Dictionary of forest structural terminology

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PREFACE

A Task Group was established in 1979 to coordinate ongoing activities, to stimulate new research and to synthesize available scientific information concerning southern African forests. During 1985 a Steering Committee for the Forest Biome Project was established to replace the Task Group.

The Steering Committee reports to the Committee for Terrestrial Ecosystems of the National Programme for Ecosystem Research, administered by the Foundation for Research Development of the CSIR. The National Programme is a cooperative undertaking of scientists and scientific institutions in South Africa concerned with research related to environmental problems. It includes research designed to meet local needs as well as projects being undertaken in South Africa as contributions to the international programme of SCOPE, the body set up in 1969 by ICSU (International Council for Scientific Unions) to act as a focus of international nongovernmental scientific effort in the environmental field.

The terms of reference for the Steering Committee are to:

- coordinate and actively support efforts to classify, map and characterize the indigenous forests of southern Africa;

- encourage studies on the biogeography and phytosociology of indigenous forests; and

- stimulate research into the functional processes of indigenous forests.

A succession of annual workshops was held during 1984-86 with the aim of developing a structural classification for the indigenous forests of southern Africa. This report is one of the products of the activities in this direction. A companion volume is the 'Proforma for structural classification of southern African forests' which appears as Occasional Report No 21, in the Occasional Report Series of Ecosystem Programmes.

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All participants at the various workshops gave willingly of their ideas. Their support and enthusiasm is very much appreciated. They are listed at the end of this report.

ABSTRACT

This report lists and defines attributes (both functional and structural) that have been used in other structural classifications of forest vegetation. Field techniques are summarized. The recommended use of each attribute and technique is presented. This is the companion report to Geldenhuys et al (1987) a 'Proforma for structural classification of southern African forests'.

SAMEVATTING

Hierdie verslag lys en definieer veranderlikes (beide funksioneel en struktureel) wat in ander strukturele klassifikasies van woudplantegroei gebruik was. Veldtegnieke word opgesom. Die aanbevole gebruik van elke veranderlike en tegniek word aangedui. Hierdie verslag vergesel Geldenhuys et al (1987) "Proforma for structural classification of southern African forests".

INTRODUCTION

Although indigenous forests occupy only a small area of the southern African subcontinent, they are of importance commercially (forest products) and also for the conservation and management of catchment areas.

Since the indigenous forests of southern Africa are floristically complex, a structural approach to identification and definition of different forest types occurring in the subcontinent was considered. The purpose of such a classification is to provide a standardized description of forest vegetation that could be used for integrating both local and regional forest studies into a national framework. The final classification should provide techniques for identifying the forest types and for describing aspects of its ecology (eg aspects of its disturbance history). This classification should also be useful to forest managers for predicting gross timber biomass and the areas' conservation value. A structural classification could facilitate studies relating forest vegetation with its physical environment.

Classifications can only be as good as the set of attributes used and the definition of these attributes. The purpose of this document is to identify, examine and define attributes and techniques useful for developing a structural classification for southern African forests.

OBJECTIVES OF FOREST STRUCTURAL DICTIONARY

In particular this document examines other classifications, paying attention to attributes used to define such classifications, and to recommend improvements or refinements for inclusion in the structural classification of southern African forests. Furthermore this dictionary should facilitate the standardization of terminology in ecological studies.

CURRENT SYSTEMS OF STRUCTURAL-FUNCTIONAL CLASSIFICATION OF FORESTS

Previous attempts to classify vegetation using structural and functional attributes (eg Fosberg 1967; UNESCO 1973; Campbell et al 1981; Edwards 1983) indicate the impossibility of defining a single system appropriate under all conditions. Attempts to classify Australian vegetation based on either floristic or structural criteria were satisfactory for most vegetation types excluding the rainforests (Walker and Hopkins 1980). White's (1983) description of continental African vegetation was based on a combination of physiognomic and floristic criteria. Edwards' (1983) classification of South African vegetation used four primary growth form types, expressed as four cover and height classes. Such approaches are inadequate for providing useful and detailed habitat descriptions for southern African forests.

A finer scale for forest classification is needed that is similar in concept to Campbell's (1985) classification of mountain fynbos. This report examines and defines all attributes and techniques initially considered useful for developing such a classification based on their use in previous classifications.

ORGANIZATION OF THE DICTIONARY

The dictionary consists of sections which deal with definition of the functional/structural attributes of forest vegetation and the techniques used in expressing their structural composition.

Each attribute is defined with respect to its purpose for inclusion in the classification. Definitions and problems with their use are summarized under separate headings. The recommended definition and/or use is boxed. Some field techniques, although initially considered, were not recommended for general use after experimenting with their application during the workshops.

GENERAL DEFINITIONS

Forest is a physiognomic vegetation unit. Definition of these terms fall outside the main section of the report, and are dealt with here.

PHYSIOGNOMY

Purpose: To describe the external appearance of a forest.

Definition:
Kruger (1978): The colour, luxuriance, seasonality and overall structural and floristic features of vegetation.

Problems: It relies heavily on a few attributes such as height, density, spinescence and deciduousness (White 1983). It is difficult to evaluate the importance of these attributes.

Physiognomy is an integration of functional and structural attributes relating to vegetation. It should be used for the final description of different forest types.

FOREST

Purpose: To distinguish forests from other major vegetation types.

Definitions:
Edwards (1983): A vegetation type possessing canopy cover $\geq$75% of trees taller than two metres.

White (1983): A continuous stand of trees, with canopy 10 to 50 m high or more, usually consisting of several strata, including a shrub layer.

Problems: There are many different types of forests. We need to define specific types. Several forests, such as mountain forests or dry forests have no shrubs, only grasses or ferns.

> A forest is a plant community having a continuous tree stratum, with or without a shrub and/or herbaceous stratum.

FOREST TYPES

Purpose: To distinguish major physiognomic types of forest.

Definitions:

Deciduous forest (also semi-evergreen, semideciduous):

Webb (1978): Semideciduous forest has deciduous and semi-deciduous emergent and top canopy species. Most leafless species are truly deciduous, but some are facultatively deciduous ie leaf-fall is controlled by the severity of the dry season.

White (1983): In deciduous forest the majority of individuals both in the upper and lower canopy, loose their leaves simultaneously, and usually remain bare for several weeks or months. In semi-evergreen forest some canopy species are briefly deciduous but not necessarily at the same time. Most understorey plants are evergreen.

Dry forest:

White (1983): Dry forest experience a dry season lasting several months, is shorter, simpler in structure and poorer floristically than rain forest.

Rain forest or rainforest:

Webb (1978): Rainforest is distinguished from other closed-canopy forests by the prominence of characteristic life forms such as epiphytes, lianes, root and stem structures, and by the absence of annual herbs on the forest floor. The term rainforest (in contrast to rain forest) is used to indicate its status as a fully independent plant formation which is subject to a variety of environmental determinants besides moisture.

Walker and Hopkins (1980): Vegetation with trees dominated by soft-leaved species whose combined strata have overlapping crowns; and further distinguished by a dominance of epiphytes, lianes and distinctive root and stem structures, and an absence of forest floor forbs (based on definitions by Webb 1959, 1968, 1978; Webb et al 1970, 1976).

White (1983): Rain forest is tall forest (>30 m canopy height), commonly occurring on well drained soils throughout Africa.

Scrub Forest:

White (1983): Vegetation intermediate in structure between true forest and bushland/thicket, normally 10 to 15 m high. Trees with well defined and upright boles may not form a closed canopy. Smaller woody plants contribute as much as trees to the vegetation structure.

Thicket:

Webb (1978): Stunted rainforest in which the canopy closes at three to nine metres. The use of scrub is avoided.

Edwards (1983): Vegetation with both total tree cover and shrub cover over 10% and trees five to ten metres and shrubs two to five metres high.

White (1983): In thicket, bushes are so densely interlaced as to form an impenetrable community except along animal tracks. Bushes are woody plants intermediate between a shrub and a tree, between three to seven metres high and usually multistemmed.

Undifferentiated forest:

White (1983): Forest vegetation which undergo rapid and kaleidoscopic change in structure and composition over short distances.

Problems: Most southern African forests could be considered as rainforest within the Webb (1978) and Walker and Hopkins (1980) definitions. At the end points of environmental or disturbance gradients the vegetation becomes stunted and/or sometimes with relatively open canopy. It may be difficult to distinguish between stunted forest and taller forest, and to distinguish between semideciduous (evergreen) forest, dry forest and undifferentiated forest.

> Southern African forests are rainforest or undifferentiated forest. The term forest, as defined, should be prefixed by two sets of terms: high, tall, short or low as defined by Edwards (1983) and evergreen or semideciduous (after Webb 1978). **Scrub forest** is a well established name (Afrikaans = kreupelwoud) and in our context is used as a collective term for short and low forest. Thicket (after Edwards 1983; White 1983) is excluded from sampling.

DEFINITION OF FUNCTIONAL AND STRUCTURAL ATTRIBUTES

Table 1 is a generalized scheme, which identifies and defines the components used in discriminating functional from structural attributes. This scheme was developed from definitions of function and structure encountered in the literature. The organization of information in the dictionary follows this scheme, which in turn reflects the organization of the structural classification field sheets (A-D) Geldenhuys et al (1987) (See Appendix).

FUNCTIONAL ATTRIBUTES

Purpose: To relate morphological adaptations of plants to their present and past environments.

Problems: It may be difficult to separate functional groups. For example, are life forms structural or functional attributes.

> Functional attributes are morphological adaptations that relate to individual species. These include growth or life forms of plants (considered as structural for species assemblages), root systems and buttress types, bark types, shape size and deciduousness in leaves; and architecture of the tree crowns.

STRUCTURAL ATTRIBUTES

Purpose: To describe the three-dimensional structure of forests, which determines their internal microclimates and the energy available for other organisms, and which therefore controls the distribution of biota contained in the forest (Richards 1983).

Definition:

Kruger (1978): Structural attributes pertain to the spatial distribution of biomass in terms of stratification and pattern and to the distribution amongst species.

Walker and Hopkins (1980): The characteristic appearance of vegetation as expressed by growth forms (trees, shrubs, herbs) at varying height (strata) and abundance (cover).

Edwards (1983): Organization in space of individuals, and the primary elements (after Dansereau 1957) are growth form, stratification and cover.

Problems: Definition or estimation of height and cover classes are difficult.

> Structural attributes describe the spatial organization of biomass. The basic units of measurement are height, cover and stem diameter, and are used to express the importance of the functional attributes. Structural attributes will be assessed for species assemblages rather than at an individual species level, and will include cover of growth form strata at different heights, and stem diameters.

TABLE 1. Attribute definition

FUNCTIONAL: Morphological adaptation of individual species to present and past abiotic or biotic environments

STRUCTURAL: Spatial organization of biomass of species assemblages

FUNCTIONAL/STRUCTURAL ATTRIBUTES (growth forms)

Woody plants
Stems are woody.

Trees
Self-supporting, either single stemmed DBH > 10 mm and > 3 m tall, or multistemmed > 5 m tall.

Shrubs
Self-supporting, either single stemmed < 3 m tall or multistemmed < 5 m tall.

Half-woody shrubs
Self-supporting, partly woody, excluding tree ferns.

Lianes
Not self-supporting but winding, sprawling or climbing, with DBH > 10 mm.

Epiphytes
Multistratal aerially supported, including lichens, bryophytes, ferns and other plants.

Herbaceous plants
< 5 m tall with nonwoody stems.

Vines
Not self-supporting, but winding, sprawling or climbing, with DBH < 10 mm.

Graminoids
Tufted, erect < 2 m tall including Poaceae, Cyperaceae, Juncaceae and Restionaceae.

Geophytes
Nongraminoid monocotyledons, < 2 m tall with strap-like leaves.

Forbs
Angiosperms, <2 m tall excluding graminoids, geophytes and vines.

Ferns
Nonflowering and vascular.

Bryophytes
Nonvascular < 250 mm tall.

Lichens
Nonvascular, fungal-algal, < 250 mm tall.

DOMINANTLY FUNCTIONAL ATTRIBUTES

Leaves (canopy tree and shrub strata)
Shape: simple, compound.
Size: classes defined on field sheets.
Deciduousness: seasonal leaf loss.

Spinescence (on stem below 3 m)
Trees, shrubs, and lianes.

Architecture (canopy trees)
Spatial organization of foliage, sensu Webb et al (1976).

Bark

Texture
fine - surface relief < 5 mm
rough - surface relief > 5 mm.

Structure
smooth - without cracks, furrows or flakes
fissured - vertical cracks/furrows
blocky - cracks/furrows vertical and horizontal
flaky - scaly or papery appearance.

Buttresses (canopy trees): Normal, star (spur), plank or stilt.

DOMINANTLY STRUCTURAL ATTRIBUTES (see field sheets for category definition)

Height
Identifies strata.

Crown cover
Indicates spatial distribution of foliage and importance of functional attributes.

Stem diameter at breast height (DBH)
Estimates gross volume of woody material.

FUNCTIONAL/STRUCTURAL ATTRIBUTES

GROWTH/LIFE FORMS

Purpose: To relate the prominence of particular growth/life forms to particular environments (Mueller-Dombois and Ellenberg 1974).

Definition:

Raunkiaer (1934):

ephiphytes - air plants, no roots in soil.
phanerophytes - aboveground plants, renewable buds exposed on upright shoots. Five subsections include trees, shrubs, stem succulents, herbaceous stems and lianes (vines).
chamaephytes - surface plants, renewable bud at surface of the ground.
hemicryptophytes - tussock plants, bud in or just below the soil surface.
cryptophytes/geophytes - earth plants; bud below surface on a bulb, corm or rhizome.
therophytes - annuals, complete life cycle from seed in one vegetative period, survive unfavourable seasons as seeds.

Problems: Raunkiaer (1934) places undue emphasis on perennating organs (see White 1983).

A plant may assume different growth forms at different stages of its development.

> Specific growth/life forms are defined on the following pages, in three main categories: woody plants, herbaceous plants and epiphytes.

WOODY PLANTS
TREES

Purpose: To distinguish major forest types using the dominant organisms in the forest. Trees determine the general physiognomy, primary production and life-cycles for the entire forest community (Longman and Jenik 1974).

Definitions:

Walker and Hopkins (1980): Woody plants greater than three metres tall, with a single stem at the base (ie 200 mm from the ground).

Edwards (1983): Woody plant with one or a few definite trunks branching at, or above the ground.

Campbell et al (1981): Woody plants mostly single-stemmed at base and greater than two metres tall and DBH > 100 mm, but where definite multiple stems exist, then greater than five metres tall and DBH > 50 mm.

<u>Problems</u>: Ambiguity of definition of a tree and of what constitutes a multistemmed plant.

A tree is a self-supporting woody plant, with DBH at least 10 mm, at least three metres tall if single stemmed, and at least five metres tall if multi-stemmed. A multistemmed plant has more than one definite trunk which originate between ground level and 1,3 m ie breast height. A multistemmed plant is recorded as a single individual if the stem splits above breast height, otherwise each stem is measured and counted separately and recorded as multistemmed. A multistemmed plant is counted as a single individual in the calculation of species richness or diversity. Stilt roots (eg *Ficus trichopodi)* are not recorded as stems. Trees are also recorded by crown cover in different height classes.

FIGURE 1. A stand of *Syzygium cordatum* trees in swamp woodland at Kosi Bay.

WOODY PLANTS
SHRUBS

Purpose: To distinguish major forest types using the density and height of the shrub stratum. Shrubs may be the dominant organism in the subcanopy eg *Trichocladus crinitus* in southern Cape forests (Phillips 1931).

Definitions:

Longman and Jenik (1974): Genuine shrubs are seldom found in untouched rainforest. The majority of small woody plants in the understorey are either seedlings of bigger trees, palms or "pygmy" trees. The latter have a distinct, often unbranched axis with a small head of large leaves which seldom exceed five metres height.

Walker and Hopkins (1980): Woody plant, multistemmed at base (<200 mm from ground), or if single-stemmed less than two metres tall.

Edwards (1983): Rooted woody, self-supporting plants, multistemmed or branching at or near the ground when two to five metres tall, or either multistemmed or single-stemmed when less than two metres tall.

Campbell et al (1981): Woody, self-supporting plants less than two metres tall, or two to five metres tall if multistemmed (branch below 0,5 m) or if DBH is <100 mm.

Problems: Definition of a shrub and of what constitutes a multistemmed plant is ambiguous. *Trichocladus crinitus* is an example of a pygmy tree, but is often recorded as a shrub. In addition there are half-woody shrubs.

> A shrub is a self-supporting woody plant, less than three metres tall if single stemmed and less then five metres tall if multistemmed. Half-woody shrubs, ie those plants which appear to be woody, have been given a separate category, for species such as *Sparmannia africana*, *Piper capense*, *Dracaena hookerana*, *Aloe* species, *Clutia* species, *Plectranthus* species, and members of Acanthaceae such as *Isoglossa woodii* but excluding tree ferns. Shrubs are recorded by crown cover in height classes below five metres. Shrub stems are also counted in the 10 to 99 mm DBH category.

WOODY PLANTS
LIANES

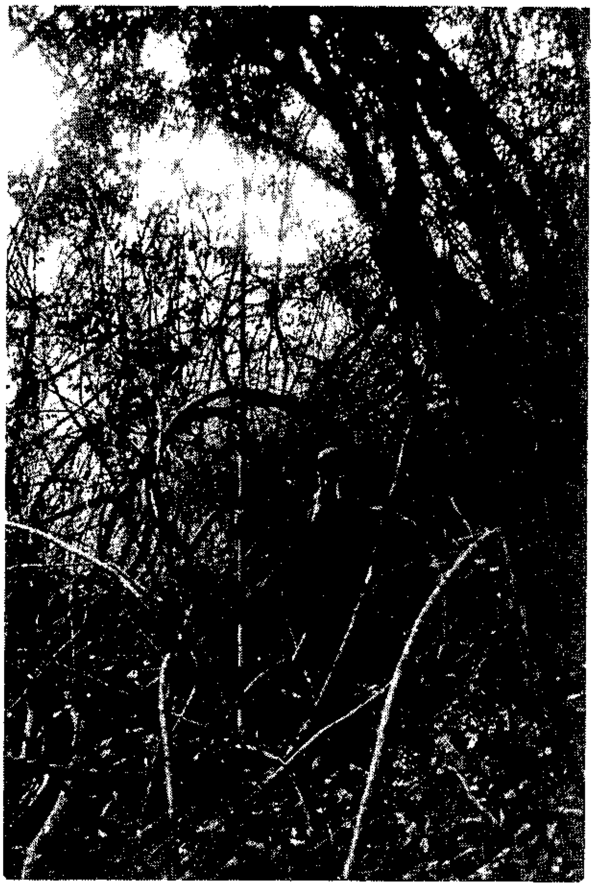
Purpose: To distinguish major forest types, using lianes together with vines. They add complexity to vertical forest structure. Lianes are common in forest clearings and in secondary or regrowth forest types and forest margins. They are frequently restricted to tropical environments (Walter 1979).

Definition:

Walker and Hopkins (1980): Lianes are woody plants which root in the ground, but are not self-supporting, and include scandents but exclude stranglers.

Problems: Lianes are only one category of woody and herbaceous climbers. Others encountered are: stranglers, twiners, root-climbers, tendril-climbers or vines. Such plants have also been defined with respect to presence of feather palm leaves, thorns, prickles, hooks etc (Webb et al 1976).

> Lianes are not self-supporting but winding, sprawling or climbing woody plants with stem DBH $\geq$ 10 mm. Stranglers are excluded from this category, but should be noted where present. Lianes are recorded by crown cover in height classes greater then one metre and individual stems are counted in the DBH categories.



Liane

Strangling fig

FIGURE 2. Illustrations of lianes.

HERBACEOUS PLANTS

Purpose: To distinguish major forest types using the distribution of herbaceous plants through the stand.

Definition:

Webb et al (1976): Herbaceous plants are up to three to four metres tall: with soft, long, wide leaves (eg bananas, gingers); with long narrow leaves <20 mm in width (eg grasses); with long strap leaves >20 mm in width (eg lilies); with strap leaves and cutting edges (eg sedges).

Problems: It includes many growth forms eg vines, graminoids, geophytes, forbs, ferns and epiphytes.

The term is not easily defined on a family or generic basis (Walker and Hopkins 1980).

Herbaceous plants may sometimes appear slightly woody and therefore be confused with half-woody shrubs.

> Herbaceous plants are plants less than five metres tall, possessing nonwoody stems, and rooted in the ground. An epiphyte is a special type of herbaceous plant and is defined separately.

HERBACEOUS PLANTS
VINES

Purpose: To distinguish major forest types, using vines together with lianes. They add complexity to vertical forest structure.

Definition: See definition for lianes.

Problems: It is difficult to visually distinguish between vines and lianes, especially when dealing with young plants.

> Vines are herbaceous plants, not self-supporting, but winding, sprawling or climbing, with DBH <10 mm. Vines are recorded by crown cover in height classes below five metres.

HERBACEOUS PLANTS
GRAMINOIDS

Purpose: To distinguish major forest types, using the lowest layers. Graminoids may indicate richer substrates or disturbance.

Definitions:

Walker and Hopkins (1980): Herbaceous, cyperaceous plants, usually perennial and erect, with tufted habit, arising from stolons, tubers, bulbs, rhizomes or seeds (sedges).

Campbell et al (1981) and Edwards (1983): Herbaceous plants resembling grasses, belonging to the families Poaceae, Cyperaceae and Restionaceae.

Problems: The definitions above exclude other plants with grasslike leaves, eg Juncaceae, or plants with long, narrow (wiry) leaves, eg some Cyperaceae.

Some of the bambusoids may exceed five metres in height and therefore are best considered to be either trees or shrubs (Edwards 1983).

> Graminoids are herbaceous plants, with tufted, erect or creeping habit, and grasslike or wiry leaves, including Poaceae, Cyperaceae, Juncaceae and Restionaceae. The following are generic examples: *Ficinia*, *Schoenoxiphium*, *Carex*, *Oplismenus*, *Ehrharta*, *Prosphytochloa*. Graminoids are recorded by crown cover in height classes.

HERBACEOUS PLANTS
GEOPHYTES

Purpose: To distinguish major forest types, using the lowest layers.

Definition:

Webb et al (1976): Plants with long strap leaves >20 mm in width.

Problems: May sometimes be included with herbs and forbs.

> Geophytes are herbaceous, nongraminoid monocotyledons, less than two metres tall, with strap-like leaves and with underground storage organs such as bulbs, corms, or rhizomes. The following are generic examples: *Aristea*, *Chlorophytum*, *Commelina*, *Dietes*, *Scadoxus*, *Zantedeschia* and *Bonatea*. *Oxalis* is excluded. Geophytes are recorded by crown cover in height classes.

HERBACEOUS PLANTS
FORBS/HERBS

Purpose: To distinguish major forest types using the lowest layers. The occurrence and abundance of forbs/herbs may be an indication of drier or open forest habitat.

Definitions:

Walker and Hopkins (1980): A forb is a herbaceous or slightly woody annual or sometimes perennial plant which may arise from stolons, tubers, bulbs, rhizomes or seeds. Foliage of a forb usually covers the majority of branches in shrubby and creeping forms. Forbs rarely exceed 0,5 m in height, unless a climbing species.

Edwards (1983): A herb includes all herbaceous, non-grasslike plants. Woodiness, if present, is confined to ground level.

Problems: Are the terms forb/herb interchangeable?

We prefer the term forb, to include herbaceous angiosperms, less than two metres tall, excluding graminoids, geophytes and vines. Forbs are recorded by crown cover in height classes.

HERBACEOUS PLANTS
FERNS

Purpose: To distinguish major forest types, due to their frequent association with mesic, shady conditions and broad altitudinal distributions (Jacobsen 1983).

Definitions:

Webb et al (1976):

tree ferns - >0,5 m tall, occurring in cool, damp conditions (Walter 1979).
ground ferns - or herb-like ferns.

Jacobsen (1983):

stem ferns - with upright or procumbent and exposed stem (eg *Blechnum*);
lianes - with exposed stems and climbing habit;
epiphytes - with exposed rhizomes and aerially supported by trees;
lithophytes - exposed rhizomes and attached to rocks;
chasmophytes - rhizomes shallowly rooted in crevices;
chasmaephytes - procumbent stems and rooted in the soil;
geophytes - rhizome rooted in soil growing either deeply or shallowly amongst boulders (including tufted and stoloniferous ferns);
helophytes - growing in periodically inundated or permanently submerged soil;
hydrophytes - floating on water.

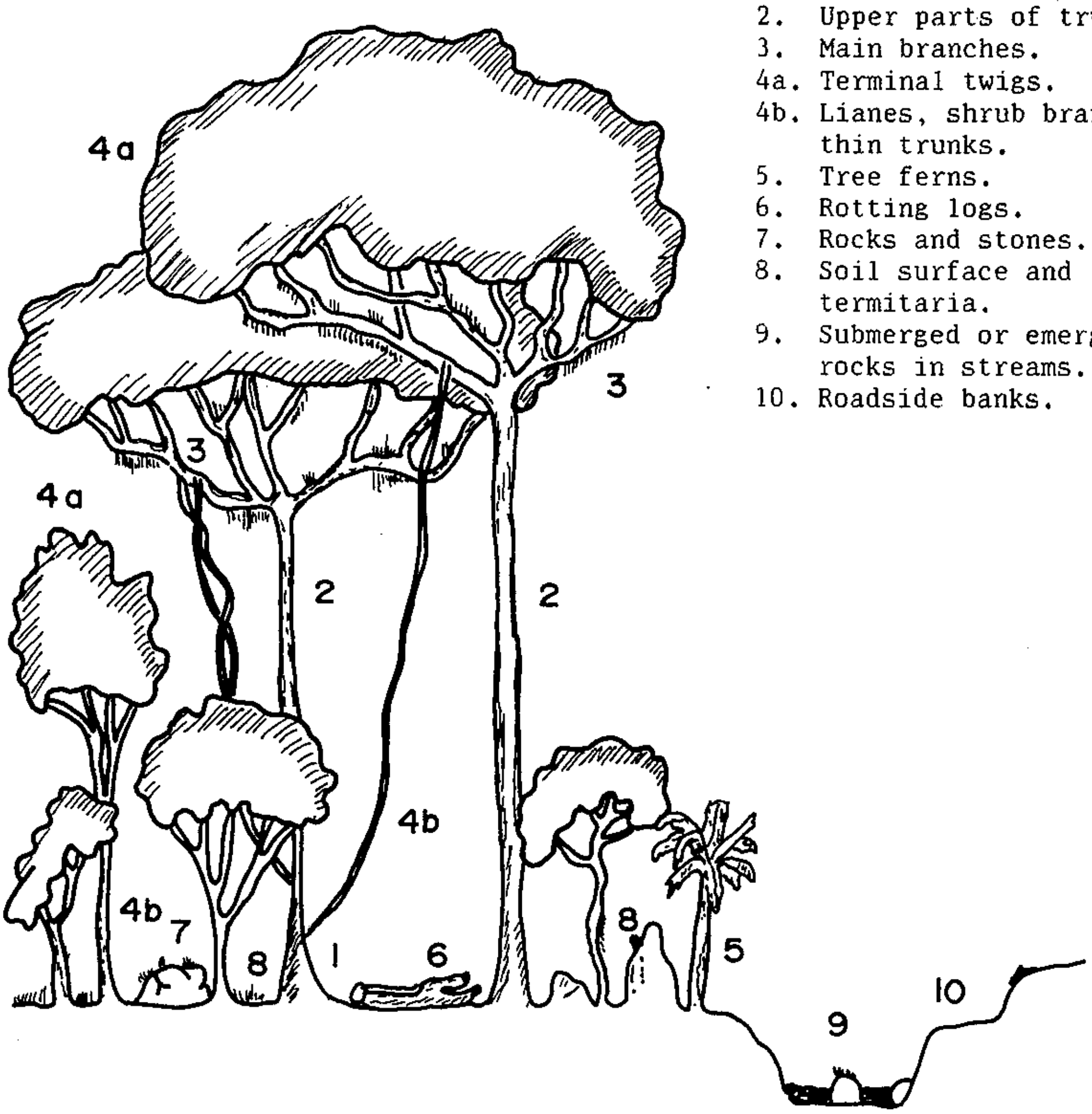
Problems: Since ferns include a wide range of growth forms they are difficult to categorize.

> Ferns are herbaceous, vascular non-flowering plants. We include stem ferns, chasmophytes and geophytes under the herbaceous fern category. Liane ferns are included under the liane or vine category; ephiphytic ferns under a separate epiphyte category and lithophytes with a ground layer substrate cover category. Ferns are recorded by crown cover in height classes in the different categories.

FIGURE 3. *Phymatoides* in dune forest at Mtunzini.

HERBACEOUS PLANTS
BRYOPHYTES

Purpose: To distinguish major forest types from the association of specific growth forms with specific microhabitats (Figure 4). Bryophytes have correlated positively with rainfall and have a considerable capacity to intercept rainfall in montane forests (Pocs 1982). Bryophytes also play an important role in nutrient cycling in forest ecosystems due to their absorptive properties and high ion exchange capacities (Rieley et al 1979).



1. Bases of large trees.
2. Upper parts of trunks.
3. Main branches.
4a. Terminal twigs.
4b. Lianes, shrub branches thin trunks.
5. Tree ferns.
6. Rotting logs.
7. Rocks and stones.
8. Soil surface and termitaria.
9. Submerged or emergent rocks in streams.
10. Roadside banks.

FIGURE 4. Bryophyte microhabitats in southern African forest. Modified from Pocs (1982).

HERBACEOUS PLANTS
BRYOPHYTES

Definition:

Russell (1984): Recognized several growth forms for bryophytes (Figure 5).

Problems: Bryophytes may not be easily distinguished from lichens or filmy ferns.

> Bryophytes are small nonvascular, herbaceous plants that are either epiphytic or terrestrial. This category includes filmy ferns (Hymenophyllaceae). The different growth forms can be recorded in specific detailed studies, but are not included in the structural proforma. Bryophytes are recorded by crown cover in different height classes in the different categories.

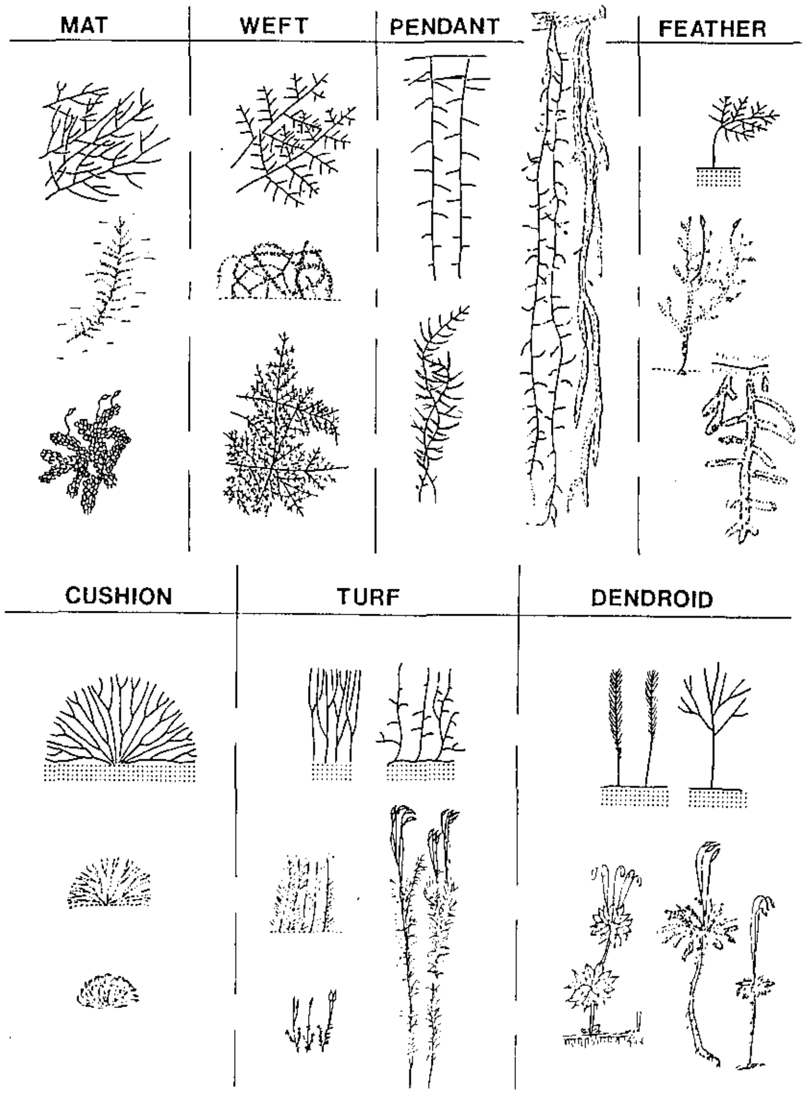


FIGURE 5. Bryophyte growth forms (Russell 1984).

HERBACEOUS PLANTS
LICHENS

Purpose: To distinguish major forest types. Lichens may play a role in interception of rainfall and nutrient cycling.

Problems: Lichens may not be easily distinguished from bryophytes.

Lichens include small nonvascular herbaceous plants that are composites of fungi and algae, and that are either epiphytic or terrestrial. Lichens are recorded by crown cover in height classes in the different categories.

FIGURE 6. Forest with lichens borne on main branches of trees.

EPIPHYTES

Purpose: To distinguish major forest types. Epiphytes are most frequently associated with conditions of high humidity and rainfall, particularly montane forests and mist belts eg bryophytes (Pocs 1982). Epiphytic orchids increase in importance from temperate to tropical areas (Harrison 1972). Epiphytes have a major impact on biogeochemical cycling (Rieley et al 1979; Benzing 1983) and play a role in moisture interception (Pocs 1982) and therefore influence structure and performance of the forest ecosystem (Benzing 1983). Epiphytes are bio-indicators of particular microclimatic and physiognomic forest types (Russell 1984) (Figure 4). Tree base species have low photosynthetic light compensation points, low dessication resistance and mainly vegetative methods of reproduction. This zone of maximum change in humidity has the greatest differentiation in zones of epiphytic cryptogam flora. Tree top species have high light compensation points, high dessication resistance and wind-blown spores, and the flora is fairly constant (Longman and Jenik 1974).

Definitions:

Webb et al (1976): Plants not rooted in the ground, but perched on tree trunks and branches to which they are attached by surface roots. Hemi-epiphytes are herbaceous plants which adhere to the lower parts of tree trunks, but remain rooted in the ground.

Problems: Evaluation may be difficult due to the small size of plants.

> Epiphytes are plants attached to tree trunks, branches and leaves by surface roots. We exclude woody or herbaceous plants growing in accumulated organic material in hollows on trees, such as tree seedlings. We recognize four epiphytic categories: lichens, bryophytes, ferns and angiosperms, and record them by crown cover in specific epiphyte height classes. The occurrence of non-epiphytic plants and stranglers on the trees should be noted.

FIGURE 7. Forest epiphytes.

DOMINANTLY FUNCTIONAL ATTRIBUTES

ROOT SYSTEMS AND BUTTRESS TYPES

Purpose: To relate the composition of the attributes in the forest to its adaptive significance. Root systems and buttress types are adapted to conditions for nutrient uptake and anchorage. They reflect on interaction of environment with hereditary factors (Longman and Jenik 1974). Plank buttressing is prevalent in emergent trees and in tropical trees occurring in shallow soils, at fairly low altitudes and under high rainfall conditions. They are generally absent in temperate areas. Stilt roots are usually associated with waterlogged or swampy sites.

Definition:

Longman and Jenik (1974) and Webb et al (1976): (see Figure 8).

normal stem: Weak surface root system but possessing a prominent tap root. Trunk base is swollen or club-like. It is most frequent in smaller trees and big woody climbers.
star root or spur buttress: Root system with thick horizontal surface roots and well developed tap root. Weak, rounded spur-buttressing may develop, which we define as joining the trunk below 0,5 m height.
Plank buttress: Root system with thick horizontal surface roots, frequently merging into large buttresses. Tap root may be entirely absent. Plank buttressing in tropical trees may extend up to 10 m along the main stem.
stilt roots: root system possessing numerous, large aerial roots and a network of weaker underground roots.

Use the types defined in Figure 8 and 9. Record buttress types by crown cover of canopy trees in each category.

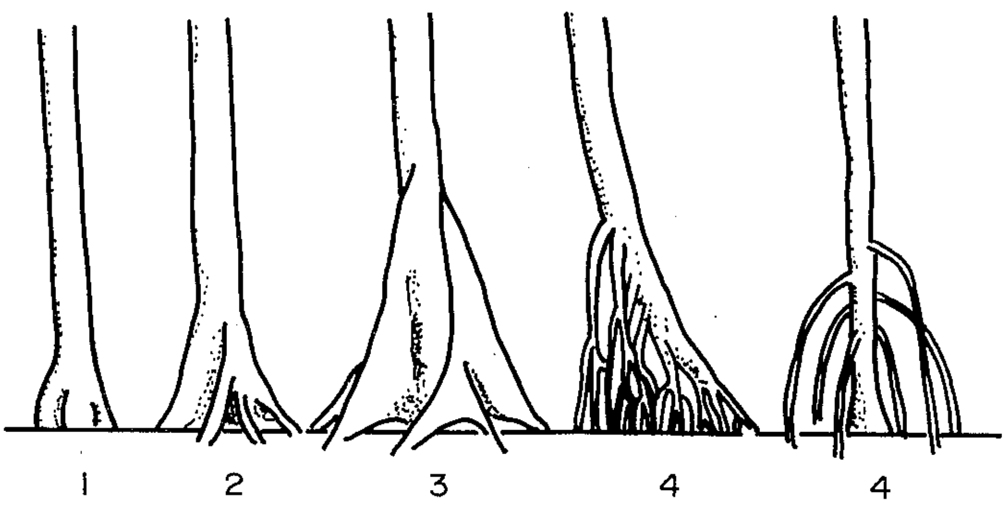


FIGURE 8. Root systems and buttress types (after Webb et al 1976): (1) normal stem; (2) star root or spur buttress; (3) plank buttress; and (4) stilt roots.

ROOT SYSTEMS AND
BUTTRESS TYPES

(a)

(b)

FIGURE 9. Illustration of (a) a normal stem; and (b) star root.

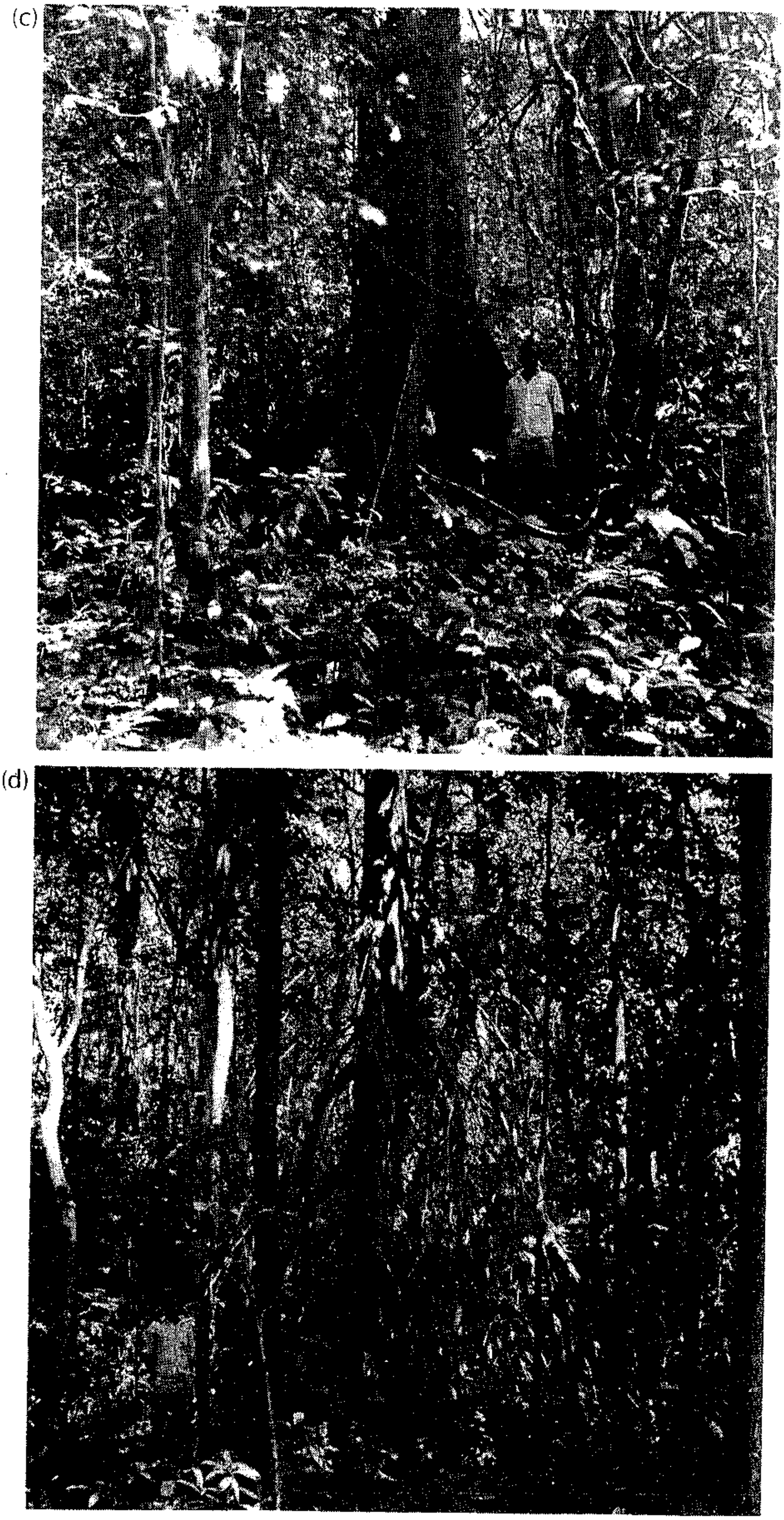


FIGURE 9. Illustration of (c) plank buttress; and (d) stilt root system.

BARK TYPES

Purpose: To relate the composition of bark types in a stand to the adaptive significance of bark texture and structure. Bark provides protection (Penfold and Willis 1961; Roth 1981) and conduction of photosynthates (Harder et al 1965). It may provide aeration for plants growing under high atmospheric humidity (Roth 1981). The thickness of bark may provide resistance to fire (Hare 1965). Bark structure and colour has been related to overheating of the cambium (Nicolai 1986). Rainforest trees usually have thin, smooth, light-coloured bark (Roth 1981). Bark thickness varies between species within a forest, but increases with age and diameter of a tree and with increasing altitude, latitude, aridity, exposure, decreasing temperature and fertility of soil (Van Laar and Geldenhuys 1975; Roth 1981).

Definitions:

Roth (1981): Categories of bark thickness.
Very thin 1 to 3 mm
Thin 3,1 to 4,9 mm
Medium 5 to 10 mm
Thick 10,1 to 15 mm
Very thick 15,1 to 20 mm
Extraordinarily thick 20,1 to 25 mm
Extremely thick 25,1 to 46 mm

Webb et al (1976): Categories of bark texture.
Smooth and glossy
Smooth with fine cracks, pustules
Rough, with fissures >10 mm deep
Rough, with shallow fissures
Rough, with dimples/scrolls/craters/coarse pustules
Flaky and scaly
Transverse hoops and ridges
Papery
Fibrous
Upper stem glassy smooth, lower not
Soft mossy, covering
Stems bearing flowers and fruits (cauliflory)
Possessing sucker shoots or other prominent features.

Problems: These are ambiguous, multiple definitions. Bark type varies with the age of trees and exposure to light. Classification depends on the state in which the bark is found. Bark types are difficult to record objectively in the field. Bark thickness is also difficult to measure accurately.

We only consider the bark surface of trees and exclude thickness, colour and consistency. Bark of the lowest three metres above the main buttress is to be examined. View the bark from at least five metres away. Bark is to be divided into two texture classes: fine less than five millimetres relief; and rough greater than five millimetres relief. Within each are to be found four structural categories: smooth, fissured, blocky and scaly (see Figure 10 and Table 1). Note the following: Smooth bark of old trees or of trees on marginal sites may become fissured, blocky or flaky. Rough-textured smooth bark has an uneven surface or contains rings, ridges, pustules, sculptures, cork prickles, knobs, protuberances or projections of such density that it overrides the appearance of the fine-textured matrix of the bark. Fissured bark has a netted or parallel pattern. Blocky bark forms distinctive rectangular or semicircular sections. Flaky bark lifts from the main bark in scales or strips, and may or may not be regularly shed. Bark type is recorded by crown cover of canopy trees in each category.

BARK TYPES

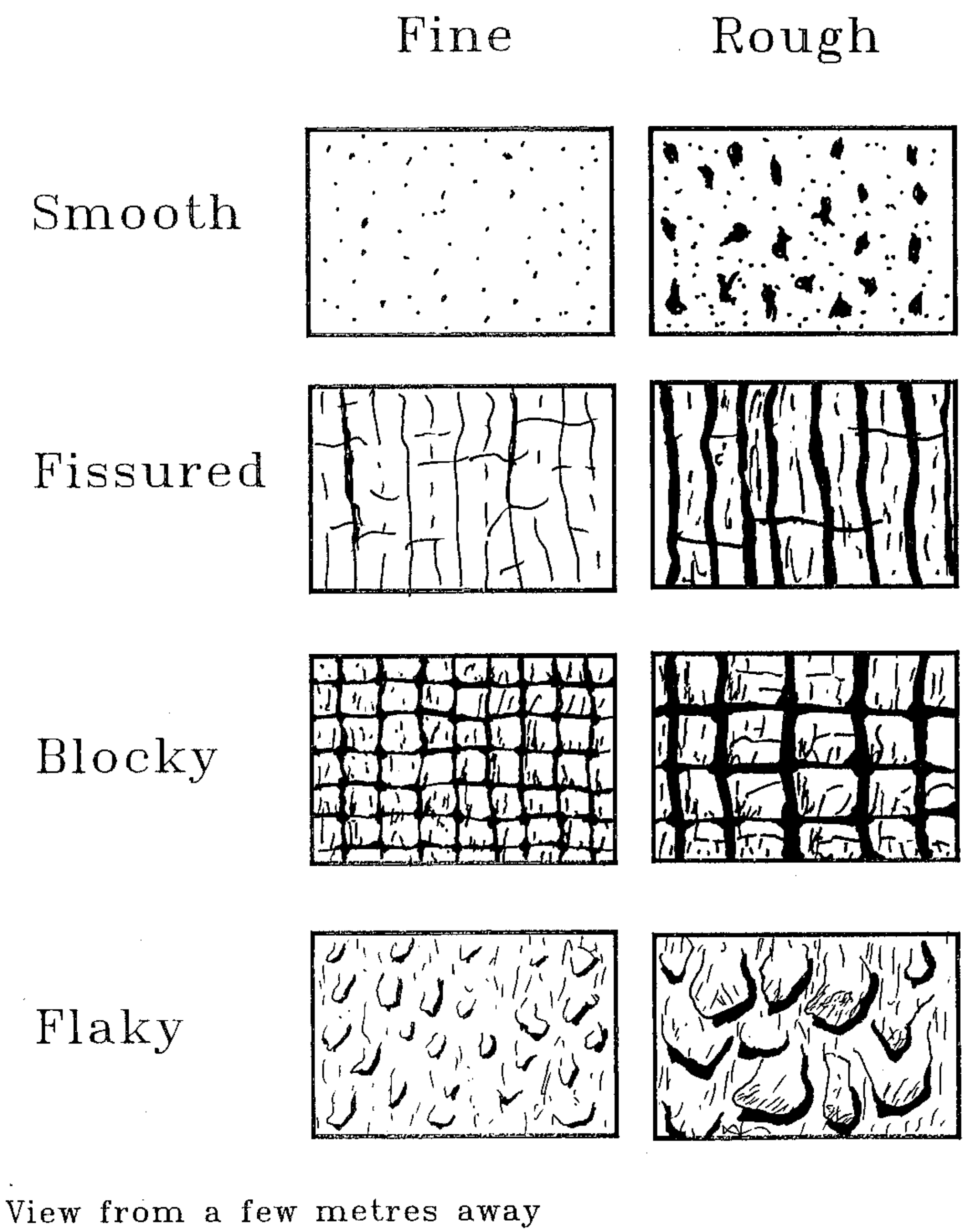


FIGURE 10. Diagrammatic representation of various bark types: fine smooth, fine fissured, fine blocky, fine flaky, rough smooth, rough fissured, rough blocky and rough flaky.

BARK TYPES

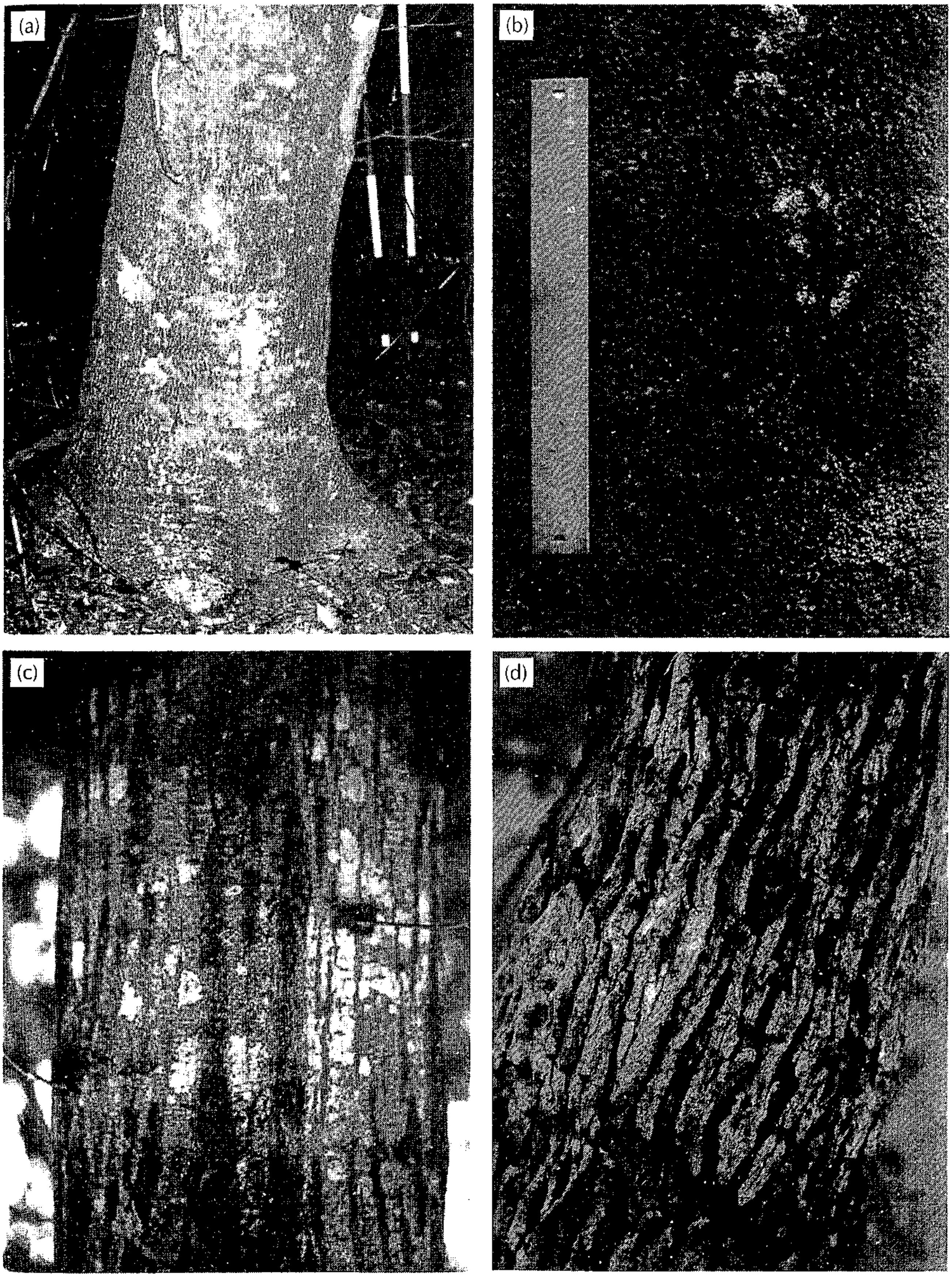


FIGURE 11. Photographic illustration of (a) fine smooth bark; (b) rough smooth bark; (c) fine fissured bark; and (d) rough fissured bark.

BARK TYPES

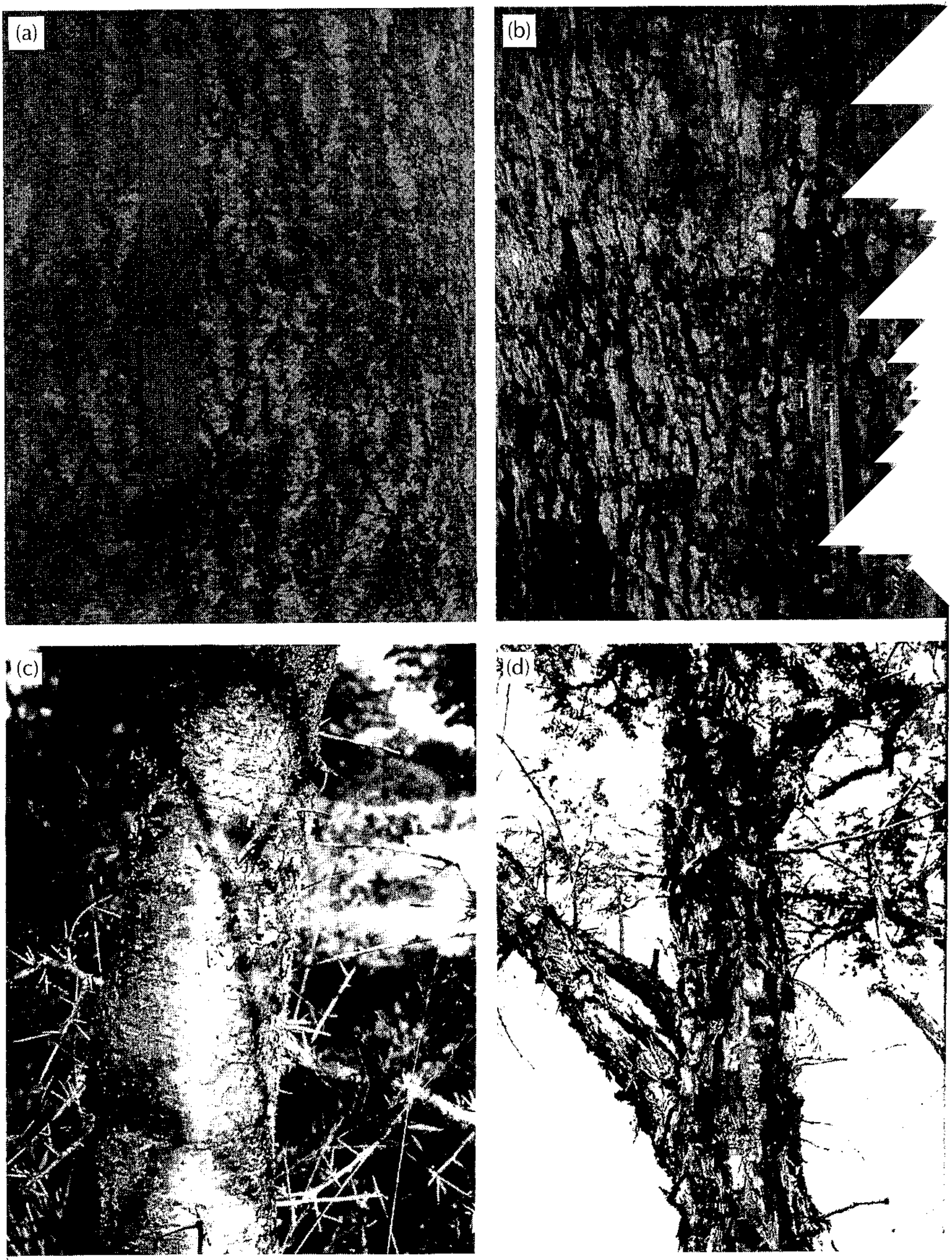


FIGURE 12. Photographic illustration of (a) fine blocky bark; (b) rough blocky bark; (c) fine flaky bark; and (d) rough flaky bark.

SPINESCENCE

Purpose: To relate the composition of spinescent plants in a forest to the adaptive significance of the attribute. Spinescent trunks are characteristic of tropical forests in dry climates and may be occasionally found in rainforests. Spinescence may be a response to increasing aridity and protection against browsing (Bews 1925). It may also be important on nutrient rich soils, or soils where less leaching has occurred, such as under lower rainfall climates (Cowling and Campbell 1983; Campbell 1985).

Problems: This attribute has not been categorized.

> We record woody, or thorny protuberances on branches or stems below three metres height for trees, shrubs and lianes by crown cover.

(a)

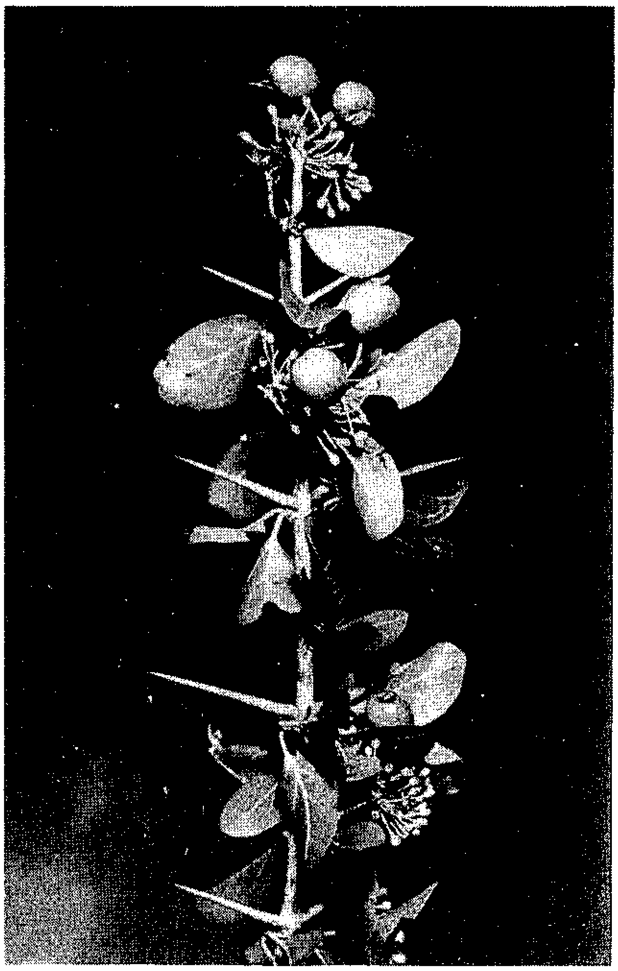
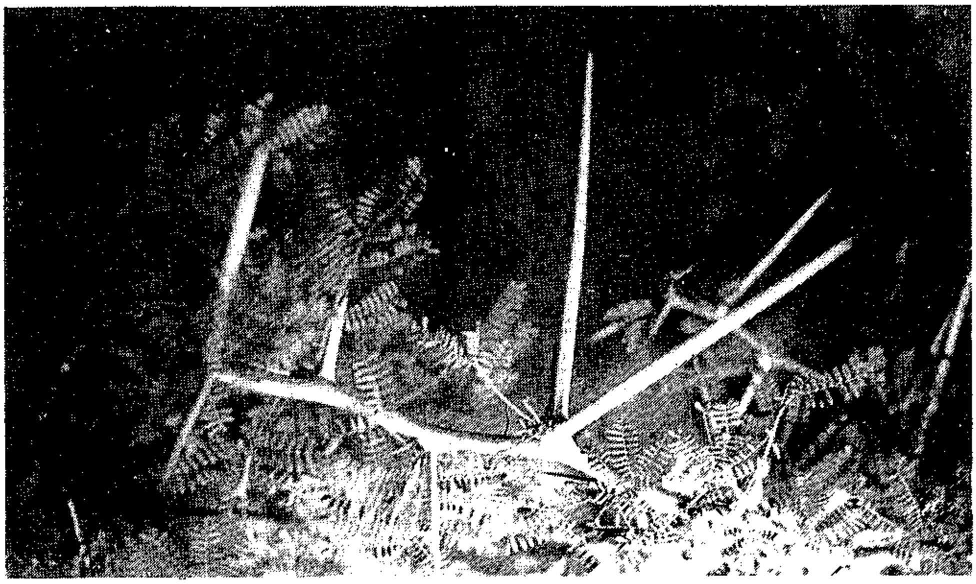
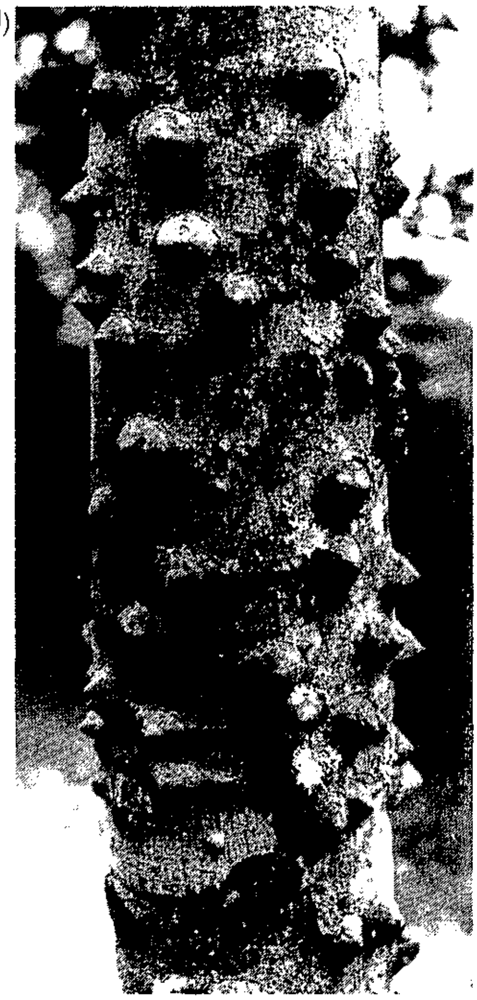


FIGURE 13. Illustration of spinescence in: (a) *Plectroniella armata*.

(b)



(d)



(c)

FIGURE 13. Illustration of spinescence in: (b) *Acacia karroo*; (c) *Carissa macrocarpa*; and (d) *Zanthoxylum capense*.

LEAVES

<u>Purpose</u>: To relate the composition of leaf types in a forest to the adaptive significance of specific leaf characteristics. Leaves are responsible for carbohydrate production and cooling through transpiration.

<u>Problem</u>: Leaves occur in many sizes, shapes and textures each of which needs to be independently defined.

We use leaf shape and leaf size of trees and shrubs.

LEAF SHAPE

<u>Purpose</u>: To relate the importance of different leaf shapes in a forest type to the environment. Compound leaves may be adapted to warm and seasonally arid situations, and may be associated with a deciduous habit or with species that occupy light gaps or are early pioneers (Givnish 1978). Drip-tip leaves may be important in tropical areas and may prevent excess water accumulating on the leaves (Walter 1979).

<u>Definition</u>:

Webb et al (1976):

needle/scale eg conifers;
much divided/deeply lobed eg certain fast growing pioneer tree species found in forest gaps;
toothed or finely irregular margins

<u>Problems</u>: It is difficult to categorize leaf shape.

We only distinguish simple from compound leaves in both the canopy strata of trees and shrubs. Record crown cover for each leaf shape in each main forest stratum.

LEAF SHAPE

(a)

(b)

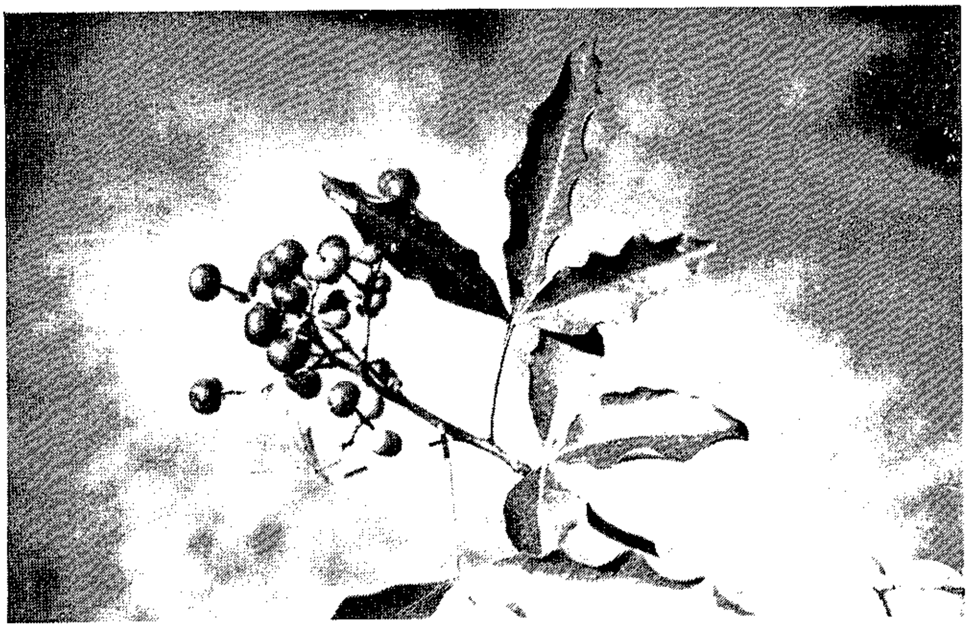
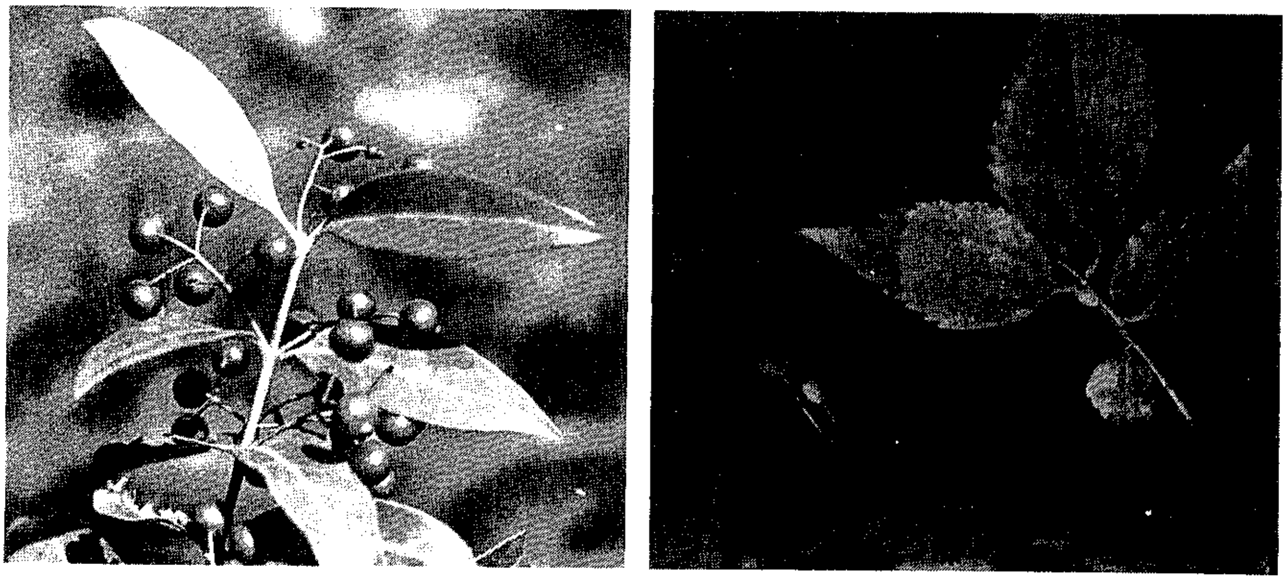


FIGURE 14. Examples of (a) simple and (b) compound leaves.

LEAF SHAPE

(a)



(b)

FIGURE 15. Illustration of (a) simple (*Celtis africana* and *Kraussi floribunda*) and (b) compound (*Acacia karoo* and *Clausena anisata*) leaves.

LEAF SIZE

Purpose: To relate the composition of different leaf sizes in a forest type to the environment. It has been related to rainfall (Raunkiaer 1934), mean annual biotemperature (Holdridge et al 1971; Dolph and Dilcher 1980) or temperature and humidity of the air (Walter 1979).

Definition:

Webb et al (1976) and Walker and Hopkins (1980) define the following leaf size categories.

Leaf size category	Leaf area mm²	Approximate length (mm)	
		Lanceolate leaf	Cordate or peltate leaf
Macrophyll	>18225	>250	>160
Mesophyll	4500-18225	125-250	80-160
Notophyll	2025- 4500	75-125	60- 80
Microphyll	225- 2025	25- 75	20- 60
Nanophyll	25- 225	<25	< 20

Problems: When looking up through the understorey, leaves appear larger than reality (Webb et al 1976). Using leaves that have fallen to the forest floor only gives a guide to dominant leaf size. Allowance must be made for exaggeration due to contribution of generally larger shade leaves in the lower layers compared to the more exposed sun leaves. It is difficult to include leaves of palms, aroids and vines (Walker and Hopkins 1980). Compound leaves create difficulties, in forcing decisions as to what is a leaf and what a leaflet.

We use leaf size classes of Webb et al (1976) and Walker and Hopkins (1980), shown above and/or (on field sheet B, appendix) (on the proforma (Geldenhuys et al 1987)). Use canopy leaves of the dominant tree and shrub species. Use leaf area and not leaf length as a guide, but exclude petiole length. The leaflet of a compound leaf is to be measured. Record crown cover for each leaf size category of canopy plants in each of the tree and shrub strata.

LEAF SIZE

(a)

(b)

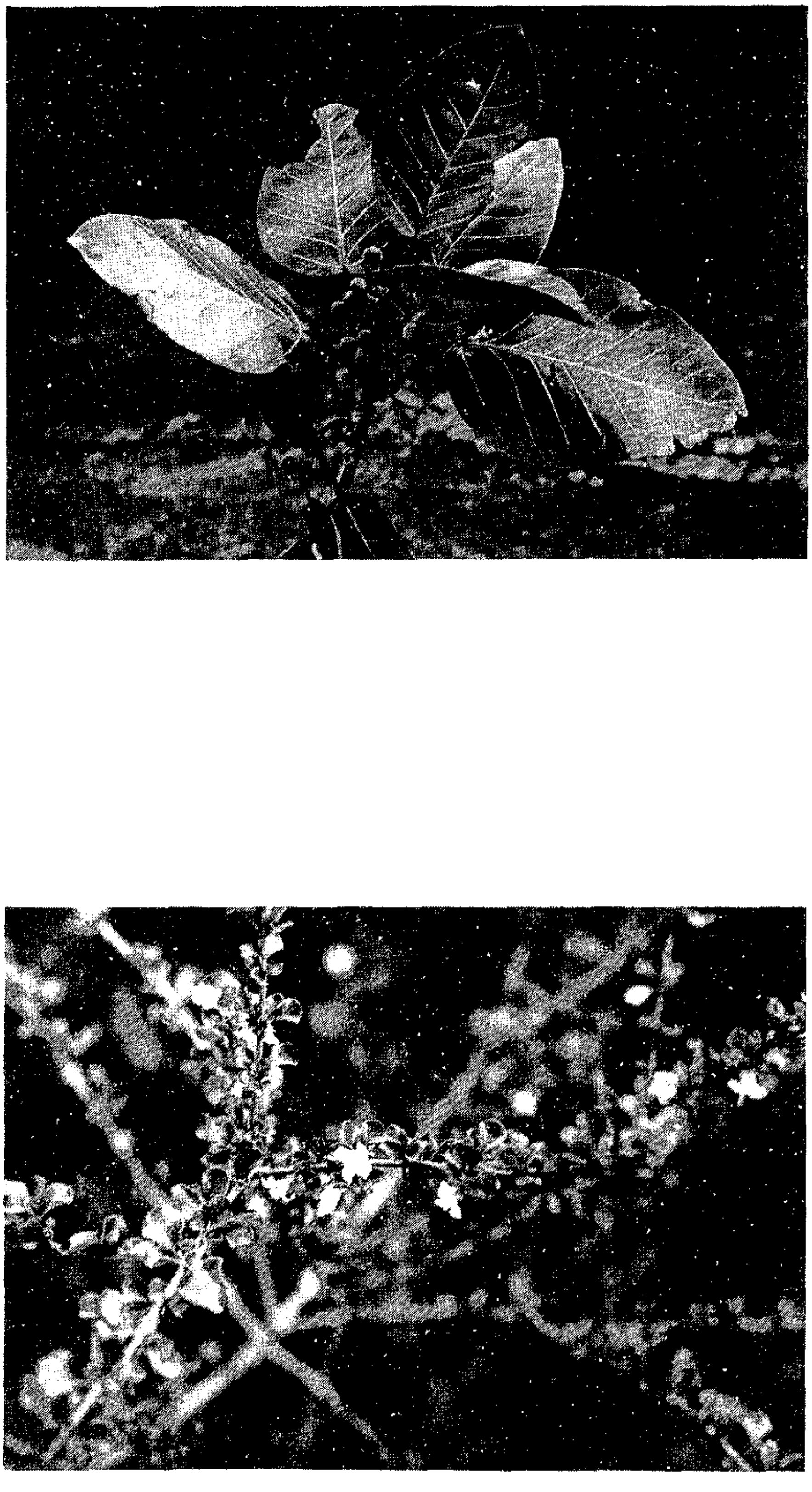


FIGURE 16. Illustration of (a) macrophyllous (*Ficus trichopoda*) and (b) nanophyllous (*Xeromphis rudis*) leaf sizes.

LEAF DECIDUOSITY

Purpose: To relate the ratio between deciduous and evergreen trees in a forest to the adaptive significance of deciduosity. Deciduosity may be related to length of dry season in tropical forests (Webb 1959; Dittus 1977; Whitmore 1978), or to periods when freezing conditions occur (Harder et al 1965; Veblen et al 1979), or to a greater availability of soil nutrients (Webb 1959, 1963, 1968; Van Daalen 1984).

Definition:

White (1983): A deciduous tree looses all its leaves simultaneously and usually remain bare for several weeks or months.

Problems: Requires too much ecological knowledge that is not observable in the field (Walker and Hopkins 1980).

A tree is deciduous if it simultaneously looses all its leaves each year and remain bare for several weeks or months. This attribute is recorded where evident by crown cover of canopy trees.

LEAF TEXTURE/CONSISTENCY

Purpose: To correlate the attribute with climatic regions and to soil nutrient status (Cowling and Campbell 1983).

Definitions:

Cowling and Campbell (1983):
Sclerophyllous leaves are hard, coriaceous and thick, and break when folded eg *Sideroxylon inerme* and are usually evergreen.
Orthophyllous leaves are soft, thin and pliant when folded eg *Ocotea bullata* and *Clutia pulchella*, which can be either deciduous or evergreen.

Grubb (1977): **Sclerophyllous** leaves are long-lived and possess relatively thick cuticles and wax cover and may be more resistant to nutrient loss than orthophyllous leaves.

Van Daalen (1984): **Sclerophyllous** leaves of forest trees have a specific mean mass of >140 gm^{-2}.

Problems: Cowling and Campbell (1983) definitions were based on 'feel', which by implication, is subjective.

Van Daalen's definition (1984) requires tedious measurement.

The use of this attribute is rejected due to the difficulty of recording it in the field.

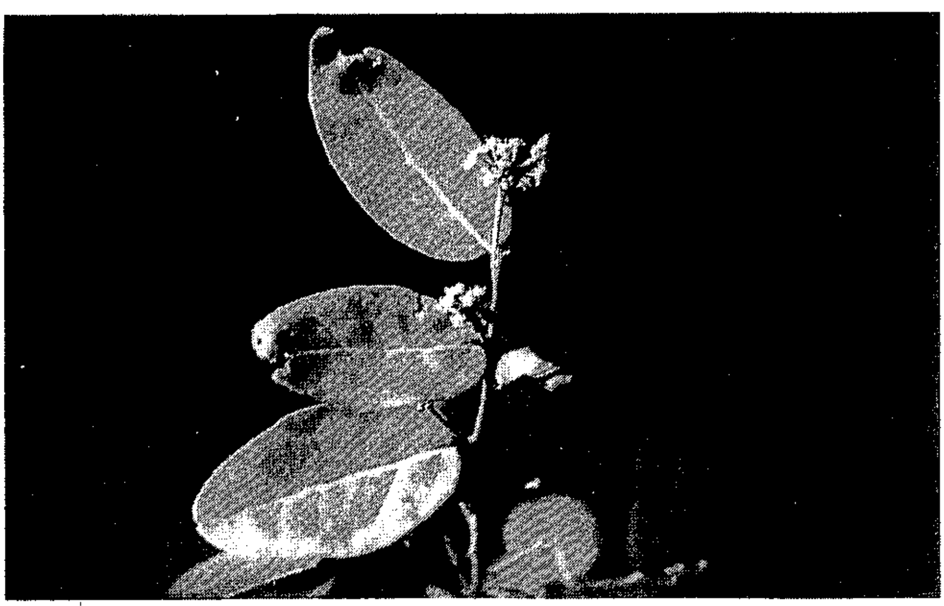


FIGURE 17. Leaf of *Cassine tetragona* displaying sclerophyllous texture.

TREE ARCHITECTURE

Purpose: To relate the vertical extension of tree crown foliage to the tree environment. The vertical distribution of foliage as affected by size, frequency, depth and nature of canopy breaks, may be an important attribute in dealing with disturbed or regenerating vegetation (Webb et al 1976).

Definition:

Webb et al (1976) (see Figure 18).
(1) foliage confined to the uppermost part of the tree,
(2) foliage covers the upper third of the tree,
(3) foliage covers the upper half of the tree,
(4) foliage covers more than the upper half of the tree,
(5) foliage comes near to the base of the tree.

Problems: The architecture of trees has been expressed directly and indirectly in a variety of ways (Halle and Oldeman 1975; Halle et al 1978; Tomlinson 1978, 1983).

> We use the categories of Webb et al (1976). Record the crown cover of canopy trees in each category.

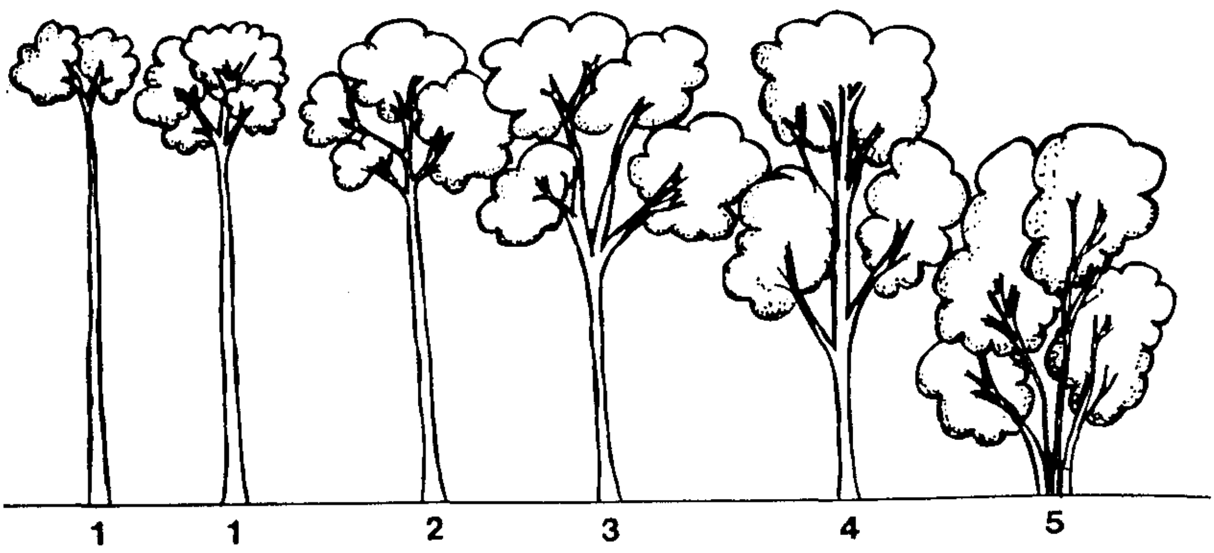


FIGURE 18. Architecture of trees (after Webb et al 1976): Foliage is confined to uppermost top of tree (1), or occurs down to a third (2), upper half (3), more than upper half (4), or to near the base (5).

TREE ARCHITECTURE

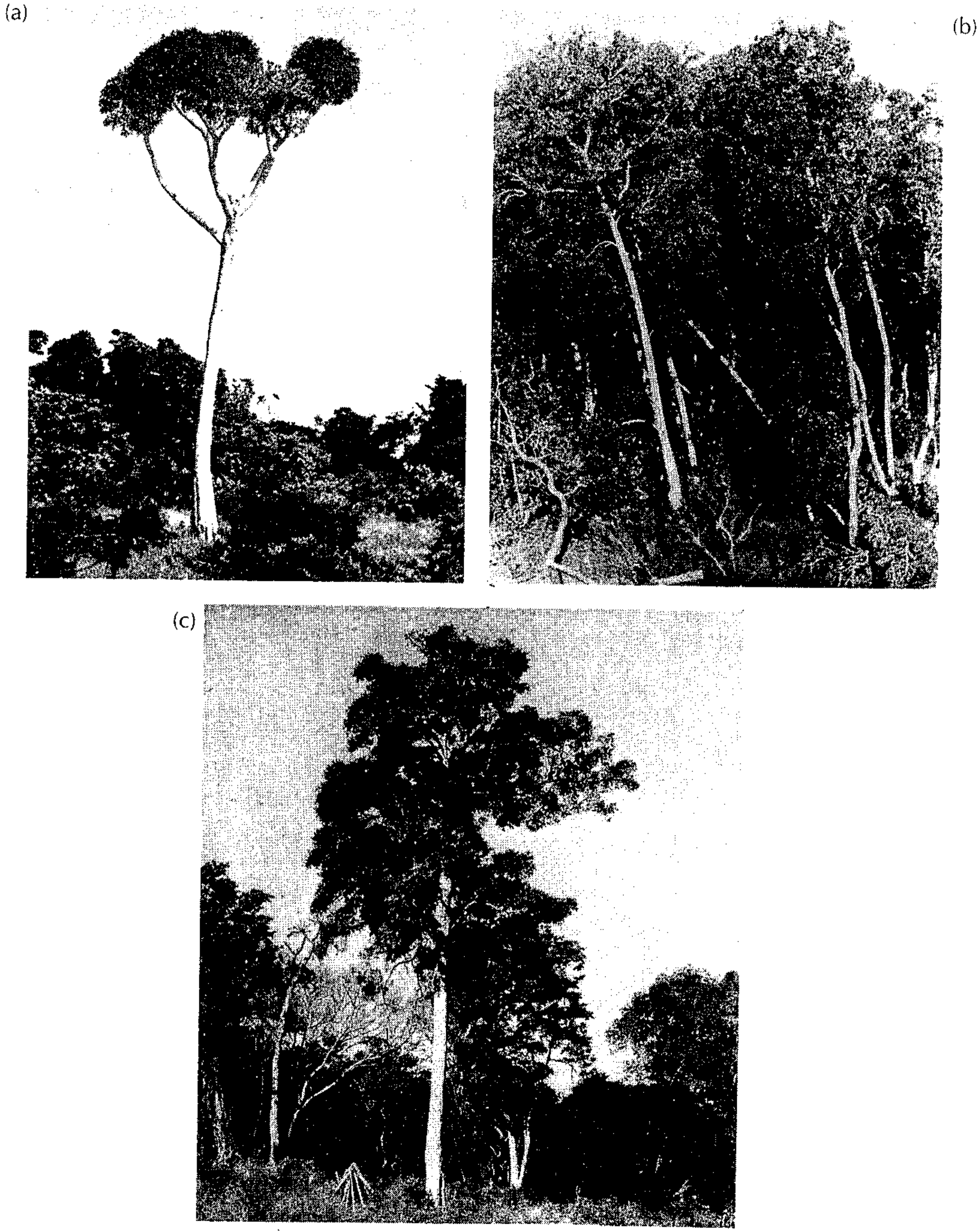


FIGURE 19. Illustration of (a) foliage confined to uppermost top of tree; (b) foliage confined to upper third of tree; (c) foliage confined to upper half of tree.

(d)

(e)

FIGURE 19. Illustration of (d) foliage covering more than the upper half of a tree; and (e) foliage reaching to near the base of the tree.

DOMINANTLY STRUCTURAL ATTRIBUTES

HEIGHT CLASSES

Purposes: To arbitrarily define the layers within each stratum (Longman and Jenik 1974) of vegetation as a basis for classification (as forest, woodland, shrubland or grassland) and structural description. Canopy height increases with increasing rainfall to a point where a maximum is reached, and may decline, possibly as a result of poor nutrient status (Longman and Jenik 1974; Hall and Swaine 1976).

Definitions:

Webb et al (1976 - after Fosberg 1967):

upper stratum = tallest trees with almost touching canopies.

mid stratum = below upper strata, greater than one metre in height. (Including trees, lianes, shrubs and ferns).

ground stratum = less than one metre in height. (Excludes trees, shrubs and lianes - but includes small tree seedlings, forbs, graminoids, ferns and bryophytes).

Longman and Jenik (1974):

upper tree layer (includes emergent trees, woody climbers and epiphytes).

middle tree layer (includes large trees, woody climbers).

lower tree layer (includes subcanopy trees and woody climbers).

shrub layer (includes tree seedlings, shrubs and small trees of one to five metres in height).

herb layer (includes all herbaceous plants).

Walker and Hopkins (1980):

Height m	Trees, Climbers	Shrubs	Ferns, Grasses, Sedges, Forbs
>35,0	Extremely tall		
20,1 -35,0	Very tall		
12,1 -20,0	Tall		
6,1 -12,0	Mid-high	Extremely tall	
3,1 - 6,0	Low	Very tall	Extremely tall
1,1 - 3,0	Dwarf (if <2 m)	Tall	Very tall
0,51- 1,0		Mid-high	Tall
0,26- 0,5		Low	Mid-high
≤0,25		Dwarf	Low

HEIGHT CLASSES

Edwards (1983):

	Trees	Shrubs	Grasses and Herbs
High	> 20 m	2-5 m	> 2 m
Tall	10-20 m	1-2 m	1-2 m
Short	5-10 m	0,5-1 m	0,5-1 m
Low	2- 5 m	<0,5 m	<0,5 m

Problem: Strata can only be arbitrarily defined (Longman and Jenik 1974; Webb et al 1976). Recognition of strata will vary depending on height and complexity of vegetation.

We do not recognize strata, but apply the following height classes (in m) during collection of field data: 0-0,25; 0,26-0,5; 0,51-1,0; 1-2; 2-3; 3-5; 5-7,5; 7,5-10; 10-15; 15-20; 20-25; 25-30; >30. For descriptive purposes we use the height categories of Edwards (1983). Estimate canopy height within the plot from the measurement of at least two canopy trees. Note the height range and dominant species of visible layers (if present) in the plot surroundings (see field sheet A).

EMERGENTS

Purpose: To record canopy characteristics of a particular type of forest. Trees above the canopy form a specific structure which may or may not reflect disturbance history.

Definition:

Walker and Hopkins (1980): Emergents are conspicuous trees above the canopy, with exposed crowns. Emergents should be at a density of five to 20 crown diameters apart (>20 crowns = isolated trees).

Problems: From below the canopy it is difficult to distinguish between emergent and isolated trees.

> We use the Walker and Hopkins (1980) definition.
> Record emergents by species and height.

FIGURE 20. Illustration of emergent trees in a forest.

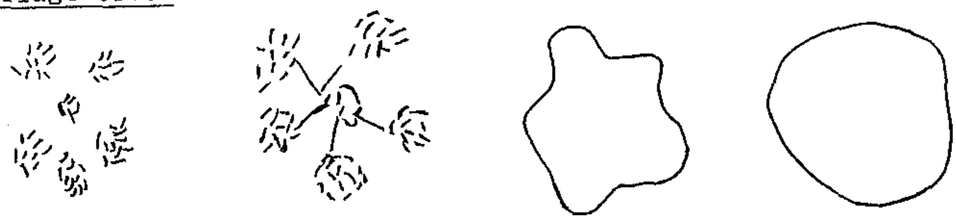
COVER TYPES

Purpose: To express the importance of those functional attributes in a forest which cannot be measured accurately.

Definition:

Walker and Hopkins (1980):

Projective foliage cover	Canopy cover	Crown cover	REALITY
Projected leaf area (after Specht et al 1974)	Projected leaf and branch area (after Carnaghan 1976)	Projected area within the crown perimeter	Approximation of crown cover



Problems: No satisfactory method is available for the first three types.

> We use the fourth category "REALITY" ie approximation of crown cover.

CROWN COVER CLASSES

Purpose: To simplify classes for structural description. Cover classes are the units of measurement.

Definitions:

Webb et al (1976):

Closed = overlapping or touching crowns of tallest trees.
Dense = where average space between crowns is less than average crown diameter.
Mid-dense = where average spacing is greater than one crown diameter.

CROWN COVER CLASSES

Walker and Hopkins (1980):

Dense = crowns overlapping.
Mid-dense = crowns touching or barely separated
Sparse = crowns slightly separated.
Very sparse = crowns well separated.
Isolated plants = tress >100 m apart, shrubs >25 m apart.
Isolated clumps = clump of two to five woody plants >200 m apart.

Edwards (1983):

Cover category		% Cover	Crown:Gap
Primary	Secondary		
Closed		11-100	0-2
	Continuous (Overlapping or nearly so)	76-100	<0,1
	Subcontinuous	51-75	0,1-0,3
	Moderately open	26-50	0,3-0,9
	Semi-open	11-25	0,9-2,0
Open		1-10	2,0-8,5
Sparse		0,1- 1	8,5-30
Scattered		<0,1	>30

Problems: The scales are not familiar to ecologists and managers who are conversant with Braun-Blanquet cover classes. We need to standardize a cover category which is appropriate for all growth forms.

Cover of vines and lianes is difficult to estimate since their foliage is mixed with that of the plants supporting them.

Use Braun-Blanquet (BB) cover classes for field estimates of crown cover as follows:

Symbol	% Crown cover	Cover on 400 m² plot
+	<1	<4
1	1- 5	4- 20
2	6-25	21-100
3	26-50	101-200
4	51-75	201-300
5	>75	301-400

See next section for epiphyte cover estimates.

EPIPHYTE COVER

Purpose: To estimate cover of micro- and macro-epiphytes (lichens, bryophytes, ferns and other plants including orchids) in forest microhabitats.

Problems: Estimates of cover/abundance due to small size of plants and the diversity of microhabitats (Figure 4) is difficult. Methods for estimates of cover/abundance are not standardized. Scott (1966) used point quadrats to sample and identify all species. Holdridge et al (1971) noted general, nonquantified impressions of abundance. It is also difficult to integrate epiphyte cover into narrowly-defined height classes throughout the plot. Maximum information can usually be gained by closely examining the lowest parts of the trunks (below three metres).

> Estimate epiphyte cover as percentage of substrate cover. Up to five metres height use the BB scale. Above five metres use cover classes of rare (one to five per cent), frequent (six to 25%) and abundant (>25%) for three zones, ie upper trunk, crown branches, and terminal twigs. The BB scale is retained on field sheet B as alternative (Appendix).

PROFILE DIAGRAMS

Purpose: To portray stand geometry, understorey crowding and forest characteristics such as crown position, size distribution of stems and conspicuous growth forms. It is a two dimensional illustration of forest structure on transects not exceeding 60 m X 10 m, and should be, but often is not, accompanied by a ground plan of the profile strip.

Applications:

Richards 1952, 1983; Robbins 1962; Anonymous 1978.
F von Breitenbach (personal communication) currently uses the method in description of Transvaal and Natal forests.

Problems: Methods are not standardized.

It is labour intensive.

Sampling is restricted to a small area relative to the variability occurring within a forest.

> The method is not considered practicable in the classification system, although it may be very important for specific studies.

FOLIAGE PROFILES

Purpose: To quantify spatial distribution of foliage. The foliage profile could be used to predict distribution and usage by fauna, in regeneration studies, and primary productivity. Generally vegetation density is taken as the reciprocal of the distance from the observer to a point at which 50% of a vertical plane is obscured by foliage. This is measured at different heights in the forest. The area under the profile at fractions of the total stand height is used as variables in multivariate analyses.

Applications:

Occurrence and distribution of birds (MacArthur and MacArthur 1961; MacArthur and Horn 1969; Yeaton and Cody 1974; Terborgh 1977; Cody 1978, 1983); of small mammals (Bond et al 1980; Breytenbach 1982); primate preferences (Guatior-Hion et al 1981); estimates of photosynthesis, transpiration or nutrient content within a forest canopy (Aber 1979a); and stand dynamics (De Moor et al 1977; Aber 1979b).

Problems: Methods are not standardized.

It is labour intensive (MacArthur and Horn 1969; Aber 1979a,b; De Moor et al 1977).

It is difficult to apply above three metres (Yeaton and Cody 1974; Terborgh 1977).

Density of lower layers of vegetation may be overemphasized. It is difficult to apply if large forest gaps or forest edges are encountered.

Methods used to estimate crown cover based on light readings or visual point quadrats should be avoided. They have limited application in layered vegetation due to blockage of line of sight (Walker and Hopkins 1980).

The following general method was considered.
Eight points were selected systematically on a line running from the lowest point on the plot boundary, through the plot midpoint to the highest point on the plot boundary. Starting at the lower point,vegetation density at all heights was estimated along the contour, alternatively to the left and to the right of the line. The method provides a reasonable estimate of the vertical distribution of foliage in the stand, and for calculation of standard error. However, the method was rejected on grounds of three sources of error, viz:-

- estimation of height
- estimation of horizontal distances at a particular height
- judgement when 50% of foliage obscures vertical plane.

We estimate foliage profiles from total BB value for each height class over all growth forms, excluding epiphytes (see field sheet B, Appendix). BB value (X-axis) is plotted against height class. The integration of growth form, height and crown cover provide a foliage profile for each particular structural type. This method is, however, more subjective than the general method, and does not allow for error estimates.

STRUCTURAL GROUPS

Purpose: To define the gross forest character.

Definition:

Edwards 1983: Forest and woodland have total tree cover >0,1% and shrub cover <10% if >1 m high. Forest has total tree cover of 75-100% and mean crown: gap ratio of 0-0,1 as mean crown diameters apart. Woodland has total tree cover of 0,1-75% and mean crown: gap ratio of 0,1-30. Thicket has total tree cover of 10-100% and shrub cover >10% and >1 m high.

High forest = canopy trees >20 m; Tall forest = canopy trees 10-20 m; Short forest = canopy trees 5-10 m; Low forest = canopy trees 2-5 m.

Problems: System includes d = mean crown to gap ratio, which was not considered appropriate for use with all life forms. We need to standardize a cover category which is appropriate for all growth forms.

The shrub cover definition is not appropriate for all forest types.

We use Edwards (1983) system for forest, woodland and thicket until a better system has been developed.

STEM DIAMETER AT BREAST HEIGHT (DBH)

Purpose: To relate diameter range of a forest to environmental factors. DBH class distribution may be used to predict gross volume of timber (Anonymous 1978), to predict age structure and state of forest (Odum 1971; Lorimer 1980); as an indicator of natural and man-induced disturbance history (Lorimer 1980); and may be related to the environment (Anonymous 1978). Webb et al (1976) used the ratio of small to large stems as index of forest complexity. DBH is the easiest tree measurement.

The strategy of trees to develop multiple stems in the absence of injury is important where seed production is spasmodic or inadequate or where seedlings are either competitively inferior or subject to high mortality (see Johnson and Lacey 1983).

Problems: Measurement is labour intensive.

Estimation is unreliable.

Analyses of diameter distribution in regression and multivariate studies present many difficulties eg are mathematical fits of diameter distributions biologically meaningful when a high degree of variability of tree numbers within various classes has been found (Anonymous 1978)?

> Actual diameter at breast height (1,3 m) is recorded by species for stems >99 mm DBH. Stems 10 to 99 mm DBH for trees, shrubs, lianes and tree ferns are counted by species. For multistemmed trees each stem >99 mm DBH is measured, and recorded as belonging to the same tree. For quick surveys where species are not required, tally diameters on field sheet B (Appendix). For buttressed trees or coppice stems on old stumps, measure diameter 0,5 m above buttress or old stump.

FIGURE 21. Difficulty of measuring DBH of buttressed trees.

CONCLUSIONS

This report has achieved the first aim of the workshops held on the topic, namely: to examine attributes and techniques used in existing classifications of forest vegetation. This report represents the first synthesis on the use of structural and functional attributes and field techniques in forest vegetation.

The companion report - Geldenhuys, Knight and Jarman (1987), has achieved the second aim of the workshop, namely: to identify and define structural and functional attributes that are to be used for characterization of southern African forests. Field sheets (Appendix) are used to record functional and structural attributes on plots of 400 m² in stands of homogeneous forest vegetation.

The third aim, namely to produce standardized descriptions of southern African indigenous forest vegetation, based on structural and functional attributes, is being undertaken in a current project funded with the Forest Biome Project. Forest researchers are encouraged to participate in the project by contacting the authors.

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FOREST BIOME PROJECT STRUCTURAL CLASSIFICATION FIELD SHEET A

RECORDER(S) ....

RELEVE NO |_|_|_|_| GRID REFERENCE |_|_|_|_|_|_|_|_| DATE |_|_|_|_|_|_|

ASPECT ° |_|_|_| SLOPE ° |_|_| ALTITUDE m |_|_|_|_| GEOLOGY |_|_|_|_|

SOIL SERIES |_|_|_|_| SOIL DEPTH |_|_|_|_| GEOMORPHOLOGICAL UNIT (diagram)

FOREST SIZE ha |_|_|_|_| DISTURBANCE |_| macro |_| micro |_|

CANOPY HEIGHT m |_|_;_| EMERGENTS m |_|_;_|

FOREST FLOOR COVER (%) SOIL |_|_|_| ROCK |_|_|_| WOOD |_|_|_|

NEAREST METEOROLOGICAL STATION

Mean annual rainfall mm From: To: |_|_|_|_|

Mean monthly rainfall mm From: To:

J	F	M	A	M	J	J	A	S	O	N	D

Mean monthly temperature °C From: To:

	J	F	M	A	M	J	J	A	S	O	N	D
Maximum												
Abs max												
Minimum												
Abs min												

NOTES

STRATUM	HEIGHT RANGE m	DOMINANT SPECIES
Canopy	to	
Sub canopy 1	to	
Sub canopy 2	to	
Sub canopy 3	to	
Shrub 1	to	
Shrub 2	to	
Herb 1	to	
Herb 2	to	

....
....
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....
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APPENDIX 1

STRUCTURAL CLASSIFICATION FIELD SHEETS

NATIONAL PROGRAMME FOR ECOSYSTEM RESEARCH : TERRESTRIAL ECOSYSTEMS SECTION
FOREST BIOME PROJECT STRUCTURAL CLASSIFICATION FIELD SHEET B

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Scales:

BB cover per cent	+=<1 3=26-50	1= 1- 5 4=51-75	2= 6- 25 5=76-100

Epiphyte descriptor % of stem covered	r=rare <1-5	f=frequent 6-25	a=abundant 26-100

GROWTH FORMS (Crown cover)

Height classes m	0-0,25	0,26-0,50	0,5-1	1-2	2-3	3-5	5-7,5	7,5-10,0	10-15	15-20	20-25	25-30	>30
WOODY PLANTS													
Trees						+12345	+12345	+12345	+12345	+12345	+12345	+12345	+12345
Shrubs	+12345	+12345	+12345	+12345	+12345	+12345							
Lianes >10 mm DBH				+12345	+12345	+12345	+12345	+12345	+12345	+12345	+12345	+12345	+12345
HALF WOODY SHRUBS	+12345	+12345	+12345	+12345	+12345	+12345							
HERBS													
Vines <10 mm DBH	+12345	+12345	+12345	+12345	+12345	+12345							
Graminoids	+12345	+12345	+12345	+12345									
Geophytes	+12345	+12345	+12345	+12345									
Forbs	+12345	+12345	+12345	+12345									
Ferns	+12345	+12345	+12345	+12345	+12345	+12345							
Bryophytes	+12345												
Lichens	+12345												
TOTAL: WOODY & HERBS	+12345	+12345	+12345	+12345	+12345	+12345	+12345	+12345	+12345	+12345	+12345	+12345	+12345

EPIPHYTES (Cover of stems)

Height m	0-0,25	0,26-	0,5-1	1-2	2-3	3-5	upper trunks	crown branches	terminal twigs
Lichens	+12345	+12345	+12345	+12345	+12345	+12345	rfa(+12345)	rfa(+12345)	rfa(+12345)
Bryophytes	+12345	+12345	+12345	+12345	+12345	+12345	rfa(+12345)	rfa(+12345)	rfa(+12345)
Ferns	+12345	+12345	+12345	+12345	+12345	+12345	rfa(+12345)	rfa(+12345)	rfa(+12345)
Other	+12345	+12345	+12345	+12345	+12345	+12345	rfa(+12345)	rfa(+12345)	rfa(+12345)
TOTAL EPIPHYTES	+12345	+12345	+12345	+12345	+12345	+12345	rfa(+12345)	rfa(+12345)	rfa(+12345)

DIAMETER DISTRIBUTION

DBH (mm) **WOODY STEMS** including lianes	Number
10- 99	
100-199	
200-299	
300-399	
400-499	
500-599	
600-699	
700-799	
800-899	
900-999	
>1000	
Total	

SPECIAL FEATURES

COMPOUND LEAVES	
Trees	+12345
Shrubs	+12345

SIMPLE LEAVES	
Trees	+12345
Shrubs	+12345

LEAF SIZE see diagram		Canopy Trees	Shrubs
Nano	1	+12345	+12345
Micro	2	+12345	+12345
Noto	3	+12345	+12345
Meso	4	+12345	+12345
Macro	5	+12345	+12345

DECIDUOUSNESS of canopy trees	+12345

GROUND LAYER SUBSTRATE COVER	Rock	Wood
Bryophytes	+12345	+12345
Lichens	+12345	+12345
Ferns	+12345	+12345

ARCHITECTURE of canopy trees	
Foliage uppermost top of tree	+12345
Foliage down to upper third	+12345
Foliage down to upper half	+12345
Foliage more than upper half	+12345
Foliage down to near tree base	+12345

BARK TYPE of canopy trees to 3m above buttress	Smooth	Blocky	Fissured	Flaky
Fine	+12345	+12345	+12345	+12345
Rough	+12345	+12345	+12345	+12345

BUTTRESS TYPES of canopy trees	
Normal	+12345
Star	+12345
Plank	+12345
Stilt	+12345

SPINES below 3 m	
Trees	+12345
Shrubs	+12345
Lianes	+12345

NO OF SPECIES	
Trees	
Shrubs	
Herbs	
Lianes/ Vines	
TOTAL	

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Diameter at breast height (DBH) and height for woody species =>100 mm DBH, and count for stems 10-99 mm DBH. Record dead trees. Record separate measurements of multi-stemmed trees, but count as one plant.

No.	Species	DBH mm	Ht m	No 10-99	No.	Species	DBH mm	Ht m	No 10-99
1					22				
2					23				
3					24				
4					25				
5					26				
6					27				
7					28				
8					29				
9					30				
10					31				
11					32				
12					33				
13					34				
14					35				
15					36				
16					37				
17					38				
18					39				
19					40				
20					41				
21					42				

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FOREST BIOME PROJECT STRUCTURAL CLASSIFICATION FIELD SHEET D

RELEVE NO __________ DATE ______________ RECORDER ____________________

BB cover values for understorey plants <10 mm DBH, and epiphytes.

Species	BB	Species	BB	Species	BB
Trees (=> 0,25 m height)					
Shrubs (including half woody shrubs)					
Vines					
Graminoids					
Geophytes					
Ferns					
Other herbs					
Epiphytes					

No.	Species	DBH mm	Ht m	No 10-99	No.	Species	DBH mm	Ht m	No 10-99
43					68				
44					69				
45					70				
46					71				
47					72				
48					73				
49					74				
50					75				
51					76				
52					77				
53					78				
54					79				
55					80				
56					81				
57					82				
58					83				
59					84				
60					85				
61					86				
62					87				
63					88				
64					89				
65					90				
66					91				
67					92				

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