LANDSCAPE-ECOLOGY OF UJUNG KULON (WEST JAVA, INDONESIA)

Patrick W.F.M. Hommel

Promotor: dr.ir. I.S. Zonneveld
Buitengewoon hoogleraar in de vegetatiekundige overzichtskaartering

Co-promotor: dr. M.M.J. van Balgooy
Botanicus, Rijksherbarium, Leiden.

STELLINGEN

1. Actief ingrijpen in de natuurlijke vegetatieontwikkeling in Ujung Kulon met als doel de beschikbaarheid van voedselplanten voor de Javaanse neushoorn te verhogen is op dit moment niet nodig en strijdig met andere natuurbehoudsdoelstellingen.
   Ref.: Schenkel, R., L. Schenkel-Hulliger & W.S. Ramono, 1978. Area management for the Javan rhinoceros (Rhinoceros sondaicus Desm.). A pilot study. The Malayan Nature Journal XXXI (4), p. 253-275.

2. Gebrek aan landschappelijk inzicht heeft in Ujung Kulon geleid tot onderschatting van de waarde van het binnenland als neushoornhabitat en waarschijnlijk ook van de grootte van de neushoornpopulatie.
   Ref.: Ammann, H., 1985. Contributions to the ecology and sociology of the Javan rhinoceros (Rhinoceros sondaicus Desm.). Diss.; Basle. p. 38-51.

3. De ontvolking van Java's westpunt is in belangrijker mate het gevolg van de asregens die het gebied ten tijde van de Krakatau uitbarsting hebben bedolven, dan van de tsunamis (door de uitbarsting veroorzaakte vloedgolven).
   Ref.: Hoogerwerf, A., 1970. Udjung Kulon, the land of the last Javan rhinoceros. Brill; Leiden. p. 10-11.

4. Mueller-Dombois en Ellenberg stellen ten onrechte dat de indeling van plantensoorten in levensvormen, zoals gedefinieerd door Raunkiaer, zonder meer toepasbaar is in de tropen.
   Ref.: Mueller-Dombois, D. & H. Ellenberg, 1974. Aims and methods of vegetation ecology. Wiley; New York. p. 142-145.

5. De verschillende indelingen voor het klimaat van Indonesië houden onvoldoende rekening met de ecologische betekenis van het incidenteel optreden van zeer droge jaren.
   Ref.: Voor een opsomming van deze indelingen, zie dit proefschrift, p. 32-35.

6. De afwezigheid van vulkanische as in het bodemprofiel van grote delen van de noordelijke kuststrook van Ujung Kulon vormt een aanwijzing dat de asregens in 1883 grotendeels voorafgingen aan de tsunamis.

7. Een vergelijking van de met de hoogte boven zeeniveau samenhangende zonering van de flora van Ujung Kulon met de gegevens voor het vasteland van Java toont aan, dat het telescoopeffect niet alleen de physiognomie van de vegetatie, maar ook de floristische samenstelling van een gebied beïnvloedt.
   Ref.: Steenis, C.G.G.J. van, 1962. The mountain flora of the Malaysian tropics. Endeavour XXI (83-84), p. 183-193.

8. De vaak geuite en door van Steenis helder geformuleerde bezwaren tegen het in tropische bossen toepassen van de Braun-Blanquet methode van vegetatieclassificatie zijn grotendeels onjuist.
Ref.: Steenis, C.G.G.J. van, 1958. Basic principles of rain forest sociology. In: Proceedings of the Symposium on the study of tropical vegetation. Kandy, Ceylon (Sri Lanka) (1956). p. 159-165.

9. De met de hoogte boven zeeniveau samenhangende florazonering van Java zoals beschreven door van Steenis, berust waarschijnlijk meer op de neiging van veel floristen om de hoogte zeer globaal te schatten dan op de werkelijke toestand.
Ref.: Steenis, C.G.G.J. van, 1965. Concise plant-geography of Java. p. 48-51. In: Backer, C.A. & R.C. Bakhuizen van den Brink Jr. Flora of Java, vol. II. Noordhoff, Wolters; Groningen.

10. De moderne ontwikkelingen in het landschap overziende, mag worden gesteld dat Lörzing's opmerking over de invloed van de in het beleid gehanteerde doelstelling "behoud dan wel versterking van natuurwetenschappelijke, landschappelijke en cultuurhistorische identiteit" geen hout snijdt.
Ref.: Lörzing, H., 1982. De angst voor het nieuwe landschap. Staatsuitgeverij; 's Gravenhage. p. 34.

11. De computermatige verwerking van vegetatieopnamen tot een classificatie is niet zozeer meer objectief dan het ouderwetse handwerk, maar verhult het (overigens zeer nuttige) subjectieve element.

12. Hoewel de landschapsecologie pretendeert zo volledig mogelijk geïntegreerd landschapsonderzoek te bedrijven, wordt in de praktijk van het onderzoek en ook binnen de Werkgemeenschap Landschapsecologisch Onderzoek te weinig aandacht besteed aan de historisch-landschappelijke invalshoek.

13. Op ten behoeve van het natuurbeheer vervaardigde vegetatie- en bodemkaarten zijn, ongeacht de schaal, naar patroon en samenstelling goed beschreven vegetatiecomplexen, respectievelijk bodemassociaties veelal van meer waarde dan sterk gegeneraliseerde, enkelvoudige eenheden.

14. De waarde van de modelmatige benadering van ecosystemen is eerder het nauwkeurig afbakenen van hiaten in kennis dan het opvullen van dergelijke hiaten. Eenzijdige aandacht voor een modelmatige benadering leidt daarom op korte termijn tot stagnatie in de wetenschap, op langere termijn tot het verdwijnen van kennis.

behorende bij: Patrick W.F.M. Hommel. Landscape-ecology of Ujung Kulon (West Java, Indonesia).

Patrick W.F.M. Hommel

LANDSCAPE-ECOLOGY OF UJUNG KULON (WEST JAVA, INDONESIA)

Proefschrift
ter verkrijging van de graad van
doctor in de landbouwwetenschappen,
op gezag van de rector magnificus,

dr. C.C. Oosterlee,

in het openbaar te verdedigen
op vrijdag 12 juni 1987
des namiddags te vier uur in de aula
van de Landbouwuniversiteit te Wageningen.

ABSTRACT

Hommel, Patrick W.F.M., 1987. Landscape-ecology of Ujung Kulon (West Java, Indonesia); 206 pages, 29 tables, 11 figures, 155 references, 6 appendices; English and Indonesian summaries; privately published doctoral thesis, Wageningen.

This study deals with the Ujung Kulon peninsula, situated on the westernmost tip of the island of Java (Indonesia). Descriptions are given of the area's history, climate, geology, gemorphology, soils, flora, vegetation and fauna. For three of these land-attributes, viz. geomorphology (landform), soils and vegetation, classification systems are presented. The classification of vegetation types is based on their complete floristic composition and carried out by tabular comparison of plot-data. Relations between all land-attributes are studied, resulting in the description of landscape units that are shown on a landscape-ecology map (scale 1 : 75 000). Special attention is paid to the impact of the 1883 Krakatau eruption on soils and vegetation, the orographic vegetation zones as determined by the so-called 'telescope-effect' and the availability of foodplants for the Javan rhinoceros.

Privately published by:
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1987.

to my parents

in memory of
dr. marius jacobs

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Furthermore, I am very grateful to my promoter, Prof.Dr.Ir. I.S. Zonneveld, who taught me the principles of landscape science, visited me in the field in 1982 and whose many suggestions and continuous enthousiasm were a great stimulus to me. Likewise, I would like to thank my co-promotor, Dr. M.M.J. van Balgooy, who generously agreed to replace Dr. Jacobs in supervising the taxonomic and plantgeographical part of the study. He did so in a very accurate and friendly way. Moreover, his profound knowledge of the nature in Indonesia has in many ways contributed to the value of this study.

The co-author of the chapter on soils, Ir. H. van Reuler (Agricultural University, Wageningen; formerly UNESCO, Jakarta) supervised the pedological part of the study. He joined me on three fieldtrips and spent countless hours interpreting the many hundreds of collected soil samples. I am most grateful to him for his patience, his encouragements and for the many discussions we had, from which, in fact, many of the views, expressed in this booklet, originated. Moreover, I want to thank Henk and Peggy van Reuler for their cordial hospitality, both in Bogor and in Wageningen.

Here to be mentioned are also my jungle companions who made my stay in Ujung Kulon a marvellous and unforgettable one. Sincere thanks go to all PPA guards who accompanied me into the forest, especially my regular companion Bpk. Sarpan, whose inexhaustible energy and continuous high spirits contributed in many ways to the success of the survey. I also would like to thank my counterpart (student-assistant) Benny Hedianto (Universitas Nasional, Jakarta) and my good friends and colleagues of the WWF rhino-research project: Haerudin R. Sajudin, Benny Djaja and Sukianto Lusli.

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CHAPTER 1: INTRODUCTION

1.1 Ujung Kulon

This study deals with the Ujung Kulon peninsula and adjacent areas, situated on the utmost western tip of the island of Java (Indonesia). The area has been a Nature Reserve since 1921 and has been included in the National Park of the same name since 1980.

Fame and importance of Ujung Kulon as a conservation area are in the first place due to its population of Javan rhinoceros, which is probably the last remaining one in the world. The area is, however, also known for the occurrence of other valuable, rare species such as banteng, Javan deer, leopard, wild dog, Javan gibbon and until recently Javan tiger, as well as for its scenic beauty.

As early as 1854, the famous naturalist Junghuhn drew attention to the superb nature of this out-of-the-way corner of Java. In the thirties of this century Ujung Kulon became the favourite reserve of A. Hoogerwerf, the godfather of conservation in the Indonesian archipelago, who was later to write a fascinating monograph on the area (1970).

During the past two decades, the World Wildlife Fund has been involved in both management and research in Ujung Kulon. The first grant was made in 1965 for the purchase of equipment, and in 1967 Prof.Dr. R.Schenkel started his research on the ecology and behaviour of the Javan rhino. An almost continuous series of WWF sponsored researchers have worked in Ujung Kulon ever since, mainly focussing on the most important animal species of the area.

In 1977, Blower and van der Zon considered Ujung Kulon to be 'the most widely known conservation area in South East Asia'. In the past few years, especially since the area changed status from Nature Reserve to National Park, the number of visitors, scientists as well as tourists, has increased again.

1.2 Research objectives

Considering all interest in the area, one might assume that Ujung Kulon is a scientifically very well known area. The truth is, however, quite different. As Schenkel and Schenkel-Hulliger (1969) point out, a systematic study of the area's vegetation cover was never made. Other ecologically important aspects of the landscape (e.g. soils) were also still very poorly understood. This holds even for something as basic as topography.

These lacunae in knowledge can be explained by the fact that Ujung Kulon with its superb wildlife, but predominantly secondary vegetation was likely to attract zoölogists rather than botanists. Moreover, the very inaccessible and unsurveyable character of some of the area's vast thorny shrub-vegetations, combined with the fact that aerial photographs of a reasonable quality were lacking until very recently, made it extremely difficult to get an overall picture. Of course, these phenomena implied a most serious handicap to all management and conservation orientated research (Hommel, 1982).

The first and major objective of our study was therefore to fill in some of these gaps in knowledge, especially concerning the area's major vegetation types and their distribution.

A second objective was to give a broad estimate of the suitability as a rhino-habitat for the various sub-regions within the area. Moreover, information was to be gathered on possible vegetation changes, which might affect the availability of rhino food negatively and on that account require active vegetation management on behalf of the growing rhino population.

The possibility of such vegetation changes was put forward by Schenkel (1982). The results of a pilot-study on active vegetation management were published by the same author (et al.) in 1978.

1.3 Methods

As for methods, we have opted for a broad landscape-ecological approach, as described by Zonneveld (e.g. 1979). Thus, our study was aimed primarily at the landscape as a fully integrated entity, in which vegetation is but one of the ingredients, though (within the scope of this study) the most important one. In this case, a landscape-orientated approach will be seen to have several advantages:

- It results in the description of so-called landscape-units, which can be interpreted in terms of suitability as rhino-habitat (based on the qualities of the total ecosystem) and for which broad vegetation changes can be described or predicted.
- It will provide a framework for more thorough studies on aspects of the landscape, other than vegetation, such as geology, geomorphology and soils.
- Moreover, it is a very practical approach (in comparison to a pure vegetation survey) for the compilation of a map in an area of which no reliable topographical map is available and where orientation is extremely difficult.

For a more detailed discussion of the methods used we can refer to Chapter 2.

1.4 Course of the study

The fieldwork for this study was done in the period from May 1981 to February 1983, with only some minor interruptions.

Fieldwork was executed by one expatriate researcher (i.e. the present author) and a student-assistant from Universitas Nasional in Jakarta, both biologists. We were happy to work in close cooperation with both the staff of the Indonesian Directorate for Nature Conservation (PPA) and the WWF sponsored rhino-research team under the leadership of Haerudin Sajudin.

The preliminary results of the survey, including a landscape-ecological map, were published as a WWF report (Hommel, 1983). In fact, the present study is mainly an elaboration of that report.

The fieldwork was fully sponsored by the World Wildlife Fund, an organization with, as stated above, a longstanding tradition of sponsoring conservation-orientated research in Ujung Kulon. The elaboration of the preliminary results which lead to the present publication was made possible by a grant from the Agricultural University in Wageningen.

CHAPTER 2: METHODS

2.1 Introduction

The methods used for our survey are derived from Zonneveld (1979). As for the vegetation part of the survey, a more detailed description of methods can be found in van Gils and Zonneveld (1982). See also Zonneveld (in prep.).

Main characteristics of the approach are:

- the emphasis on the use of aerial photographs;
- using aerial photographs before the actual fieldwork, thus providing a base for the sample strategy;
- its 'holistic' nature, i.e. the environment is considered to be a fully integrated (holistic) entity, that can and should be studied as a whole.

The use of aerial photographs is, in fact, the core of most landscape-ecological research. Ordinary black-and-white imagery is to be preferred. The scale should be at least as large as the eventual map, if possible larger. The photographs should be overlapping at least 50 per cent (preferably more) within each flightline to allow three-dimensional viewing (stereoscopy). For more details on the handling of aerial photographs, see also Avery (1978).

Not all literature cited may be generally available in Indonesia. Even so, other researchers there, dealing with similar projects may be interested in the methods used in our survey. The next section (2.2) gives therefore a rather detailed outline of the procedure followed.

Since our study focusses strongly on the vegetation aspect, it seems justified to pay special attention to some methodological facets of the vegetation survey. We shall do so in section 2.3.

Some more practical aspects of the fieldwork will be discussed briefly in the next chapter in relation to the specific terrain characters of the study area.

2.2 Description of the survey procedure in steps

The following description is (only slightly modified) derived from Zonneveld (1979). To the general paraphrase of each step a few annotations are added, dealing more specifically with the present study.

a. Study of reference material such as literature, topographical maps, herbarium collections, existing vegetation and soil maps, etc. This study is continued throughout the survey.

References to the most important literature on the area and the existing maps are given in the other chapters, dealing with specific aspects of the area's landscape. Three bibliographies which are a most useful expedient for any student of the area are Anonymous (1969 and 1974) and a very elaborate list of references by Hoogerwerf (1970).

As for the preparatory study of the area's flora, the author was introduced to the flora of West Java by the late Dr. M. Jacobs in the Rijksherbarium in Leiden and by Prof. Dr.A. Kostermans on Peucang Island. There a transect of already identified and labelled trees and an herbarium collection of Peucang plants (generously placed at our disposal by Dr. K. Kartawinata) also proved to be a very useful expedient for our studies.

b. A first glance at the aerial photographs in order to establish a rough subdivision of the area into major units, to become familiar with the photo-features and to compile a preliminary photo-interpretation legend.

For our survey we had two sets of aerial photographs at our disposal: one set of poor quality, dating from 1946 on a scale 1 : 50 000 and one set of reasonable to good quality, dating from 1981/1982 on a scale 1 : 75 000 (enlargements: 1 : 37 500).

Since no aerial photographs were available in time, this step had to be postponed until after the preliminary field inspection (c; see also step i).

As for the first subdivision of the area into major units, the study by Verstappen (1956) proved to be a very useful expedient (see also chapter 6).

c. Preliminary field inspection in order to become acquainted with the main landscape features. Some samples may be taken of the most characteristic plant species, soil types, rock outcrops etc., but no detailed site descriptions (such as plots for vegetation analysis) or long excursions should be made.

This stage of our study was greatly facilitated by the valuable aid received from the WWF rhino-research team (Sajudin et al.) which, at that time was active in Ujung Kulon.

d. Preliminary photo-interpretation. This implies the study of photo-features, linking them to land-features and delineating areas with relevant similarities in photo/land-features. This step results in a preliminary 'photo-interpretation map', with a legend, which is defined in terms of photo-features with a more or less hypothetical relation to land-features.

Photo-features include tone, texture, shape, spatial pattern, location and, if more than one set of photographs is available, temporal changes (van Gils & Zonneveld, 1982). Selection of relevant photo-features and linking them to land-features is facilitated by the field-experience gathered during step c. Drawing of the photo-interpretation map starts with the delineation of the main landforms, subsequently adding the major vegetation and (former) land-use boundaries.

e. Tracing and colouring of the preliminary map

f. Fieldwork

Fieldwork implies 'sampling', i.e. the description of the various aspects of the landscape, such as soil and vegetation (synonymous with 'land-attributes'; Zonneveld, 1979)* from a number of carefully chosen spots (see below). On these sample points, the landscape-aspects should be described simultaneously in order to facilitate later correlations.

The number of sample points depends on several factors such as internal variation of the area, time and funds and (most of all) the quality (i.e. the definitive character) of the preliminary photo-interpretation.

In our case, where relatively good quality imagery became available only at a late stage, and where the relevant differences in photo-features in many cases proved to be very subtle, we decided to describe a rather large number of sample points (more than 300). All these points are listed in Appendix A.

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* The vertical components of the land(scape) e.g. rock, atmosphere, landform, soil, vegetation etc. are called: attributes, the horizontal components: land-elements (Zonneveld, in prep.).

Their exact location, some important site characteristics and the classification of both soil and vegetation are added.

As for the distribution of sample points there are various possibilities, such as random, systematical, stratified and preferential sampling strategies. Purely random and systematical strategies have a clear disadvantage in giving too much prominence to relatively large map units. Moreover, a large proportion of transitional situations may be sampled which, later on, will thwart the classification of data and consume large amounts of time and effort.

For our survey, we used generally a stratified sampling strategy, i.e. in every photo-interpretation legend unit a more or less equal number of sample points was planned. Units of high internal complexity did, however, require a higher density of sample points ('preferential sampling'). Moreover, the sample points were theoretically random within the units, but clustered along expected gradients in order to save time.

The attributes of the landscape described in the field were vegetation, soil, geomorphology (landform) and geology (lithology only), each requiring its own approach. As for vegetation, a small patch of overgrowth (a 'plot') was described at each sample point. In contrast to more quantitative methods of vegetation analysis (see: Mueller-Dombois & Ellenberg, 1974), both size and shape of the plot are considered to be of minor importance. It is, however, essential to select a plot that is a strictly homogeneous example of the vegetation type studied (as far as physiognomy is concerned) and is large enough to contain a reasonable reflection of its floristic composition. Guidelines for plot sizes are given in table 2a.

Table 2a. Guidelines for sizes of plots for vegetation analysis (modified after: van Gils and Zonneveld, 1982).

Short to medium-tall grass and forb* land:	4 m^2
Tall grass and forb land:	25 m^2
Shrubland:	25-50 m^2
Woodland and forest:	250-1000 m^2

* forbs are herbs other than grasses and pseudo-grasses.

Within each plot floristic compostion and structure were described systematically. Height and cover of the various strata were estimated to describe structure. As for the floristics, density or cover of the species were estimated on a 14 point scale (table 2b). Unknown species were collected. Non-systematic data were collected on density of seedlings and saplings and on tree trunk diameters.

Table 2b. Cover/density classes for vegetation analysis (after van Gils and Zonneveld, 1982)

r = rare, cover less than 5%
p = few, cover less than 5%
a = abundant, cover less than 5%
m = many, cover less than 5%
01 = cover about 10%, density irrelevant
02 = cover about 20%, density irrelevant
03 = cover about 30%, density irrelevant
04 = cover about 40%, density irrelevant
etcetera

For practical reasons (e.g. to allow future computer processing), the 14 point field-scale was later reduced to a 9 point scale (see Appendix E).

For a more detailed discussion of some theoretical aspects of the study of the vegetation we can refer to section 2.3.1.

As for the study of soil, texture and colour of the various horizons, as well as soil depth (if perceptible) were described systematically. Non-systematic data were recorded on pH, structure and erosional features. All these data were collected by augering; from each horizon a small sample was taken. Only in the final stage of the survey were a number of pits on carefully selected sites described in order to study the various types of soil in more detail. The preliminary classification of the soil (based on these collected samples and augerhole descriptions), leading to the selection of these sites and the actual description of the pits, were performed by H. van Reuler, at that time soil-scientist of the UNESCO Man-And-Biosphere project in Bogor (Indonesia).

As for geomorphology (s.l.), a field indication of the landform was given, together with some general site-characteristics, such as altitude, slope (type) and relief type of the surrounding landscape.

As for geology (lithology), rock samples were taken as much as possible on or near the observation points.

g. A study of correlations between the various landscape aspects.

h. Classification of the data. For each single attribute, a classification system was worked out. The classification of the vegetations of the area was done by means of 'tabular comparison' of the plot data (see section 2.3.2). The final classification of the soils of Ujung Kulon was also performed by H. van Reuler (see above). As Zonneveld (1979) points out, every classification implies a generalization by abstraction and results in a series of 'types' constructed on the basis of a set of equal properties.

This also holds for the classification of landscapes. A map legend is also such a classification, but here the horizontal distribution plays an important role as well. For landscape classification we make, for practical reasons, not a separate general classification but describe directly a map legend.

This landscape-unit legend is based on:

- the classification systems for the individual attributes;
- the correlations between these attributes (results of step g);
- the map picture of the preliminary map;
- additional field data, including observations made during supplementary fieldwork (if any).

The study of correlations between the (classification systems for) various landscape-aspects is essential in compiling the landscape-unit-legend. In fact the search for 'convergence of evidence' in landfeatures (at landscape-scale!) can be considered as one of the keystones of landscape-ecology.

In addition to the theoretical demand to maximalize this 'convergence of evidence', there is also a practical side to the compilation of the landscape-unit-legend: the units should be both suitable for evaluation and clearly recognizable in the field. This may imply that extra emphasis should be put on certain attributes, in our case on vegetation and landform (geomorphology) respectively.

i. Final photo-interpretation. In this step the process of photo-interpretation as described for step d is redone once, since the data collected during the fieldwork are likely to indicate errors in the original photo-interpretation or at least demand adaptation or addition.

The landscape-unit legend (result of step h) and the final photo-interpretation should now fit. In our case photo-interpretation needed more than the usual two rounds. The preliminary interpretation could be greatly improved when, in 1982, imagery of much better quality became available. Still, some of the differences in photo-characteristics, correlated with important differences in vegetation and landform, proved to be very subtle. This led to a more or less continuous process of adaptations of our photo- interpretation during and after the period of fieldwork.

j. Drawing of the final landscape ecological map. Sometimes separate maps for some of the individual landscape attributes are made. In this study this was not considered necessary. The individual attributes are in general only shown in the map legend.

k. Evaluation, i.e. linking the map and its legend to the purpose of the survey. The presentation of the results can be done in several ways:

- by a mere description in words;
- in table form, supplementary to a map legend;
- in special maps with their own legenda in terms of evaluation.

In our case, a most important aspect of land-evaluation concerns the suitability as a habitat for rhino. The landscape units are evaluated in terms of such a suitability with special reference to the availability of food-plants. This evaluation is presented in chapter 11. A map showing varying degrees of suitability is included there. Moreover, in chapter 12 some major conclusions with regard to the management of the area will be forwarded.

l. Reporting and reproduction. The results of this step are being read by the reader. As mentioned before, some preliminary results have already been published as a WWF report (Hommel, 1983).

2.3 Some methodological aspects of the vegetation survey

2.3.1 The floristical approach

In this study vegetation types are described as plant-communities. This implies that floristic composition is considered as a basic feature of the vegetation. This is not a point of general agreement among vegetation ecologists. Some of them, especially those from the 'Anglo-American tradition' consider a plant-community (i.e. a vegetation type also defined by its species composition) to be less practical or even un-scientific (see: Mueller-Dombois and Ellenberg, 1974), while others doubt the suitability of the concept in the (humid) tropics (e.g. van Steenis, 1958, Jacobs, 1981 and to a certain extent Ewusie, 1980).

Instead of trying to solve the general controversy between advocates and adversaries of the floristical approach beforehand, we just tried to see whether it worked or not. We simply started from the principle that Küchler's (1967) definition of a vegetation type, 'a part of the vegetation that is relatively uniform in structure and floristic composition (....)', can be applied to any vegetation on earth (see also: van Gils and Zonneveld, 1982).

Still, one may question why well-known scientists deny that the concept is applicable in the specific case of the humid tropics. The arguments against such an approach in the (primary) tropical rain-forest are listed by van Steenis (1958). His arguments can easily be extrapolated to many types of older secondary forest as well. In short his arguments are:

a. We are dealing with very large numbers of species (in general none of them being dominant). This implies that the minimal area of a sample plot must be exceedingly large. Which also implies that not only is the method highly impractical, but also that there is a general conflict between the need for very large plot sizes and of homogeneity of abiotic factors within the plot.
b. Within the forest one finds very complex mosaics, caused by local regeneration processes and resulting in capricious patterns in the floristic composition.
c. In many cases we are dealing with very gradual transitions, as far as the abiotic factors are concerned, resulting likewise in gradual transitions in the species composition.

Although these arguments obviously do not all fully apply to many vegetation-types in Ujung Kulon (where dominance of one species is far from uncommon and many strikingly abrupt changes in abiotic factors occur), it seems worthwile to give some more general comments on these arguments. Our comments thus concern not only the species-rich primary vegetations in Ujung Kulong, but also the application of plant-sociology in rain-forest areas in general.

ad a: First, we should stress that the phenomenon of dominance of a given species is rather irrelevant within views of the so-called French-Swiss school of the plant-sociology (see e.g. Mueller-Dombois & Ellenberg, 1974). Only within the more or less out-dated views of the so-called 'Scandinavian school' is dominance of great importance. Unfortunately, it was an advocate of this latter direction, Booberg (1929, 1931), who tried to stimulate plant-sociological studies on Java; he did so without much success.

Second, unlike most herbarium botanists, a vegetation-scientist is not very interested to know all the rare and dispersely occurring species of a given stand or region. He is primarily interested in knowing the characteristic combination of the more frequently occurring species. This concerns the ones which usually make up the bulk of the vegetation, as well as the ones that statistically show sufficient affinity with specific species-combinations and thus become good diagnostic characteristics for vegetation types. This implies that the theoretical minimum-area even in tropical rain-forests is not excessively large. Moreover, the minimum-area concept has fallen largely into disuse nowadays (van Gils & Zonneveld, 1982).

In fact, it is obvious that a plot may contain more species (and its size can thus be kept within reasonable limits) if there is no dominance of one species, occupying the room within the plot which could be occupied by many other species growing in low densities. One might even state that the lack of dominance in rain-forests may facilitate plant-sociological studies!

Moreover, it is obvious that a plot includes more species if all growth-forms and age classes are taken into account. Theories on the minimal area should not be based on inventories of fully grown trees only, as van Steenis does. This does not only give a highly exaggerated picture of the minimal size of the sample plot, it also completely ignores the importance of herbs and seedlings as indicators of environmental factors and thus as members of a plant-community.

The importance of recording all growth-forms and age classes is clearly illustrated by the work of Meijer Drees (1954) who studied two stands of rain-forest (one of primary, one of old secondary nature) on the island of Bangka (Indonesia). In both stands a surface of 0.25 ha proved to include (virtually) all species, if all growth-forms and age classes were taken into account. If only full-grown 'timber trees' were included, a plot size of even 1 ha was not sufficient by far. These figures correspond well with the results of a so-called nested plot study in the coastal plain of Peucang Island (Hommel, in prep.). However, for the common practice of a vegetation survey much smaller surfaces proved to be sufficient in Ujung Kulon (see Appendix E). As for the dispersely occurring species that will be missed, the experience in non-tropical regions with a high species diversity (mediterranean regions, dune areas in the Netherlands, etc.) shows that there also some about a third to half the species are too dispersed to have statistical diagnostic value (Zonneveld, pers.comm.).

ad b: As for the internal floristic variation of the forest, caused by intricate regeneration patterns, van Steenis is partly right. This may be a serious problem to the vegetation scientist. Because of the large number of species involved, this problem seems to be more complicated in tropical forests than in temperate ones. However, again this problem is exaggerated unnecessarily if one ignores all plants, but the fully-grown trees. Including all growth-forms and ageclasses in the relevé provides a most practical buffer on unwanted variation in the species composition of the plot. Differences in the regeneration stage will thus lead to different cover and density figures of the species involved, rather than to completely different species lists. Still, obviously one should not create problems by including recent gaps or other distrubed sites in a forest-plot. Therefore stratification and homogenity are basic prerequisites.

ad c: The problem of gradual changes in abiotic factors is, of course, not one restricted to the tropics. In all natural regions, smooth boundaries provide serious problems for the vegetation-scientist, but also not rarely the most interesting situations. In fact, in tropical forests the problems may be assumed to be relatively small. As van Steenis himself points out, in the species-rich tropical forests one finds many species with a more or less identical autecology. Even when abiotic factors change very gradually, this may result in clear demarcations in the floristic composition.

Concluding, one may state that the arguments against defining strict plant-communities in a tropical forest area are not very firm. The lack of such studies in many tropical countries, Indonesia included, seems to originate from scientific tradition rather than from scientific theory.

2.3.2 Classification by tabular comparison

Classification of vegetation types was performed by grouping the floristic data of all plots by means of tabular comparison which is, in fact, a statistical matrix method, that can be manipulated by hand or by computer; see also

Zonneveld, in prep.). This procedure is one of the keystones of the French-Swiss approach of vegetation description and dealt with in extenso in many textbooks (e.g. Küchler, 1967; Mueller-Dombois & Ellenberg, 1974; Whittacker, 1973). Therefore, we shall not discuss the basic procedure here.

Tabular comparison is often practised using selected parts of the total amount of data, i.e. with floristically related plots. Afterwards, one has the choice to publish the results in several partial vegetation tables or to combine them in one gross table. Following van Gils and Zonneveld (1982; see also Whittacker, 1973) we have chosen the second possibility. We have tried to include all plots and all species in one and the same vegetation table. Only a few plots, the floristic composition of which is known only very incompletely haven been omitted. These plots were sampled only as reference points for the map (so-called 'quick relevés; 10 per cent of the total number of plots). All species (as far as their identification admitted) were used, though for practical reasons not all were included in the published vegetation table (Appendix E).

The compilation of one gross table has both advantages and disadvantages. The major disadvantage is the fact that well coherent (sociological) groups of species differentiating between floristically related vegetation types must be split up again when other, floristically more remote types are included in the table. Here, the author must seek a balance between accuracy and convenient arrangement. Important advantages are the objectiveness and great diagnostic value of such a table (any stand of vegetation can be classified in the field using one table) and the frank and open way in which arbitrary decisions of the investigator are presented. Moreover, by including many vegetation types (and thus many types of environment) in one table, the resulting sociological groups of species acquire more and more the character of species groups with a more or less identical ecology (i.e. so-called ecological groups). Thus, the compilation of one gross table may also serve as an expedient of autecological studies. Still, there is one more very important advantage: the compilation of one gross table allows a more detailed classification. For example, in Ujung Kulon many vegetations are dominated by one palm species (Arenga obtusifolia). Using tabular comparison, these can easily be subdivided into a number of plant communities. Most of these communities show a very good correlation with a specific set of abiotic factors. However, there is one large rest group of plots (classified as the community of Pterospermum diversifolium and Arenga obtusifolia) which may occur on very different soils and types of parent material. Attempts to subdivide this community further by means of tabular comparison without taking the other communities into account failed. Still, by using sociological groups, which were defined for floristically remote communities, as diagnostic characters in the same gross table, three subtypes originated within the Pterospermum Arenga community which proved to show a remarkably good correlation with the parent material. Irregularities (see plot 88) as well as similarities (two types of tuff in different geomorphological units) in the geological composition of the area which, until were then not yet known, could be traced by means of these subtypes.

In the gross table (Appendix E), we distinguished between species-groups with a obligatory and a facultative occurrence in the various plant-communities. This distinction is, from sheer necessity, based on many arbitrary decisions. The system was derived from van Gils and Zonneveld (1982). Indications of compulsary or facultative dominance of species(groups) are included only in the summarized version of the gross table (see table 9a). The diagnostic value of dominance is limited in our study area. In Ujung Kulon, species dominance is far from uncommon, but is never a constant character of a vegetation type.

In general, we refrained from distinguishing plant-communities, based on only only one sample plot. However, in a number of cases this was inevitable. The sites at issue were already recognized in the field as being strongly aberrant. In general, they obviously differed in vegetation characteristics (flora and structure) as well as in abiotic aspects (soil, etc.). Eventually, these one plot communities proved to contain a relatively large number of very interesting (i.e. extremely rare) species.

All manipulations mentioned above were done 'by hand' instead of by computer processing. This was done mainly for practical reasons (the available computer-facilities appeared to be too time-consuming). Still, manual processing also has an important advantage. Our data are from sheer necessity not very homogeneous with regard to plot sizes, completeness of the relevé and representativeness of the plot. Such imperfections are a necessary evil of a reconnaissance survey in a very remote and inhospitable terrain. For computer processing a not very homogeneous set of data provides serious problems. If one accepts that a subjective element will enter the procedure, most problems can easily be solved. This can be done in the most efficient and frank way by handwork.

The plant communities which finally resulted from the procedures sketched above should be considered as local types. According to Küchler (1967) the success of the procedure followed (i.e. Zonneveld's approach) is the fact that not an a priori accepted classification system (e.g. sensu Braun Blanquet) is embraced. For our area such a system is not available. Whether an eventual fitting into such a system will once be possible is at present not a relevant question.

2.3.3 Growth forms and life forms

Plants are classified taxonomically into families, genera, species, etc. However, species can also be grouped into growth form or life form classes on the basis of similarities in structure and function (Mueller-Dombois and Ellenberg, 1974). Unlike the taxonomical classification for which, since Linné, one system has been accepted throughout the world, there is no generally accepted classification system available for the world's plant growth and life forms. The first system published, dates back to the so-called 'Hauptformen' described by von Humboldt (1806), but ever since many modified versions and new systems have been proposed and used. Life form systems are especially useful as a way of typifying the environment by means of vegetation characters. Therefore more than one system, each focussed on a special (set of) abiotic factor(s) would be preferable (see Iversen, 1936; Zonneveld e.g. 1960 and 1982).

Any classification based on gross similarities in growth-habit results in the description of 'growth forms'. 'Life forms', on the other hand are defined as those growth forms which display an obvious relationship to important environmental factors (Mueller-Dombois and Ellenberg, 1974). This means that life form systems are classification systems for which the diagnostic morphological characteristics are chosen on the basis of ecological guidelines. However, form and function are two sides of the same coin. So, systems without some ecological guiding principles hardly exist, while practical diagnostic characters are always morphological in character. The terms life-form and growth-form are often even used as synonyms.

Of the existing systems, we shall discuss briefly the most widely-known one (viz. the life form system of Raunkiaer, e.g. 1937) as a possible ecological indicator. The purely morphological system devised by Eiten (1968) will be discussed in the next section.

The Raunkiaer system uses as morphological diagnostic characters the position of the buds or organs from which new shoots or foliage develop after an unfavourable season, i.e. in the temperate zone (in general) the winter, and in the tropics and subtropics the dry season (if any). Thus, the system may be of use in studying climatological zonation within our study area.

The Raunkiaer system distinguishes between five main classes of life forms, which are shortly typified by Küchler (1967) as follows:

1. Phanerophyta	Buds more than 25-30 cm above the ground.
2. Chamaephyta	Buds above the ground but less than 25-30 cm.
3. Hemicryptophyta	Buds at the surface of the ground.
4. Geophyta	Buds below the surface of the ground.
5. Therophyta	'Buds' in the seed: annuals.

The original Raunkiaer system has been elaborated and modified several times, partly by himself, partly by others (see Küchler, 1967). The latest revision was undertaken by Ellenberg & Mueller-Dombois (1967; see also Mueller-Dombois & Ellenberg, 1974). In their version, the boundary between phanerophyta and chamaephyta has been raised to 50 (-100) cm. Moreover, in subdividing the main classes, they put more emphasis on plant behaviour characteristics during the growing season. The later changes of the Raunkiaer system are not generally accepted as improvements. According to Zonneveld (pers. comm.), the original clear principle was partly distorted.

An important application of the Raunkiaer system in vegetation science is the listing of life forms of all species of a plant-community. This results in a so-called 'life-form-spectrum' which can be visualized in a bar-diagram of some sort. Comparing the life-form-spectra of various communities gives insight into their ecological differences (Mueller-Dombois & Ellenberg, 1974; see also Zonneveld, 1960).

To what extent is such a procedure feasible in the present study? Since plant behaviour during the unfavourable season in warm climates is very similar to plant behaviour during winter in the temperate climates, Mueller-Dombois & Ellenberg claim that (their version of) the Raunkiaer system can also be applied to areas outside the temperate zone.

In general, this is undoubtedly true. The Raunkiaer life form spectra of tropical vegetations show clear differences with those of other climatic areas. For example, one might characterize the vegetation of the humid tropics by the strong dominance of the phanerophyta. Moreover, van Steenis (1965) points to the relatively large number of geophyta in true monsoon forests compared to rain-forests.

However, the application of the Raunkiaer system in a tropical area (like Ujung Kulon) is thwarted by two serious complications. First, there is a problem of practical nature: our knowledge on the behaviour during the unfavourable season of many of the species involved is just insufficient. Additional study of this aspect would be very time-consuming and is beyond the scope of this study. Moreover, some of the Raunkiaer life forms are of a potential character and not always constant in time and space. We believe the latter problem to be much more serious in tropical areas than in temperate ones, though admittedly fluctuations in the severity of the unfavourable season may occur in any climate, allowing for instance annuals to behave as bi-annuals or even (semi) perennials in favourable years.

Seasonal cold and seasonal drought as stress-factors for plant-life act on different scales and with a different regularity. Obviously, seasonal stress caused by drought may vary largely from one year to another and even within a small area from place to place, e.g. according to differences in soil characteristics and vegetation structure.

For instance, Backer and Bakhuizen van den Brink (1968) state, discussing the Javan grass-flora, that for many of the more tender species (e.g. Isachne miliacea) the difference between annuals and perennials is obscure. Undoubtedly, the same holds for many cyper grasses and dicotyledonous herbs.

Examples, mentioned by Backer c.s. and occuring in Ujung Kulon are Cyperus polystachyos, Cyperus tenuispica, Fimbristylis dichotoma, Fimbristylis miliacea and the dicotyledonous herb, Struchium sparganophorum. Thus, the therophyta as a group are rather poorly delimitated.

Likewise, one may assume that for many perennials in Ujung Kulon the degree of shoot-reduction during the dry season is not a constant character. Presumably perennial species like Axonopus compressus, Cyperus cf. kyllingia and Sida javensis may serve as an example: evergreen when growing in forests on not excessively drained soils, with almost completely dying superterranean parts when growing in relatively open vegetations on sandy soils. Thus, the boundary between chamaephyta and hemicryptophyta is also obscure.

Finally, the group of geophyta in Ujung Kulon provides similar problems. A substantial portion of the species which can survive the unfavourable season as tubers may also keep their superterraneous parts alive all year round if the seasonal stress is not too dramatic. Moreover, they can choose the golden mean and become deciduous. It is an interesting phenomenon that all examples of this group of 'potential geophyta' we came across in Ujung Kulon are climbers: Ampelocissus arachnoidea, Merremia peltata and several species of Discorea.

Concluding, we may state that the application of the Raunkiaer system within this study is hampered by a number of practical problems. Classifying all species of the area within the Raunkiaer system is not feasible, since the life forms do not form a constant character in the (humid) tropics when an area as Ujung Kulon is studied as a whole. On the other hand it is well possible to use the Raunkiaer system for a broad characterization of the climatic zones within an area. We shall do so in chapter 5. Still more promising is the use of the system to typify the various plant-communities by determining the life form of the most frequently occurring species. Since most of these communites have a rather constant structure and are more or less bound to specific soil types, it must be possible to describe them by means of lifeform spectra. In the context of this study time prohibited us to do so. Obviously, plenty of possibilties for future studies are available here.

2.3.4 Vegetation forms

Next to their utility as an expedient to visualize unknown plant species, growth forms (s.s.) can be used as materials for a physiognomic description (or classification) of plantcommunities. Physiognomy depends on the dominant growth forms of a community, but also on its biomass-structure and vegetative periodicity characters in the principal layers (Küchler, 1974).

However, not all growth form classification systems fit to one of the existing and, for our purpose suitable, physiognomic classification systems for plantcommunities. For instance, the growth form system, which was designed by Booberg (1931) especially for the island of Java, would for this reason not be a fortunate choice (moreover, Booberg's growth form classes are rather poorly defined).

In contrast, the work of Eiten (1968) answers to the specific demands of our study. It provides not only a classification of species into (well-defined) growth forms, it also gives a global system of (again well-defined and still flexible) vegetation physiognomy (or vegetation forms).

Still, to meet the specific demands of the Ujung Kulon vegetation, Eiten's system also had to be modified slightly. For instance, subtypes of growth forms were described in lianas, herbaceous climbers and epiphytes. Moreover, strangling figs were added as a new growth form.

Table 2c provides an enumeration of the growth form nomenclature based on the work of Eiten, as it is used in this study.

The incorporation of the species of Ujung Kulon in this system is given in Appendix C. The (floristically defined) vegetation types are incorporated in the classification system of vegetation forms in chapter 9.

Deciduousness has been included in Eiten's classification system for growth forms. On this point, one might argue that deciduousness is an ecological interpretation rather than a merely morphological character. However, we agree with Eiten that it is primarily a visible character of the species or vegetation itself and may thus be incorporated in a growth form system.

Nevertheless, the ecological significance of deciduousness as an adaptation to seasonal drought is obvious. We shall recur on this subject when discussing the broad climatic zonation of Ujung Kulon in Chapter 5. Furthermore, Eiten's vegetation forms are used in this study to complete the description of the vegetation types. Of all these types a (synecological) interpretation will be given, based on the floristic composition, the major lifeforms and the vegetation form (see chapter 9).

Table 2c. List of growth-forms occuring in Ujung Kulon
(slightly modified after Eiten, 1968).

Trees s.l.
ET evergreen broadleaf tree
DT deciduous broadleaf tree
TP tree-palmoid
TB tufted bamboo
RT rosette tree (pandan)
SF strangling fig
AT aphyllous tree (casuarina)
PT pachycaul tree

Scrub elements
(not-climbing, terrestrial)
BS broadleaf shrub*
SP scrub-palmoid
RS rosette scrub
PS pachycaul scrub
GA giant aroid

Woody climbers
BL broadleaf liana*
PL palmoid liana
CB climbing bamboo

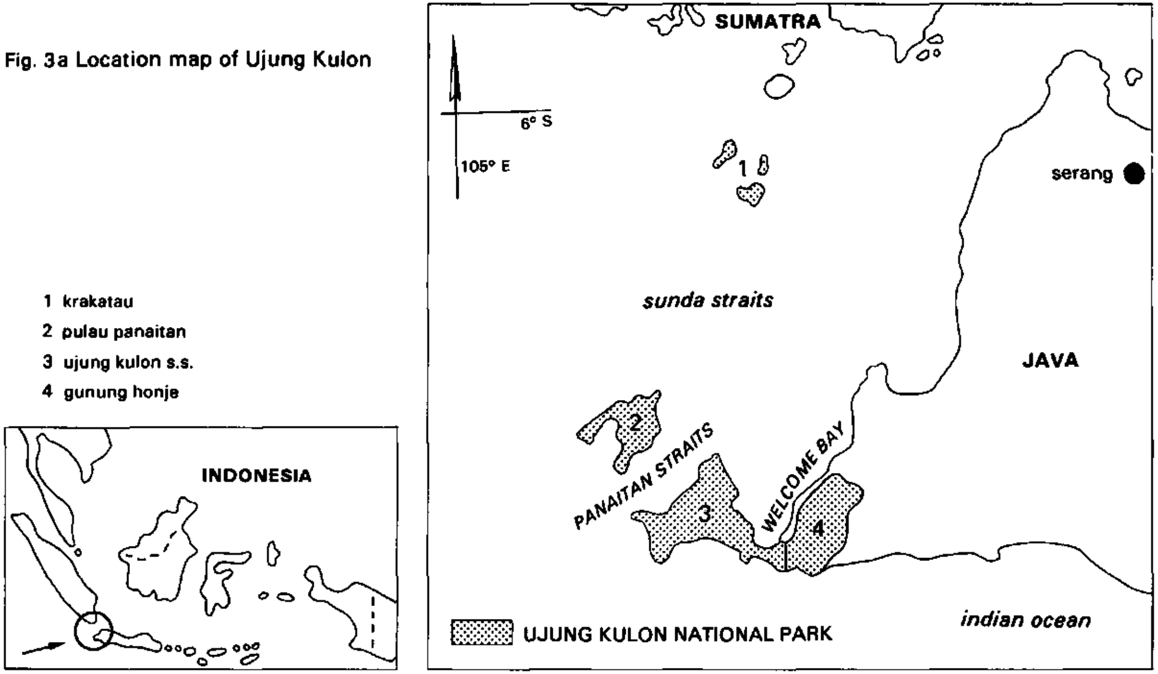
Herbaceous elements***
BH broadleaf herb (forb)*
GH graminoid herb
TG tussock graminoid
CH cushion herb
AF acaulescent fern
AH aphyllous herb

Herbaceous climbers
BV broadleaf vine*
GV graminoid vine
CF climbing fern
AV aphyllous vine

Epiphytes**
SE scrub epiphyte
HE broadleaf herbaceous epiphyte
FE fern epiphyte

* both evergreen and deciduous.
** including climbing hemi-epiphytes.
*** not-climbing, terrestrial and aquatic

Fig. 3a Location map of Ujung Kulon



CHAPTER 3: THE STUDY-AREA

3.1 Introduction

This chapter is meant as a first acquaintance with Ujung Kulon, our study area. It provides some broad descriptions of the major physiographic units, the most common types of vegetation and the wildlife.

In addition, some basic topographical data are presented, as well as some annotations on the practical side of the fieldwork. For more elaborate descriptions of the area we can refer to the next chapters and (especially for the faunistic significance of the area) to the work of Hoogerwerf (1970).

3.2 Location, boundaries and extent

As indicated in figure 3a Ujung Kulon is situated on the utmost western tip of the Island of Java (Indonesia). Along its northern coastline, it abuts on the Sunda Straits, while the Indian Ocean washes its western and southern coasts. On the eastern side, Ujung Kulon is connected to the mainland of Java by an isthmus of only 1.5 km wide.

From an administrative point of view the area is part of the district ('kabupaten') of Pandeglang in the province of West Java. However, in common parlance, as well as in the literature the western part of West Java is generally refered to as Banten (or Bantam), the name of a former sultanate in those parts.

Literally, Ujung Kulon simply means 'west-tip' and the demarcation of the region commonly indicated by this name is not strictly defined. Moreover, the conservation-area called Ujung Kulon has been enlarged several times (see chapter 4). This study refers to the terrestrial part of the Ujung Kulon Nature Reserve, as included in the National Park of the same name in 1980.

Thus, our study-area encloses the Ujung Kulon peninsula, the island of Peucang, the group of Handeuleum islands and an adjacent zone east of the isthmus (see fig. 3b). Along its eastern boundary Ujung Kulon is separated from the Mt.Honje reserve by an undemarcated line partly coinciding with the Cikalejetan rivulet.

Serious demarcation problems are restricted to the utmost north-eastern part of the area. There, the official boundary is a straight line running eastwards from Cape Lame (see fig. 3b). However, south of this line relatively long and well-established wet rice-fields ('sawah') are present up to the Cicangkeuteuk rivulet. Even on the south-bank of the Cicangkeuteuk one comes across an illegal settlement (Legon Pakis) and some cultivated fields.

At present, this illegal settlement is gradually being cleared by the Park-Managing authority (PPA). Abandoning the rice-fields north of the Cicangkeuteuk is not very realistic. A shift of the boundary southwards to this rivulet seems to be the best solution.

As for the total extent of Ujung Kulon, there is much confusion in the literature, partly due to differences in demarcation of the area. Our estimates for the study-area as defined above lead to a figure of approximately 30,000 ha, which corresponds very well with Hoogerwerf's statement (1970). The definite calculation of the area's surface awaits the publication of the new topographical maps (see section 3.6).

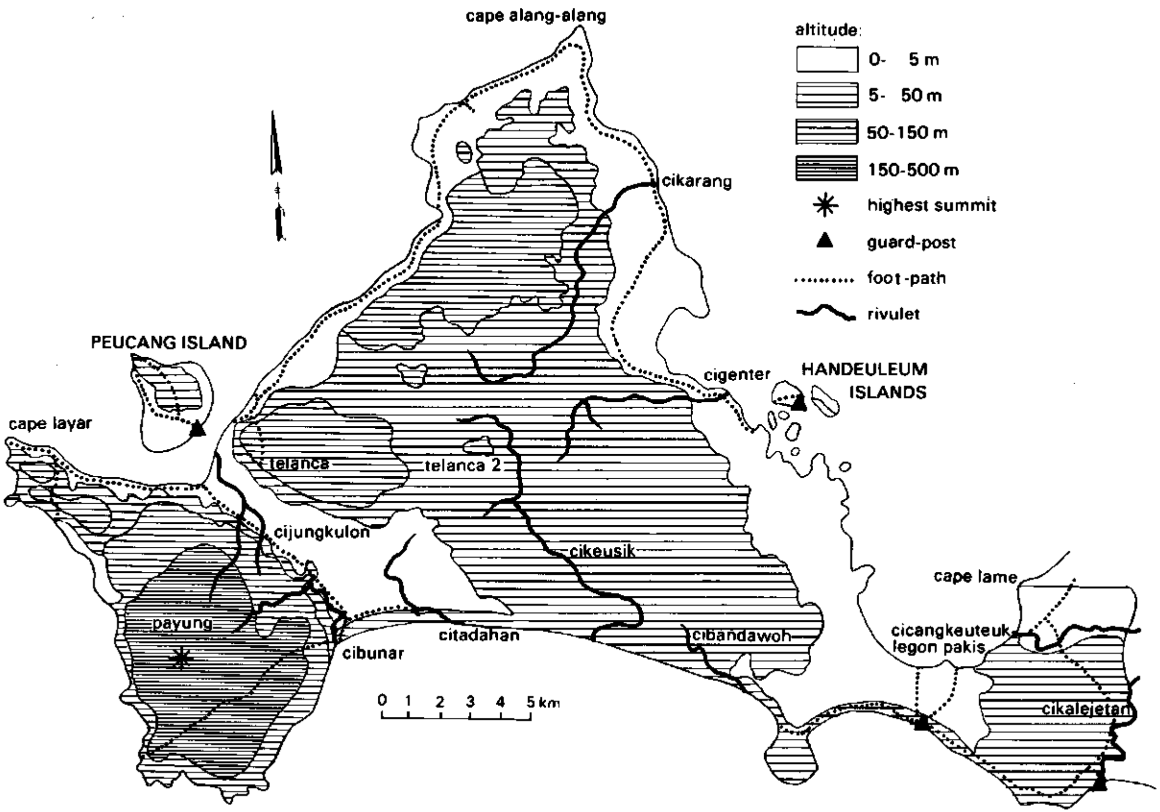


Fig. 3b Topographical sketch-map of Ujung Kulon

3.3 Physiography, vegetation and wildlife

The island of Java as a whole is composed of a mountainous, almost wholly volcanic area and two large lowland areas in West and East Java connected by a narrow stretch of low country along the northern coast in central Java (van Steenis, 1965). The differences in altitude are considerable throughout the island. About sixty summits are 2000 m or higher, fifteen of them are even more than 3000 m. Compared to the mainland of Java, the differences in altitude within Ujung Kulon are only moderate (see fig. 3b). In the western part several summits of the Payung 'mountain' range are approximately 500 m. high. The kernel of the peninsula consists however of a plateau-landscape which locally is approximately 150 m high (Mt.Telanca). These two elevated regions are separated by a broad fluvio-alluvial plain, while also in other parts of the area, especially along the north coast, vast plains are present. A more detailed outline of structure and development of the Ujung Kulon landscape is given in chapter 6.

As for the major types of vegetation, luxurious rainforest is only found on the upper slopes of Mt. Payung. On the lower slopes the vegetation is strongly dominated by one species of palm tree (Arenga obtusifolia or 'langkap'). Similar palm forests are also found in both the fluvio-alluvial plain and the central elevated region. There extensive stands of bamboo-forests and shrub jungles are also found. These shrub jungles are generally dominated by spiny rattan species of a very dense character. In fact, the common occurrence of these rattan shrublands has greatly contributed to Ujung Kulon's fame as a most inaccessible and inhospitable terrain and thus, indirectly, to the survival of its superb wildlife, including the Javan rhinoceros, the banteng and the panther.

The coastal plains mentioned above are very different in character. Here, for example, one finds extensive mangrove areas, but also hundreds of hectares of unusual very monotonous forest types commonly dominated by the treelet *Ardisia humilis* ('lampeni').

As will be mentioned later, these lampeni-forests are a relic of former, man-made savannas in these regions (see e.g. chapter 4). At present, there are only a few, small-sized grassland areas left which serve as grazing grounds for the bantengs and which are of great interest to visitors to the reserve. From watch-towers, constructed on the edge of the grazing areas, one may observe not only herds of banteng, but also peacocks, jungle fowl and bee-eaters.

The only other low herbaceous vegetations of more than negligible size are found in depressions in the coastal plain. During the wet season, these depressions are inundated, during the dry season they become dessicated and hydrophylic vegetations (with e.g. *water-lilies*) give way to herbaceous swamp vegetations (with e.g. Typha, cat's-tails). These sites are renowned for their abundant bird-life. For instance, the lesser adjutant bird, the white-necked stork and several species of herons and egrets can be observed in large numbers. An observation tower has also been constructed on the edge of one of these swamps.

Finally, two regions should be mentioned which are very different compared with all other regions within Ujung Kulon. Both are renowned for their scenic beauty, as well as for their abundant wildlife. In virtually all other respects they are quite different. First, there is a sandstone beach ridge along the south coast, which is locally weathered and blown-up to sand dunes. The vegetation cover here is low and irregular, the shape of the treelets distorted by the strong sea winds. Tracks and feeding marks of the Javan rhino are remarkably common in this region, although the animals themselves generally remain invisible, as in all other parts of the peninsula.

Second, we should mention the island of Peucang. The island is covered with tall and very species-rich, semi-deciduous forest types, which are very different from the forests found on the mainland of Ujung Kulon. Large herbivores such as rhino and banteng are absent on the island, the same holds for all major predators such as the panther. On the other hand, wild boar, macaque monkeys and deer occur in large numbers. The many Javan deer of Peucang are especially renowned. Every afternoon before sunset they gather in large numbers on the small clearing, where the field station, tourist facilities and guardposts are situated.

3.4 Accessibility, infrastructure and fieldwork

Java is one of the most densely populated islands in the world. At the time of our survey its population was rapidly approaching 100 million. However, the Javan population is not distributed very regularly. The westernmost part for instance is not yet very densely populated, and its infrastructure is practically non-existent.

In 1981-1983 Ujung Kulon was still not accessible by a trafficable road. The normal way to Ujung Kulon leads first to Labuan, a small market-town on Java's northern coast some 60 km from the boundaries of the reserve. There, one must find a ship that is heading west, either a fishing boat or a vessel owned by the park-managing authority (PPA). There, too, one may stock up with supplies needed for the period one plans to remain within the park: rice, cabbage, eggs, dried meat etc. Once inside the forest the menu may be supplemented by forest products such as wild fruits, foliage, palm-shoots and rattan-marrow.

From Labuan one may sail directly to one of the field stations (Peucang Island or Handeuleum Island) or disembark at the village of Tamanjaya near the eastern boundary of the reserve, from where one can proceed on foot along the south coast. In the latter case one follows in the footsteps of the great naturalist F.Junghuhn, who reached Cape Layar in May 1846 along this route. Junghuhn's famous description (1854, 1867) of the slaughter of green turtles by a group of wild dogs most likely took place on the beach of the south coast, very close to the boundary of the present reserve.

Within Ujung Kulon the infrastructure, as far as trails are concerned, is very limited. In fact, in the part west of the isthmus there are but three trails of any length: one connecting Peucang Bay to Cibunar at the south coast (through the alluvial plain, along the foot of Mt.Payung), one leading from Cibunar over the summits of Mt.Payung to Sanghiyangsirah in the extreme south-west and finally one leading all along the north-coast from Cape Layar to Cigenter (see fig. 3b).

In the central parts of the area there are no trails at all. Moreover, rivulets are of little importance as ways of penetrating the interior. Although the area is intersected by many rivulets, most of them are very narrow and even the widest ones such as Cigenter and Cikarang are only navigable by canoe for the last few kilometers downstream. Moreover, many rivulets more or less dry up during the dry season. Eventually, fresh water in large quantities is still available in the interior only in the Payung area and in the periphery of the limestone plateaus (see chapter 6).

Therefore, the only efficient way of penetrating the interior is to cut through the vegetation with a jungle knife along a fixed compass-bearing. This may imply the step-by-step cutting of a corridor through extremely dense and thorny vegetation. In some of the worst parts it may thus easily take a full hour of hard work to advance a mere 100 metres. En route, orientation is facilitated by the use of compass, step-counter and aerial photographs.

The primitive infrastructure and difficult terrain are, of course, a serious handicap for the fieldworker. Obviously, daily trips to the forest from one of the field stations or guardposts as base-camp can cover only a small part of the study-area efficiently. For the study of more remote parts we used either existing shelters as base-camps (in coastal regions) or constructed a provisional bivouac for the night from some saplings, palm leaves and a piece of tarpaulin (in the interior). Normally, we returned to one of the field stations (mostly Peucang Island) after a stay of some 10 to 14 days in the forest.

3.5 Habitation and land use

As for the present land-use, the primary objective of the area is obviously nature conservation with tourism becoming more and more important since the change of status from a strict reserve to a National Park in 1980 (see chapter 4). Other forms of land-use are far less important, especially since the area is completely uninhabited with the exception of the lighthouse at Cape Layar, the illegal settlement at Legon Pakis and four permanently manned guardposts (see fig. 3b). However, two other traditional human activities in Ujung Kulon, which have survived until the present day, should be mentioned here: the collecting of edible swift nests and pilgrimages to an ancient grave. Both the swift nests and this grave are located at Sanghiyangsirah in the utmost SW of Ujung Kulon. A ban on the collecting of swift nests in the National Park is urgently needed, at least in the opinion of the present author.

3.6 Available topographical maps

The official topographical maps currently available (Army Map Service U.S. Army, 1943) are based on old Dutch maps, dating back to 1932. According to Blower & Van der Zon (1977) the 1932 maps are based on still older original maps dating back to 1894. If so, the maps are entirely based on ground-survey.

An interesting feature of these maps (the 1943 ones) is the abundance of local names for both rivulets and elevated parts of the interior.

However, beyond that the maps are not very useful. Apart from the coastline, the location of most of the river mouths and some striking details of the interior (e.g. the location of Mt.Telanca 2, see fig. 3b), they are completely unreliable, as e.g. Schenkel & Schenkel-Hulliger (1969) experienced.

Some of the most striking errors of these maps (and therefore also of more recent maps based on them) include:

- the course of the rivulets;
- the size and shape of the fluvio-alluvial plain, mentioned above;
- the width of the coastal strip along the NW coast (i.e. part of the 'erosional plain', see: chapter 6).

Because of their unreliability, it would in fact be better not to use these maps at all. New topographical maps are at present being prepared by the Indonesian Topographic Service and will be based on recent aerial photographs.

For the time being, the landscape-ecological map, which is attached to this report as an appendix may prove useful, since we tried to include as much topographical information as possible, e.g. the trails, guard-posts, shelters, major elevations and rivulets.

CHAPTER 4: HISTORY

4.1 Introduction

Even a summary account of the history of (West) Java would be far beyond the scope of this study. This chapter merely attempts to give an impression of Ujung Kulon's history of occupation and its history as a conservation area. Especially the early history is very poorly known and, therefore, our account must be more or less speculative.

The eruption of the nearby Krakatau volcano in 1883 can be considered as by far the most important event in Ujung Kulon's history. Therefore, a special section is devoted to this famous catastrophe (4.3).

Other sections deal with, respectively, the 'pre- and post-Krakatau history' (4.2 and 4.4).

4.2 Period before 1883

Probably there is hardly any part of the world which has been inhabited by man longer and has witnessed more migrations of people than the island of Java. Therefore, it is not unlikely that even an out-of-the-way corner like Ujung Kulon has been inhabited since ancient times. However, relics of former occupation are very scanty in this region.

On the top of Mt. Raksa, on nearby Panaitan Island, two small Hindu statues have been found (pictures in: Hoogerwerf, 1951), but from Ujung Kulon no such findings have been reported. In general, Hindu relics are rare in West Java, in contrast to the central and eastern parts of the island. Van Tricht (1928) points out that, although the Hindus reigned in West Java from the 5th until the 16th century, Hinduism was far from generally accepted by the common man, who stuck to his ancient religion of ancestor worship, the 'Agama Sunda'.

Sacred areas associated with this Agama Sunda, and not uncommon in West Java, are the so-called 'kabuyutan' and 'pamujaan'. These terms refer respectively to remote spots where old, sacred heirlooms were kept and to open oratories, often terraced and paved (van Tricht, 1928).

The name of a rivulet in the Kalunggung part of the Payung massif and in the vicinity of the Sanghiyangsirah grave- ('Cikabuyutan') suggests the former occurence of a kabuyutan in Ujung Kulon. In this respect, van Tricht indicates a most interesting detail: clearing of forest covering a kabuyutan-mountain was considered 'buyut', i.e. taboo, a tradition often also respected by later Islamitic generations. Indeed, the forest covering the upper part of Mt.Payung can be considered as one of the few remaining coherent stands of primary vegetation in Ujung Kulon (see chapter 9).

Pamujaan have, in general, only been preserved in mountain areas. In Ujung Kulon their occurrence has not yet been proved, but the slopes of the Payung massif are still very insufficiently explored. Moreover, former pavements are at present likely to be obscured by the layer of Krakatau ashes (see chapter 7). Likewise, the two statues on Panaitan Island had also almost vanished underneath a humus layer (in 1956; van Balgooy, pers. comm.). In Ujung Kulon, a pink-coloured soft rock, possibly an old brick-layer of unknown origin, was found under 12 cm of ashes on one of the summits of the Payung massif (plot 119).

The Islam made its debut in West Java in 1523 and became the religion of the ruling class in 1579, when the old Hindu empire collapsed. However, people who stuck to the old Agama Sunda, the so-called 'abdi' (i.e. 'slaves'), were still very numerous in Banten up to and including the 18th century (van Tricht, 1928).

No data are available on the spreading of the Islam in Ujung Kulon. Only one remarkable detail should be discussed here: on the old topographic maps we find in the central part of Ujung Kulon the indication: Pr. Badoeis. The Badui are a small, but legendary ethnic group, which until the present day seeks to preserve the old pre-islamitic civilization of West Java through strict isolation (Geise, 1952).

The exact origin and former distribution area of the Badui are unknown. Jacobs and Meijer (1891), who wrote a monograph on this tribe, do not mention any settlement west of their present refugium in the Kendeng mountains. It is therefore uncertain whether the indication on the topographic map really refers to a former settlement of Badui or only rather inaccurately to 'common' abdi.

Very soon after the coming of the Islam, West Java was to undergo another dramatic change. In 1596 the first four Dutch trade ships arrived in Bantam, ringing in a colonial epoch of three and a half centuries.

The old Dutch topographical names 'Welkomst Baai' (Welcome Bay) and 'Behouden Passage' (Safe Passage, i.e. Panaitan Straits) suggest that Ujung Kulon had now become of some importance for ships of the Dutch East Indies Company (V.O.C.) as a first anchorage in the archipelago. However, one should probably not overestimate this importance. Neither locality is included in van Dam's list of 'principal localities', nor mentioned anywhere else in his voluminous work on the V.O.C. (1701). Moreover, in the piles of V.O.C. reports which have been preserved and recently published by Coolhaas (1960-1979) Welcome Bay is mentioned only once (1715) and Safe Passage not at all.

Since the beginning of the 19th century specific data on Ujung Kulon became available, which are discussed briefly by Hoogerwerf (1970). Apparently, in this period the most ambitious plans were made to develop Ujung Kulon, both in a strategic and an economic sense. However, all attempts to create a second Singapore failed in a very early stage and Ujung Kulon's contribution to the world-economy remained restricted to the export of relatively large quantities of Indiarubber, gathered from wild Ficus elastica trees.

In fact, it is not unlikely that during the last century, in spite of all wild economic schemes and rapid population growth in most parts of Java, the population of Ujung Kulon only decreased. At least, this seems to have been the overall tendency in Banten. In this respect, we can refer to both Multatuli's dramatic descriptions of the migration of Banten people to S.Sumatra (1860) and to van Steenis' vegetation map of Java (1965), which shows extensive secondary forests (i.e. formerly cultivated areas) especially in this part of the island.

Although no data on a population decrease in Ujung Kulon are available, the situation on nearby Panaitan Island may be illustrative. The famous navigator, James Cook, claims to have visited the 'town of Semadang' there in

1771 (cited from Van Borssum Waalkes, 1951). According to Veth (1903), the island was used by the sultans of Banten (who reigned until the end of the 18th century) as a place of exile. The expedition of Mollier (1863), however, found the island uninhabited, though remnants of former settlements were encountered.

At the time of the Krakatau eruption, the main village in Ujung Kulon was Djungkulan, situated on the mainland opposite Peucang Island. Other settlements were known to exist on Peucang Island, near the mouth of the Cibunar river, upstream of the rivers Cigenter, Cikarang and Cibandawoh and on the Tanjung Tereleng peninsula (Hoogerwerf, 1970).

In the surroundings of these settlements foodcrops were grown, undoubtedly rice being the main product. As has been the tradition until recently in the whole region directly east of Ujung Kulon, dry-land rice-growing by shifting cultivation was preferred above permanent cultivation on sawahs, even in the coastal areas. Still, there are indications that locally wet rice agriculture was also practised. Ammann (1985) found earth-walls crossing each other at right angles, possibly remnants of sawah-dikes, in the Citadahan region.

Other temporary settlements must also have existed in the interior. According to Kools (1935), who described the shifting cultivation system in Banten, the complete population of a village moved at the beginning of the ladang season from their main (i.e. more or less permanent) settlement to the fields. There, a temporary village was erected for one season. After the harvest, everyone returned to the main village which had been deserted for months. Because of their migrating habits, these people were called 'jelma manuk', the bird people.

After only two to five years, the same piece of land could be used for ricegrowing again. However, if possible, clearing of forest-covered sites was preferred to the use of recently deserted sites. This could result in the more or less total destruction of the forest in a shifting cultivation area (Kools, 1935. For more information on shifting cultivation, see also de Bie, 1901-1902).

Still, the occupation of the central part of Ujung Kulon was not apparently common knowledge during the nineteenth century. Junghuhn, (1854), who travelled along Ujung Kulon's south coast, had the impression that the area was completely uninhabited.

Next to the shifting cultivation, a further impact on the natural vegetation may be presumed by the collecting of all kinds of forest products. However, the Indiarubber trade had probably as good as died out by 1883. According to Koorders (cited from Heyne, 1950), wild Ficus elastica trees rapidly became very scarce in S.Banten in the second half of the 19th century.

4.3 1883: the Krakatau eruption

The 1883, eruption of the Krakatau volcano is considered to be one of the biggest catastrophes in human history. The amount of literature on the subject is, in proportion, enormous. However, the major source of data remains the voluminous nineteenth-century study by Verbeek (1885) A recent and most lively narrative on the event is given by Francis (1976); the most up-to-date general work on the subject is by Simkin and Fiske (1983). For the most recent studies on more specific subjects we can refer to the Proceedings of the Krakatau Symposium in Jakarta (1985).

The distance between the Krakatau volcano and Ujung Kulon measures only some 60 km. One can imagine how strongly the area was effected by an eruption which was, in one way or another, noticeable all over the world and for instance audible almost 5.000 km away (Francis, 1976).

Actually, the impact of the eruption on the Ujung Kulon peninsula was twofold, i.e. by tidal waves and by ash-deposition (Hommel and van Reuler, 1985).

Tidal waves with a height of approximately 10 to 15 metres swept away the villages, crops and relics of natural vegetation in the coastal zone. Although these tidal waves (according to Francis more properly called 'tsunamis') killed no less than 36,000 people in Java, the number of victims in Ujung Kulon seems to have been relatively small. Moreover, the impact on the vegetation of the interior has often been overestimated, e.g. by Pellek (1977).

A second effect of the eruption was a rain of ashes, which covered the peninsula and its vegetation. These ashes can still clearly be recognized in the soil profiles, with an average thickness of approximately 20 centimeters. The rain of ashes had, most of all, important consequences for the shifting cultivation sites. Probably, the young rice plants, not yet planted out, were killed and the workability of the fields, just cleared and burnt (see Kools, 1935) greatly reduced. Moreover, the ash layer on these treeless and very exposed sites is thought to have greatly influenced vegetation development. In many parts succession leaded towards a dense rattan-shrubland, which contrasts enormously with the surrounding forest-types and allows a readily demarcation of the area of shifting cultivation sites in 1883. However, this is only true of areas with an ash-topsoil and a less well-drained (sub)soil (see chapter 9). Thus, the present vegetation does not give a good indication of the land use in 1883 for areas with no ash-topsoil or a relativelly well-drained (sub)soil. Major examples of such areas are large parts of the (coastal) plains, respectively the undissected plateaux, (the lower parts) Mt. Payung and the higher part of the western hills (see chapter 6). However, we assume that the latter three areas were not of great importance for the ladang-farmers. In the Payung area and the higher part of the western hills, the slopes are in general too steep, while both in the latter area and on the undissected plateaux no drinking water is available, which makes these regions very unattractive as a location for the temporary villages of the 'bird people' (Avé, pers.comm.). The ladang field and the temporary settlements were always located close together (Kools, 1935). Thus, the areas mentioned above were, in general also not suitable as ladang sites. We may presume that the settlement on Peucang Island has never been of much significance for the same reason.

From the information presented above, one may gather that, at least on the more elevated parts, the present area of rattan-shrublands provides a good indication of the extent of fields (humas) and recently deserted grounds (reumas) in 1883. Fig. 4a shows the assumed extent of former humas and reumas based on this relation. It is interesting to note that this corresponds well with Hoogerwerf's records as cited in the previous section. Moreover, one may notice that the former inhabitants of Ujung Kulon tended to avoid the periphery of the central elevated parts. Again, this seems to indicate a people who deliberately sought isolation. However, fear of the malaria-infested swamps in the eastern part of the coastal plain may also be of importance.

4.4 Period after 1883

After the disaster Ujung Kulon remained (even) less populated than before 1883. Food-shortage and reduced workability of the fields were probably important reasons for this phenomenon. Furthermore, regular explosions of malaria and dysentery and a tiger plague (both indicating serious ecological instability) did not make the area very attractive. Migration of people due, to the menace of man-eating tigers in W.Banten about 1885 was described by Meijer (1891, see also Kal, 1910).

In the beginning of this century, the area was finally completely evacuated by Goverment decree. The official explanation for this measure was the outbreak of disease and the tiger plague mentioned above. The real reason, however, according to Hoogerwerf (1970) might have been: to facilitate setting the area aside as a nature reserve. In the meantime, Ujung Kulon had indeed become famous among naturalists and big-game hunters for its extremely abundant wildlife. Regular hunting parties were organized for the happy few of Batavia, and vast areas in the coastal zone were kept free of forest by cutting and burning to satisfy the hunters (and poachers!). This management resulted in an artificial savanna landscape which was known to attract large herds of banteng.

Eventually, in 1921, the Ujung Kulon peninsula became a strict nature reserve and an end was put to most of the hunting activities. Later, in 1937, the status of the reserve was changed into a game sanctuary, apparently to allow more flexibility, especially where the maintenance of the artificial savannas was concerned. On the same occasion, Peucang Island, the Handeuleum archipelago and a strip of land east of Karang Ranjang were newly included in the conservation area.

In 1958, the status of the area was changed back to nature reserve. Long before that, the maintenance of the savannas had been more and more neglected.

Finally, in 1980 the status was changed again to a National Park, which also included Panaitan Island, the Mt.Honje reserve and the Krakatau archipelago.

As already mentioned before, the World Wildlife Fund has played an important role in the conservation and management of Ujung Kulon since 1965. For many years, Prof.Dr. R. Schenkel (Basel University, Switzerland) worked in the area, studying rhino and assisting the Indonesian authorities in setting up a more efficient guard system. He was also extremely active in providing financial and other support for the reserve through the Swiss National Appeal of WWF.

During its history as a conservation area, poaching has always been the major problem in Ujung Kulon. As Hoogerwerf (1970) points out, it brought the Javan rhino to the very verge of extinction several times. When Dr. Schenkel started his programme in 1967, the situation was extremely precarious again. In our opinion, it is beyond any doubt that without his continuous exertions and infectious enthusiasm, the Javan rhino would have

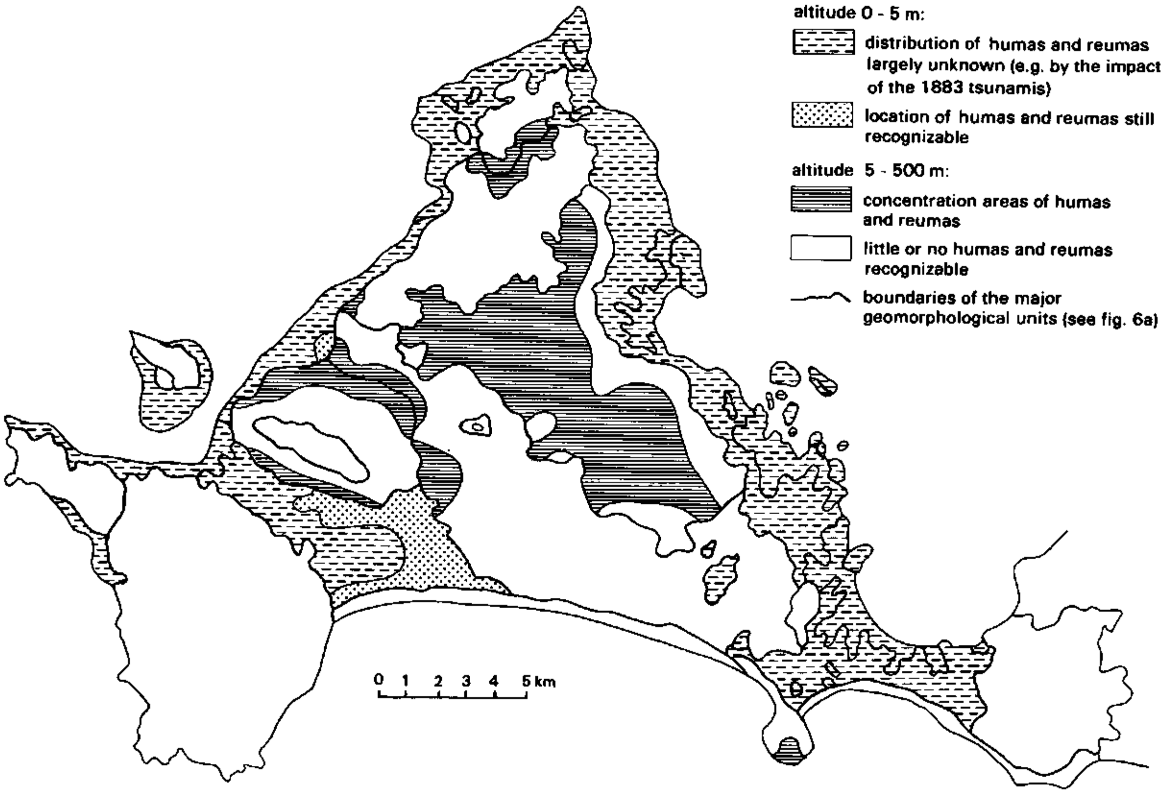


Fig. 4a Location of shifting cultivation sites (humas) and recently deserted fields (reumas) in 1883 (as indicated by the present vegetation).

become extinct several years ago.

After Schenkel, a series of WWF sponsored researchers worked in Ujung Kulon, the present author being one of them and the first to study the area's vegetation in a systematic way.

CHAPTER 5: CLIMATE

5.1 Introduction

Climatological data for Ujung Kulon are scarce. On the other hand the climate of Java as a whole has been studied thoroughly, allowing a readily interpretation of the Ujung Kulon data.

The following sections enumerate the data available, summarize some major approaches to classify the Ujung Kulon climate and indicate in which ways the climate may express itself in the area's vegetation. Finally, we shall try to gather support for our hypotheses on climate-vegetation relations from the distribution of (groups of) plant species, which are considered to be correlated with the various types of climate. The climatological factors which are most important in determining the character of the vegetation in the tropics are temperature and precipitation (Whitmore, 1975; Jacobs, 1981). We shall therefore focus on these two factors. In addition, some attention will be paid to wind and atmospheric humidity.

5.2 Climatological data

5.2.1 Temperature

According to van Steenis (1962) the average temperature in the Malaysian archipelago is about 26.3 °C at sea-level. This corresponds very well with measurements by Ammann (1985) in the forest on Peucang Island from August 1978 to May 1979.

Whitmore (1975) states that in all tropical climates the variation in temperature from one time of the year to another does not exceed the diurnal range. In Indonesia, the averages for the coldest and warmest months do not even deviate more than 1 °C from the yearly average (Schmidt and Ferguson, 1951). Again this corresponds well with the data provided by Ammann.

According to Halder (1975), temperatures outside the forest (i.e. on grazing grounds or in shrublands) do not seem to be higher than inside (at the same altitude).

The more elevated parts of Ujung Kulon can be expected to be slightly colder. Since the average temperature is assumed to decrease by approximately 0.6 °C for every 100 m of elevation (van Steenis, 1962), the temperature range from coast to mountain-top would be about 3 °C in Ujung Kulon. Unfortunately, measurements are not available (but see section 8.4).

5.2.2 Precipitation

Rainfall was recorded for a period of nearly 40 years at the former lighthouse at Java's First Point. However, one may question whether these data are representative of the whole of Ujung Kulon's lowland-area. Hoogerwerf (1970) indicates to a considerable difference in rainfall between the south-western mountain-area and the eastern part of Ujung Kulon. He considers Java's First Point to be part of the mountain-area and therefore the data collected there as not being representative of Ujung Kulon's lowlands. We cannot agree with this opinion. The hinterland of Java's First Point clearly does not belong to the south-western mountain area: amongst other reasons because of its lower altitude (see section 6.3). The (former) lighthouse itself was situated at an altitude of only 40 m (Schmidt and Ferguson, 1951). Moreover, its location was well within the rain-shadow of the mountains, at least during the dry season, i.e. the season in which considerable differences in precipitation between mountains and lowlands occur (see below).

In short, there seems to be no real objection to consider the rainfall data collected at Java's First Point as being representative for the whole of Ujung Kulon's lowland-area. Indeed, rainfall data collected from August 1978 to May 1980 on Peucang Island correspond very well with the data collected at Java's First Point, which were mentioned above (Vogel, 1979; cited from Ammann, 1985).

These rainfall data for Java's First Point show an annual average of 3249 mm (Hoogerwerf, 1970). In most years, the rainfall is very unequally distributed throughout the year. The monthly averages are given in Table 5a. The figures show the strong influence of the eastern monsoon, which causes a dry season lasting from May to September.

Table 5a: Average monthly rainfall at Java's First Point (after: Hoogerwerf, 1970: p. 30)

January	: 443 mm	May	: 171 mm	September	: 141 mm
February	: 377 mm	June	: 178 mm	October	: 263 mm
March	: 325 mm	July	: 130 mm	November	: 351 mm
April	: 258 mm	August	: 138 mm	December	: 474 mm

As mentioned above, Hoogerwerf states that the rainfall in the SW mountain-area is much more abundant than in other parts of Ujung Kulon. This corresponds very well with our own field observations. However, quantitative data are not available. We shall return to this subject while discussing atmospheric humidity (see below).

Hoogerwerf, finally, points to the considerable variation in rainfall from one year to another. In some years there is no dry season at all, while on the other hand extremely dry years are not uncommon. This also fits in well with our own field observations. The dry season of 1982/83 for instance was almost rain-free and unusually long (with only some five to ten rainy days in six months). According to Schenkel and Schenkel-Hulliger (1969) 1967 was an exceptionally dry year.

5.2.3 Atmospheric humidity

For this factor also, only a few exact data are available. Humidity in the forest of Peucang Island was 95 per cent or more throughout the rainy season (Ammann, 1985).

Seasonal variation in rainfall generally runs parallel with a variation in relative humidity (Ewusie, 1980). However, in Ujung Kulon the drop during the dry season is likely to be strongly mitigated by the surrounding seas. Indeed, during periods with no rain in the dry season, Ammann still measured a humidity of 90 per cent in the Peucang forest. However, vegetation structure proves to be of great importance, as far as (fluctuations in) humidity are concerned. In open vegetations such as shrublands and grazing grounds the average humidity is lower, the fluctuations greater. On Cidaun grazing-ground Halder (1975) measured a humidity range of 100 per cent (maximum during the rainy season) to 65 per cent (minimum during a not extreme dry season).

Furthermore, Ewusie (1980) points out that on tropical mountains, atmospheric humidity tends to rise with increasing elevation up to a certain height (which varies in different sites) where it reaches saturation. Here, the forest is engulfed in cloud and drizzle. The cloud cover may be (almost) perpetual, but in Ujung Kulon this is not the case, most likely because of the uncertainty of the sea-winds. The average height of the cloud-cover which regularly engulfs the upper parts of the Ujung Kulon mountains can, according to rough field-observations, be estimated to be only 150 to 200 m.

This very low altitude is explained by the so-called telescope effect. Relatively low, isolated mountain-complexes are known to reflect the vegetation-zoning of higher mountains in a condensed, 'telescoped' way. One explanation of this phenomenon is given by van Steenis (1962): their summits and crests being the highest elevations in a wide expanse of sea, attract the clouds or, in the words of Max Havelaar in his famous speech to the chiefs of S. Bantan: 'mountains suck the clouds down to the earth' (Multatuli, 1860; cited from Jacobs, 1981).

In general, cloud forming in mountain-areas is explained by the uplift of air caused by wind corographic clouds). In the specific case of (low) mountaineous islets, this process is at least partly replaced by cloud formation in convection currents: the differing capacity to absorb 'solar heat initiates strong upward currents (Watts, 1955). The relatively low level of the cloud cover is explained by van Steenis (1972) by the low cloud levels above the surrounding seas.

5.2.4 Wind

The alternation of dry and wet season parallels an alternation of two wind systems (monsoons). During the dry season, the prevailing wind is almost exclusively east to south-east and in the rainy season west to north-west (Hoogerwerf, 1970). During the rainy season, especially between December and March, very strong winds are not uncommon (Blower and van der Zon, 1977). However, no quantitative data for Ujung Kulon are available. For more details on the monsoons in this part of the world, see e.g. Braak (1945).

5.3 Classification of Ujung Kulon's climate

Various attempts have been made to characterize climates and to map them. According to Whitmore (1975), the most widely known and used of world climatological classifications is that of Köppen (see below). However, world climatological classifications can hardly be expected to be sensitive enough to discriminate within a relatively small area. Therefore, it is better to turn to a regional classification system. Four different classifications have published for the island Java which, in addition next to Köppen's system, will shortly be discussed.

5.3.1 Köppen's system

The first version was published in 1901, definite versions in 1918 and 1936. Köppen's system is based on a simultaneous evaluation of temperature and precipitation. The various climatic types are assumed to be correlated with types of natural vegetation.

Five major climatic types are distinguished. The Ujung Kulon climate easily fits into the A-type, i.e. the 'tropical rain climate'. This type is defined by an average temperature in the coldest month (t) of at least 18 °C and an average annual precipitation of at least 20 (t + 14) mm (in areas with summer rains such as Ujung Kulon).

Since no month has an average rainfall of less than 60 mm and the warmest month has an average temperature exceeding 22 °C, the Ujung Kulon climate can further be classified as a 'Afa-climate', i.e. a continuously moist and warm tropical rain climate (cited from Schmidt and Ferguson, 1951).

The applicability of the lower ranks of Köppen's classification system in the humid tropics has, however, proved to be limited. The climatic subtypes coincide insufficiently with the various types of natural vegetation. Their suitability in agriculture and pedology is also limited (Whitmore, 1975). Above all, Köppen's system insufficiently discriminates between climatic types with a dry season of varying strength.

5.3.2 Van Bemmelen's system

A first attempt to specify more precisely the strength of the dry season in the various parts of Java was undertaken by van Bemmelen (1916). A revised version of his climatic map was compiled by Boerema (1931) and more recently published again by van Steenis (1965).

Van Bemmelen's system is based on the number of rainy days during the four consecutive driest months of the year ('RDFCDM'). The revised version discerns seven climatic types; the map scale is appr. 1 : 2,500,000.

As for Ujung Kulon, a differentiation is made in a rather inaccurate way between the western and eastern part, for which respectively the third and fourth wettest types are indicated.

Although van Bemmelen's system in several cases has proved to be useful in correlating both land-use and natural vegetation to climate (van Steenis, 1965), the system was more or less forgotten when theoretically more advanced system came into use (see below).

5.3.3 Mohr's system

In 1933 Mohr published a classification system for tropical climates, especially for those found in Indonesia (revised version in English: Mohr et al., 1972). It is based on differences in the moist regime of the soil, rather than on differences in natural vegetation. Mohr's classification of climate types proved to be very useful for agricultural purposes and was also successfully applied in other tropical regions e.g. Trinidad and Zaïre (Schmidt and Ferguson, 1951).

In addition to Köppen's limit for dry months, i.e. precipitation less than 60 mm (evaporation exceeding precipitation), Mohr introduced a limit for wet months: precipitation more than 100 mm (precipitation exceeding evaporation). With a monthly precipitation between 60 and 100 mm ('a moist month') precipitation and evaporation are considered to be more or less in balance.

Mohr's key to the classification of climatic types is based on the ratio of wet and dry months. Six different types are distinguished. Using the data of not less than 2492 rain guage stations, these types could be mapped for the island of Java at a scale of approximately 1 : 1,500,000.

For Ujung Kulon a continuously moist to wet climate is indicated (type 5, no month with less than 60 mm rainfall), which corresponds with the whole NW coast of Bantam. Only the western part of Ujung Kulon (including the Payung massif and the western hills down to Java's First Point) are considered to be continuously wet (type 6, no month with less than 100 mm rainfall).

As stated before, it seems more appropriate to consider Java's First Point and its hinterland climatologically as a part of Ujung Kulon's lowlands, rather than (as Van Bemmel did as well) of the Payung massif (see section 5.2.2).

In addition, a general shortcoming of Mohr's system is the fact that the significance of a seasonal dry period is underestimated for areas where the beginning and end of the dry season is very irregular (Schmidt and Ferguson, 1951). Ujung Kulon is such an area.

5.3.4 Schmidt and Ferguson's system

The classification system for tropical climates, published in 1951 by Schmidt and Ferguson, can be considered as an improved version of Mohr's system. It is especially more accurate for areas with an irregular dry period (see above).

Like Mohr's system, Schmidt and Ferguson's classification is based on the annual ratio of dry and wet months. However, instead of using the average monthly totals over a period of years, the last authors determine the number of dry and wet months year by year.

Seven successively drier types (A-G) are distinguished. These types could be mapped for the island of Java at a scale 1 : 2,000,000 and for the whole of Indonesia at a scale 1 : 5,000,000. In Java, the climatic range covers the types A to F; E and F climates being of minor importance and completely restricted to the extreme NE.

As for Ujung Kulon, only one type (B) is indicated on this map, based on the data for Java's First Point. However, on closer inspection, Schmidt and Ferfuson prove to deal with Ujung Kulon in a most inaccurate way. Classification of the rainfall data for Java's First Point according to their own key ought to lead to a C-climate, while the map indicates a B-climate and the attached table a D-climate, all for the same area.

Moreover, it would have been more correct to map the upper slopes of the Payung mountain-area as a region with a wetter climate. However, whether we are dealing there with an A or a B-climate is uncertain, because of the lack of quantitative data.

5.3.5 Oldeman's system

The most recent attempt to classify the climate of Java was undertaken by Oldeman (1975). His system in fact combines the merits of all previous regional systems. It uses van Bemmelen's concept of consecutive months (though for the wet and not for the dry season), it uses Mohr's concept of wet, dry and intermediate months (though defined differently) and finally it uses Schmidt and Ferguson's idea of calculating the climatic status of an area year by year and taking the average values of the outcome. Oldeman's system was devised to serve agricultural purposes. As far as known, it has not yet been applied to natural vegetation.

The climate of Ujung Kulon was classified, on the highest level as a B-climate (the second wettest out of five types), meaning there are 7 to 9 consecutive wet months. On a lower level, it was classified as a B2-climate, meaning the number of dry months is 2-4. Even Oldeman made no regional differentiation within our study-area, and this is not due to the scale, which is 1 : 1 000 000, thus larger than the one used by the other authors dealing with the climate of Java.

5.3.6 Utility of these systems

As mentioned above (5.3.1), the climatic subtypes of Köppen's system coincide insufficiently with the various types of natural vegetation. As for the other three regional systems known in 1965, van Steenis investigated the correlation between climatic type and the distribution of a number of selected plant species. He concluded that the differences between the three systems were small. For his further investigations (i.e. the definition of drought-classes for plant-species, he decided to use van Bemmelen's system. Van Steenis' conclusion is contradicted by Whitmore (1975) who, applying the system of Schmidt and Ferguson to the whole of the tropical Far East, concluded that no other climatic scheme yet developed gives a better correlation with the range of vegetation typen. As stated before, Oldeman's system has not yet been applied to natural vegetation.

As for the specific case of Ujung Kulon, we must point to a general shortcoming of all four systems: they all classify the climate according to the situation in an average year, thus neglecting the ecological significance of the incidental occurrence of a climatologically exceptional year, such as an exceptionally pronounced dry season. Several authors, e.g. Whitmore (1975) and Jacobs (1981) stress the significance of such rare climatic events.

5.4 Ecological significance

In this section, we will try to formulate an ecological interpretation of the information presented above. Above all, we will focus on the question of the natural climax vegetation, as far as this is determined by climatic factors.

5.4.1 The lowlands

In the previous sections it has been suggested that the climatological data for Java's First Point can be considered as being representative of the whole of Ujung Kulon's lowlands. Classification of these data according to both van Bemmelen (1916) and Schmidt and Ferguson (1951) leads to a climate with a distinct dry season. Whitmore (1975), using Schmidt and Ferguson's system, points out that in general such a climate inhibits the growth of rain forest, in favour of a so-called monsoon forest.

Van Steenis (1965) states more specifically that on Java the growth of rain forest is bound to climates with at least '(30 to)40' rainy days during the four consecutive months of the year. Java's First Point with 30 to 40 RDFCDM (Van Bemmel, 1916; in: van Steenis, 1965) is thus just on or below the limit.

In such a borderline case the occasional very dry season which occurs in Ujung Kulon may be of great importance in inhibiting the growth of rain forest.

Moreover, it is interesting to note that the extensive teakforests of Central and East Java (a typical form of monsoon forest) mapped by van Steenis (1965) show a remarkable correlation with Schmidt and Ferguson's C-climate, i.e. the climate of Ujung Kulon's lowlands.

Summarizing, we may state that it is most likely that the climax vegetation of Ujung Kulon's lowlands is a monsoon forest. Thus van Steenis (1965) is wrong in mapping the whole of Ujung Kulon as a rain forest.

5.4.2 The mountains

With increasing altitude, the climate changes and obviously the vegetation changes along with it. In Java the vegetation-altitude relations are fairly well understood thanks to the effors of van Steenis, who published widely on the subject (e.g. 1934, 1935a, 1961a, 1962, 1965, 1972). Although van Steenis mainly focussed on the higher altitudes, it is also easily possible to extrapolate his conclusions to lower altitudes.

The 'telescope' effect, described by van Steenis refers to rain forest covered 'low' mountains of 800 to 1000 m high. There, the telescoped zoning is a matter of physiognomy rather than floristics. However, in the case of Ujung Kulon, with mountains up to appr. 500 m, the effect is different. As described above, the strength of the dry season inhibits the growth of rain forest in Ujung Kulon's lowlands, but the strikingly trifling height of the clouds in the Payung mountain area (150 to 200 m on average) guarantees a higher atmospheric humidity (i.e. a lower evaporation) and a more equal distribution of rainfall throughout the year. This clearly explains the growth of rain forest on the upper slopes of Mt.Payung.

So, in Ujung Kulon the telescope effect brings about a transition from monsoonforest to rain forest at an altitude of only 150 m. Of course, such a transition is not only a matter of changing physiognomy, but also involves a change in floristic composition.

In addition, the 'normal' telescope effect can also be observed in Ujung Kulon: the vegetation of the highest summits more or less imitates the physiognomy of forest types generally bound to far higher altitudes.

In the same, region a change in floristic composition can be observed. However, this may be partly a matter of coincidence. The altitude of 500 m presents in Javan rain forests a transition from the lowland to the colline zone (van Steenis, 1972). Such demarcations can be defined relatively precisely, as the altitudinal distribution of rain forest species mainly depends on temperature, a factor assumed to be most strictly correlated with altitude in the humid tropics (van Steenis, 1962). However, there are strong indications that on mountains showing the telescope effect, the situation is more complicated. We shall return to this subject in section 8.3.2.

Real mountain forest is not to be expected in Ujung Kulon. In Java, the montane zone is defined between 1500 and 2400 m (van Steenis, 1965). On relatively high mountains, montane species may descend to much lower altitudes (van Steenis, 1961), but on 500 m high Mt.Payung this is certainly not the case. Even so, the altitudinal range of many species on Mt.Payung is very aberrant in comparison to their range on other Javan mountains. Again, we can refer to section 8.3.2. for more details.

5.4.3 Local wind influence

An outline of the various ways in which wind influence may alter normal vegetation development in the tropics is given by Ewusie (1980). The major mechanisms being mechanical destruction, dessication and salt-spray, wind influence is most prominent in coastal and steeply mountaineous areas.
In Ujung Kulon, several examples can be encountered. Stunted tree-growth and tangles of compact vegetation occur locally on peaks and ridges. Thus in summit-regions wind-influence reinforces the telescope effect mentioned above. All along the seashore 'normal' vegetation development is inhibited mainly by the influence of the sea winds. Locally, this influence is extended inland: on Peucang Island a transitional forest type with a conspicuously aberrant flora is found (see section 9.3.XI). On the steepest and most exposed slopes on the outskirts of Mt.Payung and on the southern beach ridge vegetations occur which are characterized by a scarcity of emergent trees and an abundance of wind-cut shrubs.

Incidental destruction of trees covering many hectares ('storm-forest') as reported for nearby Panaitan Island (Blower and van der Zon, 1977) is not known from Ujung Kulon. However, in recent years a great deal of wind damage has been observed in the coastal plain of Peucang Island. Hoogerwerf (1972) suspects the construction of a food-path across the island to be the reason for this phenomenon, but this is very unlikely. The unusual homogeneity in age-classes of the forest trees as a result of the partial destruction of the forest by the 1883 tidal waves seems a better explanation.

5.5 Species and species-groups as climate indicators

5.5.1 Drought classes of plant-species

A classification of (a number of) Javan plant-species was published by van Steenis (1965). It is based on a comparison of unpublished plant distribution maps by Backer and the climate map of Java by van Bemmelen (1916). The list does not claim to be complete; it merely provides examples. An outline of the seven classes of climate indicators as defined by van Steenis and their representation in our area is given in table 5b.

Now, it is interesting to investigate if a correlation exists between the distribution of the indicator species and altitude. An outline of the altitudinal range within which the indicator species were encountered is given in table 5c. Isolated finds well outside their proper distribution area are given in brackets. Species which are indifferent to climate (class 0) are omitted.

When analysing these data we must take into account that our sample points are far from homogeneously distributed over the area as far as altitude is concerned. Ignoring this fact may lead to false conclusions, especially where the distribution of relatively rare indicator species is concerned. A practical solution to this problem is to focus on altitudes above 5 m. Above this (still very low) altitude it is easy to distinguish ecologically relevant altitudinal zones with comparable numbers of sampling points (see table 5d).

Table 5b Drought classes of plant species as defined by van Steenis (1965)

Class	Definition	Climate types*	RDFDCM**	Number in Java***	Number in Ujung Kulon	%
0	Indifferent to climate	I-VI	80-0	12	5	42
1	Bound to everwet conditions (not tolerant of even a feeble dry season****	I-III	80-30(-20)	184	26	14
2	Everwet, but tolerant of a feeble dry season	II-IV	40-20	3	0	0
3	Preference for a pronounced dry season	II-V(-VI)	30-10(-5)	9	1	11
4	Preference for a rather strong dry season	III-V(-VI)	30-5(-0)	39	5	13
5	Bound to a strong dry season	IV-VI	20-0	43	1	2
6	Semi-arid, bound to a severe dry season	V-VI	10-0	16	0	0
			Total:	306	38	12

* defined by van Bemmelen (1916)
** rainy days during the four driest consecutive months of the year
*** as provided by van Steenis; see text
**** note that this addition to the definition is in contradiction with the range of climatic types: type II is characterized by a feeble, type III by a slight dry monsoon

Species bound to ever-wet conditions

The total number of such species in Ujung Kulon is, as far as is known, 26. However, we used only 23 in our calculations. Gnetum cuspidatum and Sterculia urceolata are omitted because their distribution in Ujung Kulon is insufficiently known. During the fieldwork, both species were confused with related ones and in our vegetation table they have been included in species-groups (e.g. Gnetum spec.).

Moreover, Aglaia latifolia has been omitted since its classification as an indicator of ever-wet conditions is undoubtedly erroneous. According to Backer & Bakhuizen van den Brink (1965) and our own experience, the species prefers periodically very dry localities.

Table 5d clearly proves that the number of wet climate indicators increases with altitude. Even so, several species are rare or even absent at higher altitudes. Many possible reasons may be put forwarded for this phenomenon, lack of suitable soil conditions or vegetation structure at higher altitudes, lack of data (in the case of rare species), etc. However, if we assume that as far as the climate is concerned there is no upper limit to the potential area of *all these species (within Ujung Kulon's range of altitudes), it becomes* relevant to present the same data in a cumulative way, as done in fig. 5a. This figure shows a rapid increase of 'wet' indicator species between 100 and 200 m and a second, less spectacular increase above 400 m. This suggests the presence of a climatological boundary at these altitudes and corresponds very well with our observations on the physiognomy of the vegetation, which was also assumed to reflect a climatological zonation (see section 5.4).

Species preferring a periodically dry climate

The total number of drought-indicating species in Ujung Kulon is only 7, belonging to three different classes as defined by van Steenis (i.e. class 3, 4 and 5). This low number does not imply that drought indicators are less well represented in Ujung Kulon. The total number of drought-indicating species for Java as provided by van Steenis is relatively small. However, the percentage of the total number occurring in Ujung Kulon is comparable with the percentage of wet-climate indicating species in the area (see table 5b:

drought classes 1, 3 and 5).

Still, even for our primitive statistical approach a total of seven species is rather insubstantial. Additional data can be derived from a list of plants considered to be characteristic for the monsoon forest on Java, also provided by van Steenis (again, this list is not complete but provides examples). Of course, this list shows a considerable overlap with the list of drought indicators. However, the overlap is incomplete. Apparently, for some species, no distribution maps were available. We may conclude from the climatological definition of a true monsoon forest, that these additional indicator species belong to drought class 3 or more.

The additional indicator species used in our calculations, are registered with their altitudinal range in table 5c. Not included are species which are a relic of a former cultivation, e.g. Tamarindus indica which occurs on Handeuleum Island and Tectona grandis, which is said to grow very locally on the outskirts of the reserve, near Tamanjaya. Also omitted are Albizia lebbekoides which is mentioned for Ujung Kulon by Satmoko (1961), but for which no proof or further details could be found and Ailanthus integrifolia, of which the distribution is insufficiently known (see Appendix C). Besides, it is questionable whether the latter species, which is on the whole very rare in Java, but has been found twice at approx. 350 m on Mt.Payung is rightly classified as a monsoon plant.

To analyse the distribution of the drought-indicating species (both proper and additional) we may procede in a way similar to our analysis of the wet climate indicators. From tables 5c and 5d it becomes obvious that the number of drought indicators is inversely correlated with altitude. Above 200 m they are completely absent. In fig. 5a the distribution of drought-indicating species in relation to altitude is presented in an inversely cumulative way. The main conclusion from this line is that it is obviously a good counterpart of the one for the wet climate indicators. However, three points merit comment.

In the first place, the high number of drought-indicators between 0 and 5 m. is not only due to the high density of sampling points in this zone. We should also realize that several habitats in which the impact of a dry period is of great importance, is restricted to this zone, e.g. grasslands and herbaceous swamp vegetation. We will return later to this point when discussing the distribution of annual plants (see section 5.5.2).

Furthermore, it is interesting to note that some of the highest records of drought indicators refer to small patches of relatively young secondary vegetation, e.g. Pterospermum diversifolium in a former clearing in the Payung area (plot 134; alt. 200 m) and Ervàtamia floribunda in a former ladang on the highest parts of the Telanca massif (plot 313; alt. 125 m).

Apparently, the outskirts of the rain forest area suffer more from a dry spell (even a slight one) when the forest cover is damaged. Again, we will return to this subject when discussing the distribution of deciduous trees (see also section 5.5.2).

Finally, we should point to the fact that in the lowlands, where both drought indicators and indicators of an ever-wet climate seem to grow together, soil conditions and micro-climate are obviously very important factors. For instance, the drought indicator Buchanania arborescens is best represented (with a coverage of up to 90 per cent) on the periodically very

Tabel 5c: Altitudinal distribution of climate indicating species

Drought class	Species	Altitudinal range (m)
1	Aglaia latifolia (Meliaceae)	2-25
1	Antidesma velutionosum (Euphorbiaceae)	(75-) 150-500
1	Ardisia blumii (Myrsinaceae)	120-350
1	Cryptocarya densiflora (Lauraceae)	200-300 (-450)
1	Dalbergia pinnata (Papilionaceae)	2-475
1	Dinochloa scandens (Poaceae) 1)	2-500
1	Diospyros frutescens (Ebenaceae)	(5-) 150-500
1	Ficus deltoidea (Moraceae)	450-500
1	Ficus obscura (Moraceae)	80-250
1	Glochidion rubrum (Euphorbiaceae)	65
1	Gnetum cuspidatum (Gnetaceae)	?
1	Heterosmilax micrantha (Smilacaceae)	475
1	Horsfieldia glabra (Myristicaceae)	(90-) 200-350
1	Knema laurina (Myristicaceae)	5
1	Lindernia ruelloides (Scrophulariaceae) 1)	3-4; 60-75
1	Litsea noronhae (Lauraceae) 1)	1-350
1	Macaranga javanica (Euphorbiaceae)	200
1	Macaranga triloba (Euphorbiaceae)	350
1	Meliosma nitida (Sabiaceae)	(75-) 150-500
1	Pometia pinnata (Sapindaceae)	3-350
1	Pternandra azurea (Melastomaceae)	150-250
1	Spatholobus ferrugineus (Papilionaceae)	6-100
1	Sterculia coccinea (Sterculiaceae)	150-500
1	Sterculia macrophylla (Sterculiaceae)	3-120
1	Sterculia urceolata (Sterculiaceae)	?
1	Tinomiscium phytocrenoides (Menispermaceae)	1
3	Dactyloctenium aegyptium (Poaceae)	5
4	Bacopa monnieri (Scrophulariaceae)	½-1
4	Buchanania arborescens (Anacardiaceae)	½-150
4	Celastrus paniculatus (Celastraceae)	2
4	Cynometra ramiflora (Caesalpiniaceae)	0-75 (-125)
4	Sterculia foetida (Sterculiaceae)	20-75
5	Ervatamia floribunda	1-125
-2)	Cordia dichotoma (Boraginaceae)	½-75 (-125)
-	Corypha utan (Arecaceae)	½-70
-	Pterospermum diversifolium (Sterculiaceae)	1-150 (-200)
-	Tetrameles nudiflora (Datiscaceae)	?3

1) Species with a strikingly discontinous distribution

2) Additional drought indicators, see text.

Tabel 5d Distribution of climate indicating species over altitudinal classes')

Alt.classes	0-5	6-25	26-50	51-100	101-500	Total
number of sampling points	182	48	37	36	33	336
%	56	14	11	11	10	100
number of wet climate indicators	8	5	6	9	13	23")
number of drought indicators	10	7	7	7	3	11

') Isolated founds far outside their proper distribution area have been ignored (see text and table 5b).

") Three species have been omitted here (see text).

dry soils of the uplifted pseudo barrier reef in the northern part of the area. On the other hand, some of the most common wet-climate indicating species occurring on low altitudes (Litsea noronhae, Linderna ruelloides and less clearly Pometia pinnata) show a remarkable preference for swampy sites or wooded river banks. Both habitats are presumably characterized by a relatively high atmospheric humidity.

5.5.2 Life forms and deciduousness

As stated in section 2.3.3 it is (at present) not possible to give life-form-spectra (sensu Raunkiaer) for all plant communities of Ujung Kulon. Such an approach would yield interesting information on the adaptation of each vegetation type to the stress of the unfavourable season and thus indirectly to the unfavourable (i.e. the dry) season itself. Still, it is possible to give some main lines, especially concerning the altitudinal zones.

Obviously, the phanerophyta and to a lesser degree the chamaephyta are the predominating life form classes in Ujung Kulon. In the forests, including those on low altitudes, other life forms are virtually missing. This corresponds with the observation of Ammann (1985) that underneath the canopy of the lowland forest of Peucang Island, humidity does not fall below 90 per cent even in the dry season. This means that generally there is not a very severe seasonal stress caused by drought (favouring hemicryptophyta, geophyta and therophyta) on the forest floor. However, there is a notable difference between the forests of the relatively wet mountains and the seasonally dry lowlands. On the forest floor of the rain forests of Mt.Payung (above 150 m), low perennial herbs and other chamaephyta occur in great abundance. On lower altitudes they are scarce, there the undergrowth (if any) is dominated by (young stages of) phanerophyta, indicating a less constant and favourable micro-climate.

Outside the forests, the situation is entirely different. Here, hemicryptophyta and therophyta occur in large numbers. In grasslands and other low herbaceous vegetations, they even dominate the vegetation. This corresponds well with Halder's observation that in such open vegetations (ocurring on low altitudes only) the humidity may fall to 65 per cent (and probably even lower) during the dry season.

The distribution of the annuals (therophyta) is in this respect the most significant. Of the 16 members of this group occurring in Ujung Kulon all are completely restricted to the seasonally dry lowlands and only one (Benincasa hispida) reaches 150 m. All the others are restricted to very low altitudes (5 m. or below), mainly because the habitats in which herbs are most vulnerable to seasonal drought (i.e. low herbaceous vegetations without tree or shrub cover of significance) are restricted to these altitudes: 25 per cent of the annuals is bound to the herbaceous swamp vegetations of the depressions, 56 per cent to grassland vegetations. The difference in percentages between (relatively dry) grasslands and swamp vegetations reflect the reinforcing, respectively mitigating effect of edaphic factors on the seasonal drought.

As for the fifth life-form class, the geophyta, no such relation to climate could be found. Although van Steenis (1965) states that in seasonal forests there is an abundancy of geophyta, this is certainly not the case in Ujung

Kulon. One of the most common and conspicuous geophyta of the area, Amorphophallus variabilis, shows even a clear preference for the higher altitudes. On the other hand, the group of so-called 'potential geophyta' (see section 2.3.3) is obviously best represented in the shrubvegetations of the lowlands.

A further indication of seasonal stress caused by drought can be obtained from the distribution of deciduous trees. All deciduous trees and bamboo vegetations (which are also mostly deciduous) are restricted to the seasonally dry lowland zone, i.e. to altitudes below 150 m. There are but two exceptions. Spondias pinnata can locally be observed on or near the ridges of Mt.Payung, but is there probably an indicator of banteng activity rather than climate. Second, Ficus racemosa was once observed at an altitude of 250 m (plot 115). Its habitat there, however, is a very exposed and (by natural courses) disturbed site with a shrubby vegetation. This agrees well with our observations on drought-indicating species in damaged parts of the rain forest (see section 5.5.1).

5.6 Altitudinal zonation (conclusions)

From the results of the statistical manipulations presented in the previous sections we may conclude that indeed two main climatological zones can be distinguished in Ujung Kulon:

- 0-150 m. the seasonally dry lowlands;
- 150-500 m. the ever-wet mountains.

The floristically determined boundary (the 150 m contour) coincides with a change in physiognomy of the vegetation which can also be interpreted as a climatological demarcation. However, three critical annotations should be made:

First, the proposed climatic demarcation line also coincides to some extent with the boundary between primary and secondary forest. We shall return to this subject in chapter 9.

Second, one should realize that the seasonally dry lowlands are climatologically to be considered as borderline-cases in which the incidental occurrence of a very severe dry season forces succession in general towards a monsoon forest as climax vegetation. However, locally elements of an ever-wet climate may be found, mainly due to favourable edaphic conditions.

Third, it should be stressed that the term 'mountains' as used in this study has a pure regional significance. For Java as a whole, van Steenis (e.g. 1972) puts the lower limit of his floristically defined orographic montane zone at 1000 m. In his terminology the whole of Ujung Kulon can be considered as 'lowland' with the summits of Mt.Payung just touching the lower limit of the colline zone.

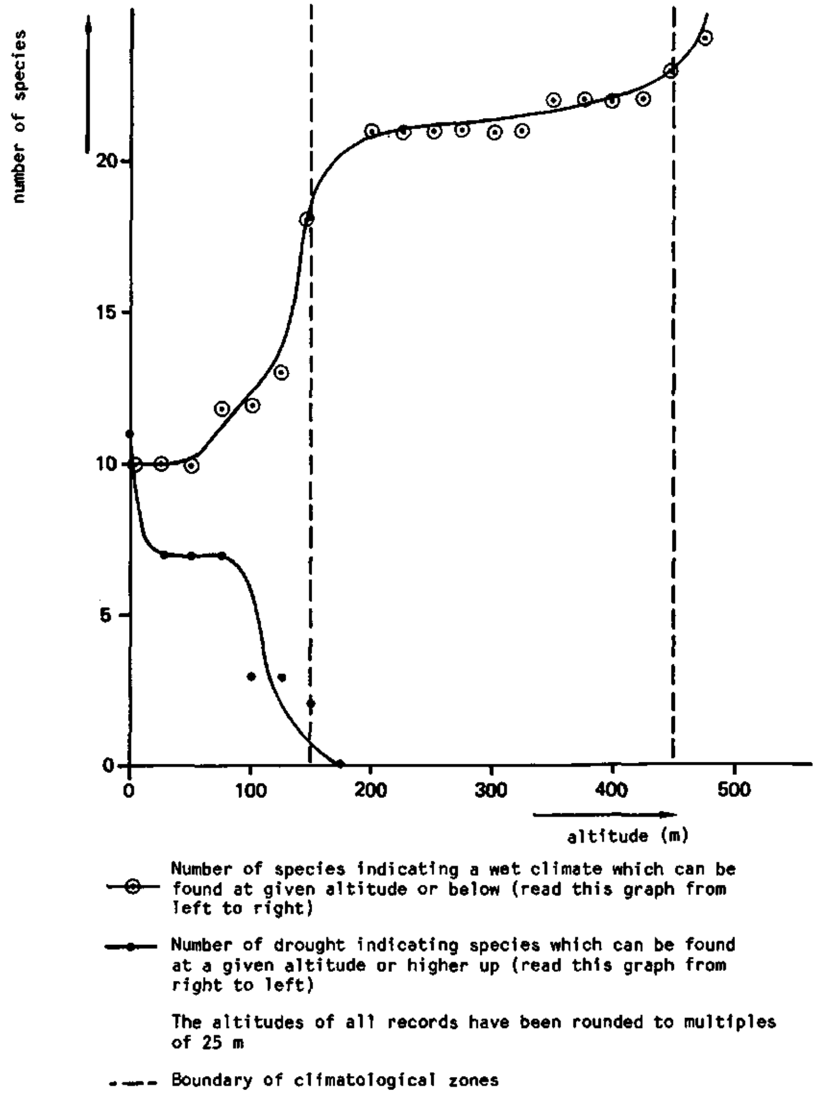
As far as the subdivision of the proposed main zones is concerned, a summit subzone may be distinguished above the 450 m. contour. This boundary has been chosen rather arbitrarily, since it fits well into the gradual change in physiognomy at this altitude and represents a clear demarcation as far as plant-communities are concerned (see Chapter 9).

Although a clear floristic boundary can be observed at 5 m. we refrain from using this contour for subdividing the lowlands as it can clearly be correlated with the upper limit of habitats which are mainly defined by edaphic factors or activities of nature management. Moreover, the climatological significance of a 5 m countour is likely to be negligible.

Finally, it is interesting to note that a substantial part of the areas flora as a whole respects the 150 m contour as a boundary.

Approximate percentages for species, found to be restricted is the lowlands, indifferent with regard to the boundary and restricted is the mountain zone are respectively 65, 15 and 20 per cent respectively. Isolated localities far outside of the normal distribution area of each species are neglected in this calculation.

Fig. 5a Numbers of climate indicating species in relation to altitude, presented in a cumulative way



—⊙— Number of species indicating a wet climate which can be found at given altitude or below (read this graph from left to right)

—●— Number of drought indicating species which can be found at a given altitude or higher up (read this graph from right to left)

The altitudes of all records have been rounded to multiples of 25 m

- - - Boundary of climatological zones

CHAPTER 6: GEOLOGY AND GEOMORPHOLOGY

6.1 Introductoion

Within the framework of this study, the geological history of Ujung Kulon is of importance for two reasons. In the first place it explains the present diversity of geomorphological units ('landforms'). Furthermore, it throws some light on the phyto-geographical position of the area.

From a geological point of view, Ujung Kulon is a very young area. Its oldest rock-formations date back only to the Miocene (Verstappen, 1956a; see below). Furthermore, it was only by the end of the same period that in this region for the very first time land emerged above sea level, allowing the establishment of terrestrial life.

An account of the major geological processes from the Miocene onwards, focussing on both landscape development and aspects which are of phyto-geographical importance, is given in section 6.2, an enumeration of present landforms in section 6.3.

For a more complete discussion of the geology of (West) Java, we can refer to e.g. van Bemmelen (1949).

6.2 Geological history (Miocene-hodie)

An outline of the geological history of Ujung Kulon, focussing on landscape-development (geomorphology) is given by Verstappen (1956a). His work is based on the 1947 aerial photographs, topographical and sea maps, older literature and his own field observations.

As major older references Verstappen mentions: Junghuhn (1852-1854), who visited Cape Layar and gave the first physiographic descriptions, Aquasi Boachi (1855), who mentioned the occurrence of coal along the Bay of Peucang and Verbeek & Fennema (1896), who published data on Ujung Kulon in their 'Geological description of Java and Madura'. Other authorities on respectively the geology and geomorphology of Java, such as van Bemmelen (1949) and Pannekoek (1949) hardly touched upon Ujung Kulon.

Up to the present day, Verstappen's study has remained the basic work on Ujung Kulon's geology and geomorphology. His views were unchanged by Hoogerwerf (1970) and Pellek (1977). In this respect, it is curious to note that the latter author does not explicitly mention Verstappen's study. Verstappen's views can be summarized as follows:

The oldest part of Ujung Kulon is the south-west hilly region, including the Mt. Payung 'mountain' range. Together with Mt. Honje and parts of Panaitan Island, it is a remnant of a former more extensive land area, composed mainly of sedimentary rock, which dates back to the Miocene. However, due to fissure eruption, some eruptive rock is also present. For more details on the complex lithology of this region, see the next section.

During or after the Pliocene marine strata, mainly marls were deposited around this massif. The lifting of parts of the area covered with these sediments gave rise to the present central plateau and uplands. The plateau is strikingly tilted towards the north-east.

Along the south coast, a deviation from the plateau can be encountered: a raised bar of calcareous sandstone. Both wind and surf have acted upon this bar. Where the surf influence has been predominant, the sandstone beds have been truncated to a platform; where the influence of the wind has been predominant, the sand, which originated due to weathering of the sandstone, has been blown up to sand dunes.

The remaining part of Ujung Kulon was formed more recently. The most important process took place during the Holocene: the upheaval of a 'pseudo-barrier reef' and its lagoon, which resulted in the formation of a coastal plain along the north and east coast of the peninsula.

Not mentioned by Verstappen (because of their minor significance for the landscape-development) are the considerable fluctuations in sea level during the Pleistocene. These fluctuations were due to the alternation of glacial and interglacial periods. According to Haile (1971; cited from Whitmore, 1975) sea levels around the Malay peninsula have been periodically lower than they are now by up to 100 m. Consequently, much of the Sunda- shelf (i.e. the continental shelf on which the Malay peninsula, Sumatra, Borneo, Palawan and Java are situated) has been at times dry land.

The situation during the periods with high sea levels (the interglacials) is less clear. Van Steenis (1965), on the ground of phyto-geographical data suspects that the island of Java consisted of an island-arc for a long time (see also Chapter 8). However, there is no evidence that at any time during either Pleistocene or Holocene, sea levels were more than 3 m higher than they are at present, at least round Malaya (Haile, 1971). This corresponds well with Yancey's statement (1973; cited from Whitmore, 1975) that about 5000 to 6000 years ago (i.e. earlier in the present interglacial period, the Holocene) the sea level was about 3 m higher than it is now over much of 'Sunda- land'.

Obviously, such fluctuations in the sea level resulting at one time in land-bridges, at another time in geographical boundaries have been of enormous importance for the distribution of plants and animals (see also chapter 8).

6.3 The landforms

The following outline of geomorphological units ('landforms') is for the most part based on the views of Verstappen. However, the use of much better aerial photographs than those available in 1956a and a large amount of terrain data, enabled us to make some additions and corrections.

Compared with Verstappen's account, the landforms III, V and VIII are new (see below). Moreover, the latter author underestimates the size of the alluvial plain (landform VI; see also section 4.3) and wrongly considers the Tereleng peninsula to be a tombolo (i.e. a sandbar connecting an island to the mainland; Desaunettes, 1977).

The location of the various landforms is shown in fig. 6a. As for nomenclature, there is no such thing as a world-wide accepted check-list of landforms. Although a catalogue of landforms for Indonesia is available (Desaunettes, 1977), the nomenclature used in this study is based on the subdivision of landforms, used in soil mapping legends as proposed by Sombroek & Van de Weg (1980). The latter system has the advantage of being less technical and therefore being more accessible to the ecologist.

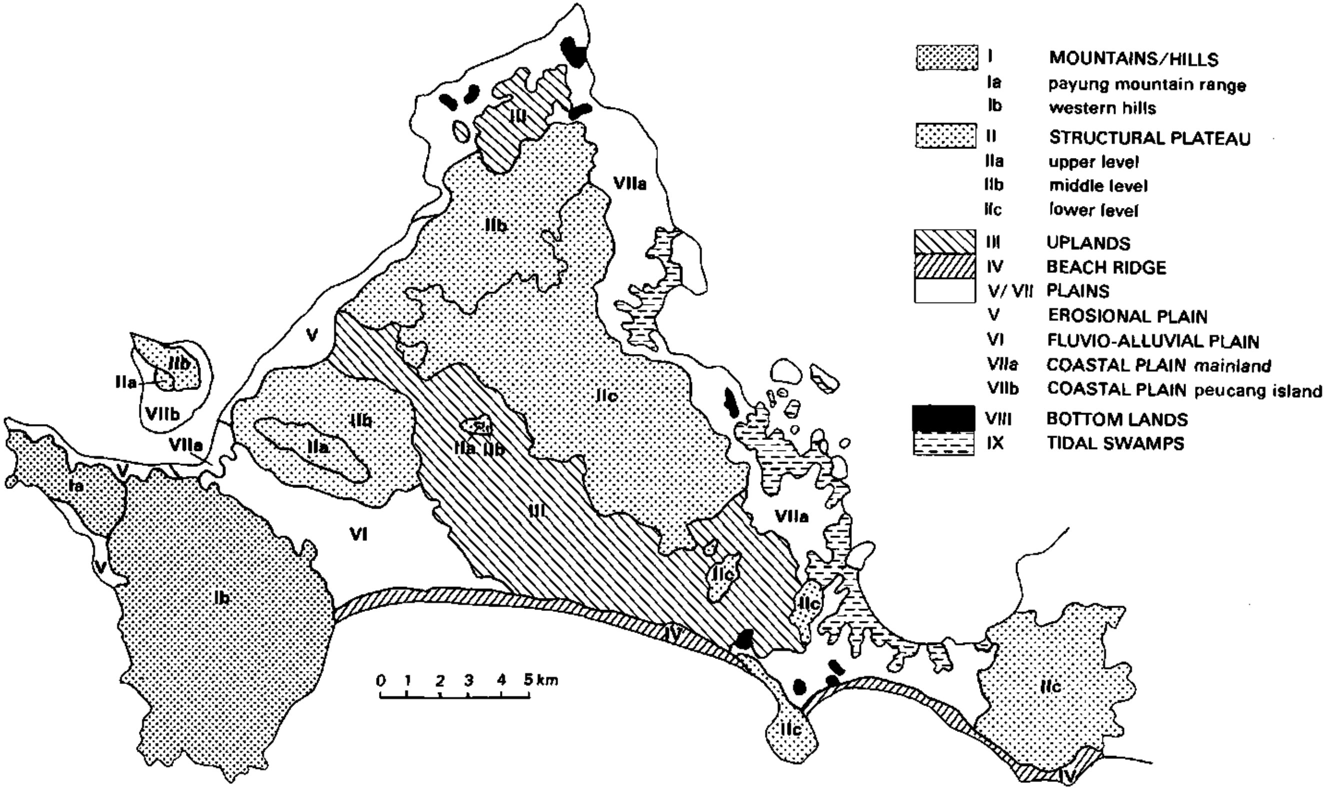


Fig. 6a Geomorphological map of Ujung Kulon

I. Mountains and hills

Lithology: mixed sedimentary and eruptive rock of various types.
We can distinguish two sub-units:

a. the Payung 'mountains'
   Lithology: mainly tuff; eruptive rock (e.g. basalt) is only locally present.
   Max. altitude: 500 m.
   Relief type: steeply dissected to mountainous.
   Relief amplitude: 100 to 350 m.
b. the western hills.
   Lithology: mainly tuffs in the relatively high, most western part and eruptive rock (probably andesite) in the lower parts bordering upon the Mt. Payung massif. The tuffs of the western hills seem to be younger than those of Mt. Payung (Buurman, pers.comm.).
   Max. altitude: 150 m.
   Relief type: hilly.
   Relief amplitude: 25 to 150 m.

II. Structural plateau

Part of the central calcareous area.
Lithology: marls (calcareous rock).
We can distinguish three sub-units or levels:

a. upper level, strongly dissected with crest-like parts.
   Max. altitude: 150 m (Gn. Telanca), 100 m (Gn. Telanca 2), 40 m (Peucang Island).
   Relief type: steeply dissected.
   Relief amplitude: 10 to 25 m.
b. middle level, mainly undissected plateau.
   Max. altitude: 100 m (Telanca), ?75 m (Karang), 20 m (Peucang Island).
   Relief type: almost flat.
   Relief amplitude: 0(to 10) m.
c. lower level, mainly dissected plateau.
   Max. altitude: 50 m.
   Relief type: almost flat to steeply dissected.
   Relief amplitude: 0 to 20 m.

Note: On the lower level of the plateau locally soils are present which to a certain extent resemble the soils of the uplands. Though not as poorly drained as the real upland soils they may have developed in marine sediments instead of in weathered rock (see below).

III. Uplands

Part of the central calcareous area.
Lithology unclear. The uplands may possibly be considered depressions in the central plateau. The parent material is unknown, but drainage and erosional features as well as some specific characters of the soil profile seem to indicate that the upland soils have developed into heterogeneous, calcareous, marine sediments (Buurman, pers.comm.).
Max. altitude: 50 m.

Relief type: partly rolling, partly hilly; with distinctly convex slopes.
Relief amplitude: 10 to 25 m.
Note: It is dubious whether the elevated parts west of Jamang (i.e. in the N.part of Ujung Kulon) really belong to the uplands as indicated in fig. 6a. Both in soil characteristics and relief type the area more or less forms an intermediate between plateau and uplands.

IV. Beach ridge

(partly a truncated platform, partly sand dunes).
Part of the central calcareous area.
Lithology: calcareous sandstone; sand.
Max. altitude: 8 m (platform); ? 50 m (dunes).
Relief type: almost flat (platform); rolling to hilly (dunes).
Relief amplitude: 5 to ?50 m.
Note: From a geologist's point of view, the difference between the structural plateau and this beach ridge is probably rather insignificant (Buurman, pers.comm.).

V. Erosional plain

Along the north and west coasts of the more elevated areas, i.e. the 'mountains and hills' (I), the 'structural plateau' (II) and the 'uplands' (III) a wave-cut plain has been formed, giving the impression of a narrow coastal plain. However, since it was not formed by marine sedimentation, but by erosion it should be referred to as an 'erosional plain' (Sombroek, pers.-comm.).
Lithology: see I, II and III.
Max. altitude: 10 m.
Relief type: almost flat to undulating.
Relief amplitude: 0 to 5 m.

VI. Fluvio alluvial plain

Lithology: various alluvial sediments, originating from Ia and IIa/b.
Max. altitude: 5 m.
Relief type: (almost) flat.
Relief amplitude: 0 m.
Note: It is not unlikely that locally in the fluvio-alluvial plain soils are present which have developed in weathered rock but have not been recognized as such during the fieldwork.

VII. Coastal plain

Lithology: various marine sediments including coral.
Max. altitude: 2 m.
Relief type: (almost) flat.
Relief amplitude: 0 to 1 m.
We can distinguish two sub-units:

a. on the mainland an uplifted 'pseudo barrier reef' with its lagoon filled with sediments varying from coral debris to clay. (Opposite Peucang Island a more or less similar coastal plain, but smaller, is present. Instead of a raised coral reef, one finds there a beach wall of sand and coral debris in front of a kind of lagoon).

b. on Peucang Island: an uplifted and weathered coral flat.

VIII. Bottomlands

Depressions in the coastal plain of the mainland (VIIa), seasonally flooded and influenced by brackish water.
Lithology: marine sediments (mainly calcareous clay).
Max. altitude: 1 m.
Relief type: flat.
Relief amplitude: 0 m.
Note: Deeply buried Krakatau ash in some of the profiles indicate very rapid sedimentation processes in this environment.

IX. Tidal swamps

Areas influenced by incursions of salty water.
Geol. age: Holocene.
Lithology: peat of various depths on marine sediments (mainly clay).
Max. altitude: 0 m.
Relief type: flat.
Relief amplitude: 0 m.

CHAPTER 7: SOILS

by H. van Reuler* and P.W.F.M. Hommel

7.1 Introduction

This chapter deals with the various types of soil which can be found in Ujung Kulon. Section 7.2 gives a concise literature review. The main section (7.3) enumerates the soil types, encountered during our survey. Please note that these types resulted from a classification of point observations. The major objective of this classification is to produce a soil typology that can be compared with the typology for other land attributes, especially vegetation, eventually resulting in the compilation of a landscape-unit legend.

The classification of soil types is thus not meant to serve as a legend for a soil map in the strict sense (see Chapter 2). This implies that in some cases soil types with a very limited extent are described. For the compilation of an ordinary soil map these soils are of little significance and may even be neglected in the accompanying report. For the landscape ecologist, however, such soils may provide crucial information on the relation between soil, vegetation, etc.

The characterization of the soils of Ujung Kulon is greatly complicated by the fact that over large areas the original profiles have been covered with a 0 to 30 cm thick layer of volcanic ash, originating from the 1883 Krakatau explosion. This ash layer was neglected in the process of soil classification, the results of which are presented in section 7.3. This was done primarily because, in general, the vegetation shows a far better correlation with the underlying, original profile, than with the present thickness of the ash cover. Even so, the ash layer is considered to be of great ecological significance and cannot simply be ignored. Therefore, some of the most important aspects of this layer are discussed briefly in a separate section (7.4). A more detailed description of the ash layer, its spatial variation and ecological significance will be published elsewhere. Finally, in section 7.5 some attention will be paid to another aspect of (some of) the area's soils, which is not apparent from the classification presented in section 7.3, viz. their (assumed) vertic properties.

7.2 Literature review

The soils of Ujung Kulon have, up to now, been studied in far less detail than the soils of many other parts of Java. This may be due to the remote and inaccessible character of the area.

The first studies dealing with the soils of Ujung Kulon focussed on the impact of the 1883 Krakatau eruption. Verbeek (1884-1885) reports on the influence of the tsunamis (tidal waves), which accompanied the 1883 eruption and the thickness of the ash deposition at Java's First Point.

The first true soil survey in the Ujung Kulon peninsula was carried out by Faber (1952a). Due to bad weather conditions and the limited time available

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his studies were restricted to the coastal area. In the same year, a schematic soil map, scale 1 : 100 000, was published by the same author (1952b). The legend of this map is based on the geological maps and data provided by Verbeek & Fennema (1896) and Van Es (1916).

Faber (1952a) reports on the presence of Krakatau ash in the western part of the peninsula and as alluvial deposits at the mouth of the main rivers.

Verstappen (1956) describes the landscape development of the peninsula. In this study the presence of big coral boulders is mentioned as a consequence of the tsunamis. In 1962 a soil map of Java and Madura at a scale 1 : 250 000 was published by Lembaga Penelitian Tanah. In the report of Blower & van der Zon (1977) an enlargement of this map was used. Soerinagara (1969) studied four profiles on Peucang Island and four profiles in the Mt.Honje area (1979). Strictly speaking the latter profiles are not situated in our study area. However, they can be used for comparison. Moreover, Soerianegara's studies are the first to present some analytical data.

Pellek (1977) studied the soils of the peninsula at eight different locations. His field-descriptions are accompanied by extensive analytical data. In 1986 the same author published an article on the soil genesis in the volcanic ash present in the peninsula.

In 1983 Hommel published a preliminary enumeration of soil types of Ujung Kulon. His landscape-ecology map can also be read as a soil map (scale 1 : 75 000). In 1983 the same author and van Reuler presented the preliminary results of their study on the impact of the Krakatau eruption on the soils (and vegetation) of the peninsula at the Centennial Krakatau Commemoration Symposium (Hommel & van Reuler, 1986; see also van Reuler, 1986).

7.3 The soils

For this study we compiled primarily a local typology of soils, which was only afterwards 'translated' into the terminology of the legend of the soil map of the world (FAO/UNESCO, 1974).

A concise key to the terminology used is given in Table 7a. A comparison of the FAO/UNESCO system with other soil classification systems used in Indonesia is given in Table 7b.

Table 7a Concise key to the terminology of the soil map of the world

The following units of the legend occur in Ujung Kulon:

Cambisols - soils with some changes due to weathering in situ
Fluvisols - soils developed in recent fluviatile, lacustrine or colluvial sediments and having certain properties
Gleysols - soils with hydromorphic features near the surface
Lithosols - soils with hard rock at very shallow depth
Luvisols - soils with clay illuviation and a relatively high base saturation
Nitosols - soils with clay illuviation; however, the clay content decreases slowly with depth
Regosols - soils with weak or no soil development

The following prefixes are used:

Calcic/Calcaric - indicating the presence of calcareous material within a certain depth
Eutric/Dystric - indicating the relative chemical fertility of the soils, respectively high and low
Gleyic - indicating the presence of hydromorphic features within certain depth
Thionic - indicating with sulfidic material within certain depth

Table 7b Correlations between the various classificationsystems for soils, which are at present used in Indonesia (as far as relevant to Ujung Kulon)

FAO-UNESCO (1974)	PPT (1981)	Soil Survey Staff (1975)
Lithosol	Lithosol	Lithic subgroups
Regosol	Regosol	Entisol
Cambisol	Kambisol	Inceptisol
Luvisol	Mediteran	Alfisol
Nitosol	Latosol	Ultisol
Fluvisol	*Tanah Alluvial*	Entisol (suborder Fluvent)
Gleysol	Gleisol	Aquic suborders

(slightly modified after: van Reuler, 1982)

Our classification, is from sheer necessity, based mainly on qualitative, morphological, diagnostic characteristics, since only a limited number of soil samples could be analysed. The main characters used are: depth, horizon sequence, texture, colour, mottling and calcium carbonate content (reaction to HCl). The (probable) parent material was used as an additional character and added to the names of the soil types as presented below.

The terminology used in the description of the soil types is derived from FAO (1977) and the colour codes are according to the Munsell Soil Colour Charts notation. The soil depth is defined as the depth to which an 'Edelman' auger can penetrate. The soil depth classes used are given in Table 7c.

Table 7c Soil depth classes

0 to 10 cm	very shallow
10 to 50 cm	shallow
50 to 80 cm	moderately deep
80 to 120 cm	deep
over 120 cm	very deep.

The interpretation of the horizon-symbols used is given in Table 7d. Symbols in brackets indicate that the horizon at issue may locally be absent.

For the description of deposits originating from the Krakatau volcano the following definition is used slightly modified after the Soil Conservation Service (1981):

'Volcanic ash and cinders may be regarded as unconsolidated igneous rock, but they have moved from their place of origin and mostly they have been reworked by wind and locally by water. Ashes are volcanic ejecta smaller than 2 mm. Ash smaller than 0.05 mm may be called 'fine ash'. Cinders are ejecta of 2 mm of larger'.

The soils are grouped and (within the groups) arranged according to their estimated drainage properties. The classes are also as defined by the Soil Conservation Service (1981).

Both in arranging the soils according to drainage and in translating the local typology into the FAO-UNESCO-terminology, many arbitrary decisions had to be taken, since in many cases the necessary (analytical) data are lacking.

For most of the soil types described below (including all important ones) a more detailed description of a reference profile, including some analytical data, is given in Appendix B.

Table 7d Horizon symbols
(simplified after *FAO*, 1977; only parts of the definitions relevant to the *Ujung Kulon* soils are given)

Master horizons:

H : An organic horizon formed or forming from accumulation of organic material deposited on the surface, that is saturated with water for prolonged periods.
O : Idem, but not saturated with water for more than a few days a year.
A : A mineral horizon formed or forming at or adjacent to the surface, showing an accumulation of humified organic matter.
B : A mineral horizon in which rock structure is obliterated or is but faintly evident, characterized by an illuvial concentration of silicate clay or a certain alteration of material from its original condition.
C : A mineral horizon of unconsolidated material from which the soil is presumed to have formed.
R : A layer of continuous indurated rock.

Transitional horizons
indicated by the combination of two capital letters, e.g. AB.

Letter suffixes*
t : illuvial accumulation of clay
w : alteration in situ as reflected by clay content, colour or structure.

Figure suffixes
indicating a vertical subdivision of a (sub)horizon starting at the top, e.g. Bt1, Bt2, etc.

Figure prefixes
indicating a lithological discontinuity, e.g. A-C ash-profile on top of the complete original profile: A-C-2A-2B-2C.

* In many profiles in Ujung Kulon mottled (sub)horizons (reflecting variations in oxidation and reduction) and strongly reduced (sub)horizons (resulting from almost permanent saturation with groundwater) occur. However, we refrained from using the appropriate letter suffixes (resp. g and r), which would greatly complicate the codes indicating the horizon sequence of the profiles. The characteristics at issue are always explicitely mentioned in the descriptions.

Group I: Excessively drained soils:

a. Lithosols developed on various types of rock.

Description:

Lithosols are by definiton very shallow. The horizon sequence is A-R. The colour and texture of the A-horizon are highly variable. Often the A-horizon has a dark yellowish brown (10YR4/4) colour and a gravelly loam texture. The amount of ash admixture varies from small to nil. No reference profile available.

Distribution

Mainly on the Payung massif, especially on lower altitudes along the S. and W coast.

b. Calcaric fluvisols developed in alluvial sand.

Description:

The soil depth varies from shallow to moderately deep. The horizon sequence is (A)-C. The A-horizon has a very dark greyish brown (10YR3/2) to dark yellowish brown (10YR4/4-4/3) colour, in most cases a sandy loam texture and is sometimes calcareous. The thickness varies from 5 to 15 cm. Small amounts of ash might be admixtured. The C-horizon has a white (10YR8/2) to very pale brown (10YR7/4) colour and is always calcareous. The calcareous sand is mixed with pieces of shell and coral. No reference profile available.

Distribution

On sandy beaches; more rarely on sandy beach-walls covered with forest.

c. Calcic cambisols developed in alluvial sand

Description

More or less the same type of soil as above. The major difference is the presence of a cambic B-horizon. Consequently, the horizon sequence is A-Bw-(C). The B-horizon has a brown to dark brown (10YR4/3) colour, a sandy to loamy texture and is calcareous. No reference profile available.

Distribution

On sandy beach-walls (and similar localities) covered with forest; more rarely on sandy beaches.

d. Calcaric regosols developed on coral

Description

The soil depth varies from shallow to deep. The horizon sequence is A-C-R. The A-horizon has a very dark brown (10YR2/2) to black (10YR2/1) colour, a gravelly (sandy) loam texture and is in most cases calcareous. The thickness varies from 5 to 15 cm. The amount of ash-admixture varies from small to nil. Sometimes some volcanic cinders may be found in this horizon. The C-horizon has a heterogeneous colour and consists mainly of pieces of coral. The R-horizon consists of coral. Reference profile no. 321 (see Appendix B).

Distribution

Restricted to the so-called pseudo-barrier reef and the transitional zone towards the former lagoon in the coastal plain of the mainland (see Chapter 6); there the most common type.

Group II: Somewhat excessively drained soils

e. Calcaric regosols developed in coral sand

Description

The soil depth is shallow to moderately deep. The horizon sequence is (A)-(C)-(2BA)-2Bw-C-R. The thickness of the ash cover varies from 0 to 30 cm. The 2BA-horizon has a dark yellowish brown (10YR3/4) to pale brown (10YR6/3) colour and a sandy loam to loam texture. The colour of the 2Bw-horizon is dark yellowish brown (10YR5/4-5/8) and the texture is sand. The 2C-horizon has a (very) pale brown (10YR6/3-8/4) to white (10YR8/2) colour and the texture is gravelly sand. The whole profile is calcareous. Reference-profile: no. 310 (see Appendix B).

Distribution

Restricted to the coastal plain of Peucang Island; there the most common type.

f. Dystric cambisols developed on calcareous sandstone or limestone

Description

The soil depth varies from shallow to moderately deep. The horizon sequence is (A)-(C)-2Bw-2C. The thickness of the ash cover varies from 0 to 20 cm and is sometimes slightly calcareous. The 2Bw-horizon has a (dark) yellowish brown (10YR4/4-5/6) to strong brown (7.5YR5/6) colour, a sandy clay loam to sandy loam texture and is 10 to 40 cm thick. The 2C-horizon has a heterogeneous colour with white (10YR8/2) and yellowish brown (10YR4/6) colours dominating; it has a sand texture and is strongly calcareous. Reference-profile: no. 146 (see Appendix B).

Distribution

Very common on the calcareous beach-ridge along the S.coast, but also very locally on the limestone plateaux; there both on the highest parts of the Telanca massif and on the lowest plateau level (in coastal regions).

g. Dystric cambisols developed in alluvial sand

Description

The soil depth varies from deep to very deep. The horizon sequence is A-C 2-Bw-2C-3C. The thickness of the ash cover is 20 to 25 cm. The 2Bw-horizon has a dark brown to dark yellowish brown colour (10YR3/3-3/4) and a sandy texture. The 2C-horizon has a very dark brown to dark yellowish brown colour (10YR2/3-3/4). It has a (fine) sand texture and is not calcareous. The 3C-horizon (below 90 cm) is whitish. It has a (coarse) sand texture and is strongly calcareous. No reference profile available.

Distribution

This soil type was found only twice. Both localities are situated in the SW part of the erosional plain, bordering upon the western hills (plots 35 and 91).

h. Dystric cambisols developed on sedimentary rock (including tuff)

Description

The soil depth varies from shallow to moderately deep. The horizon sequence is (A)-(Bw)-(C)-2Bw. The ash cover is rarely present and less than 20 cm thick. The 2Bw-horizon has a (dark) yellowish brown (10YR5/4-5/8) colour and a clay loam to gravelly sandy loam texture. No reference profile available.

Distribution

On the Payung massif; below 150 m the most common type, but also not rare on higher altitudes.

Group *III*: Well drained soils

i. Eutric cambisols developed on tuff

Description

The soil depth varies from moderately deep to deep. The horizon sequence is A-(Bw)-C-2Bw-2C. The thickness of the ash cover is usually between 15 and 25 cm. The 2Bw-horizon has a brown to dark brown (10YR5/3-4/3) colour and a clay loam texture with a high silt content. The thickness varies from 30 to 80 cm. The C-horizon consists of brown (10YR5/3) coloured weathered tuff. Reference profile: no. 308 (see Appendix B).

Distribution

The most common type on the highest part of the western hills; also on Cape Gede (plot 307), on Mt.Kendeng (plot 101) and locally on the lower part of the western hills (plot 88).

i. Dystric nitosols developed on sedimentary rock (including tuff)

Description

The soil depth varies from deep to very deep. The horizon sequence is A-

Bw-(C)-2Bt. The thickness of the ash cover varies usually between 10 to 20 cm. The 2Bt-horizon has a strong brown (7.5YR5/6-5/8) reddish yellow (7.5YR6/6) or yellowish red (7.5YR4/6-5/8) colour and a clay texture.
Reference profiles: nos. 303, 304 and 335 (see Appendix B) profiles 303 and 304.

Distribution

In Ujung Kulon restricted to the Payung massif; the most common type on altitudes above 150 m; on lower altitudes apparently rather rare; also found on nearby Mt. Honje (plot 335).

k. Dystric cambisols developed on limestone

Description

The soil depth is very deep. The horizon sequence is A-Bw-(C)-2Bw. The thickness of the ash cover varies from 5 to 30 cm. The 2B-horizon has a (dark) yellowish brown (10YR4/3-4/6) to (strong) brown (7.5YR5/4-5/8) to dark brown (7.5YR3/4) colour and a clay texture. On two locations 2B-horizons with a dark reddish brown (5YR3/4) colour were observed.
Reference profile: no. 292 (see Appendix B).

Distribution

Very common on the undissected plateaux; only locally on the dissected plateaux; not found in the adjacent parts of the erosional plains.

l. Eutric cambisols developed on limestone

Description

The soil depth varies from shallow to deep. The horizon sequence is A-Bw-C-(2BA)-2Bw-2BC-(R). The thickness of the ash cover varies from 5 to 25 cm. The 2BA-horizon has a dark brown (10YR5/3) to dark yellowish brown (10YR4/4) colour and a clay texture. The colour of 2Bw-horizon is yellowish brown (10YR5/4) to dark yellowish brown (10YR4/4-4/6) and this horizon has a (slightly gravelly or stony) clay texture. Sometimes, some mottling is present. The gravels or stones are calcareous. The 2BC-horizon has variable colours with (dark) yellowish brown (10YR4/4-5/4) and light olive brown (2.5Y5/4) being dominant. The texture is slightly gravelly, stony clay. The gravels and stones are calcareous. Reference profiles: nos. 284 and 324 (see Appendix B).

Distribution

On limestone plateaux and adjacent parts of the erosional plains; especially (but certainly not exclusively) on dissected parts and marginal areas of undissected parts.

Group IV: Moderately well drained soils

m. Eutric cambisols developed on limestone

Description

The soil depth varies from shallow to moderately deep. The thickness of the ashcover varies from 0 to 25 cm. The horizon sequence is (A)-(C)-2Bw-2BC-R. The 2Bw- and 2BC-horizons have light olive brown (2.5Y5/4-5/6) to olive brown (2.5Y4/4-4/6) colours and a clay texture. In the BC-horizons calcareous gravels and stones occur. No reference-profile available.

Distribution

Locally on limestone plateaux and adjacent parts of the erosional plains; generally in the periphery of the undissected plateaux.

n. Gleyic luvisols developed on limestone or in clayey material of unknown origin (poorly developed)

Description

The soil depth varies from moderately deep to deep. The thickness of the ash cover varies from 0 to 30 cm. The horizon sequence is (A)-(Bw)-(C)-(2A)-2Bw-2BC. The depth at which the mottling starts is highly variable, but always present in the 2Bw-horizon. The 2A-horizon has a (dark)yellowish brown (10YR5/4-6/4) colour with, sometimes mottles. The texture is clay loam. The 2Bw-horizon has dark yellowish brown (10YR3/6-4/6) colour with common mottles and a clay texture. The colour of the 2BC-horizon varies from greyish brown (10YR5/2) to olive brown (2.5Y4/4) with common to many mottles. The texture is slightly gravelly clay. The gravels may be calcareous. Reference-profile: no. 319 (see Appendix B).

Distribution

Locally on the limestone plateaux (on the dissected parts even predominating) and in the upland area west of Jamang. In the latter area probably also predominating.

Note:

This heterogeneous type represents a wide range of soils which are more or less intermediate between Type k and Type t. In fact, the reference profile (319) is not very representative. The soils of the upland area west of Jamang (319, 320) are among the wettest ones included in this type. Moreover, this region is aberrant of character, both in a geomorphological and a botanical sense. The soils, included in this type, occurring on the plateaux are in general slightly better drained. Some of them might in fact better be classified as Gleyic (or even Dystric) cambisols, but unfortunately the necessary data are lacking.

o. Eutric cambisols developed on andesite

Description

The soil depth varies from moderately deep to very deep. The horizon sequence is A-(Bw)-C-2B-2BC. The thickness of the ash cover varies from 10 to 25 cm. The colour of the 2B-horizon varies from dark yellowish brown (10YR3/4) to strong brown (7.5YR4/6-5/8) to reddish brown (5YR5/4). The texture is clay. The lower part of the 2B-horizon and the 2BC-horizon have a heterogeneous colour. The clay content increases with depth (see Appendix B, profile 306).

Distribution

The most common type on the lower part of the western hills; locally also on the adjacent part of the Payung massif; there, the parent material is unknown.

Note:

A rather heterogeneous type; both better and less well drained forms can be found.

p. Gleyic cambisols developed on parent material of unknown origin

Description

The soil depth varies from moderately deep to very deep. The horizon sequence is A-Bw-C-2Bw-2BC. The thickness of the ash cover varies from 10 to 25 cm. The 2Bw-horizon has a heterogeneous colour with yellowish brown (10YR5/6), strong brown (7.5YR5/6) and yellowish red (5YR5/8). At varying depths red (2.5YR4/8) mottles occur. The texture is gravelly sandy clay. The 2BC-horizon has a light grey (10YR7/2) colour with many red (2.5YR4/8) mottles. The texture is slightly gravelly sandy clay.

Reference profile: nos. 325 and 326 (see Appendix B).

Distribution

Only found in several locations in the area east of the isthmus, close to the S coast, but behind the sandstone beach-ridge.

q. Eutric regosols developed in alluvial sand or loam

Description

The soil depth is very deep. The horizon sequence (A)-(C)-2C. The thickness of the ash cover varies from 0 to 20 cm but is usually much less than 10 cm. The 2C-horizon has a (dark) yellowish brown (10YR5/4-4/4) to brown (7.5YR5/4) colour and a (loamy) sand to sandy loam texture. In the lower part of the 2C-horizon mottling occurs, though not very pronounced. Groundwater may be present within 1 metre. At one location, calcareous material was found at 1 metre depth. No reference profile available.

Distribution

In the coastal plain, in small areas near the mouth of the major rivulets. These areas coincide largely with the present grazing grounds and their vicinity. Also found in the Cicangkeuteuk area between the intrusions of the mangrove area into the interior (plot 235).

Notes:

The areas with soil type q in the Cicangkeuteuk area are clearly recognizable on the aerial photographs (by a more coarse texture of the canopy), but not so in the field. This type probably merges into type s in a very gradual way. Plot 99 represents a more or less intermediate form.

r. Gleyic cambisols developed in alluvial loam or clay

Description

The soil depth is moderately deep to very deep. The general horizon sequence is (A)-(C)-(2BA)-2Bw-2C. Due to the nature of the parent material there is a great variation in colour, texture and intensity of the mottling. The thickness of the ash cover varies from 0 to 30 cm (very locally even 55 cm). Locally a horizon of buried ash may also be found. The 2BA-horizon generally has a brown (10YR5/3) to yellowish brown (10YR5/4) colour and a loam to sandy clay loam texture. The colour of the 2Bw-horizon becomes lighter with depth; a common colour is light brownish grey (10YR6/2) with a sandy clay loam to loam texture. Sometimes a clay texture is found. Generally mottles are found throughout the profile.

Reference-profile: no. 301 (see Appendix B).

Distribution

The most common type of the fluvio-alluvial plain; also locally occurring in other regions, especially in the northern erosional plain and the uplands; there in the vicinity of rivulets.

Note:

A most heterogeneous group of soils. Locally, the 2Bw-horizon is absent. In that case the soil should strictly speaking be classified as a Dystric fluvisol. Moreover, where the mottling becomes very pronounced, classification as a Dystric gleysol would be more appropriate. However, in general the name Gleyic cambisol seems the best choice for this heterogenous group of soils.

Group V: Somewhat poorly drained soils

s. Dystric gleysols developed in alluvial silty clay

Description

The soil depth varies from deep to very deep. The horizon sequence is A-Bw. The A-horizon has a black (N2/0) to very dark greyish brown (10YR3/2) colour and a silt loam to clay texture. The colour of the Bw-horizon varies from light grey (10YR7/2), dark grey (10YR4/1), (dark) greyish brown (10YR5/2-4/2) to yellowish brown (10YR5/6-5/4). The colours become more pale with depth. The texture is silty clay. In this horizon, pieces of shell and coral may occur. Throughout the profile mottles are found and groundwater is normally within 1 metre.

Reference profiles: nos. 318 and 332 (see Appendix B).

Distribution

The most common soil type in the coastal plain of the mainland, the pseudo barrier reef and beach ridges excepted (see chapter 6).

Note:

Profile 332 is the most representative one, profile 318 is situated in the transitional zone towards the pseudo barrier reef and illustrates the landscape development (see chapter 6).

t. Gleyic luvisols developed in clayey material of unknown origin

Description

The soil depth is deep to very deep. The horizon sequence is (A)-(C)-(2A)-2Bt-2BC. The thickness of the ash cover varies between 0 and 20 cm. The A-horizon has a yellowish brown (10YR5/4) colour and a clay texture. The thickness is less than 10 cm. The 2Bt-horizon has heterogeneous colour with grey (10YR5/1) dominating besides pale brown (10YR6/3) and yellowish brown (10YR5/4). This horizon is strongly mottled. The texture is slightly gravelly clay and the gravels are sometimes calcareous. The 2BC-horizon has grey (10YR5/1), greyish brown (10YR5/2), brown (10YR5/3) and white (10YR8/2) colours and is strongly mottled. The white colour is caused by powdery lime. The texture is slightly gravelly, slightly stony clay. The gravels and stones are sometimes calcareous.

Reference profiles: nos. 311, 314 and 336 (see Appendix B).

Distribution

The most common type of the uplands, the area west of Jamang excepted; also locally in the adjacent part of the erosional plain and the Mt. Honje area.

u. Dystric gleysols developed in alluvial clay

Description

This type comprised all more poorly-drained forms of the soils described as type r. The soils of type u differ from those of type r by the presence of a permanently reduced zone, starting somewhere between 60 and 120 cm. Above this zone the whole profile is strongly mottled. No reference-profile available.

Distribution

Rather common in the fluvio-alluvial plain; possibly also elsewhere.

Note:

See note at type r.

Group VI: Poorly drained soils

v. Calcaric fluvisols developed in alluvial sand

Description

The soil depth is moderately deep to very deep. The horizon sequence is A-C. The A-horizon consists of clayey peat and is approximately 20 cm thick. The C-horizon has a light yellowish brown (10YR6/4) colour which changes at greater depth into white (10YR8/2). The texture is sand which is calcareous. Groundwater is present within 1 metre. Periodically these profiles may be flooded with brackish or salt water. No reference profile available.

Distribution

Observed only in depressions in the coastal plain of Peucang Island (plot 75).

w. Dystric fluvisols developed in alluvial sand or (clay) loam

Description

The soil depth is deep to very deep. The soils are stratified, the horizon sequence is C-2C-3C or more. The colours of the different C-horizons are highly variable. The texture varies from sandy loam or gravelly sand to sandy clay loam. Horizons with this latter texture have permanent reduced colours. Horizons with a more sandy texture are strongly mottled. In the subsoil, calcareous material may be found. These soils are periodically flooded with seawater. No reference profile available.

Distribution

The most common type of the inner part of mangrove areas, also on low sand bars within or in front of the outer mangroves.

Group VII: Very poorly-drained soils

x. Calcaric fluvisols developed in various alluvial sediments

Description

The soils depth is moderately deep. The soils are strongly stratified, the horizon sequence (H)-(A)-C-2C-3C or more. The peaty topsoil (if present) is black (N2/1) and some 5 to 10 cm thick. As for the C-horizons, the colours and texture are highly variable. Locally, burried horizons of Krakatau ash are also present. Generally, the permanently reduced zone starts within 0 to 15 cm of the surface. One or more of the C-horizons may be calcareous. The soils are flooded for much the wet season.

Reference profile: no. 315 (see Appendix B).

Distribution

Restricted to depressions in the coastal plain of the mainland (the 'bottomlands'); there the dominant soil type.

y. Thionic fluvisols developed in various alluvial sediments

Description

The soil depth is deep. The soils are strongly stratified. The horizon sequence is A-C-2C-3C or more. The colours of all horizons vary from black (N2/1) to grey (10YR5/1) and the texture generally varies from loam to clay. Only very locally a fine sandy texture is found (plot 230). In the subsoil calcareous material sometimes is found. These soils are flooded at high tide. No reference profile available.

Distribution

Restricted to the outer part of the mangrove areas: there the dominant soil type.

Note:

The classification of these soils is only based on the presence of yellow spots in dried soil samples.

7.4 The Krakatau ash

7.4.1 Introduction

The Krakatau archipelago is located at a distance of 56 to 84 km in a NNE direction of the Ujung Kulon peninsula. In 1883, a series of eruptions took place with a climax between August 26th and 28th. As stated in section 4.3, these events were of great importance for Ujung Kulon, which became covered with volcanic ejecta and was partly inundated by the tidal waves (tsunamis) following the eruptions. Here, we shall focus on those aspects which are of significance for the soils of the area.

In the publications discussing the 1883 eruption contradicting data on the amount of erupted material are reported. Verbeek combined all eye witness accounts with field observations (1884-1885). According to this author approx. 18 km^3 of material has been ejected. Other authors, like Wexler (1951) believe this to be an underestimate.

The surface of the area where the material was deposited is also the subject of discussion. Stehn (1929) reports that the Krakatau ejecta, irrespective of size, covered an area of 827 000 km^2.

As for the total amount of ejecta in relation to the distance from the source, both Verbeek and Wexler provide some quantitative data.

Both authors point to the fact that the average thickness of the ash layer is inversely correlated with the distance from the source. At a distance of more than 50 km the average thickness is less than 20 cm. However, this figure is not true for Ujung Kulon (see 7.4.2).

No information is available on the range of distribution of the ejecta in relation to the particle size, mineralogical composition or weight. Mohr (1944) described one sample of Krakatau ash with the following composition:

pumic	69.8%	magnetite	0.9%
heavy glass particles	21.1%	pyroxene	2.2%.
feldspars	6.0%		

Due to the location of Krakatau, a substantial part of the ejected material was deposited in the sea. Therefore, the profiles developed in recent marine sediments may contain a considerable amount of volcanic material. The amount and particle size distribution of these sediments are strongly related to the location where they were deposited. Examples of soils developed in this type of sediment are profiles 318 and 332 (see Appendix B), both classified as Dystric Gleysols.

7.4.2 Morphological characteristics

In Ujung Kulon, the Krakatau ash deposits are in most cases easily recognizable in the field, due to the contrasting colours and textures compared with the underlying profiles. In most parts the ash-cover is much paler in colour and of a coarser texture than the underlying profile (see below).

The thickness of the ash cover varies from 0 to some 30 cm. Locally, in alluvial situations even thicker ash layers can be found. The variation in thickness may be caused by differences in the amount of material deposited. However, erosion is believed to be a factor of greater importance. We assume that the erosion of the ash layer is influenced by a complex of factors, such as slope, character of the vegetation, character of the underlying profile and incidental flooding. As for the underlying profile, there are indications that the erosion of the ash cover proceeds relatively quickly on well to excessively drained soils, especially on soils with a more or less sandy texture. As for the impact of incidental flooding, it is interesting to note that in many low-lying areas, especially along the north coast, the ash cover is virtually absent. In many parts, this cannot be due to seasonal flooding of the rivulets. Probably, the erosional impact of the 1883 tidal waves provides a better explanation for this phenomenon. A broad indication of the average ash cover in the major physiographic units is given in Fig. 7a.

The texture of the ash cover is also very variable, both horizontally and vertically. The horizontal variation is caused by local variation of the deposited material, and to a lesser extent, by some mixing with the underlying material. The vertical variation is a more interesting phenomenon. In virtually all sites the texture of the ash proved to become more coarse with depth. In general, the texture of the ash cover ranges from (clay)loam above to sandy loam below. In the C-horizon very often a few gravels are found as well. The change in texture may be due to two factors. Possibly, at the time of the ash deposition first the 'coarse' particles were deposited and later the finer particles. Another possibility is that the ash was deposited homogeneously, but that the soil fauna caused a differentiation in texture. A similar process was described by Wielemaker (1984) in Kenya. Biological activity in the ashcover and below is indicated by the fact that the ash cover on calcareous profiles is also slightly calcareous and by the (not very clear) relation between the texture of the ash cover and the underlying profile. However, we assume that the activity of the soil fauna is not very high, since the horizon boundaries within the ash cover and between ash and underlying profile are generally abrupt (see below). Thus, the vertical differentiation in texture is assumed to reflect primarily different stages of deposition.

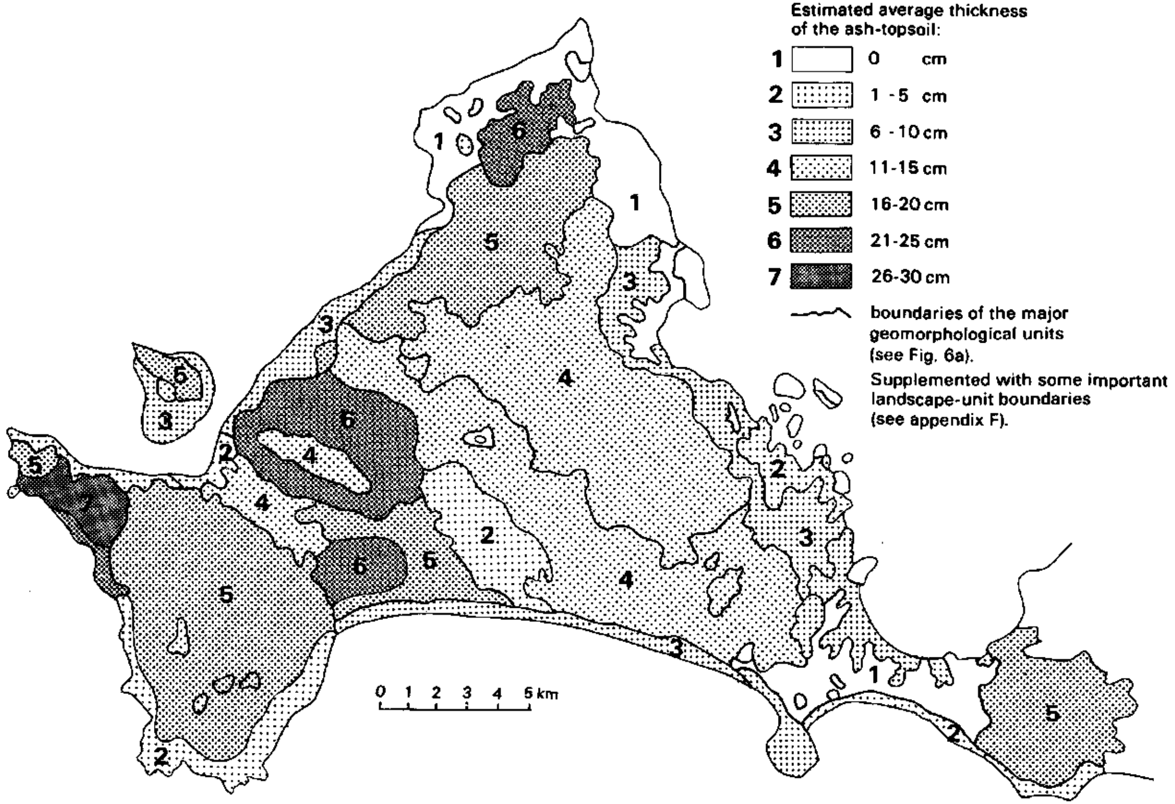

fig. 7a Distribution of the Krakatau -ash

In addition to the textural gradient, some profile development can be discerned. Within the ash cover, an AC- or ABC-horizon sequence developed. The A-horizon is characterized by darker colours due to organic matter. It is generally some 2 to 6 cm thick, but in exceptional cases it may comprise virtually the whole ash profile (see Appendix B, profile 310). In some locations, a B-horizon could be distinguished. This horizon is characterized by a different colour compared with both the A- and C-horizons and can therefore be more precisely indicated as Bw. The average thickness of this horizon is some 10 cm. The development of a B-horizon in the ash cover is limited to the well drained, moderately well-drained and one group of somewhat excessively drained soils (viz. type f).

The C-horizon represents the unaltered ash. The most common colour of this horizon is yellowish brown, when moist. In a dry condition, the colours of the ash cover are much paler and therefore contrast much more with the underlying profile. The C-horizon may even be somewhat whitish when dry. Within the ash cover, the colour of the different horizons sometimes vary in only in one of more value or chroma units. In the ash cover, mottling sometimes occurs due to stagnating water (see 7.4.3).

The horizon boundaries of the ash cover with the underlying profile is always abrupt and smooth. The horizon boundary between the A-horizon in the ash cover and the underlying horizon is often clear. This change is probably due to the activity of roots and soil fauna.

Pellek (1986) also studied the profile development in the ash cover. In contrast to our studies he did not distinguish a Bw-horizon, but probably indicated this horizon as A12. However, it is important to note that his results are based on observations at only 8 locations. According to Pellek (1986), the post-Krakatau soil formation on top of the C-horizon represents one or more of the following processes:

- weathering and alteration of the C itself;
- alluvial or colluvial accretion or both;
- in situ soil genesis due to mineralization of organic matter;
- accretion due to inverted horizons in wind blown mounds.

Pellek does not mention the relative importance of these processes. Moreover, the relation between the rate of weathering and drainage conditions (see above), the activity of the soil fauna and the conditions under which the ash was deposited are also not mentioned (see also 7.4.3).

7.4.3 Physical properties

Unfortunately, no data on the water holding capacity of the ash layer have been collected. Taking into consideration the texture of the ash, we have to assume that the water holding capacity is low to medium.

The infiltration capacity of the profiles is hindered by the abrupt boundary between the cover and the underlying profile. It is known that an abrupt change in pore system hinders water infiltration. The presence of mottling in the (lower part of the) ash cover is an indication of this phenomenon.

Moreover, it was observed repeatedly that, during the dry season, the ashcover of exposed sites, with only a brief, if any, vegetation cover, dried out completely, while the underlying profile was still moist. In the rainy season the same sites may become saturated again.

This complete change in structural properties provides a serious handicap for the vegetation development. It is believed that these unfavourable conditions helped to prevent regrowth of the forest on the shifting cultivation sites in many places (both used and recently abandoned in 1883), thus explaining the occurrence of Ujung Kulon's notorious rattan shrublands. In this respect, it is interesting to note that these rattan shrublands are absent in those parts of the erosional and coastal plains where the 1883 tidal waves removed the ash cover. Moreover, the rattan shrublands are (almost) completely restricted to the (only) moderately well and somewhat poorly drained soils (see Table 11b). In better drained soils, the ash layer and subsoil differ less strongly as far as drainage features are concerned; in even more poorly drained soils, the difference between the dry and wet season is less pronounced. As can be still observed today, the situation within the (shady) forests is far less extreme. Moreover, there is another factor which influences the physical properties of the ash cover and is related to the nature of the vegetation at the time of deposition. At places with a closed and complex vegetation cover, the ash will have reached the soil more gradually, allowing some mixing of the deposited materials by roots. This may have further enlarged the difference in vegetation development between the forest-covered areas (in 1883) and the shifting cultivation sites, which were just cleared and burnt (see also Hommel and van Reuler, 1986).

It is important to note that only extensive soil physical research can prove these hypotheses.

7.4.4 Chemical properties

As indicated above, there is a relation between the properties of the ash cover and the properties of the underlying profile. Even so, it is relatively easy to distinguish the ash cover from the underlying profile on the basis of chemical properties only, thus ignoring the evident morphological differences (see Appendix B).

However, it is difficult to give a general chemical characterization of the ash. Horizons which are morphologically identified as ash may have quite different chemical characteristics. For example the pH-H_2O of the A-horizon of the ash cover varies from 7.3 to 4.3. The very high value can be explained by the calcareous subsoil (profile 310) but the low value not because the underlying profile has higher pH values (profile 304).

Finally, as for the fertility of the volcanic ash the following annotations can be made. The ash deposition, as defined by the Soil Conservation Service (1981), increases the natural chemical fertility of the soil. The relatively high fertility of the island Java is based on regular depositions of volcanic ash. Small deposits can easily be mixed with soil material by soil animals or, in the case of arable land, by cultivation. Deposits of several centimetres can be recognized for long periods. Verstappen (1956b) studied the distribution of ash deposits originating from the 1883 eruption in South Sumatra. There, the thickness of the ash layer in the most southern part of South Sumatra amounted to some 5 to 15 cm. According to Verstappen, the Krakatau ash in

South Sumatra enhanced the fertility of the soil. Even so, it is dubious whether the farmers in Ujung Kulon (as ladang-people in general not used to ploughing)* were very pleased to see an ash layer of some 30 cm or more cover their fields. A thick layer of young volcanic ash, not mixed with the underlying soil, is not fertile by definition, due to the lack of organic matter. Moreover, the thickness of the ash-cover may (at least temporarily) have influenced the workability of the fields in a negative way. The same holds for physical properties of the profile (see 7.4.3). Thus, it is believed that the ash rains of 1883 contributed to the process of depopulation, which followed in the years after the catastrophe (see also chapter 4 and Hommel and van Reuler, 1986).

7.5 Vertic properties

In many tropical and subtropical regions, soils are found which seasonally shrink and crack. The cracks may become filled with surface material. When the soil gets wet again, it expands causing the churning of the whole soil mass and the forming of a typical form of microreliëf. Another result of this mechanism is the production of polished and grooved faces, called 'slickensides' (Mohr et al., 1972).

In the FAO-UNESCO-system (1974), soils which show such characteristics in a pronounced way are called vertisols. On a lower level, less pronounced 'vertic' properties are used to subdivide the main groups of Luvisols and Cambisols.

True vertisols also occur on Java. They were for example, described for East Central Java by Dames (1955) as margalite soils. They may occur on various types of (mainly basic) parent material, such as limestone, tuff and types of eruptive rock, but also in alluvial sediments. According to Mohr et al. (1972), the conditions for their genesis are: a pronounced seasonal climate (in Indonesia with an average annual amount of rainfall of 2000 mm or less), a clayey texture and a specific clay mineralogy.

In Ujung Kulon true vertisols are absent. The average annual rainfall is much too high (see Chapter 5).

However, soils showing some vertic properties may be present, since periodically very dry years occur with an (estimated) annual rainfall of less than 2000 mm. Moreover, in many soils smectites are not uncommon clay minerals, which can shrink and swell strongly. In other soils kaolinite and illite are relatively well represented. The latter two clay minerals may also cause vertic properties, though not as strongly as smectites do (Soil Survey Staff, 1975).

Indeed, cracks in the soil (i.e. in the subsoil and ash cover) were observed frequently during the exceedingly dry season of 1982, especially in the uplands (soil type t) and the fluvio-alluvial plain (soil types r and u). An extreme example was provided by the soil in plot 156 (soil type u), where cracks of at least 105 cm deep and more than 1 cm wide were observed. The

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* See Kools, 1935; the Badui, mentioned in Chapter 4, even considered plough and draught-animals taboo (Jacobs & Meijer, 1891)

site at issue was covered with a relatively open type of rattan-shrubland, dominated by Eupatorium odoratum. Unfortunately, vertic properties were less clearly perceptible during the rainy season, i.e. during the period in which the reference profiles were described. However, in some cases cracks and slickensides were observed, most clearly in plots 284 and 336 (resp. soil types l and t; see Appendix B). However, we lack the information to decide in which soil types vertic properties are present to such a degree that the soil can be classified as a Vertic cambisol or Luvisol. Therefore, we refrained from using the prefix vertic at all in the classification of soil types presented in section 7.3.

However, on account of the texture, clay mineralogy and sensitivity to seasonal drought, we may conclude that some vertic properties can be expected in all well, moderately well and somewhat poorly drained soils, with the exception of type q (sand). The vertic properties are probably most pronounced in type t (well developed gleyic luvisols in clayey material). They are likely to be rather weak in type i (eutric cambisols on tuff) and the more coarsely textured parts of some other types (e.g. i, p and r). The occurrence of vertic properties in type s (dystric gleysols in alluvial silty clay) is uncertain, since it is dubious if these soils ever dessicate strongly.

The impact of vertic properties on the vegetation may be considerable. In many tropical areas with vertisols the vegetation is a savanna (Soil Conservation Service, 1981; Burnham, 1975; Mohr et al., 1972), indicating that succession towards forest (after destruction) is slow if not almost impossible, especially since seasonal drought is felt more severely once the forest microclimate has been disturbed (see Chapter 5). This phenomenon is clearly illustrated by the example of plot 156 mentioned above.

In Ujung Kulon, the assumed vertic properties of some soil types may help to explain the specific character of two common types of secondary vegetation: the palm forests and the bamboo forests (see 9.4.1 and 9.4.2). The occurrence of rattan shrublands, i.e. areas where a hundred years after destruction the forest has not yet returned, is explained primarily by the physical properties of the ash cover. Vertic properties of the subsoil may reinforce these (unfavourable) properties but are themselves not considered to be a key-factor.

CHAPTER 8: FLORA AND PLANT-GEOGRAPHY

8.1 Introduction

This chapter deals with all plant-species which are known to occur in Ujung Kulon.

The floristic composition of the area is discussed in section 8.2. Enumerations of species are provided in Appendix C and D.

All these species are primarily used as materials for the compilation of the plant-communities, which are discussed in the following chapter. Still, the floristical aspect is of importance for more reasons. Rare species for instance, contribute to the significance of Ujung Kulon as a conservation area (see section 8.2.3).

Selected groups of species may furthermore contribute to our understanding of the study area as a whole. The concepts of growth - and life-forms have already been discussed in chapter 3. The use of species(groups) as indicators of climatic conditions has already been dealt with in chapter 5. Here we shall pay attention to a third possibility of using selected groups of species, viz. in clarifying the area's plant geographical position (see section 8.3). Finally, in section 8.4 attention is paid to the altitudinal distribution of the species in comparison to Java as a whole.

8.2 Floristic composition

8.2.1 Results of our explorations

Our main objective during the period of fieldwork, as far as botanical aspects were concerned, was to describe the floristic composition of our sampling points, i.e. the plots.

This implies that piles of specimens of plants, many of them sterile or even juvenile, had to be collected for later identification. On the other hand, for practical reasons, we had to refrain from collecting too wide a choice of (fertile) specimens en route outside the plots, as well as from collecting already well known species inside the plots.

From a herbarium-botanist's point of view, this approach results in a rather unattractive or at least unusual collection. Moreover, accurate identification of sterile and especially juvenile specimens, is in many cases a very timeconsuming activity and sometimes even impossible. Still, thanks to the generous and prolonged help of many specialists at the Rijksherbarium in Leiden, including the junior author of the flora of Java, Dr. Bakhuizen van den Brink, this part of the work could be succesfully rounded off (see Acknowledgements). In only a few cases, the identification of sterile specimens proved to be impossible, mainly in parts of the families of Annonaceae, Lauraceae and Meliaceae, as well as in parts of the genera Ficus, Piper and Syzygium.

The names of all identified plants are given in Appendix C, which enumerates all plant species, sampled or not, which were encountered in the study area during the survey.

All samples are at present kept in the Rijksherbarium in Leiden. A collector's list is in preparation.

8.2.2 Additional data

No attempt is made to provide a complete check-list of Ujung Kulon's flora. Since many botanists have visited the area, especially during the last decades and their collections have spread over quite a number of herbaria throughout the world, this would be a most arduous task, far beyond the scope of this study.

Still, spending many months in the Leiden herbarium for the identification of plant-specimens collected during the survey, we came across many Ujung Kulon specimens, partly by mere chance, partly led by literature references. A selection of these herbarium specimens is listed in Appendix D, as far as relevant for this study. Mainly references of rare species, localities outside the main distribution area and species of which no sample was collected during our survey were included in this list.

The reason for producing such a list is to provide reference material for the sections which follow (on rare species and plant-geography) as well as for the sections on climatic indicators included in chapter 5. Moreover, it may serve as an expedient for future fieldworkers.

No more literature references have been included. It seems more valuable to provide an incomplete list of documented and reliable records, than a mere compilation of existing species lists of varying quality, which (unlike most herbarium-collections) are in general rather easily accessible to any student of the area.

The major enumerations of species up till now have been compiled by Satmoko (1961), Wirawan (1965), Hoogerwerf (1970), Dransfield (1971), Kartawinata & Apandi (1977), PPA (1979) and Djaja c.s. (1982).

8.2.3 Rare species

As stated in the introduction to this chapter, rare species contribute to the significance of Ujung Kulon as a conservation area. However, rarity may be defined on several levels e.g. on a global scale, within Malesia or within Java.

Mainly for practical reasons we confine ourselves here to the island of Java, which is floristically far better known than, for example, the adjacent islands of Sumatra and Borneo. An enumeration of species which are considered rare for Java by Backer & Posthumus (1939) and Backer & Bakhuizen van den Brink (1963-1968) or are simply missing in their floras, is given in Table 8a. We can assume that most of the species enumerated here also occur in nearby Sumatra (and in many cases elsewhere too). However, there are at least three exceptions:

- Knema globularia, a species of rocky coasts and small islands which is known from many localities in Malaya but not from the mainland of Sumatra (De Wilde, pers.comm.). (Such 'island-species' are a most interesting ecological phenomenon, which deserves further study. Other examples in Ujung Kulon are Smythea lanceolata and to a certain extent also Pandanus bidur).
- Launaea sarmentosa, of which our record in Ujung Kulon represents the only recent find spot in the whole of Malesia.
- Heritiera percoriacea. which is probably an endemic species of West Java,

Table 8a Rare species in Ujung Kulong

Name:	Occurence in Jave outside of Ujung Kulon
Adina trichotoma (Rubiaceae)	very rare in W.
Ailanthus integrifolia (Simarubaceae)	very rare in C and E.
Asidopterys tomentosa (Malpighiaceae)	in environs of Bogor and on Mt.Parang (W).
Beilschmidia roxburghiana (Lauraceae)	in extreme W. of W.
Bolbitis appendiculata (Polypodiaceae)	rare in W and C.
Botryophora geniculata (Euphorbiaceae)	absent
Calamus rhomboideus (Arecaceae)	possibly formerly found on Megamendun (W)
Calamus 'tunggal' (Arecaceae)	probably absent
Calophyllum soulattri (Clusiaceae)	very local in W.
Calophyllum teysmanni (Clusiaceae)	rare in W, C and E.
Canarium asperum (Burseraceae)	on Bawean Island (C).
Canarium littorale (Burseraceae)	rare in W, C and E.
Cleidion spiciflorum (Euphorbiaceae)	absent
Connarus semidecandrus (Connaraceae)	very long ago found (somewhere) in Java
Cotylanthera tenuis (Gentianaceae)	scarce in W, C and E.
Desmodium laxum (Papilionaceae)	rare in W, C and E.
Digitaria heterantha (Poaceae)	collected only once in W.
Drypetes ovalis (Euphorbiaceae)	on Watangan (E)
Endocomia macrocarpa ssp. prainii (Myr.)	absent
Garcinia rostrata (Clusiaceae)	very rare in W.
Genianthus ellipticus (Asclepiadaceae)	?formerly mainland of Java's and Nusa Kambangan (C)
Heliciopsis lanceolata (Proteaceae)	rare in W, C and E.
Heritiera percoriacea (Sterculiaceae)	absent
Hornstedtia minor (Zingiberaceae)	rare in W.
Hypobathrum microcarpum (Rubiaceae)	possibly long ago collected on some mountain
Ischaemum fieldingianum (Poaceae)	uncertain, possibly absent.
Ixora umbellata (Rubiaceae)	locally in W of W.
Korthalsia junghuhnii (Arecaceae)	very rare in W.
Korthalsia laciniosa (Arecaceae)	possibly absent
Knema globularia (Myristicaceae)	absent
Lasianthus reticulatus (Rubiaceae)	rare in W.
Launaea sarmentosa (Asteraceae)	once collected along the south of Bantam
?Leuconotis eugenifolia (Apocynaceae)	absent
Licuala gracilis (Arecaceae)	possibly once collected
Loeseneriella pauciflora (Hippocrateaceae)	rare in W.
Memecylon excelsum (Melastomaceae)	rare in W.
Micrechites micrantha (Apocynaceae)	formerly on Mt. Salak
Microtropis elliptica (Celastraceae)	on Mt. Pulusari (W.)
Nephelium juglandifolium (Sapindaceae)	very rare in W.
Notapodytes montana (Icacinaceae)	? collected very long ago near Telaga Bodas (W)
Pandanus bidur (Pandanaceae)	on Thousand Islands
Pothos oxyphyllus (Araceae)	in environs of Bogor (W)
Pterygota horsfieldii (Sterculiaceae)	very rare in W and E.
Ptychopyxis javanica (Euphorbiaceae)	Pelabuan Ratu (W)
Randia spinosa (Rubiaceae)	very rare in W, C and E.
Rhynchodia verrucosa (Apocynaceae)	very long ago collected on Mt. Salak
Saprosma arboreum (Rubiaceae)	rare in W and C.
Saraca thaipingensis (Caesalpiniaceae)	scarce in W and E.
Scirpodendron ghaeri (Cyperaceae)	rare in W and C.
Scyphiphora hydrophyllacea (Rubiaceae)	rare in W, C and E.
Smythea lanceolata (Rhamnaceae)	isl. in Sunda-Straits & Java Sea; N.Kambangan (C)
Strychnos villosa (Loganiaceae)	very local in C.
Trigonostemon macgregorii (Euphorbiaceae)	absent
Trigonostemon ovatifolius (Euphorbiaceae)	once collected in C
Tylophora laevis (Asclepiadaceae)	very local in W.
Vatica bantamensis (Dipterocarpaceae)	formerly in S. Bantam
Vavaea bantamensis (Meliaceae)	in a few localities in W.

presently restricted to the vicinity of the lighthouse on Java's First Point in Ujung Kulon (Kostermans, 1959).

Furthermore, it should be stressed again that the list given in Table 8a is far from complete. Undoubtedly, it does not cover all the rare species, which have ever been collected in Ujung Kulon. Many of them are likely to linger in some herbarium-box, waiting to be rediscovered some day. Moreover, one may assume that there are many interesting plants occuring in Ujung Kulon that have never been collected (see also section 8.3.2). In this respect, it is significant that the relatively small island of Peucang, which has been explored many times by many botanists and in great detail, keeps yielding new species (such as the first two 'island-species' mentioned above). In contrast to Peucang Island, the rain-forest of Mt.Payung and (even more promising!) of the adjacent Mt. Honje have not yet been investigated thoroughly. Moreover, the botanical value of the Arenga obtusifolia forests of Ujung Kulon's lowlands is often underestimated (see chapter 9). Here too, many interesting finds are still to be expected.

8.3 Plant-geographical aspects

8.3.1 General considerations

A full account of the plant-geographical position of Ujung Kulon is beyond the scope of this study. However, some brief annotations may be of value for two reasons. First, a plant-geographical study helps to rate the specific floristic composition of an area at its true value, which is all the more important if one is dealing with a conservation area. Second, it helps to understand certain patterns in the species composition, which is an important expedient to the vegetation mapper.

The main source of information on any aspect of Javan plant-geography is the work of van Steenis (1950 and 1965). In the following sections we can rely on the results of his studies almost continuously.

Three aspects will be discussed briefly: the plant-geographical position of Java within the Malay archipelago, the differences in species composition between West and East Java and finally the phenomenon of altidutinal distribution of species. In all three cases a comparison will be made between the specific situation in Ujung Kulon and the general concept as described for Java as a whole.

The differences between the North and South coast of Java will not be dealt with in this chapter. However, the subject will be discussed briefly, while discussing the coastal plant-communities (see chapter 9).

8.3.2 The plantgeographical position of Java

The island of Java forms part of the plant-geographical region of Malesia, which covers the whole of the Malay archipelago, including the peninsula of Malaya and the island of New Guinea (Irian). This huge area is divided into three plantgeographical provinces. One of these, South Malesia, covers Java, Madura and the Lesser Sunda islands. The latter have basically only a depauperized Javan flora. Here, we shall confine ourselves to the island of Java itself. A plantgeographical typification of any area is facilitated by describing the representation of the various flora elements, here defined as groups of genera with a more or less identical distribution. We shall do so in a very condensed way. The indigenous flora of Malesia comprises five such elements (van Steenis, 1965):

1. Widely distributed genera (mostly ranging from Asia to Australia).
2. Asia-centred genera.
3. Malesia-centred genera.
4. Endemic genera (which are basically a special category within the Malesian element).
5. The eastern element (covering both Australia- and Pacific-centred genera).

Of these elements, the latter two are of very minor importance in Java. Only 18 genera of the eastern element have been recorded, only of which seven occur in West Java. None of them is present in Ujung Kulon. Likewise, the number of endemic genera is low (4), especially in comparison with islands in West Malesia (such as Borneo with no less than 60 endemic genera). None of the four Javan endemic genera is present in Ujung Kulon.

The Malesian element is, of course, far better represented (with 316 genera). Still, compared to West Malesia, the Javan flora is also poor in this respect. More than 120 genera of this group occur both in Sumatra and Borneo, but are completely lacking in Java. Moreover, other genera are present in Java, but are proportionally very poorly represented. Good examples of this phenomenon provides the family of Dipterocarpaceae which forms the skeleton of the lowland rain forests of West Malesia but is hardly of any significance in Java.

On the other hand, the two remaining flora elements, the groups of widely distributed and Asia-centred genera are abundantly represented with 630 and 402 genera, respectively, i.e. 92, and 65 per cent of all such genera in Malesia.

Altogether, the abundance of widely distributed and Asia-centred genera, the almost complete lack of endemic genera and the relative small significance of the Malesian element, induce plant-geographers to speak of the typical lack of character, or even 'paucity' of the Javan flora. Please note that this rather weird term only refers to the diversity on the level of genera (not of species) and to a comparison with areas with an extremely rich flora. Now the question arises, why does the Javan flora differ so much from the floras of the adjacent islands on the Sunda shelf Borneo and Sumatra? Various answers to this question are possible. One can point to the fact that certain Malesia-centred genera on Borneo and Sumatra are bound to soil conditions, which are missing on Java, while on the other hand a number of Javan genera are bound to a two-seasoned (monsoon) climate which is virtually absent on Sumatra and Borneo. The latter group of monsoon plants belong almost exclusively to the group of widely distributed or Asia-centred genera, which are so abundantly represented in Java.

However, both the pedological and the climatological answers cannot fully explain the deviating character of the Javan flora. Therefore, Endert (1935, 1936) has forwarded the theory that the absence of the characteristic Sunda shelf element was due to the serious effects of volcanism in the Tertiary followed by the destruction of the Javanese fores by man (cited from van Steenis, 1965). The fact that some Dipterocarpaceae, which are now absent (e.g. Dryobalanops) were abundantly present in Java during the Miocene and Pliocene (den Berger, 1927) nicely fits this theory.

Moreover, van Steenis stresses still another possible explanation: The *dispersal necessary for an exchange with Sumatra and penetration from Sumatran* primary forest vegetation must have been hampered in some way. This was possibly, for a long time, Java consisted of an island-arc, similar to the lesser Sunda Islands now. The fact that a number of Malesia-centred genera are in Java, restricted to the extreme west and, apparently, never got any further fits well with this theory.

Van Steenis' island arch theory seems to be in conflict with the fact that during the Pleistocene, sea-levels were far lower than they are now and much of the Sunda continental shelf must have been dry land (Haile, 1971, cited from Whitmore, 1975), facilitating plant dispersal considerably. However, as van Meeuwen et al. (1961) indicate, lower sea levels during the Pleistocene coincided with drier climates, restricting the rainforest area to isolated mountain tops, but favouring the growth and dispersal of monsoon plants.

If one accepts van Steenis' theory, isolated populations of Sumatran rainforest plants should be expected in Ujung Kulon as the most western part of West Java. Indeed, a number of 'Sumatran' genera proves to have its only representatives in Java growing in Ujung Kulon, e.g. Endocomia, Botryophora, Vatica and probably Leuconotis.

However, in 1965 van Steenis observed that the number of 'Sunda-elements' found by Kostermans et al. in Ujung Kulon was rather small. This statement deserves some critical comment. In the first place, intensive botanical exploration of Ujung Kulon had just started in those days. Second, up till now all important collectors, Junghuhn, UNESCO (see Appendix D) and Wirawan excepted, focussed strongly on Peucang Island which,just like all Ujung Kulons lowlands obviously has a monsoon climate, a fact completely ignored by van Steenis (see chapter 5). A spectacular increase in records of Sunda plants is not to be expected there, but rather on the ever-wet parts of Mt. Payung and (evenmore so) of the adjacent Mt. Honje.

We expect further botanical exploration of those regions to yield many interesting finds, which will further clarify the complicated plant-geographical position of the area and thus contribute, indirectly, to our knowledge of the geological history of the Sunda shelf as a whole.

8.3.3 West and East Javan species

The flora of Java is known to change rather strongly along a west-east gradient. An analysis of this phenomenon is presented by van Steenis (1965). It is based on a tripartition of the island in a western, central and eastern part, as used also by Backer & Posthumus (1939) and Backer and Bakhuizen van den Brink (1963-1968). The boundaries used are not the administration boundaries of the provinces of the same name (West Java, etc.) but the meridians of Cheribon and Kediri.

Van Steenis concludes that the flora of West Java is by far the richest, as far as the total number of species is concerned. As for species which are restricted to only one of the three regions, again West Java is the richest. The lowest total number of species is found in East Java, the lowest number of species restricted to one region in Central Java.

An explanation of these phenomena is found primarly in the climatic west-east gradient of Java. Continuously wet conditions (resulting in a high diversity of species) prevail in West Java, but in Central and East Java they are restricted to some small and isolated 'wet-islands'. On the other hand seasonally dry conditions, characterized by a considerable number of monsoon-plants, predominate in Central and East Java, but are also far from uncommon in the western part, especially in the northern coastal plain westwards as far as Jakarta. A second explanation can be found in the plant geographical position of Java, as described in the previous section. Obviously, the flora of West Java has been enriched by former migration of Sumatran species. On the other hand, the migration of species from the Lesser Sundas towards East Java is negligible.

Table 8b shows the representation of West and East Javan species in Ujung Kulon in relation to their altitudinal distribution (using the climatological zones described). As for the West Javan species, a difference has been made between species which are (almost) completely restricted to West Java proper and species which also occur in central Java. Species which are hardly known to occur, if at all, in West Java outside of Ujung Kulon are lumped together in one group, regardless of whether their main distribution area is Central Java, East Java, or both.

Table 8b The preference of West, Central and East Javan species for the altitudinal zones.

		total	>450 m	>150 m	indifferent	<150 m
West Javan species	N	74	4	30	17	27
	%	100	5	41	23	36
West and Central Javan species	N	105	55	35	16	54
	%	100	5	33	15	51
Central and East Javan species	N	11	0	1	1	9
	%	100	0	9	9	82

From the data presented in Table 8b the following conclusions can be drawn. As has been stated for the total flora of Ujung Kulon, most of the typically West or East Javan species also prove to respect the boundary between the wet 'mountains' and the seasonally dry lowlands. Furthermore, the large number of typically western species is striking (179, i.e. approximately 20 per cent of the total flora). Indeed, we are dealing with the most western part of West Java.

If we focus on the first, most strict category of typically West Javan species, it can be seen that they are well represented in the lowlands, but even more so in the mountains. The 'preference' of species restricted to West Java for the relatively high parts, i.e. for the continuously wet conditions becomes even more striking if one takes the far lower density of sampling points on higher altitudes in account: 41 per cent of the West Javan species is restricted to only 8 per cent of our plots (150 m. or higher).

The East Javan species occuring in Ujung Kulon show a completely different picture. Only one species was found in the continuously wet mountain zone (the fern Lomagramma sinuata) but most of the other species are restricted to the dry lowlands, confirming our picture of Ujung Kulons lowlands as a drought-island in the predominantly continuously wet West Java.

Tabel 8c List of species which occur in Ujung Kulon 100 m or more below the lower limit of their normal distribution area in Java

Species	Lower limit of distribution area		Difference
	in Ujung (m.)	in Java (m.)	(m)
Alyxia reinwardti (Apocyancea)	475	800	325
Amomum compactum (Zingiberaceae)	1	200	199
Anodendron coriaceum (Apocynaceae)	350	750	400
Ardisia macrocarpa (Myrsinaceae)	200	350	150
Asplenium amboinense (Polypodiaceae)	350	600	250
Asplenium nidus (Polypodiaceae)	1	(0)250	249
Asplenium tenerum (Polypidiaceae)	480	600	120
Begonia isoptera (Begoniaceae)	150	250	100
Calamus javensis (Arecaceae)	(5-)150	500	350
Calamus reinwardti (Arecaceae)	2	300	298
Calophyllum grandiflorum (Clusiaceae)	90	300	210
Carex cryptostachys (Cyperaceae)	8	500	492
Cephaelis stipulacea (Rubiacceae)	350	600	250
Cinnamonum sintoc (Lauraceae)	350	700	350
Coptophyllum fulvum (Rubiaceae)	150	600	450
Cryptocarya densiflora (Lauraceae)	200	650	450
Cyathea junghuhniana (Cyatheaceae)	150	1000	850
Cyrtandra picta (Gesneriaceae)	(3-)150	320	170
Cyrtandra sandei (Gesneriaceae)	150	600	450
Daemonorops ruber (Arecaceae)	(120-)450	800	350
Dioscorea pentaphylla (Dioscoreaceae)	3	500	497
Dipterocarpus trinervis (Dipterocarp.)	(15-)350	(50-)900	550
Drypetes longifolia (Euphorbiaceae)	3	150	147
Eurya acuminata (Theacaea)	(75-)150	(600-)700	550
Ficus deltoidea (Moraceae)	450	(450-)800	350
Ficus stupenda (Moraceae)	1	200	199
Freycinetia imbricata (Panddamaceae)	350	800	450
Freycinetia javanica (Pandanaceae)	350	700	350
Gynotroches axillaris (Rhizophoraceae)	250	400	150
Heliciopsis lanceolata (Proteaceae)	250	1000	750
Hypobathrum frutescens (Rubiaceae)	1	1000	999
Hypolythrum nemorum (Cyperaceae)	7	150	143
Imperata exaltata (Poaceae)	1	250	249
Korthalsia junghuhnii (Areceae)	1	600	599
Labisia pumila (Myrsinaceae)	900	150	750
Lindsaea obtusa (Polypodiaceae)	150	600	450
Macaranga glaberrimus (Euphorbiaceae)	350	700	350
Mallotus dispar (Euphorbiaceae)	40	200	160
Mapania cuspidata (Cyperaceae)	350	500	150
Microglossa pyrifolia (Asteraceae)	15	500	485
Microtropis elliptica (Celastraceae)	450	1250	800
Myrsine hasseltii (Myrsinaceae)	350	1400	1050
Nephelium juglandifolium (Sapindaceae)	50	650	600
Oleandra neriformis (Polypodiaceae)	60	(250-)500	440
Palaquium ottolanderi (Sapotaceae)	15	300	285
Phyllanthus hasskarlianus (Euphorbiaceae)	150	300	150
Picrasma javanica (Simarubaceae)	1	150	149
Pisonia umbelliflora (Nyctaginaceae)	5	150	145
Pyrenaria serrata (Theaceae)	1	200	199
Rhaphidophora montana (Araceae)	2	200	198
Sacciolepis indica (Poaceae)	1½	(9-)400	399
Scindapsus pictus (Araceae)	(150-)250	350	100
Stelechocarpas burahol (Annonaceae)	2	150	148
Uncaria ferrea (Rubiaceae)	5	150	145
Ternstroemia penangiana (Theaceae)	250	400	150
Tetrastigma dichotomum (Vitaceae)	(3-)250	1000	750
Trichomanes obscurum (Hymenophyllaceae)	475	1000	525

The figures for the less strict category of West Javan species show, as could be expected, a more or less intermediate picture.

8.4 Altitudinal distribution of species in comparison to data for Java as a whole

The phenomenon of altitudinal distribution of species in the tropics has frequently been described by van Steenis (see chapter 5). One of his major starting-points is that the temperature in the tropics would decrease very regularly with increasing altitude (0,6 °C for every 100 m). This would imply that for each species the potential altitudinal distribution area, given by its temperature tolerance, can be defined by absolute altitude and independent of the relative altitude and mass dimensions of the mountain complex on which the species at issue occurs. Thus, the situation in the tropics would deviate far from the one in the temperate zone, where the altitude of isotherms on a given mountain complex is not correlated with the absolute altitude but influenced by the total mountain mass, a phenomenon known as 'mountain mass elevation'.

The actual altitudinal range of the species of the Javan flora is given by Backer & Posthumus (1939) and Backer & Bakhuizen van den Brink (1963-1968). Since the Javan flora has been studied very thoroughly and for a very long time, we may assume that the records of Backer et al., based on all this accumulated knowledge, are fairly complete. Now, it is of interest to compare the distribution of the Ujung Kulon species in our study area with these records of Backer et al.

It proves that only a very limited number of species exceeds the upper limits given by Backer et al. and in most cases only by a few tens of metres. Obviously, the occurence of species at abnormally high altitudes is a phenomenon of little importance in Ujung Kulon.

On the other hand, the number of species which occur below their normal lower limit is astonishingly high. We estimate that at least 15 per cent of all species in Ujung Kulon occur 'too low'. However, in many cases the difference between the normal lower limit and the one in Ujung Kulon is too small to be significant. Still, some 57 species (i.e. appr. 8 per cent) occurs 100 m or more too low (see table 8c).*

Of course, abnormally low occurences of species have also been observed outside Ujung Kulon. Van Steenis (1965) enumerates a number of situations from which such low occurences have been recorded, e.g. near waterfalls, along watercourses in shaded valleys, in lowland swamps, in beach vegetation and occurence as an epiphyte on abnormally low altitudes of species which normally grow terrestrial. Of the latter four situations, examples can be found in Ujung Kulon, for example, respectively the occurence of Neesia altissima, Antidesma velutinosum, Cyrtandra picta, etc. in a very sheltered, shaded valley in the Payung area at only 75 m (Plot 131; this habitat of rainforest plants, even by Ujung Kulon standards is abnormally low). Furthermore, Stelechocarpus burahol occurs in the Salacca-dominated swamp vegetations of the fluvio-alluvial plain, Asplenium nidus along the west coast of the Payung area and Ficus deltoidea on the summits of an Payung. Moreover, one may state that for very rare species, the potential altitudinal range cannot be established with certainty. Such an explanation may hold for the occurrence of, for example, Hypobathrum frutescens on Peucang Island.

However, if this sufficient to explain the relatively large amount of

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* In fact, both figures are probably under estimations, since part of the altitudinal data, as presented in the flora of Java, may refer to records from Ujung Kulon (van Balgooy; pers.comm.).

abnormally low occurences in Ujung Kulon, one would expect the species at issue to be randomly distributed throughout the area, or possibly even concentrated at lower altitudes, for the lower a plant grows, the greater the odds are that it grows too low. On the contrary, it proves that in our study area the abnormally low occurences are concentrated on relatively high altitudes and the stricter the definition of 'too low occurence' is chosen, the clearer the correlation between too low occurence and high altitude becomes (see Table 8d).

Table 8d Numbers of abnormally low occuring species in relation to altitude

		occuring below the lower limit of the distribution area in Java; difference (in m.) at least:				
		100	250	500	750	1000
above 450 m	N	6	5	2	1	0
	%	11	15	17	14	0
above 150 m	N	34	24	9	6	1
	%	60	71	75	86	100
Indifferent	N	5	1	1	0	0
	%	9	3	8	0	0
below 150 m	N	18	9	2	1	0
	%	32	26	17	14	0
Total	N	57	34	12	7	1
	%	100	100	100	100	100

According to the theory developed by van Steenis, abnormally low occurrences of species in mountain-areas are only to be expected if the total height of the mountain reaches into the normal distribution zone of the species concerned. Such abnormal occurences are thus caused by vicinity and gravitation. This is obviously not the case in Ujung Kulon. No less than 76 per cent of the species which grow abnormally low in the 'mountain zone' of Ujung Kulon are in Java normally restricted to altitudes of 500 m or more, i.e. to altitudinal zones which are absent in Ujung Kulon.

Thus, we can only conclude that in Ujung Kulon on a mountain of relatively very modest height we find species occuring far lower than normal without having the possibility of explaining their occurence by a continuous flux of seedlings from above. The species at issue are simply 'at home' on Mt.

Payung. In other words: we found the telescope effect as described in chapter 5 not only determined the physiognomy of the vegetation, but also its floristic composition.

This is a most interesting conclusion since it is highly contradictory to the currently accepted theories of van Steenis. We shall now forward two tentative explanations for this curous phenomenon.

First, one may wonder whether Van Steenis does not over estimate the regularity of temperature decrease with increasing altitude. Average cloud-cover and thus the amount of daily solar heat generally does not change regularly, but rather abruptly along a mountain slope and temperature can at least to some degree be expected to change with it. Since the average altitude of the cloud cover is at least in areas like Ujung Kulon related to the total height of the mountain complex (this is the essence of the telescope-effect) this would provide a reasonable explanation. In addition, both Watts (1955) and Strahler (1969) point to the fact that convectional currents, inducing adiabatic cooling of rising air masses complicate the simple temperature-altitude relations as defined for still air. Moreover, lower air temperatures above the surrounding seas may be of importance. In any case, a low level of the clouds, formed in convection currents, is a token of a steep lapse-rate (aerial temperature - altitude relation) (Watts, 1955).

A second solution may be found in the principle of 'substitution of ecological factors', a concept forwarded by Schimper (1898) and used by van Steenis to explain altitudinal abnormalities. Strangely enough, van Steenis accepts substitution of climatic factors by edaphic ones in explaining permanent occurrence of coastal plants near salt wells in the mountains, but does not accept substitution of one climatic factor (temperature) by another (atmospheric humidity) as a base for permanent occurrence outside the normal altitudinal range. However, all examples of situations in which mountain species are found on too low altitudes and which were mentioned above, can be interpreted as situations with an increased atmospheric humidity. Only the low epiphytic occurrence of terrestrial mountain plants cannot in general, be explained by this type of substitution of ecological factors. On the contrary, according to Ewusie (1980), the atmospheric humidity in the canopy of a rainforest is on average low in comparison to the forest floor.

Still, in conclusion one may assume that what van Steenis considers to be exceptional and temporary on the mainland of Java is the rule in areas affected by the telescope-effect as Ujung Kulon.

CHAPTER 9: VEGETATION

9.1 Introduction

This chapter deals with the various vegetation types, described as plant-communities, which can be found in Ujung Kulon.

First, an outline is given of the available literature on the vegetation types of Ujung Kulon itself and of the Malayan region as a whole (9.2). Next, comes the main section which gives an enumeration of the 39 different community-types which can be distinguished as a result of our study (9.3).

At this point we must differentiate carefully between the definition, description and (synecological) interpretation of each type.

Each type is defined by the presence (either obligatory or facultative) or absence of various sociological groups of species. These groups originated just like the types themselves as a result of the procedure of tabular comparison of the sample plots (see chapter 3). The definition of each type can most accurately be gathered from the vegetation table (Appendix E). However, a more practical concise version of this table is given in tabel 9a. From both tables 10 (provisional) main groups of communities can be derived These (floristically defined) groups prove to have an obvious ecological significance. Moreover, they are rather constant as far as their physiognomy is concerned. Still, they do not fully coincide with the main formations of the area (see below). The status of the communities and the groups of communities within a fixed hierarchical system, sensu Braun-Blanquet, is still unknown.

The communities are described in section 9.3. For practical reasons the information on floristic composition and physiognomy is not strictly separated. This is possible since most types, though defined by their floristic composition only, are quite homogeneous as far as their physiognomy is concerned.

A concise and tentative synecological interpretation is added in separate sub-sections. Much attention is paid to the successional status of the communities at issue. For four so-called formations (i.e. groups of plant-communities, *which are dominated by one particular life-form, and recur on more or* less similar habitats; see Mueller-Dombois & Ellenberg, 1974), which are of special importance within the scope of this study, a more elaborate interpretation is added in section 9.4. Unlike the definition and description of the various types, the interpretative parts are necessarily rather speculative in nature. Field-data can at best give only indirect evidence for the successional status of a stand and literature-references on this subject are very scarce. In trying to solve the many riddles the Ujung Kulon vegetation offers, van Steenis' list of 'Axiomas and criteria of vegetatiology' (1961) proved a useful expedient.

Finally, for each type some notes are included (in section 9.3) on the internal spatial differentation and the distribution through the area. For the latter item relationship with soil-types had to be mentioned in some cases, but this was done as little as possible. The final integration of the various aspects of the landscape (including vegetation and soil) is presented in chapter 11. In the same chapter some predictions of possible, future changes in the vegetation cover will be given.

36	.	1	1	1	.	.	1	1	1	.	.	.	.	.	2	2	1	1	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	Oncosperma tig., Pyrenaria ser., 'Paku anjing'(Pol.)
37	.	1	1	1	.	.	.	.	1	.	.	.	.	1	.	3	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Salacca edulis
38	2	1	1	2	.	1	1	1	.	.	.	.	.	.	.	.	1	2	1	.	2	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Dioscorea nummularia, Smilax leuc., Dinochloa scand.
39	.	.	.	.	.	2	.	.	1	.	.	.	.	1	1	1	2	2	2	1	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	Merremia pelt., Hyptis rh., Lepistemon bi./Merr.vit.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Albizia procera, Hedyotis coerulea, Canthium horrid.
41	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Schizostachyum zollingeri
42	.	.	.	1	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Sterculia foetida, Macaranga tanar., Tectaria spec.
43	1	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	2	.	.	.	.	.	.	.	2	.	.	1	.	.	.	.	.	.	.	.	Syzygium pseudof., Planchonella ob., Claoxylon pol.
44	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Aglaia latif., Dendrocnide st., Pseuderanthemum div.
45	.	1	1	1	2	1	2	2	1	2	1	1	.	.	.	.	.	.	.	.	2	1	2	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	Polyalthia lateriflora, Ardisia lanc., Drypetes lon.
46	.	2	3	1	2	2	4	3	4	2	1	.	.	1	4	1	1	1	1	1	1	1	4	1	.	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	Arenga obtusifolia
47	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	.	1	1	.	2	.	1	.	.	.	.	1	1	.	.	.	.	.	.	.	.	1	.	Piper spec., Syzygium spec. (rest), Symplocos spec.
48	2	2	2	2	2	1	1	1	1	.	.	.	.	1	1	1	2	2	2	.	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Amomum megalocheilos, Pinanga coronata, Apama tom.
49	2	2	2	2	2	2	2	2	2	.	.	.	.	2	2	2	2	2	2	1	2	2	2	2	.	1	.	1	.	.	1	.	.	.	.	.	.	.	1	.	.	.	Homalomena cordata, 'Kilalayu' (Sapind.), Donax cann.
50	.	1	1	2	1	2	2	2	2	.	.	.	.	2	2	2	3	3	2	2	2	2	2	3	1	1	.	.	.	1	1	.	.	1	.	.	.	.	2	1	1	.	Daemonorops melanoch., Lygodium ciricin., Ficus mont.
51	.	1	1	1	2	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	1	1	2	2	1	2	.	.	.	.	.	1	.	.	.	.	.	.	2	.	1	.	Leea sambucina, Tetracera scandens, Tetrastigma lan.
52	.	.	.	.	2	1	.	.	1	.	.	.	.	2	.	1	1	1	1	1	.	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Amomum compactum, Arenga pinnata, Cissus discolor
53	.	.	1	1	.	.	1	1	1	1	1	1	.	1	.	.	1	1	1	1	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Spondias pinnata, Embelia spec., Cananga odorata
54	.	.	.	.	.	.	1	1	1	.	.	.	.	2	2	1	1	1	1	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	Licuala spinosa
55	.	.	.	.	.	.	.	1	1	.	1	.	.	.	2	1	1	1	1	.	.	.	.	3	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Syzygium polyanthum
56	.	.	.	.	.	.	1	1	1	1	1	1	.	1	1	1	1	1	1	.	.	1	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	Lagerstroemia flos-reg., Vitex pub., Micromelum min.
57	.	.	.	.	.	.	.	1	1	.	.	.	.	1	.	1	1	1	1	1	.	1	.	2	2	.	.	.	.	.	.	1	.	.	.	.	.	1	3	2	1	.	Nauclea coadunata, Corypha utan, Cayratia trifolia
58	.	.	.	1	.	2	.	.	.	.	.	.	.	.	.	.	2	2	2	1	1	3	1	1	1	2	1	1	1	1	1	1	.	1	.	1	.	1	1	1	1	.	Eupatorium odoratum, Mikania cordata, Gmelina ell.
59	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	2	.	.	1	.	1	.	1	2	1	1	.	.	1	.	.	.	.	.	.	.	1	.	.	Lantana camara
60	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	Glochidion zeylanicum
61	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	Mallotus philipp., Curculigo orch., Diospyros ferrea
62	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	2	2	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	Ximenia americana, Pteris vitt., Stachytarpheta jam.
63	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Dodonaea viscosa, Calotropis gigantea
64	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Digitaria heter., Dactyloctenium aeg., Eclipta pros.
65	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	Desmodium triflorum, Phyllanthus ur., Imperata spec.
66	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	Fimbristylis dich., Chrysopogon acic., Borreria art.
67	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	Murdannia nudiflora, Alysicarpus vagin., Sida rhomb.
68	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	.	1	2	2	.	1	2	1	1	1	1	1	2	2	2	.	1	.	.	.	.	.	1	.	1	.	.	Axonopus comp.,'Jampang piit' (Poac.), Cyperus spec.
69	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	Fimbristylis miliacea, Hygrophila er., Hedyotis dif.
70	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	1	.	.	.	.	.	.	.	.	.	.	Barringtonia as., Messerschmidia arg., Pandanus bid.
71	.	.	.	.	.	1	1	1	1	2	2	2	3	1	1	1	1	1	1	1	1	2	1	2	4	3	2	1	1	.	2	2	1	.	.	1	.	1	2	3	1	.	Ardisia humilis, Ficus septica, Buchanania arboresc.
72	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	1	.	3	1	.	.	.	1	2	.	.	.	.	.	.	.	1	1	.	Calophyllum inoph., Guettarda speciosa, Ixora palud.
73	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.	1	1	2	.	.	.	.	.	.	Sophora tomentosa, Scaevola taccada, Cassytha filif.
74	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	2	1	2	.	.	.	.	.	.	.	1	.	Hernandia peltata, Terminalia catappa, Cerbera meng.
75	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	2	3	.	.	.	.	.	.	.	1	.	Desmodium umbellatum, Mallotus tiliaef., Pemphis ac.
76	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1	.	.	.	.	1	.	.	.	1	2	.	.	.	.	.	.	.	.	.	Cycas rumphii, Pongamia pinnata, Crinum asiaticum
77	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	3	2	.	4	.	.	.	.	.	.	.	.	Pandanus tectorius
78	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	.	1	1	1	3	.	1	1	.	.	3	.	.	.	.	1	1	.	Ischaemum muticum
79	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	1	1	.	1	2	1	.	.	.	.	.	.	Fimbristylis cym., Euphorbia atoto, Thuarea involuta
80	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	Ischaemum fieldingianum, Cymbogon rectus
81	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	Najas indica, Utricularia ?gibba, Nymphaea nouchali
82	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	3	.	1	.	.	Phyla nodiflora, Eleocharis dulcis, Typha angustif.
83	2	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	.	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	Pandanus furcatus, Scleria spec.
84	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	.	.	.	Scirpodendron ghaeri, Livistona rotundifolia
85	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	1	1	.	.	.	.	.	2	.	.	.	Premna corymbosa
86	2	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	1	.	2	.	.	Breynia spec.
87	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	4	1	1	Lumnitzera spec., Casuarina equisetifolia
88	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	1	1	1	3	.	Acrostichum aureum, Derris heteroph, Nypa fruticans
89	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	2	2	Sonneratia alba, Aegiceras cornic., Ceriops decandra
90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	3	Rhizophora apiculata, Rhizophora spec., Ceriops tag.

Legend: . = this group should not occur; 1 = at least one species of this group may occur; 2 = at least one species of this group should occur; 3 = like 2; at least one species is dominant in 25-74% of the plots; 4 = like 2; at least one species is dominant in 75-100% of the plots. Dominant species have a cover of more than 45%; the species at issue are underlined. * Insufficiently known community.

Table 9a: Vegetation table (summarized version)

Plant-communities

Sociological groups	I Kibara-Flacourtia	II Garcinia-Neesia	III Pentace-Arenga	IV Rubus-Gleichenia*	V Saraca-Sumbaviopsis	VI Uncaria-Sumbaviopsis*	VIIa Pterosp.-Arenga-Steno.	VIIb Pterosp.-Arenga-Myris.	VIIc Pterosp.-Arenga-Bisch.	VIII Parinari-Gnetum	IX Pterygota-Rinorea*	X Bischofia-Ficus	XI Cerbera-Buchanania	XII Bambusa-Drypetes	XIII Areca-Arenga	XIV Oncosperma-Salacca	XVa Hyptis-Daemon.-Dill.	XVb Hyptis-Daemon.-Lant.	XVI Canthium-Albizia*	XVII Schizostachyum	XVIII Sterculia-Syzygium	XIX Dendrocnide-Syzygium	XX Dendrocnide-Arenga*	XXI Nauclea-Syzygium	XXII Corypha-Ardisia	XXIII Ximenia-Ardisia	XXIV Calotropis-Dodonaea*	XXV Dactyloct.-Digitaria*	XXVI Fimbrist.-Chrysopogon	XXVII Fimbrist.-Oplismenus	XXVIII Barringtonia-Syzygium	XXIX Sophora-Calophyllum	XXX Pemphis-Lumnitzera	XXXI Mikania-Pandanus	XXXII Ipomoea-Ischaemum	XXXIII Ischaemum-Scaevola*	XXXIV Nymphaea-Najas*	XXXV Phyla-Eleocharis	XXXVI Pandanus-Scirpodendr.	XXXVII Lumnitzera-Ardisia*	XXXVIII Derris-Sonneratia	XXXIX Sonneratia-Rhizophora	main species:
1	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Kibara cor., Aeschynanthus rad., Microtropis ellipt.
2	2	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Phyllanthus hassk., Eurya acum., Cyathea? junghuhn.
3	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	Asplenium nidus
4	2	2	1	1	1	1	1	.	.	.	.	.	.	1	.	.	1	.	1	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Lasianthus retic., Pandanus nit., Alocasia longiloba
5	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Garcinia rost., Parartocarpus ven., Cryptocarya den.
6	2	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Calamus orn., 'Paku lenta' Polyp., Cyrtandra ?picta
7	.	3	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Neesia altis., Lasianthus hirs., Xanthophytum frut.
8	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Gleichenia truncata, Amomum spec., Ficus racemosa
9	2	2	2	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Calamus jav., Diospyros frut., Aglaia ?odoratissima
10	.	2	2	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Myristica iners, Payena acuminata, Neonauclea calyc.
11	.	1	2	1	2	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Amorphophallus variab., Ardisia lur., Lerchea long.
12	.	.	.	.	2	4	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Sumbaviopsis alb., Elaeocarpus glab., Ardisia cymul.
13	.	1	.	.	.	.	2	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	Stenochlaena palustris
14	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Mallotus blumeanus, ?Wendlandia glab., Capparis pyr.
15	1	2	2	2	1	1	2	2	2	.	1	.	.	.	1	2	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Baccaurea javanica, Dillenia excelsa, Artocarpus el.
16	.	1	2	1	1	1	2	2	2	1	1	1	.	1	1	1	1	1	1	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Diospyros macrophylla, Garcinia parv., Galearia fil.
17	.	1	1	1	1	1	.	2	1	1	1	1	.	.	1	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Stelechocarpus bur., Planchonia val., Dracontom. pub.
18	.	.	1	1	1	1	1	1	1	1	1	1	.	1	1	1	.	.	.	.	.	.	1	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	Ficus spec. ('strangler', not F.microc., stup.&tinc.)
19	.	.	.	.	2	1	1	1	1	2	2	.	.	.	1	1	1	1	1	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Diospyros cauliflora, sterculia macr., Bombax valet.
20	.	.	.	.	1	1	.	.	.	2	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Rinorea cymulosa, Mallotus moritzianus, Kopsia arb.
21	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Pterygota horsfieldii, Ficus magnoliaefolia
22	1	2	2	1	2	1	1	1	1	2	2	2	2	1	1	1	1	1	1	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Aglaia/Dysoxylum spec., Syzygium zol., ?Anacolosa f.
23	.	.	.	1	2	1	1	1	1	1	1	2	2	.	.	1	1	1	1	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Pterospermum javanicum
24	.	.	.	.	2	2	.	1	1	2	2	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Aglaia argentea, Cryptocarya fer., Scolopia spinosa
25	1	.	.	.	.	.	.	.	1	2	2	2	2	.	.	.	1	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Suregada glomerulata, Rauvolfia reflexa
26	.	.	.	.	.	.	.	.	.	.	2	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Ficus pubinervis, Myristica guat., Zanthoxylum nit.
27	.	.	.	.	2	2	1	1	1	2	1	1	1	1	.	.	1	.	.	.	1	.	1	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	Pterospermum div., Diospyros malab., Schefflera ell.
28	.	.	.	.	.	.	3	1	.	.	.	.	.	1	1	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Dillenia obovata, Microcos tomentosa, Lepionurus sy.
29	.	.	.	.	.	.	.	1	2	1	1	.	.	3	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Drypetes ovalis, Streblus spec., Diospyros polyalth.
30	.	.	1	1	1	1	.	1	1	2	2	2	1	2	.	.	1	1	1	1	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Hypobathrum racemosum, Dalbergia pinn., Uvaria spec.
31	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	1	1	1	1	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Bambusa blumeana, Panicum not., Mischocarpus sund.
32	.	.	1	1	1	1	1	1	1	1	1	.	.	2	1	.	1	.	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Aporosa aurita, Vitex glabrata
33	.	.	.	.	.	.	.	.	1	1	1	2	1	.	2	.	.	.	2	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Bischofia javanica
34	.	.	.	.	.	.	.	1	.	.	.	.	.	.	2	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Lindernia ruell., Ophiorrhiza trich., Nervilia spec.
35	.	.	.	.	.	1	.	1	1	.	.	.	.	.	2	1	1	1	1	.	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	Areca cathecu, Catimbium malaccensis, Alocasia macr.

Table 9b: Classification of vegetation-types as presented in this study and the corresponding classification according to other systems

	Hommel, (1987)[3]	Hommel (1983)[3]	Ammann (1985)[4]	van Steenis (1935)[1]	van Steenis (1965)[2]	other authors[4]
	Community of:	Community of:				
I	Kibara-Flacourt.	Neesia altissima(n)		evergreen forest (61)	mixed lowland and hill rain forest on dry land (viii)	zone C: 200-480 m (w)
II	Garcinia-Neesia	Neesia altissima(n)	mountain forest	evergreen forest (61)	mixed lowland and hill rain forest on dry land (viii)	zone C: 200-480 m (w)
III	Pentace-Arenga	Arenga obtusifolia (a)	Arenga forest	secondary forest (20)	degraded rain forest (viii)	zone B: 0-200 m (W)
IV	Rubus-Gleichenia	-	-	cremnophytes (12)	cremnophytes (viii)	-
V	Saraca-Sumbaviop.	'Kilaja kecil' (m)	-	monsoon forest (57)	monsoon forest (xii)	-
VI	Uncaria-Sumbaviop.	'Kijahe' (l)	-	shrubjungle (14)	degraded moonsoon forest (xii)	-
VIIa	Pterosp.-Ar.-Sten.	Arenga obtusifolia (a) 'Kilaja kecil' (m)	Arenga forest	secondary forest (20)	degraded monsoon forest (xii)	-
VIIb	Pterosp.-Ar.-Myris.	Arenga obtusifolia (a)	Arenga forest	secondary forest (20) monsoon forest (57)	(degraded) monsoon forest (xii)	zone B: 0-200 m (W)
VIIc	Pterosp.-Ar.-Bisch.	Arenga obtusifolia (a)	Arenga forest	secondary forest (20)	(degraded) monsoon forest (xii)	-
VIII	Parinari-Gnetum	Parinari corymbosum (q) 'Kilaja kecil' (m)	-	monsoon forest (57)	monsoon forest (xii)	mixed forest zone (K)
IX	Pterygota-Rinorea	-	-	monsoon forest (57)	monsoon forest (xii)	-
X	Bischofia-Ficus	Ficus pubinervis (i)	-	monsoon forest (57) secondary forest (20)	(degraded) monsoon forest (xii)	Ficus pubinervis zone (k)
XI	Cerbera-Buchanania	Buchanania-Radermachera	-	secondary forest (20)	degraded monsoon forest (xii)	Buchanania zone (H)
XII	Bambusa-Drypetes	Drypetes-Bambusa (h)	bambu duri	bamboo forest (48)	degraded monsoon forest (xii)	-
XIII	Areca-Arenga	Arenga obtusifolia (a)	Arenga forest	secondary forest (20) Oncosperma forest (36)		-
XIV	Oncosperma-Salacca	Salacca edulis (t)	salak 'forest' shrubland + trees	? savanna (15) secondary forest (20)	degraded monsoon forest (xii)	-
XVa	Hyptis-Daem.-Dill.	Calamus-Amomum (d)	shrubland, no trees shrubland + bushes shrubland + trees	shrubjungle (14) savanna (15) rotan vegetation (38)	degraded monsoon forest (xii)	-
XVb.	Hyptis-Daem.-Lant.	Calamus-Amomum (d)	shrubland, no trees	shrubjungle (14) rotan-vegetation (38)	degraded monsoon forest (xii)	-
XVI	Canthium-Albizia	-	-	secondary forest (20)	degraded monsoon forest (xii)	-
XVII	Schizostachyum	Schizostach. zoll.	bambu cangkeuteuk	bamboo forest (48)	degraded monsoon forest (xii)	-

XVIII	Sterculia-Syzygium	Sterculia foetida (w)	-	cremnophytes (12) savanna (15) secondary forest (20)	cremnophytes (viii) degraded monsoon forest (xii)	-
XIX	Dendrocn.-Syzygium	Dendrocn.-Eupat. (g)	shrubland, no trees shrubland + bushes shrubland + trees	dune vegetation (5) shrubjungles (14) savannas (15)	dune vegetation (iv.c) degraded monsoon forest (xii)	-
XX	Dendrocnide-Arenga	Arenga obtusifolia (a)	Arenga forest	secondary forest (20)	degraded monsoon forest (xii)	-
XXI	Nauclea-Syzygium	Syzygium polyanthum (x)	-	secondary forest (20)	degraded monsoon forest (xii)	-
XXII	Corypha-Ardisia	Ardisia-Buchanania (b)	-	secondary forest (20)	degraded monsoon forest (xii)	-
XXIII	Ximenia-Ardisia	Ardisia-Buchanania (b)	-	secondary forest (20)	degraded monsoon forest (xii)	-
XXIV	Calotropis-Dodonaea	Imperata-Calotropis (j)	-	savanna (15)	degraded monsoon forest (vii)	-
XXV	Dactyloct.-Digitar.	Chrysopogon acicul. (f)	-	?± tegalan (155)	artificial grassland (xii)	-
XXVI	Fimbrist.-Chrysop.	Chrysopogon acicul. (f)	-	?± tegalan (155)	artificial grassland (xii)	-
XXVII	Fimbrist.-Oplism.	Chrysopogon acicul. (f)	-	?swamp vegetation (6) ?± tegalan (155)	artificial grassland (xii)	-
XXVIII	Barringtonia-Syz.	Sophora-Calophyllum (v)	-	beach vegetation (15) Pandanus vegetation (49)	Barringtonia formation (iv.b)	zone A: beach (W)
XXIV	Sophora-Calophyl.	Sophora-Calophyllum (v)	-	beach vegetation (5)	Barringtonia formation (iv.b)	Calophyllum inophyllum zone (K)
XXX	Pemphis-Lumnitz.	Sophora-Calophyllum (v)	-	beach vegetation (5)	Barringtonia formation (iv.b)	-
XXXI	Mikania-Pandanus	Pandanus tectorius (p)	-	Pandanus vegetation (49)	Barringtonia formation (iv.b)	-
XXXII	Ipomoea-Ischaemum	Ipomoea pescaprae (k)		beach vegetation (5)	Pes-caprae formation (iv.a)	Pes-caprae formation (K)
XXXIII	Ischaemum-Scaevola	-	-	?cremnophytes (12)	cremnophytes (viii)	-
XXXIV	Nymphaea-Najas	-	-	fresh water vegetation (6)	hydrophytic vegetation (vi)	-
XXXV	Phyla-Eleocharis	Phyla nodiflora (r)	-	swamp vegetation (6)	hydrophytic vegetation (vi)	-
XXXVI	Pandanus-Scirpod.	Nypa-Acrostichum (o)	-	(palm)savanna (15) Corypha/Livistona veg. (39) Pandanus vegetation (49)	?mangrove (iii)	-
XXXVII	Lumnitzera-Ardisia	Ardisia-Buchanania (b) Casuarina-Lumnitzera (e)	-	secondary forest (20) Casuarina forest (40)	?mangrove (iii)	-
XXXVIII	Derris-Sonneratia	Nypa-Acrostichum (o)	-	Nypa vegetation (32) Sonneratia mangroves (65)	mangrove (iii)	?fresh water swamp (K)
XXXIX	Sonneratia-Rhizoph.	Rhizophoraceae (s)	-	Rhizophora mangroves (63)	mangrove (iii)	-

The authors cited give classification systems of vegetation-types for 1) Indonesia, 2) Java, 3) Ujung Kulon and 4) a part of Ujung Kulon.
The figures and small letters in brackets refer to the codes given by the authors cited.
The capitals in brackets (last column) stand for author's names:
H = Hoek & Kostermans (1950; cited from Hoogerwerf, 1970); K = Kartawinata (1965; see also Kartawinata et al., 1986); W = Wirawan (1965).

9.2 Literature review

Broad vegetation descriptions of Ujung Kulon were given by many authors, e.g. Satmoko (1961), Schenkel and Schenkel-Hulliger (1969) and Hoogerwerf (1970). These authors do not however define proper vegetation types.

Pellek (1977) studied both soil and vegetation in eight different localities in Ujung Kulon, but he focussed mainly on gathering a wealth of quantitative data. He did not define soil- or vegetation types, neither did he give many correlations or generalizations.

Djaja et al. (1982) studied food preference of the Javan rhinoceros in relation to the availability of foodplants, gathering much valuable data on vegetation. The identification of plant-communities was however not an objective of their survey.

More detailed descriptions of floristically defined vegetation-zones were given for Peucang Island by Kartawinata (1965; see also Kartawinata et al., 1986) and for Mt. Payung by Wirawan (1965).

The first area-covering enumeration of plant-communities was provided by Hommel (1983). The present study is in fact a more detailed elaboration of this report.

Recently, the zoölogist Ammann (1985) published an outline of vegetation-types of his study-area (and adjacent regions) in Ujung Kulon. Though his study area was only of moderate size (some 15 square kilometers), it was remarkably well chosen, especially in view of the fact that during the time of his fieldwork no reliable topographical map or vegetation map of the area was available. Most of the main vegetation types of Ujung Kulon are included in his study-area. Ammann defined his vegetation types mainly on physiognomy and dominant species, but he states that they correspond well with our preliminary types (1983) which were defined by their total floristic composition.

A comparison of our definite classification with some, others, formerly published, is given in Table 9b.

As stated in chapter 3, phytocenological studies, in which plant-communities are defined by their total floristic composition (like the present study), have until now been very rare in the Malayan region. Therefore it is impossible to fit the plant-communities defined here for Ujung Kulon, into any existing regional system based on the same approach. Of course this does not imply that the diversity of vegetations in the region has not been studied at all. On the contrary, van Steenis published an extensive study on this subject in 1935, not only giving a full account of the major literature references (in which the monumental works of Junghuhn (1850-1854) hold a central position), but also enumerating all of the then known vegetation types. His study should be considered as a reconnaissance survey and the vegetation types discerned are, of necessity, of varying status. They include *vegetation zones correlated with altitude and climate, true formations*, vegetations dominated by one characteristic species and even some broad plant-communities sensu Braun-Blanquet (by van Steenis less correctly called formations).

In 1957 the same author published a shortened revision of this study and in 1965 an (again shortened) version especially dealing with the island of Java. In table 9c an attempt is made to fit our plant-communities of Ujung

Kulon into the broader types as described by van Steenis (1935 and 1965).

9.3 The plant-communities

For each community some notes on the sociological species groups and a classification of the vegetation- form according to the system of Eiten (1968), are added (see Chapter 3). The numbers in brackets following each species-name also refer to the sociological species-groups (see tabel 9a).

A. Neesia altissima community-group (I-IV)

(mainly evergreen forests of the mountain-region)

I. Community of Kibara coriacea and Flacourtia rukam

Soc.groups: the total number is 16; 1, 2, 6 and 9 are the most important ones.

Low to medium-tall evergreen broadleaf forest.

Description

Three principal layers can be distinguished.

There is but one tree-layer, which is closed and only 6-12 m high. It consists of evergreen, broadleaved, unbuttressed and relatively thin-stemmed trees. Locally slightly gnarled specimens occur. There are no true dominants. The major tree species are Flacourtia rukam (1), Kibara coriacea (1), Myrsine hasseltii (2) and Microtropis elliptica (1).

The high shrub layer is open or closed and 1-3 m high. It consists mainly of tree-saplings and seedlings, but also includes patches of thorny palmlets, mainly Licuala gracilis (2) and Daemonorops cf. ruber (1) and some scattered treeferns, viz. Cyathea cf. junghuhniana (2).

The mixed groundlayer is also open or closed and up to 1 m high. It consists mainly of seedlings, patches of small-sized rattans (Calamus javensis; 9) and various terrestrial ferns and herbs, of which a typically spotted form of Phrynium pubinerve ('patat maung'; 49) and the leguminose Desmodium laxum (1) are the most conspicuous.

On the whole, lianas and vines are not abundant. However, some species such as Dioscorea nummularia, Smilax leucophylla and the climbing bamboo Dinochloa scandens (all 38) are frequentely present.

Epiphytes occur abundantly and in great variety. Most conspicuous are the beautifully flowering herb Aeschynanthus radicans and the scrub-epiphytes Ficus deltoidea and Schefflera fastigiata (all 1). Tree-trunks are partly covered with epiphytic mosses.

Distribution

Restricted to the summit regions of Mt. Payung, upwards from approximately 450 m.

Variation

A strikingly constant vegetation-type; towards the lower limit of its distribution area gradually merging into the community of Garcinia rostrata and Neesia altissima.

Synecological interpretation

As for its physiognomy the summit forest of Mt. Payung mimics in some respects, the subalpine forest which normally occurs in Java at altitudes of

2400 m or more. However, the species are those of the Javan lowland and hill rainforest. This phenomenon is due to the so-called telescope-effect, described by van Steenis (see Chapter 5). But many species occur below their normal altitudinal range in Java. Thus obviously, the telescope-effect has floristic consequences as well. This phenomenon has been discussed at length in chapter 8.

Locally, parts of the summit forest may have been cleared in the past, e.g. in the environs of the triangulation point (plot 128) or in a still further remote history as sacred areas (see chapter 4). Still, all stands of this type are notably similar and we may assume that regeneration on disturbed sites was completed long ago.

Finally, we may assume this forest type to be strongly influenced by the sea-winds, which may seasonally be very violent (see Chapter 5). Undoubtedly, the stunted character of the summit forest can also be interpreted as an adaptation to such harsh conditions. Moreover, the presence of some species point in the same direction, e.g. the climbers of soc. group 38, which are mainly species of the secondary shrubvegetations of the lowlands and Syzygium pseudoformosum (43), which normally thrives in beach forests, on coastal cliffs, etc.

II. Community of Garcinia rostrata and Neesia altissima

Soc. groups: the total number is 26; no. 2, 5., 6, 7 and 9 are the most important ones.
Evergreen broadleaf tall forest.

Description

In general at least four distinct layers can be distinguished.

The upper tree-layer covers at least 60% and is up to 35 (locally even 40) m. high. Its upper surface is uneven, but true emergents are probably scarce. Generally, Neesia altissima (7) is dominant, locally covering even 50-60% of the ground surface. Other common species are e.g. Parartocarpus venenosa (5), Pentace polyantha (7), Dipterocarpus trinervis (5) and Syzygium cf. syzygioides (2). Many trees of this layer are buttressed.

The lower tree-layer also covers at least 60%. It is a rather complex and uneven storey of treelets in height varying from approximately 5-15 m. There are no dominants and on the whole the floristic diversity is far greater than in the upper tree-layer. Next to many young specimens of trees of the upper- storey, a wide variety of small-sized trees can be encountered. Some of the more common ones are Garcinia rostrata (5), Phyllanthus hasskarlianus (2). Diospyros frutescens (9), Sterculia coccinea (2) and Cryptocarya densiflora (5). In many of these species the difference between treelet and high shrub is quite obscure.

Next, a more distinct high shrub layer is present. It is 1-3 m high and covers 40-80%. It consists mainly of thorny palmlets: Licuala gracilis (2), which tends to dominate the layer and some rattan-species. Tree seedlings and some scattered treeferns, Cyathea cf. junghuhniana (2) are present as well.

The mixed ground-layer is up to 1 m. high and covers 30-50%. It consists mainly of a wide variety of broadleaved shrublets, such as the Rubiaceae Lasianthus reticulatus (4), L. hirsutus (7) and Xanthophytum fruticulosum

(7). A small-sized rattan (Calamus javensis; 9), herbs, ferns and of course many tree-seedlings are also present. Among the herbs one finds many Araceae, e.g. Schismatoglottis calyptrata (7) and Alocasia longiloba (4).

Climbers, both woody and herbaceous are rather abundant, climbing pandans (Freycinetia spec.; 2) being the most conspicuous. Epiphytes are also quite common, but not to the same extent as in the summit community of Kibara and Flacourtia. Scrub-epiphytes are generally absent.

Distribution

Covering the slopes of Mt. Payung upwards from 150 m. to approximately 450 m. Also present on nearby Mt. Honje, there, probably upwards from 200 m.

Spatial variation

Towards the upper limit of its distribution area gradually merging into the community of Kibara and Flacourtia. The lower boundary is in general rather abrupt. At an altitude of 350 m. and higher, the physiognomy of the Neesia-forest gradually changes. The total height decreases (ultimately to 15-20 m), the distinction between the two tree-layers becomes less evident and the share of the epiphytes (including mosses on treetrunks) increases. The general aspect of the forest becomes less shady and far less luxuriant.

This change in physiognomy is paralleled by a certain shift in floristic composition. Some species have a preference for relatively low altitudes, e.g. Myristica iners (10) and Cryptocarya densiflora (5); others thrive mainly on higher altitudes, e.g. Dipterocarpus trinervis (5), Cinnamonum sintoc (2) and Myrsine hasseltii (2).

However, on the whole, the Neesia forest has a remarkably constant floristic compostion. A description of two distinct community types does not seem very realistic.

On ridges, a rather aberrant form of the Neesia forest can be found, bearing witness to both wind influence and intensive animal activity. The forest there is in general, less high and the layer of thorny palmlets in many places very dense. On the ridges one may also encounter many species which are otherwise mainly restricted to lower altitudes, their seedlings probably sprouting from dung. The most conspicuous are Oncosperma tigillaria (36) and Salacca edulis (37).

Finally, on nearby Mt. Honje a form of Neesia forest was encountered (plot 335), which included virtually all the characteristic species known from Mt. Payung. However, the Honje forest seems to be still richer, while dominance of species does not occur. This corresponds well with the experience of other investigators (Mc. Kinnon, pers.comm.).

Synecological interpretation

This community represents a type of real evergreen tropical rainforest, of obvious primary nature. Its occurence on Mt. Payung is explained by the so-called telescope-effect, causing relatively humid climatic conditions during the NE monsoon (see chapter 5). The consequenses of the telescope effect on the flora of the area have been discussed in chapter 8 (see also the Kibara-Flacourtia community).

An interesting aspect of the rainforest on Mt. Payung is the occurence of more or less dominating species, an abnormality in rain forest habitats (see e.g. van Steenis, 1965, Whitmore, 1975 and Jacobs, 1981). As was mentioned above, on nearby Mt. Honje a similar forest type was found, which lacks dominance and is probably floristically richer.

Two possible explanations can be proposed to explain this phenomenon:

First, one may assume that the rainforest of Mt. Payung grows at the limits of its possibilities as far as tolerance of a seasonal climate is concerned. Mt. Honje, on the contrary, is notably wetter during the dry season.

Second, the extremely high diversity known from most rain forest stands, depends on the (former) existence of vast areas of the same habitat. However, unlike Mt. Honje, Mt. Payung is but a very small and isolated 'wet-island'. One may assume this island-character has always negatively influenced the area's floristic diversity. Moreover, it may have become fatal to many rare and selective species after the ash-rains following the Krakatau eruption which temporarily destroyed the rainforest micro-climate (by causing abnormal deciduousness) and influenced germinating and growing conditions for seeds and seedlings (by ash deposition) for a long time.

III. Community of Pentace polyantha and Arenga obtusifolia

Soc. groups: the total number is 26; no. 7, 10, 15 and 46 are the most important ones.

Evergreen broadleaf and palm tall forest with emergents.

Description

In general the physiognomy of this type is rather similar to the physiognomy of all other communities which are dominated by the 'langkap' palm, Arenga obtusifolia (46) (i.e. comm. no. 7a, 7b, 7c, 13 and 20).

This implies that there are four more or less distinct structural layers:

First there is an uneven upper tree layer. It may cover 30-80% and the tallest trees may reach a height of 25-30 m, locally even more. Usually there are some real emergents, not rarely giant strangling figs.

Next comes a closed layer of medium-tall trees, mostly covering 80-100% and 10-15 m high. This layer is strikingly dominated by palms of which Arenga obtusifolia is by far the most important one. The share of the dicotyledonous trees is rather variable.

The following two layers are both of minor importance. Mostly their coverage is only modest, they are even more or less absent.

First, there may be a high shrub layer of some 2-3 m high, which is generally dominated by juvenile palmtrees. Scattered rattanscrubs, a few gingers and some dicotyledonous treelets (incl. saplings and tall seedlings) may be present as well.

Next, there may be a mixed groundlayer of 0-1 m high, again mainly consisting of palmseedlings, but also a variable amount of shrublets, herbs, etc.

Both climbers and epiphytes are rather rare.

The main impression of a 'langkap' forest is one of a heavy, dark forest with very scanty undergrowth.

The various types of 'langkap' forest may vary more or less clearly as far as the accompanying species are concerned. Variations on the general physiognomic plan are of minor importance.

The type at issue, i.e. the community of Pentace and Arenga may be considered to be the least typical of all. As for its physiognomy, it differs from the other types of 'langkap' forest in being evergreen, having a relatively modest dominance of (Arenga) palms in the lower tree layer (never more than 60%, often much less) and having a relatively abundant undergrowth, occasionally covering 60% of the soil surface.

The most common species of the upper tree layer are, next to various species of strangling figs (18), Pentace polyantha (7), Neesia altissima (7), Artocarpus elasticus (15) and Myristica iners (10).

In the lower tree layer we find, alongside the dominant Arenga, species like Baccaurea javanica (15), Drypetes longifolia (45) and the palm Oncosperma tigillaria (36).

The main rattan species of the high shrub layer are Calamus ornatus (6) and Daemonorops melanochaete (50). In between, treelets like Dillenia excelsa (15) and Barringtonia macrocarpa (15) are quite common.

In the mixed groundlayer a wide variety of shrublets and herbs can be encountered which also occur (and in most cases far more abundantly!) in the adjacent Neesia forest at higher altitudes. Only a few species seem to have a preference for the community under consideration e.g. Loxonia hirsuta (11) and the conspicuous geophyte Amorphophallus variabilis (11).

Distribution

On Mt. Payung, from approximately 50 m. up to 150 m.; at higher altitudes very locally on former clearings (e.g. plot 134 on 200 m.). Also observed on Mt. Honje (not sampled).

Spatial variation

Towards the lower limit of its distribution area the Pentace-Arenga community very gradually merges into the community of Pterospermum and Arenga (subtype with Myristica iners). On the other hand, the transition to the Neesia forest uphill is rather abrupt, especially on the northern and eastern side of Mt. Payung.

In between these two boundaries, from high to low altitude, the share of Arenga obtusifolia increases, while both the share of typical mountain species and the density of the undergrowth decrease.

Synecological interpretation

This community can be considered to be characteristic of the transitional zone between the everwet mountains and seasonally dry lowlands.

In this respect there is a clear similarity with the community of Saraca thaipingensis and Sumbaviopsis albicans (no. V; occuring on the higher parts of the Telanca-massif), with which it has indeed many species in common (e.g. soc. group 11). However, there are also notable differences between the two communities.

First, the Saraca-Sumbaviopsis forest can be considered to be more or less of primary nature, while we assume that all Arenga forests are secondary growth (see section 8.4).

Second, compared to the Pentace-Arenga forest, the Saraca-Sumbaviopsis forest shows far more dry lowland - and far fewer rainforest - characteristics. This is the more conspicuous, since the Pentace-Arenga forest descends to far lower altitudes. There are three possible explanations for this phenomenon. First, one may point to the difference in parent material, i.e. tuff vs. limestone. The occurrence of limestone is known to reinforce the impact of seasonal drought (Whitmore, 1975).

Second, the Pentace-Arenga forest may be assumed to enjoy a continuous stream of diaspores from the Neesia rainforest above (vicinism). Probably, a considerable part of the 'mountain-species' found in the forest in question occur there in fact, only 'pseudo-permanently' as van Steenis (e.g. 1961) puts it, describing this phenomenon for the mountains of Java in general. Of course, in the case of the Saraca-Sumbaviopsis community such an inflow of mountain elements is impossible because of lack of any rainforest uphill.

Third, the telescope-effect, for which Mt. Payung is indebted to its relatively wet climate, can be assumed to be far less effective in the habitat of the Saraca- Sumbaviopsis forest, i.e. on the highest parts of a relatively low plateau.

For a more detailed interpretation of this and the other types of 'langkap'-forest, we can refer to section 9.4.

IV. Community of Rubus mollucanus and Gleichenia truncata

Main soc. groups: the total number is 31; no. 8, 15, 32, 43 and 50 are the most important ones.

Semideciduous broadleaf open low forest with closed scrub.

Insufficiently known community; the following description is based on one single plot (115).

Description

There are three principal layers.

The single tree layer is open and very uneven. Its height is generally less than 7 m, but locally reaching up to 15 m. The main species is Vitex glabrata (32). Also present are e.g. Dillenia excelsa, Baccaurea javanica (both 15), Syzygium pseudoformosum (43) and the deciduous fig-tree Ficus racemosa (8).

Underneath, a high shrub layer is found. It is completely closed, very dense and reaching up to 3 m. It is composed mainly of various types of climbers, which grow in an inextricable tangle. Most conspicuous are the climbing fern Gleichenia truncata (8) and the rattan-species Daemonorops melanochaete (50). Several species of dicotyledonous lianas (e.g. Rubus moluccanus; 8) and the climbing bamboo Dinochloa scandens are present as well. In between we find patches of giant gingers (Amomum spec.;8), some scattered wild bananas (Musa acuminata; 42), young treelets, etc.

The third layer, a mixed groundlayer reaching up to 1 m is very sparse. It contains tree-seedlings, but also several species of herbs and shrublets, e.g. Begonia isoptera and Xantophytum fruticulosum (both 7).

Distribution

Locally on Mt. Payung; in relatively small patches on steep and very exposed slopes and ridges; probably not below 150 m.

Spatial variation

Unknown.

Interpretation

Regrowth on very exposed sites where the evergreen climax forest has been damaged by storms or landslides.

The vegetation shows similarities with both the secondary shrublands occurring at lower altitudes (with a predominance of rattan-scrub and gingers) and the Sterculia foetida forest (with Musa acuminata and Syzygium pseudoformosum) of the cliff-coasts of Mt. Payung.

The presence of a truely deciduous tree, points to the relatively strong impact of even a slightly seasonal climate in places where the rainforest cover has been damaged. We discussed this phenomenon in chapter 8.

In the plant-community in question, the more selective species of the evergreen forests are in fact restricted to the relatively sheltered groundlayer. The bulk of the vegetation, however, is formed by species which are either completely restricted to this community or have their major distribution in Ujung Kulon at lower altitudes.

B. Pterospermum diversifolium community-group (V-XIII)

(mainly semideciduous forests of the lowlands, not including the coastal plain of the mainland, coastal swamps and beaches).

V. Community of Saraca thaipingensis and Sumbaviopsis albicans

Soc. groups: the total number is 25; no. 9, 12, 19 and 22 are the most important ones.
Semi-deciduous broadleaf medium-tall forest.

Description

A rather variable forest-type without a very pronounced layering. Only with some effort can one distinguish four structural layers:

First, there is an upper tree-layer covering 60-90% and 15-20 m high. It consists of broadleaved trees like Aglaia argentea (24), Dysoxylum spec. (22), Pterospermum diversifolium (27), Pterospermum javanicum (23) and Bombax valetonii (19), of which the latter two are deciduous. Strangling figs (18) may be present as well. True dominants are absent.

Next, there is a lower tree layer of approximately 5-8 m high, covering 50-80%. Some of its most conspicuous species are Saraca thaipingensis (11), Elaeocarpus glaber (12), both Diospyros cauliflora (19) and D.frutescens (9), Sumbaviopsis albicans (12) and an unidentified Annonaceae-treelet. The latter two species may locally become dominant within this layer. Palmtrees (Arenga obtusifolia) are present, but only in small numbers.

The high shrub layer of 1-2 m high is of little significance, covering only 20-40%. It consists mainly of treeseedlings and patches of the small-sized rattan Calamus javensis (9).

The groundlayer (of some 30 cm high) does not cover more than 30% and occasionally less. However, next to the inevitable treeseedlings it comprises some conspicuous herbs and shrublets like Amorphophallus variabilis (11) and Ardisia cymosa (12).

Both climbers and epiphytes are rare.

Distribution

Restricted to the higher parts of the Telanca-massif; there mainly on steep limestone-crests.

Hommel (1983) erroneously mentions this community for the limestone-crests of Mt. Telanca 2 and Peucang Island. Though quite identical in physiognomy, the crest vegetations in those localities belong to respectively the Pterospermum-Arenga community (subtype with Bischofia; VIIc) and the Parinari-Gnetum community (VIII).

Spatial variation

Insufficiently studied.

Synecological interpretation

One may assume the stands of this community to be relicts of primary vegetation on the Telanca massif. They are intermingled with stands of secondary vegetation, mainly Langkap forest. The boundaries are in general strikingly sharp, while in most cases no abrupt change in edaphic conditions could be traced. See also section 8.4.

Furthermore, this forest type is characteristic of the transition zone between the everwet mountains and seasonally dry lowlands. It is interesting to observe that it has many species in common with both other strongholds of primary vegetation in Ujung Kulon: everwet Mt. Payung and seasonally dry Peucang Island. The species of soc. group 9 recall of the rainforests of Mt. Payung; species of soc. group 20, 22 and especially 24, point to kinship with Peucang Island.

Moreover, there is a clear resemblance with the other transitional forest type, the Pentace-Arenga community, with which it has e.g. the species of soc. group 11 in common. For a discussion of the differences between both communities see 8.3.III

VI. Community of Uncaria spec. and Sumbaviopsis albicans

Soc. group: the total number is 30; no. 12, 39 and 48 are the most important ones.

Semi-deciduous broadleaf medium-tall open forest with closed scrub.

Insufficiently known community; the following description is based on one single plot (313).

Description

There are three distinct structural layers.

The main layer is a dense, closed thicket of some 4 m high, consisting mainly of dicotyledonous lianas and shrubs. Rattans are rather rare.

Above this thicket a very uneven open layer of low to medium-tall trees, including some scattered palms, is present. It reaches up to 15 m.

The open groundlayer of some 30 cm high consists of herbs, ferns, tree- and liana seedlings and shrublets.

The floristic composition of this community closely resembles the one described for the community of Saraca and Sumbabaviopsis. However, there are some notable differences too. First, the 'rain forest species' known from Mt. Payung (soc. group 9) are completely lacking. Second, Sumbaviopsis albicans is even more predominant. Third, there is the (abundant) presence of several species of lianas, e.g. Uncaria spec. (39), Caesalpinia spec. (48), Merremia peltata (39) and Paederia scandens (39).

Distribution

Restricted to the higher parts of the Telanca massif; there on relatively low and flat sites in a mosaic with stands of Arenga forest.

Spatial variation Unknown.

Synecological interpretation

In spite of its great floristic resemblance to the primary Saraca-Sumbaviopsis forest occurring in the same region, the physiognomy of the Uncaria-Sumbaviopsis community points to some former disturbance. This impression is reinforced by the fact that species with a preference for everwet conditions (soc. group 9) are missing and by the abundant occurrence of lianas which more commonly can be found in the secondary shrublands at lower altitudes (soc. group 39 and 48).

Apparently, this community locally replaces the community of Hyptis and Daemonorops which elsewhere indicates the location of shifting cultivation sites, which were in use at the time of the Krakatau eruption (see section 8.4).

The reason for this replacement is unclear. The soil profile of plot 313 shows some colluvial influence, but this is likely to be but a local deviation. More probable explanations are different conditions on the higher parts of the Telanca-massif as far as the seasonal drought and the availability of pioneer-plants are concerned.

VII. Community of Pterospermum diversifolium and Arenga obtusifolia

Soc. groups: the total number is 42; no. 15, 16, 18, 27 and 46 are the most important ones.

Semi-deciduous tall broadleaf and palm forest with emergents.

Note that the minimal area in these Arenga forests is assumed to be extremely large (see Chapter 3). This implies that all our plots give a more or less incomplete picture of the floristic composition of the stand sampled. Therefore it is uncertain which sociological groups may occur and which should occur.

Description

The physiognomy of this community corresponds with the physiognomic plan as described for Arenga obtusifolia forests in general (see 9.3.III).

Some of the most common species of the upper tree layer are strangling figs (18; frequently real forest giants emerging above all other trees), Pterospermum diversifolium (27), Pterospermum javanicum (23), Alstonia scholaris (22), Diospyros macrophylla (16), Artocarpus elasticus (15), Bombax valetonii (19), Spondias pinnata (53), Lagerstroemia flos-reginae (56) and Vitex pubescens (56).

The lower tree layer is generally completely dominated by Arenga obtusifolia (cover 80-100%). The most common trees in between are Baccaurea javanica (15) and Diospyros cauliflora (19). The treelets Barringtonia macrocarpa (15), Dillenia excelsa (15) and Leea sambucina (51) are also quite common but rarely reach out above the sparse shrub layer, which consists mainly of young Arenga palms and some scattered scrubs of the rattan Daemonorops melanochaete (50).

Climbers, epipytes and herbs are on the whole quite rare.

Distribution

Very common throughout the area on altitudes below 125 m.; on Mt. Payung below 50 m; on well or moderately well drained soils; in many places forming a capricious mosaic with rattan shrublands, but also frequently (especially on the undissected plateaux) in very extensive uninterrupted stands; not on Peucang Island.

Spatial variation

On Mt. Payung gradual transitions with the Pentace-Arenga community occur, in the plains transitions towards the Areca-Arenga community can be encountered. Furthermore, the boundaries of this community are in general strikingly abrupt.

On the basis of their floristical composition 3 subtypes can be defined. These subtypes can hardly be identified using single species but are distinguished very clearly using the sociological groups as a whole. This may be a specific character of the vegetation at issue, but may also be due to the incompleteness of our sample plots in the 'langkap' forests, as mentioned above (see also chapter 3).

The subtypes show a remarkable correlation with abiotic factors, especially with the parent material from which the soil profiles underneath the forest have developed. The subtypes distinguished are:

a. subtype with Stenochlaena palustris.
   On soils developed from andesitic rock in the western hills; also locally in the extreme SW outskirts of the Honje-massif on similar soil types (parent material unknown).
b. subtype with Myristica iners.
   On soils developed from tuffs, both in the western hills and on the lower slopes of Mt. Payung; also present in the adjacent parts of the erosional plain.
c. subtype with Bischofia javanica.
   On soils developed from the calcareous rock of the plateaux of the mainland of Ujung Kulon; also present in the adjacent (and very locally also in more remote) parts of the erosional plain; not on or directly behind the calcareous sandstone ridge.

The distribution of the differentiating sociological groups and their main species is given in table 9c.

Table 9c

List of sociological groups which differentiate between the subtypes of the community of Pterospermum diversifolium and Arenga obtusifolia with their main species.

soc. group	subtype a	b	c	Main species:
13	——			Stenochlaena palustris
4	-----			Pandanus nitidus
28	——	-----		Dillenia obovata, Microcos tomentosa
10	-----	-----		Payena acuminata, Neonauclea calycina (Myristica iners only in subtype b)
14	-----	-----		Mallotus blumeanus
38	-----	-----		Smilax leucophylla
45	——	——	-----	Polyaltia lateriflora, Drypetes longifolia
34		-----		Ophiorrhiza trichocarpos
42		-----		Sterculia foetida
17		——	-----	Dracontomelon puberulum, Stelechocarpus burahol
24		-----	-----	Aglaia argentea, Cryptocarya ferrea
30		-----	-----	Hypobathrum racemosum
35		-----	-----	Areca cathecu, Cinnamonum iners
55		-----	-----	Syzygium polyanthum
57		-----	-----	Cordia dichotoma
29		-----	——	Drypetes ovalis, Streblus spec.
25			-----	Rauvolfia reflexa
33			-----	Bischofia javanica
37			-----	Salacca edulis
39			-----	Merremia peltata
52			-----	Amomum compactum, Cissus discolor

—— should occur, ----- may occur (but see note above)

In all subtypes, but mainly in the stands of subtype b in the western hills, deviating forms can be found with an abnormally low density of Arenga palms. On the other hand, locally pure stands of Arenga obtusifolia may be encountered in relatively small patches (especially in subtype c).

Synecological interpretation

We assume that this community is a type of secondary monsoon forest. The very special character of this and all other types of langkap forest is thought to be caused by the incidental occurrence of unusual dry years, vertic properties of the (sub)soil and possibly (repeated) forest fires.

Local stands with a low density of Arenga palms may be due to local deviations of soil conditions, but also to a relatively low intensity of former human influence and fire. Pure stands may be explained as a rather rare successional stage.

For a more detailed discussion of the synecology of the 'langkap' forests (including aspects of succession) we can refer to section 9.4.

VIII. Community of Parinari corymbosum and Gnetum gnemon

Soc. groups: the total number is 22; no. 20, 22, 24 and 27 are the most important ones.

Medium-tall to tall semi-deciduous broadleaf forest.

Description

There are three not very distinct structural layers:

The main tree layer is closed, but very irregular; its height is generally 20-25 m, but locally much less. On the other hand, some emergents, mainly strangling figs (18) may grow significantly taller. There are no dominants. Some of the most common species are Pterospermum diversifolium (27), Garcinia celebica (22), Knema cinerea (22), Aglaia argentea (24) and Bombax valetonii (19). Palmtrees (Arenga obtusifolia, 46) occur only in very small numbers.

Next, there is an open layer of some 3-8 m high, consisting of both saplings and small-sized treelets and high shrubs. The most conspicuous common species here are Gnetum gnemon (24), Suregada glomerulata (25), Rinorea cymulosa (20), Scolopia spinosa (24) and several species of Mallotus.

The groundlayer of some 0-1 m high is rather sparse, but apparently less strongly influenced by browsing than the corresponding layer in the community of Bischofia and Ficus pubinervis. A characteristic shrublet which occurs very locally in this layer is Gendarussa vulgaris (24).

Epiphytes are rare; broadleaved lianas like Salacia chinensis (71) are quite common, but rattans (both climbing and scrub-like) are virtually completely missing.

Distribution

Restricted to the higher parts of Peucang Island, i.e. the plateau and the limestone crest.

Spatial variation

Considerable, but insufficiently studied.

On valley-slopes, palmtrees (Arenga obtusifolia) are somewhat more abundant. Towards the N.tip of the island (Karang-Copong) the vegetation shows some resemblance to the cliff-coast forest of Mt. Payung (community no. 18, with Sterculia foetida).

Synecological interpretation

This vegetation can be considered as a typical monsoon-forest, which can be assumed to be mainly of primary nature. Its flora is extremely rich. A relatively large number of species of this community had to be left unidentified during our survey (especially Lauraceae and Meliaceae). For a more detailed description of the island's floristic composition we can refer to Kartawinata (1965) and Kartawinata & Apandi (1977).

In spite of the predominantly primary nature of the vegetation, some former human interference is probable. The stands of Gendarussa vulgaris may indicate former grave sites (Sarpan, pers. comm.). Gnetum gnemon is said to indicate human influence as well (Endert, 1951).

Whether or not there have been any shifting cultivation sites on Peucang Island is uncertain. If so, they were probably restricted to the central plateau (i.e. to the area covered by the community in question), since the most fertile soils occur in this central part (van Reuler, pers. comm.). However, at present no relics of former clearings can be traced. In fact, most of the species which grow abundantly in the rattan shrublands which are thought to indicate former shifting cultivation sites on the mainland, are (virtually) completely missing on Peucang (soc. groups 39 en 58). The same holds for many species which occur commonly in almost all not strictly coastal vegetations of the mainland (soc. groups 48, 49, 50), thus stressing the strongly deviating character of the island's vegetation-types.

Possibly, human occupation of Peucang island has always been of minor importance, which can be explained by the lack of fresh water on the island. Moreover, one may assume that the island has long been spared from forest-fires. Combined with the island-nature of Peucang, these may be the reasons for the very aberrant character of the community in question, as compared with the secondary Arenga forests which grow on very similar localities on the mainland of Ujung Kulon (see 8.4).

Finally, the very uneven and locally obviously disturbed character of the canopy of this forest-type is thought to be due not to former human activities, but to seasonal wind-damage. Both field experience and the transition towards a kind of cliff-coast forest on the northern tip of the plateau point to this.

IX. Community of Pterygota horsfieldii and Rinorea cymulosa

Soc. groups: the total number is 25; no. 20, 21, 22, 24 and 26 are the most important ones.

Semi-deciduous broadleaf tall forest.

Insufficiently known community; the following description is based on one single plot (287).

Description

The physiognomy of this type is rather similar to the one described for the community of Parinari and Gnetum. In short, there is a closed uneven main tree layer with emerging forest giants including some strangling figs, a middle-layer of treelets, shrubs and saplings and a groundlayer of mainly seedlings.

However in the Pterygota forest the lower layers are more developed: the treelet-layer is more or less closed, while the groundlayer is far from sparse with a cover of approximately 50%. Moreover, the forest as a whole is notably taller, the emergents reaching up to an estimated height of some 35 m.

The main species of the canopy is Pterygota horsfieldii (21), which covers (at least in the one plot analyzed) 50% of the soil-surface. Other species which are notably present are Ficus pubinervis (26), Planchonia valida (17), Artocarpus elasticus (15), Aglaia argentea (24) and Alstonia scholaris (22).

The layer of treelets and shrubs is strikingly dominated by Rinorea cymulosa (20), while species like Cryptocarya ferrea (24) and Chisocheton microcarpus (24) are conspicuously present as well.

Distribution

Restricted to a rather narrow strip in the south-western part of the coastal plain of Peucang Island along the foot of the central plateau. In fact, this strip does not belong to the coastal plain proper, but forms a kind of erosional plain or wave-cut-platform merging into the real coastal plain (see Chapter 6). As for it's lithology and soil-profile it is part of the central plateau rather than of the coastal plain proper.

Spatial variation

Unknown.

Synecological interpretation

The Pterygota forest grows at the transition of the central plateau to the coastal plain of Peucang Island. Its floristic composition represents in fact a combination of the floras of the communities bound to plateau and coastal plain, i.e. respectively the Parinari-Gnetum community (VIII) and the Bischofia - Ficus pubinervis community (X).

For instance, the soc. group 20 (with Rinorea cymulosa) represents the plateau-element, soc. group 26 (with Ficus pubinervis) recalls the coastal plain forest. Only two species, Pterygota horsfieldii and Ficus magnoliaefolia (both 21) are characteristic for the transitional habit.

On the whole, the plateau element is the most important one, which is not surprising. As was explained above, the Pterygota forest, though seemingly occuring in the coastal plain, is in fact bound to a plateau-soiltype.

Just like the Parinari-Gnetum forest, the community of Pterygota and Rinorea can be considered as a typical monsoon forest of primary nature.

Although extensive parts of the coastal plain forest of Peucang Island are assumed to have been heavily damaged by the tidal waves which followed the Krakatau eruption in 1883, the Pterygota forest does not show signs of such disturbance. Probably, the adjacent central plateau more or less sheltered the Pterygota forest from the waves which hit the island on the north-eastern side (see also the interpretation of the next community).

X. Community of Bischofia javanica and Ficus pubinervis

Soc. groups: the total number is 18; no. 22, 23, 24, 26 and 33 are the most important ones.

Semi-deciduous broadleaf tall forest.

Description

As far as its physiognomy is concerned, this forest type shows many similarities with the two previously described communites. Again there are three structural layers:

The upper tree layer is closed and of variable height (20-35, locally even 40 m). In general, its surface is strikingly even (see: 'spatial variation'). Floristically, it is characterized by the (non-strangling) fig-tree Ficus pubinervis (26) which generally covers 20-30% of the soil surface. Other common trees of this layer are Bischofia javanica (33), Pterospermum javanicum (23), Aglaia argentea (24) and Lagerstroemia flos-reginae (56). Emergent trees, including strangling figs (18) are present, but not in abundance. During the dry season, deciduousness may be rather pronounced in this layer.

The lower tree-layer is open, variable in height (generally 5-15 m) and not very well separated from the upper one; many trees such as Myristica guatterrifolia (26) grow somewhere in between. Like many juvenile specimens of taller trees, this layer is, for example, rich in various small sized Meliaceae trees (22) and treelets from sociological group 71, including Ardisia humilis, Buchanania arborescens and Ficus septica. Palm trees are completely absent.

Underneath we find a very characteristic, sparse to open layer composed of tree-seedlings, 1 m high, growing in patches and very intensively browsed by deer. Locally, this layer may be virtually absent.

In both the structural layers, juvenile stages of the dominant species Ficus pubinervis, are very poorly represented.

Epiphytes, climbers and herbs are scarce. Rattans are absent.

Distribution

Restricted to the sandy soils of the coastal plain of Peucang Island.

Spatial variation

Transitions with other communities (including the next community, no. XI) are of little significance.

The main variation within this community is found in its structure. Locally, mainly in the southern part of the island, a form is found which, on the whole is taller and more heterogeneous, as far as the size (both height and stem-diameter) of the trees of the upper layer is concerned. On aerial photographs these stands are recognizable by a more coarse texture. Both forms are not well separated, but gradually merge into each other. Differences in floristic composition have been insufficiently studied, but are probably not very significant. In the tall, heterogeneous form Ficus pubinervis seems less prominently present.

Synecological interpretation

We assume that the relatively low and homogeneous (fine-textured) stands represent a second growth after destruction by the tidal waves following the Krakatau eruption of 1883.

The relatively tall and heterogeneous (coarse-textured) stands may thus be considered as relics of the (probably more or less primary) forest, as it must have covered most of the coastal plain of Peucang before 1883. As stated before, we may assume that agriculture on Peucang (if any at all) has probably been restricted to the far more fertile soils of the elevated part in the interior, although the village was probably situated in the coastal plain.

The combination of fine photo-texture, homogeneous structure and relatively moderate height of the canopy, indicating the destructive impact of the 1883 tidal waves, is encountered more often on Ujung Kulon's coastal plains. Clear examples can be found in the Syzygium polyanthum forest of the coastal plains (see 8.3.XXI) and parts of the Arenga obtusifolia forests of the erosional plains along the N-coast (see 8.4). The relatively pronounced character of the deciduousness in (the upper tree layer of) this community is explained by the combination of the overall seasonal dry climate of Ujung Kulon's lowlands and the excessively drained soils of Peucang's coastal plains.

XI. Community of Cerbera manghas and Buchanania arborescens

Soc. groups: the total number is 16; nos. 26, 71, 72 and 74 are the most important ones.
Semi-deciduous broadleaf medium-tall forest.

Description

As far as its physiognomy is concerned, this community more or less resembles the previous one. Again, there are three structural layers: an upper tree layer, a lower layer of mainly treelets and saplings and a heavily browsed groundlayer of seedlings.

Even so, there are some notable differences. The height of the closed upper tree layer never exceeds 20 m. The lower tree layer is on the whole lower (4-10 m) and more coherent (covering 40-80%, locally very densely). The groundlayer, finally, clearly shows a greater variety of growth forms.

As for the floristic composition, there are also many similarities with the Bischofia-Ficus pubinervis community. Almost all the characteristic species of that community are also here present, but most of them occur in a far lower density. Only the species of sociological group 71 come more into prominence. In most cases, Buchanania arborescens and Ardisia humilis dominate the lower tree layer together, while Radermachera gigantea (also 71) becomes a very common tree in the upper tree layer.

Moreover, a number of representatives of sociological groups, which are more or less characteristic for beach forest also appear. Conspicuous examples are the scrub-palmoid Cycas rumphii (76; real palms, incl. rattans are completely absent), the beautifully flowering shrublet Ixora paludosa (72) and especially the trees Cerbera manghas (74) and Calophyllum inophyllum (72). Some very impressive, old specimens of the latter species may have survived the Krakatau catastrophe (Hoogerwerf, 1970).

Distribution

Restricted to a narrow, but distinct zone (some 50 m wide on the average) behind the beach forest on the coastal plain of Peucang Island.

Spatial variation

Probably of no importance.

Synecological interpretation

Obviously, we are dealing here with a transitional vegetation type with an affinity to both beach forest and inland forest, a kind of Ficus pubinervis forest which is strongly influenced by the nearby sea. The mechanism behind this influence may be complex: salt spray, incidental inundation with seawater and especially seasonal brackishness of the groundwater. This latter phenomenon is clearly perceptible in the well of Peucang Island, which is situated in the zone occupied by the community at issue.

XXII. Community of Bambusa blumeana and Drypetes ovalis

Soc. groups: the total number is 27; nos. 29, 31, 32, 50 and 54 are the most important ones.
Semi-deciduous medium-tall broadleaf and bamboo forest.

Description

The physiognomy of this forest type is very complex: the number of growth-forms is relatively large, while the strata shade into one another.

The main characteristic is a more or less closed, very conspicuous layer of giant, spiny bamboos (Bambusa blumeana, 31), some 15 m high and growing in clumps.

The bamboo layer is interwoven with a layer of mainly broadleaved trees, in height varying from some 10 to 20 m and covering 40-80% of the surface. Within this tree layer we may discern an upper part with mainly Pterospermum diversifolium (27), Diospyros polyalthioides (29) Vitex pubescens (56) and some strangling figs (18). The lower sublayer is generally dominated by the treelet Drypetes ovalis (29). Other common species are Aporosa aurita (32) and Cynometra ramiflora (57).

Next comes an open 'shrub layer' of some 2-3 m high, which contains mainly young trees (again Drypetes is abundantly present), thorny palmlets such as Licuala spinosa (54) and Salacca edulis (37), the rosette scrub Pandanus furcatus (83) and some broadleaved shrubs, like Memecylon floribundum (31) with its amazingly blue flowers.

Finally, an open mixed groundlayer of some 0-1 m high can be observed in which tree seedlings are abundantly present. Moreover, small sized rattans (Calamus viminalis, 61), broadleaved shrublets (like the spiny Moracea Streblus spec.; 29) and several (mainly graminoid) herbs like Panicum notatum (31) and the delicate ginger Globba pendula (31) are very common.

Distribution

Restricted to the uplands with their predominantly somewhat poorly drained soils.

Spatial variation

A very constant vegetation type throughout its distribution area in Ujung Kulon. The boundaries with other types are remarkably distinct; no transitional forms have been observed.

The major variation concerns the abundancy of Bambusa, which may locally be less well represented. North of Cibandawoh, one finds a curious variety with almost no Bambusa at all.

Synecological interpretation

Obviously, we are dealing with a type of monsoon forest, which replaces the community of Pterospermum diversifolium and Arenga obtusifolia (subtype with Bischofia javanica) on the more poorly drained clay soils developed on calcareous parent material in the elevated central part of Ujung Kulon.

Although the general appearance of both communities is entirely different and boundaries between the two look quite spectacular in the field, it is interesting to note that, as far as the total floristic composition is concerned, both communities prove to be not so very different at all (see Table 9a).

We may assume that the community at issue is, like the Arenga forests, of secondary nature. For a more detailed discussion of this and other bamboo-forests in Ujung Kulon we can refer to section 8.4.

Only one more remarkable phenomenon needs to be mentioned here. In the Bambusa-Drypetes community one may find, distributed over the various strata, a number of species which are more commonly found on very low altitudes, i.e. in the forests of the coastal plain. The most common examples are Corypha utan, Cynometra ramiflora (both 57) and Calamus viminalis (61). The latter two species grow in the Drypetes forests of Ujung Kulon, several tens of metres above the upper limit of their distribution area on the mainland of Java. Which (edaphic) factor causes this phenomenon is not known.

XIII. Community of Areca cathecu and Arenga obtusifolia

Soc. groups: the total number is 24; nos. 18, 33, 36, 46 and 56 are the most important ones.

Semi-deciduous tall broadleaf and palm forest with emergents.

Description

The physiognomy of this community corresponds with the physiognomic outline as given for the Arenga obtusifolia forests in general (see 8.3.III). More specifically, the present community shows much resemblance to the Pterospermum-Arenga community (8.3.VII).

In short, this implies that there is an uneven upper tree layer, which may be open or closed and contains some huge emergents, mainly strangling figs (18). Next there is a closed lower tree layer, notably dominated by palms, mainly Arenga obtusifolia (46). The sparse undergrowth consists mainly of young specimens of Arenga and some scattered rattan shrubs.

Even so, the present community also has some distinct features of its own.

In the upper tree layer, for instance, both Pterospermum species (23, 27) are completely absent, while Bischofia javanica (33) is always there, often as huge and possibly very old trees. Other common trees of this layer are, next to the strangling figs mentioned above, Syzygium polyanthum (55), Lagerstroemia flos-reginae (56) and Dillenia obovata (28). Another Dillenia species, D. indica (34) is not common, but in Ujung Kulon it is probably restricted to this community.

In the lower tree layer, the predominance of palm trees is reinforced by the fact that many of the trees which grow intermingled with the dominant Arenga are also palms: Areca cathecu (35) and Oncosperma tigillaria (36). The occurrence of Areca cathecu, the betel palm, is interesting. In Java it is found mainly in cultivation, but in the present community undoubtedly it thrives spontaneously.

In the generally very sparse undergrowth, scrub-palmoids like Salacca edulis (37) and Licuala spinosa (54) are absent, though (as stated above) some scattered rattan shrubs may be present. The forest floor is furthermore relatively rich in small herbs: Geophila repens (35), Ophiorrhiza trichocarpos (34), Lindernia ruelloides (34) and a geophytic Orchidacea, Nervilia spec. (34).

Distribution

Restricted to the fluvio-alluvial and erosional plains; there always on or near the banks of rivulets; on relatively well-drained soils.

Spatial variation

Transitions towards the Pterospermum-Arenga community (VII) and the Oncosperma-Salacca community (XIV) are common.

Moreover, a form in which Oncosperma gradually replaces Arenga obtusifolia as the dominant species is found downstream of the rivulet Cidaon.

Synecological interpretation

This type of Arenga forest is not very strictly bound to one specific soil type, parent material or geomorphological unit. On the other hand, it is strictly bound to one specific habit: (moderately) well-drained banks of rivulets.

Which ecological factors of the rivulet side habitat are responsible for the specific character of the Areca-Arenga community is not known; possibly incidental inundation is of great importance.

The aberrant form in which Oncosperma replaces Arenga as the dominant species can be explained from a slightly brackish influence on the groundwater. Brackisness is obviously far better tolerated by Oncosperma than by Arenga.

Finally, the Areca-Arenga community can, just like the Pterospermum-Arenga community, be considered as a kind of secondary monsoon forest. For a more detailed discussion of Arenga forests in general we can refer to section 9.4.

C. Eupatorium odoratum community-group (XIV-XX)

(Mainly semi-decidious open forests and shrublands of the lowlands, not including coastal plains, coastal swamps and beaches)

XIV. Community of Oncosperma tigillaria and Salacca edulis

Soc, groups: the total is 26; nos. 17, 36, 37, 50 and 54 are the most important ones.

Semi-deciduous, broadleaf and palm, tall forest

or: semi-deciduous, broadleaf and palm, open tall to medium tall forest with closed thorny palmoid scrub.

Description

A most variable vegetation type, in general consisting of three structural layers.

The tree layer may be open or closed (covering 15 to 90%!) and is some 15-25 m high. In stands with a notably well-developed canopy, some differentiation in an upper and lower tree layer may be discerned but this is generally not the case. The main species is the spiny palm Oncosperma tigillaria (36), growing in clumps and locally covering 60% of the soil surface. Other common trees are, for example, strangling figs (18), Planchonia valida (17), Dracontomelon puberulum (17), Dillenia excelsa (15) and Stelechocarpus burahol (17). The latter two species are generally only of moderate size.

Next, comes the most characteristic layer of this type: a generally more or less closed layer of Salacca edulis shrubs (37), intermingled with some rattans, gingers and young trees. This layer is some 3 m high.

The sparse ground layer is of little significance. It consists mainly of some scattered seedlings and herbs. Most of the small herbs which are commonly found in the Areca-Arenga forest, however, are absent (e.g. soc. group 34).

Both epiphytes and climbers are scarce. The scarcity of herbaceous climbers is in great contrast to the abundancy of such plants (mainly soc. group 39) in the slightly similar and adjacent Daemonorops vegetations.

Distribution

Almost completely restricted to the fluvio-alluvial plain; there mainly in the south-west, but also not uncommon in the northern part, in between stands of Areca-Arenga forest; very locally also downstream along Cikeusik and its branches; with a (not strict) preference for moderately well-drained soils.

Spatial variation

As stated above, a most variable vegetation type varying from closed well-developed forest to homogeneous Salacca stands with only little tree cover. These various forms shade into each other, often at very short distances.

Transitions towards the Areca-Arenga community and the Hyptis-Daemonorops community are also common. Plot 302 (a well-developed forest) represents the first type of such transitional vegetations; its soil profile is somewhat better drained than the other Salacca profiles. Conversely, there is however no real evidence that all homogeneous Salacca stands with little tree cover are bound to the very wettest sites as Hommel (1983) assumes.

A very aberrant form in which both Bambusa blumeana and Schizostachyum zollingeri are abundantly present, was encountered only once along a branch of Cikeusik (plot 168).

Synecological interpretation

We can assume that all Salacca vegetations are of secondary nature. This assumption is based on their physiognomic appearance and their location in an area which was most likely the most densely and permanently inhabited part of Ujung Kuylon in the past (see chapter 4).

However, what causes the aberrant character of these vegetations and their internal mosaic like differentiation is difficult to decide.

Generally, the soil profiles are less well-drained than the soils under Arenga forest in the same physiographic unit (with the exception of plot 302), but there is no significant difference with the soils of the rattan shrubland (Hyptis-Daemonorops community) there. Only the average thickness of the ash-topsoil is somewhat higher (see fig. 7a).

Also, the capricious mosaic of (slightly) different soil types, characteristic of such a fluvio alluvial plain cannot fully explain the community's internal spatial variation.

Two possible additional explanations can, however, be put forward, although no real proof is available.

First, the predominance of Oncosperma tigillaria may indicate a slight brackish (possibly incidental) influence on the groundwater (see Whitmore, 1975). This might explain why the community is restricted to low areas near the mouth of the major rivulets. However, this does not explain why the community is absent in the coastal plain in the eastern part of the reserve, where more or less similar edaphic conditions prevail (see 8.3.XXI). Possibly, the lack of a distinct ash-topsoil in the coastal plain provides an answer to this question.

Second, one may presume that the areas covered by Salacca vegetations (i.e. near the former main settlements) were in contrast to the adjacent rattan shrublands in the fluvio-alluvial plain, temporarily put into agricultural use again after the 1883 ash rains. This may have forced succession to follow a different path (see also 9.4).

Even so, all these hypotheses are highly speculative and fail to explain completely the internal differentiation of the Salacca vegetations.

XV. Community of Hyptis rhomboidea and Daemonorops melanochaete

Soc.groups: the total number is 40; nos. 39, 48, 49, 50, 58 and 68 are the most important ones.
Closed thorny palmoid scrub with emergents.

Description

A compact and almost inaccessible shrubland with three more or less distinct structural layers.

The major vegetation component is a very dense spiny thicket of some 3 m high rattans with long creeping horizontal stems. Daemonorops melanochaete (50) is the most prominent species. In between grow, for example, the spiny palmlets Salacca edulis (37; more or less restricted to subtype a) and Licuala spinosa (54), the robust ginger Amomum megalocheilos (48) and several small treelets such as Leea sambucina (51), Barringtonia macrocarpa and Dillenia excelsa (both 15; only in subtype a). An interesting feature of these thickets is the presence of species which, in other vegetations, grow into tall trees, but here only occur in a very stunted habit, hardly emerging, if at all, above the surrounding rattans. This phenomenon was observed most commonly with specimens of Lagerstroemia flos-reginae (56).

The rattan thickets are intermingled with narrow twisting banteng trails (in general leading to nowhere) and small clearings, which are covered with a predominantly herbaceous vegetation (up to 1.5 m high and covering, on average, some 25% of the soil surface). The most conspicuous species here are the robust broadleaved herbs Eupatorium odoratum (58) and Hyptis rhomboidea (39), in subtype b accompanied by the abundantly flowering shrublet Lantana camara (59).

Moreover, on these trails and clearings we find a more or less closed ground layer, which is as good as absent underneath the rattans. It includes mainly seedlings, some small ferns (36) and relatively many graminoid herbs, e.g. Cyperus spec. (68), Axonopus compressus (68) and several more delicate grasses which are lumped together under the vernacular name 'Jampang piit' (68).

This intricate complex of rattan thickets and herbaceous vegetations on trails and clearings is thoroughly interwoven and partly covered by spiny lianas such as *Smilax leucophylla (38) and Uncaria spec. (39)*. Other parts are more or less buried under a blanket of less robust vines such as Merremia peltata, Merremia umbellata, Ampelocissus arachnoidea (all 39), Mikania cordata (58) and many others.

Above this complex, trees emerge, either isolated or in small groups, covering less than 10%. Their height is variable, usually 15-20 m, sometimes much more. Pterocymbium tinctorium (30) and Cananga odorata (53) seem to have a certain preference for these vegetations, but many other tree species are there as well. However, fully grown palm trees such as Arenga obtusifolia (46) and Areca cathecu (35) are quite rare.

Distribution

Very common on the dissected plateaus, in the uplands and in the fluvio-alluvial plain; also quite common in the erosional plain along the NW-coast (mainly on the inland side) and in a narrow zone on the transition of the coastal plain towards the plateaus or calcareous sandstone ridge; rare in the Payung area below 150 m.a.s.l. (mainly in the northern and eastern parts) and in the andesitic part of the western hills; not on Peucang Island.

Spatial variation

Generally, the boundaries between the Daemonorops vegetations and other, adjacent vegetation types are notably distinct, especially in the uplands where rattan shrublands border upon Bambusa forests. Transitional vegetations are rare, though in many locations intricate mosaics of Daemonorops and other vegetations can be found.

The major internal differentiation which is visible at first glance refers to the proportion between the rattan and herbaceous component. The latter may cover locally 50% of the soil surface, on other sites only 10%. However, these are both exceptions. Some 25% is normal (see above). Only in one case (plot 96) was the herbaceous component sampled separately. Generally, the two components are interwoven in such a highly intricate way that separate sampling (resulting in the description of different communities) would be very impractical.

Here, two more plots with a notable aberrant character should be mentioned: plot 42 (near the coast, N of the mouth of Cigenter; with Calamus polystachys as dominating rattan species) and plot 105 (on a sandy bank downstream Cibunar; with no rattans at all). These plots are not only exceptional as far as their floristic composition is concerned, but also because of their aberrant physiographic position, soil profile and history. In finding a general explanation for the phenomenon of Ujung Kulon's rattan shrublands such exceptions prove to be very useful (see 9.4).

On the basis of their complete floristic composition the 'normal' Daemonorops vegetations can be divided into two subtypes:

a. with Dillenia excelsa
b. with Lantana camara

These subtypes are best typified by differences in occurrence of the sociological groups defined for Ujung Kulon as a whole.

On the level of separate species, we may indicate the fact that many common species, mainly treelets like Dillenia excelsa (15), Barringtonia macrocarpa (15), Baccaurea javanica (15), Drypetes ovalis (29) and Stelechocarpus burahol (17), but also the palm shrub Salacca edulis (37) are absent in subtype b. Only one species has a distinct preference for subtype b: Lantana camara (59).

As stated above, there is no strict relation between these subtypes and the classification of soil types or parent material on which the soil profiles developed. Moreover, neither sub-types are completely separated; transitional forms are not uncommon. Still, the two sub-types do not grow in all locations in the same proportion. Sub-type a predominates in the upland-area and in the fluvio-alluvial plain. On the dissected plateaux the two sub-types occur approximately in equal proportions. We assume the sub-types to represent different successional stages. We shall return to this subject in section 9.4.

Synecological interpretation

The notorious rattan shrublands of Ujung Kulon can best be considered as relics of former shifting cultivation sites, which were in use, or had only recently been deserted, at the time of the Krakatau eruption in 1883. We assume that the impact of the ash rains on the more or less open soil surface forces succession to follow such a remarkable path. We shall return to this subject in more detail in section 9.4.

XVI. Community of Canthium horridum and Albizia procera

Soc. groups: the total number is 32; nos. 33, 40, 48, 58 and 59 are the most important ones.

Semi-deciduous, open, medium tall broadleaf forest with emergents and closed scrub.

Insufficiently known community; the following description is based on one single plot (336).

Description

There are four more or less distinct structural layers:

The main tree layer is rather open (covering 50% and some 10-15 m high. It is completely dominated by Albizia procera (40) trees of various age classes (stem-diameter 10-35 cm). Only two other trees were observed between the Albizias: one Lagerstroemia flos-reginae (56) and one Mallotus ricinoides (30).

Above this tree layer arise some isolated emergents, in plot 336 one old specimen of Bischofia javanica (33, dbh 75 cm!, cover 20% and height some 25 m).

Underneath the main tree layer there is a more or less closed scrub layer of some 1-2 m high, which consists of a mosaic of mainly shrubs like Lantana camara (59), Callicarpa albida (39) and Canthium horridum (40; the only thorny species of the scrub layer), robust gingers (Amomum megalocheilos, 48) and tall broadleaved herbs (Eupatorium odoratum, 58). Some small treelets and saplings are also present,for example, Barringtonia macrocarpa (15) and Leea sambucina (51).

This scrub layer rather gradually merges into an open ground layer (on average some 0.5 m high) of mainly tree seedlings, graminoid herbs (Cyperus spec., Axonopus compressus and 'Jampang piit', all soc. group 68) and some scattered small broadleaved herbs such as Hedyotis coerulea (40). Medium tall herbs like Stachytarpheta jamaicensis (62) and Hyptis rhomboidea (39) thrive somewhere in between the two lower layers.

Epiphytes are (? completely) absent, but climbers are very abundantly present, especially the tender vine Mikania cordata (58). All climbing species are unarmed (with the exeption of Dioscorea hispida; 40)); thus rattans are also completely absent.

Distribution

Found only once in the outskirts of the Mt. Honje massif on a shifting cultivation site, which had been deserted for thirteen years (Nassar, pers.

comm.). The plot is situated at an altitude of some 75 m; the soil profile is somewhat poorly drained and resembles the upland profiles of Ujung Kulon. (However, the presence of e.g. Bischofia javanica seems to contradict complete similarity). The community is probably completely absent within the boundaries of Ujung Kulon.

Spatial variation
Unknown.

Synecological interpretation
Since aberrant succession on shifting cultivation sites (which were abandoned in 1883 or shorty after) is one of the major processes which explain the special character of Ujung Kulon's vegetation cover, it seemed interesting for comparison to study a far more recently deserted site in the region.
We shall recur on this subject in more detail in section 9.4.

The emergent Bischofia javanica in plot 336 obviously represents a relic of the forest which was cleared by the shifting cultivation farmers. The saving of some tall, mature trees is common practice in the ladang system.

In Ujung Kulon itself, some recently abandoned agricultural fields are also present in the Legon Pakis area. However, these are much younger and succession has not passed the shrubland stage yet. Again, we can refer to section 9.4.

XVII. Community of Schizostachyum zollingeri

Soc. groups: the total number is 17; no. 41 is the most important one.
(Semi)deciduous low bamboo forest with emergents.

Description
A very simply structured community with three layers:

The main structural layer is a closed and almost pure stand of tufted bamboos (Schizostachyum zollingeri; 41), some 3-5 m high. Generally, the only other species of this layer are some scattered climbers, mainly belonging to soc. group 39 (e.g. Derris elliptica and Merremia umbellata).

Above this coherent thicket only very few trees of varying height emerge, covering less than 5% of the soil surface. Most common are species from soc. group 29 (e.g. Drypetes ovalis) and Sterculia macrophylla (19), a species which is quite commonly found in many other vegetation types, but rarely as a fully grown tree.

Underneath the bamboos, the ground layer is, in most cases, almost completely lacking. Only a few scattered seedlings (e.g. of Leea sambucina; 51) and herbs may be present. Among the latter category, creeping Cucurbitaceae are notably common, e.g. Benincasa hispida (51). Moreover, locally some small rattan shrublets may be present (e.g. Calamus unifarius; 49).

Distribution
Mainly in the dissected plateau landscape and the uplands, very locally also in the outskirts of Mt. Payung at low altitudes and in the coastal plain behind Legon Cangkeuteuk; in all these regions along rivulets (especially along Cikeusik and Cikarang) or on (often steep) valley slopes, locally extending upwards on relatively level terrain. Mostly in very extensive and monotonous stands.

Spatial variation

Probably of little importance.

Synecological interpretation

A special form of secondary growth in regions with a distinct dry season. Its origin is rather unclear.

Possibly formerly restricted to sites which are very exposed to (various forms of) erosion (such sites are still the core of the community's distribution-area) and only after the 1883 ash rains expanded into adjacent areas.

The almost complete lack of undergrowth can only partly be explained by erosion processes. The extremely dense root system which characterizes most bamboo stands is probably of more significance (Hildebrand, 1954).

XVIII. Community of Sterculia foetida and Syzygium pseudoformosum

Soc. groups: the total number is 20; nos. 42, 43, 45, 49 and 74 are the most important ones.

Semi-deciduous broadleaf medium tall open forest with closed scrub.

(Locally also closed forest or woodland, i.e. open forest with open scrub).

Description

A very variable vegetation type with an irregular structure. In general, four not very distinct structural layers can be discerned:

First, there is an open or sparse upper tree layer (some 15-20 m high), in which the deciduous trees Sterculia foetida (42) and Terminalia catappa (74) are the most conspicuous species.

Underneath, there is an open lower tree layer, generally dominated by Syzygium pseudoformosum (43), which may also shed a substantial part of its leaves during the dry season. In between we find other broadleaved, dicotyledonous trees such as Macaranga tanarius (42) and Polyaltia lateriflora (45), but also clumps of banana trees (Musa acuminata; 42), scattered palm trees (e.g. Arenga obtusifolia, 46), rosette shrubs (Pandanus furcatus, 83) and locally some bamboo clumps (e.g. Schizostachyum blumii, 50). There is also a very variable (open or) closed scrub layer of some 1-2 m high. Again, monocotyledonous species are remarkably well represented.

Generally, the layer is dominated by a combination of the robust herbs Donax cannaeformis (49) and Homalomena cordata (49), while some Pleomele shrubs (4) are also notably present. Common dicotyledonous species of this layer are the tall herb Eupatorium odoratum (58) and the shrub Allophylus cobbe (71).

Underneath, one finds a sparse groundlayer in which the fern Tectaria spec. (42), the broadleaved herb Hemigraphis bicolor (58) and the graminoid herbs of soc. group 68 are commonly present.

Epiphytes are (? completely) absent; climbers (e.g. Smilax leucophylla, 38) are always there but not very abundantly.

Distribution

Restricted to steep slopes in the periphery of Mt. Payung and in the western hills (Cape Gede), which are very exposed to the influence of both ocean winds and erosion: possibly up to 150 m.; generally at far lower altitudes.

Spatial variation

Very variable in structure, but rather constant in species composition.

Synecological interpretation

The local occurrence of Schizostachyum blumii points to some former human influence. Moreover, one may assume that this periodically very dry vegetation type formerly suffered from forest fires (see 9.4).

Even so, it is above all the extreme instability of the environment which is thought to cause the vegetation's secondary appearance and to hamper further succession.

The definite (semi) deciduous character of the Sterculia-Syzygium community shows how the dessicating effect of the salty sea winds reinforces the impact of the seasonal drought. The common presence of species from soc. group 74 (next to Terminalia catappa also Hernandia peltata, Cerbera manghas and Erythrina orientalis) even causes some resemblance to a true beach forest.

XIX. Community of Dendrocnide stimulans and Syzygium pseudoformosum

Soc. groups: the total number is 24; nos. 25, 43, 44, 58 and 71 are the most important ones.

Semi-deciduous, broadleaf, uneven, closed, low trees and scrub with emergent palm trees or: semi-deciduous, broadleaf, open, medium tall forest with closed scrub.

Description

As for its structure, a most variable vegetation type. In general, three not very distinct structural layers can be discerned.

The central scrub layer is generally the most significant one. It consists of a mosaic of high herbs (1-2 m), shrubs (2-3 m) and treelets (4-8 m), in varying percentages of cover. The main species are the herb Eupatorium odoratum (58), the shrubs Lantana camara (59) and Gmelina elliptica (58) and the treelets (c.q. high shrubs) Aglaia latifolia (44), Rauvolfia reflexa (25), Syzygium pseudoformosum (43) and the notorious nettle tree Dendrocnide stimulans (44).

Above this generally coherent scrub layer, a 8-15 m high tree layer may be found, varying from some scattered emergents (in this case mainly the fan-palm Corypha utan; 57) to an open forest cover with full grown specimens of Dendrocnide stimulans, Pongamia pinnata (76) and Syzygium pseudoformosum. In relatively well developed tree layers, the latter species obviously becomes dominant (see below). During the dry season most trees shed a substantial part of their leaves.

Underneath the scrub layer, a sparse to open ground layer is found, which is most prominent on small clearings and narrow twisting banteng trails through the scrub layer. In addition to some inconspicuous graminoid herbs (e.g. soc. group 68), beautifully flowering species such as the shrublet Pseuderanthemum diversifolium (44) and the delicate herb Sida javensis (44) are very common. The latter species dies off completely during the dry season (at least as far as the superterraneous parts are concerned) just like many other herbs of this layer.

Epiphytes are (? completely) absent; climbers, including rattans, are usually present but are far from abundant. Only the tender vine Mikania cordata (58) may locally form extensive veils covering other plants.

Distribution

Predominantly on the calcareous sandstone ridge along the south coast. Also observed very locally on level ground between beach forest and mountain foot at Sanghiyangsirah (on more or less identical soils).

Spatial variation

As stated above most variable. Very aberrant forms include a curiously coherent, almost pure stand of Lantana camara (west of the mouth of Cikeusik; plot 175), a more or less closed Syzygium-Dendrocnide forest with an undergrowth dominated by Donax cannaeformis (49) (east of Cape Tereleng; plot 203) and a more varied open forest of relatively tall growth (east of Karang Ranjang; plot 209).

Synecological interpretation

The internal variation of this vegetation type can probably primarily be explained as a result of former cutting and burning practices, not everywhere equally ancient or intensive. Differences in distance to the seashore, depth of the soil profile and in the thickness of the ash topsoil are also thought to contribute to the internal variation of this type.

Probably, all different forms can be considered as secondary growth. The impact of the dry season is obvious; undoubtedly it is reinforced by both sea winds and edaphic factors, but not really as strongly as on the cliffs covered with Sterculia-Syzygium forest.

XX. Community of Dendrocnide stimulans and Arenga obtusifolia

Soc. groups: the total number is 19; nos. 43, 44, 45 and 46 are the most important ones.

Semi-deciduous medium tall broadleaf and palm forest with emergents.

Insufficiently known community; the following description is based on only three plots, one of which is very incomplete because of its small size (006) and one is not very typical (142).

Description

As far as its physiognomy is concerned, this community is rather similar to the other types of Arenga forest (see 9.3.III): Its main characteristic is a closed layer of Arenga obtusifolia palms (46) with only a few dicotyledonous trees in between. Above this palm layer there is an open, uneven upper tree layer including some true emergents (e.g. strangling figs; though not in one of the plots). The undergrowth is very sparse.

In some details the Dendrocnide-Arenga forest shows a strong resemblance to the Pterospermum-Arenga forest (see 8.3.7), although there are some notable differences:

On the whole, the upper tree layer is far less developed: it is lower (20 m, rarely more) and more open, frequently more or less absent. Many common species of the upper tree layer of the Pterospermum-Arenga forest are missing, e.g. Diospyros macrophylla (16) and Artocarpus elasticus (15).

Of the common trees and treelets growing between and underneath the Arenga palms, Dillenia excelsa (15), Barringtonia macrocarpa (15) and Baccaurea javanica (15) are also (almost) completely absent. They are replaced by species which are more or less characteristic of the Dendrocnide-Syzygium community e.g. Syzygium pseudoformosum (43), Aglaia latifolia (44), Claoxylon polot (43) and, of course, the nettle tree Dendrocnide stimulans (44) itself.

Moreover, on the almost barren forest floor we also find some other elements of the Dendrocnide-Syzygium community: the Acanthaceae Lepidagathis javanica and Pseuderanthemum diversifolium (both 44).

Distribution

On the lee side slope of the calcareous sandstone ridge and on an adjacent narrow strip in the fluvio-alluvial plain; also locally in a non-typical form in the erosion plain on the west side of Mt. Payung.

Spatial distribution

Insufficiently known; the form on the west side of Mt. Payung (plot 142) represents a transition towards the Pterospermum-Arenga forest.

Synecological interpretation

A type of secondary monsoon forest replacing the forest form of the Dendrocnide-Syzygium community on sites which are more or less sheltered against the dessicating sea winds.

For a more detailed discussion of the Arenga forests in general, see section 9.4.

D. Ardisia humilis community-group (XXI-XXIV)

(Mainly semi-deciduous forests of the coastal plain of the mainland.)

XXI. Community of Nauclea coadunata and Syzygium polyanthum

Soc. groups: the total number is 35; nos. 50, 55, 56, 57 and 71 are the most important ones.

Semi-deciduous broadleaf medium tall forest.

Description

A very constant vegetation type with four distinct structural layers.

The main characteristic of this community is a structurally very homogeneous tree layer of some 20-25 high above a dense, but not quite coherent shrub layer, up to 3 m high.

Neither layer is very rich in species. The tree layer is almost completely formed by Syzygium polyanthum (55; often dominant covering up to 60%!), Nauclea coadunata (57), Lagerstroemia flos-reginae (56), Cordia dichotoma (57), Vitex pubescens (56), Pterospermum javanicum (23) and Dillenia obovata (28). Most of these species shed a considerable number of their leaves during the dry season, the latter two are truly deciduous.

Palm trees are not rare in this layer, the tall fan-palm Corypha utan (57) being the most common. Locally, the sugar palm Arenga pinnata (52) and clumps of the spiny stemmed Oncosperma tigillaria (36) are also present.

The shrub layer is dominated by the rattan species Daemonorops melanochaete (50) and Calamus polystachys (57). Other common species include Licuala spinosa (54), Pandanus furcatus (83) and locally the robust Cyperacea Scirpodendron ghaeri (84).

In between these two prominent layers, there is an open thin layer of treelets (5-10 m high) including both young specimens of canopy trees and treelets such as Ardisia humilis (71), Leea sambucina (51) and Glochidion zeylanicum (60).

The ground layer, finally, is sparse and of little significance. In addition to many seedlings it includes some graminoid herbs (soc. group 68) and some forbs, mainly monocotyledons, e.g. Phrynium pubinerve (49).

Epiphytes are (? completely) absent; climbers are of little significance.

Distribution

Mainly on the land side of the coastal plain; bound to (very) deep moderately well-drained soils, their texture varying from silty clay (type r) to (loamy) sand (type q). Never on the shallow excessively drained soils of the uplifted pseudo barrier reef.

Very locally also downstream on level terrain along rivulets in the uplands on more or less comparable soils.

Spatial variation

As stated above, a very constant vegetation type, both in physiognomy and floristic composition. The only aberrant form of significance is a young pioneer forest surrounding the present grazing grounds. It differs from the main form in being less tall, in the more open character of both main structural layers and in the abundant presence of Eupatorium odoratum (58) and Lantana camara (59).

Synecological interpretation

A type of secondary monsoon forest. The very fine photo texture (i.e. a structurally very homogeneous canopy), lack of gaps and homogeneity of tree diameters indicate a secondary growth which has not yet reached maturity.

The original (primary?) vegetation is thought to have been completely destroyed by the 1883 tidal waves, or partly even before that, for agricultural purposes (see chapter 4).

The local presence of Oncosperma tigillaria and Scirpodendron ghaeri may indicate a certain, possibly seasonal, brackish influence on the groundwater. In this respect there is some resemblance to the Oncosperma-Salacca community.

Differences between both communities can possibly be explained by differences in land use after 1883. Moreover, edaphic factors (e.g. the presence or absence of a distinct ash topsoil) may be of importance (see 9.3.XIV).

XXII. Community of Corypha utan and Ardisia humilis

Soc. groups: the total number is 14; nos. 56, 57, 61 and 71 are the most important ones.

Semi-deciduous, medium tall, broadleaf and palm stub forest.

Description

There are four distinct structural layers:

The major characteristic is a closed layer of dwarf trees (some 8 m high), generally growing in more stemmed stubs. This layer is very strongly dominated by Ardisia humilis (71) which covers 80-100% of the soil surface. Other species are e.g. Buchanania arborescens (71), Mallotus phillipensis (61), Diospyros ferrea (61) and Glochidion zeylanicum (60), but none of these occur abundantly.

Above this very characteristic stub-layer there is an open tree layer, some 12-20 m high. The most common and conspicuous species is the tall fan palm Corypha utan (51). Other (dicotyledonous) trees are Nauclea coadunata (57), Lagerstroemia flos-reginae (56), Vitex pubescens (56), Cordia dichotoma (57) and (less commonly) Syzygium polyanthum (55) or, in short, most of the common species of the canopy of the Nauclea-Syzygium community. Some of these trees also grow in (few stemmed) stubs, others have the typical habit of trees which grew up free-standing and only later became closed in by other trees.

Underneath the stub-layer, a 1 to 3 m high sparse to open scrub layer is found. In addition to tree seedlings and saplings, it is mainly composed of the rattan shrub Calamus viminalis (61) and (less commonly) of the broadleaved shrub Bridelia stipularis (61).

Finally, there is a very sparse ground layer. Two creeping vines are the most conspicuous species here: Cayratia trifolia (57) and the beautifully flowering Asclepiadacea Tylophora laevis (71).

Epiphytes are (? completely) absent; real climbers are scarce.

Distribution

Mainly in the northern part of the coastal plain; there between the Nauclea-Syzygium forest (XXI) on the inland side and the Ximenia-Ardisia forest (XXIII) on the sea-side; on soils developed in lagoonal deposits (mainly silty clay, towards the uplifted pseudo barrier reef with an increasing amount of coral fragments); not on the very lowest and wettest sites (there replaced by the Lumnitzera-Ardisia community) (XXXVII).

Spatial variation

On the whole, a rather constant vegetation type. The major variation concerns the share of stub forms, especially in the lower tree layer and the density of the scrub layer.

Of both, possibilities, plot 318 represents an example: there are hardly any stubs and the scrub layer is abnormally dense (cover 80%). Moreover, this plot represents both in its soil profile and its floristic composition a transition towards the Ximenia-Ardisia forest on the uplifted pseudo barrier reef. Such transitions are not uncommon.

Synecological interpretation

Just like the other (Ardisia) stub forests, the Corypha-Ardisia community originated on the former artificial savanna landscape of the coastal plain after the slash-and-burn management had been stópped.

The Corypha-Ardisia community has many species (especially those of the upper tree layer) in common with the Nauclea-Syzygium community which is thought not to be affected by slashing and burning, but generally grows on similar soils. The boundary between both communities is strikingly sharp and typically 'man made'.

The internal variation of the Corypha-Ardisia community is assumed to be based on local variations in soil conditions and former land use.

For a more detailed discussion of the (Ardisia-) stub forests in general, we can refer to section 9.4).

XXIII. Community of Ximenia americana and Ardisia humilis

Soc. groups: the total number is 21; nos. 51, 61, 62, 71 and 72 are the most important ones.

Semi-deciduous broadleaf medium tall stub forest.

Description

Its physiognomy is very similar to the Corypha-Ardisia community, i.e. the main characteristic is a closed layer of dwarf trees, many of which grow in stubs, with an open upper tree layer above and in general little undergrowth. The floristic composition of both communities also shows many similarities. However, there are also some notable differences.

The main difference concerns the floristic composition of the upper tree layer. All species from soc. groups 55 (Syzygium polyanthum), 56 (e.g. Lagerstroemia flos-reginae) and 57 (e.g. Nauclea coadunata and Corypha utan) are absent. They are mostly replaced by two species from soc. group 72: Guettarda speciosa and Calophyllum inophyllum. The latter species generally dominates the upper tree layer with impressive more-stemmed and, apparently very old, specimens.

The lower tree layer is far more like its counterpart in the Corypha-Ardisia community. Again Ardisia humilis (71) is very abundant, while species like Glochidion zeylanicum (60), Diospyros ferrea (61) and Mallotus phillipensis (61) occur regularly, but in low densities. However, characteristic of the Ximenia-Ardisia community is the relative abundance of species from soc. group 71, other than Ardisia humilis: Ficus septica, Diospyros maritima and especially Buchanania arborescens, which locally even replaces Ardisia as the dominant species (see below).

As for the undergrowth, again it is generally very scarce. The species are usually the same as described for the Corypha-Ardisia community. However, there are some conspicuous differentiating species: The beach shrub Desmodium umbellatum (75) is generally present in the scrub layer, while the shrublets Ximenia americana (62), Ixora paludosa (72) and Stachytarpheta jamaicensis (62), combined with the terrestrial fern Pteris vittata (62) and the creeping, spiny liana Maclura cochinchinensis (62) typify the ground layer.

Distribution

Restricted to the coastal plain; only on the uplifted pseudo barrier reef.

Spatial variation

In general a rather constant vegetation type.

As also described for the Corypha-Ardisia community, the major variation concerns the portion of the stub forms of the lower tree layer and the density of the undergrowth.

Moreover, two aberrant forms can be mentioned:

First, on the highest and driest parts of the pseudo barrier reef, i.e. in general the parts nearest the coast, Buchanania arborescens gradually replaces Ardisia humilis as the dominant species. In this zone, locally some impressive tall Buchanania emergents are present, a rare phenomenon in Ujung Kulon.

Second, locally, mainly near Legon Penyu (plot 38), a taller and far more varied forest can be found, which shows some remarkable similarity to the Cerbera-Buchanania forest (XI) on the coastal plain of Peucang Island, with e.g. Radermachera gigantea (71), Cycas rumphii (76), Pterospermum diversifolium (27) and Gnetum gnemon (24). A more or less comparable, but more open and apparently rather disturbed form is found on fragments of the pseudo barrier reef which protude like capes from the mangrove area in the east of Ujung Kulon (plot 330).

Synecological interpretation

Just as the Corypha-Ardisia community, the Ximenia-Ardisia forest originated in the former artificial savanna landscape of the coastal plain after the slash-and-burn management has been stopped.

The absence of soc. groups 55, 56 and 57 and the abundant presence of soc. groups 72 and 75 indicate that this community (at least in its typical form) is, in the ecological sense, more related to beach forests than to inland secondary forests.

The internal variation of the community can generally be explained by local differences in soil conditions, former management and sea influence.

The taller and more varied forms have presumably never been affected by slashing and (possibly) less severely by burning. They represent a form of secondary growth after destruction of the original vegetation by the 1883 tidal waves. Their affinity with the Cerbera-Buchanania forest of Peucang Island is interesting, but in fact quite logical, considering their location and the soil conditions.

For a more detailed discussion of Ujung Kulon's stub forests in general we can refer to section 9.4.III.

XXIV. Community of Calotropis gigantea and Dodonaea viscosa

Soc. groups: the total number is 12; nos. 59, 62, 63, 65 and 71 are the most important ones.

Semi-deciduous, broadleaf, open, low forest.

Insufficiently known community; the following description is based on one single plot (323).

Description

There are three more or less distinct structural layers:

First, there is an open, thin layer of single stemmed dwarf trees, some 4-5 m high, dominated by Dodonaea viscosa (63). The fully grown Dodonaea treelets were mistakenly identified by Hommel (1983) as some sort of invading tree seedlings. In the same layer, both Buchanania arborescens (71) and Ardisia humilis (71) are also abundant; especially the latter species, mainly growing in stubs.

In addition, there is a more or less closed scrub layer, up to 1 m high. The main species are Lantana camara (59), Stachytarpheta jamaicensis (62) and the beautifully flowering, robust Asclepiadacea Calotropis gigantea (63). Eupatorium odoratum (58) and Gmelina elliptica (58) are also present.

Finally, there is a rather sparse, low, herbaceous ground layer. Its main species is Fimbristylis cymosa (79), a cyper grass which is just like the grass, Ischaemum muticum (78) (that is also present) more commonly found in herbaceous beach vegetations. Furthermore, the grassland soc. group 75 is notably well represented with Imperata spec., Desmodium triflorum, Phyllanthus urinaria and Euphorbia hirta.

Epiphytes were absent in plot 323, but the local occurrence of Dendrophthoe pentandra (71) in this community does seem not unlikely, considering the habitat preference of this species elsewhere in Ujung Kulon. The only climber observed was the strange leafless parasite Cassytha *filiformis (73), a typical species of scrubby beach forest.*

Distribution

In small patches along the north coast of the coastal plain, especially near cape Alang-alang.

Spatial variation

Insufficiently known; the density of the tree layer seems to be rather variable.

Synecological interpretation

Just like both types of Ardisia stub forest described above, the Calotropis-Dodonaea community can be considered to have originated from the former artifical savannas in the coastal plain.

Obviously, it shows most affinity with the Ximenia-Ardisia forest, which is also situated on the uplifted pseudo barrier reef. Thanks to the abundant presence of soc. group 75 (including Imperata spec.) and the characteristic Calotropis scrubs, the Calotropis-Dodonaea community shows most resemblance to the original Imperata grasslands which once covered large areas in Ujung Kulon.

Even so, we cannot simply regard this community as a last relict of these *grasslands. Predominant species such as Dodonaea viscosa and Fimbristylis* cymosa are elements of coastal vegetations (beach forest and pioneer situations respectively) rather than of grasslands in the interior. They have never been reported from the Imperata grasslands.

We may assume that the special character of this community is due not only to the succession from artificial savanna to forest, but also to the influence of the strong sea winds near Cape Alang-alang. It is probably of great significance that these sea winds also have a definite impact on the soil profile. The profile of plot 323 is notably sandy compared to other profiles on the uplifted pseudo barrier reef. This is obviously caused by the (regular) blowing about of beach sand, which explains the abundant presence of the beach pioneer Fimbristylis cymosa.

In fact, the presence of Dodonaea viscosa is even more characteristic of this ecologically complicated situation. The species occurs in Java in two forms and habitats, one on calcareous beaches and one in the mountains of eastern Java above 1450 m. as a pioneer after forest fires (van Steenis, 1965). Its occurrence in the Calotropis-Dodonaea community seems to be the combination of two such different habitats (in spite of the fact that the two forms currently are considered to be different species; see Leenhouts, 1983).

Moreover, the occurrence of Dodonaea viscosa along the north coast of Ujung Kulon is of interest for yet another reason: up till now the beach form of the species was almost exclusively known from Java's south coast.

E. Murdannia nudiflora community-group (XXV-XXVII)

(seasonal grasslands of the interior).

XXV. *Community of Dactyloctenium aegyptium and Digitaria heterantha*

Soc. groups: the total number is 10; nos. 64, 65, 68 and 79 are the most important ones.

Seasonal short grass field.

Insufficiently known community; the following description is based on one single plot (009).

Description

Low herbaceous closed vegetation dominated by graminoid herbs, with some scattered forbs and very sparse, low scrub elements.

The predominating graminoid species are Digitaria heterantha (64; a very rare species in Java) and Fimbristylis cymosa (79). Also abundant are Axonopus compressus (68) and Dactyloctenium aegyptium (64).

Most of the forb species belong to the common grassland soc. group 65: Phyllanthus urinaria, Desmodium triflorum and Lindernia ciliata. Also present are Eclipta prostrata (64) and Hedyotis pterida (71).

Only three scrub elements were observed: the palmoid scrub Cycas rumphii (76), the broadleaved shrub Gmelina elliptica (58) and a seedling of the common treelet Lepisanthes montana (49).

Distribution

Locally on the calcareous sandstone ridge; there only in small patches directly behind the Pandanus tectorius belt; probably only between Cibunar and Citadahan.

Spatial variation

Unknown; probably with transitions towards the uneven low trees and scrub form of the Dendrocnide-Syzygium community (XIX) and the grazy form of the Ipomoea-Ischaemum community (XXXII).

Synecological interpretation

Artificial grasslands of the calcareous sandstone ridge; created by slash-and-burn management; replacing the community of Fimbristylis and Chrysopogon (XXVI) of the major grazing grounds in the coastal plain.

Although succession is hampered by intensive grazing by bantengs, the community gradually gives way to the Dendrocnide-Syzygium community (XIX) and will eventually dissappear completely if additional management is omitted.

The species of soc. group 65 indicate an ecological similarity to the Fimbristylis-Chrysopogon community, but the affinity with coastal vegetations (soc. group 76 and especially 79) is obviously more important. Both Gmelina (58) and Lepisanthes (49) may be considered as pioneers of the Dendrocnide-Syzygium community.

The most important element, however, is soc. group 64, i.e. a group of species which are restricted to this community.

XXVI. Community of Fimbristylis dichotoma and Chrysopogon aciculatus

Soc. groups: the total number is 8; nos. 65, 66, 67, 68 and 78 are the most important ones.
Seasonal short grass field.

Description

Low herbaceous, closed vegetation, dominated by graminoid herbs, with many scattered forbs and (very) few scrubs and free-standing trees.

The most important graminoid species are Chrysopogon aciculatus (66) and Ischaemum muticum (78). One of these or the two combined, dominate(s) the vegetation. The cyper grass Fimbristylis dichotoma (66) is an inconspicuous, but very constant species; Imperata spec. (65) and the minute annual Sacciolepis indica (66) are generally of less importance. Locally, Axonopus compressus (68) grows quite abundantly.

Among the many, mostly tiny forbs of this community Phyllanthus urinaria (65), two species of Borreria (B. articularis and B. ocymoides; both 66) and two clover-like species (Desmodium triflorum and Alysicarpus vaginalis; resp. 65 and 67) are the most characteristic.

The species of the very sparse tree layer correspond with those mentioned for the upper tree layer of the Nauclea-Syzygium community. Lagerstroemia flos-reginae (56) and Dillenia obovata (28), both with bright coloured blossom during the dry season, are by far the most common ones.

The density of scrubs is highly variable in time since the grazing grounds covered with this community are (on average) once a year cleared of all new wild shoots. The most common species are Eupatorium odoratum (58), Melastoma affine (58), Lantana camara (59), Ardisia humilis (71) and on Peucang Island also Stachytarpheta jamaicensis (62).

Distribution

Almost completely restricted to the grazing grounds in the coastal plains (of the mainland, Peucang Island and Handeuleum Island). Also very locally down stream along the Cibunar river.

Spatial variation

In general a rather constant vegetation type.

Towards the edges of the grazing ground the density of somewhat taller forbs (e.g. Elephantopus scaber; 66) and scrub elements increases. The creeping vine Tylophora laevis (71) is also locally abundant in this zone.

On Cigenter grazing ground a number of conspicuous alien species are present: the stout herbs Cassia occidentalis and Cassia tora and the fruit tree Psidium guajava (all 66).

The grazing grounds on the island are probably somewhat poorer as far as their species composition is concerned, but essentially not different. Only the very sparse tree layer is quite aberrant with e.g. some planted trees such as Citrus cf. grandis (66) on Peucang Island and Tamarindus indica (66) on Handeuleum island. However, no detailed study of these grasslands was made.

The only truly aberrant form occurs downstream along the Cibunar river. Here species diversity is very low; Chrysopogon for instance is completely absent.

Synecological interpretation

Artifical grasslands, created and maintained by active management, i.e. annual cutting of wild shoots and incidentally also burning, especially on Cigenter grazing ground. Intensive grazing by bantengs (on the islands by Javan deer) also hampers succession.

The grazing grounds covered with this community cannot simply be considered as accidental relics of the Imperata dominated savannas which once covered extensive parts of the coastal plains.

The fact is that the grazing grounds of the mainland are strictly bound to one specific, relatively sandy soil type which is rather rare within the coastal plains as a whole. Possibly, on these soils succession towards forest is relatively slow and a cut-and-burn management more effective, even after a period of neglected maintenance. Still, eventually only the grazing grounds in the direct vicinity of the permanently manned guardposts survived.

We have little information on the nature of the present grazing grounds in former times compared to the surrounding Imperata savanas. However, old reports (e.g. Hoogerwerf, 1937 and 1952) suggest that here too the share of Imperata was much more significant than in the present situation. The change in the vegetation in the last decades may be explained by a change in management (more regular cutting, less frequent burning) and probably a very considerable increase in grazing pressure.

Without any management, the Fimbristylis-Chrysopogon community (of the mainland) will develop into a Nauclea-Syzygium forest (XXI). As mentioned above, the scattered trees of the grazing grounds are reminiscent of such a forest. The unusual density of Dillenia obovata is explained by the fact that young specimens of this tree were often saved when the grazing grounds were cleared, not only because the fruits of this tree provide good food for the bantengs, but also because the wood is quite hard and quickly blunts the chopping knifes (Sakmin, pers.comm.).

Finally, the aberrant character of the grassland downstream along the Cibunar may be explained by regular inundation by brackish water.

XXVII. Community of Fimbristylis miliacea and Oplismenus compositus

Soc. groups: the total number is 6; nos. 67, 68 and 69 are the most important ones.

Seasonal short grass field.

Description

Low, open herbaceous vegetation, more or less dominated by graminoid herbs, but with very abundant (locally co-dominant) forbs. No scrubs or trees.

The major graminoid species are Oplismenus compositus, Cyperus spec. (mainly C.halpan) Axonopus compressus (all 68) and Fimbristylis miliacea (69). Other not uncommon species are e.g. Panicum paludosum (69), Echinochloa colonum (69) and Eleocharis dulcis (82).

The most characteristic forbs (s.l.) of this community are Hygrophila erecta, Hedyotis diffusa and the Umbelliferae-like fern Ceratopteris thalictroides (all 69), while locally abundant species such as Alysicarpus vaginalis, Murdannia nudiflora and Sida rhombifolia (all 67) are reminiscent of the Chrysopogon grasslands described above.

Distribution

Scattered throughout the area, mainly at very low altitudes; probably not above 100 m.

The community was observed in depressions in the grazing grounds of the mainland (e.g. plot 74 and 79), in low, swampy glades in the forests and shrublands of both the coastal and fluvio-alluvial plains (e.g. plots 4 and 149 respectively) and in rhino-wallows (e.g. plot 95).

In all these locations the community covers only a few (tens of) square metres.

Spatial variation

A rather variable vegetation type, which is probably due to the fact that the community may occur in very different landscapes and always covers only small areas.

Synecological interpretation

Vegetation characteristic of relatively low swampy sites, where the original vegetation has been removed by human or animal activity and succession is hampered by grazing, trampling and wallowing. The swampy character of the sites may be either natural or induced by wallowing. The vegetation of these sites is, like the surrounding vegetation, affected by the dry season, but less strongly and later, thus forming periodically 'green herbaceous islands' in a dessicating mainly woody environment. This explains their attraction for grazing herbivores.

Ecologically, these vegetations show some affinity with both the Chrysopogon grasslands (XXVI, see e.g. soc. group 67) and the Phyla swamps (XXXV, see e.g. soc. group 82). The abundant presence of soc. group 69 indicates the specific character of the community.

The affinity with the Phyla swamps seems to indicate some brackish influence on the groundwater. Considering the location of most sites with Fimbristylis- Oplismenus vegetation, this is quite logical, but not so in the case of wallows at higher altitudes. Even so, it is the wallow plot 95 at 60 m.a.s.l. which shows the most resemblance to the brackish Phyla swamps: Eleaocharis dulcis (82) covers some 30% and even the mangrove fern Acrostichum aureum (88) is present. An explanation may be found in the fact that rhinos usually urinate into wallows and heavily impregnate the mud with their scent (Ammann, 1985), thus creating a kind of artificial brackish habitat.

F. Pandanus tectorius community-group (XXVIII-XXXI)

(mainly semi-deciduous beach forests).

XXVIII. Community of Barringtonia asiatica and Syzygium pseudoformosum

Soc. groups: the total number is 16; nos. 43, 70, 71, 74 and 77 are the most important ones.

Semi-deciduous medium tall broadleaf and pandan forest
or less commonly: semi-deciduous broadleaf open medium tall forest with closed scrub.

Description

As far as its physiognomy is concerned, a rather variable community; in general three not very distinct structural layers may be discerned:

First, there is a tree layer, which is 8-15 m high and generally closed. However, locally it may cover as little as 20%. It is very uneven and includes both robust, thick stemmed species like Barringtonia asiatica (70), Hernandia peltata (74) and Terminalia catappa (74) and more modestly sized species such as Polyalthia lateriflora (45) and Syzygium pseudoformosum (43). The very conspicuous rosette tree Pandanus bidur (70; a very rare species in Java) is also a rather common element of this layer, locally even a dominant one. Calophyllum inophyllum (72) is not uncommon, but by no means as predominant as in the Sophora-Calophyllum community (XXIX).

In addition, there is an open or closed scrub layer of some 2-4 m high. It is best developed in stands with an open tree layer. The main species are Messerschmidia argentea (70), Hibiscus tiliaceus (71) and the rosette shrub Pandanus tectorius (77). Many tree seedlings and saplings may also be present, especially under a closed upper tree layer . However, the common beach shrubs of soc. group 73 (e.g. Sophora tomentosa) and 75 (e.g. Vitex paniculata) are notably absent.

Finally, there is a sparse and variable ground layer (0-1 m high), which includes small shrublets such as Allophylus cobbe (71), small seedlings and locally also some herbs, mainly Araceae such as Homalomena cordata (49) and Rhaphidophora montana (49).

Climbers are not common and epiphytes generally absent. A curious exception is the fern Asplenium nidus (3) which is more commonly found in the rain forests of Mt. Payung.

Distribution

More or less restricted to the coasts of the Payung region and the south coast of the western hills; there the predominant type of beach forest. A rather extensive stand of Pandanus bidur, SW of the mouth of the Cimayang, has not been studied; it may belong to the same community. Likewise a stand of Pandanus bidur is said to be present on the Tereleng peninsula. The specimen near the guardpost on Peucang Island is suspected to have been planted.

Spatial variation

The major variation, from closed to open forest with closed scrub, has already been described above.

The most typical form (closed forest with Pandanus bidur) is generally situated in the central part of the bays surrounding the Payung massif. Towards the edges of these bays, i.e. towards the capes separating them, the vegetation gradually merges into the open forest form of this community and finally into the Sophora-Calophyllum community (XXIX). (The capes themselves are generally covered with Sterculia-Syzygium forest XVIII).

On the south coast of the western hills the open forest form of the Barringtonia - Syzygium community is predominant. Pandanus bidur is quite rare in this region, although on the isthmus connecting Cape Gede to the mainland an almost pure stand is found (plot 92).

Synecological interpretation

Compared with other forms of beach forest, this community is notably rich in species which are more commonly found in inland vegetations (e.g. soc. group 49). Even the Lankap palm Arenga obtusifolia (46) is frequently present, though never in high densities.

In this respect, the community at issue may be considered as being the counterpart of both the Sterculia-Syzygium and the Dendrocnide-Syzygium communities, which are both not really coastal but show a considerable affinity with beach forests.

Indeed, there are clear similarities between the three communities, e.g. the abundant presence of species from soc. group 43 (e.g. Syzygium pseudoformosum) and 45 (e.g. Polyalthia lateriflora).

One may wonder which ecological factor allows the presence of inland species in a beach forest. Apparently, the sea influence is mitigated in some way. The most likely explanation is found in the presence of extensive, somewhat uplifted coral flats all along the coasts of the Payung massif and parts of the coast of the western hills, which cause the waves to break and calm down at some distance from the shore line. Obviously, this effect is most pronounced in the central part of the bays and less so towards its edges.

The presence of the rain forest - epiphyte Asplenium nidus in the community at issue may be explained by the high atmospheric humidity caused by the violent crashing of the waves in front of the coastline. Similar low occurrences of rain forest plants in beach forests are mentioned by van Steenis (1965; see also chapter 8).

Finally, we may point to the fact that on average (but not consistantly) the soil profiles of this community are somewhat more developed than those of other types of beach vegetation.

XXIX. Community of Sophora tomentosa and Calophyllum inophyllum

Soc. groups: the total number is 19; nos. 72, 73, 74, 75, 76 and 77 are the most important ones.
Varying from: Evergreen, broadleaf, closed scrub
to: semi-deciduous broadleaf medium tall forest.

Description

This community type includes a wide variety of non-herbaceous coastal vegetations ranging from coherent shrublands (height 2-3 m) with hardly any tree cover to closed forests (height 5-15 m) with or without a fringing zone of shrubs. The forest form resembles the previous community (Barringtonio-Syzygietum, XXVIII) as far as structure is concerned. However, the groundlayer may be somewhat more developed.

By far the most characteristic tree species is Calophyllum inophyllum (72). Other common species are Guettarda speciosa (72), Hernandia peltata (74), Terminalia catappa (74), Erythrina orientalis (74), Premna corymbosa (85) and Barringtonia asiatica (70), although the last species is not as predominant as in the Barringtonia-Syzygium community.

The main species of the shrub layer are Sophora tomentosa, Scaevola taccada (both 73), Desmodium umbellatum, Vitex paniculata, Mallotus tiliaefolius (all 75), Hibiscus tiliaceus (71) and Messerschmidia argentea (70). The latter species is in Java generally restricted to the south coast (van Steenis, 1965), but in Ujung Kulon it can also be found along the N-coast, eastwards up to Cape Alang-alang. In between the broadleaved, often abundantly flowering shrub-species mentioned above, the rosette scrub Pandanus tectorius (77) and the palmoid Gymnosperm Cycas rumphii (76) can be found.

The ground layer also includes some beautifully flowering species: Tylophora laevis, a creeping Asclepiadacea (71), the pachycaul lily Crinum asiaticum (76) and the 'low melati' shrublet Ixora paludosa (72).

Two very characteristic parasites, not uncommon in the closed scrub form of the community, are the epiphytic shrublet Dendrophthoe pentandra (71) and the leafless vine Cassytha filiformis (73, mainly on Sophora tomentosa).

Distribution

Very common along the seashore. Best developed in places where the surf has built up a beach-wall of sand or coral debris. Where there is less direct influence of the sea on the vegetation, e.g. along the more or less elevated coastal parts of the erosional plains, it is less conspicuous.

Along the south coast of the western hills and in the Payung region for the greater part replaced by the Barringtonia-Syzygium community (XXVIII).

Spatial variation

As described above. Furthermore, an aberrant form dominated by thickets of Pemphis acidula (75), occurs on very exposed sites.

Transitional forms towards the Barringtonia-Syzygium community and the Ipomoea-Ischaemum community are not uncommon.

Synecological interpretation

The most common type of beach vegetation, in structure and floristic composition varying according to substratum, intensity of the sea influence and successional stage. The closed scrub form is a relatively young stage, characteristic of accreting parts of the coast. In the succession it follows after the Ipomoea-Ischaemum community, XXXII. In more forest-like forms locally very robust trees occur, mainly Calophyllum, which are thought to be very old, even dating from before the 1883 tidal waves (Hoogerwerf, 1970).

XXX. Community of Pemphis acidula and Lumnitzera spec.

Soc. groups: the total number is 9; nos. 74, 75, 76 and 87 are the most important ones.

Evergreen broadleaf medium tall forest
or: Evergreen broadleaf open medium tall forest with closed scrub.

Description

A most variable type with three rather distinct structural layers:

The tree layer is mostly closed and quite uneven. It is dominated by Lumnitzera spec. (87; up to 10 m) or less commonly by Sonneratia alba (89, up to 20 m). Other common and relatively tall trees are e.g. Rhizophora spec. (90), Heritiera littoralis (88) and Hernandia peltata (74).

The shrub layer of some 2-3 m high may also be open or closed. It is most dense in stands with a relatively open tree layer. The main species is Pemphis acidula (75), which locally thrives in almost pure stands, but is (virtually) absent in other places. Other common shrub species include Desmodium umbellatum (75), Hibiscus tiliaceus (71), Mallotus tiliaefolius (75) and Scyphiphora hydrophyllacea (88). The palmoid Gymnosperm Cycas rumphii (76) is also quite common.

The ground layer is of notably little significance. It consists mainly of some scattered seedlings. Locally, the mangrove fern Acrostichum aureum (88) may be present.

Climbers such as Salacia chinensis (71) are not very common. Epiphytes have not been observed.

Distribution

On relatively low sandy bars in front of or in mangrove areas and in small sized low mangroves such as sandy areas behind a more distinct beach wall.

Spatial variation

As described above; extensive, almost pure stands of Pemphis acidula are present on Handeuleum island. Where coral boulders are abundant on the coastline, such stands may merge into the Pemphis form of the Sophora-Calophyllum community (XXIX).

Synecological interpretation

Both in habitat and floristic composition intermediate between beach forest (soc. groups 74-76) and mangrove (soc. groups 87-90). The internal variation of the community is explained by local differences in the relative importance of both elements: in some places the beach-forest element predominates, in other places the mangrove element predominates.

It is interesting to observe that in all places most of the tree species are mangrove trees, while most of the shrub species are beach plants. One explanation could be that the soil profiles underneath the Pemphis-Lumnitzera forest are sandy, but wet (low in the profile generally even permanently reduced); the groundwater is brackish or saline. Thus one might say that the profiles change in character from beach-soil-like above to mangrove-soil-like below. Possibly, the trees root on average deeper than the shrubs.

Another interesting phenomenon is the fact that this forest type is evergreen, an exceptional situation at such a low altitude in Ujung Kulon. Apparantly, the root-environment is also during the dry season sufficiently wet; not seasonal drought, but the saline character of the environment is the predominating stress factor to plant life. In this respect, the Pemphis-Lumnitzera resembles the forest of the outer mangrove, which is also evergreen unlike (most of) the inner mangrove forest and beach forest.

Note

During fieldwork we could not sufficiently discern the difference between Lumnitzera littorea and L. racemosa. Afterwards, only the 'padi-padi' trees of plot 22 could be identified up to the species (L. littorea). The fact that in general L. littorea occurs along Java's south coast, while L. racemosa is more or less restricted to the north coast (van Steenis, 1965) does not offer a mainstay: in Ujung Kulon both species are with certainty present along the north coast.

XXXI. Community of Mikania cordata and Pandanus tectorius

Soc. groups: the total number is 6; no. 77 is the most important one.
Closed pandan scrub.

Description

A coherent and almost impenetrable thicket of pandans (Pandanus tectorius; 77), which grow in more or less pure stands up to some 5 m high.

Trees are absent or grow only very sparsely. Near the Cibunar-shelter there is, for instance, a conspicuously emerging specimen of Planchonella obovata (43) which frequently serves as a look-out for the white-bellied sea-eagle.

There is no real ground layer; only a few herbs are present, most of them climbing or ascending, the most common one is Mikania cordata (58).

Distribution

In a five metres wide belt fringing the calcareous beachridge along the south coast; there the predominating vegetation type up to Karang Ranjang, but less so further eastwards; occurring both on sandy soils (dunes) and sandstone cliffs (truncated platform).

Also known from a steep, coastal slope covered with loose, rocky debris near Sanghiyangsirah (plot 122); there up to 50-100(?) m.

Spatial variation

As for its physiognomy and for the extreme dominance of Pandanus tectorius a very homogenous community. However, among the few accompanying species, there are but very few more or less constant ones.

Synecological interpretation

Coastal vegetation of very exposed, ecologically unstable, but rarely inundated sites. The community shows some affinity with both the Sterculia-Syzygium community (XXVIII, especially plot 122, with Musa acuminata; 42) and various types of beach vegetation.

C. Fimbristylis cymosa community group (XXXII-XXXIII)

(mainly low, open, seasonal vegetations, both herbaceous and woody of dry coastal habitats)

XXXII. Community of Ipomoea gracilis and Ischaemum muticum

Soc. groups: the total number is 3; nos. 78 and 79 are the most important ones.

Seasonal short herb or short grass field.

Description

Low herbaceous vegetation, either open and more or less dominated by forbs or closed and notably dominated by graminoid herbs.

The major species are the graminoids Ischaemum muticum (78) and Fimbristylis cymosa (79) and the forbs Euphorbia atoto, Ipomoea gracilis and Ipomoea pes-caprae (all 79). The first species of Ipomoea occurs more frequently, the latter in higher densities (if present). Both are very conspicuous, thanks to their brightly coloured beautiful corollas.

Of the less constant species of this community (most of them belonging to soc. group 79) Lepturus repens should be mentioned. This species was considered to be very strictly restricted to the north coast of Java, a strange phenomenon described by van Steenis (1965). However, in Ujung Kulon we collected the species twice (in plots 8 and 12) along the south coast and never along the north coast.

Finally, the local occurrence of seedlings of shrubs (e.g. Sophora tomentosa; 73) and trees (e.g. Calophyllum inophyllum; 72) should be mentioned.

Distribution

Locally on sandy beaches, but nowhere really abundant; the closed grazy form dominated by Ischaemum muticum (see below) also occurs on the edge of the calcareous sandstone ridge in front of or between stands of Pandanus tectorius scrub; still another aberrant form (see below) grows on crumbled fragments of the sandstone slabs.

Spatial variation

The open form dominated by forbs (mainly Ipomoea spec.) is the most typical one; grazing by bantengs hampers further succession to beach forest, but leads to a closed grassland dominated by Ischaemum muticum (e.g. plot 29).

Furthermore, aberrant forms include sparse vegetations with Portulaca tuberosa (79) on the sandstone slabs mentioned above (plot 8), open stands of Spinifex littoreus (79) on embryonal dunes on the beach (plot 177) and transitions towards the community of Fimbristylis and Chrysopogon (XXXVI) near the mouths of the major rivulets e.g. Citadahan (plot 159).

Synecological interpretation

Pioneer vegetation on stable or accreting sandy coasts; if not hampered and modified by grazing (see above), succession will lead to some kind of beach forest, generally to the closed scrubform of the Sophora-Calophyllum community.

In contrast to the opinion expressed by Eiten (1968), we classified the vegetations belonging to this community as seasonal, since one of the major species, Ischaemum muticum, shows very considerable shoot reduction during the dry season.

XXXIII. Community of Ischaemum fieldingianum and Scaevola taccada

Soc. groups: the total number is 6; nos. 73 and 80 are the most important ones.

Seasonal, open broadleaf and graminoid scrub.

Insufficiently known community; the following description is based on one single plot (013).

Description

An open, uneven vegetation in which the structural layering is obscured by the irregular and extremely steep character of the habitat.

The aspect is determined by evergreen, stunted shrubs, viz. Scaevola taccada (73) and Melastoma affine (58), and coarse, seasonal grasses, viz. Ischaemum fieldingianum (80; a very rare species in Java, not mentioned by Backer & Bakhuizen van den Brink, 1968) and Cymbogon rectus (80). Both elements reach up to some 0.5 m, just like the locally present mangrove-fern Acrostichum aureum (88).

In between, one finds some scattered seedlings (Ficus septica; 71) and low herbs: Fimbristylis cymosa (79), Hedyotis pterida (71) and a yet unidentified Papilionacea (coll.no. 13 i; soc. group 80).

Distribution

On extremely steep to almost perpendicular, coastal precipices, which are only if at all very rarely inundated by seawater, up to 50 (-100?) m.; probably not on loose, rocky slopes; restricted to the outskirts of Mt. Payung, Cape Gede and the Cape Layar region; there both on the mainland and on small rocky islands; in the latter locations often the predominating vegetation type.

Spatial vegetation

Unknown. Acrostichum aureum (and possibly Fimbristylis cymosa, too) can be assumed to be restricted to lower altitudes.

The very rare Ischaemum fieldingianum also occurs with certainty in the Cape Layar area. It was collected there by Danser in 1926 (coll.no. 6434).

Transitions towards the Sterculia-Syzygium forest (XVIII) have not been observed, but are likely to occur.

Synecological interpretation

Comparable with the Sterculia-Syzygium community (XVIII), but adapted to an even more extreme environment. The presence of the soc. groups 73, 79 and 88 indicates a strong impact of the seawinds e.g. by means of the salt spray. The relatively abundant presence of species which are in Ujung Kulon restricted to this community (soc. group 80) indicates, on the other hand, the very special (viz. extreme) character of the habitat.

H. Eleocharis dulcis community group (XXXIV-XXXV)

(low, seasonal, herbaceous vegetations, including grasslands, of coastal swamps and pools).

XXXIV Community of Nymphaea nouchali and Najas indica

Soc. groups: the total number is 2; no. 81 is the most important one.
Seasonal short herb field.
Insufficiently known community; the following description is based on one single plot (056).

Description

Two-layered community of aquatic herbs. Only three species were observed: Najas indica and Utricularia cf. gibba with submerged foliage and Nymphaea nouchali with floating leaves (all 81).Of the latter species the green parts die off for the greater part during the dry season.

Distribution

More or less restricted to the bottomlands, i.e. the depressions in the coastal plains of the mainland. There during the dry season restricted to the creeks, but during the wet season expanding into other parts of the bottomlands, thus alternating in time with the Phyla-Eleocharis community.

Possibly, also very locally on Peucang Island, viz. in the small seasonal swamp in the SW-corner. Najas indica and the Hydrocharitacea Ottelia alismoides, a species with a comparable habitat preference, were reported by Kartawinata and Apandi (1977) to occur on the island.

Spatial variation

Unknown; in shallow water intermingled with elements of the Phyla-Eleocharis community.

Synecological interpretation

Vegetation of seasonally desiccating, brackish, aquatic habitats. The salinity of the water may vary considerably in time, during the wet season by rainfall and occasional penetration of seawater, during the dry season by dessication. According to Backer and Bakhuizen van den Brink (1968) Najas indica tolerates a salinity of up to 3%. All three species mentioned may also occur in fresh water.

XXXV. Community of Phyla nodiflora and Eleocharis dulcis

Soc. groups: the total number is 8; no. 82 is the most important one.
Seasonal short grass field
or less commonly:
Seasonal tall grass field.

Description

A closed and generally one-layered herbaceous vegetation, dominated by graminoid herbs. Variable in regard to the dominants, but less so to the accompanying species.

The most common dominants are Eleocharis dulcis and the relatively tall cat's tail Typha angustifolia, but locally finer grasses are predominant e.g.

Panicum repens (all 82).

The most common accompanying species are forbs such as Cayratia trifolia (57; more or less creeping), Polygonum barbatum. Alternanthera sessilis, Heliotropium indicum and above all Phyla nodiflora (all 82). The latter two are most conspicuous, because of their beautiful, many-coloured and abundant flowers.

Within the vegetations belonging to the Phyla-Eleocharis community one finds many coral boulders, strongly varying in diameter and height (from a few tens of centimetres up to 1 or 2 metres). Some of them hardly protrude above the surface. Such spots are often recognizable in the field by coherent, pure stands of Phyla nodiflora.

The more distinctly protruding 'coral-islands' are generally covered by a crowded group of stunted treelets, densely covered with epiphytes. Strictly speaking these forest fragments do not belong to the Phyla-Eleocharis community, but should be considered as an aberrant form of the Lumnitzera-Ardisia community (XXXVII).

However, for practical reasons these coral-islands were included in the sample plots of the Phyla-Eleocharis community. In the vegetation-table (Appendix E) species which are restricted to the forest fragments and do not occur in the surrounding herbaceous vegetation are given in brackets. For a description of the floristic composition of these forest fragments we can refer to section 9.3.XXXVII.

Distribution

Restricted to the bottomlands, i.e. the depressions in the coastal plains of the mainland.

Spatial variation

The variation in regard to the dominant species has been mentioned above.

In general, the boundaries of this community are rather sharp. However, locally transitions to other communties occur: in the northern part of the coastal plain towards the community of Lumnitzera and Ardisia (XXXVII) and in the southern part to the community of Pandanus and Scirpodendron (XXXVI). The latter transitional form was sampled in plot 223.

Synecological interpretation

Vegetation of low areas which are seasonally inundated with brackish water, but dessicate during the following dry season.

Probably the herbaceous vegetations of the bottomlands in the northern part of the coastal plains were formerly influenced by the cut-and-burn management of the surrounding Imperata savanas; the comparable vegetations in the southern part were not.

Since this form of management was stopped, decades ago, the forest closed in, until only the present Phyla-Eleocharis clearings remained. One may assume that these present clearings are too low, c.q. too long inundated with brackish water each year to allow the growth of forest. The parts of the bottomlands which became covered with forest in the last decades are probably slightly higher and their former herbaceous vegetation cover of a different nature.

This does not imply that the present Phyla-Eleocharis clearings will have eternal life. We know from the literature (Backer, 1917) and our own augerings in the bottomlands (using the Krakatau ash as a reference) that sedimentation may be extremely rapid in such environments. Further sedimentation may easily stimulate succession towards forest.

Finally, which factors are responsible for the variation in dominant species is unknown. Probably, both edaphic factors and differences in grazing-pressure (possibly correlated with differences in duration of inundation) are important.

I. Acrostichum aureum community-group (XXXVI-XXXVIII)

(mainly semi-deciduous, open forests of coastal swamps, including the inner part of mangrove-areas).

XXXVI. Community of Pandanus furcatus and Scirpodendron ghaeri

Soc. groups: the total number is 15; nos. 50, 57, 83, 84 and 85 are the most important ones.
Varying from: closed rosette scrub
to: semi-deciduous, medium tall, broadleaf and palm forest.

Description

As for its physiognomy and floristic composition a very varied community, partly due to the considerable difference between well and poorly developed forms. The best developed stands consist of four distinct structural layers:

First, there may be an open to closed upper tree layer of some 15 to 25 m high. Generally, it consists of one single palm species: either Corypha utan (57) or Livistona rotundifolia (84). The upper tree layer may also be completely absent.

Next, there may be an open, lower tree layer, up to 10 m high and consisting of species such as Nauclea coadunata, Cordia dichotoma (both 57), Premna corymbosa (85), the strangling fig Ficus microcarpa and the deciduous mangrove tree Dolichandrone spathacea (both 88). This layer is best developed in stands dominated by Corypha palms, in other forms it is hardly present or even completely absent.

The third layer is the most typical and constant one of the community: a closed, but uneven layer of rosette scrubs in heights varying from 1.5 to 4 m. It is strongly dominated by the robust Cyperaceae Scirpodendron ghaeri (84, in habit resembling a small pandan) and the sparingly branched true pandan Pandanus furcatus (83). In between, other growth forms may also be present, e.g. the broadleaved shrub Hibiscus tiliaceus (71; generally with horizontal stems), the spiny palmlet Licuala spinosa (54) and several species of rattan.

Finally, there is an insignificant sparse ground layer. It consists mainly of seedlings, but locally the mangrove fern Acrostichum aureum (88) may be rather abundantly present.

Climbing species are also quite abundant. Common examples are Flagellaria indica, Cayratia trifolia (both 57), Mikania cordata (58) and Merremia peltata (39). Locally, the mangrove liana Derris heterophylla (88) is also present. Epiphytes have not been observed.

Distribution

In coastal regions; not rare, but never occupying large surfaces. The community has been observed in the following situations:

a. in a more or less continuous, but narrow zone (estimated some 50 m wide) on the landside of the vast mangrove areas in the eastern and southern parts of Ujung Kulon.
b. At the extreme ends of the tidal creeks penetrating into the Nauclea-Syzygium forest of the coastal plain.
c. As small forest fragments, surrounded by Phyla-Eleocharis vegetation in the bottomland north of the mouth of the Cibandawoh.

Spatial variation

Three different forms, which are correlated with the three types of habitat described above, have been observed.

The most common and best developed form, dominated by Corypha utan is found at the inner fringe of the mangroves (plots 236 and 254).

The structurally most simple form, generally without any tree cover is commonly found at the ends of the tidal creeks (plot 211).

A third, structurally more or less intermediate form, occurs in the bottomland north of Cibandowoh (plot 222). Here, the Corypha palm is replaced by Livistona.

In all but the latter cases, the Pandanus-Scirpodendron community has rather abrupt boundaries with the surrounding vegetations. Transitions between the first and second form mentioned have not been observed, but are most likely to occur.

Synecological interpretation

Bound to slightly brackish, seasonally dessicating habitats.

In the salinity-gradient of the coastal plains, the Pandanus-Scripodendron community is bound to a habitat which is generally both ecologically and topographically intermediate between the Nauclea-Syzygium and the Derris-Sonneratia community (resp. XXI and XXXVIII). This intermediate position is also reflected in the floristic composition.

Soc. group 88 represents the mangrove element. The species of soc. group 57 are reminiscent of the Nauclea-Syzygium forest. Tree species such as Nauclea coadunata and Cordia dichotoma, which belong to the latter group, obviously do not grow optimally in this community; they are not able to reach the canopy. On the other hand. Corypha utan (also 57) thrives very well in this community. Backer and Bakhuizen van den Brink (1968) clearly underestimate the species' tolerance to brackish conditions.

The reason for the occurrence of a form of the Pandanus-Scirpodendron community in the bottomland north of Cibandawoh is rather unclear. There are indications in the soil profile that the site of plot 222 is slightly higher than those covered by the surrounding Phyla-Eleacharis vegetations (van Reuler, pers. comm.). However, why in that case, succession did not lead towards the (related) community of Lumnitzera and Ardisia is not really understood. The problem is further complicated by the fact that the dominating tree species, Livistona rotundifolia, is not considered to be a native species in West Java (Backer & Bakhuizen van den Brink, 1968).

XXXVII. Community of Lumnitzera littorea and Ardisia humilis

Soc. groups: the total number is 14; nos. 71 and 87 are the most important

ones.
Semi-deciduous (?), medium tall, (Casuarina and) broadleaf stub forest.

Description

There are four more or less distinct structural layers.

The most constant feature is a more or less closed tree layer of only 6-8 m high, which is strongly dominated by Lumnitzera littorea (87) and Ardisia humilis (71). The first species is characterized by clumps of knee-shaped pneumatophores, surrounding the stem, the latter grows mainly in more stemmed stubs.

Above this layer there may be an open upper tree layer up to 25 m high, completely formed by Casuarina equisetifolia trees (87), resembling Conifers with their strongly reduced leaves and green, drooping twigs. Some of the Casuarina trees are also more stemmed (up to five). In other places, the upper tree layer may be completely absent or represented by a single Nauclea coadunata tree (57).

Underneath there is a sparse shrub layer of 1 m high, with species such as Allophylus cobbe (71) and Lantana camara (59) and an open to sparse ground layer in which Acrostichum aureum (88) is commonly present and locally the delicate herb Dentella repens (82) forms conspicuous cushions.

Climbers are of little importance, although Flagellaria indica and Cayratia trifolia (both 57) are commonly present. Epiphytes are generally absent, but may in aberrant forms be very abundant (see below).

The soil surface below this community is mostly strikingly uneven, due to the presence of numerous coral boulders and clumps of pneumatophores. Most ligneous plants root on the 'islands' formed by these protrusions, while most herbs grow on the low level parts in between.

Distribution

Restricted to the coastal plains, there locally fringing the bottomlands or growing along the seasonal creeks which connect the bottomlands to the coast.

The form with Casuarina equisetifolia is restricted to a relatively vast area west of Jamang.

An aberrant form (see below) is found as small forest fragments covering the coral islands surrounded by Phyla-Eleocharis vegetation in the bottomlands, as described in section 9.3.XXXV).

Spatial variation

The most conspicuous variation concerns the presence (plot 47) or absence (plot 48) of Casuarina equisetifolia.

The aberrant form on the coral islands in the bottomlands is characterized by a stunted, dense habit. In general, the vegetation is only some 3 m high. Lumnitzera is always absent (as far as is known), while Premna corymbosa (85) and the strangling fig Ficus microcarpa (88) are, next to Ardisia humilis, the most common treelets. Epiphytes are strikingly abundant; examples are Dendrophthoe pentandra (71), the ferns Drynaria sparsisora and Pyrosia lanceolata (both 82) and young specimens of Ficus microcarpa.

Moreover, locally and especially along the seasonal creeks mentioned above stands dominated by Ficus microcarpa occur (not sampled). They can be considered as transitions towards the Derris-Sonneratia community (XXXVIII), in which also local dominance of Ficus microcarpa may occur.

Stands without any stubs have not been observed but are likely to occur.

Synecological interpretation

Forest type, characteristic of the lowest parts of the coastal plain, in which growth of forest is still possible. During the wet season inundation with (slightly) brackish water takes place. In even lower localities where the duration of the inundation period is longer and the water may reach a higher level, the community is replaced by Phyla-Eleocharis vegetation (XXXV).

Both its location and floristic composition reflect the intermediate position of this community between the Phyla-Eleocharis community of the bottomlands and the other Ardisia forests of the coastal plains (mainly the Corypha-Ardisia community, XXII). Soc. group 82 represents the bottomland element, while the (predominating) coastal-plain-element is represented by e.g. soc. groups 57 and 71). Moreover, the abundant presence of species from soc. groups 87 and 88 stress the affinity with vegetations of the inner-mangrove.

The stub-habit of the forest is a relic of the former cut-and-burn management in the coastal plains. For a more detailed discussion of Ardisia stub-forests in general, we can refer to section 9.4.

The Casuarina trees in the Lumnitzera-Ardisia forest, west of Jamang, are possibly the off-spring of trees which were originally planted as a beacon for sailors (see Hoogerwerf, 1951). The same holds for the other two (minor) stands of Casuarina in Ujung Kulon, in beach forests near Niur and on Peucang Island.

The combination of Lumnitzera littorea and Casuarina equisetifolia in the Jamang region probably does not occur elsewhere in Java. Outside of Ujung Kulong, Lumnitzera littorea is only known from the south coast of the island, while Casuarina equisetifolia seems to be restricted to the north coast (van Steenis, 1965).

XXXVIII. Community of Derris heterophylla and Sonneratia alba

Soc. groups: the total number is 18; nos. 87, 88 and 89 are the most important ones.

Generally: Semi-deciduous, medium tall, open forest with closed scrub.

Description

A floristically rather constant community; however, its physiognomy is very variable and in most cases rather complex. In general, three main structural layers can be discerned:

First, there is an uneven, generally more or less open tree layer. Sonneratia alba (89) is the most common species with pneumatophores arising vertically from horizontal roots buried in the soil. It is usually also the tallest species, reaching up to some 15 or 20 m. Not rarely, it strongly dominates the tree layer. Other common, but generally less tall species are e.g. Lumnitzera spec. (87), Heritiera littoralis, the strangling fig Ficus microcarpa and the deciduous tree Dolicandrone spathacea (all 88).

Underneath there is a closed scrub layer. In most cases it is dominated by coherent stands of either the fern Acrostichum aureum (88), which may grow as high as 1.5 m in this community, or the (almost) stemless palm Nypa fruticans (88). In the latter case, Acrostichum is generally also very abundantly present underneath the Nypas, and accompanied by the beautifully flowering shrublet Acanthus ilicifolius (also 88). Also far from uncommon are forms with a very dense, almost impenetrable mixed scrub layer on which, next to the species mentioned above, taller broadleaved shrubs like Scyphiphora hydrophyllacea (88) may be abundantly present.

The sparse ground layer, finally, is very poorly developed. It consists completely of seedlings.

On the other hand, climbing species occur in great abundance, especially in the mixed scrub layers. The main species are the vine Mikania cordata (58) and the lianas Derris heterophylla, Caesalpinia crispa and Finlaysonia obovata (all 88). Epiphytes, other than young strangling figs, have not been observed.

An interesting aspect of the area covered by the Derris-Sonneratia community is the abundance of 'crab-hillocks' on the forest floor.

Distribution

The predominant vegetation of the inner part of the mangrove areas. Also very locally and in an aberrant form on Peucang Island.

The form with a dominance of Nypa occurs mainly in regions near the mouths of the main rivulets and the mixed impenetrable form is generally found on the inland side of the inner mangrove, thus bordering the Pandanus-Scirpodendron community (XXXVI).

Spatial variation

The three major forms have been described above. The form with a dominance of Acrostichum aureum is probably the most typical. However, these forms are far from well separated; transitional situations are very common.

Very aberrant forms also include stands of closed forest, dominated by Ficus microcarpa (observed in a depresssion in the coastal plain of Peucang Island; plot 75) or Oncosperma tigillaria (36; observed in a transitional position between Nypa-forest and the Areca-Arenga community (XIII) in the Cidaon-Cijungkulon region; plot 100).

Synecological interpretation

The common vegetation of the inner part of the mangrove area, which is normally inundated by seawater at high tide, but is shut off from the sea influence and thus dessication during at least part of the dry season. This is also true for the Nypa-dominated stands near the mouths of the main rivulets. Generally, these mouths are more or less closed by a sandbar during the driest months of the year. The presence of a fully deciduous tree such as Dolichandrone and the semi-deciduous behaviour of other species indicate this seasonal dessication. In this respect, the Derris-Sonneratia community differs from the evergreen outer mangrove.

Even so, the abundant presence of species from soc. groups 87 and 89 indicate a strong affinity with the Rhizophora forest of the outer mangrove. However, the many species of soc. group 88 are predominant, stressing the specific character of this community.

Finally, an interesting aspect of the Derris-Sonneratia community is the common dominance of Acrostichum and the abundance of Acanthus, two species considered by van Steenis (1965) to be indicators of degradation. Indeed, large parts of the Derris-Sonneratia forest have a very disturbed, unstable appearance. However, most parts if not all, have not been touched by man for at least one hundred years. A possible explanation may be that the original mangrove forest which was destroyed by the 1883 tidal waves never really recovered in this zone, since succession was influenced for decades by the continuous sedimentation of volcanic ashes, due to erosion processes in the interior.

J. Rhizophora apiculata community group (XXXIX)

(evergreen forests of the outer part of mangrove areas).

XXXIX. Community of Sonneratia alba and Rhizophora spec.

Soc. groups: the total number is 3; nos. 89 and 90 are the most important ones.

Evergreen, broadleaf, medium tall forest with or without emergents.

Description

A community with a very simple physiognomy and only few species. In general, there are three structural layers:

The main one is a closed and strikingly homogeneous tree layer of variable height (in general 10-15 m). This layer consists mainly of species belonging to the Rhizophoraceae-family, e.g. Bruguiera cylindrica, Ceriops decandra (both 89), C.tagal, Rhizophora mucronata, R.stylosa and R.apiculata (90). The latter species is the most common.

Above, there are generally some emergents, up to 20 m high. Locally, even an open upper tree layer is present, covering some 40%. The main emergent species is Sonneratia alba (89). In some stands of the Sonneratia-Rhizophora community only dead specimens of Sonneratia were observed. The same holds for the less common Lumnitzera spec. (87) in the main tree layer. In such cases the species is indicated between brackets in the vegetation table (Appendix E).

Below the main tree layer one finds a variable amount of tree seedlings and saplings of various sizes. Only one shrub species is present, though not very commonly: Aegiceras corniculatum (89). Terrestrial herbs, vines and lianas are completely absent. Epiphytes have not been observed.

The forest floor is dominated by (and often almost inaccessible because of) an abundance of various types of stilt roots, aerial roots and pneumatophores.

Distribution

Restricted to the outer parts of the main mangrove areas.

Spatial variation

At least two rather distinct subzones can be discerned: an outer one dominated by Rhizophora species and an inner one dominated by Ceriops species. However, our data are too limited to describe real subtypes.

In general, this community and its internal zonation is best developed in the widest parts of the mangrove.

Synecological interpretation

Forest adapted to daily inundation by seawater at high tide, also during the dry season. Seasonal drought is a factor of no great significance in such an environment, which explains the evergreen character of the vegetation. However, lack of epiphytes in a mangrove area is considered as an indication of seasonal drought (van Steenis, 1965).

The outer mangrove is an extreme habitat, very different from all inland habitats. As for its species composition, there is only a certain overlap with the inner mangrove (soc. group 87 and 89), but most of its species are restricted to the community at issue (soc. group 90). Their number is relatively low as is normally the case in a very dynamic environment.

The high mortality of both Sonneratia and Lumnitzera is a remarkable phenomenon. A possible explanation may be that seedlings of both species were at an advantage, when the Rhizophora forest was at least partly destroyed by the 1883 tidal waves. Both species have their optimum in Ujung Kulon in the inner-mangrove, which was described as a rather unstable habitat with a relatively open tree layer (see 9.3.XXXVIII). Now, the Rhizophora canopy has recovered in the outer mangrove and things are getting back to normal, so we may assume that both species will be pushed back to their normal (yet unknown) density in this zone.

9.4 Some interesting formations

9.4.1 Palm forests

(communities III, VII, XIII and XX).

In Ujung Kulon several communities can be discerned with a striking dominance of (pinnate-leaved) palm trees. In almost all cases, the dominating species is Arenga obtusifolia, although in the alluvial Areca-Arenga community (XIII) other species may also be predominant, viz. Oncosperma tigillaria and Areca catechu.

Next to the dominance of palm trees, the scarcity of the undergrowth is a common feature of such forests. It is generally explained by the fact that hardly any light penetrates to the forest floor through the dense layer of palm leaves (e.g. Van Borssum Waalkes, 1951). This phenomenon has serious implications for the forest dynamics. For regeneration, the tree species of the upper canopy are almost completely dependent on incidental gaps in the Arenga layer. Such gaps are created by the down-fall of forest giants, especially Ficus trees and are usually stocked with seedlings and saplings, a few of which are destined to become the emergents of the future. Note that this mechanism can provide even a pure stand of Arenga with a new layer of emergents: it was observed several times how strangling figs had developed from the crown of an Arenga palm. These stranglers will grow into forest giants, die off and create a large gap with plenty of possibilities for invading seedlings. A pure stand of Arenga is therefore not necessarily a final stage in succession!

The Arenga obtusifolia forests are far from common in the Malayan region. They are not mentioned in any of the enumerations of vegetation types compiled by van Steenis (1935, 1957 and 1965). According to the experienced forester and botanist Endert, who visited Ujung Kulon in 1931, the Arenga forests are not known from any other locality in the region (cited from Hoogerwerf, 1970).

However, this is not entirely correct (anymore). Similar vegetations are known to occur on Siberut, an island near the south/west coast of Sumatra (Whitten, 1980), Panaitan Island in the Sunda Straits N. of Ujung Kulon (van Borssum Waalkes, 1951) and on the most western part of the adjacent

Mt.Honje region (pers. obs.). During a visit to the Ujung Genteng peninsula (south coast of West Java) van Balgooy (pers. comm.) observed a similar, albeit small, patch of Arenga obtusifolia forest. Moreover, a photograph (without annotations on the species composition) of a forest on Nusa Kambangan, an island near the south coast of Central Java (Detmer, 1907) shows great resemblance with the forest type at issue.

A satisfactory explanation of the striking dominance of Arenga obtusifolia cannot be found in the literature, although many authors dealing with Ujung Kulon touch upon the subject. A discussion of various possibilities is provided by Hommel (1983).

Obviously the Arenga forests do not represent a normal successional stage following shifting cultivation practices: if that were the case Arenga forest would be far more common in West Java, where secondary forests cover large areas (van Steenis, 1965). As for the relation with the soil, Arenga forest in Ujung Kulon can be found on several soil types, in general ranging from somewhat excessively to moderately well drained, and developed from various types of parent material. In fact, the various communities to which the Arenga forests belong show a far better correlation with specific types of soil and parent material; see table 11b. The top soil of volcanic ashes is also not likely to be a key factor: descriptions of Ujung Kulon before 1883 (Anonymous, 1854) seem to indicate that the Arenga forest was already there, while at present the parts of the erosional plain, where the Krakatau ashes are missing, are mainly covered by Arenga forest. The same holds for the isolated eastern summit of the Telanca massif (see fig. 7a).

Influence of the 1883 tidal waves as suggested by Pellek (1977) seems absurd, since the Arenga forest covers the slopes of Mt. Payung up to an approximate altitude of 150 m., while the height of the tidal waves probably hardly exceeded 15 m.

The impact of the browsing activity of banteng and rhino is finally also not the solution to our problem: Arenga forest is present on Panaitan island, banteng and rhino are not. On the other hand the distribution of Javan deer is seemingly of more importance: the species occurs in very high densities on Peucang Island (where Arenga forest is missing), but is absent on Panaitan Island and relatively scarce on the mainland of Ujung Kulon (where Arenga forest is present). Moreover, we never found an Arenga seedling on Peucang Island which was not heavily browsed on. However, this relation is probably only accidental. Most seedlings on Peucang are heavily browsed on regardless of the species, while the present distribution of Javan deer strongly differs form the situation several decades ago, when the species was more common on the mainland and less common on Peucang than it is now (see chapter 10).

Even so, there is a possible explanation for the phenomenon of Arenga forests.

Obviously, all areas from which such forests are known have one feature in common. They are islands or peninsulas, (almost) completely surrounded by seawater, but situated close to a vast land mass with a more or less constantly wet climate. This holds even for Nusa Kambangan: although Central Java generally speaking has a more seasonal climate, the SW-part in which Nusa Kambangan is situated is notably wetter (Boerema, 1931). As stated in Chapter 5, this borderline location resulted in Ujung Kulon in a specific climate with, incidentally, a very dry season, while annual fluctuations on the adjacent mainland, even at a small distance, are known to be less pronounced. It is very well possible that the same climatological situation also exists in the other regions mentioned.

Still, one cannot simply consider the dominance of Arenga obtusifolia as some mysterious adaptation to an unstable climate. In some parts of Ujung Kulon, Arenga forests are lacking where they could be expected as far as altitude and soil are concerned. The most clear example of such a situation is the central part of Peucang Island.

It is now of interest to realize that the Peucang forest, in view of its floristic composition and physiognomy, is generally considered to be of primary nature (e.g. Kartawinata, 1965; Kostermans, pers. com.). On the other hand, the phenomenon of strong dominance of one species in a tropical forest is generally interpretated as a token of former disturbance (e.g. van Steenis, 1965).

Thus, we may assume that the dominance of Arenga is due to climatological 'instability' or, more precisely, to the incidental occurrence of exceedingly dry years, but is a phenomenon which is restricted to secondary forests. A possible explanation is provided by the fact that Arenga palms have the capacity for rapid vegetative reproduction by means of subterraneous shoots which undoubtedly gives the species an advantage above invading seedlings other species especially during a period of climatic hardship. Still, in our experience, Arenga does not behave like an agressive weed after destruction of the natural vegetation. Obviously, the species is not of great significance in the early stages of succession. We shall return to this subject in chapter 9.

Two factors assumed to enhance the impact of unusual drought should be mentioned here: fire and vertic properties of the soil.

Fire has strongly influenced succession in areas with a true monsoon climate all over Java (van Steenis, 1965) and it is most likely that it also did so (and in a specific way) in areas with an incidental very dry season.

In the past, deliberate incendiarism on behalf of shifting cultivation practices and the maintenance of the artificial savanna landscape may easily have lead to incidental, uncontrolled forest fires. Only recently, part of nearby Panaitan Island suffered from forest fires resulting from neglected cooking fires of fishermen (Blower and Van der Zon, 1977). As stated before, human influence on Peucang Island has always been of minor importance, which might explain the survival of the primary vegetation there.

Possibly, palm trees, which do not have their vascular bundles concentrated in the outer part of the trunk, are less vulnerable to a not too severe forest fire. Moreover, as mentioned above, Arenga obtusifolia, has the capacity of rapid recuperation after destruction of the supra-terraneous parts, by means of subterraneous shoots. Some other palm species have this capacity as well. Indeed, Eiten (1968) describes the occurrence of a semi-deciduous broadleaf and palm (open) forest in Brasil after the burning of the original forest. However, these relations are only hypothetical. Of course, many dicotyledonous species are also adapted to survive forest fires, e.g. Tectona grandis, but such species are inhabitants of true monsoon forests and are in general absent in Ujung Kulon.

Furthermore, we assume that the vertic properties of some of the most common soil types of Ujung Kulon (see section 7.5) are also involved. Young Arenga palms, sprouting from firm subterraneous shoots, can be assumed to be less vulnerable to the churning of the soil mass following an exceedingly dry season than 'normal' tree seedlings and saplings. Indeed, most of the soil types on which Arenga forest is present are assumed to possess vertic properties (see section 7.5). Only three types (all of limited extent) have no vertic properties, but do carry Arenga forest. However, in all three cases we are dealing with somewhat excessively drained soils on which the vegetation's sensibility for seasonal drought is self-evident. We even assume that here Arenga itself reaches the limits of its ecological amplitude.

In summary, we assume that Arenga forests are bound to areas (with an appropriate soil and a seasonal climate, where the original semi-deciduous broadleaf forest has been destroyed by fire or man. Differences in specific composition and degree of dominance of Arenga may be interpreted as differences in intensity and frequency of destruction and in age of the stand (of course, in addition to differences in soil types).

In this respect it is interesting to note that the isolated plateau-fragments with Arenga forest, which rise up from the uplands north of Cibandawoh and which are covered with a sound form of Drypetes forest, still have a remarkably rich flora (e.g. with Dipterocarpus trinervis) and that the upper limit of the Arenga forest on Mt. Payung coincides with the lower limit of the constantly wet zone which is less vulnerable to forest fires.

Conversely, one might conclude that forests with few or no Arenga obtusifolia, growing at altitudes and on landforms where the species is dominant elsewhere in Ujung Kulon are primary forests. Examples of such primary relics are the central part of Peucang Island and parts of both the tuff-hills in the westernmost and the upper part of the Telanca massif. However, not all such stands are of primary nature. Local pedological abnormalities may also be of great importance, e.g. the well-known species-rich forest fragments east of the Cibandawoh shelter (mentioned by both Kappeler, 1981 and Ammann, 1985) seems to be bound to a part of the limestone plateau which has weathered to an unusual sandy soil. Likewise, the Drypetes ovalis dominated slope-forest west of the trail Cibom-Ciramea is bound to an extremely shallow soil profile.

9.4.2 Bamboo-forests

(communities XII and XVII)

In Ujung Kulon two forest-types can be found which are dominated by bamboo-species growing in clumps. The two species at issue are Schizostachyum zollingeri which forms (almost) pure stands (XVII) and Bambusa blumeana which generally dominates a specific type of mixed forest (comm. no. 12) together with Drypetes ovalis. Although most of the bamboo species occurring on Java are not truely native, these two are according to Hildebrand (1954).

The same author mentions the occurrence of forests dominated by these species for several locations on Java (partly following Backer, 1928). Apparently the habitat of the Schizostachyum and Bambusa forests elsewhere on Java corresponds fairly well with the present situation in Ujung Kulon.

Thus, Schizostachyum stands are most common on steep slopes and river banks at low altitudes. In addition, in Ujung Kulon they can also locally be found on adjacent parts of the limestone plateaus, replacing the rattan-shrublands. This can be explained by the principle of primarity.

The habitat of Bambusa forest also corresponds with the situation described for other parts of Java. It is bound to the heavy, periodically very wet soils of the uplands of Ujung Kulon, including the slightly better drained parts west of Jamang. However, Backer's observation that stands of Bambusa indicate a soil poor in phosphates probably does not hold for Ujung Kulon (van Reuler, pers. comm.).

As for the successional status of the Javan bamboo forests, van Steenis (1935, 1965) considers all cases of pronounced dominance of bamboos as a token of former human interference. All bamboos are light-demanding species, which are capable of a quick response once the forest-canopy has been opened and once established they are not easily superseded by other plants thanks to the competing capacity of their dense root system.

Possibly, next to former logging activities, forest fires have also been of importance. In many places the bamboo forests border upon Arenga forests which are at least partly assumed to be influenced by (repeated) forest fires (see 9.4.1).

Moreover, bamboo clumps are generally surrounded by piles of highly inflammable litter. Thus, it is most likely that formerly the bamboo forests also suffered from incidental fires. If the subterraneous rhizomes of the bamboos survived the fire, again the bamboo clumps could profit from the destruction of the forest-canopy. If so, they followed the same strategy as truly fire-adapted species such as Casuarina junghuhniana (see Burger, 1930). However, no indication of such a strategy could be found in the literature on bamboos.

Even so, it is interesting to note that the stands of the Bambusa-Drypetes forest in which Bambusa is the least abundantly present occur in the same region (viz. north of Cibandawoh) in which notably species-rich forms of Arenga forest occur. These are also assumed to reflect a relatively weak impact of former forest fires (see 9.4.1).

The Bambusa forests, probably even more than the Arenga forests, are bound to soils which possess distinct vertic properties (see section 7.5). The capacity of bamboos to sprout from firm subterraneous rhizomes is likely to give them an advantage above normal seedlings during churning of the soil mass during an exceedingly dry season. Thus, also in this respect, there is an interesting parallel between Arenga and Bambusa forests.

Finally, we must point to the fact that the former inhabitants of Ujung Kulon planted small bamboo groves throughout the area. Although not considered as being the most valuable of bamboo species (Hildebrand, 1954), this probably also holds for Schizostachyum zollingeri and Bambusa blumeana. Thus, small stands of both species outside their normal distribution area in Ujung Kulon and generally situated along the (centuries-old) footpathes can be explained. Examples are the stand of Schizostachyum on Gn. Kendeng (described by Pellek, 1977) and the stand of Bambusa NE of the mouth of Citelanca.

9.4.3 Stub-forests (communities XXII, XXIII and XXXVII).

In the northern part of the coastal plain of Ujung Kulon, vast stands of forest occur which are characterized by a special growth-form of the dominant species: a many-stemmed stub. In habit these forests rather closely resemble a European oak-coppice.

These stub-forests can be subdivided into three plant-communities, which show a clear relation with abiotic factors (see 9.3). In all three, the most common dominant species is Ardisia humilis, locally covering up to 100%.

However, Buchanania arborescens may replace Ardisia in some stands of the Ximenia-Ardisia community (no. XXIII), while in the area west of Jamang we find Casuarina equisetifolia predominant in the Lumnitzera-Ardisia community (no. XXXVII). Of Casuarina, only some of the specimens occur in many-stemmed stubs.

In the literature, we could not find any reference to similar vegetations elsewhere in the Malayan region. However, there is no problem in tracing the origin of the Ujung Kulon stub-forests. Clues can be derived from the existing literature on the area (mainly from the reports of Hoogerwerf, 1937, 1938, 1952, 1970 and 1972) and from the memory of the older PPA guards (e.g. Pak Sakmin).

The stub-forests originated from the artificial savanna-landscape after the gradual neglect of their maintenance. This savanna consisted mainly of Imperata dominated grasslands, with scattered trees and shrubs. We have little information on the floristic composition and the (probably considerable) internal variation of these vegetations. The parts which were situated on the raised pseudo barrier reef and which would develop into the present Ximenia-Ardisia forest probably showed some similarity to the present Calotropis-Dodonaea vegetations (comm. no. XXIV) which occur in small glades along the north coast near Cape Alang-alang.

We know for certain that species such as Calotropis gigantea and Saccharum spontaneum were once very common in the coastal plain. At present, Calotropis is restricted to the glades mentioned above, while Saccharum was not encountered at all during our survey. (Still, the species has not yet completely disappeared from Ujung Kulon according to Djaja et al., 1982). Furthermore, we may assume that the wettest forms with the strongest brackish influence, which would develop into the present Lumnitzera-Ardisia forest, showed some affinity with the present Phyla-Eleocharis vegetations (XXXV) of the bottomlands. Finally, the forms which would develop into the Corypha-Ardisia community can be assumed to have been of a more or less intermediate nature, possibly with abundant occurrence of Saccharum.

That is about as far as our knowledge and speculations on the nature of the disappeared savanna landscape go. Anyway, it is definitely wrong to consider the present grazing grounds as representative relics (see 9.3.XXVI).

The maintenance of the savanna involved a regular, if possible annual cut-and-burn management. However, maintenance was neglected frequently and the area was invaded by species such as Ardisia humilis, Lantana camara and Melastoma affine. In fact the same species which also tend to invade the present grazing grounds. Of course there were local differences, mainly related to differences in soil conditions. In relatively wet areas, the fan palm Corypha utan was a most noxious weed, as photographs of the Cikarang area (once a famous pasture) clearly show (Hoogerwerf, 1970).

Of all pioneer species invading the pastures, Ardisia humilis was one of the most persistent, since treelets of this species are not killed by fire. In this respect, the report of Van Borssum Waalkes (1951) is interesting. He witnessed the burning of an Imperata field on nearby Panaitan island. The fire killed most of the scattered growing trees, but the Ardisia stands were spared. Therefore, it was necessary to cut the wild shoots before setting fire to the area. fire. As we know from the report of Kortz (1952) this was done effectively only by chopping the stems at ground level and not above. This must have been an arduous task, especially since in many places the soil surface of the coastal plain is strewn with coral debris, blunting the chopping-knives even more quickly than the Ardisia stems could with their notoriously hard wood. In this respect, it is interesting to note that in the vicinity of Legon Penyu, where the Krakatau waves also deposited loads of pumice, one did not even bother to maintain grasslands. At present, one finds reasonably fully-grown forest in this region (see 9.4.XXII), a very rare phenomenon on the raised pseudo barrier reef.

Inaccurate cutting of wild shoots did not exterminate them but induced stub-forming. We may assume that the present variation in density of stub-forms reflects differences in effectivenss and regularity of the former management.

We may also assume (although exact data are not available) that both Buchanania and Casuarina equisetifolia, although more selective as far as soil conditions are concerned, are to some degree also fire-resistant, just like Ardisia humilis. This is especially interesting in the case of the latter species which thus shows an ecological parallel to Casuarina junghuhniana, the most notorious fire-adapted tree-species of the mountain regions of Central and East Java (Burger, 1930; van Steenis, 1935; see also 9.4.2).

9.4.4 Rattan-shrublands (community XV).

This section deals with the notorious, almost inaccessible, shrubby jungles, dominated by long-creeping rattans (i.e. thorny palm-lianas) and other types of lianas and vines, which cover vast parts of the interior of Ujung Kulon.

These vegetations are most abundantly present on the dissected parts of the limestone plateaus, on the uplands and in the fluvio-alluvial plain. Elsewhere, they are of less significance or completely absent. As for soils, the rattan shrublands are (almost) completely restricted to moderately-well or somewhat poorly drained conditions (see section 7.4.3 and table 11b).

All rattan-shrublands of Ujung Kulon belong to one plant community (the Hyptido-Daemonoropsetum) two subtypes of which are described (see 9.3.XV).

A remarkable feature of these vegetations is the fact that their boundaries with adjacent vegetation (mainly forests) are, in general, strikingly abrupt, while no sudden change in abiotic circumstances (e.g. soil conditions) can be observed. On the other hand, where the rattan-shrublands cross important soil-boundaries, causing spectacular changes in the vegetation of forest covered areas, the shrublands do not show a significant change in physiognomy or floristic composition.

On the basis of their physiognomy and the abrupt character of their boundaries (unrelated to abiotic factors), the rattan-shrublands can be interpreted as an early succession stage following deforestation by man (see: van Steenis, 1961).

In his enumerations of vegetation-types of the Malayan region, van Steenis (1935, 1957, 1965) does not go into detail as far as such forms of early secondary growth are concerned. However, in 1939 the same author published a special paper on vegetations dominated by lianas and vines, including types of secondary growth.

According to van Steenis, dominance of climbing species (including rattans) is far from uncommon in both shrubby and forest-like forms of secondary vegetation. The same author describes how blankets of vines may completely envelop treelets, strongly reducing their vitality and not rarely killing them. As stated in section 9.3.XV, such stunted treelets are very common in the Ujung Kulon rattan-jungles. Moreover, many species mentioned by van Steenis (e.g. several Convolvulaceae) are also most abundant in our study area.

Unfortunately, van Steenis does not give much information on the conditions under which secondary vegetations may become dominated by vines and lianas. As for Ujung Kulon, Hommel and Van Reuler (1986) drew up the following theory (see also Hommel, 1983 and Van Reuler, 1986).

By the end of the previous century large parts of Ujung Kulon were under cultivation as 'dry' rice-fields or only recently deserted (a description of the shifting cultivation system in these parts of Java is given in chapter 4). One of the major impacts of the 1883 Krakatau eruption was the deposition of a layer of volcanic ashes (up to 30 cm thick), which killed the young rice plants (not yet planted out) and also most of the adjacent low, secondary vegetation. The surrounding forests were affected less dramatically, although much of the undergrowth suffered.

Consequently, the area was completely depopulated for a variety of reasons (see chapter 4) and vast, ash-covered fields remained. Due to some specific properties of the ash layer (see section 7.4), these fields did not provide favourable conditions for invading seedlings. Thus, climbing species which are in general abundant in forest edges and which always strongly respond to light (van Steenis, 1939), were at an advantage, invading the ash-covered glades by horizontal growth. Thorny species (e.g. rattans) had a special advantage, because of the considerable browing pressure. The many large herbivores of the area can be assumed to have suffered from food-shortage, because of the impact of the ash deposition on the lower vegetation of the whole peninsula. Predominance of thorny species in secondary vegetations in relation to browsing pressure has been described before by van Steenis (1957).

Further succession was difficult. Van Steenis (1939) points to the fact that underneath vegetations dominated by vines and lianas the availability of light is very limited. Thus, the conditions for seedlings are not very favourable. Reduction in the vitality of treelets because of the all-enveloping vine-blankets has already been mentioned. Still, it is strange that even after one hundred years, the shrublands have not evolved very significantly. The present pattern of rattan-vegetations still shows, both on aerial photographs and in the field, the pattern of agricultural fields which were under cultivation in or shortly before 1883.

A possible (additional) explanation for this phenomenon can be found in the exceptionally harsh soil conditions of the open, exposed areas, where (in contrast to the surrounding forests) the structure of the ash-topsoil hardly improved. Unfortunately, Pellek who studied plant-soil relations (1977) and soil-genesis in the ash-layer (1986) in Ujung Kulon was apparently unaware of the existence of the rattan-shrublands. Our own observations on this point of detail are of a rather descriptive nature and exact data are lacking (see chapter 7). Even so, it is interesting to note that in clearings on soils which have been covered by forest for the greater part of the previous hundred years, succession proceeds in a far more rapid and 'normal' way.

Recently deserted shifting cultivation sites in the Legon Pakis area (near the eastern boundary of Ujung Kulon) are covered with a shrubland which, in many places, is dominated by Lantana camara. Young treelets occur abundantly, but rattans are virtually absent. Such successional patterns are much more similar to the normal vegetation development on former shifting cultivations sites in this part of Java (see: Backer, 1913).

A shifting cultivation site in the adjacent part of the Mt. Honje area was found to be covered by open, medium-tall forest only thirteen years after being abandoned (see 9.3.XVI), but this does not prove very much since on the site studied (plot 336) the ash-topsoil was absent.

Thus, succession of the Ujung Kulon rattan-shrublands proceeds very slowly, but this does not imply that these vegetations will last forever eternity. Gradually, trees will manage to break through the compact mass of entangled vines and lianas. In this respect, it is interesting to note that the rattan-shrublands can roughly be subdivided into two subtypes which are assumed to reflect a difference in succession: a 'primitive' subtype, with abundant growth of the pioneer-shrub Lantana camara, but poor in treelets and a further developed subtype without Lantana but relatively rich in treelets. It is of importance to note that neither palms (Arenga) nor bamboos (Bambusa) seem to be of much significance in the most developed phases of the rattan-shrublands. The same holds for the more recently originated secondary vegetations mentioned above. We shall return to this subject in chapter 11, when discussing the main lines of vegetation dynamics in the area.

CHAPTER 10. FAUNA

10.1 Introduction

The area's fauna will be discussed in less detail than the botanical aspect.

The reason for this procedure is primarily the fact that the fauna aspect, unlike most of the other land-attributes, has been dealt with thoroughly by a whole series of other students. A further justification is found in the fact that of all mutually connected land components, the fauna is, at least in the case of Ujung Kulon probably the most dependent one: it is determined far more by the other land-attributes than it determines those aspects itself. In other words, lack of detail as far as the fauna is concerned is less a barrier for understanding the main landscape units, as would be the case if knowledge about other land-attributes such as vegetation or soil were insufficient.

In the following sections, attention will be paid above all (but still concisely) to the ecology of the Javan rhinoceros (10.2). As stated before (see chapter 1) Ujung Kulon's fame and importance as a conservation area are largely due to this species. Moreover, it is an attendant objective of this study to pay attention to the food availability of this animal in relation to possible vegetation changes and active habitat management. Therefore, after a short enumeration of some general information, we will focus on the feeding ecology of the rhino. In addition, other habitat requirements will be discussed briefly. It is of importance to note that the various habitat requirements (including food availability) apply to areas of varying size and status (viz. stands of one specific vegetation type, larger and more complex landscape units or even still broader geographical regions). Still, we shall try to give an evaluation of the various parts of Ujung Kulon (mainly on the level landscape units) in terms of suitability as rhino-habitat as a result of the integration of all habitat requirements. This evaluation will be presented in the next chapter (11).

After discussing the Javan rhinoceros, attention will be paid to some of the most important other animal species of the area (10.3). Some important literature references will be given and a few details believed to be relevant for the management of Ujung Kulon will be forwarded. However, not the slightest degree of completeness will be pursued. Moreover, no attempt to evaluate the various parts of Ujung Kulon in terms of suitability as habitat for any other species than rhino could be undertaken within the frame-work of this study. We hope that this booklet may stimulate others to start such an evaluation using the landscape data presented in this study.

10.2 The Javan rhinoceros

10.2.1 General information

Of the five species of rhinoceros which have survived until the present day, three are living in Asia: the Indian, Sumatran and Javan rhino. Of these the Javan rhino (Rhinoceros sondaicus Desm. or badak in the local language) is at present by far the most rare. The 70 specimens living in Ujung Kulon probably represent the entire world population of the species.

However, its distribution area was formerly much larger and included

Java, Sumatra, the Malay peninsula and adjacent parts of Continental SE Asia. By the end of the last century, the species was still present in most parts of its original area. As early as 1934, the last remaining specimen known to live outside of Ujung Kulon was killed near Tasikmalaya in West Java (Hoogerwerf, 1970).

The reasons for this dramatic decrease are the rapidly increasing population pressure, big game hunting and poaching. Although the rhinos have been fully protected by law in Ujung Kulon since 1921, even there poaching has remained a threat to the last remaining specimens of the species even up to the present day. Poachers persecute the animal for its horn, skin and blood which are still sold in China as medicine, especially as a charm of supposedly aphrodisiac action (Schenkel and Schenkel-Hulliger, 1969). Although poaching is more or less under control at present, several times in the recent past it brought the species to the very edge of extinction. For instance when the Schenkels started their research programme in 1967, they estimated the total number of surviving rhinos at only 21-28. The number has increased ever since to an estimated total of 47-57 (mean 52) in 1980 (Ammann, 1985) and 50-54 (again mean 52) in 1984 (Sajudin et al., 1984). However, according to Ammann, these estimates, based on the census-method as developed by the Schenkels, are somewhat too low. Ammann estimates the actual population size at the 70 individuals mentioned above.

Moreover, every now and then reports appear of observations of Rhinceros sondaicus in other parts of its former distribution area e.g., in Thailand, Vietnam and Malaya. Until now these reports have not been confirmed by scientific research and even if some of these reports eventually prove to be right, it is highly unlikely that they refer to more than some scattered and isolated specimens (Hoogerwerf, 1970).

The Ujung Kulon population of the Javan rhino has been studied thoroughly over the last decades. The most important students were Hoogerwerf (1970), Schenkel et al., (1969, 1978), the WWF rhino research team (e.g. Djaja et al., 1982; Lusli, 1982; Sajudin et al., 1984) and Ammann (1985). Even, much is still unknown as far as the ecology of this species is concerned. This is due to the very shy character of the animal and the inaccessibility of many parts of the area. Most of our current knowledge on the Ujung Kulon rhinos is based on indirect observations, such as feeding marks, footprints and excrements.

For a more thorough description of the life-history of the Javan rhino, we can refer to the literature references given above. Here, only a few main points need to be mentioned before we can discuss the animal's habitat requirements, as will be done in the next sections. The following information is derived from Amman (1985).

The Javan rhino is a solitary animal. All adult specimens, both male and female, have their own home-range, i.e. a specific part of the area to which they confine most (but not all) of their activities. These home-ranges are generally overlapping and of varying size, the ones occupied by the males are on the average larger than those occupied by the females. Possibly, the home-ranges of some males have the status of territories in which they have the (almost) exclusive right of mating.

Within their home-range, the animals are in general more or less constantly on the move. Their habits are those of true wanderers. However, they do not distribute their activities equally over the total area of their home-range. They appear to spend most of their time in areas with a high abundance of food. While roaming around, the rhinos frequently stick to fixed trails, but Ammann remarks that the rhino's tendency to follow trails is overestimated by other authors. The length of the path covered by solitary rhinos per 24 hours was determined by Ammann to be some 1.4 to 3.8 km. Females accompanied by a calf cover, on the average, a slightly lesser distance in 24 hours. However, the animals are apparently capable of covering far longer distances if necessary. Ammann mentions one case in which a mother with calf covered no less than 6 to 8 km in 12 to 24 hours. Hoogerwerf (1970) is even convinced that rhinos quite frequently travel 15 to 20 km on one single day.

The home-range concept allows the incidental movement of animals outside their home-range. We do not know if the rhinos do so frequently. However, from various literature-sources one gets the impression that the animals are not very strongly bound to their home-range. All animals are, for instance, assumed to visit the coast occasionally, while there is no evidence that the home- ranges of all rhinos actually border the coastline. Moreover, most authors indicate regular changes in the distribution of rhinos over the area.

10.2.2 Broad description of food preference and feeding behaviour

The Javan rhino is a browser. It mainly feeds on foliage, small branches and (more rarely) the bark of shrubs and treelets. The green parts of tall gingers and climbers also provide an important source of food.

Fruits are generally of little importance, possibly since most of them are beyond the animal's reach. Still, if available, the animals may show a great liking for this type of food as we once observed when coming across an adult bull, which forgot its usual shyness while devouring a large fallen wild nangka (teureup; Artocarpus elasticus). However, smaller types of fruit may be completely ignored (Ammann, 1985).

Low herbaceous plants (and seedlings?) are probably of very little significance as food plants. Junghuhn's statement (1854) that the animal mainly feeds on grasses is definitely wrong, at least as far as the Ujung Kulon population is concerned. Not one record of grazing rhinos is available for our study area. Moreover, Schenkel and Schenkel-Hulliger (1969) point out that the lips and teeth of the animals are specialized for browsing.

Thus, browsing on shrubs and treelets is the main form of feeding. While, doing so, the animal may reach up to some 2.5 m (Hoogerwerf, 1970). Even so, the rhino has to bring much of his food within its reach by tearing off branches and breaking or up-rooting stems. According to Schenkel and Schenkel-Hulliger (1969), this is done mainly by crashing the stem between the jaws; according to Hoogerwerf (1970) by pushing with the head and neck. More rarely, the animal simply squashes a treelet under its feet, or more precisely under its belly.

As for the size of the treelets on which the rhinos can feed, opinions also differ. Djaja et al. (1982) state that almost 90 per cent of all recorded feeding marks concerned plants with a stem-diameter of 2 to 10 cm (including tall gingers etc.). A maximum size, however, is not given. Schenkel and Schenkel-Hulliger (1969), however, give a maximum diameter, 12 cm, which corresponds fairly well with the figure given by Ammann (1985), viz. 15 cm. However, Hoogerwerf (1970) considers 10 to 15 cm as the usual range but gives a maximum of no less than 23 cm. In this respect it is interesting to note that the same author mentions feeding on a clump of Ardisia humilis stems of 12 to 15 cm in diameter. The wood of this species is notoriously hard and strong. Very soft-stemmed pseudo-trees such as pandan and banana are, of course, kept out of the comparison presented above.

As already mentioned, one of the most striking features of the rhino's feeding behaviour is the habit of strolling through the forest, not rarely along fixed tracks, consuming only small bits left and right of each food-source. This is true even when it takes a considerable effort to bring the foliage within reach, e.g. by molesting a complete tree. Moreover, having finished with a foodplant, the animals tend to ignore all nearby plants of the same species.

Ammann (1985) points out that this seemingly very inefficient way of feeding in fact not only guarantees an optimal balance of nutrients, but also helps to avoide a damaging amount of toxins.

Furthermore, several authors indicate that the rhino greatly profits from its savage manners. Although in general the quantity of food actually eaten is out of all proportion to the damage done, most trees manage to survive after being broken or up-rooted. They sprout again, generally with more than one fresh new shoot, easily within reach of the rhino, which may pass along the same track again before long.

10.2.3 Important species of food plants

Now, we come to the question of whether the animals have a preference for certain plant species and, if so, which? Most authors dealing with the Javan rhino have touched upon this subject and produced a list of food plants with some indication of the frequency with which each species was observed to be browsed on. It is interesting to note, that some of these lists do not generally overlap. For instance, Hoogerwerf (1970) considers Glochidion zeylanicum as the most important food plant, while neither Schenkel and Schenkel-Hulliger (1969) nor Ammann (1985) list the species at all.

This curious phenomenon can simply be explained from the data supplied by our study. All authors more or less focussed on a specific part of Ujung Kulon. During his numerous visits to Ujung Kulon, Hoogerwerf spent most of his time in the coastal plains east of Nyewaän. The Schenkels focussed on the western hills and the coastal regions west of Nyewaän. Both Ammann and Djaja and his colleagues had their main study area in the Cibunar-Citadahan region. All these regions are quite different as far as their vegetation and flora are concerned, which results in differences in the availability of food plants. Moreover, differences in research methods may also be of importance. Ammann's list contains a relatively high percentage of climbing species, which can at least partly be explained by the fact that he was the only one who gathered most of his data by tracking the rhinos. Feeding marks on climbers do not remain visible for long and are thus easily neglected when roaming through the forest at random (Ammann, 1985).

Thus, we face the problem that each list only has a regional significance. But this is not the only problem. A mere list of species with an indication of the frequency with which it was recorded as a food plant does not tell us how much was eaten or how much was available, i.e. whether the species is a substantial ingredient of the rhino's menu or a preferred food plant.

Ammann (1985) solved the two latter problems for his study area using a very elegant method. By giving a numerical value to each feeding event in proportion to the quantity consumed by the rhino, and by summing up these values for each species, an 'index of the quantity consumed' (QI) was computed, which can be subsequently expressed as a percentage of the total sum for all species.

Thus, from 190 species of food plants only four species together provide almost 45 per cent of the total quantity eaten. The same four species were also the most frequently eaten, though in a different sequence (see Table 10a). To illustrate the significance of these four principal food species (as Ammann calls them) one may point to the relatively low quantity index of the fifth species in line (the climber Poikilospermum suaveolens), viz. only 2.8 per cent.

Next, in order to determine the rhino's preference for specific food plants Ammann estimated (by means of an analysis of sample plots) the total quantity of all potential food plants and compared these results with the figures for the quantitites of each species which were actually eaten. The resulting relative preferebality index (RPI; after Petrides, 1975) thus represents the ratio of the proportion of a food species in the diet to its relative availability.

Table 10a The four principal species of food plants of the Javan rhinoceros

Species:	QI	%Q	F	%F
Spondias pinnata	519	19.0	72	5.9
Amomum spec.	257	9.4	337	27.6
Leea sambucina	242	8.8	86	7.0
Dillenia excelsa	189	6.9	55	4.5

QI = index of the quantity consumed (see text)
%Q = percentage of the total quantity consumed
F = recorded number of feeding events
%F = percentage of the total number of feeding events.

(after: Ammann, 1985)

The results as far as the species with a RPI larger than 1 (the preferred food species) are concerned, are given in Table 10b. There is very little correlation between RPI and QI, i.e. most preferred food species are actually, in a quantitative sense, of little significance as a source of rhino food. On average, a preferred food species, contributes only 1 to 3 per cent or less to the rhino's menu. This can be explained the fact that the preferred food species are, in contrast to the principal food species, not available in great quantities, at least not in Ammann's study area. On the other hand, the rhino does not show much preference for his principal food species. For three of them, it has even a (very) slightly negative preference; in our opinion this can be explained by the fact that these species (Amomum, Leea and Dillenia) generally grow more or less gregariously. As mentioned in the previous section, the rhino tends to neglect more specimens of the same species while feeding.

The great exception to both rules (i.e. insignificance of preferred species

Table 10b Relative preferability indices of foodplants of the Javan rhinoceros

Only preferred species (RPI more than 1) are listed:

Species:	RPI
Kleinhovia hospita	270.84
Ficus variegata	223.74
Sumbaviopsis albicans	23.02
Planchonia valida	21.59
Poikilospermum suaveolens	21.59
Dracontomelon puberulum	20.88
Spondias pinnata	15.20
Derris elliptica	3.67
Uncaria spec.	3.35
Merremia vitifolia	2.67
Embelia ribes	2.24
Merremia umbellata	1.82
Saccopetalum horsfieldii	1.52

(after: Ammann, 1985).

and lack of preference for principal food species) is Spondias pinnata, which belongs to both categories. Typically, it does not grow gregariously but can commonly be found scattered throughout Ujung Kulon's lowlands. As mentioned in the previous chapter, it was often observed to sprout from banteng dung. Thus, banteng obviously have (in this respect) a positive impact on the availability of rhino food plants. Until now, this aspect has not been mentioned in discussions on the food-competition between the two species (see 10.3).

Although Ammann's research was primarily aimed at a study area of only moderate size, his results may to a certain extent be extrapolated for the whole of Ujung Kulon.

A first and major conclusion may be that food preference (on the floristic level) as such is of little significance. The rhino feeds on an extremely wide variety of species, given they are available in the right sizes. Ammann even states that 'given a sufficiently long observation time, the diet of the Javan rhino would probably be seen to include nearly all plant species of suitable size'. However, only those species which are available in great quantities (in some region or throughout the area) may be of importance as substantial ingredients of the rhino's menu. Only for these species is it interesting to know the animal's degree of preference.

From our own results, an outline of such common and abundant species may be compiled. Moreover, Djaja et al. (1982) provided a list of species, arranged in order of their 'importance value' (see: Mueller-Dombois and Ellenberg, 1974) based on the analysis of three north-south transects through the central part of Ujung Kulon. For most of the interesting, i.e. common and abundant species we can gather the rhino's preference from the results of Ammann. This is true even for species which are quite rare and thus of little importance within his study-area. For species which are absent in his study-area (or extremely rare and thus of little statistical value) we have to turn to the lists of food plants (with indications of browsing frequency) of the other authors mentioned. Together, we may assume these lists to be more or less area-covering. In doing so, we are confronted with a number of practical problems such as differences in the delimitation of taxa, (possible) mis-identifications of species, contradictory records of the rhino's preference and the risk that some data have become outdated because of recent changes in the vegetation of some areas.

As an example of such practical problems we may point to the case of the treelet Drypetes ovalis. The correct name of this species has been uncertain for a long time. Hommel (1983) wrongly used the name Drypetes longifolia. Moreover, it is as good as certain that the species at issue is also called Drypetes longifolia by Ammann (1985) and Diospyros pendula by Djaja et al. (1982). With the latter species, Drypetes ovalis indeed shows a large resemblance as far as the foliage is concerned. This Drypetes ovalis is rather common in many parts of Ujung Kulon but especially so in the Bambusa forests of the uplands. There it grows not only very abundantly but also in sizes prefered by the rhinos. We now face the problem that, according to Ammann, the rhinos show no interest at all either in this species as a food plant, or in Bambusa vegetations as a feeding habitat. However, the same author indicates the major distribution area of the Bambusa vegetations as an area with a relatively high density of rhinos. Moreover, the same species was found to be browsed on by rhino six times by Djaja et al., leading to a classification as a slightly important food plant (see Table 10c).

Obviously, in solving such problems many arbitrary decisions had to be taken. This fact, combined with the heterogeneous character of the data, causes our outline of the most important species of rhino food plants to be broad and preliminary. Even so, it seems of value to publish such a tentative list (see Table 10c), since we trust it is of sufficient detail to help judge the value of each landscape unit as a habitat for the Javan rhino (see chapter 11).

Even a quick glance at Table 10c shows that a positive preference for species is only of importance in a few cases. However, negative preference (i.e. dislike) for a given species is of far greater significance and responsible for the absence of many of the most common species on the list. For instance, the rhino hardly feed on palms at all (neither on palm-treelets, shrubs or lianas) or bamboo (Ammann, 1985).

Finally, we can indicate an interesting aspect of the rhino's menu, mentioned e.g. by Hoogerwerf (1970). As a rule, the rhino's food plants are inhabitants of secondary vegetations. This is even more true than Hoogerwerf himself realized. The exceptions to this rule that he mentioned (after personal communication with van Steenis), i.e. Diospyros macrophylla and Lepisanthes spec. (most probably L.montana) are actually in Ujung Kulon also species of secondary vegetations.

This phenomenon may simply be explained by the fact that easily accessible areas and secondary vegetations more or less coincide (see section 10.2.4).

On the other hand, there may be a relation with the availabilty of light which, on average, is rather scarce in the lower layers of primary forests. Ammann observes that even within secondary vegetations, the rhino has a clear preference for species growing in light, open situations. He explains this phenomenon by the higher nutritional value and lower toxicity of rapidly growing plants in an unshaded environment.

Possibly, both explanations are true, which means that the rhino prefers easily accessible terrain with good food (which sounds quite plausible), but

Table 10c List of important food plants of the Javan rhinoceros

Data derived from:	Schenkel & Schenkel-Hull. (1969)	Hoogerwerf (1970)	Djaja et al. (1982)	Ammann (1985)			
Species:	F	F	F	F	Q	P	I
Acanthus ilicifolius	-	+	-	-	-	-	+
Alstonia scholaris	-	+	-	-	-	-	+
Amomum compactum	?	-	++	+++	++	-	+++
Amomum megalocheilos	++	+	+				+++
Annonaceae ('Kilaja')	-	-	+	+	+	+	+
Ardisia humilis	-	+	+	-	-	-	+
Arenga pinnata (seeds)	-	+	-	-	-	-	+
Barringtonia macrocarpa	-	-	+	-	-	-	+
Bombax valetonii	+	-	-	-	-	?++	++
Buchanania arborescens	-	+	-	-	-	-	+
Cordia dichotoma	-	(+)	-	-	-	-	+
Croton argyratus	-	+	-	-	-	-	+
Dendrocnide stimulans	-	+	-	-	-	-	+
Derris elliptica	-	-	+	+	+	+	+
Desmodium umbellatum	++	+++	-	-	-	-	+++
Dillenia excelsa	++	-	++	+	++	-	++
Dillenia obovata	?	(+)	-	-	-	-	+
Diospyros macrophylla	+	-	-	-	-	-	+
Dracontomelon puberulum	-	-	-	-	+	+++	++
Drypetes ovalis	-	-	(+)	-	-	-	+
Embelia ribes	-	-	-	+	-	+	+
Ficus septica	++	++	-	-	-	-	++
Garcinia celebica	+	-	-	-	-	-	+
Garcinia parvifolia	+	-	-	-	-	-	+
Glochidion zeylanicum	-	+++	-	-	-	-	+++
Hibiscus tiliaceus	+	+		+	+	?++	++
Lagerstroemia flos.regina	+	+		+	+		+
Lantana camara	-	+	-	+	-	-	+
Leea *sambucina*	+++	-	++	++	++	-	+++
Lepisanthes montana	+	-	-	-	-	-	+
Mallotus philippensis	+	-	-	-	-	-	+
Merremia peltata	-	-	+	-	-	-	+
Merremia umbellata	-	-	-	-	-	+	+
Merremia vitifolia	-	-	-	+	+	+	+
Messerschmidia arentea	+	+	-	-	-	-	+
Mikania cordata	-	-	+	+	+	-	+
Musa acuminata	-	-	-	-	+	?++	++
Myristica iners	-	-	+	-	-	-	+
Nauclea coadunata	-	+	-	-	-	-	+
Pandanus tectorius	-	(+)	-	-	-	-	+
Pemphis acidula	-	+	-	-	-	-	+
Planchonia valida	-	-	-	-	+	+++	++
Poikilospermum suaveolens	-	-	+	+	+	+++	++
Pterospermum javanicum	+	-	-	-	-	-	+
Spondias pinnata	+++	-	(+)	++	+++	+++	+++
Streblus spec.	(++)	-	(+)	-	-	-	++
Sambaviopsis albicans	-	-	-	-	+	+++	++
Syzygium polyanthum	++	-	+	+	-	-	++
Syzygium spec.	+	+	-	-	-	-	+
Uncaria spec.	-	(+)	+	+	+	+	++
Vitex paniculata	-	+	-	-	-	-	+
Vitex pubescens	+	-	-	-	-	-	+
Zanthoxylum rhetsa	++	-	-	-	-	-	++

F = frequency, i.e. percentage of total number of registered feeding events
+ = 1-5% (Schenkel: occasionally)
++ = >5-10% (Schenkel: more often)
+++ = >10% (Schenkel: very often)

Q = quantity, i.e. percentage of total quantity consumed +, ++ and +++: percentages as indicated for frequency

P = preference, based on RPI (see text)
+ = RPI: 1-5
++ = RPI: >5-10
+++ = RPI: >10

I = estimated importance
+ = slightly important foodplant
++ = important foodplant
+++ = very important foodplant

Note: species which are rare throughout the area were neglected; symbols in brackets indicate uncertainly because of presumed misidentification of species by the authors cited (see text).

will turn to less ideal areas if necessary. In fact according to Hoogerwerf (1970) this is exactly what happened during the last centuries on the mainland of Java: the ever-increasing human population density gradually drove the rhinos from the plains towards the highest mountain regions.

10.2.4 Other habitat requirements

Next to the availability of food plants a number of other habitat requirements of the Javan rhino may be of importance:

Accessibility

A first requisite of an area to be suitable as a rhino habitat is its accessibility. It may be expected that a heavy and unwieldy animal like the Javan rhino is unable to cross steeply dissected or very swampy terrain. Moreover, very compact vegetation may provide an obstacle. However, the animals prove to be far less clumsy than one would expect:

According to Hoogerwerf (1970; citing Junghuhn, 1850-1854), the Javan rhino once occurred on even the highest and steepest peaks and ridges of some of the volcanoes of the western and central parts of the island. In 1978 to 1980 almost the whole Payung mountain region formed part of the home-range of one rhino (Ammann, 1985). As for the accessibility of swampy sites, Hoogerwerf (1970) mentions a rhino track in very soft mud. The footprints were some 40 to 60 cm deep. Finally, as for the density of the vegetation, anyone who has come across a rhino in the Ujung Kulon jungle can witness the horrifying ease with which the animals can break through even the most dense and thorny bushes, when fleeing or charging.

However, this does not imply that the rhinos are completely indifferent as far as terrain conditions are concerned. The Payung-rhino the home-range of which was studied by Ammann (see above), clearly avoided the very steepest southern part of the mountains. Moreover, the density of rhinos in the Payung area has, as far as is known, always been relatively low, while the Ujung Kulon rhinos are not known ever to have shown any interest in the higher parts of the adjacent Mt. Honje (Hoogerwerf, 1970). As far as terrain difficulties on level ground are concerned, Ammann (1985) made an interesting observation: he describes how a rhino while roaming through the fluvio-alluvial plain, obviously avoided very swampy and densely overgrown terrain. The animal changed direction before the difficulties became visible, which also proves the good memory of the rhinos for the terrain features of their home-range.

Water

Rhinos need water to drink and to bathe. The first need is self-evident, the second requires some comment. Like wallowing (see below), bathing is a well known phenomenon among pachyderms (Zonneveld, pers. comm.). The use of bathing is manyfold: it satisfies the animals need for rest, it serves to keep the skin moist, it gives protection against skin parasites (thanks to the cleaning activities of fishes and crustaceans) and it may regulate body temperature (Ammann, 1985).

At least the first three functions may also be fulfilled by wallowing. Bathing and wallowing are thus to some extent interchangeable activities. In addition, the rhinos can rest while laying down on solid ground but also when standing. Ammann (1985) studied the frequency of both bathing and wallowing. He concluded that rhinos can go without bathing facilities for periods up to four days, if there is enough opportunity to wallow (which is generally the case). If wallowing and bathing are considered together, an average of 1.8 times per 24 hours was found.

As for the bathing location, we can also lean on the work of Ammann. He states that rhinos bathe both in streams and pools. The lower courses of most major streams are deep enough for the rhinos throughout the year. During the dry season, these lower courses normally turn brackish, but this does not seem to bother the rhinos. Further upstream, pools deep enough for the rhinos are frequently found. However, we may assume that many (but not all) of these pools become too shallow for the rhinos to bathe in during the dry season. In this respect, Schenkel and Schenkel-Hulliger (1969) made an interesting observation: in the (very) dry season of 1967 they found concentrations of rhino-tracks near the lower river courses with brackish water, but not near the remaining basins and rivulets with fresh water (in the interior). We may interpret this observation as follows: during the dry season, bathing localities may become scarce (and the remaining ones therefore more intensively visited), while drinking-water remains available in sufficient quantities throughout the area.

Mud-wallows

Wallowing is one of the rhino's most important and best studied activities. Hoogerwerf (1970) published an impressive series of photographs of wallowing rhinos (dating from 1940-1941). The most elaborate quantitative data are provided by Ammann (1985).

According to this last author, any depression on level terrain or gentle slopes where a rhino can roll itself in loamy or muddy soil may serve as a wallow. Thus, wallows can be found in most parts of Ujung Kulon, not only in the plains but also in the elevated central part. According to Ammann (1985) the rhinos do not show much preference for specific vegetation types as an environment for wallowing. Only a certain preference for Arenga forest and an obvious dislike of Bambusa forest was found. The latter conclusion is rather surprising, since Bambusa forest grows on poorly drained clay soils in a gently rolling or hilly landscape which seems to provide plenty of opportunities for wallowing. Specific structural properties of the (very compact) soil may provide an explanation. On the other hand (and this seems a more likely explanation), Bambusa forests were included only very marginally in Ammann's study area and the lack of wallows there may be mere chance.

Repeated wallowing on the same location may create mudholes in which rain- water gathers. In this way more or less permanent wallows originate. However, both a pronounced dry season and temporary lack of rhino activity may cause dessication of a wallow. It becomes filled with dead plant material and less atractive for rhinos.

Wallowing has many functions in common with bathing, i.e. resting, protection against skin parasites, moistening of the skin and possibly also regulation of the body temperature (see above). In addition, urination in the wallow is assumed to give a specific scent to the skin and thereby to the rhino's trail (Schenkel and Schenkel-Hulliger, 1969).

As stated above, wallowing and bathing are to a certain extent interchangeable activities. However, wallowing seems to be a more vital activity. The rhinos can go up to 4 days without bathing in open water, but can go without wallowing for only 1 to 1½ day (Ammann, 1985). On the other hand, wallowing facilities are much wider spread even in the dry season, although permanent wallows are found especially in shaded locations where evaporation is less important (Ammann, 1985). Still, even wallows in shaded localities may also dessicate occasionally. In such cases, the rhino turns to riversides or the coastal tidal forests for wallowing (Hoogerwerf, 1970).

Salt

Herbivores are confronted with the problem of how to satisfy their mineral requirements, especially their need for sodium, a rare element in most plants (Ammann, 1985). All other rhino species solve this problem by visiting salt licks, but no licks have been found in Ujung Kulon. It is assumed that the Javan rhino there satisfies its need for salt when visiting the shore and brackish rivers (Schenkel and Schenkel-Hulliger, 1969).

In addition, Ammann (1985) points to the fact that food plants growing in coastal regions may also provide an important source of salt. Leaves of coastal specimens of the very important food plant Spondias pinnata for instance, proved to contain 6 to 7 times as much sodium as leaves of Spondias specimens growing in the interior. Moreover, the crystalline salt covering the leaves of food plants growing in the direct vicinity of the coastline (e.g. Pandanus tectorius) may also be of importance.

Cover

The significance of cover for the rhinos may be twofold. It may protect the animals against adverse climatic conditions and may help them in finding a hiding place. Both functions are closely related with vegetation structure, though not in an identical way.

In Ujung Kulon, relatively small differences in altitude are assumed to cause considerable differences in climate. Moreover, differences between open and closed canopies cause significant variations in the microclimate of the forest floor (see also chapter 5). However, we may assume that Ujung Kulon as a whole has a far from extreme climate in comparison to the variety of climatic conditions within the former distribution area of the species (as described by Hoogerwerf, 1970). Therefore, we may also assume that differences in protection against adverse climatic conditions, as provided by the various vegetation types and climatic zones, are, within Ujung Kulon, of very little importance for the rhinos. In this respect, it is interesting to note that Ammann (1985) found no proof that the animals prefer shaded (thus cooler) locations for wallowing, while wallowing (like bathing) is assumed to have a function in regulating the animals' body temperature. Thus, this function if existing at all, is not very important. On the other hand, most authors stress the shy character of the animal and its intolerance to man. Hoogerwerf (1970) states that the rhinos generally retire to the most dense and inaccessible parts during daytime. The same author also remarks that wallowing normally takes place in well-hidden, concealed locations. The latter statement is contradicted by the results of Ammann's study (1985), who could not prove any preference for concealed wallowing sites. Also, Hoogerwerf's first statement cannot be true for all parts of Ujung Kulon, since in some areas rhinos are present, but inaccessible vegetations not (e.g. the western hills). Thus, we can conclude that the rhinos may show a tendency to hide in dense vegetation, but the presence of such vegetations is by no means essential for their occurrence.

Absence of pathogenic germs

The importance of this factor was dramatically shown by the sudden death of at least five rhinos during the rainy season of 1981 to 1982 (PPA, 1982). Although it was suspected that the cause of death was anthrax, this could not be proved. Moreover, there is also strong evidence against anthrax being the cause of death, viz. the apparent species-specific character of the disease.

Schenkel and Schenkel-Hulliger (1982) indicated that pathogenic germs (e.g. of anthrax) may be present, hidden below the soil surface and survive there for decades. However, heavy rains can stir up muddy soil and permit the germs to reach the water surface.

This would imply that areas which tend to become muddy during the wet season, i.e. large parts of the fluvio-alluvial and coastal plains and to a lesser degree also the uplands, are areas with a relatively high risk of becoming the source of diseases.

This is a very disquieting thought, since large parts of these areas can be considered as very important rhino habitats (see chapter 11). However, the risk is far from certain since (as stated above) neither the character of the rhino disease, the way it has spread throughout the area, nor the chance it will happen again, is known.

10.3 Some other importants species

The major source of information on the faunistic significance of Ujung Kulon is the monumental work of Hoogerwerf (1970). It includes detailed descriptions of e.g. the ecology and conservation of all important species and checklists for several taxonomic groups. Such lists are also provided by Satmoko (1961). Moreover, several monographs on mammal species in Ujung Kulon have recently been published (see below). Unfortunately, we have little information on the exact numbers of all species other than the Javan rhino. Still, as for their relative density, the list of Sajudin et al. (1984) is of great interest. Here, only a few species belonging to three groups of mammals, viz. primates, carnivores and even-toed hoofed mammals, will be discussed. Both from a conservation point of view and as far as the impact of the fauna on the vegetation is concerned, these groups include some very important species. Moreover, the last group included all major herbivores of the area (other than the Javan rhino) and thus the most important potential food competitors of the badak.

Primates

In Ujung Kulon one may find, in addition to some Homo sapiens, four species of primates, including three species of monkey and one ape. Most common are two monkey species: the Javan or long-tailed macaque (Macaca mulatta fascicularis (Raffles); monyet or kra) and the black langoor (Trachypithecus cristatus sondaicus (Robinson & Kloss); lutong). The first species can be found throughout the area, both in the canopy and on the ground. However, it seems to prefer open country, especially coastal regions and riversides (Hoogerwerf, 1970). On Peucang Island, the monyet is extremely common and may occassionally terrorize the camp with guardpost and tourist facilities. But, the lutong is absent on Peucang Island. According to Hoogerwerf (1970), the species also prefers coastal regions and riversides, but this is not in agreement with our experience. We observed lutung most frequently in the Arenga obtusifolia-dominated forests of the interior and especially at the beginning of the wet season in the freshly sprouting Bambusa forests. The lutong monkeys obviously do not like very open vegetations and were never seen on the ground.

The grey langoor or silvered leaf monkey (Presbytis angula angula (Linnaeus); surili) is undoubtedly much rarer. This species is also absent on Peucang Island. According to Hoogerwerf (1970), the grey langoors stick to trees to an even greater extent than their black relatives do. Due to lack of data, their habitat preference in Ujung Kulon is not well understood. Hoogerwerf observed the species seven times, mainly in closed forest. Our own observations (only three) seem to indicte a preference for tall open forest, especially on the transition of closed forest towards shrub jungles.

The fourth species of primate, the grey or Javan gibbon (Hylobates lar moloch (Sody); wau-wau or oa) is the rarest one. In Ujung Kulon, it is confined to the most eastern parts, bordering the Mt. Honje area and a small coastal area between the mouth of the Cibandawoh river and Cape Tereleng. Ecology and behaviour of the Ujung Kulon gibbons were studied in detail by Kappeler (1981).

Within their distribution area, the gibbons are apparently bound to closed forests including both Arenga obtusifolia-dominated forests of the lowlands (wrongly considered as primary rain forest by Kappeler), and rain forests on higher altitudes. It is interesting to note that the area inhabited by the isolated population near Cibandawoh, corresponds with an exceptionally divers and well-developed patch of forest (see chapter 9).

The gibbons avoid the ground and even its proximity; thus discontinuities in the forest cover may provide an impregnable obstacle. This explains why the gibbons do not extend their distribution area towards the western part of Ujung Kulon, where excellent gibbon habitat is available, e.g. on the limestone plateaus, but especially on the rain forest covered slopes of Mt. Payung (Kappeler, pers.comm.). Even so, it does not explain why the gibbons are absent in those parts at present. If Kappeler is right in considering the Cibandawoh population as an isolated one, this proves that a gibbon population can survive, at least for some decades, in a very small area. Hoogerwerf (1970) observed gibbons on exactly the same location in 1943, in 1952 and again in 1956. However, the gibbon-area near Cibandawoh, as indicated by Kappeler, measures only some 150 to 200 ha, while in the Payung area over 5,000 ha uninterrupted, potential gibbon habitat is present. Possibly, the gibbon population in the western part of Ujung Kulon did not survive the complete defoliation of the forest following the 1883 ash-rains and the area was never re-occupied for reasons explained above. We tend to believe that the Cibandawoh population is not entirely isolated, but is the farrest point in westward direction which gibbons from the Honje area can reach without having to leave the forest canopy.

Carnivores

In Ujung Kulon a wide variety of carnivores can be found (Hoogerwerf, 1970). Here we will discuss only three of the larger species, viz. the wild dog, the Javan tiger and the panther.

The wild dog (Cuon alpinus javanicus (Desmarest); ajag) is one of Java's most ferocious predators. In spite of its relatively small size (the animal more or less resembles the European fox), it is known to be able to bring down large and strong quarries, even buffaloes and tigers. The wild dog's success as a hunter is due to the close cooperation within the groups which hunt down their prey with great persistence and cunning. Wild dogs were once very common in Java. On the south coast of Banten, near the eastern boundary of Ujung Kulon, Junghuhn (1854, 1867) found the beach covered with carcasses of the green turtle (Chelonia mydas Linnaeus) slaughtered by wild dogs, and at night watched a group of at least thirty of these predators attack other turtles (coming ashore to lay their eggs). At present, the wild dogs, according to the local people (Sarpan, pers.comm.), have become rare and large groups have not been seen for many years. This corresponds with our experience and that of other investigators (e.g. Schenkel and Schenkel-Hulliger, 1969). Hoogerwerf stated in 1970 (on a basis of former experiences) that the species was not endangered, but had to admit in 1972 after visiting the area again that he had not been able to find one single track of wild dogs.

The same holds for the Javan tiger (Panthera tigris sondaica (Temminck); harimau or macan loreng). The last probable record of a tiger print in Ujung Kulon dates from 1969 or 1970 (Hoogerwerf, 1972), the last reliable sighting was even longer ago. In spite of Hoogerwerf's scepticism (1970), one now can hardly that deny Schenkel and Schenkel-Hulliger (1969) rightly omitted the Javan tiger from their list of larger mammals in Ujung Kulon. From the data provided by Hoogerwerf (1970) himself, one may even conclude that resident tigers were never very common in Ujung Kulon, since tigers are known to be capable of and need to roam far and quickly. Possibly, the migrating tendency of the Ujung Kulon tigers was further stimulated by the degradation of their favourite feeding habitat, the savanna landscape of the coastal plain. Outside the boundaries of the reserve, the tigers could easily become victims of poisoning of wild boar, their favourite prey. Poisoning of wild boar is believed to be the most important cause of the general decline of the species throughout Java during the first half of this century (Hoogerwerf, 1970). Since also no recent records are available of the Javan tiger in their last refugium on the island (Meru Betiri, East Java), one must fear that this subspecies of Panthera tigris is now completely extinct (Mc.Kinnon, pers.comm.).

As for the third large predator, the panther (Panthera pardus melas (Cuvier); macan tutul), the situation is far less tragic. It is beyond any doubt that the number of this species, in spite of a general decline on the mainland of Java, had only increased on the Ujung Kulon peninsula during the last decades. It is significant that Hoogerwerf (1970) during his many visits to Ujung Kulon between 1932 and 1957 never once saw a panther, while most of the more recent authors dealing with Ujung Kulon consider the species to be not uncommon (e.g. Schenkel and Schenkel-Hulliger, 1969; Sajudin, 1984). During our survey we actually saw a panther five times (including a dead specimen on the Cikuya grazing ground). All these five observations concerned spotted (thus not melanistic) specimens and were made in coastal regions. Moreover, tracks of panther were encountered quite frequently, mainly on the beach. Since such observations correspond well with the experience of both the park staff and other investigators (see above), we consider Hoogerwerf's scepticism about the increase in the number of panthers in Ujung Kulon to be completely unjustified.

The increase in the panther population is probably correlated with the decrease in the number of tigers. Apparently, the two species do not go together very well and Hoogerwerf (1970) quotes Prater (1965) stating that the panther's chief enemy is the tiger.

The principal prey of the panther consists of monkeys, deer and smaller animals (Hoogerwerf, 1970). Wild boar is not of great importance as a prey, which is one of the reasons why the panther is not heading towards extinction on Java as quickly as the tiger did. Still, in Ujung Kulon wild boar is at least occasionaly eaten by panthers. We once found a wild boar which had obviously been attacked and almost killed by a panther only a few minutes previously. Probably, banteng calves are sometimes killed and eaten as well. We once observed a panther stalking a small group of banteng with some calves. However, the panther was distracted by the human scent and no attack followed. As for rhino calves, the panther is not considered as a danger by Hoogerwerf (1970). Since the tiger became extinct, there remains apart from micro- organisms, only one enemy for the Javan rhinoceros: man.

Even-toed hoofed mammals

This group includes all species of large herbivores of the area, apart from the Javan rhinoceros. They are therefore of special importance as potential food competitors of the rhino. The group is represented in Ujung Kulon by wild boar and some ruminants viz. three species of deer and one wild ox, the banteng.

The wild boar (Sus scrofa milleri Jentink; babi hutan) is considered by Schenkel and Schenkel-Hulliger (1969) as the most successful large animal of Ujung Kulon. It is very common throughout the area, but probably most numerous in coastal regions. On Peucang Island, large numbers of wild pigs are also present. The diet of this animal consists mainly of fruits, but also of small animals and carrion (Pauwels in prep.; cited from Ammann, 1985). Ammann, however, points out that wild boar may compete with the rhinos for the same plants, since female pigs construct large nests of plant material in which to have their young. For the construction of these nests, they preferably use small saplings. Ammann (1985) considers the impact of such activities as insignificant as far as the food availability of the Javan rhino is concerned. However, it may be of significance for the regeneration of the forest in an area like Peucang Island, where both wild boar and occur in very high densities.

The largest deer species of Ujung Kulon is the Javan deer (Rusa timorensis russa (Müller & Schlegel); rusa). According to Hoogerwerf (1970), the Javan deer prefers open country with grasses and sedges, but may feed on the leaves of trees and shrubs as well. The same author considers the Javan deer as less strictly bound to pastures than the banteng, but (as will be discussed below) he vastly overestimated the banteng's dependence on such areas. It is not improbable that the reverse is true, Javan deer being most dependent on the availability of pastures. As Hoogerwerf (1970) points out, the Javan deer population has fluctuated rather strongly during the last half century. There was an increase during the post-war years, followed by an obvious decrease, that could not be fully explained. At present, the species can undoubtedly be considered as rare on the mainland. Probably, it is restricted to the coastal plain of the northern and eastern parts (Ammann, 1985). According to Hoogerwerf (1970), feeding of rusa and banteng together was quite common, but this does not correspond well with our experience. At present, in the area where both species occur together, the banteng seem to prefer the dry, Chrysopogon-dominated grazing ground of Cigenter, while Javan deer were more often observed on the various seasonally dessicating bottomlands with Phyla vegetation.

On both Peucang Island and Handeuleum Island, one finds an entirely different situation. There, Javan deer occur in very high densities. On Peucang Island their number was estimated at 30 to 50 during the twenties of this century (Pieters, 1954; cited from Hoogerwerf, 1970). More recently, higher estimates have been published, viz. 50 to 60 by Satmoko (1961) and even 125 by Verschuren (1967). On Handeuleum Island, the species has arrived only recently (by swimming); estimated numbers are not known.

The success of the Javan deer on the islands is striking, especially since the species has to compete with wild boar, barking deer and (at least formerly) mouse deer. All these species profit from the current absence of predators and poachers. As mentioned above, the Javan tiger, in fact the only good swimmer of the area's larger carnivores, has been extinct in Ujung Kulon for some fifteen years. The occurrence of tigers on Peucang Island in bygone times is mentioned by Kal (1910, cited from Hoogerwerf, 1970).

Among its competitors, the Javan deer may be at an advantage because of its extreme ability to withstand drought and its more or less flexible feeding behaviour. Next to feeding on the islands' grazing grounds and in the forest of the interior, the animals can frequently be observerd browsing on beach vegetation. They seem to have a special liking for the leaves of the Scaevola taccada shrubs and fallen leaves of the deciduous tree, Terminalia catappa (pers. obs.). As already mentioned, the impact of the high densities of browsers (and wild pigs) on the regeneration of the Peucang forests is probably very considerable. We shall return to this subject in chapter 12.

As for a possible competition for food with the rhinoceros population of the mainland of Ujung Kulon, Ammann (1985) considers the impact of the Javan deer on the availability of rhino food plants negligible. In most parts of the rhino's distribution area, the Javan deer is absent and where the two species occur together the deer population is still rather insignificant. Moreover, the two species have a very different food and habitat preference.

The second deer species of Ujung Kulon is the barking deer (Muntiacus muntjak muntjak (Zimmermann); kijang, muncak). Unlike the Javan deer, it is not attracted by extensive open plains; neither does it feed on grasses or grasslike plants very often (Hoogerwerf, 1970). Barking deer generally prefer secondary forests and shrub jungles, but there is some disagreement in the literature in relation to its habitat preference in Ujung Kulon. According to our experience, Schenkel and Schenkel-Hulliger (1969) rightly consider the tall forests of the interior as the animals' chief habitat. Barking deer is a browser, feeding mainly on tree foliage. In addition, they are known to be fond of jungle fruits. The species is quite common, both on the mainland of Ujung Kulon and on Peucang Island. There are no indications of any increase or decline in the population size over the last decades (Hoogerwerf, 1970).

From the information presented above, one might assume that the barking deer is a serious food competitor for the Javan rhino. However, according to Ammann (1985), this is not the case, mainly because of the low population density of this widely distributed, but solitarily living species and because of its relatively small biomass. On the other hand, the barking deer are even known to have some profit from the rhino's feeding behaviour. Because rhinos often bring down shrubs and saplings while feeding, barking deer may often be found in their tracks (Hoogerwerf, 1970).

The third and smallest species of deer is the mouse deer (Tragulus javanicus (Osbeck); kancil). In fact, this is not a real deer species. Mouse deer belong to the small group of Tragulina which are more or less an intermediate between pigs, camels and deer (Storer and Usinger, 1965). Just like barking deer, mouse deer generally prefer forests and shrublands above open grasslands. According to our experience, the animal seems to be most common in areas with a dense undergrowth and more specifically in Salacca-dominated vegetations and along the inner margin of the mangroves. In spite of Hoogerwerf's (1970) scepticism on this point, this again corresponds well with the data provided by Schenkel and Schenkel-Hulliger (1969).

There are no indications of a recent increase or decline in the mouse deer population on the mainland. On the other hand, it is doubtful whether the species is still present on Peucang Island, where it was probably once quite common (Hoogerwerf, 1972). In fact, Peucang is a local word for mouse deer. Possibly the decline of the mouse deer population on this island reflects the growing scarcity of undergrowth, i.e. tree seedlings, there.

As a possible foodcompetitor for the Javan rhino, the mouse deer is probably of even less significance than the barking deer, because of its far lower biomass and comparibly low population density. Moreover, mouse deer eat, proportionally, even more fruit (Hoogerwerf, 1970; Ammann, 1985).

The last ruminant species to be discussed is the wild ox or banteng (Bos javanicus javanicus (d'Alton)), next to the Javan rhino the largest herbivore of Ujung Kulon. Ecology and behaviour of this species have been studied in detail recently by Halder (1975). Moreover, much information is provided by Hoogerwerf (1970 and many earlier reports).

The species is missing on Peucang Island but very common on the mainland of Ujung Kulon. The population size was estimated at some 200 individuals in 1971, but there are indications that their number has strongly increased eversince (Ammann, 1985). This phenomenon might be explained by the extinction of the Javan tiger (see above), but this is far from certain.

One of the most important results of the study done by Halder (1975) is the conclusion that the banteng is far less dependent on grasslands than presumed by Hoogerwerf. In fact, many bantengs probably never set foot on one of the grazing grounds at all (Halder, 1975). The recent increase in the population is further proof of this independence of grazing areas. It is in great contrast with Hoogerwerf's pessimistic view that neglect of the extensive grazing areas in the northern and eastern coastal plain formed a serious threat to the viability of the entire population.

Even so, there is much left to be studied as far as the distribution and habitat requirements of the Ujung Kulon bantengs are concerned, since Halder focussed strongly on the few remaining coastal grazing grounds. As for the 'forest-bantengs' it is generally assumed that dense shrub jungles are important feeding areas, but that the animal is attracted to other vegetations as well. In fact, one may come across banteng tracks in any part of the mainland of Ujung Kulon, only the mangrove areas and very steep mountain slopes excluded (Halder, 1979). Although some individuals prove very loyal to the grazing grounds as a feeding area even in unfavourable (i.e. very dry) periods, migration patterns of bantengs due to seasonal changes of the habitat are also not uncommon (Halder, 1975). In our experience, there is a strongly increased activity of bantengs observable in the freshly sprouting Bambusa vegetations of the uplands at the beginning of the rainy season. This corresponds well with the findings of Halder, who reported that many bantengs tend to leave the swampy parts of the coastal plains during the same period. In additon, diurnal migration patterns are also very interesting. Halder describes such patterns on and around the grazing grounds in detail. In the interior, we observed several times that small groups of banteng retreated at evening twilight from the shrub jungles to the adjacent Arenga forests. This phenomenon may be explained by the fact that bantangs tend to reserve this part of the day for social activities and thus need some room to move (Halder, 1975).

As for its feeding behaviour, the banteng may be considered to be an 'intermediate feeder'; i.e. it can behave like a grazer (bulk feeder) or a browser (concentrate selector) depending on season and local conditions (see: van Gils et al., 1982). Lists of food plants of the banteng are given by various authors e.g. Hoogerwerf (1970), Halder (1975) and Djaja et al. (1982). Ammann (1985) points out that, in contrast to the diet of the Javan rhino, monocotyledonous plants such as grasses, palms and bamboos are of great importance as banteng food plants. The same author remarks that there is still insufficient knowledge about the feeding ecology of the banteng. Data on food preference, or quantities eaten of the various food species (as collected by Ammann for the rhino), are not available. However, on a basis of all available data, Ammann concludes that there is at present little competition for food between banteng and rhino, in spite of a general tendency in literature to consider banteng and rhino as food competitors. The overlap in diet is small, while of the species eaten by both animals there are only a few in short supply. Moreover, bantengs tend to eat younger treelets than rhinos do and may, by their feeding activities, retard the growth of the food plants (just like rhinos do), which is advantageous for both species. In addition, one may point to the distribution of the seedlings of food plants such as Spondias, which is stimulated by the liking of the bantengs for the fruits of such species (see 10.2.3). Even so, further increase in the banteng population may enhance the intraspecific food competition and thus a change in diet, as Ammann points out. This may eventually have serious consequences for the interspecific food competition between rhino and banteng. Obviously, there is much left to be studied on this point and (as Ammann's study proves) merely focussing on a further extension of the list of communial food plants is not the most fruitful direction for further research.

CHAPTER 11: LANDSCAPE UNITS

11.1 Introduction

This chapter gives a further integration of the various aspects of the landscape which were discussed in the preceding chapters. This integration is presented in the form of a legend to the landscape ecological map, added to this report as an appendix (see: section 11.2).

Furthermore, a broad interpretation of the various landscape units in terms of suitability as a habitat for the Javan rhinoceros is given in section 11.3.

Finally, a last section (11.4) will touch upon the subject of the major recent and present changes in the vegetation cover of the landscape units. In addition, some attention will be paid to the impact of these changes on the food availability of the Javan rhino.

11.2 Legend of the landscape ecological map

The Roman figures, capitals and again Roman figures in brackets refer to the classification of land forms, soils and plant communities respectively, i.e. to sections 6.3, 7.3 and 9.3.

The estimated share of the various vegetation and soil types within the landscape units is given in Table 11a and 11c respectively. An outline of the relations between soil and vegetation is given in Table 11b. In order to avoid unnecessary duplications, the legend given below (in general) enumerates only the most important types. The types of minor importance (for instance some types of beach vegetation and most types of coastal soils) can be traced by means of Tables 11a and 11c; their distribution is described in sections 7.3 and 9.3.

The names of the landscape units are derived from the land form at issue and one of the most characteristic plant species. This does not necessarily have to be a dominant species or the main species of a sociological group.

Basic units (no. 1 to 26):

1. Flacourtia crest

Landform: mountains (Ia); altitude more than 450 m.
Soils: dystric nitosols (j) and dystric cambisols (h), both developed on sedimentary rock (including tuff).
Vegetation: Kibara-Flacourtia forest (I), towards the boundaries of the landscape unit gradually merging into the Garcinia-Neesia forest (II).

2. Neesia mountains

Land form: mountains (Ia; altitudes between 150 and 450 m).
Soils: dystric nitosols (j) and dystric cambisols (h), both developed on sedimentary rock (including tuff).
Vegetation: Garcinia-Neesia forest (II), towards the lower boundaries of the landscape unit gradually merging into the Pentace-Arenga forest.

3. Arenga mountains

Land form: mountains (Ia; altitudes below 150 m).
Soils: dystric cambisols (h) and dystric nitosols (j), both developed on

sedimentary rock (including tuff).
Vegetation: Pentace-Arenga forest (III), downhill gradually merging into the Petrospermum-Arenga forest (VIIb: sub-type with Myristica or, only in the NW part, VIIa: sub-type with Stenochlaena).

Table 11a Estimated cover of the plant-communities in the landscape units (based on plot-data, field observations) and photo-interpretation)

	Plant-communities Landscape units	I Kibara-Flacourtia	II Garcinia-Neesia	III Pentace-Arenga	IV Rubus-Gleichenia*	V Saraca-Sumbaviopsis	VI Uncaria-Sumbaviopsis*	VIIa Pterosp.-Arenga-Steno.	VIIb Pterosp.-Arenga-Myris.	VIIc Pterosp.-Arenga-Bisch.	VIII Parinari-Gnetum	IX Pterygota-Rinorea*	X Bischofia-Ficus	XI Cerbera-Buchanania	XII Bambusa-Drypetes	XIII Areca-Arenga	XIV Oncosperma-Salacca	XVa Hyptis-Daemon.-Dill.	XVb Hyptis-Daemon.-Lant.	XVI Canthium-Albizia*	XVII Schizostachyum	XVIII Sterculia-Syzygium	XIX Dendrocnide-Syzygium	XX Dendrocnide-Arenga*	XXI Nauclea-Syzygium	XXII Corypha-Ardisia	XXIII Ximenia-Ardisia	XXIV Calotropis-Dodonaea*	XXV Dactyloct.-Digitaria*	XXVI Fimbrist.-Chrysopogon	XXVII Fimbrist.-Oplismenus	XXVIII Barringtonia-Syzygium	XXIX Sophora-Calophyllum	XXX Pemphis-Lumnitzera	XXXI Mikania-Pandanus	XXXII Ipomoea-Ischaemum	XXXIII Ischaemum-Scaevola*	XXXIV Nymphaea-Najas*	XXXV Phyla-Eleocharis	XXXVI Pandanus-Scirpodendr.	XXXVII Lumnitzera-Ardisia*	XXXVIII Derris-Sonneratia	XXXIX Sonneratia-Rhizophora
1	Flacourtia crest	9	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	Neesia mountains	.	10	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3	Arenga mountains	.	.	7	.	.	.	1	2	.	.	.	.	.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4	Sterculia cliff coast	.	.	2	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	6	+	+	.	.	.	.	.	.	.	+	+	.	+	+	+	.	.	.	.	.	.
5	High Arenga hills	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	+	.	.	.	.	.	.
6	Low Arenga hills	.	.	.	.	.	.	7	2	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	+	.	.	.	.	.	.	.
7	Sumbaviopsis crest	.	.	.	.	6	1	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8	Arenga crest	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9	Rinocera crest	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10	Arenga plateau	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	Rinorea plateau	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12	Arenga slopes/diss.plateau	.	.	.	.	.	.	.	+	8	.	.	.	.	.	.	.	1	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13	Daemon.slopes/diss.plateau	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	3	3	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14	*Bambusa-Daemonorops uplands*	.	.	.	.	.	.	.	.	.	.	.	.	.	8	.	.	2	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15	Bambusa-Schizost.uplands	.	.	.	.	.	.	.	.	.	.	.	.	.	9	.	+	+	+	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16	Dendrocnide beach ridge	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9	1	.	.	.	.	+	.	.	.	.	.	+	+	.	.	.	.	.	.	.
17a	Arenga plains (fluv.)	.	.	.	.	.	.	.	1	.	.	.	.	.	.	8	+	2	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17b	Arenga plains (eros.)	.	.	.	.	.	.	.	2	3	.	.	.	.	.	3	+	1	+	.	.	.	.	+	1	.	.	.	.	.	.	+	+	.	.	+	+	.	.	.	.	.	.
18	Salacca plain	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	8	1	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
19a	Daemonorops plains (fluv.)	.	.	.	.	.	.	.	.	2	.	.	.	.	.	+	1	6	1	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
19b	Daemonorops plains (eros.)	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	7	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20	Syzygium plains	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	1	+	.	+	.	.	.	8	.	+	.	.	.	+	.	+	.	.	+	.	.	.	+	.	+	.
21	Ficus plain	.	.	.	.	.	.	.	.	.	.	1	8	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	.	+	.	.	.	.	.	+	.
22	Ardisia plain	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	3	4	2	+	.	.	.	.	+	.	.	+	.	.	+	.	1	+	.
23	Chrysopogon graz.grounds	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	+	.	.	.	.	.	.	.	.	.	.	.	.
24	Phyla swamps	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		V10	+	+	.	.
25	Casuarina-Lumnitzera swamp	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	10	.	.
26	Rhizophora-Nypa mangrove	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	3	7

Legend: + = cover: less than 5%; 1 = cover: 5-14%; 2 = cover: 15-24%; etc. 10 = cover: 95-100%; V = strongly variable in the course of a year; * = insufficiently known community

Table 11b Correlation between the classification of plant-communities and the classification of soils (based on plot-data only)

Soil types		Excessively drained				Somewhat excessively drained				Well drained				Moderately well drained						Somewhat poorly drained			Poorly drained		Very poorly drained		Water	
Plant-communities		a lithosols (various types of rock)	b calcaric fluvisols (all. sand)	c calcic cambisols (all. sand)	d calcaric regosols (coral)	e calcaric regosols (coral sand)	f dystric cambisols (sand-/limestone)	g dystric cambisols (all. sand)	h dystric cambisols (var. sed. rock)	i eutric cambisols (tuff)	j dystric nitosols (var. sed. rock)	k dystric cambisols (limestone)	l eutric cambisols (limestone)	m eutric cambisols (limestone)	n gleyic luvisols (clay; ?origin)	o eutric cambisols (andesite)	p gleyic cambisols (?parent material)	q eutric regosols (all. sand/loam)	r gleyic cambisols (all. loam/clay)	s dystric gleysols (all. silty clay)	t gleyic luvisols (clay; ?origin)	u dystric gleysols (all. clay)	v calcaric fulvisols (all. sand)	w dystric fluvisols (all.sand/clayl.)	x calcaric fluvisols (var. all. sed.)	y thionic fluvisols (var. all. sed.)	•	Total number of plots
I	Kibara-Flacourtia	.	.	.	.	.	.	.	4	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
II	Garcinia-Neesia	.	.	.	.	.	.	.	2	.	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	17
III	Pentace-Arenga	1	.	.	.	.	.	.	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10
IV	Rubus-Gleichenia*	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
V	Saraca-Sumbaviopsis	.	.	.	.	.	3	.	.	.	.	.	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	3
VI	Uncaria-Sumbaviopsis*	.	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
VIIa	Pterosp.-Arenga-Steno.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	8	1	.	.	.	.	.	.	.	.	.	.	10
VIIb	Pterosp.-Arenga-Myris.	.	.	.	.	.	.	1	1	6	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	10
VIIc	Pterosp.-Arenga-Bisch.	.	.	.	+	.	1	.	.	.	.	4	2	1	1	.	.	.	+	.	.	.	.	.	.	.	.	34
VIII	Parinari-Gnetum	.	.	.	.	.	.	.	.	.	.	3	6	1	.	.	.	.	.	.	.	.	.	.	.	.	.	7
IX	*Pterygota-Rinorea**	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	1
X	Bischofia-Ficus	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
XI	Cerbera-Buchanania	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
XII	Bambusa-Drypetes	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	9	.	.	.	.	.	.	15
XIII	Areca-Arenga	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	7	.	.	2	.	.	.	.	.	10
XIV	Oncosperma-Salacca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	9
XVa	Hyptis-Daemon.-Dill.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	3	.	4	1	.	.	.	.	.	27
XVb	Hyptis-Daemon.-Lant.	.	.	.	.	.	.	.	.	.	.	.	1	.	6	1	.	.	2	.	.	.	.	.	.	.	.	9
XVI	Canthium-Albizia*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	1
XVII	Schizostachyum	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	7	.	1	.	.	.	.	.	.	7
XVIII	Sterculia-Syzygium	.	.	.	.	.	.	.	8	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
XIX	Dendrocnide-Syzygium	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11
XX	Dendrocnide-Arenga*	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
XXI	Nauclea-Syzygium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	6	.	1	.	.	.	.	.	16
XXII	Corypha-Ardisia	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	.	.	.	.	2	.	.	5
XXIII	Ximenia-Ardisia	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12
XXIV	Calotropis-Dodonaea*	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
XXV	Dactyloct.-Digitaria*	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10
XXVI	Fimbrist.-Chrysopogon	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8	2	.	.	.	.	.	.	.	.	6
XXVII	Fimbrist.-Oplismenus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	6	.	.	.	.	.	5
XXVIII	Barringtonia-Syzygium	.	2	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8
XXIX	Sophora-Calophyllum	.	1	7	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	19
XXX	Pemphis-Lumnitzera	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	7	.	.	.	3
XXXI	Mikania-Pandanus	2	2	.	.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
XXXII	Ipomoea-Ischaemum	1	6	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	9
XXXIII	Ischaemum-Scaevola*	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
XXXIV	Nymphaea-Najas*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	1
XXXV	Phyla-Eleocharis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	12
XXXVI	Pandanus-Scirpodendr.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8	2	.	.	4
XXXVII	Lumnitzera-Ardisia*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	2
XXXVIII	Derris-Sonneratia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	9	.	.	.	11
XXXIX	Sonneratia-Rhizophora	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.	7

Legend: + = less than 5%; 1 = 5-14%; 2 = 15-25%, etc., 10 = 95-100%.
Example: Plant-community I occurs in 35-44% of the plots on soil-tyype h, i.e. in 2 of the 5 plots.
* = insufficiently known community

Table 11c Estimated extent of the soil-types in the landscape units (based on plot-data, soil-vegetation relations and field-observations

Soil types	Excessively drained				Somewhat excessively drained				Well drained				Moderately well drained						Somewhat poorly drained			Poorly drained		Very poorly drained	
Landscape units	a lithosols (various types of rock)	b calcaric fluvisols (all. sand)	c calcic cambisols (all. sand)	d calcaric regosols (coral)	e calcaric regosols (coral sand)	f dystric cambisols (sand-/limestone)	g dystric cambisols (all. sand)	h dystric cambisols (var. sed. rock)	i eutric cambisols (tuff)	j dystric nitosols (var. sed. rock)	k dystric cambisols (limestone)	l eutric cambisols (limestone)	m eutric cambisols (limestone)	n gleyic luvisols (clay; ?origin)	o eutric cambisols (andesite)	p gleyic cambisols (?parent material)	q eutric regosols (all. sand/loam)	r gleyic cambisols (all. loam/clay)	s dystric gleysols (all. silty clay)	t gleyic luvisols (clay; ?origin)	u dystric gleysols (all. clay)	v calcaric fulvisols (all. sand)	w dystric fluvisols (all.sand/clayl.)	x calcaric fluvisols (var. all. sed.)	y thionic fluvisols (var. all. sed.)
1 Flacourtia crest	.	.	.	.	.	.	.	4	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2 Neesia mountains	+	.	.	.	.	.	.	2	.	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3 Arenga mountains	+	.	.	.	.	.	.	5	+	4	.	.	.	.	1	.	.	+	.	.	.	.	.	.	.
4 Sterculia cliff coast	2	+	+	.	.	+	.	6	+	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5 High Arenga hills	+	+	+	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6 Low Arenga hills	.	+	+	.	.	.	.	.	2	.	.	.	.	.	8	.	.	+	.	.	+	.	.	.	.
7 Sumbaviopsis crest	+	.	.	.	.	2	.	.	.	.	4	2	2	.	.	.	.	.	.	.	.	.	.	.	.
8 Arenga crest	1	.	.	.	.	.	.	.	.	.	.	9	.	.	.	.	.	.	.	.	.	.	.	.	.
9 Rinorea crest	1	.	.	.	.	.	.	.	.	.	.	9	.	.	.	.	.	.	.	.	.	.	.	.	.
10 Arenga plateau	+	.	.	.	.	.	.	.	.	.	10	+	.	+	.	.	.	.	.	.	.	.	.	.	.
11 Rinorea plateau	+	.	.	.	.	.	.	.	.	.	7	2	1	.	.	.	.	.	.	.	.	.	.	.	.
12 Arenga slopes/diss.plateau	+	.	.	.	.	+	.	.	.	.	2	+	.	8	.	.	.	.	.	.	.	.	.	.	.
13 Daemon.slopes/diss.plateau	+	.	.	.	.	.	.	.	.	.	2	+	.	8	.	.	.	+	.	.	.	.	.	.	.
14 Bambusa-Daemonorops uplands	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	7	.	.	.	.	.
15 Bambusa-Schizost.uplands	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	9	+	.	.	.	.
16 Dendrocnide beach ridge	+	+	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
17a Arenga plains (fluv.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.
17b Arenga plains (eros.)	.	+	+	.	.	.	2	.	.	.	.	5	+	.	.	.	.	+	1	.	2	.	.	.	.
18 Salacca plain	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.
19a Daemonorops plains (fluv.)	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	6	.	.	4	.	.	.	.
19b Daemonorops plains (eros.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.
20 Syzygium plains	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	+	1	1	7	.	.	.	1	.	.
21 Ficus plain	.	+	+	.	.	9	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	+	.	.	.
22 Ardisia plain	.	+	+	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7	.	.	.	+	1	.
23 Chrysopogon graz.grounds	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.
24 Phyla swamps	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.
25 Casuarina-Lumnitzera swamp	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.
26 Rhizophora-Nypa mangrove	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	7

Legend: + = less than 5%; 1 = 5-14%; 2 = 15-24%, etc.; 10 = 95-100%

4. Sterculia cliff coast

Land form: mountains (Ia; altitudes below 150 m) (see also notes below).
Soils: dystric cambisols (h), dystric nitosols (j) and Lithosols (a), all developed on sedimentary rock (including tuff).
Vegetation: Sterculia-Syzygium forest on steep and exposed sites, alternated with Arenga forests (III and downhill VIIb) on less steep and exposed sites,

especially in valleys; on coastal precipices with thickets of Ischaemum-Scaevola vegetation (XXXII); the main type of beach vegetation is the Barringtonia- Syzygium forest (XXVIII).

Notes: Locally, especially along the west coast of this unit, narrow strips of erosional plains (V) occur (Arenga plains; landscape unit 17b). The area covered by these plains is too small to allow their delineation on the map. The Cape Gede peninsula was also included in this landscape unit on account of its vegetation. It can be considered as part of the (higher) western hills (Ib) as far as lithology and soils are concerned.

5. High Arenga hills

Land form: hills (Ib); western part.

Soil: eutric cambisols developed on tuff (i).

Vegetation: Pterospermum-Arenga forest (VIIb: sub-type with Myristica; the main-type of beach-vegetation is (?) the Barringtonia-Syzygium forest (XXVIII).

Notes: In this unit, many stands of community VIIb can be found in which Arenga obtusifolia is only moderately well represented; an aberrant form of this community on a steep slope bordering the Cibom-Ciramea trail was erroneously classified as a form of Bambusa-Drypetes forest (XII) by Hommel (1983).

Along the south coast of this unit, a narrow, not mappable erosional plain (V) is present (compare: landscape unit 4).

6. Low Arenga hills

Land form: hills (Ib); eastern part.

Soils: eutric cambisols developed on andesite (o) or (more locally) on tuff (i).

Vegetation: Pterospermum-Arenga forest (VIIa: subtype with Stenochlaena; on soil type: VIIb, sub-type with Myristica); very locally patches of Hyptis-Daemonorops shrubland (XV); the main type of beach vegetation is (?) the Barringtonia-Syzygium forest (XXVIII).

Note: Reinterpretation of the aerial photographs proved that the share of rattan shrublands (XV) in this unit is far less than assumed by Hommel (1983).

7. Sumbaviopsis crest

Land form: structural plateau, strongly dissected, upper level (IIa, the Telanca massif).

Soil: dystric (k and f) and eutric (l and m) cambisols, all developed on limestone.

Vegetation: Saraca-Sumbaviopsis forest (V) on the steep, crest-like parts; a mosaic of Pterospermum-Arenga forest (VIIc: sub-type with Bischofia) and open forest of the Uncaria-Sumbaviopsis community (VI) on the more level parts.

Note: This unit includes some interesting bat-caves in the SW corner.

8. Arenga crest

Land form: structural plateau, strongly dissected upper level (IIa, Mt. Telanca 2).

Soils: eutric cambisols (l) and lithosols (a), both developed on limestone.

Vegetation: Pterospermum-Arenga forest (sub-type with Bischofia VIIc) in a form with only a moderate density of Arenga obtusifolia.

9. Rinorea crest

Land form: structural plateau, strongly dissected upper level (IIa, Peucang Island).
Soil: eutric cambisols (l) and lithosols (a), both developed on limestone.
Vegetation: Parinari-Gnetum forest (VIII).

10. Arenga plateau

Land form: structural plateau, undissected middle level (IIb).
Soils: mainly dystric cambisols (k) developed in limestone.
Vegetation: Pterospermum-Arenga forest (VIIc: sub-type with Bischofia); small patches of Hyptis-Daemonorops shrubland (XV) occur only very locally along the margins of the plateaux and are (as far as is known) bound to poorly developed gleyic luvisols (n).

11. Rinorea plateau

Land form: structural plateau, undissected middle level (IIb) of Peucang Island.
Soils: dystric (k) and eutric (l and m) cambisols, all developed on limestone.
Vegetation: Parinari-Gnetum forest (VIII).

12. Arenga slopes and dissected plateau

Land form: structural plateau, dissected lower level (IIc).
Soils: gleyic luvisols, developed on limestone or in clayey material of unknown origin (n) and dystric cambisols, developed on limestone (k).
Vegetation: A mosaic of Pterospermum-Arenga forest (VIIc: sub-type with Bischofia; the dominant type) and Hyptis-Daemonorops shrubland; the former on both luvisols and cambisols, the latter only on luvisols.
Note: The map unit between the isthmus and the Mt.Honje massif which is classified as landscape unit 12 was insufficiently explored. Along its southern edge, stands of the Pterospermum-Arenga forest are present belonging to the sub-type with Stenochlaena palustris (VIIa) are present, growing on the gleyic cambisols developed on parent material of unknown material (p). This does not fit into the general picture of the dissected plateaux of Ujung Kulon. The extent of this and possible other deviations is not known.

13. Daemonorops slopes and dissected plateau

Land form: structural plateau, dissected lower level (IIc).
Soils: gleyic luvisols, developed on limestone or in clayey material of unknown origin (n) and dystric cambisols, developed on limestone (k).
Vegetation: A mosaic of Hyptis-Daemonorops shrubland (XV; the dominant type) and Pterospermum-Arenga forest (VIIc: sub-type with Bischofia); the first only on luvisols, the second both on luvisols and cambisols; locally also Schizostachyum forest (XVII), either replacing the Hyptis-Daemonorops vegetations, or along rivulets, e.g. Cikarang (on gleyic cambisols, r).

14. Bambusa-Daemonorops upland

Land form: uplands (III); mainly hilly parts.
Soils: gleyic luvisols, developed in clayey material of unknown origin (t and n, the latter only in the area west of Jamang, mentioned below).
Vegetation: Bambusa-Drypetes forest (XII).
Generally with many patches of Hyptis-Daemonorops shrubland (XV). Only towards the western edge of the main map unit belonging to this landscape

(i.e. upstream Citadahan) does the shrubland tend to dominate the Bambusa stands.
Note: The classification of the elevated area west of Jamang as Bambusa-Daemonorops uplands is rather dubious as far as geomorphology and soils are concerned. However, the pattern of vegetation types corresponds well with the general picture of this landscape unit.

15. Bambusa-Schizostachyum upland
Land form: uplands (III), mainly rolling parts.
Soils: gleyic luvisols, developed in clayey material of unknown origin (t) and gleyic cambisols, developed in alluvial loam or clay (r); the latter only along the major rivulets.
Vegetation: mainly Bambusa-Drypetes forest (XII); Schizostachum vegetation: (XVII) only on the gleyic cambisols (r).

16. Dendrocnide beach ridge
Land form: beach ridge (IV), partly a truncated platform, partly sand dunes.
Soils: dystric cambisols, developed on calcareous sandstone (f).
Vegetation: Dendrocnide-Syzygium vegetation, (XIX), in structure ranging from closed forest to shrubland; along the coast with a narrow strip of Mikania-Pandanus scrub (XXXI), along the lee side with a narrow strip of Dendrochide-Arenga forest (XX); in the western part, locally with small patches of Dactyloctenium-Digitaria grassland (XXV) directly behind the Pandanus belt.

17. Arenga plains
Land form: fluvio-alluvial plain (VI) in sub unit 17a and erosional plain (V) in sub unit 17b.
Soils: gleyic cambisols, developed in alluvial loam or clay (r) in sub unit 17a; eutric cambisols, developed on limestone (l) and dystric gleysols, developed in alluvial clay (u) or silty clay (s) in sub unit 17b; in the part of sub unit 17b along the SW coast: dystric cambisols developed in alluvial sand (g).
Vegetation: the main vegetation type is the Areca-Arenga forest (XIII). It is dominant only in sub unit 17a. In sub unit 17b, various other types of Arenga forest are also of importance, depending on the parent material of the soil profiles; more locally also patches of Hyptis-Daemonorops shrubland (XV) and Nauclea-Syzygium forest (XXI), the latter on the dystric gleysols (s); the main type of beach vegetation (17b) is the Sophora-Barringtonia forest.

18. Salacca plain
Land form: fluvio-alluvial plain (VI).
Soils: gleyic cambisols, developed in alluvial loam or clay (r).
Vegetation: mainly Oncosperma-Salacca forest and shrubland (XIV); locally stands of Areca-Arenga forest (XIII) and Hyptis Daemonorops shrubland (XV).

19. Daemonorops plains
Land form: fluvio-alluvial plain (VI) in sub unit 19a and Erosional plain (V) in sub unit 19b.
Soils: gleyic cambisols, developed in alluvial loam or clay (r), dystric gleysols developed in alluvial clay (u) (both in sub unit 19a) and gleyic luvisols developed in clayey material of unknown origin (t) (in sub unit 19b).

Vegetation: Hyptis Daemonorops shrubland (XV) predominates; in sub unit 19a also some stands of Pterospermum-Arenga forest (VIIc; sub type with Bischofia) and Oncosperma-Salacca vegetation (XIV); in sub unit 19b probably with some stands of the Bambusa-Drypetes forest (XII; not seen).

20. Syzygium plain

Land form: coastal plain of the mainland (VIIa), as described for landscape unit 21, but in many places without an uplifted pseudo barrier reef.

Soils: mainly dystric gleysols, developed in alluvial silty clay (s), but many other soil types are also present.

Vegetation: Nauclea-Syzygium forest (XXI); along the inner margin of the coastal plain generally with a strip of Hyptis Daemonorops shrubland (XV) along the outer margin and along creeks various forms of the Pandanus-Scirpodendron community (XXXVI); where bordering upon the sea, the beach forest is not well developed.

21. Ficus plain

Land form:coastal plain (VIIb) of Peucang Island, an uplifted and weathered coral flat; along the western edge of the central plateau of Peucang Island, the broad coastal plain merges into a narrow erosional plain.

Soils: mainly calcaric regosols developed in coral sand (e); locally in depressions: calcaric fluvisols developed in alluvial sand (V); on the erosional plain: eutric cambisols developed on limestone (mainly type m).

Vegetation: mainly Bischofia-Ficus forest (X) towards the coast merging into the Cerbera-Buchanania forest (XI; both on the regosols); in the depressions: either a form of the Derris-Sonneratia forest (XXXVIII), which is strongly dominated by Ficus microcarpa, or (in more coastal locations) Pemphis-Lumnitzera forest (XXX); on the cambisols: Pterygota-Rinorea forest (IX); the most common type of beach forest is the Sophora-Calophyllum community (XXXIX).

22. Ardisia plain

Land form: coastal plain of mainland (and the Handeuleum archipelago), an uplifted 'pseudo-barrier reef' with its lagoon filled up with various marine sediments (VIIa); locally there are small depressions ('bottomlands'; see unit 24) situated directly behind the barrier reef.

Soils: mainly calcaric regosols developed on coral (d) on the barrier reef and dystric gleysols developed in alluvial silty clay (u) in the former lagoon.

Vegetation: from the interior towards the coast there is a clear zonation: Nauclea-Syzygium forest (XXI) and Corypha-Ardisia forest (XXII) on the gleysols, Ximenia-Ardisia forest on the regosols. The most common type of beach forest is the Sophora-Calophyllum community (XXXIX), which on very exposed and rocky places is strikingly dominated by Pemphis acidula. Directly behind the beach forest, small patches of Calotropis-Dodonaea savanna (XXIV) are present, especially near Cape Alang-Alang. On the boundary with the more elevated parts in the interior, there is a narrow strip of Hyptis-Daemonorops shrubland (XV).

Notes: This landscape unit represents the parts of the coastal plain of the mainland where the pattern of vegetation types is strongly influenced by former vegetation management in the coastal zone (i.e. in the parts now covered by Ardisia forest).

Also included are some smaller map units (capes and small islands) in which only the Ximenia-Ardisia forest (generally in an aberrant form) is dominantly present, although former vegetation management is considered to be of little or no significance.

23. Chrysopogon grazing grounds
Land form: coastal plain of the mainland (VIIa), only some regions of moderate size near the mouth of some of the major rivulets.
Soils: only eutric regosols developed in alluvial sand or loam (q).
Vegetation: mainly Fimbristylis-Chrysopogon grasslands (XXVI); in small depressions low herbaceous vegetations of the Fimbristylis-Oplismenus community (XXVII); these grasslands are regularily cleared of regrowth, when neglected, species of the Nauclea-Syzygium community settle.

24. Phyla swamp
Land form: 'bottomlands' (VIII).
Soils: calcaric fluvisols developed in various alluvial sediments (x).
Vegetation: herbaceous vegetation of the community of Phyla and Eleocharis (XXXV); when inundated during the rainy season temporarily dominated by the hydrophytic community of Nymphaea and Najas (XXXIV); coral boulders are locally present forming tiny islets covered with a form of Lumnitzera-Ardisia forest (XXXVII), strikingly rich in epiphytes.

25. Casuarina Lumnitzera swamp
Land form: coastal plain of the mainland (VIIa); very low area in the lagoon, but not as low as the bottomlands (VIII).
Soils: calcaric fluvisols developed in various alluvial sediments (x).
Vegetation: Lumnitzera-Ardisia forest (XXXVII), partly in a form which is dominated by Casuarina equisetifolia.

26. Rhizophora mangrove
Land form: tidal swamps (IX).
Soils: thionic fluvisols developed in various alluvial sediments (y) in the outer mangrove and dystric fluvisols developed in alluvial sand or (clay)loam in the inner mangrove (w).
Vegetation: Sonneratia-Rhizophora forest (XXXIX) in the outer mangrove and open forest of the community of Derris and Sonneratia (XXXVIII) in the inner mangrove.

Complex units (nos. 27 to 30)

27. Transition of Arenga slopes and dissected plateau (12) to Syzygium plain (20).
The structural plateau (II) is lifted and tilted and tends to dip gradually into the coastal plain on the NE side. Exact boundaries are locally difficult to trace.

28. Transition of Arenga slopes and dissected plateau (12) to cultivated lands.
This unit includes relics of Arenga obtusifolia forest, young secondary vegetations and fields which are still under cultivation. Like the adjacent area of Arenga slopes and dissected plateaux east of the isthmus, this whole map, c.q. landscape unit was insufficiently explored.

The Arenga forest relics, probably belong to the community of Pterospermum and Arenga (sub-type with Bischofia javanica; VIIc).
The young secondary vegetations closely resemble the shrublands of the Hyptis-Daemonorops community (sub-type with Lantana camara; XVb), but lack the characteristic rattan component.

29. Transition of Daemonorops slopes and dissected plateau (13) to Bambusa-Daemonorops uplands (14).

This landscape unit is very strongly dominated by Hyptis-Daemonorops shrubland (XV). The exact boundary between the structural plateau (II) and uplands (III) cannot be traced, neither on the aerial photographs, nor in the field.

30. Transition of Bambusa-Schizostachyum uplands (15) to the Syzygium plain (20).

The pattern of the boundaries is too intricate to be shown on our mapping scale.

11.3 Suitability as a habitat for the Javan rhinoceros

The major habitat requirements of the Javan rhinoceros were described briefly in the preceding chapter. Here we shall take stock of the extent to which the various parts (or landscape units) of Ujung Kulon respond to these requirements. An integration of the value of a given area (or landscape unit) with regard to the various requirements results in an indication of the suitability of that area as a habitat for the Javan rhinoceros.

This approach is derived from the FAO methodology for land evaluation (1976; see also Zonneveld, 1985). In the FAO terminology the Javan rhinoceros is here considered as a 'land utilization type' (LUT). The properties of the environment that determine the suitability in relation to the requirements are called 'qualities' (or also 'limitations' if they are negative). In applying the land evaluation approach on a wildlife LUT, van Wijngaarden's study (1983) on the Baoule region (Mali) was used as an example.

Due to insufficient knowledge of some of the requirements and of some of the 'qualities' of the landscape units, our manipulations must result in only a very broad indication of the suitability for the Javan rhino. Even so, it is of interest to compare the results with the existing sketch map of the distribution of the species (Schenkel & Schenkel-Hulliger, 1969).

Of the various habitat requirements described in the preceding chapter, we shall focus on accessibility, availability of drinking water and availability of forage. For some of the other requirements we do not have sufficient information to rate the various parts of Ujung Kulon at their relative value, viz. the need for cover of the rhino and the absence of pathogenic germs. For others requirements, such as the need for salt, mud-wallowing and bathing we do have more or less sufficient information. It is however, assumed that these habitat requirements do not provide problems for the rhinos living in any part of Ujung Kulon. The animals are assumed to meet their demand for salt by incidental visits to the coast. Wallowing is only impossible on sandy or very shallow soils and nowhere do these cover large coherent surfaces: wallowing-facilities are thus always easily within reach of the rhinos from any point in the area. Bathing facilities are more scarce, especially during the dry season. However, the rhinos can go without bathing for four days (Amman, 1985; see chapter 10). We may assume that even in the dry season a rhino can come across a pool to bathe in at least once every two days in any part of Ujung Kulon.

This leaves the three requirements mentioned above (accessibilty, drinking water and forage) to determine the overall suitability as a rhino habitat. The qualities or limitations in relations to these requirements were assessed for the various parts of the area. The results are presented in three sketchmaps (Fig. 11a-c), each depicting a quality (limitation).

The limitations are given for the unfavourable season in an average year. In exceptionally unfavourable years, the rhinos probably leave their home-ranges and (temporarily?) migrate to more favourable regions.

The map showing areas with difficult accessibility and areas that are (almost) inaccessible (Fig. 11a) is more or less self-explanatory. Please note that small swampy sites (e.g. in the fluvio-alluvial plain) were neglected. Moreover, the obstacles provided by very compact, thorny vegetations were also neglected. The rhinos generally make use of fixed trails through areas covered with such vegetation.

The map showing areas where the availability of fresh water is uncertain during the dry season (Fig. 11b) needs some comment. Shown are those areas assumed to be more than one kilometre away from the nearest supply of drinking water during an average dry season. Here we are facing serious uncertainties due to the lack of detailed knowledge on the availability of open water and the ability of the rhino to live temporarily on slightly brackish water.

The map showing the availability of forage (Fig. 11c) is based on the relative value of the various landscape-units as a source of forage. First, the relative value of each plant community was estimated on the basis of the abundancy of important food plant species and structural characters (see Tables 11d, e and f). Next, the quality of the landscape units was estimated on the basis of the qualities of the plant-communities. In case of doubt, the complexity of the pattern of vegetations within the units was used as an additional (positive) character. The results are given in Table 11g.

Eventually, the information presented in the three sketch-maps mentioned above was combined into one final map indicating the estimated suitability as a rhino-habitat (Fig. 11d). The procedure is as follows: We start from the quality as a source of forage, indicated by means of four classes presented in Table 11g. Areas which have either difficult accessibility or which have seasonal water shortage are set back one class. Areas which provide a combination of these two limitations are set back two classes. Areas which are inaccessible are, of course, always considered to be unsuitable. The results are presented in Table 11n and Fig. 11d.

We shall now compare Fig. 11d with Schenkel's map (1969), which indicates concentrations of rhino tracks in 1967 and 1968 and may thus serve as a sort of distribution map (Fig. 11e). In many respects, the two maps correspond well. In many areas which are classified as marginally or not suitable for the Javan rhino, no concentrations of tracks were found. Examples are the mangrove areas, the northern part of the coastal plain, the upper and

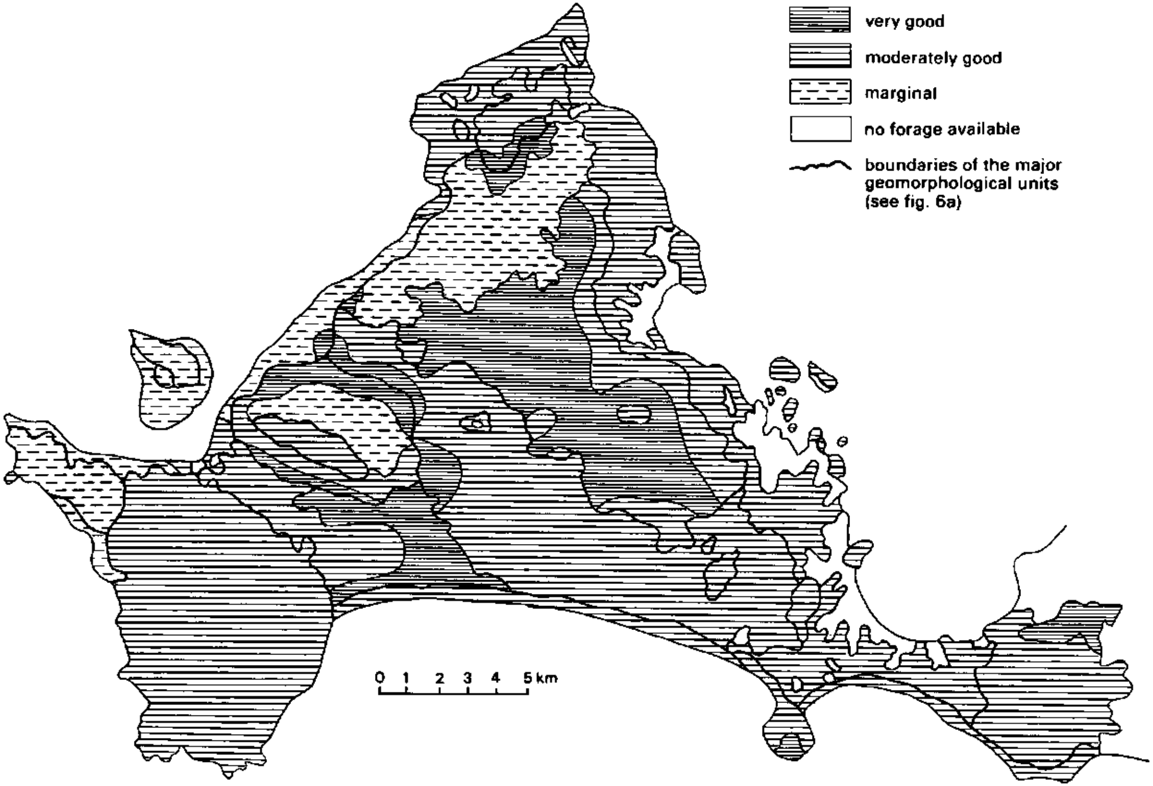

Fig. 11c Quality and quantity of forage for the Javan rhinoceros

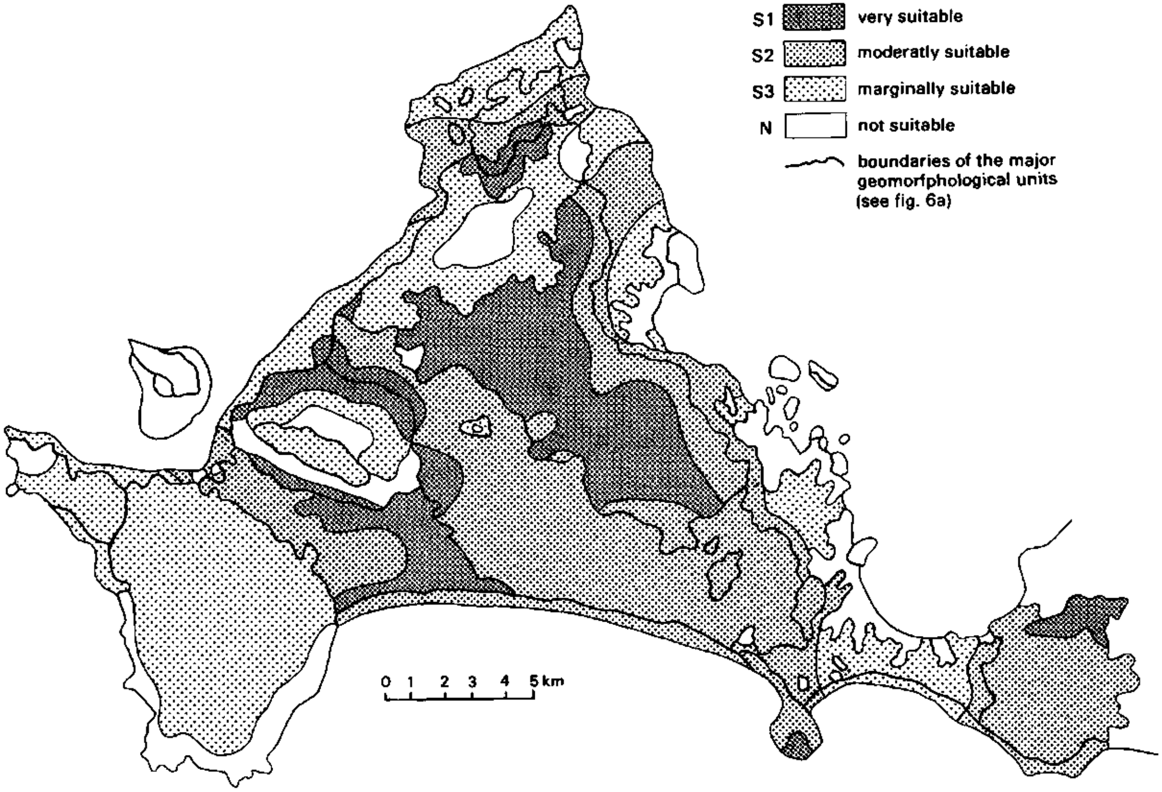

Fig. 11d Suitability map for the Javan rhinoceros

Table 11d Estimate of the quality of the plant-communities as a source of forage for the Javan rhinoceros, based on structure only

Shrublands and forests:	open	closed
high density of saplings	++	+
low density of saplings	+	-
grasslands and other non-woody vegetations: -		

Legend: ++ high quality
+ mediocre quality
- low quality

Table 11e Estimate of the quality of the plant-communities as a source of forage for the Javan rhinoceros

	structure*	++	+	-
availability of important food plants	high (h)	1	1	2
	mediocre (m)	1	2	3
	low (l)	2	3	4

Legend: 1 very high quality
2 high to mediocre quality
3 low quality
4 very low quality

* see table 11d.

Table 11f List of plant-communities and their estimated quality as a source of forage for the Javan rhinoceros, based on the availability of important foodplants and structure

No.	Community	I	S	F	No.	Community	I	S	F
I	Kibara & Flacourtia	m	+	2	XIX	Dendrocnide & Syzyg.	m	+	2
II	Garcinia & Neesia	m	+	2	XX	Dendrocnide & Arenga	m	-	3
III	Pentace & Arenga	m	-	3	XXI	Nauclea & Syzygium	m	+	2
IV	Rubus & Gleichenia	m	++	1	XXII	Corypha & Ardisia	m	+	2
V	Saraca & Sumbaviopsis	m	-	3	XXIII	Ximenia & Ardisia	m	+	2
VI	Uncaria & Sumbaviopsis	h	++	1	XXIV	Calotropis & Dodonaea	m	++	1
VIIa	Pterosp., Arenga & Sten.	m	-	3	XXV	Dactyloctenium & Digitaria	l	-	4
VIIb	Pterosp., Arenga & Myr.	m	-	3	XXVI	Fimbristylis & Chrysop.	l	-	4
VIIc	Pterosp., Arenga & Bis.	m	-	3	XXVII	Fimbristylis & Oplism.	l	-	4
VIII	Parinari & Gnetum	m	-	3	XVIII	Barringtonia & Syzygium	m	+	2
IX	Pterygota & Rinorea	m	+	2	XXIX	Sophora & Calophora	m	+	2
X	Bischofia & Ficus	m	-	3	XXX	Pemphis & Lumnitzera	m	-	3
XI	Cerbera & Buchanania	m	+	2	XXXI	Mikania & Pandanus	m	+	2
XII	Bambusa & Drypetes	m	+	2	XXXII	Ipomaea & Ischaemum	l	-	4
XIII	Areca & Arenga	m	-	3	XXXIII	Ischaemum & Scaevola	l	+	3
XIV	Oncosperma & Salacca	m	+	2	XXXIV	Nymphaea & Najas	l	-	4
XVa	Hyptis, Daemon. & Dill.	h	++	1	XXXV	Phyla & Elecharis	l	-	4
XVb	Hyptis, Daemon. & Lant.	h	++	1	XXXVI	Pandanus & Scirpod.	m	+	2
XVI	Canthium & Albizia	m	++	1	XXXVII	Lumnitzera & Ardisia	m	+	2
XVII	Schizostachyum	l	-	4	XXXVIII	Derris & Sonner.	m	+	2
XVIII	Sterculia & Syzygium	m	+	2	XXXIX	Sonneratia & Rhizophora	l	-	4

Legend: I = quality, based on the availability of important foodplants (see table 10c)
S = quality, based on structure (see table 11d)
F = quality, based on availability of important foodplants and structure (see table 11e).

Table 11g: Estimated quality of the landscape units as a source of forage for the Javan rhinoceros

1	Flacourtia crest	2
2	Neesia mountains	2
3	Arenga mountains	2
4	Sterculia cliff coast	2
5	High Arenga hills	3
6	Low Arenga hills	3
7	Sumbaviopsis crest	2
8	Arenga crest	3
9	Rinorea crest	3
10	Arenga plateau	3
11	Rhinorea plateau	3
12	Arenga slopes and diss. plateau	2
13	Daemonorops slopes and diss. plat.	1
14	Bambusa-Daemonorops uplands	2
15	Bambusa-Schizostachyum uplands	2
16	Dendrocnide beachridge	2
17	Arenga plains (a/b)	2
18	Salacca plain	2
19	Daemonorops plains (a/b)	1
20	Syzygium plains	2
21	Ficus plain	3
22	Ardisia plain	2
23	Chrysopogon grazing grounds	4
24	Phyla swamps	4
25	Casuarina Lumnitzera swamp	2
26	Rhizophora-Nypa mangrove	3
27	Transition of 12 to 20	2
28	Transition of 12 to cult.lands	2
29	Transition of 13 to 14	1
30	Transition of 15 to 20	2

Legend: 1: very high quality; 2: high to mediocre quality; 3: low quality; 4: very low quality

Table 11h Estimated suitability of the landscape units as a habitat for the Javan rhinoceros, based on accessibility, availability of drinking water and forage

1	Flacourtia crest	S3 (a,f)
2	Neesia mountains	S3 (a,f)
3	Arenga mountains	S3 (a,f)
4	Sterculia cliff coast	N (a,f)
5	High Arenga hills	N (f,a)
6	Low Arenga hills	S3 (f)
7	Sumbaviopsis crest	S3 (a,f)
8	Arenga crest	N (f,a)
9	Rinorea crest	N (a,d,f)
10	Arenga plateau	S3 (f)or N (f,d)
11	Rhinorea plateau	N (a,d,f)
12	Arenga slopes an dissected plateau	S2 (f)
13	Daemonorops slopes and dissected	S1
14	Bambusa-Daemonorops uplands	S2 (f) or S3
15	Bambusa-Schizostachyum uplands	S2 (f) S3 (d,f)
16	Dendrocnide beachridge	S2 (f)or S3 (d,f)
17a	Arenga plain (fluv.)	S2 (f)
17b	Arenga plain (eros.)	S3 (f)
18	Salacca plain	S2 (f)
19	Daemonorops plains (a/b)	S1
20	Syzygium plains	S2 (f) or S3 (d,f)
21	Ficus plain	N (a,f,d)
22	Ardisia plain	S2 (f) or S3 (d,f) or N (a,(d),f)
23	Chrysopogon grazing grounds	N (f)
24	Phyla swamps	N (f,(d),a)
25	Casuarina Lumnitzera swamp	N (d,a,f)
26	Rhizophora-Nypa mangrove	N (a,(d),f)
27	Transition of 12 to 20	S2 (f)
28	Transition of 12 to cult.lands	S1
29	Transition of 13 to 14	S1
30	Transition of 15 to 20	S2 (f)

Legend: S1: very suitable; S2: moderately suitable; S3: marginally suitable; N: not suitable

Limitations with respect to: accessibility (a), availability of drinking water (d) or forage (f) are given in brackets in order of significance.

undissected parts of the limestone plateaux and the upper parts of the Payung massif. On the other hand, most of the suitable areas correspond with areas showing concentrations of tracks; especially the southern half of Ujung Kulon's triangular central part (including the fluvio-alluvial plain, most of the uplands and the calcareous beach ridge and the dissected plateau in the Cigenter region). The high density of tracks in the coastal area near Citerjun is explained by the availability of many hectares of very suitable terrain in the hinterland.

Even so, there are also some striking differences. The isthmus area, for instance, was classified as marginally suitable, but did show concentrations of tracks. This may be due to seasonal differences in rhino distribution. Our map gives an indication of the average suitability throughout the year, thus including the situation during a period of drought. Schenkel's map is at least

Figure 11e Concentrations of rhinotracks in 1967/1968/after: Schenkel and Schenkel-Hulliger, 1969)

partly based on the results of the rhino census of 1967 and 1968. A rhino-census is never undertaken in a period of continuous drought, since the tracks are only visible in more or less moist soil (Ammann, 1985). The lack of rhino tracks in the very suitable transitional zone to cultivated lands in the area east of the isthmus is easily explained by the shy character of the rhinos. For the relatively high density of tracks in the not very suitable western hills there is no clear explanation. The high density of tracks there as suggested by Schenkel is not confirmed by the results of Sajudin et al. (1984) or Ammann (1985).

Another point of difference is the Tereleng peninsula, protruding from the south coast, which is classified as moderately to very suitable. Schenkel does not indicate concentrations of tracks there, but Ammann (1985) does. Haerudin et al. (1984) even mention the tracks of four individuals concentrated on this relatively small area.

However, the major point of difference is the status of the very central part of Ujung Kulon, i.e. the dissected plateau mainly covered with rattan shrublands, roughly north of the line Cijung Kulon-Cigenter. On our map this area is part of the largest coherent surface of very suitable terrain, but Schenkel does not indicate a high density of rhino tracks, neither do Haerudin or Ammann mention the area as a densely populated rhino region. Even so, the area fully answers Ammann's description of an optimal rhino habitat viz. 'large areas of shrubland (....) with patches of forest, clumps of trees and other types of vegetation in a fine mosaic-like pattern'. As indicated in fig. 11a and 11b neither accessibility nor availability of freshwater are limiting factors in this area. Moreover, as was explained above, Schenkel's map reflects the distribution of rhinos at a time of year when lack of water is not a factor of great importance throughout Ujung Kulon. The solution to this problem is thought to be: the area is not covered sufficiently during a rhino census. The method of the rhino census as introduced and described by Schenkel and Schenkel-Hulliger (1969) is based on a count of tracks along transects across the peninsula. These transects do not always follow a fixed compass bearing because this is considered to be too time-consuming in some types of terrain. However, to facilitate orientation the routes usually follow topographical features, such as streams and mountain ridges (Ammann, 1985). In the case of the central area at issue, this means that the Cikarang river is followed all across the northern part of the dissected plateau. However, from the banks of the Cikarang river one cannot get a good impression of the region as a whole. It is a specific character of this river that its banks and the vicinity around them are covered by an almost pure stand of Schizostachyum zollingeri bamboo. As a source of forage of the Javan rhino, we considered such a vegetation as rather worthless (see Table 11f). Ammann (1985) is of the same opinion. Since a census is never undertaken in a period of continuous drought (see above) one may assume that the rhinos are in no way dependent on the main stream to satisfy their various needs for fresh water. Thus, it is far from unlikely that they tended to avoid the bamboo forests along the Cikarang river at the time of the census. This is an interesting hypothesis, since it implies the attractive possibility that the number of rhinos in Ujung Kulon is even higher than Ammann's correction of the census-results suggests. Further research on this point is of great importance.

11.4 Regions with important vegetation changes

11.4.1 Introductory remarks

Vast areas in Ujung Kulon are covered with secundary vegetation. As mentioned before, this is due to:

- destruction caused by the tidal wave, following the 1883 eruption of the Krakatau volcano;
- former inhabitance and cultivation, for the greater part ending in 1883;
- former vegetation management, at first on behalf of hunting, later on to increase the availability of food-plants for banteng. This management implied the maintenance of extensive artificial savannas by cutting and burning.

Recovery from these disturbances started one century ago, and again much more recently. Here we are mainly interested in knowing which processes are of importance at present and which changes occurred over the last decades, since information on these processes and changes is needed for the planning of an optimal terrain management.

Clues can be found in the comparison of recent and old (1946) aerial photographs and in field observations. However, neither approach provides very detailed information. The two series of aerial photographs are very different in quality as well as photograph characteristics such as tone and texture. This implies that not all the differences in these characteristics can be interpreted as differences in vegetation. Moreover, the necessary data of a ground survey of areas which have evidently changed strongly, e.g. the northern part of the coastal plain are missing, so we cannot understand in detail the vegetation pattern shown on the 1946 pictures. As for the field observations, these are more or less incidental of character, since the main objective of our research was to study the actual pattern of vegetations, not their dynamics. It should be stressed that a detailed study of vegetation dynamics requires a different approach (see e.g. Hallé et al., 1978), The compilation of a vegetation or landscape-ecological map such as we have produced, can be considered as a most useful, if not indispensable expedient, but is only one part of such a study. We shall return to this subject in the following chapter (12).

In the next paragraphs, four regions will be discussed in which present or recent vegetation changes are (or were) most prominent. In each case, the impact of the vegetation changes on the food availability of the Javan rhino will be discussed briefly. These regions are:

- the northern part of the coastal plain of the mainland;
- the rattan shrublands of the interior;
- the beach ridge;
- the present grazing grounds.

11.4.2 The northern part of the Coastal plain (landscape unit 21).

Here, since 1946, the last vast areas of (alang-alang) savanna have disappeared. At present, these areas are covered by specific, very homogeneous forest types generally dominated by Ardisia humilis (comm. XXII, XXIII and XXXVII; see also section 9.4). Further succession is believed to lead very slowly towards a more diverse forest type. This would be a more mature form of the Ximenia-Ardisia community (XXIII; compare plot 38) on the raised pseudo-barrier reef, a Nauclea-Syzygium forest (XXI) in most parts of the lagoon and possibly a form of the Derris-Sonneratia forest (XXXVIII) in the lowest, more or less permanently brackish parts of the lagoon. However, there are no indications that such changes will take place within the next few decades to come.

The change of savanna to forest in this area undoubtedly reduced the availability of food plants to the rhino. As mentioned above, the area is not used intensively by rhinos at present. Formerly, the situation was very different. According to Hoogerwerf (1970), the coastal plain was once one of the major feeding areas of the rhino (apparently in spite of its seasonal water shortage). In fact, Hoogerwerf mentions as the major food plants two species which are (as far as non-littoral vegetations are concerned) more or less restricted to the coastal plain, viz. Glochidion zeylanicum and Desmodium umbellatum. Possibly, these species grew more abundantly in the savannas than they do now in the Ardisia shrub forests. Moreover, as Ammann (1985) points out foodplants are more attractive to the rhinos when they grow in unshaded vegetation. In fact, this principle also applies to the dominant species of the stub forests (Ardisia humilis). Although this species may be considered as a (slightly) important foodplant species (see Table 10c), and their trunks in the stub forests are not yet too thick for the rhinos to break, we never observed feeding marks on Aridisia in the stub forests. The only case of feeding on Ardisia in the coastal plain was observed in a remnant of the former Imperata dominated savannas near Niur (Calotropis-Dodonaea community).

Succession towards more diverse forest types can be assumed to imply a certain increase in the suitability of the district as a feeding area.

11.4.3 The rattan shrublands of the interior (mainly landscape units 12, 13, 14 and 19)

In many parts, the pattern of former fields in the interior can still be more or less clearly be recognized: instead of being covered by forest again, the former humas (dry rice fields) and reumas (i.e. recently deserted humas) have, for the greater part, turned into extensive and impenetrable rattan-shrublands, 'glades' as Schenkel et al. (1978) call them (Hyptis-Daemonorops comm., no. XV). Obviously, the total area covered by these vegetations is far more extensive than realized by Schenkel et al..

Succession towards more woodlike vegetations is strikingly slow. We do not agree with Schenkel's assumption that rapid changes occur in these vegetations. (Note that Schenkel did not have any imagery at his disposal, neither out-dated nor recent and that an inventory of the area's plant communities was not one of his objectives). Vegetation changes do, however, occur and though the exact mechanism is not yet fully understood, they are likely to lead in the long run, according to soil-characteristics to forest types related to either the Bambusa-Drypetes community (XII) or the Pterospermum-Arenga community (VII). As for the number of hectares involved, the latter process is the most important one. However, it is interesting to note that in our experience wherever in Ujung Kulon rattan shrublands showed signs of succession towards a more forest-like vegetation, Arenge obtusifolia (as a species) was never observed to be a pioneer of any significance. Moreover, the species is virtually lacking in the more mature secondary forests in the western-most part of the Salacca plain, where (in contrast to most parts of this landscape unit) the clay soils are sufficiently well-drained to allow the occurrence of Arenga (see plot 302).

Vegetation changes within the rattan shrub jungles are of very great importance as far as food availability to the rhinos is concerned, since these vegetations cover an enormous surface in Ujung Kulon and have proved an excellent feeding area. Unfortunately, our knowledge on the (slow) changes in the vegetation is limited. Even so, it is possible to indicate some main lines. We may assume that the succession in the rattan shrublands (which all belong to the Hyptis-Daemonorops community) proceeds along the following steps:

a. Succession from sub type with Lantana camara to sub type with Dillenia excelsa. Gradually, the Lantana shrubs disappear, while the density of sapling-sized treelets (belonging to various species) strongly increases.
b. Appearance of taller trees and small groups of trees emerging above the closed shrub layer.
c. Gradual closing of the tree layer. Simultaneously, there is a gradual decline of the shrub layer, including small sized treelets and tall gingers.

ad a: As for food availability to the rhino, step a. is undoubtedly an important improvement, since the Dillenia sub type, with regard to both species composition and structure, is an even more ideal feeding habitat than the Lantana sub type. Ammann (1985) is of the same opinion. Although he does not discern floristically defined sub types of shrublands, he does mention once Lantana dominated forms as being a non-optimal feeding area.

ad b: We assume this step to be a slight improvement, although the total area of the valuable shrublands is somewhat reduced. The parts of the shrubland where trees occur are less intensively used by the rhinos (Ammann, 1985), but the landscape as a whole, viz. a mosaic of open shrubland, shrubland with scattered trees and small groups of trees is considered to be the optimal feeding area by the same author. This is undoubtedly due to the abundance of transitional vegetations rich in food plants.

ad c: This step is a very complex one, since more than one forest type can be expected to develop, depending on differences in soil (see above). We assume that the dominance of Arenga obtusifolia in secondary vegetations on relatively well-drained soils originates, when successional stage c coincides with an exceedingly dry year. The impact of which is probably reinforced by vertic properties of the (sub)soil and eventual forest fires. Under such circumstances young Arenga trees, sprouting from subterraneous shoots, are less vulnerable to (climatic) hardship than 'normal' treelets. (On the less well drained soils, the same story holds for the young offshoot of Bambusa blumeana).

The hypothesis presented above implies that the genesis of Arenga-dominated vegetations depends on a number of uncertain factors (of varying importance):

- the coincidence of an exceedingly dry year and successional stage c.
- the availability of some scattered, mature Arenga trees from which subterraneous shoots can sprout (vicinity).
- possibly the occurrence of forest fires.

In addition, we may point to a most important uncertainly for the distant future: the impact of the ash cover on the vertic character of the subsoil. Vertic processes imply the mixing of material from the surface and topsoil with lower horizons. In the specific case of Ujung Kulon, this implies that the subsoils will gradually become somewhat more coarse in texture. This will in turn reduce the vertic character of the subsoil. There are indications that even small differences in the (original) texture of the subsoil are even at present of great importance for the succession. For instance, soil types o and p are in many respects rather similar and both carry the same type of Arenga forest (VIIa). However, type p is (slightly) sandy and the predominance of Arenga (consequently?) less pronounced. More such examples could be given. Further study must however prove this assumed relation. As for the availability of rhino food plants, the various types of secondary forest, resulting from step c, vary largely. Moreover, they may vary with regard to the average size and density of gaps. With their abundance of rapid-growing tree seedlings and saplings, gaps are of enormous importance as a source of rhino-food (Hommel, 1983; Ammann, pers.comm.; Ammann, 1985). However, gaps are very scarce in young secondary forests. Even in the one hundred year old stands of the Bischofia-Ficus community (X) and the Nauclea-Syzygium community (XXI) in Ujung Kulong gaps, are rare; at least they were until recently. Thus, we may conclude that step c implies primarily a decline of food availability. Only in the long run can a renewed increase in food plants be expected, when the frequency of gap forming increases. When strangling figs start to invade the forest, the average gap-size will increase notably. Moreover, in the very distant future the dominance of Arenga palms may be assumed to decline gradually, as shade-tolerant species will settle. The closed canopy of the Arenga forest allows such settling, since the forest micro climate is readily buffered against seasonal drought. However, availability of seeds (vicinity) is the major constraint.

Although quantitative data are lacking, we assume that at present, in most stands of the rattan shrublands, step b (i.e. appearence of taller trees and small groups of trees) prevails. This implies that currently in these landscape units food availability is slightly increasing and we assume that this situation will not alter much during the next few decades. However, more detailed, quantitative research is urgently required.

11.4.4 The beach ridge (landscape unit 16)

The two series of aerial photographs both show in many parts of the beach ridge a rather complex pattern of different vegetations. However, it proves that nearly all these vegetations can, at least at present, be considered as different forms of one and the same community (Comm. of Dendrocnide and Syzygium; XIX). Probably, the situation formerly was, on average, not very different, although at times the share of the grassland communities (no. XXV and XXXII p.p.) must have been much greater.

The internal variation of the stands of the Dendrocnide-Syzygium community can primarily be explained as the result of irregular, former cutting and burning practices, although other aspects are also of importance (see section 9.3.XIX).

It is very likely that illegal 'vegetation management' by poachers persisted in this remote zone, which is reknowned for its abundant wildlife, for far longer than in the northern coastal plain. On the other hand, vegetation management as a tool of nature conservation has always been of minor importance in this region.

By comparising of the two series of photographs, we learn that east of the mouth of Citadahan, succession has lead to relatively closed vegetations, more than is the case in the western area between Cibunar and Citadahan.This phenomenon can easily be explained. In the eastern part natural processes prevailed, while the western part was again submitted to vegetation management only recently (in the seventies). The actual area in which management practices were executed also actually covered a small part of the adjacent fluvio-alluvial plain, situated between the beach ridge and the Cibunar river.

As for the impact of these vegetation changes on food availability to the rhinos, there are many similarities with the situation as described for the rattan shrublands. However, it seems that on the beach ridge succession proceeds less slowly, which can be explained by the lack of Krakatau ash in most parts (see section 9.4). Thus a decrease in rhino food is to be expected on the beach ridge much sooner than in the rattan shrublands of the interior. Considering the small total surface of this landscape unit, this is not a very dramatic development. Even so, it seems (for more than one reason) worthwhile to set back the succession now and then in parts of the area (see chapter 12).

11.4.5 The present 'grazing grounds' (landscape unit 23)

As stated before, it is not correct just to consider the few small grazing areas situated opposite Peucang Island and the Handeuleum archipelago, as representative relics of the extensive savannas which once occured along Ujung Kulon's north coast.

Their vegetation cover (mainly the community of Fimbristylis and Chrysopogon; XXVI) and their soil profiles differ significantly from the average situation in the former savanna landscape (see section 9.3.XXVI). Even so, the forest type which constantly tries to occupy these artificial clearings is a very common one, viz. the community of Nauclea and Syzygium (no. XXI), which also covers extensive parts of the interior of the coastal plains.

In fact, to allow the grazing grounds to survive, annual management is preferable and currently in general, also executed. During the years of our fieldwork, the park managing authority, PPA, put a lot of effort into the rehabilitation of one of these sites, viz. the grazing ground situated between the mouths of the Cikuya and Cidaon rivers. At present, the boundaries of all three Chrysopogon grazing grounds correspond fairly well (again) with the situation as shown on the 1946 imagery.

However, there is one striking difference. In 1946 there was a third grazing area opposite Peucang Island, viz. west of the mouth of the Cikuya river (plot 99). At present, this site is completely covered with Nauclea-Syzygium forest. The soil profile of this site is less characteristic (i.e. more loamy) than the ones below the remaining grazing areas. Possibly, less unfavourable soil conditions stimulated a more vigirous growth of invading forest pioneer species, which in turn explains the fact that the site was given up as a grazing ground.

As far as availability of rhino foodplants is concerned, this obviously implied an improvement. However, considering the very small size of the locality this improvement is rather insignificant.

As far as the remaining grazing grounds are concerned, the continuous alternation of management and sprouting of regrowth is hardly of interest for the rhinos. Young treelets are removed before they reach the size preferred by the rhino.

CHAPTER 12: ASPECTS OF MANAGEMENT

12.1 Introduction

This chapter presents some conclusions with regard to the management of Ujung Kulon. We shall restrict ourselves to aspects concerning the food availability of both rhino and banteng, the possible reintroduction of the tiger and gibbon and the botanical value of the area. The conclusions for the greater part correspond with the ones formulated by Hommel (1983). Only some minor corrections and additions have been made. Finally, some recommendations for management and future research will be summarized.

12.2 Food availability of the Javan rhinoceros

Active vegetation management in order to increase the food availability of rhino food plants has been described by Schenkel et al. (1978). This management implies the local cutting of Arenga obtusifolia (langkap) palms in vegetations dominated by this species. In 1982, Schenkel & Schenkel-Hulliger proposed starting such management activities.

The background of this proposal is formed by a number of assumptions:

- Arenga forest is of little importance for the Javan rhino, as far as food availability is concerned;
- rapid vegetation changes are occurring in Ujung Kulon especially in the rattan shrublands, which contain important food sources for the Javan rhino (such as giant gingers, treelets and saplings), but are at present threatened by the rapidly invading Arenga;
- a change in feeding behaviour of the rhino indicates a shortage of food plants.

In spite of our great respect for Prof. Schenkel's longstanding experience in Ujung Kulon and his enormous merits concerning the conservation of the Javan rhino, we tend to believe that these assumptions are not all quite correct and at present there is no real need for an active vegetation management on behalf of the Javan rhino.

As for the significance of Arenga obtusifolia forest as a food source for the rhino, we do agree that the food availability in the Arenga forest itself is indeed very limited. However, large gaps in the palm layer are regularly caused by the downfall of forest giants, such as strangling figs and temporarily provide a wealth of saplings, i.e. rhino food. These natural gaps are in fact very similar to the 'management plots' described by Schenkel et al. Furthermore, the marginal zones and (as Schenkel himself also indicates) the forest edges are important sources of food plants.

As for the presumed rapid changings in the rattan shrublands it proves that succession in these vegetations is on the contrary remarkably slow. Moreover, we assume that succession in these shrublands (and also in Ujung Kulon as a whole) over the last decades have not lead to a decrease in the food availability but, on the contrary, to a slight increase. There is also no need to fear a decrease in immediate future.

As for the suggested change in feeding behaviour, this hypothesis is contradicted by the conclusions of the WWF-rhino research team (Sajudin, pers. comm.). Moreover, the different results of the various students of rhino food plants can at least for the greater part, be explained by different research methods and different study areas.

Finally, it is of importance to observe that there are indications that in the long run Schenkel's management approach may yield the opposite of its purpose. After a few years, the Arenga palms seem to return (sprouting from subterraneous shoots) in higher densities than before, as observed in Schenkel's experimental plots (Hilligers, pers. comm.) Unfortunately, the exact location of these plots is not well indicated. After the return of the Arenga forest, the sites no longer strongly contrast with the surrounding vegetation and at present they cannot be traced.

12.3 Food availability of the banteng

With the alang-alang savannas, obviously important feeding areas for the banteng have disappeared. However, no decrease in numbers of this species has occurred. Apparently, the banteng is far less dependent on open grasslands than Hoogerwerf (e.g. 1970) realized.

The rattan shrublands of the interior can also be considered as being an important source of foodplants for the banteng. Though a decrease in the total area of these shrub lands may eventually lead to a certain decrease in the number of bantengs in Ujung Kulong, we may assume that the species is ecologically flexible enough. No dramatic collapse of the population is expected, not even in the distant future.

At present, there is absolutely no need for restoration of the former alang-alang savannas as far as the food-availability for banteng is concerned.

12.4 Reintroduction of the tiger and gibbon

The Javan tiger disappeared from Ujung Kulon over fifteen years ago. At present, the Javan tiger (a distinct subspecies) has probably died out in all parts of its former distribution area. There are no specimens left in zoos either. Reintroduction of tigers in Ujung Kulon would thus imply the import of an alien subspecies, e.g. the Sumatran tiger. If the savanna-landscape in the northern part of the coastal plain were to be restored, this might be feasible. It would certainly contribute to the completeness of Ujung Kulon's ecosystem and its value as a National Park. However, we strongly advise against such an experiment. There are no guarantees that the animals can be kept within the park's boundaries, which means that there are no guaranties they will survive. Moreover, it will negatively influence the villagers' attitude towards the vicinity of a conservation area. Finally, the presence of tigers can be considered as a threat for the Javan rhino, in a direct way as a (possible) predator on rhino-calves, but (more important) in an indirect way; since fear of tigers cannot be expected to stimulate the park staff to patrol very intensively, especially in the interior. Although the last tiger died years ago in West Java, the fear of this large predator is still very much alive.

As for a possible reintroduction of the Javan gibbon there are no such objections. We may assume that gibbons occured in Ujung Kulon before the Krakatau eruption, but did not survive the complete defoliation of the forest. At present, large areas of ideal gibbon habitat are (again) available, especially on Mt.Payung and the central plateaus. It is assumed that the gibbons from nearby Mt.Honje cannot reach the central and most western parts of Ujung Kulon, because of discontinuities of forest cover. The animals avoid the ground and its proximity. This means that after the reintroduction of gibbons, uninterrupted forest stands may become of great importance, regardless of their width. Thus, the narrow strips of Areca-Arenga forest in the fluvio-alluvial plain and (even more important) the Dendrocnide-Arenga forest on the land side of the calcareous beach ridge may become of great significance as gibbon corridors. This provides an additional reason to refrain from any vegetation management (sensu Schenkel) in these stands.

12.5 Botanical value

Ujung Kulon is one of the last remaining wilderness areas in the lowlands of Java. It contains extensive stands of primary and old secondary vegetations in which many rare species are present. The special climatical and plant-geographical position of the area further contributes to its botanical significance. From a botanical point of view, the upper parts of Mt.Payung (primary, evergreen rainforest) and both Peucang Island and the upper parts of Mt. Telanca (primary and old secondary semi-deciduous forest) are the most valuable parts. However, the botanical significance of the Arenga forests of the lower altitudes on the mainland is often underestimated. Here we find many relics of the former primary, semi-deciduous forests (though in very low densities), some of them lacking on Peucang Island and possibly also on Mt. Telanca (e.g. Palaquium ottolanderi). From a botanical point of view, area management (sensu Schenkel) in Arenga forests is not very attractive. The younger secondary vegetations including those which are still, or until recently, influenced by management practices are less interesting. This also holds for the rattan shrublands of the interior, in spite of the remarkably high species-diversity of many of them. One exception to this rule is the man-made grasslands on the calcareous beach ridge along the south coast, in which an extremely rare grass (Digitaria heterantha) can be found. Continuation of the management (cutting and burning) there (i.e. near Cibunar) is thus desirable. Compared to the rainforest of Mt.Payung, the primary forests of Mt.Honje are of even greater botanical value. In spite of their status as conservation area they are still very much endangered. Rapid action here is urgently required.

12.6 Recommendations

- The conservation of the Javan rhino should remain the very first objective the management of the Ujung Kulon National Park. As Schenkel stressed many times, this greatly depends on the attitude and physical welfare of the guards. This means that they should always receive sufficient payment, appreciation for their work and medical care (see also Schenkel, 1982).
- Reintroduction of tigers is strongly advised against; reintroduction of Javan gibbon should be seriously considered.
- Strict protection should be given to the last remnants of primary forest on Mt.Payung, Mt. Telanca, Mt.Honje and Peucang Island.
- Area-management (sensu Schenkel) in the Arenga forests of the interior is

not at present required and is advised against.

- Area-management in the northern parts of the coastal plain is not needed for the food availability of either rhino or banteng.

  However, some sort of vegetation management in areas which were formerly covered by alang-alang savannas may be considered desirable, e.g. to increase the visibility of the animals on behalf of visitors. In that case we recommend a system of 'shifting management', i.e. regularly clearing one relatively small part of the total area, which consequently should be neglected for at least five years. The resulting diversity in both vegetation and scenery may be considered as an improvement of an area which is at present little more than an ecological ruin.

  In a considerable part of the former savannas, however, succession should be allowed to proceed without human intervention.
- A similar type of management is proposed for the (western part of) the calcareous beach ridge and the environs of the present grazing grounds, but should not extending beyond the boundaries of the Nauclea-Syzygium forest.
- The following research items are considered to be urgent:
  a. the succession from rattan shrubland to forest;
  b. the influence of both rhino and banteng on succession;
  c. food-competition of these two species in relation to succession;
  d. possibilities for translocation of rhinos to other areas as soon as the population size allows it;
  e. the impact of the high densities of herbivores on the regeneration of the forest on Peucang Island.

SUMMARY

I. Introduction

the study area

Ujung Kulon is a peninsula situated on the utmost western tip of the island of Java (Indonesia). The area covers some 30 000 ha. Its fame and importance are mainly due to its population of Javan rhinoceros, which is probably the last remaining one in the world.

background of the study

Scientific research in Ujung Kulon has focussed until now mainly on the rhinoceros and some other big mammals. A systematic study of the area's vegetation cover has never been undertaken. Other aspects of the landscape (e.g. soils) were also poorly understood. This holds even for something as basic as topography.

objectives of the study

The first and major objective of our study was to fill in some of these gaps in the knowledge, especially concerning the area's major vegetation types and their distribution. A second objective was to give a broad estimate of the suitability as a rhino-habitat for the various sub-regions. Moreover, information would be gathered on possible vegetation changes, which might affect the availability of rhino-foodplants.

methods

As for methods, we have opted for a broad landscape-ecological approach. Thus, the landscape was studied as a fully integrated entity, in which vegetation is but one of the ingredients (or 'attributes'). In this report the major attributes (history, climate, geology, geomorphology, soils, flora, vegetation and fauna) are first described in separate chapters. The next step is an integration of all information, resulting in the description of landscape-units. These are shown on the landscape-ecological map, which is attached to this report as an appendix. The landscape-units (or parts of them) can be interpreted in terms of suitability for rhino. Moreover, they provide a basis to describe and judge the major lines of succession. Finally, conclusions can be given in terms of recommendations for management and future research.

II. Aspects of the landscape ('land-attributes')

history

Once, the area was inhabited and partly under cultivation. Depopulation followed as the aftermath of the 1883 eruption of the Krakatau, a volcano situated only 60 km from Ujung Kulon. Tidal waves (tsunamis) swept away the coastal villages and volcanic ash covered the fields in the interior. The pattern of the former fields can still be recognized, at least on the less well drained soils. Once deserted, the area became a hunting-area and later (in 1921) a nature reserve. In the northern part of the coastal plain vast savannas were maintained by regular cutting and burning of regrowth. During the last decades, this form of vegetation management has largely been neglected.

climate

The climatological position of Ujung Kulon is of special interest. Rainfall data for Java's First Point (representative of Ujung Kulon's lowlands) show a yearly average of 3 249 mm and some 30 to 40 rainy days during the four consecutive driest months of the year. This implies that, in theory, the area is a borderline case as far as the possibility of the growth of evergreen rainforest is concerned. However, in practice, the regular occurrence of an exceedingly dry season prevents the growth of rainforest. Thus the climax vegetation of the area's lowlands is a (semi)deciduous monsoon forest. On the other hand, evergreen rainforest does occur on the higher parts of Ujung Kulon's mountain area (Mt. Payung). The ecologically important contrast between lowlands and mountains of only moderate height (500 m) is caused by the so-called telescope-effect: relatively low, isolated mountains, surrounded by sea, reflect the physiognomic vegetation-zoning of higher mountains in a condensed, 'telescoped' way. Moreover, on Mt. Payung rainforest species occur at far lower altitudes than usual on the mainland of Java.

geology and geomorphology

Geologically, Ujung Kulon is a very young area. Its oldest parts (Mt. Payung) date back to the Miocene. An outline of the various geomorphological units (with notes on their geology) is given in section 6.3. The units can be grouped as follows:

- the SW hilly region (including the Mt. Payung massif). This is the highest and most steeply dissected part of the area.
  The major types of rock are tuffs and eruptive rock (probably andesite).
- the central calcareous region, consisting of both limestone plateau fragments and rolling to hilly uplands with heterogeneous marine sediments as parent material.
- the plains, consisting of both a fluvio-alluvial plain (separating the two main units mentioned above) and several types of coastal plains (s.l.) varying significantly in their origin and lithology.

Soils

An outline of the various soil types of Ujung Kulon is given in section 7.3. The soils are classified according to the FAO-UNESCO system (1974) and grouped and arranged according to drainage features. An important aspect of the soils (not included in the classification) is the topsoil of Krakatau ash. The thickness of the ash topsoil (0 to 30 cm) is determined by a complex of factors, e.g. drainage of the subsoil, slope (percentage and length) and altitude. On low altitudes along the north coast, the ash-layer is generally lacking, which is mainly due to the erosional impact of the 1883 tidal waves.

Flora and plant-geography

The plant-geographical position of Ujung Kulon is very interesting. The lowlands can be considered as a drought island in predominantly ever-wet West Java, showing some similarity in flora with the seasonally dry eastern part of the island. The rainforests of the 'mountains' have some genera in common with the rainforests of nearby Sumatra, which are lacking elsewhere on Java. Moreover, many species occur in Ujung Kulon which are rare elsewhere in Java or are believed to be extinct there. One species even is not known to occur anywhere outside of Ujung Kulon (Heritiera percoriacea, Sterculiaceae).

Vegetation

An outline of the various vegetation types of Ujung Kulon is given in section 7.3. The types are described as plant-communities; they are defined on a basis of their complete floristic composition, unbiased by any existing classification system. A gross vegetation table, showing all vegetation types and all sociological species groups is attached to this report as an appendix.

A shortened version is given in Table 9a. The plant-communities, on account of their floristic composition, can also be clustered into a smaller number of community groups. These groups, like the communities themselves, can readily be interpreted in an ecological way. Moreover, they are rather homogeneous as far as their physiognomy is concerned. However, they do not fully correspond with the various formations which are found in the area. Therefore, the most characteristic formations are discussed in a special section (9.4). These formations are:

- palm forests: secondary forests, more or less restricted to relatively well drained soils; on lower altitudes; probably to a large extent influenced by the incidental occurrence of an exceedingly dry year. Both forest fires in the past and vertic properties of the soil are assumed to be of additional importance.
- bamboo forests: secondary forests, replacing the palm forests on less well drained soils or (more locally) replacing the rattan shrublands (see below; mainly on locations strongly influenced by erosion processes).
- stub forests: secondary forests of the coastal plains, which originated from the artificial savannas after the gradual neglect of their maintenance.
- rattan shrublands: secondary shrub vegetations of the lowlands, restricted to only moderately well or somewhat poorly drained soils; remnants of the former fields, where the contrast in physical properties between the subsoil and the ash-topsoil, in combination with the exposed location and the seasonally dry climate, hampered normal succession towards forest.

fauna

The fauna was not dealt with in great detail, mainly because many others have studied Ujung Kulon's abundant wildlife. Attention was paid to only a few (groups of) mammals, viz. the Javan rhinoceros, the primates, the larger carnivores and the even-toed hoofed mammals. The latter group comprises all larger herbivores of the area, other than the rhino, thus all its potential food competitors. As for the Javan rhinoceros, the major habitat requirements are discussed, viz. accessibility, absence of pathogenic germs and availability of salt, water (to drink and bath), mud (to wallow) and cover (protection against climatic hardship and to provide hiding places).

III. Integration and evaluation

the landscape-units

An outline of the various landscape-units is given in section 11.2 (see also the attached landscape-ecological map). For each of the landscape-units, the cover of the various vegetation types and soil types was estimated (see resp. Tables 11a and 11c).

suitability as rhino-habitat

Of all habitat requirements described, three are assumed to show important regional differences. These requirements are: availability of forage, availability of drinking water and accessibility. The suitability of the environment in relation to each of these requirements is shown on three draft-maps (Fig. 11a-c), using the landscape-ecological map as a basis. The three aspects are integrated into one 'suitability-map' (Fig. 10d) using a very simple, semi-quantitative model. Due to the lack of detailed information and the rough character of the procedure, the resulting map is only of indicative value. Even so, it is interesting to compare this map with the distribution map of the rhino, as given by Schenkel and Schenkel-Hulliger (1969). We assume that the size of the distribution area and the total number of rhinos have been systematically underestimated by former students, due to imperfection of the census method.

important changes in the vegetation

Vast areas in Ujung Kulon are covered with secondary vegetations of very different age. Large areas thus carry a vegetation cover which is still far remote from its climax state. An outline of areas in which at present (or only recently) important changes in the vegetation cover are taking (or have taken) place, is given in section 11.4. As for the suitability for rhino, the change of the rattan shrublands in the interior towards forest is the most important. Eventually, this will lead to a decrease in the availability of forage. However, the succession is strikingly slow, while intermediate stages are assumed to provide more forage than the initial ones. At present and for the next few decades, no decrease of available forage is to be feared.

IV. Conclusions

aspects of management

The final chapter of this study (12) presents some conclusions with regard to the management of the area. Attention is paid to the food availability of the Javan rhino and the banteng (wild ox), possible reintroduction of tiger and gibbon and the botanical value of the area.

recommendations

A number of practical recommendations are enumerated in section 12.6. These are briefly:

- the conservation of the Javan rhinoceros should remain the very first objective of the management in Ujung Kulon. This depends for the greater part on the attitude and physical welfare of the guards;
- reintroduction of tigers is strongly advised against, reintroduction of gibbons (in the central part of the area) should be seriously considered;
- strict protection should be given to the last remnants of primary forest on Mt. Payung, Mt. Honje, Peucang Island and Mt. Telanca;
- area-management in the Arenga palm-forests of the interior is at present not needed and is not advised;
- area-management in the northern part of the coastal plain is not necessary as far as the food availability for rhino or banteng is concerned. However, some sort of vegetation management may locally be applied for other reasons;
- some vegetation management (periodically clearing of regrowth) is proposed for the utmost western part of the beach ridge along the south coast and the environs of the present grazing areas (in addition to the regular management of the grazing grounds themselves).

In addition, some recommendations for future research are given:

- the succession of the rattan shrublands towards forest;
- the influence of both rhino and banteng on succession;
- food-competition between these two species in relation to succession;
- possibilities for translocation of rhinos to other areas as soon as the population size allows;
- the impact of the high density of herbivores on the regeneration of the forest on Peucang Island.

RINGKASAN (Concise summary in Indonesian language)

Semenanjung Ujung Kulon yang terletak di titik paling barat pulau Jawa adalah salah satu dari dataran rendah rimbaraya yang terakhir di pulau itu. Sebagai daerah cagar-alam, Ujung Kulon penting sekali karena daerah itu kemungkinan merupakan satu-satunya tempat penhuni badak jawa di dunia.

Semenanjung yang sekarang tidak berpenghuni itu sebelumnya memang ditinggali dan sebagian besar terpakai sebagai tanah pertanian. Titik balik sejarah Ujung Kulon disebabkan oleh letusan terkenal dari gunung Krakatau yang terletak di dekatnya pada tahun 1883. Letusan ini diiringi air bah yang menyapu bersih desa-desa dan tumbuh-tumbuhan di selusur pantai. Karenanya juga seluruh semenanjung, termasuk tanah pertanian ditutupi oleh lapisan abu tebal dari gunung berapi itu.

Sekarang, satu abad sesudah bencana, tanam-tanaman yang tumbuh, memperlihatkan pola ragam dari berbagai jenis vegetasi terutama vegetasi sekunder. Dan ternyata keaneka-ragaman itu ditentukan oleh sejumlah faktor yang cukup besar. Pertama-tama hal itu dapat diamati dengan hubungan antara vegetasi dengan geomorfologi dan tanah. Selanjutnya hal itu sebagian besar dapat dijelaskan dengan perbedaan iklim, pengaruh dari binatang dan terutama penggunaan tanah sebelumnya.

Karena sifat-sifat tertentu yang sangat tidak menguntungkan dari abu lapisan atas tanah bagi semai muda, kita masih bisa mengenali dengan cukup jelas keadaan pola tanah dari tahun 1883. Daripada ditumbuhi lagi dengan hutan, tanah itu sekarang hanya dipadati dengan semak belukar berduri. Namun begitu, semak itu sangat kaya akan makanan untuk badak-badak Jawa.

Jenis vegetasi di daerah pantai mencerminkan bentuk pemakaian tanah yang berbeda jauh dengan pemakaian sebelumnya. Di sana, padang rumput buatan dipertahankan dengan cara 'pengelolaan vegetasi', yaitu dengan penebangan dan pembakaran.

Perubahan-perubahan vegetasi dari Ujung Kulon dalam 30-40 tahun terakhir kemungkinan tetap terbatas pada justru daerah-daerah di mana dulu dibakar dan ditebang dan pada bekas tanah-tanah pertanian.

Perubahan-perubahan di daerah-daerah tebang-bakar berlangsung lancar dan menghasilkan jenis hutan yang sangat homogen dan khas. Sekarang jenis hutan ini secara pelahan-lahan akan terus berkembang menjadi hutan yang kaya jenisnya. Sedangkan perkembangan selanjutnya dari semak-belukar yang menutupi bekas tanah-tanah pertanian merupakan proses yang jauh lebih muskil dan juga belum jelas sama-sekali. Jadi perubahan-perubahan yang terjadi di sini sangat lambat sekali.

Hingga kini, keseluruhan perubahan dalam vegetasi pasti tidak jelek bagi badak-badak Jawa. Karena akhirnyapun perkembangan selanjutnya dari tumbuh-tumbuhan di bekas tanah-tanah pertanian mungkin memang akan berarti kemunduran dari tersedianya bahan makanan.

Namun jumlah wilayah semak-belukar yang begitu penting bagi badak-badak Jawa sebenarnya masih sangat banyak. Perubahan perubahannya seperti yang telah disebut di atas, sangat lambat dan ada kemungkinan bahwa bahan makanan untuk badak Jawa yang terdapat dalam antar-periode/fase, akan lebih kaya lagi daripada semak-belukar yang sudah ada sekarang.

Oleh karena itu, untuk sementara waktu, tentunya tidak ada alasan untuk berpindah ke sistim 'pengelolaan vegetasi aktif'.

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APPENDIX A: SUMMARIZED PLOT-DATA

Column 1: Plot number
Column 2: Location, see Landscape-ecology map
(Appendix F); * = in Mt.Honje region
Column 3: altitude (m)
Column 4: slope (%); * = almost perpendicular
Column 5: vegetation type, see section 9.3;
* = insufficiently known; more or less intermediate
between type XIV and XXI
Column 6: soil type, see section 7.3; * = water.
Column 7: depth of ash (cm); * = burried ash-layer, starting
below 7 to 60 (mean 30) cm and 5 to 50+ (mean 22) cm thick.

1	2	3	4	5	6	7
1	N10	1½	0	XXVI	q	0
2	N10	2	0	XXI	q	0
3	N10	1½	0	XXI	s	0
4	N10	1½	0	XXVII	u	0
5	O13	5	0	VII?b	r	10
6	Q16	3	3	XX	f	30
7	Q16	5	15	XXXI	f	10
8	Q16	4	5	XXXII	a	0
9	Q16	5	5	XXV	f	20
10	Q16	10	5	XIX	f	10
11	Q16	12	6	XIX	f	0
12	t7	1	5	XXXII	b	0
13	t7	8	*	XXXIII	a	0
14	S7	2	15	XXVIII	c	0
15	R6	3	3	XXVIII	c	10
16	N2	80	1	VII?a	o	30
17	j14	2	0	XXIX	c	0
18	K14	5	1	XIII	u	*
19	K14	5	1	XIII	u	*
20	K15	10	0	XIII	l	20
21	M7	1½	0	XXIX	c	0
22	M7	1	0	XXX	v	0
23	M7	2	0	XI	e	?
24	K9	1½	0	XXIX	b	0
25	j14	2½	1	VIIc	l	25
26	k15	12	2	VIIc	l	5
27	K9	3	0	X	e	0
28	K9	2	0	XI	e	0
29	Q16	5	2	XXXII	f	10
30	Q16	5	2	XXXI	f	10
31	t7	2	1	XXXII	c	0
32	q6	1	2	XXVIII	b	0
33	q6	6	0	VIIb	h	0
34	o4	1½	0	XXIX	c	0
35	O4	3	0	VIIb	g	20
36	n3	1	1	XXXII	b	0
37	n3	1½	1	XXXII	b	0
38	G20	1	0	XXIII	d	0
39	e20	½	0	XXXV	x	?15
40	e20	1	0	XXIX	d	0
41	e20	1	0	XXIII	d	0
42	k33	2	1	XVb	l	0
43	g31	1	0	XXIII	d	0
44	F29	1	0	XXIII	d	0
45	D27	1	0	XXIX	d	0
46	D27	1	0	XXIII	d	0
47	D26	1	0	XXXVII	x	0
48	D26	1	0	XXXVII	x	0
49	D26	½	0	XXXV	x	0
50	D26	½	0	XXXV	x	0
51	D26	½	0	XXXV	x	0
52	D26	½	0	XXXV	x	*
53	d26	1	0	XXII	x	0
54	d25	1	0	XXII	s	0
55	d26	½	0	XXXV	x	0
56	d26	0	0	XXXIV	*	0
57	E22	1	0	XXIX	d	0
58	E22	1	0	XXIII	d	0
59	e20	1	0	XXII	d	0
60	e20	½	0	XXXV	x	0
61	g20	1	3	XXIX	c	0
62	J16	2	0	VIIc	l	10
63	19	1	2	XXIX	c	0
64	M8	1	0	XXIX	c	0
65	N10	1½	0	XXVI	q	0
66	M8	1	0	XXIX	c	0
67	N10	1½	0	XXVI	q	0
68	n11	4	1	XIV	r	*

1	2	3	4	5	6	7
69	n12	3	0	XIII	r	*
70	n11	3	0	XIII	r	20
71	N10	0	0	XXXVIII	w	0
72	N12	3	0	XIII	r	25
73	N12	3	0	XIII	r	25
74	N10	1½	0	XXVII	q	0
75	17	1	0	XXXVIII	v	0
76	m10	1	3	XXIX	c	0
77	m10	1	3	XXIX	c	0
78	m10	0	0	XXXVIII	w	0
79	N10	1½	0	XXVII	q	0
80	N11	2	0	XIII	r	20
81	n2	½	20	XXXII	b	0
82	n2	1	3	XXVIII	c	0
83	n2	15	30	VIIa	o	10
84	n2	70	2	VIIa	o	35
85	n2	60	20	VIIa	o	30
86	N2	70	15	XVb	o	25
87	N2	60	5	VIIa	o	30
88	N2	25	10	VIIb	i	5
89	m3	4	1	VIIc	r	10
90	m3	4	13	XXI	s	0
91	n3	1½	1	VIIa	g	25
92	N1	2	3	XXVIII	c	0
93	m1	2	1	XXVIII	c	0
94	m1	40	38	VIIb	i	25
95	N2	60	0	XXVII	u	45
96	N2	60	25	XVa	u	0
97	m2	75	0	VIIb	i	10
98	N9	1½	0	XXVI	q	10
99	N8	1½	0	XXI	q	55
100	N10	½	0	XXXVIII	w	0
101	P15	50	35	VIIb	i	25
102	q15	½	30	XXVIII	c	0
103	R15	50	60	XVIII	h	0
104	q15	50	75	XVIII	h	0
105	Q16	½	0	XVb	r	0
106	Q16	1½	6	XXVI	r	0
107	Q15	50	35	VIIb	j	25
108	Q16	4	1	XIII	r	15
109	g14	150	38	II	j	15
110	q14	250	55	II	j	20
111	R12	350	40	II	j	30
112	r11	450	40	II	j	4
113	r12	450	40	II	j	15
114	r12	350	30	II	h	16
115	S13	250	65	IV	h	25
116	S13	150	65	III	h	30
117	S10	500	55	I	j	12
118	s8	350	35	II	j	16
119	S10	475	50	I	j	15
120	S10	450	35	II	j	20
121	T7	150	25	III	j	15
122	t7	25	75	XXXI	a	0
123	T7	3½	5	XXVIII	c	0
124	T7	5	1	XIX	?f	10
125	T7	50	70	XVIII	h	0
126	s8	250	35	II	j	15
127	r10	475	55	I	j	20
128	R12	480	55	I	?h	20
129	n11	50	70	III	?h	20
130	n11	45	5	XVa	r	0
131	O11	75	25	III	h	10
132	o10	150	40	III	j	20
133	P10	250	40	II	j	5
134	P10	200	40	III	h	15
135	Q9	500	10	I	?h	15
136	Q9	450	38	II	j	20
137	q10	350	40	II	j	15
138	Q8	450	70	II	h	10
139	Q8	350	50	II	h	10
140	Q8	250	60	II	j	3
141	Q6	150	70	III	a	0
142	Q6	3	2	XX	?f	15
143	Q6	35	65	XVIII	h	0
144	m13	120	45	V	f	0
145	M12	120	1	V	1	20
146	Q16	6	0	XIX	f	13
147	p18	2	0	XVa	r	15
148	p18	2	0	XIV	r	15
149	p18	2	0	XXVII	u	0
150	P18	3	0	XIV	r	30
151	P18	3	0	XVa	r	18
152	P18	3	0	XIV	r	20
153	o18	3	0	XIV	r	25
154	o18	3	0	XIV	r	15
155	O18	7	0	XVa	r	25
156	O18	7	0	XVa	u	10
157	O18	8	1	XVa	u	0
158	n18	25	5	VIIc	f	0
159	p21	½	0	XXXII	u	*
160	p21	5	1	XVa	r	25
161	p21	25	30	XIX	f	0
162	P21	5	0	*	u	12

A3

1	2	3	4	5	6	7
163	o22	18	5	XVa	t	12
164	P21	5	0	XVa	u	40
165	p21	5	1	XVa	r	15
166	p21	25	40	XIX	f	0
167	p26	25	3	XVa	t	20
168	p26	2	0	XIV	r	10
169	p26	8	5	XII	t	0
170	P27	8	4	XII	t	20
171	P27	8	0	XII	t	20
172	p27	8	1	XVa	t	0
173	p26	15	5	XVa	t	0
174	Q26	25	35	XX	f	0
175	Q26	25	13	XIX	f	5
176	Q26	3	50	XXXI	b	0
177	Q26	1	0	XXXII	b	0
178	Q16	5	40	XIX	f	0
179	l18	1	5	XXIX	c	0
180	i18	45	4	XVb	n	15
181	i18	45	1	VII?C	l	14
182	i18	70	0	XVa	n	25
183	j18	40	3	XVII	r	50
184	K18	45	2	XII	t	20
185	J18	70	1	VII?c	k	15
186	K19	70	1	VIIc	k	15
187	k18	45	6	XII	t	17
188	j18	75	1	VIIc	k	12
189	K19	50	2	VIIc	l	5
190	k19	45	1'	XII	t	10
191	k19	40	20	XVII	r	5
192	j20	50	2	XVb	n	10
193	j20	50	3	VIIc	k	20
194	j20	50	3	XVb	n	15
195	l18	5	2	VIIc	l	0
196	l18	20	13	VIIc	l	25
197	J15	2	0	XXIX	c	0
198	J15	3	1	XXI	s	*
199	J16	8	15	XII	t	0
200	n11	5	0	XIII	r	15
201	R43	2	0	VIIc	d	0
202	S41	7	40	XXXI	f	0
203	S41	15	5	XIX	f	0
204	r41	2	0	XVa	r	0
205	q41	0	0	XXXIX	y	0
206	q41	0	0	XXXIX	y	0
207	q41	½	0	XXXVIII	w	0
208	T45	2	0	XXIX	b	0
209	s45	4	0	XIX	f	0
210	s45	2	0	XXI	s	0
211	s45	1½	0	XXXVI	w	0
212	s45	5	0	VII?	p	0
213	S37	1	0	XXXV	x	*
214	S37	1	0	XXXV	x	*
215	r37	½	0	XXXVIII	w	0
216	r35	3	1	VIIc	f	10
217	R35	20	15	XII	t	0
218	p36	5	0	XXI	u	0
219	p38	10	0	XVa	n	20
220	p38	15	10	?VIIc	n	0
221	p37	15	2	VIIc	k	5
222	q35	1	0	XXXVI	x	*
223	q35	1	0	XXXV	x	0
224	R35	2	0	XVa	r	15
225	R35	4	3	VIIc	f	7
226	s37	5	0	VIIc	k	15
227	S37	2	0	XVa	n	?10
228	R42	1	0	XXXVIII	w	70
229	j31	0	1	XXX	w	0
230	J31	0	0	XXXIX	y	0
231	J31	0	0	XXX	w	0
232	J31	0	0	XXXIX	y	0
233	J30	½	0	XXXVIII	w	0
234	J30	½	0	XXXVIII	w	0
235	J30	2	1	XXI	q	19
236	J29	½	0	XXXVI	w	20
237	J28	5	2	XXI	s	25
238	J27	25	20	XVb	n	15
239	J27	30	15	VIIc	n	0
240	i25	40	0	VIIc	k	15
241	i26	20	0	XVII	r	40
242	k34	1	2	XXIX	c	0
243	k34	0	0	XXXVIII	w	0
244	L34	1	0	XXIII	d	0
245	L34	½	0	XXXV	x	*
246	k36	½	10	XXX	?w	0
247	k36	2	0	XXIII	d	0
248	k36	4	0	XXIII	d	0
249	k36	1½	0	XXIX	d	0
250	k36	2	0	XXIII	d	0
251	M35	0	0	XXXIX	y	0
252	m35	0	0	XXXIX	y	0
253	m35	½	0	XXXVIII	w	5
254	m35	1	0	XXXVI	w	0
255	N35	1½	0	XXI	s	10
256	133	1½	0	XXI	s	13
257	M32	18	0	VIIc	n	11
258	M32	5	5	XVb	r	45

1	2	3	4	5	6	7
259	N19	40	3	XVa	t	10
260	N19	40	10	XVII	t	0
261	N20	60	1	VIIc	k	0
262	M22	80	0	VIIc	k	0
263	N17	125	30	VII?c	m	0
264	M10	1	0	XXI	q	0
265	N18	70	15	VII?c	m	25
266	m22	70	10	XII	t	0
267	M22	100	2	VIIc	l	0
268	l24	35	10	XVII	r	15
269	l25	75	1	VIIc	n	18
270	M23	50	15	XII	t	8
271	l24	75	2	XVII	n	15
272	l24	75	4	XVb	n	15
273	l24	75	1	VIIc	k	14
274	k24	70	2	XVII	r	18
275	L24	75	4	VIIc	k	9
276	N22	65	15	XII	t	0
277	M21	60	3	XVa	t	10
278	N22	65	7	XVa	t	4
279	N20	60	15	XVa	t	0
280	K8	1	0	XI	e	0
281	K8	1	0	X	e	?20
282	k8	20	1	VIII	k	12
283	L8	17	30	VIII	l	0
284	k8	20	0	VIII	l	22
285	L8	17	25	VIII	m	0
286	M8	2	2	XI	e	0
287	l8	3	1	IX	m	?*
288	K6	20	1	VIII	k	20
289	L8	40	20	VIII	l	15
290	L16	75	2	XVa	t	15
291	L16	75	1	VIIc	m	25
292	l15	100	1	VIIc	k	30
293	M14	150	0	V	m	20
294	k16	50	10	VIIc	m	25
295	k15	30	15	XVa	n	8
296	k16	40	1	XII	t	0
297	k14	10	3	VIIc	m	12
298	N7	12	10	VIIa	o	?4
299	n7	90	20	III	?h	?12
300	n7	30	15	VIIa	o	25
301	P16	5	0	XIV	r	22
302	P15	5	1	XIV	r	25
303	q13	300	40	II	j	18
304	q15	50	5	III	j	20
305	q15	45	45	III	j	12
306	n3	75	10	VIIa	o	23
307	n1	40	50	XVIII	i	15
308	m2	125	5	VIIb	i	24
309	m2	75	50	VIIb	i	0
310	l8	2	0	X	e	25
311	K15	10	1	XVa	t	17
312	l15	100	1	VII?	k	20
313	M14	125	3	VI	?k	*
314	k17	50	0	XII	t	19
315	e22	½	0	XXXV	x	0
316	e22	1	0	XXII	s	0
317	e22	1½	0	XXI	s	*
318	E26	1	0	XXII	s	0
319	e26	15	3	XII	n	28
320	e25	20	5	XII	n	20
321	D27	1	0	XXIII	d	0
322	c26	1	0	XXIX	c	0
323	c26	1	0	XXIV	d	0
324	L8	40	5	VIII	l	14
325	t50	15	0	VIIa	p	14
326	t48	5	1	VII?	p	22
327	t51	2	2	XIX	f	?20
328	r51	25	1	VII?	k	?20
329	Q39	0	0	XXXIX	y	0
330	o41	1	0	XXIII	d	0
331	k33	1½	0	XXVI	q	0
332	L33	2	0	XXI	s	0
333	L33	2	0	XXI	s	0
334	L33	2	0	XXI	q	?0
335	*	200	5	II	j	16
336	*	75	5	XVI	t	0

APPENDIX B: REFERENCE-PROFILES

(By H. van Reuler (see Chapter 7))

(for site-characteristics, see Appendix A)

Part 1: morphological descriptions

Plot 146 (Dystric cambisol developed on calcareous sandstone)

0 2-0 :

A 0-2 : Dark yellowish brown (10 YR 3/4); sandy clayloam; strong fine and medium granular; non sticky, non plastic, friable moist; many very fine, fine and common medium roots; slightly calcareous; clear smooth boundary.

Bw 2-8 : Dark yellowish brown (10 YR 3/4) and (10 YR 3/6); sandy clay loam; strong fine subangular blocky; slightly sticky, slightly plastic, friable moist; common very fine and fine pores; common very fine, fine and medium roots; abrupt broken boundary.

C 8-13 : Yellowish brown (10 YR 5/4); loam; weak fine subangular blocky; non sticky, non plastic, friable moist; few very fine and fine pores; few very fine, fine, and medium roots; abrupt irregular boundary.

2Bw 13-32/49 : Dark yellowish brown (10 YR 3/6); sandy clayloam; moderate fine subangular blocky; slightly sticky, slightly plastic very friable moist; common very fine, fine and few medium pores; common very fine, fine and medium roots; abrupt wavy boundary.

2C 32/49-60+ : White (10 YR 8/2) and dark yellowish brown (10 YR 4/6); sandy loam; single grain; non sticky, non plastic, loose moist; strongly calcareous.

Plot 284 (Eutric cambisol developed on limestone)

0 3-0 :

A 0-4 : Dark brown (10 YR 3/3) and black (N2/0); clay loam; moderate fine subangular blocky; slightly sticky, slightly plastic, friable moist; common very fine, fine and few medium pores; many very fine, fine, medium and few coarse roots; clear smooth boundary.

Bw 4-15 : Dark yellowish brown (10 YR 4/4); clay loam; strong fine subangular blocky; slightly sticky, slightly plastic, very friable moist; many very fine, fine and common medium pores; many very fine, fine, medium and few coarse roots; abrupt smooth boundary.

C 15-22 : Yellowish brown (10 YR 5/4) mixed with dark yellowish brown (10 YR 4/4); loam; weak fine and medium subangular blocky; non sticky, non plastic, friable moist; common very fine, fine and medium pores; common very fine, fine, medium and few coarse roots; abrupt wavy boundary.

2A 22-36 : Brown to dark yellowish brown (10 YR 4/3.5); clay; strong medium subangular blocky; sticky, plastic, friable moist; many pores of all sizes; small pieces of charcoal; many very fine, fine, common medium and few coarse roots; clear wavy boundary.

2BA 36-49 : Dark yellowish brown (10 YR 4/5); clay; strong fine and medium subangular blocky; sticky, plastic, friable moist; many very fine, fine common medium and few pores; many very fine, fine, common medium and few coarse roots; clear wavy boundary.

2Bw1 49-73 : Yellowish brown (10 YR 5/4), yellowish red (5 YR 5/8); clay; strong moderate subangular blocky; common very fine and fine pores; few very fine and fine roots; gradual wavy boundary.

2BC 73-96/108 : Yellowish brown (10 YR 4/5) and (10 YR 5/4) and light yellowish brown to olive yellow (2,5 Y 6/5); (gravelly stony) clay; strong medium and coarse subangular blocky; sticky, plastic, friable moist; common very fine and fine pores; gravels and stones are strongly calcareous; very few fine and fine roots; abrupt wavy boundary.

R 96/108-120 : Strongly calcareous white coloured rock.

Note: In the subsoil weak slickensides-like features have been noticed.
Special attention has to be paid to the possible human influence on this profile.
Of this site a soil monolith has been collected.

Plot 292 (Dystric cambisol developed on limestone)

0 3-0 :

A 0-6 : Dark brown (10 YR 3/3) clay; strong fine and medium subangular blocky; slightly stricky, slightly plastic, friable when moist; many very fine, fine and few medium, coarse pores; many roots of all sizes; clear smooth boundary.

Bw 6-18 : Dark yellowish brown (10 YR 3/6) clay loam; moderate fine subangular blocky; slightly sticky, slightly plastic, friable when moist; common very fine, fine and few medium pores; many roots of all sizes; abrupt wavy boundary.

C 18-30 : Pale brown (10 YR 6/3) sandy loam; weak fine subangular blocky; non sticky, non plastic, very friable when moist; common very fine and fine pores; common roots of all sizes; abrupt wavy boundary.

2A 30-40 : Dark brown to dark yellowish brown (10 YR 3/4) clay; strong fine and medium subangular blocky; slightly sticky, slightly plastic, friable when moist; many pores of all sizes; common very fine, fine and few medium, coarse roots; clear smooth boundary.

2Bw1 40-51 : Dark yellowish brown (10 YR 4/4) clay; moderate fine subangular blocky; sticky, plastic, friable when moist; common pores of all sizes; common very fine, fine and few medium, coarse roots; clear smooth boundary.

2Bw2 51-61 : Dark yellowish brown (10 YR 4/5) clay; strong fine subangular blocky; sticky, plastic, friable when moist; many very fine, fine common medium, coarse pores; common very fine, fine and few medium, coarse roots; clear smooth boundary.

2Bw3 61-74 : Dark yellowish brown (10 YR 4/6) clay; strong fine and medium subangular blocky; sticky, plastic, friable when moist; common pores of all sizes; common very fine, fine and few medium, coarse roots; clear smooth boundary.

2Bw4 74-103 : Dark yellowish brown (10 YR 4/6) with common fine distinct sharp black mottles; clay; strong fine subangular blocky; sticky, slightly plastic, friable when moist; common pores of all sizes; few very fine and fine roots; clear smooth boundary.

2Bw5 103-140+ : Dark yellowish brown (10 YR 4/6) with many fine distinct sharp black mottles ; clay; moderately fine subangular blocky; slightly sticky, slightly plastic, friable when moist; common very fine, fine and few medium, coarse roots; few very fine and fine roots.

Plot 301 (Gleyic cambisol developed in alluvial clayloam)

0 2-0 :

A 0-8 : Dark brown (10 YR 3/3) with common fine distinct clear gray (10 YR 5/1) mottles; silt loam, moderate very fine and fine subangular blocky, slightly sticky, slightly plastic, friable moist; common to few very fine and fine pores; many very fine, fine and common medium, coarse roots; abrupt smooth boundary.

Bw 8-13/17 : Brown (10 YR 4.5/3) with common fine distinct strong brown (7.5 YR 4/6 and 5/6) mottles; silt loam; weak very fine subangular blocky; slightly sticky, slightly plastic, very friable moist; many very fine, fine and common medium pores; common roots of all sizes; clear wavy boundary.

C 13/17-22 : Grayish brown (10 YR 5/2) with common fine and medium distinct strong brown (7.5 YR 5/6) mottles; (sandy) silt loam; slightly sticky, slightly plastic, very friable moist; common very fine, fine and medium pores; common roots of all sizes; clear broken boundary.

2BA 13/17-29 : Yellowish brown (10 YR 5/4) with few fine faint sharp strong brown (7.5 YR 5/6) mottles; sandy clayloam; weak fine subangular blocky; slightly sticky, weak fine subangular blocky; slightly sticky, slightly plastic, friable moist; common very fine, fine and few medium pores; common roots of all sizes; clear smooth boundary.

2Bw1 29-43 : Light brownish gray to grayish brown (10 YR 5.5/2) and yellowish brown (10 YR 5/4) with many fine and medium distinct sharp yellowish red (5 YR 5/8) mottles; slightly gravelly clayloam; weak fine subangular blocky; slightly sticky, slightly plastic, friable moist; common very fine, fine and few medium pores; common roots of all sizes; clear smooth boundary.

2Bw2 43-59 : Light brownish gray (10 YR 6/2) with many fine prominent sharp reddish yellow (5 YR 6/8) mottles; slightly gravelly clay(loam); weak fine and medium subangular blocky, sticky, plastic, friable moist; common very fine, fine and few medium pores; common very fine, fine and few medium, coarse roots; clear smooth boundary.

2Bw3 59-100+ : Heterogeneous colour, pale brown (10 YR 6/3), light gray (10 YR 7/2) and yellowish brown (10 YR 5/4) with many fine and medium prominent sharp strong brown (7.5 YR 5/8) mottles; gravelly sandy clay(loam); weak medium subangular blocky; slightly sticky, slightly plastic, friable moist; common very fine, fine and few medium pores; few very fine and fine roots.

Plot 303 (Dystric nitosol developed on sedimentary rock)

0 3-0 :

A 0-11 : Dark yellowish brown (10 YR 3/6) clay loam; moderate fine subangular blocky; slightly sticky, slightly plastic, friable moist; common to few very fine and fine pores; many roots of all sizes; abrupt wavy boundary.

C 11-18 : Brown (10 YR 5/3) loam; weak very fine subangular blocky; non sticky, non plastic, very friable when moist; common very fine, fine and few medium pores; common roots of all sizes; abrupt wavy boundary.

2Bw1 18-33 : Strong brown to yellowish brown (9 YR 5/8) clay; strong fine and medium subangular blocky; slightly sticky, slightly plastic, friable when moist; many pores of all sizes; many roots of all sizes; clear wavy boundary.

2Bw2 33-49 : Strong brown (7.5 YR 5/6) clay; strong medium subangular blocky; slightly sticky, slightly plastic, friable when moist; common pores of all sizes; many very fine, fine and common medium and coarse roots; clear smooth boundary.

2Bw3 49-83 : Strong brown (7.5 YR 5/7) clay; strong fine and medium subangular blocky; sticky, plastic, friable when moist; common to many very fine and fine pores, common coarse and medium pores; few very fine, fine and common medium coarse roots; clear smooth boundary.

2Bw4 83-122 : Strong brown (7.5 YR 5/8) with few fine faint clear brownish yellow (10 YR 6/8) mottles; clay; strong medium subangular blocky, sticky, plastic, friable when moist; common pores of all sizes; few roots of all sizes; clear smooth boundary.

2Bw5 122-160 : Strong brown to yellowish red (7 YR 5/8) with few fine faint clear brownish yellow (10 YR 6/8) mottles; clay; strong medium subangular blocky; sticky, slightly plastic, friable when moist; common pores of all sizes.

Plot 304 (Dystric nitosol developed on sedimentary rock)

O 3/5-0 :

A 0-4 : Brown to dark yellowish brown (10 YR 4/3.5); with locally common fine distinct sharp strong brown (7.5 YR 5/8) mottles; sandy clayloam; weak fine subangular blocky; slightly sticky; slightly plastic, very friable moist; common very fine, fine and medium pores; many roots of all sizes; clear smooth boundary.

Bw 4-14 : Dark yellowish brown (10 YR 3.5/6); sandy clayloam; moderate very fine and fine subangular blocky; slightly sticky, slightly plastic, friable moist; few to common very fine and fine pores; many roots of all sizes; abrupt wavy boundary.

C 14-20 : Yellowish brown (10 YR 5/4), partly mixed with Bw material; loam; weak fine subangular blocky; non sticky, non plastic, very friable moist; common very fine and fine pores; common roots of all sizes; abrupt wavy boundary.

2BA 20-52 : (Dark) brown (7.5 YR 4/4) sandy; clayloam; strong fine subangular blocky; sticky, plastic, friable moist; common very fine, fine and few medium pores; many very fine, fine and common medium, coarse roots; clear smooth boundary.

2Bw1 52-87 : Strong brown (7.5 YR 4/6), clay; strong fine and medium subangular blocky; sticky, slightly plastic, friable moist; many very fine, fine medium and coarse pores; many very fine, fine and common medium, coarse roots; clear smooth boundary.

2Bw2 87-115 : Strong brown to yellowish red (7 YR 4/6); clay; strong fine and medium subangular blocky; sticky, slightly plastic, friable moist; common very fine, fine and medium pores; common very fine, fine, medium and few coarse roots; gradual smooth boundary.

2Bw3 115-150+ : Strong brown to yellowish (7 YR 4/6); clay; strong medium subangular blocky; sticky, slightly plastic, friable moist; many very fine, fine and common medium pores; common very fine, fine and few medium and coarse roots.

Note: In the 2Bw horizons vague indications for clay illuviation have been found. Regarding the pore volumes the clay illuviation should reach its maximum in the 2Bw2 horizon. In the 2Bw1 horizon the pore volume is high due to a termites nest.

Plot 306 (Eutric cambisol developed on andesite)

O 3-0 :

A 0-3 : Dark yellowish brown (10 YR 3/4); silty clayloam; moderate very fine subangular blocky; slightly sticky, slightly plastic, friable moist; common very fine, fine and few medium pores; many roots of all sizes; abrupt clear boundary.

Bw 3-15 : Dark yellowish brown (10 YR 4/4); silty clayloam moderate very fine and fine subangular blocky; sticky, plastic, friable moist; many very fine, fine and common medium pores; many roots of all sizes; clear wavy boundary.

C 15-23 : Light yellowish brown (10 YR 6/4); loam; weak fine subangular blocky; non sticky, non plastic, friable moist; common very fine and fine pores; common roots of all sizes; abrupt wavy boundary.

2A 23-25 : Dark yellowish brown (10 YR 3/6); silty clay; strong very fine and fine subangular blocky; sticky, plastic, friable moist; many very fine, fine and common medium pores; common roots of all sizes; clear wavy boundary.

2BA1 25-42 : Dark yellowish brown (10 YR 4/4); silty clay; strong fine subangular blocky; sticky; plastic, friable moist; many very fine, fine and common medium pores; strong fine subangular blocky; sticky, plastic, friable moist; many very fine, fine and common medium pores; common roots of all sizes; clear smooth boundary.

2BA2 42-53 : Dark brown to brown (7.5 YR 4/4); silty clay; strong fine and medium subangular blocky; sticky, plastic, friable moist; many very fine, fine and common medium pores; common roots of all sizes; clear smooth boundary.

2Bw1 53-68 : Strong brown (7.5 YR 4/6) with about 5% brown (7.5 YR 5/4) spots; clay; strong medium subangular blocky; sticky, plastic, friable moist; many very fine, fine and common medium pores; common very fine, fine and few medium, coarse roots; clear smooth boundary.

2Bw2 68-91 : Heterogeneous colour, reddish brown (5 YR 4/4) and about 20% brown (7 YR 5/4); clay; sticky, plastic, friable moist; few to common very fine, fine and few medium pores; common very fine, fine and few medium roots; clear smooth boundary.

2BC 91-130+ : Heterogeneous colour, brown (7.5 YR 5/4) and 15 to 40% reddish brown (5 YR 4/4); (sligthly stony) clay; moderate fine and medium subangular blocky; sticky, plastic friable moist; few very fine and fine pores; few very fine and fine roots.

Plot 308 (Eutric cambisol developed on tuff)

O 3-0 :

A 0-4 : Dark brown (10 YR 3/3); loam; strong medium granular; slightly sticky; sligthly plastic, very friable moist; many roots of all sizes; clear smooth boundary.

Bw 4-17 : Dark yellowish brown (10 YR 4/4) with locally common fine distinct sharp strong brown (7.5 YR 5/8) mottles; loam; moderate very fine and fine subangular blocky; common very fine, fine and few medium pores; many roots of all sizes; abrupt wavy boundary.

C 17-24 : Yellowish brown (10 YR 5/3), mixed with Bw and 2BA material; slightly gravelly loam; weak fine subangular blocky; non sticky, non plastic, friable moist; common very fine, fine and few medium pores; few very fine, fine and medium root.

2BA 24-32 : Brown to dark brown (10 YR 4/3); loam; moderate fine subangular blocky sticky, slightly plastic, friable moist; many very fine, fine and common medium, coarse pores; common roots of all sizes; clear wavy boundary.

2Bw 32-59 : Brown to dark brown (10 YR 4/3); clay loam strong fine subangular blocky; sticky, plastic, friable moist; many very fine, fine, medium and coarse pores; common roots of all sizes; clear wavy boundary.

2BC 59-69 : Brown to dark brown (10 YR 4/3); (gravelly sandy) clayloam; strong fine and medium subangular blocky; sticky, plastic, friable moist; common very fine, fine and few medium pores; few very fine, fine and medium root abrupt wavy boundary.

2C 69-100+ : Weathered rock (tuff?) within cracks dark brown to brown (10 YR 4/3); sandy loam moderate fine subangular blocky; sticky, plastic, friable moist; common very fine, fine and few medium pores; very few very fine and fine roots.

Plot 310 (Calcaric regosol developed in coral sand)

O 3-0 :

A 0-14/23 : Black (N2/0) with white (10 YR 8/2) sandgrains; sandy loam; strong fine and medium granular; slightly sticky, slightly plastic, very friable moist; calcareous; many roots of all sizes; abrupt wavy boundary.

C 14/23-25 : Pale brown (10 YR 6/3); sandy loam; single grain; non sticky, non plastic, loose moist; calcareous; few roots of all sizes; abrupt wavy boundary.

2BA 25-35 : Dark yellowish brown (10 YR 3/4) and pale brown (10 YR 6/3) sandy, loam; weak very fine subangular blocky; slightly sticky, slightly plastic, very friable moist; common very fine and fine pores; strongly calcareous; many roots of all sizes; clear wavy boundary.

2Bw 35-43 : Yellowish brown (10 YR 5/4); sand; single grain; non sticky, non plastic, loose moist; strongly calcareous; common very fine, fine and few medium roots; clear wavy boundary.

2C 43-82 : Very pale brown (10 YR 8/4); (slightly) gravelly sand; single grain; non sticky, non plastic, loose moist; strongly calcareous; few very fine and fine roots; abrupt wavy boundary.

R 82-100+ : White (10 YR 8/2) with along the few roots C material, strongly calcareous.

Plot 311 (Gleyic luvisol developed in clayey material of unknown origin)

O 4-0 :

A 0-9 : Very dark grayish brown (10 YR 3/2) sandy clay; strong very fine and fine subangular blocky; sticky, plastic, friable when moist; many very fine fine and common medium pores; many roots of all sizes; abrupt wavy boundary.

C 9-17 : Yellowish brown (10 YR 5/5) sandy loam; weak fine subangular blocky; slightly sticky, slightly plastic, friable when moist; common very fine, fine and few medium pores; common very fine, fine and few medium roots; abrupt wavy boundary.

2BA 17-26 : Yellowish brown (10 YR 5/4) clay; moderate medium and coarse angular blocky; sticky, plastic, firm when moist; common very fine, fine and few medium, coarse pores; few very fine, fine and medium roots; clear smooth boundary.

2Bw1 26-52 : Yellowish brown (10 YR 5/4) to brownish yellow (10 YR 6/6) clay; moderable medium angular blocky; sticky, plastic, firm when moist; common very fine, fine and few medium pores; few very fine and fine roots; clear smooth boundary.

2Bw2 52-73 : Yellowish brown (10 YR 5/4) with commong faint fine clear strong brown (7.5 YR 5/8) mottles slightly gravelly (calcareous) clay; moderate medium angular blocky, sticky, plastic firm when moist; few very fine and fine pores, few very fine roots; abrupt wavy boundary.

2BC 73-100+ : Brown (10 YR 5/3) and white (10 YR 8/2) with common faint fine clear strong brown (7.5 YR 5/8) gravelly (calcareous) clay; weak medium angular blocky; sticky, plastic, firm when moist; common very fine and fine pores; very few very fine roots.

Plot 314 (Gleyic luvisol developed in clayey material of unknown origin)

O 2-0 :

A 0-9 : Gray (10 YR 5/1) with common fine distinct sharp strong brown (7.5 YR 5/6) mottles; siltloam; strong fine subangular blocky; slightly sticky, slightly plastic, friable moist; common pores of all sizes; many roots of all sizes; abrupt smooth boundary.

C 9-19 : Light yellowish brown (10 YR 6/4); (slightly gravelly sandy) loam; weak very fine and fine subangular blocky; non sticky, non plastic, friable moist; few to common very fine, fine and few medium, coarse pores; common roots of all sizes; abrupt smooth boundary.

2A 19-22 : Yellowish brown (10 YR 5/4); (slightly gravelly) clay; moderate fine and medium subangular blocky; sticky, plastic, friable moist; common pores of all sizes; common roots of all sizes; clear smooth boundary.

2BA 22-30/33 : Yellowish brown (10 YR 5/6); clay; strong, fine and medium subangular blocky; sticky, plastic, firm moist; few very fine, fine and medium pores; common roots of all sizes; clear wavy boundary.

2Bw1 30/33-52 : Heterogeneous colour, yellowish brown (10 YR 5/6) and (10 YR 5/8) and pale brown (10 YR 6/3); (slightly gravelly) clay; sticky; plastic, firm moist; few very fine, fine and medium pores; common very fine, fine and few medium roots; clear smooth boundary.

2Bw2 52-70 : Grey (10 YR 5/1) with many medium and coarse prominent sharp light olive brown (2.5 Y 5/4) mottles; slightly gravelly clay; moderate medium angular sticky; sticky, plastic, firm moist; few very fine and fine pores; gravels are strongly calcareous; common very fine, fine and few medium roots; clear smooth boundary.

2BC1 70-87 : Grey (10 YR 5/1) and grayish brown (10 YR 5/2) with many medium and coarse prominent sharp light olive brown (2.5 Y 5/4) mottles; slightly gravelly slightly stony clay; sticky, plastic, firm moist; few very fine and fine pores; gravels and stones are strongly calcareous; few very fine and fine roots; clear smooth boundary.

2BC2 87-130+ : Gray (5 YR 5/1) with common fine distinct sharp light olive brown (2,5 Y 5/4), common coarse prominent sharp strong brown (7.5 YR 5/8) and few fine prominent sharp black (N2/0) mottles; slightly gravelly slightly strong clay; strong medium angular blocky; sticky, plastic, firm moist; few very fine and fine pores; gravels strongly calcareous and matrix calcareous; very few very fine and fine roots.

<u>Plot 315 (Calcaric fluvisol developed in various alluvial sediments)</u>

A1 0-11/19 : Grayish brown (10 YR 5/2); (slightly gravelly) (shells) clay; strong medium and coarse angular blocky; sticky, plastic, firm moist; few very fine and fine pores; strongly calcareous; common very fine and fine roots; clear wavy boundary.

A12 11/19-14/22: Dark gray (10 YR 4/1); (slightly gravelly (shells)) clay; moderate fine and medium subangular blocky; sticky, plastic, friable moist; many very fine, fine and common medium pores; strongly calcareous; common very fine and fine roots; abrupt irregular boundary.

C1 14/22-27/30: Light brownish gray (2.5 Y 6/2); (slightly gravelly) silty clay; slightly sticky; slightly plastic, very friable moist; common very fine and fine pores; calcareous; few very fine and fine roots; abrupt smooth boundary.

C2 27/30-28/32: White (10 YR 8/2); sand; single grain; non sticky, non plastic, loose moist; strongly calcareous very few roots; abrupt irregular boundary.

C3 28/32-29/51: Gray (10 YR 5/1) with common fine distinct sharp (dark) yellowish brown (10 YR 4/6, 10 YR 3/6 and 10 YR 5/8) mottles; (slightly gravelly (shells)) clay; moderate medium columnar breakable into fine and medium angular blocky; sticky, plastic, friable moist; few very fine, fine and common medium, coarse pores; strongly calcareous; common very fine, fine and medium roots; abrupt irregular boundary.

C4 29/51-65+ : Light gray (2.5 Y 7/2) with many fine and medium prominent strong brown (7.5 YR 5/8) mottles; (gravelly (coral debris)) silt; non sticky, non plastic; very friable moist; common very fine, fine and few medium pores; strongly calcareous; very fine and fine roots.

<u>Plot 318 (Dystric gleysol developed in alluvial silty clay)</u>

0 2-0 :

A 0-9/18 : Black (N2/0) with white (10 YR 8/2) sand grains; (slightly gravelly) clay; strong medium granular and moderate fine subangular blocky; slightly sticky, slightly plastic, very friable moist; many very fine, fine and few medium pores; strongly calcareous; many roots of all sizes; abrupt irregular boundary.

BA 9/18-23 : Grayish brown (10 YR 5/2) with common fine distinct sharp yellowish brown (10 YR 5/8) mottles; very gravelly clay; moderate fine subangular blocky, sticky, plastic, friable moist; common very fine and fine pores; strongly calcareous; common roots of all siezes; clear wavy boundary.

Bw1 23-56 : Grayish brown (10 YR 5/2) and yellowish brown (10 YR 5/4) with common fine distinct sharp yellowish brown (10 YR 5/8) mottles; very gravelly silty clay; sticky, plastic, friable moist; very fine and fine pores; strongly calcareous; common very fine, fine and fine medium roots; abrupt smooth boundary.

Bw2 56-100+ : (light) gray (10 YR 6/1) and light brownish gray (10 YR 6/2) with many medum and coarse prominent sharp yellowish brown (10 YR 5/8) mottles; very gravelly; silty clay weak fine subangular blocky; slightly sticky, slightly plastic very friable moist; few very fine and fine pores; strongly calcareous; very few very fine and fine roots.

Plot 319 (Poorly developed gleyic luvisol developed in clayey material of unknown origin)

0 3-0 :

A 0-2 : Dark yellowish brown (10 YR 3/4); loam; moderate very fine and fine subangular blocky; slightly sticky, slightly plastic, friable moist; common very fine, fine and few medium pores; many roots of all sizes; abrupt smooth boundary.

Bw 2-12 : Dark yellowish brown (10 YR 4/5) and (10 YR 4/4); clayloam; strong fine and medium subangular blocky; slightly sticky, slightly plastic, friable moist; common very fine, fine and few medium pores; meny roots of all sizes; abrupt smooth boundary.

C 12-28 : Yellowish brown (10 YR 5/4); slightly gravelly loam; weak fine subangular blocky; non sticky, non plastic, very friable moist; common very fine, fine and few medium pores; common roots of all sizes; abrupt wavy boundary.

2A 28-43 : (Dark) yellowish brown (10 YR 5/4 and 10 YR 4/4) with common fine faint sharp strong brown (7.5 YR 5/8) mottles; clayloam; strong fine angular blocky; sticky, plastic, friable moist; common very fine, fine, medium and few coarse pores; common roots of alle sizes; clear wavy boundary.

2BA 43-60 : Yellowish brown (10 YR 5/4) with many fine and medium distinct sharp dark yellowish brown (10 YR 4/6), common fine distinct sharp strong brown (7.5 YR 5/8), few fine distinct sharp black (N2/0) and few fine faint sharp red (2.5 YR 4/6) mottles; clayloam; moderate fine angular blocky; common very fine, fine and few medium pores; few very fine, fine and medium roots; clear wavy boundary.

2Bw1 60-79 : Brown (10 YR 5/3) with many fine and medium prominent sharp yellowish red (5 YR 4/6), few fine distinct sharp red (2.5 YR 4/6) and few fine distinct sharp black (N2/0) mottle slightly gravelly clay; moderate fine angular blocky; sticky, plastic, firm moist; few very fine, fine and medium pores; few very fine and fine roots; clear wavy boundary.

2Bw2 79-125+ : Grayish brown (10 YR 5/2) with many coarse prominent sharp red (2.5 YR 4/6), common fine and medium distinct sharp yellowish brown (10 YR 5/6) and few fine distinct sharp black (N2/0) mottles; slightly gravelly clay; moderate coarse angular blocky; sticky, plastic, firm moist; few very fine, fine and medium pores; few very fine and fine roots.

Note: An augering in the bottom of the pit till 2 m has been made and showed dominating grayish colours with yellowish brown mottles. No stones were found.

Plot 321 (Calcaric regosol developed on coral)

0 3-0 :

A 0-10/12 : Black (N2/0), very dark brown (10 YR 2/2) and white (10 YR 8/2), gravelly loam; strong fine and medium granular; non sticky, non plastic, very friable, moist; strongly calcareous, many roots of all sizes; abrupt wavy boundary.

C 10/12-90+ : Heterogeneous colour, light brownish gray (10 YR 6/4), light yellowish brown (10 YR 6/3), and white (10 YR 8/1); gravelly stony sand; single grain; non sticky, non plastic, loose moist; strongly calcareous, very few roots.

Plot 324 (Eutric cambisol developed on limestone)

0 3-0 :

A 0-4 : Black (N2/0); silty clayloam; strong fine granular, slightly sticky, slightly plastic, very friable moist; many roots of all of all sizes; clear smooth boundary.

Bw 4-9 : Dark brown (10 YR 3/3) mixed with A1 material; slightly gravelly silty; clayloam; strong fine; subangular blocky; slightly sticky, slightly plastic, very friable moist; common very fine, fine and few medium pores; many roots of all sizes; abrupt smooth boundary.

C 9-14 : Very pale brown (10 YR 7/4) mixed with B2 material; slightly gravelly loamy sand; weak fine subangular blocky; non sticky, non plastic, very friable moist; common very find and fine pores; common roots of all sizes; abrupt irregular boundary.

2BA 14-26/32 : Dark yellowish brown (10 YR 4/4); clay; strong fine subangular blocky; sticky, plastic, firm moist, many very fine, fine and common medium pores; common roots of all sizes; clear smooth boundary.

2Bw2 26/32-33/45: Dark yellowish brown (10 YR 4/6), slightly gravelly slightly stony clay; strong fine subangular blocky; sticky; plastic; friable moist; common very fine, fine and medium pores; gravels and stones are strongly calcareous; common roots of all sizes; abrupt smooth boundary.

2BC 33/45-60+ : Dark yellowish brown (10 YR 4/6); slightly gravelly very stony clay; weak fine subangular blocky; sticky; plastic; friable moist; common very fine, fine and medium pores; gravels and stones are strongly calcareous; few very fine and fine roots.

Plot 325 (Gleyic cambisol developed on parent material of unknown origin

0 2-0 :

A 0-3/5 : Dark brown (10 YR 3/3); sandy loam; strong fine granular; slightly sticky, non plastic, very friable moist; many roots of all sizes; abrupt wavy boundary.

Bw 3/5-14 : Yellowish brown (10 YR 5/4) with common fine and medium prominent sharp yellowish red (5 YR 5/8) mottles; (sandy) loam; weak fine angular blocky; slightly sticky; slightly plastic, friable moist; few to common very fine and fine pores; common roots of all sizes; clear smooth boundary.

2Bw1 14-25 : Dark yellowish brown (10 YR 4/6) and yellowish brown (10 YR 5/6) with few fine faint sharp yellowish red (5 YR 5/8) mottles; clayloam; moderate fine subangular blocky; sticky; slightly plastic, friable moist; common very fine, fine and few medium pores; common roots of all sizes.

2Bw2 25-31 : Essentially similar to horizon above but with frequent, medium, hard irregular iron (?) nodules abrupt smooth boundary.

2Bw3 31-50 : Heterogenous colour, yellowish brown (10 YR 5/6), strong brown (7.5 YR 5/6) and yellowish red (5 YR 5/8) with few fine faint sharp yellowish red to red (3.5 YR 5/8) mottles; gravelly sandy clay; weak fine subangular blocky; sticky, plastic friable moist; common very fine, fine and few medium pores; very few, medium, hard, irregular iron (?) nodules; few very fine, fine and medium roots; clear smooth boundary.

2Bw4 50-69 : Heterogenous colour, yellowish brown (10 YR 5/6), pale brown (10 YR 6/3), and yellowish red (5 YR 5/8) with common fine prominent sharp red (2.5 YR 4/8) mottles; gravelly sandy clay, weak fine angular blocky; sticky, plastic, friable moist; few to common very fine and fine pores; very few very fine and fine roots; clear smooth boundary.

2Bw5 69-87 : Heterogenous colour; pale brown (10 YR 6/3) and yellowish brown (10 YR 5/8) with many fine prominent sharp red (2.5 YR 4/8) mottles; slightly gravelly sandy clay; weak fine angular blocky; sticky, plastic, friable moist; common very fine and fine pores; very few very fine and fine roots; gradual smooth boundary.

2BC1 87-114 : Light gray (10 YR 7/2) with common fine distinct sharp yellowish brown (10 YR 5/8) and many fine and medium prominent sharp red (2.5 YR 4/8) mottles; slightly gravelly sandy clay; weak fine angular blocky; sticky, plastic, friable moist; few very fine and fine pores; very few very fine and fine roots; gradual smooth boundary.

2BC2 114-135+ : Light gray (10 YR 7/2) with common fine distinct sharp red (2.5 YR 4/8) and many medium prominent sharp yellowish brown (10 YR 5/8) mottles; slightly gravelly sandy clay; weak fine angular blocky; sticky, plastic, friable moist; very few fine and fine pores; very few very fine and fine roots.

Plot 326 (Gleyic cambisol developed on parent material of unknown origin)

0 2-0 :

A 0-3 : Very dark grayish brown to dark brown (10 YR 3/2.5); clay; strong fine granular; slightly sticky, slightly plastic, friable moist; many roots of all sizes, abrupt smooth boundary.

Bw 3-19 : Dark yellowish brown (10 YR 4/4); clay; strong fine subangular blocky; slightly sticky, slightly plastic, friable moist; common very fine, fine and medium pores; many roots of all sizes; abrupt smooth boundary.

C 19-22 : Yellowish brown (10 YR 5/4); sandy loam; weak fine subangular blocky; slightly sticky, non plastic, friable moist; common very fine and fine pores; many roots of all sizes; abrupt broken boundary.

2Bw1 22-39 : Heterogenous colour, yellowish brown (10 YR 5/4), dark yellowish brown (10 YR 4/4) and black (N2/0); clay; moderate fine subangular blocky; sticky, plastic, friable moist; common very fine, fine and medium pores; common roots of all sizes; clear smooth boundary.

2Bw2 39-62 : Heterogenous colour, yellowish brown (10 YR 5/4 and 10 YR 5/6) and black (N2/0); clay; weak fine subangular blokcy; sticky, plastic, friable moist; common very fine and fine pores; few very fine roots; clear smooth boundary.

2Bw3 62-90+ : Heterogenous colour, dark yellowish (10 YR 4/6), black (N2/0) and yellowish brown (10 YR 5/6); clay; weak fine subangular blocky; sticky, plastic, friable moist; common very fine and fine pores, few very fine roots.

Plot 332 (Dystric gleysol developed in alluvial silty clay)

0 3-0 :

A1 0-5 : Black (N2/0); silt loam; moderate very fine and fine subangular blocky; slightly sticky, slightly plastic, very friable moist; common very fine, fine and few medium pores; many very fine, fine, medium and common coarse roots; clear smooth boundary.

A2 5-13 : Very dark grayish brown (10 YR 3/2); silty clayloam; moderate very fine and fine subangular blocky; slightly sticky, slightly plastic, very friable moist; few to common very fine, fine and very few medium pores; many very fine, fine, medium and common coarse roots; clear wavy boundary.

Bw1 13-21 : Dark grayish brown (10 YR 4/2) and brown (10 YR 5/3); silty clayloam; moderate fine subangular blocky; slightly sticky, slightly plastic, friable moist; common very fine and fine pores; many very fine, fine, medium and few coarse roots; clear wavy boundary.

Bw2 21-36 : Yellowish brown (10 YR 5/4) and brown (10 YR 5/3) with few fine faint sharp strong brown (7.5 YR 5/8) mottles; clay; weak fine and medium subangular blocky; slightly sticky, slightly plastic, friable moist; common very fine, fine and few medium pores; common very fine, fine, medium and few coarse roots; clear smooth boundary.

Bw3 36-62 : Yellowish brown (10 YR 5/6) and (10 YR 5/4) with common fine faint sharp strong brown (7.5 YR 5/5) mottles; clay, moderate medium subangular blocky, sticky, plastic, friable moist; common very fine, fine and medium pores; common very fine, fine and few medium, coarse roots; clear smooth boundary.

BC1 62-89 : Grayish brown (10 YR 5/2) and yellowish brown (10 YR 5/4) with common fine distinct sharp yellowish brown (10 YR 5/8) and strong brown (7.5 YR 5/8) mottles; slightly stony slightly gravelly silty clay; weak medium subangular blocky, sticky, plastic, very friable moist; many very fine, fine and common medium pores; small pieces of coral and white coloured shells: calcareous (matrix); common very fine, fine and few medium coarse roots; clear smooth boundary.

BC2 89-110+ : Grayish brown (10 YR 5/2) with many fine and medium distinct diffuse yellowish brown (10 YR 5/6 and 10 YR 5/8) mottles; slightly stone gravelly silty clay; weak medium subangular blocky; sticky, plastic, very friable moist; many very fine, fine and common medium pores, small pieces of coral and white coloured shell calcareous (matrix); few very fine and fine roots.

Note: Groundwater occurs at 110 cm.

Plot 335 (Dystric nitosol developed on sedimentary rock)

AO 3-0 :

A 0-2 : Dark yellowish brown (10 YR 4/4); (sandy) silty clayloam; moderate very fine and fine subangular blocky; slightly sticky, flightly plastic, very friable moist; many very fine, fine and common medium pores; many roots of all sizes; abrupt smooth boundary.

Bw 2-12/14 : Dark yellowish brown to strong brown (9 YR 4/6); (sandy) silty clayloam; moderate fine sbuangular blocky; slightly sticky, slightly plastic, very friable moist; common very fine, fine and few medium pores; many roots of all sizes, abrupt wavy boundary.

C 12/14-16/17: Yellowish brown (10 YR 5/4), partly mixed with B2 material; sandy loam; weak fine subangular blocky; non sticky, slightly plastic, very friable moist; many very fine, fine and common medium pores; common very fine, fine, medium and few coarse roots; abrupt wavy boundary.

2BA 16/17-28 : Yellowish red to strong brown (6 YR 5/8); clay; moderate very fine and fine subangular blocky; sticky, slightly plastic, friable moist; many very fine, fine, medium and common coarse pores; common very fine, fine and few medium, coarse roots; clear smooth boundary.

2Bw1 28-41 : Yellowish red (5 YR 5/8); clay; moderate fine subangular blocky; sticky, slightly plastic, firm moist; many very fine, fine, common medium and few coarse roots; common very fine, fine and few medium, coarse roots; clear smooth boundary.

2Bw2 41-66 : Yellowish red (5 YR 5/8) with common fine and medium distinct sharp light gray (10 YR 7/2) spots; clay; strong fine and medium subangular blocky; sticky, plastic, firm moist; common very fine, fine and few medium pores; few very fine, fine and very few medium roots; clear smooth boundary.

2Bw3 66-93 : Yellowish red (5 YR 5/8) with many fine and medium distinct sharp light gray (10 YR 7/2) and common fine distinct sharp yellowish red to red (4 YR 5/8) spots; clay; strong medium subangular blocky; sticky, plastic, firm moist; common very fine, fine and few medium pores; few very fine and fine roots; gradual smooth boundary.

2Bw4 93-124 : Heterogeneous colour, 45% light gray (10 YR 7/2) 35% yellowish red (5 YR 5/8) and 20% yellowish red to red (4 YR 5/8); clay; moderate fine and medium subangular blocky; sticky, plastic, friable moist; common very fine, fine and few medium pores; very few very fine and fine roots; abrupt smooth boundary.

2BC 124-150+ : Heterogeneous colour, light gray (10 YR 7/2), 25% red (2.5 YR 5/8), 20% yellowish red (5 YR 5/8) and 5% red (2.5 YR 4/6); slightly gravelly clay; moderate fine and medium subangular blocky; sticky, plastic, firm moist; few very fine and fine pores;

Note: On the transition of the B24 to the B31 horizon some small stones occur with red colours (2.5 YR 4/6 and 10 R 4/6).
Vague indications for clay illuviation have been found in the B22 and B23.

Plot 336 (Gleyic luvisol developed in clayey material of unknown origin)

A 0-8/12 : Dark brown (10 YR 3/3); sandy clay loam; moderate very fine and fine subangular blocky; slightly sticky, slightly plastic, very friable moist; common very fine, fine and few medium pores; weakly calcareous; many very fine, fine, medium and few coarse roots; abrupt wavy boundary.

Bw1 8/12-24 : Brownish yellow (10 YR 6/6) and 20% yellowish brown (10 YR 5/4); clay; moderate fine and medium subangular blocky; sticky, plastic, friable moist; common very fine, fine and medium pores; common very fine, fine and few medium, coarse roots; clear smooth boundary.

Bw2 24-37/40 : Pale brown (10 YR 6/3) and brownish yellow (10 YR 6/6) with 5% black (N2/0); clay; weak medium and coarse subangular blocky; sticky, plastic, friable moist; few to common very fine, fine and few medium pores; few to common very fine, fine and few medium roots; clear smooth boundary.

BC1 37-51 : Light yellowish brown (10 YR 6/4) with many medium prominent sharp brownish yellow (10 YR 6/8) motthles; gravelly clay; sticky, plastic, friable moist; few very fine, fine and medium pores; few very fine and fine roots; abrupt broken boundary.

BC2 37/51-79/61: Light gray to gray (10 YR 6/1) with many medium prominent sharp brownish yellow (10 YR 6/8) and many fine distinct sharp yellowish brown (10 YR 5/4) mottles; slightly stony gravelly clay; sticky, plastic, friable moist; few very fine and fine pores; strongly calcareous gravels and stones, clay calcareous; very few very fine and fine roots; clear wavy boundary.

BC3 59/62-100+ : Light gray to gray (5 Y 6/1) with many medium prominent sharp yellowish brown (10 YR 5/8) mottles; sandy clay; moderate medium and coarse angular blocky; sticky, plastic, friable moist; few very fine and fine pores sand as well as clay calcareous; very few very fine and fine roots.

Note: In the B33 weakly developed slickensides occur.

Part 2

Analytical data

Note that not for all reference profiles analytical data are available. Moreover of some reference profiles, only part of the horizons were samples.

Legend:
The depth is given in cm.
The particles size classes, CaC03 content, the organic C and N content and the base saturation (B.S.) are given in percentages.
The exchangeable bases, including the cation-exchange capacity (C.E.C.) are given in mmol (+)/kg.

The P-Olsen is given in mg/kg.

The particle size classes are defined as follows:

sand	2-0.05 mm
silt	0.05-0.002 mm
clay	0.002-0 mm
very coarse sand	2-1 mm
coarse sand	1-0.5 mm
medium sand	0.5-0.25 mm
fine sand	0.25-0.10 mm
very fine sand	0.10-0.05 mm
coarse silt	0.05-0.02 mm
fine silt	0.02-0.002 mm
gravel	more than 2 mm

For the mineralogical data the following codes are used:

kaol	kaolinite
mi/ill	mica/illite
chlor	chlorite
smec	smectite
mix	chloritized smectite
quartz	quartz
feld	feldspars
goeth	goethite
crist	cristobalite
(+)	very small amount
+	small amount
+(+)	small to moderate amount
++	moderate amount (higher amounts do not occur)

In general:

-	not detected
blanc	not analyzed

Plot no.	146					284							292						
Depth from	0	2	8	13	32/49	0	4	15	22	36	49	73	0	6	18	30	51	74	103
to	2	8	13	32/49	60+	4	15	22	36	49	73	96/108	6	18	30	40	61	103	140+
sand	51.8	48.0	41.7	49.3	72.7	27.1	24.6	32.0	8.4	5.9	4.3	5.7	20.6	26.3	36.3	15.9	6.7	5.0	3.8
silt	22.4	24.8	46.3	21.2	15.0	39.7	40.8	48.5	42.1	25.6	17.5	17.3	30.1	34.0	48.1	19.7	11.4	11.2	9.8
clay	24.8	27.3	11.9	29.7	13.4	33.2	34.6	19.5	59.5	68.7	79.0	78.2	49.3	39.8	15.6	64.3	82.0	83.9	86.5
v. coarse sa.	1.0	0.9	3.4	1.7	0.6	1.2	1.7	5.8	0.7	0.5	0.3	0.8	1.2	1.4	4.6	0.7	0.2	0.2	0.1
coarse sa.	8.6	8.5	8.4	9.6	11.6	4.2	4.2	6.9	1.0	0.7	0.4	0.5	3.3	4.0	6.9	1.0	0.4	0.3	0.3
medium sa.	23.6	20.6	11.3	21.8	38.0	7.1	5.9	5.4	1.1	0.5	0.4	0.5	4.6	6.8	7.5	2.9	1.2	1.0	0.7
fine sa.	12.5	11.1	9.8	10.1	15.6	7.7	6.1	6.7	2.6	1.8	1.4	1.2	6.8	8.4	8.8	7.7	3.3	2.4	1.8
very fine sa.	6.1	6.9	8.8	5.5	5.8	6.9	6.7	7.2	3.0	2.4	1.8	1.5	4.7	5.7	8.5	3.6	1.6	1.1	0.9
coarse silt	7.6	6.9	13.9	6.2	7.6	11.6	11.7	17.5	5.5	6.0	0.4	1.9	9.3	10.5	13.8	5.2	3.3	4.2	1.4
fine silt	15.8	17.9	32.4	15.0	7.4	28.1	29.1	31.0	26.6	19.6	17.1	15.4	20.8	23.5	34.3	14.5	8.1	7.0	8.4
gravel	-	-	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CaC03					84.9														
org.C	4.7	1.9	0.8	4.7	0.1	7.9	2.2	0.7	1.7	1.2	0.9	0.6	7.2	1.7	0.6	1.3	1.1	1.0	0.8
org.N													0.5	0.2	0.1	0.2	0.2	0.1	0.1
pH-H20	6.7	5.4	6.2	6.7	8.8	6.2	5.7	5.9	5.9	5.8	5.5	7.7	6.1	5.6	5.1	5.6	5.3	5.2	5.2
pH-KCl	6.5	4.4	4.8	6.5	8.3	5.5	4.5	4.5	4.4	4.0	4.0	6.6	5.2	4.4	4.4	4.6	4.2	3.9	3.9
Exch.bases:																			
Ca	194	69	24	46		306	150	107	287	266	295	605	160	35	14	57	53	42	45
Mg	60	28	11	22		72	56	35	90	73	46	36	37	23	9	36	37	29	22
Na	1	3	3	2		0	0	2	4	4	2	2	2	1	3	1	0	1	1
K	20	5	3	2		11	7	3	3	3	3	3	9	4	3	9	3	3	2
sum	274	105	40	72		389	213	146	384	346	346	647	207	63	29	102	93	75	69
C.E.C.	347	221	116	244		443	227	122	341	361	366	524	402	184	100	240	257	255	255
B.S.	79	47	35	30		88	94	>100	>100	96	94	>100	52	34	29	42	36	29	27
P.Olsen	108.0	19.1	30.9	57.6	24.9														
kaol.	+	+	+	+	+	+(+)	+(+)	+	+	+(+)	++	+	+	+	+	++	++	++	++
mi/ill.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(+)	(+)	(+)	(+)
chlor.	-	(+)	(+)	(+)	-	-	-	-	-	-	-	-	-	-	(+)	(+)	-	-	-
smec.	-	-	-	-	-	(+)	(+)	(+)	(+)	(+)	(+)	++	-	-	-	-	-	-	-
mix	+	+	(+)	+	+	-	-	-	-	-	-	-	(+)	+	(+)	+	+	+	+
quartz	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
feld	(+)	(+)	(+)	(+)	(+)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
goeth.	+	+	(+)	+	+	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
crist.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Plot no.	303				304							306								
Depth from	0	11	49	122	0	4	14	20	52	87	115	0	3	15	23	25	42	53	68	91
to	11	18	83	160+	4	14	20	52	87	115	150+	3	15	23	25	42	53	68	91	130+
sand	26.9	39.7	4.4	4.9	58.5	52.4	46.0	49.4	38.3	40.0	40.3	19.7	19.5	31.4	9.6	5.8	3.4	2.8	2.1	4.3
silt	35.0	45.7	33.0	37.4	17.7	17.7	33.8	16.1	14.2	14.4	13.1	45.6	42.2	45.6	47.9	48.3	42.6	37.6	33.9	30.6
clay	38.0	14.4	62.7	57.6	23.8	29.9	20.3	34.5	47.5	45.6	46.6	34.7	38.2	23.0	42.6	46.0	53.9	59.6	64.0	65.1
v. coarse sa.	2.1	4.6	0.1	0.2	0.3	0.7	3.9	0.3	0.2	0.3	0.4	1.2	1.1	4.6	1.0	0.3	0.3	0.1	0.2	1.6
coarse sa.	5.8	8.0	0.4	0.5	1.5	1.7	5.4	1.2	0.7	0.8	0.9	2.9	3.0	5.9	1.7	0.8	0.4	0.3	0.3	0.6
medium sa.	7.4	8.6	0.7	0.8	5.3	4.9	6.2	3.5	2.4	2.7	2.6	5.1	5.2	5.7	2.2	1.1	0.5	0.4	0.3	0.4
fine sa.	7.1	9.4	1.5	1.6	23.5	20.5	13.6	18.7	14.7	15.0	15.8	5.3	5.6	7.1	2.2	1.8	0.9	0.8	0.5	0.6
very fine sa.	4.5	9.1	1.7	1.8	27.9	24.6	16.9	25.7	20.3	21.2	20.6	5.2	4.6	8.1	2.5	1.8	1.3	1.2	0.8	1.1
coarse silt	9.2	13.3	6.9	8.8	7.5	6.6	9.1	4.5	4.2	3.1	3.3	10.9	9.5	12.1	10.1	11.6	9.1	7.9	7.5	6.4
fine silt	25.8	32.4	26.1	28.6	10.2	11.1	24.7	11.6	10.0	11.3	9.8	34.7	32.7	33.5	37.8	36.7	33.5	29.7	26.4	24.2
gravel	-	-	-	-	-	1.0	2.1	-	-	-	-	-	-	3.9	-	-	-	-	-	-
CaCO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
org.C	5.4	1.4	1.0	0.5	2.7	1.7	1.0	0.5	1.1	0.5	0.1	4.8	1.0	0.6	1.2	1.0	1.1	1.0	1.0	1.2
org.N	0.3	0.1	0.1	<0.05																
pH-H2O	4.6	5.0	4.8	4.7	4.3	4.4	5.1	5.2	4.9	4.9	5.0	5.5	5.6	6.0	6.0	6.1	5.7	5.2	5.1	5.3
pH-KCl	4.0	4.4	4.0	3.9	3.8	3.9	4.2	3.8	3.8	3.9	3.9	4.8	4.3	4.4	4.4	4.4	4.1	3.7	3.7	3.9
Exch.bases:																				
Ca	0	4	0	0	37	6	0	0	0	2	0	92	65	41	80	68	82	59	62	71
Mg	9	2	11	5	19	14	7	23	18	8	7	94	69	40	91	111	111	84	70	77
Na	5	3	0	2	0	1	2	1	2	1	1	2	3	3	4	6	6	5	5	5
K	4	3	1	1	6	4	4	3	3	3	3	15	8	4	5	3	3	3	2	2
sum	17	12	12	8	62	25	13	26	23	14	11	202	145	88	180	188	201	150	129	155
C.E.C.	212	99	135	120	132	128	83	112	148	135	130	940	576	504	643	622	551	508	480	439
B.S.	8	12	9	7	47	20	15	23	16	10	8	62	66	76	66	66	68	49	42	54
P.Olsen					10.3	3.2	2.1	0.5	1.1	0.1	0.1									
kaol.	++	+	++	++	+(+)	++	+(+)	++	++	++	++	+(+)	++	+(+)	++	++	++	++	++	++
mi/ill.	-	-	-	-	(+)	(+)	(+)	(+)	(+)	(+)	-	-	-	-	-	-	-	-	-	-
chlor.	-	+	-	-	-	-	(+)	-	-	-	-	-	-	(+)	-	-	-	-	-	-
smec.	-	-	-	-	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
mix	(+)	(+)	(+)	(+)	+	+	+(+)	+	+	+	+	+	+	+(+)	+	+	+	+	+	+
quartz	(+)	(+)	-	-	(+)	(+)	(+)	(+)	(+)	(+)	(+)	-	-	-	-	-	-	-	-	-
feld	-	-	-	-	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
goeth.	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
crist.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Plot no.	308							310			314				315 (continued on p. B13)				
Depth from	0	4	17	24	39	59	69	0	14/23	25	0	9	32	70	0	11/19	14/22	27/30	28/32
to	4	17	24	32	59	69	100+	14/23	25	35	9	19	52	87	11/19	14/22	27/30	28/32	29/51
sand	33.4	32.7	39.2	32.1	27.6	33.5	66.2	73.7	64.4	58.9	18.9	31.9	0.6	24.9	21.4	1.2	19.0	88.6	23.5
silt	42.1	43.4	44.4	41.1	40.3	34.5	23.6	15.5	22.4	24.4	55.3	48.8	31.3	22.3	20.8	14.4	69.0	2.4	10.9
clay	24.4	23.9	16.4	26.8	32.1	31.9	10.2	10.9	13.1	6.7	25.8	19.2	68.0	52.6	57.8	84.4	20.9	9.0	65.6
v. coarse sa.	0.4	1.3	4.5	0.6	0.3	2.5	5.1	2.1	2.7	0.3	0.6	7.2	0.0	0.5	1.9	0.0	0.2	8.0	0.0
coarse sa.	2.9	4.1	6.6	2.7	2.0	5.3	13.5	4.7	5.3	0.5	3.0	6.3	0.1	2.3	3.3	0.2	0.4	28.3	0.2
medium sa.	8.5	8.1	8.0	7.6	6.0	7.5	18.3	12.3	11.3	8.0	4.5	5.2	0.1	6.1	2.8	0.2	1.1	34.5	1.2
fine sa.	12.9	11.1	11.3	12.2	11.8	12.1	20.2	48.1	36.2	54.2	5.4	6.6	0.2	11.6	6.0	0.4	2.9	15.3	15.6
very fine sa.	8.7	8.1	8.8	9.0	7.5	6.1	9.1	6.5	8.9	5.9	5.4	6.6	0.2	4.4	7.4	0.4	5.6	2.5	6.5
coarse silt	13.8	12.1	11.8	12.0	10.5	8.7	8.3	4.0	4.2	2.0	19.6	14.2	5.9	3.9	3.5	5.2	21.1	1.8	3.5
fine silt	28.3	31.3	32.6	29.1	29.8	25.8	15.3	11.5	18.2	22.4	35.7	34.6	25.4	18.4	17.3	9.2	47.9	0.6	7.4
gravel	-	-	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CaCO3								46.5	65.5	57.6	1.3	-	1.9	10.2	26.0	44.3	9.9	57.0	10.5
Org.C	5.6	1.6	0.7	0.8	0.7	0.5	0.1	10.0	1.6	6.6	3.8	0.8	0.4	0.2	3.7	4.6	0.3	0.6	1.5
Org.N								0.8	0.2	0.7	0.3	0.1	0.1	<0.05					
pH-H20	5.7	4.9	5.6	5.6	5.7	5.8	6.1	7.3	8.1	7.5	5.4	5.7	5.6	8.0	7.4	7.1	8.1	8.7	8.1
pH-KCl	5.1	4.0	4.3	4.2	4.2	4.1	4.2	6.9	7.4	7.2	4.4	4.3	3.9	7.0	7.0	6.8	7.3	8.3	7.1
Exch.bases:																			
Ca	131	39	26	62	82	92	85	349	77	239	57	39	179	254	201	203	114		183
Mg	73	44	19	49	42	44	73	21	4	8	27	21	57	63	87	63	47		107
Na	3	2	3	2	1	1	1	0	1	0	1	1	1	1	11	6	7		14
K	16	8	6	7	7	6	3	4	1	1	6	3	4	2	8	6	6		7
Sum	224	93	54	120	131	142	161	375	83	248	91	64	241	320	307	277	174		311
C.E.C.	329	181	106	178	197	208	219	571	771	918	240	130	366	326	505	462	250		486
B.S.	68	51	51	67	67	68	74	66	82	60	38	49	66	98	61	60	70		64
P.Olsen	19.5	5.5	2.0	1.6	0.6	0.4	0.3								11.4	20.0	3.2	3.3	9.1
kaol.	+	+	+	+	+	+	(+)	-	-	(+)	+	+	++	++	+	+	+	+	+
mi/ill.	-	-	-	-	-	-	-	-	-	-	(+)	(+)	(+)	(+)	-	-	-	-	-
chlor.	-	-	(+)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
smec.	(+)	(+)	(+)	(+)	(+)	(+)	-	-	-	(+)	+(+)	(+)	++	++	++	+	+(+)	+(+)	++
mix	+	+	+	+	+	(+)	(+)	-	-	-	-	-	-	-	+(+)	++	+(+)	+(+)	+(+)
quartz	-	-	-	-	-	-	-	-	-	-	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
feld	(+)	(+)	(+)	(+)	(+)	(+)	(+)	-	-	-	-	-	-	-	(+)	-	-	-	(+)
goeth.	-	-	-	-	-	-	-	(+)	(+)		(+)	(+)	(+)	(+)	(+)	-	-	-	(+)
crist.	++	++	++	++	++	++	++	-	-	-	-	-	-	-	-	-	-	-	-

Plot no.	315	318				319							321	
Depth from	29/51	0	9/18	23	56	0	2	12	28	43	60	79	0	10/12
to	65+	9/18	23	56	100+	2	12	28	43	60	79	125+	10/12	90+
sand	6.8	19.7	6.5	1.1	1.3	34.3	30.6	33.9	29.6	26.6	19.2	14.1	33.7	2.5
silt	88.5	33.0	29.3	54.5	78.7	39.5	36.3	46.9	31.0	33.6	22.3	22.9	39.9	37.3
clay	4.7	47.3	64.1	44.4	19.9	26.2	33.2	19.2	39.4	39.7	58.4	63.1	26.4	602
v. coarse sa.	0.0	0.4	0.4	0.0	0.0	0.6	1.4	4.4	0.3	0.2	0.3	0.2	6.3	0.0
coarse sa.	0.0	4.8	1.8	0.1	0.2	1.6	1.9	5.8	0.4	0.3	0.4	0.2	9.9	0.3
medium sa.	0.2	6.6	1.8	0.2	0.2	2.4	2.0	4.2	0.9	0.5	0.3	0.2	6.6	0.3
fine sa.	4.7	4.4	1.1	0.3	0.2	3.7	2.6	6.3	1.5	1.1	0.7	0.4	7.1	0.6
very fine sa.	1.9	3.5	1.4	0.5	0.7	26.1	23.0	13.2	26.5	24.5	17.5	13.1	3.8	1.3
coarse silt	87.3	9.1	10.0	10.1	16.5	17.4	16.6	15.3	16.6	19.5	9.3	10.8	9.6	4.9
fine silt	1.2	23.9	19.3	44.4	62.2	22.1	19.7	31.6	14.4	14.1	13.0	12.1	30.3	32.4
gravel	-	-	80	70	70	-	-	2.1	-	-	-	-	53	60
CaCO3	60.6	17.5	36.6	38.8	74.2								55.8	87.5
Org.C	0.6	10.7	2.4	0.9	0.3	4.7	1.1	0.5	0.9	0.9	0.8	0.5	11.9	0.9
Org.N														
pH-H2O	8.5	7.5	8.0	8.2	8.7	6.0	5.6	6.2	6.1	6.3	6.5	6.4	7.3	8.3
pH-KCl	7.8	7.2	7.3	7.3	7.9	5.6	4.3	4.4	4.5	4.7	4.9	5.0	7.2	8.0
Exch.bases:														
Ca		488				158	79	51	89	89	128	150		
Mg		27				52	46	30	45	42	61	87		
Na		1				2	2	2	2	1	4	8		
K		11				15	9	8	5	4	4	4		
Sum		527				227	136	91	142	137	196	248		
C.E.C.		764				293	189	114	184	187	247	297		
B.S.		69				78	72	79	77	73	79	84		
P.Olsen	11.6	41.5	4.8	1.8	3.1	34.5	3.2	4.0	1.1	1.1	0.6	0.6	56.1	1.7
kaol.	+	+	+	+	+	+(+)	++	+	++	+(+)	+(+)	++	+	+
mi/ill.	-	(+)	(+)	(+)	(+)	(+)	-	-	-	-	-	-	(+)	(+)
chlor.	-	-	-	-	-	-	-	(+)	-	-	-	-	-	-
smec.	++	++	++	+(+)	+	+	(+)	(+)	+	(+)	(+)	(+)	(+)	(+)
mix	+	+	+	+(+)	++	++	++	++	+	+	+(+)	++	+	+
quartz	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
feld	(+)	-	-	-	+	-	-	-	-	-	-	-	-	-
goeth.	-	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
crist.	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX C

List of plant-species which were observed in Ujung Kulon during the survey

Column 1: Families and species(groups).

The nomenclature of the ferns generally follows Backer and Posthumus (1939). However, where necessary it has been brought up-to-date*. In such cases (where the nomenclature deviates from Backer and Posthumus) the obsolete synonym is given in column 7. Only the new names, deviating from Backer's nomenclature, are registered fully, i.e. with their author's name.

The nomenclature of the seedplants consequently follows Backer and Backhuizen van den Brink (1963-1968). Only species which are not included in Backer's flora are registered with their authors name.

In cases where species have been mixed up during the fieldwork, species groups have been introduced, which are in most cases also registered in the vegetation tabel (Appendix E).

Column 2: Growth-form

Classification slightly modified after Eiten (1968). See table 2c.

Column 3: Sociological group. See table 9a.

When in brackets: in sufficiently known, because the species concerned is (1) too rare to be included in the vegetation table (i.e. it occurs in less than 10% of the plots in which the sociological group with which it shows most affinity should occur) or (2) the species is included in the vegetation table as a part of a species-group. In the latter case the sociological group to which the species-group as a whole belongs is indicated.

Column 4: Included in the vegetation table?
\+ = included
\- = not included.

Column 5: Sample collected during the survey?
\-   = no sample collected
(-) = no sample collected, but occurence of the species in the area proven by other collections or reliable literature data.
\+   = sample collected.

Comlumn 6: local name.
? = uncertain (very dubious names have been omitted)
pp = pro parte, i.e. the same local name is used for more than one species.

Column 7: miscellaneous remarks.
Including notes on the distribution of species which are not included in the vegetation table or have been combined into species-groups.

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* by Dr. P. Hovekamp (Rijksherbarium, Leiden).

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
FERNS						
Ceratopteridaceae						
Ceratopteris thalictroides	AF	69	+	+	-	
Cyatheaceae						
Cyathea cf. junghuhniana Copel.	TP	2	+	+	Paku haji	synonymous with Hemitelia junghuhniana
Gleicheniaceae						
Gleichenia truncata Spr. var. truncata	CF	8	+	+	?Paku rempang (pp)	synonymous with G.laevigata
Hymenophyllaceae						
Trichomanes javanicum	AF	(6)	(+)	+	Paku lenta, ?Paku rempang (pp)	collected in plot III; in veg.table included 'Paku lenta'
Trichomames maximum	AF	(6)	(+)	+	Paku lenta, ?Paku rempang (pp)	collected in plot 139; in veg.table included in 'Paku lenta' see also Lindsaea (Polyp.)
Trichomanes obscrurum	AF	1	+	+	Paku toke	-

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
<u>Polypodiaceae</u>						
Acrostichum aureum	AF	88	+	+	Paku rawa	
Arcypteris irregularis (Presl.) Holttum	AF	(36)	+	+	Paky (anjing) (pp)	synonymous with Tectar. irregularis; in veg.table included in 'Paku anjing' collected in several localities
Asplenium amboinense	FE	(5)	-	+	-	Found only once (plot 139)
Asplenium nidus	FE	3	+	+	Kadaka (pp)	-
Asplenium tenerum	FE	(1)	-	+	-	found only once (plot 128)
Asplenium unilaterale	AF	(5)	-	+	-	found only once (plot 136)
Bolbitis appendiculata (Willd.) Iwats	AF	(46)	-	+	-	synonymous with Egenolfia appendiculata rare in Arenga obtusifolia forest
Bolbitis heteroclita	AF	7	+	+	-	-
Davallia denticulala	FE	(82)	-	+	-	found only once (plot 49)
Davallia spec.	FE	62	+	+	-	looks like D.trichomanoides, but both habitat and altitude do not correspond all with data provided by Backer & Posthumus (1939)
Diplazium bantamense	AF	5	+	+	-	
Diplazium pallidum	AF	(5)	-	+	-	found only once (plot 138)
Drynaria sparsisora	FE	82	+	+	Kadaka (pp)	-
Lindsaea obtusa J.Sm.	AF	(6)	(+)	+	-	?synonymous with Lindsaya davaillioides; in veg.table included in "Paku lenta"; collected in plot 109 and 117
Lindsaea repens (Bory) Yhwaites var. pectinata (Bl.) Mett.	FE	(6)	(+)	+		Synonymous with Lindsaya pectinata; in veg. table included in 'paku lenta' collected in plot III; see also Trichoman. (Hymenoph.)
Lomagramma sinuata	CF	(5)	-	+	-	found only once (plot 139)
Microlepia speluncae	AF	(36)	(+)	+	Paku (anjing) (pp)	in veg.table included in "paku anjing"; collected in various localities
Nephrolepsis cf. biserrata	AF	(87)	-	+	Paku laut? (pp)	found only once (plot 48)
Oleandra neriiformis	AF	(14)	-	+	-	found only once (plot 87)
Pteris cretica	AF	(43)	-	+	-	found only once (plot 172)
Pteris ensiformis	AF	(55)	-	+	-	found only once (plot 332)
Pteris cf.quadriaurita	AF	(39)	-	+	-	found only once (plot 151)
Pteris vittata	AF	62	+	+	Paku laut pp	-
Pyrrosia lanceolata	FE	(82)	-	+	Ar.rama tebal	found only once (plot 51)
Stenochlaena palustris	CF	13	+	+	Paku hurang	-
Taenitis blechnoides	AF	6	+	+	Paku hahataan	-
Tectaria cf.melanocaula	AF	10	+	+	-	-
Tectaria cf.siifolia	AF	(11)	-	+	-	found only once (plot 129)
Tectaria vasta	AF	7	+	+	Kadaka (pp)	-
Tectaria spec.	AF	42	+	+	Paku besi	-
Thelypteris malayensis (C.Chr.) Reed	AF	2	+	+	Paku toritip	synonymous with Dryopteris malayensis

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Thelypteris terminans	AF	(36)	(+)	+	Paku (anjing) pp	synonymous with Dryopteris interrupta Ching sensu Backer & Posthumus. With certainty found only once (plot 336, foot of Honje); possibly also in Ujung Kulon. In veg.table included in 'Paku anjing'
Thelypteris triphylla	AF	(5)	-	+		synonymous with Dryopteris triphylla; found only once (plot 111)
<u>Schizaeaceae</u>						
Lygodium circinnatum	CF	50	+	+	(Paku) hata	-
<u>Selaginellaceae</u>						
Selaginella cf.plana	BH	(48)	(+)	+	Paku rane pp	collected in plot 125; in veg.table included in s.spec.
Selaginella spec.	BH	48	+	+	Paku rane	-
<u>SEEDPLANTS</u>						
<u>Acanthaceae</u>						
Acanthus ilicifolius	BS	88	+	(-)	Jaruju	-
Gendarussa vulgaris	BS	(24)	-	+	-	found only twice (plot 282 and 319) possibly indicating ancient grave sites
Hemigraphis bicolor	BH	(58)	-	+	Buntut kucing (pp)	rare; mainly in rattan- and Sterculia foetida vegetation
Hemigraphis cf.javanica	BH	39	+	+	Buntut kucing (pp)	-
Hygrophila erecta	BH	69	+	+	?Mata udang	-
Lepidagathis javanica	BH	44	+	+	Kiwisa	-
Pseuderanthemum diversifolium	BS	44	+	+	Kimelati laut (pp)	-
Rungia blumeana	BH	49	+	+	Kumis ucing (pp)	-
Staurogyne elongata	BH	6	+	+	Reundeuh (pp)	-
<u>Agavaceae</u>						
Pleomele elliptica	RS	4	(+)	+	Hanjuang (pp)	in veg.table included in Pleomele spec.
Pleomele cf.flexuosa	PS	4	(+)	+	Hanjuang (pp)	in veg.table included in Pleomele spec.
<u>Aizoaceae</u>						see: Molluginaceae
<u>Alangiaceae</u>						
Alangium salvifolium	BL	(39)	-	+	-	found only once (plot 167)
<u>Amaranthaceae</u>						
Achyranthes aspera	BH	(31)	-	+	?Kirêmề	found only twice (plot 99 and 270)
Alternanthera sessilis	BH	82	+	+	Rumput urang aring (pp)	-
<u>Amaryllidaceae</u>						
Crinum asiaticum	PS	76	+	+	Bakung, Lili laut	-

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Anacardiaceae						
Anacardium occidentale	ET	(66)	-	+	Jambu mèdè	a single tree was found on the Cijungkulor on grazing ground
Buchanania arborescens	ET	71	+	+	Kitanjung	-
Dracontomelon puberulum	ET	17	+	+	Kidahu	-
Mangifera foetida	ET	(5)	-	-	Mangga limus tipung	found only once (plot 118)
Mangifera cf.indica	ET	(50)	-	+	Mangga	found only twice (plot 18 and 107)
Mangifera odorata	ET	5	+	+	Mangga ganarasa	-
Semecarpus heterophylla	ET	17	+	+	Reunghas	the common 'Reunghas'of Ujung Kulon is Semecar. and not Gluta renghas
Spondias pinnata	DT	53	+	+	Kedongdong	maybe locally confused with S.dulcis; Spondias seedling were observed frequently in banteng dung.
Annonaceae						
Annona cf.muricata	ET	(66)	-	-	Nangka belanda	a few trees are growing near the watch tower at the Cijungkulon grazing ground
Desmos chinensis	BS	(51)	-	+	Hadangan	rather rare; in various vegetation types
Orophea cf. enneandra	BS	(20)	-	+	Kilja kecil (pp)	collected in plot 289, see Annonaceae rest.
Stelechocarpus burahol	ET	17	+	+	Turalak	-
Trivalvaria macrophylla	ET	(71)	-	+	Kilaja kecil (pp)	-
Uvaria cf. rufa	BL	(30)	(+)	+	Ar.kilaja (pp)	Herb.specimen from plot 99; in veg.table included in U.spec.
Uvaria spec.	BL (BS)	30	+	+	Ar.kilja (pp), Ar.perengkel (pp)	-
Annoncaceae rest	ET BS BL	-	-	+	Kilja (pp) Ar.kilja (pp)	the family of the Annocaceae is very well represented in Ujung Kulon (see e.g. Kartawinata & Apandi, 1977) However, identification of sterile specimens, esp. juvenile stages, provides serious problems in most species. Only the most characteristic species have been included in the vegetation table. The species neglected general are of little importance in the vegetation cover.
Cananga odorata	ET	53	+	+	Kenanga	-
Polyalthia Lateriflora	ET	45	+	+	Kilaja (pp)	-
Apiaceae						
Centella asiatica	BH	(68)	-	+	-	Rare; in rattan shrubland and grasslands.
Apocynaceae						
Alstonia angustiloba	ET	(11)	-	+	Lame hitam	found only once (plot 141)
Alstonia scholaris	ET	22	+	+	Lame putih	-
Alstonia spectabilis	ET	(88)	-	+	-	found only once (plot 75)

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Alyxia reinwardti	BS	(1)	-	+	-	found only once (plot 119)
Anodendron coriaceum	BL	(5)	-	+	-	found only once (plot 114)
Anodendron paniculatum	BL	88	+	+		-
Catharanthus roseus	BH	(66)	-	-		run wild near guard-post on P.Handeuleum and P.Peucang
Cerbera manghas	ET	74	+	+		-
Chonemorpha fragrans	BL	(39)	-	+		found only once (plot 173)
Ervatamia blumeana	BS	(48)	-	+		rather rare; in various types of forest
Ervatamia floribunda	BS	(51)	-	+		rather rare; mainly in rattan shrublands and forest on low altitudes
Kopsia arborea	ET	20	+	+	-	-
?Leuconotis eugenifolia	BL	7	+	+	-	-
Rauvolfia reflexa	ET	25	+	+	Melati laut (pp)	-
Araceae						
Aglaomena simplex	BH	(49)	(+)	+	?Lolo beula (pp)	collected in plot 174 & 287; in veg. table included in Arac. 'Lolo'
Alocasia indica	BH	(34)	-	+	?Kareyo biah	found only once (plot 73)
Alocasia longiloba	BH	4	+	+	Kareyo sente	-
Alocasia macrorrhiza	CA	35	+	+	Kareyo	-
Amorphophallus variabilis	BH	11	+	+	Acung	-
Amydrium medium	BV	(49)	(+)	+	?Lolo beula (pp)	collected in plot 111; in veg.table included in Araceae 'Lolo'
Anadendrum microstachyum	BV	(49)	(+)	+	Lolo (pp)	collected in plot 26; in veg. table included in Araceae 'Lolo'
Colocasia esculenta	BH	(44)	-	+	Biah	found only once (plot 6)
Homalomena cordata	BH	49	+	+	Cariang	-
Pothos oxyphyllus	BV	9	+	+	-	-
Pothos roxburghii	BV	(49)	-	+	Ar.kigepeng	rather rare; mainly in forests
Rhaphidophora montana	BV	(49)	(+)	+	Lolo (pp)	in veg. table included in Araceae 'Lolo'
Schismatoglottis Calyptrata	BH	7	+	+	Sente	-
Scindapsus pictus	BV	2	+	+	Ar.kicorelat	-
Araliaceae						
Schefflera elliptica	BS	27	+	+	-	-
Schefflera fastigiata	SE	1	+	+	-	-
Arecaceae						Among the local people there is hardly any consensus on name for rattan species. The names provided here are common, but far from generally accepted
Areca cathecu	TP	35	+	(-)	Jambe	-
Arenga obtusifolia	TP	46	+	+	Langkap	-
Arenga pinnata	TP	52	+	(-)	Aren	-
Calamus javensis	PL	9	+	+	Rotan cacing	-
Calamus cf.orantus	PL	6	+	+	?Rotan seuti, ?Rotan bubuway	- -
Calamus polystachys	PL	57	+	+	Rotan gelang	-
Calamus reinwardti	PL	(50)	-	+	-	rather rare; mainly in forest below 100 m
Calamus rhomboideus	PL	5	+	+	?Rotan leles	-
Calamus 'tunggal'	PL	10	+	(-)	Rotan tunggal	unidentified species
Calamus unifarius	PL	49	+	+	Rotan patis; Rotan walat	- -

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Calamus viminalis	PL	61	+	+	Rotan korot	-
Caryota mitis	PL	49	+	(-)	Sayar	-
Ceratolobus glaucescens	PL	4	+	+	Rotan beula	-
Cocos nucifera	TP	70	+	(-)	Kelapa	-
Corypha utan	TP	57	+	(-)	Gebang	-
Daemonorops melanochaete	PL	50	+	(-)	Rotan seel	-
Daemonorops cf. ruber	PL	1	+	(-)	-	-
Korthalsia junghuhnii	PL	49	+	(-)	Rotan bulu	-
Licuala gracilis	SP	2	+	+	?Sadang gunung	-
Licuala spinosa	SP	54	+	(-)	Sadang hutan	-
Livistona rotundifolia	TP	84	+	+	Sadang	-
Nypa fruticans	SP	88	+	(-)	Nipah	-
Oncosperma tigillarria	TP	36	+	(-)	Nibung	-
Pinanga coronata	TP	48	+	(-)	Pinang; ?Bingbin	maybe locally confused with Areca latiloba
Salacca edulis	SP	37	+	(-)	Salak	-
Aristolochiaceae						
Apama tomentosa	BH	48	+	+	Kutak	-
Asclepiadiaceae						
Calotropis gigantea	BS	63	+	+	Widuri	
Dischidia bengharensis	HE	(88)	-	+	Ar.lelentalan	founds only once (plot 228)
Finlaysonia obovata	BL	88	+	+	-	-
?Genianthus ellipticus	BL	(1)	-	+	-	found only once (plot 117)
Heterostemma acuminatum	BV	(47)	-	+	?Ar.kalameta	found only twice (plot 119 and 71)
Tylophora laevis	BV	71	+	+	Ar.ciciap (laut)	-
Asteraceae						
Ageratum conyzoides	BH	(39)	-	+	Babadotan	found only once (plot 147)
Eclipta prostrata	BH	64	+	+	Kipelik (pp)	-
Elephantopus scaber	BH	(66)	-	+	-	included in plot only once (67); also on Cigenter grazing ground
Eupatorium odoratum	BH	58	+	-	Nampong	-
Grangea maderaspatana	BH	82	+	+	-	-
Gynura cf.procumbens	BV	(39)	-	+	?Ar.balagaduk	found only once (plot 192)
Launaea sarmentosa	BH	(77)	-	+	-	found only once (plot 104)
?Microglossa pyrifolia	BS	(39)	-	+	?Ar.sintrong	found only once (plot 173) maybe confused with Blumea riparia
Mikania cordata	BV	58	+	+	Capituheur	-
Struchium sparganophorum	BH	82	+	+	Kipelik (pp), Pepelikan rawa	- -
Vernonia cinerea	BH	66	+	+	-	
Wedelia biflora	BV	(74)	-	+	Nampong laut, Tulangkotok	found only twice (plot 45 and 102)
Begoniaceae						
Begonia isoptera	BH	7	+	+	Krokot karang	-
Bignoniaceae						
Dolicandrone spathacea	DT	88	+	+	Dedelanan	-
Oroxylum indicum	ET	(49)	-	+	Gompong	rather rare; mainly in shrub-and woodlands
Radermachera gigantea	ET	71	+	+	Padali	-
Bombacaceae						
Bombax valetonii	DT	19	+	(-)	Dangdeur	-
Durio zibethinus	ET	(11)	-	-	Kadu	found only once (plot 134)
Neesia altissima	ET	7	+	(-)	Bengang	-

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Boraginaceae						
Cordia dichotoma	ET	57	+	+	Kenal	
Cordia subcordata	ET	(77)		+	Kenal laut	found only twice (plot 24 and 30)
Heliotropium indicum	BH	82	+	+	Kikuntul	-
Messerschmidia argentea	BS	70	+		Babakoan (pp)	-
Tournefortia tetandra	BL	(88)	-	+	-	found only once (plot 215)
Burseraceae						
Canarium asperum	ET	(22)	(+)	+	Kenari (pp)	in veg.table included in C.spec.; sampled once (plot 86)
Canarium denticulatum	ET	(22)	(+)	+	Kenari (pp)	sampled once (plot 86) most common Canarium spec.; probably restricted to altitudes below 150 m.
Canarium hirsutum	ET	(22)	(+)	+	Kenari (pp)	in veg. table included in C.spec.; sampled twice (plot 5 and 107)
Canarium littorale	ET	(22)	(+)	+	Kenari (pp)	in veg. table included in C.spec.; sampled twice (plot 118 & 129).
Caesalpiniaceae						
Caesalpinia cf. bonduc	BL	(58)	(+)	+	Ar.jingjing kulit (pp)	collected in plot 15; in veg.table included in C.spec.
Caesalpinia cf. cinclidocarpa	BL	(58)	(+)	+	Ar.jingjing kulit (pp)	collected in plot 44; in veg.table included in C.spec.
Cassia occidentalis	BH	(66)	-	+	Kastroli	found only once (plot 331)
Cassia timoriensis	ET	(39)	-	+	Haringin	found only twice (plot 160 and 336)
Cassia tora	BH	(66)	-	+	Ketepeng	found only once (plot 331)
Cynometra ramiflora	ET	57	+	+	Kibatok	-
Peltophorum pterocarpum	ET	(71)	-	+	Jeunjing laut	rather rare; mainly in coastal vegetation
Saraca thaipingensis	ET	11	+	+	?Kimangsi	-
Tamarindus indica	ET	(66)	-	-	-	planted on P. Handeul.
Capparaceae						
Capparis micracantha	BS	31	+	+	-	-
Capparis pyrifolia	BS	14	+	+	-	-
Crateva nurvala	DT	(39)	-	+	Barunai	found only once (plot 105)
Caricaceae						
Carica papaya	PT	(44)	-	(-)	Gedang	locally cultivated near guardposts
Casuarinaceae						
Casuarina equisetifolia	AT	87	+	+	Camara	-
Celastraceae						for Salacia see: Hippocrateace
Celastrus paniculatus	BL	(39)	-	+	-	found only once (plot 204)
Euonymus javanicus	ET	(26)	-	+	-	found only once (plot 310)
Microtropis elliptica	ET	1	+	+	Lameutang pasir (pp)	-
Chloranthaceae						
Chloranthus elatior	BS	(12)	-	+	-	found only once (plot 144)

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Clusiaceae						
Calophyllum grandiflorum	ET	7	+	+	Nyanyamplungang (pp)	-
Calophyllum inophyllum	ET	72	+	(-)	Nyamplung	-
Calophyllum soulattri	ET	5	+	+	Nyanyamplungan-(pp)	
Calophyllum teysmanni	ET	(9)	-	+	Nyanyamplungan (pp)	found only twice (plot 140 and 145)
Garcinia celebica	ET	22	+	+	Manggu leuweung (pp)	-
Garcinia dulcis	ET	6	+	+	Manggu leuweung (pp)	-
Garcinia lateriflora	ET	2	+	+	Manglid	-
Garcinia parvifolia	ET	16	+	+	Ceuri	-
Garcinia rostrata	ET	5	+	+	Kimenyan	-
Combretaceae						
Combretum cf. punctatum	BL	(11)	-	+	Tarawelot (pp)	found only once (plot 129)
Lumnitzera littorea	ET	(87)	(+)	+	Padi-padi (pp)	in veg.table included in L.spec.
Lumnitzera racemosa	ET	(87)	(+)	+	Padi-padi (pp)	idem
Terminalia catappa	DT	74	+	-	Ketapang	-
Commelinaceae						
Aneilema herbaceum	CH	(50)	-	+	?Bawang hutan	found only twice (plot 3 and 9)
Commelina spec.	CH	(50)	-	+	?Wuwudulan	rather rare in Arenga and Dendrocnide vegetation
Murdannia nudiflora	CH	67	+	+	Kikoret	-
Compositae						see: Asteraceae
Connaraceae						
Agelaea borneensis	BL	(5)	-	+	-	found only once (plot 335, Mt. Honje)
Agelaea macrophylla	BL	(49)	-	+	Ar.kawao (pp)	collected in plot 2. *Probably often con*fused with Connarus and Derris species ('Ar. kawao')
Connarus semidecandrus	BL	(73)	-	+	-	collected only once (plot 64), but see Agelaea macrophylla
Roureopsis emarginata	BL	6	+	+	?Ar.dingding	-
Convolvulaceae						
Ipomoea cf.gracilis	BH	79	+	+	Mamantangan	-
Ipomoea cf.pes-caprae	BH	79	+	+	Katang-katang	-
Ipomoea cf. trifida	BV	(68)	-	+	?Ar.lolopangan rawa (pp)	found only twice (plot 95 and 96)
Lepistemon binectariferus	BV	(39)	(+)	+	Ar.lolopangan bulu;(pp);Ar. palungpung bulu (pp)	collected in plot 10 and 86 in veg.table combined with Merremia vitifolia
Merremia peltata	BV	39	+	+	Ar.palungpung (merah)	-
Merremia umbellata	BV	39	+	+	Ar.palungpung reuteun	-
Merremia vitifolia	BV	(39)	(+)	+	Ar.lolopangan bulu (pp); Ar.Palung pung bulu	collected in plot 147; in veg.table combined with Lepistemon binectariferus.
Operculina riedeliana	BV	(77)	-	+	Ar.mamantagan putih	found only once (plot 122)
Cucurbitaceae						
Benincasa hispida	BV	(51)	-	+	Ar.kunur monyet	rather rare, in var. vegetation types.

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Luffa aegyptiaca	BV	(51)	-	+	Ar.lopang monyet	collected only in plot 92; probably rather rare in various vegetation types; during fieldwork confused with Momordica charantia
Momordica charantia	BV	(51)	-	+	Ar.lopang monyet	coll. only in plot 95; see Luffa aegyptiaca
Trichosanthes bracteaca	BV	(51)	-	+	?Ar.lolopangan rawa (pp) ?Ar.silayran	rather rare, mainly in shrublands, also on Pulau Peucang
<u>Cycadaceae</u>						
Cycas rumphii	SP	76	+	-	Pakis	-
<u>Cyperaceae</u>						
Carex cryptostachys	GH	(39)	-	+	Ilat huma	found only once (plot 172)
Cyperus compressus	GH	(68)	(+)	+	?Leuleuyetan piit	collected in plot 331; in veg.table included in C.spec.
Cyperus cyperinus	GH	(68)	(+)	+	-	collected in plot 146 and 334; in veg.table included in C.spec.
Cyperys halpan ssp.halpan	GH	(68)	(+)	+	Jajagoan (pp)	collected in plot 74 and 149; in veg.table included in C.spec.
Cyperus javanicus	GH	(68)	(+)	+	(Ilat)jajagoan(pp)	collected in plot 122; in veg.table included in C.spec.
Cyperus kyllingia	GH	(68)	(+)	+	Teki	by far the most common Cyperus of the area; in veg.table included in C.spec.
Cyperus pedunculatus	GH	79	+	+	Ilat laut (pp)	-
Cyperus polystachyos	GH	(68)	(+)	+	-	collected in plot 74; in veg.table included in C.spec.
Cyperus stoloniferus	GH	(68)	(+)	+	Ilat (pp)	collected in plot 36, in veg.table included in C.spec.
Cyperus cf.tenuispica	GH	(68)	(+)	+	-	collected in plot 180; in veg.table included in C.spec.
Eleocharis dulcis	GH	82	+	+	Babawangan badak	-
Eleocharis geniculata	GH	82	+	+	Babawangan ranca	-
Fimbristylis acuminata	GH	66	+	+	-	-
Fimbristylis complanata	GH	(66)	+	+	-	found only once (plot 1)
Fimbristylis cymosa	GH	79	-	+	Ilat laut (pp)	-
Fimbristylis dichotoma	GH	66	+	+	-	-
Fimbristylis miliacea	GH	69	+	+	Ilat banteng	-
Hypolythrum nemorum	GH	(49)	-	+	Harashas minyak	found only twice (plot 113 and 155)
Mapania cuspidata	GH	(5)	-	+	?Parasi pandan	found only once (plot 111)
Rhynchospora corymbosa	TG	82	+	+	Ilat (pp)	-
Scirpodendron ghaeri	PS	84	+	+	Harashas (pp)	-
Scleria spec.	GH	83	+	+	Ilat piit; ilat badak	-
<u>Datiscaceae</u>						
Tetrameles nudiflora	DT	(26)	-	(-)	-	only found on coastal plain of Peucang Isl. (labelled tree)

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Dilleniaceae						
Dillenia excelsa	ET	15	+	(-)	Segel	-
Dillenia indica	ET	(34)	-	-	Sempur batu	in plot 69; outside plots regularely observed in similar habitats
Dillenia obovata	DT	28	+	(-)	Sempur	-
Tetracera scandens	BL	51	+	+	Ar.kiasahan	-
Dioscoreaceae						
Dioscorea hispida	BV	40	+	+	Ar.gadung	-
Dioscorea nummularia	BV	38	+	+	Ar.huy sabut hutan; Ar. gagadungang	-
Dipterocarpaceae						
Dipterocarpus trinervis	ET	5	+	+	-	-
Ebenaceae						
Dipspyros buxifolia	ET	(49)	-	+	?Pacar gunung	found only twice (plot 296 and 335)
Dipspyros cauliflora	ET	19	+	(-)	Kigentel	even very small seedlings easily recognizable by the fetid, Stachys-like smell from the inner bark
Diospyros ferrea	ET	61	+	+	Kitenyek (pp)	-
Diospyros ferrea cf. var. litorea	ET	(61)	(+)	+	Kitenyek (pp)	found only once (plot 4) in veg.table included in D.ferrea
Diospyros frutescens	ET	9	+	+	Kisiri	-
Diospyros hermaphroditica	ET	(7)	-	+	?Kinadah	found only twice (plot 129 and 140)
Diospyros cf.javanica	ET	(71)	(+)	+	Kilutung laut	possibly a form of D. maritima found only once (plot 38); in veg.table included in D.maritima
Diospyros macrophylla	ET	16	+	+	Kicalung	-
Diospyros malabarica	ET	27	+	+	Kilutung (asli) (pp)	-
Diospyros maritima	ET	71	+	+	Kilutung laut (pp)	-
Diospyros pendula	ET	71	+	+	?Kihareng gunung; ?Kilancip (pp)	a not Diospyros like species; not very common, mainly in Arenga forest, see: Drypetes ovalis
Diospyros polyathiodes	ET	29	+	+	Kilutung (pp)	-
Elaeocarpaceae						
Elaeocarpus glaber	ET	12	+	+	Katulampa	-
Elaeocarpus obtusus	ET	(12)	-	+	?Katulampa badak	found only once (plot 145)
Eriocaulaceae						
Eriocaulon truncatum	GH	(69)	-	+	-	found only once (plot 4)
Erythroxylaceae						
Erythroxylum cuneatum	ET	(20)	-	(-)	-	found only once (plot 282); tree labeled by Kostermans c.s.
Euphorbiaceae						
Alchornea javanensis	BS	(12)	-	+	Pohon singugu	found only once (plot 144)
Antidesma velutinosum	ET	6	+	+	Kiseuheur (pp)	-
Antidesma spec.	ET	71	+	+	Huni	includes both A.bunius and A.montanum
Aporosa aurita	ET	32	+	(-)	Peuris (asli)	-

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Baccaurea dulcis	ET	(47)	-	-	Menteng	rather rare; mainly in Arenga forest
Baccaurea javanica	ET	15	+	+	Kiheucit	-
Bischofia javanica	ET	33	+	+	Gadog	
Blumeodendron tokbrai	ET	22	+	+	Jambu bol hutan (pp) Kisero	the vernacular'tokbrai' is generally used for Aglaia latifolia in Ujung Kulon
Breynia cernua	BS	(86)	(+)	+	Kipare (pp); Kipacikrak (pp)	in veg.table combined with B.racemosa
Breynia racemosa	BS	(86)	(+)	+	Kipare (pp)	in veg.table combined with B.cernu
Bridelia monoica	ET	(71)	-	+	Pohon kanyere badak/biasa	not very common; mainly in Ardisia and rattan vegetation
Bridelia stipularis	BS	61	+	+	Ar.kanyere badak	-
Claoxylon polot	ET	43	+	+	Talingkup	-
Cleisthanthus sumatranus	ET	(29)	-	+	-	found only twice (plot 97 and 171)
Croton argyratus	ET	20	+	+	Kijahe (pp)	-
Croton caudatus	BL	(39)	-	+	Ar.jalatong (pp)	found only once (plot 259)
Croton oblongus	ET	1	+	+	Kijahe gunung	-
Drypetes longifolia	ET	45	+	+	Kokosan hutan ?Kitulang gunung	-
Drypetes ovalis	ET	29	+	+	Kitulang (pp) Papancaran	most likely mista.. for Diospyros pendula by Djaja et al. (1982) see also D. serrata
Drypetes rhacodiscus	ET	9	+	+	Kibolendrang	-
Drypetes cf.serrata	ET	(26)	-	+	-	found only once (plot 310) possibly confused with D.ovalis Leaf margin possibly less diagnostic that stated in Flora of Java
Euphorbia atota	BH	79	+	+	R.ramukasang	-
Euphorbia hirta	BH	65	+	+	R.nanangkaān	-
Excoecaria agallocho	DT	(87)	-	+	Kiapu	found only once (plot 246)
Excoecaria virgata	ET	29	+	+	Kisereh	-
Galearai filiformis	ET	16	+	+	Kileho	-
Glochidion cf. kollmannianum	ET	(1)	-	+	Manggong	found only once (plot 135)
Glochidion cf. philippicum	ET	(26)	-	+	?Peuris merah	found only once (plot 28)
Glochidion rubrum	BS	(39)	-	+	?Ar.simpeureum	found only once (plot 278)
Glochidion zeylanicum	ET	60	+	+	Reu'eun	-
Glochidion spec.	ET	48	+	+	-	-
Macaranga glaberrimus	ET	(5)	-	+	?Tengek guning	found only once (plot 114)
Macaranga laevigatus	ET	(12)	-	+	-	found only once (plot 293)
Macaranga tanarius	ET	42	+	+	Mara (biasa)	-
Macaranga triloba	ET	(5)	-	+	Mara bangkong	found only once (plot 139)
Mallotus blumeanus	ET	14	+	+	Bungbulang (pp)	-
Mallotus dispar	ET	24	+	+	-	-
Mallotus floribundus	ET	(58)	-	+	Waru rot	rather rare, mainly in rattan vegetation
Mallotus mortizianus	BS	20	+	+	Bungbulang (pp)	-

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Mallotus philippensis	ET	61	+	+	Hareno laut; Daruwak laut	- -
Mallotus ricinoides	ET	(30)	-	+	Calik angin	rare, in various vegetation type on low altitudes
Mallotus tiliaefolius	BS	75	+	+	Waru laut (pp)	-
Margaritaria indica	ET	(51)	-	+	?Angrit (pp)	found only twice (plot 25 and 41)
Phyllanthus hasskarlianus	BS	2	+	+	Kinereng (gunung)	-
Phyllanthus niruri	BH	(82)	-	+	-	found only once (plot 39)
Phyllanthus urinaria	BH	65	+	+	Beubeunyeran	-
Ptychopyxis javanica	ET	7	+	+	Kibeusi gunung	-
Sumbaviopsis albicans	BS	12	+	+	Kijahe (pp)	-
Suregada glomerulata	ET	25	+	+	Kitulang laut; Lameutang pasir (pp)	-
Trigonostemon ovatifolius	BS	(19)	-	+	-	found only twice (plot 107 and 282); see Anacolosa (Olac.)
Flacourtiaceae						
Casearia flavovirens	ET	(71)	(+)	+	Kiseu'eur laut (pp)	collected in many localities; in veg.table included in C.spec.
Casearia grewiaefolia	ET	(71)	(+)	+	Kiseu'eur laut (pp)	collected in many localities; in veg.table included in C.spec.
Flacourtia rukam	ET	1	+	+	Rukem (pp)	-
Scolopia spinosa	ET	24	+	+	Rukem (pp)	-
Flagellariaceae						
Flagellaria indica	GV	57	+	+	Oar	
Gentianaceae						
Cotylanthera tenuis	AH	(46)	-	-	-	once found in langkap forest on the edge of limestone plateau S. of Nyewaan.
Gesneriaceae						
Aeschynanthus radicans	HE	1	+	+	-	-
Cyrtandra cf.picta	BH	6	+	+	R.krokot	-
Cyrtandra sandei var. glabrescens	BS	(7)	-	+	Kikoyong	found only thrice (plot 138, 139 and 141)
Loxonia hirsuta	BH	11	+	+	-	-
Gnetaceae						
Gnetum gnemon	ET	24	+	(-)	Tangkil	possibly indicating former inhabitation
Gnetum latifolium	BL	(11)	+	+	Ar.kasunka (pp)	in veg.table included in Gnetum spec.
Gnetum spec.	BL	11	+	+	Ar. kasunka	Gnetum cuspidatum + G. L latifolium
Gonystylaceae						
Gonystylus macrophyllus	ET	(7)	-	+	Jambu bol. hutan (pp)	found only twice (plot 118 and 141)
Goodeniaceae						
Scaevola taccada	BS	73	+	(-)	Babakoan (pp)	-
Gramineae						see Poaceae
Hernandiaceae						
Hernandia peltata	ET	74	+	(-)	Kampis	-
Hippocrateaceae						

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Loeseneriella pauciflora	BL	(51)	-	-	Ar.kijaha (pp)	rather comm., but frequently confused with Rubiaceae-climbers during fieldwork
Salacia chinensis	BL	71	+	+	Ar.kacepot Ar.parengkel (pp)	-
Salacia spec.	BL	(11)	-	+	-	found only once (plot 129)
Hypericaceae						
Cratoxylum cf.formosum	ET	(39)	-	+	?Pohon simperem	*found only once (plot* 180)
Cratoxylum sumatranum	ET	(39)	-	+	-	found only once (plot 279)
Hypoxidaceae						
Curculigo orchiordes	GH	61	+	+	Parasi (pp)	possibly sometimes confused with Molineria
Molineria latifolia	GH	49	+	+	Parasi (pp)	-
Icacinaceae						
Gomphandra javanica	ET	7	+	+	-	-
Phytocrene macrophylla	BL	(58)	-	+	?Ar.kacepot bulu	found only twice (plot 203 and 219)
Lamiaceae						
Anisomeles indica	BH	(39)	-	+	-	found only once in rattan vegetation at low altitude
Hyptis rhomboidea	BH	39	+	+	Paci-paci	-
Lauraceae						
Actinodaphne glabra	ET	(46)	-	+	-	rather rare; mainly in Langkap forest
Cassytha filiformis	AV	73	+	-	-	-
Cinnamonum iners	ET	35	+	+	Kiteja	-
Connamonum sintoc	ET	2	+	+	Kiteja gn.(pp)	-
Cryptocarya densiflora	ET	5	+	+	Kiteja gn.(pp)	-
Cryptocarya ferrea	ET	24	+	+	Kilja laut (pp) Kilja putih (pp)	-
Dahaasia caesia	ET	(20)	-	(-)	-	found only once (plot 282, tree labelled by Kostermans c.s.)
Litsea noronhae	ET	36	+	+	Kibayawak	-
Lauraceae rest	ET	-	-	+	Huru, Hanjat	the family of the Lauraceae is very well represented in Ujung Kulon (see e.g. Kartawinata & Apandi, 1977).However, identification of sterile specimens, esp. juvenile stages, provides serious problems in most species. Only the most charact. spec. have been included in the vegetation table. The species neglected are all of little importance in the vegetation cover
Lecythidaceae						
Barringtonia asiatica	ET	70	+	(-)	Butum	-
Barringtonia macrocarpa	ET	15	+	(-)	Songgom	-
Barringtonia racemosa	ET	(57)	-	+	Songgom anjing	found only twice (plot 68 and 100)
Planchonia valida	ET	17	+	(-)	Putat	-
Lentibulariaceae						
Utricularia cf.gibba ssp. exoleta	BH	81	+	+	Lukut ramat	-

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Liliaceae						
Ophiopogon caulescens	GH	(39)	-	+	?Rumput babakungan	found only once (plot 96)
Loganiaceae						
Strychnos ignatii	BL	(5)	-	+	-	found only once (plot 335, Gn.Honje).
Strychnos villosa	BL	(50)	-	+	-	found only twice (plot 221 and 278)
Loranthaceae						
Dendrophtoe pentandra	SE	(71)	-	+	mangandeuh	rare; in var. coastal and shrubby vegetations
Lythraceae						
Lagerstroemia flos-reginae	ET	56	+	(-)	Bungur	-
Pemphis acidula	ES	75	+	(-)	Cantigi	-
Magnoliaceae						
Talauma candollii	ES	5	+	+	?Kiparay	-
Malpighiaceae						
Aspidopterys tomentosa	BL	(51)	-	+	?Ar.jajamian	rare in various vegetation types below 150 m
Malvaceae						
Hibiscus surattensis	BV	(58)	-	-	Ar. gamet	found only once within a plot (105); also com. on sandstone ridge near the Cibunar shelter
Hibiscus tiliaceus	BS	71	+	+	Waru laut (pp)	-
Sida javensis	BH	44	+	+	Lopang laut	-
Sida rhombifolia ssp.retusa	BH	67	+	+	Sidagori	-
Thespesia populnea	ET	(73)	-	+	Waru laut (pp)	with certainly found only once (plot 24). Possibly locally mistaken for Hibiscus tiliaceus.
Marantaceae						
Donax cannaeformis	BH	49	+	(-)	Bangban	-
Phrynium pubinerve	BH	49	+	+	Patat (incl. Patat maung)	-
Melastomaceae						
Astronia macrophylla	ET	5	+	+	?Harendong bulu ?Babalimpingan	- -
Medinilla radicans	BS	1	+	+	?Kibuek	-
Melastoma affine	BS	58	+	+	Harendong	-
Memecylon ambiguum	ET	31	(+)	+	?Peutag (pp)	in veg.table included in M.spec. (= M. ambiguum + M. edule + M. myrsinoides
Memexylon edule var.ovatum	ET	31	(+)	+	?Peutag (pp)	idem
Memecylon excelsum	ET	51	+	+	Hareuyheuy (pp)	-
Memecylon floribundum	BS	31	+	+	-	-
Pternandra azurea	ET	5	+	+	-	-
Meliaceae						
Aglaia argentea	ET	24	+	(-)	Kakaduan	-
Aglaiia elaeagnoidea	ET	74	+	+	Kibatok (pp)	-
Aglaia latifolia	ET	44	+	+	Tokbrai	-
Aglaia cf. odoratissima	ET	9	+	+	?Surundun (pp)	-
Aglaia/Dysoxylum spec.	ET	22	+	+	?Surundun (pp)	rest group. Strikingly well represented on Peucang Isl.(see Kartawina & Apandi, 1977 for species list), sterile specimens of these species especially juvenile

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
						stages, are very hard to identify.
Aphanamixis humile	ET	(22)	-	-	?Kokosan asli	found only twice (plot 27 and 335)
Chisocheton microcarpus	ET	24	+	+	-	-
Sandoricum Koetjape	ET	5	+	+	Kecapi	-
Vavaea bantamensis	ET	(12)	-	+	-	found only once (plot 145)
Menispermaceae						
Pericampylus glaucus	BV	39	+	+	Ar.geureung	
Pycnarrhena cauliflora	BS	(22)	-	+	-	rather rare; mainly on Mt.Payung and Peucang
Stephania japonica var. discolor	BV	(73)	-	+	-	found only once (plot 66)
Tinomiscium phytocrenoides	BL	(73)	-	+	Ar.geureung laut	found only once (plot 40)
Tinospora glabra	BL	(51)	-	+	-	rare in various vegetation types below 150 m
Mimosaceae						
Albizia procera	ET	40	+	+	Kihiang	-
Albizia retusa	ET	(72)	-	+	Kihiang laut	found only twice (plot 242 and 248)
?Leucaena leucocephala	BS	(74)	-	+	Pohon balanding	found only once (plot 92)
Parkia roxburghii	ET	(50)	-	+	Pete hutan	included in plot only once (26);also observed in rattan vegetation
Pithecellobium clyeparia	ET	1	+	+	Phon jeunjing (gunung) (pp)	-
Pithecellobium ellipticum	BS	(50)	-	+	Pareket (pp)	rare in various vegetation types below 150 m
Molluginaceae						
Glinus oppositifolius	BH	82	+	+	Gegelangang rawa (pp)	-
Monimiaceae						
Kibara coriacea	ET	1	+	+	Kibantelik	-
Moraceae						
Artocarpus elasticus	ET	15	+	(-)	Teureup	-
Ficus altissima	SF	(18)	(+)	+	Kiara koang (pp); Kiara jingkang (pp)	collected in various localities in below 150 m; in veg.table included Ficus 'strangled
Ficus ampelas	ET	7	+	+	Hampelas (pp)	-
Ficus annulata	SF	(18)	(+)	+	?Kiara biasa (pp)	dub. sample from plot, 173, in veg.table incl. in Ficus 'strangler';
Ficus callophylla	SF	(18)	(+)	+	Kiara biasa (pp) ?Kiara koang (pp)	deciduous in veg.table incl.in Fic.'strangl.', collected in various localities below 150 m
Ficus callosa	ET	(51)	-	+	Pangsor	not very common, mainly in Arenga forest and rattan shrubland; rarely coastal
Ficus deltoidea	SE	1	+	+	-	-
Ficus elastica	SF	(18)	(+)	+	Kiara koang (pp) Kiara jingkang (pp)	collected in plot 5, 70 and 186 In veg.table incl. in F.'strangler'
Ficus fistulosa	ET	(51)	-	+	Leles	rare in forests throughout the area
Ficus hispida	ET	(49)	-	+	?Beunying	not very comm. in forests and shrublands throughout the area
Ficus magnoliaefolia	ET	21	+	(-)	-	-
Ficus microcarpa	SF	88	+	+	Kiara biasa (pp)	-

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Ficus montana	BS	50	+	+	Amis mata	-
Ficus obscura	BT	11	+	+	-	-
Ficus pubinervis	ET	26	+	+	Hampelas (pp)	-
Ficus racemosa	DT	8	+	+	?Kitako	-
Ficus septica	ET	71	+	+	Bisoro	-
Ficus sinuata	BS	5	+	+	Pangsor gunung	-
Ficus stupenda	SF	(51)	-	+	Karet kebo	not very common in forest types below 450 m
Ficus superba	SF	(18)	(+)	+	-	collected in plot 24; in veg.table included in Ficus 'strangler'
Ficus tinctoria	SF	(49)	-	+	?Hampelas tangkal	not very common in forest and shrubland throughout the area, but not recorded on Peucang Isl.
Ficus variegata	DT	(51)	(+)	+	-	not very common in various vegetation types below 100 m, rarely coastal
Ficus cf. virens	SF	(18)	(+)	+	-	collected in veg.table in plot 186; included in Ficus 'strangler'; deciduous
Ficus spec. ('strangler')	SF	18	+	+	Kiara etc.	combination of all strangling figs, not including F.microcarpa, F. stupenda and F.tinctoria.
Maclura cochinchinensis	BL	62	+	+	Ar.kuderang	-
Parartocarpus venenosa	ET	5	+	+	Purut	-
Poikilospermum suaveolens	BL	57	+	+	Ar. leuksa	-
Streblus asper	ET	(20)	-	+	-	found only once (plot 284)
Streblus spinosus	BS	(29)	(+)	+	Jejerukan (pp)	in veg.table combined with S. taxoides
Streblus taxoides	BS	(29)	(+)	+	Jejerukan (pp)	in veg.table combined with S. spinosus
Musaceae						
Musa acuminata	TP	42	+	(-)	Pisang kole	-
Myristicaceae						
Horsfieldia glaba	ET	7	+	+	Kimokla (pp)	-
Horsfieldia irya	ET	(71)	-	+	Kelapaciung	rare, mainly in swampy areas on low altitude
Knema cinerea	ET	22	+	+	Kimokla (pp)	-
Knema intermedia	ET	(7)	-	+	?Kicarang dahan	found only twice (plot 118 and 121)
Knema laurina	ET	(46)	-	+	Kimokla (pp)	found only once (plot 326)
Myristica guatteriifolia	ET	26	+	+	Kmokla (pp)	-
Myristica iners	ET	10	+	+	Pala hutan	-
Myrsinaceae						
Aegiceras corniculatum	BS	89	+	+	Bangka kecil	-
Ardisia cf.blumii	BS	9	+	+	-	-
Ardisia crispa	BS	(10)	-	+	?Kikuya	a rare, but loyal member of soc.group 10
Ardisia cymosa	BS	12	+	+	-	-
Ardisia humilis	ET	71	+	+	Lampeni merah; lampeni hijau (pp)	-
Ardisia lanceolata	ET	45	+	+	Lampeni gunung (pp); Lampeni hijau (pp)	-
Ardisia lurida	ET	11	+	+	Lampeni gunung (pp)	-
Ardisia macrophylla	BS	5	+	+	-	-
Embelia cf. javanica	BL	(53)	(+)	+	Ar. kacembang	in veg.table included in E.spec.
Labisia pumila	BS	2	+	+	Babakoan gunung	-
Myrsine hasseltii	ET	2	+	+	?Kitengek piit, ?Harupat	-

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Myrtaceae						
Acmena acuminatissima	ET	(46)	-	+	Heas (pp)	found only once (plot 158)
Decaspermum fruticosum	ET	(71)	-	+	?Kimerak	collected only once (plot 330); possibly also in Bambusa forest
Psidium guajava	ET	(66)	-	-	Jambu piit	a few trees on Cigenter grazing ground
Rhodamnia cinerea	ET	(11)	-	+	Hareuyheuy (pp)	found only once (plot 125)
Syzygium polyanthum	ET	55	+	(-)	Salam	-
Syzygium pseudoformosum	ET	43	+	+	Kopo besar; Kopo laut	- -
Syzygium cf. syzygioides	ET	2	+	+	Kopo kecil (pp)	-
Syzygium zollingerianum	ET	22	+	+	Kopo lalay	-
Syzygium spec.	ET	47	+	+	Kopo (pp) Heas (pp) Jambu hutan	rest group; the genus Syzygium is well represented in Ujung Kulon However, most species are very diffucult to identify in a sterile state.
Najadaceae						
Najas indica	GH	81	+	+	-	-
Nyctaginaceae						
Pisonia aculeata	BL	(71)	-	+	Ar. gerang	found only twice (plot 203 and 248)
Pisonia umbelliflora	ET	(26)	-	(-)	-	labeled tree along trail on Peucang Isl.
Nymphaeaceae						
Nymphaea nouchali	BH	81	+	+	?Eceng gondok	-
Olacaceae						
Anacolosa frutescens	ET	22	+	-	*Kituak, Kopi* leuweung	*locally confused with* Lepionurus (Opil.) and Trigonostemon (Euph)
Ximenia americana	BS	62	+	+	?toto'et	very variable; small seedlings may be confused with Gmelina seedlings. However Ximenia has spirally arranged leaves.
Oleaceae						
Ligustrum glomerulatum	ET	61	+	+	Ar. katumpang	-
Linociera montana	BS	5	+	+	Cangkuladuk	-
Myxopyrum nervosum	BL	52	+	+	Ar. kupa-kupa	-
Onagraceae						
Ludwigia adscendens	BH	82	+	+	-	
Ludwigia hyssopifolia	BH	(69)	-	+	?Rumput gaga'angan	found only once (plot 74)
Opiliaceae						
Lepionurus sylvestris	ES	28	+	+	Kituak (pp)	see Anacolosa (Olacaceae)
Orchidaceae						
Nervilia spec.	BH	34	+	+	Rumput kakaloan	-
Tropidia spec.	BH	(5)	-	+	-	found only once (plot 112)
Vanilla albida	EL	(11)	-	+	Ar. panelli hutan	Found only once (plot 121)
Oxalidaceae						
Averrhoa bilimbi	ET	(22)	-	-	Bilimbing	included in plot only twice (226 and 310);

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
						also observed in higher part of Telanca massif
<u>Palmae</u>						see: Arecaceae
<u>Pandanaceae</u>						
Freycinetia cf. imbricata	GL	2	+	+	Ar. harashas	collected in plot 111; in veg.table included in F.spec.
Pandanus bidur	RT	70	+	(-)	Bidur	-
Pandanus furcatus	RS	83	+	+	Cangkuang	-
Pandanus nitidus	RS	4	+	+	Harashas (pandan); Pandan kecil	-
Pandanus tectorius	RS	77	+	(-)	Pandan (laut)	-
<u>Papilionaceae</u>						
Abrus fruticulosus	BL	(58)	-	+	-	found only twice (plot 4 and 58)
Alysicarpus vaginalis	BH	67	+	+	-	-
Canavalia cathartica	BV	(71)	-	+	-	not very comm.in beach-forest, rarely the interior;during fieldwork confused with Vigna mar.
Dalbergia candenatensis	BL	88	+	+	Ar. apuy rawa	-
Dalbergia pinnata	BL	30	+	+	Ar. apuy	-
Derris heterophylla	BL	88	+	+	Ar. gadel rawa	-
Derris cf. elliptica	BL	39	+	+	Ar. tualaleur	-
Desmodium laxum	BH	1	+	+	Ar. jaja'atan (pp)	-
Desmodium triflorum	BH	65	+	+	Ar. sariawan laut	Probably mistaken for D. heterocarpa by Hoogerwerf, 1970
Desmodium umbellatum	BS	75	+	+	Kanyere laut	-
Erythrina orientalis	DT	74	+	+	Dadap	-
Milletia seriacea	BL	(43)	-	+	Ar. kawao (pp)	see Agelaea (Conn.) with certainly found only once (plot 32)
Mucuna acuminata	BL	(77)	-	+	-	found only once (plot 30)
Pongamia pinnata	ET	76	+	+	Malapari	-
Pueraria phaseoloides	BV	39	+	+	Ar. rarawea	-
Sophora tomentosa	BS	73	+	+	?Tarum	-
Spatholobus ferrugineus	BL	39	+	+	Ar. gongseng	-
Spatholobus littoralis	BL	(5)	-	+	-	found only once (plot 109)
Uraria lagopodioides	BH	(58)	-	+	?Sariawan kucing	In dry grass- and shrublands; rare
Vigna marina	BV	(71)	(+)	+	?Ar.kakalapaăn	see Canavalia cathar.
<u>Passifloraceae</u>						
Adenia macrophylla var. macrophylla	BV	(58)	-	+	-	rare in shrubland; once in Bambusa forest.
Passiflora foetida	BV	(58)	-	+	Ar.pirangrung	Found only twice (plot 47 and 311)
<u>Piperaceae</u>						
Peperomia pellucida	BH	(58)	-	+	-	rare in rattan veg. also once in Syzygium polyanthum forest
Piper aduncum	ET	(58)	-	+	Babanyaran	like Peperomia, also rarely coastal
Piper caninum	BL	(47)	(+)	+	Ar.peupeudesan	collected in plot 70 & 117; in veg.table incl. in Piper spec.
Piper spec.	BL	47	+	+	Karu, Seuseureuhan, Etek, Ar. peupeudesan	Restground; sterile spec. are very hard to identify, esp.juvenile stages, which may deviate strongly from adult plants.

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Poaceae						
Axonopus compressus	GH	68	+	+	Jampang biasa	-
Bambusa blumeana	TB	31	+	+	Bambu haur, bambu duri	mistaken for B. arundinaceae by Djaja et al., 1982.
Centotheca lappacea	TG	(68)	(+)	+	Jampang piit (pp), Jampang kejobear (pp)	in veg.table incl. in Poaceae 'Jampang piit'
Chrysopogon aciculatus	GH	66	+	+	Dongdoman	-
Cymbogon rectus	TG	80	+	+	-	-
Cynodon dactylon	GH	79	+	+	?Jampang badak	-
Cyrtococcum accrescens	GH	(68)	(+)	+	Jampang piit (pp)	in veg.tabel incl. in Poaceae 'Jampang piit'
Cyrtococcum oxyphyllum	GH	(68)	-	+	?Jampang rawi	found only twice (plot 95 & 96, i.e. the wallow-plots in the western hills)
Dactyloctenium aegyptium	GH	64	+	+	?Jampang kurita	-
Digitaria heterantha	GH	64	+	+	-	-
Dinochloa scandens	GL	38	+	+	Bambu cangkore	-
Echinochloa colonum	TG	69	+	+	Jampang ping-ping kasir (pp)	-
Gigantochloa apus	TB	(39)	-	-	Bambu apus	found only twice (plot 167 and 279; occurence probably due to former cultivation
Imperata exaltata	GH	(65)	(+)	+	Euri,alang-alang	in veg.table included in Imperata spec. (= cylindr.+ exalt.) Imperata exalt. is far more common in Java than realized by Backer & Bakhuizen van den Brink (Veldkamp, pers.comm.)
Isachne miliacea	GH	(68)	(+)	+	Jampang piit (pp)	in veg.table included in Poac. 'Jampan piit'
Ischaemum fieldingianum	GH	80	+	+	-	by Backer & Bakhuizen van de Brink incl. in I.barbatum
Ischaemum muticum	GH	78	+	+	Jampang merah	-
Lepturus repens	GH	79	+	+	Jampang laut (pp)	
Oplismenus compositus	GH	(68)	(+)	+	Jampang piit (pp)	in veg.table incl. in Poaceae 'Jampang piit'
Panicum notatum	GH	31	+	+	Rumput bambu piit, Jampang *oar*	resembling a miniature bambu
Panicum paludosum	GH	69	+	+	?Jampang paparean	-
Panicum repens	GH	82	+	+	Jampang jaruju	-
Panicum sarmentosum	GH	(39)	-	+	?Jampang benyer	found only once (plot 147)
Paspalum conjugatum	TG	(69)	-	+	-	found only once (plot 95)
Paspalum scorbiculatum	TG	82	+	+	?Jampang karang; ?Jampang pingping kasir (pp)	var.bispicatum
Paspalum vaginatum	TG	(77)	-	+	-	rare in various coastal vegetations both dry and humid
Sacciolepis indica	TG	66	+	+	-	rare in various veg. on low altitudes
Schizostachyum blumii	TB	(50)	-	+	Bambu bunar; ?bambu serat	formerly cultivated; does not occur spontaneously in Java
Schizostachyum zollingeri	TB	41	+	+	Bambu cangkeuteuk	-
Spinifex littoreus	TG	(79)	-	+	?Jukut kiara	found only once (plot 177)

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Thuarea involuta	CH	79	+	+	Jampang laut (pp)	-
Podocarpaceae						
Podocarpus blumei	ET	(15)	-	+	Taritik	rare in forest on Mt. Payung and western hills (on tuff soils only?)
Polygonaceae						
Polygonum barbatum	BH	82	+	+	Gunda	Probably mistaken for P.longisetum by Hoogerwerf, 19..)
Portulacaceae						
Portulaca tuberosa	BH	(79)	-	+	Gelang (pp)	found only once (plot 8)
Proteaceae						
Helicia serrata	ET	(7)	+	+	-	found only twice (plot 129 and 335)
Heliciopsis lanceolata	ET	(5)	-	+	?Bangkong	found only once (plot 110)
Rhamnaceae						
Smythea lanceolata	BL	(26)	-	+	-	found only once (plot 310)
Ziziphus horsfieldii	BL	16	+	+	Ar. kiterong	-
Ziziphus oenoplia	BL	(50)	-	+	Ar. kiterong bulu	found only twice (plot 266 and 277)
Rhizophoraceae						
Bruguiera cylindrica	ET	89	+	+	Bangka (pp)	-
Carallia brachiata	ET	(51)	-	+	Kuhkuran (pp)	not very common in various vegetations below 100 m; not coastal
Ceriops decandra	ET	89	+	+	Bangka tingi (pp) Bangka tunggul (pp)	-
Ceriops tagal	ET	90	+	+	Bangka tingi (pp) Bangka tunggul (pp)	-
Gynotroches axillaris	ET	2	+	+	Kiendog	
Rhizophora apiculata	ET	90	+	+	Bangka (pp)	-
Rhizophora stylosa	ET	(90)	(+)	+	Bangka (pp)	in veg.table included in R.spec.
Rhizophora spec.	ET	90	+	+	Bangka (pp)	= Rhizophora mucronata + R. stylosa
Rosaceae						
Parinari corymbosum	BT	20	+	(-)	-	-
Parinari sumatranum	BT	36	+	+	-	-
Rubus mollucanus	BL	8	+	+	Ar. hareues	-
Rubiaceae						
Adina trichotoma	ET	(46)	-	+	-	found only twice (plot 18 and 89)
Amaracarpus pubescens	BS	(18)	-	+	-	rather rare in forest below 100 m; not coastal; not on Peucang Isl.
Anthocephalus chinensis	ET	(41)	-	(-)	Hanja	with certainty found only once (plot 260); possible sometimes confused with Nauclea
Argostemma neurocalyx	BH	(29)	-	+	-	found only once (plot 309); cremnophyte
Borreria articularis	BH	66	+	+	-	-
Borreria ocymoides	BH	66	+	+	-	-
Canthium horridum	BS	40	+	+	?Toto'et (pp)	-

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Coptophyllum fulvum	BH	(7)	-	+	-	found only twice (plot 139 and 141)
Dentella repens	CH	82	+	+	?Rumput kiaralus	-
Geophila repens	BH	35	+	(-)	Mata babi	-
Guettarda speciosa	ET	72	+	+	Hamerang	-
Hedyotis auricularia	BH	(51)	-	+	?Rumput asmina	rather rare; only recorded in rattan shrubland and Syzygium polyanthum forest
Hedyotis coerulea	BH	40	+	+	-	-
Hedyotis diffusa	BH	69	+	+	Rumput kakawatan	-
Hedyotis pterida	BH	(71)	+	+	-	rather rare in various vegetations in coastal areas; also in rattan shrublands of the interior. Not on P.Peucang
Hypobathrum racemosum	ET	30	+	+	Haremang	-
Ixora grandifolia	BS	1	+	+	-	-
Ixora javanica	BS	(11)	-	+	-	found only once (plot 121)
Ixora paludosa	BS	72	+	+	Melati laut (pp)	-
Ixora salicifolia	BS	(15)	-	+	-	found only twice (plot 309 and 335)
Ixora umbellata	BS	20	+	+	-	-
Lasianthus cyanocarpus	BS	5	+	+	Kiregas bulu	-
Lasianthus hirsutus	BS	7	+	+	?Jalatong bulu	-
Lasianthus reticulatus	BS	4	+	+	Kiregas	-
Lerchea longicauda	BS	11	+	+	Reundeuh badak	-
Morinda citrifolia	ET	71	+	+	Cangkudu	-
Mussaenda frondosa	BS	(42)	-	+	-	included in plot only once (125); also found elsewhere e.g. on sandstone ridge near Cibunar
?Mycetia javanica	BS	(49)	-	+	?Kikangkareng	our own records are dubious; with certainty growing on Mt.Payung (Wirawan, coll.no.335)
Nauclea coadunata	ET	57	+	+	Gempol	-
Neonauclea calycina	ET	10	+	-	Cangcaratan	-
Ophiorrhiza cf. canescens	BH	61	+	+	Cacabean	-
Ophiorrhiza trichocarpos	BH	34	+	+	Reundeuh (pp)	-
Paederia scandens	BL	39	+	+	Ar. kipuak	-
Psychotria laxiflora	BV	5	+	+	Ar.orang aring	-
Psychotria robusta	BS	5	+	+	-	-
Randia spinosa	BS	(55)	-	+	-	found only once (plot 2)
Saprosma arboreum	ET	6	+	+	Pohon kipuak	-
Scyphiphora hydrophyllacea	BS	88	+	+	Bangka pedis	-
Uncaria cordata	BL	(39)	(+)	+	Ar. kiheulang (pp)	collected in plot 8 in veg.table combined with U.ferrea
Uncaria ferrea	BL	(39)	(+)	+	Ar. kiheulang	collected in isthmus-area
Urophyllum arboreum	BS	2	-	+	-	-
?Wendlandia glabrata	ET	14	+	+	Kicarat	-
Xanthophytum fruticulosum	BS	7	+	+	Reureundeuhan	-
Rutaceae						
Citrus cf.grandis	ET	(66)	-	-	Jeruk ?bali	a single tree on the clearing on Peucang Isl.
Glycosmis pentaphylla	BS	24	+	+	-	-
Luvunga sarmentosa	BL	11	+	+	Ar. cerukcuk	-
Micromelum minutum	ET	56	+	+	Kamaler	in some regions many seedlings can be found. trees are on the whole rather rare
Pleiospermium dubium	BS	24	+	+	Jeruk ragi	-
Zanthoxylon nitiodum	BL	26	+	+	-	-
Zanthoxylum rhensa	ET	30	+	+	-	-

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Sabiaceae						
Meliosma nitida	ET	6	+	+	Kigonyor	-
Meliosma lanceolata	ET	(5)	-	+	-	during our survey only found in plot 335 (Mt. Honje), but also known to grow in Ujung Kulon (see Appendix D)
Sapindaceae						
Allophylus cobbe	BS	71	+	+	Sampang	-
Aphania montana	ET	(46)	-	+	Pohon kawao	found only twice (plot 26 and 35)
Dodonaea viscosa	ET	63	+	+	-	-
Erioglossum rubiginosum	ET	(49)	(+)	+	Kilalayu (pp)	collected in plot 44, 80 and 100;in veg.table included in Sapindaceae 'Kilalayu'
Harpullia arborea	ET	(49)	(+)	+	Kilalayu (pp)	collected in plot 25
Lepisanthes montana	ET	(49)	(+)	+	Kilalayu (pp)	collected in plot 9, 10, 11 and 35; in veg.table included in Sapindaceae 'Kilalayu';probably the most common 'Kilalayu' species
Mischocarpus sundaicus	BS	31	+	+	?Ar.parukpuk	-
Nephelium juglandifolium	ET	(11)	-	+	?Kibonteng	found only once (plot 129)
Pometia pinnata	ET	17	+	(-)	Leungsir	-
Xerospermum noronhianum	ET	5	+	+	?Surundun (pp)	-
Sapotaceae						
Mimusops elengi	ET	(46)	-	+	?Puperutatan	found only once (plot 87) In Java very rare wild, often planted; relict of cultivation
Palaquium ottolanderi	ET	(46)	-	+	Nanangkaān gunung	found only twice (plot 101 and 221)
Payena acuminata	ET	10	+	+	Pohon melati gunung	-
Planchonella duclitan	ET	24	+	+	-	-
Planchonella obovata	ET	4	+	+	Nanangkaān	-
Saurauiaceae						
Saurauia reinwardtiana	ET	(7)	-	+	?Kinangsi gunung	found only twice (plot 111 and 116)
Schisandraceae						
Kadsura scandens	BL	16	+	+	Ar.hunyur bu'ut	-
Scrophulariaceae						
Adenosma javanica	BH	(55)	-	+	-	found only once (plot 3)
Bacopa monnieri	BH	(82)	-	+	Gegelangang rawa (pp)	found only twice (plot 47 and 50)
Lindernia ciliata	BH	65	+	+	?Danca laut	-
Lindernia crustacea	BH	66	+	+	?R.mata keuyeup (pp)	-
Lindernia pusilla	BH	67	+	+	?R. kokotakan	-
Lindernia ruelloides	BH	34	+	+	?R.mata keuyeup (pp); ?Antanan	-
Torenia violacea	BH	(34)	-	+	?Cacaremean	found only once (plot 70)
Simarubaceae						
Ailanthus spec.	ET	(51)	-	+	Tuakelapa	Rather rare though out the area; not coastal. Probably mainly A.triphysa A.integrifolia is a very rare tree more or less restricted to C. &

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
						E.Java. However, it has also been recorded for Peucang Isl.(see Appendix D)
<u>Smilacaceae</u>						
Heterosmilax micrantha	BL	(1)	-	+	?Ar.cacanaran minyak	found only once (plot 119)
Smilax leucophylla	BL	38	+	+	Ar.canar	-
Smilax cf. zeylanica	BL	(5)	-	+	?Ar.cacainavan polos	found only once (plot 13)
<u>Solanaceae</u>						
Solanum melongena	BH	(68)	-	+	-	never incl. in a plot; observed on Peucang on remnant of an old guard post;on the mainland in glades,often associated with Alocasia macrorrh.
<u>Sonneratiaceae</u>						
Sonneratia alba	ET	89	+	(-)	Pidada	-
Sonneratia caseolaris	ET	(88)	-	+	Bogem	found only once (plot 243)
<u>Sterculiaceae</u>						
Heritiera javanica	ET	2	+	+	?Kiharengas	-
Heritiera littoralis	ET	88	+	+	Kakaduan laut	-
Kleinhovia hospita	ET	(58)	-	+	Tangkele	found only twice (plot 11 and 182)
Pterocymbium tinctorium	DT	30	+	+	Tongtolok	-
Pterospermum diversifolium	ET	27	+	+	Cerlang	-
Pterospermum javanicum	DT	23	+	(-)	Bayur	-
Pterygota horsfieldii	ET	21	+	(-)	-	-
Sterculia coccinea	ET	2	+	+	Hantap bu'ut	-
Sterculia foetida	DT	42	+	+	Hantap anjing	-
Sterculia macrophylla	DT	19	+	+	(Ar.jalatong or Tongtolok buluh	for juvenile stages; Muncang hutan for fullgrown trees in forest throughout the area; not coastal
Sterculia spec.	DT/ET	(51)	-	+	Hantap	mainly S.cordat and S.urceolata
<u>Symplocaceae</u>						
Symplocos spec.	ET	47	+	+	Peuris buluh Phohon jalatong	Both S.brandisii and S. fascicul. are recorded for Ujung Kulon. (see Appendix D)
<u>Taccaceae</u>						
Tacca palmata	BH	(71)	-	+	Hamperubumi	rare in Ardisia humilis and Ficus pubinervis forest
<u>Theaceae</u>						
Eurya acuminata	ET	2	+	+	Kuhkuran (pp)	-
Eurya cf. nitida	ET	(39)	-	+	-	found only once (plot 272)
Pyrenaria serrata	ET	36	+	+	Sariawan tangkal	juvenile specimens resemble Symplocos seedlings probably sometimes confused during fieldwork
Ternstroemia penangiana	ET	(5)	-	+	-	found only once (plot 126)

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Thymelaeaceae						
Phaleria octandra	BS	(55)	-	+	?Kililin	found only twice (plot 256 and 33.)
Tiliaceae						
Microcos tomentosa	ET	28	+	+	Daruwak	-
Pentace polyantha	ET	7	+	+	Angrit gunung	-
Triuridaceae						
Sciaphila tenella	AH	(46)	-	+	-	found only once (plot 26)
Typhaceae						
Typha angustifolia	CH	82	+	+	Walingi badak	-
Ulmaceae						
Celtis wightii	ET	(46)	-	+	?Kihu'ut (pp)	found only once (plot 101)
Celtis spec.	ET	(20)	-	(-)	-	found only once (plot 283, tree labelled by Kosterman c.S.)
Urticaceae						
Dendrocnide stimulans	ET	44	+	+	Pulus	-
Pilea microphylla	BH	(66)	-	+	-	on foundation of buildings and boulders of dam through Cijungkulon mangrove
Pouzolzia zeylanica	BH	(50)	-	+	-	found only twice (plot 3 and 157)
Verbenaceae						
Avicenna alba	ET	89	+	+	Api-api	
Avicennia officinalis	ET	90	+	+	-	-
Callicarpa albida	BS	39	+	+	Phon kalumpang	-
Gmelina elliptica	BS	58	+	+	Wareng	-
Lantana camara	BS	59	+	+	Cente	-
Phyla nodiflora	BH	82	+	+	Antanan rawa	-
Preman corymbosa	ET	85	+	+	Lameutang laut	-
Stachytarpheta jamaicensis	BS	62	+	+	Jarong	-
Vitex glabrata	ET	32	+	+	Laban bihbul	-
Vitex paniculata	BS	75	+	-	Laban laut	according to Backer and Bakhuizen van den Brink (1965) this is the common coastal Vitex and not V.negundo
Vitex pubescens	ET	56	+	+	Laban biasa	-
Vitex cf. quinata	ET	(62)	-	(-)	Laban kapas	found only once (plot 43)
Violaceae						
Rinorea cymulosa	BS	20	+	+	-	-
Vitaceae						
Ampelocissus arachnoidea	BV	39	+	+	Ar. bungburutu	-
Cayratia trifolia	BV	57	+	+	Ar. kibarela rawa Ar. kibarela laut	- -
Cissus diffusa	BL	47	+	+	Ar. krokot	-
Cissus discolor	BL	52	+	+	Ar. katomas	-
Leea aequata	BS	20	+	+	Sulangkar (pp)	-
Leea angulata	ET	(50)	-	+	Kitanah	not very common, mainly in forest on very low altitude (coastal plain and erosional plain along Nw coast
Leea sambucina	ET	51	+	+	Sulangkar (pp)	-
Tetrastigma dichotomum	BL	(48)	-	+	Ar. kibarela (pp)	rare in Neesia forest; also locally in shrubland en local altitude

Families and species (groups)	growth form	soc. group	in veg. table	sample	local name	miscellaneous remarks
Tetrastigma lanceaolarium	BL	51	+	+	Ar. kibarela (pp)	-
<u>Zingiberaceae</u>						
Amomum aculeatum	GH	4	+	+	Parahulu	-
Amomum compactum	GH	52	+	+	Kapol	when bruised strongly smelling of shoe-polish
?Amomum maximum	GH	(55)	-	+	Hangasa	founds only once (plot 99)
Amomum megalocheilos	GH	48	+	-	Tepus	-
Amomum spec.	GH	8	+	-	Tepus cangri	mountain species with pubescent sheath
Catimbrium malaccensis	GH	35	+	+	Laja goa	-
Costus speciosus	BH	4	+	-	Pacing	-
?Curcuma spec.	GH	(55)	-	-	Kuning	found only once (plot 2)
Globba pendula	GH	31	+	+	Lampuyang (pp)	-
Hornstedtia minor	GH	(16)	-	+	Pining	rare in forest below 150 m
?Languas galanga	GH	31	+	+	Laja biasa	-
Nicolaia spec.	GH	(39)	-	-	Honje	found only once (plot 295)
?Zingiber zerumbet	GH	(49)	-	+	Lampuyang (pp)	rare in both forest and shrubland throughout the area

APPENDIX D: Additional records of plant-species

(see section 8.2.2).

Species	Collection*	Locality and altitude
ALANGIACEAE		
Alangium salvifolium	KO 23A(1964)	Peucang Isl., Caloph.zone
ANACARDIACEAE		
Mangifera cf. odorata	KO 21850	Mt.Payung, 200 m.
Semecarpus heterophylla	KKSS 411	Peucang Isl.
ANNONACEAE		
Artabotrys suaveolens	WI 439	Peucang Isl.
Platymitra macrocarpa	SI 9988	Peucang Isl., beachforest
Saccopetalum horsfieldii	KK 55	Peucang Isl., 10 m.
Trivalvaria macrophylla	SI 10012	Peucang Isl., central hill
	SO 291	Peucang Isl., 40 m.
	KO s.n.(1964)	Peucang Isl., 5 m.
	WI 431	Peucang Isl.
Uvaria concava	SO 304	Peucang Isl.
Uvaria littoralis	WI 123	Mt.Payung 200-300 m.
Uvaria purpurea	WI 362	Peucang Isl.
APOCYNACEAE		
Micrechites micrantha	KO 21845	Mt.Payung, 150 m.
ARACEAE		
Pothos roxburghii	KO 19339	isthmus
ARALIACEAE		
Schefflera elliptica	WI 353	Peucang Isl.
ARECACEAE		
Calamus javensis	UN 136	Mt.Payung 250 m.
Calamus polystachys	DR 1475	trail to Cibunar
Calamus reinwardtii	DR 1420	idem
Calamus unifarius	DR 1441/1442	Citerjun, near seashore
Calamus viminalis	DR 1442	Cibunar, seashore
Korthalsia laciniosa	DR 1424	trail to Cibunar
Livistona hasseltii	DR 1459	idem
Oncosperma tigillaria	DR 1491	behind Nypa vegetation
ASTERACEAE		
Launaea sarmentosa	HA s.n.(1823)	S.coast, sandy beach
BOMBACACEAE		
Bombax valetonii	KO s.n.(1958)	Peucang Isl., 10 m.
Neesia altissima	UN 184	Mt. Payung, 300 m.
BORAGINACEAE		
Messerschmidia argentea	SI 9997	Peucang Isl.
CAESALPINIACEAE		
Cassia javanica	UN 58	Peucang Isl., low alt.
Cassia timoriensis	KO 9990	near lighthouse
Crudia bantamensis	UN s.n.(1960)	Mt.Payung
	WI 112	Mt.Payung, 50-300 m.
	WI 346	Mt.Payung, 100-300 m.
Intsia bijuga	WI 386	Peucang Isl., 0 m.

Species	Collection*	Locality and altitude
Peltophorum pterocarpum	WI 19	Cigenter 5 m.
	SO 281	Peucang Isl., sealevel
	UN 57	Peucang Isl., low alt.
Saraca thaipingensis	WI 325	Mt.Payung, 50-100 m.
CLUSIACEAE		
Calophyllum soulattri	KO s.n.(1964)	Mt.Payung, 200 m.
Garcinia rostrata	WI 98	Mt.Payung, 50-300 m.
COMBRETACEAE		
Lumnitzera littorea	KO 4013	near Handeuleum
Lumnitzera cf. littorea	KO s.n.(1964)	Peucang Isl.
Lumnitzera cf. racemosa	SO 323	Peucang Isl., swamp
CONNARECEAE		
Connarus monocarpus	KA 295	Peucang Isl., coral limestone
	KO 63A(1964)	Peucang Isl., 5 m.
Connarus semidecandrus	UN 59	Peucang Isl., low alt.
	WI 81	Mt.Payung, 50-250 m.
	WI 382	Peucang Isl., 0 m.
	WI 422	Peucang Isl.
CONVOLVULACEAE		
Ipomoea gracilis	KO s.n.(1964)	near Cape Layar
CYPERACEAE		
Fimbristylis complanata	HO 1911(1938)	grassland Cidaon
Fimbristylis cymosa	BO 1410	Peucang Isl., beach
Fimrbistylis miliacea	HO 191(1938)	grassland Cidaon
DIOSCOREACEAE		
Dioscorea pentaphylla	WI 29	trail Cigenter-Jamang
DIPTEROCARPACEAE		
Vatica bantamensis	UN 120	top Mt. Payung
	WI 188, 250	Mt. Payung, 300-400 m.
EBENACEAE		
Diospyros cauliflora	KO 21818	Cape Layar
	WI 36	Cigenter
Diospyros hermaphroditica	KK 31	Peucang Isl.
Diospyros macrophylla	WI 68	Mt. Payung, 0-50 m.
	WI 432	Peucang Isl.
ELAEOCARPACEAE		
Elaeocarpus glaber	RE s.n. (1971)	Peucang Isl., low alt.
	KO 19A (1964)	Peucang Isl., 5 m.
	UN 56	Peucang Isl., near stream
Elaeocarpus obtusus	KA 299	Peucang Isl., low alt.
	KO 21835	West coast mainland
EUPHORBIACEAE		
Alchornea javanensis	KK 66	Peucang Isl., low alt.
	SO 269	Peucang Isl.
Antidesma bunius	SO 325	Peucang Isl.
	UN 47	Peucang Isl., low alt.
Antidesma ghaesembilla	KO 9987	No loc., 5 m.
Antidesma montanum	KKSS 409	Peucang Isl.

Species	Collection*	Locality and altitude
Aporosa aurita	KO 29A (1964)	Peucang Isl., 5 m.
	WI 419	Peucang Isl., 7 m.
	SQ 327	Peucang Isl.
Blumeodendron tokbrai	WI 92	Mt. Payung, 50-250 m.
	UN 100	Cibunar, 5 m.
Claoxylon polot	WI 319	Mt. Payung, 100-300 m.
	UN 75	Mt. Payung, 5 m.
Cleidion spiciflorum	WI 427	Peucang Isl.
(Burm.f.) merr.	SO 274	Peucang Isl.
Croton argyratus	WI 396	Mt. Payung, 0 m.
Drypetes rhakodiskos	WI 191	Mt. Payung
	UN 114	Mt. Payung, 470 m.
Glochidion philippicum	SO 300	Peucang Isl., sea-level
Glochidion rubrum	WI 37	Cigenter, 0-5 m.
	SO 329	Peucang Isl.
Glochidion zeylanicum	HO 34 (1938)	Cikarang pasture
	WO 6	Cigenter, 0 m.
	WI 105	Mt. Payung, 50-300 m.
	UN 240	Peucang Isl., 1 m.
Macaranga glaberrima	WI 242	Mt. Payung, 300-400 m.
Macaranga javanica	WI 340	Mt. Payung, 100-300 m.
Macaranga tanarius	KK 82	Handeuleum Isl., low alt.
Macaranga triloba	UN 214	Mt. Payung, 350 m.
Mallotus dispar	SO 297	Peucang Isl.
Mallotus floribundus	SO 328	Peucang Isl.
Mallotus moritzianus	WI 402	Peucang Isl., 0 m.
	UN 226	Mt. Payung, 300 m.
Mallotus oblongifolius	WI 321	Mt. Payung, 50-100 m.
Mallotus philippensis	KO s.n. (1964)	Mt. Payung, low alt.
Mallotus ricinoides	SI 9986	Handeuleum Isl., beach forest
Margaritaria indica	KO s.n. (1964)	Peucang Isl., 20 m.
	KKSS 413	Peucang Isl.
Suregada glomerulata	KO s.n. (1964)	Mt. Payung, 20 m.
	KO 21882	Mt. Payung, 300 m.
	WI 163	Mt. Payung, 300-400 m.
	WI 197	Mt. Payung, 300-480 m.
Trigonostemon macgregorii	KK 41	Peucang Isl.
	KKSS 390	Peucang Isl.
Trigonostemon ovatifolius	DAL 183	Peucang Isl., 12 m.
	SO 296	Peucang Isl.
FLACOURTIACEAE		
Casearia flavovirens	WI 435	Peucang Isl.
	UN 48	Peucang Isl., low alt.
Flacourtia rukam	UN 104	Cibunar, 5 m.
	UN 223	Cidaon-Cape Layar, 2 m.
GNETACEAE		
Gnetum cuspidatum	KO s.n.(1963)	Peucang Isl., 20 m.
Gnetum gnemon	BO 142	Cigenter(?), low alt.
Gnetum latifolium	WI 23	Cigenter, 5 m.

Species	Collection*	Locality and altitude
GOODENIACEAE		
Scaevola taccada	VO 1573	Peucang Isl.
HERNANDIACEAE		
Hernandia peltata	VO 1383	Peucang Isl.
	DAL 194	Peucang Isl.
HIPPOCRATEACEAE		
Loeseneriella pauciflora	KO 28(1964)	Peucang Isl., 5 m.
	SI 10007	Peucang Isl., centre
	WI 342	Mt.Payung, 300-400 m.
	WI 383	Peucang Isl., 0 m.
	RE 145	Peucang Isl., 0 m.
Salacia chinensis	KO 21815	near lighthouse, 0 m.
	WI 11	Cigenter, coast
HYPERICACEAE		
Cratoxylum sumatranum	KKSS 420	Peucang Isl.
	WI 371	Peucang Isl., 0 m.
	UN 19	Peucang Isl., low alt.
ICACINACEAE		
Gomphandra javanica	WI 221	Mt.Payung, 300-400 m.
Notapodytes montana	KK 53	Peucang Isl., low alt.
Stemonurus secundiflorus	RE 144	Peucang Isl., low alt.
LAURACEAE		
Actinodaphne glabra	UN 101	Cibunar, 5 m.
Beilschmidia gemmiflora	UN 6	Peucang Isl., low alt.
	UN 15	Peucang Isl., low alt.
Beilschmidia roxburghiana	KO 62A(1964)	Peucang Isl., 5 m.
	KKSS 416	Peucang Isl.
	SO 278	Peucang Isl.
	UN 31	Peucang Isl., low alt.
	UN 40	Peucang Isl., 0 m.
Cassytha filiformis	VO 1575	Peucang Isl. (on Sophora)
Cinnamonum iners	UN 90	Cibunar, 5 m.
Cinnamonum sintok	WI 150	Mt.Payung, 300-400 m.
Cryptocarya densiflora	KO 21872	Mt.Payung, 200 m.
	KO 23030	Mt.Payung, 100 m.
	WI 279	Mt.Payung, 300-400 m.
	UN 134	Mt.Payung, 250 m.
	UN 158	Mt.Payung, 300 m.
Cryptocarya nitens	KK 24	Peucang Isl., low alt.
	SI 10001	Peucang Isl.
	KKSS 397	Peucang Isl.
	RE 147	Peucang Isl., low alt.
Dehaasia caesia	KO s.n.(1960)	Peucang Isl., 15 m.
	WI 244	Mt.Payung, 300-400 m.
	WI 412	Peucang Isl., 0 m.
Litsea glutinosa	KKSS 388	Peucang Isl.
Litsea noronhae	UN 89	Cibunar, 5 m.

Species	Collection*	Locality and altitude
Notaphoebe umbelliflora	KO s.n.(1960)	Peucang Isl.
	UN 20	Peucang Isl., low alt.
	UN 46	Peucang Isl., low alt.
LECYTHIDACEAE		
Planchonia valida	WI 404	Peucang Isl., 0 m.
LOGANIACEAE		
Fagraea ceilanica	WI 434	Peucang Isl.
LORANTHACEAE		
Dendrophtoë pentandra	UN 92	Cibunar, 5 m. (on Baccaurea)
LYTHRACEAE		
Lagerstroemia flos-reginae	SI 10005	Peucang Isl., centre
	WI 389	Peucang Isl., 0 m.
	SO 287	Peucang Isl., 40 m.
	UN 71	Cibnar, 5 m.
MELASTOMACEAE		
Astronia macrophylla	WI 240	Mt.Payung, 400 m.
Melastoma affine	UN 211	Mt.Payung, 200 m.
Memecylon ambiguum	KO 26A(1964)	Peucang Isl., 5 m.
	WI 125	Mt.Payung, 200-300 m.
	WI 436	Peucang Isl.
Memecylon floribundum	KO 21861	near lighthouse, 20 m.
Memecylon myrsinoides	KKSS 418	Peucang Isl.
	UN 60	Peucang Isl., low alt.
Memecylon panicultatum	WI 304	Mt.Payung, 300-400 m.
MELIACEAE		
Aglaia argentea	KO s.n.(1958)	Peucang Isl.
	KO s.n.(1965)	Peucang Isl., low alt.
	VO 1394	Peucang Isl., low alt.
Aglaia elliptica	KO 5A(1964)	Peucang Isl., 5 m.
	KO 41A(1964)	Peucang Isl., 5 m.
	KK 33	Peucang Isl., low alt.
	WI 327	Mt.Payung, 50-100 m.
	WI 405	Peucang Isl., 0 m.
Aglaia heptandra	KO 55A	Peucang Isl., 10 m.
	KK 79	Peucang Isl., 10 m.
Aglaia latifolia	KO s.n.(1965)	Peucang Isl., 20 m.
	KK 52	near lighthouse
Aglaia odoratissima	KO 31A(1964)	Peucang Isl., 5 m.
	KO s.n.(1965)	Peucang Isl., low alt.
	WI 364	Peucang Isl., 0 m.
	WI 366	Peucang Isl., 0 m.
Dysoxylum arborescens	WI 7	Cigenter, along river
Dysoxylum caulostachyum	KK 26	Peucang Isl., low alt.
	WI 32	Cigenter-Jamang, 0-5 m.
	WI 360	Peucang Isl., 0 m.
	SO 301	Peucang Isl., sea-level
Sandoricum koetjape	UN 18	Peucang Isl., low alt.
	UN 115	Mt.Payung, 470 m.

Species	Collection*	Locality and altitude
Vavaea bantamensis	KK 75	Peucang Isl., 15 m.
	WI 365	Peucang Isl., 0 m.
	FO 39694	Peucang Isl., centre
	SO 308	Peucang Isl., sea-level
MENISPERMACEAE		
Pericampylus glaucus	UN 76	Mt.Payung, 5 m.
Tinomiscium phytocrenoides	WI 64	Mt.Payung, 0-50 m.
	WI 433	Peucang Isl.
	UN 238	Peucang Isl.
Tinospora glabra	KO 21858	near lighthouse, 20 m.
MIMOSACEAE		
Albizia retusa	KO 10A(1964)	Peucang Isl.. 5 m.
Entada phaseoloides	WI s.n.(1964)	Peucang Isl.
Pithecellobium clyeparia	WI 155	Mt.Payung, 300-400 m.
MORACEAE		
Ficus altissima	KO s.n.(1964)	Peucang Isl.
	UN 218	Peucang Isl., low alt.
Ficus annulata	WI 399	Peucang Isl., 0 m.
Ficus callophylla	SI 10009	Peucang Isl., centre
	SO 285	Peucang Isl., sea level
Ficus callosa	WI 442	Peucang Isl.
Ficus deltoidea	WI 248	Mt.Payung, 300-400
Ficus magnoliaefolia	KO 36A(1964)	Peucang Isl., 5 m.
Ficus montana	KO 21819	near lighthouse, 5 m.
Ficus punctata	WI 87	Mt.Payung, 50-250 m.
Ficus variegata	UN 88	Cibunar, 5 m.
Poikilospermum suaveolens	SO 318	Peucang Isl.
Streblus spinosus	KO s.n.(1964)	Peucang Isl. 20 m.
	KKSS 405	Peucang Isl.
Streblus taxoides	UN 230	Cape Layar, 50 m.
MYRISTICACEAE		
Endocomia macrocoma (Miq.) de Wilde ssp.prainii (King) de Wilde	KK 58	Peucang Isl.
Horsfieldia irya	WI 429	Peucang Isl.
	SO 279	Peucang Isl., sea-level
	UN 52	Peucang Isl., swamp.
Knema cinerea	KO s.n.(1949)	on rocks, coastal (where?), 10 m.
	KO s.n.(1950)	Peucang Isl., 15 m.
	SI 10010	Peucang Isl., centre
	KA 293	Peucang Isl. low alt.
	WI 393	Peucang Isl., 0 m.
	UN 8	Peucang Isl., low alt.
Knema globularia (Lamk.)Warb.	VO 1577	Peucang Isl. low alt.
Knema intermedia	WI 97	Mt.Payung, 50-300 m.
	UN 112	Mt.Payung, 470 m.
	UN 132	Mt.Payung, 250 m.

Species	Collection*	Locality and altitude
Myristica guatteriaefolia	KO 60A(1964)	Peucang Isl., 5 m.
	WI 374	Peucang Isl., 0 m.
MYRSINAECEAE		
Ardisia lanceolata	KO 4012	Peucang Isl., 20 m.
	SI 10006	Peucang Isl., centre
Ardisia macrophylla	WI 131	Mt.Payung, 200-300 m.
Labisia pumila	KO s.n.(1964)	no locality mentioned
	WI 133	Mt.Payung, 200-300 m.
	UN 188	Mt.Payung, 300 m.
Myrsine hasseltii	WI 204	Mt.Payung, 300-480 m.
MYRTACEAE		
Acmena acuminatissima	WI 179	Mt.Payung, 300-400 m.
Decaspermum fruticosum	KO 21A(1964)	Peucang Isl., 5 m.
Rhodamnia cinerea	WI 313	Mt.Payung, 100-300 m.
Syzygium litorale	WI 20	Cigenter, 5 m.
	SO 299	Peucang Isl., 10 m.
Syzygium polyanthum	KK 69	Cidaon, low alt.
Syzygium zollingerianum	WI 31	Cigenter-Jamang, 0-5 m.
	WI 38	Peucang Isl., 0 m.
	SO 268	Peucang Isl.
NYCTAGINACEAE		
Pisonia umbelliflora	SO 275	Peucang Isl.
OLACACEAE		
Olax imbricata	SO 289	Peucang Isl., 40 m.
Strombosia javanica	UN 24	Peucang Isl., low alt.
OLEACEAE		
Linociera montana	WI 331	Mt.Payung, 50-100 m.
Myxopyrum nervosum	KA 304	low alt., no loc. mentioned
OPILIACEAE		
Lepionurus sylvestris	KO 21828	near lighthouse, 20 m.
	KO 21883	Mt.Payung, 300 m.
	WI 162	Mt.Payung, 300-400 m.
OXALIDACEAE		
Averrhoa bilimbi	WI 370	Peucang Isl., 0 m.
PANDANACEAE		
Freycinetia javanica	WI 164	Mt.Payung, 300-400 m.
Pandanus bidur	JU s.n. (Herb.LD.no.877)	beachforest (where?)
	WI 352	Cibunar
PAPILIONACEAE		
Canavalia cf. cathartica	KO s.n.(1964)	Peucang Isl., beach
Dalbergia junghuhnii	KO s.n.(1964)	Peucang Isl., 10 m.
Dalbergia pinnata	UN 28	Peucang Isl., 15 m.
Desmodium laxum	WI 114	Mt.Payung, 50-300 m.
	UN 137	Mt.Payung, 250 m.
	UN 161	Mt.Payung, 350 m.
Milletia sericea	KK 81	Peucang Isl., low alt.
Spatholobus ferrugineus	KO 49A(1964)	Peucang Isl., 5 m.
	WI 345	Mt.Peucang, 100-300 m.

Species	Collection*	Locality and altitude
PASSIFLORACEAE		
Adenia macrophylla	WI 124	Mt.Payung, 200-300 m.
PIPERACEAE		
Piper aduncum	FO 44534	Handeuleum Isl.
POACEAE		
Ischaemum fieldingianum	DAN 6434	near lighthouse
	DAN s.n. (1926)	idem
	AM 47	idem
POLYGONACEAE		
Polygonum barbatum	HO 5(1938)	Citelang, pasture
PROTEACEAE		
Heliciopsis lanceolata	WI 120	Mt.Payung, 200-300 m.
RHIZOPHORACEAE		
Carallia brachiata	UN 45	Peucang Isl., 15 m.
Gynotroches axillaris	KO 21876	Mt.Payung, 300 m.
	WI 148	Mt.Payung, 300-400 m.
	UN 183	Mt.Payung, 300 m.
ROSACEAE		
Parinari corymbosum	UN 22	Peucang Isl., low alt.
Parinari sumatranum	KO 23A(1964)	Peucang Isl., 20 m.
	KO 21855	no loc.
	KO 21859	near lighthouse, 30 m.
	WI 67	Mt.Payung, 0-50 m.
	KK 57	Peucang Isl., 15 m.
	UN 44	Peucang Isl., 15 m.
RUBIACEAE		
Borreria ocymoides	SI 10019	trail to lighthouse
Canthium dicoccum	SO 294	Peucang Isl., 40 m.
Canthium glabrum	WI 167	Mt.Payung, 300-480 m.
Cephaelis stipulacea	WI 236	Mt.Payung, 300-400 m.
Coptophyllum fulvum	WI 307	Mt.Payung, 300-400 m.
Geophila repens	UN 98	Cibunar, 5 m.
Guettarda speciosa	UN 220	Peucang Isl., seashore
Hypobathrum frutescens	KKSS 385	Peucang Isl.
	SI 9999	Peucang Isl., beachforest
Hypobathrum racemosum	SI 10014	Cijungkulon, forestedge
Ixora grandifolia	WI 255	Mt.Payung, 300-400 m.
Ixora paludosa	DAL 204	Peucang Isl., 3 m.
	KO 8A(1964?)	Peucang Isl., 5 m.
	WI 14	Cigenter, 10 m.
	WI 359	Peucang Isl.
Ixora umbellata	KO s.n.(1964)	Peucang Isl.
	KO 3A(1964)	Peucang Isl., 5 m.
	WI 86	Mt.Payung, 50-250 m.
	WI 271	Mt.Payung, 300-400 m.
	WI 390	Peucang Isl., 0 m.
Lasianthus cyanocarpus	WI 132	Mt.Payung, 200-300 m.
Lasianthus reticulatus	KO 21875	Mt.Payung, 300 m.
	UN 119	Mt.Payung, 470 m.

Species	Collection*	Locality and altitude
Lerchea longicauda	UN 39	Peucang Isl., near K.Copong
Mussaenda frondosa	WI 170	Mt.Payung, 300-480 m.
Mycetia javanica	WI 335	Mt.Payung, 400 m.
Nauclea coadunata	KK 68	Cidaon, low alt.
Psychotria laxiflora	WI 276	Mt.Payung, 300-400 m.
Saprosma arboreum	UN 160	Mt.Payung, 300 m.
	WI 149	Mt.Payung, 300-400 m.
Xanthophytum fruticulosum	WI 173	Mt.Payung, 300-480 m.
RUTACEAE		
Acronychia laurifolia	WI 102	Mt.Payung, 50-300 m.
	WI 211	Mt.Payung, 300-480 m.
	UN 148	Mt.Payung, 300 m.
Micromelum minutum	SI 10017	Cijungkulon
	WI 13	Cigenter, 10 m.
Pleiospermium dubium	KO s.n.(1964)	Peucang Isl., 20 m.
	KO 37A(1964)	Peucang Isl., 5 m.
Zanthoxylum rhetsa	UN s.n.(1960)	Peucang Isl., 10 m.
	WI 417	Peucang Isl.
SABIACEAE		
Meliosma lanceolata	UN 135	Mt.Payung, 250 m.
	WI 161	Mt.Payung, 300-400 m.
Meliosma nitida	UN 121	Mt.Payung, 470 m.
	UN 129	Mt.Payung, 200 m.
	UN 144	Mt.Payung, 200 m.
SAPINDACEAE		
Aphania montana	UN 1	Peucang Isl., low alt.
	UN 96	Cibunar, 5 m.
Harpullia cupanioides	WI 372	Peucang Isl., 0 m.
Lepisanthes montana	HO 8(1956)	Cibunar
	KO s.n.(1964)	Mt.Payung, 150 m.
	KO 21814	near lighthouse, 20 m.
	UN 69	Cibunar, 5 m.
Mischocarpus sundaicus	WI 143	Mt.Payung, 200-300 m.
	WI 308	Mt.Payung, 100-300 m.
Otophora amoena	WI 63	Mt.Payung, 50 m.
Xerospermum noronhianum	KO 21834	near lighthouse, 10 m.
SAPOTACEAE		
Planchonella duclitan	KO s.n.(1964)	Peucang Isl., coast
	KO 21832	near lighthouse, 20 m.
	WI 367	0 m.
Planchonella obovata	KKSS 415	Peucang Isl., coast
SAURAUIACEAE		
Saurauia reinwardtiana	WI 189	Mt.Payung, 300-400 m.
SCROPHULARIACEAE		
Lindernia ciliata	UN 216	Mt.Payung, coast, 4 m.
SIMARUBACEAE		
Ailanthus integrifolia	UN 200	Mt.Payung, 350 m.
	WI 264	Mt.Payung, 300-400 m.

Species	Collection*	Locality and altitude
Picrasma javanica	KA 291	Peucang Isl., low alt.
	KO 32A(1964)	Peucang Isl., 5 m.
	KKSS 396	Peucang Isl.
	WI 375	Peucang Isl., 0 m.
	WI 378	Peucang Isl. 0 m.
STERCULIACEAE		
Heritiera javanica	WI 350	Mt.Payung, 100-300 m.
Heritiera littoralis	KO s.n.(1958)	Peucang Isl.
	RE 180	Cigenter, riverbank
	WI 12	Cigenter, 0-5 m.
	WI 24	Cigenter, 0 m.
Heritiera percoriacea	KO s.n.(1960)	near lighthouse, 20 m.
	KO s.n.(1960)	near lighthouse, 30 m.
	KO 14100	near lighthouse, 40 m.
	KO 19353	Mt.Honje, 50 m.
	KO 21812	near lighthouse, 20 m.
	KO 21864	near lighthouse, low alt.
	SI 10021	slope above lighthouse
Kleinhovia hospita	KO s.n.(1964)	Peucang Isl., behind Caloph.zone
Pterospermum javanicum	KK 28	Peucang Isl., low alt.
	SI 9998	Peucang Isl.
Pterygota horsfieldii	KO s.n.(1958)	Peucang Isl., 10 m.
	KO s.n.(1964)	Peucang Isl., 0-20 m.
	SI 9991	Peucang Isl.
	WI 414	Peucang Isl. 0 m.
Sterculia coccinea	KO 21867	Mt.Payung, 200 m.
	UN 175	Mt.Payung, 300 m.
	WI 89	Mt.Payung, 50-250 m.
	WI 223	Mt.Payung, 300-400 m.
Sterculia cordata	UN 231	near lighthouse, 50 m.
Sterculia macrophylla	KO 21813	near lighthouse, 20 m.
	WI 90	Mt.Payung, 50-300 m.
	WI 415	Peucang Isl., 0 m.
SYMPLOCACEAE		
Symplocos brandissii	KA 301	mainland, low alt.
	KO 43A(1964)	Peucang Isl., low alt.
	KKSS 410	Peucang Isl.
	UN 30	Peucang Isl., 15 m.
Symplocos fasciculata	KO 21853	Mt.Payung, 200 m.
	UN 130	Mt.Payung, 200 m.
THEACEAE		
Eurya acuminata	WI 230	Mt.Payung, 300-400 m.
THYMELAEACEAE		
Phaleria octandra	KO s.n.(1964)	Peucang Isl., 10 m.
	WI 10	Cigenter, 0 m.
TILIACEAE		
Pentace polyantha	WI 65	Mt.Payung, 0-50 m.
	WI 91	Mt.Payung, 50-300 m.

Species	Collection*	Locality and altitude
URTICACEAE		
Dendrocnide stimulans	WI 34	*Jamang-Cigenter, 0-5 m.*
	WI 326	Mt.Payung, 50-100 m.
Pouzolzia zeylanica	KO s.n.(1950)	Niur, on boulder, 3 m.
VERBENACEAE		
Clerodendrum inerme	KO 20A(1964)	Peucang Isl., 5 m.
Vitex cf.paniculata	BO 1400	Peucang Isl., beach
	DAL 206	Peucang Isl., 1.5 m.
Vitex pubescens	KA 303	Peucang Isl. low alt.
Vitex quinata	KO 30A(1964)	Peucang Isl., 5 m.
	WI 363	Peucang Isl. 0 m.
VIOLACEAE		
Rinorea cymulosa	KO 25A(1964)	Peucang Isl., 5 m.
	RE 183	Peucang Isl.
	SO 270	Peucang Isl.
	UN 3	Peucang Isl., low alt.
	WI 318	Mt.Payung, 50-100 m.
VITACEAE		
Ampelocissus arachnoidea	KO 21826	near lighthouse, 20 m.
Cissus discolor	KO 21863	near lighthouse, 20 m.
	SI 10018	trail to lighthouse
Leea aequata	SO 326	Peucang Isl.
Leea sambucina	KK 62	Peucang Isl., low alt.
	UN 190	Mt.Payung, 300 m.

* Abbreviations of collectors' names:

AM	Amdjah
BO	van Borssum Waalkes
DAL	Dali
DAN	Danser
DR	Dransfield
FO	Fosberg
HA	van Hasselt
HO	Hoogerwerf
JU	Junghuhn
KA	Kartawinata
KK	Kartawinata & Kostermans
KKSS	KK, Soegeng & Soepadmo
KO	Kostermans
RE	Reksodihardjo
SI	Sinclair
SO	Soepadmo
UN	Unesco Training Course (1960)
VO	de Vogel
WI	Wirawan

CURRICULUM VITAE

The author was born in 1952 in The Hague, The Netherlands. After completing secondary school in 1970, he started his studies in biology at the University of Leiden. In 1979, he obtained his degree with distinction, with a specialization in plant-geography, experimental plant-taxonomy and environmental science.

From 1979 to 1981, he was employed as a junior scientist by the Centre of Environmental Studies of the University of Leiden.

From 1981 to 1983, he carried out a landscape-ecological survey in the Ujung Kulon National Park (West Java, Indonesia). The present thesis is based on the results of this survey. The fieldwork was funded by the World Wildlife Fund.

After returning to The Netherlands, he was employed for short periods by, again, the Centre for Environmental Studies in Leiden and by the Department of Vegetation Science of the Agricultural University in Wageningen.

At present, he is employed as a landscape-ecologist by the Soil Survey Institute in Wageningen.