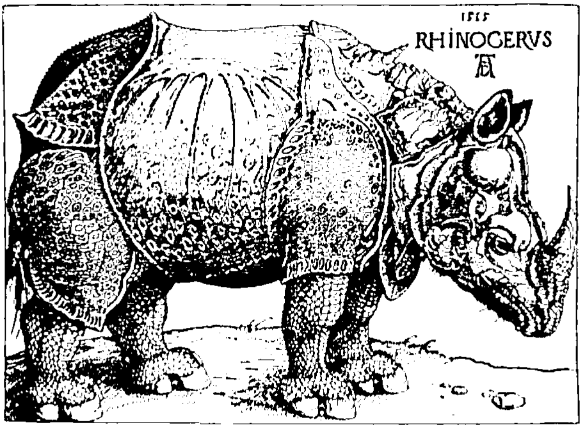
LANDSCAPE-ECOLOGY OF UJUNG KULON (WEST JAVA, INDONESIA)



Patrick W.F.M. Hommel

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(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
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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 western-most 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.

to my parents

in memory of
dr. marius jacobs

Privately published by:
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P.O. Box 98, 6700 AB Wageningen, The Netherlands.
1987.

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ACKNOWLEDGEMENTS

This study would not have been possible without the assistance of many individuals and institutes. From this place I wish to thank all of them, although there is only space to mention a few.

First, I am greatly indebted to the late Dr. M. Jacobs (Rijksherbarium, Leiden), whose inspiring lectures introduced me to the fascinating field of tropical botany and who later initiated the present study. Throughout the period of fieldwork we maintained a regular correspondence. Upon my return to Holland I was shocked by the news that Dr. Jacobs had suffered a stroke from which he did not recover. With him we lost not only a most inspiring project-coach, but also one of the most enthousiastic and knowledgeable advocates of conservation in the tropics.

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.

Furthermore, I want to thank Prof.Dr. A.J.G.H. Kostermans (Herbarium, Bogor) for introducing me to the flora of Peucang Island, Dr. K. Kartawinata (formerly Herbarium, Bogor), Mr. A. Gadrinab (BIOTROP, Bogor) for his advice on photo-interpretation and Dr. J. Mc.Kinnon, Mr. K. Proud (both formerly WWF, Bogor), Ir. A. Fernhout (WWF, Gland) and Mr. A. Tobrani (PPA, Bogor) for coordinating the survey and their practical assistance.

As for the eventual elaboration of the data collected and the preparation of this thesis, I received support from many people. In particular, I want to thank: Drs. J.B. Avé (Ethnological Museum, Leiden) for his advice on the history of West Java, and more specifically on the practice of shifting cultivation, Dr. P. Buurman (Agricultural University, Wageningen) for the identification of the rock samples, Ir. P.J.M. Hillegers (formerly School for Environmental Conservation Management, Bogor) and Dr. P. Ketner (Agricultural University, Wageningen) for their suggestions on methodology, Dr.Ir. W. Sombroek (ISRIC, Wageningen) for his suggestions on the nomenclature of landforms, Drs. R. Voskuil (ITC, Enschede) for his assistance in the reinterpretation of the aerial photographs and his suggestions on geomorphology, Drs. R.W. de Waal (STIBOKA, Wageningen) for his suggestions on the pedological part and more specifically on vertic properties, and Dr.Ir. W. van Wijngaarden (ITC, Enschede) for his advice on landevaluation.

Special thanks also go to the many staff-members of the Rijksherbarium who put a lot of effort into identifying parts of the plant specimens collected. In particular, I am very grateful to Dr. R.C. Bakhuizen van den Brink Jr., Dr. M.M.J. van Balgooy, Dr. R. Geesink, Dr. D. Hou, Dr. P. Hovekamp, Dr. P.W. Leenhouts, Dr. H.P. Nooteboom, Dr. H. Sleumer, Dr. J.F. Veldkamp, Dr. W. Vink, Dr. E.F. de Vogel and Dr. W.J.J.O. de Wilde.

As for the production and lay-out of the report and appendices, I want to thank Mr. L. Kasigara (ITC, Enschede) and his supervisors Mr. J. van de Worm and Mr. A. Brown for the compilation of the landscape-ecology map, Mrs. A. Chadwick for correcting the English text, Drs. S. Roels-Sianturi for translating a concise version of the summary into Bahasa Indonesia and Mr. K. Hulsteijn for the graphics. Very special thanks go to Mrs. H.E. Michel-Knaap, who typed out the various versions of the text and the gross vegetation-table. She did so in a very accurate way and, what is more, without once losing her temper when time was pressing and the chaos of loose manuscripts still increased. During the final stage of the study her support has been of great importance to me.

As for the various institutes, involved in this study, I want to thank the World Wildlife Fund for sponsoring the fieldwork, the Indonesian Nature Conservation Service (PPA) for allowing me access to the study-area, the Agricultural University of Wageningen for appointing me for nine months to facilitate the writing of this thesis, the Rijksherbarium in Leiden for providing hospitality during the many months of identification of plant species and to the ISRIC in Wageningen for the free analysis of soil samples. Moreover, I would like to thank my present colleagues and superiors of the Soil Survey Institute, most notably Mr. J.G. Vrielink, Drs. J.A.J. Vervloet and Dr. J.A. Klijn, for their encouragements and patience.

Finally, I am greatly indebted to my family, Hester, Michiel and Frans, for their support and tolerance. More than anyone else they will feel greatly relieved this booklet is finished at last.

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. <u>List of growth-forms occuring in Ujung Kulon</u>
(slightly modified after Eiten, 1968).

<u>Trees s.l.</u>

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

<u>Scrub elements</u>
(not-climbing, terrestrial)

BS	broadleaf shrub*
SP	scrub-palmoid
RS	rosette scrub
PS	pachycaul scrub
GA	giant aroid

<u>Woody climbers</u>

BL	broadleaf liana*
PL	palmoid liana
CB	climbing bamboo

<u>Herbaceous elements***</u>

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

<u>Herbaceous climbers</u>

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

<u>Epiphytes**</u>

SE	scrub epiphyte
HE	broadleaf herbaceous epiphyte
FE	fern epiphyte

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

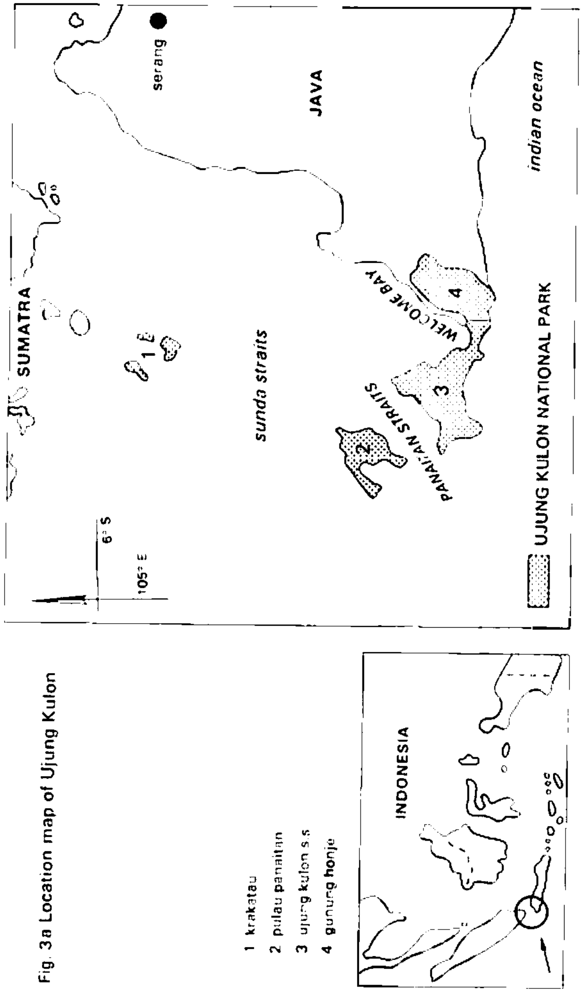


Fig. 3a Location map of Ujung Kulon

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).

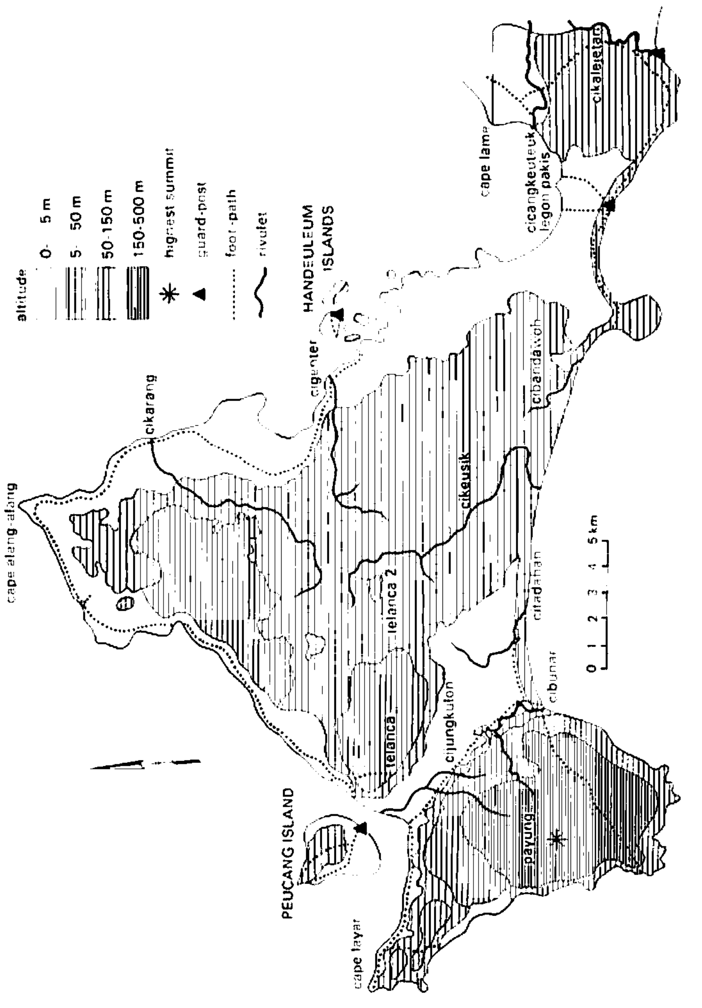


Fig. 3b Topographical sketch-map of Ujung Kulon

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 bricklayer 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

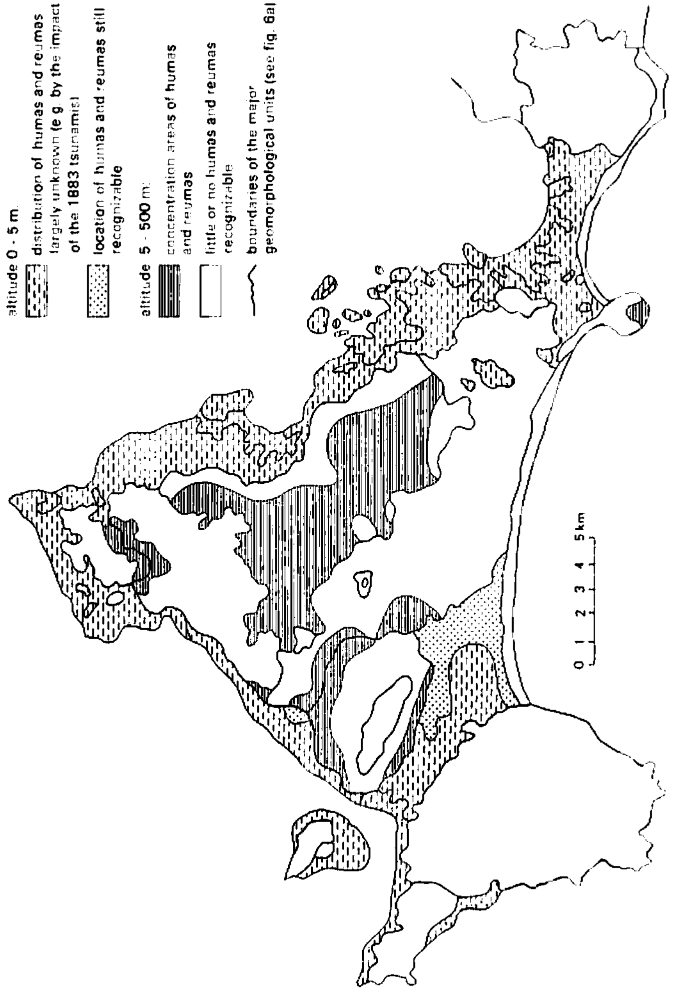


Fig. 4a Location of shifting cultivation sites (humas) and recently deserted fields (reumas) in 1883 (as indicated by the present vegetation).

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 Ervatamia 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 classes1)

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

1) 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.

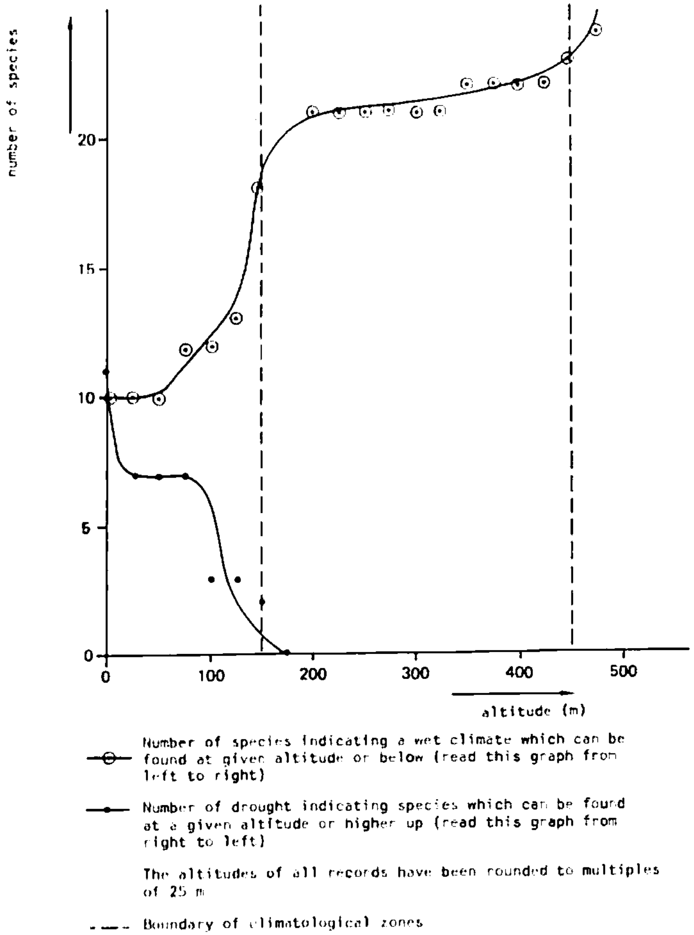
As far as the subdivision of the proposed main zones is concerned, a summit subzone may be distinguished above the 450 m. contour. This boundary has been chosen rather arbitrarily, since it fits well into the gradual change in physiognomy at this altitude and represents a clear demarcation as far as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



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.

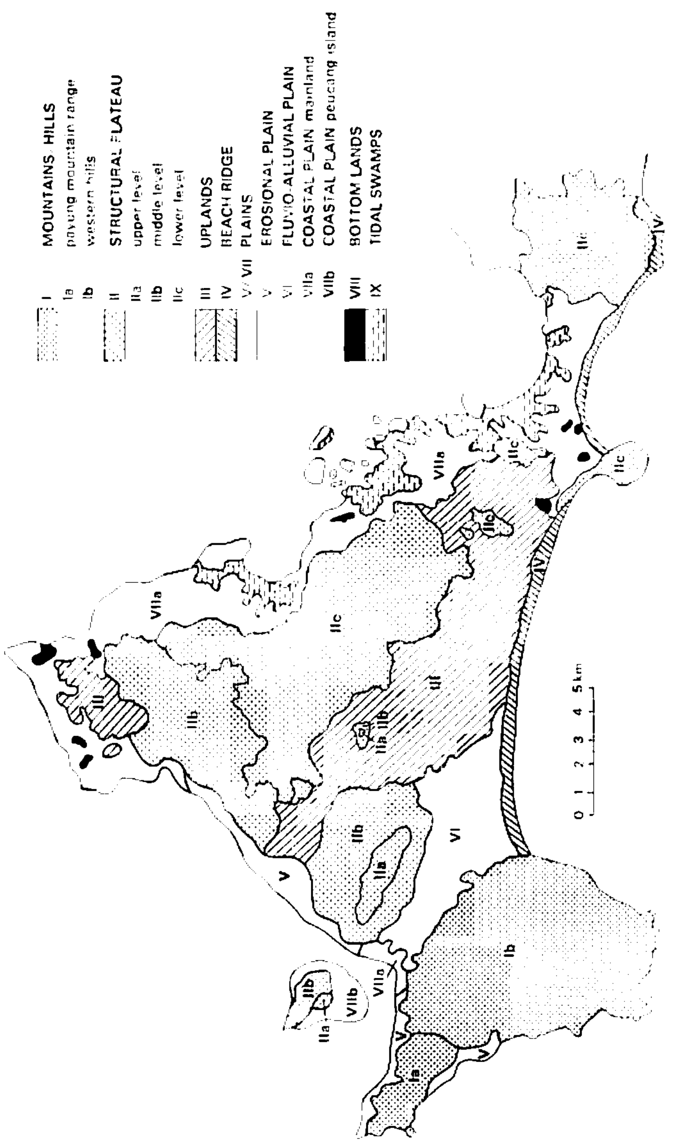


Fig. 6a Geomorphological map of Ujung Kulon

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 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).

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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 km³ 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 km².

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.

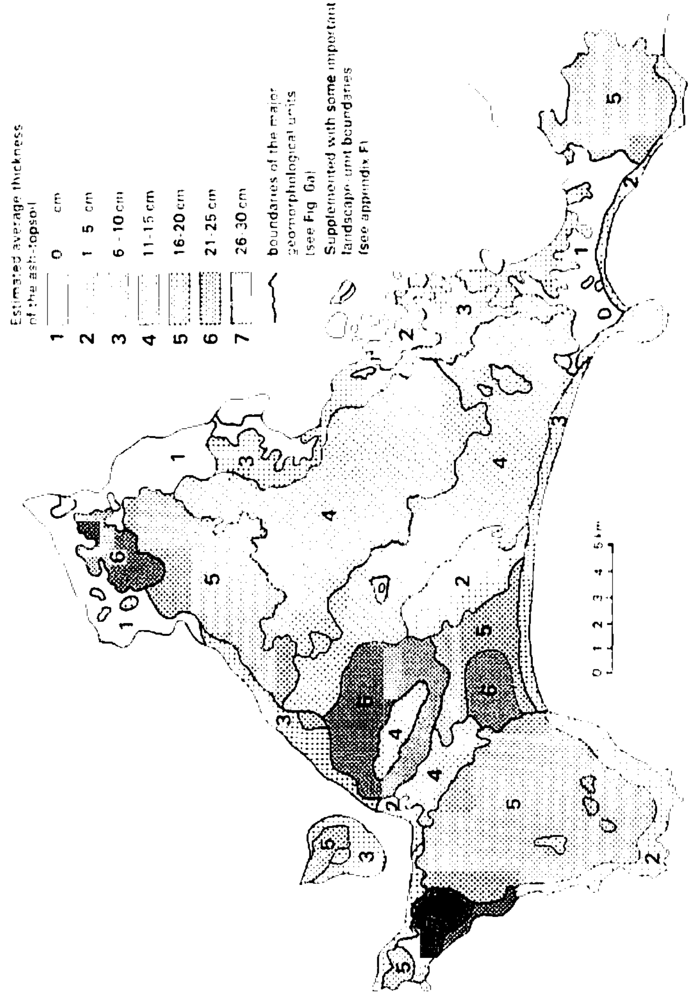

fig. 7a Distribution of the Krakatau ash

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 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.

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

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
Cinnamomum 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 (Rhizophoracsae)	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 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 8c 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.

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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.).

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.