

9.2 Literature review

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

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

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

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

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

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

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

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

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

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

9.3 The plant-communities

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

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

(mainly evergreen forests of the mountain-region)

1. Community of *Kibara coriacea* and *Flacourtia rukam*

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

Low to medium-tall evergreen broadleaf forest.

Description

Three principal layers can be distinguished.

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

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

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

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

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

Distribution

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

Variation

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

Synecological interpretation

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

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

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

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

11. Community of *Garcinia rostrata* and *Neesia altissima*

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

Evergreen broadleaf tall forest.

Description

In general at least four distinct layers can be distinguished.

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

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

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

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

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

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

Distribution

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

Spatial variation

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

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

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

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

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

Synecological interpretation

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

An interesting aspect of the rainforest on Mt. Payung is the occurrence of more or less dominating species, an abnormality in rain forest habitats (see e.g. van Steenis, 1965, Whitmore, 1975 and Jacobs, 1981). As was mentioned

above, on nearby Mt. Honje a similar forest type was found, which lacks dominance and is probably floristically richer.

Two possible explanations can be proposed to explain this phenomenon:

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

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

III. Community of *Pentace polyantha* and *Arenga obtusifolia*

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

Evergreen broadleaf and palm tall forest with emergents.

Description

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

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

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

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

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

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

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

Both climbers and epiphytes are rather rare.

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

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

The type at issue, i.e. the community of *Pentace* and *Arenga* may be considered to be the least typical of all. As for its physiognomy, it differs from the other types of 'langkap' forest in being evergreen, having a relativ-

ely modest dominance of (*Arenga*) palms in the lower tree layer (never more than 60%, often much less) and having a relatively abundant undergrowth, occasionally covering 60% of the soil surface.

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

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

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

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

Distribution

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

Spatial variation

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

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

Synecological interpretation

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

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

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

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

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

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

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

IV. Community of Rubus mollucanus and Gleichenia truncata

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

Semideciduous broadleaf open low forest with closed scrub.

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

Description

There are three principal layers.

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

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

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

Distribution

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

Spatial variation

Unknown.

Interpretation

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

The vegetation shows similarities with both the secondary shrublands occurring at lower altitudes (with a predominance of rattan-scrub and ginger) and the *Sterculia foetida* forest (with *Musa acuminata* and *Syzygium pseudo-*

formosum) of the cliff-coasts of Mt. Payung.

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

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

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

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

V. Community of Saraca thaipingensis and Sumbaviopsis albicans

Soc. groups: the total number is 25; no. 9, 12, 19 and 22 are the most important ones.

Semi-deciduous broadleaf medium-tall forest.

Description

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

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

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

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

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

Both climbers and epiphytes are rare.

Distribution

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

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

Spatial variation

Insufficiently studied.

Synecological interpretation

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

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

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

VI. Community of *Uncaria spec.* and *Sumbaviopsis albicans*

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

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

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

Description

There are three distinct structural layers.

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

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

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

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

Distribution

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

Spatial variation Unknown.

Synecological interpretation

In spite of its great floristic resemblance to the primary *Saraca*-*Sumbaviopsis* forest occurring in the same region, the physiognomy of the *Uncaria*-*Sumbaviopsis* community points to some former disturbance. This impression is

reinforced by the fact that species with a preference for everwet conditions (soc. group 9) are missing and by the abundant occurrence of lianas which more commonly can be found in the secondary shrublands at lower altitudes (soc. group 39 and 48).

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

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

VII. Community of *Pterospermum diversifolium* and *Arenga obtusifolia*

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

Semi-deciduous tall broadleaf and palm forest with emergents.

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

Description

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

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

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

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

Distribution

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

Spatial variation

On Mt. Payung gradual transitions with the Pentace-Arenga community occur, in the plains transitions towards the Areca-Arenga community can be en-

countered. Furthermore, the boundaries of this community are in general strikingly abrupt.

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

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

a. subtype with *Stenochlaena palustris*.

On soils developed from andesitic rock in the western hills; also locally in the extreme SW outskirts of the Honje-massif on similar soil types (parent material unknown).

b. subtype with *Myristica iners*.

On soils developed from tuffs, both in the western hills and on the lower slopes of Mt. Payung; also present in the adjacent parts of the erosional plain.

c. subtype with *Bischofia javanica*.

On soils developed from the calcareous rock of the plateaux of the mainland of Ujung Kulon; also present in the adjacent (and very locally also in more remote) parts of the erosional plain; not on or directly behind the calcareous sandstone ridge.

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

Table 9c

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

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

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

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

Synecological interpretation

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

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

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

VIII. Community of *Parinari corymbosum* and *Gnetum gnemon*

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

Medium-tall to tall semi-deciduous broadleaf forest.

Description

There are three not very distinct structural layers:

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

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

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

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

Distribution

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

Spatial variation

Considerable, but insufficiently studied.

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

with *Sterculia foetida*).

Synecological interpretation

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

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

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

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

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

IX. Community of *Pterygota horsfieldii* and *Rinorea cymulosa*

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

Semi-deciduous broadleaf tall forest.

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

Description

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

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

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

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

Distribution

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

Spatial variation

Unknown.

Synecological interpretation

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

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

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

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

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

X. Community of *Bischofia javanica* and *Ficus pubinervis*

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

Semi-deciduous broadleaf tall forest.

Description

As far as its physiognomy is concerned, this forest type shows many simi-

larities with the two previously described communities. Again there are three structural layers:

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

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

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

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

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

Distribution

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

Spatial variation

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

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

Synecological interpretation

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

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

The combination of fine photo-texture, homogeneous structure and

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

XI. Community of *Cerbera manghas* and *Buchanania arborescens*

Soc. groups: the total number is 16; nos. 26, 71, 72 and 74 are the most important ones.

Semi-deciduous broadleaf medium-tall forest.

Description

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

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

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

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

Distribution

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

Spatial variation

Probably of no importance.

Synecological interpretation

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

situated in the zone occupied by the community at issue.

XXII. Community of *Bambusa blumeana* and *Drypetes ovalis*

Soc. groups: the total number is 27; nos. 29, 31, 32, 50 and 54 are the most important ones.

Semi-deciduous medium-tall broadleaf and bamboo forest.

Description

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

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

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

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

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

Distribution

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

Spatial variation

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

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

Synecological interpretation

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

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

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

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

XIII. Community of *Areca cathecu* and *Arenga obtusifolia*

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

Semi-deciduous tall broadleaf and palm forest with emergents.

Description

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

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

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

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

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

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

Distribution

Restricted to the fluvio-alluvial and erosional plains; there always on or near

the banks of rivulets; on relatively well-drained soils.

Spatial variation

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

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

Synecological interpretation

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

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

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

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

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

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

XIV. Community of *Oncosperma tigillaria* and *Salacca edulis*

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

Semi-deciduous, broadleaf and palm, tall forest

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

Description

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

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

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

The sparse ground layer is of little significance. It consists mainly of some

scattered seedlings and herbs. Most of the small herbs which are commonly found in the *Areca*-*Arenga* forest, however, are absent (e.g. soc. group 34).

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

Distribution

Almost completely restricted to the fluvio-alluvial plain; there mainly in the south-west, but also not uncommon in the northern part, in between stands of *Areca*-

Arenga forest; very locally also downstream along Cikeusik and its branches; with a (not strict) preference for moderately well-drained soils.

Spatial variation

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

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

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

Synecological interpretation

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

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

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

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

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

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

this question.

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

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

XV. Community of *Hyptis rhomboidea* and *Daemonorops melanochaete*

Soc. groups: the total number is 40; nos. 39, 48, 49, 50, 58 and 68 are the most important ones.

Closed thorny palmoid scrub with emergents.

Description

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

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

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

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

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

Above this complex, trees emerge, either isolated or in small groups, covering less than 10%. Their height is variable, usually 15-20 m, sometimes much more. *Pterocymbium tinctorium* (30) and *Cananga odorata* (53) seem to

have a certain preference for these vegetations, but many other tree species are there as well. However, fully grown palm trees such as *Arenga obtusifolia* (46) and *Areca cathecu* (35) are quite rare.

Distribution

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

Spatial variation

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

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

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

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

- a. with *Dillenia excelsa*
- b. with *Lantana camara*

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

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

As stated above, there is no strict relation between these subtypes and the classification of soil types or parent material on which the soil profiles developed. Moreover, neither sub-types are completely separated; transitional forms are not uncommon. Still, the two sub-types do not grow in all locations

in the same proportion. Sub-type a predominates in the upland-area and in the fluvio-alluvial plain. On the dissected plateaux the two sub-types occur approximately in equal proportions. We assume the sub-types to represent different successional stages. We shall return to this subject in section 9.4.

Synecological interpretation

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

XVI. Community of *Canthium horridum* and *Albizia procera*

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

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

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

Description

There are four more or less distinct structural layers:

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

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

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

This scrub layer rather gradually merges into an open ground layer (on average some 0.5 m high) of mainly tree seedlings, graminoid herbs (*Cyperus spec.*, *Axonopus compressus* and 'Jampang piit', all soc. group 68) and some scattered small broadleaved herbs such as *Hedyotis coerulea* (40). Medium tall herbs like *Stachytarpheta jamaicensis* (62) and *Hyptis rhomboidea* (39) thrive somewhere in between the two lower layers.

Epiphytes are (? completely) absent, but climbers are very abundantly present, especially the tender vine *Mikania cordata* (58). All climbing species are unarmed (with the exception of *Dioscorea hispida*; 40); thus rattans are also completely absent.

Distribution

Found only once in the outskirts of the Mt. Honje massif on a shifting cultivation site, which had been deserted for thirteen years (Nassar, pers.

comm.). The plot is situated at an altitude of some 75 m; the soil profile is somewhat poorly drained and resembles the upland profiles of Ujung Kulon. (However, the presence of e.g. *Bischofia javanica* seems to contradict complete similarity). The community is probably completely absent within the boundaries of Ujung Kulon.

Spatial variation

Unknown.

Synecological interpretation

Since aberrant succession on shifting cultivation sites (which were abandoned in 1883 or shortly after) is one of the major processes which explain the special character of Ujung Kulon's vegetation cover, it seemed interesting for comparison to study a far more recently deserted site in the region.

We shall recur on this subject in more detail in section 9.4.

The emergent *Bischofia javanica* in plot 336 obviously represents a relic of the forest which was cleared by the shifting cultivation farmers. The saving of some tall, mature trees is common practice in the ladang system.

In Ujung Kulon itself, some recently abandoned agricultural fields are also present in the Legon Pakis area. However, these are much younger and succession has not passed the shrubland stage yet. Again, we can refer to section 9.4.

XVII. Community of *Schizostachyum zollingeri*

Soc. groups: the total number is 17; no. 41 is the most important one.

(Semi)deciduous low bamboo forest with emergents.

Description

A very simply structured community with three layers:

The main structural layer is a closed and almost pure stand of tufted bamboos (*Schizostachyum zollingeri*; 41), some 3-5 m high. Generally, the only other species of this layer are some scattered climbers, mainly belonging to soc. group 39 (e.g. *Derris elliptica* and *Merremia umbellata*).

Above this coherent thicket only very few trees of varying height emerge, covering less than 5% of the soil surface. Most common are species from soc. group 29 (e.g. *Drypetes ovalis*) and *Sterculia macrophylla* (19), a species which is quite commonly found in many other vegetation types, but rarely as a fully grown tree.

Underneath the bamboos, the ground layer is, in most cases, almost completely lacking. Only a few scattered seedlings (e.g. of *Leea sambucina*; 51) and herbs may be present. Among the latter category, creeping *Cucurbitaceae* are notably common, e.g. *Benincasa hispida* (51). Moreover, locally some small rattan shrublets may be present (e.g. *Calamus unifarius*; 49).

Distribution

Mainly in the dissected plateau landscape and the uplands, very locally also in the outskirts of Mt. Payung at low altitudes and in the coastal plain behind Legon Cangkeuteuk; in all these regions along rivulets (especially along Cikeusik and Cikarang) or on (often steep) valley slopes, locally extending upwards on relatively level terrain. Mostly in very extensive and monotonous stands.

Spatial variation

Probably of little importance.

Synecological interpretation

A special form of secondary growth in regions with a distinct dry season. Its origin is rather unclear.

Possibly formerly restricted to sites which are very exposed to (various forms of) erosion (such sites are still the core of the community's distribution-area) and only after the 1883 ash rains expanded into adjacent areas.

The almost complete lack of undergrowth can only partly be explained by erosion processes. The extremely dense root system which characterizes most bamboo stands is probably of more significance (Hildebrand, 1954).

XVIII. Community of *Sterculia foetida* and *Syzygium pseudoformosum*

Soc. groups: the total number is 20; nos. 42, 43, 45, 49 and 74 are the most important ones.

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

(Locally also closed forest or woodland, i.e. open forest with open scrub).

Description

A very variable vegetation type with an irregular structure. In general, four not very distinct structural layers can be discerned:

First, there is an open or sparse upper tree layer (some 15-20 m high), in which the deciduous trees *Sterculia foetida* (42) and *Terminalia catappa* (74) are the most conspicuous species.

Underneath, there is an open lower tree layer, generally dominated by *Syzygium pseudoformosum* (43), which may also shed a substantial part of its leaves during the dry season. In between we find other broadleaved, dicotyledonous trees such as *Macaranga tanarius* (42) and *Polyalthia lateriflora* (45), but also clumps of banana trees (*Musa acuminata*; 42), scattered palm trees (e.g. *Arenga obtusifolia*, 46), rosette shrubs (*Pandanus furcatus*, 83) and locally some bamboo clumps (e.g. *Schizostachyum blumii*, 50). There is also a very variable (open or) closed scrub layer of some 1-2 m high. Again, monocotyledonous species are remarkably well represented.

Generally, the layer is dominated by a combination of the robust herbs *Donax cannaeformis* (49) and *Homalomena cordata* (49), while some Pleomele shrubs (4) are also notably present. Common dicotyledonous species of this layer are the tall herb *Eupatorium odoratum* (58) and the shrub *Allophylus cobbe* (71).

Underneath, one finds a sparse groundlayer in which the fern *Tectaria spec.* (42), the broadleaved herb *Hemigraphis bicolor* (58) and the graminoid herbs of soc. group 68 are commonly present.

Epiphytes are (? completely) absent; climbers (e.g. *Smilax leucophylla*, 38) are always there but not very abundantly.

Distribution

Restricted to steep slopes in the periphery of Mt. Payung and in the western hills (Cape Gede), which are very exposed to the influence of both ocean winds and erosion: possibly up to 150 m.; generally at far lower altitudes.

Spatial variation

Very variable in structure, but rather constant in species composition.

Synecological interpretation

The local occurrence of *Schizostachyum blumii* points to some former human influence. Moreover, one may assume that this periodically very dry vegetation type formerly suffered from forest fires (see 9.4).

Even so, it is above all the extreme instability of the environment which is thought to cause the vegetation's secondary appearance and to hamper further succession.

The definite (semi) deciduous character of the *Sterculia-Syzygium* community shows how the desiccating effect of the salty sea winds reinforces the impact of the seasonal drought. The common presence of species from soc. group 74 (next to *Terminalia catappa* also *Hernandia peltata*, *Cerbera manghas* and *Erythrina orientalis*) even causes some resemblance to a true beach forest.

XIX. Community of *Dendrocnide stimulans* and *Syzygium pseudoformosum*

Soc. groups: the total number is 24; nos. 25, 43, 44, 58 and 71 are the most important ones.

Semi-deciduous, broadleaf, uneven, closed, low trees and scrub with emergent palm trees or: semi-deciduous, broadleaf, open, medium tall forest with closed scrub.

Description

As for its structure, a most variable vegetation type. In general, three not very distinct structural layers can be discerned.

The central scrub layer is generally the most significant one. It consists of a mosaic of high herbs (1-2 m), shrubs (2-3 m) and treelets (4-8 m), in varying percentages of cover. The main species are the herb *Eupatorium odoratum* (58), the shrubs *Lantana camara* (59) and *Gmelina elliptica* (58) and the treelets (c.q. high shrubs) *Aglaia latifolia* (44), *Rauvolfia reflexa* (25), *Syzygium pseudoformosum* (43) and the notorious nettle tree *Dendrocnide stimulans* (44).

Above this generally coherent scrub layer, a 8-15 m high tree layer may be found, varying from some scattered emergents (in this case mainly the fan-palm *Corypha utan*; 57) to an open forest cover with full grown specimens of *Dendrocnide stimulans*, *Pongamia pinnata* (76) and *Syzygium pseudoformosum*. In relatively well developed tree layers, the latter species obviously becomes dominant (see below). During the dry season most trees shed a substantial part of their leaves.

Underneath the scrub layer, a sparse to open ground layer is found, which is most prominent on small clearings and narrow twisting banteng trails through the scrub layer. In addition to some inconspicuous graminoid herbs (e.g. soc. group 68), beautifully flowering species such as the shrublet *Pseuderanthemum diversifolium* (44) and the delicate herb *Sida javensis* (44) are very common. The latter species dies off completely during the dry season (at least as far as the superterraneous parts are concerned) just like many other herbs of this layer.

Epiphytes are (? completely) absent; climbers, including rattans, are usually present but are far from abundant. Only the tender vine *Mikania cordata* (58) may locally form extensive veils covering other plants.

Distribution

Predominantly on the calcareous sandstone ridge along the south coast. Also observed very locally on level ground between beach forest and mountain foot at Sanghiyangsirah (on more or less identical soils).

Spatial variation

As stated above most variable. Very aberrant forms include a curiously coherent, almost pure stand of *Lantana camara* (west of the mouth of Cikeusik; plot 175), a more or less closed *Syzygium-Dendrocnide* forest with an undergrowth dominated by *Donax cannaeformis* (49) (east of Cape Tereleng; plot 203) and a more varied open forest of relatively tall growth (east of Karang Ranjang; plot 209).

Synecological interpretation

The internal variation of this vegetation type can probably primarily be explained as a result of former cutting and burning practices, not everywhere equally ancient or intensive. Differences in distance to the seashore, depth of the soil profile and in the thickness of the ash topsoil are also thought to contribute to the internal variation of this type.

Probably, all different forms can be considered as secondary growth. The impact of the dry season is obvious; undoubtedly it is reinforced by both sea winds and edaphic factors, but not really as strongly as on the cliffs covered with *Sterculia-Syzygium* forest.

XX. Community of *Dendrocnide stimulans* and *Arenga obtusifolia*

Soc. groups: the total number is 19; nos. 43, 44, 45 and 46 are the most important ones.

Semi-deciduous medium tall broadleaf and palm forest with emergents.

Insufficiently known community; the following description is based on only three plots, one of which is very incomplete because of its small size (006) and one is not very typical (142).

Description

As far as its physiognomy is concerned, this community is rather similar to the other types of *Arenga* forest (see 9.3.111): Its main characteristic is a closed layer of *Arenga obtusifolia* palms (46) with only a few dicotyledonous trees in between. Above this palm layer there is an open, uneven upper tree layer including some true emergents (e.g. strangling figs; though not in one of the plots). The undergrowth is very sparse.

In some details the *Dendrocnide-Arenga* forest shows a strong resemblance to the *Pterospermum-Arenga* forest (see 8.3.7), although there are some notable differences:

On the whole, the upper tree layer is far less developed: it is lower (20 m, rarely more) and more open, frequently more or less absent. Many common species of the upper tree layer of the *Pterospermum-Arenga* forest are missing, e.g. *Diospyros macrophylla* (16) and *Artocarpus elasticus* (15).

Of the common trees and treelets growing between and underneath the *Arenga* palms, *Dillenia excelsa* (15), *Barringtonia macrocarpa* (15) and *Baccaurea javanica* (15) are also (almost) completely absent. They are replaced by species which are more or less characteristic of the *Dendrocnide-Syzygium* community e.g. *Syzygium pseudoformosum* (43), *Aglaia*

latifolia (44), *Claoxylon polot* (43) and, of course, the nettle tree *Dendrocnide stimulans* (44) itself.

Moreover, on the almost barren forest floor we also find some other elements of the *Dendrocnide-Syzygium* community: the *Acanthaceae* *Lepidagathis javanica* and *Pseuderanthemum diversifolium* (both 44).

Distribution

On the lee side slope of the calcareous sandstone ridge and on an adjacent narrow strip in the fluvio-alluvial plain; also locally in a non-typical form in the erosion plain on the west side of Mt. Payung.

Spatial distribution

Insufficiently known; the form on the west side of Mt. Payung (plot 142) represents a transition towards the *Pterospermum-Arenga* forest.

Synecological interpretation

A type of secondary monsoon forest replacing the forest form of the *Dendrocnide-Syzygium* community on sites which are more or less sheltered against the desiccating sea winds.

For a more detailed discussion of the *Arenga* forests in general, see section 9.4.

D. *Ardisia humilis* community-group (XXI-XXIV)

(Mainly semi-deciduous forests of the coastal plain of the mainland.)

XXI. Community of *Nauclea coadunata* and *Syzygium polyanthum*

Soc. groups: the total number is 35; nos. 50, 55, 56, 57 and 71 are the most important ones.

Semi-deciduous broadleaf medium tall forest.

Description

A very constant vegetation type with four distinct structural layers.

The main characteristic of this community is a structurally very homogeneous tree layer of some 20-25 high above a dense, but not quite coherent shrub layer, up to 3 m high.

Neither layer is very rich in species. The tree layer is almost completely formed by *Syzygium polyanthum* (55; often dominant covering up to 60%!), *Nauclea coadunata* (57), *Lagerstroemia flos-reginae* (56), *Cordia dichotoma* (57), *Vitex pubescens* (56), *Pterospermum javanicum* (23) and *Dillenia obovata* (28). Most of these species shed a considerable number of their leaves during the dry season, the latter two are truly deciduous.

Palm trees are not rare in this layer, the tall fan-palm *Corypha utan* (57) being the most common. Locally, the sugar palm *Arenga pinnata* (52) and clumps of the spiny stemmed *Oncosperma tigillaria* (36) are also present. The shrub layer is dominated by the rattan species *Daemonorops melanochaete* (50) and *Calamus polystachys* (57). Other common species include *Licuala spinosa* (54), *Pandanus furcatus* (83) and locally the robust *Cyperaceae* *Scirpodendron ghaeri* (84).

In between these two prominent layers, there is an open thin layer of treelets (5-10 m high) including both young specimens of canopy trees and treelets such as *Ardisia humilis* (71), *Leea sambucina* (51) and *Glochidion zeylanicum* (60).

The ground layer, finally, is sparse and of little significance. In addition to many seedlings it includes some graminoid herbs (soc. group 68) and some forbs, mainly monocotyledons, e.g. *Phrynium pubinerve* (49).

Epiphytes are (? completely) absent; climbers are of little significance.

Distribution

Mainly on the land side of the coastal plain; bound to (very) deep moderately well-drained soils, their texture varying from silty clay (type r) to (loamy) sand (type q). Never on the shallow excessively drained soils of the uplifted pseudo barrier reef.

Very locally also downstream on level terrain along rivulets in the uplands on more or less comparable soils.

Spatial variation

As stated above, a very constant vegetation type, both in physiognomy and floristic composition. The only aberrant form of significance is a young pioneer forest surrounding the present grazing grounds. It differs from the main form in being less tall, in the more open character of both main structural layers and in the abundant presence of *Eupatorium odoratum* (58) and *Lantana camara* (59).

Synecological interpretation

A type of secondary monsoon forest. The very fine photo texture (i.e. a structurally very homogeneous canopy), lack of gaps and homogeneity of tree diameters indicate a secondary growth which has not yet reached maturity.

The original (primary?) vegetation is thought to have been completely destroyed by the 1883 tidal waves, or partly even before that, for agricultural purposes (see chapter 4).

The local presence of *Oncosperma tigillaria* and *Scirpodendron ghaeri* may indicate a certain, possibly seasonal, brackish influence on the groundwater. In this respect there is some resemblance to the *Oncosperma-Salacca* community.

Differences between both communities can possibly be explained by differences in land use after 1883. Moreover, edaphic factors (e.g. the presence or absence of a distinct ash topsoil) may be of importance (see 9.3.XIV).

XXII. Community of *Corypha utan* and *Ardisia humilis*

Soc. groups: the total number is 14; nos. 56, 57, 61 and 71 are the most important ones.

Semi-deciduous, medium tall, broadleaf and palm stub forest.

Description

There are four distinct structural layers:

The major characteristic is a closed layer of dwarf trees (some 8 m high), generally growing in more stemmed stubs. This layer is very strongly dominated by *Ardisia humilis* (71) which covers 80-100% of the soil surface. Other species are e.g. *Buchanania arborescens* (71), *Mallotus philippensis* (61), *Diospyros ferrea* (61) and *Glochidion zeylanicum* (60), but none of these occur abundantly.

Above this very characteristic stub-layer there is an open tree layer, some 12-20 m high. The most common and conspicuous species is the tall fan palm *Corypha utan* (51). Other (dicotyledonous) trees are *Nauclea coadunata* (57),

Lagerstroemia flos-reginae (56), *Vitex pubescens* (56), *Cordia dichotoma* (57) and (less commonly) *Syzygium polyanthum* (55) or, in short, most of the common species of the canopy of the *Nauclea-Syzygium* community. Some of these trees also grow in (few stemmed) stubs, others have the typical habit of trees which grew up free-standing and only later became closed in by other trees.

Underneath the stub-layer, a 1 to 3 m high sparse to open scrub layer is found. In addition to tree seedlings and saplings, it is mainly composed of the rattan shrub *Calamus viminalis* (61) and (less commonly) of the broadleaved shrub *Bridelia stipularis* (61).

Finally, there is a very sparse ground layer. Two creeping vines are the most conspicuous species here: *Cayratia trifolia* (57) and the beautifully flowering *Asclepiadacea Tylophora laevis* (71).

Epiphytes are (? completely) absent; real climbers are scarce.

Distribution

Mainly in the northern part of the coastal plain; there between the *Nauclea-Syzygium* forest (XXI) on the inland side and the *Ximania-Ardisia* forest (XXIII) on the sea-side; on soils developed in lagoonal deposits (mainly silty clay, towards the uplifted pseudo barrier reef with an increasing amount of coral fragments); not on the very lowest and wettest sites (there replaced by the *Lumnitzera-Ardisia* community) (XXXVII).

Spatial variation

On the whole, a rather constant vegetation type. The major variation concerns the share of stub forms, especially in the lower tree layer and the density of the scrub layer.

Of both, possibilities, plot 318 represents an example: there are hardly any stubs and the scrub layer is abnormally dense (cover 80%). Moreover, this plot represents both in its soil profile and its floristic composition a transition towards the *Ximania-Ardisia* forest on the uplifted pseudo barrier reef. Such transitions are not uncommon.

Synecological interpretation

Just like the other (*Ardisia*) stub forests, the *Corypha-Ardisia* community originated on the former artificial savanna landscape of the coastal plain after the slash-and-burn management had been stopped.

The *Corypha-Ardisia* community has many species (especially those of the upper tree layer) in common with the *Nauclea-Syzygium* community which is thought not to be affected by slashing and burning, but generally grows on similar soils. The boundary between both communities is strikingly sharp and typically 'man made'.

The internal variation of the *Corypha-Ardisia* community is assumed to be based on local variations in soil conditions and former land use.

For a more detailed discussion of the (*Ardisia*-) stub forests in general, we can refer to section 9.4).

XXIII. Community of *Ximania americana* and *Ardisia humilis*

Soc. groups: the total number is 21; nos. 51, 61, 62, 71 and 72 are the most important ones.

Semi-deciduous broadleaf medium tall stub forest.

Description

Its physiognomy is very similar to the *Corypha-Ardisia* community, i.e. the main characteristic is a closed layer of dwarf trees, many of which grow in stubs, with an open upper tree layer above and in general little undergrowth. The floristic composition of both communities also shows many similarities. However, there are also some notable differences.

The main difference concerns the floristic composition of the upper tree layer. All species from soc. groups 55 (*Syzygium polyanthum*), 56 (e.g. *Lagerstroemia flos-reginae*) and 57 (e.g. *Nauclea coadunata* and *Corypha utan*) are absent. They are mostly replaced by two species from soc. group 72: *Guettarda speciosa* and *Calophyllum inophyllum*. The latter species generally dominates the upper tree layer with impressive more-stemmed and, apparently very old, specimens.

The lower tree layer is far more like its counterpart in the *Corypha-Ardisia* community. Again *Ardisia humilis* (71) is very abundant, while species like *Glochidion zeylanicum* (60), *Diospyros ferrea* (61) and *Mallotus philippensis* (61) occur regularly, but in low densities. However, characteristic of the *Ximenia-Ardisia* community is the relative abundance of species from soc. group 71, other than *Ardisia humilis*: *Ficus septica*, *Diospyros maritima* and especially *Buchanania arborescens*, which locally even replaces *Ardisia* as the dominant species (see below).

As for the undergrowth, again it is generally very scarce. The species are usually the same as described for the *Corypha-Ardisia* community. However, there are some conspicuous differentiating species: The beach shrub *Desmodium umbellatum* (75) is generally present in the scrub layer, while the shrublets *Ximenia americana* (62), *Ixora paludosa* (72) and *Stachytarpheta jamaicensis* (62), combined with the terrestrial fern *Pteris vittata* (62) and the creeping, spiny liana *Maclura cochinchinensis* (62) typify the ground layer.

Distribution

Restricted to the coastal plain; only on the uplifted pseudo barrier reef.

Spatial variation

In general a rather constant vegetation type.

As also described for the *Corypha-Ardisia* community, the major variation concerns the portion of the stub forms of the lower tree layer and the density of the undergrowth.

Moreover, two aberrant forms can be mentioned:

First, on the highest and driest parts of the pseudo barrier reef, i.e. in general the parts nearest the coast, *Buchanania arborescens* gradually replaces *Ardisia humilis* as the dominant species. In this zone, locally some impressive tall *Buchanania* emergents are present, a rare phenomenon in Ujung Kulon.

Second, locally, mainly near Legon Penyau (plot 38), a taller and far more varied forest can be found, which shows some remarkable similarity to the *Cerbera-Buchanania* forest (XI) on the coastal plain of Peucang Island, with e.g. *Radermachera gigantea* (71), *Cycas rumphii* (76), *Pterospermum diversifolium* (27) and *Gnetum gnemon* (24). A more or less comparable, but more open and apparently rather disturbed form is found on fragments of the pseudo barrier reef which protude like capes from the mangrove area in the

east of Ujung Kulon (plot 330).

Synecological interpretation

Just as the *Corypha-Ardisia* community, the *Ximenia-Ardisia* forest originated in the former artificial savanna landscape of the coastal plain after the slash-and-burn management has been stopped.

The absence of soc. groups 55, 56 and 57 and the abundant presence of soc. groups 72 and 75 indicate that this community (at least in its typical form) is, in the ecological sense, more related to beach forests than to inland secondary forests.

The internal variation of the community can generally be explained by local differences in soil conditions, former management and sea influence.

The taller and more varied forms have presumably never been affected by slashing and (possibly) less severely by burning. They represent a form of secondary growth after destruction of the original vegetation by the 1883 tidal waves. Their affinity with the *Cerbera-Buchanania* forest of Peucang Island is interesting, but in fact quite logical, considering their location and the soil conditions.

For a more detailed discussion of Ujung Kulon's stub forests in general we can refer to section 9.4.III.

XXIV. Community of *Calotropis gigantea* and *Dodonaea viscosa*

Soc. groups: the total number is 12; nos. 59, 62, 63, 65 and 71 are the most important ones.

Semi-deciduous, broadleaf, open, low forest.

Insufficiently known community; the following description is based on one single plot (323).

Description

There are three more or less distinct structural layers:

First, there is an open, thin layer of single stemmed dwarf trees, some 4-5 m high, dominated by *Dodonaea viscosa* (63). The fully grown *Dodonaea* treelets were mistakenly identified by Hommel (1983) as some sort of invading tree seedlings. In the same layer, both *Buchanania arborescens* (71) and *Ardisia humilis* (71) are also abundant; especially the latter species, mainly growing in stubs.

In addition, there is a more or less closed scrub layer, up to 1 m high. The main species are *Lantana camara* (59), *Stachytarpheta jamaicensis* (62) and the beautifully flowering, robust *Asclepiadacea Calotropis gigantea* (63). *Eupatorium odoratum* (58) and *Gmelina elliptica* (58) are also present.

Finally, there is a rather sparse, low, herbaceous ground layer. Its main species is *Fimbristylis cymosa* (79), a cyper grass which is just like the grass, *Ischaemum muticum* (78) (that is also present) more commonly found in herbaceous beach vegetations. Furthermore, the grassland soc. group 75 is notably well represented with *Imperata spec.*, *Desmodium triflorum*, *Phyllanthus urinaria* and *Euphorbia hirta*.

Epiphytes were absent in plot 323, but the local occurrence of *Dendrophthoe pentandra* (71) in this community does seem not unlikely, considering the habitat preference of this species elsewhere in Ujung Kulon. The only climber observed was the strange leafless parasite *Cassytha*

filiformis (73), a typical species of scrubby beach forest.

Distribution

In small patches along the north coast of the coastal plain, especially near cape Alang-alang.

Spatial variation

Insufficiently known; the density of the tree layer seems to be rather variable.

Synecological interpretation

Just like both types of *Ardisia* stub forest described above, the *Calotropis-Dodonaea* community can be considered to have originated from the former artificial savannas in the coastal plain.

Obviously, it shows most affinity with the *Ximenesia-Ardisia* forest, which is also situated on the uplifted pseudo barrier reef. Thanks to the abundant presence of soc. group 75 (including *Imperata spec.*) and the characteristic *Calotropis* scrubs, the *Calotropis-Dodonaea* community shows most resemblance to the original *Imperata* grasslands which once covered large areas in Ujung Kulon.

Even so, we cannot simply regard this community as a last relict of these grasslands. Predominant species such as *Dodonaea viscosa* and *Fimbristylis cymosa* are elements of coastal vegetations (beach forest and pioneer situations respectively) rather than of grasslands in the interior. They have never been reported from the *Imperata* grasslands.

We may assume that the special character of this community is due not only to the succession from artificial savanna to forest, but also to the influence of the strong sea winds near Cape Alang-alang. It is probably of great significance that these sea winds also have a definite impact on the soil profile. The profile of plot 323 is notably sandy compared to other profiles on the uplifted pseudo barrier reef. This is obviously caused by the (regular) blowing about of beach sand, which explains the abundant presence of the beach pioneer *Fimbristylis cymosa*.

In fact, the presence of *Dodonaea viscosa* is even more characteristic of this ecologically complicated situation. The species occurs in Java in two forms and habitats, one on calcareous beaches and one in the mountains of eastern Java above 1450 m. as a pioneer after forest fires (van Steenis, 1965). Its occurrence in the *Calotropis-Dodonaea* community seems to be the combination of two such different habitats (in spite of the fact that the two forms currently are considered to be different species; see Leenhouts, 1983).

Moreover, the occurrence of *Dodonaea viscosa* along the north coast of Ujung Kulon is of interest for yet another reason: up till now the beach form of the species was almost exclusively known from Java's south coast.

E. *Murdannia nudiflora* community-group (XXV-XXVII)
(seasonal grasslands of the interior).

XXV. Community of *Dactyloctenium aegyptium* and *Digitaria heterantha*

Soc. groups: the total number is 10; nos. 64, 65, 68 and 79 are the most important ones.

Seasonal short grass field.

Insufficiently known community; the following description is based on one

single plot (009).

Description

Low herbaceous closed vegetation dominated by graminoid herbs, with some scattered forbs and very sparse, low scrub elements.

The predominating graminoid species are *Digitaria heterantha* (64; a very rare species in Java) and *Fimbristylis cymosa* (79). Also abundant are *Axonopus compressus* (68) and *Dactyloctenium aegyptium* (64).

Most of the forb species belong to the common grassland soc. group 65: *Phyllanthus urinaria*, *Desmodium triflorum* and *Lindernia ciliata*. Also present are *Eclipta prostrata* (64) and *Hedyotis pterida* (71).

Only three scrub elements were observed: the palmoid scrub *Cycas rumphii* (76), the broadleaved shrub *Gmelina elliptica* (58) and a seedling of the common treelet *Lepisanthes montana* (49).

Distribution

Locally on the calcareous sandstone ridge; there only in small patches directly behind the *Pandanus tectorius* belt; probably only between Cibunar and Citadahan.

Spatial variation

Unknown; probably with transitions towards the uneven low trees and scrub form of the *Dendrocnide-Syzygium* community (XIX) and the grazy form of the *Ipomoea-Ischaemum* community (XXXII).

Synecological interpretation

Artificial grasslands of the calcareous sandstone ridge; created by slash-and-burn management; replacing the community of *Fimbristylis* and *Chrysopogon* (XXVI) of the major grazing grounds in the coastal plain.

Although succession is hampered by intensive grazing by bantengs, the community gradually gives way to the *Dendrocnide-Syzygium* community (XIX) and will eventually disappear completely if additional management is omitted.

The species of soc. group 65 indicate an ecological similarity to the *Fimbristylis-Chrysopogon* community, but the affinity with coastal vegetations (soc. group 76 and especially 79) is obviously more important. Both *Gmelina* (58) and *Lepisanthes* (49) may be considered as pioneers of the *Dendrocnide-Syzygium* community.

The most important element, however, is soc. group 64, i.e. a group of species which are restricted to this community.

XXVI. Community of *Fimbristylis dichotoma* and *Chrysopogon aciculatus*

Soc. groups: the total number is 8; nos. 65, 66, 67, 68 and 78 are the most important ones.

Seasonal short grass field.

Description

Low herbaceous, closed vegetation, dominated by graminoid herbs, with many scattered forbs and (very) few scrubs and free-standing trees.

The most important graminoid species are *Chrysopogon aciculatus* (66) and *Ischaemum muticum* (78). One of these or the two combined, dominate(s) the vegetation. The cyper grass *Fimbristylis dichotoma* (66) is an inconspicuous, but very constant species; *Imperata spec.* (65) and the minute annual *Sacciolepis indica* (66) are generally of less importance. Locally, *Axonopus compressus*

sus (68) grows quite abundantly.

Among the many, mostly tiny forbs of this community *Phyllanthus urinaria* (65), two species of *Borreria* (*B. articularis* and *B. ocymoides*; both 66) and two clover-like species (*Desmodium triflorum* and *Alysicarpus vaginalis*; resp. 65 and 67) are the most characteristic.

The species of the very sparse tree layer correspond with those mentioned for the upper tree layer of the *Nauclea-Syzygium* community. *Lagerstroemia flos-reginae* (56) and *Dillenia obovata* (28), both with bright coloured blossom during the dry season, are by far the most common ones.

The density of scrubs is highly variable in time since the grazing grounds covered with this community are (on average) once a year cleared of all new wild shoots. The most common species are *Eupatorium odoratum* (58), *Melastoma affine* (58), *Lantana camara* (59), *Ardisia humilis* (71) and on Peucang Island also *Stachytarpheta jamaicensis* (62).

Distribution

Almost completely restricted to the grazing grounds in the coastal plains (of the mainland, Peucang Island and Handeuleum Island). Also very locally downstream along the Cibunar river.

Spatial variation

In general a rather constant vegetation type.

Towards the edges of the grazing ground the density of somewhat taller forbs (e.g. *Elephantopus scaber*; 66) and scrub elements increases. The creeping vine *Tylophora laevis* (71) is also locally abundant in this zone.

On Cigenter grazing ground a number of conspicuous alien species are present: the stout herbs *Cassia occidentalis* and *Cassia tora* and the fruit tree *Psidium guajava* (all 66).

The grazing grounds on the island are probably somewhat poorer as far as their species composition is concerned, but essentially not different. Only the very sparse tree layer is quite aberrant with e.g. some planted trees such as *Citrus cf. grandis* (66) on Peucang Island and *Tamarindus indica* (66) on Handeuleum island. However, no detailed study of these grasslands was made.

The only truly aberrant form occurs downstream along the Cibunar river. Here species diversity is very low; *Chrysopogon* for instance is completely absent.

Synecological interpretation

Artificial grasslands, created and maintained by active management, i.e. annual cutting of wild shoots and incidentally also burning, especially on Cigenter grazing ground. Intensive grazing by bantengs (on the islands by Javan deer) also hampers succession.

The grazing grounds covered with this community cannot simply be considered as accidental relics of the Imperata dominated savannas which once covered extensive parts of the coastal plains.

The fact is that the grazing grounds of the mainland are strictly bound to one specific, relatively sandy soil type which is rather rare within the coastal plains as a whole. Possibly, on these soils succession towards forest is relatively slow and a cut-and-burn management more effective, even after a period of neglected maintenance. Still, eventually only the grazing grounds in the direct vicinity of the permanently manned guardposts survived.

We have little information on the nature of the present grazing grounds in former times compared to the surrounding Imperata savannas. However, old reports (e.g. Hoogerwerf, 1937 and 1952) suggest that here too the share of Imperata was much more significant than in the present situation. The change in the vegetation in the last decades may be explained by a change in management (more regular cutting, less frequent burning) and probably a very considerable increase in grazing pressure.

Without any management, the *Fimbristylis-Chrysopogon* community (of the mainland) will develop into a *Nauclea-Syzygium* forest (XXI). As mentioned above, the scattered trees of the grazing grounds are reminiscent of such a forest. The unusual density of *Dillenia obovata* is explained by the fact that young specimens of this tree were often saved when the grazing grounds were cleared, not only because the fruits of this tree provide good food for the bantengs, but also because the wood is quite hard and quickly blunts the chopping knives (Sakmin, pers.comm.).

Finally, the aberrant character of the grassland downstream along the Cibunar may be explained by regular inundation by brackish water.

XXVII. Community of *Fimbristylis miliacea* and *Oplismenus compositus*

Soc. groups: the total number is 6; nos. 67, 68 and 69 are the most important ones.

Seasonal short grass field.

Description

Low, open herbaceous vegetation, more or less dominated by graminoid herbs, but with very abundant (locally co-dominant) forbs. No scrubs or trees.

The major graminoid species are *Oplismenus compositus*, *Cyperus spec.* (mainly *C. halpan*) *Axonopus compressus* (all 68) and *Fimbristylis miliacea* (69). Other not uncommon species are e.g. *Panicum paludosum* (69), *Echinochloa colonum* (69) and *Eleocharis dulcis* (82).

The most characteristic forbs (s.l.) of this community are *Hygrophila erecta*, *Hedyotis diffusa* and the Umbelliferae-like fern *Ceratopteris thalictroides* (all 69), while locally abundant species such as *Alysicarpus vaginalis*, *Murdannia nudiflora* and *Sida rhombifolia* (all 67) are reminiscent of the *Chrysopogon* grasslands described above.

Distribution

Scattered throughout the area, mainly at very low altitudes; probably not above 100 m.

The community was observed in depressions in the grazing grounds of the mainland (e.g. plot 74 and 79), in low, swampy glades in the forests and shrublands of both the coastal and fluvio-alluvial plains (e.g. plots 4 and 149 respectively) and in rhino-wallows (e.g. plot 95).

In all these locations the community covers only a few (tens of) square metres.

Spatial variation

A rather variable vegetation type, which is probably due to the fact that the community may occur in very different landscapes and always covers only small areas.

Synecological interpretation

Vegetation characteristic of relatively low swampy sites, where the original vegetation has been removed by human or animal activity and succession is hampered by grazing, trampling and wallowing. The swampy character of the sites may be either natural or induced by wallowing. The vegetation of these sites is, like the surrounding vegetation, affected by the dry season, but less strongly and later, thus forming periodically 'green herbaceous islands' in a desiccating mainly woody environment. This explains their attraction for grazing herbivores.

Ecologically, these vegetations show some affinity with both the *Chrysopogon* grasslands (XXVI, see e.g. soc. group 67) and the *Phyla* swamps (XXXV, see e.g. soc. group 82). The abundant presence of soc. group 69 indicates the specific character of the community.

The affinity with the *Phyla* swamps seems to indicate some brackish influence on the groundwater. Considering the location of most sites with *Fimbristylis*-*Oplismenus* vegetation, this is quite logical, but not so in the case of wallows at higher altitudes. Even so, it is the wallow plot 95 at 60 m.a.s.l. which shows the most resemblance to the brackish *Phyla* swamps: *Eleocharis dulcis* (82) covers some 30% and even the mangrove fern *Acrostichum aureum* (88) is present. An explanation may be found in the fact that rhinos usually urinate into wallows and heavily impregnate the mud with their scent (Ammann, 1985), thus creating a kind of artificial brackish habitat.

F. *Pandanus tectorius* community-group (XXVIII-XXXI) (mainly semi-deciduous beach forests).

XXVIII. Community of *Barringtonia asiatica* and *Syzygium pseudoformosum*

Soc. groups: the total number is 16; nos. 43, 70, 71, 74 and 77 are the most important ones.

Semi-deciduous medium tall broadleaf and pandan forest

or less commonly: semi-deciduous broadleaf open medium tall forest with closed scrub.

Description

As far as its physiognomy is concerned, a rather variable community; in general three not very distinct structural layers may be discerned:

First, there is a tree layer, which is 8-15 m high and generally closed. However, locally it may cover as little as 20%. It is very uneven and includes both robust, thick stemmed species like *Barringtonia asiatica* (70), *Hernandia peltata* (74) and *Terminalia catappa* (74) and more modestly sized species such as *Polyalthia lateriflora* (45) and *Syzygium pseudoformosum* (43). The very conspicuous rosette tree *Pandanus bidur* (70; a very rare species in Java) is also a rather common element of this layer, locally even a dominant one. *Calophyllum inophyllum* (72) is not uncommon, but by no means as predominant as in the *Sophora-Calophyllum* community (XXIX).

In addition, there is an open or closed scrub layer of some 2-4 m high. It is best developed in stands with an open tree layer. The main species are *Messerschmidia argentea* (70), *Hibiscus tiliaceus* (71) and the rosette shrub *Pandanus tectorius* (77). Many tree seedlings and saplings may also be

present, especially under a closed upper tree layer. However, the common beach shrubs of soc. group 73 (e.g. *Sophora tomentosa*) and 75 (e.g. *Vitex paniculata*) are notably absent.

Finally, there is a sparse and variable ground layer (0-1 m high), which includes small shrublets such as *Allophylus cobbe* (71), small seedlings and locally also some herbs, mainly *Araceae* such as *Homalomena cordata* (49) and *Rhaphidophora montana* (49).

Climbers are not common and epiphytes generally absent. A curious exception is the fern *Asplenium nidus* (3) which is more commonly found in the rain forests of Mt. Payung.

Distribution

More or less restricted to the coasts of the Payung region and the south coast of the western hills; there the predominant type of beach forest. A rather extensive stand of *Pandanus bidur*, SW of the mouth of the Cimayang, has not been studied; it may belong to the same community. Likewise a stand of *Pandanus bidur* is said to be present on the Tereleng peninsula. The specimen near the guardpost on Peucang Island is suspected to have been planted.

Spatial variation

The major variation, from closed to open forest with closed scrub, has already been described above.

The most typical form (closed forest with *Pandanus bidur*) is generally situated in the central part of the bays surrounding the Payung massif. Towards the edges of these bays, i.e. towards the capes separating them, the vegetation gradually merges into the open forest form of this community and finally into the *Sophora-Calophyllum* community (XXIX). (The capes themselves are generally covered with *Sterculia-Syzygium* forest XVIII).

On the south coast of the western hills the open forest form of the *Barringtonia - Syzygium* community is predominant. *Pandanus bidur* is quite rare in this region, although on the isthmus connecting Cape Gede to the mainland an almost pure stand is found (plot 92).

Synecological interpretation

Compared with other forms of beach forest, this community is notably rich in species which are more commonly found in inland vegetations (e.g. soc. group 49). Even the Lankap palm *Arenga obtusifolia* (46) is frequently present, though never in high densities.

In this respect, the community at issue may be considered as being the counterpart of both the *Sterculia-Syzygium* and the *Dendrocnide-Syzygium* communities, which are both not really coastal but show a considerable affinity with beach forests.

Indeed, there are clear similarities between the three communities, e.g. the abundant presence of species from soc. group 43 (e.g. *Syzygium pseudoformosum*) and 45 (e.g. *Polyalthia lateriflora*).

One may wonder which ecological factor allows the presence of inland species in a beach forest. Apparently, the sea influence is mitigated in some way. The most likely explanation is found in the presence of extensive, somewhat uplifted coral flats all along the coasts of the Payung massif and parts of the coast of the western hills, which cause the waves to break and calm

down at some distance from the shore line. Obviously, this effect is most pronounced in the central part of the bays and less so towards its edges.

The presence of the rain forest - epiphyte *Asplenium nidus* in the community at issue may be explained by the high atmospheric humidity caused by the violent crashing of the waves in front of the coastline. Similar low occurrences of rain forest plants in beach forests are mentioned by van Steenis (1965; see also chapter 8).

Finally, we may point to the fact that on average (but not consistently) the soil profiles of this community are somewhat more developed than those of other types of beach vegetation.

XXIX. Community of *Sophora tomentosa* and *Calophyllum inophyllum*

Soc. groups: the total number is 19; nos. 72, 73, 74, 75, 76 and 77 are the most important ones.

Varying from: Evergreen, broadleaf, closed scrub
to: semi-deciduous broadleaf medium tall forest.

Description

This community type includes a wide variety of non-herbaceous coastal vegetations ranging from coherent shrublands (height 2-3 m) with hardly any tree cover to closed forests (height 5-15 m) with or without a fringing zone of shrubs. The forest form resembles the previous community (Barringtonia-Syzygium, XXVIII) as far as structure is concerned. However, the ground-layer may be somewhat more developed.

By far the most characteristic tree species is *Calophyllum inophyllum* (72). Other common species are *Guettarda speciosa* (72), *Hernandia peltata* (74), *Terminalia catappa* (74), *Erythrina orientalis* (74), *Premna corymbosa* (85) and *Barringtonia asiatica* (70), although the last species is not as predominant as in the Barringtonia-Syzygium community.

The main species of the shrub layer are *Sophora tomentosa*, *Scaevola taccada* (both 73), *Desmodium umbellatum*, *Vitex paniculata*, *Mallotus tiliaefolius* (all 75), *Hibiscus tiliaceus* (71) and *Messerschmidia argentea* (70). The latter species is in Java generally restricted to the south coast (van Steenis, 1965), but in Ujung Kulon it can also be found along the N-coast, eastwards up to Cape Alang-alang. In between the broadleaved, often abundantly flowering shrub-species mentioned above, the rosette scrub *Pandanus tectorius* (77) and the palmoid *Gymnosperm Cycas rumphii* (76) can be found.

The ground layer also includes some beautifully flowering species: *Tylophora laevis*, a creeping *Asclepiadacea* (71), the pachycaul lily *Crinum asiaticum* (76) and the 'low melati' shrublet *Ixora paludosa* (72).

Two very characteristic parasites, not uncommon in the closed scrub form of the community, are the epiphytic shrublet *Dendrophthoe pentandra* (71) and the leafless vine *Cassytha filiformis* (73, mainly on *Sophora tomentosa*).

Distribution

Very common along the seashore. Best developed in places where the surf has built up a beach-wall of sand or coral debris. Where there is less direct influence of the sea on the vegetation, e.g. along the more or less elevated coastal parts of the erosional plains, it is less conspicuous.

Along the south coast of the western hills and in the Payung region for

the greater part replaced by the Barringtonia-Syzygium community (XXVIII).

Spatial variation

As described above. Furthermore, an aberrant form dominated by thickets of *Pemphis acidula* (75), occurs on very exposed sites.

Transitional forms towards the Barringtonia-Syzygium community and the Ipomoea-Ischaemum community are not uncommon.

Synecological interpretation

The most common type of beach vegetation, in structure and floristic composition varying according to substratum, intensity of the sea influence and successional stage. The closed scrub form is a relatively young stage, characteristic of accreting parts of the coast. In the succession it follows after the Ipomoea-Ischaemum community, XXXII. In more forest-like forms locally very robust trees occur, mainly *Calophyllum*, which are thought to be very old, even dating from before the 1883 tidal waves (Hoogerwerf, 1970).

XXX. Community of *Pemphis acidula* and *Lumnitzera spec.*

Soc. groups: the total number is 9; nos. 74, 75, 76 and 87 are the most important ones.

Evergreen broadleaf medium tall forest

or: Evergreen broadleaf open medium tall forest with closed scrub.

Description

A most variable type with three rather distinct structural layers:

The tree layer is mostly closed and quite uneven. It is dominated by *Lumnitzera spec.* (87; up to 10 m) or less commonly by *Sonneratia alba* (89, up to 20 m). Other common and relatively tall trees are e.g. *Rhizophora spec.* (90), *Heritiera littoralis* (88) and *Hernandia peltata* (74).

The shrub layer of some 2-3 m high may also be open or closed. It is most dense in stands with a relatively open tree layer. The main species is *Pemphis acidula* (75), which locally thrives in almost pure stands, but is (virtually) absent in other places. Other common shrub species include *Desmodium umbellatum* (75), *Hibiscus tiliaceus* (71), *Mallotus tiliaefolius* (75) and *Scyphiphora hydrophyllacea* (88). The palmoid *Gymnosperm Cycas rumphii* (76) is also quite common.

The ground layer is of notably little significance. It consists mainly of some scattered seedlings. Locally, the mangrove fern *Acrostichum aureum* (88) may be present.

Climbers such as *Salacia chinensis* (71) are not very common. Epiphytes have not been observed.

Distribution

On relatively low sandy bars in front of or in mangrove areas and in small sized low mangroves such as sandy areas behind a more distinct beach wall.

Spatial variation

As described above; extensive, almost pure stands of *Pemphis acidula* are present on Handeuleum island. Where coral boulders are abundant on the coastline, such stands may merge into the *Pemphis* form of the *Sophora-Calophyllum* community (XXIX).

Synecological interpretation

Both in habitat and floristic composition intermediate between beach forest (soc. groups 74-76) and mangrove (soc. groups 87-90). The internal variation of the community is explained by local differences in the relative importance of both elements: in some places the beach-forest element predominates, in other places the mangrove element predominates.

It is interesting to observe that in all places most of the tree species are mangrove trees, while most of the shrub species are beach plants. One explanation could be that the soil profiles underneath the Pemphis-Lumnitzera forest are sandy, but wet (low in the profile generally even permanently reduced); the groundwater is brackish or saline. Thus one might say that the profiles change in character from beach-soil-like above to mangrove-soil-like below. Possibly, the trees root on average deeper than the shrubs.

Another interesting phenomenon is the fact that this forest type is evergreen, an exceptional situation at such a low altitude in Ujung Kulon. Apparently, the root-environment is also during the dry season sufficiently wet; not seasonal drought, but the saline character of the environment is the predominating stress factor to plant life. In this respect, the Pemphis-Lumnitzera resembles the forest of the outer mangrove, which is also evergreen unlike (most of) the inner mangrove forest and beach forest.

Note

During fieldwork we could not sufficiently discern the difference between *Lumnitzera littorea* and *L. racemosa*. Afterwards, only the 'padi-padi' trees of plot 22 could be identified up to the species (*L. littorea*). The fact that in general *L. littorea* occurs along Java's south coast, while *L. racemosa* is more or less restricted to the north coast (van Steenis, 1965) does not offer a mainstay: in Ujung Kulon both species are with certainty present along the north coast.

XXXI. Community of *Mikania cordata* and *Pandanus tectorius*

Soc. groups: the total number is 6; no. 77 is the most important one. Closed pandan scrub.

Description

A coherent and almost impenetrable thicket of pandans (*Pandanus tectorius*; 77), which grow in more or less pure stands up to some 5 m high.

Trees are absent or grow only very sparsely. Near the Cibunar-shelter there is, for instance, a conspicuously emerging specimen of *Planchonella obovata* (43) which frequently serves as a look-out for the white-bellied sea-eagle.

There is no real ground layer; only a few herbs are present, most of them climbing or ascending, the most common one is *Mikania cordata* (58).

Distribution

In a five metres wide belt fringing the calcareous beachridge along the south coast; there the predominating vegetation type up to Karang Ranjang, but less so further eastwards; occurring both on sandy soils (dunes) and sandstone cliffs (truncated platform).

Also known from a steep, coastal slope covered with loose, rocky debris near Sanghiyangsirah (plot 122); there up to 50-100(?) m.

Spatial variation

As for its physiognomy and for the extreme dominance of *Pandanus tectorius* a very homogenous community. However, among the few accompanying species, there are but very few more or less constant ones.

Synecological interpretation

Coastal vegetation of very exposed, ecologically unstable, but rarely inundated sites. The community shows some affinity with both the *Sterculia-Syzygium* community (XXVIII, especially plot 122, with *Musa acuminata*; 42) and various types of beach vegetation.

G. *Fimbristylis cymosa* community group (XXXII-XXXIII)

(mainly low, open, seasonal vegetations, both herbaceous and woody of dry coastal habitats)

XXXII. Community of *Ipomoea gracilis* and *Ischaemum muticum*

Soc. groups: the total number is 3; nos. 78 and 79 are the most important ones.

Seasonal short herb or short grass field.

Description

Low herbaceous vegetation, either open and more or less dominated by forbs or closed and notably dominated by graminoid herbs.

The major species are the graminoids *Ischaemum muticum* (78) and *Fimbristylis cymosa* (79) and the forbs *Euphorbia atoto*, *Ipomoea gracilis* and *Ipomoea pes-caprae* (all 79). The first species of *Ipomoea* occurs more frequently, the latter in higher densities (if present). Both are very conspicuous, thanks to their brightly coloured beautiful corollas.

Of the less constant species of this community (most of them belonging to soc. group 79) *Lepturus repens* should be mentioned. This species was considered to be very strictly restricted to the north coast of Java, a strange phenomenon described by van Steenis (1965). However, in Ujung Kulon we collected the species twice (in plots 8 and 12) along the south coast and never along the north coast.

Finally, the local occurrence of seedlings of shrubs (e.g. *Sophora tomentosa*; 73) and trees (e.g. *Calophyllum inophyllum*; 72) should be mentioned.

Distribution

Locally on sandy beaches, but nowhere really abundant; the closed grazed form dominated by *Ischaemum muticum* (see below) also occurs on the edge of the calcareous sandstone ridge in front of or between stands of *Pandanus tectorius* scrub; still another aberrant form (see below) grows on crumbled fragments of the sandstone slabs.

Spatial variation

The open form dominated by forbs (mainly *Ipomoea spec.*) is the most typical one; grazing by bantengs hampers further succession to beach forest, but leads to a closed grassland dominated by *Ischaemum muticum* (e.g. plot 29).

Furthermore, aberrant forms include sparse vegetations with *Portulaca tuberosa* (79) on the sandstone slabs mentioned above (plot 8), open stands of *Spinifex littoreus* (79) on embryonal dunes on the beach (plot 177) and transitions towards the community of *Fimbristylis* and *Chrysopogon* (XXXVI)

near the mouths of the major rivulets e.g. Citadahan (plot 159).

Synecological interpretation

Pioneer vegetation on stable or accreting sandy coasts; if not hampered and modified by grazing (see above), succession will lead to some kind of beach forest, generally to the closed scrubform of the *Sophora-Calophyllum* community.

In contrast to the opinion expressed by Eiten (1968), we classified the vegetations belonging to this community as seasonal, since one of the major species, *Ischaemum muticum*, shows very considerable shoot reduction during the dry season.

XXXIII. Community of *Ischaemum fieldingianum* and *Scaevola taccada*

Soc. groups: the total number is 6; nos. 73 and 80 are the most important ones.

Seasonal, open broadleaf and graminoid scrub.

Insufficiently known community; the following description is based on one single plot (013).

Description

An open, uneven vegetation in which the structural layering is obscured by the irregular and extremely steep character of the habitat.

The aspect is determined by evergreen, stunted shrubs, viz. *Scaevola taccada* (73) and *Melastoma affine* (58), and coarse, seasonal grasses, viz. *Ischaemum fieldingianum* (80; a very rare species in Java, not mentioned by Backer & Bakhuizen van den Brink, 1968) and *Cymbogon rectus* (80). Both elements reach up to some 0.5 m, just like the locally present mangrove-fern *Acrostichum aureum* (88).

In between, one finds some scattered seedlings (*Ficus septica*; 71) and low herbs: *Fimbristylis cymosa* (79), *Hedyotis pterida* (71) and a yet unidentified *Papilionacea* (coll.no. 13 i; soc. group 80).

Distribution

On extremely steep to almost perpendicular, coastal precipices, which are only if at all very rarely inundated by seawater, up to 50 (-100?) m.; probably not on loose, rocky slopes; restricted to the outskirts of Mt. Payung, Cape Gede and the Cape Layar region; there both on the mainland and on small rocky islands; in the latter locations often the predominating vegetation type.

Spatial vegetation

Unknown. *Acrostichum aureum* (and possibly *Fimbristylis cymosa*, too) can be assumed to be restricted to lower altitudes.

The very rare *Ischaemum fieldingianum* also occurs with certainty in the Cape Layar area. It was collected there by Danser in 1926 (coll.no. 6434).

Transitions towards the *Sterculia-Syzygium* forest (XVIII) have not been observed, but are likely to occur.

Synecological interpretation

Comparable with the *Sterculia-Syzygium* community (XVIII), but adapted to an even more extreme environment. The presence of the soc. groups 73, 79 and 88 indicates a strong impact of the seawinds e.g. by means of the salt spray. The relatively abundant presence of species which are in Ujung Kulon

restricted to this community (soc. group 80) indicates, on the other hand, the very special (viz. extreme) character of the habitat.

H. *Eleocharis dulcis* community group (XXXIV-XXXV)

(low, seasonal, herbaceous vegetations, including grasslands, of coastal swamps and pools).

XXXIV Community of *Nymphaea nouchali* and *Najas indica*

Soc. groups: the total number is 2; no. 81 is the most important one.

Seasonal short herb field.

Insufficiently known community; the following description is based on one single plot (056).

Description

Two-layered community of aquatic herbs. Only three species were observed: *Najas indica* and *Utricularia cf. gibba* with submerged foliage and *Nymphaea nouchali* with floating leaves (all 81). Of the latter species the green parts die off for the greater part during the dry season.

Distribution

More or less restricted to the bottomlands, i.e. the depressions in the coastal plains of the mainland. There during the dry season restricted to the creeks, but during the wet season expanding into other parts of the bottomlands, thus alternating in time with the *Phyla-Eleocharis* community.

Possibly, also very locally on Peucang Island, viz. in the small seasonal swamp in the SW-corner. *Najas indica* and the *Hydrocharitacea* *Ottelia alismoides*, a species with a comparable habitat preference, were reported by Kartawinata and Apandi (1977) to occur on the island.

Spatial variation

Unknown; in shallow water intermingled with elements of the *Phyla-Eleocharis* community.

Synecological interpretation

Vegetation of seasonally desiccating, brackish, aquatic habitats. The salinity of the water may vary considerably in time, during the wet season by rainfall and occasional penetration of seawater, during the dry season by desiccation. According to Backer and Bakhuizen van den Brink (1968) *Najas indica* tolerates a salinity of up to 3‰. All three species mentioned may also occur in fresh water.

XXXV. Community of *Phyla nodiflora* and *Eleocharis dulcis*

Soc. groups: the total number is 8; no. 82 is the most important one.

Seasonal short grass field

or less commonly:

Seasonal tall grass field.

Description

A closed and generally one-layered herbaceous vegetation, dominated by graminoid herbs. Variable in regard to the dominants, but less so to the accompanying species.

The most common dominants are *Eleocharis dulcis* and the relatively tall cat's tail *Typha angustifolia*, but locally finer grasses are predominant e.g.

Panicum repens (all 82).

The most common accompanying species are forbs such as *Cayratia trifolia* (57; more or less creeping), *Polygonum barbatum*, *Alternanthera sessilis*, *Heliotropium indicum* and above all *Phyla nodiflora* (all 82). The latter two are most conspicuous, because of their beautiful, many-coloured and abundant flowers.

Within the vegetations belonging to the Phyla-Eleocharis community one finds many coral boulders, strongly varying in diameter and height (from a few tens of centimetres up to 1 or 2 metres). Some of them hardly protrude above the surface. Such spots are often recognizable in the field by coherent, pure stands of *Phyla nodiflora*.

The more distinctly protruding 'coral-islands' are generally covered by a crowded group of stunted treelets, densely covered with epiphytes. Strictly speaking these forest fragments do not belong to the Phyla-Eleocharis community, but should be considered as an aberrant form of the Lumnitzeria-Ardisia community (XXXVII).

However, for practical reasons these coral-islands were included in the sample plots of the Phyla-Eleocharis community. In the vegetation-table (Appendix E) species which are restricted to the forest fragments and do not occur in the surrounding herbaceous vegetation are given in brackets. For a description of the floristic composition of these forest fragments we can refer to section 9.3.XXXVII.

Distribution

Restricted to the bottomlands, i.e. the depressions in the coastal plains of the mainland.

Spatial variation

The variation in regard to the dominant species has been mentioned above.

In general, the boundaries of this community are rather sharp. However, locally transitions to other communities occur: in the northern part of the coastal plain towards the community of Lumnitzeria and Ardisia (XXXVII) and in the southern part to the community of *Pandanus* and *Scirpodendron* (XXXVI). The latter transitional form was sampled in plot 223.

Synecological interpretation

Vegetation of low areas which are seasonally inundated with brackish water, but desiccate during the following dry season.

Probably the herbaceous vegetations of the bottomlands in the northern part of the coastal plains were formerly influenced by the cut-and-burn management of the surrounding Imperata savanas; the comparable vegetations in the southern part were not.

Since this form of management was stopped, decades ago, the forest closed in, until only the present Phyla-Eleocharis clearings remained. One may assume that these present clearings are too low, c.q. too long inundated with brackish water each year to allow the growth of forest. The parts of the bottomlands which became covered with forest in the last decades are probably slightly higher and their former herbaceous vegetation cover of a different nature.

This does not imply that the present Phyla-Eleocharis clearings will have eternal life. We know from the literature (Backer, 1917) and our own

augerings in the bottomlands (using the Krakatau ash as a reference) that sedimentation may be extremely rapid in such environments. Further sedimentation may easily stimulate succession towards forest.

Finally, which factors are responsible for the variation in dominant species is unknown. Probably, both edaphic factors and differences in grazing-pressure (possibly correlated with differences in duration of inundation) are important.

I. Acrostichum aureum community-group (XXXVI-XXXVIII)

(mainly semi-deciduous, open forests of coastal swamps, including the inner part of mangrove-areas).

XXXVI. Community of *Pandanus furcatus* and *Scirpodendron ghaeri*

Soc. groups: the total number is 15; nos. 50, 57, 83, 84 and 85 are the most important ones.

Varying from: closed rosette scrub

to: semi-deciduous, medium tall, broadleaf and palm forest.

Description

As for its physiognomy and floristic composition a very varied community, partly due to the considerable difference between well and poorly developed forms. The best developed stands consist of four distinct structural layers:

First, there may be an open to closed upper tree layer of some 15 to 25 m high. Generally, it consists of one single palm species: either *Corypha utan* (57) or *Livistona rotundifolia* (84). The upper tree layer may also be completely absent.

Next, there may be an open, lower tree layer, up to 10 m high and consisting of species such as *Nauclea coadunata*, *Cordia dichotoma* (both 57), *Premna corymbosa* (85), the strangling fig *Ficus microcarpa* and the deciduous mangrove tree *Dolichandrone spathacea* (both 88). This layer is best developed in stands dominated by *Corypha* palms, in other forms it is hardly present or even completely absent.

The third layer is the most typical and constant one of the community: a closed, but uneven layer of rosette scrubs in heights varying from 1.5 to 4 m. It is strongly dominated by the robust Cyperaceae *Scirpodendron ghaeri* (84, in habit resembling a small pandan) and the sparingly branched true pandan *Pandanus furcatus* (83). In between, other growth forms may also be present, e.g. the broadleaved shrub *Hibiscus tiliaceus* (71; generally with horizontal stems), the spiny palmlet *Licuala spinosa* (54) and several species of rattan.

Finally, there is an insignificant sparse ground layer. It consists mainly of seedlings, but locally the mangrove fern *Acrostichum aureum* (88) may be rather abundantly present.

Climbing species are also quite abundant. Common examples are *Flagellaria indica*, *Cayratia trifolia* (both 57), *Mikania cordata* (58) and *Merremia peltata* (39). Locally, the mangrove liana *Derris heterophylla* (88) is also present. Epiphytes have not been observed.

Distribution

In coastal regions; not rare, but never occupying large surfaces. The community has been observed in the following situations:

- a. in a more or less continuous, but narrow zone (estimated some 50 m wide) on the landside of the vast mangrove areas in the eastern and southern parts of Ujung Kulon.
- b. At the extreme ends of the tidal creeks penetrating into the *Nauclea-Syzygium* forest of the coastal plain.
- c. As small forest fragments, surrounded by *Phyla-Eleocharis* vegetation in the bottomland north of the mouth of the Cibandawoh.

Spatial variation

Three different forms, which are correlated with the three types of habitat described above, have been observed.

The most common and best developed form, dominated by *Corypha utan* is found at the inner fringe of the mangroves (plots 236 and 254).

The structurally most simple form, generally without any tree cover is commonly found at the ends of the tidal creeks (plot 211).

A third, structurally more or less intermediate form, occurs in the bottomland north of Cibandawoh (plot 222). Here, the *Corypha* palm is replaced by *Livistona*.

In all but the latter cases, the *Pandanus-Scirpodendron* community has rather abrupt boundaries with the surrounding vegetations. Transitions between the first and second form mentioned have not been observed, but are most likely to occur.

Synecological interpretation

Bound to slightly brackish, seasonally desiccating habitats.

In the salinity-gradient of the coastal plains, the *Pandanus-Scirpodendron* community is bound to a habitat which is generally both ecologically and topographically intermediate between the *Nauclea-Syzygium* and the *Derris-Sonneratia* community (resp. XXI and XXXVIII). This intermediate position is also reflected in the floristic composition.

Soc. group 88 represents the mangrove element. The species of soc. group 57 are reminiscent of the *Nauclea-Syzygium* forest. Tree species such as *Nauclea coadunata* and *Cordia dichotoma*, which belong to the latter group, obviously do not grow optimally in this community; they are not able to reach the canopy. On the other hand, *Corypha utan* (also 57) thrives very well in this community. Backer and Bakhuizen van den Brink (1968) clearly underestimate the species' tolerance to brackish conditions.

The reason for the occurrence of a form of the *Pandanus-Scirpodendron* community in the bottomland north of Cibandawoh is rather unclear. There are indications in the soil profile that the site of plot 222 is slightly higher than those covered by the surrounding *Phyla-Eleocharis* vegetations (van Reuler, pers. comm.). However, why in that case, succession did not lead towards the (related) community of *Lumnitzera* and *Ardisia* is not really understood. The problem is further complicated by the fact that the dominating tree species, *Livistona rotundifolia*, is not considered to be a native species in West Java (Backer & Bakhuizen van den Brink, 1968).

XXXVII. Community of *Lumnitzera littorea* and *Ardisia humilis*

Soc. groups: the total number is 14; nos. 71 and 87 are the most important

ones.

Semi-deciduous (?), medium tall, (*Casuarina* and) broadleaf stub forest.

Description

There are four more or less distinct structural layers.

The most constant feature is a more or less closed tree layer of only 6-8 m high, which is strongly dominated by *Lumnitzera littorea* (87) and *Ardisia humilis* (71). The first species is characterized by clumps of knee-shaped pneumatophores, surrounding the stem, the latter grows mainly in more stemmed stubs.

Above this layer there may be an open upper tree layer up to 25 m high, completely formed by *Casuarina equisetifolia* trees (87), resembling Conifers with their strongly reduced leaves and green, drooping twigs. Some of the *Casuarina* trees are also more stemmed (up to five). In other places, the upper tree layer may be completely absent or represented by a single *Nauclea coadunata* tree (57).

Underneath there is a sparse shrub layer of 1 m high, with species such as *Allophylus cobbe* (71) and *Lantana camara* (59) and an open to sparse ground layer in which *Acrostichum aureum* (88) is commonly present and locally the delicate herb *Dentella repens* (82) forms conspicuous cushions.

Climbers are of little importance, although *Flagellaria indica* and *Cayratia trifolia* (both 57) are commonly present. Epiphytes are generally absent, but may in aberrant forms be very abundant (see below).

The soil surface below this community is mostly strikingly uneven, due to the presence of numerous coral boulders and clumps of pneumatophores. Most ligneous plants root on the 'islands' formed by these protrusions, while most herbs grow on the low level parts in between.

Distribution

Restricted to the coastal plains, there locally fringing the bottomlands or growing along the seasonal creeks which connect the bottomlands to the coast.

The form with *Casuarina equisetifolia* is restricted to a relatively vast area west of Jamang.

An aberrant form (see below) is found as small forest fragments covering the coral islands surrounded by *Phyla-Eleocharis* vegetation in the bottomlands, as described in section 9.3.XXXV).

Spatial variation

The most conspicuous variation concerns the presence (plot 47) or absence (plot 48) of *Casuarina equisetifolia*.

The aberrant form on the coral islands in the bottomlands is characterized by a stunted, dense habit. In general, the vegetation is only some 3 m high. *Lumnitzera* is always absent (as far as is known), while *Premna corymbosa* (85) and the strangling fig *Ficus microcarpa* (88) are, next to *Ardisia humilis*, the most common treelets. Epiphytes are strikingly abundant; examples are *Dendrophthoe pentandra* (71), the ferns *Drynaria sparsisora* and *Pyrosia lanceolata* (both 82) and young specimens of *Ficus microcarpa*.

Moreover, locally and especially along the seasonal creeks mentioned above stands dominated by *Ficus microcarpa* occur (not sampled). They can be considered as transitions towards the *Derris-Sonneratia* community (XXXVIII), in which also local dominance of *Ficus microcarpa* may occur.

Stands without any stubs have not been observed but are likely to occur.

Synecological interpretation

Forest type, characteristic of the lowest parts of the coastal plain, in which growth of forest is still possible. During the wet season inundation with (slightly) brackish water takes place. In even lower localities where the duration of the inundation period is longer and the water may reach a higher level, the community is replaced by Phyla-Eleocharis vegetation (XXXV).

Both its location and floristic composition reflect the intermediate position of this community between the Phyla-Eleocharis community of the bottomlands and the other Ardisia forests of the coastal plains (mainly the Corypha-Ardisia community, XXII). Soc. group 82 represents the bottomland element, while the (predominating) coastal-plain-element is represented by e.g. soc. groups 57 and 71). Moreover, the abundant presence of species from soc. groups 87 and 88 stress the affinity with vegetations of the inner-mangrove.

The stub-habit of the forest is a relic of the former cut-and-burn management in the coastal plains. For a more detailed discussion of Ardisia stub-forests in general, we can refer to section 9.4.

The Casuarina trees in the Lumnitzera-Ardisia forest, west of Jamang, are possibly the off-spring of trees which were originally planted as a beacon for sailors (see Hoogerwerf, 1951). The same holds for the other two (minor) stands of Casuarina in Ujung Kulon, in beach forests near Niur and on Peucang Island.

The combination of Lumnitzera littorea and Casuarina equisetifolia in the Jamang region probably does not occur elsewhere in Java. Outside of Ujung Kulong, Lumnitzera littorea is only known from the south coast of the island, while Casuarina equisetifolia seems to be restricted to the north coast (van Steenis, 1965).

XXXVIII. Community of Derris heterophylla and Sonneratia alba

Soc. groups: the total number is 18; nos. 87, 88 and 89 are the most important ones.

Generally: Semi-deciduous, medium tall, open forest with closed scrub.

Description

A floristically rather constant community; however, its physiognomy is very variable and in most cases rather complex. In general, three main structural layers can be discerned:

First, there is an uneven, generally more or less open tree layer. Sonneratia alba (89) is the most common species with pneumatophores arising vertically from horizontal roots buried in the soil. It is usually also the tallest species, reaching up to some 15 or 20 m. Not rarely, it strongly dominates the tree layer. Other common, but generally less tall species are e.g. Lumnitzera spec. (87), Heritiera littoralis, the strangling fig Ficus microcarpa and the deciduous tree Dolichandrone spathacea (all 88).

Underneath there is a closed scrub layer. In most cases it is dominated by coherent stands of either the fern Acrostichum aureum (88), which may grow as high as 1.5 m in this community, or the (almost) stemless palm Nypa fruticans (88). In the latter case, Acrostichum is generally also very abundantly present underneath the Nypas, and accompanied by the beautifully

flowering shrublet Acanthus ilicifolius (also 88). Also far from uncommon are forms with a very dense, almost impenetrable mixed scrub layer on which, next to the species mentioned above, taller broadleaved shrubs like Scyphiphora hydrophyllacea (88) may be abundantly present.

The sparse ground layer, finally, is very poorly developed. It consists completely of seedlings.

On the other hand, climbing species occur in great abundance, especially in the mixed scrub layers. The main species are the vine Mikania cordata (58) and the lianas Derris heterophylla, Caesalpinia crista and Finlaysonia obovata (all 88). Epiphytes, other than young strangling figs, have not been observed.

An interesting aspect of the area covered by the Derris-Sonneratia community is the abundance of 'crab-hillocks' on the forest floor.

Distribution

The predominant vegetation of the inner part of the mangrove areas. Also very locally and in an aberrant form on Peucang Island.

The form with a dominance of Nypa occurs mainly in regions near the mouths of the main rivulets and the mixed impenetrable form is generally found on the inland side of the inner mangrove, thus bordering the Pandanus-Scirpodendron community (XXXVI).

Spatial variation

The three major forms have been described above. The form with a dominance of Acrostichum aureum is probably the most typical. However, these forms are far from well separated; transitional situations are very common.

Very aberrant forms also include stands of closed forest, dominated by Ficus microcarpa (observed in a depression in the coastal plain of Peucang Island; plot 75) or Oncosperma tigillaria (36; observed in a transitional position between Nypa-forest and the Areca-Arenga community (XIII) in the Cidaon-Cijungkulon region; plot 100).

Synecological interpretation

The common vegetation of the inner part of the mangrove area, which is normally inundated by seawater at high tide, but is shut off from the sea influence and thus dessication during at least part of the dry season. This is also true for the Nypa-dominated stands near the mouths of the main rivulets. Generally, these mouths are more or less closed by a sandbar during the driest months of the year. The presence of a fully deciduous tree such as Dolichandrone and the semi-deciduous behaviour of other species indicate this seasonal dessication. In this respect, the Derris-Sonneratia community differs from the evergreen outer mangrove.

Even so, the abundant presence of species from soc. groups 87 and 89 indicate a strong affinity with the Rhizophora forest of the outer mangrove. However, the many species of soc. group 88 are predominant, stressing the specific character of this community.

Finally, an interesting aspect of the Derris-Sonneratia community is the common dominance of Acrostichum and the abundance of Acanthus, two species considered by van Steenis (1965) to be indicators of degradation. Indeed, large parts of the Derris-Sonneratia forest have a very disturbed, unstable appearance. However, most parts if not all, have not been touched by man

for at least one hundred years. A possible explanation may be that the original mangrove forest which was destroyed by the 1883 tidal waves never really recovered in this zone, since succession was influenced for decades by the continuous sedimentation of volcanic ashes, due to erosion processes in the interior.

J. Rhizophora apiculata community group (XXXIX)

(evergreen forests of the outer part of mangrove areas).

XXXIX. Community of Sonneratia alba and Rhizophora spec.

Soc. groups: the total number is 3; nos. 89 and 90 are the most important ones.

Evergreen, broadleaf, medium tall forest with or without emergents.

Description

A community with a very simple physiognomy and only few species. In general, there are three structural layers:

The main one is a closed and strikingly homogeneous tree layer of variable height (in general 10-15 m). This layer consists mainly of species belonging to the Rhizophoraceae-family, e.g. *Bruguiera cylindrica*, *Ceriops decandra* (both 89), *C.tagal*, *Rhizophora mucronata*, *R.stylosa* and *R.apiculata* (90). The latter species is the most common.

Above, there are generally some emergents, up to 20 m high. Locally, even an open upper tree layer is present, covering some 40%. The main emergent species is *Sonneratia alba* (89). In some stands of the *Sonneratia-Rhizophora* community only dead specimens of *Sonneratia* were observed. The same holds for the less common *Lumnitzera spec.* (87) in the main tree layer. In such cases the species is indicated between brackets in the vegetation table (Appendix E).

Below the main tree layer one finds a variable amount of tree seedlings and saplings of various sizes. Only one shrub species is present, though not very commonly: *Aegiceras corniculatum* (89). Terrestrial herbs, vines and lianas are completely absent. Epiphytes have not been observed.

The forest floor is dominated by (and often almost inaccessible because of) an abundance of various types of stilt roots, aerial roots and pneumatophores.

Distribution

Restricted to the outer parts of the main mangrove areas.

Spatial variation

At least two rather distinct subzones can be discerned: an outer one dominated by *Rhizophora* species and an inner one dominated by *Ceriops* species. However, our data are too limited to describe real subtypes.

In general, this community and its internal zonation is best developed in the widest parts of the mangrove.

Synecological interpretation

Forest adapted to daily inundation by seawater at high tide, also during the dry season. Seasonal drought is a factor of no great significance in such an environment, which explains the evergreen character of the vegetation. However, lack of epiphytes in a mangrove area is considered as an indication of seasonal drought (van Steenis, 1965).

The outer mangrove is an extreme habitat, very different from all inland habitats. As for its species composition, there is only a certain overlap with the inner mangrove (soc. group 87 and 89), but most of its species are restricted to the community at issue (soc. group 90). Their number is relatively low as is normally the case in a very dynamic environment.

The high mortality of both *Sonneratia* and *Lumnitzera* is a remarkable phenomenon. A possible explanation may be that seedlings of both species were at an advantage, when the *Rhizophora* forest was at least partly destroyed by the 1883 tidal waves. Both species have their optimum in Ujung Kulon in the inner-mangrove, which was described as a rather unstable habitat with a relatively open tree layer (see 9.3.XXXVIII). Now, the *Rhizophora* canopy has recovered in the outer mangrove and things are getting back to normal, so we may assume that both species will be pushed back to their normal (yet unknown) density in this zone.

9.4 Some interesting formations

9.4.1 Palm forests

(communities III, VII, XIII and XX).

In Ujung Kulon several communities can be discerned with a striking dominance of (pinnate-leaved) palm trees. In almost all cases, the dominating species is *Arenga obtusifolia*, although in the alluvial *Areca-Arenga* community (XIII) other species may also be predominant, viz. *Oncosperma tigillaria* and *Areca catechu*.

Next to the dominance of palm trees, the scarcity of the undergrowth is a common feature of such forests. It is generally explained by the fact that hardly any light penetrates to the forest floor through the dense layer of palm leaves (e.g. Van Borssum Waalkes, 1951). This phenomenon has serious implications for the forest dynamics. For regeneration, the tree species of the upper canopy are almost completely dependent on incidental gaps in the *Arenga* layer. Such gaps are created by the down-fall of forest giants, especially *Ficus* trees and are usually stocked with seedlings and saplings, a few of which are destined to become the emergents of the future. Note that this mechanism can provide even a pure stand of *Arenga* with a new layer of emergents: it was observed several times how strangling figs had developed from the crown of an *Arenga* palm. These stranglers will grow into forest giants, die off and create a large gap with plenty of possibilities for invading seedlings. A pure stand of *Arenga* is therefore not necessarily a final stage in succession!

The *Arenga obtusifolia* forests are far from common in the Malayan region. They are not mentioned in any of the enumerations of vegetation types compiled by van Steenis (1935, 1957 and 1965). According to the experienced forester and botanist Endert, who visited Ujung Kulon in 1931, the *Arenga* forests are not known from any other locality in the region (cited from Hoogerwerf, 1970).

However, this is not entirely correct (anymore). Similar vegetations are known to occur on Siberut, an island near the south/west coast of Sumatra (Whitten, 1980), Panaitan Island in the Sunda Straits N. of Ujung Kulon (van Borssum Waalkes, 1951) and on the most western part of the adjacent

Mt. Honje region (pers. obs.). During a visit to the Ujung Genteng peninsula (south coast of West Java) van Balgooy (pers. comm.) observed a similar, albeit small, patch of *Arenga obtusifolia* forest. Moreover, a photograph (without annotations on the species composition) of a forest on Nusa Kambangan, an island near the south coast of Central Java (Detmer, 1907) shows great resemblance with the forest type at issue.

A satisfactory explanation of the striking dominance of *Arenga obtusifolia* cannot be found in the literature, although many authors dealing with Ujung Kulon touch upon the subject. A discussion of various possibilities is provided by Hommel (1983).

Obviously the *Arenga* forests do not represent a normal successional stage following shifting cultivation practices: if that were the case *Arenga* forest would be far more common in West Java, where secondary forests cover large areas (van Steenis, 1965). As for the relation with the soil, *Arenga* forest in Ujung Kulon can be found on several soil types, in general ranging from somewhat excessively to moderately well drained, and developed from various types of parent material. In fact, the various communities to which the *Arenga* forests belong show a far better correlation with specific types of soil and parent material; see table 11b. The top soil of volcanic ashes is also not likely to be a key factor: descriptions of Ujung Kulon before 1883 (Anonymous, 1854) seem to indicate that the *Arenga* forest was already there, while at present the parts of the erosional plain, where the Krakatau ashes are missing, are mainly covered by *Arenga* forest. The same holds for the isolated eastern summit of the Telanca massif (see fig. 7a).

Influence of the 1883 tidal waves as suggested by Pellek (1977) seems absurd, since the *Arenga* forest covers the slopes of Mt. Payung up to an approximate altitude of 150 m., while the height of the tidal waves probably hardly exceeded 15 m.

The impact of the browsing activity of banteng and rhino is finally also not the solution to our problem: *Arenga* forest is present on Panaitan island, banteng and rhino are not. On the other hand the distribution of Javan deer is seemingly of more importance: the species occurs in very high densities on Peucang Island (where *Arenga* forest is missing), but is absent on Panaitan Island and relatively scarce on the mainland of Ujung Kulon (where *Arenga* forest is present). Moreover, we never found an *Arenga* seedling on Peucang Island which was not heavily browsed on. However, this relation is probably only accidental. Most seedlings on Peucang are heavily browsed on regardless of the species, while the present distribution of Javan deer strongly differs from the situation several decades ago, when the species was more common on the mainland and less common on Peucang than it is now (see chapter 10).

Even so, there is a possible explanation for the phenomenon of *Arenga* forests.

Obviously, all areas from which such forests are known have one feature in common. They are islands or peninsulas, (almost) completely surrounded by seawater, but situated close to a vast land mass with a more or less constantly wet climate. This holds even for Nusa Kambangan: although Central Java generally speaking has a more seasonal climate, the SW-part in which Nusa Kambangan is situated is notably wetter (Boerema, 1931). As stated in Chapter 5, this borderline location resulted in Ujung Kulon in a

specific climate with, incidentally, a very dry season, while annual fluctuations on the adjacent mainland, even at a small distance, are known to be less pronounced. It is very well possible that the same climatological situation also exists in the other regions mentioned.

Still, one cannot simply consider the dominance of *Arenga obtusifolia* as some mysterious adaptation to an unstable climate. In some parts of Ujung Kulon, *Arenga* forests are lacking where they could be expected as far as altitude and soil are concerned. The most clear example of such a situation is the central part of Peucang Island.

It is now of interest to realize that the Peucang forest, in view of its floristic composition and physiognomy, is generally considered to be of primary nature (e.g. Kartawinata, 1965; Kostermans, pers. com.). On the other hand, the phenomenon of strong dominance of one species in a tropical forest is generally interpreted as a token of former disturbance (e.g. van Steenis, 1965).

Thus, we may assume that the dominance of *Arenga* is due to climatological 'instability' or, more precisely, to the incidental occurrence of exceedingly dry years, but is a phenomenon which is restricted to secondary forests. A possible explanation is provided by the fact that *Arenga* palms have the capacity for rapid vegetative reproduction by means of subterranean shoots which undoubtedly gives the species an advantage above invading seedlings of other species especially during a period of climatic hardship. Still, in our experience, *Arenga* does not behave like an aggressive weed after destruction of the natural vegetation. Obviously, the species is not of great significance in the early stages of succession. We shall return to this subject in chapter 9.

Two factors assumed to enhance the impact of unusual drought should be mentioned here: fire and vertic properties of the soil.

Fire has strongly influenced succession in areas with a true monsoon climate all over Java (van Steenis, 1965) and it is most likely that it also did so (and in a specific way) in areas with an incidental very dry season.

In the past, deliberate incendiaryism on behalf of shifting cultivation practices and the maintenance of the artificial savanna landscape may easily have led to incidental, uncontrolled forest fires. Only recently, part of nearby Panaitan Island suffered from forest fires resulting from neglected cooking fires of fishermen (Blower and Van der Zon, 1977). As stated before, human influence on Peucang Island has always been of minor importance, which might explain the survival of the primary vegetation there.

Possibly, palm trees, which do not have their vascular bundles concentrated in the outer part of the trunk, are less vulnerable to a not too severe forest fire. Moreover, as mentioned above, *Arenga obtusifolia*, has the capacity of rapid recuperation after destruction of the supra-terrestrial parts, by means of subterranean shoots. Some other palm species have this capacity as well. Indeed, Eiten (1968) describes the occurrence of a semi-deciduous broadleaf and palm (open) forest in Brasil after the burning of the original forest. However, these relations are only hypothetical. Of course, many dicotyledonous species are also adapted to survive forest fires, e.g. *Tectona grandis*, but such species are inhabitants of true monsoon forests and are in general absent in Ujung Kulon.

Furthermore, we assume that the vertic properties of some of the most common soil types of Ujung Kulon (see section 7.5) are also involved. Young *Arenga* palms, sprouting from firm subterranean shoots, can be assumed to be less vulnerable to the churning of the soil mass following an exceedingly dry season than 'normal' tree seedlings and saplings. Indeed, most of the soil types on which *Arenga* forest is present are assumed to possess vertic properties (see section 7.5). Only three types (all of limited extent) have no vertic properties, but do carry *Arenga* forest. However, in all three cases we are dealing with somewhat excessively drained soils on which the vegetation's sensibility for seasonal drought is self-evident. We even assume that here *Arenga* itself reaches the limits of its ecological amplitude.

In summary, we assume that *Arenga* forests are bound to areas (with an appropriate soil and a seasonal climate, where the original semi-deciduous broadleaf forest has been destroyed by fire or man. Differences in specific composition and degree of dominance of *Arenga* may be interpreted as differences in intensity and frequency of destruction and in age of the stand (of course, in addition to differences in soil types).

In this respect it is interesting to note that the isolated plateau-fragments with *Arenga* forest, which rise up from the uplands north of Cibandawoh and which are covered with a sound form of *Drypetes* forest, still have a remarkably rich flora (e.g. with *Dipterocarpus trinervis*) and that the upper limit of the *Arenga* forest on Mt. Payung coincides with the lower limit of the constantly wet zone which is less vulnerable to forest fires.

Conversely, one might conclude that forests with few or no *Arenga obtusifolia*, growing at altitudes and on landforms where the species is dominant elsewhere in Ujung Kulon are primary forests. Examples of such primary relics are the central part of Peucang Island and parts of both the tuff-hills in the westernmost and the upper part of the Telanca massif. However, not all such stands are of primary nature. Local pedological abnormalities may also be of great importance, e.g. the well-known species-rich forest fragments east of the Cibandawoh shelter (mentioned by both Kappeler, 1981 and Ammann, 1985) seems to be bound to a part of the limestone plateau which has weathered to an unusual sandy soil. Likewise, the *Drypetes ovalis* dominated slope-forest west of the trail Cibom-Ciramea is bound to an extremely shallow soil profile.

9.4.2 Bamboo-forests (communities XII and XVII)

In Ujung Kulon two forest-types can be found which are dominated by bamboo-species growing in clumps. The two species at issue are *Schizostachyum zollingeri* which forms (almost) pure stands (XVII) and *Bambusa blumeana* which generally dominates a specific type of mixed forest (comm. no. 12) together with *Drypetes ovalis*. Although most of the bamboo species occurring on Java are not truly native, these two are according to Hildebrand (1954).

The same author mentions the occurrence of forests dominated by these species for several locations on Java (partly following Backer, 1928). Apparently the habitat of the *Schizostachyum* and *Bambusa* forests elsewhere on Java corresponds fairly well with the present situation in Ujung Kulon.

Thus, *Schizostachyum* stands are most common on steep slopes and river

banks at low altitudes. In addition, in Ujung Kulon they can also locally be found on adjacent parts of the limestone plateaus, replacing the rattan-shrublands. This can be explained by the principle of primarity.

The habitat of *Bambusa* forest also corresponds with the situation described for other parts of Java. It is bound to the heavy, periodically very wet soils of the uplands of Ujung Kulon, including the slightly better drained parts west of Jamang. However, Backer's observation that stands of *Bambusa* indicate a soil poor in phosphates probably does not hold for Ujung Kulon (van Reuler, pers. comm.).

As for the successional status of the Javan bamboo forests, van Steenis (1935, 1965) considers all cases of pronounced dominance of bamboos as a token of former human interference. All bamboos are light-demanding species, which are capable of a quick response once the forest-canopy has been opened and once established they are not easily superseded by other plants thanks to the competing capacity of their dense root system.

Possibly, next to former logging activities, forest fires have also been of importance. In many places the bamboo forests border upon *Arenga* forests which are at least partly assumed to be influenced by (repeated) forest fires (see 9.4.1).

Moreover, bamboo clumps are generally surrounded by piles of highly inflammable litter. Thus, it is most likely that formerly the bamboo forests also suffered from incidental fires. If the subterranean rhizomes of the bamboos survived the fire, again the bamboo clumps could profit from the destruction of the forest-canopy. If so, they followed the same strategy as truly fire-adapted species such as *Casuarina junghuhniana* (see Burger, 1930). However, no indication of such a strategy could be found in the literature on bamboos.

Even so, it is interesting to note that the stands of the *Bambusa-Drypetes* forest in which *Bambusa* is the least abundantly present occur in the same region (viz. north of Cibandawoh) in which notably species-rich forms of *Arenga* forest occur. These are also assumed to reflect a relatively weak impact of former forest fires (see 9.4.1).

The *Bambusa* forests, probably even more than the *Arenga* forests, are bound to soils which possess distinct vertic properties (see section 7.5). The capacity of bamboos to sprout from firm subterranean rhizomes is likely to give them an advantage above normal seedlings during churning of the soil mass during an exceedingly dry season. Thus, also in this respect, there is an interesting parallel between *Arenga* and *Bambusa* forests.

Finally, we must point to the fact that the former inhabitants of Ujung Kulon planted small bamboo groves throughout the area. Although not considered as being the most valuable of bamboo species (Hildebrand, 1954), this probably also holds for *Schizostachyum zollingeri* and *Bambusa blumeana*. Thus, small stands of both species outside their normal distribution area in Ujung Kulon and generally situated along the (centuries-old) footpaths can be explained. Examples are the stand of *Schizostachyum* on Gn. Kendeng (described by Pellek, 1977) and the stand of *Bambusa* NE of the mouth of Citelanca.

9.4.3 Stub-forests (communities XXII, XXIII and XXXVII).

In the northern part of the coastal plain of Ujung Kulon, vast stands of forest occur which are characterized by a special growth-form of the dominant species: a many-stemmed stub. In habit these forests rather closely resemble a European oak-coppice.

These stub-forests can be subdivided into three plant-communities, which show a clear relation with abiotic factors (see 9.3). In all three, the most common dominant species is *Ardisia humilis*, locally covering up to 100%.

However, *Buchanania arborescens* may replace *Ardisia* in some stands of the *Ximenesia-Ardisia* community (no. XXIII), while in the area west of Jamang we find *Casuarina equisetifolia* predominant in the *Lumnitzera-Ardisia* community (no. XXXVII). Of *Casuarina*, only some of the specimens occur in many-stemmed stubs.

In the literature, we could not find any reference to similar vegetations elsewhere in the Malayan region. However, there is no problem in tracing the origin of the Ujung Kulon stub-forests. Clues can be derived from the existing literature on the area (mainly from the reports of Hoogerwerf, 1937, 1938, 1952, 1970 and 1972) and from the memory of the older PPA guards (e.g. Pak Sakmin).

The stub-forests originated from the artificial savanna-landscape after the gradual neglect of their maintenance. This savanna consisted mainly of *Imperata* dominated grasslands, with scattered trees and shrubs. We have little information on the floristic composition and the (probably considerable) internal variation of these vegetations. The parts which were situated on the raised pseudo barrier reef and which would develop into the present *Ximenesia-Ardisia* forest probably showed some similarity to the present *Calotropis-Dodonaea* vegetations (comm. no. XXIV) which occur in small glades along the north coast near Cape Alang-alang.

We know for certain that species such as *Calotropis gigantea* and *Saccharum spontaneum* were once very common in the coastal plain. At present, *Calotropis* is restricted to the glades mentioned above, while *Saccharum* was not encountered at all during our survey. (Still, the species has not yet completely disappeared from Ujung Kulon according to Djaja et al., 1982). Furthermore, we may assume that the wettest forms with the strongest brackish influence, which would develop into the present *Lumnitzera-Ardisia* forest, showed some affinity with the present *Phyllanthus-Eleocharis* vegetations (XXXV) of the bottomlands. Finally, the forms which would develop into the *Corypha-Ardisia* community can be assumed to have been of a more or less intermediate nature, possibly with abundant occurrence of *Saccharum*.

That is about as far as our knowledge and speculations on the nature of the disappeared savanna landscape go. Anyway, it is definitely wrong to consider the present grazing grounds as representative relics (see 9.3.XXVI).

The maintenance of the savanna involved a regular, if possible annual cut-and-burn management. However, maintenance was neglected frequently and the area was invaded by species such as *Ardisia humilis*, *Lantana camara* and *Melastoma affine*. In fact the same species which also tend to invade the

present grazing grounds. Of course there were local differences, mainly related to differences in soil conditions. In relatively wet areas, the fan palm *Corypha utan* was a most noxious weed, as photographs of the Cikarang area (once a famous pasture) clearly show (Hoogerwerf, 1970).

Of all pioneer species invading the pastures, *Ardisia humilis* was one of the most persistent, since treelets of this species are not killed by fire. In this respect, the report of Van Borssum Waalkes (1951) is interesting. He witnessed the burning of an *Imperata* field on nearby Panaitan island. The fire killed most of the scattered growing trees, but the *Ardisia* stands were spared. Therefore, it was necessary to cut the wild shoots before setting fire to the area. As we know from the report of Kortz (1952) this was done effectively only by chopping the stems at ground level and not above. This must have been an arduous task, especially since in many places the soil surface of the coastal plain is strewn with coral debris, blunting the chopping-knives even more quickly than the *Ardisia* stems could with their notoriously hard wood. In this respect, it is interesting to note that in the vicinity of Legon Penyu, where the Krakatau waves also deposited loads of pumice, one did not even bother to maintain grasslands. At present, one finds reasonably fully-grown forest in this region (see 9.4.XXII), a very rare phenomenon on the raised pseudo barrier reef.

Inaccurate cutting of wild shoots did not exterminate them but induced stub-forming. We may assume that the present variation in density of stub-forms reflects differences in effectiveness and regularity of the former management.

We may also assume (although exact data are not available) that both *Buchanania* and *Casuarina equisetifolia*, although more selective as far as soil conditions are concerned, are to some degree also fire-resistant, just like *Ardisia humilis*. This is especially interesting in the case of the latter species which thus shows an ecological parallel to *Casuarina junghuhniana*, the most notorious fire-adapted tree-species of the mountain regions of Central and East Java (Burger, 1930; van Steenis, 1935; see also 9.4.2).

9.4.4 Rattan-shrublands (community XV).

This section deals with the notorious, almost inaccessible, shrubby jungles, dominated by long-creeping rattans (i.e. thorny palm-lianas) and other types of lianas and vines, which cover vast parts of the interior of Ujung Kulon.

These vegetations are most abundantly present on the dissected parts of the limestone plateaus, on the uplands and in the fluvio-alluvial plain. Elsewhere, they are of less significance or completely absent. As for soils, the rattan shrublands are (almost) completely restricted to moderately-well or somewhat poorly drained conditions (see section 7.4.3 and table 11b).

All rattan-shrublands of Ujung Kulon belong to one plant community (the *Hyptido-Daemonoropsetum*) two subtypes of which are described (see 9.3.XV).

A remarkable feature of these vegetations is the fact that their boundaries with adjacent vegetation (mainly forests) are, in general, strikingly abrupt, while no sudden change in abiotic circumstances (e.g. soil conditions) can be observed. On the other hand, where the rattan-shrublands cross important

soil-boundaries, causing spectacular changes in the vegetation of forest covered areas, the shrublands do not show a significant change in physiognomy or floristic composition.

On the basis of their physiognomy and the abrupt character of their boundaries (unrelated to abiotic factors), the rattan-shrublands can be interpreted as an early succession stage following deforestation by man (see: van Steenis, 1961).

In his enumerations of vegetation-types of the Malayan region, van Steenis (1935, 1957, 1965) does not go into detail as far as such forms of early secondary growth are concerned. However, in 1939 the same author published a special paper on vegetations dominated by lianas and vines, including types of secondary growth.

According to van Steenis, dominance of climbing species (including rattans) is far from uncommon in both shrubby and forest-like forms of secondary vegetation. The same author describes how blankets of vines may completely envelop treelets, strongly reducing their vitality and not rarely killing them. As stated in section 9.3.XV, such stunted treelets are very common in the Ujung Kulon rattan-jungles. Moreover, many species mentioned by van Steenis (e.g. several Convolvulaceae) are also most abundant in our study area.

Unfortunately, van Steenis does not give much information on the conditions under which secondary vegetations may become dominated by vines and lianas. As for Ujung Kulon, Hommel and Van Reuler (1986) drew up the following theory (see also Hommel, 1983 and Van Reuler, 1986).

By the end of the previous century large parts of Ujung Kulon were under cultivation as 'dry' rice-fields or only recently deserted (a description of the shifting cultivation system in these parts of Java is given in chapter 4). One of the major impacts of the 1883 Krakatau eruption was the deposition of a layer of volcanic ashes (up to 30 cm thick), which killed the young rice plants (not yet planted out) and also most of the adjacent low, secondary vegetation. The surrounding forests were affected less dramatically, although much of the undergrowth suffered.

Consequently, the area was completely depopulated for a variety of reasons (see chapter 4) and vast, ash-covered fields remained. Due to some specific properties of the ash layer (see section 7.4), these fields did not provide favourable conditions for invading seedlings. Thus, climbing species which are in general abundant in forest edges and which always strongly respond to light (van Steenis, 1939), were at an advantage, invading the ash-covered glades by horizontal growth. Thorny species (e.g. rattans) had a special advantage, because of the considerable browsing pressure. The many large herbivores of the area can be assumed to have suffered from food-shortage, because of the impact of the ash deposition on the lower vegetation of the whole peninsula. Predominance of thorny species in secondary vegetations in relation to browsing pressure has been described before by van Steenis (1957).

Further succession was difficult. Van Steenis (1939) points to the fact that underneath vegetations dominated by vines and lianas the availability of light is very limited. Thus, the conditions for seedlings are not very favourable. Reduction in the vitality of treelets because of the all-enveloping vine-

blankets has already been mentioned. Still, it is strange that even after one hundred years, the shrublands have not evolved very significantly. The present pattern of rattan-vegetations still shows, both on aerial photographs and in the field, the pattern of agricultural fields which were under cultivation in or shortly before 1883.

A possible (additional) explanation for this phenomenon can be found in the exceptionally harsh soil conditions of the open, exposed areas, where (in contrast to the surrounding forests) the structure of the ash-topsoil hardly improved. Unfortunately, Pellek who studied plant-soil relations (1977) and soil-genesis in the ash-layer (1986) in Ujung Kulon was apparently unaware of the existence of the rattan-shrublands. Our own observations on this point of detail are of a rather descriptive nature and exact data are lacking (see chapter 7). Even so, it is interesting to note that in clearings on soils which have been covered by forest for the greater part of the previous hundred years, succession proceeds in a far more rapid and 'normal' way.

Recently deserted shifting cultivation sites in the Legon Pakis area (near the eastern boundary of Ujung Kulon) are covered with a shrubland which, in many places, is dominated by *Lantana camara*. Young treelets occur abundantly, but rattans are virtually absent. Such successional patterns are much more similar to the normal vegetation development on former shifting cultivations sites in this part of Java (see: Backer, 1913).

A shifting cultivation site in the adjacent part of the Mt. Honje area was found to be covered by open, medium-tall forest only thirteen years after being abandoned (see 9.3.XVI), but this does not prove very much since on the site studied (plot 336) the ash-topsoil was absent.

Thus, succession of the Ujung Kulon rattan-shrublands proceeds very slowly, but this does not imply that these vegetations will last forever eternally. Gradually, trees will manage to break through the compact mass of entangled vines and lianas. In this respect, it is interesting to note that the rattan-shrublands can roughly be subdivided into two subtypes which are assumed to reflect a difference in succession: a 'primitive' subtype, with abundant growth of the pioneer-shrub *Lantana camara*, but poor in treelets and a further developed subtype without *Lantana* but relatively rich in treelets. It is of importance to note that neither palms (*Arenga*) nor bamboos (*Bambusa*) seem to be of much significance in the most developed phases of the rattan-shrublands. The same holds for the more recently originated secondary vegetations mentioned above. We shall return to this subject in chapter 11, when discussing the main lines of vegetation dynamics in the area.

CHAPTER 10. FAUNA

10.1 Introduction

The area's fauna will be discussed in less detail than the botanical aspect.

The reason for this procedure is primarily the fact that the fauna aspect, unlike most of the other land-attributes, has been dealt with thoroughly by a whole series of other students. A further justification is found in the fact that of all mutually connected land components, the fauna is, at least in the case of Ujung Kulon probably the most dependent one: it is determined far more by the other land-attributes than it determines those aspects itself. In other words, lack of detail as far as the fauna is concerned is less a barrier for understanding the main landscape units, as would be the case if knowledge about other land-attributes such as vegetation or soil were insufficient.

In the following sections, attention will be paid above all (but still concisely) to the ecology of the Javan rhinoceros (10.2). As stated before (see chapter 1) Ujung Kulon's fame and importance as a conservation area are largely due to this species. Moreover, it is an attendant objective of this study to pay attention to the food availability of this animal in relation to possible vegetation changes and active habitat management. Therefore, after a short enumeration of some general information, we will focus on the feeding ecology of the rhino. In addition, other habitat requirements will be discussed briefly. It is of importance to note that the various habitat requirements (including food availability) apply to areas of varying size and status (viz. stands of one specific vegetation type, larger and more complex landscape units or even still broader geographical regions). Still, we shall try to give an evaluation of the various parts of Ujung Kulon (mainly on the level landscape units) in terms of suitability as rhino-habitat as a result of the integration of all habitat requirements. This evaluation will be presented in the next chapter (11).

After discussing the Javan rhinoceros, attention will be paid to some of the most important other animal species of the area (10.3). Some important literature references will be given and a few details believed to be relevant for the management of Ujung Kulon will be forwarded. However, not the slightest degree of completeness will be pursued. Moreover, no attempt to evaluate the various parts of Ujung Kulon in terms of suitability as habitat for any other species than rhino could be undertaken within the frame-work of this study. We hope that this booklet may stimulate others to start such an evaluation using the landscape data presented in this study.

10.2 The Javan rhinoceros

10.2.1 General information

Of the five species of rhinoceros which have survived until the present day, three are living in Asia: the Indian, Sumatran and Javan rhino. Of these the Javan rhino (*Rhinoceros sondaicus* Desm. or badak in the local language) is at present by far the most rare. The 70 specimens living in Ujung Kulon probably represent the entire world population of the species.

However, its distribution area was formerly much larger and included

Java, Sumatra, the Malay peninsula and adjacent parts of Continental SE Asia. By the end of the last century, the species was still present in most parts of its original area. As early as 1934, the last remaining specimen known to live outside of Ujung Kulon was killed near Tasikmalaya in West Java (Hoogerwerf, 1970).

The reasons for this dramatic decrease are the rapidly increasing population pressure, big game hunting and poaching. Although the rhinos have been fully protected by law in Ujung Kulon since 1921, even there poaching has remained a threat to the last remaining specimens of the species even up to the present day. Poachers persecute the animal for its horn, skin and blood which are still sold in China as medicine, especially as a charm of supposedly aphrodisiac action (Schenkel and Schenkel-Hulliger, 1969). Although poaching is more or less under control at present, several times in the recent past it brought the species to the very edge of extinction. For instance when the Schenkels started their research programme in 1967, they estimated the total number of surviving rhinos at only 21-28. The number has increased ever since to an estimated total of 47-57 (mean 52) in 1980 (Ammann, 1985) and 50-54 (again mean 52) in 1984 (Sajudin et al., 1984). However, according to Ammann, these estimates, based on the census-method as developed by the Schenkels, are somewhat too low. Ammann estimates the actual population size at the 70 individuals mentioned above.

Moreover, every now and then reports appear of observations of *Rhinoceros sondaicus* in other parts of its former distribution area e.g. in Thailand, Vietnam and Malaya. Until now these reports have not been confirmed by scientific research and even if some of these reports eventually prove to be right, it is highly unlikely that they refer to more than some scattered and isolated specimens (Hoogerwerf, 1970).

The Ujung Kulon population of the Javan rhino has been studied thoroughly over the last decades. The most important students were Hoogerwerf (1970), Schenkel et al., (1969, 1978), the WWF rhino research team (e.g. Djaja et al., 1982; Lusli, 1982; Sajudin et al., 1984) and Ammann (1985). Even, much is still unknown as far as the ecology of this species is concerned. This is due to the very shy character of the animal and the inaccessibility of many parts of the area. Most of our current knowledge on the Ujung Kulon rhinos is based on indirect observations, such as feeding marks, footprints and excrements.

For a more thorough description of the life-history of the Javan rhino, we can refer to the literature references given above. Here, only a few main points need to be mentioned before we can discuss the animal's habitat requirements, as will be done in the next sections. The following information is derived from Amman (1985).

The Javan rhino is a solitary animal. All adult specimens, both male and female, have their own home-range, i.e. a specific part of the area to which they confine most (but not all) of their activities. These home-ranges are generally overlapping and of varying size, the ones occupied by the males are on the average larger than those occupied by the females. Possibly, the home-ranges of some males have the status of territories in which they have the (almost) exclusive right of mating.

Within their home-range, the animals are in general more or less constantly

on the move. Their habits are those of true wanderers. However, they do not distribute their activities equally over the total area of their home-range. They appear to spend most of their time in areas with a high abundance of food. While roaming around, the rhinos frequently stick to fixed trails, but Ammann remarks that the rhino's tendency to follow trails is overestimated by other authors. The length of the path covered by solitary rhinos per 24 hours was determined by Ammann to be some 1.4 to 3.8 km. Females accompanied by a calf cover, on the average, a slightly lesser distance in 24 hours. However, the animals are apparently capable of covering far longer distances if necessary. Ammann mentions one case in which a mother with calf covered no less than 6 to 8 km in 12 to 24 hours. Hoogerwerf (1970) is even convinced that rhinos quite frequently travel 15 to 20 km on one single day.

The home-range concept allows the incidental movement of animals outside their home-range. We do not know if the rhinos do so frequently. However, from various literature-sources one gets the impression that the animals are not very strongly bound to their home-range. All animals are, for instance, assumed to visit the coast occasionally, while there is no evidence that the home-ranges of all rhinos actually border the coastline. Moreover, most authors indicate regular changes in the distribution of rhinos over the area.

10.2.2 Broad description of food preference and feeding behaviour

The Javan rhino is a browser. It mainly feeds on foliage, small branches and (more rarely) the bark of shrubs and treelets. The green parts of tall gingers and climbers also provide an important source of food.

Fruits are generally of little importance, possibly since most of them are beyond the animal's reach. Still, if available, the animals may show a great liking for this type of food as we once observed when coming across an adult bull, which forgot its usual shyness while devouring a large fallen wild *angka* (*teureup*; *Artocarpus elasticus*). However, smaller types of fruit may be completely ignored (Ammann, 1985).

Low herbaceous plants (and seedlings?) are probably of very little significance as food plants. Junghuhn's statement (1854) that the animal mainly feeds on grasses is definitely wrong, at least as far as the Ujung Kulon population is concerned. Not one record of grazing rhinos is available for our study area. Moreover, Schenkel and Schenkel-Hulliger (1969) point out that the lips and teeth of the animals are specialized for browsing.

Thus, browsing on shrubs and treelets is the main form of feeding. While, doing so, the animal may reach up to some 2.5 m (Hoogerwerf, 1970). Even so, the rhino has to bring much of his food within its reach by tearing off branches and breaking or up-rooting stems. According to Schenkel and Schenkel-Hulliger (1969), this is done mainly by crashing the stem between the jaws; according to Hoogerwerf (1970) by pushing with the head and neck. More rarely, the animal simply squashes a treelet under its feet, or more precisely under its belly.

As for the size of the treelets on which the rhinos can feed, opinions also differ. Djaja et al. (1982) state that almost 90 per cent of all recorded feeding marks concerned plants with a stem-diameter of 2 to 10 cm (including tall gingers etc.). A maximum size, however, is not given. Schenkel and Schenkel-Hulliger (1969), however, give a maximum diameter, 12 cm, which

corresponds fairly well with the figure given by Ammann (1985), viz. 15 cm. However, Hoogerwerf (1970) considers 10 to 15 cm as the usual range but gives a maximum of no less than 23 cm. In this respect it is interesting to note that the same author mentions feeding on a clump of *Ardisia humilis* stems of 12 to 15 cm in diameter. The wood of this species is notoriously hard and strong. Very soft-stemmed pseudo-trees such as pandan and banana are, of course, kept out of the comparison presented above.

As already mentioned, one of the most striking features of the rhino's feeding behaviour is the habit of strolling through the forest, not rarely along fixed tracks, consuming only small bits left and right of each food-source. This is true even when it takes a considerable effort to bring the foliage within reach, e.g. by molesting a complete tree. Moreover, having finished with a foodplant, the animals tend to ignore all nearby plants of the same species.

Ammann (1985) points out that this seemingly very inefficient way of feeding in fact not only guarantees an optimal balance of nutrients, but also helps to avoid a damaging amount of toxins.

Furthermore, several authors indicate that the rhino greatly profits from its savage manners. Although in general the quantity of food actually eaten is out of all proportion to the damage done, most trees manage to survive after being broken or up-rooted. They sprout again, generally with more than one fresh new shoot, easily within reach of the rhino, which may pass along the same track again before long.

10.2.3 Important species of food plants

Now, we come to the question of whether the animals have a preference for certain plant species and, if so, which? Most authors dealing with the Javan rhino have touched upon this subject and produced a list of food plants with some indication of the frequency with which each species was observed to be browsed on. It is interesting to note, that some of these lists do not generally overlap. For instance, Hoogerwerf (1970) considers *Glochidion zeylanicum* as the most important food plant, while neither Schenkel and Schenkel-Hulliger (1969) nor Ammann (1985) list the species at all.

This curious phenomenon can simply be explained from the data supplied by our study. All authors more or less focussed on a specific part of Ujung Kulon. During his numerous visits to Ujung Kulon, Hoogerwerf spent most of his time in the coastal plains east of Nyewaän. The Schenkels focussed on the western hills and the coastal regions west of Nyewaän. Both Ammann and Djaja and his colleagues had their main study area in the Cibunar-Citadahan region. All these regions are quite different as far as their vegetation and flora are concerned, which results in differences in the availability of food plants. Moreover, differences in research methods may also be of importance. Ammann's list contains a relatively high percentage of climbing species, which can at least partly be explained by the fact that he was the only one who gathered most of his data by tracking the rhinos. Feeding marks on climbers do not remain visible for long and are thus easily neglected when roaming through the forest at random (Ammann, 1985).

Thus, we face the problem that each list only has a regional significance. But this is not the only problem. A mere list of species with an indication of

the frequency with which it was recorded as a food plant does not tell us how much was eaten or how much was available, i.e. whether the species is a substantial ingredient of the rhino's menu or a preferred food plant.

Ammann (1985) solved the two latter problems for his study area using a very elegant method. By giving a numerical value to each feeding event in proportion to the quantity consumed by the rhino, and by summing up these values for each species, an 'index of the quantity consumed' (QI) was computed, which can be subsequently expressed as a percentage of the total sum for all species.

Thus, from 190 species of food plants only four species together provide almost 45 per cent of the total quantity eaten. The same four species were also the most frequently eaten, though in a different sequence (see Table 10a). To illustrate the significance of these four principal food species (as Ammann calls them) one may point to the relatively low quantity index of the fifth species in line (the climber *Poikilospermum suaveolens*), viz. only 2.8 per cent.

Next, in order to determine the rhino's preference for specific food plants Ammann estimated (by means of an analysis of sample plots) the total quantity of all potential food plants and compared these results with the figures for the quantities of each species which were actually eaten. The resulting relative preferability index (RPI; after Petrides, 1975) thus represents the ratio of the proportion of a food species in the diet to its relative availability.

Table 10a The four principal species of food plants of the Javan rhinoceros

Species:	QI	%	F	%F
<i>Spondias pinnata</i>	519	19.0	72	5.9
<i>Amomum spec.</i>	257	9.4	337	27.6
<i>Leea sambucina</i>	242	8.8	86	7.0
<i>Dillenia excelsa</i>	189	6.9	55	4.5

QI = index of the quantity consumed (see text)

% = percentage of the total quantity consumed

F = recorded number of feeding events

%F = percentage of the total number of feeding events.

(after: Ammann, 1985)

The results as far as the species with a RPI larger than 1 (the preferred food species) are concerned, are given in Table 10b. There is very little correlation between RPI and QI, i.e. most preferred food species are actually, in a quantitative sense, of little significance as a source of rhino food. On average, a preferred food species, contributes only 1 to 3 per cent or less to the rhino's menu. This can be explained the fact that the preferred food species are, in contrast to the principal food species, not available in great quantities, at least not in Ammann's study area. On the other hand, the rhino does not show much preference for his principal food species. For three of them, it has even a (very) slightly negative preference; in our opinion this can be explained by the fact that these species (*Amomum*, *Leea* and *Dillenia*) generally grow more or less gregariously. As mentioned in the previous section, the rhino tends to neglect more specimens of the same species while feeding.

The great exception to both rules (i.e. insignificance of preferred species

Table 10b Relative preferability indices of foodplants of the Javan rhinoceros

Only preferred species (RPI more than 1) are listed:

Species:	RPI
<i>Kleinhovia hospita</i>	270.84
<i>Ficus variegata</i>	223.74
<i>Sumbaviopsis albicans</i>	23.02
<i>Planchonia valida</i>	21.59
<i>Poikilospermum suaveolens</i>	21.59
<i>Dracontomelon puberulum</i>	20.88
<i>Spondias pinnata</i>	15.20
<i>Derris elliptica</i>	3.67
<i>Uncaria spec.</i>	3.35
<i>Merremia vitifolia</i>	2.67
<i>Embellia ribes</i>	2.24
<i>Merremia umbellata</i>	1.82
<i>Scaevola taccada</i>	1.52

(after: Ammann, 1985).

and lack of preference for principal food species) is *Spondias pinnata*, which belongs to both categories. Typically, it does not grow gregariously but can commonly be found scattered throughout Ujung Kulon's lowlands. As mentioned in the previous chapter, it was often observed to sprout from banteng dung. Thus, banteng obviously have (in this respect) a positive impact on the availability of rhino food plants. Until now, this aspect has not been mentioned in discussions on the food-competition between the two species (see 10.3).

Although Ammann's research was primarily aimed at a study area of only moderate size, his results may to a certain extent be extrapolated for the whole of Ujung Kulon.

A first and major conclusion may be that food preference (on the floristic level) as such is of little significance. The rhino feeds on an extremely wide variety of species, given they are available in the right sizes. Ammann even states that 'given a sufficiently long observation time, the diet of the Javan rhino would probably be seen to include nearly all plant species of suitable size'. However, only those species which are available in great quantities (in some region or throughout the area) may be of importance as substantial ingredients of the rhino's menu. Only for these species is it interesting to know the animal's degree of preference.

From our own results, an outline of such common and abundant species may be compiled. Moreover, Djaja et al. (1982) provided a list of species, arranged in order of their 'importance value' (see: Mueller-Dombois and Ellenberg, 1974) based on the analysis of three north-south transects through the central part of Ujung Kulon. For most of the interesting, i.e. common and abundant species we can gather the rhino's preference from the results of Ammann. This is true even for species which are quite rare and thus of little importance within his study-area. For species which are absent in his study-area (or extremely rare and thus of little statistical value) we have to turn to the lists of food plants (with indications of browsing frequency) of the other authors mentioned. Together, we may assume these lists to be more or less area-covering. In doing so, we are confronted with a number of practical problems such as differences in the delimitation of taxa, (possible) mis-iden-

tifications of species, contradictory records of the rhino's preference and the risk that some data have become outdated because of recent changes in the vegetation of some areas.

As an example of such practical problems we may point to the case of the treelet *Drypetes ovalis*. The correct name of this species has been uncertain for a long time. Hommel (1983) wrongly used the name *Drypetes longifolia*. Moreover, it is as good as certain that the species at issue is also called *Drypetes longifolia* by Ammann (1985) and *Diospyros pendula* by Djaja et al. (1982). With the latter species, *Drypetes ovalis* indeed shows a large resemblance as far as the foliage is concerned. This *Drypetes ovalis* is rather common in many parts of Ujung Kulon but especially so in the *Bambusa* forests of the uplands. There it grows not only very abundantly but also in sizes preferred by the rhinos. We now face the problem that, according to Ammann, the rhinos show no interest at all either in this species as a food plant, or in *Bambusa* vegetations as a feeding habitat. However, the same author indicates the major distribution area of the *Bambusa* vegetations as an area with a relatively high density of rhinos. Moreover, the same species was found to be browsed on by rhino six times by Djaja et al., leading to a classification as a slightly important food plant (see Table 10c).

Obviously, in solving such problems many arbitrary decisions had to be taken. This fact, combined with the heterogeneous character of the data, causes our outline of the most important species of rhino food plants to be broad and preliminary. Even so, it seems of value to publish such a tentative list (see Table 10c), since we trust it is of sufficient detail to help judge the value of each landscape unit as a habitat for the Javan rhino (see chapter 11).

Even a quick glance at Table 10c shows that a positive preference for species is only of importance in a few cases. However, negative preference (i.e. dislike) for a given species is of far greater significance and responsible for the absence of many of the most common species on the list. For instance, the rhino hardly feed on palms at all (neither on palm-treelets, shrubs or lianas) or bamboo (Ammann, 1985).

Finally, we can indicate an interesting aspect of the rhino's menu, mentioned e.g. by Hoogerwerf (1970). As a rule, the rhino's food plants are inhabitants of secondary vegetations. This is even more true than Hoogerwerf himself realized. The exceptions to this rule that he mentioned (after personal communication with van Steenis), i.e. *Diospyros macrophylla* and *Lepisanthes spec.* (most probably *L. montana*) are actually in Ujung Kulon also species of secondary vegetations.

This phenomenon may simply be explained by the fact that easily accessible areas and secondary vegetations more or less coincide (see section 10.2.4).

On the other hand, there may be a relation with the availability of light which, on average, is rather scarce in the lower layers of primary forests. Ammann observes that even within secondary vegetations, the rhino has a clear preference for species growing in light, open situations. He explains this phenomenon by the higher nutritional value and lower toxicity of rapidly growing plants in an unshaded environment.

Possibly, both explanations are true, which means that the rhino prefers easily accessible terrain with good food (which sounds quite plausible), but

Table 10c. List of important food plants of the Javan rhinoceros

Data derived from:	Schenkel & Schenkel-Hell (1969)		Hoogerwerf (1970)	Djaja et al. (1982)	Ammann (1985)			
	F	I	F	F	F	Q	P	I
Species:								
<i>Acanthus illicifolius</i>	-	-	+	-	-	-	-	+
<i>Alstonia scholaris</i>	-	-	+	-	-	-	-	+
<i>Annonum compactum</i>	?	-	-	++	+++	++	-	+++
<i>Annonum megalocheilos</i>	++	-	-	++	+	-	-	++
Annonaceae ('Kilaja')	-	-	-	-	-	+	+	+
<i>Ardisia humilis</i>	-	-	-	-	-	-	-	+
<i>Arenga pinnata</i> (seeds)	-	-	-	-	-	-	-	+
<i>Barringtonia macrocarpa</i>	-	-	-	+	-	-	-	+
<i>Berberis veletanii</i>	-	-	-	-	-	-	2++	++
<i>Buchanania arborescens</i>	-	-	-	-	-	-	-	+
<i>Cordia dichotoma</i>	-	-	(+)	-	-	-	-	+
<i>Croton argyrobatus</i>	-	-	-	-	-	-	-	+
<i>Dendroide stimulosus</i>	-	-	-	-	-	-	-	+
<i>Derris elliptica</i>	-	-	-	+	-	-	-	+
<i>Desmodium umbellatum</i>	++	-	+++	-	-	-	-	+++
<i>Dillenia excelsa</i>	++	-	-	++	-	++	-	++
<i>Dillenia obovata</i>	?	-	(+)	-	-	-	-	+
<i>Diospyros macrophylla</i>	+	-	-	-	-	-	-	+
<i>Dracontolobium puberulum</i>	-	-	-	-	-	-	+++	++
<i>Drypetes ovalis</i>	-	-	-	(+)	-	-	-	+
<i>Embellia ribes</i>	-	-	-	-	-	-	-	+
<i>Ficus septica</i>	++	-	++	-	-	-	-	++
<i>Garcinia celebica</i>	+	-	-	-	-	-	-	+
<i>Garcinia parvifolia</i>	+	-	-	-	-	-	-	+
<i>Glochidion zeylanicum</i>	-	-	+++	-	-	-	-	+++
<i>Hibiscus tiliaceus</i>	+	-	+	-	-	-	7++	++
<i>Lagerstroemiailus, regina</i>	+	-	+	-	-	+	-	+
<i>Lantana camara</i>	-	-	+	-	-	-	-	+
<i>Leuca bambucina</i>	+++	-	-	++	++	++	-	+++
<i>Lepisanthes montana</i>	+	-	-	-	-	-	-	+
<i>Mallotus philippensis</i>	-	-	-	-	-	-	-	+
<i>Merremia peltata</i>	-	-	-	-	-	-	-	+
<i>Merremia umbellata</i>	-	-	-	-	-	-	-	+
<i>Merremia vitifolia</i>	-	-	-	-	-	+	-	+
<i>Messerschmidia armita</i>	+	-	-	-	-	-	-	+
<i>Mikania cordata</i>	-	-	-	+	-	-	-	+
<i>Musa acuminata</i>	-	-	-	-	-	-	7++	++
<i>Myristica laevis</i>	-	-	-	+	-	-	-	+
<i>Nauclea cordata</i>	-	-	-	-	-	-	-	+
<i>Pandanus tectorius</i>	-	-	(+)	-	-	-	-	+
<i>Pennisetum glaberrimum</i>	-	-	+	-	-	-	-	+
<i>Planchonia validata</i>	-	-	-	-	-	-	+++	++
<i>Poikilospermum suaveolens</i>	-	-	-	-	-	-	+++	++
<i>Pterospermum javanicum</i>	-	-	-	-	-	-	+++	++
<i>Spondias pinnata</i>	+++	-	-	(+)	++	+++	-	+++
<i>Streblus spec.</i>	(++)	-	-	(+)	-	-	-	++
<i>Sambucus javanicus</i>	-	-	-	-	-	-	+++	++
<i>Syzygium puleyanthum</i>	++	-	-	+	-	-	-	++
<i>Syzygium spec.</i>	+	-	+	-	-	-	-	+
<i>Uncaria spec.</i>	-	-	(+)	+	-	+	-	++
<i>Vitex paniculata</i>	+	-	-	-	-	-	-	+
<i>Vitex pubescens</i>	+	-	-	-	-	-	-	+
<i>Zanthoxylum rhetsa</i>	++	-	-	-	-	-	-	++

F = frequency, i.e. percentage of total number of registered feeding events.

+ = 1-5% (Schenkel: occasionally)

++ = 5-10% (Schenkel: more often)

+++ = >10% (Schenkel: very often)

Q = quantity, i.e. percentage of total quantity consumed +, ++ and +++: percentages as indicated for frequency.

P = preference, based on RPI (see text) I = estimated importance

+ = RPI: 1-5 + = slightly important foodplant

++ = RPI: 5-10 ++ = important foodplant

+++ = RPI: >10 +++ = very important foodplant

Note: species which are rare throughout the area were neglected; symbols in brackets indicate uncertainty because of presumed misidentification of species by the authors cited (see text).

will turn to less ideal areas if necessary. In fact according to Hoogerwerf (1970) this is exactly what happened during the last centuries on the mainland of Java: the ever-increasing human population density gradually drove the rhinos from the plains towards the highest mountain regions.

10.2.4 Other habitat requirements

Next to the availability of food plants a number of other habitat requirements of the Javan rhino may be of importance:

Accessibility

A first requisite of an area to be suitable as a rhino habitat is its accessibility. It may be expected that a heavy and unwieldy animal like the Javan rhino is unable to cross steeply dissected or very swampy terrain. Moreover, very compact vegetation may provide an obstacle. However, the animals prove to be far less clumsy than one would expect:

According to Hoogerwerf (1970; citing Junghuhn, 1850-1854), the Javan rhino once occurred on even the highest and steepest peaks and ridges of some of the volcanoes of the western and central parts of the island. In 1978 to 1980 almost the whole Payung mountain region formed part of the home-range of one rhino (Ammann, 1985). As for the accessibility of swampy sites, Hoogerwerf (1970) mentions a rhino track in very soft mud. The footprints were some 40 to 60 cm deep. Finally, as for the density of the vegetation, anyone who has come across a rhino in the Ujung Kulon jungle can witness the horrifying ease with which the animals can break through even the most dense and thorny bushes, when fleeing or charging.

However, this does not imply that the rhinos are completely indifferent as far as terrain conditions are concerned. The Payung-rhino the home-range of which was studied by Ammann (see above), clearly avoided the very steepest southern part of the mountains. Moreover, the density of rhinos in the Payung area has, as far as is known, always been relatively low, while the Ujung Kulon rhinos are not known ever to have shown any interest in the higher parts of the adjacent Mt. Honje (Hoogerwerf, 1970). As far as terrain difficulties on level ground are concerned, Ammann (1985) made an interesting observation: he describes how a rhino while roaming through the fluvio-alluvial plain, obviously avoided very swampy and densely overgrown terrain. The animal changed direction before the difficulties became visible, which also proves the good memory of the rhinos for the terrain features of their home-range.

Water

Rhinos need water to drink and to bathe. The first need is self-evident, the second requires some comment. Like wallowing (see below), bathing is a well known phenomenon among pachyderms (Zonneveld, pers. comm.). The use of bathing is manifold: it satisfies the animals need for rest, it serves to keep the skin moist, it gives protection against skin parasites (thanks to the cleaning activities of fishes and crustaceans) and it may regulate body temperature (Ammann, 1985).

At least the first three functions may also be fulfilled by wallowing. Bathing and wallowing are thus to some extent interchangeable activities. In

addition, the rhinos can rest while laying down on solid ground but also when standing. Ammann (1985) studied the frequency of both bathing and wallowing. He concluded that rhinos can go without bathing facilities for periods up to four days, if there is enough opportunity to wallow (which is generally the case). If wallowing and bathing are considered together, an average of 1.8 times per 24 hours was found.

As for the bathing location, we can also lean on the work of Ammann. He states that rhinos bathe both in streams and pools. The lower courses of most major streams are deep enough for the rhinos throughout the year. During the dry season, these lower courses normally turn brackish, but this does not seem to bother the rhinos. Further upstream, pools deep enough for the rhinos are frequently found. However, we may assume that many (but not all) of these pools become too shallow for the rhinos to bathe in during the dry season. In this respect, Schenkel and Schenkel-Hulliger (1969) made an interesting observation: in the (very) dry season of 1967 they found concentrations of rhino-tracks near the lower river courses with brackish water, but not near the remaining basins and rivulets with fresh water (in the interior). We may interpret this observation as follows: during the dry season, bathing localities may become scarce (and the remaining ones therefore more intensively visited), while drinking-water remains available in sufficient quantities throughout the area.

Mud-wallows

Wallowing is one of the rhino's most important and best studied activities. Hoogerwerf (1970) published an impressive series of photographs of wallowing rhinos (dating from 1940-1941). The most elaborate quantitative data are provided by Ammann (1985).

According to this last author, any depression on level terrain or gentle slopes where a rhino can roll itself in loamy or muddy soil may serve as a wallow. Thus, wallows can be found in most parts of Ujung Kulon, not only in the plains but also in the elevated central part. According to Ammann (1985) the rhinos do not show much preference for specific vegetation types as an environment for wallowing. Only a certain preference for Arenga forest and an obvious dislike of Bambusa forest was found. The latter conclusion is rather surprising, since Bambusa forest grows on poorly drained clay soils in a gently rolling or hilly landscape which seems to provide plenty of opportunities for wallowing. Specific structural properties of the (very compact) soil may provide an explanation. On the other hand (and this seems a more likely explanation), Bambusa forests were included only very marginally in Ammann's study area and the lack of wallows there may be mere chance.

Repeated wallowing on the same location may create mudholes in which rain-water gathers. In this way more or less permanent wallows originate. However, both a pronounced dry season and temporary lack of rhino activity may cause dessication of a wallow. It becomes filled with dead plant material and less attractive for rhinos.

Wallowing has many functions in common with bathing, i.e. resting, protection against skin parasites, moistening of the skin and possibly also regulation of the body temperature (see above). In addition, urination in the wallow is assumed to give a specific scent to the skin and thereby to the

rhino's trail (Schenkel and Schenkel-Hulliger, 1969).

As stated above, wallowing and bathing are to a certain extent interchangeable activities. However, wallowing seems to be a more vital activity. The rhinos can go up to 4 days without bathing in open water, but can go without wallowing for only 1 to 1½ day (Ammann, 1985). On the other hand, wallowing facilities are much wider spread even in the dry season, although permanent wallows are found especially in shaded locations where evaporation is less important (Ammann, 1985). Still, even wallows in shaded localities may also desiccate occasionally. In such cases, the rhino turns to riversides or the coastal tidal forests for wallowing (Hoogerwerf, 1970).

Salt

Herbivores are confronted with the problem of how to satisfy their mineral requirements, especially their need for sodium, a rare element in most plants (Ammann, 1985). All other rhino species solve this problem by visiting salt licks, but no licks have been found in Ujung Kulon. It is assumed that the Javan rhino there satisfies its need for salt when visiting the shore and brackish rivers (Schenkel and Schenkel-Hulliger, 1969).

In addition, Ammann (1985) points to the fact that food plants growing in coastal regions may also provide an important source of salt. Leaves of coastal specimens of the very important food plant *Spondias pinnata* for instance, proved to contain 6 to 7 times as much sodium as leaves of *Spondias* specimens growing in the interior. Moreover, the crystalline salt covering the leaves of food plants growing in the direct vicinity of the coastline (e.g. *Pandanus tectorius*) may also be of importance.

Cover

The significance of cover for the rhinos may be twofold. It may protect the animals against adverse climatic conditions and may help them in finding a hiding place. Both functions are closely related with vegetation structure, though not in an identical way.

In Ujung Kulon, relatively small differences in altitude are assumed to cause considerable differences in climate. Moreover, differences between open and closed canopies cause significant variations in the microclimate of the forest floor (see also chapter 5). However, we may assume that Ujung Kulon as a whole has a far from extreme climate in comparison to the variety of climatic conditions within the former distribution area of the species (as described by Hoogerwerf, 1970). Therefore, we may also assume that differences in protection against adverse climatic conditions, as provided by the various vegetation types and climatic zones, are, within Ujung Kulon, of very little importance for the rhinos. In this respect, it is interesting to note that Ammann (1985) found no proof that the animals prefer shaded (thus cooler) locations for wallowing, while wallowing (like bathing) is assumed to have a function in regulating the animals' body temperature. Thus, this function if existing at all, is not very important. On the other hand, most authors stress the shy character of the animal and its intolerance to man. Hoogerwerf (1970) states that the rhinos generally retire to the most dense and inaccessible parts during daytime. The same author also remarks that wallowing normally takes place in well-hidden, concealed locations. The latter

statement is contradicted by the results of Ammann's study (1985), who could not prove any preference for concealed wallowing sites. Also, Hoogerwerf's first statement cannot be true for all parts of Ujung Kulon, since in some areas rhinos are present, but inaccessible vegetations not (e.g. the western hills). Thus, we can conclude that the rhinos may show a tendency to hide in dense vegetation, but the presence of such vegetations is by no means essential for their occurrence.

Absence of pathogenic germs

The importance of this factor was dramatically shown by the sudden death of at least five rhinos during the rainy season of 1981 to 1982 (PPA, 1982). Although it was suspected that the cause of death was anthrax, this could not be proved. Moreover, there is also strong evidence against anthrax being the cause of death, viz. the apparent species-specific character of the disease.

Schenkel and Schenkel-Hulliger (1982) indicated that pathogenic germs (e.g. of anthrax) may be present, hidden below the soil surface and survive there for decades. However, heavy rains can stir up muddy soil and permit the germs to reach the water surface.

This would imply that areas which tend to become muddy during the wet season, i.e. large parts of the fluvio-alluvial and coastal plains and to a lesser degree also the uplands, are areas with a relatively high risk of becoming the source of diseases.

This is a very disquieting thought, since large parts of these areas can be considered as very important rhino habitats (see chapter 11). However, the risk is far from certain since (as stated above) neither the character of the rhino disease, the way it has spread throughout the area, nor the chance it will happen again, is known.

10.3 Some other important species

The major source of information on the faunistic significance of Ujung Kulon is the monumental work of Hoogerwerf (1970). It includes detailed descriptions of e.g. the ecology and conservation of all important species and checklists for several taxonomic groups. Such lists are also provided by Satmoko (1961). Moreover, several monographs on mammal species in Ujung Kulon have recently been published (see below). Unfortunately, we have little information on the exact numbers of all species other than the Javan rhino. Still, as for their relative density, the list of Sajudin et al. (1984) is of great interest. Here, only a few species belonging to three groups of mammals, viz. primates, carnivores and even-toed hoofed mammals, will be discussed. Both from a conservation point of view and as far as the impact of the fauna on the vegetation is concerned, these groups include some very important species. Moreover, the last group included all major herbivores of the area (other than the Javan rhino) and thus the most important potential food competitors of the badak.

Primates

In Ujung Kulon one may find, in addition to some *Homo sapiens*, four species of primates, including three species of monkey and one ape. Most common are

two monkey species: the Javan or long-tailed macaque (*Macaca mulatta fascicularis* (Raffles); monyet or kra) and the black langoor (*Trachypithecus cristatus sondaicus* (Robinson & Kloss); lutong). The first species can be found throughout the area, both in the canopy and on the ground. However, it seems to prefer open country, especially coastal regions and riversides (Hoogerwerf, 1970). On Peucang Island, the monyet is extremely common and may occasionally terrorize the camp with guardpost and tourist facilities. But, the lutong is absent on Peucang Island. According to Hoogerwerf (1970), the species also prefers coastal regions and riversides, but this is not in agreement with our experience. We observed lutong most frequently in the *Arenga obtusifolia*-dominated forests of the interior and especially at the beginning of the wet season in the freshly sprouting *Bambusa* forests. The lutong monkeys obviously do not like very open vegetations and were never seen on the ground.

The grey langoor or silvered leaf monkey (*Presbytis angula angula* (Linnaeus); surili) is undoubtedly much rarer. This species is also absent on Peucang Island. According to Hoogerwerf (1970), the grey langoors stick to trees to an even greater extent than their black relatives do. Due to lack of data, their habitat preference in Ujung Kulon is not well understood. Hoogerwerf observed the species seven times, mainly in closed forest. Our own observations (only three) seem to indicate a preference for tall open forest, especially on the transition of closed forest towards shrub jungles.

The fourth species of primate, the grey or Javan gibbon (*Hylobates lar moloch* (Sody); wau-wau or oa) is the rarest one. In Ujung Kulon, it is confined to the most eastern parts, bordering the Mt. Honje area and a small coastal area between the mouth of the Cibandawoh river and Cape Tereleng. Ecology and behaviour of the Ujung Kulon gibbons were studied in detail by Kappeler (1981).

Within their distribution area, the gibbons are apparently bound to closed forests including both *Arenga obtusifolia*-dominated forests of the lowlands (wrongly considered as primary rain forest by Kappeler), and rain forests on higher altitudes. It is interesting to note that the area inhabited by the isolated population near Cibandawoh, corresponds with an exceptionally diverse and well-developed patch of forest (see chapter 9).

The gibbons avoid the ground and even its proximity; thus discontinuities in the forest cover may provide an impregnable obstacle. This explains why the gibbons do not extend their distribution area towards the western part of Ujung Kulon, where excellent gibbon habitat is available, e.g. on the limestone plateaus, but especially on the rain forest covered slopes of Mt. Payung (Kappeler, pers.comm.). Even so, it does not explain why the gibbons are absent in those parts at present. If Kappeler is right in considering the Cibandawoh population as an isolated one, this proves that a gibbon population can survive, at least for some decades, in a very small area. Hoogerwerf (1970) observed gibbons on exactly the same location in 1943, in 1952 and again in 1956. However, the gibbon-area near Cibandawoh, as indicated by Kappeler, measures only some 150 to 200 ha, while in the Payung area over 5,000 ha uninterrupted, potential gibbon habitat is present. Possibly, the gibbon population in the western part of Ujung Kulon did not survive the complete defoliation of the forest following the 1883 ash-rains and

the area was never re-occupied for reasons explained above. We tend to believe that the Cibandawoh population is not entirely isolated, but is the farthest point in westward direction which gibbons from the Honje area can reach without having to leave the forest canopy.

Carnivores

In Ujung Kulon a wide variety of carnivores can be found (Hoogerwerf, 1970). Here we will discuss only three of the larger species, viz. the wild dog, the Javan tiger and the panther.

The wild dog (*Cuon alpinus javanicus* (Desmarest); ajag) is one of Java's most ferocious predators. In spite of its relatively small size (the animal more or less resembles the European fox), it is known to be able to bring down large and strong quarry, even buffaloes and tigers. The wild dog's success as a hunter is due to the close cooperation within the groups which hunt down their prey with great persistence and cunning. Wild dogs were once very common in Java. On the south coast of Banten, near the eastern boundary of Ujung Kulon, Junghuhn (1854, 1867) found the beach covered with carcasses of the green turtle (*Chelonia mydas* Linnaeus) slaughtered by wild dogs, and at night watched a group of at least thirty of these predators attack other turtles (coming ashore to lay their eggs). At present, the wild dogs, according to the local people (Sarpan, pers.comm.), have become rare and large groups have not been seen for many years. This corresponds with our experience and that of other investigators (e.g. Schenkel and Schenkel-Hulliger, 1969). Hoogerwerf stated in 1970 (on a basis of former experiences) that the species was not endangered, but had to admit in 1972 after visiting the area again that he had not been able to find one single track of wild dogs.

The same holds for the Javan tiger (*Panthera tigris sondaica* (Temminck); harimau or macan loreng). The last probable record of a tiger print in Ujung Kulon dates from 1969 or 1970 (Hoogerwerf, 1972), the last reliable sighting was even longer ago. In spite of Hoogerwerf's scepticism (1970), one now can hardly deny Schenkel and Schenkel-Hulliger (1969) rightly omitted the Javan tiger from their list of larger mammals in Ujung Kulon. From the data provided by Hoogerwerf (1970) himself, one may even conclude that resident tigers were never very common in Ujung Kulon, since tigers are known to be capable of and need to roam far and quickly. Possibly, the migrating tendency of the Ujung Kulon tigers was further stimulated by the degradation of their favourite feeding habitat, the savanna landscape of the coastal plain. Outside the boundaries of the reserve, the tigers could easily become victims of poisoning of wild boar, their favourite prey. Poisoning of wild boar is believed to be the most important cause of the general decline of the species throughout Java during the first half of this century (Hoogerwerf, 1970). Since also no recent records are available of the Javan tiger in their last refugium on the island (Meru Betiri, East Java), one must fear that this sub-species of *Panthera tigris* is now completely extinct (McKinnon, pers.comm.).

As for the third large predator, the panther (*Panthera pardus melas* (Cuvier); macan tutul), the situation is far less tragic. It is beyond any doubt that the number of this species, in spite of a general decline on the mainland of Java, had only increased on the Ujung Kulon peninsula during

the last decades. It is significant that Hoogerwerf (1970) during his many visits to Ujung Kulon between 1932 and 1957 never once saw a panther, while most of the more recent authors dealing with Ujung Kulon consider the species to be not uncommon (e.g. Schenkel and Schenkel-Hulliger, 1969; Sajudin, 1984). During our survey we actually saw a panther five times (including a dead specimen on the Cikuya grazing ground). All these five observations concerned spotted (thus not melanistic) specimens and were made in coastal regions. Moreover, tracks of panther were encountered quite frequently, mainly on the beach. Since such observations correspond well with the experience of both the park staff and other investigators (see above), we consider Hoogerwerf's scepticism about the increase in the number of panthers in Ujung Kulon to be completely unjustified.

The increase in the panther population is probably correlated with the decrease in the number of tigers. Apparently, the two species do not go together very well and Hoogerwerf (1970) quotes Prater (1965) stating that the panther's chief enemy is the tiger.

The principal prey of the panther consists of monkeys, deer and smaller animals (Hoogerwerf, 1970). Wild boar is not of great importance as a prey, which is one of the reasons why the panther is not heading towards extinction on Java as quickly as the tiger did. Still, in Ujung Kulon wild boar is at least occasionally eaten by panthers. We once found a wild boar which had obviously been attacked and almost killed by a panther only a few minutes previously. Probably, banteng calves are sometimes killed and eaten as well. We once observed a panther stalking a small group of banteng with some calves. However, the panther was distracted by the human scent and no attack followed. As for rhino calves, the panther is not considered as a danger by Hoogerwerf (1970). Since the tiger became extinct, there remains apart from micro-organisms, only one enemy for the Javan rhinoceros: man.

Even-toed hoofed mammals

This group includes all species of large herbivores of the area, apart from the Javan rhinoceros. They are therefore of special importance as potential food competitors of the rhino. The group is represented in Ujung Kulon by wild boar and some ruminants viz. three species of deer and one wild ox, the banteng.

The wild boar (*Sus scrofa milleri* Jentink; babi hutan) is considered by Schenkel and Schenkel-Hulliger (1969) as the most successful large animal of Ujung Kulon. It is very common throughout the area, but probably most numerous in coastal regions. On Peucang Island, large numbers of wild pigs are also present. The diet of this animal consists mainly of fruits, but also of small animals and carrion (Pauwels in prep.; cited from Ammann, 1985). Ammann, however, points out that wild boar may compete with the rhinos for the same plants, since female pigs construct large nests of plant material in which to have their young. For the construction of these nests, they preferably use small saplings. Ammann (1985) considers the impact of such activities as insignificant as far as the food availability of the Javan rhino is concerned. However, it may be of significance for the regeneration of the forest in an area like Peucang Island, where both wild boar and occur in very high densities.

The largest deer species of Ujung Kulon is the Javan deer (*Rusa timorensis rusa* (Müller & Schlegel); rusa). According to Hoogerwerf (1970), the Javan deer prefers open country with grasses and sedges, but may feed on the leaves of trees and shrubs as well. The same author considers the Javan deer as less strictly bound to pastures than the banteng, but (as will be discussed below) he vastly overestimated the banteng's dependence on such areas. It is not improbable that the reverse is true, Javan deer being most dependent on the availability of pastures. As Hoogerwerf (1970) points out, the Javan deer population has fluctuated rather strongly during the last half century. There was an increase during the post-war years, followed by an obvious decrease, that could not be fully explained. At present, the species can undoubtedly be considered as rare on the mainland. Probably, it is restricted to the coastal plain of the northern and eastern parts (Ammann, 1985). According to Hoogerwerf (1970), feeding of rusa and banteng together was quite common, but this does not correspond well with our experience. At present, in the area where both species occur together, the banteng seem to prefer the dry, *Chrysopogon*-dominated grazing ground of Cigenter, while Javan deer were more often observed on the various seasonally desiccating bottomlands with *Phyla* vegetation.

On both Peucang Island and Handeuleum Island, one finds an entirely different situation. There, Javan deer occur in very high densities. On Peucang Island their number was estimated at 30 to 50 during the twenties of this century (Pieters, 1954; cited from Hoogerwerf, 1970). More recently, higher estimates have been published, viz. 50 to 60 by Satmoko (1961) and even 125 by Verschuren (1967). On Handeuleum Island, the species has arrived only recently (by swimming); estimated numbers are not known.

The success of the Javan deer on the islands is striking, especially since the species has to compete with wild boar, barking deer and (at least formerly) mouse deer. All these species profit from the current absence of predators and poachers. As mentioned above, the Javan tiger, in fact the only good swimmer of the area's larger carnivores, has been extinct in Ujung Kulon for some fifteen years. The occurrence of tigers on Peucang Island in bygone times is mentioned by Kal (1910, cited from Hoogerwerf, 1970).

Among its competitors, the Javan deer may be at an advantage because of its extreme ability to withstand drought and its more or less flexible feeding behaviour. Next to feeding on the islands' grazing grounds and in the forest of the interior, the animals can frequently be observed browsing on beach vegetation. They seem to have a special liking for the leaves of the *Scaevola taccada* shrubs and fallen leaves of the deciduous tree, *Terminalia catappa* (pers. obs.). As already mentioned, the impact of the high densities of browsers (and wild pigs) on the regeneration of the Peucang forests is probably very considerable. We shall return to this subject in chapter 12.

As for a possible competition for food with the rhinoceros population of the mainland of Ujung Kulon, Ammann (1985) considers the impact of the Javan deer on the availability of rhino food plants negligible. In most parts of the rhino's distribution area, the Javan deer is absent and where the two species occur together the deer population is still rather insignificant. Moreover, the two species have a very different food and habitat preference.

The second deer species of Ujung Kulon is the barking deer (*Muntiacus*

muntjak muntjak (Zimmermann); kijang, muncak). Unlike the Javan deer, it is not attracted by extensive open plains; neither does it feed on grasses or grasslike plants very often (Hoogerwerf, 1970). Barking deer generally prefer secondary forests and shrub jungles, but there is some disagreement in the literature in relation to its habitat preference in Ujung Kulon. According to our experience, Schenkel and Schenkel-Hulliger (1969) rightly consider the tall forests of the interior as the animals' chief habitat. Barking deer is a browser, feeding mainly on tree foliage. In addition, they are known to be fond of jungle fruits. The species is quite common, both on the mainland of Ujung Kulon and on Peucang Island. There are no indications of any increase or decline in the population size over the last decades (Hoogerwerf, 1970).

From the information presented above, one might assume that the barking deer is a serious food competitor for the Javan rhino. However, according to Ammann (1985), this is not the case, mainly because of the low population density of this widely distributed, but solitarily living species and because of its relatively small biomass. On the other hand, the barking deer are even known to have some profit from the rhino's feeding behaviour. Because rhinos often bring down shrubs and saplings while feeding, barking deer may often be found in their tracks (Hoogerwerf, 1970).

The third and smallest species of deer is the mouse deer (*Tragulus javanicus* (Osbeck); kancil). In fact, this is not a real deer species. Mouse deer belong to the small group of *Tragulina* which are more or less an intermediate between pigs, camels and deer (Storer and Usinger, 1965). Just like barking deer, mouse deer generally prefer forests and shrublands above open grasslands. According to our experience, the animal seems to be most common in areas with a dense undergrowth and more specifically in *Salacca*-dominated vegetations and along the inner margin of the mangroves. In spite of Hoogerwerf's (1970) scepticism on this point, this again corresponds well with the data provided by Schenkel and Schenkel-Hulliger (1969).

There are no indications of a recent increase or decline in the mouse deer population on the mainland. On the other hand, it is doubtful whether the species is still present on Peucang Island, where it was probably once quite common (Hoogerwerf, 1972). In fact, Peucang is a local word for mouse deer. Possibly the decline of the mouse deer population on this island reflects the growing scarcity of undergrowth, i.e. tree seedlings, there.

As a possible food competitor for the Javan rhino, the mouse deer is probably of even less significance than the barking deer, because of its far lower biomass and comparably low population density. Moreover, mouse deer eat, proportionally, even more fruit (Hoogerwerf, 1970; Ammann, 1985).

The last ruminant species to be discussed is the wild ox or banteng (*Bos javanicus javanicus* (d'Alton)), next to the Javan rhino the largest herbivore of Ujung Kulon. Ecology and behaviour of this species have been studied in detail recently by Halder (1975). Moreover, much information is provided by Hoogerwerf (1970 and many earlier reports).

The species is missing on Peucang Island but very common on the mainland of Ujung Kulon. The population size was estimated at some 200 individuals in 1971, but there are indications that their number has strongly increased ever since (Ammann, 1985). This phenomenon might be explained by the extinction of the Javan tiger (see above), but this is far from certain.

One of the most important results of the study done by Halder (1975) is the conclusion that the banteng is far less dependent on grasslands than presumed by Hoogerwerf. In fact, many bantengs probably never set foot on one of the grazing grounds at all (Halder, 1975). The recent increase in the population is further proof of this independence of grazing areas. It is in great contrast with Hoogerwerf's pessimistic view that neglect of the extensive grazing areas in the northern and eastern coastal plain formed a serious threat to the viability of the entire population.

Even so, there is much left to be studied as far as the distribution and habitat requirements of the Ujung Kulon bantengs are concerned, since Halder focussed strongly on the few remaining coastal grazing grounds. As for the 'forest-bantengs' it is generally assumed that dense shrub jungles are important feeding areas, but that the animal is attracted to other vegetations as well. In fact, one may come across banteng tracks in any part of the mainland of Ujung Kulon, only the mangrove areas and very steep mountain slopes excluded (Halder, 1979). Although some individuals prove very loyal to the grazing grounds as a feeding area even in unfavourable (i.e. very dry) periods, migration patterns of bantengs due to seasonal changes of the habitat are also not uncommon (Halder, 1975). In our experience, there is a strongly increased activity of bantengs observable in the freshly sprouting *Bambusa* vegetations of the uplands at the beginning of the rainy season. This corresponds well with the findings of Halder, who reported that many bantengs tend to leave the swampy parts of the coastal plains during the same period. In addition, diurnal migration patterns are also very interesting. Halder describes such patterns on and around the grazing grounds in detail. In the interior, we observed several times that small groups of banteng retreated at evening twilight from the shrub jungles to the adjacent Arenga forests. This phenomenon may be explained by the fact that bantengs tend to reserve this part of the day for social activities and thus need some room to move (Halder, 1975).

As for its feeding behaviour, the banteng may be considered to be an 'intermediate feeder'; i.e. it can behave like a grazer (bulk feeder) or a browser (concentrate selector) depending on season and local conditions (see: van Gils et al., 1982). Lists of food plants of the banteng are given by various authors e.g. Hoogerwerf (1970), Halder (1975) and Djaja et al. (1982). Ammann (1985) points out that, in contrast to the diet of the Javan rhino, monocotyledonous plants such as grasses, palms and bamboos are of great importance as banteng food plants. The same author remarks that there is still insufficient knowledge about the feeding ecology of the banteng. Data on food preference, or quantities eaten of the various food species (as collected by Ammann for the rhino), are not available. However, on a basis of all available data, Ammann concludes that there is at present little competition for food between banteng and rhino, in spite of a general tendency in literature to consider banteng and rhino as food competitors. The overlap in diet is small, while of the species eaten by both animals there are only a few in short supply. Moreover, bantengs tend to eat younger treelets than rhinos do and may, by their feeding activities, retard the growth of the food plants (just like rhinos do), which is advantageous for both species. In addition, one may point to the distribution of the seedlings of food plants

such as *Spondias*, which is stimulated by the liking of the bantengs for the fruits of such species (see 10.2.3). Even so, further increase in the banteng population may enhance the intraspecific food competition and thus a change in diet, as Ammann points out. This may eventually have serious consequences for the interspecific food competition between rhino and banteng. Obviously, there is much left to be studied on this point and (as Ammann's study proves) merely focussing on a further extension of the list of communal food plants is not the most fruitful direction for further research.

CHAPTER 11: LANDSCAPE UNITS

11.1 Introduction

This chapter gives a further integration of the various aspects of the landscape which were discussed in the preceding chapters. This integration is presented in the form of a legend to the landscape ecological map, added to this report as an appendix (see: section 11.2).

Furthermore, a broad interpretation of the various landscape units in terms of suitability as a habitat for the Javan rhinoceros is given in section 11.3.

Finally, a last section (11.4) will touch upon the subject of the major recent and present changes in the vegetation cover of the landscape units. In addition, some attention will be paid to the impact of these changes on the food availability of the Javan rhino.

11.2 Legend of the landscape ecological map

The Roman figures, capitals and again Roman figures in brackets refer to the classification of land forms, soils and plant communities respectively, i.e. to sections 6.3, 7.3 and 9.3.

The estimated share of the various vegetation and soil types within the landscape units is given in Table 11a and 11c respectively. An outline of the relations between soil and vegetation is given in Table 11b. In order to avoid unnecessary duplications, the legend given below (in general) enumerates only the most important types. The types of minor importance (for instance some types of beach vegetation and most types of coastal soils) can be traced by means of Tables 11a and 11c; their distribution is described in sections 7.3 and 9.3.

The names of the landscape units are derived from the land form at issue and one of the most characteristic plant species. This does not necessarily have to be a dominant species or the main species of a sociological group.

Basic units (no. 1 to 26):

1. Flacourtia crest

Landform: mountains (1a); altitude more than 450 m.

Soils: dystric nitosols (j) and dystric cambisols (h), both developed on sedimentary rock (including tuff).

Vegetation: Kibara-Flacourtia forest (I), towards the boundaries of the landscape unit gradually merging into the *Garcinia-Neesia* forest (II).

2. Neesia mountains

Land form: mountains (1a; altitudes between 150 and 450 m).

Soils: dystric nitosols (j) and dystric cambisols (h), both developed on sedimentary rock (including tuff).

Vegetation: *Garcinia-Neesia* forest (II), towards the lower boundaries of the landscape unit gradually merging into the Pentace-Arenga forest.

3. Arenga mountains

Land form: mountains (1a; altitudes below 150 m).

Soils: dystric cambisols (h) and dystric nitosols (j), both developed on

9. Rinorea crest

Land form: structural plateau, strongly dissected upper level (IIa, Peucang Island).

Soil: eutric cambisols (l) and lithosols (a), both developed on limestone.

Vegetation: Parinari-Gnetum forest (VIII).

10. Arenga plateau

Land form: structural plateau, undissected middle level (IIb).

Soils: mainly dystric cambisols (k) developed in limestone.

Vegetation: Pterospermum-Arenga forest (VIIc: sub-type with Bischofia); small patches of Hyptis-Daemonorops shrubland (XV) occur only very locally along the margins of the plateaux and are (as far as is known) bound to poorly developed gleyic luvisols (n).

11. Rinorea plateau

Land form: structural plateau, undissected middle level (IIb) of Peucang Island.

Soils: dystric (k) and eutric (l and m) cambisols, all developed on limestone.

Vegetation: Parinari-Gnetum forest (VIII).

12. Arenga slopes and dissected plateau

Land form: structural plateau, dissected lower level (IIc).

Soils: gleyic luvisols, developed on limestone or in clayey material of unknown origin (n) and dystric cambisols, developed on limestone (k).

Vegetation: A mosaic of Pterospermum-Arenga forest (VIIc: sub-type with Bischofia; the dominant type) and Hyptis-Daemonorops shrubland; the former on both luvisols and cambisols, the latter only on luvisols.

Note: The map unit between the isthmus and the Mt. Honje massif which is classified as landscape unit 12 was insufficiently explored. Along its southern edge, stands of the Pterospermum-Arenga forest are present belonging to the sub-type with Stenochlaena palustris (VIIa) are present, growing on the gleyic cambisols developed on parent material of unknown material (p). This does not fit into the general picture of the dissected plateaux of Ujung Kulon. The extent of this and possible other deviations is not known.

13. Daemonorops slopes and dissected plateau

Land form: structural plateau, dissected lower level (IIc).

Soils: gleyic luvisols, developed on limestone or in clayey material of unknown origin (n) and dystric cambisols, developed on limestone (k).

Vegetation: A mosaic of Hyptis-Daemonorops shrubland (XV; the dominant type) and Pterospermum-Arenga forest (VIIc: sub-type with Bischofia); the first only on luvisols, the second both on luvisols and cambisols; locally also Schizostachyum forest (XVII), either replacing the Hyptis-Daemonorops vegetations, or along rivulets, e.g. Cikarang (on gleyic cambisols, r).

14. Bambusa-Daemonorops upland

Land form: uplands (III); mainly hilly parts.

Soils: gleyic luvisols, developed in clayey material of unknown origin (t and n, the latter only in the area west of Jamang, mentioned below).

Vegetation: Bambusa-Drypetes forest (XII).

Generally with many patches of Hyptis-Daemonorops shrubland (XV). Only towards the western edge of the main map unit belonging to this landscape

(i.e. upstream Citadahan) does the shrubland tend to dominate the Bambusa stands.

Note: The classification of the elevated area west of Jamang as Bambusa-Daemonorops uplands is rather dubious as far as geomorphology and soils are concerned. However, the pattern of vegetation types corresponds well with the general picture of this landscape unit.

15. Bambusa-Schizostachyum upland

Land form: uplands (III), mainly rolling parts.

Soils: gleyic luvisols, developed in clayey material of unknown origin (t) and gleyic cambisols, developed in alluvial loam or clay (r); the latter only along the major rivulets.

Vegetation: mainly Bambusa-Drypetes forest (XII); Schizostachyum vegetation: (XVII) only on the gleyic cambisols (r).

16. Dendrocnide beach ridge

Land form: beach ridge (IV), partly a truncated platform, partly sand dunes.

Soils: dystric cambisols, developed on calcareous sandstone (f).

Vegetation: Dendrocnide-Syzygium vegetation, (XIX), in structure ranging from closed forest to shrubland; along the coast with a narrow strip of Mikania-Pandanus scrub (XXXI), along the lee side with a narrow strip of Dendrocnide-Arenga forest (XX); in the western part, locally with small patches of Dactyloctenium-Digitaria grassland (XXV) directly behind the Pandanus belt.

17. Arenga plains

Land form: fluvio-alluvial plain (VI) in sub unit 17a and erosional plain (V) in sub unit 17b.

Soils: gleyic cambisols, developed in alluvial loam or clay (r) in sub unit 17a; eutric cambisols, developed on limestone (l) and dystric gleysols, developed in alluvial clay (u) or silty clay (s) in sub unit 17b; in the part of sub unit 17b along the SW coast: dystric cambisols developed in alluvial sand (g).

Vegetation: the main vegetation type is the Areca-Arenga forest (XIII). It is dominant only in sub unit 17a. In sub unit 17b, various other types of Arenga forest are also of importance, depending on the parent material of the soil profiles; more locally also patches of Hyptis-Daemonorops shrubland (XV) and Nauclea-Syzygium forest (XXI), the latter on the dystric gleysols (s); the main type of beach vegetation (17b) is the Sophora-Barringtonia forest.

18. Salacca plain

Land form: fluvio-alluvial plain (VI).

Soils: gleyic cambisols, developed in alluvial loam or clay (r).

Vegetation: mainly Oncosperma-Salacca forest and shrubland (XIV); locally stands of Areca-Arenga forest (XIII) and Hyptis Daemonorops shrubland (XV).

19. Daemonorops plains

Land form: fluvio-alluvial plain (VI) in sub unit 19a and Erosional plain (V) in sub unit 19b.

Soils: gleyic cambisols, developed in alluvial loam or clay (r), dystric gleysols developed in alluvial clay (u) (both in sub unit 19a) and gleyic luvisols developed in clayey material of unknown origin (t) (in sub unit 19b).

Vegetation: Hyptis Daemonorops shrubland (XV) predominates; in sub unit 19a also some stands of Pterospermum-Arenga forest (VIIC; sub type with Bischofia) and Oncosperma-Salacca vegetation (XIV); in sub unit 19b probably with some stands of the Bambusa-Drypetes forest (XII; not seen).

20. Syzygium plain

Land form: coastal plain of the mainland (VIIa), as described for landscape unit 21, but in many places without an uplifted pseudo barrier reef.

Soils: mainly dystric gleysols, developed in alluvial silty clay (s), but many other soil types are also present.

Vegetation: Nauclea-Syzygium forest (XXI); along the inner margin of the coastal plain generally with a strip of Hyptis Daemonorops shrubland (XV) along the outer margin and along creeks various forms of the Pandanus-Scirpodendron community (XXXVI); where bordering upon the sea, the beach forest is not well developed.

21. Ficus plain

Land form: coastal plain (VIIB) of Peucang Island, an uplifted and weathered coral flat; along the western edge of the central plateau of Peucang Island, the broad coastal plain merges into a narrow erosional plain.

Soils: mainly calcaric regosols developed in coral sand (e); locally in depressions: calcaric fluvisols developed in alluvial sand (V); on the erosional plain: eutric cambisols developed on limestone (mainly type m).

Vegetation: mainly Bischofia-Ficus forest (X) towards the coast merging into the Cerbera-Buchanania forest (XI; both on the regosols); in the depressions: either a form of the Derris-Sonneratia forest (XXXVIII), which is strongly dominated by Ficus microcarpa, or (in more coastal locations) Pemphis-Lumnitzera forest (XXX); on the cambisols: Pterygota-Rinorea forest (IX); the most common type of beach forest is the Sophora-Calophyllum community (XXXIX).

22. Ardisia plain

Land form: coastal plain of mainland (and the Handeuleum archipelago), an uplifted 'pseudo-barrier reef' with its lagoon filled up with various marine sediments (VIIa); locally there are small depressions ('bottomlands'; see unit 24) situated directly behind the barrier reef.

Soils: mainly calcaric regosols developed on coral (d) on the barrier reef and dystric gleysols developed in alluvial silty clay (u) in the former lagoon.

Vegetation: from the interior towards the coast there is a clear zonation: Nauclea-Syzygium forest (XXI) and Corypha-Ardisia forest (XXII) on the gleysols, Ximenia-Ardisia forest on the regosols. The most common type of beach forest is the Sophora-Calophyllum community (XXXIX), which on very exposed and rocky places is strikingly dominated by Pemphis acidula. Directly behind the beach forest, small patches of Calotropis-Dodonaea savanna (XXIV) are present, especially near Cape Alang-Alang. On the boundary with the more elevated parts in the interior, there is a narrow strip of Hyptis-Daemonorops shrubland (XV).

Notes: This landscape unit represents the parts of the coastal plain of the mainland where the pattern of vegetation types is strongly influenced by former vegetation management in the coastal zone (i.e. in the parts now covered by Ardisia forest).

Also included are some smaller map units (capes and small islands) in which only the Ximenia-Ardisia forest (generally in an aberrant form) is dominantly present, although former vegetation management is considered to be of little or no significance.

23. Chrysopogon grazing grounds

Land form: coastal plain of the mainland (VIIa), only some regions of moderate size near the mouth of some of the major rivulets.

Soils: only eutric regosols developed in alluvial sand or loam (q).

Vegetation: mainly Fimbristylis-Chrysopogon grasslands (XXVI); in small depressions low herbaceous vegetations of the Fimbristylis-Oplismenus community (XXXVII); these grasslands are regularly cleared of regrowth, when neglected, species of the Nauclea-Syzygium community settle.

24. Phyla swamp

Land form: 'bottomlands' (VIII).

Soils: calcaric fluvisols developed in various alluvial sediments (x).

Vegetation: herbaceous vegetation of the community of Phyla and Eleocharis (XXXV); when inundated during the rainy season temporarily dominated by the hydrophytic community of Nymphaea and Najas (XXXIV); coral boulders are locally present forming tiny islets covered with a form of Lumnitzera-Ardisia forest (XXXVII), strikingly rich in epiphytes.

25. Casuarina Lumnitzera swamp

Land form: coastal plain of the mainland (VIIa); very low area in the lagoon, but not as low as the bottomlands (VIII).

Soils: calcaric fluvisols developed in various alluvial sediments (x).

Vegetation: Lumnitzera-Ardisia forest (XXXVII), partly in a form which is dominated by Casuarina equisetifolia.

26. Rhizophora mangrove

Land form: tidal swamps (IX).

Soils: thionic fluvisols developed in various alluvial sediments (y) in the outer mangrove and dystric fluvisols developed in alluvial sand or (clay)loam in the inner mangrove (w).

Vegetation: Sonneratia-Rhizophora forest (XXXIX) in the outer mangrove and open forest of the community of Derris and Sonneratia (XXXVIII) in the inner mangrove.

Complex units (nos. 27 to 30)

27. Transition of Arenga slopes and dissected plateau (12) to Syzygium plain (20).

The structural plateau (II) is lifted and tilted and tends to dip gradually into the coastal plain on the NE side. Exact boundaries are locally difficult to trace.

28. Transition of Arenga slopes and dissected plateau (12) to cultivated lands.

This unit includes relics of Arenga obtusifolia forest, young secondary vegetations and fields which are still under cultivation. Like the adjacent area of Arenga slopes and dissected plateaux east of the isthmus, this whole map, c.q. landscape unit was insufficiently explored.

The Arenga forest relics, probably belong to the community of *Pterospermum* and Arenga (sub-type with *Bischofia javanica*; VIIIc).

The young secondary vegetations closely resemble the shrublands of the *Hyptis-Daemonorops* community (sub-type with *Lantana camara*; XVb), but lack the characteristic rattan component.

29. Transition of *Daemonorops* slopes and dissected plateau (13) to *Bambusa-Daemonorops* uplands (14).

This landscape unit is very strongly dominated by *Hyptis-Daemonorops* shrubland (XV). The exact boundary between the structural plateau (II) and uplands (III) cannot be traced, neither on the aerial photographs, nor in the field.

30. Transition of *Bambusa-Schizostachyum* uplands (15) to the *Syzygium* plain (20).

The pattern of the boundaries is too intricate to be shown on our mapping scale.

11.3 Suitability as a habitat for the Javan rhinoceros

The major habitat requirements of the Javan rhinoceros were described briefly in the preceding chapter. Here we shall take stock of the extent to which the various parts (or landscape units) of Ujung Kulon respond to these requirements. An integration of the value of a given area (or landscape unit) with regard to the various requirements results in an indication of the suitability of that area as a habitat for the Javan rhinoceros.

This approach is derived from the FAO methodology for land evaluation (1976; see also Zonneveld, 1985). In the FAO terminology the Javan rhinoceros is here considered as a 'land utilization type' (LUT). The properties of the environment that determine the suitability in relation to the requirements are called 'qualities' (or also 'limitations' if they are negative). In applying the land evaluation approach on a wildlife LUT, van Wijngaarden's study (1983) on the Baoule region (Mali) was used as an example.

Due to insufficient knowledge of some of the requirements and of some of the 'qualities' of the landscape units, our manipulations must result in only a very broad indication of the suitability for the Javan rhino. Even so, it is of interest to compare the results with the existing sketch map of the distribution of the species (Schenkel & Schenkel-Hulliger, 1969).

Of the various habitat requirements described in the preceding chapter, we shall focus on accessibility, availability of drinking water and availability of forage. For some of the other requirements we do not have sufficient information to rate the various parts of Ujung Kulon at their relative value, viz. the need for cover of the rhino and the absence of pathogenic germs. For others requirements, such as the need for salt, mud-wallowing and bathing we do have more or less sufficient information. It is however, assumed that these habitat requirements do not provide problems for the rhinos living in any part of Ujung Kulon. The animals are assumed to meet their demand for salt by incidental visits to the coast. Wallowing is only impossible on sandy or very shallow soils and nowhere do these cover large coherent surfaces: wallowing-facilities are thus always easily within reach of

the rhinos from any point in the area. Bathing facilities are more scarce, especially during the dry season. However, the rhinos can go without bathing for four days (Amman, 1985; see chapter 10). We may assume that even in the dry season a rhino can come across a pool to bathe in at least once every two days in any part of Ujung Kulon.

This leaves the three requirements mentioned above (accessibility, drinking water and forage) to determine the overall suitability as a rhino habitat. The qualities or limitations in relations to these requirements were assessed for the various parts of the area. The results are presented in three sketchmaps (Fig. 11a-c), each depicting a quality (limitation).

The limitations are given for the unfavourable season in an average year. In exceptionally unfavourable years, the rhinos probably leave their home-ranges and (temporarily?) migrate to more favourable regions.

The map showing areas with difficult accessibility and areas that are (almost) inaccessible (Fig. 11a) is more or less self-explanatory. Please note that small swampy sites (e.g. in the fluvio-alluvial plain) were neglected. Moreover, the obstacles provided by very compact, thorny vegetations were also neglected. The rhinos generally make use of fixed trails through areas covered with such vegetation.

The map showing areas where the availability of fresh water is uncertain during the dry season (Fig. 11b) needs some comment. Shown are those areas assumed to be more than one kilometre away from the nearest supply of drinking water during an average dry season. Here we are facing serious uncertainties due to the lack of detailed knowledge on the availability of open water and the ability of the rhino to live temporarily on slightly brackish water.

The map showing the availability of forage (Fig. 11c) is based on the relative value of the various landscape-units as a source of forage. First, the relative value of each plant community was estimated on the basis of the abundance of important food plant species and structural characters (see Tables 11d, e and f). Next, the quality of the landscape units was estimated on the basis of the qualities of the plant-communities. In case of doubt, the complexity of the pattern of vegetations within the units was used as an additional (positive) character. The results are given in Table 11g.

Eventually, the information presented in the three sketch-maps mentioned above was combined into one final map indicating the estimated suitability as a rhino-habitat (Fig. 11d). The procedure is as follows: We start from the quality as a source of forage, indicated by means of four classes presented in Table 11g. Areas which have either difficult accessibility or which have seasonal water shortage are set back one class. Areas which provide a combination of these two limitations are set back two classes. Areas which are inaccessible are, of course, always considered to be unsuitable. The results are presented in Table 11n and Fig. 11d.

We shall now compare Fig. 11d with Schenkel's map (1969), which indicates concentrations of rhino tracks in 1967 and 1968 and may thus serve as a sort of distribution map (Fig. 11e). In many respects, the two maps correspond well. In many areas which are classified as marginally or not suitable for the Javan rhino, no concentrations of tracks were found. Examples are the mangrove areas, the northern part of the coastal plain, the upper and

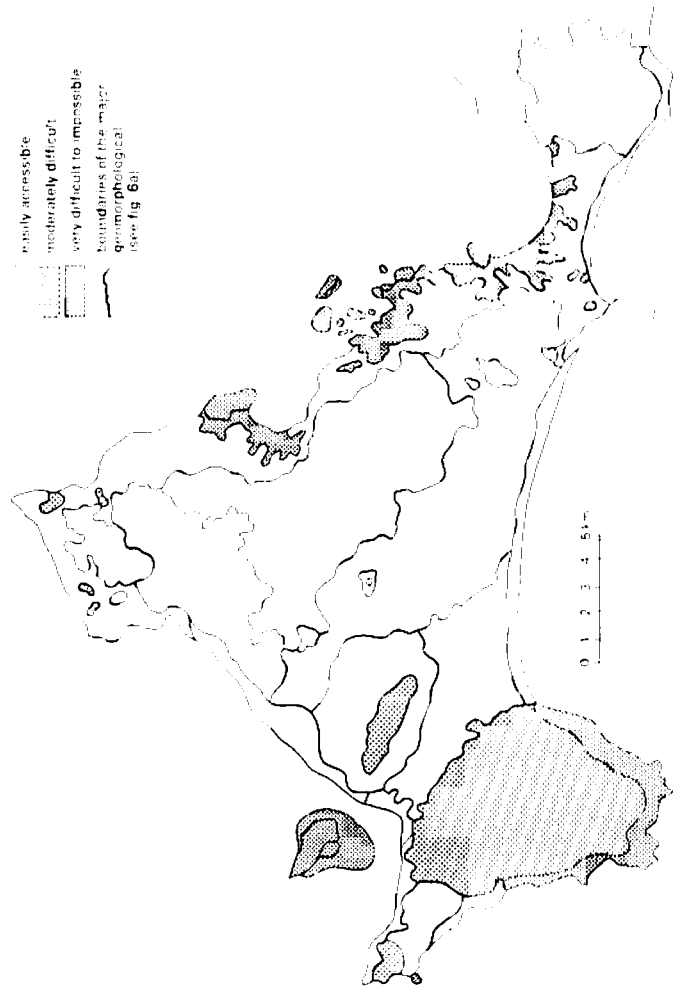


Fig. 11a Accessibility for the Javan rhinoceros

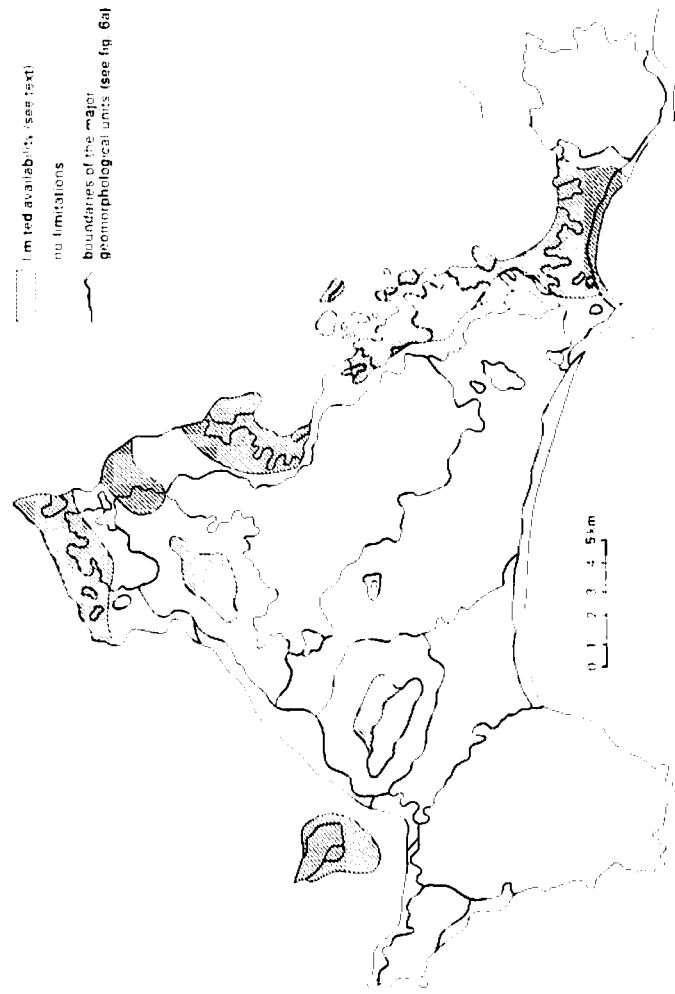


Fig. 11b Availability of drinking water for the Javan rhinoceros

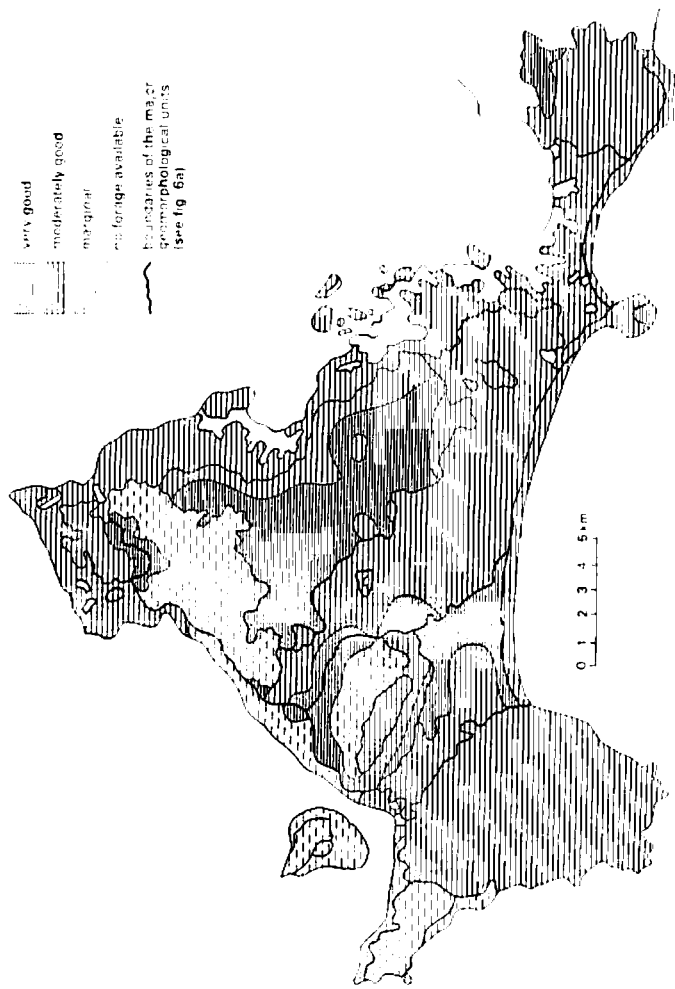


Fig. 11c Quality and quantity of forage for the Javan rhinoceros

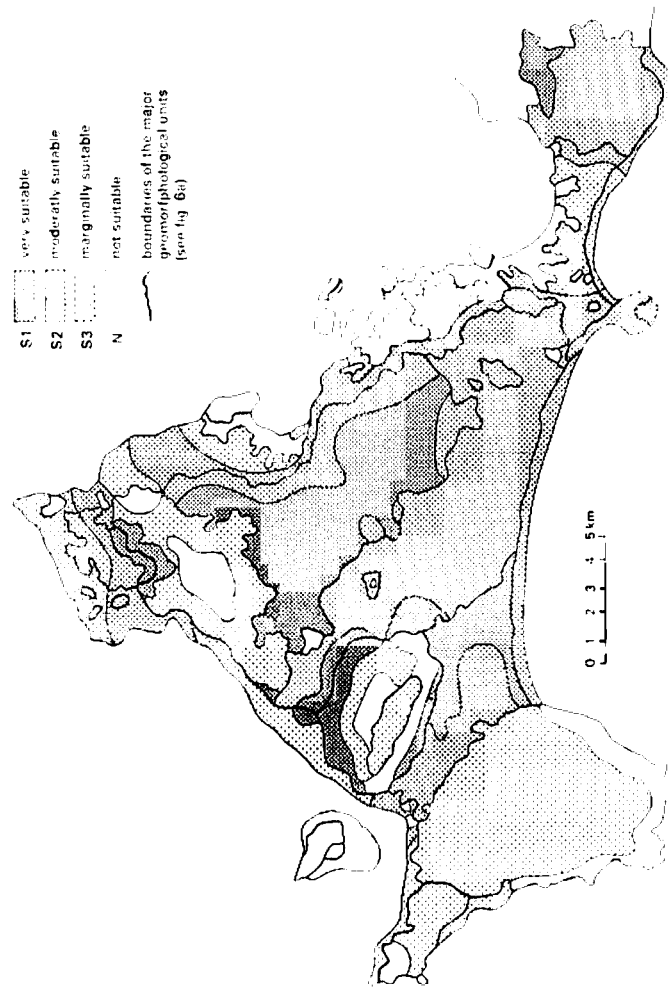


Fig. 11d Suitability map for the Javan rhinoceros

Table 11d Estimate of the quality of the plant-communities as a source of forage for the Javan rhinoceros, based on structure only

Shrublands and forests:	open		closed	
	high density of saplings	++		+
low density of saplings	+		-	
grasslands and other non-woody vegetations: -				

Legend: ++ high quality
+ mediocre quality
- low quality

Table 11e Estimate of the quality of the plant-communities as a source of forage for the Javan rhinoceros

availability of important food plants	structure*	++	+	-
		high (h)	1	1
mediocre (m)		1	2	3
low (l)		2	3	4

Legend: 1 very high quality
2 high to mediocre quality
3 low quality
4 very low quality

* see table 11d.

Table 11f List of plant-communities and their estimated quality as a source of forage for the Javan rhinoceros, based on the availability of important foodplants and structure

No.	Community	I	S	F	No.	Community	I	S	F
I	Kibara & Flacourtia	m	+	2	XIX	Dendrocnide & Syzyg.	m	+	2
II	Garcinia & Neesia	m	+	2	XX	Dendrocnide & Arenga	m	-	3
III	Pentace & Arenga	m	-	3	XXI	Nauclea & Syzygium	m	+	2
IV	Rubus & Gleichenia	m	++	1	XXII	Corypha & Ardisia	m	+	2
V	Saraca & Sumbaviopsis	m	-	3	XXIII	Ximena & Ardisia	m	+	2
VI	Uncaria & Sumbaviopsis	h	++	1	XXIV	Calotropis & Dodonaea	m	++	1
VIIa	Pterosp., Arenga & Sten.	m	-	3	XXV	Dactyloctenium & Digitaria	l	-	4
VIIb	Pterosp., Arenga & Myr.	m	-	3	XXVI	Fimbristylis & Chrysop.	l	-	4
VIIc	Pterosp., Arenga & Bis.	m	-	3	XXVII	Fimbristylis & Oplism.	l	-	4
VIII	Perinari & Cactum	m	-	3	XXVIII	Barringtonia & Syzygium	m	-	2
IX	Pterygota & Rinorea	m	+	2	XXIX	Sophora & Calophora	m	+	2
X	Uncaria & Ficus	m	-	3	XXX	Pemphis & Lumitzera	m	-	3
XI	Cerbera & Buchanania	m	+	2	XXXI	Hikania & Pandanus	m	+	2
XII	Bambusa & Drypetes	m	+	2	XXXII	Ipomea & Ischaemum	l	-	4
XIII	Areca & Arenga	m	-	3	XXXIII	Ischaemum & Scariosa	l	+	3
XIV	Oncosperma & Salacca	m	+	2	XXXIV	Nymphaea & Najas	l	-	4
XVa	Hyptis, Daemon. & Dill.	h	++	1	XXXV	Phyla & Elecharis	l	-	4
XVb	Hyptis, Daemon. & Lant.	h	++	1	XXXVI	Pandanus & Scirpod.	m	+	2
XVI	Canthium & Albizia	m	++	1	XXXVII	Lumitzera & Ardisia	m	+	2
XVII	Schizostachyum	l	-	4	XXXVIII	Derris & Sonner.	m	+	2
XVIII	Sterculia & Syzygium	m	+	2	XXXIX	Sonneratia & Rhizophora	l	-	4

Legend: I = quality, based on the availability of important foodplants. (see table 10c)
S = quality, based on structure (see table 11d)
F = quality, based on availability of important foodplants and structure (see table 11e).

Table 11g: Estimated quality of the landscape units as a source of forage for the Javan rhinoceros

1 Flacourtia crest	2	16 Dendrocnide beachridge	2
2 Neesia mountains	2	17 Arenga plains (a/b)	2
3 Arenga mountains	2	18 Salacca plain	2
4 Sterculia cliff coast	2	19 Daemonorops plains (a/b)	1
5 High Arenga hills	3	20 Syzygium plains	2
6 Low Arenga hills	3	21 Ficus plain	3
7 Sumbaviopsis crest	2	22 Ardisia plain	2
8 Arenga crest	3	23 Chrysopogon grazing grounds	4
9 Rinorea crest	3	24 Phyla swamps	4
10 Arenga plateau	3	25 Casuarina Lumitzera swamp	2
11 Rhinorea plateau	3	26 Rhizophora-Nypa mangrove	3
12 Arenga slopes and diss. plateau	2	27 Transition of 12 to 20	2
13 Daemonorops slopes and diss. plat.	1	28 Transition of 12 to cult. lands	2
14 Bambusa-Daemonorops uplands	2	29 Transition of 13 to 14	1
15 Bambusa-Schizostachyum uplands	2	30 Transition of 15 to 20	2

Legend: 1: very high quality; 2: high to mediocre quality; 3: low quality; 4: very low quality

Table 11h: Estimated suitability of the landscape units as a habitat for the Javan rhinoceros, based on accessibility, availability of drinking water and forage

1 Flacourtia crest	S3 (a,f)	16 Dendrocnide beachridge	S2 (f) or S3 (d,f)
2 Neesia mountains	S3 (a,f)	17a Arenga plain (fluv.)	S2 (f)
3 Arenga mountains	S3 (a,f)	17b Arenga plain (eros.)	S3 (f)
4 Sterculia cliff coast	N (a,f)	18 Salacca plain	S2 (f)
5 High Arenga hills	N (f,a)	19 Daemonorops plains (a/b)	S1
6 Low Arenga hills	S3 (f)	20 Syzygium plains	S2 (f) or S3 (d,f)
7 Sumbaviopsis crest	S3 (a,f)	21 Ficus plain	N (a,f,d)
8 Arenga crest	N (f,a)	22 Ardisia plain	S2 (f) or S3 (d,f) or N (a,d,f)
9 Rinorea crest	N (a,d,f)	23 Chrysopogon grazing grounds	N (f)
10 Arenga plateau	S3 (f) or N (f,d)	24 Phyla swamps	N (f,(d),a)
11 Rhinorea plateau	N (a,d,f)	25 Casuarina Lumitzera swamp	N (d,a,f)
12 Arenga slopes and dissected plateau	S2 (f)	26 Rhizophora-Nypa mangrove	N (a,d,f)
13 Daemonorops slopes and dissected	S1	27 Transition of 12 to 20	S2 (f)
14 Bambusa-Daemonorops uplands	S2 (f) or S3	28 Transition of 12 to cult. lands	S1
15 Bambusa-Schizostachyum uplands	S2 (f) or S3 (d,f)	29 Transition of 13 to 14	S1
		30 Transition of 15 to 20	S2 (f)

Legend: S1: very suitable; S2: moderately suitable; S3: marginally suitable; N: not suitable
Limitations with respect to: accessibility (a), availability of drinking water (d) or forage (f) are given in brackets in order of significance.

undissected parts of the limestone plateaux and the upper parts of the Payung massif. On the other hand, most of the suitable areas correspond with areas showing concentrations of tracks; especially the southern half of Ujung Kulon's triangular central part (including the fluvio-alluvial plain, most of the uplands and the calcareous beach ridge and the dissected plateau in the Cigenter region). The high density of tracks in the coastal area near Citerjun is explained by the availability of many hectares of very suitable terrain in the hinterland.

Even so, there are also some striking differences. The isthmus area, for instance, was classified as marginally suitable, but did show concentrations of tracks. This may be due to seasonal differences in rhino distribution. Our map gives an indication of the average suitability throughout the year, thus including the situation during a period of drought. Schenkel's map is at least