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HOW EFFECTIVE ARE INDONESIAN NATIONAL PARKS AT CONSERVING BIODIVERSITY? A SPATIAL ANALYSIS

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Being a Dissertation submitted to the faculty of The Built Environment as part of the requirements for the award of the MSc International Planning at University College London:
I declare that this Dissertation is entirely my own work and that ideas, data and images, as well as direct quotations, drawn from elsewhere are identified and referenced.

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List of Acronyms

ADB	Asian Development Bank
BAPPENAS	The National Development Planning Agency, Republic of Indonesia
BNWNP	Bogani Nani Wartabone National Park
CBD	Convention on Biological Diversity
CI	Conservation International
CIFOR	Centre for International Forestry Research
FAO	Food and Agriculture Organisation of the United Nations
FoE	Friends of the Earth
FWI	Forest Watch Indonesia
GFW	Global Forest Watch
GIS	Geographical Information Systems
GOI	Government of Indonesia
IFL	Intact Forest Landscape
IUCN	International Union for the Conservation of Nature
MOE	Ministry of Environment, Republic of Indonesia
MOF	Ministry of Forestry, Republic of Indonesia
NBII	National Biological Information Infrastructure
NGO	Non Governmental Organisation
NP	National Park
PA	Protected Area
RALUCIAPA	Rapid Assessment of Land Use Change In and Around Protected Areas
RQ	Research Question
RS	Remote Sensing
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
WCPA	World Commission on Protected Areas
WCS	World Conservation Society
WDPA	World Database on Protected Areas
WRI	World Resources Institute
WWF	World Wide Fund for Nature

Disclaimer

As is contractually required with using the World Database on Protected Area's (WDPA) datasets, the expression below is provided where WDPA datasets are used:

"UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein"

The following expression is required also, and provides more information about the WDPA.

"World Database on Protected Areas (WDPA) is a joint venture of UNEP and the IUCN, produced by *UNEP-World Conservation Monitoring Centre (UNEP-WCMC)* and the IUCN World Commission on Protected Areas with governments and collaborating NGOs. *The WDPA is updated continuously providing the most current data on protected areas worldwide please go to www.unep-wcmc.org/wdpa"*

ABSTRACT

In a world of declining biodiversity, Indonesia stands out in particular due to the richness of its diversity, and because of the rapidity of its decline. In response to this decline, Indonesia ratified the Convention on Biological Diversity, and additional protected areas have been established, with the most significant category being national parks.

This study sets out to investigate how effective national parks are at conserving biodiversity, and examining whether they have improved since the Convention on Biological Diversity was ratified. Current literature on the issue primarily considers issues relating to management and illegal activities, and frequently focuses on only parts of Indonesia, whilst other issues such as location and design are overlooked. The literature also does not establish whether national park effectiveness can be established. To address this, an exploratory methodological stance is adopted, a variety of methods are considered, with two key approaches, geographical information systems and remote sensing being selected.

Following guidance on factors that effect protected area effectiveness, the author develops new, experimental methods which investigate different aspects of national park effectiveness, with the intention of exploring the methods' utility and spatial analysis more generally. In particular they analyse eco system representativeness, the quality of the environment protected, their size and shape, their connectedness and how much encroachment has occurred. Despite the limitations of the methods, the study proves that there is utility and potential in combining geographical information systems and remote

sensing methods and that national parks can be evaluated in terms of biodiversity effectiveness. The paper establishes that there are design and location issues with national parks and that they have not generally improved noticeably regarding design and location since the CBD was ratified. It also establishes the limitations of spatial analytical techniques, advocating a multi disciplinary approach to investigating this issue, and points to further study and other methods that would assist this investigation.

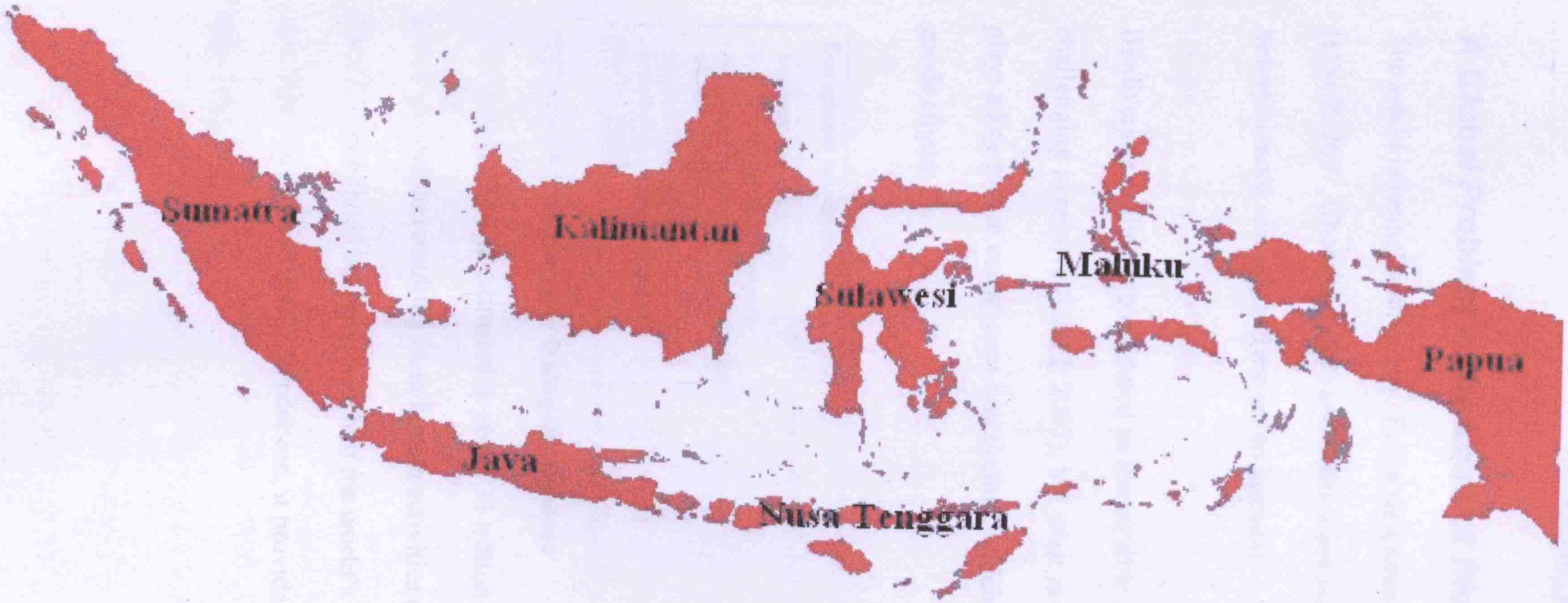

Figure 1 – Indonesia and its major regions *(Source: developed by author, base map extracted from FAO, 2008. Scale: 1:89,115,370)*

INRODUCTION

A Global Problem – The Loss of Biodiversity

The world is losing biodiversity. Extinction rates are estimated to be between 100 times (UNEP, 2007, Chomitz, 2007) and 1000 times (Greenpeace, 2008) the rate they were before humans existed, and are set to increase.

Biodiversity decline is considered as irreversible as climate change, and almost as challenging to resolve (UNEP 2007), but what is the significance of this? Biodiversity plays a key role in eco system functioning, which is needed for eco systems services and goods (figure 2).

Eco system services	**Intangible Services**
- nutrient and water recycling - soil formation and retention - resistance against invasive species - plant pollination, - climate regulation - pest and pollution control (IUCN, 2007)	- Cultural Identity - Spirituality - Aesthetics and Pleasure - Minority Cultures and Traditional Knowledge (UNEP, 2007; Chomitz, 2007)

Figure 2 – Eco system and Intangible services

The value of these is estimated to about 33 trillion dollars per year – nearly twice the global production resulting from human activities (IUCN, 2007). Biodiversity underpins food and livelihood security, with half the world's jobs depending on forestry, agriculture and fisheries (UNEP, 2007). In addition, it provides less tangible services to humanity also (figure 2).

The Significance of Indonesia in terms of Global Biodiversity

Biodiversity is particularly at risk in tropical rainforests, were over half the world's biodiversity is based (WCMC, Undated), but where most of the world's deforestation is occurring (FAO, 2005, 2006. UNEP, 2007) and where most of the worlds threatened species are (Greenpeace, 2004, UNEP 2007, 2006, FAO, 2006). This is significant given that the conversion of natural habitat to other land uses, in particular deforestation, is the main reason behind worldwide biodiversity loss (Sodhi et al, 2004; UNEP, 2007; Greenpeace, 2004). 50% of tropical moist forest has been lost in the last 30 years (Thorsell and Sigaty, 1997), whilst deforestation of closed tropical rainforests may account for up to 100 species per day being lost (WWF/IUCN, 2006).

Of the worlds regions, Southeast Asia and Asia Pacific have experienced the largest proportional decline in forest area in the world, with forest area clearance accelerating especially in primary forests (FAO (2007a, Greenpeace, 2008; Greenpeace, Undated, UNEP RRC AP, 2004). This is problematic because the region has some of the highest endemism in the world, with 11 species declared extinct (Sodhi et al, 2004).

The greatest losses in the region and in Asia have been in Indonesia (FAO, 2007a, 2007, 2006). Out of 6 million hectares of primary forest loss annually, Indonesia and Brazil account for an annual primary forest loss of 4.9 million hectares out of a global loss of 6 million hectares. Despite Indonesia having only the 7th largest area of primary forest, as compared to Brazil having the largest (FAO 2006, 2005), Indonesia has the highest loss of primary forest in the world, at 13% in five years as opposed to Brazil at 4% (FAO, 2007a, UNEP, 2007). Indonesia is one of the 17 "megadiverse" countries with 10% of the world's biodiversity (Greenpeace, 2004, 2004a) being second only to Brazil (BAPPENAS). This does not include coral reef and cave biota however, of which Indonesia has the greatest diversity (BAPPENAS, Hilman). Some statistics on the significance of Indonesia's biodiversity is provided in figure 3.

Type of Biodiversity	Percentage of World Total
flowers	10%
Mammals	12% (the highest in the world)
Reptiles	7.3% (third highest in the world
Birds	17% (fourth highest in the world)
Timber producing trees with economic value	Over 50%

Figure 3 – Indonesian Biodiversity Statistics ***(Source: BAPPENAS, 2003 and CBD, 2008)***

Responses to Biodiversity Loss

At the international level, the response to biodiversity decline was the establishment of Convention on Biological Diversity (CBD) (United Nations, 1993). This is of great significance due to it being adopted by 187 countries (Mulongoy and Chape) and was ratified by Indonesia in 1994 (CBD, 2008). The nature of the convention is such that both sovereign authority and responsibility remain with the nation state (United Nations, 1993; p6; Secretariat of the Convention on Biological Diversity, 2000). Thus, signatories are responsible and are the authority that implements this convention within its jurisdiction.

Within this flexible framework, a particularly significant aspect to biodiversity conservation has been *In Situ* conservation, and in particular Protected Areas (PA's). These are defined as:

> An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means.
> (Mulongoy and Chape, 2006; p8)

They are described by various sources as forming the cornerstone of international and national biodiversity conservation efforts (Nellemann et al, 2007; James et al, 1999; Mulongoy and Chape, 2006; IUCN-WCMC, 2008; WWF, 2008; Sodhi et al, 2004).

Covering 12% of the worlds landmass (Mulongoy and Chape, 2006), PA's represent one of the largest changes of land use in history (Chomitz, 2007), and are therefore one of the most significant planning policies in the world.

The Rationale and Aims of this Study

Given the evidence above, the rationale of this study is to contribute to the body of knowledge regarding Indonesian PA's. For this, the initial aims are to:

1. Explore current knowledge on Indonesian PA's and the issues surrounding them, with particular regard to the significance of the CBD.
2. Observe gaps in current knowledge, and carry out research that seeks to provide this knowledge

These aims are achieved in the literature review. Following the literature review, more refined research questions are proposed.

LITERATURE REVIEW

MacAndrews (1998) states that of the Indonesian conservation based PA categories (nature reserves, wildlife sanctuaries, hunting parks, recreation areas, grand forest parks and national parks), national parks (NP's) are the most significant, being the largest, most supported and financed category (World Bank, 2006 agrees).

Taking a case study approach, he finds that despite their significance, Indonesia has failed to manage NP's effectively because of the Ministry of Forestry's (MoF) top down, exclusionary management and inefficient and unequal staffing and financing allocations between the parks, with larger parks sometimes having less staff and financing than smaller ones (Momberg et al, 2000 and Cochrane, 2000 agree). This inequality is linked to excessive bureaucracy and insufficiently experienced and trained staff. Finding that NP encroachments are increasing, MacAndrews recommends that Indonesia must resolve these management issues before NP's can be effective, rather than Indonesia's approach of creating more NP's.

Using previous statistics, the Government of Indonesia (GOI) (BAPPENAS, 2003) finds that deforestation has increased in all forest areas except in PA's, although deforestation and encroachment did increase in PA's during the economic crisis (*Krismon*) and the reform and decentralisation era (1998-2002) because of poor law enforcement, inadequate staffing, regional political interference and misunderstood development objectives (Hilman, 2005 and Nellemann et al, 2007 agree). Java and Papua[1] saw slight reforestation however, mostly due to expanded PA's.

Unlike other PA's, NP's have a clear legal basis, implementation and management authority (the MoF). Nevertheless, problems in NP's remain including illegal logging especially. In addition other PA's suffer from policy dualism over mining activities and vague boundaries. There are six internationally recognised biosphere reserves with NP's at their centre.

Later GOI opinion (Hilman, 2005) finds that whilst Indonesia has a representative and substantial PA network, most PA's are under intense multiple threats, including disharmonious PA management legislation; local and regional governments allowing destructive activities (World Bank 2006, 2006a agree); inadequate enforcement; hunting and the international wildlife trade; and illegal logging (also mentioned by IFCA, undated) (including famous, internationally supported PA's (FWI/GFW, 2002 and Nellemann et al, 2007 agree)); and fire risk increases due to logging litter.

The GOI repeatedly emphasises the size and number of PA's, in particular NP's, and management initiatives, as evidence of achieving the CBD. It intends to add 18 new PA's, emphasising that 9 new NP's will be established by 2010 (CBD, 2008 agrees). This PA selection is based on the area's level of endemism and on representing all eco-systems. Much of the GOI policy also seems to apply either solely or mainly to NP's,

[1] Please see figure 1 for a map of Indonesia showing the major regions

such as cross border cooperation, capacity building, community involvement in planning and management and joint research.

Holmes has been highly influential, (see Hilman (2005), BAPPENAS (2003), ADB (2005), FWI/GFW (2002) and World Bank 2006, 2006a)) regarding deforestation in Indonesia. By comparing 1985-1997 remote sensing data for Sumatra, Kalimantan and Sulawesi[2], he establishes that deforestation rates have increased, with Sumatra's lowland rainforest largely being destroyed outside PA's by 2005 and Kalimantan's by 2010 (Holmes, 2002). Whilst total area of forest cover is higher in conservation forest (forested PA's) than the other two forestry categories (protection and production forest), he finds that logging is increasing shifting to conservation forests (IFCA[3], Undated agrees), due to a lack of supply elsewhere, with increased degradation in several NP's (Greenpeace, 2004, World Bank, 2006, 2006a and Nellemann et al, 2007 agree). He concludes that only PA's in the high rainfall areas of the three regions may survive, but needs effective enforcement and a new management paradigm; that Sulawesi's lowland forests depend upon Rawa Aopa Watumohai NP; and that given the rapid deforestation in Sumatra, all remaining lowland forest in Sumatra should be given permanent protection status (conservation and protection forests).

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[2] Please see figure 1 for a map of Indonesia showing the major regions
[3] Indonesian Forest Climate Alliance

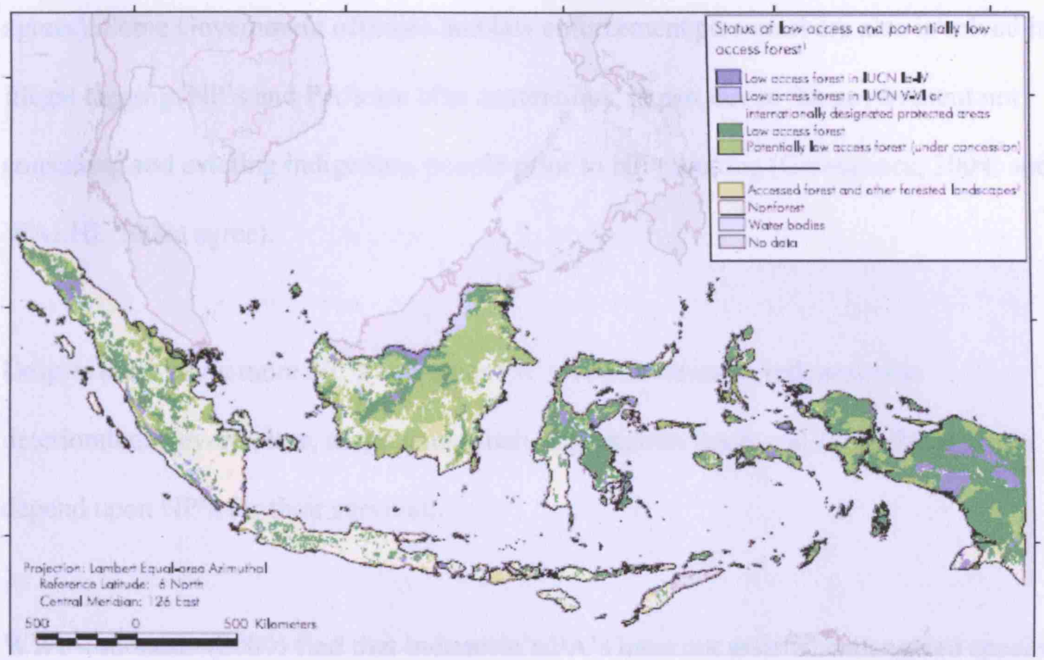

Figure 4 – Map of Indonesia, showing low access forest and PA's ***(source: FWI/GFW, 2002, p96)***

FWI/GFW (2002) also wrote an influential report on Indonesia's forests (see World Bank, 2006, 2006a, Nellemann et al, 2007 and Chomitz, 2007). By comparing low access forest with PA's (figure 4), they find that almost half the low access forest protected under IUCN categories I-IV[4] is in Papua; and most of the rest is in Sumatra and Kalimantan. Despite this protection, approximately 1.3 million hectares of low access forest are simultaneously protected and within logging concessions. The reasons behind illegal activity in PA's is complex however, with economic, social, cultural, political, and environmental dimensions to it, including increasing lawlessness following the *Krismon,* with deforestation being driven not by local poverty, but by outside avarice (Chomitz, 2007 agrees). PA boundaries provide little defence against illegal logging, encroachment and poaching, with law enforcement being almost nonexistent in NP's (WALHI, 2008

[4] International Union for the Conservation of Nature. The category numbers mentioned refer to a global system for categorising different types of PA. I-IV are the stricter forms of protection. For more information please see http://cmsdata.iucn.org/downloads/iucn_pa_categories_guidelines_final_draft.doc.

agrees). Some Government officials and law enforcement personnel are also involved in illegal logging. NP's and PA's are also contentious, in part due to the government not consulting and evicting indigenous people prior to NP gazetting (Greenpeace, 2004; and WALHI, 2008a agree).

Despite there being more NP's and other PA's, conservation in Indonesia has deteriorated. Nevertheless, mega fauna such as Sumatran tigers and Javan Rhinoceros depend upon NP's for their survival.

WWF-Indonesia (2004) find that Indonesia's PA's have not assisted endangered species to establish viable populations because in particular they are not appropriately planned, protected or managed, are too small and too genetically isolated (Walhi, 2004 agrees). WWF (2004) however commended Indonesia for the 9 new NP's created, expanding Kerinci Seblat NP in 2004 and for promoting collaborative PA management. One of the new NP's is Tesso Nilo in Sumatra, which is home to 3% of the world's mammal species and some of the highest lowland plant biodiversity (2004a). The 9 new NP's will also protect over 500 different indigenous communities. Factors such as poor governance and lack of law enforcement remain an issue however (WWF, 2004b). WWF (2007) also commended Indonesia's joint declaration with Malaysia and Brunei over the "Heart of Borneo" initiative, which will conserve almost a third of Borneo through cross border PA's.

The ADB[5] (2005) found that although local governments are now responsible for non NP PA's, since decentralisation there is confusion over local governments' role regarding forest management. Many biologically diverse PA's remain proposed due to the slow and often confusing process of demarcating forest boundaries, and conflicting claims to the land. Local governments must also generate revenue to maintain PA's, but tourism has not generated adequate funds to offset the loss in potential tax revenue from natural resource exploitation (also noted by World Bank, 2006). Compliance with and enforcement of existing laws is weak, in particular regarding logging, due to poor guidance; insufficient staffing; weak judicial procedures and penalties; absence of investigations into where and to whom the illegal logs are sent; and forging of logs transportation papers and manifests.

Using previous statistics, the World Bank (2006, 2006a) finds that due to decentralisation, more open and transparent governance involving multiple stakeholders can now redirect misguided proposals in PA's. In addition, innovative partnerships involving NGO's are also providing more resources for conservation initiatives (also noted by BAPPENAS, 2003).

The World Bank (2006) finds that the expansion of overall ecosystem representation is an encouraging development, as is the appointment of highly committed conservation-oriented staff in key positions in the MOF. Financial resources for management remain constrained however, with insufficient financial resources available to manage the PA system properly, and over-dependency on NGO's and donors. Due to this, the three GOI departments most responsible for

[5] Asian Development Bank

PA's and biodiversity[6] are coordinating efforts to improve conservation financing, calling for greater contributions from Indonesian sources, such as entrance fees, local government incentives and taxes. Improvements are also needed in management, efficiency, cost-effectiveness, resource allocation, and boundary demarcation in NP's.

Compared to effective and successful PA systems in other countries, Indonesia lacks a national vision; brand name recognition within the conservation community and the NP's, public personalities who promote nature appreciation; well-developed local tourism markets linked to domestic recreation needs; an aware and concerned public; and a monitoring framework (2006, p141). Indonesia's PA system has however improved its human resources, with experienced professionals linked to international networks being employed by the MOF.

[6] Ministries of Forestry, Marine Affairs and Fisheries, and Environment

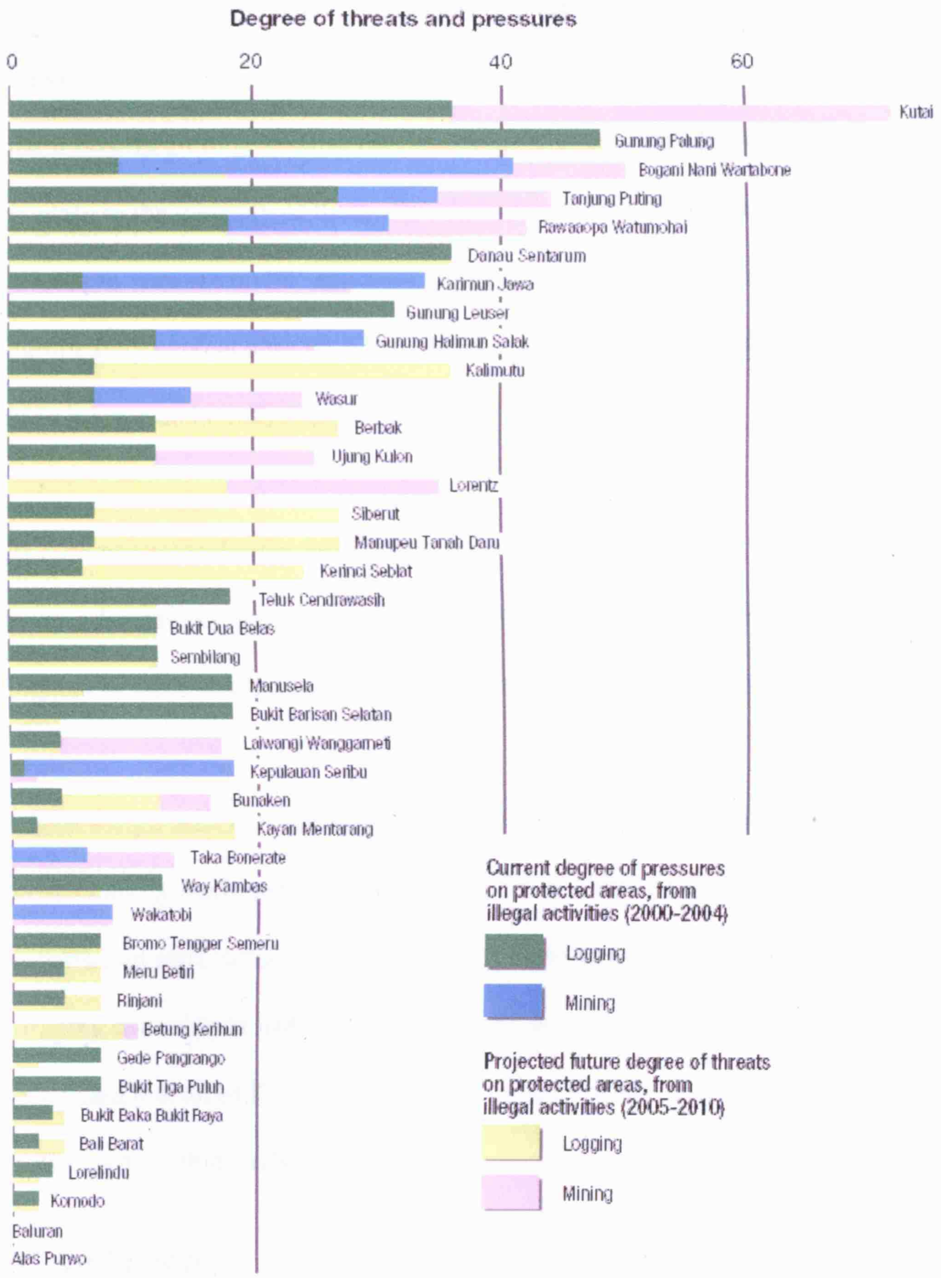

Figure 5 – Illegal logging and mining pressures in Indonesia's NP's *(Source: Nellemann et al, 2007; p19)*

In Nellemann et al (2007) NP's are assessed in relation to Orang-utan habitat loss in particular, concentrating on their range in Sumatra and Kalimantan. Using MOF data (based on WWF's RAPPAM[7] methodology), mining and logging pressures in some of Indonesia's NP's are analysed. Figure 5 shows that there is variety between NP's, and that it is difficult to generalise on their pressures, but it is clear that pressures are set to increase in the majority of them, that there are impact in most of them and that the most severe pressure are on NP's in Sulawesi and Kalimantan. Fires and plantations are also significantly encroaching on NP's. Satellite imagery also confirms that up to half of some PA's have been heavily logged.

At current encroachment rates, many PA's are likely to be severely degraded by 2012. Encroachment has been so severe that some NP's have had park offices destroyed by loggers or were abandoned until safety and security was restored.

These illegal activities are organised by globally linked companies, who operate using bribery and armed "security firms" (FWI/GFW, 2002 agrees), whilst park rangers have insufficient staff, arms, training and equipment to cope. In 2001 the majority of legal logging concessions had expanded illegally into PA's, pretending to be legal. It's also predicted that all of Kalimantan's well-drained lowland forest will be lost by 2012 to 2018, even within PA's.

Conclusion

There appears to be a considerable correlation of opinions in the literature, with some key themes being researched and discussed frequently, and statistics reused. In particular

[7] Rapid Assessment and Prioritisation of PA's Management – this methodology is designed to establish existing and future threats PA's face in order to develop solutions, in five stages. For more information see http://www.panda.org/about_wwf/what_we_do/forests/our_solutions/protection/tools/rappam/index.cfm)

illegal and legal logging, financing, staffing and management issues are raised. In terms of trends, it is not clear whether PA's are becoming more effective, as there more of them and they are more representative, but persistent problems remain, and illegal logging is increasing.

All of the studies find that Indonesian PA's need to improve in order to protect biodiversity, often using the same statistics to place emphases on different issues. Despite this, PA's, and in particular NP's, are more effective than other land use categories at conserving biodiversity.

Previous research is lacking in some respects however. Studies including Holmes (2002), Nellemann et al (2007) and MacAndrews (1998) focus on only some regions of Indonesia, and thus may show issues that are unique to those respective regions. Issues such as PA design and location also seem generally overlooked despite their importance being highlighted by Davey (1998) Mulongoy and Chape (2006) WWF-USA (2008), BAPPENAS (2003) and the CBD (Hilman, 2005).

Research Questions of this Study

Firstly, given the significance of NP's to Indonesia's PA system, and that there has been more research on these, they will be the focus of the study. Given the lack of literature and background information on Indonesian marine NP's, the focus will also be on terrestrial NP's. As many previous studies have only looked at parts of Indonesia, this study sets out to research all of Indonesia's NP's also.

However, it is not clear from the literature if their biodiversity effectiveness can be tested. Therefore, the first question is:

RQ1. Can the effectiveness of Indonesian terrestrial national parks at conserving biological diversity be ascertained?

Therefore, the rest of this will explore this issue. The following question will also be asked:

RQ2. Are Indonesian terrestrial national parks currently effective at conserving biodiversity?

As shown in the introduction, and given NP's significance, it is very important to ascertain how effective NP's are currently. One last question is also considered:

RQ3. Have Indonesian terrestrial national parks have become more effective at conserving biological diversity after since ratifying the CBD?

This third question is asked because the literature does not discuss this issue, and also because it may shed light on 1) how influential the CBD has been to Indonesia and 2) what impact the many changes Indonesia has experienced recently have had on NP effectiveness.

METHODOLOGY

Approach – from ad hoc/by proxy to spatial analysis

As the first research question is to investigate whether Indonesian NP effectiveness could be established, the initial approach was to explore in an open minded and flexible way what information was already available, what research had already been done and possible research methods there could be for this study. From this, the methodology could respond to emerging themes (Denzin and Lincoln, 2003). This was necessary as the study was constrained by the author speaking only English, time and financial resources, thus making travel to Indonesia impossible.

Therefore, the sources of information sought needed to be in English (with the exception of some statistics in Bahasa Indonesian that were understood using Sederet translation software[8]) and not excessively costly and time consuming to obtain. Therefore, a procedure was followed based on obtaining data in a cost effective and timely manner (for details of this procedure, see figure 6).

The procedure below was followed in order to obtain initial information and reports:

- a website search AND
- search engine search (using Google™, Google Indonesia™, Metalib™, UCL, ULRS search engine, University of London, British Library Search Engine, British Library) were carried out
- if the information needed was not found, emails would be sent regarding the information (with the possibility of interviews/questionnaires being considered if suitable)
- if there was no reply, the organisation/individual was telephone called with a telephone message (with the possibility of interviews/questionnaires being considered if suitable)

if there was no reply, a letter was sent or the place with the information source was visited (with the possibility of interviews/questionnaires being considered if suitable)

Figure 6 – The Initial procedure for obtaining information

[8] yyy.sederet.com

Various organisations were selected based on the references of the literature previously read and previous knowledge of the subject as the starting point (see figure 7). The reason for choosing them was to allow comparison broadly between the GOI, the UN, and NGO's data/information. Links to other organisations from these websites were followed also. In addition to this, libraries and map rooms were visited also. They had limited information on the subject, they proved useful for providing background information and establishing what is known on the subject. The maps found provided a useful reference for comparing Indonesian NP's now with those that existed when the CBD was ratified[9] (RQ3). Additional sources were also investigated following the information obtained at the libraries and map rooms.

[9] The intention was to photocopy and compare the maps, but due to copyright law this was not possible.

UN Sources	GOI sources	NGO Sources	Libraries and Map Rooms
WCMC The World Bank The IMF Food and Agricultural Organisation World Database on Protected Areas United Nations Development Programme United Nations Environment Programme Convention on International Trade in Endangered Species of Wild Fauna and Flora	Ministry of Forestry Ministry of Environment The Indonesian Embassy, London The Indonesian student association, London	the British Council International Union for the Conservation of Nature World Resources Institute Asian Development Bank World Wide Fund for Nature WWF-Indonesia Centre for International Forestry Research United States Agency for International Development Conservation International Wildlife Conservation Society Friends of the Earth International Greenpeace International World Commission on Protected Areas	The British Library, London The Royal Geographical Society, London University of London Research Services, London Library Services, UCL, London

Figure 7 – Initial sources of Information

The Indonesian Embassy was also visited. Following a conversation there regarding particular NP's, an email with more information was received by the embassy and these sources were investigated also.

Results of this approach

The conclusion of this method was that whilst there was a considerable body of knowledge relating to the subject, there was little information/data that could be used to conduct new research on the subject. The reasons for this are summarised in the conclusions section of the literature review.

Questionnaires and interviews were also considered, but were found to be inappropriate also. The reasons why this was found are in figure 8. Despite the difficulties encountered, such approaches may be viable for future studies on the subject.

Questionnaires were inappropriate because of:	**Interviews** were inappropriate because of:
- language difficulties (many of the experts were Indonesian and didn't necessarily understand English) - a likely low response rate; this was inferred due to the poor response rate to emails sent out regarding sources of information (see above) a limited time period for responses - sample selections problems as it often wasn't clear who had the expertise - the literature review didn't yield a sufficient number of particular individuals who had the appropriate knowledge (they often appeared to have only partially related or highly specific expertise)	- the physical distance from the experts, who predominantly were in Indonesia, making unstructured interviews difficult - the loss of body language as a source of analysis due to face to face interviews being mostly impossible (Robson, 2002) - the cost of making international phone calls - the likely ineffectiveness of telephone calls; this was inferred due to telephone calls having been made to the Indonesian Embassy and Royal Geographical Society which didn't yield a useful response - the literature review didn't yield a sufficient number of particular individuals who had the appropriate knowledge (they often appeared to have only partially related or highly specific expertise)

Figure 8 – Problems encountered with Questionnaires and Interviews

Spatial Analysis

Some raw data was obtained, however, and this data could be manipulated and analysed in order to answer RQ2 and 3. This consisted of Geographical Information Systems (GIS) datasets and Aerial and/or Satellite Imagery and other forms of remote sensing.

Compared with other sources, GIS allows one to look at different variables in a spatially consistent (such as consistent scale, size, shape, etc.) manner, making comparison more accurate (Maguire et al., 2005). The data was also more comprehensive, covering the entire Indonesian archipelago.

Various forms of remote sensing provide more detailed information regarding particular NP's than previous literature, websites and/or GIS sources. Thus this data source was better for analysing particular NP's. These then may give an indication of how effective NP's are more generally.

More generally, these spatial analytical tools are also well suited to analysing NP's in terms of their design and location, which has been generally overlooked by the literature. The two tools being used in tandem for research purposes is also relatively unique for this subject. Thus, this combination should assist in answering research question one.

Therefore, on considering the different sources of information available, GIS datasets and remote sensing were selected as the methods for this study. However, other data obtained were relevant are discussed in the analysis and conclusions.

The six methods

Six methods were designed by the author in order to test different spatial aspects to NP's that relate to biodiversity conservation effectiveness. They were designed by the author because the literature found on spatial analysis and PA's was rather theoretical (for example, Vainwright et al, 1991, Pressey et al, 1996; Roberge and Angelstam, 2002) or related to PA's selection, rather than spatially analysing existing PA's (see Church et al, 1996; Cocks and Baird, 1989; Bedward et al, 1992; Nicholls and Margules, 1993, Kirkpatrick, 1983). No method was found in the literature that could be used to assess an entire NP system, as they were quite specialist. Therefore, the author developed more general methods and criteria in order to assess Indonesian NP's.

A multi method approach was chosen because this study is exploratory (RQ1) and the issues are complex and relatively under-researched. Given this, it would be arbitrary to assume that one issue takes precedence over others.

The six methods investigate:

- Eco-system representativenss
- The presence of high quality natural landscapes
- The size and shape of NP's
- The connectedness of the NP's
- Levels of encroachment around particular NP's boundaries
- Levels of forest cover change in particular NP's

These methods take guidance from Davey (1998, p13-17) and Mulongoy and Chape (2006, p36-37). They also broadly follow key research questions considered by WWF USA (2008) regarding biodiversity conservation. Such issues have also been raised by the CBD in Hilman (2005) and by the GOI in BAPPENAS (2005).

The six methods primarily consider location and design issues. Other issues such as community relations, management effectiveness, the role of indigenous peoples and NP politics are not being researched. Davey (1998, p13) points out that these issues cannot be separated from each other, or the above issues being examined, and this is acknowledged. Given that previous literature has pursued these issues however, these previous findings will be discussed in relation to the findings and conclusions of the methods.

Given the interrelated nature of the issues being researched, where possible they have been combined (such as size and shape). In order to bring the issues together, the results of each method are considered collectively in the conclusions.

The basic assessment method – from benchmarks to percentages

To allow effective collective analysis and comparison, a common assessment method is required. The initial approach was to use quantifiable measures, which would set the benchmark for what would be deemed effective, neutral and ineffective. Problems were encountered when try to apply this, as is described in figure 9.

In attempting to set minimum standards for different factors, it was acknowledged that there is an inevitable degree of arbitrariness, particularly considering the relative uniqueness (and therefore incomparability) of this study. Due to:

1. The lack of literature on the subject regarding design and location, increasing the arbitrariness of the benchmarks;
2. The impracticability of such benchmarks, having attempted to set some standards;
3. The exploratory methods being used in this study;

It was considered inappropriate to set benchmarks.

Figure 9 – Problems with benchmarks

It was found that by instead presenting data in a percentage format, it allowed:

- A greater degree of variation, and therefore a richer interpretation of the analysis.
- A more detailed comparison between the results of each analysis, therefore allowing particular problems to be identified, in effect, letting the data speaks for itself.
- Future researchers and readers to interpret and use the data in a different way to this study,
- The data to be utilised more effectively for future study also.

Presenting data in percentages does not necessarily make the methodologies any more factual however, even though it appears to be more scientific (Robson, 2002). This approach is also potentially more arbitrary than the benchmark method as the evaluation comes after the data has been collected, rather than setting the evaluative standard before. As these methods appear relatively untested however, it is unreasonable and prejudicial to set standards against which they can be judged against prior to the results.

In order to develop percentages however, there needs to be criteria in which to test the NP's against. It is acknowledged that these still remain essentially arbitrary, as mentioned by Davey (1998, p15). As the methods and criteria are relatively untested, the results are expected to reveal their operational utility and credibility at attempting to answer research questions 2 and 3, and in the process reveal if they can be answered (RQ1).

Spatial Analysis over Time

In regard to answering RQ3, the initial intention of the study was to compare similar data on NP's from (approximately) 1993, 1998, 2003 and 2008.
However, due to only one suitable dataset being available[10], insufficient remote sensing data and the difficulties of comparing non GIS data with GIS data, it was not possible.

By comparing pre 1994 and post 1994 NP's however, it should be possible to broadly indicate whether more recent NP's are more or less effective. This is based on the assumptions that the pre 1994 NP's have not changed, but this can be verified to an extent by comparing the GIS/RS data with pre 1994 maps with NP's. Using pre 1994 maps (Nelles, 1989) it appears that the size, shape and location of most pre 1994 NP's have not changed significantly compared to the GIS/remote sensing data[11]
Nevertheless it can only give a limited indication, as the pre 1994 parks would have inevitably changed in ways that cannot be verified using spatial analysis.

By separating results between post and pre 1994 NP's, different percentages can be drawn up, allowing trends to be observed. Figure 10 below indicates how the results will be presented.

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[10] A PA dataset was available from NBII (2004). However, there were unclear copyright issues regarding its use and it was not sufficiently old. Given the lack of other PA datasets from other time periods available, it was decided that it was best to use only one dataset.
[11] Kerinci Seblat NP, Sumatra and Rawa Aopa Watumohai NP, Sulawesi, have changed slightly.

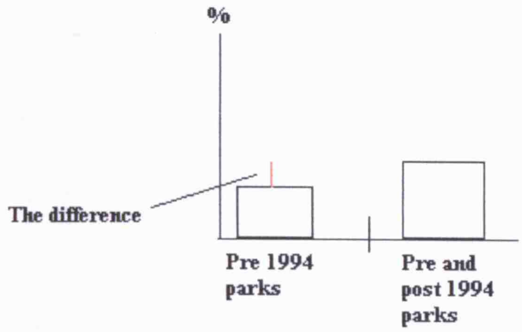

Figure 10 – Indication of results display for RQ3 *(drawn by author)*

APPROACH ONE - GIS Datasets analysis

The Selection of the national parks to be analysed

The GIS[12] analyses will give a broad overview of Indonesian terrestrial NP's. In order to do this however, the NP data must be added to a base map[13]. The WDPA 2007 datasets (WDPA, 2007) were used for this. The WDPA data is split between point data, which provides only the approximate central location on any particular NP, whilst polygon data shows the outline of the park (figure 11 provides an illustration of this). As only either point or polygon data are allowed to be used (this is a contractual requirement of using the data), and not both simultaneously, the polygon data was chosen.

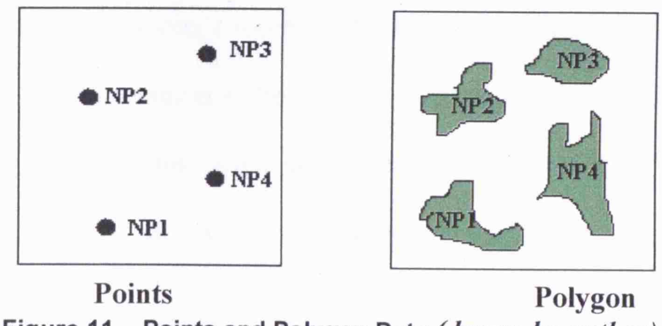

Figure 11 – Points and Polygon Data *(drawn by author)*

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[12] The software used for the GIS analysis was ESRI™ ARC/INFO™. PC Version 9

[13] The base map was extracted from the "Coastline and International Boundaries of the World (Vmap0)" dataset (FAO, 2001).

This polygon data needed to be refined before it could be used. Details of this refining process are in appendix 1.

Following the refining of the data, 29 NP's remain. These 29 are the NP's that are on the five major regions/islands of Indonesia (Java, Sumatra, Kalimantan, Sulawesi and Papua). But according to the WDPA (2008) there are 67 NP's. So where did the other 38 NP's go?

- 15 have been deliberately removed for analytical reasons (6 are sea based, 1 is proposed and 8 are small island NP's, see appendix 1)
- 6 are proposed NP's – however in the dataset Alas Purwo is listed as designated rather than proposed, and therefore is included in the analyses.
- The other 23 NP's are presumed to be points although this cannot be verified as they cannot both be used.
- However 1 is repeated (Gunung Lorentz) in the WDPA website list. As Gunung Lorentz is in the polygon list, it is considered to simply be an anomaly and therefore is discounted from the list. Therefore, there are only 66 NP's and only 22 NP's with no spatial definition.

Total National Parks	66
National Parks presumed to be points data	22
Deliberately removed National Parks	15

Total National parks retained for analysis	29

So what are the implications of this? The NP's which cannot be used because they are points are twenty-two in total, which is one third of the total NP's. The names of these NP's have neither sea (*laut*) nor islands (*Kepulauan*) in their titles so these may be on the five regions. Assuming that they are all on the five main islands, this would represent 51 NP's. 22 missing NP's from this total is 43%, or potentially only 57% of all the NP's on the five main islands are in this analysis.

Because of this, it is acknowledged that the analyses below are limited in their potential to achieve the aims of this study. Weighting (such as multiplying the results by 43%) in order to be more representative was contemplated as a way to remedy this, but it is considered inappropriate to make statistical assumptions about what could be (but is not known for sure) up to 43% of the terrestrial NP's on the five main islands, as it is not known why there is no spatial outline of these particular parks. It is quite possible that these parks are not properly or fully gazetted, as has been a problem previously (MacAndrews, 1998; World Bank, 2006) or have unknown boundaries, and this certainly would affect their effectiveness, but to investigate this is beyond the remit of this study.

Analysis over time

In order to ascertain whether new NP's had helped make the NP's system more effective since the signing of the CBD, it was necessary to isolate the pre 1994 from the post 1994 parks. However, four of the NP's had no establishment date stated, so these were checked by looking at various online sources (see appendix 2 for details of this checking). They were all found to be post 1994, and therefore feature in the post 1994 class. Two NP's were also older than stated in the WDPA data. These were also checked (see appendix 2) and found to be pre 1994, and therefore feature in the pre 1994 class.

METHOD 1 - Eco-system Representativeness

This analysis tests how many and what proportion (in percentage) of eco systems are represented meaningfully by NP's. Eco systems were chosen as the unit of diversity, as opposed to species or genetic diversity (BAPPENAS, 2003) due to the data on these other two as being insufficient and unrepresentative. Eco system approaches to conservation are the currently favoured approach (Mulongoy and Chape, 2006, p37), and the GOI (BAPPENAS, 2003; Hilman, 2005) base PA selection on eco system representativeness, so this analysis may reveal possible weakness in implementing policy.

It is important that there is meaningful representation, as otherwise it is possible for all eco systems to be represented in only a tokenistic fashion (Vainwright et al, 1991). In order to determine "meaningful" were considered. It was agreed by the CBD that the target of 10% of the world's ecological regions be protected, so 10% could be a meaningful measure (Hilman, 2005, p16). This measure refers to all PA's, not just NP's, so it is likely to be too strict a standard to compare NP's against, and it is also technically difficult to determine 10% given that eco systems cross borders.

One possible solution to this is to set a minimum area. Several figures were found, with the IFL[14] minimum of 500km2 being selected as the minimum area. A discussion of why this was chosen is in figure 12.

Figures found include100km2 (Sodhi et al., 2004), 500km2 (Intact Forests, 2008) and 50000km2 (WWF-USA, 2008).

Clearly there are great differences between these figures. 50000km2 represents the minimum threshold for a restricted range species, 100km2 represents the minimum threshold to support intact vertebrate fauna and 500km2 represents the minimum area for an Intact Forest Landscape (IFL) to exist (an IFL is a forest that appears entirely devoid of human impact), large mammals to exist and to counter "edge effects".

On testing 50000km2 as the minimum standard of representation, it was found to be unusable as some eco systems are not as large as this area (e.g. West Javan Montane Forests, see appendix 12). On the other hand, 100km2 was considered inadequate due to the limited amount of conservation value it could offer by virtue of its size. As 500km2 is the minimum required to maintain an intact forest, which is commonly seen as an important pre requisite to effective conservation, it seems a meaningful minimum standard. Therefore, meaningful representation requires at least 500km2 of an eco system being covered.

Figure 12 – Discussion of different minimum area requirements

In order to analyse this eco system data was also required. The Ecoregions dataset (Olsen et al, 2001) was selected above others considered. For details of this selection procedure, please see appendix 3.

As the dataset was displaying data on the entire world, this needed to be simplified also. For details of this, please see appendix 4.

[14] Intact Forest Landscape

METHOD 2 – High Quality Natural Landscapes

This analysis tests what proportion of NP's are protecting the highest quality environments. This analysis will also indicate how effective NP's are at maintaining high quality environments. Holmes (2002) found that generally the more intact and unaffected[15] from human influence an environment is the better it is for conserving biodiversity. This is also an issue the GOI considers as important in conservation (BAPPENAS, 2005). Therefore, an important purpose of NP's is for them to be sited in and maintain the most intact environments.

Of the different sources considered, IFL's were found to be the most suitable for this method[16]. IFL's have also been analysed before in relation to PA's so this analysis could build on these current statistics[17]. Despite their name, IFL's also classify non forested natural landscape which is intact as IFL also.

The intact environment would also need to be of a minimum size for meaningful conservation. As the IFL minimum (500km2) is applied to the issue of intact

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[15] It is important to note that there are numerous ways of defining high quality aside from how intact an environment is. "Biocultural Diversity" for example, considers the amount of biodiversity combined with the cultural diversity (UNEP, 2007), and this is an idea the GOI endorses (BAPPENAS, 2003). Unfortunately the quality of the information on this is not adequate to analyse. With improved information, this could be the subject of a future study.

[16] For this method, different sources were considered; as with above, it was found that the secondary sources (such as maps extracted from reports) were not adequate for this analysis, due to insufficient scales and detail, poor resolution and/or insufficient coverage of Indonesia.

[17] Previous statistics have shown that the amount of IFL protected by PA's under IUCN categories I to III (NP's fall under these, predominantly category II), and it is 16.6% (Greenpeace, 2006a). Rather than considering a more specific % of IFL's that are within NP's (as it will be lower than this, and clearly ineffective), it was thought more valuable to analyse what proportion of NP's protect IFLs meaningfully.

environments, it seems appropriate to use this also (in addition to the problems with the other minimum sizes discussed in figure 12).

METHOD 3 - Shape and Size

This analysis tests the general efficiency of NP's design by analysing the combined size and shape of each NP. Mulongoy and Chape (2004, p37) and Davey (1998) both agree that "edge effects" are reduced by PA's having a compact shape, which provides the largest area for the length of its perimeter (this ideally would be circular in shape, see figure 13 below), is more effective by reducing staffing demands, which is an acknowledged problem in Indonesia (see literature review). This is because it has the greatest area to its perimeter, or is the most "efficient" shape, as fewer boundaries are needed to be protected relative to its area.

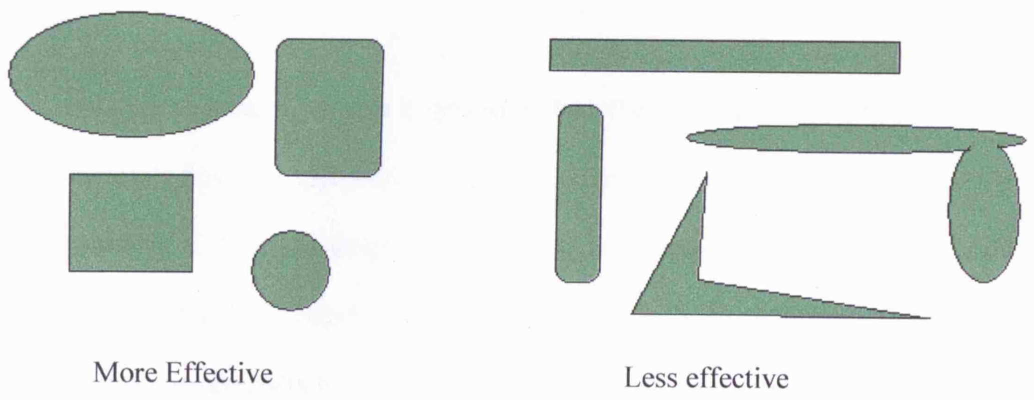


Figure 13 – More and less effective protected area shapes ***(Source: drawn by author; adapted from Davey, 1998)***

The other factor being considered for this analysis is the size. This is because the efficiency of a park's perimeter to area is also determined by size. Therefore, a small, circular park could be less efficient than a multi-angled larger park because it has relatively more perimeter to its area. Proof of this is provided in appendix 5.

As a circle shaped park is the most efficient shape, this is the shape to be used as the minimum standard. The minimum size chosen has also been the IFL standard of 500km2, as this is the minimum needed in order to be classed as an IFL.

To determine an NP's size and shape effectiveness, a ratio is needed. Using 500km2 as the starting point, the calculations (figure 14) show the minimum area/perimeter ratio to be 11.18.

If the ratio for a given NP is higher than this, it is more "efficient" than the minimum standard. If it is less, then it is less "efficient" than the minimum standard.

For each NP, an area in hectares is quoted in the NP dataset attributes table. Unfortunately this data appears to be inaccurate with some NP's such as Alas Purwo NP being listed at 43 hectares, despite being visible on a map of Indonesia. Therefore this area data was checked. Details of this method and a checking method for measuring the perimeter are in appendix 6.

In order to calculate area/perimeter, the perimeter of this theoretical circular park needs to be known.

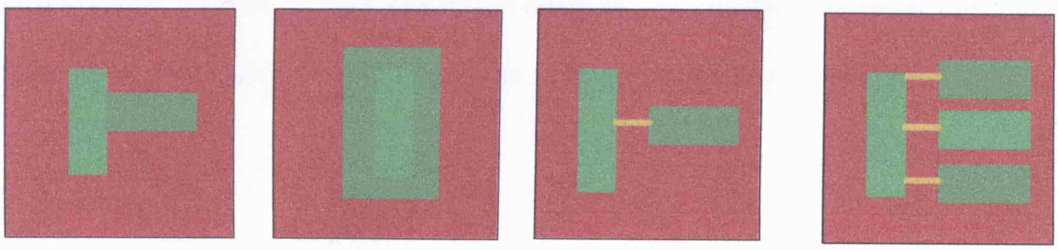
Pi*Radius squared = 500 = area
Square root of 500 = 22.36
22.36/3.141(pi) = 7.11 = radius
7.11*2 = 14.23 = diameter = D
pi*D = 44.69 = perimeter
area/perimeter = 500/44.6 = 11.18 = minimum area/perimeter ratio

(calculations made using Texas Instruments Galaxy 9x scientific calculator)

Figure 14 – Calculations for minimum area/perimeter ratio (source: author)

METHOD 4 - Connectedness

This analysis considers the NPs' connections to other PA's. Mulongoy and Chape (2004) recognise the increasing importance of connectivity[18]. Davey (1998) also considers the issue as vital to achieving broader biodiversity conservation objectives. The GOI has also taken steps to trying to improve the connectedness of its PA's (Hilman, 2003, p80). Ways that this can be achieved are through grouping PA's together, creating 'buffer zones' (Mulongoy and Chape, 2004, p37) or through providing "conservation corridors". Figure 15 below illustrates this more clearly.



A – shared boundary **B – "Buffer Zone** **C – "conservation corridor" D – "conservation corridors"**

Figure 15 – Types of connections between protected areas *(Source: drawn by author; adapted from Davey, 1998)*

[18] In order to avoid PA's becoming like islands that can "easily lose species through natural processes" (Mulongoy and Chape, 2006; p36) the connections between PA's are critical to conserving biodiversity, by maintaining a "ecological network" (p37).

This analysis will measure connectedness by noting the number of connections each NP has to any other type of PA[19]. It will score 1 for each connection. The number of parks with connections, and the number of connections overall, will be calculated as a percentage.

The data used for this will be an Indonesian PA polygon data layer adapted from the original WDPA dataset (WDPA, 2007). Details of how this dataset was refined are in appendix 7.

APPROACH TWO – Remote sensing

The second approach analyses three NP's in detail using Remote Sensing (RS) techniques. This is designed to complement the GIS methods, either by contrasting or verifying by giving more detailed insights into the effectiveness of Indonesian NP's. Due to the time consuming nature of methods using RS, three NP's were selected. It is acknowledged that this will not definitively establish how effective Indonesian NP's are, but together they should provide indications and help inform the GIS analysis.

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[19] It is important to note that this analysis does not consider trans-boundary connections (between neighbouring countries) as the focus of this study is solely on Indonesian NP's. To involve PA's in Malaysia and Papua New Guinea would be inappropriate given its absence in the literature review. This may be the subject of future studies.

The core software used for this is Google Earth™[20]. Rapid Assessment of Land Use Change In And Around PA's (RELUCIAPA™ (Google Earth, 2008a)) and MODIS VCF Change (Google Earth, 2008b) software was used in conjunction with Google Earth™.

These software were added because they display data that is specific to PA's. The WDPA Interactive (part of RELUCIAPA™) function is particularly vital for analysis as it provides outlines of the NP's' boundaries. In addition, Google Earth™ software was set to particular parameters.[21]

The selection of the National Parks

Kutai NP, East Kalimantan, Ujung Kulon NP, West Java and Bogani Nani Wartabone NP, North Sulawesi were selected. The criteria explaining why these why these were selected above others is provided in appendix 8.

For each NP there is a background information section in so that the following analyses can be understood in their particular contexts.

METHOD 5 - Encroachment

This analysis calculates what percentage of each NP has suffered encroachment on or near to the boundary. It measures the amount of territory which is not effectively

[20] This software was chosen above Terralook™ (Terralook, 2008) and Microsoft Virtual Earth™ (Microsoft, 2008) due to the compatibility of other software to be used in conjunction with it, the quality of the imagery and
the software being freely available

[21] The names and locations of settlements and roads were switched on in order to provide additional information that may not be indicated in the imagery, whilst 3D topography generation was switched off as this was found to distort the image. All the images used are viewed from a 90° angle in order to retain consistency and prevent distortion of the image (Google Earth, 2007).

protected against (e.g. "gateways") and which could potentially suffer further encroachment. MacAndrews (1998) points out the significance of encroachment to undermining biodiversity conservation, and eradicating this is a GOI aim (Hilman, 2005; p145, 148, 150). Therefore, this analysis may reveal the effectiveness of GOI policy.

For each of the NP's analysed detailed imagery at a scale of 20km*20Km (400km^2) and 2km*2km (4km2) has been analysed. The photos taken cover the entire perimeter of the parks on the mainland (e.g. the island where the majority of the parks are), but ignore any islands, as the focus is on terrestrial NP's. The photos analysed were positioned so as to have the boundary line in the centre (approximately) as this allows for identification of nearby infrastructure which is material in establishing whether a feature is an encroachment. This provides images showing 10km within and 10km outside the NP (1km within and 1km outside for the 4km2 photos). The photos taken cover the entire perimeter of the park on the mainland, but ignore any islands, as the focus of the study is on terrestrial NP's.

Two different scales have been used because having tested the method different features are visible at different scales, and it was found that most features are visible at these scales.

Because some encroachments may cover much of the boundary, but not extend far into the NP, whilst other encroachments may only cover a little of the boundary but extend deep into the NP, even widening (see figure 16), This analysis will note the width of every encroachment on the boundary and 1km within the boundary. This is due to the proximity of the disturbance to the boundary (1km or less)[22].

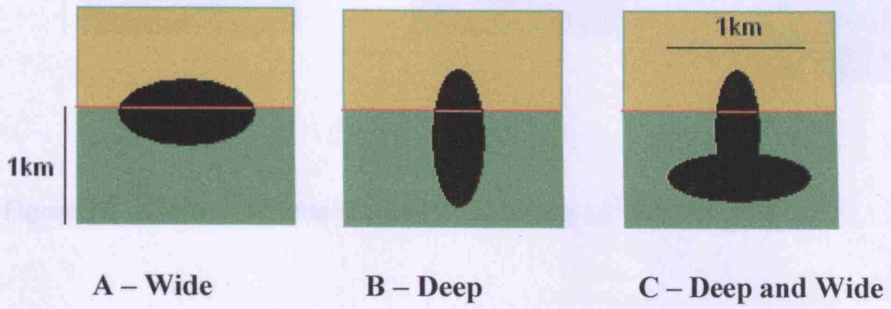

Figure 16 – Types of encroachment on the boundary ***(drawn by author)***

Beyond 1km within the NP, it becomes increasingly speculative whether a particular encroachment relates to a particular part of the boundary, and there needs to be a cut off point for this factor. The 1km scale is also used by Greenpeace (2006) for the measurement of "buffer zones" between Intact Forests and infrastructure (see figure 17, C for an illustration of this).

The measuring of encroachments within the NP will be by measuring the width of the encroachment as parallel to the nearest NP boundary.

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[22] It is also considered an encroachment because most NP's are not completely gazetted, and therefore the boundaries are not known precisely (MacAndrews, 1998). Therefore some of these encroachments may in fact be on the boundary (if there is one). It is also possible that the boundary may also be in fact larger than as is shown by the software, but it would be presumptuous to count disturbances outside the marked boundary as encroachment. Therefore only encroachments which appear within the NP's are included.

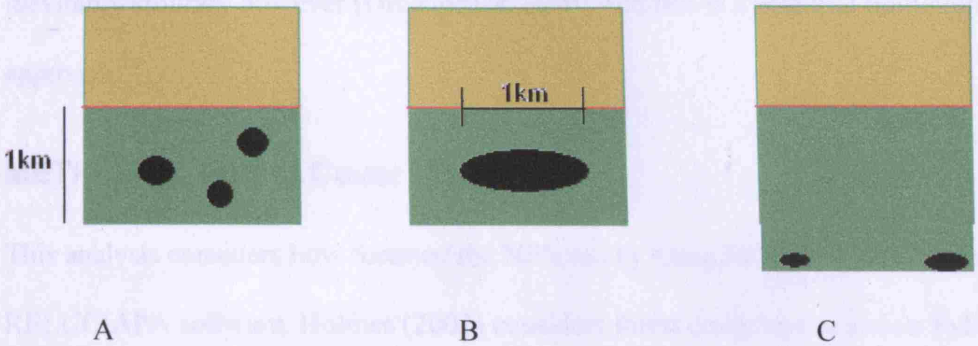

Figure 17 – Encroachments within the boundary (drawn by author)

As satellite imagery can be difficult to interpret, it is difficult to determine what is and is not an encroachment. Using criteria adapted from Greenpeace (2006) and Mulongoy and Chape (2006), the following is included as encroachment:

- presence of any infrastructure, such as roads, settlements and terraced farmland
- Plantations (they are identifiable due to the even spacing and similarity between the trees planted)
- Clearances within 500m of infrastructure
- Burnt areas that are within 500m of infrastructure (due to the correlation between human induced forest disturbance and forest fire

Having tested the method, eco-systems such as swamps, sand banks and rivers are not considered encroachment. What is and is not encroachment is acknowledged to be inevitably arbitrary however (Greenpeace, 2006), and this is a potential limitation of this approach.[23]

METHOD 6 - Forest Cover Change

This analysis considers how forested the NP's are by using MODIS VCF Change and RELUCIAPA software. Holmes (2002) considers forest cover loss as a clear indicator of habitat destruction (and therefore biodiversity), while the GOI (BAPPENAS, 2005) considers forest loss be the greatest threat to Indonesian biodiversity.

Prior to developing this method, the software used was explored to see what potential information it could yield, in order that the most useful functions were used for this analysis.

Exploration of the software

Before assessment of forest cover change can take place, particular analytical software needs to be selected. Photos from Kutai NP were used for this selection process because this is the NP that is most likely to show extensive forest cover change (see Nellemann et al, 2007; p). Criteria by which the different software were analysed against were designed in the form of questions. These criteria are in figure 18.

[23] It is also acknowledged that the factors discussed are generalised, but this is so because it is a complementary method to the GIS methods and is not a case study project and therefore it would be inappropriate to discuss the variables of different factors in too much depth.

- Does it show forest cover change which can be understood/interpreted? If the data cannot be understood then it is of no use.

- Is the NP outline visible to allow full and accurate comparison? The outline of the NP must be visible otherwise assessment is bound to extend beyond the park boundaries.

- Is it comprehensive in its display of forest cover change in the NP? If it does not have data on all of the NP then a full assessment cannot be carried out

- Can the same software provide layers of different time periods (ideally from 1993 to 2008)? If the data does not cater for these time periods sufficiently, then it is not representative enough of forest cover change over this period.

Figure 18 - Questions asked when exploring the software

General Conclusions from the exploration

For each of the software used, there were links to demonstration videos and frequently asked question documents, but these could not be accessed. It was noticed that each time the software were used that they had been altered slightly. This was because the software is very recent and is being refined (Kings College London, 2008).

In addition, there were some issues with particular functions, which are discussed in appendix 9[24]. Whilst the software provides different information, none provide an adequate timeframe for a comparison of how forest cover has changed in Kutai. Due to this, it seemed generally inappropriate to use the software for an academic study. As the software are developed they should be useful for this purpose in the future.

[24] Please note that the comments in Appendix apply to the software when used (28/07/2008) and are only to illustrate the more specific reasons why they were not used, and should in no way be considered a criticism of the software. They are solely the author's interpretation, which is limited due to a lack of explanatory materials for the software being available.

Alternatives

An alternative to using this software is to use older maps from other sources.[25] Unfortunately, the maps found do not cover each case study NP, nor are they detailed enough to allow an accurate comparison, as they are maps of Indonesia or particular islands (e.g. Sulawesi, Java, etc.). Given this it would be unreasonable to carry out an analysis of forest cover change. Therefore, the cover analysis was discounted.

[25] Other sources include maps extracted from websites and reports.

ANALYSIS AND RESULTS

APPROACH 1 – GIS Datasets Analysis

METHOD 1 - Eco systems Representativeness

There are a total of 27 different Ecoregions in the five regions. One eco region (Sunda Shelf Mangroves) is in both Sumatra and Kalimantan, and has been considered as one. The Ecoregions in each region are in figure 19a, and visually displayed in figure 19b.

Java	Sumatra	Kalimantan	Sulawesi	Papua
Western Java Rain Forests	Sumatran Peat Swamp Forests	Borneo Lowland Rainforests	Sulawesi Lowland Rainforests	1) Southern New Guinea Lowland Rainforests
Western Java Montane Rainforests	Sumatran Lowland Rainforests	Borneo Montane Rainforests	Sulawesi Montane Rainforests	2) Southern New Guinea Freshwater Swamp
Eastern Java-Bali Rainforests,	Sumatran Montane Rainforests	Borneo Peat Swamp Forests		3) New Guinea Mangroves
Eastern Java-Bali Montane Rainforests	Sumatran Tropical Pine Forests	Southwest Borneo Freshwater Swamp Forests		4) Transfly Savanna and Grasslands
	Sumatran Swamp Rainforests	Sundaland Heath Forests		5) Central Range Sub-Alpine Grasslands
	Sunda Shelf Mangroves	Sunda Shelf Mangroves		6) Central Range Montane Rainforests
				7) Vogelkop-Aru Lowland Rainforests
				8) Northern New Guinea Montane Rainforests
				9) Northern New Guinea Lowland Rain and Freshwater Swamp forests
				10) Vogelkop Montane Rainforests

Figure 19a – The Regions and their respective Ecoregions

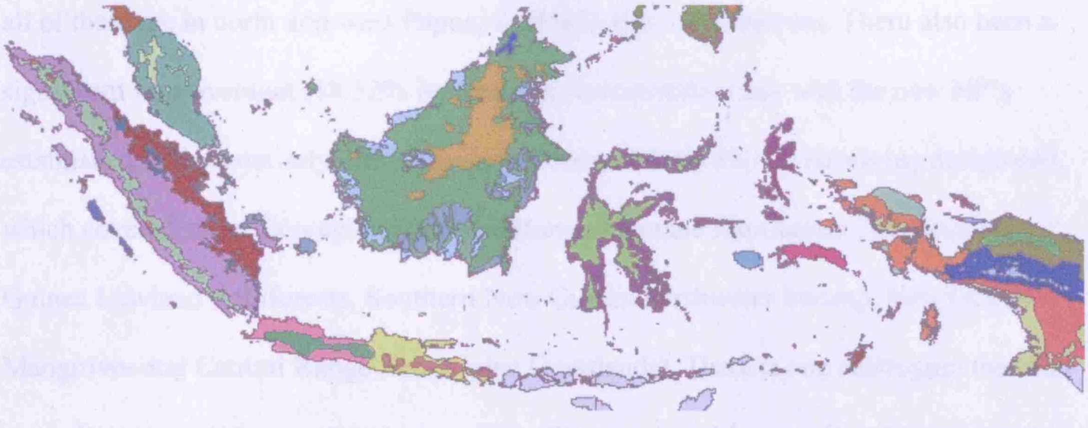

Figure 19b – Map of Indonesian Ecoregions ***(Scale - 1:89,115,370 - developed by author: base map extracted from FAO, 2001; eco region data extracted from Olsen et al, 2001)***

Results

	Pre 1994 parks	Pre and Post 1994 Parks
Total number of Ecoregions	27	27
Total number of Ecoregions represented	18	23
% of Total Ecoregions represented	66.66	85.18
Difference between total and represented	6	3
Improved % by:		18.52

Figure 20 – Summary results for representativeness analysis

Figure 20 above displays the results of this analysis. The maps and full data sheet used for this analysis are in appendix 10.

With 85.18% of Ecoregions presented, Indonesian NP's appear to be effective at representing eco systems. However, four Ecoregions (Northern New Guinea Lowland Rain and Freshwater Swamp forests, Vogelkop montane rainforests, Northern new guinea montane rainforests, Vogelkop-Aru lowland rainforests) appear to be unrepresented, and all of these are in north and west Papua, so clearly this is a weakness. There also been a significant improvement (18.52% increase) in representativeness with the new NP's established. This is entirely due to Gunung Lorentz NP (in Papua) becoming designated, which covers 5 more Ecoregions (Central Range Montane Rainforests, Southern New Guinea Lowland Rainforests, Southern New Guinea Freshwater Swamp, New Guinea Mangroves and Central Range Sub-Alpine Grasslands). There is one eco region that was very close to not being represented on Java (Western Java Montane Rainforests) but the WDPA statistics and the area calculations in this study (see appendix 12 – Size and Shape datasheet) show that it meets the criteria.

METHOD 2 – High Quality Natural Landscapes

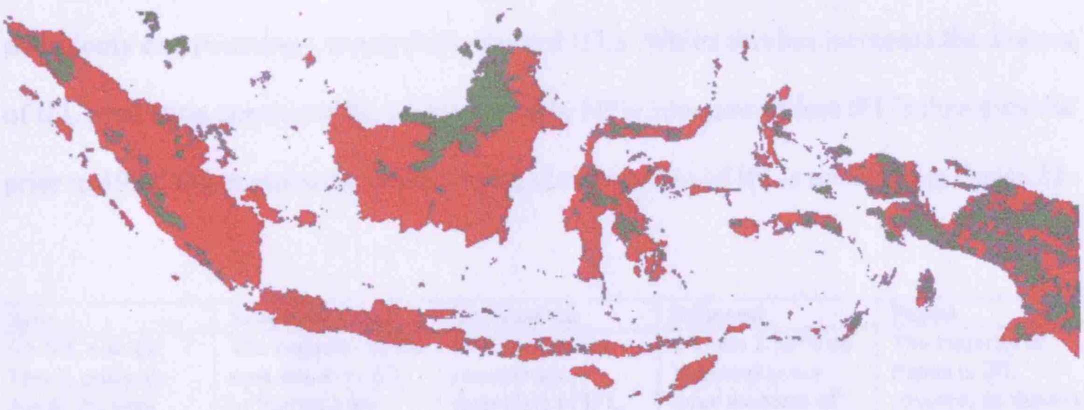

Figure 21 – Indonesia and IFL's ***(Scale - 1:89,115,370 - Source: Developed by Author; Base map extracted from FAO, 2001; IFL data extracted from Greenpeace, 2008b)***

Total Pre 1994 Parks	22
Total Pre 1994 Parks with IFL's	8
% of pre 1994 parks with IFL's	36.36
Total Post 1994 Parks	7
Total Post 1994 Parks with IFL's	1
% of post 1994 parks with IFL's	14.28
Total Parks	29
Total Parks with IFL's	9
% of Parks with IFL's	31.03
Overall % change in IFL cover	-5.33

Figure 22 – Summary results table of national parks with IFL's

Figure 22 is a summary of the results and a map of Indonesian NP's and IFL's. The full data sheet and maps are in appendix 11.

The total number of NP's with IFLs is 31.03%, which indicates that generally the NP's are not protecting or maintaining intact forests. Nevertheless, considering how little of the total percentage IFL is protected by strict PA's (16.6%, Greenpeace, 2006a), there is clearly great scope for increasing the amount of IFL protection. Of the seven post 1994 parks, only one (Gunung Lorentz NP) covered IFLs. Whilst this has increased the amount of IFL protection considerably, proportionately NP's now protect less IFL's than they did prior to 1994. Other points about the regional distribution of IFL's are noted in figure 23.

Java	**Sumatra**	**Kalimantan**	**Sulawesi**	**Papua**
No IFL's at all. This is probably due to the very high population density of this island	The majority of the area which is IFL in Sumatra are covered by NP's, so it seems they are highly effective here. There are however IFL patches that remain unprotected.	Kalimantan has considerably quantities of IFL, in particular in the centre, but many are not in NP's	2 of the 3 NP's on Sulawesi cover large amounts of IFL, although there is considerably more IFL that is unprotected.	The majority of Papua is IFL covered, so there is great scope for protection here

Figure 23 – Regional features of the IFL's

METHOD 3 - Size and Shape

Total Pre 1994 Parks	20
Total Pre 1994 Parks above minimum ratio (11.18)	5
% of pre 1994 parks above minimum ratio (11.18)	25
Total Post 1994 Parks	9
Total Post 1994 Parks above minimum ratio (11.18)	2
% of pre 1994 parks above minimum ratio (11.18)	22.2
Total Parks	29
Total Parks above minimum ratio (11.18)	7
% of parks above minimum ratio (11.18)	24.1

Figure 24 – Summary results for size and shape analysis

Figure 24 above displays a summary of the results. The full worksheet for this analysis is in appendix 12.

In total, only 24.1% of NP's are above the minimum ratio. Considering these statistics, the effectiveness of these parks can be seen as poor (24.1% of all parks meet the minimum standard). Out of seven post 1994 NP's only one has met the minimum standard (Gunung Lorentz, Papua), in effect making the NP's as a whole proportionately less effectively designed than they were in 1994, when 25% of the NP's met the minimum ratio.

Other points about the regional differences in size and shape are noted in figure 25.

Java	Sumatra	Kalimantan	Sulawesi	Papua
All of the NP's are too small and irregularly shaped to meet the minimum standard.	No regional observations	The majority of the pre 1994 NP's that meet the minimum standard are on Kalimantan	No regional observations	All of the NP's meet the minimum standard.

Figure 25 - Regional Observations of the Size/Shape of NP's

METHOD 4 – Connectedness

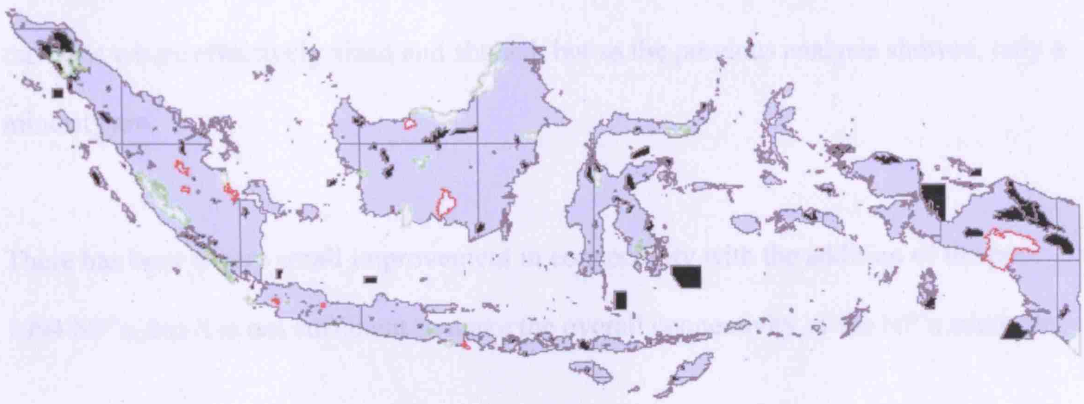

Figure 26 – Map of Indonesian NP's and PA's ***(Scale - 1:89,115,370 - Source: developed by author; base map extracted from FAO, 2001, NP and PA data extracted from WDPA (2007) "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")***

Total Pre 1994 Parks	22
Total Pre 1994 Parks with Connections	5
% of pre 1994 parks with Connections	22.72
Total Post 1994 Parks	7
Total Post 1994 Parks with Connections	2
% of pre 1994 parks with Connections	28.57
Total Number of Parks	29
Total Number of Parks with connections	7
% of Parks with connections	24.13
Net Change %	1.41

Figure 27 – Summary results of connectedness analysis

Figure 27 above shows the results of this analysis and a map showing the other PA's in relation to the NP's. For the full datasheet and maps regarding this, please see appendix 13.

Clearly there are few NP's with connections (24.13%). This would not be problematic if the NP's where effectively sized and shaped, but as the previous analysis showed, only a minority are.

There has been a very small improvement in connectivity with the addition of the post 1994 NP's, but it is not sufficient to make the overall connectivity of the NP's adequate.

Limitations of this analysis

This analysis does not consider the quality of the connections. For example Leuser NP, Sumatra, is nearly entirely surrounded by the Leuser Eco System nature reserve, which acts as a buffer zone. No other NP in Indonesia appears to have this. Other connections are to very small nature reserves, such as with Sebangau NP, Kalimantan and a small nature reserve. What defines a quality connection, such as minimum width, is a matter of debate however (Speckman and Hughes, 1995). It also does not consider the number of connections a NP has, but none of the NP's had more than one connection, so this was not an issue.

APPROACH 2 – Remote Sensing

Case study one - Kutai National Park, East Kalimantan

General Information

Kutai NP was established on 01 January 1982 (WDPA, 2008). There appears to be little literature on Kutai, but Nellemann et al, (2007) has stated that it suffers from some of the most severe logging of any Indonesian NP, and also that 95% of the forest was destroyed in 1997-8 forest fires, the worst of any Indonesian NP, and may no longer be viable. In FWI/GFW (2005) it is also found that Kutai has been significantly impacted by forest fire, with Map 12 (2005; p102) showing the large majority of the park being 50-80% burnt. It also has the greatest projected (2005-2010) pressure from mining and the second highest projected pressure from logging of any Indonesian NP, and Map 2 (FWI/GFW, 2005; p92) indicates that Kutai has had high forest loss, with some non forest land to the North, but also retains some forested areas to the south west, whilst Map 7 (2005, p97) indicates that a minority (30-40% apx.) is low access forest. In Chomitz (2007) Kutai falls within the category of being a "low forest, low poverty" region (Map 3.4, p102). Prior to this the park was potentially eligible for world heritage status (Thorsell and Sigati, 1997). Clearly Kutai has been degraded more than most NP's, so the results of this analysis may be an important contribution in its own right to Kutai's management, in addition to contributing to the conclusions of this study.

Figure 28 – Kutai national park's location in Indonesia *(Source: WDPA, 2008)*

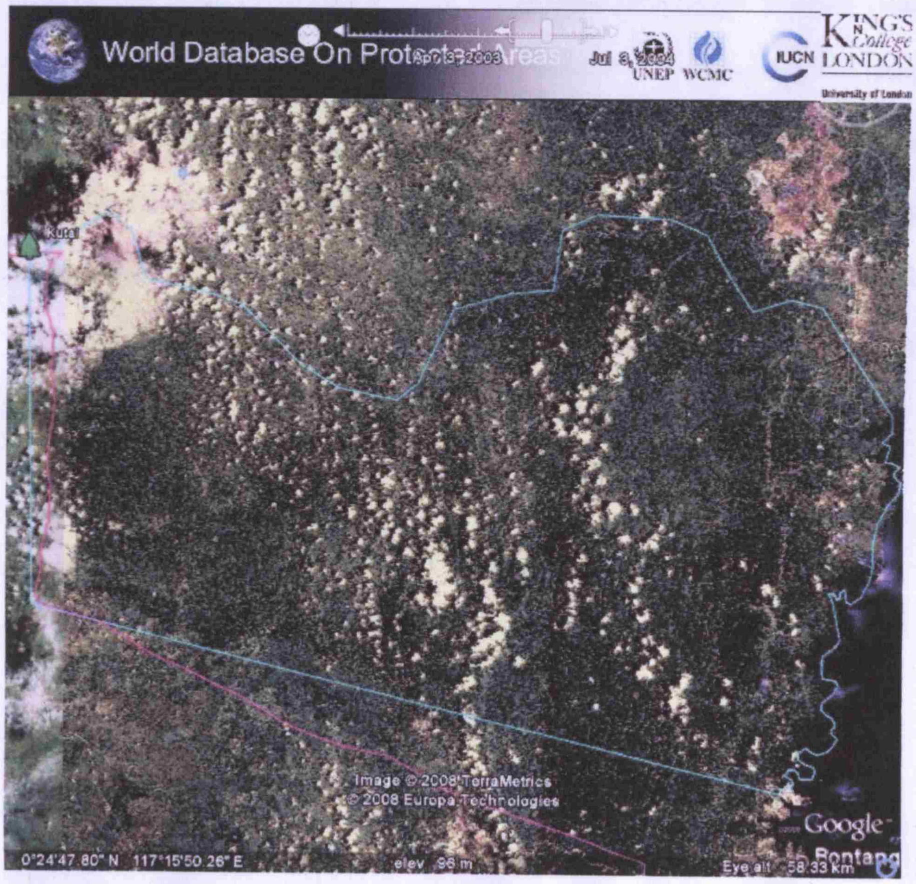

Figure 29 – Kutai National Park ***(source: Photo taken by author, base map from Google Earth (2008), overlaid with data from Google Earth (2008a) "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")***

METHOD 5 - Encroachment

Kutai	Km (apx) intact	Km (apx) encroached	Km (apx) Cloud and other obscurities
Km (apx)	118.3	54.1	37
excl. Q	100.3	54.1	
TOTAL	172.4		
excl. Q	154.4		
Encroachment %	35.03		
perimeter % not encroached	64.97		

Figure 30 – Encroachment analysis summary results table – Kutai

Figure 30 above summarises the results of the analysis. A full datasheet, a description of observations made when carrying out this analysis, and all of the 20km images used in this analysis are in appendix 14. Due to the number of images, the 2km images are in appendix 17. The results show that 64.97% of the NP has not been encroached. Considering how negative the literature is about this NP, this seems quite a positive result, although having over a third of the NP boundary encroached makes this NP vulnerable to biodiversity loss, especially considering its poor perimeter to area ratio and its lack of connections to other PA's.

Case Study two - Ujung Kulon National Park, Java

General Information

Ujung Kulon NP was established on 01 January 1992 according to the WDPA (2008), although it is likely to be older given that it is noted as being a NP in 1986 (Mackinnon, 1986).

Ujung Kulon is on the World Heritage List under Forest PA's, and achieved this in 1991 (Thorsell and Sigaty, 1997), so clearly Ujung Kulon existed before achieving NP status. It is stated by Thorsell and Sigaty (1997) that "Ujung Kulon protects one of the last extensive areas of lowland rain forest in Java and is home to the Javan rhinoceros." (1997, PAGE NO). and has a variety of different species in different parts of the park. FWI/GFW (2002) states that the majority of the rarest large mammal in the world, the Javan Rhinoceros, live in Ujung Kulon. The effective conservation of biological diversity at Ujung Kulon is therefore critical for the Javan Rhinoceros' future survival, so the results of this analysis may be an important contribution in its own right in assisting this, as well as contributing to the conclusions of this study.

Part of Ujung Kulon includes several Islands, including Palau Panaitan and Palau Peucang (figure 32, see below). These are not included in the analyses below, as the focus of this study is on terrestrial NP's in the 5 main regions.

Figure 31 – Ujung Kulon National Park's location in Indonesia (Source: WDPA, 2008)

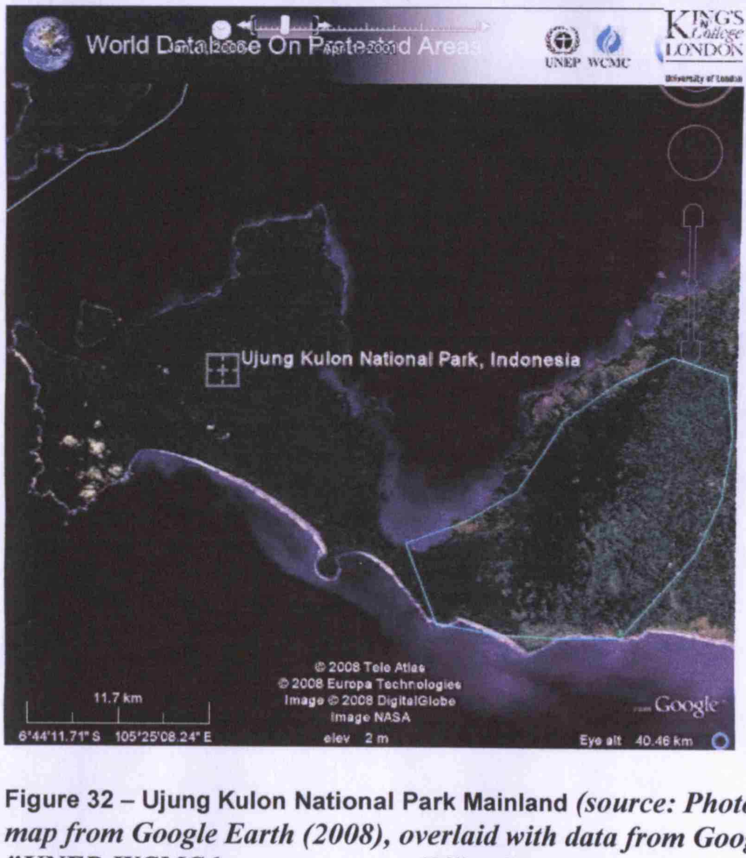

Figure 32 – Ujung Kulon National Park Mainland ***(source: Photo taken by author, base map from Google Earth (2008), overlaid with data from Google Earth (2008a) "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")***

METHOD 5 - Encroachment

Ujung Kulon	Km (apx) intact	Km (apx) encroached	Km (apx) of Cloud and other obscurities
	101.4	32.6	0.6
TOTAL	134		
Encroachment %	24.32		
perimeter % not encroached	75.68		

Figure 33 – Encroachment analysis summary results table – Ujung Kulon

Figure 33 above summarises the results of the analysis. A full datasheet, a description of observations made when carrying out this analysis, and all of the 20km images used in this analysis are in appendix 15. Due to the number of images, the 2km images are in appendix 17. The results show a much higher proportion of perimeter not encroached (75.68%). None of the encroachment has occurred on the coast to the west of the bottleneck (see figure 32 above). This suggests that having a long coastline may have assisted in this NP being effectively protected against. It also suggests that the size and shape of a park is not necessarily the most significant factor for NP'ss to be effective, as Ujung Kulon has a very weak perimeter/area ratio. However, almost a quarter of its perimeter is encroached however so this remains a problem to be addressed.

Case Study Three - Bogani Nani Wartabone National Park, North Sulawesi

General Information

Bogani Nani Wartabone NP (BNWNP) was established on 01 January 1991 according to the WDPA (2008), although it is likely to be older given that it is noted as being a NP in (MacKinnon, 1986). It has previously been called Pamoya Bone NP and Dumoga Bone NP (Vaisutis et al, 2007). According to the Wildlife Conservation Society BNWNP is "the largest PA on Sulawesi and the single most important site for conserving Sulawesi's unique and rich terrestrial flora and fauna." (WDPA, 2008). The park consists of tropical mountain forests, swamps and lowland tropical rainforests, which makes up 60% of the park and is the most floristically diverse on Sulawesi, providing for a large number of endemic species (65% of the mammals and 38% endemic to Sulawesi present in BNWNP). The park is "a home for globally threatened species include Anoa, Babirusa, 3 species of macaques, and 19 globally threatened bird species.". The rivers that flow from BNWNP are crucial to many of the activities of the surrounding human population of 492,000. BNWNP is threatened by illegal logging, shifting cultivation, mining, non timber product harvesting, poaching, illegal land conversion and agricultural encroachment (Wildlife Conservation Society, 2008). In FWI/GFW (2005) it is also found to have the greatest existing pressure and second greatest projected (2005-2010) pressure from mining of any Indonesian NP. In Chomitz (2007) BNWNP falls within the categories of "high forest, low poverty" and "high forest, high poverty" regions (Map 3.4, p103)

With the above in mind BNWNP is clearly very significant to conservation efforts in Sulawesi. Therefore, the results of this analysis may be an important contribution in its own right to its management, as well as contributing to the conclusions of this study.

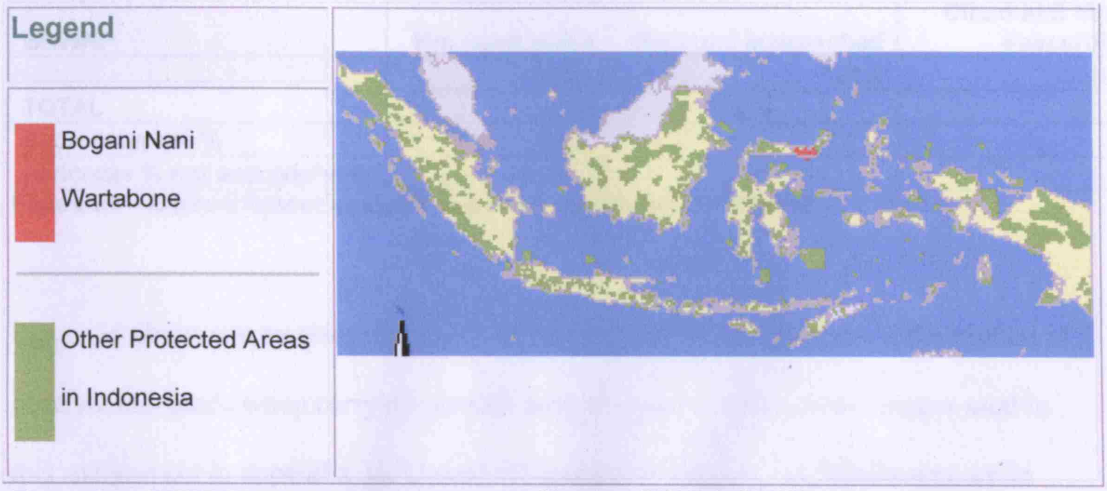

Figure 34 – BNWNP's location in Indonesia *(Source: WDPA, 2008)*

Figure 35 – Bogani Nani Wartabone National Park ***(source: Photo taken by author, base map from Google Earth (2008), overlaid with data from Google Earth (2008a) "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")***

METHOD 5 - Encroachment

BNWNP	Km (apx) intact	Km (apx) encroached	Cloud and other obscurities
	253.1	121.9	19.4
TOTAL	375		
Encroachment %	32.3		
perimeter % not encroached	67.7		

Figure 36 – Encroachment analysis summary results table - BNWNP

Figure 36 above summarises the results of the analysis. A full datasheet, a description of observations made when carrying out this analysis, and all of the 20km images used in this analysis are in appendix 16. Due to the number of images, the 2km images are in appendix 17. The results show that whilst there is not as much encroachment (as a percentage) as there is in Kutai, almost one third of BNWNP is encroached. This is partly due to its irregular shape, which skirts around numerous settlements. These settlements and their associated agricultural developments have sprawled over the boundaries. Where there are no settlements, there is little or no encroachment. This suggests that settlements' proximity to NP's is a significant factor in biodiversity loss. Due to its irregular shape, and its relative thinness (north-south) as compared to its length (east-west) BNWNP does appear more exposed than necessary to encroachment, suggesting that the perimeter/area ratio does have some analytical value.

CONCLUSIONS

RQ1. Can the effectiveness of Indonesian terrestrial National Parks at conserving biological diversity be ascertained?

The results of the GIS analyses do not reflect all Indonesian NP's. They have no bearing on marine NP's or NP's which are not in the five main regions. Due to a lack of polygon data, they do not reflect 22 NP's, which may all be in the five regions. If this is the case then 43% of NP's on the five regions may not be represented in the above analyses. Even if this is the case (which is unlikely considering the number of islands in Indonesia, numbering over 17000 (CBD, 2008)) these analyses do represent the majority of Indonesian NP's in the five regions, and are therefore an important indication of effectiveness.

Given the complex geography of Indonesia, it is difficult to spatially analyse all of the NP's collectively with a consistent set of criteria. Methods such as the encroachment analysis (method five) would be inappropriate for marine NP's due to the obscurity caused by the depth of the sea.[26] NP's which are on small islands would require different approaches to those used in this study in order to be assessed as part of an entire NP system. They may be unsuited to spatial analysis and may need to be considered in their own right. Future study on this would prove useful to resolving this.

[26] Factors regarding marine national park design would need to be considered alongside and converge with terrestrial national park design in order to develop a consistent set of analytical criteria, and would make a useful subject for future study. Datasets on marine eco systems remain to be developed also, thus limiting an assessment on how representative marine national parks are.

As was shown in method one, biodiversity does not collate to national boundaries. Due to this, significant factors like connections to Malaysian and Papua New Guinean NP's and other PA's where ignored. Considering that the actions of these countries play a key role in the future of Indonesian biodiversity (in particular considering that Kalimantan and Papua are the two regions that possess the highest quantity of IFL's), future study is needed to analyse this relationship.

Another issue is that of considering Indonesian NP's independently of the Indonesian PA system, and other GOI efforts made to protect biodiversity. As Indonesian NP's are part of a bigger picture, so is it appropriate to consider them independently, in particular on the issue of biodiversity? The literature review established the significance of NP's to protecting Indonesian biodiversity, and method four has attempted to address this issue to an extent, but nevertheless the multi faceted nature of biodiversity conservation is such that not all issues can be considered using spatial analysis, as discussed in the methodology. Other approaches such as ethnographies (MacAndrews, 1998), interviews and questionnaires can assist in covering these areas.

Therefore, the conclusion on this aim is that Indonesian NP's can be analysed in regard to their effectiveness at conserving biodiversity, but that:

1. Spatial analysis is limited by the lack of available data
2. Other approaches can consider issues which cannot be easily displayed and analysed spatially

3. A more comprehensive, multi disciplinary study, taking into account all aspects of biodiversity efforts in Indonesia, and the wider political, economic and social context is needed to answer the research question definitively.

RQ2. Are Indonesian terrestrial national parks currently effective at conserving biodiversity?

To consider whether this aim has been achieved, the results of the different analyses are brought together.

Total Ecoregions represented	85.18
Parks with IFL's	31.03
Parks above minimum ratio	24.1
Parks with connections	24.13
Perimeter not Encroached	69.45
Average %	46.78

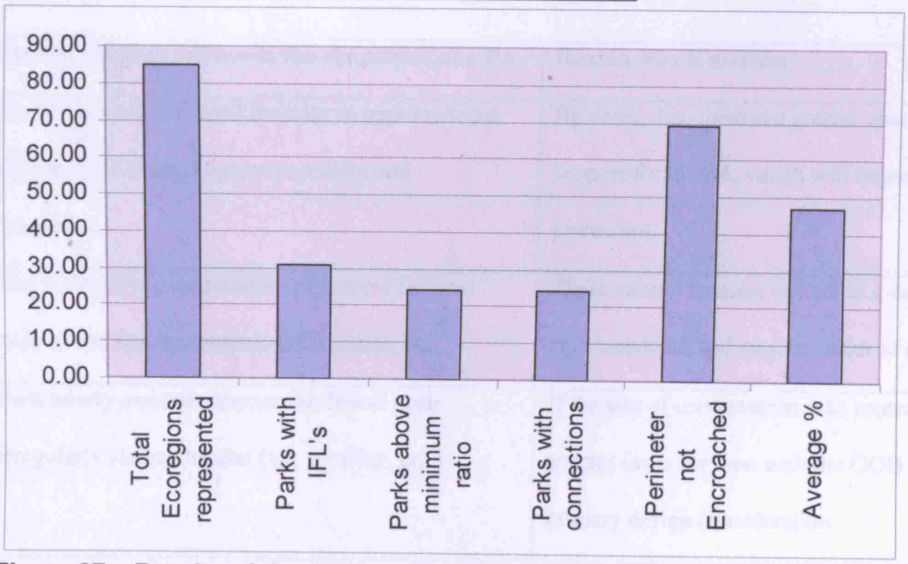

Figure 37 – Results of the Analyses in percentages and average percentage in table and chart format

The summary results of each analysis are above. Whilst only of indicative value, as mentioned above, they do show that Indonesian NP's are strong in representing Ecoregions. This is not surprising given that it is a criterion used by the GOI for PA selection (Hilman, 2005). Given that so few of the NP's have IFL's however, there are questions over how effectively these different Ecoregions are protected. A further useful study would be to see how many Ecoregions that have IFL's are NP protected.

In terms of NP design, in general Indonesian NP's are poorly connected, with only one having a "buffer zone". Poor connectedness would be less problematic if the NP's were efficiently sized and shaped, but mostly they are not. However, for reasons given in figure 38, it cannot be assumed that inefficient shape/size is a measure of ineffectiveness per se.

Factors that can influence the shape/size of a PA	**Reason why it matters**
The shape/size is altered in order to appease local stakeholders, including communities and businesses.	By doing this, there is a greater chance of their support for the PA, which will improve biodiversity protection.
The PA follows the contours of natural features such as the sea, mountains, cliffs, lakes, etc.	These natural features can act as a defence against encroachment, and may be easier to monitor.
Particularly endemic species are found in an irregularly shaped habitat (e.g. a valley, etc.)	If the aim of conservation is to protect endemic species (as is the case with the GOI) then this is the primary design consideration

Figure 38 – Factors that influence the shape/size of a PA ***(elaborated on and adapted from Davey (1998) and Mulongoy and Chape (2006)***

Nevertheless, the maps suggest that there is some correlation between poor size/shape, poor connectivity and a lack of IFL's[27].

In terms of representation, whilst it is noted that the largest parks provide the most representation, proportionately many smaller NP's would cover more Ecoregions. This does not mean that NP's cannot also be effectively shaped, well connected to other PA's and protect IFL's, however.

The results of method five are useful when compared with the other analyses. The imagery generally shows high levels of tree cover within the NP's. Whilst not synonymous with high biodiversity, it is clear that these NP's do protect some areas of high biodiversity. Therefore, it would be simplistic to state that NP's lacking IFL's do not protect high quality environments per se, although it is an important indication, and may represent some evidence of illegal activities[28].

It is also noted from method five that there is infrastructure within NP's, such as roads and offices, which are probably used by park rangers. Without this infrastructure, NP's could not effectively operate. This was a limitation of both the encroachment and IFL's analysis (method two), as they do not disseminate between positive and negative infrastructure. Therefore, it cannot be assumed that a lack of IFL's is an indication of illegal activities or deforestation within NP's per se.

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[27] Further study of this is needed to corroborate this.

[28] The Author of the IFL's data (Greenpeace, 2006) acknowledges that an absence of IFL's does not mean that the environment is not high quality.

Some anomalies were observed also amongst the forest, but which appeared to be natural (e.g. lakes, sand banks, marshes, etc.) but which are not displayed on the Ecoregions dataset. Therefore, the Ecoregions are a generalisation to an extent to consider eco region and eco system representation as the same[29].

The level of encroachment did not appear to relate to the size and shape of the park, however, with Ujung Kulon having the least encroachment despite having the weakest perimeter/area ratio (see appendix 12). This indicates that the size and shape of the park is not the only critical factor regarding vulnerability to biodiversity loss (see figure 38). As none of the NP's were connected to existing PA's, no comparison can be drawn between this method and the connectivity analysis.

The overall result (69.45%) of method five may indicate that Indonesian NP's are mostly effective at protecting their boundaries. Due to the small sample taken however, and the unique characteristics of each NP's which became apparent from this analysis, it is not considered a conclusive indicator. The results of this analysis are useful however for indicating particular issues with these particular NP's, and possibly issues relating to their surrounding areas and/or region.

The GIS and RS methods also revealed that the different regions' have their own specific issues. Papua was the only region with Ecoregions not represented. Sulawesi had no NPs that were adequately shaped. Java had only one NP (out of six) that was adequately sized.

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[29] The Author of the Ecoregions data (Olsen et al, 2001) acknowledged that there are sub eco-regions that have not been mapped yet due to a lack of data.

The types of encroachment appeared to vary between regions also, with Ujung Kulon (Java) having more rice fields as encroachment but less plantations. Due to word and time constraints however, the specific issues regarding each regions' NPs and the reasons behind these will need to be the subject of future study.

Overall Conclusions

The average of all the results is 46.78%. This figure seems inconclusive. In any case, reflecting on the analyses, categorising NP's generally as "effective" or "ineffective" has little practical value, in particular considering the NP specific factors revealed by the RS method.

Therefore, the conclusions are the following:

1. Indonesian NP's in the five main regions generally:

    a. Are poorly connected
    b. Are poorly shaped and sized
    c. lack intact forests
    d. cover most of the Ecoregions
    e. have perimeters that have little encroachment

2. Despite these findings, it is inappropriate to determine whether Indonesian NP's are effective or not simply on these results.

RQ3. Have Indonesian terrestrial national parks have become more effective at conserving biological diversity after since ratifying the CBD?

As with Aim 2, the results of the different analyses are brought together and then discussed

	Pre 1994 parks	Current Parks
Total Ecoregions represented	66.66	85.18
Parks with IFL's	36.36	31.03
Parks above minimum ratio	25	24.10
Parks with connections	22.72	24.13
Average	37.69	41.11

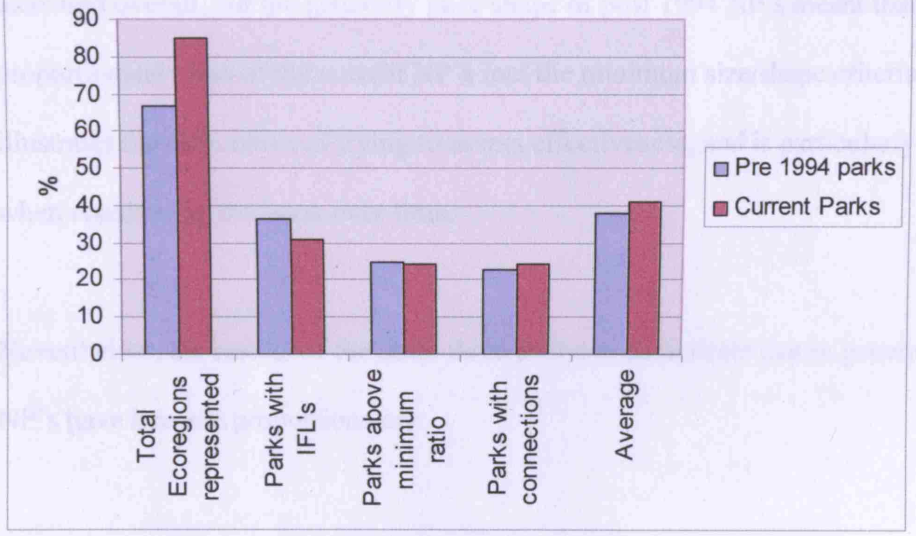

Figure 39 – Results of the pre and current parks Analyses in percentages and average percentage in table and chart format

Above are the summary results of each analysis. The results of the encroachment analysis are not included as they were all pre 1994 NP's, although it does appear that they have been relatively effective at preventing encroachment over this time.

The results are displayed side by side to allow comparison, but it must be noted that the results of the Ecoregions analysis did not look at the proportional change in the effectiveness of NP's per se, but how many more Ecoregions were covered in the 14 year period. Thus, it is not possible for the results of this analysis to decline as the pre 1994 NP's level was the base line[30]. Nevertheless, this analysis does show a significant improvement other this time.

The changes between current and pre 1994 NP's represents the proportional change, rather than the change overall. For example, overall the amount of area with NP status increased overall, but the generally poor shape of post 1994 NP's meant that proportionately less of the current NP's met the minimum size/shape criteria. This again illustrates the difficulties of trying to assess effectiveness, and is particularly problematic when considering the issue over time.

Nevertheless, the results of the other three analyses do indicate that in general post 1994 NP's have become proportionately:

1. Less effectively sized and shaped
2. Cover less IFL's
3. Better connected

[30] This analysis could be improved by considering former national parks that have lost their status over this time period. Unfortunately the specific information available for this was not available.

There is no shortage of IFL's that are not NP protected, so why were the post 1994 NP's located in IFL areas? The research on IFL's is fairly recent (between 2004-2006, as it is not specified), and thus could not have been applied until it was developed. Thus, the information may simply have not been available at the time.

The reverse is also true of the Ecoregions data, as this was developed in 2001. Thus the improvement shown may be the result of chance rather than evidence based decision making, but this is not known.

In regard to size, shape and connectedness, guidance on this seems to have existed pre 1994 (Lusigi, 1992 for example). Therefore it seems that the guidance has been ignored. There are other factors that effect PA design however (figure 37), so only limited conclusions can be drawn on how negative this trend is.

Overall conclusions

The evidence presented does not show conclusively whether post 1994 NP's are more effective than pre 1994 parks, as too many variables remain unknown. As with RQ2, the average overall percentage has little conclusive value.

Despite this, the statistics do illustrate that NP location and design has not improved substantially since the CBD was ratified by Indonesia. However, this does not mean that the overall effectiveness of Indonesian NP's has not increased. More area is covered by

NP's now than in 1994. As area is oft quoted as important, this cannot be dismissed[31]. Other factors that also cannot be dismissed are wider economic, political and social changes[32] and changes in NP management regimes. Clearly analysing NP's over time is far more complex than developing a "snap shot" of current effectiveness.

Whilst RQ3 has only been partly answered, this study should prove a reference which future studies on the subject can use as a "snap shot" which can then be compared with to see if Indonesian NP's have improved or not.

Methodological Conclusions

Whether or not the results answer RQ2 and 3 satisfactorily, the utility of using RS and GIS in tandem, and their potential, has been demonstrated in this study. Their combined use was particularly useful in provide ways in which to check the utility of the methods and their results against each other. Due to this, further exploration of GIS/RS relationship is recommended, and not only for research on PA's.

Towards an Improved Knowledge of Protected Areas

One of the most important contributions this study has made is in exploring new ways of researching Indonesian NP's. The methods developed however, can be used in other contexts, such as in other countries or with other types of PA's. Given some of the issues

[31] There has been a trend away from simply protecting more area (Schaffer, 1981), but its relative importance is beyond the scope of this study.
[32] As briefly mentioned in the literature review, events like the Krismon and decentralisation have had far reaching impacts. Unfortunately discussing these issues in any meaningful depth was beyond the remit and limits of this study, but the relationship between these events and NP effectiveness warrants further research.

raised above, it is acknowledged that many issues need to be resolved first, and the methods refined.

Due to word and time constraints, other spatial analyses and ways of displaying results were considered but could not be implemented. These are summarised in figure 38.

Forms of spatial analysis	**Ways of Utilising Results**
The relationship between PA's and: Social factors (urban/rural populations, population density, cultural groups, levels of education, etc.) Economic Factors (poverty, major roads, distance from ports, intensity of agriculture, etc.) Political Factors (Levels of political involvement, political party support in a region, etc.) Environmental/Geographical Factors (presence of rivers, altitude, centres of endemism, Combined factors (Biocultural diversity, aesthetics, etc.)	- A map of a PA showing encroachment locations - A "premier league" table of PA's, in which PA's are scored in order to identify those with the most problems - 3D display of map (e.g. isometric) to show relative significance of particular factors - Animation as a way of displaying spatial change

Figure 40 – Other forms of spatial analysis and Ways of utilising results

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APPENDICES

Appendix 1 – Refining the WDPA datasets

As several datasets were available from the WDPA, it was important to select the one which was most relevant to this study. The datasets available were:

- International polygon data
- International point data
- National polygon data
- National point data

The international data was of little use for a comprehensive assessment of Indonesian national parks, as only a few Indonesian national parks are internationally recognised, such as World Heritage sites, RAMSAR sites, etc. and these are not materially relevant to this study.

Within the national polygon dataset, it is divided up into three files:

- PA's with an IUCN category (e.g. I, II, III, etc.),
- PA's without an IUCN category but which have a designation (e.g. they are operating PA's)
- PA's without a designation (e.g. PA's that are proposed, degazetted, etc.).

As this study concerns existing national parks the PA's with a designation file was discarded.

The datasets were further refined:

- Protected Areas under country "Indonesia" were selected in order to only have Indonesian data
- From this list only national parks were selected by choosing – Designate "National Park"

Doing the above actions left the datasets with:

- 33 national parks with an IUCN category
- 10 national parks with no IUCN category but which are designated

The separation made by the WDPA of national parks that have been categorised by the IUCN or not is not relevant to this study, as the focus is on what the GOI considers to be a national park. Therefore, these two datasets are used together as if they were one dataset. The two datasets have the same information categories also so there is no information discrepancy between the two except that one has IUCN categories given.

However, the NP's were still inappropriate. This is because, firstly, the connectedness analysis (method 4) would be prejudiced by small islands, because they are naturally isolated by their size and location. An analysis including them would indicate that Indonesian national parks are either generally relatively isolated or connected by boundaries in the sea, which is irrelevant to this study as the focus is on terrestrial NP's. Secondly, the size and shape analysis (method 3) would also be prejudiced by the geographical limitations of the islands, and would thus indicate that Indonesian national parks are either generally relatively small or large due to their boundaries in the sea, which is irrelevant to this study.

Therefore, the national parks which were not based on the five main islands were removed from the datasets. These Following NP's were removed:

- Marine (*laut*) NP's:
    - Bunaken (Laut)
    - Teluk Cendrawasih (Laut)
    - Kepulauan Wakatobi
    - Kepulauan Karimun Jawa
    - Kepulauan Seribu
    - Taka Bonerate (Laut)

- Small island NP's:
    - Siberut
    - Komodo
    - Manapau – Tanah Daru
    - Gunung Rinjani
    - Gn Rinjani(this represents almost exactly the same outline as the one above and thus is assumed to be a data anomaly)
    - Bali Barat
    - Kelimutu
    - Manusela

Appendix 2 – Checking the Age of the NP's

The four NP's were checked against the WDPA website (WDPA, 2008) but this had no more info. Therefore a website search was carried out:

- Bukit Tigapuluh national park was established on 05.10.1995 (http://www.bukit30.org/index.php?bagian=profil3&bhs=english, 18.08.2008)
- Bukit Dua Belas was established on 23.08.2003 (http://www2.ohchr.org/english/bodies/cerd/docs/ngos/NGO-Indonesia.pdf, 18.08.2008)
- Danau Sentarum national park was established on 04.02.1999 (http://www.accessmylibrary.com/coms2/summary_0286-28771711_ITM, 18.08.2008)

Sempilang national park was established after June 22, 2000 (http://www.gefweb.org/Documents/Medium-Sized_Project_Proposals/MSP_Proposals/Indonesia_Berbak.pdf, 18.08.2008)

Two other NP's were checked to see their age also:

- Kerinci Seblat is listed as a national park in the 1980's (MacKinnon, 1986, and http://nationalpark.na.funpic.org/index.php?option=com_content&task=view&id=3&Itemid=27 , 18/08/08) although the UNEP (http://www.unep-wcmc.org/sites/wh/forests_of_sumatra.htm 18/08/08) state that it was officially established in 1992.
- Bukit Barisan was established as a national park in 1982 (http://www.unep-wcmc.org/sites/wh/forests_of_sumatra.htm)

Appendix 3 – Choosing the Eco systems dataset

The following layers were added to see which would provide the most useful eco system data:

- "Land Use Systems East Asia" (LUSEA) (http://www.fao.org/geonetwork/srv/en/main.home)
- "Global Dominant Eco system classes" (http://www.fao.org/geonetwork/srv/en/main.home)
- "Global Land cover map" (http://www.fao.org/geonetwork/srv/en/main.home)
- RWDB (Rain Water Drainage Basins) (http://www.fao.org/geonetwork/srv/en/main.home)
- Hydrobasins South East Asia (SEA)
- WWF Terrestial Ecoregions GIS Database http://www.worldwildlife.org/science/data/item6373.html

All of the above were found to not display sufficient data for this analysis except for the last dataset. Therefore, the WWF Terrestial Ecoregions GIS Database was used.

There are other secondary sources of information on ecosystems in Indonesia that were found; however, rather than using multiple sources, the use of one comprehensive source that could be compared easily against the locations of the national parks was considered more appropriate to this analysis. The secondary sources that were discarded were often an inappropriate scale and lacked a detailed demarcation between different eco systems. However, these secondary sources were used to check the accuracy of the source used for this analysis. For example, much of the data displays eco systems only at the biome level, which cannot distinguish between different types of forest for example (WWF-USA, 2008a). Using the biome as the eco system definition means that Indonesia is classified as having only:

- mangroves
- tropical moist broadleaf forests (the vast majority)
- tropical dry broadleaf forests

(http://www.intactforests.org/statistics/biomes.htm)

Other eco systems consider altitude:

- montane (exceeds 1000m)
- submontane (between 300-1000m)
- lowland (under 300m)

(FWI/GFW, 2005, p93)

However the Ecoregions do make distinctions between montane and lowland forests, so this is considered in the dataset. Another definition is the "Ecofloristic Zone" (Murray et al., 1996) although not enough data was obtained to be able to use this concept.
One other eco system considered was the Karst eco system. Unfortunately, there is very little data and research on these eco systems (BAPPENAS, 2005) and what data there was not sufficient for analysis. Despite these problems, it is acknowledged that the eco region data is not optimal for considering all taxa and that there is a blending of habitats at the edges of Ecoregions and that Ecoregions are a generalisations, with sub Ecoregions being within them (http://www.worldwildlife.org/science/ecoregions/item1267.html).

Appendix 4 – Refining the eco region data

It was not possible to separate out distinctly Indonesian Ecoregions as Ecoregions cross boundaries (such as on Borneo and New Guinea). All Ecoregions which do not exist on the five main islands of Indonesia were removed however. The NP's are then overlaid on the Ecoregions.

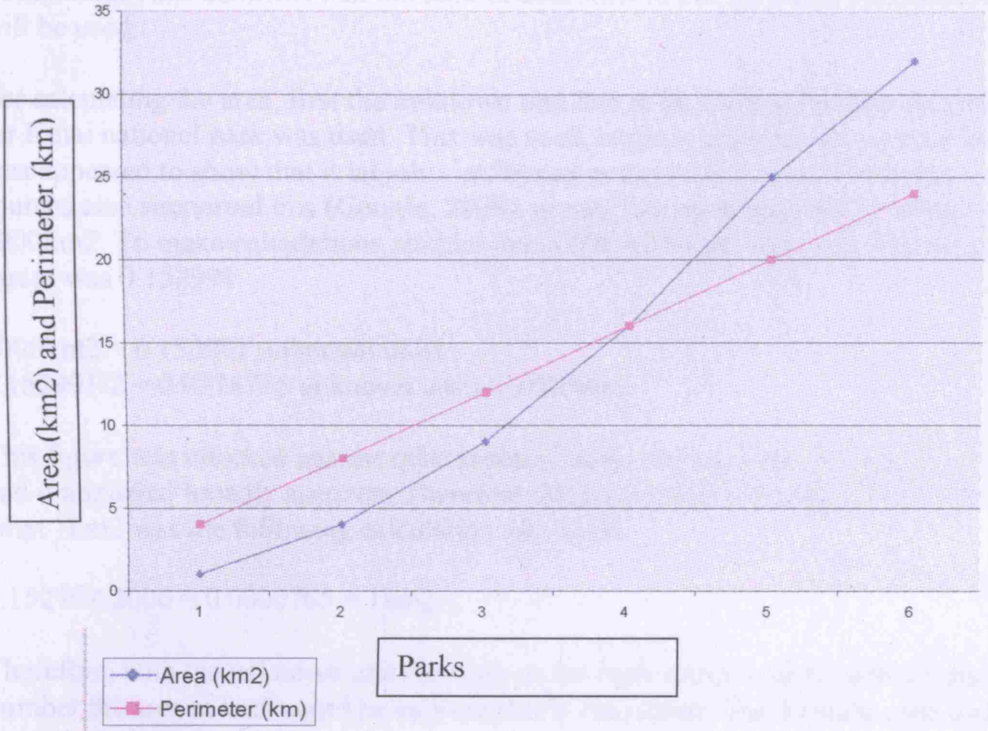
The dataset is initially separated into biome categories. Within the biome categories:

- Sulawesi and Java only have biome 1 classification (Tropical broad leaf forests)
- Sumatra has biome 1, 3 (tropical pine forests) and biome 14 (mangroves)
- Kalimantan has biome 1 and 14
- Papua has biome 1, 7 (Tropical and subtropical grasslands, savannas and shrublands), 10 (montane grasslands, steppe, alpine regions) and 14.

It is clear that each island contains a unique variety of ecosystems within these broad biome categories and that the generality of the biome data is too broad. Therefore the map is altered to display Ecoregions.

Appendix 5 – Area to Perimeter relationship

Park	Area (km2)	Perimeter (km)
1	1	4
2	4	8
3	9	12
4	16	16
5	25	20
6	32	24



The following discussion refers to the graph and table above. All of the theoretical parks above are square in shape. As the size (area) increases so does the perimeter length, but the increase in area is greater, because less perimeter is needed (proportionately) for park 6 as opposed to park 2. In effect as the parks get bigger they are becoming more efficient. The disproportional increase in area continues as they get larger. With different shapes the same trends apply, although the figures are different.
Therefore, a small, circular park could be less efficient than a multi-angled larger park because it has relatively more perimeter to its area.

Appendix 6 – Checking and Finding out the Area of the NP's

To check the data, the measuring tool is used, with the area calculated. The datasets don't appear to have an attached distance value (e.g. cm, km, miles, etc.). The distance value can be set, but the area measurement tool can't, although it does display quantities of unknown units for each national park when selected. Therefore, to calculate the area of each national park, the distance measure needs to be set, and then the area calculated using distances. The distance is set by taking a known distance and measuring it. For this a measure of the island of Pulau Panaitan in Ujung Kulon national park, west java was taken and compared against the same island on google maps (http://maps.google.co.uk/, 2008). Using this confirms that the dataset conforms to km, so this is the measure that will be used.

For calculating the area, first the unknown unit had to be known. For this, an area figure for Kutai national park was used. This was used, because approximate calculations of area appeared to show that it largely conformed to the WDPA area (1986km2). website sources also supported this (Google, 2008), giving figures of between 1986km2 and 2000km2. To make calculations simpler the 2000km2 figure was used. The unknown unit figure was 0.152991

2000km2 = 0.152991 unknown units
0.152991/2 = 0.0774755 unknown units = 1000km2

This figure was checked against other national parks that were approximately 1000km2, and it appeared broadly accurate. Therefore this calculation was seen as valid. To find out what 1km2 was the following calculation was made.

0.152991/2000 = 0.0000765 = 1km2

Therefore, with the unknown units area given for each national park, with the above number the area in km2 could be approximately calculated. The formula used was as so:

National park area (unknown units)/0.0000765 = national park area (km2)

It is divided because the number is smaller than 1.

Checking the accuracy of the information

The areas calculated were then compared with the WDPA area data and other website sources. This showed a broad correlation, although some national parks had a variety of figures online, and in some instances (such as with Alas Purwo national park) the figures were quite different. Following this, the calculated areas were considered sufficiently accurate for this analysis.

Perimeter

For the perimeter of the national parks, the measuring tool gave a figure in km2, so this was used. These were checked against perimeters measured using the measuring tool on Google Earth™, and these broadly correlated.

Appendix 7 - Refining the WDPA data for analysis

In order to carry out this analysis an Indonesian PA polygon data layer is added (sourced from WDPA, 2008), with the existing NP layers placed on top of this, so that all of the protected areas with spatial definitions can be seen. It is suspected that like with the NP's, not all of the existing protected areas are in polygon format, so this analysis may present fewer connections than actually exist. In the absence of this information this is inevitable. Again this may well be due to other protected areas also not being fully gazetted.

As this analysis considers existing protected areas, all proposed protected areas are removed from the analysis. Therefore, the IUCN no designation protected areas layer has been removed, as was done with the national parks layers used (see above).

Where protected areas are completely or almost completely covered by a national park, the old classification is considered to be out of date and therefore is discounted (e.g. Alas Purwo national park, East Java almost completely overlays Banyuwangi game reserve).

Please note that the age of the protected areas which are connected to the national parks has not been checked, because of time limitations and a lack of information on many of them.

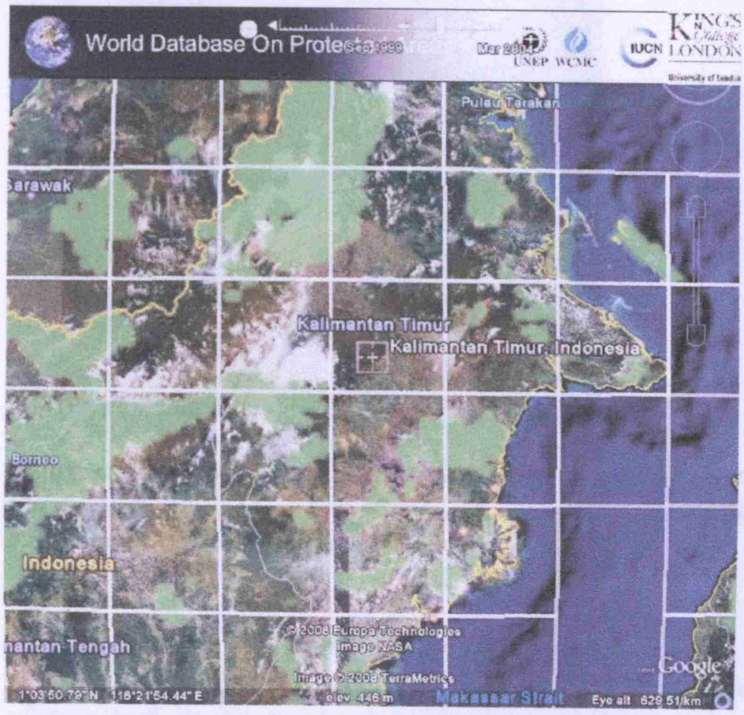
Appendix 8 – Selection criteria for case study NP's

For this the following criteria was used:

- In general National Parks on lower ground were preferred because it's expected that the imagery will be less obscured by cloud cover, which has been a problem with this method in the past (MacAndrews, 1998).
- National Parks were selected that had been in existence and categorised as National Parks since at least 1994. Using these more established National Parks allows analysis of their effectiveness over a longer period. It is set to 1994 in order to give a 15 year time period to consider and because this was when the Convention on Biological Diversity was signed by Indonesia. This information was found using a list from Mackinnon et al (1986).
- In order to be more representative, the National Parks had to be from different major islands. Five national parks were to be considered originally, as there are five major Islands in Indonesia, but it was found that in Papua and Sumatra that the only established National Parks had a considerable amount of territory in mountainous regions, where aerial photographic techniques may have been compromised.
- It was also preferred that the National Parks surveyed were relatively small, due to the time constraints of this study. The pre 1993 National Parks of Sumatra and Papua were considerably larger than suitable National Parks on the other major islands also, and thus were discounted.

Appendix 9 – Exploration of RELUCIAPA and MODIS VCF Change

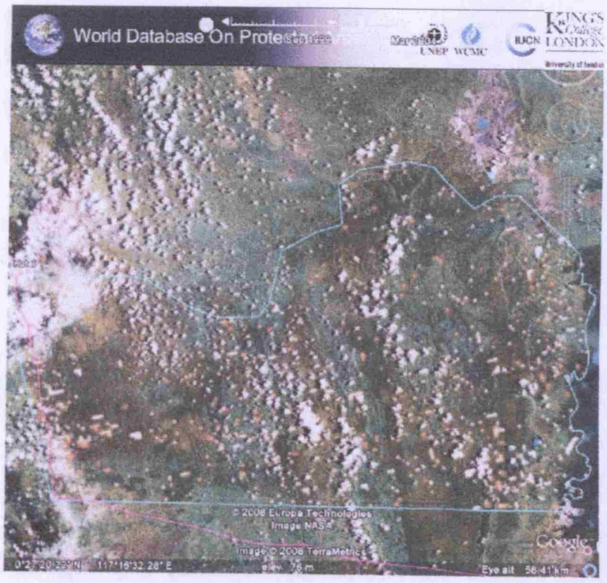
RELUCIAPA - WDPA Interactive



(Source: Photo taken by author using Google Earth™; with RELUCIAPA (Google Earth, 2008a) added - "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")

This displays the outline of the National Park (when zoomed in sufficiently). However, it displays only forest cover at a scale in which the outline of Kutai cannot be seen (see map above).

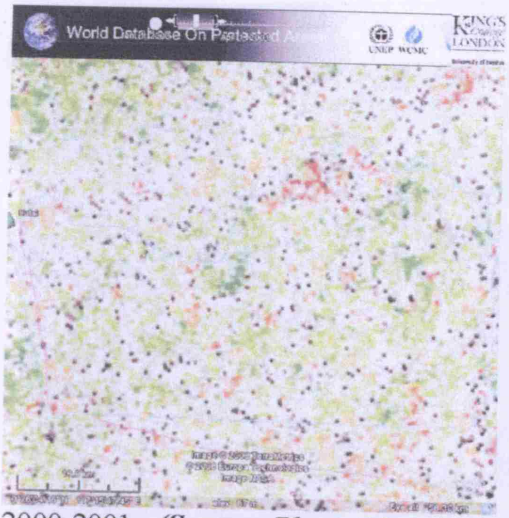
RELUCIAPA – Conservation Eye – Forest loss (2000-2005) in PA's



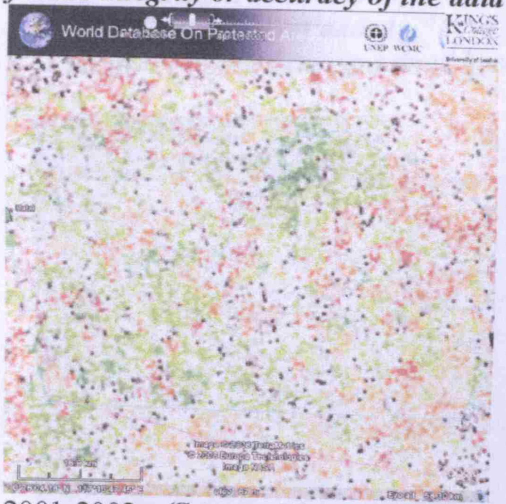
(Source: Photo taken by author using Google Earth™; with RELUCIAPA (Google Earth, 2008a) added - "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")

This layer does not appear to display enough information in order to assess Kutai as a whole in regard to forest cover change, as it only shows areas of forest loss. The colour scheme used for this also tends to blend in with the photographic image, such as the white spots with the cloud cover (see map above).

MODIS VCF Change – Change in Tree Cover



2000-2001 - ***(Source: Photo taken by author using Google Earth™; MODIS VCF Change layer (Google Earth, 2008b) added - "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")***

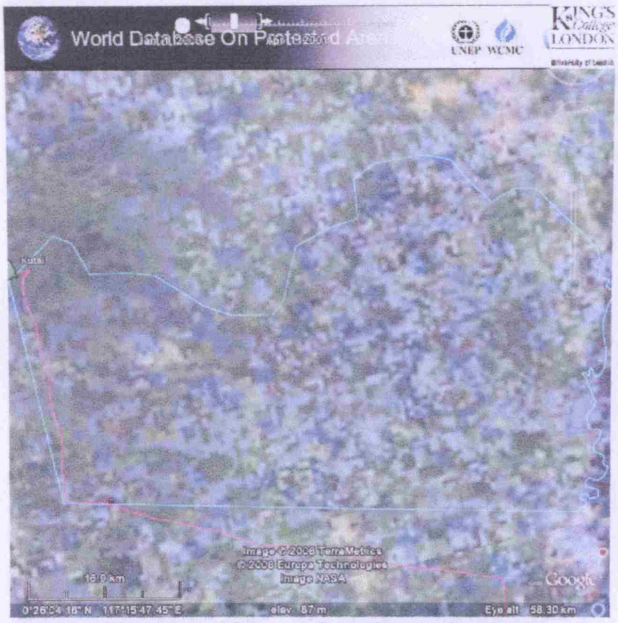


2001-2002 - ***(Source: Photo taken by author using Google Earth™; with MODIS VCF Change layer (Google Earth, 2008b) added - "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")***

Whilst this dataset layer states that it covers the period 2000-2005, the data sources only have information available for 2000-2001 and 2001-2002 (see the maps above). This is potentially useful for analysing forest cover change over time, but it is a short time period and would thus be unrepresentative (for example, the increase in red areas represent high levels of tree cover loss in 2001-2002 as compared to 2000-2001, but for other years it is not known).

RELUCIAPA – MODIS Imagery – MODIS 2000-2005

2001 - *(Source: Photo taken by author using Google Earth™; with RELUCIAPA (Google Earth, 2008a) added - "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")*

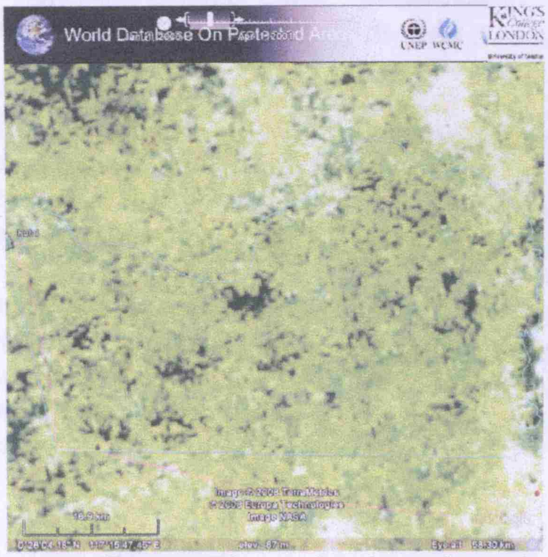


2005 - *(Source: Photo taken by author using Google Earth™; with RELUCIAPA (Google Earth, 2008a) added - "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")*

This dataset layer also states that it covers the period 2000-2005, and the data sources do have information available for 2001 and 2005 (see figure XXX and XXX below). Whilst this is still only four years, it is the longest time period thus far and the data is comprehensible, with the boundaries of Kutai being clearly visible. However, it doesn't appear to have a key/legend to explain what the colours represent so the data cannot be interpreted.

MODIS VCF Change – tree cover

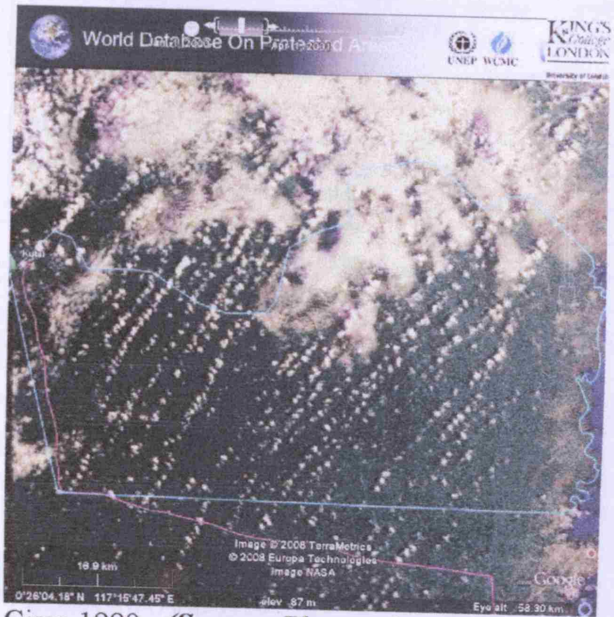
2000 - ***(Source: Photo taken by author using Google Earth™; with MODIS VCF Change layer (Google Earth, 2008b) added - "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")***



2001 - ***(Source: Photo taken by author using Google Earth™; with MODIS VCF Change layer (Google Earth, 2008b) added - "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")***

This dataset layer also states that it covers the period 2000-2005, but the data sources only have information available for 2000 and 2001 (see maps above). As this is an even shorter time period than "RELUCIAPA – MODIS VCF Change – Change in tree cover" it is considered to be unrepresentative also.

MODIS VCF Change - Terrascope



Circa 1990 - ***(Source: Photo taken by author using Google Earth™; with MODIS VCF Change layer (Google Earth, 2008b) added - "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")***

Of all the software this allows the longest time period for analysis, with satellite imagery from 1995 being available. However, due to poor resolution the image does not show forest cover in sufficient detail to allow comparison with the 2008 Google Earth™ satellite imagery (see map above).

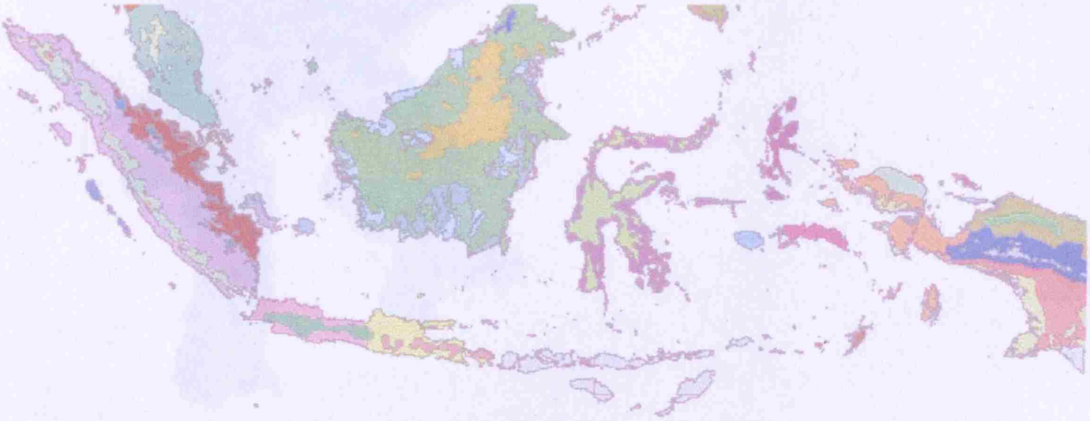
An alternative to a forest cover analysis is to use the data to give a "snap shot" of forest cover in each national park. The most suitable for this would be the "MODIS VCF Change - tree cover" function. However, due to concerns over understanding how to interpret the software, and a lack of explanatory material, it was considered inappropriate to carry out this analysis also.

Appendix 10 – Ecoregions Data and Maps

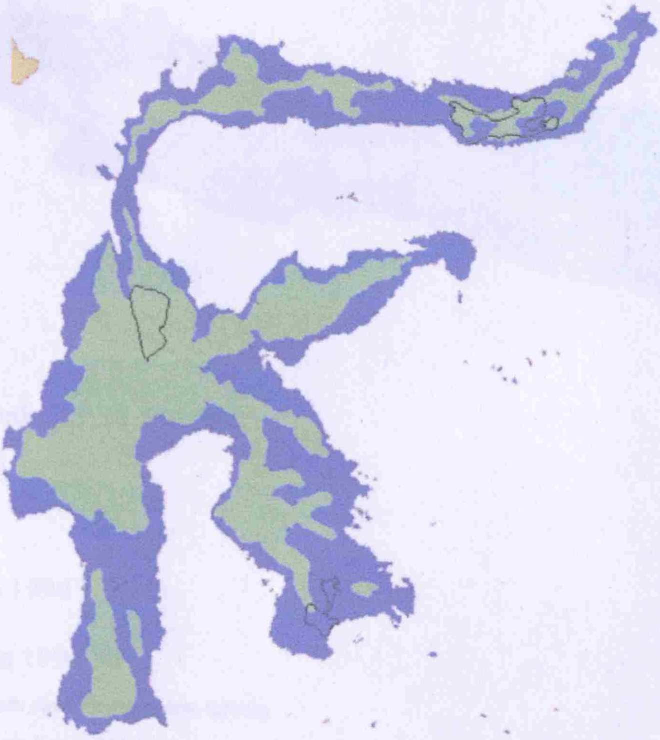
Eco-Regions	PRE 1994 REPRESENTED	REPRESENTED (over500km2)
JAVA		
western java rain forests	1	1
western java montane rainforests	1	1
Eastern java-bali montane rainforests	1	1
Eastern java-bali rainforests	1	1
SUMATRA		
sumatran swamp rainforests	1	1
Sumatran lowland rainforests	1	1
Sumatran peat swamp forests	1	1
sumatran montane rainforests	1	1
sumatran tropical pine forests	1	1
KALIMANTAN		
Sundaland heath forests	1	1
southwest borneo freshwater swamp forests	1	1
borneo peat swamp forests	1	1
Borneo montane rainforests	1	1
Borneo lowland rainforests	1	1
SUMATRA AND KALIMANTAN		
sunda shelf mangroves	1	1
SULAWESI		
Sulawesi lowland rainforests,	1	1
Sulawesi montane rainforests	1	1
PAPUA		
Vogelkop montane rainforests	0	0
Northern new guinea montane rainforests	0	0
Central range montane rainforests	0	1
transfly savanna and grasslands	1	1
Southern new guinea lowland rainforests	0	1
Southern new guinea freshwater swamp	0	1
new guinea mangroves	0	1
Central range sub-alpine grasslands	0	1
Vogelkop-Aru lowland rainforests	0	0
Northern New Guinea Lowland Rain and Freshwater Swamp forests	0	0
Total number of eco regions	27	27

Total number of eco regions represented	18	23
% of Total eco regions represented	66.67	85.19
Difference between total and represented	6	3
Improved % by:		18.52

For the maps in this appendix are sourced from: developed by author: base map extracted from FAO, 2001; eco region data extracted from Olsen et al, 2001, NP data extracted from WDPA (2007) - "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein"



Indonesia (with parts of Malaysia) - Scale - 1:89,115,370 - The Different Colour represent different Ecoregions



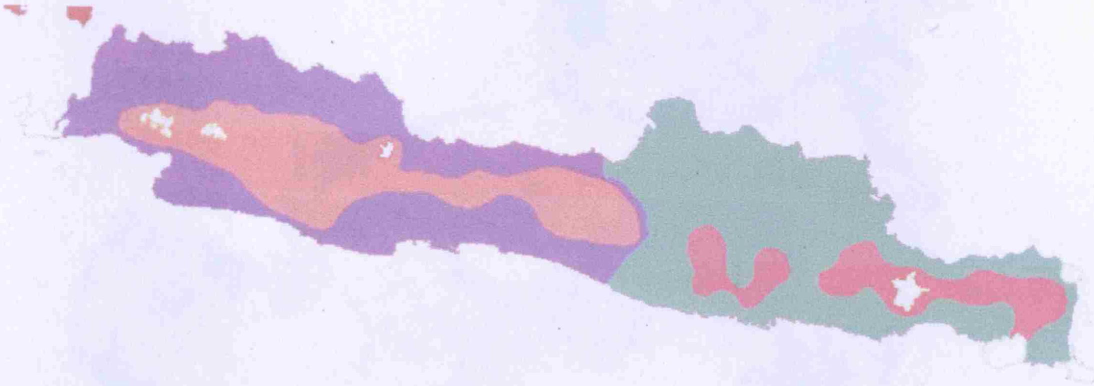
Sulawesi - Scale – 1:21,551,051

Key

Sulawesi lowland rain forests

Sulawesi montane rain forests

Black outline – Pre 1994 NP perimeter



Java - Scale – 1:18,586,504

Key

Pre 1994 NP's

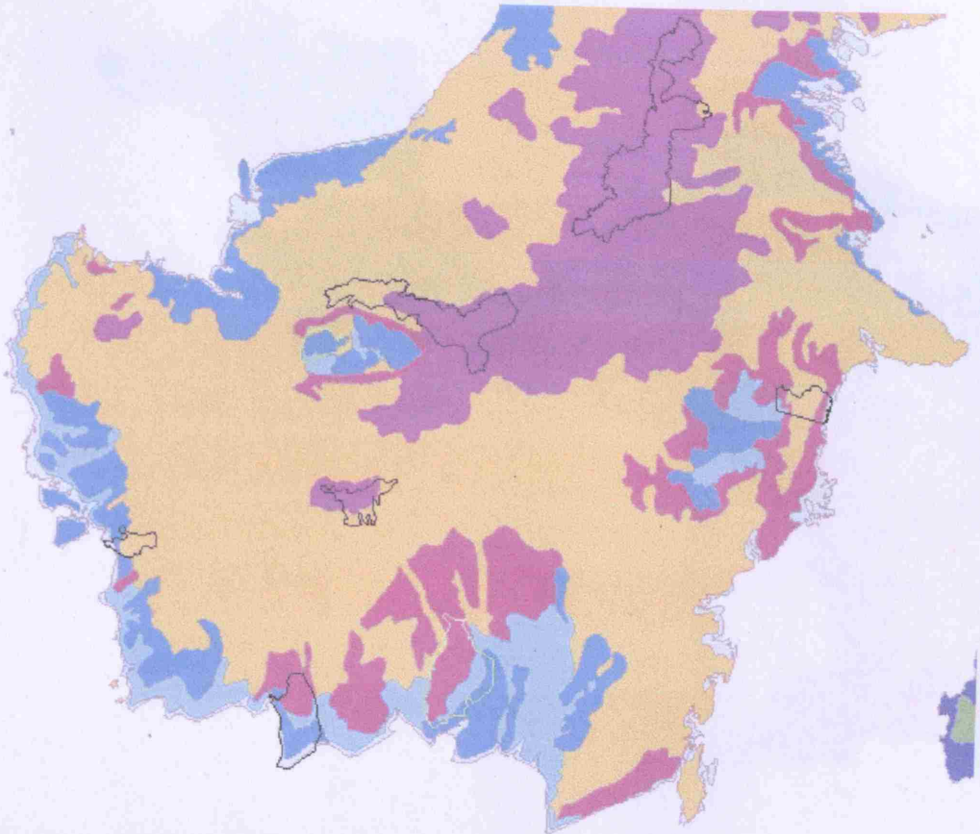
Post 1994 NP's

Western Java montane rain forests

Western Java rain forests

Eastern Java-Bali montane rain forests

Eastern Java-Bali rain forests



Kalimantan - Scale – 1:22,554,858

Key

Black outline – Pre 1994 NP perimeter

Post 1994 NP's perimeter

Borneo lowland rain forests

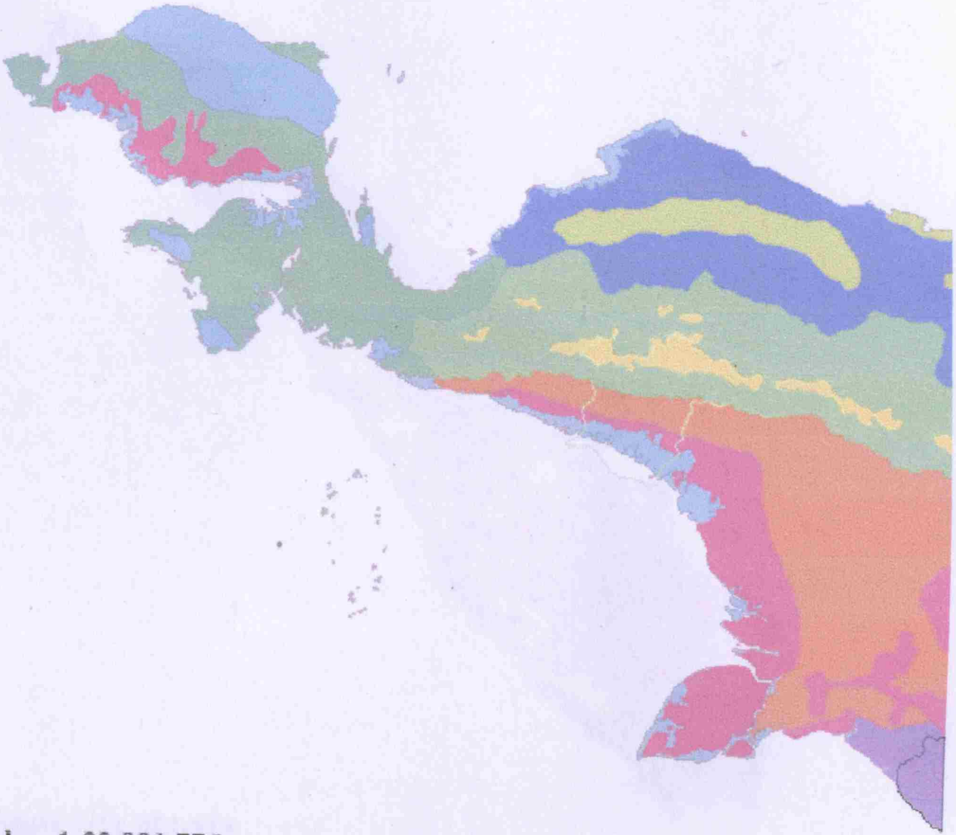
Borneo montane rain forests

Borneo peat swamp forests

Southwest Borneo freshwater swamp forests

Sunda Shelf mangroves

Sundaland heath forests



Papua - Scale – 1:22.991.776

Key

Black outline – Pre 1994 NP perimeter

Post 1994 NP's perimeter

Central Range montane rain forests

Northern New Guinea lowland rain and freshwater swamp forests

Northern New Guinea montane rain forests

Southern New Guinea freshwater swamp forests

Southern New Guinea lowland rain forests

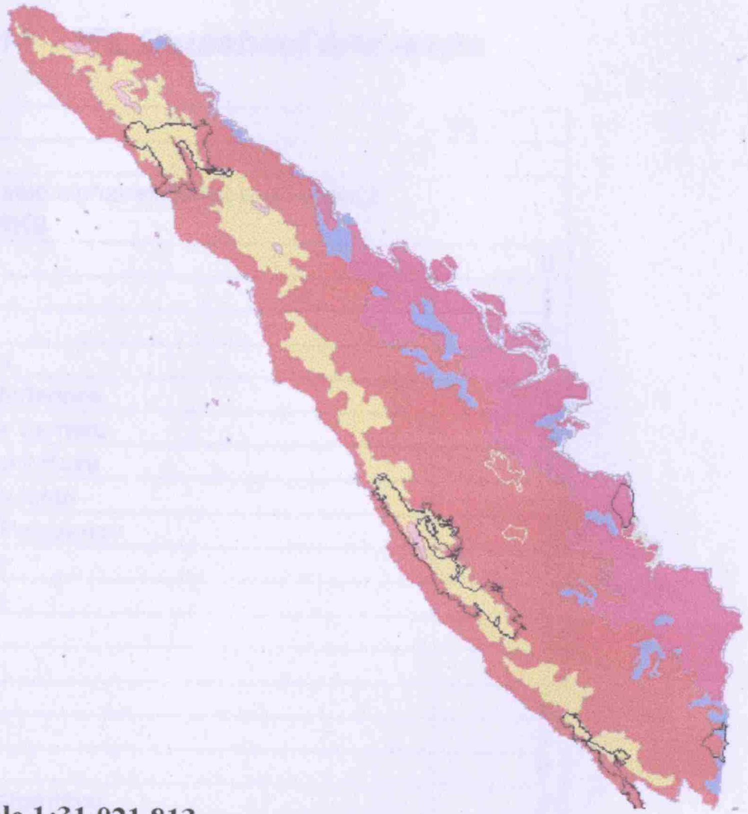
Vogelkop montane rain forests

Vogelkop-Aru lowland rain forests

New Guinea mangroves

Trans Fly savanna and grasslands

Central Range sub-alpine grasslands



Sumatra – Scale 1:31,021,813

Key

Black outline – Pre 1994 NP perimeter

Post 1994 NP's perimeter

Sumatran tropical pine forests

Sumatran freshwater swamp forests

Sumatran lowland rain forests

Sumatran montane rain forests

Sumatran peat swamp forests

Sunda Shelf mangroves

Appendix 11 – IFL Datasheet and maps

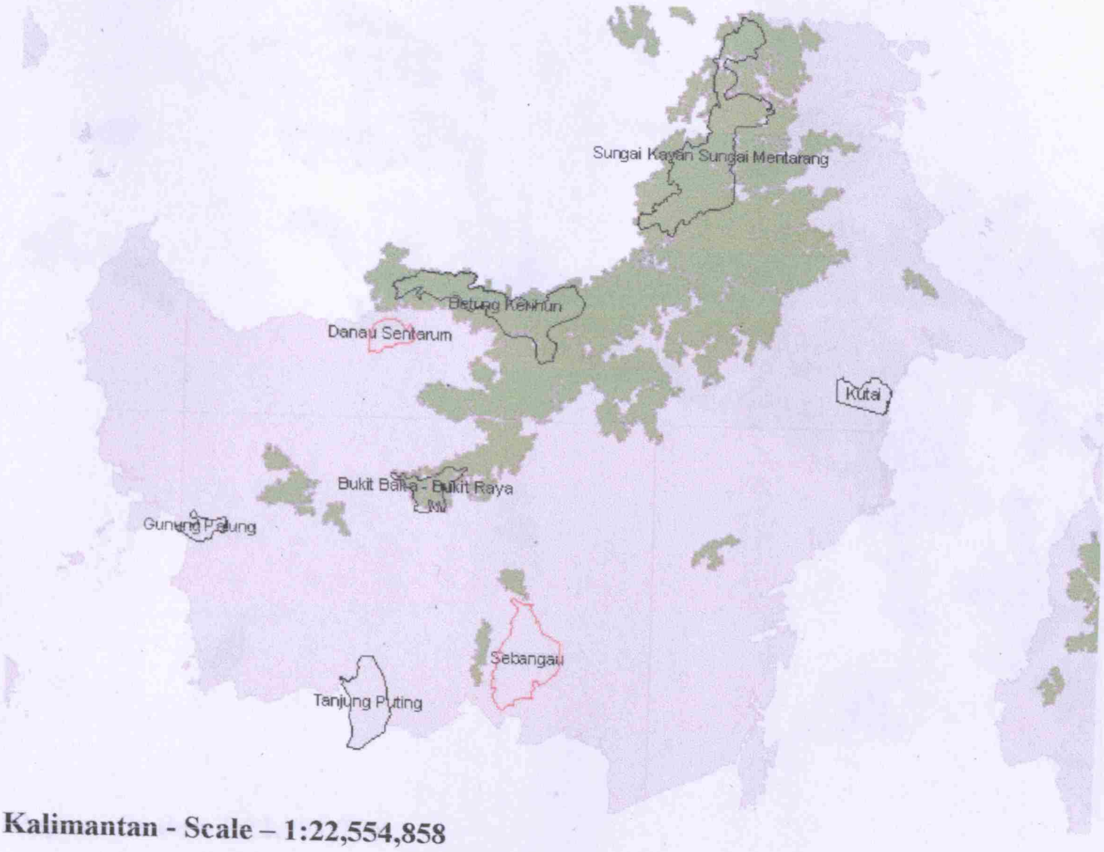
500km2	IFL
The non separated alphabetical list is on sheet 2	
PRE 1994 PARKS	
Alas Purwo	0
Baluran	0
Berbak	0
Betung Kerihun	1
Bogani Nani Wartabone	1
Bromo Tengger Semeru	0
Bukit Baka - Bukit Raya	1
Bukit Barisan Selatan	1
Gunung Gede Pangrango	0
Gunung Leuser	1
Gunung Palung	0
Halimun	0
Kerinci Seblat	1
Kutai	0
Lore Lindu	1
Meru Betiri	0
Rawa Aopa Watumohai	0
Sungai Kayan Sungai Mentarang	1
Tanjung Puting	0
Ujung Kulon	0
Wasur	0
Way Kambas	0
Total Pre 1994 Parks	22
Total Pre 1994 Parks with IFL's	8
% of pre 1994 parks with IFL's	36.36
POST 1994 PARKS	
Bukit Duabelas	0
Bukit Tigapuluh	0
Danau Sentarum	0
Gunung Ciremai	0
Gunung Lorentz	1
Sebangau	0
Sembilang	0
Total Post 1994 Parks	7
Total Post 1994 Parks with IFL's	1
% of post 1994 parks with IFL's	14.28
Total Parks	29
Total Parks with IFL's	9
% of Parks with IFL's	31.03

Overall % change in IFL cover	-5.33

For the maps in this appendix are sourced from: developed by author: base map extracted from FAO, 2001; IFL data extracted from Greenpeace, 2008b, NP data extracted from WDPA (2007) - "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein"

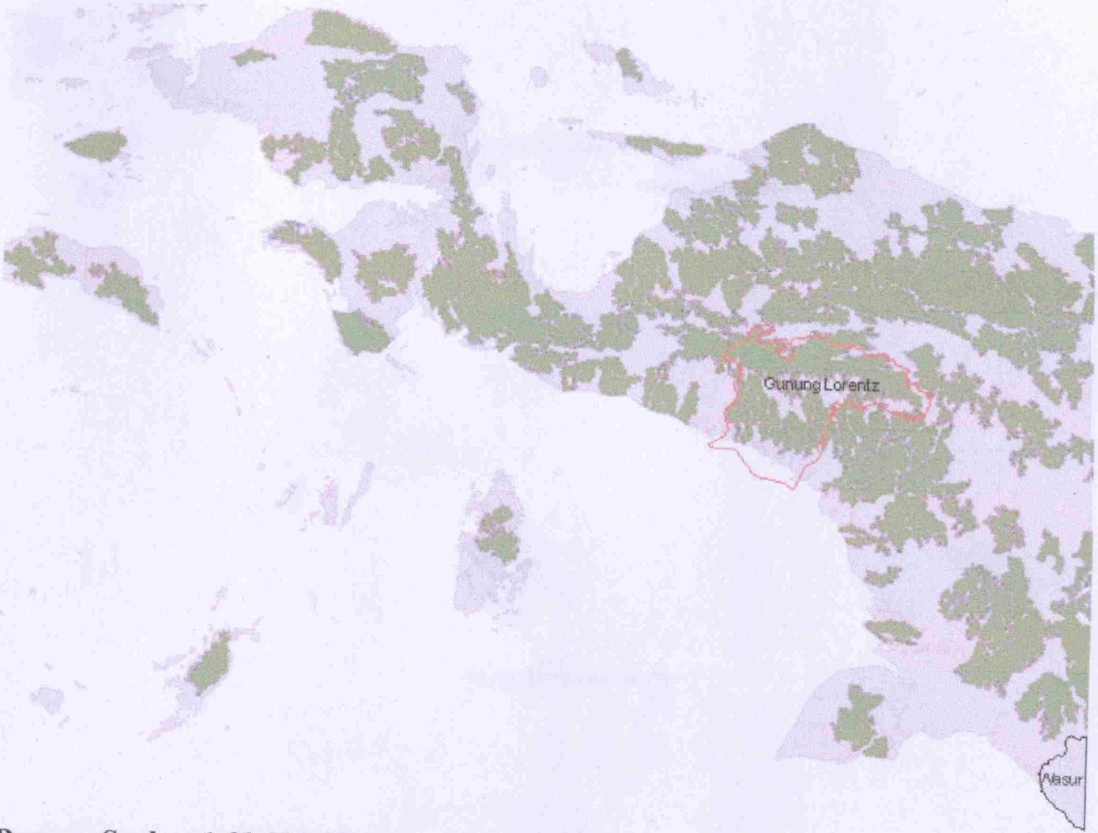
Java - Scale – 1:18,586,504

<u>Key</u>
Black outline – Pre 1994 NP perimeter
Red outline – Post 1994 NP perimeter
IFL's



Kalimantan - Scale – 1:22,554,858

Key
Black outline – Pre 1994 NP perimeter
Red outline – Post 1994 NP perimeter
IFL's



Papua - Scale – 1:22.991.776

<u>Key</u>
Black outline – Pre 1994 NP perimeter
Red outline – Post 1994
IFL's

Sulawesi - Scale – 1:21,551,051

<u>Key</u>

Black outline – Pre 1994 NP perimeter

Red outline – Post 1994 NP perimeter

IFL's

Sumatra – Scale 1:31,021,813

Key
Black outline – Pre 1994 NP perimeter
Red outline – Post 1994 NP perimeter
IFL's

Appendix 12 – Worksheet for size and shape analysis

Source: area measurements developed by author; ***(source: base map from FAO, 2001, NP data extracted from WDPA (2007)*** ***"UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")***

	Perimeter	Area	Ratio (Area/perimeter)	Unknown Units	Area Approx (km2)	WDPA Area (ha)	Website Area (km2)
	1km2			0.0000765			
PRE 1994 PARKS							
Alas Purwo	133.0	462.3	3.48	0.035363	462.3	43	434.2
Baluran	67.4	302.5	4.49	0.023142	302.5	25000	250
Berbak	176.1	1810.3	10.28	0.138485	1810.3	162700	1760
Betung Kerihun	728.1	8305.2	11.41	0.635351	8305.2	800000	8000
Bogani Nani Wartabone	429.1	3288.5	7.66	0.251567	3288.5	287115	3000
Bromo Tengger Semeru	137.6	583.3	4.24	0.044622	583.3	50276	502.76
Bukit Baka - Bukit Raya	340.6	2024.0	5.94	0.154839	2024.0	181090	
Bukit Barisan Selatan	678.4	3507.7	5.17	0.268336	3507.7	365000	3568
Gunung Gede Pangrango	90.4	187.9	2.08	0.014371	187.9	15000	151.98
Gunung Leuser	867.0	9419.6	10.86	0.720598	9419.6	792675	9500
Gunung Palung	195.0	1158.0	5.94	0.088588	1158.0	90000	
Halimun	138.3	312.1	2.26	0.023879	312.1	40000	
Kerinci Seblat	1785.6	14516.3	8.13	1.1105	14516.3	1375000	15000
Kutai	215.9	1999.9	9.26	0.152991	1999.9	198629	1986 - 2000
Lore Lindu	213.5	2468.0	11.56	0.188801	2468.0	229000	2500
Meru Betiri	130.1	1060.4	8.15	0.081119	1060.4	50000	580
Rawa Aopa Watumohai	226.4	1071.2	4.73	0.081945	1071.2	105194	1050
Sungai Kayan Sungai Mentarang	1010.8	13390.4	13.25	1.024364	13390.4	1360500	16000

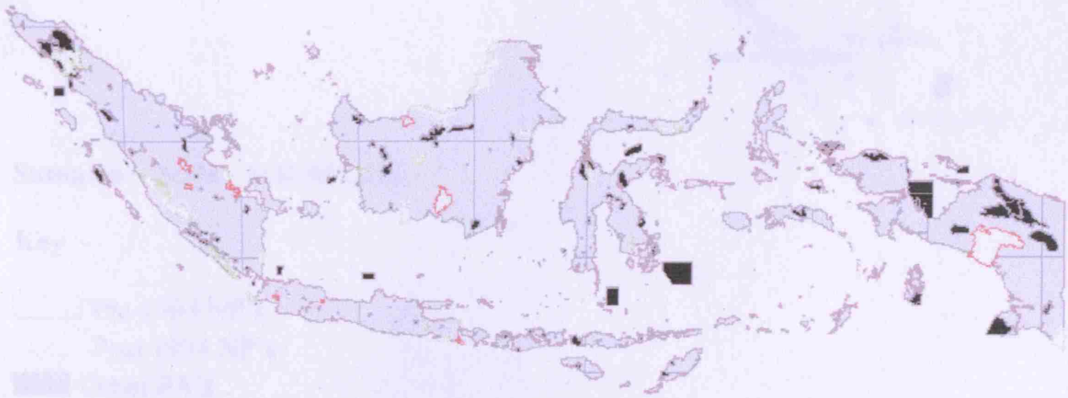
Tanjung Puting	309.7	4247.8	13.71	0.324958	4247.8	355000	4150.4
Ujung Kulon	201.7	940.5	4.66	0.071948	940.5	122956	1206 km^2 (443km2 marine)
Wasur	304.8	4365.6	14.32	0.333967	4365.6	413810	
Way Kambas	183.0	1352.6	7.39	0.103471	1352.6	130000	
Total Pre 1994 Parks			20.0				
Total Pre 1994 Parks above minimum ratio (11.18)			5.0				
% of pre 1994 parks above minimum ratio (11.18)			25.0				
POST 1994 PARKS							
Bukit Duabelas	109.6	655.4	5.98	0.050135	655.4	60500	
Bukit Tigapuluh	253.1	1538.8	6.08	0.11772	1538.8	127698	
Danau Sentarum	168.9	1484.4	8.79	0.113554	1484.4	132000	
Gunung Ciremai	58.8	172.9	2.94	0.013224	172.9	15500	
Gunung Lorentz	1003.9	27828.4	27.72	2.128874	27828.4	2505000	25000
Sebangau	403.8	6407.5	15.87	0.490174	6407.5	568700	
Sembilang	338.1	1407.4	4.16	0.107665	1407.4	205078	
Total Post 1994 Parks			9.0				
Total Post 1994 Parks above minimum ratio (11.18)			2.0				
% of pre 1994 parks above minimum ratio (11.18)			22.2				
Total Parks			29.0				
Total Parks above minimum ratio (11.18)			7.0				
% of parks above minimum ratio (11.18)			24.1				

Appendix 13 – Worksheet and Maps from Connectedness analysis

CONNECTIONS	PA's	Notes
PRE 1994 PARKS		
Alas Purwo	0	
Baluran	0	
Berbak	1	Almost joins Sembilang NP
Betung Kerihun	1	
Bogani Nani Wartabone	0	
Bromo Tengger Semeru	0	
Bukit Baka - Bukit Raya	0	
Bukit Barisan Selatan	1	
Gunung Gede Pangrango	0	
Gunung Leuser	1	
Gunung Palung	0	
Halimun	0	
Kerinci Seblat	0	
Kutai	0	
Lore Lindu	1	
Meru Betiri	0	
Rawa Aopa Wutumohai	0	
Sungai Kayan Sungai Mentarang	0	
Tanjung Puting	0	
Ujung Kulon	0	
Wasur	0	
Way Kambas	0	
Total Pre 1994 Parks	22	
Total Pre 1994 Parks with Connections	5	
% of pre 1994 parks with Connections	22.72	
Total Number of Connections (NEEDED?)	5	
POST 1994 PARKS		
Bukit Duabelas	0	
Bukit Tigapuluh	0	
Danau Sentarum	0	
Gunung Ciremai	0	
Gunung Lorentz	0	
Sebangau	1	
Sembilang	1	Almost joins Berbak NP
Total Post 1994 Parks	7	
Total Post 1994 Parks with Connections	2	
% of pre 1994 parks with Connections	28.57	

Total Number of Connections	2	
Total Number of Parks	29	
Total Number of Parks with connections	7	
% of Parks with connections	24.13	
Net Change %	28.57143	
Proportional Change in %		

***For the maps in this appendix are sourced from: developed by author: base map extracted from FAO, 2001; NP data extracted from WDPA (2007), other PA's data extracted from WDPA (2007)** - "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein"*

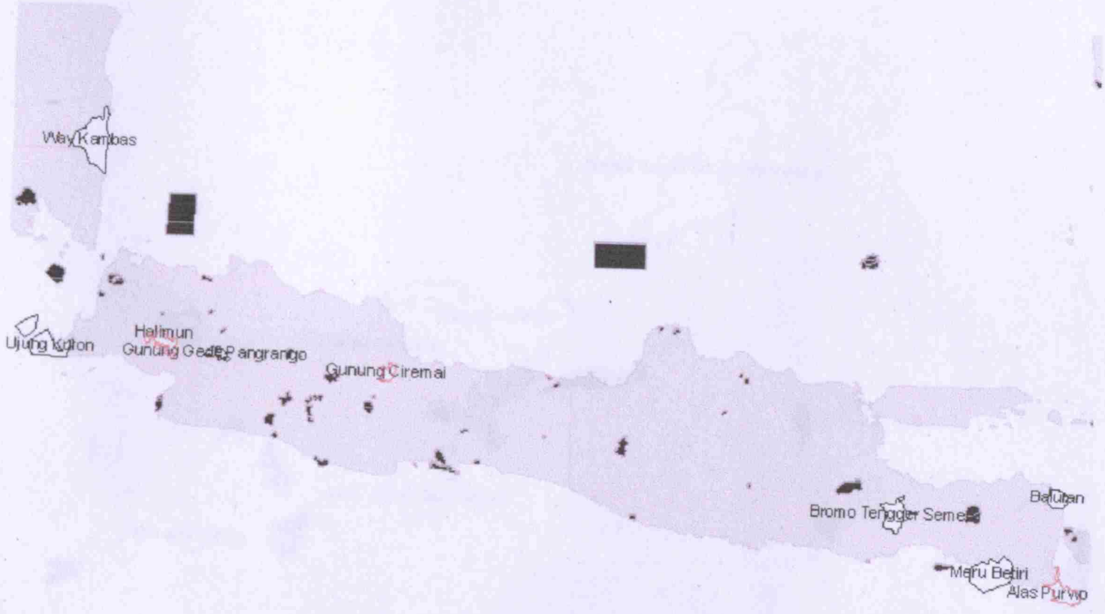


Indonesia – Scale - 1:89,115,379

Sumatra – Scale - 1:31,021,813

Key

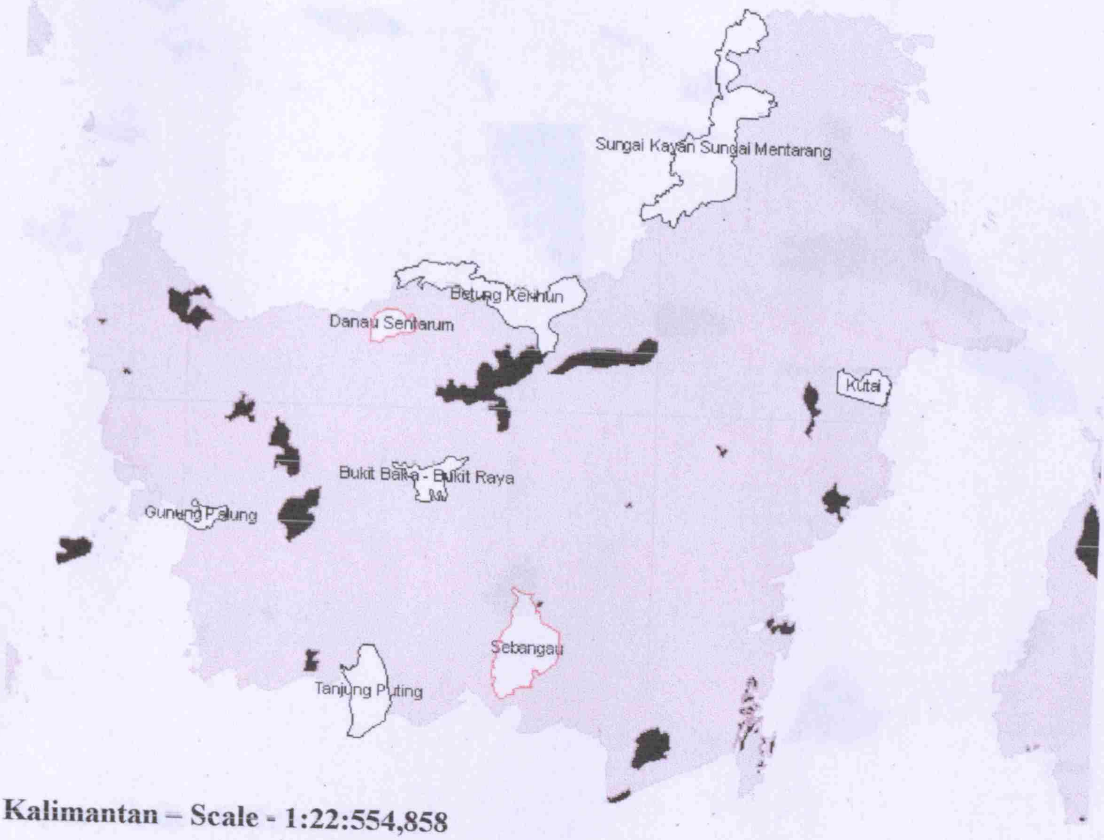
Pre 1994 NP's
Post 1994 NP's
Other PA's



Java – Scale - 1:18,586,504

Key

Pre 1994 NP's
Post 1994 NP's
Other PA's



Kalimantan – Scale - 1:22:554,858

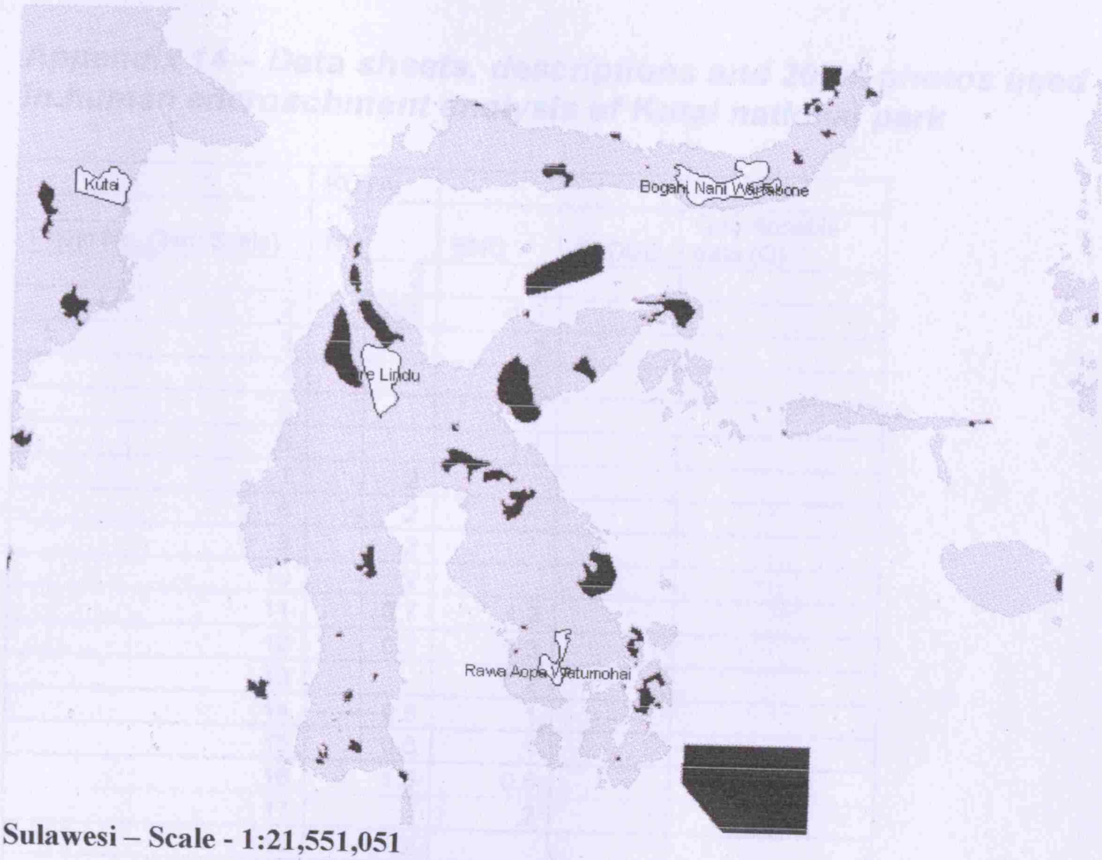
Key

Pre 1994 NP's
Post 1994 NP's
Other PA's

Papua – Scale - 1:22,991,776

Key

Pre 1994 NP's
Post 1994 NP's
Other PA's



Sulawesi – Scale - 1:21,551,051

Key

Pre 1994 NP's
Post 1994 NP's
Other PA's

Appendix 14 – Data sheets, descriptions and 20km photos used in human encroachment analysis of Kutai national park

	KUTAI			
Photo No. (2km Scale)	NO	ENC	CLOUD	Questionable data (Q)
1	2			
2	0.3	1.3		
3		2		
4		2		
5		1.7		
6		1.1		
7	2			
8	2			
9	2			
10	2			
11	0.7	1.3		
12	0.7	1.3		
13		2		
14	0.5	1		
15	0.5	1		
16	1.5	0.5		
17		2		
18	2			
19	1.4	0.6		
20	2			
21	2			
22	0.9	1.1		
23	2			
24	2			
25	2			
26	2			
27	2			
28	2			
29	2			
30	2			
31	2			
32	2		0.8	
33	2		1.8	
34	2		2	
35	2	0	2	Q
36	2	0	2	Q
37	2	0	2	Q
38	2	0	2	Q
39	2		1.8	
40	2	0	2	Q
41	2	0	2	Q

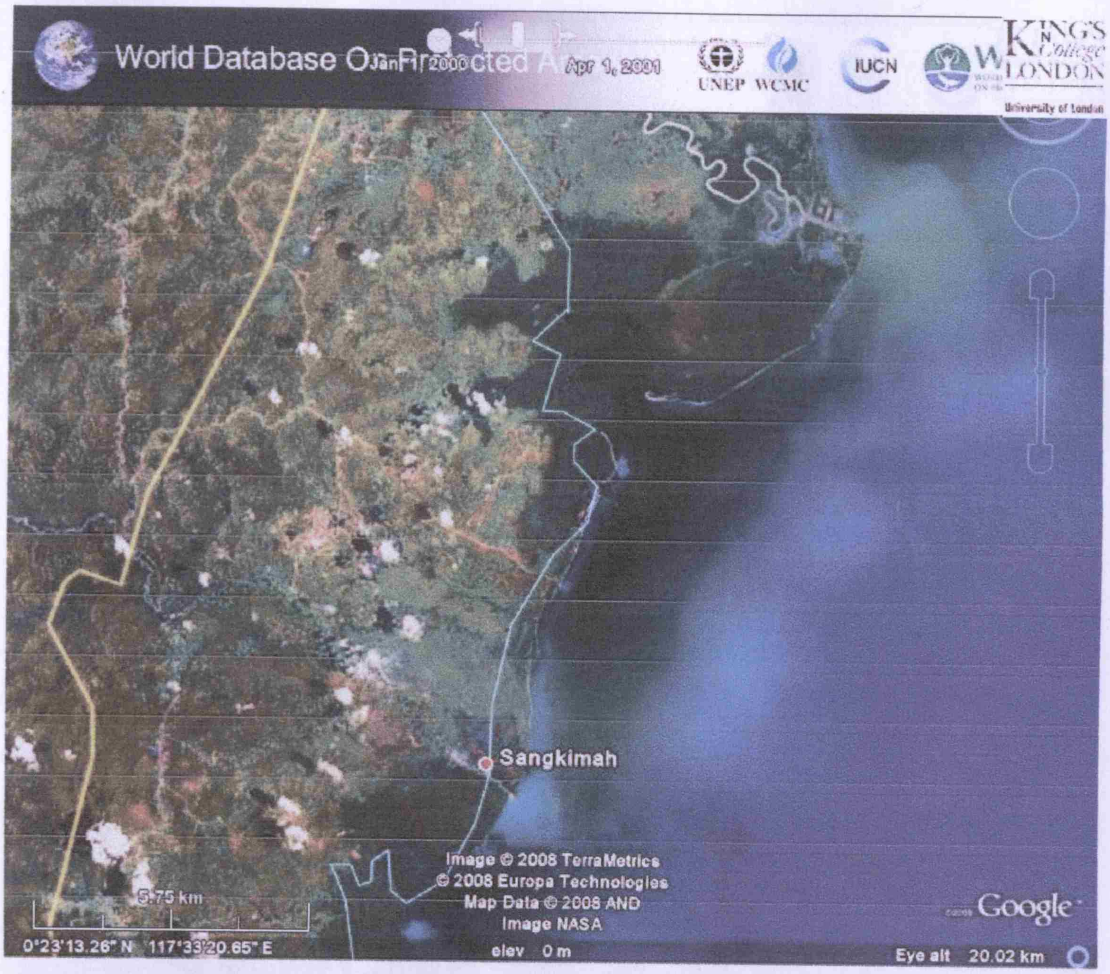
42	2	0	1.9	Q
43	0.2	1.8	1.8	
44	2	0	2	Q
45	2		2	
46	2	0	2	Q
47	2		1	
48	1.6	0.4	1.8	
49	2		2	
50	0.8		0.7	
51		2	2	
52	1.3	0.7	0.4	
53		2		
54		2		
55	0.2			
56		2		
57		2		
58		2		
59		2		
60		2		
61		2		
62		2		
63		2		
64	2			
65	2			
66	2			
67	2		1	
68	2			
69	2			
70	2			
71	2			
72	2			
73	2			
74	2			
75	0.9	1.1		
76		2		
77		2		
78	0	1		
79	2			
80	2			
81	2			
82	2			
83	0.3	1.7		
84	2			
85	2			
86	2			
87	1			
88	1.7	0.3		
89	0.2	1.8		

	90	0			
	91	0			
	92	0			
	93	1.6	0.4		
		118.3	54.1	37	
excl. Q		100.3	54.1		
TOTAL		172.4			
excl. Q		154.4			

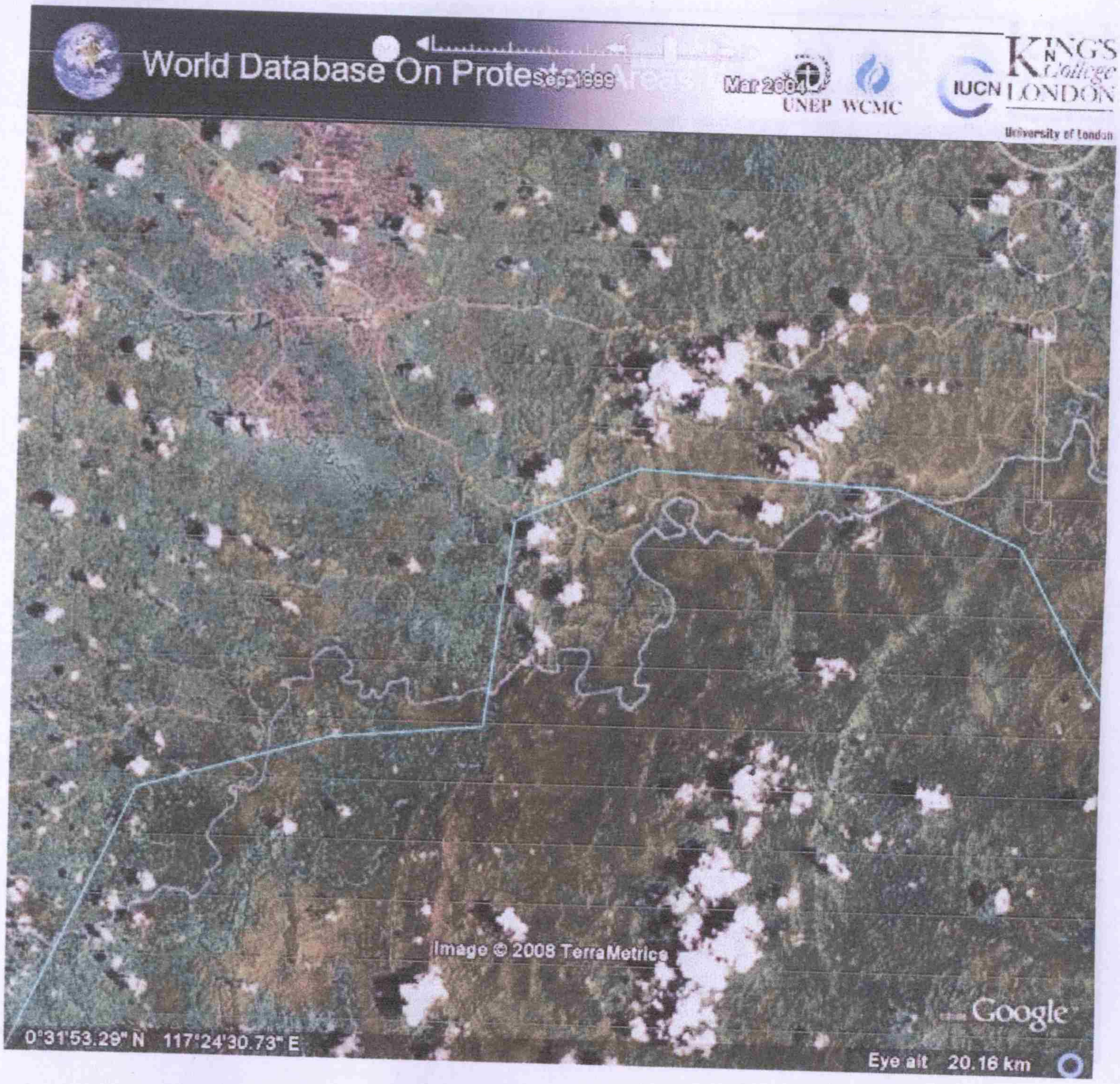
Description

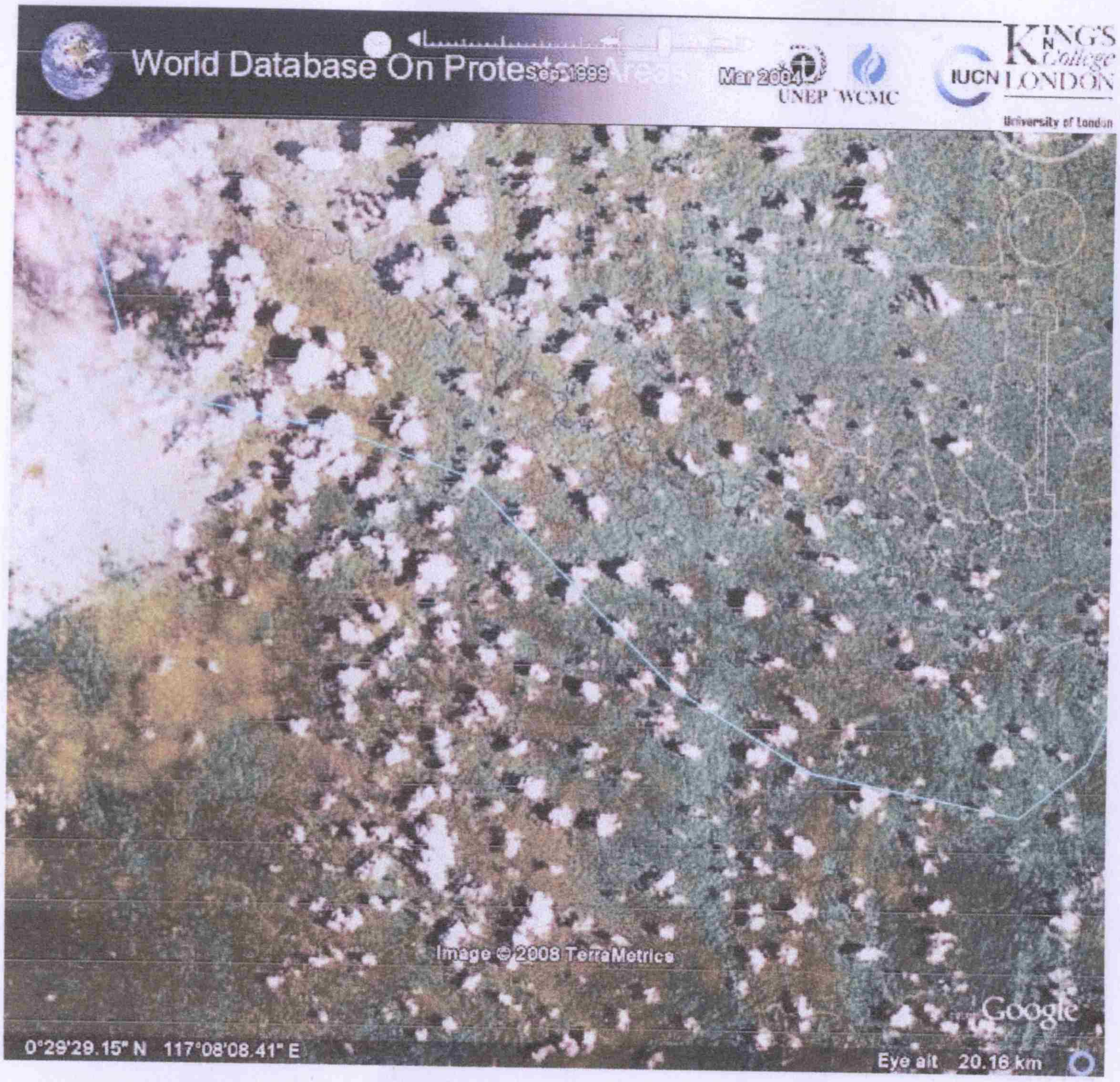
This analysis begins in the north east corner of the park at the delta and river estuary, and follows the boundary anti clockwise. The town of Sangatte close to the boundary is visible at 20km scale. In the flatlands around Sangatte is widescale encroachment, but to the west are hills that appear unencroached. The northern boundary is characterised by what appears to be a concreted road, the use of which is unknown but which winds itself in and out of the boundary, and could possibly be the boundary used by national park staff. There is also a settlement to the north of the boundary, from which some dirt roads wind into the national park. Further along the northern boundary appears to be less encroached, although the vegetation appears to be different shades of green to brown. The reason for this is not known, although it is assumed to be natural as it does not have the orderliness of a plantation. Parts of the northern boundary are obscured by cloud cover, which hinders this analysis. The clouds continue to obscure the north of the western boundary. Further down, the quality of the imagery is such that it is very difficult to establish what is on the ground at either scale. The south west and southern boundary appear to be entirely encroached, with natural forest beginning approximately 2.5km within the boundary. The natural forest follows a straight line slightly parallel to the boundary, and may represent the boundary used by national park staff. This encroachment area on the southern boundary appears to end where some kind of ridge appears, although the imagery is unclear. Natural vegetation carries on other another ridge, until the ground flattens out towards the coast, where a settlement and farmland encroaches into the south east of the park. Along the east coast there is little development, probably because of the dense mangroves and swamplands, although it increases at the northern end.

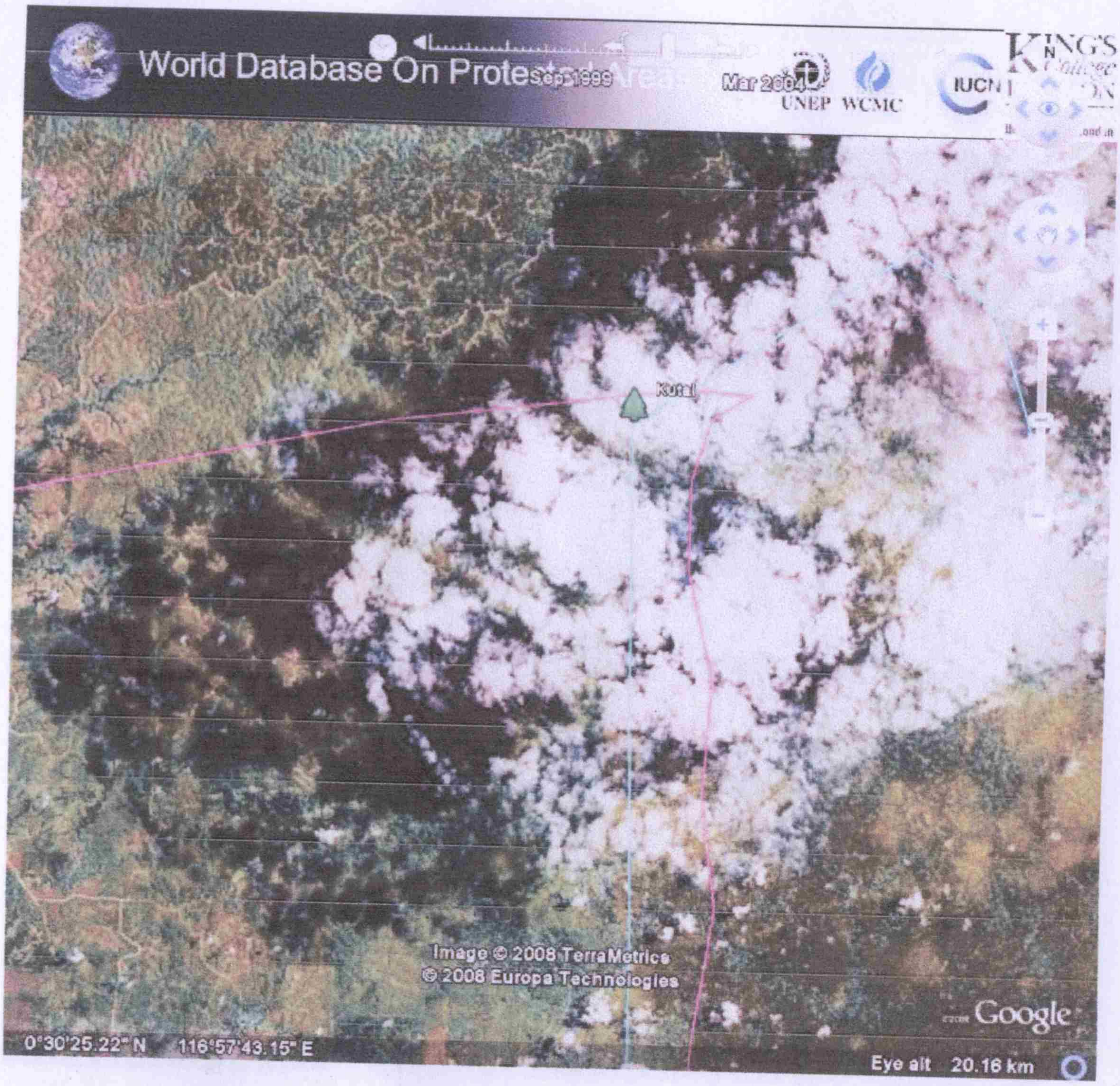
The Photos in this appendix are sourced from: Photos taken by author, base image from Google Earth (2008), overlaid with data from Google Earth (2008a) "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")

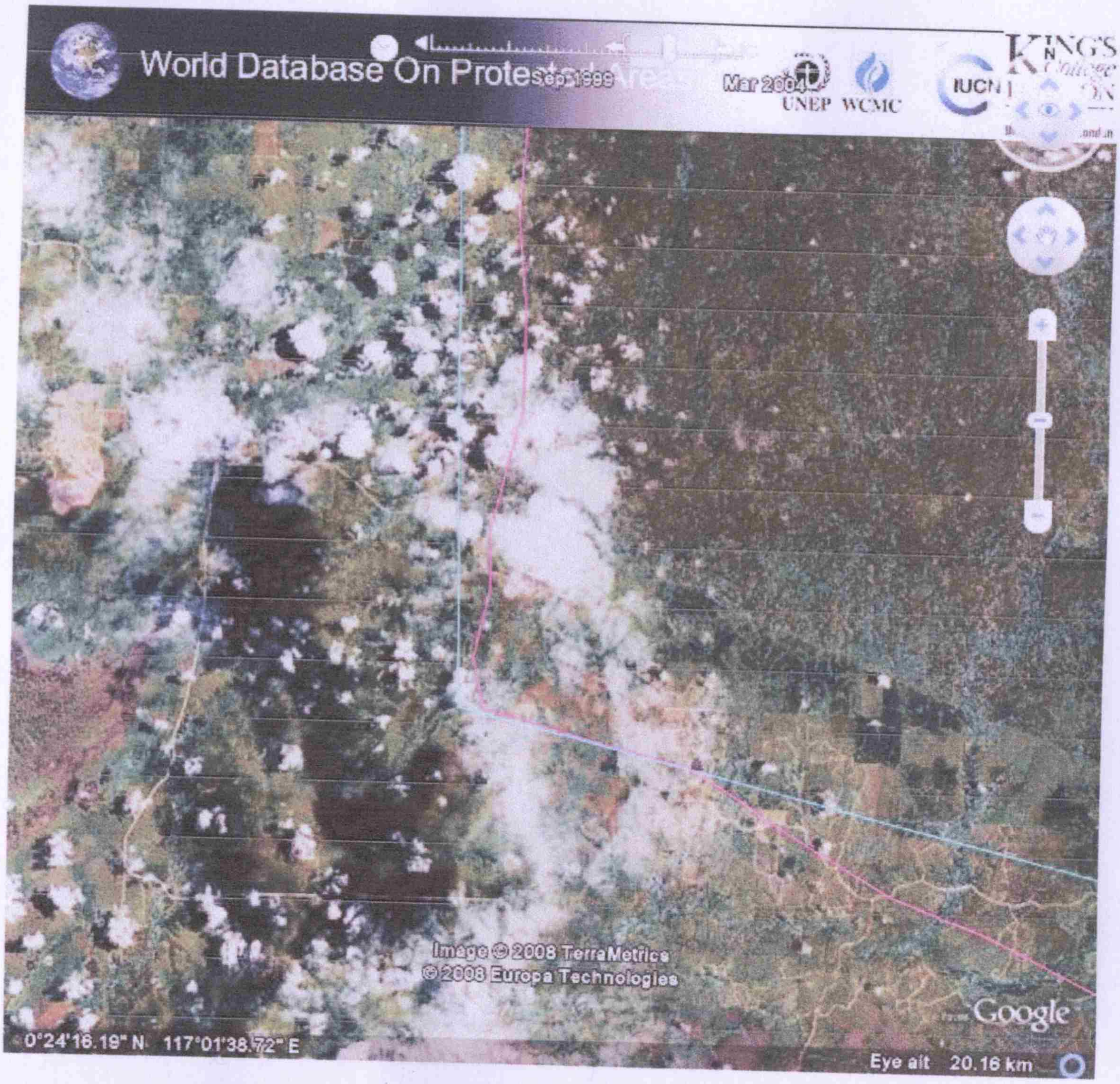

World Database On Protected A
Jan Fr 2000
Apr 1, 2001
UNEP WCMC
IUCN
KING'S College LONDON
University of London
Sangkimah
Image © 2008 TerraMetrics
© 2008 Europa Technologies
Map Data © 2008 AND
Image NASA
5.75 km
0°23'13.26" N 117°33'20.65" E
elev 0 m
Eye alt 20.02 km
Google

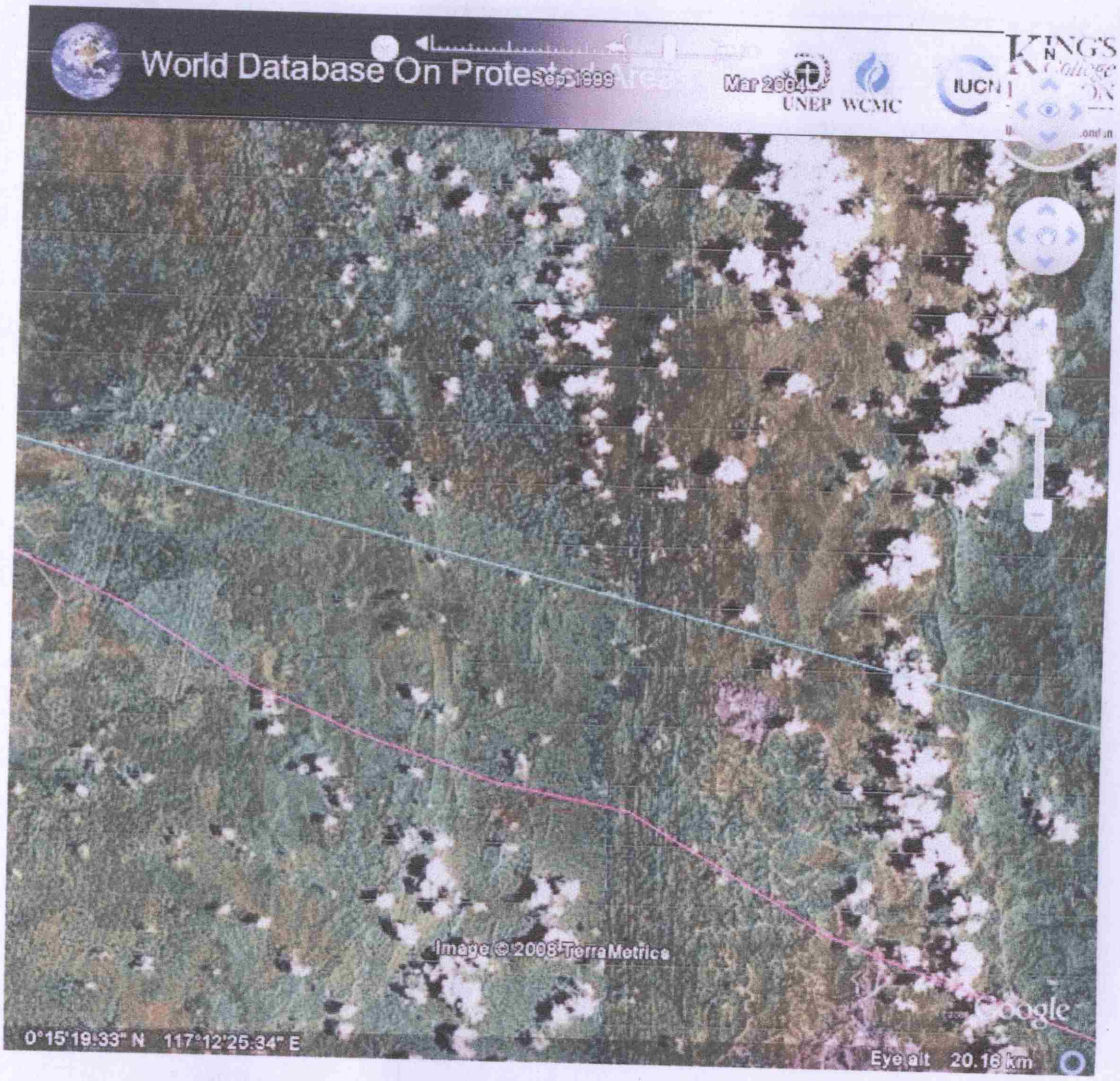

World Database On Protected Areas
Sep 1999
Mar 2004
UNEP WCMC
IUCN
KING'S College LONDON
University of London
Sangatte
Image © 2008 TerraMetrics
Image NASA
© 2008 Europa Technologies
Google
0°24'57.83" N 117°33'16.93" E
Eye alt 20.16 km

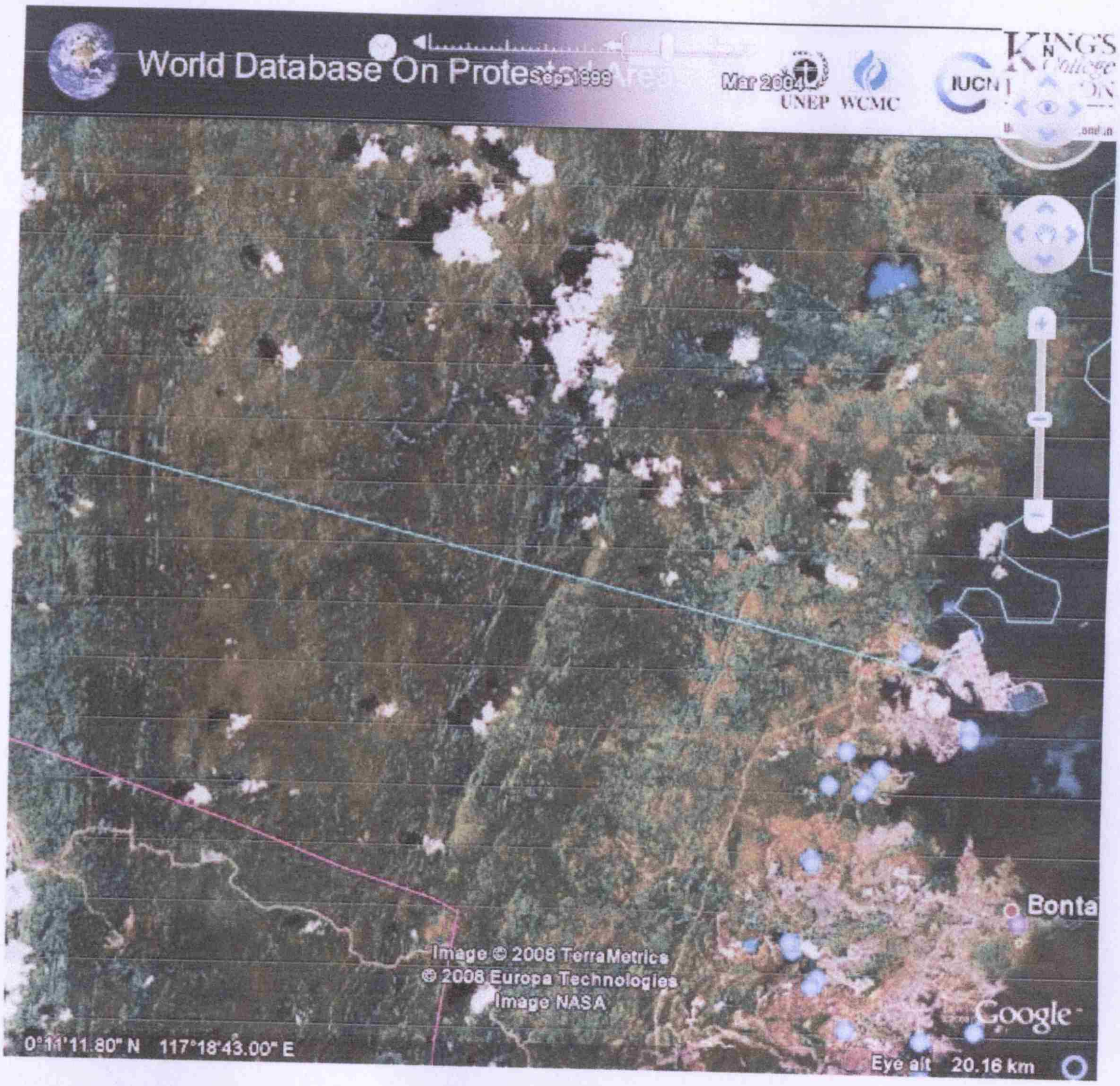

World Database On Protected Areas
Sep 1999
Mar 2004
UNEP WCMC
IUCN
KING'S College LONDON
University of London
Image © 2008 TerraMetrics
Google
0°31'53.29" N 117°24'30.73" E
Eye alt 20.16 km


World Database On Protected Areas
Sep 1999
Mar 2004
UNEP WCMC
IUCN
KING'S College LONDON
University of London
Image © 2008 TerraMetrics
Google
0°29'29.15" N 117°08'08.41" E
Eye alt 20.16 km


World Database On Protected Areas
Sep 1999
Mar 2004
UNEP WCMC
IUCN
Kutai
Image © 2008 TerraMetrics
© 2008 Europa Technologies
Google
0°30'25.22" N 116°57'43.15" E
Eye alt 20.16 km


World Database On Protected Areas
Sep 1999
Mar 2004
UNEP WCMC
IUCN
Image © 2008 TerraMetrics
© 2008 Europa Technologies
Google
0°24'16.19" N 117°01'38.72" E
Eye alt 20.16 km


World Database On Protected Areas
Sep 1999
Mar 2004
UNEP WCMC
IUCN
KING'S College LONDON
Image © 2008 TerraMetrics
Google
0°15'19.33" N 117°12'25.34" E
Eye alt 20.16 km


World Database On Protected Areas
Sep 1999
Mar 2004
UNEP
WCMC
IUCN
Bonta
Image © 2008 TerraMetrics
© 2008 Europa Technologies
Image NASA
Google
0°11'11.80" N 117°18'43.00" E
Eye alt 20.16 km


World Database On Protected A
Apr 1, 2001
UNEP WCMC
IUCN
KING'S College LONDON
University of London
Image © 2008 TerraMetrics
© 2008 Europa Technologies
Map Data © 2008 AND
Image NASA
Google
5.77 km
0°13'54.61" N 117°30'58.06" E
elev 2 m
Eye alt 20.02 km

Appendix 15 – data sheet, descriptions and 20km photos used in human encroachment analysis of Ujung Kulon national park

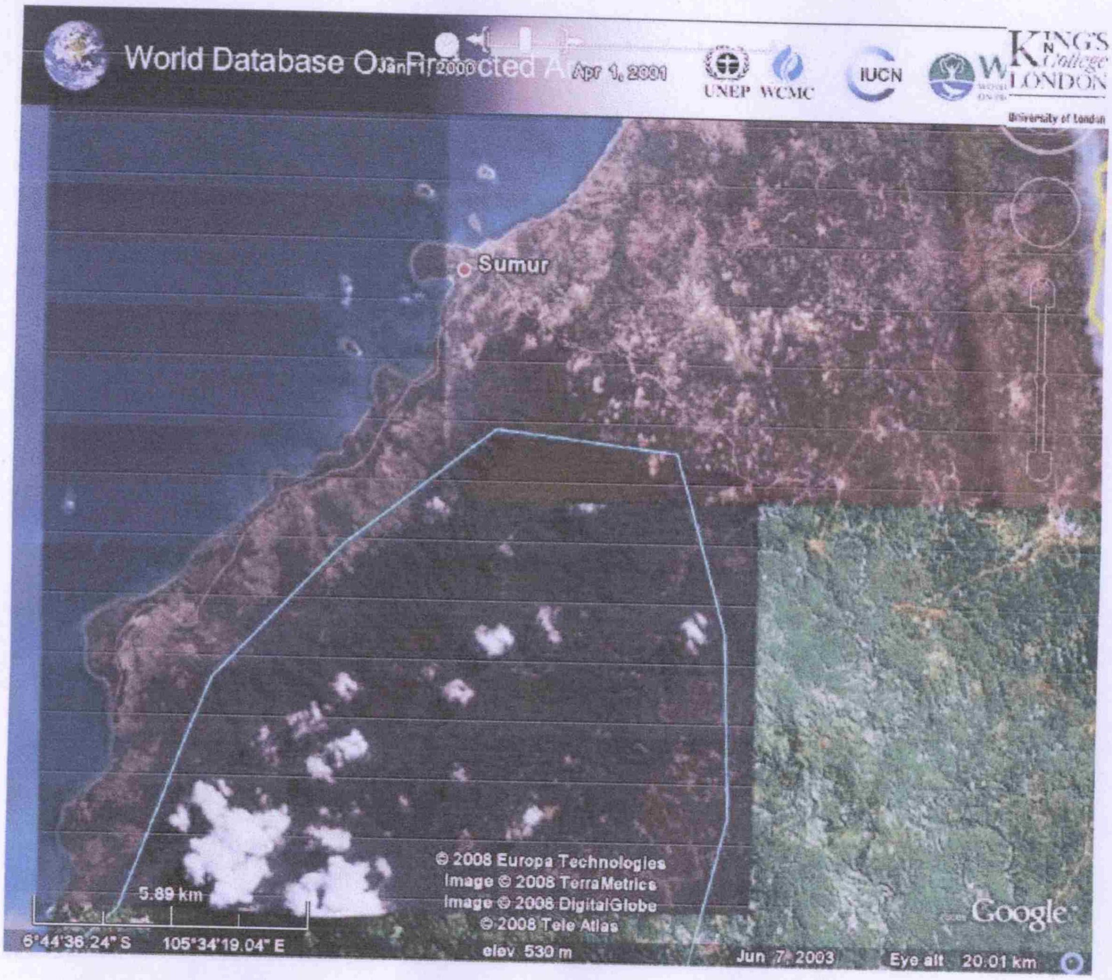
Ujung Kulon			
Photo No. (2km Scale)	NO	ENC	CLOUD
1	2		
2	1.9	0.1	
3	1.6	0.4	
4	0.4	1.6	
5	0	2	
6	0	2	
7	0.1	1.9	
8	0	2	0.6
9	0	2	
10	0	2	
11	0	2	
12	0.6	1.4	
13	0	2	
14	0.6	1.4	
15	0	2	
16	2		
17	2		
18	1.9	0.1	
19	2		
20	2		
21	2		
22	2		
23	2		
24	2		
25	2		
26	2		
27	2		
28	2		
29	2		
30	2		
31	2		
32	2		
33	2		
34	2		
35	2		
36	2		
37	2		
38	2		
39	2		
40	2		
41	2		
42	2		

	43	2		
	44	2		
	45	2		
	46	2		
	47	2		
	48	2		
	49	2		
	50	2		
	51	2		
	52	2		
	53	2		
	54	2		
	55	2		
	56	2		
	57	2		
	58	2		
	59	2		
	60	1.4	0.6	
	61	0	2	
	62	0	2	
	63	1	1	
	64	1.8	0.2	
	65	1.4	0.6	
	66	0.3	1.7	
	67	0.4	1.6	
		101.4	32.6	0.6
		134		

Description

This analysis begins in the north eastern corner of the park, and will follow the boundary clockwise. To the north of the park is the settlement of Sumur, and there's a road that follows the coastline but ends before encroaching on the park. The imagery is significantly better quality than that of Kutai, and clearly shows many encroachments, including cleared land, roads and settlements. The quality of the imagery diminishes for a bit but encroachment is still clear. Encroachments continue with a patchwork of forest and clearances to the southern coast, with the settlement of Aerdjeruk within the national park. Further along the southern coast the encroachments end. This natural state continues up the western and northern coast. At the 2km scale there is some lack of tree cover, but as there is no evidence of any human intervention for at least 5km it is assumed that they are the result of a natural landslide, and thus not encroachment. Sand banks, river estuaries and beaches are also assumed to be natural, although they do not have tree cover. This continues along the northern coast until 3km east of the narrow strip of land joining the western peninsular to the eastern region. This is close to the Settlement of Tjikawung, which is within the boundaries of the park. Encroachments are interspersed from here to the north eastern tip of the park.

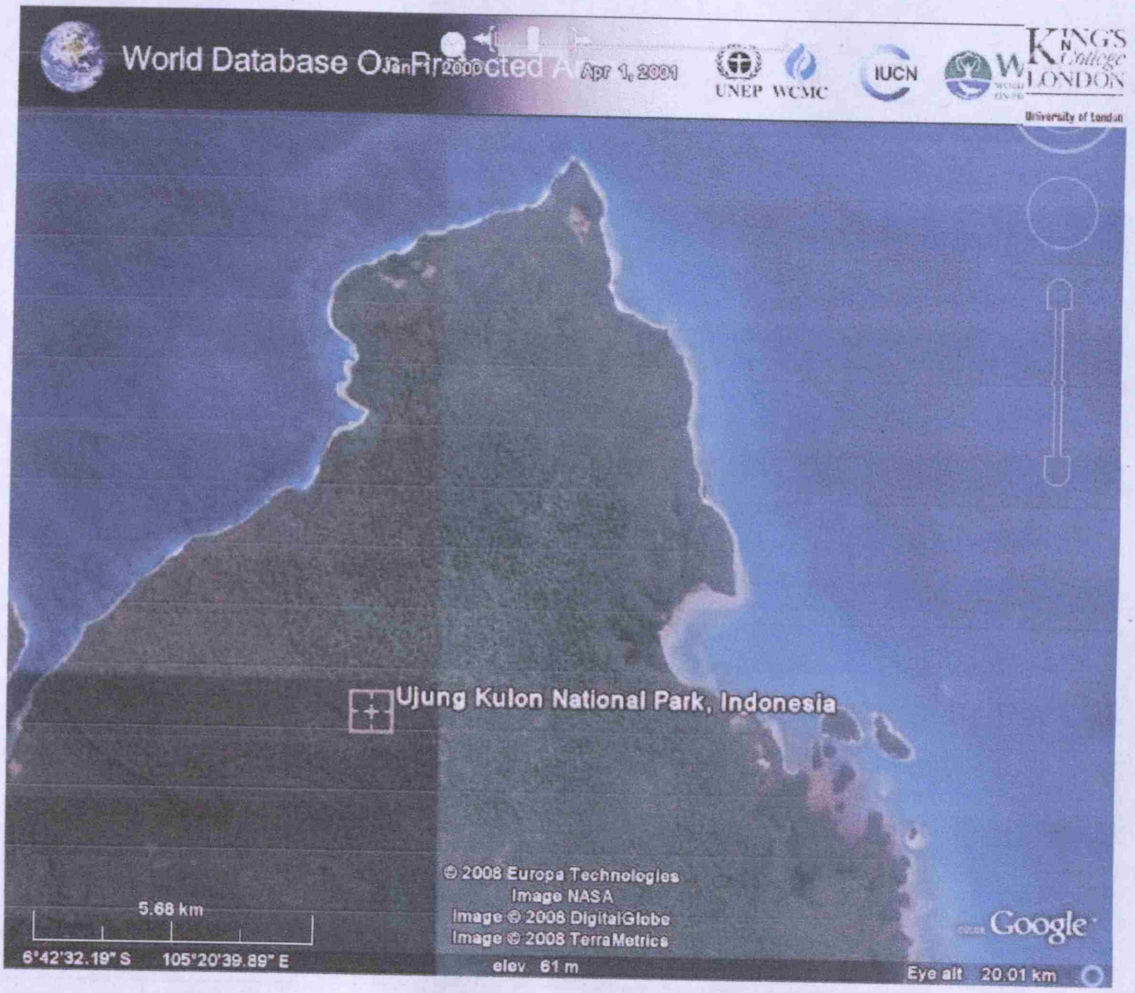
The Photos in this appendix are sourced from: Photos taken by author, base image from Google Earth (2008), overlaid with data from Google Earth (2008a) "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")


World Database On Protected A
Apr 1, 2001
UNEP WCMC
IUCN
KING'S College LONDON
University of London
Sumur
5.89 km
© 2008 Europa Technologies
Image © 2008 TerraMetrics
Image © 2008 DigitalGlobe
© 2008 Tele Atlas
Google
6°44'36.24" S 105°34'19.04" E
elev 530 m
Jun 7, 2003
Eye alt 20.01 km


World Database On Protected Areas
Apr 1, 2001
UNEP WCMC
IUCN
KING'S College LONDON
University of London
Tjikawung
© 2008 Europa Technologies
Image © 2008 TerraMetrics
Image © 2008 DigitalGlobe
© 2008 Tele Atlas
5.78 km
6°47'55.22" S 105°36'47.68" E
elev 106 m
Eye alt 20.01 km
Google


World Database On Protected Areas
Apr 1, 2001
UNEP WCMC
IUCN
KING'S College LONDON
University of London
Ujung Kulon National Park, Indonesia
© 2008 Europa Technologies
Image NASA
Image © 2008 DigitalGlobe
Image © 2008 TerraMetrics
5.78 km
6°50'43.87" S 105°26'33.96" E
elev 0 m
Jul 13, 2003
Eye alt 20.01 km
Google


World Database O
cted A
Apr 1, 2001
UNEP WCMC
IUCN
KING'S College LONDON
University of London
© 2008 Europa Technologies
Image NASA
Image © 2008 DigitalGlobe
Image © 2008 TerraMetrics
5.78 km
Google
6°47'37.52" S 105°16'07.54" E
elev 251 m
Jun 22, 2002
Eye alt 20.01 km


World Database On Protected A
Apr 1, 2001
UNEP WCMC
IUCN
KINGS College LONDON
University of London
Ujung Kulon National Park, Indonesia
© 2008 Europa Technologies
Image NASA
Image © 2008 DigitalGlobe
Image © 2008 TerraMetrics
5.68 km
6°42'32.19" S 105°20'39.89" E
elev 61 m
Eye alt 20.01 km
Google

Appendix 16 – data sheet, description and 20km photos used in encroachment analysis of Bogani Nani Wartabone national park

	BNWNP			
Photo No. (2km Scale)	NO	ENC	CLOUD	OTHER OBSCURE
1	2		2	
2	2		2	
3	2		0.3	
4	2			
5	2			
6	2			
7	2			
8	2			
9	2			
10	2			
11	2			
12	2			
13	2			
14	2			
15	2			
16	2			
17	2			
18	2			
19	2			
20	2			
21	2			
22	2			
23		2		
24		2		
25		2		
26		2		
27	0.8	1.2		
28	2			
29	2			
30	2			
31	1	1		
32	0.3	1.7		
33	1.8	0.2		
34	2			
35	1.3	0.7		
36	0.2	1.8		
37	1.4	0.6		
38	2			
39	2			
40	2		0.8	
41	2			
42	1.8	0.2		

43	2		1.4	
44	1	1		
45	0.8	1.2		
46	0	2		
47	0	2		
48	0.3	1.7		
49	0.3	1.7		
50	1.5	0.5		
51	0.3	1.7		
52		2		
53		2		
54		2		
55		2		
56		2		
57		2		
58		2		
59		2		
60		2		
61		2		
62		2		
63		2		
64		2		
65		2		
66	0.7	1.3		
67	1.5	0.5		
68	0.4	1.6		
69	0.2	1.8		
70	1.5	0.5		
71	2		0.4	
72	1	1		
73	1.5	0.5		
74	1.5	0.5		
75	2			
76	2			
77	2			
78	2			
79	2			
80		2		
81		2		
82		2		
83	2			
84	2			
85	2			
86	2		0.5	
87	2		1.2	
88	2		1.6	
89	1.7	0.3		
90	1.5	0.5		

91	1		0.7	
92		2		
93		2		
94	0.5	1.5		
95	1.9	0.1		
96	0.7	1.3		
97	0.2	1.8		
98		2		
99	0.4	1.6		
100		2		2
101	2			
102	2			
103	2			
104	2			
105	2			
106	1.7	0.3	1	
107	0.9	1.1		
108		2		
109	0.8	1.2		
110	1.7	0.3		
111	2		0.7	
112	1.5	0.5		
113	1.5	0.5		
114	1.8	0.2	1.6	
115	2			
116	2		1.6	
117	2		0.3	
118	2			
119	2			
120	2			
121	2			0.6
122	2			
123	2		0.4	
124	2			
125	2			
126	2			
127	2			
128	2			
129	2			
130	2			
131	2			
132	2			
133	0.8	1.2		
134		2		
135		2		
136		2		
137		2		
138		2		

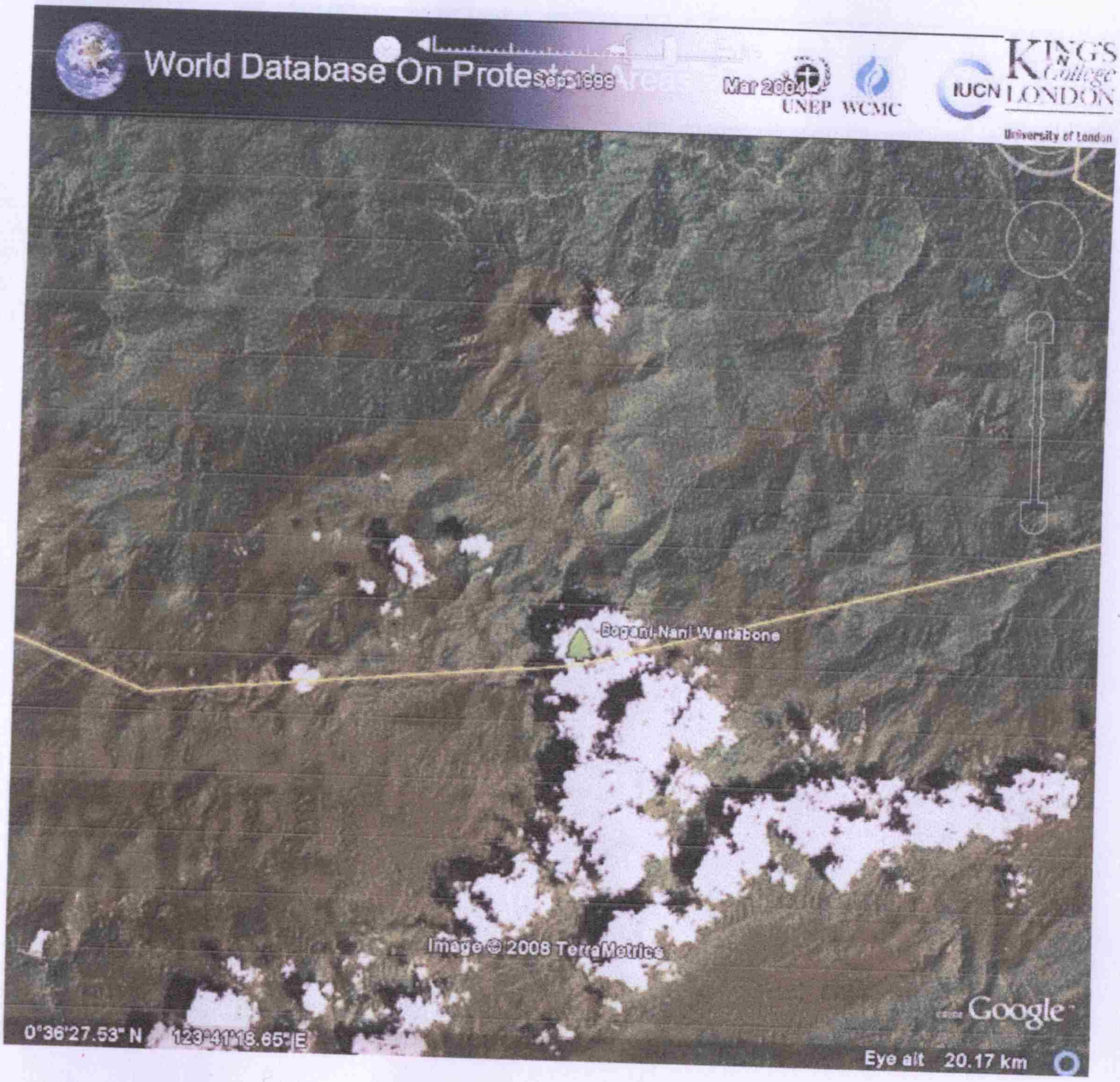
139		2		
140	1	1		
141	1.7	0.3		
142	2		0.3	
143	0.4	1.6		
144	2			
145	2			
146	1.7	0.3		
147	1.8	0.2		
148		2		
149		2		
150		2		
151		2		
152	1.1	0.9		
153	2			
154	2			
155	2			
156	1.8	0.2		
157	2			
158	0.6	1.4		
159	0.3	1.7		
160	1.5	0.5		
161		2		
162	1.7	0.3		
163	2			
164	2			
165	1.9	0.1		
166	2			
167	2			
168	2			
169	2			
170	2			
171	2			
172	1.9	0.1		
173	2			
174	2			
175	2			
176	2			
177	2			
178	2			
179	2			
180	2			
181	2			
182	2			
183	2			
184	2			
185	2			
186	2			

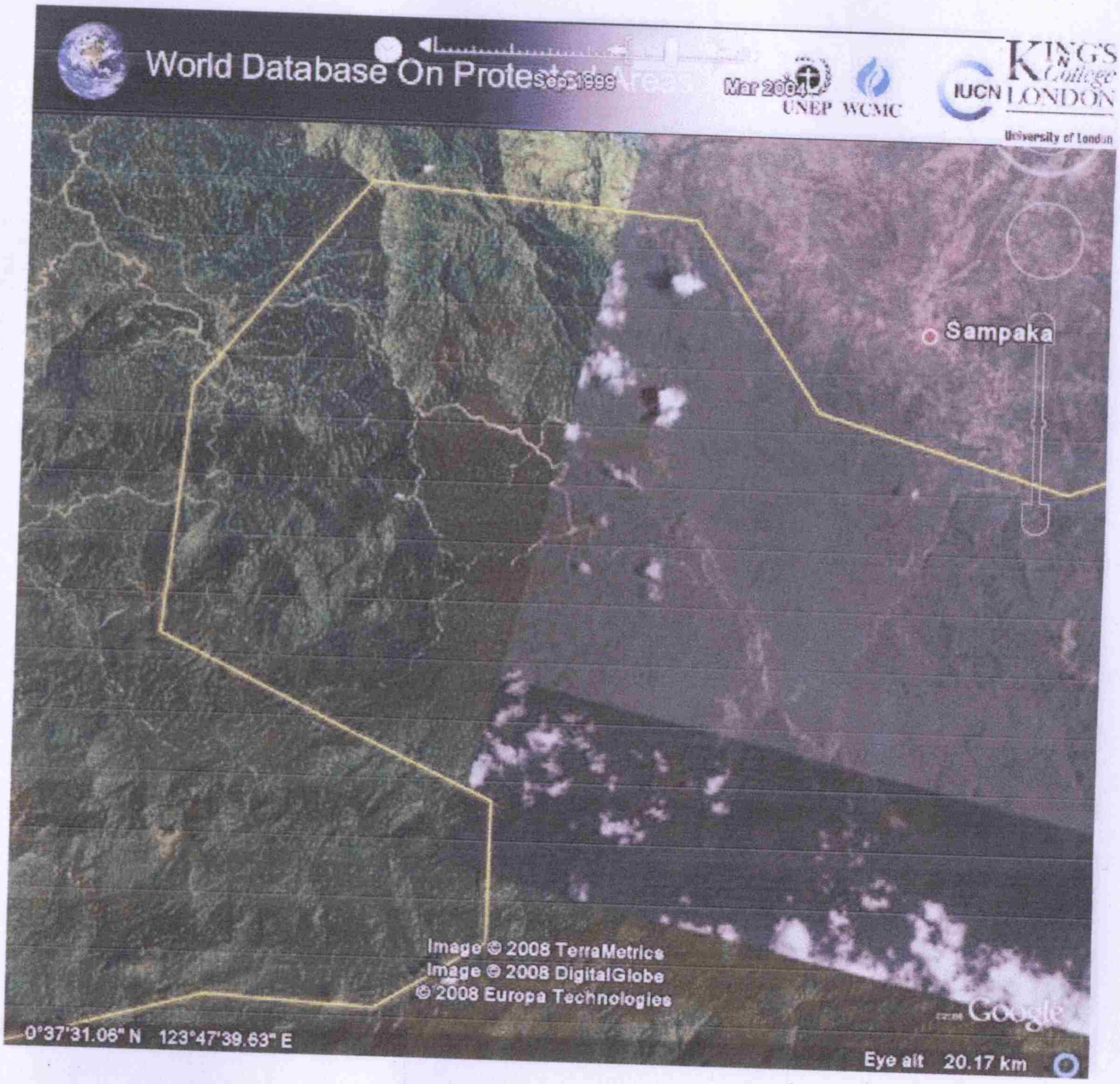
187	2			
188	2			
subtotal	253.1	121.9	16.8	2.6
TOTAL	375		Combined obscurity	19.4

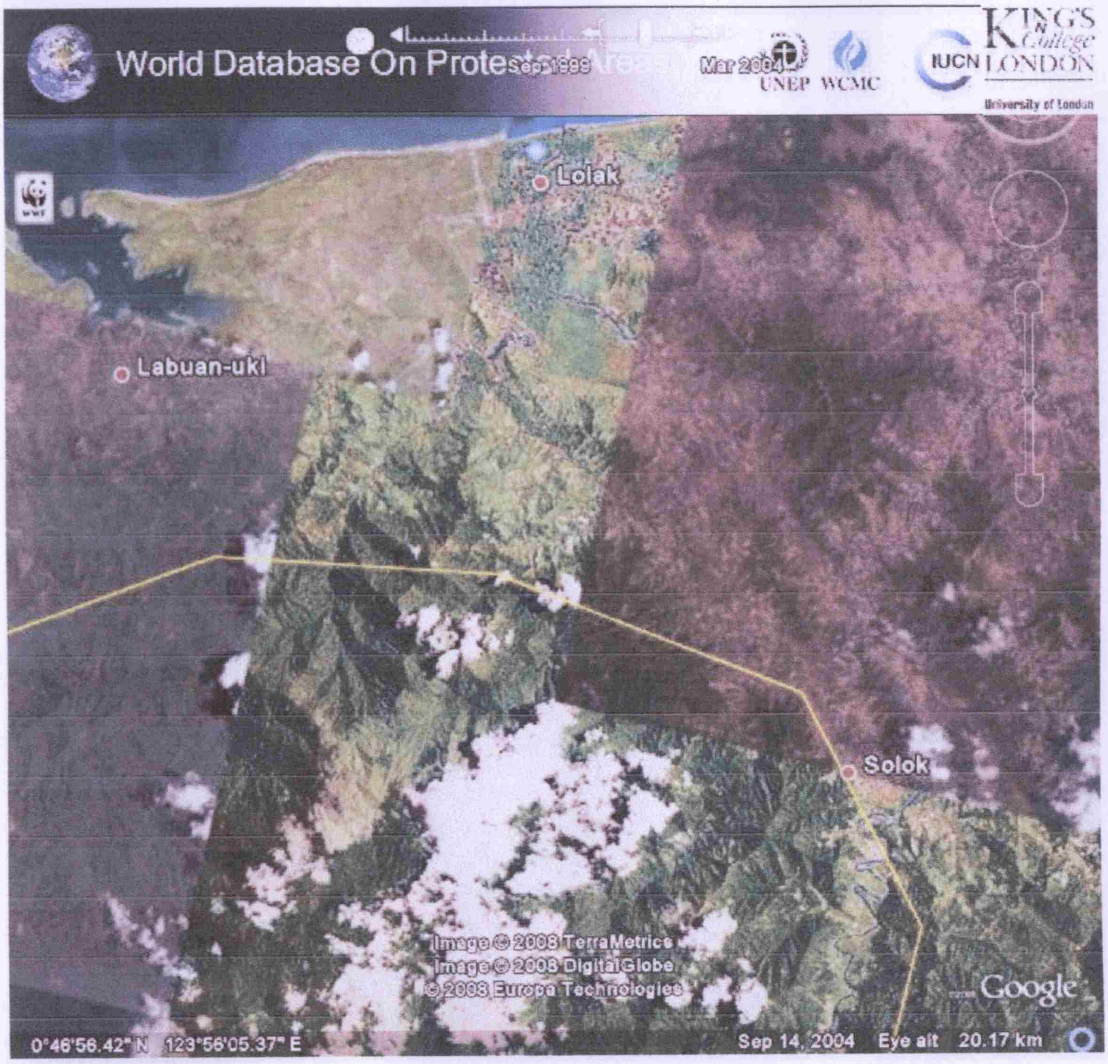
Description

This analysis begins in the centre of the northern boundary where the national park label is, and travels east and around the park. There is a little cloud cover but generally it is clear that this area hasn't been encroached upon. This continues around a bend, which turns north, west and then north. Up this northern boundary there are some white winding patterns, which are considered to be tracks. The imagery improves significantly as the boundary heads west, and shows far more encroachments than can be detected with the lower resolution imagery. This increase in encroachments is also probably due to the proximity of the settlements of Sampaka and Labuan-uki to the northern boundary. Even at 2km scale with high resolution imagery, it is difficult to distinguish small plantations from the forest. In the north east corner there is much encroachment, in particular along a river and near to the settlement of Solok. There is slightly less encroachment to the south, but then encroachment increases substantially as the boundary curves to the west. There appears to be urban and rural sprawl here, associated with the settlements of Pusian, Kinolontagan and Dumoga-ketjil. As the boundary heads to the east encroachment lessens. The south east corner shows significant encroachment again, due to proximity to an unidentified settlement. The boundary heads west, and has interspersed roads and what are probably clearings, although the imagery isn't good enough to confirm this. Further along the southern boundary there are clear encroachments, which is probably due to the park's proximity to the more highly populated coast, and proximity to the settlement of Salongo. There is a river along this coast with clearances in parts, although it is not clear whether these are sand banks and flood plains or encroachments, but given that there is little evidence of encroachment, it is assumed that they're natural. Where the eastern end of the southern boundary is close to the coast encroachment increases, whilst rural sprawl extends deeper around the settlement of Taludaa. Up the western boundary, the settlement of Tulabolo is within the national park, and is surrounded by rural infrastructure. There are also settlements of Taloemopatoe and Lembongo with associated rural development that encroaches on the western boundary. On the northern boundary is the settlement of Toemba, which is within BNWNP but doesn't appear to cause any encroachment. Because of this, it has probably been labelled in the wrong place. The northern boundary to the starting point is without encroachment.

The Photos in this appendix are sourced from: Photos taken by author, base image from Google Earth (2008), overlaid with data from Google Earth (2008a) "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")


World Database On Protected Areas
Mar 2004
UNEP WCMC
IUCN
KING'S College LONDON
University of London
Bogani Nani Wartabone
Image © 2008 TerraMetrics
Google
0°36'27.53" N 123°41'18.65" E
Eye alt 20.17 km


World Database On Protected Areas
Sep 1999
Mar 2004
UNEP WCMC
IUCN
KING'S College LONDON
University of London
Sampaka
Image © 2008 TerraMetrics
Image © 2008 DigitalGlobe
© 2008 Europa Technologies
Google
0°37'31.06" N 123°47'39.63" E
Eye alt 20.17 km


World Database On Protected Areas
Sep 1999
Mar 2004
UNEP WCMC
IUCN
KING'S College LONDON
University of London
WWF
Lolak
Labuan-uki
Solok
Image © 2008 TerraMetrics
Image © 2008 DigitalGlobe
© 2008 Europa Technologies
Google
0°46'56.42" N 123°56'05.37" E
Sep 14, 2004 Eye alt 20.17 km

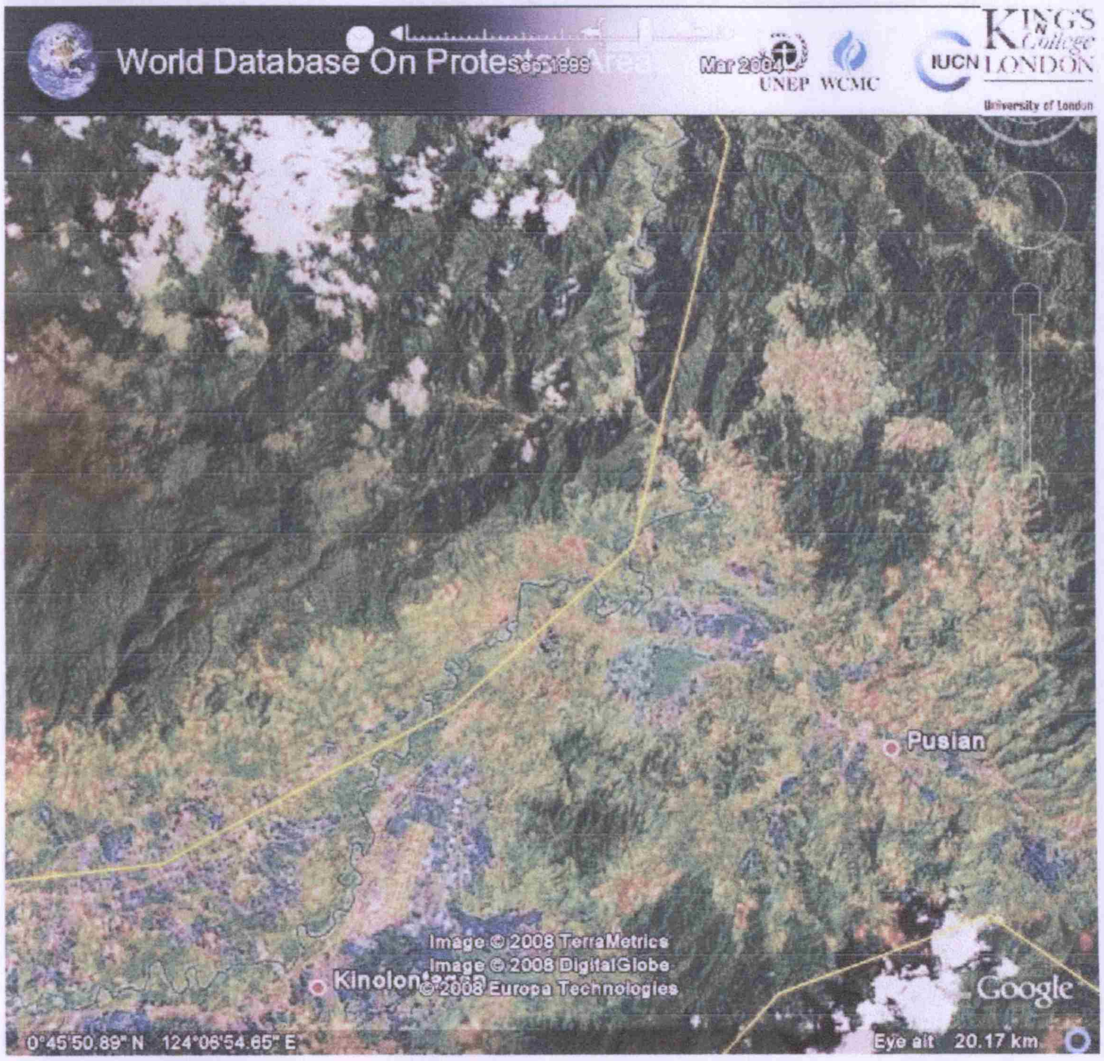

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Image © 2008 DigitalGlobe
© 2008 Europa Technologies
Google
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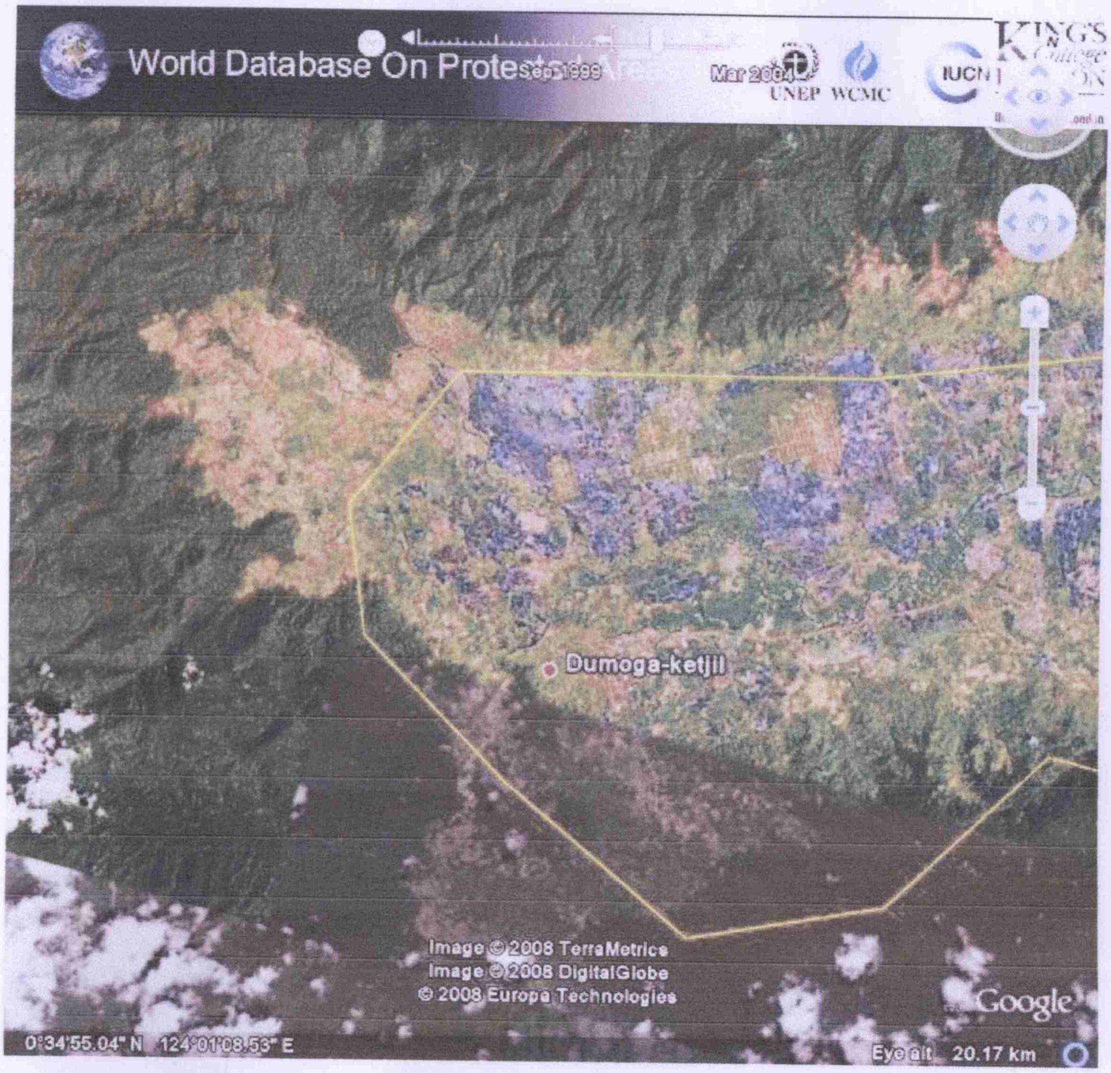

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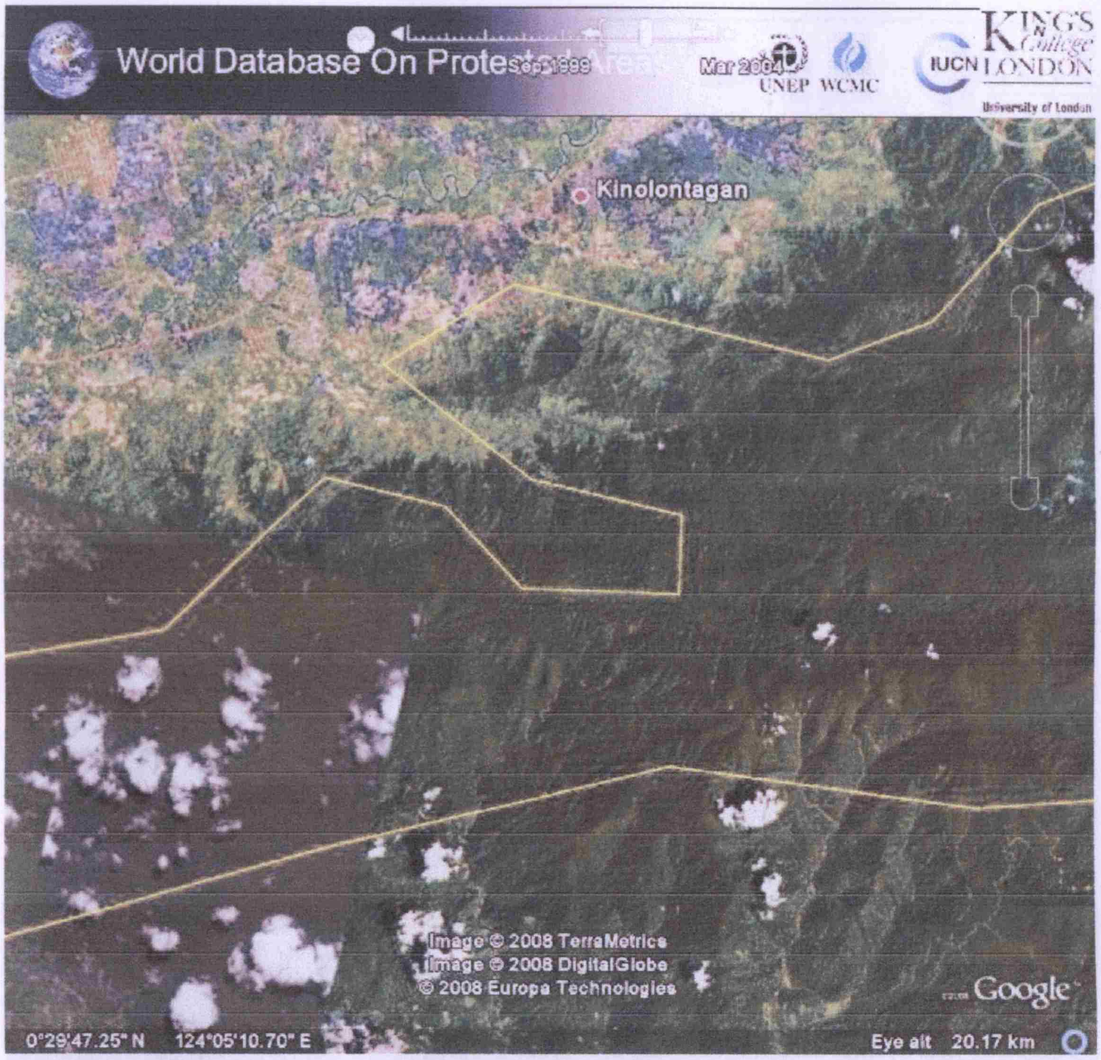
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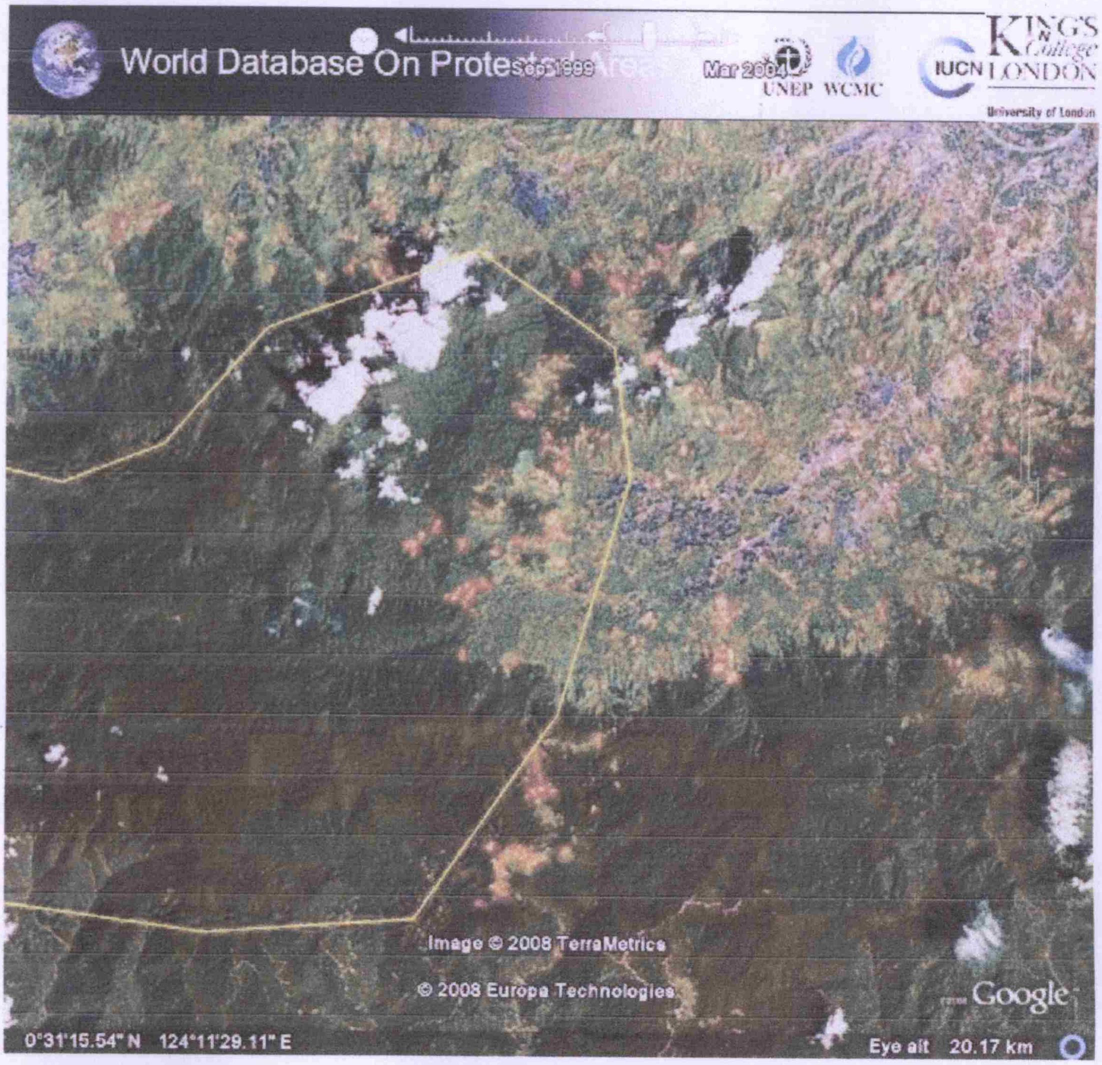
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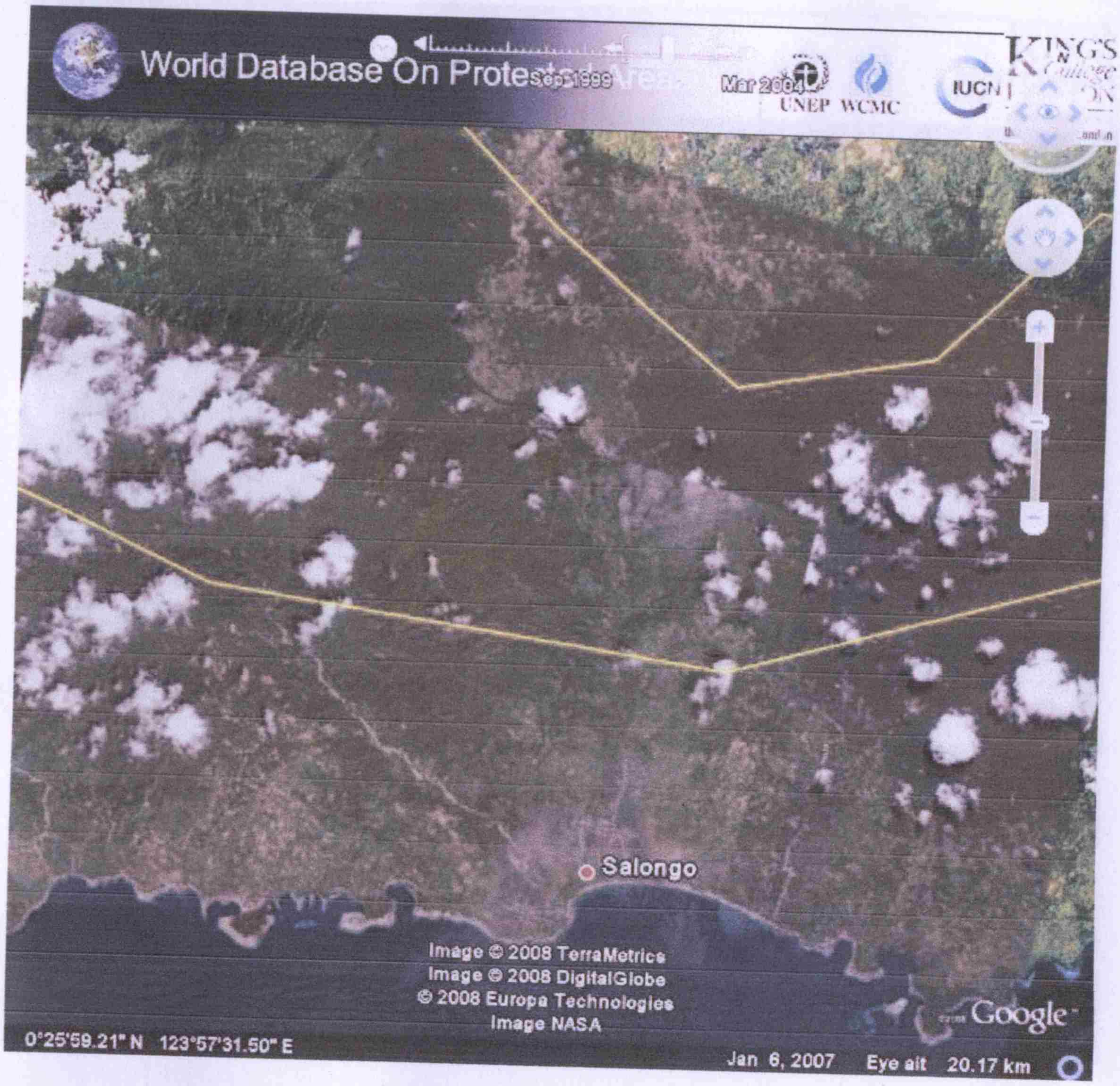
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Image NASA
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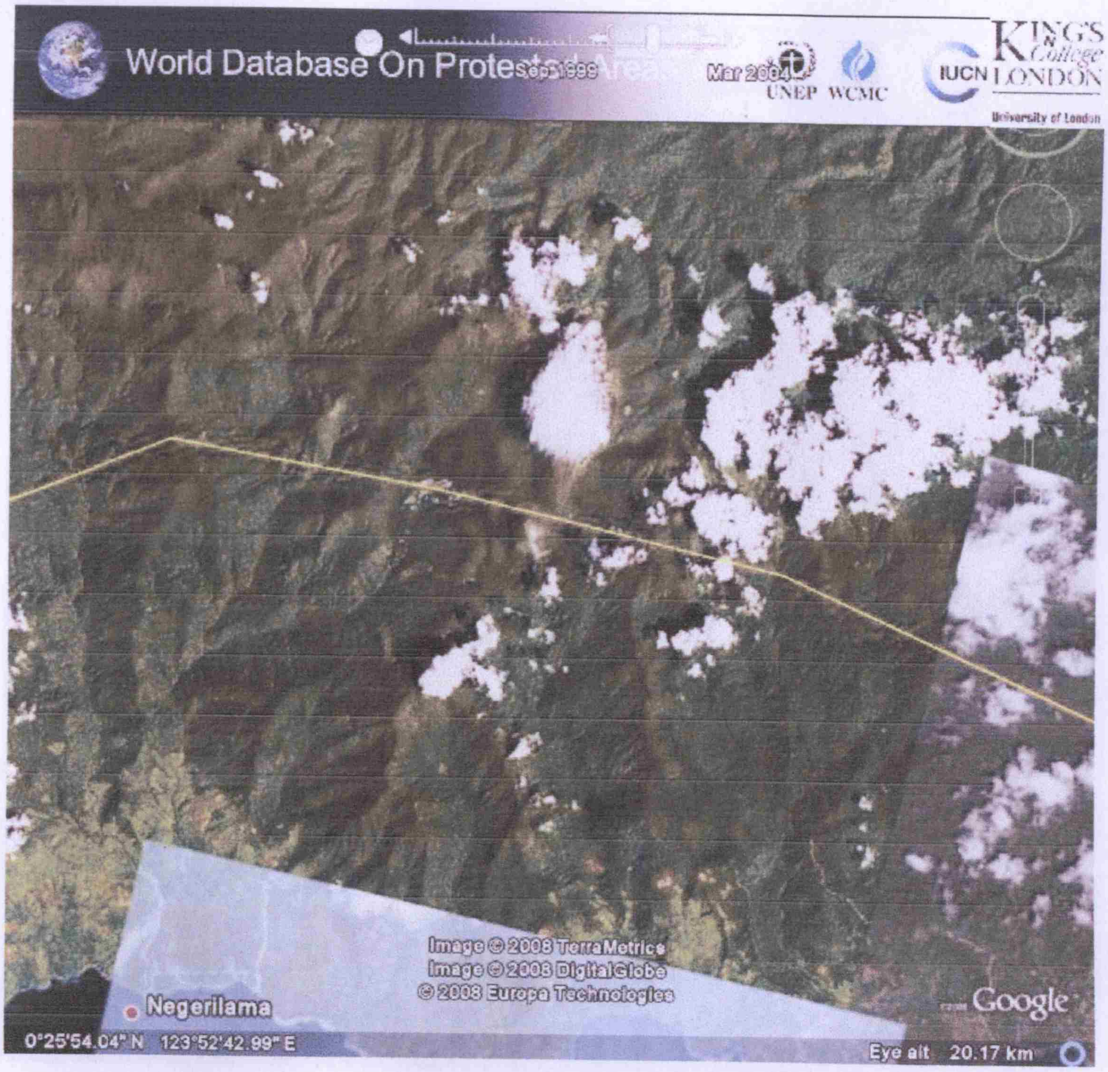
Jan 6, 2007 Eye alt 20.17 km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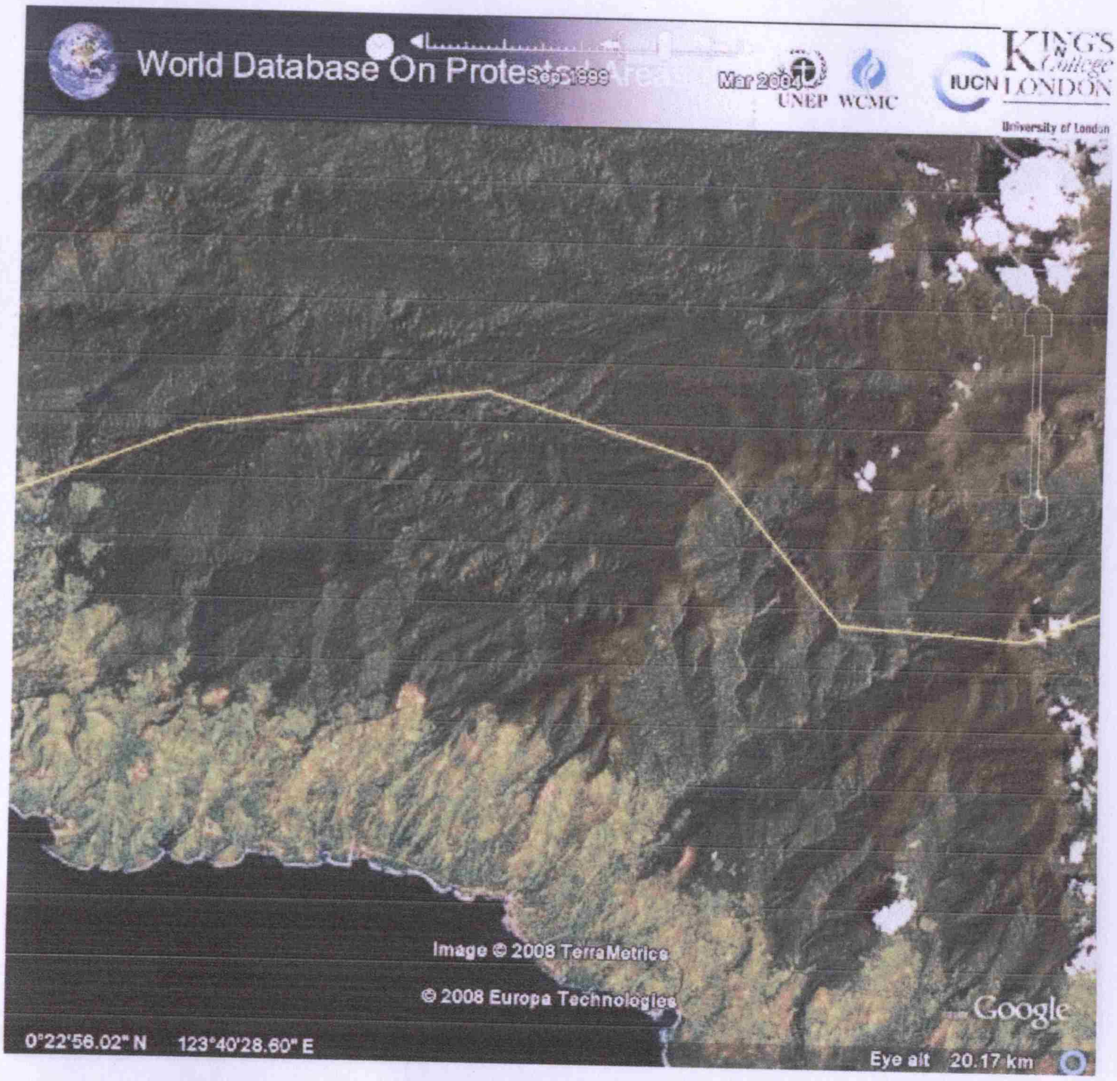
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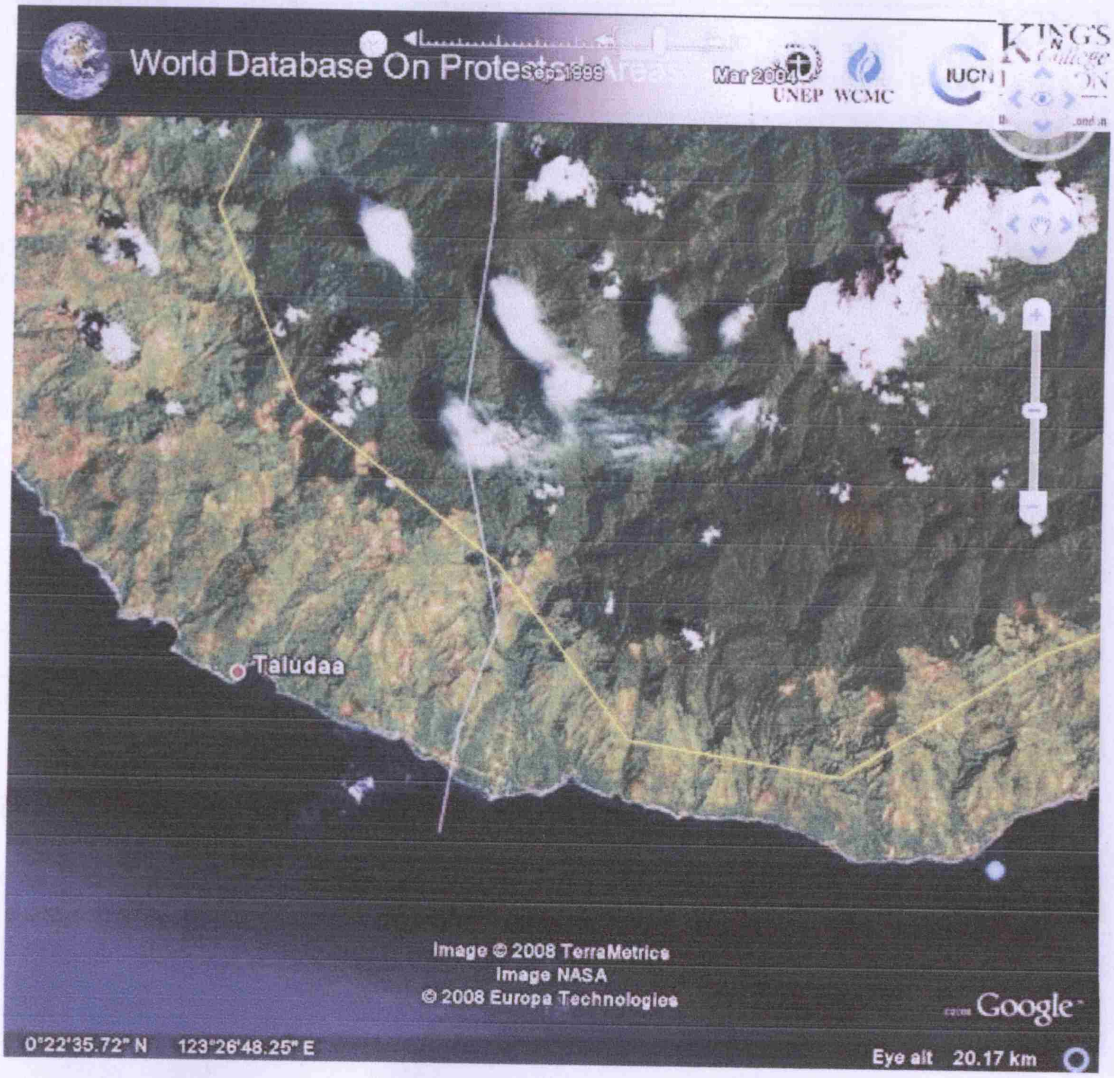
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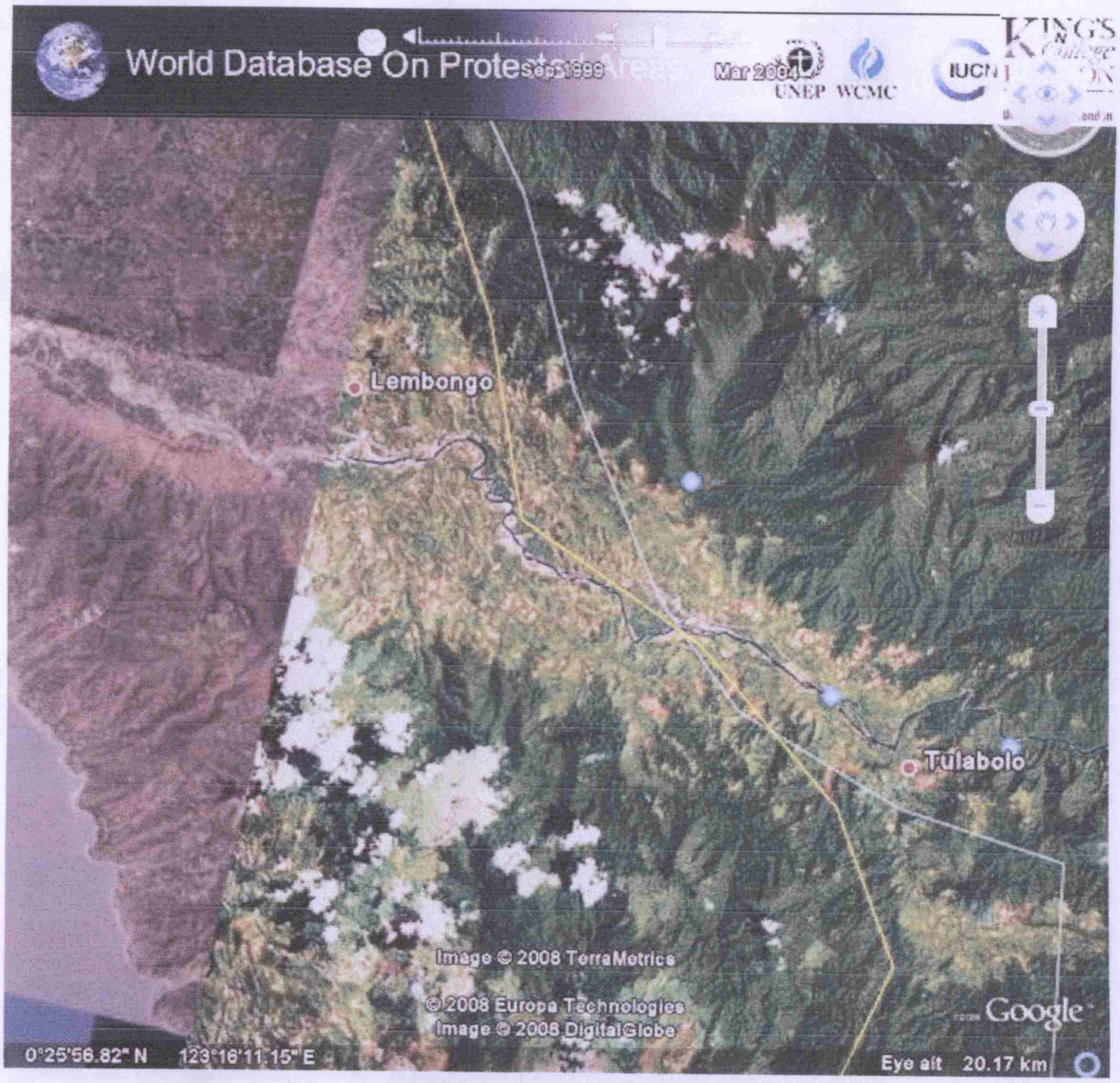
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Image © 2008 TerraMetrics
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Image © 2008 DigitalGlobe
Google
0°25'56.82" N
123°16'11.15" E
Eye alt 20.17 km


World Database On Protected Areas
Sep 1999
Mar 2004
UNEP WCMC
IUCN
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Image © 2008 DigitalGlobe
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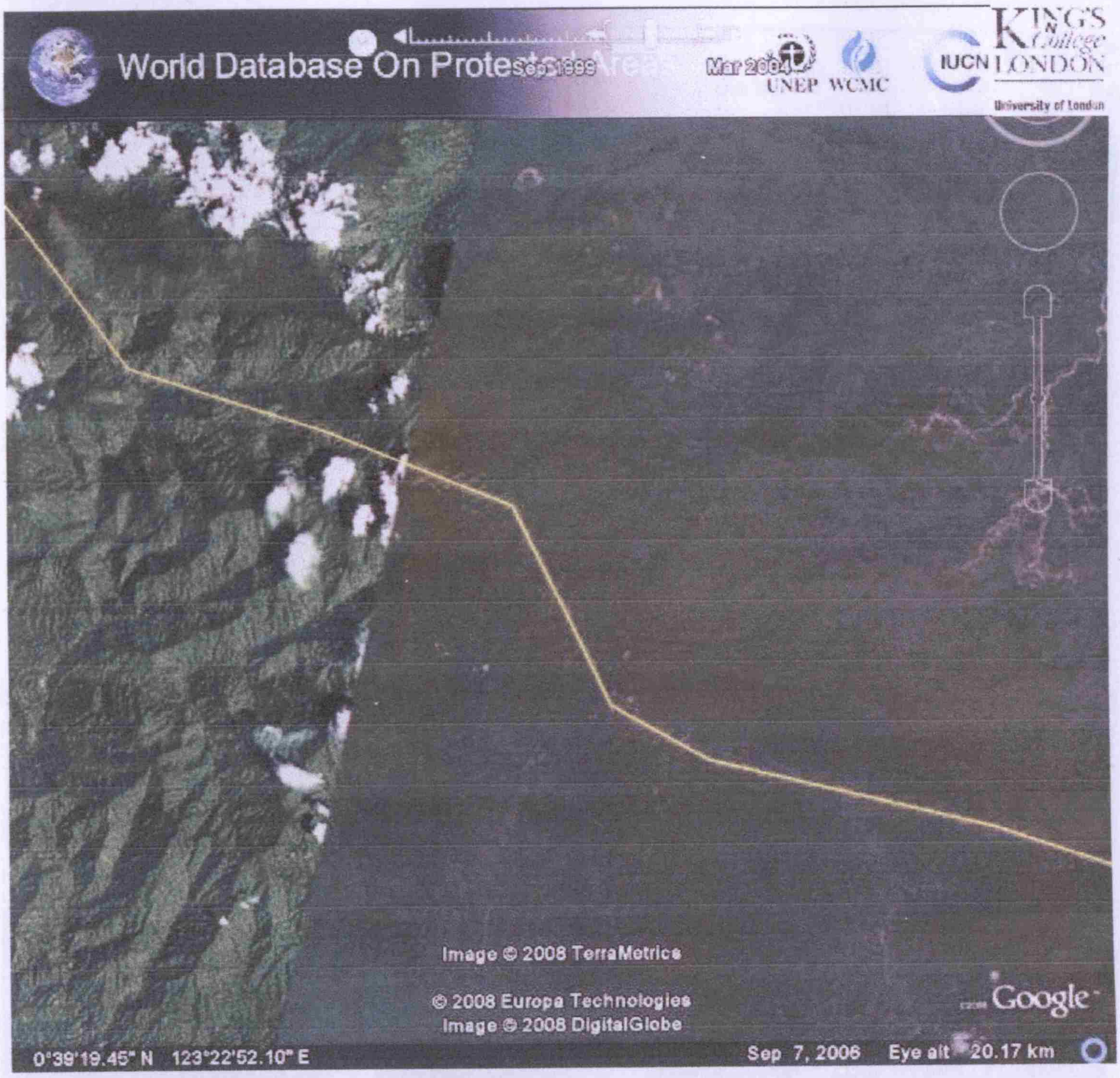
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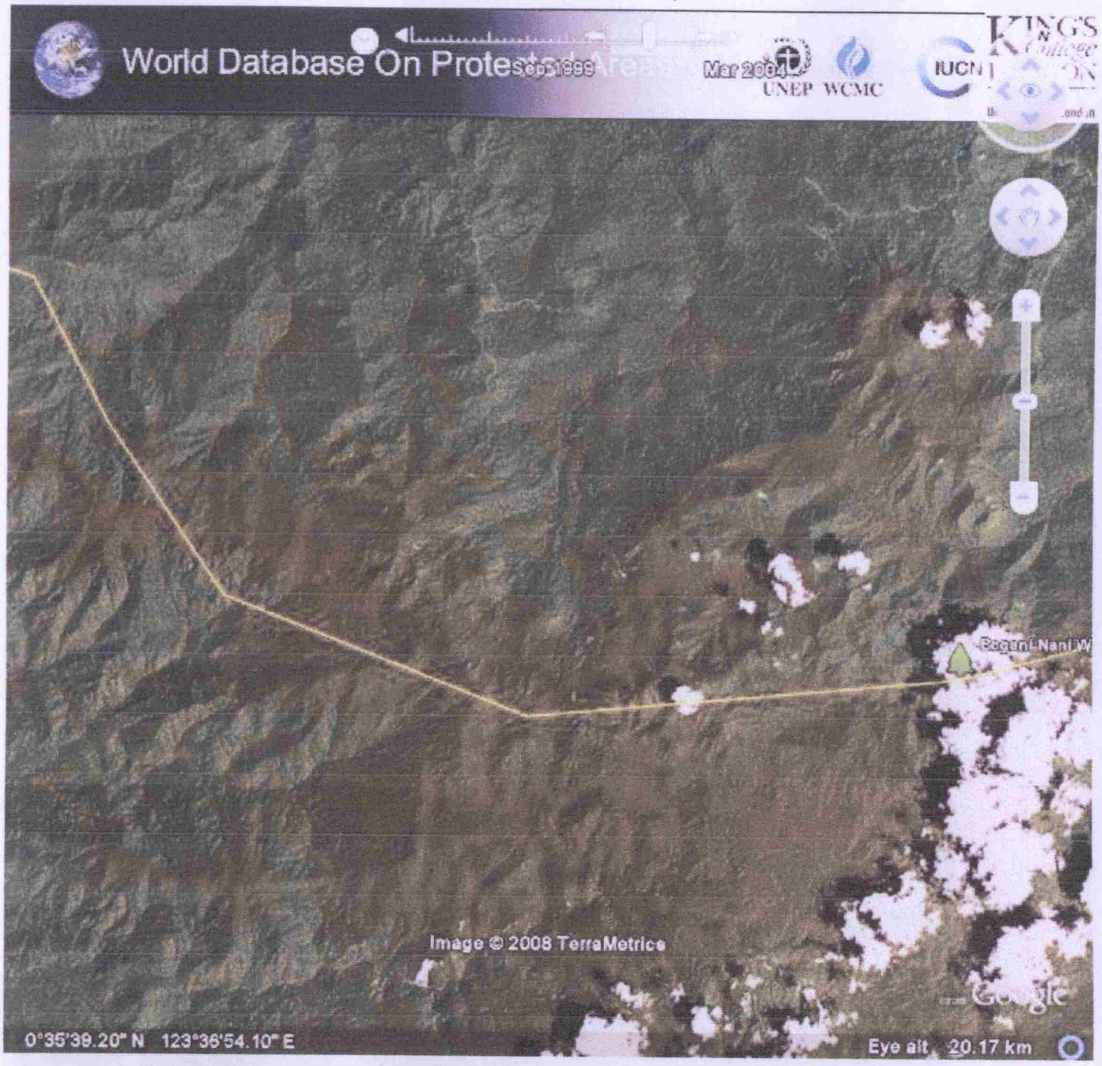

World Database On Protected Areas
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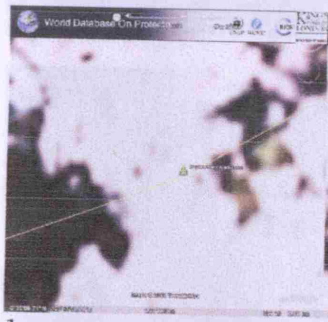
UNEP WCMC
IUCN
Image © 2008 TerraMetrics
Google
0°35'39.20" N 123°36'54.10" E
Eye alt 20.17 km

Appendix 17 – 2km photos of case study national parks' boundaries

The Photos in this appendix are sourced from: Photos taken by author, base image from Google Earth (2008), overlaid with data from Google Earth (2008a) "UNEP-WCMC bears no responsibility for the integrity or accuracy of the data contained herein")

- *Please note that these images have been scaled down for convenience, but were viewed at larger scales*
- *The number beneath the photos represent the numbers in the data sheets in Appendix 14, 15 and 16.*

17.1 - Bogani Nani Wartabone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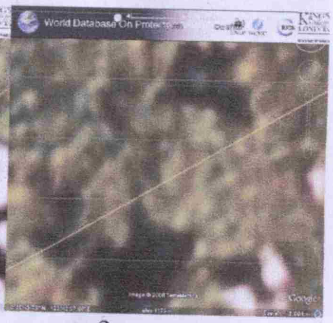
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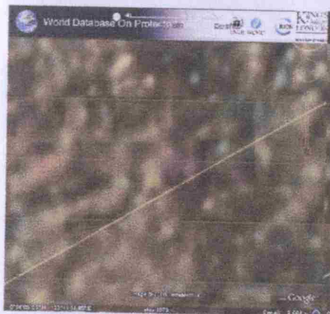
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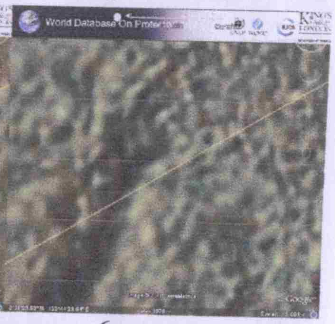
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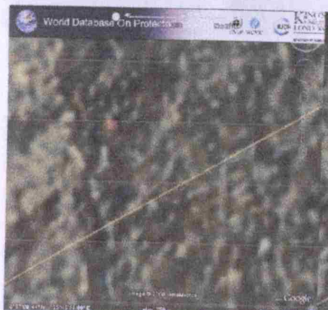
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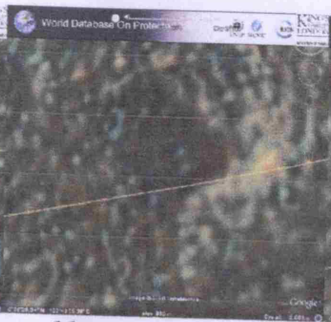

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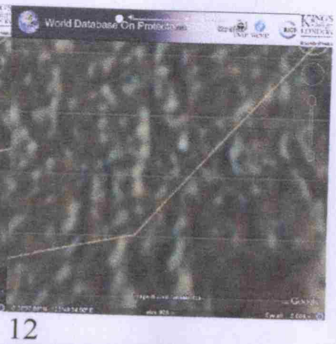

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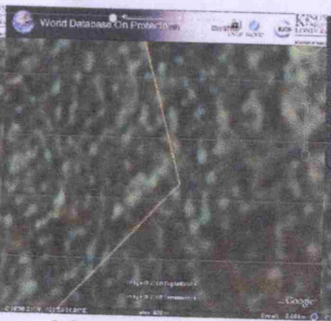

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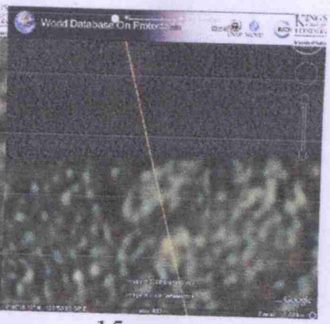

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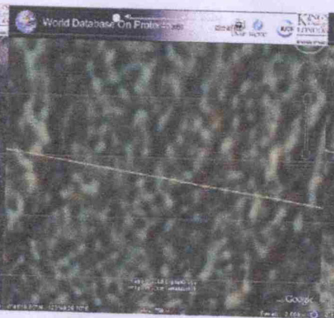

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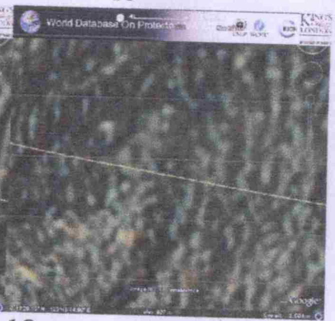

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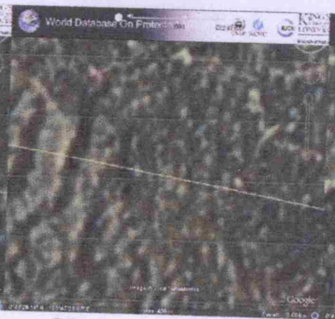

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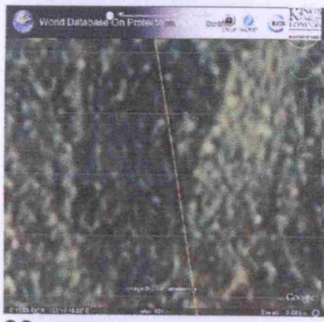

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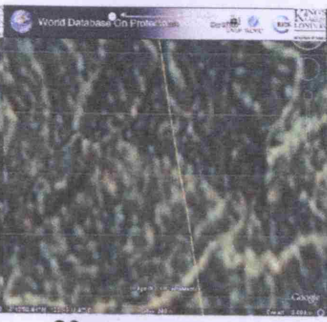

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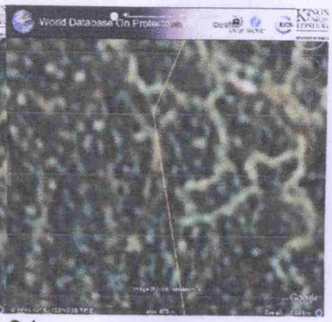

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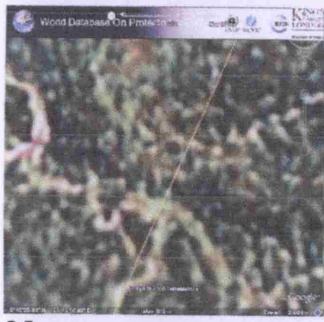

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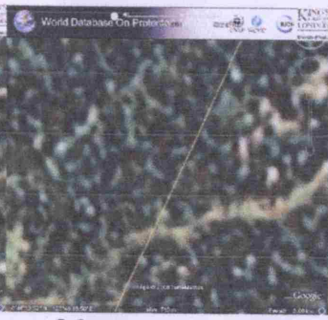

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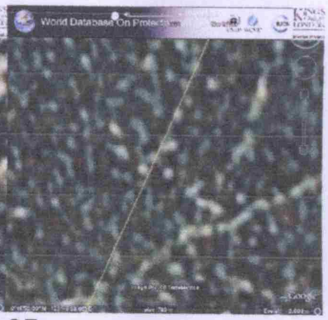

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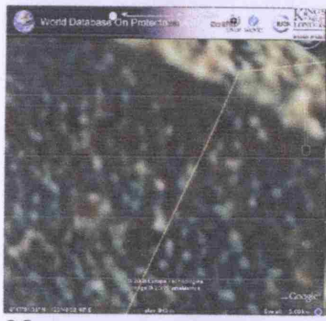

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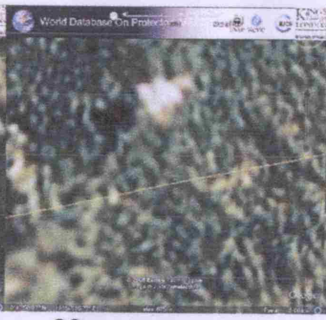

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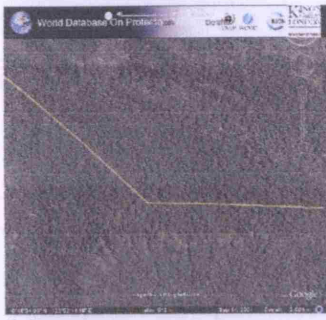

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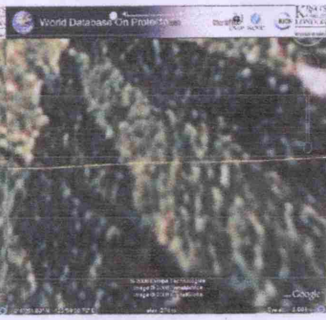

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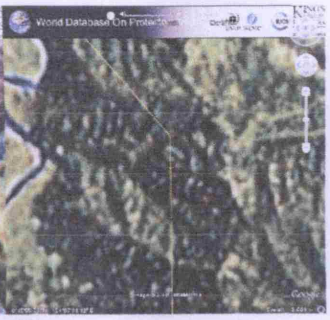
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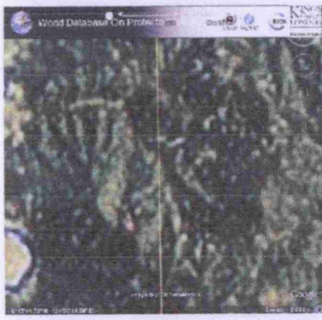
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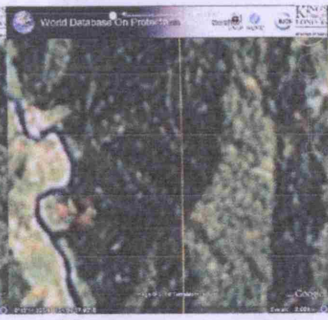
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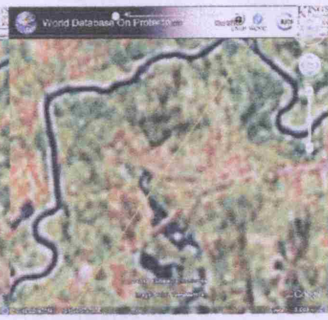
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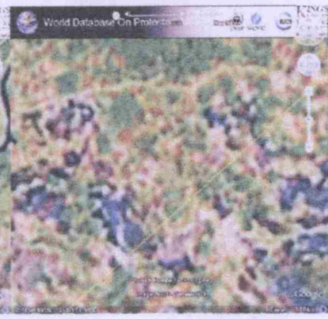
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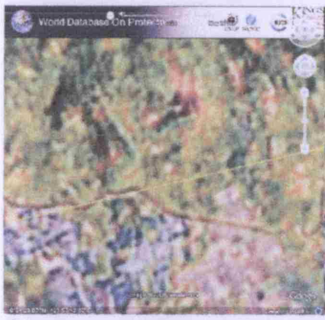
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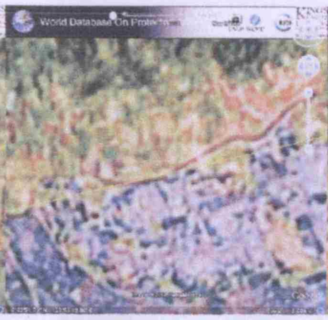
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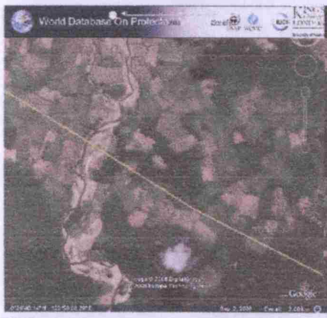
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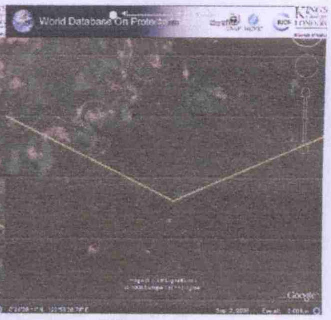
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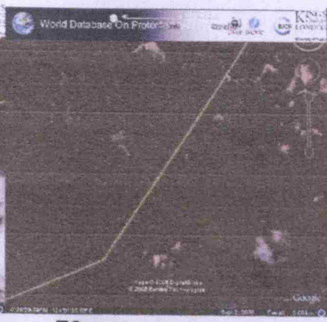
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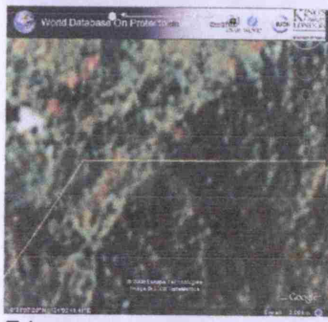
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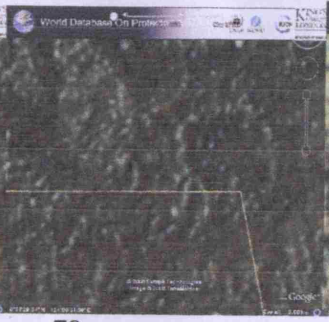
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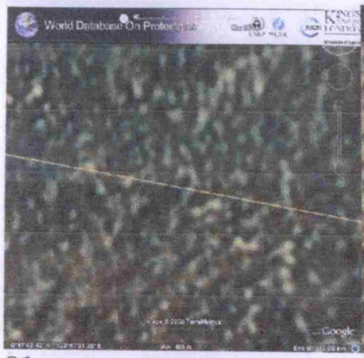
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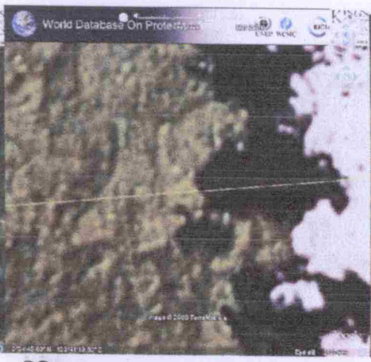
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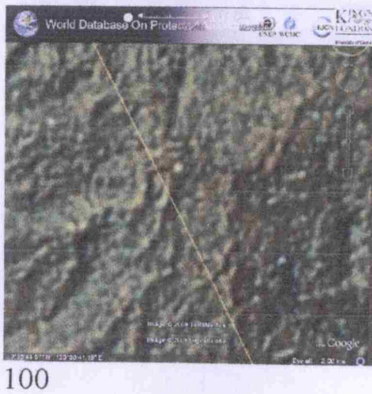
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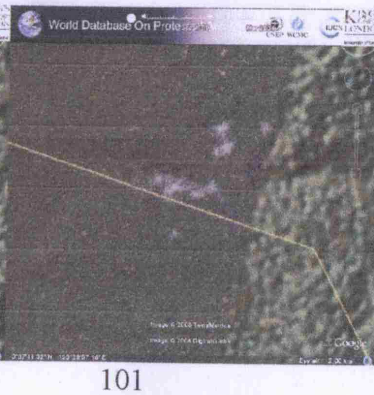
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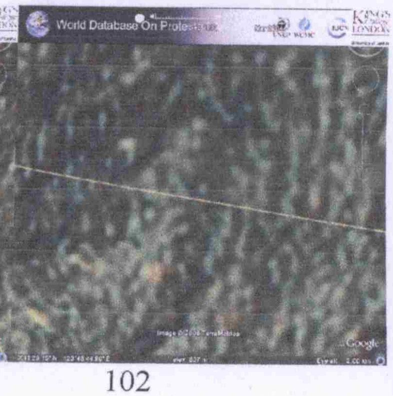
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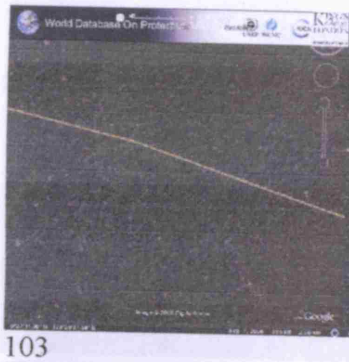
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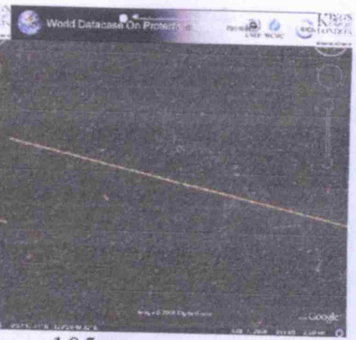
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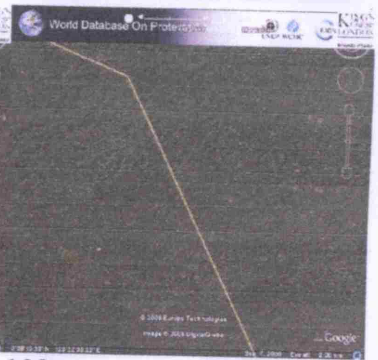
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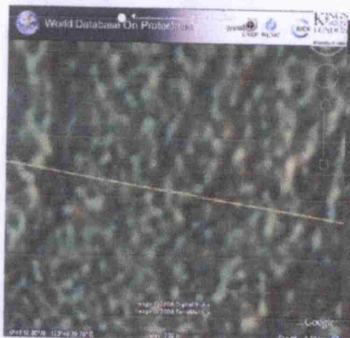
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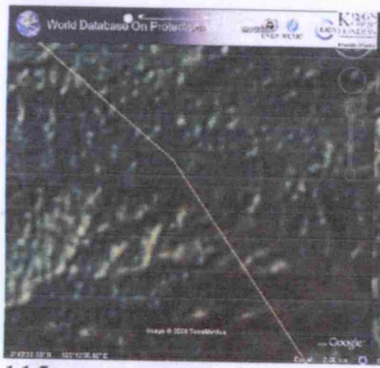
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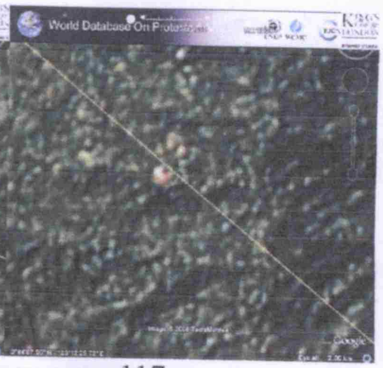
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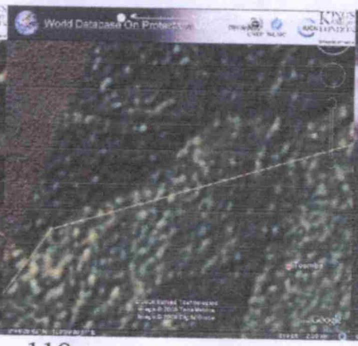
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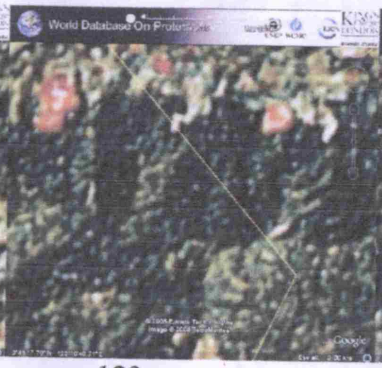
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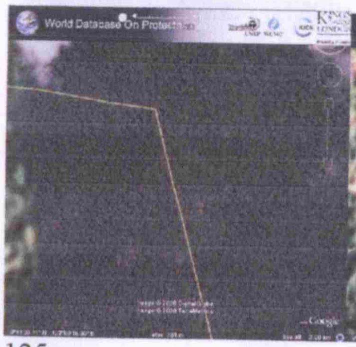
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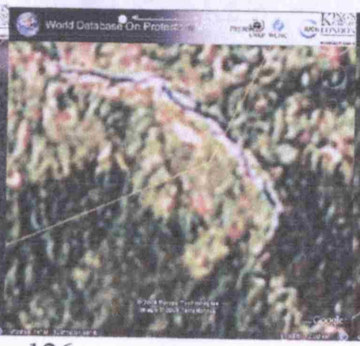
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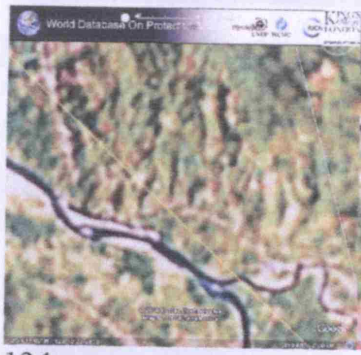

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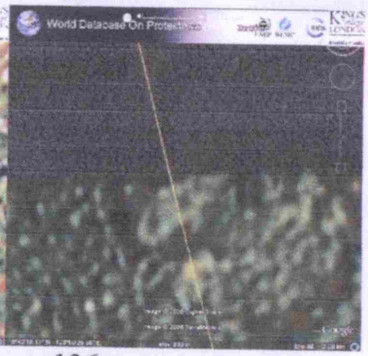

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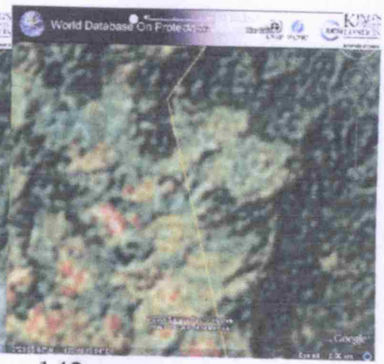
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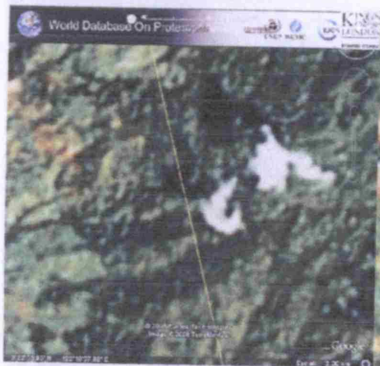
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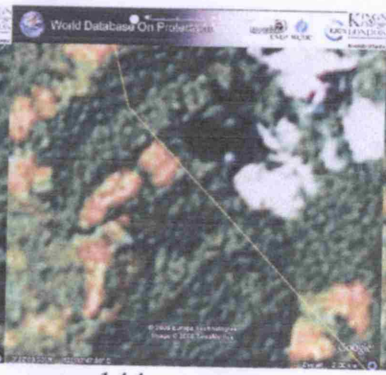
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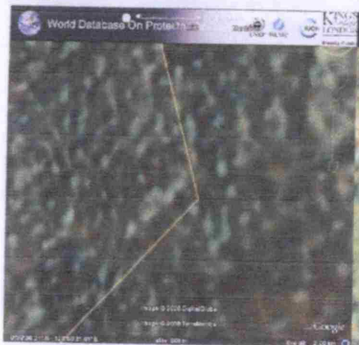
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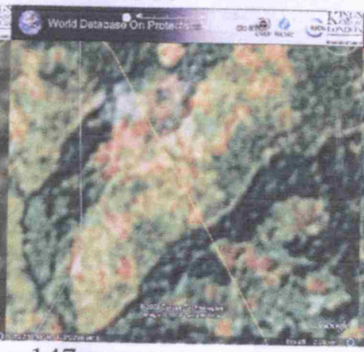
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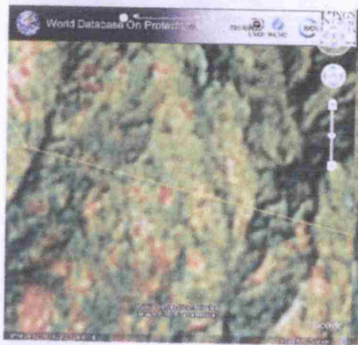
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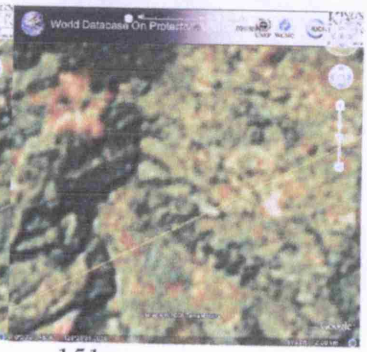
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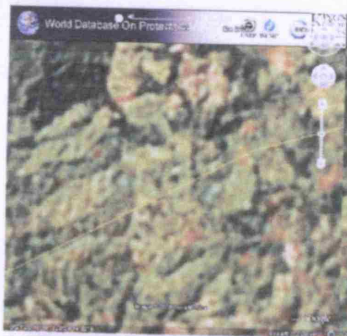
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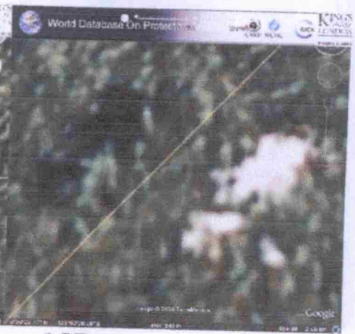
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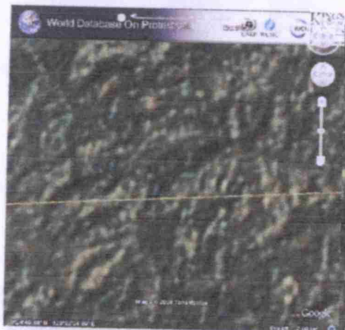
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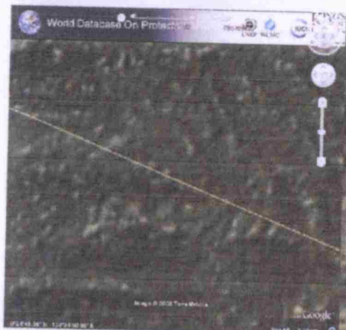
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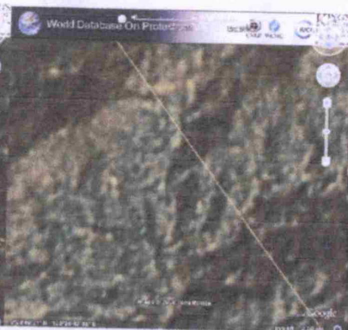
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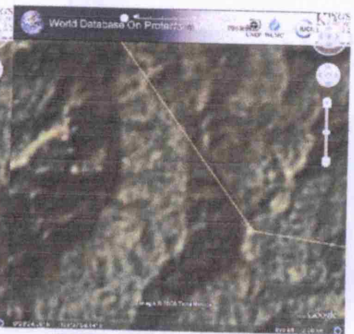
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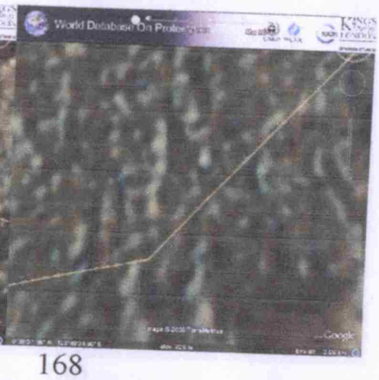
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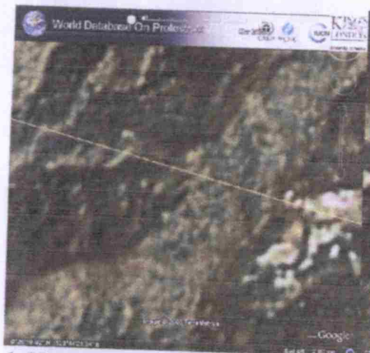
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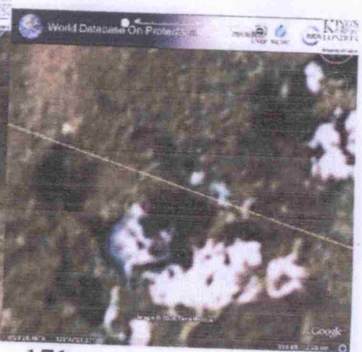
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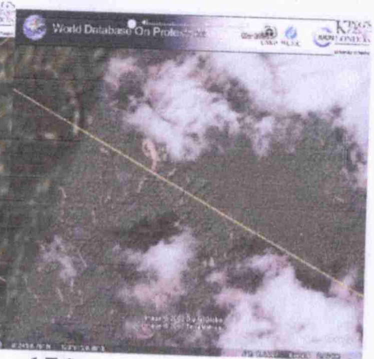
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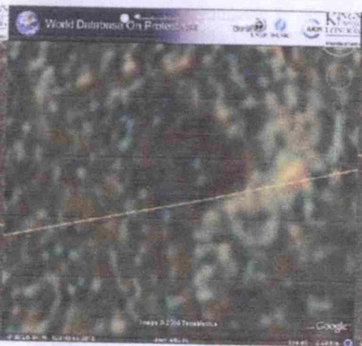

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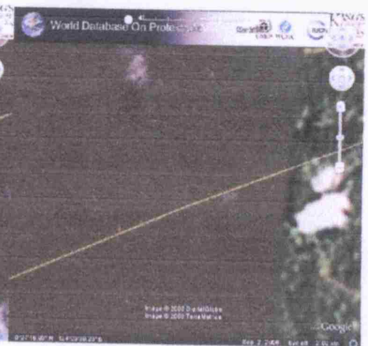

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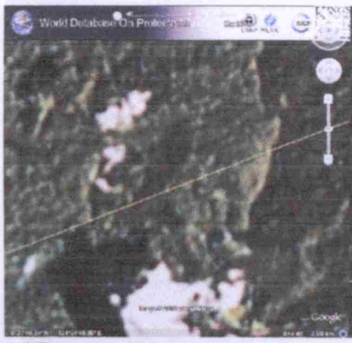
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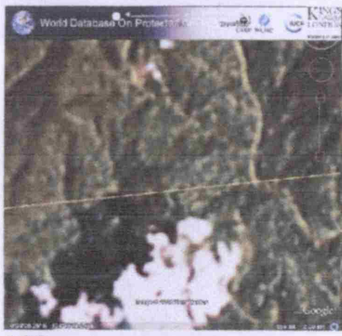
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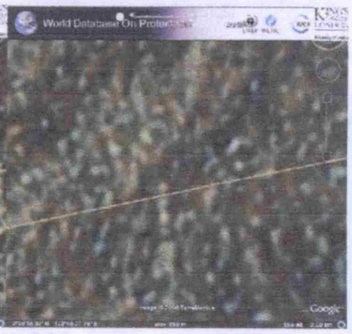
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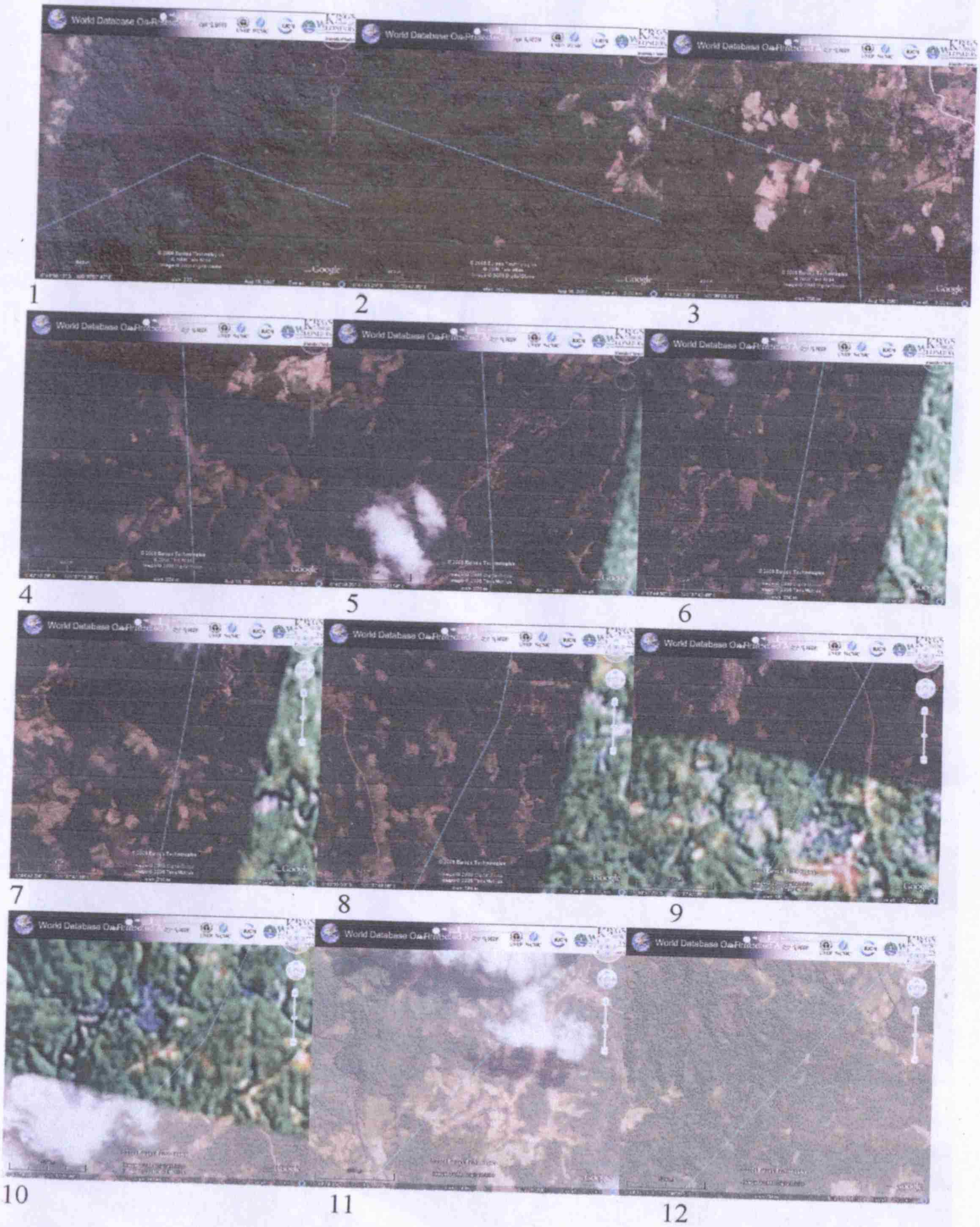

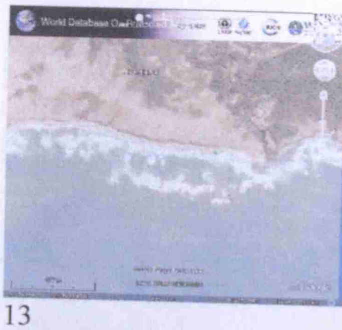
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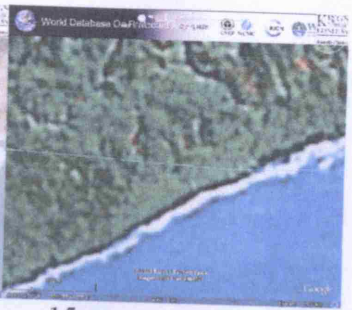
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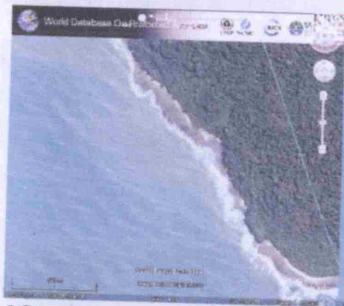
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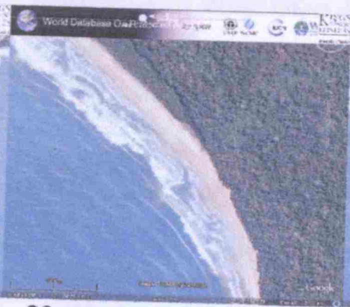
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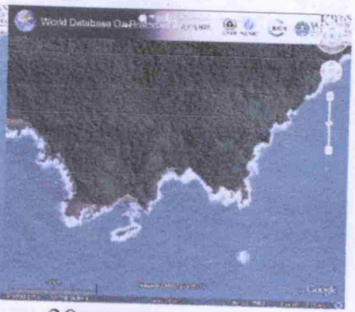

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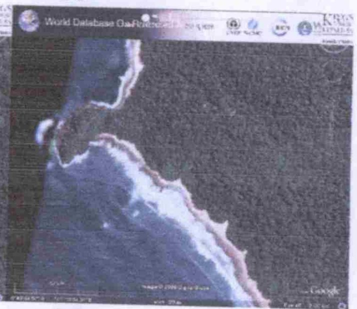

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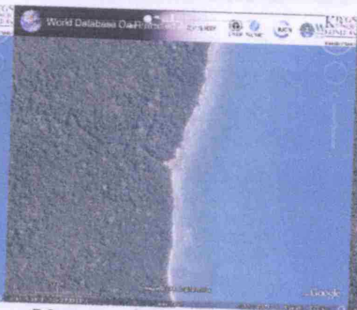
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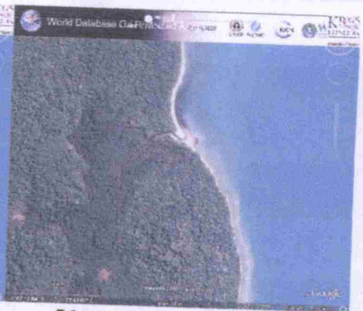
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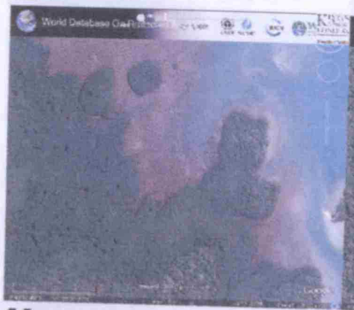
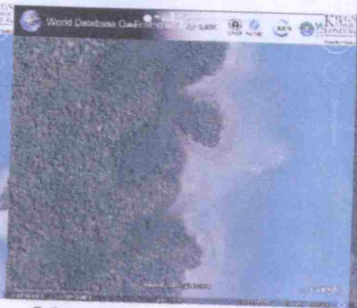


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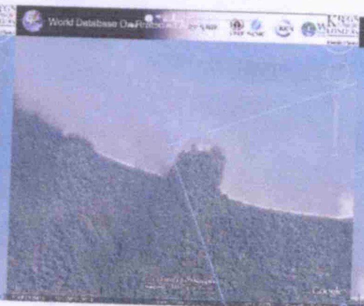
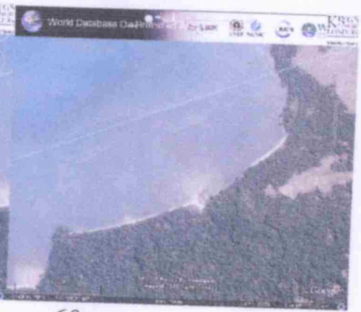

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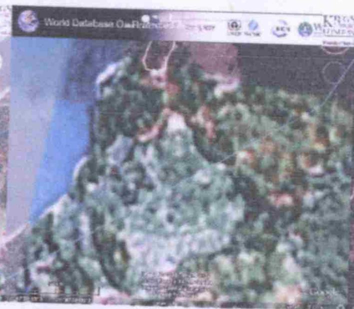
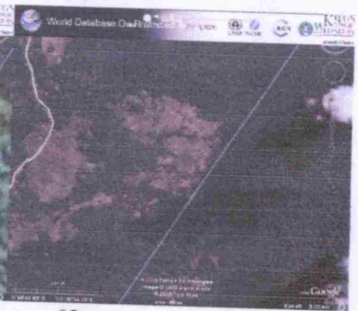

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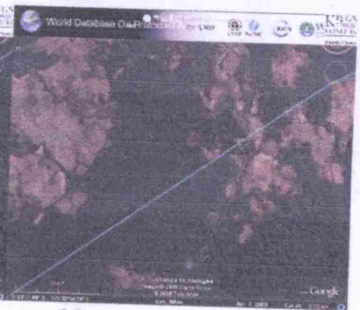

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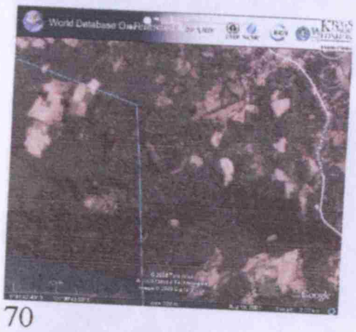
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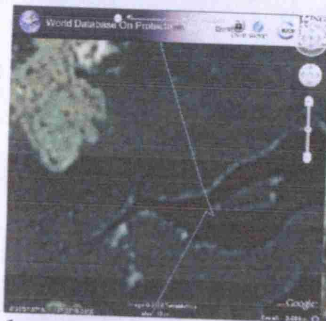

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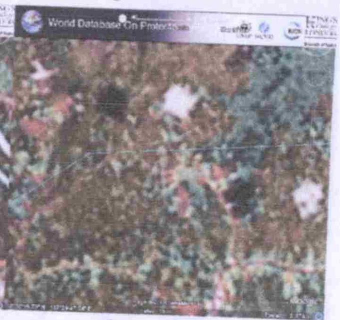

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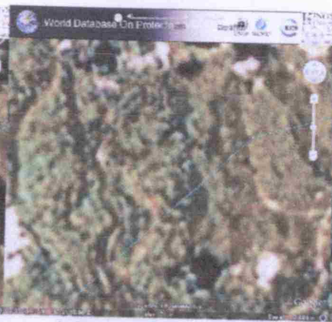

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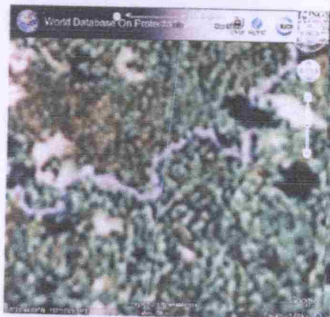

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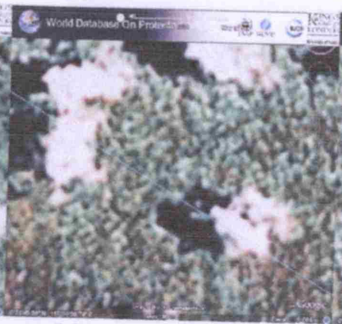
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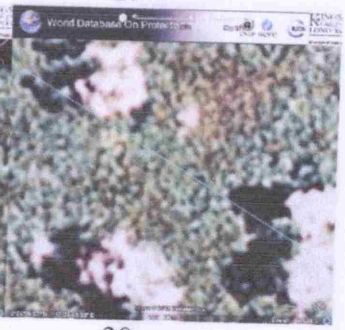
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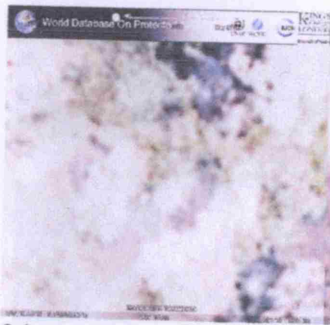
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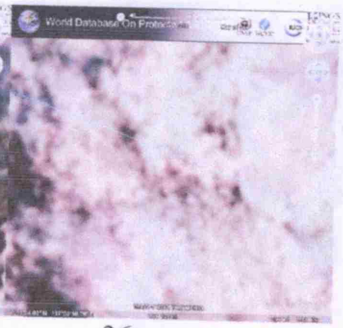
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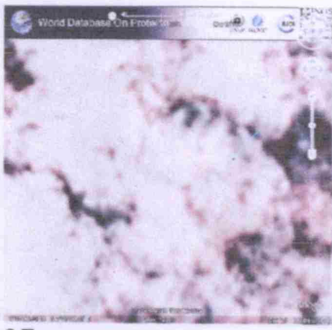
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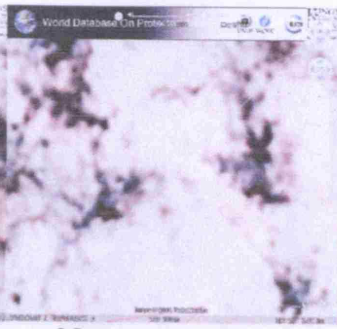
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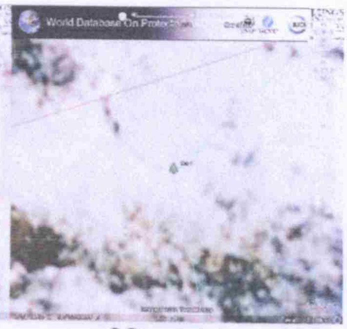
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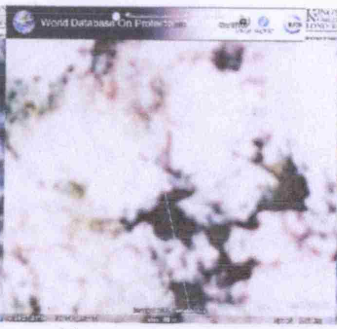
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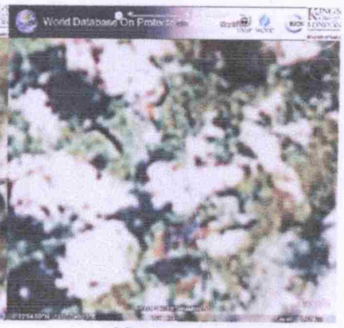
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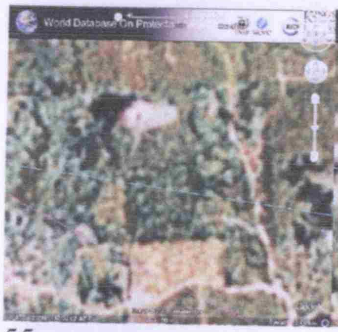
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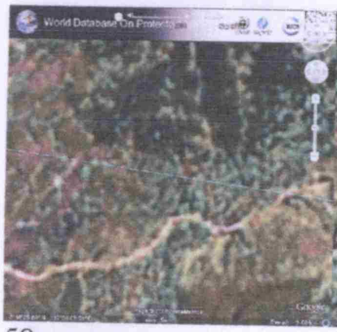
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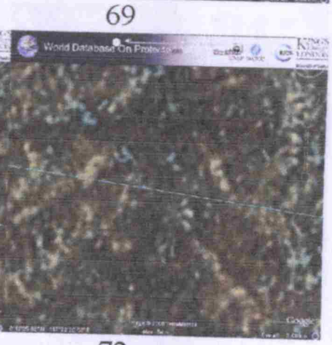
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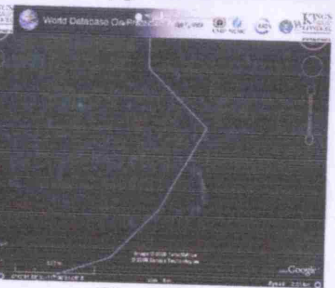
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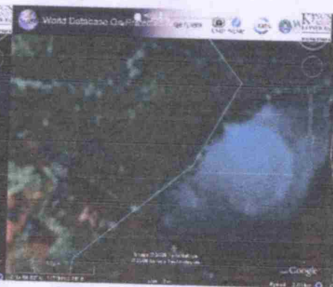
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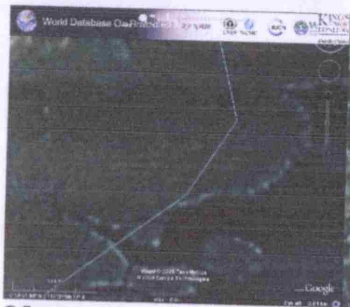
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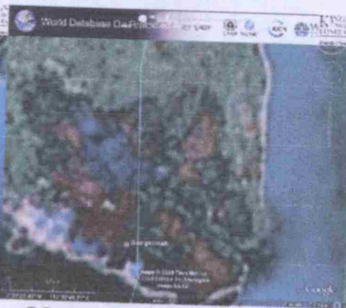
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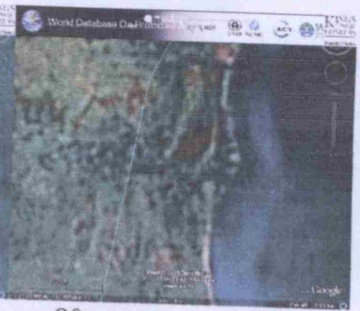
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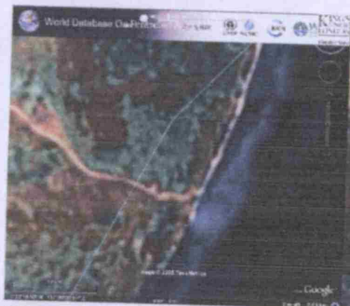
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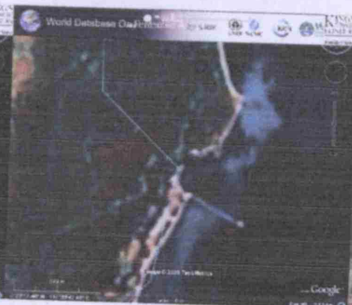
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