Definitions of soil properties described by Northcote (1974), have been used as far as possible.

## SOIL TYPES AND MAPPING UNITS

The mapping unit adopted was the soil family rather than land unit. Soil is the most significant of the factors that will influence groundnut production. Other factors which could influence production can be modified more readily than can soil type and in fact most soils are constant for these factors anyway. (They include slope, drainage, stoniness, vegetation and landscape position.)

Mapping has been to the level of soil family, possible because of the intensity of the survey and the high quality of the photography available. Some areas unsuitable for groundnut production, in fact for any production, have been mapped as complexes because they are complex in their own right and the time required to elucidate them could not be justified. These include soils of the Junction Complex, the Lateritic Complex, soils of Drainage Lines and also soils of the Sandstone and Laterite Complex.

## SOIL FAMILIES

### COCKATOO SOILS FAMILY

This family contains soils thought to be the most recently developed from the ferruginous sandstone parent material. They are the highest in the landscape, being found on crests and upper mid slopes and have the maximum slope, usually between one and two degrees, sometimes slightly higher. They are well drained internally and externally.

The Cockatoo soils have a moderate range of textures and it is not known if this is because of local variation in parent materials or pedogenetic factors.

#### Typical Cockatoo Soil

0-10 cm	Loamy sand, reddish brown (5 YR 4/3) pH 6.5, dry slightly hard consistence, earthy fabric massive structure.
10-35 cm	Sandy loam, dark red (2.5 YR 3/6) pH 6.0, dry slightly hard, earthy, massive.
35-150+ cm	Sandy loam, red (10 R 4/6) pH 6.0, moist friable massive, earthy.

It was necessary to recognise three phases of the Cockatoo soils—

- (i) Sandy phase with sandy A and B horizons,
- (ii) Normal phase with sandy A horizons and loamy sand B horizons,
- (iii) Heavy phase with loamy sand A horizons and clayey sand B horizons.

Phase (ii) would be typical of about 60 per cent of profiles described with the other two phases being about 20 per cent each. Some Cockatoo soils, usually members of phase (i) and (ii), have no A<sub>2</sub> horizon.

This survey accepted a wider range of colours for Cockatoo soils than did former surveys. This was because soils which were in other respects Cockatoo soils had this range of colours, and in order to provide a colour continuum between the Cockatoo soils and the Pago soils. (These soils are very similar and colour, together with position in the landscape and vegetation, are the main diagnostic characteristics.)

Surface horizons for all phases should be as red or redder than 7.5 YR (normally 7.5 YR 4/3 or 4/4) and subsoil horizons should be as red or redder than 5 YR usually with intermediate value and high chroma.

Most Cockatoo soils have an earthy fabric and A horizons will be single grained for the light phases and massive for the heavier phases. Light members have moist, very friable consistences and heavier phases are moist and friable. pH of all horizons ranges between 6 and 7, i.e. they have an acid to neutral soil reaction trend.



The soils support almost a monoculture of *Eucalyptus miniata*, a joint culture of *Eucalyptus miniata* and *Eucalyptus tetradonta*, rarely a monoculture of *Eucalyptus tetradonta*. Throughout these associations *Erythrohleum chlorostachyus* is usually present. Other common species are *Buchanania obovata*, *Grevillea agrifolia* (in patches) and *Persoonia falcata* and *Owenia vernicosa* (both sparsely).

## PAGO FAMILY SOILS

### Typical Pago Soil

0-15 cm	Dark brown sand (10 YR 3/3) pH 6.5, dry loose consistence, sandy/earthy fabric, massive in structure.
15-40 cm	Sand to loamy sand, yellowish brown (10 YR 4/4) pH 6.5, moist, friable, sandy/earthy fabric, massive structure.
40-150+ cm	Sand to loamy sand, strong brown (7.5 YR 5/6) pH 6.5, moist, friable and massive.

The sandier members of the Pago Family could also be described as having single grain structure and loose consistence or alternatively massive with very friable consistence.

In this survey top soil hues of 7.5 YR were accepted and it was felt that the colour of the B horizon was more constant and diagnostic than that of the A horizon. Values tend to be about a unit higher than those of Cockatoo soils. Fabric is less earthy than that of Cockatoo soils and this probably accounts for van Cuylenberg's decision to compromise between earthy and sandy fabrics.

Pago Family soils occur immediately downslope from Cockatoo Family soils with slopes about a half to one degree. They are well drained internally and moderately well drained externally.

Vegetation tends to be similar to that of the Cajuput Family soils, i.e. *E. papuana*, *E. polycarpa*, *E. foelscheana*, *Gyrocarpus americanus*, *Adenсонia gregorii*, and *Melaleuca* sp. (Tall).

Other species which form in colonies within the major type are *E. tectifica*, *Melaleuca* (Small form), *Petalostigma pubescens* and *Grevillea agrifolia*.

## CAJUPUT FAMILY SOILS

This is a local name used to describe soils of this type. In the past they have probably been mapped as Pago or Cullen but it is considered that they are quite distinct genetically. They occupy a discreet topographic position and are therefore accorded family status.

### Typical Cajuput Soil

0-10 cm	Coarse sand with a slightly moist, very friable consistence, massive structure (single grain when dry), sandy fabric, pH of 6.5 and highly porous. 10 YR 4/4.5.
10-40 cm	As above, colour 10 YR 5.5/6.
40-150+ cm	As above, colour 10 YR 6/8.

The main diagnostic feature of this soil is its subsoil colour and the fact that it is almost totally devoid of clay material. It has a discreet position in the landscape, being in places that have been worked and reworked by stream meanderings (resulting in undulating relief) in areas with very little overall slope.

Drainage within the profile tends to be very good to extreme and surface drainage is usually quite good.

Vegetation is similar to that of the Pago Family soils with the addition of *Pandanus* sp., *Grevillea pteridifolia*, *Ficus opposita* and *Buchanania obovata*.

## CULLEN FAMILY SOILS

The name Cullen is used in the literature to describe both a land system (Christian and Stewart 1953) and a soil family (Speck *et al* 1965, Story *et al* 1969, Stewart *et al* 1970 and Story *et al* 1976).

The Cullen Land System is found only on granite country rock, but the Cullen Family Soils can be found on both granitic and sedimentary land systems. The Cullen Soil Family described in this bulletin is found on lower slopes developed on material transported from adjacent ferruginous sandstone hills. They are often found where there is a flattening of a long slope or in areas of poor or slow drainage such as drainage lines or in the Junction Complex.

Cullen soils have medium to moderately heavy textured subsoils below a sandy topsoil. Hue of the subsoils must be 7.5 YR.

### Typical Cullen Soil

0-10 cm	Sand to loamy sand, dark greyish brown (10 YR 4/2), dry, slightly hard, pH 6.0, massive and earthy.
10-30 cm	Light sandy loam, brown to dark brown (7.5 YR 4/4) pH 6.0, dry, slightly hard, massive and earthy.
30-150+ cm	Sandy loam to light sandy clay loam, strong brown (7.5 YR 5/6) dry, slightly hard, pH 5.5, massive and earthy with some red and grey mottling.

Three phases of Cullen soils are recognised:

- (i) normal phase as described,
- (ii) as described but without mottling in the top 150 cm,
- (iii) heavy phase where subsoil textures can rise to a sandy medium clay with or without mottling.

The more extreme members of phase (i) could be undergoing a weak but active laterisation process.

Both surface and internal drainage of these soils is slow and this is reflected in the vegetation which includes *Melaleuca* (small form), *E. polycarpa*, *E. Clavigera*, *E. Tectifica*, *E. Foelscheana* and, in Region 3, *Brachychiton tuberosum* and *Lysophyllum cunninghamii*.

#### ELLIOT FAMILY SOILS

van Cuylenberg describes the typical Elliot Family soil as follows—

0-8 cm	Sandy loam, dark brown (10 YR 4/3) pH 6.0, massive and earthy.
8-30 cm	Light sandy clay loam, dark yellowish brown (10 YR 4/4) pH 6.0 massive and earthy.
30-80 cm	Sandy clay loam, yellowish brown (10 YR 5/6) pH 5.5, massive and earthy, onto an impermeable mottled clay layer.

This has been retained as the central concept but as some members did not have mottling in the top 150 cm the soil has been divided into two phases:

- (i) normal phase as described above,
- (ii) phase without mottling otherwise the same as that described above.

These soils are found in and around drainage lines. Some members have quite extreme mottling and this is interpreted as being weak but active laterisation. Internal drainage is poor and surface drainage is variable, usually only moderate.

Vegetation found on this soil type includes, for Region 1, *E. tectifica*, *E. papuana*, *E. clavigera* and also small *Melaleuca* forms. In Region 2 some of the Elliot soils are better drained and feature *E. clavigera* and *E. ferruginea*. In Region 3 the small *Melaleuca* form is well represented.

#### STEEPLE PEAK SOIL FAMILY

This is a new family found only south of the Cave Painting Road on the flat country south of Steeple Peak.

##### Typical Steeple Peak Soil

Phase (i)—Deep

0-15 cm Single grained to massive, earthy sand with a very friable consistence when moist. pH 6.5-7.0 (7.5 YR 4/4).

15-50 cm As above (7.5 YR 5/6).

50-150 cm As above (7.5 YR 6/6).

Phase (ii)—Shallow

At a variable depth before 150 cm a stone line about 10 cm thick will be encountered. The stones appear to be weathering ferruginous sandstone from .5 to 2 cm in diameter. They occupy 60 to 80 per cent of the soil volume. Below this would be found a sandy clay, sometimes with ferruginous mottling and usually with very low chroma e.g. 7.5 YR 7/2.5.

On the clay layer of some members of phase (ii) could be found a perched water table. Thus internal drainage of the topsoils was very rapid, but that of the subsoil very slow. Slopes over the area are generally between a half and one degree so that surface drainage is slow but finite.

The general topography of the area is gently undulating and it is possible that at some stage in the past this area served as an outwash area for surrounding hills. The phase (i) Steeple Peak soil can really be distinguished from some examples of the Pago Family by its position in the landscape and its association with phase (ii) which accounted for about 20 per cent of sample sites.

The vegetation in this area is similar to that of Cajuput and Pago soils areas but tends to be much richer in varieties represented, e.g. *Gyrocarpus americanus*, *Adansonia gregorii*, *Terminalia canescens*, *E. polycarpa*, *Melaleuca* spp., *Owenia vernicosa*, *Pandanus* sp., *E. papuana*, *Grevillea agrifolia*, *Acacia bidwillii* and others.

#### JONES SOILS

This soil is not accorded family status because it is not common, and a similar soil appears to be developing on two different parent materials. Laboratory data could separate these soils and ultimately a "very heavy" phase of Cockatoo soils could be created.

One representative was described as follows:

0-10 cm	Very friable, massive, earthy sand with pH of 7.5 and colour of 5 YR 4/4.
10-30 cm	Very friable, massive, earthy sand with pH of 7.75, 5 YR 4/6.
30-150+ cm	Sandy loam massive, firm, earthy fabric with a pH of 7.5, 5 YR 5/8. The soil material in this horizon has a high bulk density.

Textures on other examples were slightly heavier—loamy sands to sandy loams in the topsoils to loams in the subsoil. Sometimes the subsoils were subplastic and if kneaded for a few minutes progressed to a medium clay.

Jones soils appear to develop on sites with less than one degree slope and can support *Carissa lanceolata*, *E. tectifera*,

*Adansonia gregorii*, *Lisophyllum cunninghamii*, *E. clavigera* and *E. ferruginea*, *Ehretia saligna* and *Hakea arborea*.

Parent material for this soil is thought to be the same as for other soils in the area, i.e. the ferruginous sandstone and on this evidence the soil should be mapped as a phase of the Cockatoo and Sand Family. However, outside the survey area near Region 3 an apparently identical soil developed on a fossilised limestone/dolomitic type of parent material. It supported either a monoculture of *E. pruinosa* or *E. microtheca*.

For the moment the "Jones" soil is being termed a minor soil and mapped as a separate entity.

## OTHER SOIL GROUPS

### AQUITAINE SOILS

In the survey area there is one minor inclusion of "black" soil from the adjoining clay plain—this being a grey phase Aquitaine soil, which has been described by Aldrick and Moody (1977). The soil is uniform and heavy textured, poorly drained internally and externally, cracks seasonally and supports *E. microtheca*, *E. parvifolia* and *Chrysopogon fallax*.

(Northcote classification would be Ug 5.29.)

### COMPLEXES AND ASSOCIATIONS

These were mapped as such. Several complexes are recognised over the three Regions, because of their complexity and their limited suitability for agriculture.

#### Lateritic complex

This is spatially the most important complex and occupies a large area in Region 2 between the Steeple Peak Soil Family area and the large area of Cockatoo soils further to the south west.

Either indurated or loose pisolitic gravel occupies more than 80 per cent of the soil volume before 150 cm. Usually the gravel is much shallower and frequently outcrops. Where soil material has developed it is usually coarse sand on the surface and down to the gravel layer which is either in a sand or sandy clay matrix. The members upslope tend to feature the sandier profiles, those lower on the

slopes and on the flats have the heavier matrices. Accompanying the laterites are minor areas of soils from the Cullen and Elliot Families, probably not more than 15 per cent of the total area.

*Melaleuca* spp. (small forms are well represented lower in the area), *Brachychiton tuberosum*, *E. clavigera*, *Terminalia cenescens*, *Adansonia gregorii*, *E. tectifera*, *Grevillea* and *Hakea* species are common.

#### Junction complex

The Junction complex is the area between the Ivanhoe Land System and the Cockatoo Land System as defined by Stewart *et al* (1970). The former is mainly alluvial deposits of heavy clay and the latter colluvium and material from ferruginous sandstone ranges. Hence this area is highly variable.

Drainage is very poor, and slope almost negligible. Internal drainage, which is related to texture, is usually poor.

Vegetation is mainly *E. microtheca*, with *L. isophyllum cunninghamii*, some times *Carissa lanceolata* and *E. clavigera*. *Adansonia gregorii* can be found on some of the sandier patches. *E. polycarpa* also exists in places.

#### Sandstone laterite complex

This complex is found in Region 3 south of the Duncan Highway. Uplifted sandstone strata are close to the surface and control

drainage of the area. Soils are variable, ranging from shallow Cockatoo Sands to laterites. Profiles in gravel pits reveal a thin sandy A horizon over a clayey B horizon which rapidly becomes 80 per gravel and sits immediately on a sandstone basement.

Vegetation is dominated by *E. clavigera* and *E. grandifolia*.

#### Rock outcrops and colluvial slopes

This group needs little further explanation. The 'rock' is the ubiquitous ferruginous sandstone from which most of the soils in the area are derived. The colluvial slopes associated with them usually are between about two and five degrees, and excessively drained internally and externally. They

support variable vegetation which includes *Triodia racemigera*, *Eriachnae convergens*, *Terminalia canescens*, *E. dichromopholia*, *E. aspera*, *E. brachiondra*, *Ficus platyptera*, *Grevillea erythrocloda*, *E. Miniata* and *Grevillea agrifolia* often occur at the base of outcrops.

#### Soils of drainage lines

Most of these occur in Region 3. Soils are mainly Elliot, Cullen and Cajuput, with some laterisation having taken place in members with heavy textured subsoils.

Vegetation varies, but is in accord with vegetation on soils described within the appropriate family.

## LANDSCAPE POSITION AND LIKELY SEQUENCE OF DEVELOPMENT OF THE MAIN SOIL TYPES

Most of the soil material in the survey area is derived from the same ferruginous sandstone parent material and there appear to be two main pedogenetic forces in action, erosion and drainage, both of which are dependant on slope.

Soils formed immediately adjacent to the sandstone ranges and outcrops are from the Cockatoo Family. This proximity accounts for the occasional rock found floating on the surface and also the occasional shallow soil. They are sands but the parent material appears to have been able to generate enough fine material to modify the texture slightly to loamy and clayey sands. Transport has been minimal and the sands retain a coating of ferruginous material which imparts the red colour and earthy fabric.

Immediately downslope from the Cockatoo sands are soils of the Pago Family. These are slightly lighter in colour and the earthy fabric is less pronounced. Textures are similar to those of the Cockatoo Family's normal and sandy phases.

Where creeks and streams have meandered across flatter areas Cajuput soils have resulted. They are quite bleached and are

always sands with a sandy fabric. The stream meanderings have produced an undulating relief.

Cullen soils are found below Pago soils where there is a pronounced flattening of slope, and in the broad indefinite drainage lines which might run through soils of the Cockatoo or Pago Families. Cullen soils possess the colours of Pago's, but are gradational textured and have accumulated clay material along the way. They have an earthy fabric. Members with higher iron oxide content and in wetter positions can have a mottled subsoil.

Elliot Family soils are yellower in colour than Cullen Family soils but otherwise are very similar. They have accumulated more clay and are less well drained than Cullen.

Lateritic soils are thought to be a legacy of a former more humid climatic era and no generalisations can be made about them. There has probably been significant modification of the landscape since then. In some drainage lines there are indications that active laterisation is continuing.

## SOIL CHARACTERISTICS AND THEIR SUITABILITY FOR GROUNDNUT PRODUCTION

A large number of properties need to be considered when discussing the suitability of Kununurra soils for permanent groundnut culture. Some of the properties can only be estimated as appropriate laboratory data are not available.

Also at this stage it is not known what crops will be grown in association with groundnuts. In some cases limitations for groundnut culture may not be limiting for second or alternative crops. The opposite may also be the case.

The properties of each soil family are listed below and further summarised in Tables 1 and 2.

### Cockatoo Family—Sandy Phase

1. Top soil texture—sand
2. Subsoil texture—sand
3. Effective soil depth—150+ cm
4. pH—weakly acid
5. Consistence of top soil—moist, very friable
6. Hardsetting—not hardsetting
7. Stones—none
8. Slopes—1-2°
9. Surface drainage—well drained
10. Internal drainage—excessive
11. Water table—none
12. Range of available moisture—very narrow
13. Infiltration of water into topsoil—rapid

### Cockatoo Family—Normal Phase

1. Top soil texture—sand and loamy sand
2. Subsoil texture—loamy sand
3. Effective soil depth—150+ cm
4. pH—weakly acid
5. Consistence of top soil—moist, very friable
6. Hardsetting—slightly
7. Stones—rare

8. Slopes—1-2°
9. Surface drainage—well drained
10. Internal drainage—excessive
11. Water table—none
12. Range of available moisture—very narrow
13. Erosion hazard—severe
14. Infiltration of water into topsoil—very fast

### Cockatoo Family—Heavy Phase

1. Top soil texture—loamy sand
2. Subsoil texture—clayey sand
3. Effective soil depth—150+ cm
4. pH—weakly acid
5. Consistence of top soil—moist, very friable to friable
6. Hardsetting—slightly
7. Stones—rare
8. Slopes—1-2°
9. Surface drainage—well drained
10. Internal drainage—well drained
11. Water table—none
12. Range of available moisture—narrow
13. Erosion hazard—severe
14. Infiltration of water into topsoil—rapid

### Pago Family

1. Top soil texture—sand
2. Subsoil texture—sand or loamy sand
3. Effective soil depth—150+ cm
4. pH—weakly acid
5. Consistence of top soil—moist, very friable
6. Hardsetting—not
7. Stones—none
8. Slopes—about 1°
9. Surface drainage—well drained
10. Internal drainage—excessive
11. Water table—none

12. Range of available moisture—very narrow
13. Erosion hazard—severe
14. Infiltration of water into topsoil—rapid

The presence or otherwise of mottling may be indicative of internal drainage qualities. It may also be indicative of distance of transport of the soil parent material and the percentage of iron oxides in that parent material.

#### **Cajuput Family**

1. Top soil texture—sand
2. Subsoil texture—sand
3. Effective soil depth—150+ cm
4. pH—weakly acid
5. Consistence of top soil—moist, very friable
6. Hardsetting—not
7. Stones—none
8. Slopes—undulating, about 1° maximum
9. Surface drainage—moderate
10. Internal drainage—excessive
11. Water table—none
12. Range of available moisture—very narrow
13. Erosion hazard—high
14. Infiltration of water into topsoil—rapid

#### **Cullen Family—Heavy Phase**

1. Top soil texture—clayey sand
2. Subsoil texture—sandy clay
3. Effective soil depth—± 100 cm
4. pH—neutral
5. Consistence of top soil—moist, friable
6. Hardsetting—slightly
7. Stones—none
8. Slopes—less than 0.5°
9. Surface drainage—poor to very poor
10. Internal drainage—very slow
11. Water table—temporary perched
12. Range of available moisture—wide
13. Erosion hazard—slight
14. Infiltration of water into topsoil—fast to moderate

#### **Cullen Family—Phase with and without mottling**

1. Top soil texture—loamy sand
2. Subsoil texture—sandy clay loam
3. Effective soil depth—150+ cm
4. pH—neutral
5. Consistence of top soil—moist, very friable to friable
6. Hardsetting—slightly
7. Stones—none
8. Slopes—less than ½°
9. Surface drainage—poor to very slow
10. Internal drainage—moderate to slow
11. Water table—brief perched water table possible
12. Range of available moisture—wide range
13. Erosion hazard—slight
14. Infiltration of water into topsoil—fast

#### **Elliot Family—Mottled and non mottled phase**

1. Top soil texture—clayey sand
2. Subsoil texture—heavy clay
3. Effective soil depth—± 80 cm
4. pH—neutral
5. Consistence of top soil—friable
6. Hardsetting—not hardsetting
7. Stones—none
8. Slopes—less than 0.5°
9. Surface drainage—very poor
10. Internal drainage—restricted
11. Water table—temporary perched
12. Range of available moisture—wide
13. Erosion hazard—slight
14. Infiltration of water into topsoil—fast to moderate

### Steeple Peak Family—Deep Phase

1. Top soil texture—sand
2. Subsoil texture—sand
3. Effective soil depth—150+ cm
4. pH—weakly acid
5. Consistence of top soil—moist, very friable
6. Hardsetting—not hardsetting
7. Stones—none
8. Slopes—1-2°, undulating
9. Surface drainage—well drained
10. Internal drainage—excessive
11. Water table—none
12. Range of available moisture—very narrow
13. Erosion hazard—moderate
14. Infiltration of water into topsoil—rapid

### Steeple Peak Family—Shallow phase

1. Top soil texture—sand
2. Subsoil texture—sandy clay
3. Effective soil depth—about 100 cm
4. pH—weakly acid
5. Consistence of top soil—moist, very friable
6. Hardsetting—not hardsetting
7. Stones—stone line 10 cm thick immediately above clay horizon
8. Slopes—1-2°
9. Surface drainage—well drained
10. Internal drainage—restricted
11. Water table—temporary perched
12. Range of available moisture—narrow
13. Erosion hazard—moderate
14. Infiltration of water into topsoil—rapid

Table 1.—Table of soil properties and limitations for groundnut production.

	Cockatoo Family			Pago Family	Cajuput Family	Cullen Family			Elliot Family		Steeple Peak Family		Jones soils	Aquitaine Family
	Sandy	Normal	Heavy			Normal	Without mottling	Heavy	Normal	Without mottling	Deep	Shallow		
Top soil texture	S	S	LS-CS	S	S	LS	LS	LS-CS	LS-CS	LS-CS	S	S	LS-SL	mC-hC
Sub soil texture	S	LS	CS	S	S	SCL	SCL	SC	MC	MC	S	SC	L Sub pl mC	hC
Soil depth cm	150+	150+	150+	150+	150+	100	100	80	80	80	150+	100	150+	0
Top soil consistence (moist)	Loose-very friable	Very friable	Very friable	Loose-very friable	Very friable	Very friable	Very friable	Friable	Very friable-friable	Friable	Loose-very friable	Very friable	Friable	Ex. firm
Infiltration*	5½	5½	5	5½-6	5	5	5	5	5	5	5½-6	5½-6	4	½
Sub soil permeability*	5½	5-5½	5	5½-6	5½-6	2	2	1	½	½	5½-6	½	3	0-½

\* 6 Rapid/extreme

3 Moderate

0 Extremely slow/impermeable



Table 2.—Further soil properties and their limitations for groundnut production.

	Cockatoo Family			Pago Family	Cajuput Family	Cullen Family			Elliot Family		Steeple Peak Family		Jones soils	Aquitaine Family
	Sandy	Normal	Heavy			Normal	Without mottling	Heavy	Normal	Without mottling	Deep	Shallow		
Available moisture*	Ex. low (5.1)	Ex. low —	Low (6.1)	Mod-erate (8-9.5)	Variable but usually low (4.5-8)	Mod-erate	Mod-erate	Mod-high	High	High	Ex. low	Mod-erate	High	Mod-erate
Slope	1-2°	1-2°	1-2°	½-1½°	½° u	0-½°	0-½°	0-½°	0-½°	0-½°	½-1° u	½-1° u	1-2°	0°
Surface drainage	Mod-erate	Mod-erate	Mod-erate	Mod-erate	Slow	Slow-very slow	Very slow	Very slow	Very slow	Very slow	Slow	Slow	Mod-erate	Ponds
Erosion hazard	Very high	Very high	Very high	Very high	Very high	Low	Low	Low	Low	Low	Mod-erate	Mod-erate	Mod-erate	Very low
Stones surface	Rare	Rare	Rare	None	None	Rare	Rare	Rare	Rare	Rare	None	None	None	Rare
Stone Sub-surface	Rare	Rare	Rare	None	None	None	None	None	None	None	None	Stone line	None	Rare
Soil reaction	Weakly acid	Weakly acid	Weakly acid	Weakly acid	Weakly acid	Neu-tral	Neu-tral	Neu-tral	Neu-tral	Neu-tral	Weakly acid	Weakly acid	Weakly alkaline	Alkaline

u = undulating

\* Available moisture percentages based on extraction between 100 cm water suction at 15 atmospheres. Tests completed for three families only (Percentages by volume).

## RELEVANCE OF SOIL PROPERTIES TO GROUNDNUT CULTURE

Surface soil texture is probably the single most important soil property for groundnut culture as it determines the ability of the soil to accept irrigation water, i.e. infiltration, and also the tendency of the surface to form a seal. The sealing property is important as it could inhibit the emergence of the germinating seed, the infiltration of irrigation and rainfall water, and the harvesting of a clean groundnut sample. Those soils that are slightly hard-setting are also quite friable when moist. No soil encountered in this survey is likely to produce any difficulties as far as texture of the topsoil and associated properties are concerned.

Subsoil texture is important to groundnut production for three reasons. Subsoils of medium texture are likely to have the widest range of plant available moisture. Sandy subsoils will have a narrow range of plant moisture available, necessitating more frequent irrigation and probably inefficient water use with higher irrigation labour requirements. Soils of heavy subsoil texture have a favourable range of available moisture but are likely to support a perched water

table. This, for groundnuts, can lead to pod rot. However, soil which is otherwise freely draining but which has a perched water table at depths greater than 60 cm is likely to be quite suitable for groundnut production.

The soil reaction is important for a number of reasons. For instance, pH controls the release and absorption of nutrient cations on the base exchange sites of the soil colloids, within most cases the most favourable pH's ranging from weakly alkaline to weakly acidic. All soils surveyed qualify well in this respect.

However, there is the question of such things as organic matter content, buffering capacity, base saturation, etc, for which no data is available although it is possible to speculate on some of these properties. As most of the soils which are significant spatially are sands, it is likely that many of the nutrients required by groundnuts will have to be applied at least once during the growing season. Depending on the concentrations of certain nutrients in the irrigation water, it may be necessary to apply some nutrients more than once.

These soils will have a very low buffering capacity and a very low reserve of weatherable minerals. Levels of humic organic matter will be so low (unless cultural practices are aimed at increasing organic matter) as to be negligible. In some ways this is an advantage with some groundnut culture as it ensures that nuts will be free from organic stains. Nutrient imbalances are likely to arise easily and frequently and will need to be watched for. Experience has already shown that groundnuts have a calcium requirement greater than the capacity of the Cockatoo sands to provide.

Stones are important because if they have any size they damage equipment. If they are small they contaminate the sample and if they are common they limit the soil volume available for exploitation by the plant root. Fortunately stones appear to be of little consequence in any but the lateritic soils which have been discarded for these reasons as well as their variability.

The major soil types found in the survey area must be considered highly susceptible to erosion by water. They have sandy topsoils with single grain structure and loose consistence, or massive structure with a moist very friable consistence. Many areas collect runoff from high discharge sandstone hills or outcrops; alternatively they form mid or lower slopes which catch water from a large area. Most slopes are between 0.5 and 2 degrees with slope lengths reaching 500 m. Parts of experimental plots with slopes of about 1 degree have eroded badly during the current wet season. Kununurra is in a climatic zone where storms of very high intensity occur frequently during the wet season and culture for groundnuts will leave the soil bare during about the first two months of this high risk period.

If a stable culture is to be developed therefore, this can only be done if adequate erosion control measures are taken. Experience may show that measures adopted in the south of the state are not adequate and that a more intensive approach will be necessary. It is possible that appropriate measures will include fields which are laid out on the contour, vegetated buffer strips, strip cropping, trash cropping, and concrete lined storm drains and discharge points. All blocks should be protected by a "storm water cut off drain" upslope of the cultivation.

The main soil types, Cockatoo sands, Pago and Cajuput sands are quite regular; they do not have inclusions of laterite, clay soils or

water tables which would produce either difficulties in farm layout, or variability in irrigation and fertiliser requirements within a field. Furthermore, these three soils are rather similar in their properties and limitations as far as agriculture is concerned and it should be possible to consider these soils as one unit for most purposes. Steeple Peak soils are likely to have much the same characteristics as those three mentioned above—with the exception that in wetter wet seasons some areas of the shallow phase may suffer some reduction in production due to a temporary perched water table. In all cases creeks and drainage lines should be avoided, or incorporated into the mechanical conservation layout i.e. as uncultivated "waterways".

#### **Subsurface drainage**

The need for good natural drainage should not be underrated in the final land selection. Any soil block with heavier textured lower horizons may be subject to waterlogging during part of the wet season—because of high rainfall intensity and low water holding capacity of the upper layers. Once the land is cleared and irrigated this risk is increased.

When the high cost of installing and maintaining artificial drainage is considered, and the risk of crop damage through pod rot is taken into account, the need to allocate only well-drained soils becomes obvious.

On certain soils close to water sources, the cost of artificial drainage may be offset by the lower cost of piping water to the crop area.

#### **Available water capacity of soils (and irrigation systems)**

According to North American criteria, the available water capacity of a soil should not be less than 127 mm in a 1.22 m root zone, i.e. nearly 10 per cent. A local lower limit of 8 per cent is suggested, giving 96 mm available water in a 1.2 m root zone. This is based on a maximum local evapotranspiration rate of 10 mm per day, a 60 per cent depletion level (before irrigation), and during such periods a 5 or 6 day maximum frequency of irrigation.

This criterion will probably eliminate many of the areas covered by the soil/vegetation survey. Irrigation of lower-available-moisture

soils would lead to such problems as leaching of fertiliser and high labour requirements. If inherently inefficient mechanical irrigators are used, inefficiency of water application will be compounded with more frequent irrigation.

The above discussion leads to the suggestion that the only way soils of a very low water holding capacity can be successfully irrigated is through use of highly efficient mechanical irrigators (eg. of the centre pivot type).

## **SUITABILITY OF SOIL FAMILIES FOR IRRIGATED GROUNDNUT PRODUCTION**

In the first instance, farms should be subdivided according to sound farm planning principles under the supervision of a soil conservation officer.

It is only on the Cockatoo, Pago, Cajuput and Steeple Peak family soils that groundnut culture can be contemplated. All these soils have limitations associated with their coarse texture i.e. erosion hazard and low moisture availability. About 20 per cent of Steeple Peak soils have a perched water table, which could lead to serious waterlogging in especially wet years.

All the difficulties associated with low water holding capacity and low inherent fertility which are found on Cockatoo, Pago and Steeple Peak soils can be expected to be more severe on the particularly coarse textured Cajuput family sands.

Pago soils and the heaviest (Phase iii) of Cockatoo soils could suffer from waterlogging in localised patches, especially in flatter areas and near the bottom of the slope. These patches can be detected by study of the present vegetation. Moisture availability in these soils is, however, higher than in other soils mentioned above.

The two heavier phases of Cockatoo soils and Pago soils would appear at this stage to be the most suitable soils available.

The other soil types and complexes with the exception of the Lateritic complex may be suited to some form of agriculture. They are not attractive because they are limited in extent and because their properties differ markedly one from the other. Small plots appear to be most suitable and this suggests vegetables, and tree or forage crop cultivation. The Lateritic complex is probably best suited to current activities which are cattle grazing and gravel mining.

## **SOIL/VEGETATION RELATIONSHIPS**

Woody vegetation developed under conditions of natural competition can be regarded as a good integrator of all environmental factors acting on a particular site. Where a vegetation survey is confined to an area of uniform rainfall (rainfall being the main factor affecting vegetation in semi-arid regions) variation in species composition is likely to be closely related to physical or chemical soil differences.

Because of the overriding importance of water availability in an arid environment soil differences will often be reflected in plant cover through their effect on plant/soil/moisture relations. In the selection

of land for irrigation, these same soil/moisture properties become important criteria—especially as they affect surface infiltration, permeability, available moisture and subsurface drainage. It is reasonable to assume, therefore, that vegetation could be used as a guide in the assessment of potential of land for irrigation purposes, once the underlying soil relationships have been determined.

The soil requirements for irrigated groundnut production have been described earlier, as have the soil descriptions obtained for potential groundnut areas around Kununurra. As a further aid to final selection

of groundnut soils, vegetation cover in the three survey regions was therefore analysed to:

- produce a simple vegetation classification, and
- seek relationships between vegetation and soils which might assist with land selection.

### Method

Data from plots 40 m in diameter were collected at 80 sites on a stratified sample of the points on the grid setup for soil data sampling. Projected foliage cover was estimated for 46 woody and 16 herbaceous species (although a further 27 species were recorded).

Soil and physical site data were obtained from the soil survey team. When it became apparent that the 1.5 m deep auger samples were probably not deep enough to reflect certain soil changes influencing vegetation, fourteen 3 m deep soil samples were taken at locations selected to provide the information required.

### Analysis

Reciprocal averaging ordinations (Ordiflex version in the absence of a suitable Indicator Species Analysis programme) were used on the floristic data as an exploratory technique—in seeking main groups of species associated with major soil types. Certain soil data (viz, texture at 1.5 m) were superimposed on these major groupings in the vegetation data—to examine possible soil differences related to the groupings. Information from the 14 deep soil auger sites was used to confirm or refute suggestions arrived at through the above procedure.

Analysis of the data (Hill 1973) revealed four broad classes apparently related to texture of lower soil horizons. This classification, based on floristics, did not relate closely to the eight soil families classified, except for Cockatoo and Cajuput soils.

A probable explanation is that Cockatoo and Cajuput are the only soil families in which soil and site are uniform enough to support a reliable group of plant indicator species. When the soil family classification is superimposed onto the ordinations based on floristic data, in fact sites in the same family appear grouped fairly closely together—which indicates strong similarity of vegetation within

soil families. However, the amount of data and analyses used were inadequate to reveal further reliable soil family/vegetation relationships.

Thus, vegetation could be used as a means of identifying Cockatoo and Cajuput soils, but not reliably for other families (e.g. Pago, Elliot, Cullen). The groups of species associated with Cockatoo and Cajuput soils are shown below:—

#### Cockatoo soils

*Eucalyptus miniata* (Woolibutt)—dominant upper strata  
*Erythrophleum chlorostachys* (Ironwood)—common, middle, strata  
*Erythroxylon* sp.  
*Persoonia falcata*  
*Owenia vernicosa*  
*Grenvillea agrifolia* (in clumps)

#### Cajuput soils

*Melaleuca* spp. (large Cajuput trees, well spaced)  
*Eucalyptus papuana* (Ghost gum)  
*Gyrocarpus americana* (Helicopter tree)  
*Grevillea pteridifolia*  
*Pandanus* sp.  
*Ficus opposita* (Sand paper fig)

As stated earlier, two of the vegetation classes arrived at coincided closely with the two soil families mentioned above. The other two broad vegetation types suggested by the analysis appear to cover a range of soil families and are therefore of little use in identifying any one of these. They are, however, interesting as vegetation types associated with two grades of heavier textured subsoil, and are therefore shown below:

Species group associated with sand over sandy-clay-loam or sandy clay subsoil, within 2 m. Possible drainage hazard. Water holding capacity—fair to good.

*Planchonia careya*  
*Brachychiton diversifolium* (Kurrajong)  
*Grevillea erythroclada*  
*Pandanus* sp.  
*Eucalyptus tectifica* (Northern box)—small to medium trees  
*Eucalyptus ferruginea* (Rusty bloodwood)  
*Alstonia linearis*

Species group associated with sand to clay-sand over heavy subsoils (sandy-clay to clay) within 1.5 m. Marginal for irrigation without expensive artificial drainage. Water holding capacity good.

*Hakea arborea*  
*Terminalia platyptera*  
*Lysophyllum cunninghamii* (Bauhinia) where dominant  
*Brachychiton tuberculatum*  
*Ehretia saligna*  
*Melaleuca* spp. (small trees, dense stands of Cajuput)  
*Dolichondrone heterophylla*  
*Carissa lanceolata* (Conkerberry)

### Useful soil/vegetation relationships

Certain soil/plant relationships indicated by numerical analysis of the data could be valuable in the present context of land selection. These are shown below:

### Practical application of results to land selection

The species above are all common on the sand country around Kununurra. Presence or absence of individual plants or species has no value in the assessment of soil or land type but the occurrence of a particular combination of species, or a predominance of one or more species, can be very informative.

For example, the presence of a few stringybark trees can be ignored, but their joint occurrence with woolbutt and ironwood can be taken to indicate with certainty a Cockatoo soil. One *Hakea arborea* specimen means little, while several trees of this species indicate clay close to the surface—and a probable drainage risk.

In summary, vegetation could be used in the following ways:

1. Identification of Cockatoo soils (probably the best available here for groundnut production).
2. Identification of Cajuput soils (an unsuitable soil family for groundnuts because of low water holding capacity).
3. Detection of areas of impeded drainage, i.e. areas requiring artificial drainage.
4. Detection of such obstacles as rock close to surface, clay pan areas, patches of very sandy soil—within large blocks of otherwise suitable land.
5. Assessing overall uniformity of proposed blocks of land—which could affect irrigation efficiency, planning of irrigation layouts within blocks, etc.
6. Identification of other soil families, although less reliably than for 1. and 2. above.

Soil characteristic	Agricultural implications	Plant indicators
Heavy textured soil— —in root zone —below root zone	Harvesting problems Drainage problems	<i>Hakea arborea</i> , <i>Terminalia platyptera</i> , <i>Melaleuca</i> (small forms, dense clumps), <i>Planchonia careya</i> , <i>Brachychiton tuberculatum</i> , <i>Eucalyptus tectifica</i> (on flat areas).
Very light soils	Water holding capacity—very low	<i>Melaleuca</i> (large forms, well spaced), <i>Grevillea pteridifolia</i> , <i>Eucalyptus papuana</i> , <i>Pandanus</i> sp. <i>Eucalyptus miniata</i> (where dominant)
Rock close to surface	Obstacles to cultivation	<i>Calythrix</i> sp., <i>Cochlospermum fraseri</i> , <i>Grevillea heliosperma</i> , <i>Eucalyptus aspera</i> , <i>Terminalia canescens</i>
Rock close to surface	Occasional perched water table during wet	<i>Verticordia</i> sp. <i>Fimbrostylis</i> sp.
Lack of uniformity in soil type	Irrigation scheduling problem, fertiliser, leaching, etc.	Any marked change or clumping of vegetation

Certain species appeared from the data to be particularly ubiquitous in their behaviour within the sand soil areas. These are:

*Acacia tumida* (Pindan wattle)  
*A. platycarpa* (Pindan wattle)

*Eucalyptus foelscheana* (white barked Bloodwood)  
*Adansonia gregorii* (Baobab)  
*Alstonia lenearis*  
*Eucalyptus polycarpa* (long fruited Bloodwood)  
*Buchanania obovata* (wild mango)

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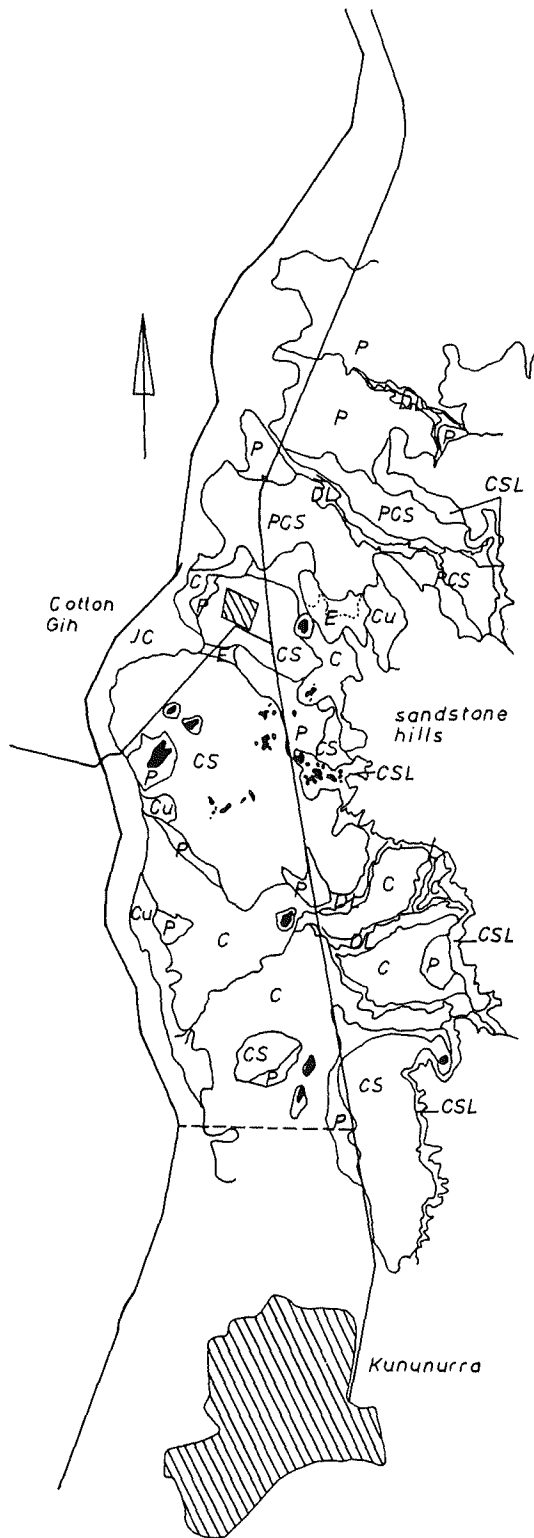
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Map 1.—Region 1. Groundnut soil survey.

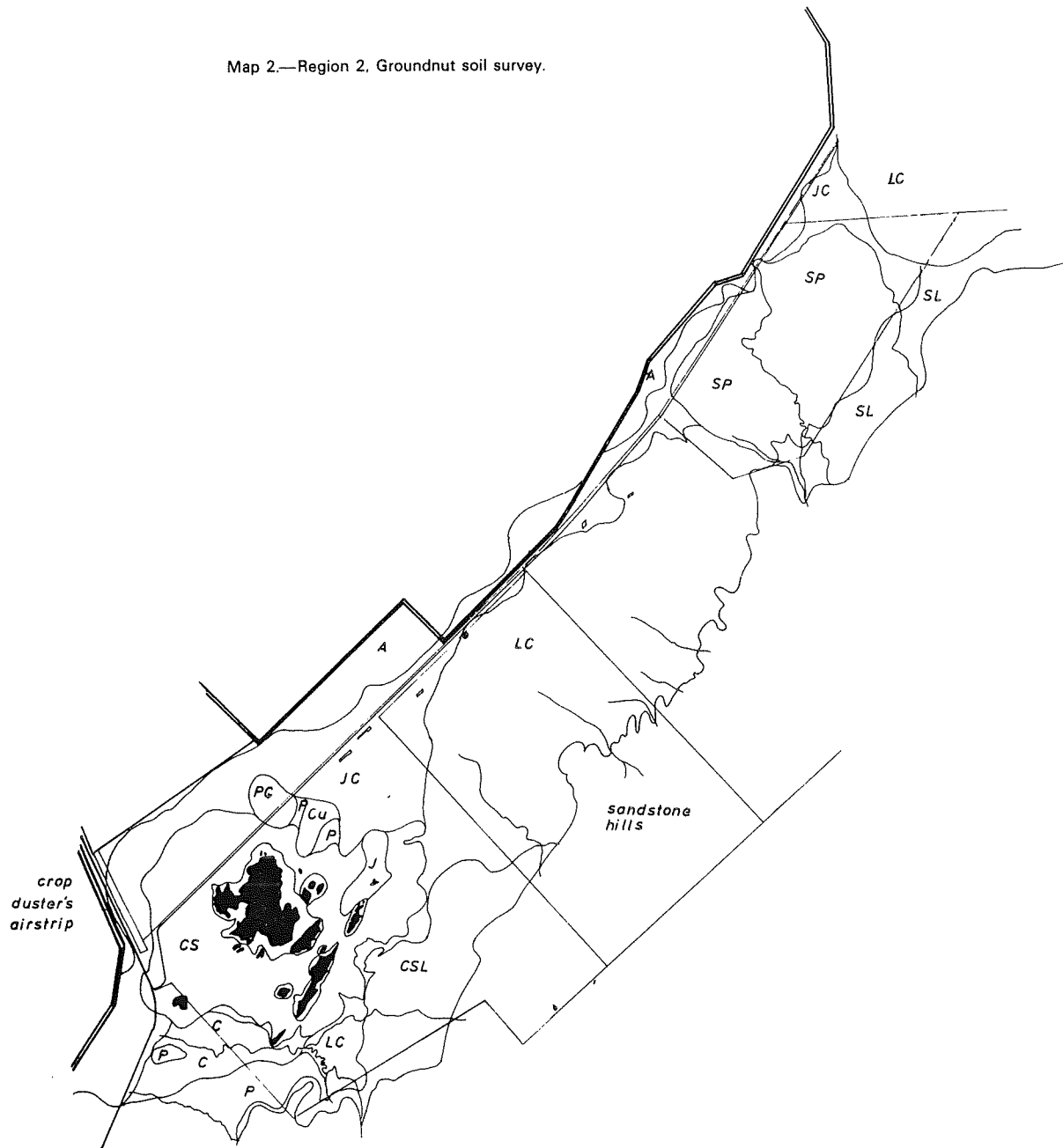


**Map Legend**

(All maps—three sheets, 1:65,000)

Cockatoo	CS
Pago	P
Cajuput	C
Steeple Peak	SP
Elliot	E
Cullen	Cu
Jones	J
Aquitaine	A
Pago/Cockatoo intergrade	PCS
Junction Complex	JC
Sandstone/Lateritic Complex	SLC
Lateritic Complex	LC
Drainage Lines	DL
Rock Outcrops	R
Swamps and Lagoons	SL
Colluvial Slopes	CSL

Map 2.—Region 2, Groundnut soil survey.



Map 3.—Region 3, Groundnut soil survey.



