THE JAVAN RHINO OF UJUNG KULON

An investigation of its population and ecology
through camera trapping

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INTRODUCTION

1.1 INTRODUCTION

Since the Pleistocene the megafauna that existed over much of the Americas, Africa and Eurasia has been steadily impoverished and today little remains. The Rhinocerotidae are some of the last examples of the great assemblages of large mammals that thrived until quite recently but now they are threatened throughout their range and in most places their numbers are down to levels barely able to sustain themselves. Of the five remaining species the Javan Rhinoceros, *Rhinoceros sondaicus* Desmarest , is the rarest and with the exception of a small population of maybe 15 individuals in Vietnam (Santiapillai et al, 1991) is known to exist only in Ujung Kulon National Park on the Western tip of the Island of Java in Indonesia. The Javan refuge is only about 30,000 ha. in extent and with a population previously estimated at between 40 and 60 individuals this last viable population must be considered as extremely endangered.

1.1.1 SAVING A VANISHING SPECIES

In order to make rational and workable decisions to ensure the long term survival of this flagship species much knowledge is needed on the current population size, ranging behaviour, population structure, and the sex ratio etc. This project is an attempt to apply a new technique , namely camera-trapping, to the problem of acquiring information about the population and ecology of the Javan rhino and to add to the knowledge contributed by several dedicated researchers (Hoogerwerf, Schenkel, Widodo, Ammann, Hommel, Haerudin and others), who spent many years in the park piecing together the ecology of this elusive animal.

Prior to this project camera trapping had rarely if ever been used on such a large scale to monitor an endangered species and it was suggested by Santiapillai and MacKinnon or WWF Indonesian programme that the information gained from this method (particularly, precise identifications of individual rhinos, clear records of physical characteristics, etc.) would strongly complement the work done by other researchers.

The need for a deeper understanding of the Javan rhino is growing ever more urgent as pressure builds from some quarters to remove them from the wild, and as alternative relocation sites to start founder populations become increasingly limited.

It has been agreed upon by the IUCN and PHPA that ultimately the number of Javan rhinos in the wild should be 2000, distributed over 10 to 20 different populations in secure areas throughout its former range. If this number is to be attained there is an urgent need to create viable strategies now in order to safeguard the Javan rhino's future.

1.1.2 THE AIMS OF THE PROJECT.

The primary aim of the project was to utilise camera trapping to assess the current situation of the Javan rhino in Ujung Kulon and to attempt to estimate the total population there. Apart from population estimates it was predicted that a great deal more information such as body size , sexual dimorphism, ranging behavior, sex ratio etc. would also be obtained from the work .
The results thus gained could act both as an independent comparison with previous research (since the data and approach are quite different for previous studies) , and as a source of knowledge not obtainable by other means.
In addition to the above, the acquisition of the photographs themselves was considered an important part of the project because with no Javan rhinos in captivity and with consequently very few photographs having been taken of the animals there was a great dearth of publicity material to use in generating public awareness about one the rarest animals in the world.

1.1.3 PREVIOUS WORK ON POPULATION SIZE

The first serious attempt to estimate the size of the population of the rhinos in Ujung Kulon was by Hoogerwerf in 1937 when he estimated the total number at 20-25 individuals, a figure that he later felt was slightly too low. In 1955 Hoogerwerf again made another estimate and this time came up with population of between 30-35 individuals.
After 1955 there seems to have been an increase in poaching activity in the park (Hoogerwerf 1970,) and by the time Schenkel came to take up residence in the park, the population was down to an estimated 24-25 individuals (Schenkel and Schenkel-Hulliger 1969). Curiously Hoogerwerf(1970) reports that he estimated the number in 1965 at between 15-20 animals.
Schenkel re implemented strict patrolling and protection of the park and his work has been attributed by some (Ammann 1985)) as saving the rhino from extinction. Schenkel undertook another census in 1978 and derived a figure of 25-26 individual rhinos.
Schenkel's method of censusing rhinos in Ujung Kulon relied heavily on an examination of tracks. And this became a standard method of estimating by the Ujung Kulon population both by other researchers and the park staff. A description of the method is given by Ammann (1985) :

"A number of groups each consisting of 3 to 4 men traversed the peninsula and the area east of the isthmus along transects which passed through all major geographical units i.e. the basin of all major streams, the central plateau Gunung Payung etc. . Transects did not follow a fixed compass bearing because this was considered too time consuming in certain types of vegetation or in mountainous terrain . To facilitate orientation the routes usually followed such topographical features as streams, mountain ridges or the coast. All participants were guards from the staff of the reserve (plus myself) and each group included at least one guard, who was known to be an experienced and reliable observer of animals tracks . All rhino tracks that were encountered were recorded by their measurements , age , direction and location. A census took three days to complete.

To estimate the size of the population only tracks approximately 36 hours old or less were counted with the exception of a few tracks which although older had not been encountered elsewhere within a radius of six kilometers, Such older tracks were not frequent however. To avoid counting the track of the some individual twice it was assumed that fresh tracks with equal measurements and found in location less than 2 km apart had been made by the same rhino: if they were more than 4 km apart two rhinos were counted. If the distance between the 2 tracks was between 2 and 4 kms they were counted as one or two rhinos. Thus for each census a higher and lower total resulted."

This methods made several assumptions.
1. That all tracks that crossed that transect would be visible by the team.
2. That the transects were close enough that a rhino would cross the transect at least once in 48 hours.
3. That the size of tracks in a given set (ie from one individual) would vary only slightly (ie less than 1-2 cm)
4. That the age of a set of tracks could be measured accurately.

A critique of this method will be addressed in the Discussion section later.
Ammann also used a method based on extrapolation of rhino densities in his study area between the Cibunar and the Citadahan rivers.
Using this method Ammann derived a number of about 70 individual rhinos in the park.

This technique also made some assumptions -
1. That the identifications of individual rhinos (and thus the study area density) using track measurements were in fact correct.
2 That relative densities of rhinos in the various parts of the park could be calculated from the track count censuses and that this variability in rhino density could be incorporated into the density extrapolation.

Subsequent to 1980 track count censuses were carried out during most years with the last one for which figures were published (Santiapillai et al, 1990) giving a figure of 52- 62

1.1.4. PROPOSED SOLUTIONS

A major problem estimating a population based on the track count method is that even if all the assumptions mentioned above are valid there is a limit to how many individual animals it is possible to discriminate on the basis of track width measurements only (van Strien 1985). A probable limit for discriminating between rhinos using track width measurements is about 50-60 animals . Thus if the population was actually higher than this number it would not be reflected in the census. The significance of this is very important as the numbers counted in the latest censuses were about this size.

Camera trapping, with its potential to finely discriminate between different individuals (many different criteria can be used from photographs of the animals to aid in identification) offered a possible alternative. Also, because the most logical way to utilize the information was to incorporate the data in *mark- recapture* calculations, it would offer a different approach to estimating the population. This would thus provide a comparison with the other method. A strong concordance in numbers between the two methods would strengthen confidence in the figures . A strong divergence on the other hand would stimulate a closer examination of the various methods and a critique of their strengths and weaknesses.

Selected vegetation types in the study area

The forests in the northern part of the study area are flooded in the wet season and ground vegetation is sparse. Such forest types do not support a high density of rhinos.

Rattan shrublands. Prime rhino foraging grounds.

This vegetation type covered extensive areas in the central and southern regions of the study area. Trails had to be cut to penetrate these dense thickets.

Arenga forest.
These forests covered much of the Telanca plateau and large areas of the north western plains.

Dune forest on the south coast. Behind this narrow band of fixed dunes, which stretched along much the south coast, ran an important thoroughfare for rhinos and many other mammals.

1.2 THE STUDY AREA

1.2.1 INTRODUCTION

Ujung Kulon National Park lies at the western end of the Island of Java and is made up of Peninsula Ujung Kulon (30,000 ha), the adjacent mountainous area of Honje to the east (about 10,000 ha) , the island of Panaitan to north in the Sunda straits (12.000 ha) and various other smaller islands (such as Peucang and Handeuleum) lying close offshore of the mainland. To the south lies the Indian Ocean. Although there is some evidence (Ammann 1985) that rhinos range a few kilometers east of the Karang Ranjang isthmus the great majority of rhinos in the Park (probably 95%) inhabit the peninsula of Ujung Kulon lying to the east. This area was chosen as the study area.

1.2.2. HISTORY OF THE STUDY AREA

The best account of the history of Ujung Kulon is given be Hoogerwerf (1970) and further information is provided by Hommel(1985). The history of the study area was punctuated by the massive eruption of Krakatau in 1883. This event was one of the most destructive natural phenomena in the last 2- 300 years and the sound of the eruption could be heard as far away as 5000 miles and the ash emitted spread around the world and is thought to have effected the climate in Europe in the following year. The impact of the eruption which was only 60 km from Ujung Kulon were devastating to the peninsula.. Tsunamis as high as fifteen meters swept the lowland areas and massive coral blocks can still be seen hundreds of meters inland on the northern plains of the peninsular. The ash that fell probably had a much greater effect on the present vegetation (Hommel 1985) and, indirectly, the fauna of Ujung Kulon

Before the eruption of Krakatau, most of peninsular Ujung Kulon with the exception of the Gunung Payung and parts of the Telanca plateau, was cultivated, with concentrations of settlements around the mouth of the Cibunar and Ciujung Kulon rivers and upstream of the Citadahan , Cibandawoh and Cigenter rivers. In the interior people carried on swidden type cultivation with the result that at the time of the eruption much of the land was deforested and some areas were even more exposed having been cleared in preparation for the planting the new rice crop. The effect of this was to render the open land unworkable for a long period and to slow down the rate of natural regeneration (Hommel 1985) . In addition most of the peninsular remained uninhabited after the disaster and those people that did return were subsequently resettled elsewhere by the Dutch government in response outbreaks of malaria and dysentery and frequent attacks by tigers(Hoogerwerf 1970). The outcome of this depopulation and the limited regrowth of vegetation was to make the area a haven for fauna - particularly the larger herbivores and the animals that preyed on them.

In the early 1900's word quickly spread of the excellent hunting to be had in Ujung Kulon and efforts were made to turn the area into a hunting reserve. This was reflected and instead in 1921 the Peninsula of Ujung Kulon was designated as a nature reserve offering in theory an even stricter protection. In practice little attention was paid to the reserve and poaching probably went on unabated.

Eventually, in 1937, the colonial government redesignated the reserve (including Pulau Peucang and Handeuleum and some land east of Karang Ranjang), as a game sanctuary which enabled a fully organized guard force to be established and links to be established between the area and the outside world. Hoogerwerf was sent to the reserve to collect information and to set up the infrastructure to manage it . This association lasted with interruptions due to sickness and war up to 1957 and resulted in the most complete work on the park yet written.

1.2.3. PHYSIOGRAPHY AND VEGETATION

Peninsular Ujung Kulon is roughly triangular in shape with its base (about 25 km long facing the bordering the Indian ocean. Most of the peninsula is low lying (ie below 200m) but at the western end Gunung Payung mountain range rises to 480m altitude. This range is heavily dissected and its western edge is characterized by numerous bays and rocky headlands. This region is covered in rich rain forest with numerous large trees(especially *Neesia* sp.) and on the lower slopes palm forests of *Arenga obtusifolia* . By contrast most of the lower lying area to the east is covered in modified vegetation - a legacy of having been extensively cultivated prior to the eruption of Krakatau in 1883 (Hoogerwerf 1971). According to Hommel (1985) the ash from the Krakatau eruption retarded the rate of regeneration of vegetation cover on areas of previously cultivated land and to this day large tracts of the peninsular are covered in dense thickets of rattan , *Lantana* etc. in a vegetation known as rattan shrublands (Hommel 1985). The steep hills in the Payung range with there intact forests withstood the impact of the ash showers better and no long term harm was done.

The area to the east of the Payung range slopes gently upwards from the low lying regions of the north west coast to the Telanca plateau which attains a maximum altitude of about 150m. Much of this plateau is covered in almost monotypic stands of Arenga palms but here and there are patches of older forest left untouched by the original settlers . The southern boundary of the Telanca plateau forms for the most part a distinct edge and in some places an escarpment , south of which the slightly dissected hills descend to the coastal plains. The hills are clothed in a mosaic of forest types, including the mixed forests dominated by *Bambusa blumeana* and extensive areas of shrub jungles. These shrublands are dense and difficult to penetrate but they offer

excellent forage for the rhinos, and are probably critical for their survival.
The Telanca plateau is separated from the Payung range by flat plains with the
exception of a narrow ridge of hills near Cikendeng.
The eastern part of the peninsular is for the most part flat and low lying and
bounds the sea for much of its length in extensive mangrove forests. The NW
coast by comparison is defined by an uplifted coral reef which forms a natural
barrier. The plains adjacent to this coast are clothed in mixed Arenga forests
in the west and in the north by *Lampeni* forest dominated by *Ardsia humilus*,
. According to Hommel(1985) these forests are a relic of the former extensive
man made savannas, created in order to increase the density of deer and other
wild game. Hoogerwerf (1970) writes that in the early 1930's there were
frequent fires as hunters burnt off the brush to produce better grazing for the
wild ungulates.
The beach on the south coast is separated from the hinterlands by a long ridge
which stretches (with a short break at Tanjung Tereleng and the mouths of
the Citadahan, Cikeusik and Cibandawoh rivers) as far as Karang Ranjang.
Most of the vegetation on the ridge is short and stunted and the side most
exposed to the sea winds is dominated by Pandanus trees.

1.2.4. CLIMATE IN THE STUDY AREA

The weather in the study area has been described in detail by Hommel (1985)
but can be summarized here as being basically similar to the climate existing
over much of the rest of West Java. This means that it can be classified a
tropical rain climate. Temperatures as measured at the lighthouse near Cibom
at the western most point of the study area average 26.3^o annually
(Hoogerwerf 1970), and this agrees closely with measurements taken by
Ammann (1985) from 1978-80 on Peucang island.

Rainfall can fall throughout the year but shows a significant reduction during
the east monsoon - a period from May through September referred to as the
dry season. Most rain falls during the North west monsoon. Some years are
very much drier than others and extend through to October and even
November. Such extended dry seasons were recorded by 1967 (Schenkel),
1982(Ammann), and by this myself in 1990 when the dry season finally broke
in late October.

1.2.5 FAUNA IN THE STUDY AREA

Hoogerwerf(1970) lists 233 birds as occurring in the peninsular Ujung Kulon,
which is about 50% of the birds listed for the whole island of Java(MacKinnon
1991). Thus the park is itself a very important refuge for avifauna.
A full description is also given by Hoogerwerf (1970) of the parks mammals
and reptiles and that is more comprehensive than the observations made

during the course of this study. In the table below a list is given for animals which were recorded by the camera traps. It is important to note here that the cameras were triggered to take exposures when the weight of a passing animals was greater than about 5 kilos, and the vast majority of passes were of animals heavier than this. However when the pressure mat neared the end of its life it would sometimes record lighter animals such as the civets, pangolin, otters, monitor lizards, mousedeer etc.

Table 1a. Species recorded by camera traps.

Common name	Latin name	No of Passes
Anteater	*Manis javanica*	1
Common Palm Civet	*Paradoxurus hermaphroditus*	3
Banteng	*Bos javanicus*	181
Barking deer	*Muntiacus muntjak*	75
leopard (Black)	*Panthera pardus*	34
Leopard (spotted	*Panthera pardus*	96
Leopard Cat	*Felis bengalensis*	1
Macaque	*Macaca fasicularis*	1
Monitor Lizard	*Varanus salvator*	8
Mousedeer	*Tragulus javanicus*	12
Otter(small clawed)	*Aonyx cinerea*	7
Peafowl	*Pavo munticus*	2
Pig	*Sus scrofa*	319
Porcupine	*Hystrix brachyura*	7
Rhino	*Rhinoceros sondaicus*	165
Rusa deer	*Cervus timorensis*	1
Wild Dog	*Cuon alpinus*	32

Several changes have occurred in the study area since Hoogerwerf's time. The Javan tiger *Panthera tigris sondaica* is now extinct. This has already been pointed out by Schenkel (1969), Hommel (1985) and was further confirmed by this study. From experience in Sumatra some of the most likely large mammals to be picked up by camera traps erected beside game trails were the large cats such as the tiger and the clouded leopard *Neofelis nebulosa*. In Ujung Kulon the experience was similar with leopards being the fourth most commonly recorded animal. Many of the camera locations were in areas that in the past were prime tiger habitat and would be expected to capture any tigers in the vicinity. The fact that no tigers were recorded is very firm confirmation, if any were still needed, that the tiger is extinct.

Leopards *Panthera pardus* would seem to be much more common than previously. Hoogerwerf (1970) remarked on their scarcity in the years just before and after World War 2. Other researchers beginning with Schenkel (1969) considered them fairly common. In addition to the high numbers recorded by the camera traps, leopards were seen by the field team on 5 occasions, and on one of these incidents the leopard rested for some 15 minutes on some rocks near the mouth of the Citadahan river in full view of two team members, who observed the situation from just across the river. Of

the visual sightings two were black variants and the remainder were spotted. This compares well with the results of the camera traps with black individuals appearing 34 times and the spotted variants 96 times. This probably reflects the actual proportion of black to spotted phases in the Ujung Kulon population. If so then this would be a much higher proportion than in Africa and India where the black colour phases are rare but less than in West Malaysia where according to Tweedie(1978) the black leopards far outnumber the spotted ones.

Banteng *Bos javanicus* were considered by Hoogerwerf to be concentrated around the grazing grounds and manmade savannas of the north coast and to a lesser extent on the south coast. This was not supported by the findings of this study which recorded Banteng in almost all areas of the park except the tidal swamps in the east of the study area. They were able to utilize areas where rhinos were rarely found such as the dense bamboo forests of *Shyzostachyum* sp. Similar findings were reported by Hommel (1985) and supports the work of Halder(1975) who concluded that Banteng were less dependent on grasslands than had previously been suspected.

A species that is almost certainly more dependent on open grasslands than the Banteng is the Rusa deer *Cervus timorensis*. These animals were observed only twice by the team (Nyur 2 , Cidaon 2) and only once recorded by the cameras traps(A male and female near the south coast). They must therefore be considered to be very rare on the mainland- a situation quite different from Peucang and Handeuleum islands where they are still plentiful. Hoogerwerf (1970) reported counting 115 different individuals in during July 1955 on three grazing grounds on the north coast, and 84 individuals in the same areas in September of 1953. So clearly deer were much more common in the past. This might be attributed to the greater areas of open grasslands in the in the years before 1945. These have since been replaced by scrub and secondary forests and offer little in the way of grazing.

In comparison to the changes in the Banteng and rusa deer numbers, the wild pig *Sus scrofa* and the Barking deer *Muntiacus muntjak* seem to exist in similar densities to those recorded by other authors with the wild pig the most commonly recorded large mammals in the study area.

During the duration of the study we never visually sighted dhole (adjak) but they passed the cameras from time to time. It was difficult to judge the size of the groups because only one animal would trigger the camera while other members of the pack might be out of field of view of the camera. However groups with as many as 5 individuals in the camera's field of view were seen and the packs may well have been bigger, The average number of dogs visible per pass was 1.4. This is slightly higher than in Leuser National Park where the maximum number ever recorded at a location was 3 and the average number per pass was 1.

A completed camera set up .
The rudimentary camouflage
was sufficient to make the
equipment appear natural to
animals.

The location of each camera was determined
using a GPS receiver. This tool could give an
accuracy to within about 60 meters. Because
the satellite signals could not penetrate the
dense vegetation an assistant had to climb to
the top of the forest canopy to get a fix.

Laying a pres-
sure mat. Set in
a shallow
depression and
covered with
topsoil and
leaves, the mats
were adjusted to
trigger the
cameras when
an animal
heavier than
about 5 kgs
stepped on
them.

The equipment had to be carried through the forest on foot to
all locations. Because of the logistical difficulties it took some 3
months to set up all the cameras.

METHODS

2.1 CAMERA TRAPPING AS A CENSUS TOOL

There are several problems in studying rainforest animals. Perhaps the most acute is the fact that they are so difficult to observe. The limited visibility, the natural wariness of the animals and the fact that many are nocturnal all combine to make efforts at observing the animals in a natural situation almost impossible - or at least so rare that the data obtained is of little use in a systematic scientific study.

In Ujung Kulon with large areas under very dense secondary vegetation the situation is even more difficult and in the case of the Javan rhino which is already rare the animal is so seldom seen that most previous work relied on indirect evidence such as feeding signs, droppings, analysis of tracks, urination patterns and vocalisations. Schenkel (Schenkel and Schenkel -Hulliger 1969) reports that in 250 days of study in the field he encountered rhinos on 27 occasions and on some of these encounters the animal was not even visible. On many of the events the observations were of only a few seconds to a few minutes duration. and on only 4 occasions was he able to observe the animals longer than 15 minutes. Amman was able to observe then 8 times in 4 months, and half of these observations were very brief. Both authors felt that merely the act of observing the animals at the short distances demanded by the nature of the vegetation could affect the behavior of the animals and so the observations were of limited value. Thus trying to base a scientific study of rhinos using visual observations alone is clearly impractical just as it would be for leopards, tigers, serow and several other large mammals that are seen even less frequently.

Direct observations, and the tracking that leads up to it, is roughly analogous in hunting terminology to stalking. Such a hunting technique is particularly suitable for savannas and large open areas that offer a clear and distant view of the prey. In most of the worlds forests however and particularly in the tropical forests trapping is the preferred method of securing game. For the same reasons camera trapping is a preferable technique if many observations are required

Originally camera trapping was developed as a way of obtaining records of elusive animals, but as the equipment has become more reliable and less bulky the technique it has reached the stage where in certain cases it can provide an alternative method of censusing rarely observed animals

The basic concept of camera trapping is to set up a camera beside a game trail in the expectation that any animals (say over a given weight or height) that pass that way will be recorded. Unfortunately the chances of target species passing can be quite rare. For rhinos in Ujung Kulon, for instance the rate was between one per 50 - 60 days of continuous operation. So, obviously , it would take an inordinately long time to develop a usefully large data base. To optimise the method, therefore, requires the use of many cameras and in the case of Ujung Kulon as many as 34 were operating during the peak of activity, or an average rate of capture of one rhino about every five days.

Schematic of Camera Trap
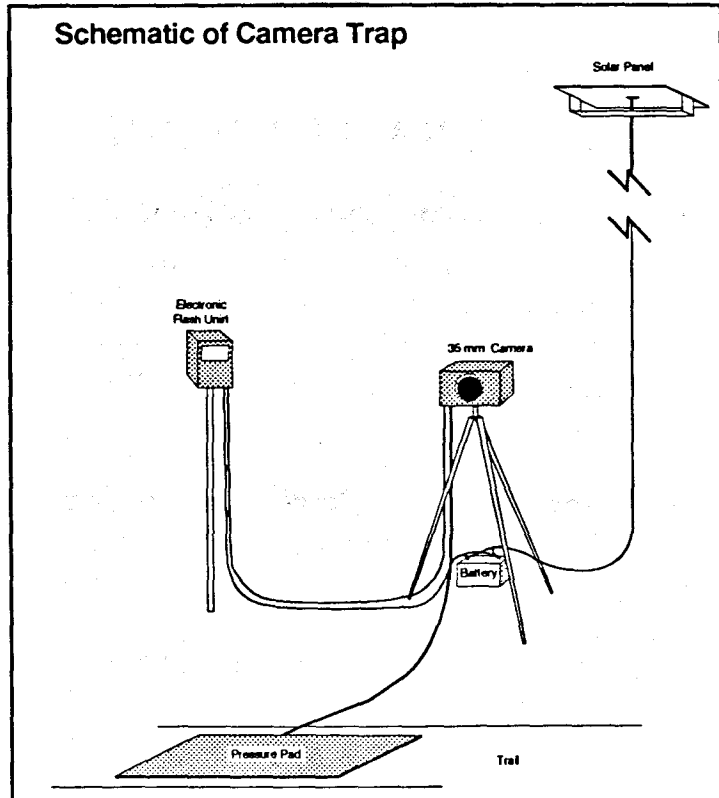
Fig 2a

Having established that it is possible to frequently record the target species the question remains as to how the data should be used. There are at least two possibilities. The first is to take the analogy of trapping a step further and design a camera trapping program along the lines of the well established technique of *mark-recapture* census method. The second utilizes data of individuals passing more than one camera location . If enough camera locations are passed by an individual it is possible to get some idea of its range size. If there are enough cameras it should be possible to generate a fairly reliable measure of the home ranges of adults of each sex. Then by extrapolating these figures to the entire study area, (taking into account the variability of habitat suitability), it should be possible to derive a figure for the whole population.

Both the above methods rely heavily on accurate identification of individuals (rf. 1.5 below). Identifications are particularly easy in the case of the large cats which have characteristic patterns of spots or stripes contrasting clearly with a softer background colour. In some animals such as barking deer and wild cattle where the animals have an essentially uniform colouring it is extremely difficult . For Javan rhinos it proved possible by comparing a combination of characteristics - skin pore patterns, pigmentation patches, horn morphology, scars, deformations etc. Because of the importance of correct identifications to all other calculations and conclusions, a great deal of effort was spent on correctly identifying individuals.

An important question to ask at this stage is - does camera trapping have any influence on the target species? ie does it modify the behavior of the animal? A test carried out in Leuser Park on Sumatran rhinos and tigers attempted to establish what impact camera and flash angles would have on an animal's behavior. Two cameras were positioned 20 meters apart on a very well used and clearly defined game trail. For three months the cameras angles were adjusted to photograph the animals from the side and for another three months the cameras were readjusted to photograph the animals almost head on. In each case the distances of camera (3.5 meters) to subject were kept the same. When the animals were photographed from the side, both the rhinos and tigers passed by both cameras and returned on subsequent visits. When the cameras were readjusted to photograph the animals head only one animal (a male tiger) passed by both cameras. This was taken as evidence that cameras set to photograph from the front could affect animal behavior at least temporally (when the cameras were reset from the side the same individual animals were recorded passing again). but that when cameras were set from the side at distances of at least 3.5 m (the cameras at Ujung Kulon were set up at 4m) the effect on behavior is negligible.

Carried a step further the non-intrusiveness on camera trapping in relation say to direct observations by observers in the field , and the fact the cameras can be operated around the clock and are not subject to judgmental biases that can affect human observations, means that certain behavioral traits can be ascertained. Particularly useful is the information regarding daily activity patterns . Although the data backs of the cameras were set to record the date only, the time of day could be roughly estimated on the basis of lighting , at the very least into nocturnal, diurnal and crepuscular. On occasion these periods could be further subdivided on the basis of lighting angles and shadows when the orientation of the cameras was known. This information could be very useful when assessing the time between the passage of two different individuals on the same day - and proved useful in the rhino census in deciding whether there was any interaction between two different animals successively passing by a given camera location.

Another feature of the camera trap method is that it is possible to study a photographed individual in great detail - photographs do not move! It is thus possible to make measurements of the animals dimensions to assess the health of the individual and to examine it for wounds and even diseases of the eye. In animals that do not exist in captivity this collateral information gained during a camera trap census can be very useful and partially offset the high cost. Implicit in the permanency of the image is that the data base can be examined by other investigators.

No method is perfect and camera trapping is not as effective as say radio tracking for delineating an individual's home range and ranging behavior.

However when used in conjunction with other research tools camera trapping can be exceptionally useful. One possibility is to set up a camera trap program prior to a radio tracking exercise. It would then be possible to identify those animals that would be most interesting to collar and in knowing where to find them. This would avoid a great deal of wastage from say collaring a small number of rhinos which were, for instance, all males.

The major disadvantages of camera trapping are expense, logistical constraints and time. It is conceivable that with improvement in technology the price per unit will fall. Technology might also help to reduce the size and weight of the equipment. The weight per unit for the Ujung Kulon census was 15 kg's. When it considered that in addition to bulky camera equipment, the men must carry food and shelter as well, and over sometimes very difficult terrain through dense vegetation, through flooded rivers, and frequently in heavy rain, the logistical problems multiply rapidly and it demands very careful planning to ensure the such a project goes smoothly. In Ujung Kulon all the equipment had to be brought in by boat and offloaded sometimes in heavy surf to be carried ashore. In order to minimise loads food caches were dropped (at the beginning of each expedition) at strategic points on the coast. The only way to shorten the time would be to install more cameras but this would create more expense and would add the logistical difficulties. If money was of secondary to speed of execution it would be possible to increase the manpower and to divide a study area in sub regions serviced by separate teams.

Conclusion.
Camera trapping can be very useful as both a census tool and as a means of obtaining information acquirable in no other way. It can compliment the data obtained by other means such and radio tracking and field observations, but because of its expense and the difficulty of successful implementation it should only be a first choice if
- the species to be studied can not be observed in any other way.
- the species is highly endangered.
- information other than that obtained by other means is considered necessary to ensure the survival of the species.
- there is sufficient financial backing.

2.2 INSTALLING CAMERA TRAPS IN UJUNG KULON

2.2.1 A BRIEF DESCRIPTION OF THE EQUIPMENT.

The cameras used in the study were 35 mm format Nikon 601 which I specially adapted for this project. The cameras were equipped with data backs for recording the date and were secured inside waterproof housings and connected to an external electronic flash which was place slightly less than a meter to one side of the camera. The flashes were powered by 6v batteries which in turn were charged by a 6 volt photovoltaic panel. The cameras were triggered by a pressure mat buried to a very shallow depth (about 1 cm) below ground. The covering of the pressure mat was made to look as natural as possible and the cameras were camouflaged using greenery plucked from nearby plants. Although most of the animals did not appear to be alerted by the presence of the camera. many were alerted when the camera and flash fired. Even then it was the sound of the camera shutter mechanism rather the light emitted from the flash that sometimes attracted the attention of the animals. In the majority of passes the rhinos seemed unfazed by the cameras, as were most of the other animals. An exception were the wild dogs that were both curious and destructive and destroyed at least 3 camera set-ups during the course of the project.

2.2.2 LOGISTICS AND ACCESS TO SITES

With the exception of a path linking Cidaon to Cibunar the study area offered almost no easy access routes. Since the camera equipment was bulky and the heavy (15 kg's per camera) and had to be carried in on the backs of the field team the most practical way to reach the interior of the park was by blazing narrow trails. This was especially important in the shrublands of the central and southern parts of the study area where progress would have been impossible without cutting through the tangled and thorny vines. Transects, though on a slightly smaller scale, had been made by previous researchers such as Amman(1985), and it was found that the lightly marked trails quickly grew over and little evidence remained of their ever having existed. In fact during the study it was a probable, at times, just keeping the trails open. This was especially in the shrublands where growth was prolific and sections of the paths could be completely overgrown in just two months.

For simplicity and ease of navigation the direction of the transects were North -South and a total of five were made. Where alternative access routes (such as up a river or along a short patrol path) existed , the field team used these to reach camera locations.

2.2.3 SELECTION OF SITES.

The basic program called for setting up a grid work of camera traps that would cover the entire area of the peninsular. In deciding how many cameras to install in the field it was decided that the maximum number permitted by logistics would be 40. In fact this number was never obtained and 34 was the maximum that ever operated at any given time.
Although the initial plan called for placing the cameras on a geometric grid (to guarantee no ecological bias), it quickly became evident that this would be impractical for data collection. Instead a compromise was arrived at wherein a well used rhino trail somewhere close to the originally planned grid positions would be chosen for sighting each camera. On those occasions when a camera was set up away from a well used rhino path no photos of rhinos were obtained.

After the cameras had been in place for about a year it was decided to move them to new locations in order to simulate a two step mark -recapture programme. Because no further transects were permitted to be made it was decided to locate the cameras at locations accessible by river. This did not mean that the new locations were beside a river in fact some were over 1 km away, but rather the rivers functioned as access routes and the cameras were placed where promising rhino paths were to be found.

The critical question to address at this stage is how random were the locations of the camera traps . This is important because an important prerequisite for the mark recapture method is an essentially random emplacement of the sampling points (or traps). This issue is dealt with in detail in section 3.4.2., but the conclusion is that if a sub region of the study area that excludes most of the Payung range and the northern tip of the peninsula the cameras are effectively located at random.

2.2.4 INDEXING THE FILMS.

After each camera was set up the film was indexed by taking an exposure of a member of the field team holding a card (showing the name of the location) and a survey pole (for later use in measuring the rhinos photographed at that location). Special care was taken in ensuring that the survey pole was held exactly parallel to the film plane to avoid any perspective distortions.
Films were collected every 4-6 weeks and, after developing, the rolls of film were cut into strips of about 5 exposures, inserted into plastic sleeves, and stored for later analysis.

2.2.5 ANALYSIS OF THE FILMS

Although several techniques for studying the films were tried - including the use of enlargement transparencies (4x5"), prints from the original slides etc. , the most practical way was found to be the direct examination of the original 35 mm transparencies with a 10x magnifier using a light box for background illumination. This afforded sufficient detail to see features as small as the skin pores of the rhinos and at the same time allowed direct comparison between several different transparencies and to assess similarities or differences. .
The date of all exposures were noted and where possible the time of day. The date was imprinted on the film by the data back and the time of day could be deduced by the quality of lighting. For simplicity the days were divided into night (no back ground light), day (subject visible in the repeat unlit exposure), and crepuscular (subject too dark to see in repeat exposure but back ground light still visible). In fact it was possible in many cases to make even closer guesses of the time of day a photo was made using the direction of light. However, this was not included in the primary data base. All species were then identified and noted, along with the direction of travel. Usually this was either right-left or left-right, but occasionally animals would approach or walk away from the camera.
Where possible the sex of the animals was noted and the number of animals in a single exposure was also recorded. After having done this the rhinos were then further analyzed, the most important exercise being to identify the individual. Considerable time was been spent on this because all future calculations based on the field data depend on the validity of the identification of the individual rhinos.

2.2.6. IDENTIFICATION OF INDIVIDUAL RHINOS

Several criteria were used to differentiate between the rhinos and before a decision could be made about an individual's identity, several features had to be in accordance. Particularly important were those features that could give information that would link two profiles of the same animal. Since the majority of the photos showed side views of the rhinos, extra care was taken in examining those features that could be either viewed from either side (such as the ears) or features that were effectively the same when viewed from either side (the horn , the dorsal edge of the neck plate or deformities in the tail). A more complete description of the identification criteria are given below.

2.2.6.1. Size
This was gauged by comparing the size of the animal with the measuring pole photographed on the index exposure *on the same roll of film.* i.e. at the same camera to subject distance. The comparison was made using an adjustable pointer on a scale engraved on the base of the 10x magnifier. Care had to be

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Selected Features Used in Identification of Rhinos

Tear

III | II

IV | I

Cut

Ear Morphology

Horn Height

Neck Plate - Dorsal Edge

Trailing Edge of Neck Plate

Neck Plate

Cheek Profile

Neck Folds

Permanent Scar

Skin Texture Pattern

Facial Wrinkles
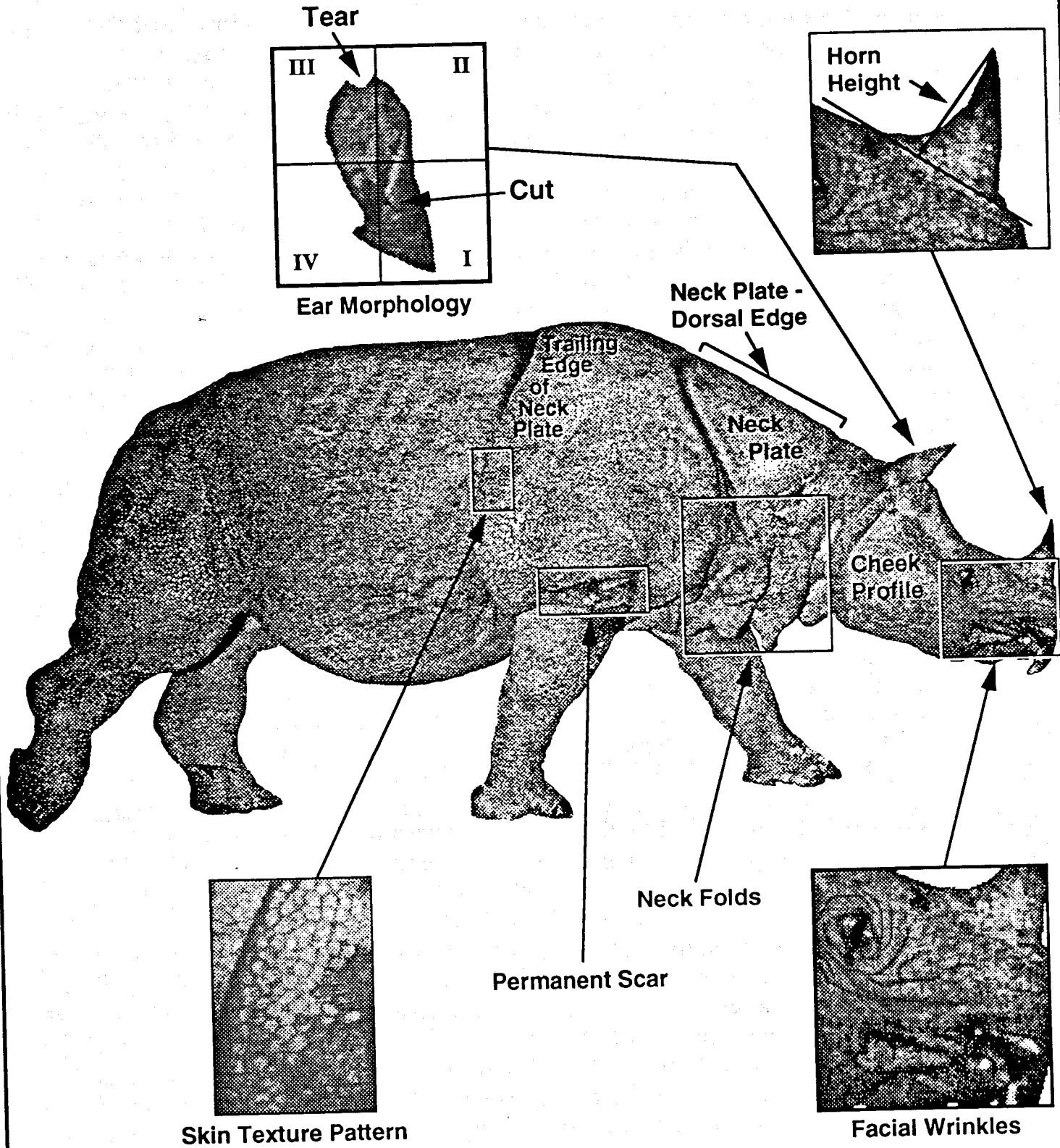
taken to ensure that perspective errors were minimised. For instance the shoulder height of a rhino might vary between plus and minus 5 cm for an adult shoulder height of about 140-cm . Only those rhinos whose shoulders were roughly above the center line of the pressure mat were measured. Typical parameters measured were shoulder height and horn height. The horn height was determined by measuring the perpendicular distance from the basal line of the horn to the tip. Strictly speaking this was shorter the actual length but using this measurement ensured greater consistency. Body length proved an unreliable parameter because of distortions inherent outside the central part of the camera's field of view and because of apparent shortening when the animal was not exactly parallel to the plane of the film. Because of a perceived risk of distortions caused by small perspective changes, body and horn sizes were not used in the initial differentiation phase. Later, only those photos that showed undistorted views were utilised for size measurements. When these were analysed they proved very useful in providing confirmation of the identifications made on the basis of other features. (see Discussion)

2.2.6.2. Horn shape
This was difficult to quantify but the horns were characterised according to shapes which were given codes. Typical shapes were; double convex (cone), double concave(funnel), and high convexo concave (tower) medium high convexo concave(classic), low convexo concave (rosethorn), etc. Additionally special characteristics such as deformities, steps, colour patterns etc. were noted. The use of horn shape in differentiating rhinos was particularly useful in that the shape is essentially the same when viewed directly from either side. This bilateral symmetry also provided one feature which assisted in determining whether two profiles represented one animal or two.

For the purposes of this study , when the face of the rhino was not exactly parallel to the film plane the horn shape could not be used as a diagnostic feature on account of apparent distortions in horn shape. Inexperience in understanding distortions such as this during the earlier stages of the project led me to produce a consistent overestimate of the number of individuals.

2.2.6.3. Facial wrinkles
Each rhino has a unique pattern of wrinkles around and in front of the eyes. The resolution obtained in the photographs was sufficient to differentiate between faces providing that the view is the same and the lighting similar. In the relocated cameras particular attention was paid to standardizing the orientation of camera and flash.

2.2.6.4. Neck folds
Considerable practice is required to differentiate rhinos on the basis of neck folds because although each rhino has distinct folds the shapes can alter as the head moves relative to the rhino's body. This extension or compression of the folds is rather similar to a concertina and the way in which the fold shapes

change must be well understood before making final judgments. Where the head was in line with the rest of the body (the situation in the majority of photographs) then direct comparisons could be made.

For practical purposes it proved sufficient just to describe the anterior neck fold and in particular whether it was continuous or broken. In certain cases a node or nodes were present where the posterior neck fold joined the neck plate and this proved a useful determinant in differentiation. Additionally the posterior neck folds on a few rhinos had highly characteristic sub folds giving a ropey appearance. In such cases this was used to help in differentiating between similar rhinos

2.2.6.5. Skin pores
Like fingerprints in humans the arrangement of skin pores/or cells on the body of a rhino are unique, and generally the photos taken in the field had sufficient under resolution 10x magnification to directly compare the pore patterns of one animal with those of another. Although this proved useful in certain cases (and it was a very positive method where applicable) it was limited by the ability of the human eyed to compare large numbers of pores. Hence the method could only be used when there were small areas of skin showing very easily recognisable patterns of pores. The most useful place to look for pore patterns was the shoulder plate. In most cases the lighting was strongest here and the view was almost invariably unmasked by extraneous vegetation. Each pore pattern was given a lettered code

2.2.6.6. Scars
Many of the rhinos photographed had deep wounds or scars, the largest of which persisted for several months and were thus useful in identifying individual rhinos over limited intervals of time. This usefulness is proportional to the freshness of the wounds but in some cases, where the scars remained visible for over a yea, the features proved invaluable in identification. Scars and wounds are particularly frequent around the trailing edges of the shoulder and abdominal plates. Lesser wounds and scratches are frequently seen on the sides of the abdomen and shoulder plate.

For the purposes of this study the trailing edges of the shoulder plate and the abdominal plate were divided into lower and upper halves and the scars were referred to as respectively, *nicks* (for small indents) and *scars* for the larger ones. The scars were further described on the basis of their orientation - e.g. ascending posteriorly.

2.2.6.7. Neck plate profile
As in the case of the horn, this feature could be used to identify individuals irrespective of which direction the animal passed the camera location. Most neck plate profiles are regular - ie straight. But in a few cases the profiles are

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wavy or even stepped (possibly a result of previous injuries). In at least three cases the analysis of the neck profiles enabled differentiation between otherwise similar looking individuals.

2.2.6.8. Cheek profile.
In certain cases the shape of the posterior edge of the Jaw or cheek could be diagnostic but because the shape is very dependent on the angle of the head relative to the camera this was at best a further check on identification rather than an independent criterion.

2.2.6.9. Ears
Because both ears could frequently be seen independent of which direction the animal was traveling examination of these features were given high priority . Two criteria were used to aid in differentiation - the attitude of the ears and deformities . It became apparent early on that rhinos that were similar in all other respects (ie the same individuals) held their ears in characteristic attitudes. Most were held erect or backward flush with the head and in such cases this normal attitude was considered to be non diagnostic. In four cases however one or other of the ears seemed unable to be held fully erect and in one individual, Heidi, both ears were unable to be held erect. The lack of erectness was described as *slightly depressed* or in more pronounce cases *depressed.*

In the case of deformities each ear was divided into 4 quadrants I, II, III, IV and the deformities were described as cuts, or tears. By describing an observed deformity and locating it in a numbered quadrant an unambiguous description of each ear could be made. These were based on a method developed by Mukinya (1990) in East Africa with black rhinos

2.2.6.10. Pigmentation patterns
Several of the rhinos observed had light coloured skin patches that were presumably the result of lack of the normally dark skin pigment. These patches were mostly seen on the abdomen and the legs and remained essentially unchanged throughout the period of the project.

On all animals it was also seen that the skin between the lower part of the shoulder plate and the abdomen and the lower part of the pelvic plate and the abdomen was lighter coloured than the surrounding skin, and also showed distinct patterning with darker bands running though the lighter coloured background.

Thirdly small light coloured patches with distinct shapes were usually visible between the neck folds. These changed slowly over time but were useful in differentiating or comparing rhinos in pictures taken less than about 9 months apart.

All these types of pigment patterns proved to be some of the most useful features to aid in identification of individual rhinos, and were especially useful in those cases when the head of the animal could not be seen.
For each rhino each of the three types of pigmentation patterns if visible were given a coded description.

2.2.6.11. Sex
Knowing the sex of a rhino was useful in reducing the number of possible options of which individual an unknown animal might be. Sex was positively determined by the external genitalia(in the case of males) and by the presence of a calf (in the case of females). As the project proceeded it became evident that all known females did not have horns and males all had horns (at least in the Ujung Kulon rhino population) so we were able to assume that this secondary sexual characteristic was useful in determining sex when the primary determinants were not visible.

2.2.6.12. Other features
In the most commonly seen individual ,Chisel, there were two additional features that were highly characteristic and specific to this animal. One was a wavy trailing edge on the right shoulder plate , when in all other instances the shoulder plate trailing edges were smoothly curved. The other feature was the shortened tail of this individual . The tails of all other rhinos observed ended in a rounded tip with a complete fringe of hair. Chisel's tail was shorter than all other adults in relation to its body and ended in square tip with no hair in the terminal edge.

2.2.7 USING THE CRITERIA.

Because of the possibilities of distortion when a feature was not in its usual orientation or was either at the edge of the cameras field of view or very close, I used in the vast majority of cases multicriteria to come to a decision as to the identity of an individual. A typical analysis would involve examining all the visible criteria mentioned above and if at least 4 were the same between two photos then the two images would be recorded as being of the same individual. In a few instances where features were uniquely diagnostic less than four features were used to confirm an individuals identity.

2.2.8. INDIVIDUALS IDENTIFIED

On the basis of the above criteria a table was compiled listing coded descriptions of all the and key criteria for each rhino. Characteristic and highly diagnostic features were then shaded in. A quick glance at this table in Appendix(///) reveals distinct patterns like bar codes for each individual identified. This illustrates that not only are the features different for each

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rhino but that the combination of characteristic diagnostic features for the rhinos are different also. This would show that the differentiations are indeed natural and real.

Further evidence supporting the validity of the identifications is discussed in section 4

Sex and age characteristics in Javan rhinos

Very young calf with mother:
Note: The extended nipple in this lactating female.

Adult female and calf.
Note : The diagnostic depressed ears in this individual, Heidi. *This female and all others accompanied by calves were hornless.*

Sub adult (male)
This rhino was called *Patch* on account of the large light pigment area at the rear of the abdomen on both sides.
Note: The very small horn, the thin neckfolds and the slight build in comparison to the adult below.

Adult (male)
This individual, *Chisel*, was the most commonly recorded rhino during the project.
Note: The rearward curving penis . When visible this feature was used to determine an individual's sex.

Javan Rhinos, Ujung Kulon
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SECTION 3
RESULTS

3.1 BIOLOGY OF THE JAVAN RHINO

3.1.1. GENERAL DESCRIPTION OF THE ANIMAL

The Javan rhino of Ujung Kulon is most similar to the Indian rhino in
appearance in that it carries only a single horn (in the male) and has a similar
arrangement of skin folds or plates. A distinct difference however is that in
the Javan rhino the neck plate is a single entity whereas in the Indian the thick
skin covering the upper surface of the neck is a continuation of the shoulder
plate. The skin is of both species is coarse and divided into numerous but
clearly visible cells giving a rough texture. In the Indian rhino these sells are
shaped like convex tubercles and have the appearance of rivets, In the Javan
rhino the texture is more uniform and each cell (referred to in this text as
pores) are shaped like small polygons. The upper lip of the Javan rhino is
pointed and extends below the lower lip. It is prehensile and well adapted to a
browsing lifestyle. The tail which is fringed by hair on the ovate tip extends
down to about the rear ankle ..

For a more complete understanding of the physical appearance of this animal
refer to the colour plates on pages 20A and 39A.

3.1.2 SEXUAL DIMORPHISM

3.1.2.1 The horn
At the beginning of the project there was some uncertainty as to whether
females might also have horns. Schenkel (1979) suggested that since he rarely
saw hornless rhinos in the park(he saw 3 hornless animals of or 27 sightings
hornlessness as a sexually diagnostic feature would result in a heavily skewed
sex ratio. And since he believed this not to be the case he assumed that some
of the horned animals might also be females. Past evidence from hunting
records, museum specimens (where verified) and from the observations
suggest otherwise. The following records were collated from
Hoogerwerf(1970), Hommel(1985) Ammann (1985) and the results of this
study. Only unambiguous records were used.

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Bogor museum. Shot by de Sturler in 1914. I female , no horn
Sody drawing 1942 .1 female , no horn
Shot be Andresy (Sody 1941). 1 female, no horn.
Shot by Vernay , British Museum. 1 female
Sclater, Calcutta museum, I female, no horn.
Gentry, British Museum. 2 females, no horn.
Gelder. American Museum of NH. I female, no horn.
Amman. Observed . I female with calf, no horn.
Hommel. Observed/photographed. I female, no horn
Hoogerwerf. Observed. I female with calf . no horn.
Griffiths. Photographed 5 females with calves, no horns.

In addition to the above the evidence of males consistently having horns is also
born out by the results of this project. All but one horned individual (Kinko)
could be sexed by the presence of external genitalia , and all these rhinos had
horns. All confirmed females (ie those with calves) had no horns. Two
individuals (Dish and Diana) had no horns and were assumed to be females
as no external genitalia could be seen in photos in which the genitalia should
have been visible (had they been present) and the chances of two hornless
individuals being males (after all other animals had been sexed) was
vanishingly small

A summary of all these findings can be given in the table 3a below

	with Penis	with Calf or examined
Horn	14	0
No Horn	0	16

Table 3a.

The conclusion of this study is that the presence of absence of a horn is indeed
a useful diagnostic secondary sexual characteristic and that this feature is a
sign of sexual dimorphism

3.1.2.2 Neck folds
Although it appeared from the photographs that the males had thicker and
wider neck folds than the females it proved more difficult to quantify this as
the folds themselves are so irregular. As a rough measure the total depth of
the neck from the a line running through the dorsal edge of the neck plate to
the bottom extension of the posterior neck fold was compared with the facial

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length as measured from the rear edge of the jaw to the front of the 'nose'. Although this measure could measure a combination of neck thickness and neck folds it was considered representative enough of the trend in fold size to be computed and compared. The results give a very clear separation between the males and females and confirm the visual evidence, and support the view there is a certain degree of sexual dimorphism between males and females.

Fig. 3.a

3.1.2.3 Size
Previous authors have suggested that the female Javan rhino is larger than the male. Hoogerwerf(1970) suggested this on the basis of his observations of living animals though this must be treated with reserve as gauging the size of a solitary animal in the forest is a notoriously difficult exercise. Ammann(1985) also felt that it was possible that the females could be larger than the males. Measurements taken from the photographs give a clear separation between females and males with males being on average 7.8% higher at the shoulder than the females. This difference is not as great as that of the Indian Rhino with a difference of 25% in body size. Details of the body size of all age and sex classes are dealt with in the next section.

3.1.2.4 Conclusion
On the evidence of this study we can say that the adults of the Javan Rhino show distinct sexual dimorphism as reflected in the presence or absence of horn, the body size and the size of the neck folds. However the degree of sexual dimorphism is not as strongly pronounced as in the morphologically related Indian rhino and this may reflect a less strongly define dominance hierarchy.

3.1.3 BODY SIZE

The most useful parameter to compare body sizes proved to be the shoulder height. This part of the body, which was closest to the center of the photograph, was least distorted by the lens and thus offered an accurate

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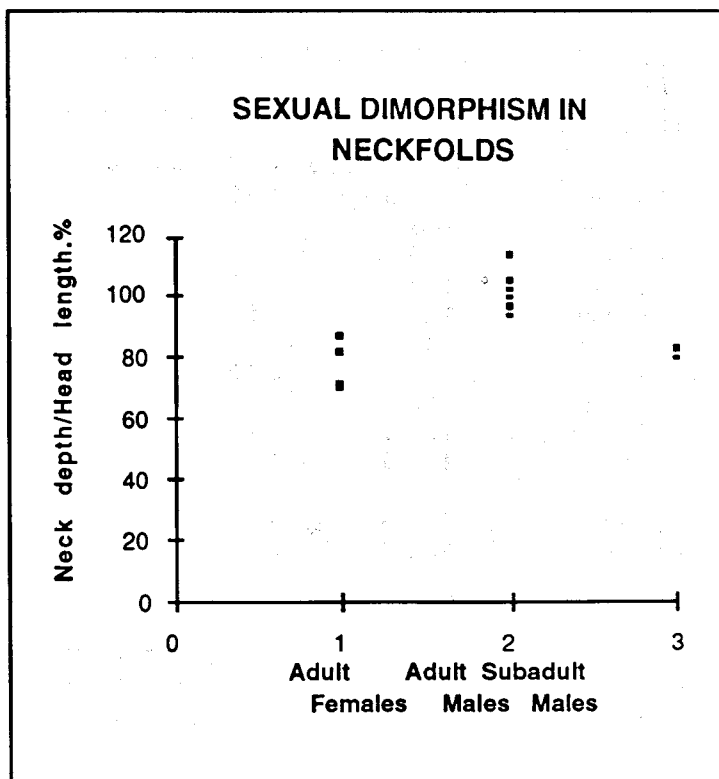
MEAN SHOULDER AND HORN SIZE (IN CM) OF MALES AND FEMALES						
	Shoulder Ht	S.D.	N	Horn Ht	S.D.	N
Atilla	150.3	1.26	4	17.3	0.58	3
Atlas	139.3	1.15	3	19.5	0.71	2
Blade	145	-	1	20	-	1
Boy	125	-	1	8	-	1
Chisel	148.0	1.00	3	19.3	1.15	3
Flattop	146.7	1.53	3	22.7	1.15	3
Haydn	143.0	0.0	2	14.0	0.0	2
Patch	113.5	2.12	2	4	-	1
Point	148	-	1	21	-	1
Roundhorn	138.0	2.83	4	10.0	0.0	2
Star	145.5	1.29	4	21.5	o.71	2
Batik	138.3	1.51	6	*	*	*
Freda	132.2	2.40	6	*	*	*
Heidi	133.5	0.71	2	*	*	*

Table 3b.

measure. It was a reasonable assumption that a higher shoulder height meant a larger body size.

The heights of various rhinos were measured by comparing the height of the shoulder with a survey pole recorded on the index photo on the same role of film and displayed in the figure 3.b.

N.B. 1 Non parametric analysis of variance indicates significant variation among individuals in shoulder height (Kruskal- Wallis, $H_{(df=11)}=36.20$, P<0.001) and horn size among males, $H_{(df=7)}=15.30$, P=0.018)

N.B. 2. There are also significant differences among age sex classes AdM-SaM-AdF: $H_{(df=3)}=8.17$, P=0.0017, using individual *means* as sample points

Median sizes ,   Shoulder ht

AdM   145.8

SaM   125.8

AdF   134.7

When the data were sorted according to shoulder height size the rhinos fell neatly into age and sex groupings. The smallest were the calves except Freda's calf which although still accompanying its mother was as large as the subadult male Patch. Interestingly Heidi's calf was about 111 cm high at the shoulder when last seen. The mother was seen four times subsequently alone and it was assumed that the calf had separated from the mother (unless it had died). This would tend to indicate that the size at which calves separate from the mothers is variable but probably takes place when the calf is between 83% and 89% of the parents size.

COMPARATIVE SIZES OF JAVAN RHINOS
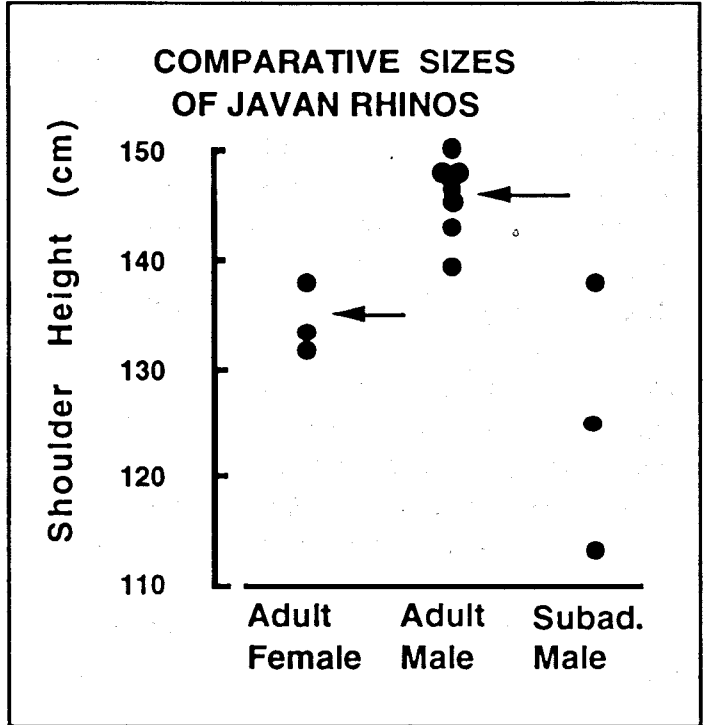
Fig 3b.

The next size group are the subadults. The two recorded in the study were both males and were characterized by short horns (4 and 8 cm respectively) relatively thin neck folds and slight build.

One individual, Roundhorn, also had some subadult characteristics ,such as small horn -10 cm, and incompletely developed neck folds, but its body was strongly built and tall enough (139cm shoulder height) to be considered intermediate between subadult and adult. However in order to preserve consistency in the calculations it was considered as a subadult throughout. Less tall than Roundhorn were the females Heidi, Batik and Freda (the other females could not be accurately measured).

Among the males there was no correlation between horn size and body size and no significant relationship between body size and home range size. This would accord with the work by Dinnerstein(1988) who found that in the case of the Indian rhinos the lower incisor teeth used in sparring were more important in dominance than body size or horn length.

3.1.4 ACTIVITY PERIODS

Most large browsers can potentially be active at all hours of the day or the night. Javan rhinos are certainly active by day as was confirmed not only by the field team but also by the observations of tourists and park staff during the course of the project. On three occasions a male rhino (most probably Atlas) was seen at the edge of the grazing ground at Cidaon and once on the beach at Citerjun. All the sightings were in the afternoon before 4pm. Our own direct observations (8 in all) were made between 8 am and 4 pm and the rhinos were either actively feeding or wallowing.

Notwithstanding these diurnal sightings the results of the camera-trapping indicated a propensity for nocturnal activity with the following breakdown according to the three time periods described above (section 2.2.5), 20% diurnal, 9% crepuscular, and 71% nocturnal (out of 162 passes). The two sexes were quite similar in their activity patterns.

Thus, the Javan rhino in Ujung Kulon should be considered to be most mobile at night In comparison with the other species of large mammals in Ujung Kulon, this is a high percentage. Why is this? First, we must note that this percentage refers to travel activity. If rhinos tend to feed away from the trails, the percentage recorded through camera-trapping will not accurately reflect the true activity period. However, it is unlikely that the pattern of an emphasis on nocturnal activity will totally disappear if this effect could be eliminated.

The results of my camera trap work in Sumatra show a similar pattern with approximately 80% of the passes of Sumatran rhinos being at night.
The natural question to ask here is, why? Most other large mammals in the rainforests of Sumatra at least show a very flexible approach to activity patterns with the large carnivores being slightly more diurnal than nocturnal and the larger herbivores spending a much of their time feeding and

It has also been shown that the large carnivores are more nocturnal close to human settlement than in areas of forest far away from man (Griffiths and van Schaik in prep.). Could this also be the case for the rhinos of Ujung Kulon? The amount of human disturbance in areas outside the eastern area of the park is actually slight with all human traffic using the trail between Cidaon and Cibunar and either the northern patrol route around the northern periphery or the beach on the south coast. So behavior modified by human disturbance in much of the park would probably not be a factor. It could be argued that in fact since much of the study area was secondary forest and shrublands that the rhinos would suffer less from the effects of irradiation whilst foraging by feeding in these areas at night.

Another possibility might also be considered - the ever present biting flies of the family *Tabanidae* . These insects and other smaller flies can be seen in clouds around rhinos and in fact on several occasions whilst near rhinos we were bitten by these flies themselves. Shortly after dusk these flies cease their activities and there are few insects that disturb one at night, except near the fresh water swamps in the north and the south coast where mosquitoes can be a serious nuisance.

It just may be therefore that rhinos also time the peak activity periods to coincide with the periods of minimum disturbance by insects and can lie up in mud wallows during the day when the flies are most bothersome.

3.2 DISTRIBUTION AND GENERAL ECOLOGY

3.2.1 TRAVEL PATHS AND TOPOGRAPHICAL FORCING

Like all wildlife, rhinos tend to follow the easiest routes when travelling. As a result, it is usually possible to recognize more or less well-defined wildlife trails in any given area. Camera locations were of course selected as much as possible along these trails. However, there is considerable variation in how sharply defined these trails are, depending on the extent to which topographical or vegetation features funnel animals onto certain pathways. This variability needs to be dealt with in a study like this one, where I will use passes to reflect the relative density in a certain geographic area or habitat type. At the outset, I knew that the camera locations were by no means random *relative to rhino travel* , precisely because they were selected as camera locations only if use by rhinos was observed or suspected. Indeed, the nature of this project made this a necessity. But it does mean that translating the observed pass rates into relative densities of use of the wider area surrounding the camera location should be made with caution. Thus, we must develop a way to factor out the effect of topography, so as to be able to measure the effect of the other, more interesting, habitat features.

In order to facilitate the factoring out of this "topographical forcing", I assigned each camera location to one of three categories:
(1) - no topographical constraints;
(2) - moderate topographical constraints, for example where there is a swamp on one side, or we have an ill-defined ridge;
(3) - strong topographical constraints, for example where there are clearly-defined game trails on ridge tops, near wallows, and near fording places across rivers.

It should be stressed that these designations were made independently of the numbers of rhinos passing through. As shown in Table AA, however, the effect of topographical forcing on pass rates of rhinos was quite considerable (X^2 (df=2)=107.47, P<0.001). In fact, where no topographical forcing was evident not a single rhino pass was recorded in 1259 camera days, despite the fact that the presence of rhinos near the camera location was known or suspected!

Effect of topographical forcing on rhino pass rates					
Forcing	N	CD	obs P	exp P	PR
none	7	1259	0	20.52	0
moderate	24	4451	40	72.55	8.99
strong	13	2388	92	38.93	38.53

Chi-square (df=2)=107.47, P<0.001

N=number of camera locations
CD= number of camera days
obs P= observed number of passes
exp P= expected number of passes
PR= pass rate of rhinos, passes per 1,000 days

Table 3c

It is clear that this strong effect of topographical forcing will mask any effects of other environmental variables, unless it is factored out. I have opted for the simplest possible way of doing this, namely by examining the impact of each environmental factor separately for forcing factors 2 and 3.

3.2.2. DISTRIBUTION IN THE PARK

Since the early work by Schenkel and Schenkel-Hulliger (1969) it is known that the rhinos do not use all parts of the park with equal intensity. And this is clearly evident from Figure 3c.

CONCENTRATION OF RHINO TRACKS IN 1967-68
(Schenkel and Schenkel-Hulliger 1969)
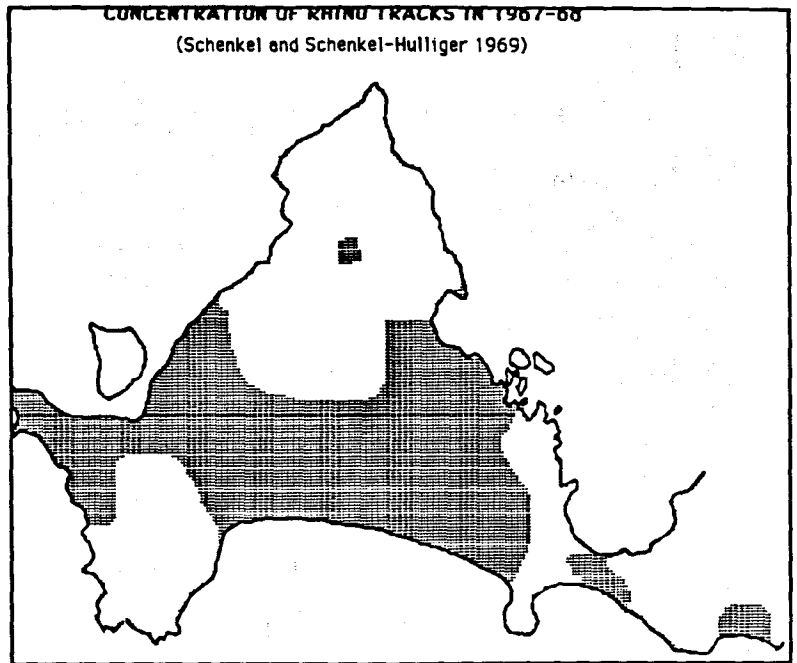
Fig 3c

A detailed compilation of all rhino tracks observed in Ujung Kulon between 1980 and 1983 (Sadjudin 1992) shows areas of concentration separated by areas of less intense use (see Figure 3d), and the concentration areas have different total numbers. Because these data were derived from footprint studies and not all of are equally suitable for this, and because the unused areas are, according to Sadjudin, traversed seasonally, we can conclude that rhinos occurred in almsot all parts of the study area, although perhaps at varying densities.

Distribution of Rhinos in Ujung Kulon c. 1990

Tg. Alang-Alang

Teluk Selamet Datang

Tg. Layar

Tg. Sanghyangsirah

Tg. Tereleng

Indian Ocean
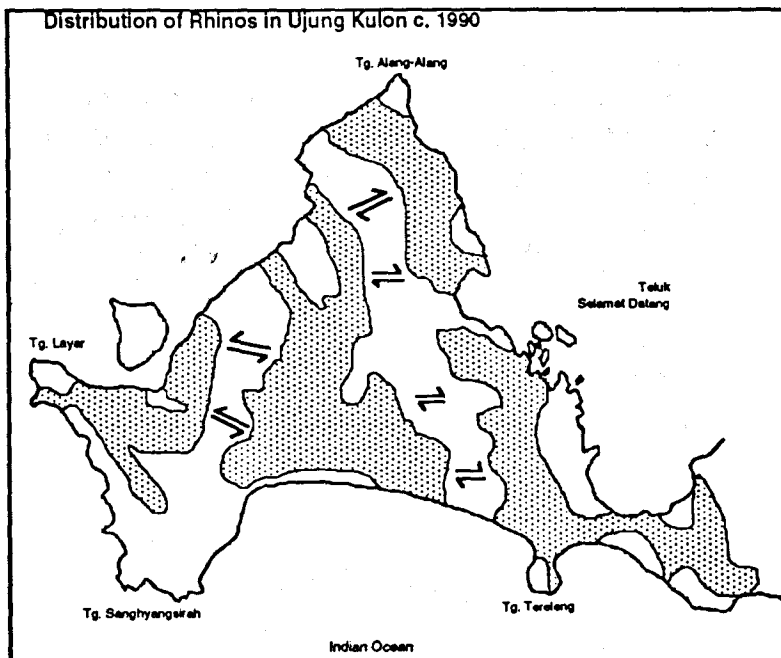
Fig 3d

The results of the camera-trapping do not confirm this pattern, if the effect of topographical forcing is taken into account. Since no rhino passes were obtained at topographical forcing = 1, we shall ignore those camera locations. Figure Y shows that rhino pass rates are highest along the south coast, intermediate in a broad belt through the center of the park and lowest in the north and east.

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It is possible that camera-trapping captures animals at somewhat different places and in somewhat different localities than a footprint study. So, it is not clear whether we are looking at a change in distribution in relation to the past, or whether the pass rates respond somewhat differently to ecological factors. Thus, both a historical and an ecological explanation could account for the observed uneven distribution. Here, we

Fig 3.e

will examine the historical explanation first, and the ecological one next.
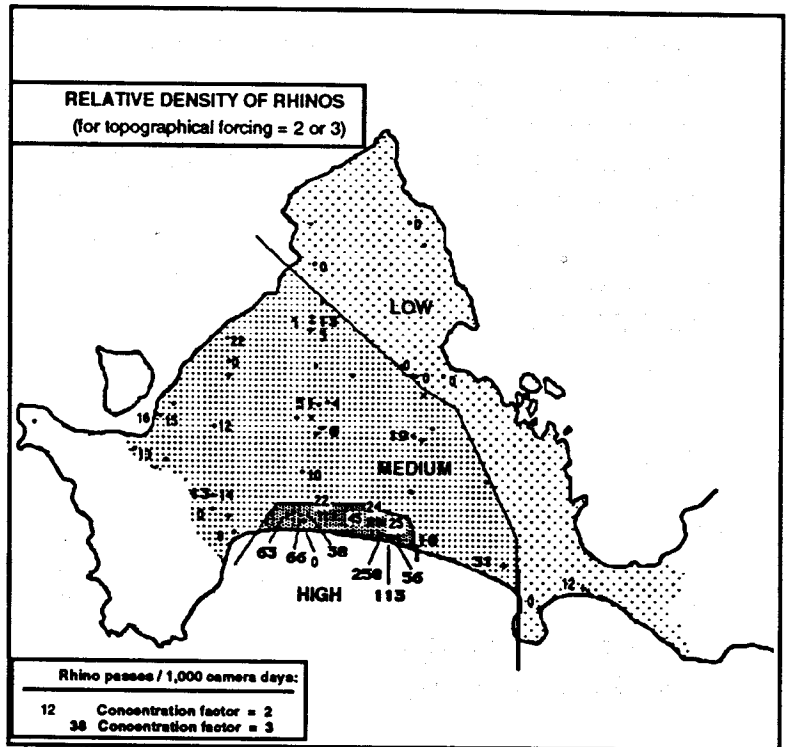
3.2.3 AN HISTORICAL PERSPECTIVE ON RHINO DISTRIBUTION

The distribution of passes in the 1991-92 period suggests that the north, east and southeast areas do not harbour many rhinos. In this general area, there are 5 locations with topographical forcing factor of 2, none of which registered rhinos. Likewise, direct observations by our team were concentrated in the south and west (Fig. QWA), even though all camera locations shown on the map were visited at approximately equal frequency (if relocated cameras and original cameras are considered together).

The distribution of dung heaps encountered during the changing of the films is shown below and agrees broadly with the direct sighting records.

Fig 3f

Thus, the situation in 1991-92 may have changed relative to that during the 1980-83 period when Sadjudin conducted his major surveys. During that same period, photographs of rhinos were obtained in the northeastern area by the Plage near Citelang and by Compost at the mouth of the Cigenter river.

Fig 3g

33
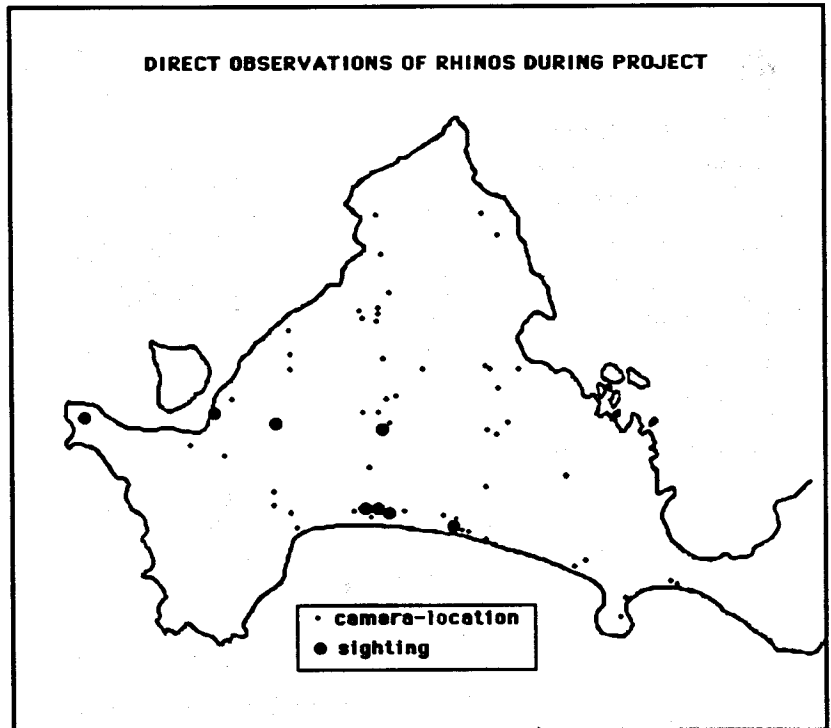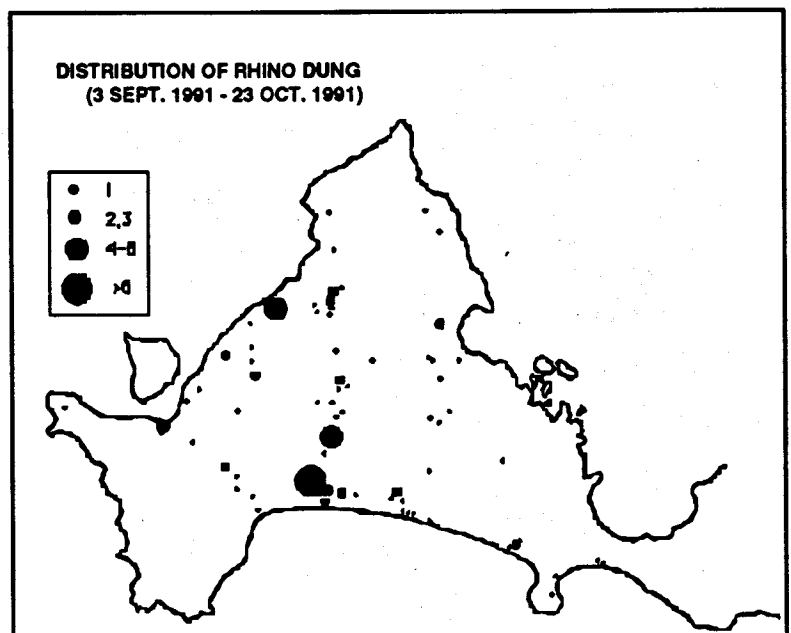
What could have caused this change?

Three possible causes come to mind.

First, the northeastern zone may be undergoing rapid vegetation succession toward a vegetation type unsuitable for rhinos. While the vegetation in this zone is somewhat different form that elsewhere in the park, there is no reason to assume that vegetation succession is either far more rapid or in a different direction than elsewhere.

Second, the disease that struck at least 5 animals in 1982 may have impacted the northeastern zone more than the other zones . However, in the 10 years that have elapsed since then, the area where the five observed rhinos died has been recolonised (Sadjudin 1992) so presumably the same would have happened to any other areas that suffered from the disease but went undetected. Another reason to doubt the impact of the disease that caused the deaths of the rhinos in 1982 is that it is difficult to imagine a disease that would be so limited in a small geographical area with such mobile animals (see Male home ranges 2.3.2). So we feel the incidence of past diseases has little impact on the present distribution in the study area.

This leaves a third possible explanation, namely poaching. In the 1980s at least 2 animals were killed by poachers (Santiapillai et al. 1990). During the last few years, the poaching pressure on rhinos has increased dramatically throughout its range (Martin 1991) and based on my own observations is also on the rise in Sumatra - especially after the price of rhino horn increased over 100% 3 years ago. Hence, it is not illogical to assume that this pressure has extended to the Javan species, and to examine this possibility of poaching in greater detail.

It is of course notoriously difficult to obtain reliable information on poaching pressure. Indirect evidence is therefore required. First, we can examine the distribution of informal human activities. One would expected people to enter the study area either by crossing the sea from the Sumur Taman Jaya coast , or overland through the Karang Ranjang ithsmus. And in fact, human activities are indeed concentrated in the northeastern zone and the south. Fishermen are frequently active both off the north and northeast coast and were seen to enter the rivers there. Evidence of banteng and crocodile poaching has been detected in the Cigenter river (Hodder pers comms) and camps were found by the field team at irregular intervals all along the coast between the mouth of the Citelang river and the mouth of the Cigenter and also deep inside the park on this side. Poachers could easily pose as fishermen and enter the area there without arousing any suspicion.

During the course of the study four cameras were stolen or disposed of. These cameras were well away from the park patrol routes and were in areas where the team had made efforts to limit any blaze marks. The people who removed the cameras were thus most likely determined and skillful people

entering the sanctuary zone of the park without permission. In one instance a potential poacher was photographed at a camera location west of Karang Ranjang. At the time this man was photographed it was dawn and during a heavy storm. It is possible that the man mistook the electronic flash for a bolt of lighting and could not hear the camera on account of the rain, and so did not detect the camera. It is fairly certain that the removal of the cameras was not done for personal gain since there were other cameras at locations much more readily accessible than the ones stolen. Additionally, one camera and housing was washed ashore several months after it had probably been thrown into the nearby Cibandawoh river.

On two occasions gunshots were heard. The first was by members of the Claborough family between the Cibunar and Citahadahan rivers. The second occasion was reported by Sadjudin (pers comm) who witnessed gun shots at the beginning of April 92 in the vicinity of Pemangangan between the headwaters of the Cihandeuleum and Cibandawoh rivers. On this occasion Sadjudin found campfires in the vicinity and found a mousedeer caught in a trap. two nights later he witnesses at least 3 men carrying heavy loads along the south coast at midnight. Somtime later rhino bones and pieces of rhino skin were found at a house in Taman Jaya Girang, but the owner fled and has not been seen since

In relation to the above the following facts are relevant . Kinko a large male whose home range included much of the south coast between Cibandawoh and the Cikeusik river was regularly recorded (times) between the 11 June 91 and the 26 March 92. After this date Kinko was not seen again in this area of very dense camera coverage depite the cameras operating up until the end of the project. Neither was he seen anywhere else. So either he moved to some area which the cameras did not cover (very unlikely) or else died. Since this individual was one of the largest in the park and showed no signs of ill health-it probably did not die of old age. It could have died of the same effect that caused the death of another male rhino near Kalejetan several months earlier, or it may have been poached. Because of the timing of the last observation of Kinko (end of March) and the gun shot poaching incidents at the beginning Kinkos it is highly possible that the two events were related and that Kinko may have been poached.

For the most part the distribution of human activity and the paucity of rhinos are nearly coincident, and we conclude that the circumstantial evidence seems to indicate that poaching may have taken place in the northeastern-southeastern zone of the study area. and around Cibandawoh in the south.

3.2.4 ECOLOGICAL CORRELATES OF RHINO PASS RATES

To better understand the distribution of rhinos in Ujung Kulon, Hommel (1990) took a landscape-ecological approach. He used information on geomorphology and vegetation to develop a habitat evaluation for the Javan rhino. He proposed that quality and quantity of forage, accessibility, drinking water, mud wallows, salt, cover, and the absence of pathogenic micro-organisms were likely factors determining the suitability of a land unit as rhino habitat.

Here I will test the impact of some of these factors on pass rates of rhinos, and make an attempt at identifying the important ones. The first part assumes no effect of poaching, a second round of tests looks only at areas certainly not affected by poaching.

A remark on the testing procedure is in order at this point. The noise in pass rates is unusually large because we are looking at rare events, so when using the results of each camera location as our sampling points we will often fail to detect a statistically significant effect even when it is there. Thus, another approach was taken. We pooled the data for all camera locations in any given ecological category, and examined the deviations from the frequencies expected on the basis of equal probability of passing under all circumstances, using the Chi-square goodness-of-fit test. This is a less conservative procedure, because some effects may be caused by the impact of an unusual factor in one location rather than the summed impact in many locations, but there is no easy alternative.

3.2.4.1 Forage Availability
Building in part on the work of Ammann (1985), Hommel (1990) developed a four-point scale to estimate forage availability, using the presence of the five most consumed plant species, the density of stems of sapling size, and the openness of the canopy as criteria. Rhino pass rates, however, turn out to be only weakly related to these forage availability categories. While camera locations in areas with marginal forage availability do indeed have low pass rates, there is basically no difference between the 'moderately good' and 'very good' categories (X^2[df=2]= 8.69, P<0.02). This pattern becomes weaker if we calculate pass rates separately for the two topographical forcing factors. Thus, while forage availability seems to play some role in habitat selection by the rhinos, it seems to have more of a threshold effect than a continuous one.

Effect of forage quality on rhino pass rates														
	All sites combined					Topogr. forcing f=2					Topogr. forcing f=3				
Forage Quality	N	CD	obs P	exp P	PR	N	CD	obs P	exp P	PR	N	CD	obs P	exp P	PR
no forage	0														
marginal	5	982	6	17.3	6.1	2	403	3	3.62	7.4	1	229	3	8.82	1.3
moderately good	31	5100	93	89.82	18.2	16	2680	28	24.08	10.5	8	1398	57	53.86	40.8
very good	20	3116	63	54.88	20.2	6	1368	9	12.29	6.6	4	761	32	29.32	42.1
	Chi-square (df=2)=8.69, P<0.02					Chi-square (df=2)=1.64, n.s.					Chi-square (df=2)=4.27, n.s.				

Based on assessment by Hommel (1990)

N= number of camera locations
CD= number of camera days
obs P= observed number of passes
exp P= expected number of passes
PR= pass rate of rhinos, passes per 1,000 days

Table 3d

3.2.4.2 Water

Water is used for drinking and bathing. Areas far from permanent water sources may thus have lower rhino densities. If all sites are considered the absence of water in the area near the camera location does seem to affect rhino pass rates (X^2[df=1]= 8.36, P<0.01). If topographical forcing is taken into account, the pattern weakens in magnitude but is still in the same direction. However, it should be stressed that only a very small proportion of the area is far from water.

Effect of presence or absence of drinking water on rhino pass rates										
Drinking water	All Sites					Topogr. forcing f= 2				
	N	CD	obs P	exp P	PR	N	CD	obs P	exp P	PR
Limited	4	738	3	13	4.07	3	497	1	4.47	2.01
Unlimited	52	8460	159	149	18.79	28	3954	39	35.53	9.86
	Chi-square= 8.36, P<0.01					Chi-square=3.03, n.s.				

N= number of camera locations
CD= number of camera days
obs P= observed number of passes
exp P= expected number of passes
PR= pass rate of rhinos, passes per 1,000 days

Table 3c

3.2.4.3 Wallows

Since potential wallow sites are numerous in Ujung Kulon and are found throughout the study area(Hoogerwerf 1970, and personal observations) it is unlikely that their distribution will affect that of the rhinos.

3.2.4.4 Disease

No ecological or topographical factors can be assigned to assess the risk of transmission of pathogenic micro-organisms.

3.2.4.5 Topography

No camera locations were inside the areas designated by Hommel as being difficult terrain, with limited accessibility. For instance, bottom lands and tidal swamps are difficult to travel in for rhinos, and they seemed to be devoid of any rhino activity (Ammann 1985, Schenkel and Schenkel-Hulliger1969) Likewise, Hommel (1990) predicted that most of the hills and part of the structural plateau would face difficult accessibility. However, direct field observations provide little support for this suggestion and it seemed that rhinos unrestricted by any topographical restraints in the study area except perhaps in the Payung range.

landform	All sites combined			Topogr. forcing f.=2			Topogr. forcing f.=3		
	N	CD	PR	N	CD	PR	N	CD	PR
hills	5	895	6.7	3	509	9.8	1	77	13.0
structural plateau	18	2547	10.21	7	1260	3.2	3	672	28.3
uplands	11	1690	16.57	6	1182	15.2	1	37	0.0
beach ridge	9	1595	29.47	3	304	3.3	5	1050	41.9
plains	13	2471	22.26	5	1196	10.0	3	552	50.7
bottom lands	0								
tidal swamps	0								

Effect of landform on rhino pass rates

Landforms taken from Hommel's (1990) geomorphological map
N= number of camera locations
CD= number of camera days
PR= pass rate of rhinos, passes per 1,000 camera days

Fig 3f

3.2.4.6 Minerals

Like all big terrestrial herbivores, rhinos need occasional access to salt. The rhinos at Ujung Kulon satisfy this need not by going to salt licks (none have been found in the interior of the study area), but by visiting the sea shore. Thus, if the availability of salt limits rhino use of a habitat, the distance to accessible sea shore should predict rhino pass rates. If we pool all data in each of three distance classes, there is indeed a significant deviation from equal pass rates. However, the deviation is due mainly to the intermediate distance class, 1-2 km from shore, having far fewer observations than expected, and is not due to a gradual decline in pass rate with distance to shore. Hence, in an area such as Ujung Kulon where most camera sites are close to the sea, relative to the rhinos' mobility, access to salt does not seem to limit densities.

Effect of distance from accessible sea shore on rhino pass rates

Distance	All sites combined					Topogr. forcing f=2					Topogr. forcing f=3				
	N	CD	obs P	exp P	PR	N	CD	obs P	exp P	PR	N	CD	obs P	exp P	PR
d< 1 km	28	5147	125	90.65	24.3	14	2453	31	22.04	12.6	8	1602	72	61.72	44.9
1km < d < 2 km	13	1959	4	34.5	2.04	6	1182	2	10.62	1.69					
d > 2km	15	2092	33	36.85	15.8	4	816	7	7.33	8.58	5	786	20	30.28	25.5

Chi-square (df=2)=40.38, P<0.001   Chi-square (df=2)=10.66, P<0.01   Chi-square (df=1)=5.20, n.s.

N= number of camera locations
CD= number of camera days
obs P= observed number of passes
exp P= expected number of passes
PR= pass rate of rhinos, passes per 1,000 days

Fig 3g

3.2.4.7 Forage Quality

Finally, in a more exploratory fashion, the effect of vegetation type on rhino use is evaluated in Table x. When all sites are combined there is some indication of differential use of vegetation types, with rattan shrublands and dune forest seeing the heaviest use by rhinos. However, if we eliminate the effect of topographical forcing, it is clear that the heavy use of dune forest is due simply to a concentration of well-defined trails in that area, whereas the rattan shrublands seem to be genuinely preferred.

Effect of vegetation type on rhino pass rates

vegetation type	All sites combined					Topogr. forcing f.=2					Topogr. forcing f.= 3				
	N	CD	obs P	exp P	PR	N	CD	obs P	exp P	PR	N	CD	obs P	exp P	PR
evergreen hill forest	6	1250	9	22	7.2	4	864	8	7.76	9.26	1	77	1		2.97 13
saltwater swamp forest	0					0					0				
freshwater swamp forest	3	641	1	11.3	1.56	1	311	0	2.79	0	0				
Arenga-dominated forest	12	2150	31	37.9	14.4	7	1246	9	11.2	7.22	3	467	22	18	47.1
Rattan shrublands	19	2648	70	46.6	26.4	5	987	15	8.87	15.2	4	781	31	30.1	39.7
Mixed giant bamboo forest	7	905	10	15.9	11.1	4	739	7	6.64	9.48	1	37	1	1.43	0
Salacca-dominated forest	1	33	0	0.58	0	0					0				
Dune forest	8	1571	41	27.7	26.1	3	304	1	2.73	3.29	4	1026	38	39.5	37
	Chi-square (df=6)=39.23, P<0.001					Chi-square (df=5)=8.59, n.s.					Chi-square (df=4)=3.71, n.s.				

Vegetation types based on Hommel (1983), simplified

N= number of camera locations
CD= number of camera days
obs P= observed number of passes
exp P= expected number of passes
PR= pass rate of rhinos, passes per 1,000 days

Fig 3h

In summary, then, these results deviate slightly from Hommel's (1990) predictions. They show that rhinos are uncommon in areas away from water or in areas with marginal abundance and quality of forage , as well as being rare in the swamps and bottomlands. If these three factors are taken to be the factors steering relative densities of rhinos, we can produce the map of Fig. 3h, which shows a reasonable similarity to the map of Fig. 3c.

3.2.4.8 Discussion

At this stage, one may ask whether the ecological impacts studied here are an artifact of the correlation between certain ecological conditions and human poaching activity. This zone contains relatively high area without drinking water and inaccessible swamp forests. These factors are thought to make the habitat suboptimal for rhinos. One could separate the effects of history and ecology by repeating the analysis using only the area not affected by the possible poaching. If we do this, all the ecological effects on pass rates remained very similar. However, there were no sites left with limited water availability, so we cannot test the effect of water availability. And of course, we still cannot test the accessibility effect. Hence, it is difficult to see whether historical or ecological accounts are independent. Because the evidence indicates that those ecological correlates that could be tested remained exactly the same if the sites were removed that were potentially affected by human activities, the safest conclusion is probably to assume that both historical and ecological factors exert an independent effect.

Fig 3h

If we accept this conclusion, we can draw up at least a rough two-level classification of habitat quality for the Ujung Kulon rhinos. We can use fig. 3h to establish the percentage of optimum rhino habitat in the study area. This yields the following distribution: optimum habitat 59.6%, suboptimum habitat 40.4%. Assuming a total area of about 30,000 ha, this yields ca 18,000 ha. of optimum habitat and 12,000 ha of suboptimum habitat.
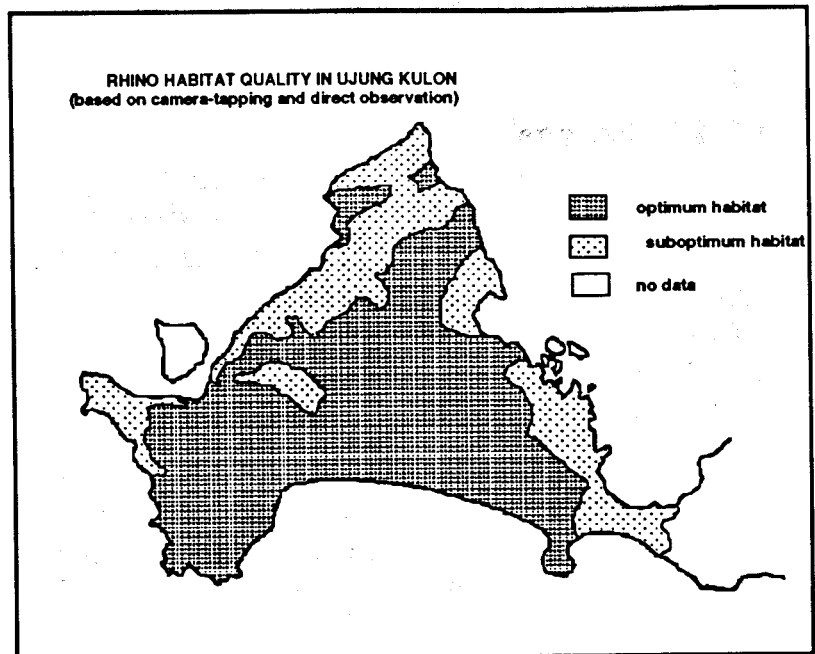
3.3 BEHAVIOUR

3.3.1 HOME RANGES

Individual rhinos did not move through the area at random: They tend to be observed repeatedly at the same or at nearby camera locations. We can get a rough idea of the size of each individual's home range by plotting all the observations on a map. Figures AA to ZZ give the locations of all camera observations for each individual that was identified.

Fig 3i

It is difficult to estimate the size of home ranges when only few points are available. However, by taking the distance between the two most distant observations, and correcting for the total number of observations if necessary, we can obtain an index of home range size. If all ranges were perfectly circular, observations numerous, and camera locations sufficiently dense, this distance would be approximately the diameter of the home range. In practice, of course, these conditions are not met, but any differences we find are likely to be real.

The age-sex classes differ in the size of the estimated home range diameters (Kruskal-Wallis test, H (df=3)= 7.48, P=0.06). Adult males have the largest ranges (mean diameter=5.93 km), adult females without calves are a close second (mean= 4.23 km). Subadult males (mean=1.03 km) and adult females with calves (mean= 0.97 km) have much smaller ranges. Pairwise comparisons indicate significant differences (at P=0.06 and P=0.05, Mann-Whitney U tests) between adult males and adult females without calves on the one hand, and subadult males and adult females with calves on the other hand.

Thus, the mean home range size of a male (estimated here, crudely, to be 27.5 km2) is about twice that of an adult female without a calf and almost ten times that of a female with a calf or a subadult male. These ratios may be overestimates since female ranges are more likely to be round than male ranges (see Figures 3j and 3k), but they do reflect clear trends.

The only other researcher to attempt to calculate home ranges was Ammann (1985) and he used a more exact method of taking numerous track observations and constructing a home range map using the convex polygon method For this discussion we will group the home ranges Ammann deduced into the classes mentioned above and take the mean of the sizes for each group.

NB In Amman's study area there was an association of two animals considered to be two females. Since no such association was recorded during the course of this study there is no possibility for comparison and that home range data is left out of consideration in the table below.

Age/Sex class	Home range size This study	Home range size Ammann
Adult male	27.5	20
Adult female	14	6.9
Sub adult	0.8	-
Adult female w/calf	0.74	2.6

Table 3i

There is still a fair degree of difference between the two results but the basic pattern is the same in both studies.

It is of course possible that the differences between the calculated home ranges for the different age/sex classes from this study reflect sample size rather than real differences in home range size. For males, home range diameter does increase with the number of passes ($r_s=0.70$, n=13, P<0.02), but it decreases for females ($r_s=-0.97$, n=6, P<0.5) because there tend to be more observations of females with calves than without calves.

If we assume that there is an effect of sample size, then, we can correct for it by doing a regression analysis of the pooled data, calculate the residuals from the regression line for each individual, and compare the various age-sex classes on their residuals. Although the regression through the pooled data is not significant in itself, this procedure leads to significant variation among the age-sex classes along the same lines. Hence, the conclusion of variation among age-sex classes is not an artifact of differential sample sizes.

A map in which all ranges of the adult males are compiled (Fig. 3j) shows the enormous overlap between male ranges. In the dunes near the south coast up to four males may be found at a single camera location, and six or seven in a small area. The much smaller subadult male ranges do not overlap among themselves, although each overlaps completely with adult males
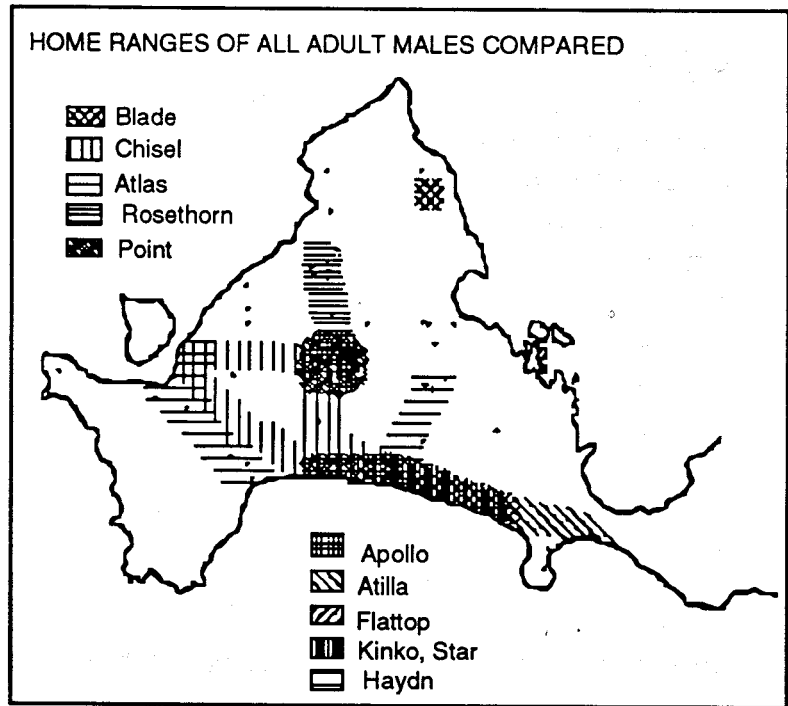
Fig 3j

Adult females' ranges overlap with each other by a small amount but we do not see more than 2 females in any one location.

A rough estimate of home range overlap can be obtained by considering the number of different individuals recorded at each camera location. If we count the number of individuals for each location with more than 4 rhino passes, we get a mean of 2.36 males per location and of 1.22 females (counting only the non-zero entries). In terms of percent home range overlap, this reveals a 136% overlap for males and a 22% overlap for females.

Fig 3k

The figure is over 100% for males because one can apparently have high overlaps with several other males. As shown by the maps, however, it is clear that there is considerable variation in overlap
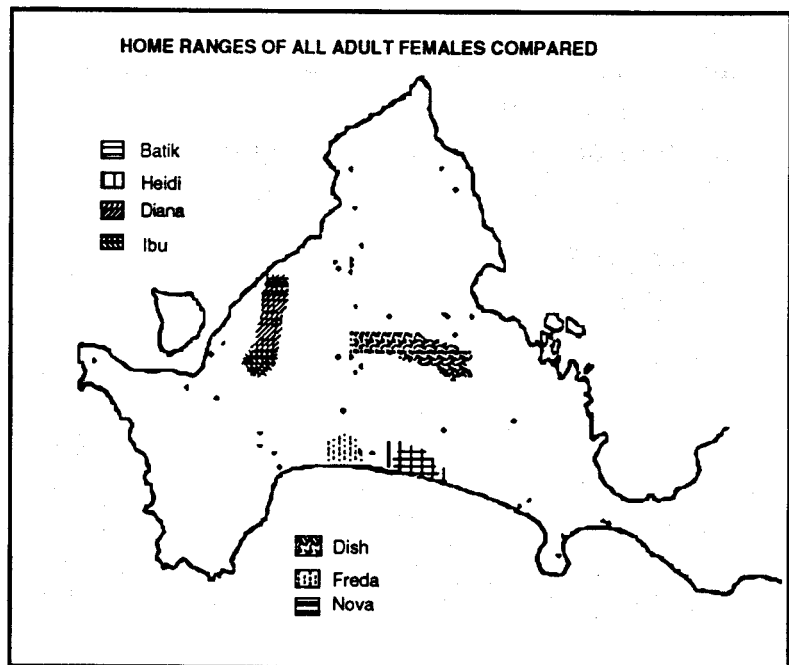
among areas, although to some extent this may be a function of sample size (and that is greatest along the south coast).

Do the sexes also differ in mobility? If they did, each individual male would be observed more often than each individual female, on average. There is only a slight trend in that direction (mean number of passes per known male=7.93, mean per female=6.57, n.s.). This result indicates that males and females are roughly equally likely to use the trail and cover roughly similar distances each day. The great number of males observed is thus obviously due to their wider ranging and greater home range overlap rather than their covering much larger distances.

3.3.2. VARIATION AMONG FEMALES AND HOME RANGE SHIFTS

A curious feature comes out of the data on home range sizes both from this study and possibly from the work of Ammann (1985). The females with calves seem to have a much smaller range than those without. This was particularly well illustrated in the case of Heidi who was observed with calf over a period of late 30 September 91 to 23 April 92 (five observations) . After this, Heidi was only seen alone, and at the same time she expanded her range to the East. Whereas her range size diameter when accompanied by her calf had been approximately 1 km it subsequently expanded to about 2.5 km as she appeared at locations she had previously never been recorded. This value for range diameter is about half way between the values for female with calf (1.0 km) and female without(4.2 km) and may represent a transition. The implications of this will be further explored in the section 4

3.4 POPULATION SIZE ESTIMATES

3.4.1 INTRODUCTION

An accurate estimate of the number of rhinos in the study area was a major aim of this study, and is the basis for any informed management decisions. The study was not long enough and the camera coverage was insufficiently denses to observe all the rhinos so we have developed three different ways to estimate these numbers. These methods differ in the assumptions they make and the procedures they use, but are not entirely independent since they do use the same basic set of observations. The first method treats the data set as a mark-recapture experiment and derives a calculation from this assumption. This method is very powerful and makes full use of the information provided by the camera. The second method extrapolates from observed range sizes and overlaps. The third method extrapolates from the number of individuals recognized in the area covered by camera. The latter two methods are conceptually closely related, and least independent.

3.4.2. CAPTURE-MARK-RECAPTURE ESTIMATES

The following information is taken directly from a specially commissioned study by Conservation Research LTD in Cambridge England and undertaken by A.Hiby and P.Lovell.

Introduction

This report concerns the use of photo-id data provided by Mike Griffiths of WWF Indonesia to estimate the number of Javan rhino remaining in the Ujung Kulon reserve. Although the report deals only with the estimation of population *size*, we recognise that the photo-id catalogue has the potential to provide other equally important information. Establishing a catalogue of recognisable individuals is the only effective way to relate survival, fecundity and migration (the determinants of population change) to local conditions. Thus the catalogue provides, for example, a basic tool for deciding how to respond to events such as an outbreak of disease, poaching or pollution or an increase in tourist pressure.

Structure of the data

We were provided with data derived from photos taken by static cameras located in the reserve from January 1991 to February 1993. Approximately 30 different cameras were used, each with a pressure pad to trigger the shutter. Cameras were moved to over 60 different locations (Figure 2) during the study. Photographs had been organised into "passes", i.e a series taken by a camera as a rhino passes by. Each pass provides the date and approximate time that the rhino was at the camera location, and close inspection of the photos had determined which passes were by which rhinos. Each rhino had been named and the age
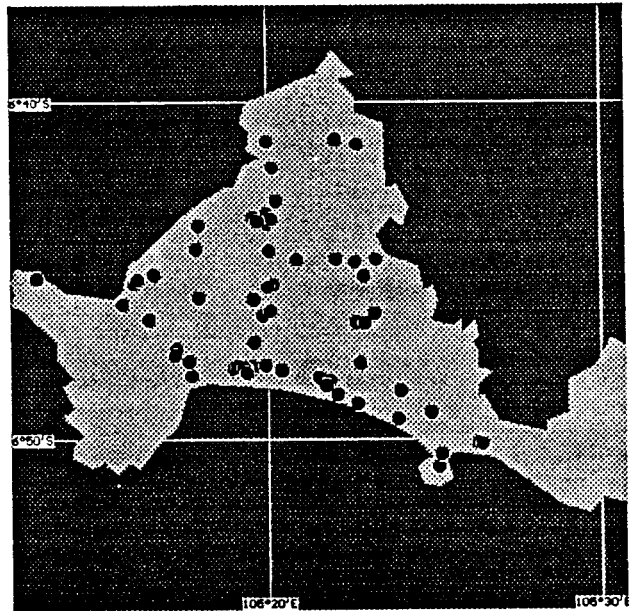
Figure 2 Camera locations used during the study

and sex class estimated, and the presence of a calf noted. It is not always possible to be certain that two names represent different rhinos, and in addition to the list of passes we used a matrix of decisions to summarise for which pairs of names it was certain. In fact, by the end of this study, all names *were* known to represent different rhinos except that Apollo and Apollo? may have been the same, Star and Star? may have been the same, and U may have been the same as any of the other females.

The exact location of each camera was also provided plus, for each location, a list of date intervals over which the camera had been active. The number of "camera-days", i.e. the total of days for which a camera had been active, was therefore available for each location.

Results relevant to the estimation of population size

1. A lower bound on population size

The minimum number of rhinos photographed by the cameras was 22, not counting the calves. 5 of the females were seen with calves giving a lower bound of 27 for the population size. The reasoning in this case is obvious - the minimum number is obtained by assuming that *Apollo* and *Apollo?* are the same, *Star* and *Star?* are same, and *U* and one of the other females are the same. When more uncertainty exists regarding which pairs of names represent different animals, determining the minimum number of animals detected is not trivial, and a method for the general case is given in Appendix A.

To estimate the total population size from the number of rhinos actually photographed we used a novel type of capture/recapture analysis. This was suggested by consideration of the spatial/temporal distribution of passes and the spatial distribution of camera locations.

2. The spatial/temporal distribution of passes

Figures 3 (males) and 4 (females) show, as white dots, the positions where passes with each named rhino occurred, superimposed on the pattern of camera locations. The passes for males, females and all rhinos combined are shown in Figures 5 and 6.
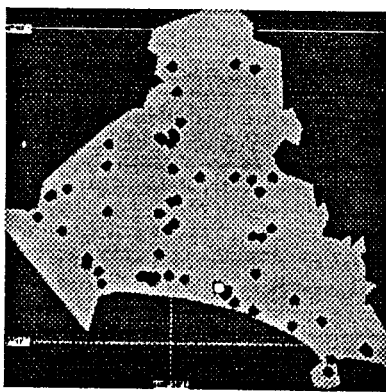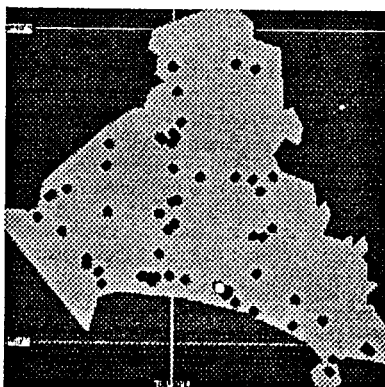
Figure 3a Apollo   Figure 3b Apollo?   Figure 3c Atilla
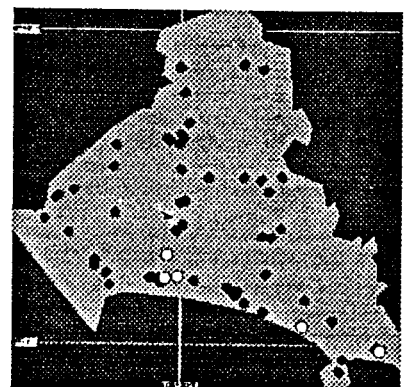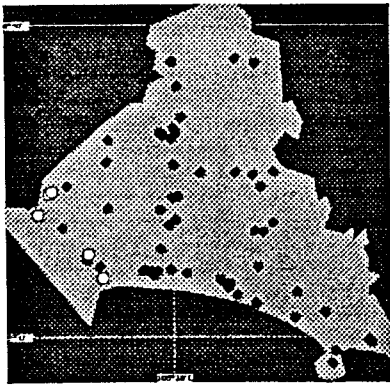
Figure 3d Atlas
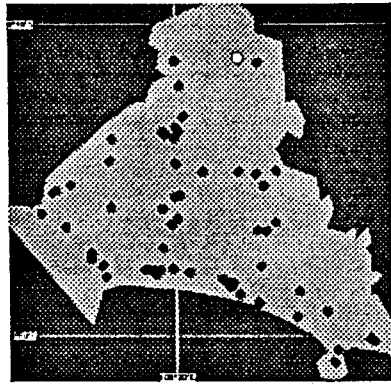
Figure 3e Blade
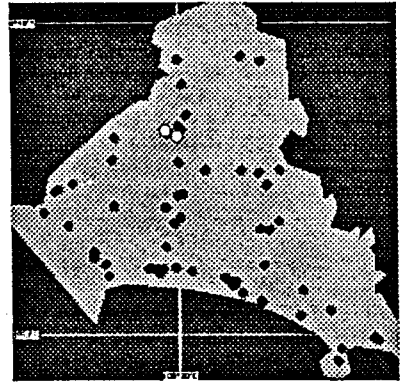
Figure 3f Boy
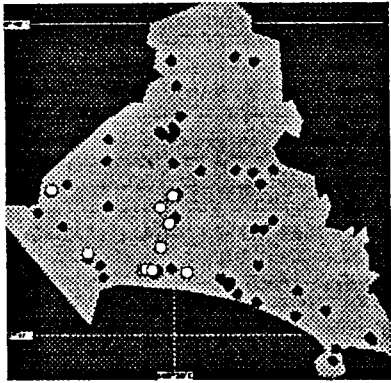
Figure 3g Chisel
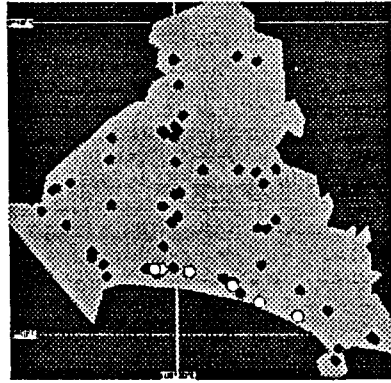
Figure 3h Flattop
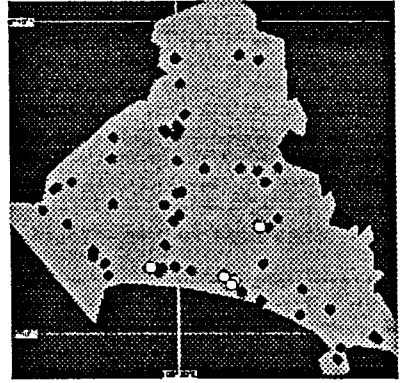
Figure 3i Haydn
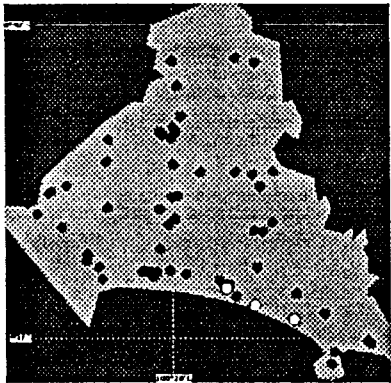
Figure 3j Kinko
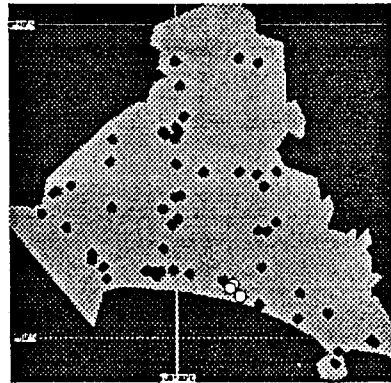
Figure 3k Patch
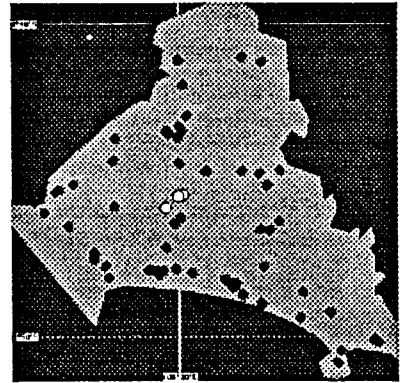
Figure 3l Point
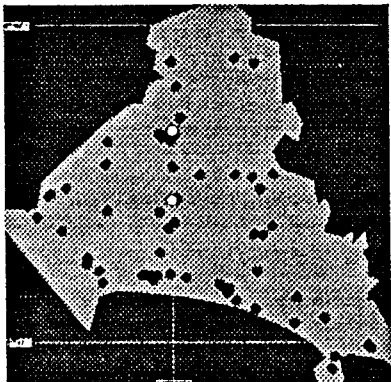
Figure 3m Rosethorn
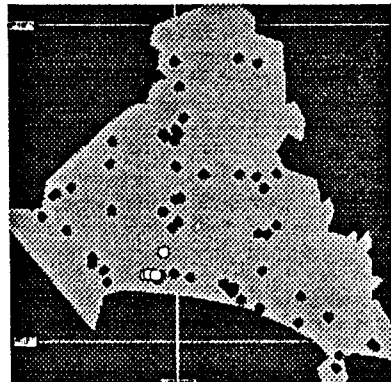
Figure 3n Roundhorn
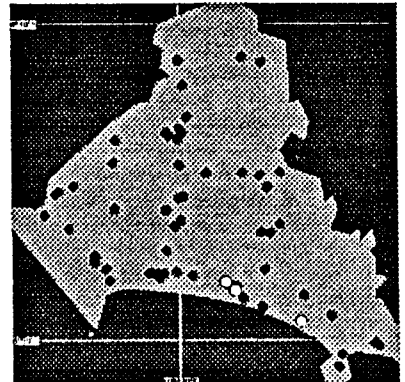
Figure 3o Star
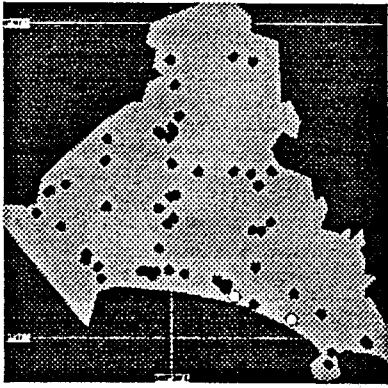
Figure 3p Star?
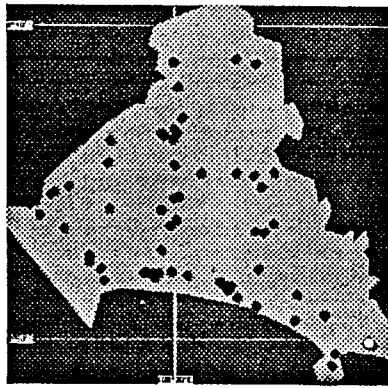
Figure 3q Ulysses
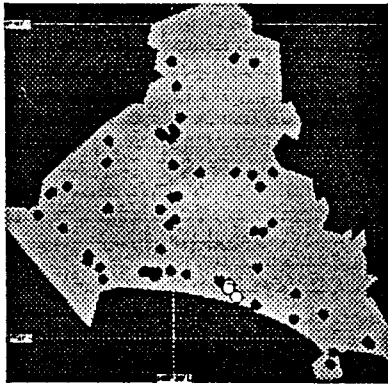
Figure 4a Batik
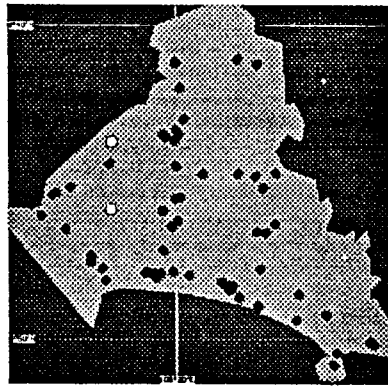
Figure 4b Diana
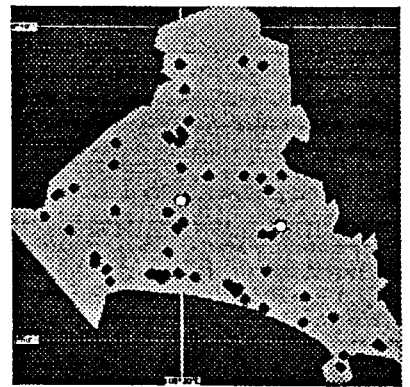
Figure 4c Dish
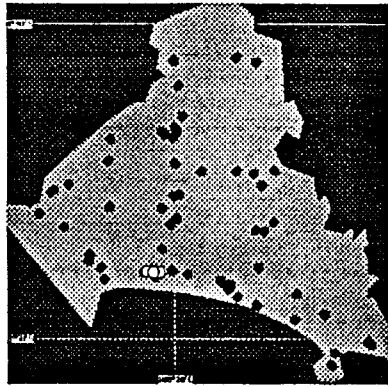
Figure 4d Freda
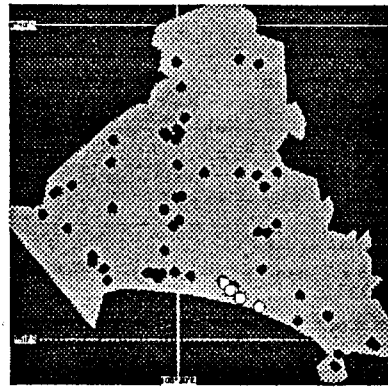
Figure 4e Heidi
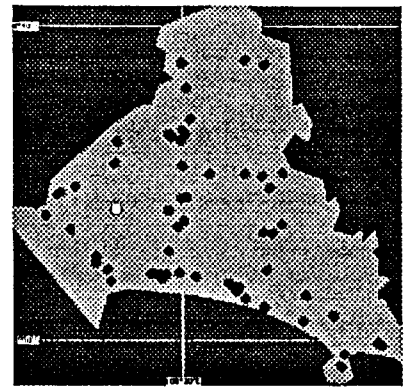
Figure 4f Ibu
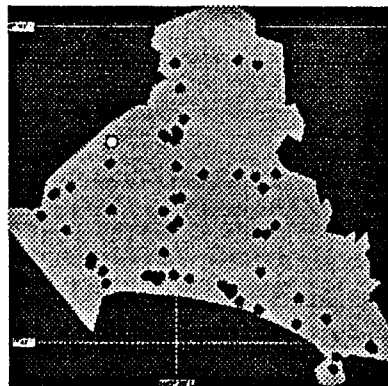
Figure 4g Nova
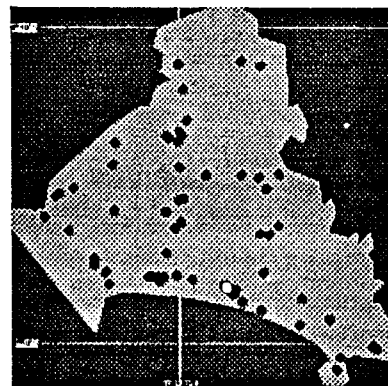
Figure 4h U
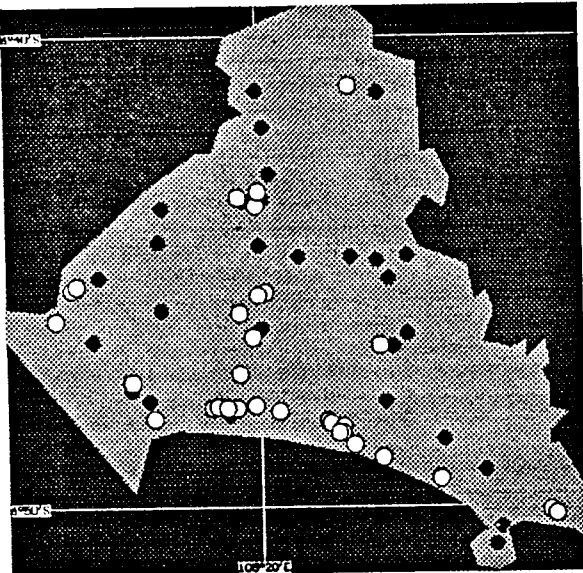
Figure 5a All males
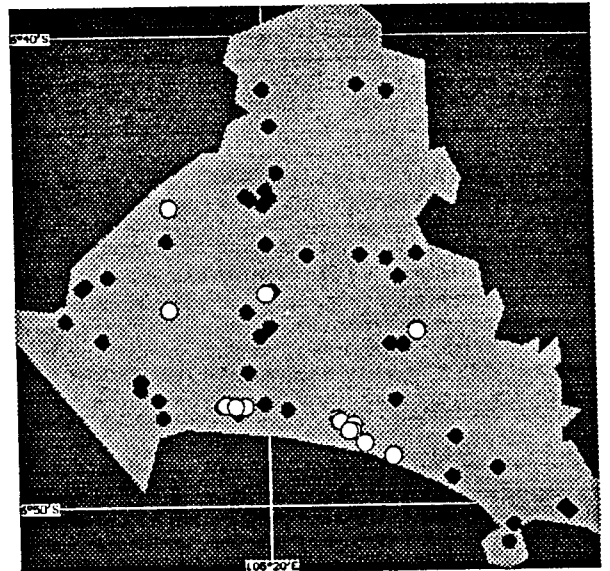
Figure 5b All females

It is tempting to infer high and low rhino density areas from the maps; however, we have not emphasised this aspect because rhino tracks representing suitable camera locations may be more difficult to detect in some areas. Limitation on the number of cameras also means that the number of passes may not increase in proportion to rhino density.

The pass locations do show that rhinos move over areas which are quite large compared to the average distance between camera locations, suggesting capture/recapture analysis as a reasonable approach to estimating the size of the population. They also suggest that males move more widely than females, leading to reduced capture probability for females which should therefore be treated separately in the analysis.
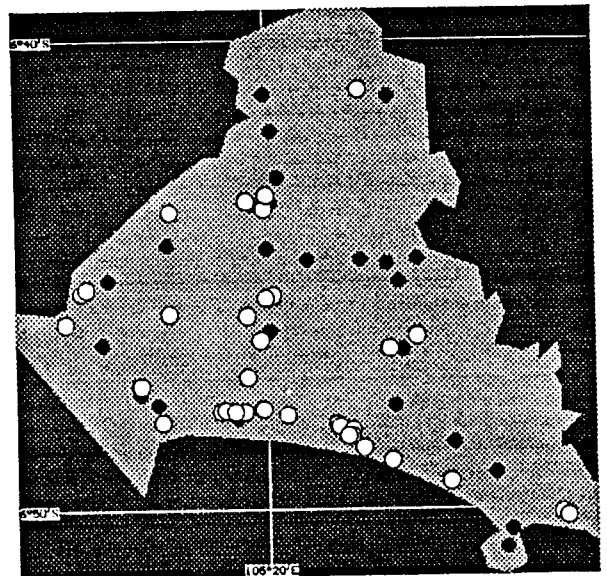
Figure 6 All rhinos

Figure 7, which gives the frequency distribution for the number of passes versus date, shows that passes occurred semi-continuously over an extended period, even after eliminating repeat passes by rhinos at the same camera. It would therefore be wasteful to use a 2-sample capture/recapture analysis for this data and we have adopted the opposite extreme of considering each pass as a different sample, i.e. a capture and a potential recapture of rhinos captured previously. Appendix B gives the derivation of an estimator based on this approach. Like the more familiar 2-sample Petersen estimator, it assumes that the population is closed to birth, death,

immigration and emigration during the period of the study, and that the probability of capture is the same for "marked" (i.e. previously captured) and unmarked individuals. Unlike the 2-sample estimator it *does* permit a degree of uncertainty about which animals have been captured previously and is therefore particularly suitable for photo-id data.
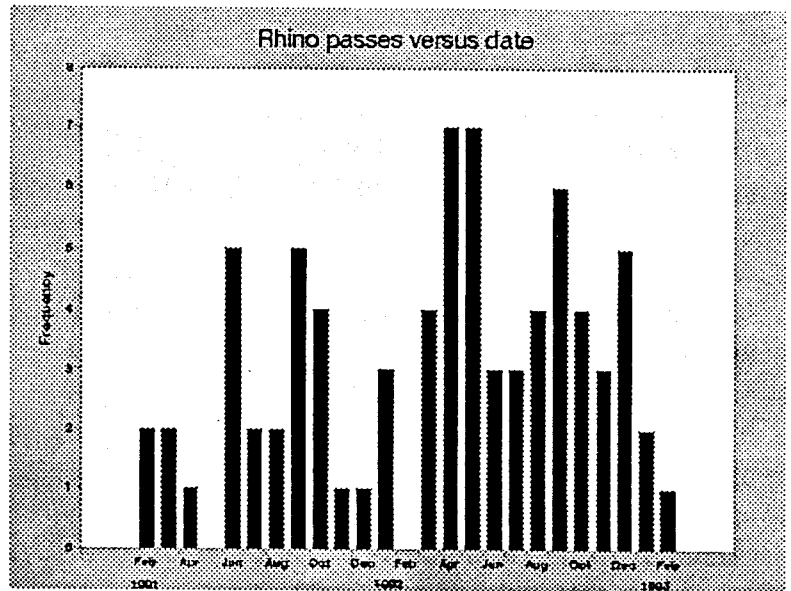
Figure 7 Number of passes plotted by month, not counting repeat passes by rhinos at the same camera

There are three ways in which the assumption of equal capture probability for marked and unmarked animals may be violated. Some animals may be inherently more easy to capture than others, in which case the marked group will contain many such animals and hence be more likely to be recaptured. Rhinos which are particularly mobile are an example of this category. However, once males and females are treated separately the rhino data does not indicate that this effect is significant. The process of capture itself may make animals more or less vulnerable to recapture. In the analysis of this data, recaptures at the same camera location are not considered so it is not conceivable that any such "trap-happy" or "trap-shy" effects could be important here. Lastly, the probability of recapture may be affected by the spatial distribution of capture effort. For example, if that effort is highly clumped and the rhinos do not move around sufficiently over the period of the study, the number of recaptures will be too high. To deal with the third problem we considered the distribution of inter-camera distances.

3. The spatial distribution of camera locations

Figure 8 shows the distribution of distances from all camera locations to all locations where passes occurred. Given limited movement by the rhinos we would seek to arrange equal capture probability for marked and unmarked animals by using randomly chosen camera locations. In particular, if a rhino has been photographed at a given location, we want the distances from that location to the other locations where it might be re-photographed to be as large as those given

Figure 8 Observed distribution of distances from all camera locations to locations used by rhinos, and theoretical distribution expected if cameras were placed at random

by random camera location. This ensures that the probability that it is photographed again is not higher than for other animals. Thus Figure 8 also shows the distribution of distances from camera locations where passes occurred to all other possible locations in the park.

It is clear that the actual inter-camera distances are less than they should be if locations had been chosen randomly throughout the park, hence in Figure 9 the expected distribution has been recalculated for the subregion shown in Figure 1. The actual and expected distributions are a better match, suggesting that the population estimate should be considered as applying to that subregion rather than the entire park. Even in Figure 9 the distribution of

Figure 9 As for Figure 8, but with the theoretical distribution based on the sub-region of the park shown in Figure 1.

actual inter-camera distances has too many values under 2 km, which is the expected distance from each camera to its nearest neighbour if cameras were located randomly.

To further ensure that recapture probabilities are not too high we therefore removed all recaptures within a distance of 2 km.

These measures remove any major source of negative bias from the estimator when used to estimate the number of rhinos in the area shown in Figure 1. We considered that removal of negative bias was particularly important in view of the fact that a lower bound on the population is already available. It is then more useful to have a population estimate in which any bias is upward than one for which the direction of bias is unknown.

4. Frequency distribution of passes per rhino

The results under sections (2) and (3) suggest that an estimator based on the frequency distribution of passes per rhino, as derived in Appendix B, will provide an estimate for the number of rhinos in the area shown in Figure 1 with, possibly, a degree of upward bias. The following tables give the frequency distribution for the number of cameras, separated by at least 2 km, passed by each rhino during the study. Because of the remaining uncertainties regarding identification, the data are consistent with several different frequency distributions. For example, the first distribution $\{f_i\}_\delta$ for the males results from assuming that *Star* and *Star?* are different animals, and that *Apollo* and *Apollo?* are different animals. The second $\{f_i\}_\delta$ row results if *Apollo* and *Apollo?* are assumed to be the same.

number of cameras passed, i		1	2	3	4	5
number of males, $\{f_i\}_\delta$		8	5	2	1	1
	or	7	5	2	1	1
	or	8	4	2	1	1
	or	7	4	2	1	1

number of cameras passed, i		1	2	3
number of females, $\{f_i\}_\female$		5	3	0
	or	4	3	0
	or	4	2	1
	or	3	4	0

Applying the estimator derived in Appendix B to these two data sets separately gives maximum likelihood (ML) estimates of 18 and 12 for males and females respectively,

and combining them gives an estimate of 29 for the total. In fact, neither of these ways of treating the data is appropriate because both ignore the expected male:female ratio in the population. The estimate for the females is very uncertain, being based on only 7 or 8 animals, so it is worth making a compromise between the value of that estimate and our belief that the number of females should not be too far below the number of males, given an even chance of newborn rhinos being male or female. That compromise can be derived as follows.

If we assume that, given the total population size N, the number of males in the population, N_δ, has a binomial distribution $B(N, \frac{1}{2})$, we can write the likelihood for N by summing over all possible values of N_δ:

$$\mathcal{L}(N \mid \{f_i\}_\delta, \{f_i\}_\varphi) = \sum_{N_\delta=0}^{N} {}^N C_{N_\delta} \frac{1}{2}^N P(\{f_i\}_\delta \mid N_\delta) \, P(\{f_i\}_\varphi \mid N-N_\delta) \qquad (1)$$

The first term in the summation is the probability that N_δ of the N are males, according to the binomial distribution. The second and third terms then give the probabilities of the male and female pass frequencies given N_δ and N_φ ($= N - N_\delta$), as defined in Appendix B. Maximising with respect to N gives the ML estimate for the total population (excluding calves) plus confidence limits via the likelihood ratio method. We can obtain the male and female estimates and confidence limits similarly, assuming a negative binomial distribution for the total population size, given N_δ or N_φ. The results are:

	ML estimate	lower 95% confidence limit	upper 95% confidence limit
males	18	15	25
females	17	8	31
males & females	34	25	52

The estimates and confidence intervals given for the male and female population sizes do not indicate which *combinations* of male and female population size are more probable than others. The shaded area in Figure 10 shows a 95% confidence region for N_δ and N_φ jointly. (This is based on considering the terms following "Σ" in equation (1) as a posterior density for N_δ, N_φ in the Bayesian sense. The corresponding prior density for N_δ, N_φ is uniform for $N_\delta + N_\varphi$ and binomial for N_δ given $N_\delta + N_\varphi$ with $p = \frac{1}{2}$). The most probable combinations of male and female population size lie in the region covered by the larger circles.

The figures represent our best estimates for the current population sizes, except that the western and eastern extremities of the park, which may contain some more rhinos,
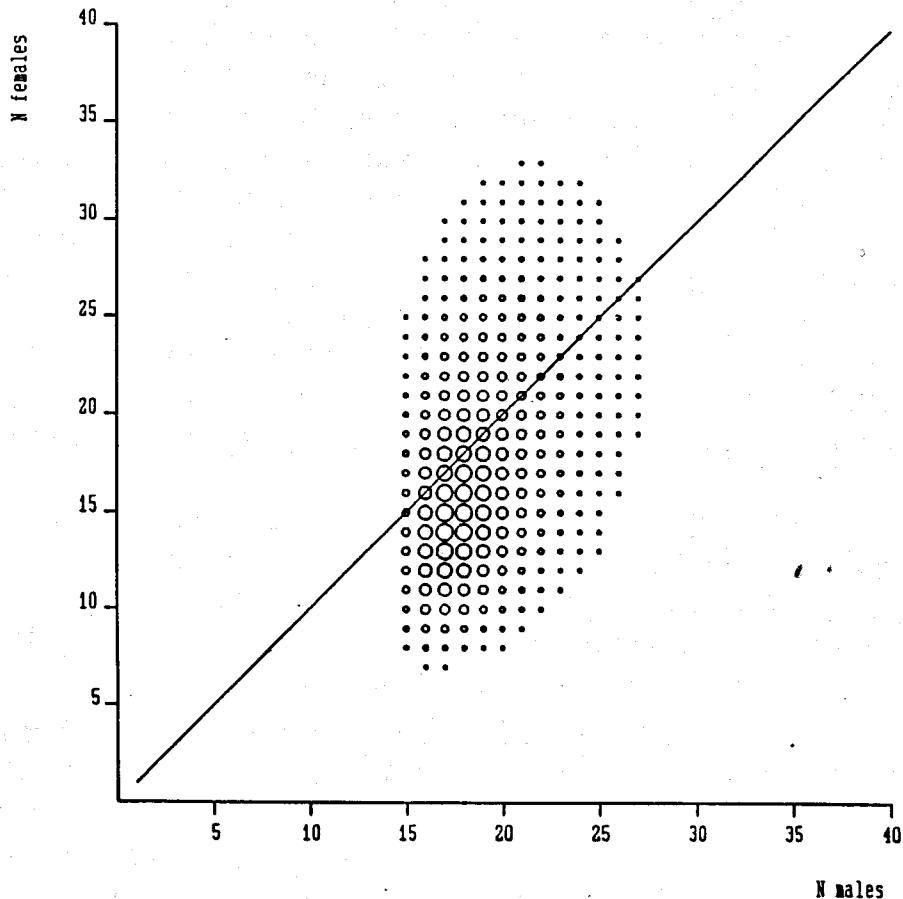
Figure 10 Bayesian 95% confidence region for N_δ, N_φ jointly.

were not considered to have been adequately covered and were excluded from our analysis (Figure 1). In addition, if we accept the ML estimate of 17 females, we can use the fact that 5 out of 7 identified females were seen with calves to derive an estimate of 12 for the calf population with 95% confidence interval from 9 to 15.

Throughout the analysis, the presence and absence of the horn in adult animals has been used to determine sex, in most cases confirmed by photographs showing the genital region or the presence of a calf. Combining the confirmed sex identifications with those mentioned in the literature, all of a total of at least of 14 male rhinos were seen with horns, and none of a total of 14 female rhinos had horns. A 95% confidence interval on the proportion of males *with* horns and the proportion of females *without* horns is from .807 ($= .05^{1/14}$) to 1. The *largest* probability of misclassification, based only on the presence or absence of a horn, is therefore 1 in 5, which is negligible given the small number of unconfirmed classifications.

3.4.3. ESTIMATES BASED ON SIZE AND OVERLAP OF HOME RANGES

If we know the average size of a home range (H) and the overlap with other ranges (V), we can calculate the total number (N) of animals in an area (A), provided that the area is homogeneous, by using the following formula:

$$N= A/ (H *[100/\{100+V\}]) \qquad (EQ. 1)$$

Another way of dealing with overlap is to calculate the mean number of individuals whose ranges cover an average point (say, I). Then, we can calculate N as:

$$N= A* I/ H \qquad (EQ. 2)$$

We have crude estimates of these parameters for the Ujung Kulon population from the camera trapping:

	Mean H	mean I
Adult males	$27.5\ km^2$	2.36
Adult females	$5.0\ km^2$	1.22

We have assumed that each female has both a small territory inhabited when she is with calf, and a large range for when she is not. We further assume that subadult males form a certain fraction of the adult males (30%, observed here) and calves a certain fraction of the adult females (70%, observed here). That implies that we do not expect the area to be filled to capacity with calves or adolescents, but that we do expect that to be the case for adults.

The assumption of complete and even packing of ranges implies that the numbers derived in this way will not necessarily reflect current population size, but rather represent the maximum possible number of rhinos to be expected in the study area given homogeneously optimum ecological conditions and no poaching. Using equation 2 on the male data gives 26 adult males in the study area of $300\ km^2$, and hence some 8 subadult males. The number of adult females in this area can be 73, and hence 51 calves. This calculation suggests a total population of 158 rhinos.

One note of caution is required at this stage. The calculations made here assume even and complete packing of ranges. As shown by Figure 3j this is a reasonable assumption for the males, but it is not for the females (see Figure 3k). For obscure reasons parts of the area that were covered quite adequately by the cameras did not have any females: Cibunar, Cikarang, Cihandeuleum. Thus, the female distribution is quite spotty. The best estimate of the number of females would be to assume that their number equals that of males (cf. the mark-recapture estimates). Using the same conventions as before this yields a total of 79 individuals, as a conservative estimate of the carrying capacity or potential rhino density in the study area. Thus, the study area can most likely support anything from 80 to 160 rhinos.

Can this same information be used to generate the current population size? There are two ways to approach this question, an ecological one and an historical one. In the following calculations we conservatively assume equal adult sex ratio, and hence that female ranges are not closely packed

From the ecological analysis, we concluded that 60% of the area is optimum habitat and 40% suboptimum. Let us assume that the suboptimum habitat has one third the density of the optimum habitat (as suggested by a comparison of pass rates in the optimum and suboptimum habitat as defined in Fig. 3h). Then we have 180 km2 with a mean exclusive male range size of 11.65 (27.5/2.36), and 120 km2 with one third of this, or 3.43, which gives 19 adult males. Assuming again the fixed proportions of males being subadult and of females having calves, this gives a total of 58.

From the historical analysis, we concluded that some parts in the distribution area are currently not used, (possibly as a result of poaching). Although it is difficult to estimate the area of impoverishment , it seems (using Fig. Y [pass rates distribution]) that 30 - 40% of the area is empty. Using these percentages, we obtain 18 and 15.5 males respectively. Thus, the total estimated population size using this scenario would be between 46 and 54 individuals.

Because we have no way to decide which of the two approaches is better, we would do best at this stage to combine these estimates, giving us an estimated **current population size using home range overlap of 46 to 58 individuals.**

3.4.4. ESTIMATES BASED ON CAMERA COVERAGE

Table X gives the observed distribution of passes for each identified individual. This table shows that there is only two males and two females who have been photographed only once. The males Blade and Ulysses were at the extreme edge of the study area. The females are Ibu and Nova, the first being recorded at the very beginning of the study and not since, and the second toward the end. Because most individuals have been recorded several times, some of them quite often, we may assume that in the area covered by the cameras almost all individuals have been encountered.
To determine the completeness of coverage more precisely, we can extrapolate the curve relating the cumulative number of individuals recognized to time elapsed since the start of the project in camera days. When these curves show signs of reaching a plateau, we can again assume that coverage is getting complete. The curve suggests complete coverage for males, but not for females.
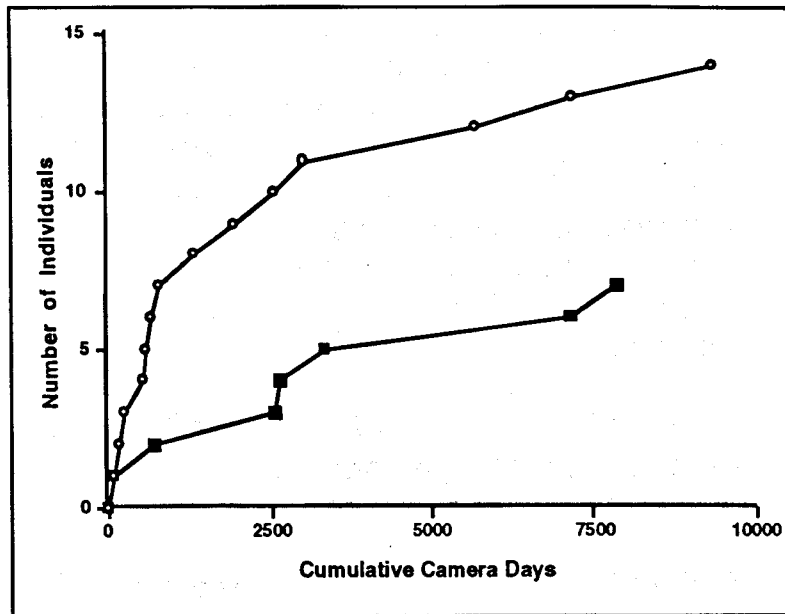
Fig 3L

For the male curve we can estimate the position of the plateau by plotting the reciprocals of the two variables. This gives a very nice straight line (r=0.992), and linear regression yields an intercept, which back-transformed, gives 16.1 males.

y = 78.120279x + .06219,
r2 = .984654
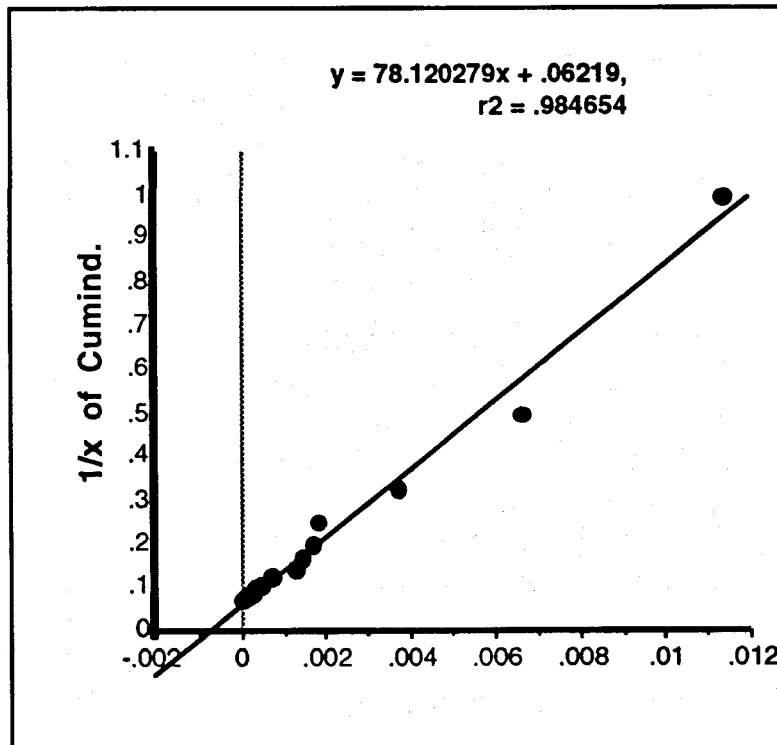
Fig 3m

Thus, in the area covered by the cameras there should be 16 males. Unfortunately, this exercise is impossible for females.

49

The difficulty, obviously, lies in estimating the percent of the area that actually is covered by the cameras, and here I can only advocate an ad hoc approach that will yield some approximate confidence limits. The cameras probably did not cover the whole study area.(this was established independently by Hiby in the MCR analysis). In the following we consider only males. Let us take two extremes. On one extreme, assume that each camera location with a topographical forcing factor of 2 or 3 will capture a rhino if it is anywhere within the range of this rhino. With a mean diameter of about 6 km, the area not covered by cameras is extremely small, about 5% of the study area. Hence, the number of males in the total study area could be 16 or 17. The other extreme is that camera locations will capture males only when they are about one home range radius away.
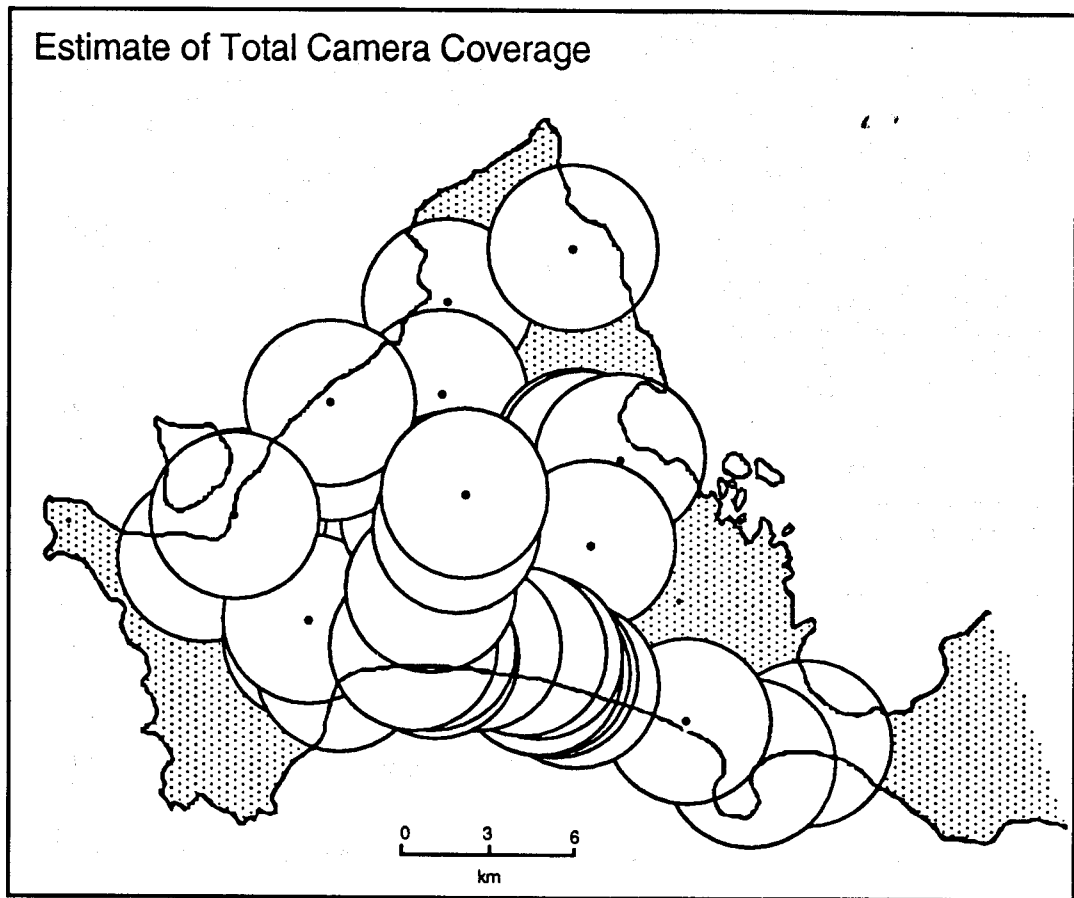
Fig 3n

This would leave about 25% of the area uncovered. Assuming that these uncovered areas (part of the Payung area, the northern tip, part of the east coast, and the area south of Handaleum islands) do contain rhinos (but see above), we would expect to have 21 males in the study area. Because these males include both subadults and adults, there are either 12 or 16 adult females (still assuming equal adult sex ratio), and the **lower and upper estimate for the total population based on camera coverage are 37 and 48 individuals.**

50

Star. One of the most handsome of the male rhinos observed in the study area.

Because this individual had few distinguishing features, identification was based on examination of skin pores, inter neckfold pigment patterns and facial wrinkles.

Atlas. This large male ranged between Cibunar on the south coast, and Cidaon in the north, where it was occasionally seen feeding at the edge of the grazing grounds there.

The depressed torn right ear and the light pigment patch on the right rear leg were positive features in the identification of this individual.

DISCUSSION

4.1 VALIDATION OF IDENTIFICATIONS

Correct identification of the individual rhinos was essential in order to make correct conclusions about the rhinos of Ujung Kulon. It was possible to check on how accurate these identifications were by seeing how well they correlated with other data not used in the original ID's and to see how closely the rate of sightings corresponded with what would be expected in a random sample

4.1.1. SHOULDER HEIGHT MEASUREMENTS

The shoulder height and (in the case of the males, the horn length) were not used as discriminatory criteria for the original analyses on which the individual rhinos were identified. But these size measurements were used later to provide information of morphology and size. When the measurements were subjected to one way analysis of variance it was found that individuals differed significantly for these size variables.

Results of one way analysis of one way variance of size parameters

Adult Male Shoulder ht	H(df=5) = 16.42	P=0.006
Adult Female Shoulder ht	H(df=3) = 9.92	P= 0.007
Male Horn Size	H(df=5) = 13.11	P=0.02
Calf/ Female Shoulder ht	See figure MM 2.1	

Table 4a

From this table it is evident that the size parameters confirmed the sorting of individuals based on the other criteria.

4.2. ESTIMATION OF POPULATION SIZE

The regular population estimates based on footprint studies indicated the following trend with time (see compilation in Sadjudin 1992). Between 1967 and 1982 there was a gradual increase in numbers from roughly 25 to somewhat over 60. Some time during 1982 or 1983 the population lost several individuals, perhaps as much as 10, and during the 1980s a slow recovery took place. Estimates in 1989 (Santiapillai et al. 1990) gave 57 individuals. Clearly, the confidence limits of these various estimates overlap, but these trends are suggestive.
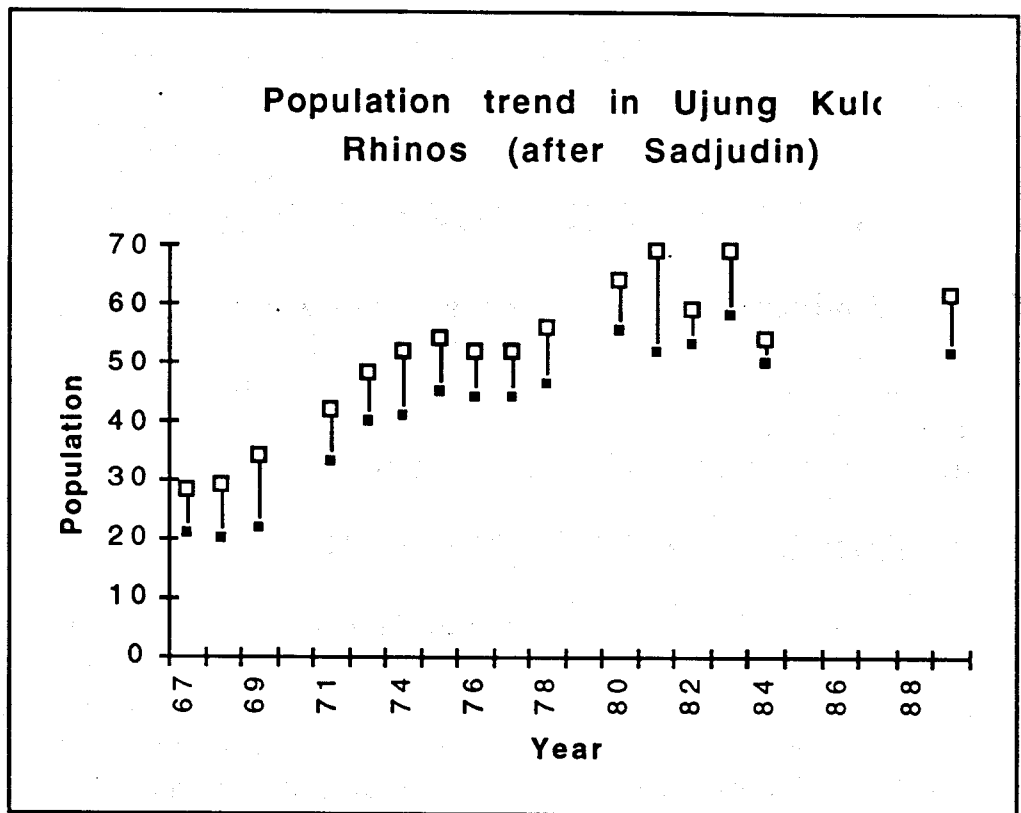
Fig 4a

Some time during 1982 or 1983 the population lost several individuals,
perhaps as much as 10, and during the 1980s a slow recovery took place.
Estimates in 1989 (Santiapillai et al. 1990) gave 57 individuals. Clearly, the
confidence limits of these various estimates overlap, but these trends are
suggestive.

The best estimate derived from this study gives considerably lower population
numbers.   But for an overview of the results refer to the table below.

Popn Est.	Explanation
27	Absolute minimum. Based on identified individuals
37-48	Realistic minimum. Based on cumulative number of newly observed rhinos. rf. 3.4.4.
31-46-74	Best estimate of current population. Based on Mark-recapture method. rf. 3.4.1
46 - 58	Estimate based on camera coverage. rf. 3.4.3
80	Realistic maximum. (carrying capacity) in the absence of any disease, poaching etc. Based on current home ranges size and ecology.

Table 4b

The lowest possible number of rhinos in the study are , assuming the identifications were correct, is 27, as that was the number actually seen by the cameras. It is almost certain that there must be more than this because the frequency of sightings of rhinos at the edge of the study area are very few and we know the home range of females are small enough to not be picked up in areas where the camera coverage was sparse. So this number is unrealistically low.

A similar population estimate based on camera coverage and the rate at which new rhinos were observed gives us a conservatively lowest figure of 37 . Conversely the estimates based on extrapolation of home range size but taking into account ecological constraints, variable habitat suitability and present impoverishment in certain areas of the park we get a higher estimate whose maximum value is 58

The highest value of about 80 is based purely on current home range data and what we believe the park could support if their were no threats such as disease, poaching. human disturbance. etc. In a sense this is a calculation of the carrying capacity but such calculations should be treated carefully because it is conceivable that as numbers rose the home ranges as a whole could shrink some what with no adverse affect on the health of the population.

The most thoroughly reasoned approach to the population was the one carried out by Hiby and Lovell, and it is significant that this lies about midway between the others. This strengthens validity of that estimate and hence this number , taking into account the confidence limits should be the one on which further decisions are made.

Using these numbers, then, we find that compared to the last previous survey, we have about 10 rhinos less in the study area. Is this difference real or are the uncertainties in both kinds of methods so great that any differences are masked by noise? Two important observations suggest that this difference is real. First, two recent track studies in 1992 also produced estimates between 42 and 48 (Ramono pers comm). Second, the north-southeastern zone of the study area, which used to contain rhinos until recently, is now not showing many signs of rhino activity. Thus we have a possible reduction in total population and a definite reduction in the distribution. If both these reductions are tied to one another then there must have been some impact such as diseased or poaching that has brought this reduction about.

The alternative is that the results of the previous censuses and distribution studies were unreliable and would thus have limited applicability.

4.3 THE SEX RATIO

Previous authors report a male biased sex ratio in the Ujung Kulon Java rhino population. Hoogerwerf (1970) for instance gives the total number of sightings where sex could be determined (between 1940 and 1954) as 151 males and 68 females giving a ration of about 2;1. Schenkel and guards (Hoogerwerf 1970) saw only three hornless individuals between 1967-68 and assumed that these might be subadults. But even assuming these were females (which in the light of section 3.1.2 they probably were then this would suggest a male female ratio derived from sightings of 9:1

Ammann (1985) reports the opposite . He determined the sex of rhinos in his study area using urination patterns and where possible the presence of a calf (confirmation of a female) and using this derived a male to female ratio of 0.64:1. Ammann's findings also suggest that female home ranges overlap greatly while those of males overlap only slightly. This is the opposite of what was derived from this study. How can the difference be explained? It is possible that the number of females was very high at the time Ammann carried out his research, in which case the current population would be seriously depleted. On the other hand it may be that the females in the study area were over- differentiated, (something that characterized the early and middle stages of this study) in which case the population may be relatively stable and the sex ratio would be closer to 1:1. This issue has yet to be resolved.

Of the two methods - visual sightings and the examination of tracks - the camera trap method is more analogous to the former. And as with the records of sightings by other researchers we get a much higher number of male sightings than females - about 2:1 - which is about the same as Hoogerwerf's records.

Before making any conclusions about the sex ratio of rhinos from the camera trap passes and visual sightings, it is important to point out that for several other species, for example, tigers in Sumatra, and leopards, kijang and banteng in Ujung Kulon the raw camera trap data give male biased sex ratios. In Ujung Kulon, for instance, the ratio for passes of male to female banteng was about 1.8:1, and for Barking Deer, 1.4:1, and for Leopards about 8:1! The chances that all these populations have a sex ratio heavily biased in favour of males must be very small so we have to explore other explanations for the bias.

One possible explanation is a behavioural one and has been touched on in 3.3.1. A strategy for males of many species is to optimize their breeding success by covering as many females as possible. In the absence of well defined territories males range constantly and their home ranges tend to be large and overlap broadly. Both these behavioural traits would result in a

relatively higher number of passes by the camera traps and give the impression of a male biased sex ratio.

The raw camera data can however be used to give a more realistic estimate of the sex ratio. Hiby 1993 assumes a roughly equal birth rate of male and females and derives from the camera trap data a roughly equal sex ratio (rf 3.4.2)

In summary then the best estimate for the sex ratio of the Javan rhinos in Ujung Kulon is roughly 1:1 and that the male biased sex ratios estimated through direct sightings or camera trap passes are probably a reflection of different behaviour patterns between males and female. The female biased sex ratio deduced from track and urination patterns in the Citadahan- Cibunar area in 1978-80 have yet to be explained but as they refer only to a small part of the park their significance may be limited.

4.4 RHINO BIOLOGY

4.4.1. HOME RANGE COMPARISONS AND HOME RANGE SHIFTS

As noted in section 3.3.2. there is a distinct difference between the home ranges of females with calves and those without. The home range size of the latter are more than four times the that of a female with calf.
It appears that not only does the *size* of the home range change but the *location* does as well and that their seems to be a trend in the choice of locations especially for the females with calves.

Four out of the five females with calves were found near the coast (Nova on the north coast. Heidi, Freda and Batik on the south coast) whereas all the females which were without calves for the duration of the time they were observed were found inland. It is even more interesting to note that the cameras had been functioning at Ikan and Gunung Cikeusik locations for a total of 82 camera days before recording, for the first time in the study area, Batik and her calf at these two locations on the 11 and 12 August 92 respectively. The implication here would be that Batik came from somewhere else in the study area - probably from inland because the camera trap coverage along the south coast was dense enough for there to be little possibility of any resident rhinos not being detected.
Conversely it is equally significant that having spent at least 7 months in a one kilometer diameter area near the mouth of the Cikeusik river Heidi moved 2.5 kilometers away soon after separating from her calf.

It is also worth mentioning here that the size of the subadults were comparable to some of the calves. Patch for instance was about the same size as Freda's calf - and both Freda (with calf) and Patch had similar home range sizes. This might suggest that the size of the female and calf home ranges is determined by the calf.

To put all this is a larger picture it would appear that females without calves use moderately sized home ranges (about 71% of the males home range size) in the interior of the study area. When the females are about to give birth they move to the coast and for the duration of the time the calf is with the mother that situation remains. As in the case of Heidi and probably the mother of the subadult Patch, the females ultimately leave their calves near where they were born and move deeper inland.

This scenario has certain parallels with the Sumatran rhinos studied by van Strien (1985) in the Mamas. There the calves were born and raised near salt licks and when the young were adolescent the mother would leave her progeny in the area and return to a separate home range in the mountains on the edge or well to the west of the study area.

It is possible that the mineral needs of the calf and the lactating mother can only be satisfied in areas near mineral springs or the sea. Whatever the reason, it seems that the coastal regions of Ujung Kulon may be of immense importance to the lives of the Javan rhinos there and this could have important ramifications in park management plans.

4.4.2. SOCIAL BEHAVIOUR

4.4.2.1 Consortships

On nine occasions two different rhinos were recorded passing the same camera locations on the same day. Of these, two events involved an adult male and a subadult male, two involved two males, and the remaining five involved an adult male and an adult female. The question arises, were these female/male events just chance encounters or did they reflect some sort of interaction between the individuals concerned. In one case (involving Atilla and Freda and calf at Citadahan) the significance would probably be slight since the male and female/calf passed the location from opposite directions. On the other four occasions the male and female were travelling in the same direction. In two of these instances the male passed after the female and in the other two instances the order was reversed. In only one instance was the same pair recorded in two consecutive days - this occurred with Chisel and Freda with her almost fully grown calf at the Katapang location.

Other researchers (Hoogerwerf, 1970, Ammann 1985) have reported that consortships between male and female Javan rhinos are brief, lasting a few days only. Ammann also reported that one male in his study area followed a pair of females for about 5 days. It may be possible that the smaller of these two females was the progeny of the larger. The results of this study suggest that female calves tend to stay with their mothers longer than the males (the height of Freda's calf, thought to be a female, was actually greater than the subadult male Patch). It is possible that both in the case of Ammann's two females and in the case of Freda and her calf that the adult female came into oestrus before separating form her young.

In the other case of possible consorting we have Batik being seen with two different males (Flattop and Star?) in the space of about three months. The first occasion occurred shortly after Batik's calf was last seen. Records of female Indian rhinos coming into oestrus two months after giving birth are cited in the literature (Hoogerwerf 1985), so it is possible that Batik may have done so as well.

Regarding the sightings of two males at the same locations on the same day, little can be concluded. In both cases Chisel and the most commonly sighted male in the study area was involved.

On the first occasion Chisel was seen running past the location at Pematang Langkap on the 13 march 92 less than a few minutes after Point (the male most often seen at this location). Point had a deep fresh wound near the lower edge of his right shoulder plate and it is conceivable that this occurred during some sort of confrontation with Chisel.

In a later event. on the 4 November 1992 at the location at Muara Daon near the lower reaches of the Cikeusik river Chisel was observed following Flattop, though the length of time that elapsed between the successive passes is uncertain. Both individuals had been wallowing and there were no visible signs of fresh wounds (both in these photographs and in subsequent ones). It is likely that many interactions between males are relatively peaceful. Hoogerwerf(1970) observed them wallowing together so clearly not all interactions between adult males are aggressive.

4.4.2.2. Dominance

Little can be said about this from the camera trap data. The data did establish that there was well defined sexual dimorphism though the degree was not as pronounced as in the Indian rhino. With the males of the Javan Rhino being clearly larger than the females (8% higher on average) the implication would be that at least some of the males are polyganous, and that this would suggest some sort of dominance hierarchy, since there would be competition for the females.

To enlarge of the possible interaction between Chisel and Point at Pematang Langkap (described above in 4.4.2.1) several things are worth enlarging on here. Firstly Pematang Langkap was the location at which Point most commonly appeared and thus was probably near the middle of his home range. Secondly Point had neck folds which the second largest in the park (and larger than Chisel). Thirdly after Chisel had chased Point passed the camera location he returned the following day. Up to this time Point had never been observed at the Pematang Langkap location although several two other rhinos had (one occasion each).

A possible scenario to account for these facts is that Chisel may have challenged Point . Although this fell within the presumed middle of Point's home range, Chisel was able to drive Point away. It is interesting to note that of all the adults observed in the study area Point has one of the smallest home ranges despite being in the center of the study area . (Two other males Blade and Ulysses that appeared to have limited home ranges were recorded at the periphery of the study area where it was impossible to get a good idea of the total range size). It might be the Point was in fact an old male with a reduced home range size, and the large neck folds might be a feature of age. Ammann (1970) was the first to suggest that old males have reduced home ranges and recorded one in the area west of Cidaon as having a home range about half the normal size of other adult males.

4.4.3. RELATIONSHIPS WITH COMPETITORS

There are three other herbivores that could be competitors with the rhino in the study area . The rusa deer *Cervus timorensis* , the barking deer *Muntiacus muntjak*, and the banteng *Bos javanicus*.
The rusa is very rare on the peninsular and was photographed by the camera trap grid only once (a male followed by a female at Ujung Pantai on the south coast) and observed only twice, once at the grazing grounds at Cidaon and again on the dried out swamp at Nyur. Compared with the barking deer which was photographed by the cameras 75 times the rusa is so rare as to not to be considered a serious competitor with the Rhino. In addition the rusa is at least partly a grazer whereas the Javan rhino is considered to be almost exclusively a browser.

Barking deer are found throughout the park but prefer forested and well shaded areas. Although they are browsers they were rarely recorded by the camera traps in the rattan shrublands which are so important as foraging areas for the rhino. They thus seem to fill quite separated niches and would not be considered competitors. Their low numbers compared with. say, Banteng and their low biomass would suggest that they are not significant competitors

More common than the barking deer are banteng (photographed by the camera traps 180 times and frequently in groups) which were found throughout the park in almost all habitats . The banteng have probably increased in total population significant since Hoogerwerf described them in 1971. In those days they were assumed to keep close to the grazing grounds on the NE and NW coast and to a lesser extent on the grassy terrace between Cibunar and Citadahan. During this study I found them throughout the park from near the summit of Cikelapabeureum to the coastal plains, both north and south. They were absent only absent only from the tidal swamps on the East coast. Ammann (1985) found that there was only limited overlap in the diet of the rhino and banteng, but suggested that insufficient evidence was available to categorically rule out the chance of significant competition.

It may be important to mention here that banteng are able to utilize habitats which are rarely used by rhinos, especially the extensive stands of dense bamboo *Schyzostachyum zollingeri* . Here signs of banteng were common and it has been suggested by Ammann(1985) that the sprouting bamboos are important food sources for these wild cattle. In general however we found that the banteng were less common in the shrublands percent-wise than the rhinos which are morphological better suited for passage through the dense vegetation. In the densest thickets along the middle of the south coast banteng were very rare although they frequented the grassy patches along the inner edge of the beach.

4.4.4 HABITAT MANAGEMENT

There has been much discussion of late regarding the need to "enhance" the habitat for rhinos in Ujung Kulon. According to work done by Hommel (1990) the habitat for rhinos should actually improve over the next few decades (say until about the year 2020) and active management should be unnecessary. It is also highly unlikely that the rapid fall in rhino distribution (less than about 4 years in the eastern park of the peninsula) could possibly be matched with commensurate rate in vegetation change, which would be expected to take decades rather than years.

Additionally , rhinos need more than just forage - they need places to wallow, access to minerals, places to shade themselves, etc. and so ill considered experiments in modifying the vegetation within the park could produce negative impacts.

Another important consideration is that Ujung Kulon is more than just a haven for the rhino. It also harbours many other rare vertebrates and is extremely important floristically.

In view of the inherent risks of tampering with the present situation and the opinion of the best research to date that the habitat will actually improve for the rhino (Hommel 1985) it should be argued that it would be best to allow the natural progression of revegetation to proceed rather than imposing arbitrary 'management'.

A further consideration is that too much emphasis on habitat quality as a potential reason for the fall in the rhino population might mask more immediate threats to the population.

Spotted leopard
Panthera pardus

Ajak
Cuon alpinus

Wild boar
Sus scrofa

Banteng (female)
Bos javanicus.

SECTION 5
RECOMMENDATIONS

The present population of Javan rhinos is Ujung Kulon is clearly not utilising all the available suitable habitat. There is strong evidence that areas where rhinos were abundant as recently as 4 -6 years ago are now almost devoid of them. Other evidence, based on past censuses suggests that the numbers of rhinos in the park have been falling.

The causes for this are most likely not habitat change or disease but active human reduction of the population. Given that it is both national and international policy to protect and ensure the long term survival of the Javan rhinos the following steps should be made. In order of priority they are.

1. Improve protection of the park and the rhinos by :
- Upgrading the motivation, well-being and expertise of the park guards through better pay, active leadership in the field, and through better recruitment, incentives and rewards.
- Empowering park guards to enforce the law when apprehending offenders
- Improviving the procedures to have offenders summarily dealt with by the relevant departments.

2. Develop an efficient patrolling system.
Actually some of the best systems were worked out in the 1940's and used again in the 1960's and 70's. If just these organisational techniques were fully implemented then the park would be considerably more secure, and better understood.

3. Begin immediately on a systematic monitoring of the rhino population.
- there should be a full track count census to compare the results with the camera trap study estimates
- there should be a long term systematic monitoring program based on plaster casts of tracks. This should be an ongoing program for several years and should be incorporated with the patrolling work
- it may be possible to include some camera trap work to correlate track casts with individuals photographed and identified.

4. For the interim, **no habitat management is recommended,** as this is an unproved procedure, is potentially harmful to other life forms in the park and would have little potential to build the population in the near term. **Also captive breeding should not be considered** as a way of increasing the population as numerous cases have proved that given adequate protection in situ breeding rates are much higher than other methods and also a lot safer.

5. Begin preparing a translocation site in Way Kambas for the development of a second population.

Before any translocation is even contemplated the security of Ujung Kulon must be demonstrated and the population proved to be increasing The security of the Park could be tested by independent agencies such as consultants, while the size of the population and its recruitment rate would be derived from the monitoring work.

6. If and when all the above stated conditions are fulfilled then **a staged translocation to form a second population** can be contemplated. This would follow a long period of research (probably involving radio collaring) and practice in techniques of selection , capture and release of rhinos. For this it might be conceivable that Sumatran rhinos already in captivity could be used. Only if all methods are proven should it be considered safe to go ahead with any translocations.

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Appendix A

The minimum number of different animals photographed

In general, identification photographs can be grouped into those definitely showing the same animal and those groups can then be taken in turn and compared to each other. If all the groups definitely show different animals we know that the number of animals photographed equals the number of groups. However, if we cannot always be sure that two groups show different animals then the minimum number of different animals photographed is no longer obvious.

A simple way to solve this problem is to represent the first group as a circle drawn on paper. The next group is compared with the first: if it definitely shows a different animal it is represented by a second circle which does not intersect the first, but if it may show the same animal the two circles intersect. The third group is compared with each of the first two: if it may show the same animal as the first group, the third circle intersects with the first; if it may show the same animal as the second group, the third circle intersects with the second; if it may show the same animal as either the first or second group, the third circle intersects both the first and second circles. The same method is used for the fourth group, the fifth and so on until all groups are represented on paper (as the number of groups increases the circles will need to be distorted in shape to achieve the necessary intersections). The minimum number of animals photographed is then the maximum number of circles that can be counted for which no two intersect. Another way to express this is to imagine the circles as cut-out paper shapes which partially overlap on the table. The minimum number of animals is then the minimum number of pins that would be required to secure all the shapes to the table.
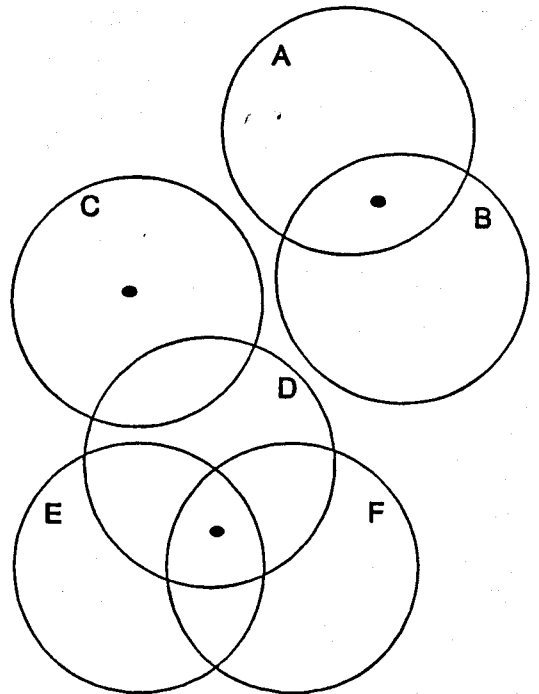
Figure 11 Example of id decision data. A and B may be the same but are definitely not C, etc. At least 3 "pins" are needed to touch all the circles.

As the number of groups increases this graphical technique becomes impractical. We have developed an algorithm MINDIFF which will calculate the minimum number of different animals given a file of difference decisions and which we can make available for future applications.

Appendix B

A population size estimator for continuous capture/recapture data

Suppose n photographs have been obtained from a population of N animals. A sufficient condition is that each possible selection of the animals to appear on the photographs is equally likely. For example if a population of 5 animals, A,B,C,D and E is photographed three times, the probability that A, B and C appear once each is be the same as that A appears twice and B once, or that D appears three times, and so on. If the photographs are shuffled before being considered in order then every possible arrangement is also equally likely - there are N^n such arrangements possible. If all the animals appearing on all the photographs can be identified, the frequency distribution $\{f_i\}$ for the number of animals appearing on exactly i photographs is known. The probability of $\{f_i\}$ given N can be found by dividing the total possible number of arrangements into the number of arrangements leading to the $\{f_i\}$ distribution, to give:

$$P(\{f_i\} \mid N) = \frac{N!}{(N - \sum f_i)! \times \prod f_i!} \times \frac{n!}{\prod (i!)^{f_i}} \times N^{-n}$$

The first term gives the number of ways of selecting the animals which appear i times, and the second term the number of ways of arranging the sets of photographs showing the same animals among the n. Given that $\{f_i\}$ is known exactly then Σf_i, i.e. the number of different animals photographed, is sufficient for N, and the ML estimate for N maximises:

$$\frac{N! \times N^{-n}}{(N - \sum f_i)!}$$

In general, however, the exact frequency distribution for number of photographs per animal will not be known; rather, there will be a number of $\{f_i\}$ distributions consistent with the data. In that case, the sum of the probabilities corresponding to each $\{f_i\}$ must be maximised with respect to N. As Σf_i is then no longer sufficient for N, the amount of calculation involved in enumerating the $\{f_i\}$'s and maximising with respect to N is considerable and must be carried out using a computer. Confidence limits on the N estimate can be obtained using the likelihood ratio method. Clearly, an increasing degree of uncertainty concerning the identifications will lead to a growth in the number of $\{f_i\}$'s and an increase in the width of the confidence interval. This can be kept in check by omitting photographs which fail to meet minimum quality criteria and by treating sets of photographs taken from very different viewpoints separately. An algorithm for deriving estimates based on this approach, given data on viewpoint and difference decisions, is under development.

Map of Study Area Showing Camera Locations

N

0 1 2 3
km

6° 40' 00" S

41'

42'

43'

44'

45'

46'

47'

48'

49'

6° 50' 00" S

Nyur

Gu

Rotan
Kiara

Cinogar Baru

Cinogar Tengah

Bambu

Tanjung Layar

Pulau Peucang

Tanjung Layar

Cidaon

Puncak
Telanca
Ciujung Kulon

Cinogar Atas

Pematang Langkap
Cikeusik Utara

Cikuya Bawah

Pohon Tinggi

Cijengkol

Cikeusik Atas

Kubangan

Cikendeng / Lebak

Pamunar

Cibunar 1
Cibunar 2

Ketapang

Jemabatan

Kubangan3
Teureu
Citadahan
Muara Citadaha

Cibunar

105° 12' 00" E

13'

14'

15'

16'

17'

18'

19'

105° 20' 00" E

Tanjung Alang-Alang

Nyur

Citelang

Gubug

Bambu Duri

Gadog

Cikarang Bawah
Cikarang Bawah 2
Cikarang Atas

Cangkeutek

Pulau Handeuleum

Cigenter 1
Cigenter 2

Gardu Buruk

Cekekan

Gunung Langkap

Cihandeuleum 1

Bojong Honje

Cihandeuleum 2

Laban

ureup

Muara Daon

an

Baru

Cikeusik Baru

dahan

Ikan

Muara Cikeusik

Gunung Cikeusik

Ong

Lereng

Cikeusik Timur

Pematang

Cibandawoh

Karang Ranjang 1
Karang Ranjang 2

**Karang
Kanjang**

Karang Ranjang 3

Treleng

21' 22' 23' 24' 26' 27'

Identification Key for Ujung Kulon Rhinos

Site	Date	Individual	Ear-traits Position L	R	Edge L	R	Horn-traits Size	Tip	Shape	Eye-wrink. L	R	Cheek-prof. L	R	Neck fold L	R	Neck Prof.	Sh. rear edge L	R	Sh. pores L	R	Pigm. neck L	R	Pigm. abd. L	R	Pigm legs	Tail length	Scars
Cikeusik Baru	2-Apr-92	Apollo	E	E	N	.	S	B	S	APM	.	.	C	.	C	.	S	U	.	APM	.	APM	.	APM	.	N	N	
Cikeusik Baru	6-May-92	Apollo	E	E	N	N	S	B	S	APM	.	C	.	.	.	S	.	.	.	.	.	.	.	.	.			
Cikeusik Baru	11-May-92	Apollo	E	E	N	N	S	B	S	APM	.	.	C	.	C	.	S	.	.	.	.	.	.	.	.			
Cikeusik Baru	16-Jul-91	Apollo (?)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
Cikeusik Baru	14-Sep-91	Apollo (?)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
Teureup	15-Sep-91	Atilla	E	E	.	N	M	B	S	.	AAM	.	A	.	K	S	.	U	.	.	AAM	.	.	.	.	N	K	
Teureup	30-Sep-91	Atilla	E	E	N	K,2	S	B	S	AAM	.	.	R	K	.	S	.	U	.	AAM	.	.	.	.	.			
Teureup	26-Feb-92	Atilla	E	E	N	K,2	S	B	S	AAM	.	.	R	K	.	S	.	U	.	AAM	.	.	.	.	.			
Citadahan	22-Apr-92	Atilla	.	E	.	.	S	B	S	.	AAM	.	R	.	K	W	.	.	K,A	.	AAM	.	.	.	N		E	
Citadahan	29-Apr-92	Atilla	.	E	N	.	S	B	S	AAM	.	.	R	K	.	W	U	.	.	AAM	.	.	.	.	.		E	
Kubangan 3	26-May-92	Atilla	.	E	.	.	S	B	S	.	AAM	.	R	.	K	W	.	.	K,A	.	AAM	.	AAM	.	AAM			
Cibandawoh	6-Jun-92	Atilla	.	E	.	N	S	B	S	.	AAM	.	R	.	K	W	.	.	K,A	.	AAM	.	AAM	.	AAM	N		
Karang Ranjang2	14-Jun-92	Atilla	E	E	N	.	S	B	S	AAM	.	.	R	K	.	w	U	.	.	AAM	.	AAM	.	.	.			
Karang Ranjang2	8-Aug-92	Atilla	E	E	N	.	M	B	S	AAM	.	.	R	K	.	w	U	.	.	AAM	.	.	.	.	.	N	E	
Cikendeng	9-Jun-91	Atlas	E	.	K,3	.	L	.	.	.	.	.	A	.	.	w	U	.	.	.	.	.	.	.	.			
Cikendeng	20-Jun-91	Atlas	E	D	K,3	T,1,3	L	.	.	.	.	.	.	.	.	w	U	.	.	ASM	.	.	.	.	.			
Cibunar 2	21-Oct-91	Atlas	E	D	N	T,1,2,3	L	B	F	.	.	.	C	.	C	W	.	U	.	.	ASM	.	ASM	.	ASM	.	N	
Cikuya Bawah	30-Nov-91	Atlas	E	D	N	C	L	W	E	.	.	.	A	.	C	W	.	U	.	ASM	.	.	.	.	.			
Cibunar 2	4-Jan-92	Atlas	.	D	N	.	L	W	F	.	ASM	.	A	.	C	W	.	U	.	.	ASM	.	ASM	.	FR			
Telanca 2	6-Mar-92	Atlas	E	D	N	C	L	W	CL	ASM	.	.	A	C	.	w	U	.	.	ASM	.	.	.	ASM	.	N		
Cibunar 2	21-Mar-92	Atlas	.	D	.	T,1,2,3	L	B	F	.	.	.	C	.	C	W	.	U	.	.	ASM	.	.	.	.			
Telanca	27-Jun-92	Atlas	E	D	N	.	L	W	F	ASM	.	.	A	C	.	w	.	U	.	ASM	.	ASM	.	ASM	.	L+AR	N	
Cikuya Bawah	29-Aug-92	Atlas	E	D	.	.	M	.	F	.	.	.	C	C	.	w	.	U	.	.	.	ASM	.	ASM	.			
Cijujung Kulon	14-Sep-92	Atlas	E	D	N	T,1,2/B,3	L	B	F	.	.	.	C	C	.	w	.	U	.	.	.	ASM	.	ASM	FR		
Lebak (Cikendeng	22-Sep-92	Atlas	E	S	.	C1,2(?),B3	L	.	F	.	.	.	A	C	.	.	.	U	.	.	ASM	.	ASM	.	LR			
Cijujung Kulon	4-Nov-92	Atlas	E	S	.	B,3	L	B	F	.	.	.	C	C	.	w	.	U	.	.	ASM	.	ASM	.	FR			
Bambu Duri	9-Feb-93	Blade	E	E	N	N	L	B	T	B	.	.	A	C	.	S	.	U	.	C	.	LM	.	.	.	N	N	
Cikarang Atas	8-Oct-91	Boy	E	E	N	.	S	B	ST	B	.	.	R	C	.	S	.	N,B	.	.	.	BOM	.	.	.	N	N	
Rotan	25-Sep-92	Boy	E	E	K,4	N	S	B	ST	.	.	.	R	R	.	U	.	U	U	.	.	BOM	.	BOM	.		N	S
Cikendeng	28-Jun-91	Chisel	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	U	.	.	.	.	.	.		C	
Kubangan	31-Aug-91	Chisel	E	E	k,3	C1,4	M	.	C	CHM	.	.	R	C	.	S	.	U	.	W	CHM	.	.	.	CHM		C	
Telanca	21-Dec-91	Chisel	.	E	.	.	M	W	CL	CHM	.	.	R	C	.	S	.	U	W	.	CHM	CHM	.	CHM	.			
Telanca	5-Jan-92	Chisel	.	E	N	C,4	M	W	CL	CHM	.	.	R	C	.	S	.	U	.	.	CHM	CHM	.	CHM	.		C	
Pematang Langka	13-Mar-92	Chisel	.	E	.	.	M	W	CL	.	.	.	A	.	C	S	.	.	W	.	CHM	.	.	.	.		C	
Pematang Langka	14-Mar-92	Chisel	.	E	N	.	M	W	CL	CHM	.	.	R	C	.	S	.	U	.	.	CHM	CHM	.	.	.		C	
Cikeusik Atas/Bar	14-May-92	Chisel	E	E	.	C,1,4	M	W	CL	.	CHM	.	R	.	.	S	.	U	.	W	CHM	CHM	.	.	.		C	
Katapang	15-May-92	Chisel	E	.	N	.	M	W	CL	.	.	.	.	.	C	S	.	U	.	W	CHM	CHM	.	.	.		C	
Cikeusik Atas/Bar	24-Jun-92	Chisel	.	E	N	C,4	M	W	CL	.	.	.	A	.	C	.	.	.	W	.	CHM	.	.	CHM	N		C	
Katapang	1-Jul-92	Chisel	E	E	N	C4(17)	M	W	CL	.	.	.	A	C	.	S	.	U	.	.	CHM	.	.	.	.		C	
Cikeusik Atas/Bar	12-Jul-92	Chisel	.	E	N	.	M	W	CL	.	.	.	R	C	.	S	.	U	.	.	CHM	.	.	CHM	.	N		
Kubangan 3	21-Jul-92	Chisel	E	E	.	C1,4	M	W	CL	CHM	.	.	.	.	C	S	.	W	.	.	CHM	.	.	.	.		C	
Kubangan 3	21-Aug-92	Chisel	E	E	k,3	.	M	W	CL	CHM	.	.	.	C	.	S	.	U	.	.	.	.	.	.	.			
Kubangan 3	7-Sep-92	Chisel	E	E	.	C4+?	M	W	CL	.	.	.	A	.	C	S	.	W	.	.	.	.	CHM	.	.		C	
Katapang	26-Sep-92	Chisel	E	E	.	C1,4	M	W	C	CHM	.	.	A	.	C	S	.	W	.	.	CHM	CHM	.	.	.			
Katulampa	12-Oct-92	Chisel	E	.	N	.	M	W	.	.	.	.	A	C	.	S	.	W	.	.	.	.	.	.	.		C	
Muara Daon	4-Nov-92	Chisel	E	E	.	C4+?	M	.	CL	.	.	.	A	C	.	S	.	W	.	.	.	.	.	.	.			
Jembatan	2-Dec-92	Chisel	E	E	N	C,4 (17)	M	W	T	CHM	.	.	A	.	C	S	.	W	.	.	CHM	.	.	.	.		C	
Kubangan 3	2-Dec-92	Chisel	.	E	k,3	.	M	.	CL	CHM	.	.	R	C	.	S	.	U	.	.	.	.	.	.	.			
Jembatan	18-Dec-92	Chisel	.	E	.	C,1,4	M	.	CL	.	CHM	.	R	.	C	S	.	U	.	.	CHM	CHM	.	.	.		C	
Muara Daon	2-Jan-93	Chisel	E	E	N	.	M	W	CL	CHM	.	.	R	C	.	S	.	U	.	.	.	CHM	.	.	.			
Katapang	12-Jan-93	Chisel	E	E	N	.	M	W	CL	.	.	.	A	C	.	S	.	.	.	.	.	.	.	.	.			
Katapang	13-Jan-93	Chisel	E	E	N	.	M	W	CL	CHM	.	.	R	C	.	S	.	U	.	.	.	CHM	.	.	.			
Muara Daon	17-Jan-93	Chisel	E	E	N	C4,K1	M	W	CL	CHM	.	.	R	C	.	S	.	U	.	.	CHM	CHM	.	.	N		C	
Cibandawoh	6-Apr-91	Flattop	E	D	.	B,2	L	B	E	.	.	.	R	.	.	W	.	U	.	FM	.	.	.	.	N			
Cibandawoh	27-May-91	Flattop	.	.	.	.	L	B	E	.	.	.	.	.	.	W	.	N,A	.	FM	.	.	.	.	N		N	
Cibandawoh	9-Aug-91	Flattop	E	D	.	B,2	L	B	E	FM	.	.	A	B	.	W	.	U	.	FM	.	.	.	.	N			
Cibandawoh	15-Oct-91	Flattop	E	S	N	B,2	L	B	E	FM	.	.	A	B	.	W	.	U	.	FM	.	.	.	.	N			
Cibandawoh	9-Nov-91	Flattop	E	S	N	.	L	B	E	FM	.	C	.	C	.	W	.	N,A	.	FM	.	FM	.	.	.	N		
Cikeusik Timur	5-Jan-92	Flattop	E	S	N	.	L	B	E	FM	.	C	.	B?	.	W	.	N,A	.	FM	.	FM	.	FM	.	N		
Citadahan	13-Jun-92	Flattop	.	E	.	B,2	M	B	E	.	FM	.	C	C	.	W	.	U	.	FM	.	.	.	FM	.	N		
Citadahan	18-Jun-92	Flattop	E	D	.	B,2	M	B	E	.	FM	.	C	C	.	W	.	U	.	.	.	.	.	.	.	N	N	
Muara Daon	4-Nov-92	Flattop	E	S	.	C1,2,+?	L	.	CL	.	FM	.	A	C	.	W	.	U	.	.	.	.	.	.	.		N	
Gunung Cikeusik	5-Jan-93	Flattop	E	D	N	.	L	B	E	.	.	C	.	C	.	W	.	N,A?	.	FM	.	FM	.	.	.			
Muara Daon	6-Jan-93	Flattop	E	D	.	C1,2)	L	B	E	FM	.	.	A	C	.	W	.	U	.	FM	.	FM	.	.	.		N	
Gunung Cikeusik	8-Jan-93	Flattop	E	D	N	.	L	B	E	.	.	C	.	C	.	W	.	N,A?	.	FM	.	.	.	.	.	N		
Gunung Cikeusik	8-Jan-93	Flattop	E	D	.	.	L	B	E	FM	.	.	C	C	.	W	.	U	.	FM	.	FM	.	.	.	N		
Kubangan 3	8-Jul-92	Flattop	E	D	.	T1,2	L	.	E	.	.	.	A	.	.	W	.	U	.	.	.	.	.	.	.		I	
Cihandaleum	21-Jun-91	Haydn	E	.	.	N	S	B	S	.	.	.	C	C	.	.	.	U	.	.	HM	.	.	.	HM	N	N	B
Cihandaleum	15-Oct-91	Haydn	S	E	.	N	S	B	S	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.			
Cihandaleum	24-Jun-92	Haydn	S	.	N	.	S	B	S	HM	.	.	C	C	.	S	.	U	.	HM	.	HM	.	HM	.	N	N	
Cihandaleum	21-Feb-92	Haydn	.	E	.	N	S	B	S	HM	.	.	C	C	.	S	.	U	.	HM	.	HM	.	HM	.	N		B
Muara Cikeusik	27-Apr-92	Haydn	.	E	.	N	.	.	.	.	.	.	C	C	.	S	.	U	.	HM	.	HM	.	HM	.			
Ikan	20-May-92	Haydn	E	.	.	N	S	B	S	HM	.	.	R	C	.	S	.	U	.	HM	.	HM	.	HM	.	N		B,G
Katapang	25-May-92	Haydn	S	.	.	N	S	.	S	HM	.	.	.	.	.	S	.	.	.	.	HM	.	.	.	.			B,G
Baru	20-Oct-92	Haydn	S	E	N	.	S	B	S	HM	.	.	R	C	.	S	.	U	.	HM	.	HM	.	.	.	N	N	
Cibandawoh	11-Jun-91	Kinko	D	E	N	.	M	B	F	KM	.	.	R	B	.	S	.	N,B	.	KM	.	KM	.	.	.	N		
Cibandawoh	11-Oct-91	Kinko	D	E	N	.	L	B	E	.	.	C	.	C	.	S	.	N,B	.	KM	.	KM	.	.	.	N		A
Cikeusik Timur	9-Jan-92	Kinko	D	E	.	K,2	M	B	F	KM	.	.	R	C	.	S	.	N,B	.	KM	.	.	.	.	.	N		A
Muara Cikeusik	26-Mar-92	Kinko	D	E	.	.	L	B	E	KM	.	C	.	C	.	S	.	N,B	.	KM	.	.	.	.	.	N		A
Muara Cikeusik	26-Mar-92	Patch	E	E	N	.	S	B	ST	PTM	.	A	.	C	.	S	.	N,M	.	PTM	.	.	.	PTM	.	FR		
Muara Cikeusik	29-Mar-92	Patch	E	E	N	.	S	.	ST	PTM	.	.	R	C	.	S	.	U	.	PTM	.	.	.	PTM	.	FR		
Ikan	7-May-92	Patch	E	.	N	.	S	.	.	.	.	.	.	.	.	U	.	.	.	.	.	.	.	PTM	.	FR	N	N
Lereng	12-May-92	Patch	E	E	.	N	S	.	ST	.	PTM	.	R	C	.	S	.	U	.	.	PTM	.	.	PTM	FR		N	
Pematang Langka	8-Feb-91	Point	.	S	.	.	M	B	.	.	.	.	.	.	C	.	.	U	.	.	.	.	.	.	.			H
Gunung Langkap	16-Mar-91	Point	S	E	N	.	M	B	F	POM	.	.	R	C	.	S	.	U	.	POM	.	POM	.	POM	.	LR	N	H
Pematang Langka	18-Jul-91	Point	.	E	.	.	.	.	.	.	.	.	.	.	.	.	.	U	.	.	.	.	.	POM	.	LR	N	H
Pematang Langka	24-Jul-91	Point	.	E	.	.	M	B	CL	POM	.	.	R	C	.	S	.	U	.	POM	.	POM	.	.	.		N	H
Pematang Langka	13-Aug-91	Point	E	.	.	.	M	B	CL	POM	.	.	A	C	.	S	.	U	.	POM	.	.	.	.	.			H
Pematang Langka	25-Oct-91	Point	.	E	.	.	M	B	.	.	.	.	C	C	.	S	.	U	.	POM	.	POM	.	.	.			H
Pematang Langka	8-Mar-92	Point	.	E	.	.	M	B	CL	POM	.	.	C	C	.	S	.	U	.	POM	.	POM	.	.	.			H
Pematang Langka	13-Mar-92	Point	E	E	.	.	M	B	CL	POM	.	.	A	C	.	S	.	U	.	POM	.	POM	.	POM	.	FR	N	H
Katulampa	19-Oct-92	Point	S	E	.	K,4	M	B	CL	POM	.	.	.	C	.	S	.	U	.	.	POM	.	.	.	SR			H
Cikarang Bawah	14-Mar-91	Rosethom	.	E	.	N	S	B	R	RSM	.	.	C	C	.	S	.	S,B	.	.	RSM	.	RSM	.	.	.			
Cikarang Bawah	14-Mar-91	Rosethom	.	E	N	.	S	B	R	RSM	.	.	.	.	.	.	.	U	.	.	.	.	.	.	.			
Pematang Langka	19-Sep-91	Rosethom	.	E	.	N	S	B	R	.	RSM	.	C	C	.	S	.	S,B	.	.	RSM	.	.	.	.			
Cikarang Bawah	22-Dec-91	Rosethom	.	E	.	N	S	B	SR	.	.	.	C	C	.	S	.	S,B	.	.	RSM	.	.	.	.		N	
Kubangan	6-Sep-91	Roundhom	E	E	.	.	S	B	D	RDM	.	.	C	C	.	S	.	U	.	.	RDM	.	.	.	.	.		.	
Jembatan	2-Dec-92	Roundhom	E	E	.	.	S	B	D	.	.	.	C	C	.	S	.	U	.	.	RDM	.	.	.	.	.			
Jembatan	12-Dec-92	Roundhom	E	E	.	N	S	B	D	.	.	.	C	C	.	S	.	U	.	.	.	.	.	.	.			
Jembatan	14-Dec-92	Roundhom	E	E	.	.	S	B	D	RDM	.	.	C	C	.	S	.	U	.	.	RDM	.	.	.	.	.			
Katapang	22-Dec-92	Roundhom	E	E	N	.	S	.	D	.	.	.	R	C	.	S	.	U	.	.	.	RDM	.	RDM	.			
Katapang	30-Dec-92	Roundhom	E	E	N	N	S	B	D	RDM	.	.	R	C	.	S	.	U	.	.	.	.	.	.	.	N		
Katapang	7-Jan-93	Roundhom	E	E	N	.	S	B	D	RDM	.	.	R	.	.	S	.	U	.	.	RDM	.	.	.	RDM	N	N	
Kubangan 3	14-Jan-93	Roundhom	E	E	.	.	S	.	D	.	.	.	V	C	.	S	.	U	.	.	.	.	.	.	.			
Gunung Cikeusik	3-Jan-93	Star	E	E	N	.	M	B	CL	SM	.	.	C	C	.	S	.	U	.	.	SM	.	SM	.	SM	N	N	
Cibandawoh	23-Apr-92	Star	E	.	.	.	S	B	A	.	.	.	C	C	.	S	.	.	.	.	.	.	.	.	.	N		
Gunung Cikeusik	16-Sep-92	Star	E	.	N	.	M	B	CL	.	.	.	C	C	.	S	.	U	.	.	SM	.	SM	.	SM	N	N	
Baru	31-Oct-92	Star	.	.	.	.	.	B	C	SM	.	.	.	C	.	S	.	U	.	.	.	.	.	.	.			

Location	Date	Name	Code																			
· Katapang	12-Jan-93	Creed		E	E	N		M		CL			A		K		S					
· Katapang	13-Jan-93	Creed		E		N		M	W	CL	O-M		R		C		S	U			· U		
Muara Daon	17-Jan-93	Creed	C4,X1	E	E	N		M	W	CL	O-M		A		C		S	U	O-M	O-M	N	C
Cibandawoh	6-Apr-91	Flattop	B,2	E	D		L	B		E			R			W		U	RM		N	RM
Cibandawoh	27-May-91	Flattop												W	N,A	RM			N	
Cibandawoh	9-Aug-91	Flattop	B,2	E	D		L	B		E	RM		A		B	W		U	RM	RM	N	
Cibandawoh	15-Oct-91	Flattop	B,2	E	S	N	L	B		E	RM		A		B	W		U	RM	RM	N	
Cikeusik Timur	5-Jan-91	Flattop		E	S	N	L	B		E	RM		C		B7	W	N,A	RM	RM	RM	N	
Citadahan	13-Jun-92	Flattop	B,2	M	B		E	RM		C		C		W		U	RM		RM	RM	N	
Citadahan	18-Jun-92	Flattop	B,2	E	D	N	M	B		E	RM		C		C		W		U		N	
Muara Daon	4-Nov-92	Flattop	C1,2,+7	E	S		L	B		CL	RM		A		C		W		U			N	
Gunung Cikeusik	5-Jan-93	Flattop		E	D	N	L	B		E			C			W	N,A7	RM	RM		N	
Muara Daon	6-Jan-93	Flattop	C1,2	E	D		L	B		E	RM		A		C		W		U	RM	RM	N	
Gunung Cikeusik	8-Jan-93	Flattop		E	D	N	L	B		E			C		C		W	N,A7	U	RM	RM	N	
Gunung Cikeusik	8-Jan-93	Flattop		E	D		L	B		E	RM		C		C		W		U	RM		N	
Kubangan 3	8-Jul-92	Flattop	T1,2	E	D		L			E			A		C		W		U			I
Cihandaleum	21-Jun-91	Haydn			E		N	B	B	S			C		C		C		U	H-M	H-M	N	B
Cihandaleum	15-Oct-91	Haydn		S	E		N	S	B	S			R				S		U	H-M	H-M	N	
Cihandaleum	24-Feb-92	Haydn		S		N	S	B	S	H-M		C		C		S		U	H-M	H-M	N	
Cihandaleum	21-Feb-92	Haydn			E		N	B	B	S		H-M		C		C		S		U	H-M	H-M	N	B
Muara Cikeusik	27-Apr-92	Haydn			E		N	S					C		C		S		U	H-M	H-M	H-M	N	
Ikan	20-May-92	Haydn		E	E		N	S	B		H-M		C		C		S		U	H-M	H-M	H-M	N	B,G
Katapang	25-May-92	Haydn		S	E		N	S		S	H-M		R		C		S			H-M			B,G
Baru	20-Oct-92	Haydn	N	S	E	N	N	S	B	S	H-M		R		C		S		U	H-M	H-M	N	N
Cibandawoh	11-Jun-91	Kinko		D	E	N	M	B	F	KM		R		B		S	N,B	KM	KM		N	A
Cibandawoh	11-Jun-91	Kinko		D	E	N	L	B	E	KM		C		B		S	N,B	KM			N	
Cikeusik Timur	9-Jan-92	Kinko	K,2	D	E		M	B	F	KM		R		C		S	N,B		KM		N	A
Muara Cikeusik	26-Mar-92	Kinko		D	E		L	B	E	KM		C		B		S	N,B	KM	KM		N	A
Muara Cikeusik	26-Mar-92	Patch		E	E	N	S	B	ST	PTM		A		C		S	N,M	PTM		PTM	RR	N	
Muara Cikeusik	29-Mar-92	Patch		E	E	N	S		ST	PTM		R		C		S		U	PTM		PTM	RR	N	
Ikan	7-May-92	Patch		E		N										S		U		PTM	PTM	RR	N	
Lereng	12-May-92	Patch	N	E	E		S		ST		PTM		R		C		S		U	PTM		PTM	RR	N	
Pematang Langka	8-Feb-91	Point			S		M	B							C			U					H
Gunung Langkap	18-Mar-91	Point		S	E	N	M	B	F	POM		R					U	POM	POM	POM	LR	N	H
Pematang Langka	18-Jul-91	Point					M									U			POM	LR	N	H
Pematang Langka	24-Jul-91	Point			E		M	B	CL	POM		R		C		S		U	POM	POM		N	H
Pematang Langka	13-Aug-91	Point		E	E		M	B	CL	POM		A		C		S		U	POM	POM			H
Pematang Langka	25-Oct-91	Point			E		M	B				C					U	POM	POM			
Pematang Langka	8-Mar-92	Point			E		M	B	CL	POM		R		C			U	POM	POM			H
Pematang Langka	13-Mar-92	Point	N	E	E		M	B	CL	POM		A		C		S		U	POM	POM	POM	RR	H
Katulampa	19-Oct-92	Point	K,4	S	E		M	B	CL	POM		C		C		S		U		POM		SR	H
Cikarang Bawah	14-Mar-91	Rosethorn	N		E		S	B	R	RBM		C		C		S		S,B	RBM	RBM			
Cikarang Bawah	14-Mar-91	Rosethorn		E	E	N	S		R	RBM		C		C			U					
Pematang Langka	19-Sep-91	Rosethorn	N	E	E		S	B	R	RBM		C		C		S		S,B	RBM			
Cikarang Bawah	22-Dec-91	Rosethorn	N	E	E		S	B	S-R			C		C		S		S,B	RBM			N
Kubangan	6-Sep-91	Roundhorn		E	E		S	B	D	RDM		R		C		S		U	RDM			
Jembatan	2-Dec-92	Roundhorn		E	E		S	B	D			C		C		S		U	RDM			
Jembatan	12-Dec-92	Roundhorn	N	E	E		S	B	D			C		C		S		U				
Jembatan	14-Dec-92	Roundhorn		E	E		S		D	RDM		C		C		S		U	RDM	RDM	RDM		
Katapang	22-Dec-92	Roundhorn	N	E	E	N	S	B	D	RDM		R		C		S		U				N
Katapang	30-Dec-92	Roundhorn	N	E	E	N	S	B	D	RDM		R		C		S		U				N
Katapang	7-Jan-93	Roundhorn	N	E	E	N	S	B	D	RDM		R				S		U		RDM	N	N
Kubangan 3	14-Jan-93	Roundhorn		E	E		S		D			V		C		S		U				
Gunung Cikeusik	3-Jan-93	Star		E	E		M	B	CL	SM		C		C		S		U	SM	SM	SM	N	N
Cibandawoh	23-Apr-92	Star		E	E	N	M	B	CL	SM		A		C		S		U		SM		N	
Gunung Cikeusik	16-Sep-92	Star		E		N	M	B	CL			C		C		S		U	SM	SM	SM	N	
Baru	31-Oct-92	Star		E		N	M	B	C	SM		S		C		S		U	SM	SM		N	
Gunung Cikeusik	22-Dec-92	Star		E			M	B	CL	SM		C		C		S		U	SM	SM	SM	N	
Cibandawoh	22-Apr-92	Star ?	N	E	E	N	M	B	C		SM?		A		C		S			SM?	SM?	N	
Lereng	17-Aug-92	Star ?	N	E	E		M	B	C		SM		A		C		S		U	SM	SM	SM		
Lereng	5-Oct-92	Star ?	N		E		L	B7	C7				A		C		S		U	SM	SM		
Karang Ranjang	22-Jul-91	Ulysses	N		E		M							C		S		U	UM			N	
Cikeusik Baru	11-Aug-91	unidentified																			
Ikan	11-Aug-92	Batik		E	E		N					A		C		S		N,A	U		BF	BF	N	F
Gunung Cikeusik	12-Aug-92	Batik	N		E		N				BF		R		C		S		U		BF	BF	BF	RR	
Gunung Cikeusik	26-Aug-92	Batik	N		E		N						R		C		S		U		BF	BF	RR	
Gunung Cikeusik	8-Sep-92	Batik		E	E	N	N				BF		R		C		S		N,A	U		BF	BF		
Lereng	23-Sep-92	Batik			E		N						R		C		S		U		BF		
Lereng	23-Sep-92	Batik		E		N	N				BF		C		C		S		U		BF		
Lereng	28-Sep-92	Batik		E			N				BF		R		C		S		N,A	U		BF		N	
Lereng	30-Sep-92	Batik			E		N						R		C		S		U		BF		
Lereng	5-Oct-92	Batik					N						R		C		S		U		BF		N	
Lereng	17-Oct-92	Batik		E	E		N				BF		C		C		S		N,A	U		BF		N	F
Gunung Cikeusik	30-Dec-92	Batik	N	E	E	N	N					BF		R		C		S		U		BF	BF		F
Gunung Cikeusik	8-Jan-93	Batik		E	E		N				BF		R		C		S		U		BF	BF		
Gunung Cikeusik	9-Jan-93	Batik	N		E		N						R		C		S		U		BF		
Gunung Cikeusik	14-Jan-93	Batik	N	E	E	N	N				BF		R		C		S		U				N	
Cinogar Atas	22-Jun-91	Diana	B,3/T,2	E	E	N	N								C		S		U	DIF			
Cinogar Baru	6-Oct-91	Diana	B,3/T,2		E								R		C		S		U		DIF		D
Cinogar Baru	30-Mar-92	Diana	B,3/T,2	E	E	N	N										S					
Pematang Langka	31-Oct-91	Dish	N	E	E	N	N				DSF		R		C		S		U	DSF	DSF	DSF	N	
Pematang Langka	31-Oct-91	Dish	N	E	E	N	N					DSF		R		C		S		U	K,B	DSF		N	
Bojong Honje	24-Nov-92	Dish	N	E	S	N	N				DSF	DSF	R	R		C		C		U	K,B	DSF	DSF	N	
Citadahan	15-Sep-91	Freda		E	E		N						FF		C		C		S		U			N	
Citadahan	17-Sep-91	Freda	N		E		N						C		C		S		U		FF		N	
Citadahan	16-Jan-92	Freda		E	E	N	N				FF		R		C		S		U		FF	FF		N	
Citadahan	29-Apr-92	Freda		E	E		N						C		C		S		U				N	
Citadahan	2-Jun-92	Freda		E	E		N						C		C		S		U		FF	FF		
Citadahan	30-Jun-92	Freda		E	E		N						R		C		S		U		FF			
Citadahan	19-Jul-92	Freda		E	E	N	N						R		C		S		U			N	N
Katapang	23-Dec-92	Freda		E	E	N	N						R		C		S		U				N
Katapang	24-Dec-92	Freda		E	E	N	N				FF		R		C		S		U				N
Kubangan 3	31-Dec-92	Freda	N	S	E	N	N					FF?		C		C		S		U		FF	FF	N
Katapang	9-Jan-93	Freda		E	E		N						R		C		S		U				N
Katapang	12-Jan-93	Freda		E	E		N				FF		C		C		S		U		FF		N	N
Katapang	13-Jan-93	Freda	N	E	E	N	N				FF		R		C		S		U		FF	FF		N
Katapang	14-Jan-93	Freda		E	E		N				FF		C		C		S		U		FF		N
Kubangan 3	16-Jan-93	Freda	N	E	E		N						C		C		S		U		FF	FF	N
Kubangan 3	6-Jan-93	Freda	N	E	E	N	N						C		C		S		U				N
Kubangan 3	9-Jan-93	Freda	N	E	E	N	N				FF		C		C		S		U		FF		N
Kubangan 3	10-Jan-93	Freda	N	E	E		N						C				S		U		FF		N
Cikeusik Baru	30-Sep-91	Heidi		D		N	N				H-F		C		C		S		N,A	H-F	H-F		C
Muara Cikeusik	1-Apr-92	Heidi	N7		D		N					H-F		C		C		S		U		H-F	N
Muara Cikeusik	2-Apr-92	Heidi		D	D	N	N				H-F		C	C		C		S		N,A	U	H-F	H-F	H-F	N	N
Lereng	23-Apr-92	Heidi			D		N					H-F		C		C		S		N,A	U	H-F		N
Cikeusik Timur	21-Jul-92	Heidi		S		N	N						R		C		S		N,A		H-F		
Cikeusik Timur	1-Aug-92	Heidi		S		N	N						C		C		S		N,A		H-F		
Baru	20-Aug-92	Heidi		E	D		N						R		C		S		N,A	H-F		N
Gunung Cikeusik	3-Jan-93	Heidi		S			N						C		C		S		N,A	H-F	H-F		N
Cinogar Atas	7-Feb-91	Ibu	N	E	E	N	N				F		R		B?		S				F		C
Cinogar Baru	26-Sep-92	Nova	T,2	E	E	N	N				NF		R				S					