3800

AREA MANAGEMENT FOR THE JAVAN RHINOCEROS [*Rhinoceros sondaicus Desm.*] A PILOT STUDY

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ABSTRACT:- The last small population of the Javan rhino *(Rh. sondaicus)* lives in Ujung Kulon Nature Reserve, in the most western tip of Java. Relentless persecution by man had almost led to the species' extinction. Javan rhinos have survived in Ujung Kulon due to its remoteness. However, even here the animals were under heavy pressure by poachers. In the last ten years, thanks to the establishment of efficient protection, the population has increased. The reserve with its many local types of forest-like vegetation does not in all its parts provide optimal food supply for the species.

Javan rhinos almost exclusively feed on a large number of tree species, i.e. on the lower branches of trees at the edge of the forest and on tree saplings in the interior of the peninsula. In large areas of Ujung Kulon, however, forest regeneration is very scarce due to a dense lower canopy of palms. Since the reserve had defined limits, it has to be envisaged that food supply can finally — in concurrence with other factors such as intraspecies intolerance — present a limiting factor for the rhino population.

Pilot experiments with the aim to enhance the growth of rhino food plants were therefore performed. Selective cutting of the palm component in specially chosen experimental plots resulted in a drastic increase of light on the forest floor and thereby of growth of tree saplings. These plots were surveyed for up to seven years. Already two years after the cutting of palms, rhino visits to the plots and feeding on saplings were observed.

It is concluded from the study that the selective cutting of the palms in certain plant communities of the forest of Ujung Kulon would be a suitable method to increase the food supply for the rhinos at a time when rhinos would show signs of population pressure and tend to leave the reserve. The method should, however, be applied with caution only, in order not to jeopardise preservation of the whole spectrum of the fauna and flora of the reserve as a whole.

INTRODUCTION

Ujung Kulon nature reserve is the most western tip of Java. With its area of about 360 km^2 it is the last refuge of the Javan rhinoceros *(Rhinoceros sondaicus)*. For scientists the identity of this species became evident in the beginning of the 19th century, yet still later it was frequently confused with the Great Indian rhino *(Rhinoceros unicornis)* with which it was sympatric in Assam and Bengal, and with the Sumatran rhino *(Didermoceros sumatrensis)* together with which it occurred in Sumatra, Malaysia, Burma, Thailand and Vietnam. In the beginning of the 20th century, the populations of all three species, were destroyed in most parts of their former distribution range. It therefore appears impossible by now to accurately define where each species had occurred, and accordingly it is equally difficult to state which type of habitat was originally preferred by each species.

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Obviously the regions where the three Asian rhinoceros species have survived up to present times are not preferred ones in terms of habitat but have provided chances for survival because they made persecution by man very difficult. This is especially true for the small populations of the Javan and the Sumatran rhino. Relentless persecution has eradicated them almost completely, and their survival is due above all to the remoteness of the areas where they still live, the difficulty with which hunters are confronted, and, in present times, to a certain degree the legal protection.

The difficulty to define the original ecological niche and position applies especially also to the Javan rhinoceros. The fact that it has been eradicated so radically suggests that in former times it was no forest dweller proper but lived in a special relationship with man in forested areas. The primitive agricultural activity of man i.e. cultivation of rice and different vegetables (casava, bananas, sugar cane etc.) with the method of shifting cultivation (malay: "ladang") attracted the rhino. Ladang activity of man has more efficiently and more reliably than storm, lightning , flood and soil erosion, and, in certain regions, the elephant, temporarily broken down the climax forest and induced successions of secondary growth, including the species cultivated by man. These plants as well as the vegetation growing in deserted ladang were to a large extent the preferred man-made basis of life of the Javan rhino.

Similarly in Africa, annual grass burning by cattle nomads has maintained the open grassland and thus created conditions for the many grass-eaters and, in consequence, the predators. Yet the relation between man and Javan rhino has by necessity led to ecological competition between them. Chances and risks for man and rhino were more or less equilibrated as long as firearms were not available in these countries. But after the introduction of firearms, the eradication of the rhino was a matter of decades only (Sody, 1959). A small population of the Javan rhino was finally able to survive. It kept to the thorny and partially swampy area of the uninhabited semi-island of Ujung Kulon and developed well helped by avoidance of human vicinity, as reported elsewhere (Schenkel & Schenkel, 1969).

The Indonesian government and WWF together endeavoured to warrant efficient protection to the area and to the endangered rhino population. Annual counts of the rhinos since 1967 indicate that in the last few years the effort to prevent poaching was successful. The population has increased from approximately 25 in 1967 to more than 45 in 1975. If this most desirable trend continues, Ujung Kulon nature reserve in its present status will eventually not be able to support the increasing rhino population any more and the question arises what could be done to harbour is still.

At present the eastern border of the actually protected area (Fig. 1) lies between Cimokla in the south and Legon Pakis in the north. The area east of this border line together with Gunung Honye which lies still further to the north, are legally part of the nature reserve. However, in all the parts of low altitude the primary forest has been destroyed by man and nowadays these parts are mostly covered by a vegetation typical for an extended area of deserted poor ladang. It is the aim of the nature conservation authorities to sort out those regions which over a long time might have agricultural value and to reintegrate all the other poor ladang regions into the actually protected area. By these

means the living space of the rhino could be considerably enlarged provided that protection continues to be effective.

As the success of these measures is so far unpredictable, the authors have also considered possibilities to provide by management within the limits of the presently protected area better living conditions for the rhino. A project of this kind must be based on a study **firstly** of the feeding habits of the rhino, **secondly** of the main plant communities occurring in the different parts of Ujung Kulon and their dependance on local conditions such as topography, altitude, soil, water household, and **thirdly** on experiments of area management by which the growth of rhino food plants might be induced.

A short description of the vegetation types in the different parts of the reserve has been given by Sody, (1959). Also Endert (1952) and Koesnadi (1961) have previously characterized to some degree the vegetation in Ujung Kulon; a comprehensive and detailed study has so far not yet been accomplished. Nevertheless it seemed useful to carry out some experiments on management locally so that the vegetation could be altered in favour of the rhino. In this context two main methods should be considered. **First method:** As described previously (Schenkel & Schenkel, 1969) in many parts of Ujung Kulon the climax vegetation hardly allows rhino food to grow. One such type of plant community consists of high trees, a dense lower canopy formed by palms, and — due to the very poor light conditions — an extremely poor undergrowth stratum with almost no seedlings. These areas provide practically no food for the rhino. However, in such an area, when a high tree breaks down due to a storm or to age, it knocks down the palm canopy. In such localities a great variety of seedlings soon grows. This observation suggests as a method of management to eliminate in selected areas the dense palm canopy and thus to promote regeneration which results in the growth of rhino food plants. **Second method:** It is a generally accepted method of forest management to grow desirable tree species, in special plots, from seeds and then to plant the young trees in specially selected areas. Obviously one might also consider a combination of the two methods.

The first method requires modest efforts compared with the second one. We therefore decided to restrict our experiments to the former. This paper attempts to briefly characterize the feeding habits of the Javán rhino, to summarize our findings as to habitat and plant communities in the different parts of Ujung Kulon, and to report on our experiments and the results obtained.

THE FEEDING HABITS OF THE JAVAN RHINOCEROS

Saplings of many tree species are the staple food of the Javan rhino (Schenkel & Schenkel, 1969). When these plants are about 3 to 7 years old and about 3 to 10 meters high, the rhino browses on the twigs and smaller branches of the top, seizing them with the prehensile tip of the upper lip and cutting them off with the premolars and possibly also with the tusk-like incisors. If the rhino cannot reach the top of the sapling, it breaks its stem, sometimes by seizing it with the jaws, sometimes by pressing it down with the chest and the head. Then it chops off the twigs as described above. In addition the rhino also feeds on several climbers and also on trees along the shore with low growing branches such as

Hibiscus tiliaceus. On rare occasions it also browses on the shrub *Lantana camara*, one of the first and most common settlers in places where the forest has been destroyed. Finally, also on rare occasions only, it seems to feed on *Pandanus* or palm leaves, since occasionally the dung contains remains of such leaves.

All the evidence of food selection shows that the rhino firstly depends on forest regeneration, secondly on plants which grow on the edge of the forest and thirdly on glades, i.e. zones where no forest proper can grow. Altogether approximately 100 plant species are regularly or occasionally eaten by the rhino.

Grazers normally feed continuously while walking slowly. As they usually occur in larger aggregations or herds, their feeding habits result in cutting off the grass vegetation in an area just above the ground. The herds then usually shift to an adjacent area. As long as the climatic conditions are favourable, grass grows quickly and the herds can again feed in the area they have left some days ago. In a pronounced dry season, however, the grass may stop to grow; its leaves dry out and die and have practically no nutritional value for mammals. Then the grass-eaters have to migrate to areas with more favourable climatic conditions. The way of life of the Javan rhino, its feeding habits and its habitat conditions are quite different from those of grass-eaters.

The forest of Ujung Kulon is partly semideciduous; many trees are evergreen, some however drop their leaves during the dry season, i.e. between July and September. The term "dry season" needs some specification. In 1967, Ujung Kulon had no rain from June until November; in 1968, on the other hand, there was no week without rainfall. In 1972 it was dry again, whilst 1974 was comparatively wet. In some years it is therefore adequate to distinguish between a wet and a dry season, yet in others seasonal climatic changes are not pronounced.

A forest of the kind we find in Ujung Kulon is a self-stabilizing system in contrast to the open grassland or savannah. However food plants of the rhino although growing more or less permanently, do not grow as quickly as the grass in the wet season. These conditions are reflected in the way of life of the rhino. There is no need for large scale seasonal migration. Yet the rhino cannot feed repeatedly in short intervals on the same plant. It feeds while on a trip, i.e. it browses on a sapling, walks for up to 50 meters and feeds on another sapling. Its food preference changes within minutes; after having fed on one specie, it may leave untouched conspecific plants nearby and select a plant of another specie. This kind of feeding implies a certain nomadism, yet no large scale migration. In fact the whole rhino population remains within the protected area of 360 km^2 of which the largest extension (west to east) is less than 40 kilometers. It seems that for restricted periods one to four individuals repeatedly use a locality with one to several mud wallows, and the paths leading to them. From such a locality as a temporary living space, the rhino undertakes its feeding trips. Generally these trips follow traditional routes. After a period of some few days to several weeks the rhino again disappears from the area. These translocations seem to usually occur spontaneously, but they can also be elicited by the presence of man in the area. When moving over longer distances, the animals again follow traditonal routes. More or less well trodden paths are used wherever topographic and vegetational obstacles canalize the moves of the rhinos. As yet it cannot be reliably established whether, on rare occasions

rhinos leave the traditional feeding and shifting routes in reconnoitering new areas. While moving, the rhino marks its route with scent by various means. As stated previously, urine plays a major role in scent-marking, yet in our previous publication (Schenkel & Schenkel, 1969) we ommited the fact that in the genus *Rhinoceros*, the fore-foot is equipped with a scent-gland by which every footprint is marked (Cave, 1962). Due to the different scent traces, for the rhino the traditional olfactorily marked routes may have the function of guiding lines within its excursion range and in addition of a communicatory system amongst conspecifics.

THE HABITAT OF UJUNG KULON AND ITS MAIN PLANT COMMUNITIES

The topography of Ujung Kulon and its main water courses are roughly outlined in Fig. 1. The semi-island consists of two main parts: the mountain **Gunung Payung** in the west with several summits of approximately 500 meters altitude, steep slopes in all directions and with an extension to the north-west, the spur of Tanjung Layar; and the **main part** of the reserve between Gunung Payung in the west and the bottle neck at Karang Ranjang in the east. The central hilly area of this main part reaches an altitude of approximately 160 meters in its highest western elevation and ends with a steep slope which faces Gunung Payung from the north and north-east. The flat areas in the north and the east of the main part lie some few meters above sea-level or in the area

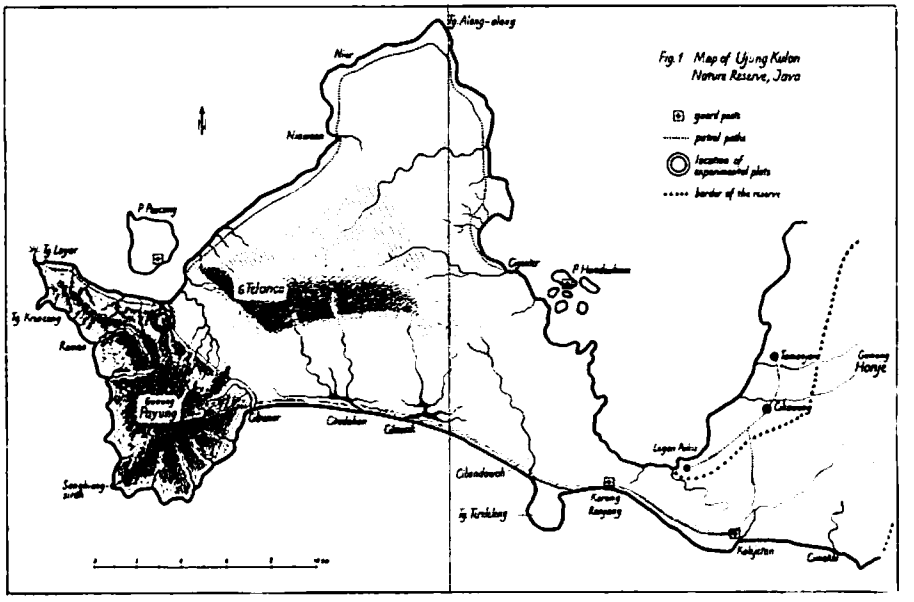

Fig. 1: Map of Ujung Kulon Nature Reserve, Java

Cicangkeuteuk and in large parts of the east coast further south — at sea-level and therefore are submerged by sea-water at high tide. Similarly the flat depression between Gunung Payung and the western slope of Gunung Telanca lies only a few meters above sea-level. Accordingly the two streams Ciujungkulon and Cidaun and similarly all the streams at the east coast are in their lower courses filled with salty or brackish water which rises and lowers with the tides. The southern coastal zone of the main part consists of a dune-like hill-system with a sandy beach from Citadahan to Karang Ranjang and a rocky coast between Cibunar and Citadahan and also between Karang Ranjang and Kalejetan. The dune-like formation between Cibunar and Citadahan is restricted to the coastal zone; in contrast, between Citadahan and Cikeusik several parallel ridges with depressions between them extend further inland. In three localities north of the coastal ridge, namely at the lower courses of Citadahan, Cikeusik and Cibanawoh, the terrain lies below sea-level. Therefore these rivers together with adjacent swampy areas are filled with brackish water of which the salt concentration increases during the dry season.

Most of the rivers of Gunung Payung form waterfalls in their higher reaches and cut deep gorges into the rock. During the dry season the amount of running water slowly decreases and eventually the rivers dry out. In contrast some of the streams of the central part, especially those of the north-western corner of Gunung Telanca, e.g. Citerjun and Cinogar, never dry out. Obviously this central hilly area contains a huge water reservoir underneath the limestone formation. All the streams which originate in the Gunung Telanca massif deposit in their upper reaches large quantities of sin her which form barrages and sin her cascades. Wherever the streams of Ujung Kulon reach a flat area, they are meandering and form many basins.

Most parts of Ujung Kulon are covered with a forest-like vegetation which however varies enormously from one place to another. Other areas are covered with low growing vegetation; these are:

Firstly an almost continuous *Pandanus* belt along the southern shore from Cibunar to the eastern border of the reserve and also along the western coast.

Secondly local glades in the interior with *Zingiberaceae* (especially *Nicolaia* sp.), *Lantana camara, Eupatorium* sp., *Melastoma polyantha,* different rattan species, and occasionally some saplings of various tree species.

Thirdly considerable parts of the northern plain which are not covered by forest for different reasons. Some flat depressions are flooded during the rainy season. Some areas (Ciujungkulon) were inhabited by man before the eruption of Krakatau in 1883; some were kept open artificially for several decades as grazing grounds for the banteng *(Bos javanicus)* and the rusa *(Cervus timorensis);* some of these are still now regularly cleared from bush and shrub. When left on their own, all artificial clearings are slowly overgrown, first by bush *(Lantana camara, Eupatorium* sp., *Melastoma polyantha),* later by a low forest of *Ardisia humilis* and *Buchanania arborescens* especially in coastal areas.

The following is an attempt to roughly characterize the prominent plant communities of the forest-like vegetation:

— The mangrove forest in the eastern zones which are flooded at high tide is mostly composed of *Rhizophora* and *Sonneratia* species.

— In brackish water swamps near the mouth of several rivers, *Nipa fruticans* grows in monotypic stands.
— In former grazing grounds of the flat northern and eastern areas, *Buchanania* and *Ardisia* species prevail.
— In the coastal strip of the north coast where the soil is solid and in some areas consists of lime stone, *Barringtonia* sp., *Calophyllum inophyllum*, *Hibiscus tiliaceus*, *Terminalia catappa* and other trees prevail.
— On the second dune-like ridge which runs parallel to the south coast, *Laportea stimulans* is locally dominant.
— Further inland, different bamboo species prevail locally, mainly on clay soil near water courses and on soft slopes.

Almost all the other parts of the interior are covered by forest proper (fig. 2). This forest has a high, sometimes discontinuous canopy level with an

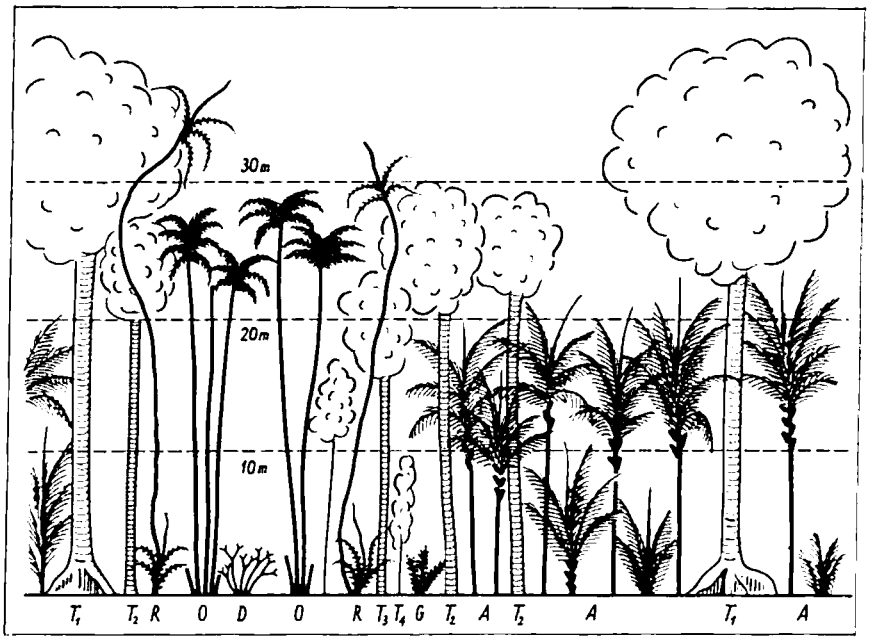

Fig. 2: Typical composition of the semi-deciduous lowland forest of Ujung Kulon Nature Reserve.

A *Arenga* obtusifolia
D *Donax* sp.
G *Zingiberaceae*
O *Oncosperma* sp.
R Rotan palms
T_1 Trees of the high discontinuous stratum
T_2 Trees of the secondary stratum
T_3 Trees of a tertiary stratum
T_4 Tree saplings

altitude of 30 to 70 meters. It is composed of many different tree species mostly of the families *Bombaceae* and *Moraceae*. e.g. *Gossampinus malabaricum*, *Ficus elastica*, *Alstonia angustiloba*, and members of other families e.g. *Spondias pinnata*, *Bischofia javanica*, *Lagerstroemia speciosa*. The trees are often loaded with lianae and rattan which as climbers may reach the top of the canopy. Where these high trees grow distant from each other, between them a second level with an altitude of approximately 30 meters forms the upper surface of the vegetation. This stratum contains mostly trees and also clusters of *Oncosperma* palms (sundanese: "Nibung"), locally.

In well drained areas, especially on moderately steep slopes, on ridges, river banks, and occasionally also in flats, *Arenga obtusifolia* (sundanese: "Langkap") forms a dense lower canopy with a height of 10 to 20 meters. Due to the poor light conditions below this canopy, there is almost no undergrowth in these localities; except for some young Langkap palms the soil is almost bare. Similarly in areas with poor water drainage, especially in depressions with clay soil, *Salacca edulis* (sundanese: "Salak") forms a dense monotypic stratum with a height of approximately 5 meters. In many Salak palm stands, undergrowth is completely missing. In yet other areas, especially in the higher reaches of Gunung Payung and also in parts of Gunung Telanca as well as elsewhere, undergrowth is comparatively rich. Locally, *Donax canniformis* (sundanese: "Bangban") may prevail; saplings of different tree species, especially *Leea indica*, *Eugenia polyantha*, *Dillenia obovata*, *Lagerstroemia speciosa*, *Pterospermum javanicum*, are intermixed with various *Zingiberaceae* and palms (Langkap, Nibung, various rattans, *Caryota mitis)*.

If we try to evaluate the different plant societies with respect to the availability and production of rhino food, we can see considerable differences. Forest with rich undergrowth, some of the glades, and the tree communities on the shore with low growing branches appear to provide most of the food for the rhino. On the other hand, in the areas where bamboo species, Nibung, Salak and Langkap palms prevail, food for the rhino is scarce or absent. Some of these areas may however cover other needs of the rhino, such as providing shelter from sunshine or from man, wallows, or possibilities for comparatively effortless shifting.

EXPERIMENTAL APPROACH

Selection Of Experimental Areas

In all the areas selected for experimentation , some high trees rise above a second stratum formed of trees and sometimes also Nibung palms; underneath these tree strata, a dense lower Langkap canopy caused very poor light conditions on the ground. Undergrowth was scarce, consisting mainly of stands of *Donax* sp. and *Zingiberaceae;* locally the soil was even bare. The areas differed as to:

— Continuity or discontinuity of the higher tree strata,
— Number of dicotyledon trees in the secondary stratum,
— Composition of the palm canopy,
— Presence or absence of stands of *Donax canniformis* and other low growing plants,

— Topographic and drainage conditions,
— Previous visits of the area by rhinos, especially presence or absence of a nearby rhino route.

Experimental Procedure

— In plots of about 50 x 50 meters, all the plants and *Donax* groups were cut at or slightly above the ground level. In plots No. 1, 2 and 3, after cutting, the palms and *Donax* were burned when dry; in the other plots, they were left to decay. In plots No. 1, 2 and 3, light intensity was measured at noon on a covered day before and after cutting the palms, by means of a photographic lightmeter (Sixtomat), in horizontal position.
— For all plots the high trees as well as those of the lower stratum were listed, and the continuity or discontinuity of the tree cover was stated.
— Each year, all the plots were examined; a detailed description of the secondary growth was carried out at different intervals (Table 1).

Table 1: Experimental plots, location and checking of plots

No.	Location	Date of cutting	Checking of plots, inventarisation of secondary growth				
			Mar. 1968	Aug. 1968	Aug. 1969	Sept. 1972	July 1974
1	Lowland, at the foot of a ridge, near Cikuya river						
2	On a sloping ridge, west of Cikuya river	Sept. 1967	x (½)*	x (1)	x (2)	x (5)	x (7)
3	Lowland on the eastern bank of Cidaun river						
4	Near plot 2, on an almost flat part of a ridge, west of Cikuya river	Aug. 1969				x (3)	x (5)
5	Adjacent to plot 3, lowland						
6	Adjacent to plot 5, lowland						
7	Adjacent to plot 6, lowland	Nov. 1970				x (2)	x (4)
8	Lowland, on the western bank of Cidaun river						

*figures in paranthesis refer to years after cutting

Results

Experimental Plot No. 1 (Fig. 3)

This plot lies at the foot of a ridge of the north-eastern slope of Gunung Payung in a fairly humid location. During heavy rains, a small meandering rivulet in a flat clay bed drains the plot although only poorly. A game path follows the foot of the hill. It is however only occasionally used by bantengs and pigs, and very rarely by rhino.

Before cutting, the plot contained several *Oncosperma* groups, a large number of rattan palms, some Salak palms and *Donax* stands, and many *Arenga* palms.

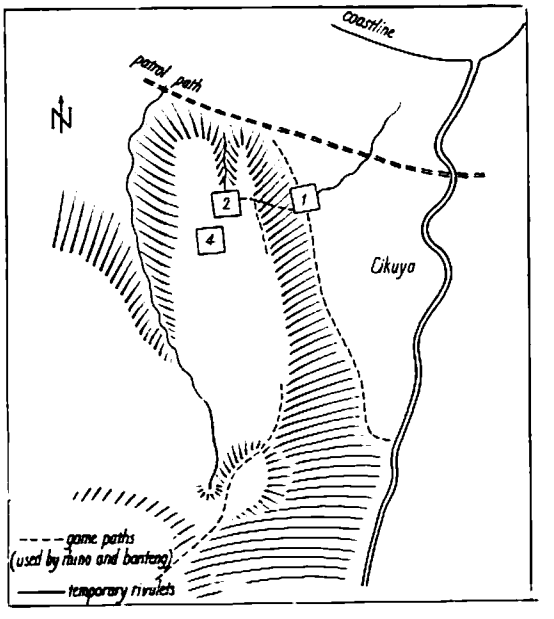

Fig. 3: Topography of sample plots Nos. 1, 2 and 4.

After the cutting of the palms, the tree cover of the high and the second stratum was still almost continuous; nevertheless the light intensity in the plot increased about 8 fold. The middle of the plot was overshaded by a large *Alstonia angustiloba*, and the sides by one *Ficus benjamina*, one *Dillenia aurea*, one *Lagerstroemia* sp., one *Pterospermum* sp. and two *Eugenia polyantha*, all in the higher stratum; the second, lower stratum consisted of four *Lagerstroemia sp.*, one *Mallotus philippinensis*, one *Gossampinus valetonii* and one unidentified tree.

On **March 28, 1968** (½ year after cutting), the plot contains many seedlings of *Spondias pinnata*, *Leea indica*, *Pterospermum* sp., some seedlings of *Eugenia polyantha*, some rattan palms, *Arenga obtusifolia*, and a few *Lantana camara* which have grown during the very wet period since November 1967.

Table 2: Secondary growth in four 5 x 5 meters' areas of experimental plot No. 1. Number of saplings on August 26, 1968 (1 year after cutting)

Species	Light intensity after cutting*				Total number of saplings per 100 m^2
	very high	high	moderate	low	
Leea indica	77	23	17	25	142
Eupatorium sp.	8	1	26	5	40
Lantana camara	6	1	3	3	13
Eugenia polyantha	3	5	5	—	13
Melastoma sp.	2	1	1	—	4
Lagerstroemia sp.	1	2	7	—	10
Spondias pinnata	—	1	—	—	1
Dillenia excelsa	—	—	—	1	1
Xanthoxylum rhetsae	—	2	—	—	2
Donax sp.	22	24	1	—	47
Rattan	—	3	1	—	4
Total	119	63	61	34	277

*1 year after cutting

On **August 26, 1968** (1 year), secondary growth of up to 2 meters covers the plot. The density of seedlings is higher than in March, and the number of species has increased. All the low growing plants were counted in four areas of 5 x 5 meters with somewhat different light conditions (Table 2). Obviously *Leea indica* is the most frequent sapling; it grows in the whole plot but seems to prefer the areas with higher light intensity. *Donax canniformis* has mostly grown from old roots. *Lantana camara* is not frequent; *Eupatorium sp.* occurs more frequently in parts with moderate light conditions.

On **September 23, 1969** (2 years), plants have grown up to 3 meters' height (*Leea indica* and also the bush *Lantana and Eupatorium* sp.). The density of saplings has almost doubled, and also the number of species has increased. Obviously in the second rainy season, saplings, especially *Lagerstroemia* sp. have come up. Again all the saplings and low growing plants were counted in 5 x 5 meters' areas (Table 3). The plot has occasionally been visited by rhinos. Some saplings of *Leea indica* have been chopped off some time ago. In the places with good growth of *Leea indica*, *Lantana* and *Eupatorium* have disappeared.

On **August 8, 1972**, (5 years), the plot is mainly overgrown by young trees of *Leea indica* which are now 4 to 6 meters high. In the lower part of the plot near the small watercourse, some palms (rattan, Salak) have come up; this area is humid and dark, and much less saplings have grown. Two rhino tracks which seem to be used occasionally only, cross the plot. Feeding traces of different age are found on *Leea indica*, *Litsea noronhae* and *Ficus septica*.

Table 3: Secondary growth in four 5 x 5 meters' areas of experimental plot No. 1 September 23, 1969 (2 years)

Species	Light intensity*				Total number of saplings
	very high	high	moderate	low	per 100 m^2
Leea indica	15	16	34	49	114
Lantana camara	5	1	4	—	10
Eupatorium sp.	16	3	4	—	23
Melastoma polyantha	4	—	3	—	7
Lagerstroemia sp.	7	—	7	12	26
Pterospermum sp.	10	107	27	25	169
Ardisia humilis	3	10	—	5	18
Eugenia polyantha	7	19	5	22	53
Donax canniformis	8	12	39	7	66
Zingiberaceae	5	12	10	11	38
Palms	5	11	1	7	24
11 other tree species	7	2	3	3	15
Total	92	193	137	141	563

*see Table 2

On **July 21, 1974,** (7 years), the plot is densely overgrown with saplings mostly of *Leea indica* with a stem-diameter of 3.5 to 6 cm and a height of 5 to 7 meters. A lot of high *Zingiberaceae* and *Haloplegia blumei* cover the more humid part of the plot. Signs of rhino visits such as feeding traces and tracks are scarce, and this suggests that the plot is only occasionally visited by a rhino.

Experimental Plot No. 2

The plot of 50 x 50 meters lies on a ridge sloping to the north. It is well drained due to its sloping and to a small creek. Prior to cutting, there were no signs of rhino visits in this locality. Further up on the mountain, there is a game route which is also occasionally used by rhinos. In 1967, rhino tracks led to an area further west which was at the time of cutting a temporary activity field of probably two rhinos.

Before the cutting of palms, the tree canopy was continuous; it consisted of two *Dillenia excelsa,* three *Alstonia angustiloba,* three *Vitex pubescens,* one *Bischofia javanica,* one *Eugenia polyantha* and one *Artocarpus* sp. as higher crowns and a number of small trees. *Arenga obtusifolia* formed a dense lower stratum, and undergrowth was completely absent.

Altogether 100 *Arenga* palms and 5 Nibung palms were cut. After cutting, the light intensity on the ground had increased about 16 fold. The trees left in the plot formed a fairly continuous cover.

On **March 28, 1968** (½ year), the ground is covered with small saplings (20 to 50 cm high) mainly of *Spondias pinnata, Leea indica* and *Pterospermum* sp.

Plot No. 2: August 1968, one year after selective cutting of the palms, saplings of *Leea indica* and *Eugenia polyantha*.

On **August 27, 1968** (1 year), the density of saplings has increased. Those of *Spondias pinnata* have however almost completely disappeared; they were eaten by insects and probably also by mouse deer and barking deer. The sapling density in the 5 x 5 meters' areas does not differ much from the more shady to the more sunny places (Table 4). *Leea indica and Eugenia polyantha* are by far the most frequent saplings. There are no signs of rhino visits to the plot but a lot of feeding traces and footprints of banteng, barking deer, mouse deer and wild pig. A well trodden animal path leads up the slope from plot No. 1 to plot No. 2.

On **August 19, 1969** (2 years), the density of saplings is still similar, but the

Table 4: Composition of secondry growth in four 5 x 5 meters' areas of experimental plot No. 2. August 27, 1968 (1 year)

Species	Light intensity*				Total number of saplings per 100 m^2
	very high	high	moderate	low	
Leea indica	60	21	65	5	151
Eugenia polyantha	13	32	2	104	151
Lantana camara	—	3	1	—	4
Dillenia excelsa	1	6	—	—	7
Lagerstroemia sp.	—	—	2	—	2
Artocarpus sp.	—	1	—	—	1
Glochidion sp.	5	3	2	—	10
Rattan	7	2	—	—	9
Arenga obtusifolia	10	6	3	—	19
Donax canniformis	14	9	8	8	39
Total	110	83	83	117	393

*see table 2

number of species has increased considerably (Table 5). There are signs of an occasional visit and of feeding by a rhino. Obviously other mammals (banteng, barking deer, mouse deer) feed more frequently in the plot.

On **August 8, 1972** (5 years), the plot is much more open to the sun. Two high trees (*Dillenia* sp.) have broken down during a heavy storm in February 1972. The dead trees cover large parts of the plot and have inhibited the growth of saplings. *Leea indica* (4 to 6 meters high) are still the most frequent saplings. There are no signs of recent rhino visits to the plot.

On. **July 21, 1974** (7 years), the fallen trees have mostly decayed. The place is covered by secondary growth of different age: *Leea indica* (about 5 to 7 meteres high, 4 to 7 cm stem-diameter) forms the top, below *Achasma* sp., rattans *Haloplegia blumei* and *Donax canniformis* form a dense jungle. A few poorly growing *Lantana camara* and some young *Arenga* palms also occur. In addition the soil is covered by small saplings (30 to 100 cm high) of various tree species. There are only few signs of rhino visits. Some time ago, a rhino had browsed on some *Leea* saplings.

Table 5: Composition of secondary growth in four 5 x 5 meters' areas of experimental plot No. 2. August 19, 1969 (2 years)

Species	Light intensity*				Total number of saplings per 100 m^2
	very high	high	moderate	low	
Leea indica	17	12	6	23	58
Eugenia polyantha	—	—	4	—	4
Lantana camara	—	—	—	4	4
Eupatorium sp.	2	3	2	—	7
Melastoma polyantha	—	1	3	3	7
Dillenia sp.	5	—	6	—	11
Lagerstroemia sp.	—	8	9	9	26
Alstonia angustiloba	—	2	—	—	2
Pterospermum sp.	—	5	—	—	5
Ficus septica	1	—	—	—	1
Diospyros macrophylla	1				
Cleisthantes sp.	—	7	25	27	59
Baccaurea javanica	9	5	4	3	21
Arenga obtusifolia	8	5	8	6	27
Zingiberaceae	10	4	6	4	24
Ferns	—	5	—	—	5
Climbers	1	2	8	1	12
Donax canniformis	18	9	10	4	41
Total	71	67	92	85	315

*see table 2

Experimental Plot No. 3 (Fig. 4)

The plot lies on the right bank of Cidaun river in the flat lowland at the foot of the ridge which extends between the two major aims of Cidaun (Fig. 4). Obviously the plot is below the surface drained into the river bed. Rhino traces are frequent in the area. They follow mainly two routes and shortcuts between them.

The high stratum consisted originally of seven *Lagerstroemia sp.*, one *Dillenia excelsa*, one *Pometia pinnata* and one unidentified tree. The secondary canopy was formed by various trees and high *Arenga* palms. Below these high *Arenga* palms, there were many saplings of about 2 meters' height (*Eugenia polyantha, Buchanania arborescens, Diospyros* sp. and others). In other places, low palms (*Arenga*, Salak, rattan) formed a dense stratum underneath the secondary canopy; in these places undergrowth was scarce.

Altogether 102 *Arenga* palms, 8 groups of *Salacca edulis* and 2 groups of rattans were cut. The light intensity increased about 8 times; some places were however fully exposed to sunlight after cutting.

On **March 28, 1968** (½ year), secondary growth is abundant; many small saplings have sprouted, but also various and in some areas grass.

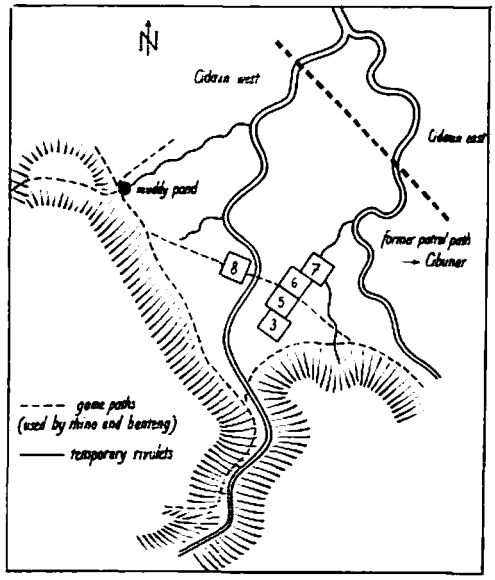

Fig. 4: Topography of sample plots Nos. 3, 5, 6, 7 and 8

On **August 27, 1968** (1 year, secondary growth has increased further (Table 6). In the sunny parts, *Lantana camara* has grown up to 2 meters high. Several

Table 6: Composition of secondary growth in four 5 x 5 meters' areas of experimental plot No. 3. August 27, 1968 (1 year)

Species	Light intensity* very high				Total number high
Lagerstroemia sp.	21	37	9	5	72
Leea indica	21	3	3	14	41
Spondias pinnata	13	3	11	1	28
Melastoma polyantha	—	3	2	—	5
Lantana camara	11	2	1	—	14
Eugenia polyantha	3	1	1	1	6
Eugenia jamboloides	2	4	—	1	7
Canarium sp.	1	1	1	—	3
Litsea sp.	2	—	7	1	10
3 other tree species	1	—	5	9	15
Donax canniformis	—	—	—	6	6
Caladium sp.	5	7	12	—	12
Total	80	54	40	45	219

*see table 2

rhino tracks are found in the plot. Bantengs regularly visit the place and feed in it: a well trodden game path often used by banteng, but sometimes also by rhino leads from Cidaun valley along the foot of the hill to the east.

On **August 19, 1969** (2 years), the plot is covered with secondary vegetation which is up to 2 meters high. Some bush (*Melastoma* and *Eupatorium*) and a lot of saplings of different tree species, and in some areas *Macaranga*. *Zingiberaceae*. ferns and climbers have developed (Table 7). Rhinos have

Table 7: Composition of secondary growth in four 5 x 5 meters' areas of experimental plot No. 3. August 19, 1969 (2 years)

Species	Light intensity*				Total number of saplings per 100 m^2
	very high	high	moderate	low	
Leea indica	10	7	9	15	41
Eugenia polyantha	2	3	12	—	17
Melastoma polyantha	1	—	1	—	2
Eupatorium sp.	3	—	—	—	3
Lagerstroemia sp.	23	—	—	—	23
Baccaurea javanica	3	—	—	—	5
Barringtonia sp.	1	1	44	—	46
Wetia macrophylla	2	10	—	—	12
Pterospermum sp.	1	11	45	—	57
13 other tree species	7	5	2	11	25
Rattan	2	2	—	2	6
Arenga obtusifolia	3	2	—	3	8
Zingiberaceae	2	3	1	—	6
Donax canniformis	1	8	—	35	44
Macaranga sp.	1	—	—	1	2
Climbers	1	2	5	1	7
Ferns	4	3	—	—	7
Total	66	60	119	68	313

*see table 2

visited the place on numerous occasions and have fed at different times on saplings of *Leea*, *Barringtonia*, *Erioglossum edule* and a *Litsea* sp.

On **September 7, 1972** (5 years), the plot is almost covered by broken trees *(Lagerstroemia, Pometia pinnata)* which have been destroyed by the big storm in February 1972. A large open place extends now from plot No. 5 over plot No. 3 to Cidaun river. The plot is covered by many young trees and some bush. Some saplings are 5 to 10 meters high, obviously those which have already been in the plot before cutting the palms. The majority reaches about 2 meters. The number of species has remarkably increased. Several tracks obviously used by rhino and banteng lead through the plot. Tops or twigs of saplings of different species and age have been chopped off; almost all the *Planchonia globosa* and *Garcinia dioica* saplings have been fed on.

On **July 21, 1974** (7 years), the plot has still a similar aspect; the secondary growth is dense and about 4 to 7 meters high. In some places, *Lantana camara* has grown. Below the higher saplings, there are many small ones (30 to 100 cm high) of *Barringtonia* sp., *Lagerstroemia* sp. and *Eugenia polyantha*. The place is transversed by several rhino tracks, one of them has been used quite recently. Many of the young trees have been broken down once and their branches have been chopped off by rhino; sometimes the sapling has grown new shoots after being chopped off once, and these new shoots have sometimes been bitten off again by a rhino.

Experimental Plot No. 4 (Fig. 3)

This plot was selected near plot No. 2 in an almost flat part of the ridge about 30 meters above sea level. The area is well drained and often rather dry. Prior to cutting, there were no signs of rhino visits in the area. The high trees on and adjacent to the plot consisted of six *Lagerstroemia*, seven *Vitex pubescens*, eight *Dillenia excelsa* and two *Dillenia aurea*, the secondary stratum of *Baccaurea javanica*, *Eugenia polyantha*, *Dillenia excelsa*, *Diospyros* sp. and *Capparis microantha*. Below this canopy, a dense stratum of *Arenga* and some *Oncosperma* palms absorbed all the light. The soil was bare in many parts, only some few tree saplings had grown.

When all the palms (129 *Arenga obtusifolia*, some *Oncosperma* and rattans) and all the *Donax canniformis* had been cut, the light intensity increased about 32 fold, yet the tree strata still provided a fairly continuous cover, except in one area where more light could enter.

On **September 10, 1972** (3 years), the secondary vegetation is about 1 to 2 meters high, but not very abundant. Many tree saplings of different species, a lot of climbers and in the more open area *Melastoma* and *Eupatorium*, and in other areas also a considerable number of young palms have grown. The plot has been visited by rhino on more than one occasion, but no real path leads through. *Hypobatrum* sp., *Litsea* sp., *Leea indica* and *Spathodea* sp. have been broken down and their tops been chopped off.

On **July 21, 1974** (5 years), the secondary vegetation has reached about 2 to 3 meters' height. It is not as abundant and as high as in other plots of this age (e.g. No. 5). The place seems to be rather dry, the palm stems cut 5 years ago are still hard and have not decayed. In the more open parts of the plot, some stands of *Eupatorium* and *Melastoma* have expanded. Some few groups of *Zingiberaceae* and *Donax* have grown. Amongst the tree saplings, *Leea indica* is the most frequent species. Quite a lot of *Arenga* and *Oncosperma* palms have developed, some from old stems, many also from seeds. A second generation of saplings (about 10 to 50 cm high) of *Eugenia polyantha*, *Pterospermum javanicum* and *Dillenia excelsa* has developed. There are only few and only old signs of rhino visits to the place. Several saplings (*Leea indica*, *Litsea* sp., *Eugenia polyantha* and others) show traces or rhino feeding.

Experimental Plot No. 5 (Fig. 4)

The plot lies north-east and adjacent to plot No. 3. The area is fairly

humid throughout the year, but not swampy. The high canopy at the time of cutting consisted of two *Eugenia polyantha*, several *Lagerstroemia* sp., one *Vitex pubescens* and one *Buchanania arborescens*. The dense lower stratum was composed of trees of the same species and many high *Arenga obtusifolia*. The undergrowth (*Donax canniformis* stands, rattans, some *Zingiberaceae* and various tree saplings) was relatively abundant.

After the cutting of the palms (143 *Arenga obtusifolia*, 17 *Oncosperma*, 16 groups of rattans) and of a large stand of *Donax*, the light had increased about 4 fold. The tree cover was still fairly continuous though not dense.

On **September 9, 1972** (3 years), the plot is more open, since in February 1972 a large *Lagerstroemia* tree had broken down in the north-western part, and now a widely open area extends from there over plot No. 3 to the river. Most of the cut palm stems have already rotted. The plot is overgrown with young trees of different age. About 25 trees (5 to 10 meters high) are abviously older than 3 years. The many new saplings are about 1 to 3 meters high. *Leea indica*, *Eugenia polyantha*, *Diospyros sp.* are frequent amongst them, but many other tree species occur. Ferns, *Haloplegia Blumie*, patches of *Caladium* sp. and some *Zingiberaceae* indicate that the place is fairly humid. Bush *(Lantana camara)* is scarce. The plot has frequently been visited by rhinos. Some well trodden paths coming from plot No. 3 lead through plot No. 5. Many tree saplings, especially *Leea indica* and *Dillenia excelsa*, and some climbers have been broken off by rhinos. Bantengs seem to feed frequently in the plot mainly on young palms and *Haloplegia blumei*.

On **July 21, 1974** (5 years), the secondary vegetation, especially *Leea indica* and *Diospyros macrophylla*, has reached a height of about 3 to 5 meters. Besides these two species *Canangium odoratum*, *Litsea sp.* and *Dillenia excelsa* are frequent. Clusters of *Donax* and of *Caladium* extend in some spots. The densely overgrown plot is transversed by several rhino trails which connect plots No. 3, 5 and 6. A lot of young trees, especially *Leea indica*, *Canangium odoratum*, *Artocarpus sp.* and *Canarium asperum*, have been chopped off, some of them have been uprooted by rhinos at some time or other. On several spots, the vegetation is sprayed with rhino urine.

Experimental Plot No. 6 (Fig. 4)

This plot was cut adjacent to plot No. 5 in a similar area, i.e. fairly humid throughout the year but not swampy. The high stratum formed by five *Lagerstroemia* trees was fairly continuous; the dense middle stratum consisted of one *Lagerstromia*, two *Diospyros* and one unidentified tree together with many palms. Undergrowth was similar to plot No. 5: stands of *Donax*, *Haloplegia*, *Blumei*, *Caladium* sp., rattans and a few tree saplings.

After the cutting of all palms and *Donax* stands, the tree cover was still relatively continuous; the place being slightly more shady than No. 5.

On **September 6, 1972** (2 years), the secondary vegetation is fairly dense. Saplings of *Eugenia polyantha* and *Lagerstroemia* sp. are frequent. *Caladium* and *Malvaceae* and in some places *Eupatorium* have grown. Rhinos frequently visit the place, they have fed on most of the *Malvaceae*, and climbers and on various tree saplings (*Eugenia* sp., *Leea indica* and others).

On **July 2, 1974** (4 years), the high tree canopy is less continuous. Some branches of the high trees have broken off during a storm. The plot is densely overgrown with plants 4 to 6 meters high. In some areas, bush *(Lantana camara, Eupatorium* and *Melastoma)*, clusters of *Caladium* and of *Donax* have grown. The place is transversed by several rhino tracks, some very recent, some older ones. Many young trees have been chopped off, mainly *Leea indica* and *Ficus septica*, and also some Lantana bush. Some young trees have been uprooted by rhinos in a display in which they also sprayed the vegetation with urine.

Experimental Plot No. 7 (Fig. 4)

This plot lies further north-east and adjacent to No. 6 (Fig. 4). It is divided into two parts by the end of a rivulet with water only during rains. The plot was covered by a continuous high and middle stratum. The high one was formed by one *Lagerstroemia*, two *Diospyros macrophylla*, one *Spondias pinnata*, one *Canarium asperum* and by several bordering trees. The lower stratum was originally formed by *Vitex pubescens* and *Cleisthantes myrianthus*, many high *Arenga* and some *Oncosperma* palms. The undergrowth consisted of *Donax* stands, *Haloplegia Blumei*, rattan groups and *Amomum* sp.

After cutting all the palms and *Donax* groups, the light influx on the undergrowth increased considerably, yet the plot was still covered by a fairly continuous tree stratum and was more shady than the other plots in the area Cidaun.

On **September 6, 1972** (2 years), secondary growth is relatively scarce. *Leea indica* has reached a height of 1 to 3 meters, most of the other tree saplings as well as the few *Zingiberaceae, Haloplegia, Blumei* and some few *Arenga* saplings are below one meter high. There are few signs of rhino visits in the plot; some *Leea indica* and *Eugenia polyantha* have been chopped off. No regular rhino paths lead through the plot.

On **July 21, 1974** (4 years), the secondary vegetation is still scarce and lower than in the adjacent plot No. 6. *Leea indica* saplings are only 3 to 4 meters high and have stem diameters of 1.5 to 3 cm. Most other tree saplings *(Diospyros macrophylla, Eugenia polyantha)* are below one meter high. There are no signs of recent rhino visits to the plot. Obviously plot No. 7 does not attract rhinos as much as the adjacent plots. This could be due to the low density and height of the saplings in the relatively shady plot.

Experimental Plot No. 8 (Fig. 4)

The plot lies in the lowland west of Cidaun river (Fig. 3). The area is fairly humid, but not swampy. Before cutting, the plot was overshaded by the top stratum (one *Spondias pinnata*, one *Canarium asperum*, one *Lagerstroemia* and one *Diospyros macrophylla*) and a dense lower stratum of a few trees intermixed with many high *Oncosperma* and *Arenga* palms. Below these strata, there were many small *Arenga* palms, *Donax* stands, some rattan palms and

some few saplings of *Spondias pinnata*.

After the cutting of all the palms and the Donax, the light intensity had increased considerably; the plot was more open to sunlight than plots No. 6 and 7.

On **September 6, 1972** (2 years), the plot is densely overgrown by bush, tree saplings and herbs. In the most open areas, *Eupatorium* and *Lantana camara* are abundant, and also saplings of *Leea indica, Lagerstroemia* and *Eugenia polyantha*. In the more shady parts, ferns, *Caladium* sp. and palms have grown. Many saplings (mainly *Leea indica* and *Eugenia polyantha)* have been fed by rhinos; there are some irregular paths in the plot. A well trodden path leads from plot No. 8 across the river to plot No. 6.

On **July 21, 1974** (4 years), the plot is widely open to the sun; obviously one higher tree has broken down. Undergrowth is dense; in the sunny areas, thickets of *Lantana camara* and *Eupatorium* intermixed with tree saplings up to 4 meters high cover the ground. *Leea indica, Litsea* sp., *Canarium asperum* and *Ardisia humilis* are most frequent. Below these higher saplings, many small saplings up to 1 meter of various tree species have grown. The cut palms have already decayed partially. Obviously the place is often visited by rhinos. Several tracks lead through the plot and down the river. Many young trees (3 to 4 meters and also 1 meter high) have been chopped off, others have been uprooted. Obviously the area has become very attractive to rhinos since the secondary growth has increased in density and height.

DISCUSSIONS AND CONCLUSIONS

The Problem

There is a real chance that if protection of Ujung Kulong nature reserve continues to be as effective as at present, the rhino population will continue to increase. This will result either in a higher population density or in emigration of rhinos into adjacent areas further east, or both. For rhinos which have emigrated, protection will be more difficult. The border zone of the reserve will be longer and closer to human settlement. On the other hand, population density will be limited by one of two main factors, namely limitation of the carrying capacity of the habitat and behavioural regulation, mainly intraspecific intolerance and avoidance. At present, these behavioural dispositions do not seem to limit population density. Emigration has not yet started, and inside the reserve, rhinos stick to traditional routes and areas. Still many areas in Ujung Kulon are not visited by rhinos. It therefore seems that the behavioural dispositions of the rhino permit a considerably higher population density, and it has to be expected that the factor which will first limit the population density will be the carrying capacity, i.e. the food supply within the reserve.

We therefore have carried out experiments with the aim to have at hand a method by which the availability of rhino food plants could be increased. The method tested requires comparatively small efforts and it does not cause a general disturbance of the habitat.

Experiments And Results

In experimental plots of 50 x 50 meters, all the palms and, if present, clusters of *Donax canniformis* were cut. All the other components of the vegetation remained untouched. By this procedure light conditions on the ground were altered drastically; the light intensity increased by a factor of 8 to 32 times. These measures resulted in a rich secondary growth on the earlier almost bare soil. In those plots where the tree canopy was discontinuous (mainly plots No. 3 and 5), grass, herbs (e.g. *Caladium* sp.), shrub (e.g. *Lantana camara, Eupatorium* sp.) were more abundant than in the plots with a continuous tree cover (plots No. 1, 4 and 7). The density of tree saplings was lower in the plots with a dense tree cover (e.g. plots No. 4 and 7). Palm saplings were scarce and grew mainly in shady areas.

The secondary vegetation showed considerable changes from year to year as to the occurence and proportion of different tree saplings. These changes were partially due to animals (especially insects) which in some cases killed all the saplings of one species, or to parasitic fungi, partially to systematic conditions of the developing plant community which resulted in a succession of the secondary vegetation. Grasses which obviously need much light, disappeared soon. *Lantana camara* and *Eupatorium* which are typical early settlers in locally or extensively destroyed forest, are not so quickly overgrown by tree saplings and therefore live longer. *Leea indica* also belongs to the most frequent early settlers; these small trees (dutch: "boomheester") grow fast until they reach a height of 5 to 10 meters and therefore persist unchallenged for more than 7 years. Under the cover of these early settlers, saplings of high trees appeared in slowly increasing numbers.

In summarizing, we can state that after the cutting of the palms in areas with almost no undergrowth, a rich secondary vegetation developed which within 7 years reached a height of approximately 7 meters. A large number of species of this secondary vegetation is fed by the rhino.

Feeding Traces Of Rhinos In The Experimental Plots

All the plots have been visited by rhinos, yet the frequency of the visits differed very much for the various plots. The plots on the ridge west of Cikuya (No. 2 and 4) were visited on few occasions only; the one on the foot of the ridge (No. 1) once or twice a year; four plots in the area Cidaun (No. 3, 5, 6 and 8) frequently; one (No. 7) in the same area only occasionally. It seems that two factors contribute to these differences: firstly the stable traditions of the rhino with regard to the localities visited, and secondly differences in the attractivity of the localities due to different types of secondary vegetation. Mainly it seems that a dense, jungle-like vegetation attracts the rhino more than scarcely distributed saplings.

Evaluation Of The Method Of Rhino Management And Considerations Concerning Its Possible Application

The method of management described in this paper, although comparatively

simple has proved to be efficient in stimulating the growth of rhino food plants in areas with a dense secondary palm canopy and very poor undergrowth. Rhino food plants are available about 2 years after cutting the palms and for perhaps 10 years or more, especially where the rhinos, by feeding and breaking saplings, prevent the regenerating vegetation from growing quickly out of their reach. However the rhino food plants induced by this method are at present not fed at all locations. It seems that they are mainly fed frequently if the location is near to traditionally used rhino routes.

It has to be expected that the rhino population when growing, will also increase in density. Then areas of the peninsula may be visited and routes developed which at present are not yet included in the activity system of the rhinos. Under such conditions the method which has been studies will, if applied in areas well selected as to topographical and vegetational features, be an adequate measure to increase the carrying capacity of the reserve with regard to the rhino.

Evidence of both, emigration and more extensive colonisation of the reserve will have to be considered as an indication to start with management in a larger number of feeding plots in different parts of the reserve. We do not recommend to cut the palms in large areas, but in complexes of small plots in areas frequently visited or trespassed by rhinos.

Meanwhile the method should also be tried out in areas with other plant communities, especially in the monotypic Salak stands under a more or less continous high tree stratum, or in areas with many low growing rattan palms.

We would like to stress that we do not advocate any large scale conversion of the vegetation, firstly because not only the rhino is worthy of protection and consideration in Ujung Kulon, but all the other components and communities of fauna and vegetation; secondly also when food would be abundant, the rhino population would finally most probably restrict its own density by behavioral mechanisms, i.e. by intraspecific intolerance and avoidance, perhaps also by other regulation systems which control fertility. In any case, large scale management would not favour the rhino population but would only be regretful from an overall conservational point of view.

All these considerations lead to the conclusion that area management for the rhino has to be carefully timed and, if indicated at all, carried out in small steps combined with a careful and continuous survey of the rhino population and the ecosystem of Ujung Kulon as a whole.

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