Developing GIS for Sumatran Tigers
STF-95-166-011 (Asia Tiger GIS)
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Project Summary
The objectives of this project were to:

1) Develop a geographic information system (GIS) map of Way Kambas National Park and its surrounding landscape as a tool to analyze field data on tiger distribution, prey abundance, habitat type, human disturbance, and other landscape-level information;

2) Obtain and incorporate additional information from maps and satellite imagery to better understand the ecology and threats to tigers at Way Kambas National Park; and

3) Develop methods, using Way Kambas as a model, to develop a Sumatra-wide database capable of handling a wide range of information from mobile tiger conservation teams, Indonesian forestry department staff, satellite images, and additional data sources on the ecology, distribution, and threats to wild Sumatran tigers.

The ultimate goal of this project is to develop a research and planning tool that can be used to identify priority tiger conservation areas and to support Indonesia's efforts to develop a long-term conservation strategy to save Sumatra's last wild tigers.

This grant was used to obtain the hardware, software, training, and data necessary to carry out these objectives. In addition, this grant enabled the Sumatran Tiger Project to obtain more than $10,000 in additional software and support, much of it in the form of in-kind grants from Erdas Inc., ESRI, and Space Imaging EOSAT to develop its Sumatra-wide tiger database. This is an on-going project. We hope to complete the Sumatra-wide map over the next 18 months in time for presentation at the CITES COP XI meeting to be held in Indonesia in 1999.

The following tasks or components for this project that have been accomplished to date include:

1. Purchased computer for GIS analysis with the following components:
- G6-200 Intel 200MHz Pentium Pro processor
- Vivitron 1100 color monitor (19.7" screen)
- 5.1 GB IEDE drive
- CD-ROM and fax/modem
- Both Windows 95 and Windows NT operating systems

2. The following software was received through generous contributions from ERDAS, Inc.:
- ERDAS Imagine 8.2 (incl. Security key and software support)
- Topix Space Imaging
- MapSheets

3. The following software was received through a grant from the Conservation Grants Program of the Environmental Systems Research Institute (ESRI), Inc.:
- ArcView GIS v3.0a (2)
- ADCW for ESRI desktop software
- ArcView GIS Spatial Analyst v1.0a (2)
- ArcWorld 1:3m R10
- Atlas GIS Win v3.x to 3.03 upgrade
- ArcAtlas: Our Earth Package

4. P. Nyhus attended a week of training at the headquarters of ERDAS, Inc., for advanced satellite imagery analysis training. This training was part of a generous grant from ERDAS for software and assistance to enable the Sumatran Tiger Project to incorporate satellite images into our GIS maps. The following three mini-courses were completed:

- *Erdas Imagine Essentials.* This course included background information for using Erdas Imagine, histogram contrast, vector display, image drape, importing SPOT and TIFF images, registration, unsupervised classification, creating map frames, and making maps.
- *Erdas Imagine Advantage.* This course included information on orthocorrection, image mosaic strategies, and using the image interpreter (including GIS analysis).
- *Erdas Imagine Professional.* This course included training in classification (including unsupervised classification), using radar, introductory spatial modeling, and elementary Erdas Macro Language.

5. Further assistance has been provided by Mr. Ben Drake, a consultant to ERDAS. Through Mr. Drake and Erdas, a free image of the Way Kambas areas was obtained from Space Imaging/ EOSAT corporation. The Sumatran Tiger Project gratefully acknowledges this generous gift. Two additional images that are more current and have less cloud cover have been ordered with funds from this grant from LAPAN, the Indonesian Remote Sensing Agency, through a US company. At the time of this report, these images have not yet arrived. The goal is to incorporate these images into the ongoing GIS maps currently being developed by the field team in Indonesia.

6. A GIS-based map of Way Kambas National Park has been developed that accurately identifies habitat types. This field-generated GIS map will then be compared to a satellite image of the same area. Spectral analysis of habitat types and verification of its accuracy will permit extrapolation of the process over all of Sumatra.

7. Field methodology for censusing tigers in Way Kambas National Park has been developed based upon a GIS-generated map of the park.

8. Approval was secured for development of a Sumatra-wide GIS map through the Sumatran Tiger Steering Committee. This includes identification of PHPA and LIPI Indonesian counterparts based at NCIC (Indonesian Biodiversity Database Center), who will be trained and will become responsible for ongoing maintenance of the GIS tiger map.

9. Maps have been obtained from the Indonesian Department of Forest Protection and Nature Conservation (PHPA) and RePProt (land use and forest status maps) of Way Kambas National Park and other areas of Sumatra. These maps are being used to digitize data into our GIS maps and will be used to support ground-truth data for the remote sensing images we are acquiring.

10. We have submitted a request to the World Wildlife Fund for Nature (WWF) to obtain digital copies of the Tiger Conservation Unit (TCU) maps published in 1997. These maps provide a framework for identifying high priority areas and actions for the conservation of tigers in the wild by prioritizing the importance of tiger habitats across Asia. These maps will be incorporated into our Sumatra-wide GIS in order to guide strategic decisions about the location of our research and conservation activities in Sumatra, and to allow us to modify and improve the accuracy of the existing maps based on our more detailed field research.

The development of the Sumatra-wide GIS map for Sumatran tigers is an ongoing process that we hope to complete in the next 18 months in time for presentation at the CITES COP XI meeting to be held in Indonesia in 1999.

Historical Status of Wild Sumatran Tiger Populations

Wild tigers are extremely difficult to census because of their secretive nature and near complete avoidance of humans. Even where tigers are censused regularly, as in the tiger reserves of India, their numbers vary from year to year and because the estimates are based primarily upon identification of individual tiger tracks, the reliability of this technique has been suggested to be without scientific basis. In Sumatran forests of Indonesia, the census of tigers is compounded by the fact that the national parks are huge, some areas within these parks are practicably inaccessible, and because of low overall prey densities in these habitats, tiger densities are correspondingly low.

The historical documentation of tigers in Sumatra is meager. In 1978 a survey of Sumatra estimated the number of tigers to be about 1,000. Since then, Sumatra has undergone much agricultural development and subsequently, pristine tiger habitat has declined. Subsequent surveys of Sumatran tigers put the number "not in the thousands but in the hundreds".

A more recent survey in 1985 estimated tiger distribution based upon information obtained from local PHPA staff and people living around areas inhabited by tigers, not from direct field observations. This survey concluded that, on average, tiger densities in Sumatra were about 1 tiger per 100 km^2 in mountainous areas and 1-3 per 100 km^2 in optimal lowland habitats. Using these density estimates, it was tentatively suggested that the 26 protected areas in Sumatra could support up to 800 tigers, but that the actual number of living tigers was probably fewer.

There is evidence for the presence of tigers in 26 protected areas in Sumatra (Table 1). These areas total 4,564,121 ha or 45,600 km^2 and account for 9.6% of the total land area of Sumatra. Within these areas, tigers inhabit an altitude range from sea level to over 1,000 m. In addition, tigers are also known outside the network of protected areas, especially in rubber plantations where many of the attacks on man and livestock have been reported.

Rain forest habitat in general does not support a high biomass of large ungulates. Optimum habitat is provided by sub-climax vegetation, such as transitional zones between forest and grasslands support a higher density of tiger's principal prey species. On the other hand, lowland forests support a greater biomass of ungulate prey such as wild pig (*Sus scrofa*), sambar (*Cervus unicolor*) and barking deer (*Muntiacus muntjak*) which are among the species preferred by tiger in Sumatra. But it is precisely such lowland forest habitats rich in prey species that are fast disappearing in Sumatra as a result of a host of development programs. It is estimated that between 65% and 80% of the forests in the lowlands of Sumatra have already been lost. The mountain areas to date have been less seriously affected, but disruption of continuous cover is already substantial in some cases, and perhaps 15% of their total area may tentatively be estimated as already removed on the evidence available.

Recent Population Estimates of Sumatran Tigers

At the Sumatran Tiger Population and Habitat Viability Analysis (PHVA) workshop in November 1992, a first-generation spatial database using Geographic Information System (GIS) was developed for the five major conservation areas of Sumatra. Indonesian Land-use and Forest Status maps (series RePPProT 1988; scale 1:250,000) were used for protected area boundaries (HSA and HL, see Table 1 for definitions) and vegetation cover. Only vegetation cover within the five major protected areas was digitized from these maps. The main forest types distinguished in the five HSA areas were lowland forest (below 1,000 m), sub-montane forest (between 1,000-2,000 m), montane forest (above 2,000 m), and inland and mangrove

swamp. In addition, other vegetation types such as bush and agriculture were included in the database.

To estimate vegetation cover outside of the five major protected areas, the World Conservation Monitoring Center (WCMC) provided a digitized coverage of vegetation on Sumatra (series RePPProT 1990; scale 1:2.5 million). WCMC's database only distinguishes between lowland forest, montane forest, inland and mangrove swamp and non-forest. Thus, all areas without forest, such as bush and agriculture, are treated as a non-forest category.

Table 1. Protected areas of Sumatra where tigers are found.

No.	Reserve/Park/Forest	Prov.	Status	Area (ha)	Alt. (m)
1	Gunung Leuser	Aceh	NP	792,675	0-3419
2	Lingga Isaq	Aceh	HR	80,000	800-2823
3	Dolok Sembelin	NSum	PFo	33,910	150-1604
4	Sibolga	NSum	NR	20,100	200-1230
5	Kerinci-Seblat	WSum	NP	1,484,650	500-3800
6	Lembah Anai	WSum	PFo	96,002	600-1811
7	Lembah Harau	WSum	PFo	23,476	600-1256
8	Maninjau	WSum	PFo	22,106	600-1724
9	Bkt.Sebelah/Pangean	WSum	PFo	22,803	600-1078
10	Bajang Air Tarusan	WSum	PFo	81,865	500-2000
11	Kerumutan Baru	Riau	GR	120,000	0-0
12	D. Pulau Besar/Bawah	Riau	GR	25,000	0-0
13	Seberida	Riau	NR	120,000	150-830
14	Bkt. Rimbang/Baling2	Riau	NR	146,000	200-1090
15	Peranap	Riau	HR	120,000	120-492
16	Siak Kecil	Riau	NR	100,000	0-20
17	Air Sawan	Riau	GR	140,000	100-176
18	Berbak	Jamb	GR	190,000	0-20
19	Merangin Barat	Jamb	PFo	64,600	1000-1931
20	Gumai Pasemah	SSum	GR	45,883	200-1776
21	Isau-Isau Pasemah	SSum	GR	12,114	500-1431
22	Gunung Raya	SSum	GR	39,500	300-2232
23	Rawas Hulu Latikan	SSum	GR	213,437	300-2384
24	Padang Sugihan	SSum	GR	75,000	0-50
25	Barisan Selatan	Ben/Lam	NP	365,000	0-1964
26	Way Kambas	Lamp	GR	130,000	0-50
	Total			4,564,121	

NB: NP=National Park; NR=Nature Reserve; HR=Hunting Reserve; GR=Game Reserve; PFo=Protection Forest. Underlined areas are lowland forests.

The database created therefore contains a distinction between the information available for vegetation cover inside and outside of the five major protected areas. Outside HSA boundaries all areas without forest are labeled non-forest, while inside HSA boundaries non-forest is divided into bush and agriculture. Roads, towns, and rivers were digitized from geological maps (Geological maps 1988; scale 1:250,000).

The Sumatran Tiger PHVA concentrated on the long-term viability (100 years) of tigers in HSA areas. Other areas, namely HL, were also discussed in terms of tiger numbers but an extensive analysis was not performed on these protected areas, because most of them are scheduled for conversion to agricultural purposes, are extremely small in size and isolated from larger protected areas. In an effort to gain an estimate of tiger numbers in a protected area, Griffith's 1994 estimates of tiger home range sizes in Gunung Leuser National Park were used.

Low tiger densities (1 male tiger per 380 km^2, 1 female tiger per 190 km^2) were assigned to montane forest and agricultural. Although agricultural areas may have a higher prey-base (and thus would be good tiger habitat), given poaching and poisoning pressures from humans and the tiger's propensity to avoid humans, it is unlikely that tigers would have an extensive part of their home range covering agricultural lands.

Medium tiger densities (1 male tiger per 274 km^2, 1 female tiger per 137 km^2) were assigned to sub-montane forest and peat-swamp forest. Sub-montane forest on the maps roughly corresponds to Griffiths' data (medium tiger densities were from 600 to 1700m, on our maps it is 1,000m to 2,000m). Peat-swamp habitat was assigned to this category, based upon conflicting reports of its suitability as tiger habitat (see section on Berbak National Park, below).

High tiger densities (1 male tiger per 180 km^2, 1 female tiger per 90 km^2) were assumed for lowland forest, swamp (except peat swamp forest), bush and logged forest. Logged forest was included in the high density category because secondary forest is thought to have a higher prey-base than primary forest. Bush and swamp were included in the high density category based upon the argument that tigers are especially associated with these habitats.

Tiger numbers for the five national parks were estimated in two ways: 1) using the vegetation cover on the RePPProT (1988) maps stored in the GIS database, and 2) using tiger presence as indicated on the maps by park officials at the PHVA workshop. Kerinci Seblat, Way Kambas, Barisan Selatan and Gunung Leuser all have complete data sets and both methods were used for these parks. Berbak was analyzed using only the vegetation types from the GIS database.

Gunung Leuser National Park

Tiger estimates from HSA areas (from data received at the PHVA workshop): There were 31 units labeled as lowland, swamp and logged. Two units were not labeled and were assigned lowland forest status based on the GIS database. One of the units labeled as swamp was indicated as not having tiger presence and was therefore removed from the analysis. Therefore, there were 30 units of the high density category comprising 3,000 km^2, for an estimated 16-17 male and 33-34 female tigers. There were 41 sub-montane units in the grid, for an estimated 14-15 male and 29-30 female tigers. There were 15 montane units in the plot, for an estimated 3-4 male and 7-8 female tigers. The total population was thus estimated to be between 102-108 tigers (33-36 male and 69-72 female).

KERINCI SEBLAT NATIONAL PARK

Tiger estimates from HSA areas (from data received at the PHVA workshop): There were 45 units of lowland and bush labeled with the presence of tigers, for an estimated 25 male and 50 female tigers. There were 30 units of sub-montane forest labeled for tiger presence, for an estimated 10-11 male and 21-22 female tigers. There were 17 units of agriculture and montane labeled for the presence of tigers, for an estimated population of 4-5 male and 8-9 female tigers. The total population was thus estimated between 118-122 (39-41 males and 79-81 females).

BARISAN SELATAN NATIONAL PARK

Tiger estimates from HSA areas (from data received at the PHVA workshop): From the tiger distribution received at the PHVA workshop, the tiger population of Barisan Selatan appears to be fragmented into five separate populations. The number of individuals is estimated for each population, from south to north.

The first population has 1,000 km^2 of lowland forest, for an estimated population of 5-6 male and 11-12 female tigers. The second population has 200 km^2 of lowland forest and 100 km^2 of agriculture, for an estimated population of 1-2 male and 2-3 female tigers. The third population has 200 km^2 of lowland and 100 km^2 of sub-montane forest, for an estimated population of 1-2 male and 2-3 female tigers. The fourth population 4 has 200 km^2 of lowland forest, for an estimated population of 1-2 male and 2-3 female tigers. The fifth population has 100 km^2 lowland forest with an estimated tiger pair.

The total population, using tiger presence from the grid, was estimated to be between 9-13 males and 18-22 females. If the tiger population is fragmented as depicted, there is suitable tiger habitat between these populations and because the distances between the populations are not great, tigers can probably cross these areas. Therefore, the populations are more than likely not genetically isolated.

WAY KAMBAS NATIONAL PARK

Tiger estimates from HSA areas (from data received at the PHVA workshop): All 12 units labeled for tigers had lowland, bush or swamp, for an estimated 6-7 male and 13-14 female tigers. The total population was estimated at 19-21 tigers.

BERBAK NATIONAL PARK

Tiger estimates from vegetation in GIS database (data from vegetation analysis): Using the vegetation types that occur within current park boundaries, there are 120 km^2 of swamp and logged forest. This results in an estimate of 1 male and 1-2 female tigers. There are 1,517 km^2 of peat-swamp forest, for an estimate of 5-6 male and 11-12 female tigers. The total estimated population for Berbak is between 18-21 tigers, 6-7 males and 12-14 females.

The results and analysis of the PHVA Workshop presented above provide a beginning, not the final result, of a commitment to ensure the long-term viability of free-ranging Sumatran tigers. As such, there are several issues that need to be further explored to gain better estimates of tiger distribution and densities. Within the context of this paper, these include: expansion of the database to include all viable tiger habitats, including both protection and production forest; identification of unsuitable habitat within these areas; better estimation of tiger home range sizes in tropical rain forest habitat; and better evaluation of the threats to wild tiger populations.

Table 2. Summary of tiger population estimates for five protected areas.

Protected Area	Vegetation analysis	Tiger distrib. from plots	PHVA				
	M	F	Total	M	F	Total	Total
Barisan Selatan	16-18	33-35	49-53	9-13	18-22	27-35	68
Berbak	6-7	12-14	18-21	6-7	12-14	18-21	50
Gunung Leuser	36-39	74-77	110-116	33-36	69-72	102-108	110
Kerinci Seblat	44-47	89-92	133-139	40-41	80-82	120-123	76
Way Kambas	7-8	14-15	21-23	6-7	13-14	19-21	20
Kerumutan	-	-	-	-	-	-	30
Rimbang	-	-	-	-	-	-	42
Totals			**339-361**[a]			**268-287**[a,b]	**396**

[a] Does not include other parks with tigers (Rimbang and Kerumutan)

[b] Includes estimates from vegetation analysis of Berbak National Park.

Base Map of Way Kambas

A digitized base map of Way Kambas National Park has been completed using data from existing maps and information collected from the field (see Map 1). This map includes basic information about vegetation types, streams and rivers, roads and villages, and the boundaries of the park. Efforts are underway to incorporate information from one or more satellite images that can be used to further refine this base map. Ultimately, this map will provide a valuable tool for staff from the Indonesian Department of Forest Protection and Nature Conservation (PHPA) for park management, conservation planning, and long-term integration of biological and human demographic and land use data. Lessons learned from this exercise will also assist Sumatran Tiger Project staff in developing a Sumatra-wide base map.

Several types of information are already being gathered from this base map and its associated layers. For example, in Map 2, the location and names of camera traps, old logging roads and other paths within the forest, and temporary structures built by STP are shown in conjunction with vegetation, hydrologic, and park boundary information. At present, this map can differentiate between major vegetation types (e.g., mature secondary forest, imperata grassland, mixed shrub forest, wetlands) and more detailed information is being collected in the field. Information about tigers and other wildlife have been incorporated into these maps to provide a variety of spatial analyses regarding the distribution, abundance, and home ranges of these animals. Additional analyses incorporating information from human activities outside the park are expected in the near future.

Using GIS to Develop a Methodology for Rapid Assessment of Tigers

One of the components of the Sumatran Tiger Project's field program is to develop a methodology for rapidly assessing the status of tigers, prey abundance and habitat quality, over a wide range of habitat types within which tigers currently occur in Sumatra. The future intention is to use the methods developed to assess tigers in other provinces of Sumatra, identified and proposed by PHPA, to be of importance and significance for tiger conservation. This will include national parks, adjacent forested areas, old logging concessions and plantations, and will provide the distribution and density information upon which any conservation strategy must be based. It will be of importance that the methodology can be rapidly implemented in the field, the data quickly and analyzed without bias. Since it is the ultimate intention that the rapid assessment be carried out by independent PHPA teams, the methodology should be cost-effective, easily replicated, quickly taught, requiring a minimum of high-maintenance equipment, and requiring a minimum of personnel for its implementation in the field.

Zone 1: A Field Test Site

This represents the first opportunity to test and develop the techniques for rapid assessment. During this initial trial a site was selected on the western border of the national park, in close proximity to adjacent villages and farmland. In the region of zone 1 the interface between the park border and the surrounding farmland is defined by the Sukadana river, and for this reason the park is easily intruded upon by villagers relying on the various resources the park area offers. The survey zone used in this region measures 10 km by 4 km, and lies parallel to the parks western borders in close proximity to the park resort office at Bungur (see Map 3). Habitat types found in the region are dominated by alang-alang grasslands (of various ages post burning), with some thick, scrub secondary forest along the border of the park with the Sukadana river. Secondary forest is also found along the course of all rivers and streams running through the survey zone, whilst more extensive regions of swamp forest can also be found in some western areas. Relative to other regions of Way Kambas National Park the survey zone is heavily intruded upon by villagers, for the purpose of burning and collecting grass, for wood (household and small commercial operation scale), for gaharu, for hunting of deer, pig and birds, and for fishing. All areas of the survey zone are affected by this intrusion, whilst well-worn paths through the area provide access to more remote areas of the park.

Components of Rapid Assessment

Between 9th and 14th July ten cameras and three passive monitors were set up within Zone 1. The cameras were randomly allocated to positions within the 2 km by 2 km grid squares. This random placement was achieved by utilizing a computer-based random latitude and longitude generator. These camera locations were then imported into portable GPS units, allowing field teams to cut trails directly to the sites by utilizing the satellite navigation system described. On reaching the predetermined site, the location, dictated by the GPS unit, was marked and the patrol team set about choosing an ideal position for the set-up of the remote camera system. In the set-up of the system it was decided that a distance of 100 m from the GPS location would be sufficient to offer enough possibilities for selecting a site that would offer some opportunity for success for making photo-captures. This radius of 100 m, centered around the predetermined GPS location, also represents the average maximum accuracy of the GPS system operating at the standard Selective Availability (SA) resolution. A smaller radius of flexibility presents problems in that it can often be difficult to select a camera position that will offer reasonable results.

Completely random placement of a camera system, for all its positional parameters, will almost without exception, result in the placement of a camera that will capture no passing wildlife during the month of operation. The final placement, however, must be completed by choosing a site that maximizes the chances of capturing photographs of the resident tigers. Thus, the final stage is the selection of the optimum site (based on the tiger ecology knowledge of the team, identification of trails, the surrounding habitat, field topography and security). With this system there is some randomness that will allow comparison of sites set up by independent groups, whilst there is also the flexibility to set camera traps that will, under the time constraints operating, still allow the collection of sufficient data to make the results and analysis valid.

A team of eight people, comprised of three PHPA forest rangers and five Sumatran Tiger Project personnel, was used during the five-day set-up periods in Zone 1. The teams entered the park from the village of Totoprojo, and headed for a central location within the Zone 1 region. A camp was set-up, from which teams could be coordinated for the duration of their period in the zone. Over the subsequent days the team was split up into smaller groups, each responsible for setting up particular cameras and passive infrared monitors, after which the groups would re-group at the central camp for re-supply and rest. In this way the maximum distance any team was required to cover in a single day was 18 km. Cameras and passive monitors were set up as shown in the map below, whilst the travel between remote camera sites provided the opportunity to commence the detailed mapping of the region. The route of each survey team was monitored and recorded using the GPS units, whilst all observations of resident fauna, habitat types, signs of human intrusion and other points of interest were noted.

Following the departure of the team from Zone 1 the cameras were allowed to operate for a 36 hour period before the data collection period was deemed to have commenced. From this point in time, and for the next 28 days, the cameras and passive monitors were left to operate undisturbed.

Analysis of Zone 1

Following 28 days of camera operation in the area of Way Kambas designated as Zone 1, the cameras and passive monitors were removed and the films processed in preparation for analysis. All cameras and monitors were retrieved, with the exception of one passive monitor, destroyed by fire during an intense period of forest fire in the region.

The vegetation and feature mapping of Zone 1 was continued and completed during this phase of field work, and this data is currently being transferred to an independent GIS map. This Zone 1 GIS map will be integrated with the larger scale GIS map of the park, and will also be stored in a manner facilitating the comparison of this area with future rapid tiger assessments within the park.

Methodology used in the rapid assessment will be refined depending on the results achieved after final analysis of data from this period of field work. If it is found that insufficient tiger data is forthcoming then modifications will be proposed regarding the number of cameras utilized and the period for which these cameras are active. Preliminary analysis of the data suggests that the time of camera operation may have to be increased from the current four weeks (28 days) to

approximately six weeks (42 days). To confirm the necessity of a longer period we believe the following needs to be carried out in the near future.

- Utilization of current rapid assessment methodology in the area known as the Tiger Intensive Monitoring Area (TIMA), where the density of tigers inhabiting the region is known with some certainty. It will provide a means of checking the accuracy of results achieved during the rapid assessment phase.

- Continuation of rapid assessment in a second site, Zone 2, using a higher density of cameras over a longer period of camera operation time.

- Repeating the assessment in Zone 1 using a variation on the method by which cameras were placed in the field during the initial pilot trial. It is proposed that cameras be placed using methods more similar to those employed in the TIMA, where it is the researchers understanding of the terrain and tiger ecology that maximize the tiger photo-capture rate. This, again, would provide some means of ascertaining the accuracy, and tiger identification rate, of the rapid assessment methodology used to-date.

Continuing Objectives for the Rapid Assessment of Wild Tigers

Following the completion of Zone 1, the team is now applying the methodology in other areas of Way Kambas. Currently there are six regions identified as sites in which rapid assessment should be used, five of which are located in close proximity to the park boundary. The sixth site is located deep within the park, overlapping the current Tiger Intensive Monitoring Area (TIMA), and will be used as a reference against which all other zones can be compared. Since this reference site is contained within the intensively studied and monitored TIMA, it will be possible to state with some confidence the number of tiger individuals that are utilizing the area encompassed by the Zone perimeter. This will be of considerable importance as it will be important to be able to estimate what proportion of tigers are identified during the relatively short period (one month) during which cameras are operational in any particular RTSA site.

Ultimately, it is the intention to attempt the rapid assessment of tigers in areas external to Way Kambas National Park, which will include abandoned logging concessions, plantations and other protected areas. A priority will be to develop the methodology for more mountainous forest areas, such as that found in Gunung Leuser, Kerinci Seblat and Barisan Selatan National Parks.

Preparations are underway to implement Sumatra-wide surveys of potential tiger habitat. This rapid evaluation of tiger status will provide information relating to the tiger's distribution, prey abundance, habitat type, human disturbance, human attitudes and land protection status. This data will be essential in future management initiatives concerning the conservation of the Sumatran tiger.

Incorporating Land Use and Demographic Data

An important application of our Way Kambas GIS map is the ability to integrate both biological and land use data. Between January and November 1996, STP staff members collected detailed

information about the location of major roads, boundaries of villages, and other key landscape features like an elephant ditch built along much of the southern border of the park.. This information was collected in more than ten villages adjacent to the park using hand-held global positioning units (GPS) These data are being incorporated into the GIS map in order to: (1) conduct spatial analyses linking land use patterns to wildlife activities within the park, (2) obtain accurate estimates of distances to villages, roads, and other structures that could affect the dynamics of park-people interactions along the park border, and (3) eventually incorporate social and economic data into our long-term data set (*e.g.,* demographic information, agricultural data) to better model the potential long-term implications of development outside the park with conservation of tigers and other wildlife within the park. Detailed socio-economic information has already been collected from the Indonesian Bureau of Statistics (BPS), regional and local governments, and from existing studies. Additional information was collected during a one-year survey of household in 12 villages near the park border.

Data have also been collected for a 20-year period on the number, location, and type of tiger-human conflicts that have occurred across Sumatra. The first systematic analysis of its kind, this dataset is being used to identify potential "hot spots" for tiger-human conflict. Preliminary analysis of these data suggest that the probability of tiger conflicts is highest in areas where humans and tigers overlap, and lowest in both undisturbed areas (*e.g.,* inside national parks) and more heavily disturbed areas. As soon as we are able to obtain the TCU maps from WWF mentioned above (we have made multiple requests for these maps over the last 6 months), and after the Sumatra-wide GIS is completed, we intend to test this hypothesis using the data we have already collected, and additional data we will be collecting in the field.

Integration of Satellite Images

One of the primary goals of this project is to develop a Sumatra-wide GIS map and database of current and potential tiger habitat, and information about land use characteristics and threats surrounding these sites. Starting in 1998, two activities have been carried out to accomplish this goal. First, multiple "tiger conservation teams" have been created and trained to carry out rapid field censuses across Sumatra. These teams will be responsible for gathering basic ecological data, information about presence or absence of tigers and their prey, and information about land use and resource use adjacent to these areas. In addition to the activities in Way Kambas National Park described above, one team has already been sent to southwest Sumatra to carry out preliminary studies. Pending final approval and permits from Indonesian authorities, these teams will begin to move across Sumatra with the goal of covering all the major protected and non-protected forests identified as potential tiger habitats. Second, to assist these teams, satellite images will be obtained of the each area to identify major vegetation types, degree of fragmentation, and disturbance types and patterns. A Landsat TM image for the site in southwest Sumatra has already been ordered. The field teams will collect ground control points and additional data to ground -truth these images and enable us to classify the current vegetation types and land use patterns in each area. Accurate estimates of the actual type and amount of forest remaining will be critical for future estimates of tiger and prey abundance, and estimates of the type and extent of threats facing these scattered populations.

One satellite image of Way Kambas National Park was provide free-of-charge from Space Imaging Eosat corporation. This full-scene, 7-band TM image (acquisition date: 04/16/89) included both Way Kambas and its surrounding areas. Both a supervised and unsupervised classification was done on this image. Unfortunately, cloud cover was 30% over the entire image, and the area of interest was largely covered by both clouds and smoke from a fire located within the park. As a result, this image will not be used for any extensive analysis. On receipt of the new image (from August 1996), however, some vegetation and land use change analyses will be possible. In particular, areas of recent logging are visible from the 1989 image. Comparisons between these two images will allow us to better understand the current vegetation types and the relationship to tiger distribution and abundance.

We intend also to obtain an additional image (TM or SPOT) taken after the fires that swept much of Sumatra and burned an estimated 60% of Way Kambas in late 1997. Analysis of the before and after fire images, and the data we are collecting in the field over this same time period, should allow us to undertake the first detailed study of the impact of fire on tigers and other lowland forest animals in Sumatra.

Current Development of a Sumatra-Wide GIS Database

The Sumatran Tiger Steering Committee discussed and approved a planning document for the conservation of Sumatran tigers over the next three years (1998-2000) at the Year of the Tiger Conference held in Dallas, TX in February 1998. One of the recommendations in the planning document concerned the development of a Sumatra-wide GIS database. In April 1998 the Steering Committee intends to approve and fund the further development of this GIS database. The objective of the recommendation and its justification is presented below.

Recommendation: *To develop a Sumatra-wide Geographic Information System (GIS) database for tigers, tiger habitat, tiger prey, and the human dimension. This information will be collected in a format that is compatible with existing PHPA and LIPI database and geographical information systems.*

Justification: The tiger database will form the foundation for training our Indonesian counterparts and local university students on the power and utility of GIS-based programs. These students will expand the GIS database to other species and habitats in Way Kambas, eventually arriving at a comprehensive species and habitat inventory of the park. Such information will allow park managers to develop an effective management program for Way Kambas. In essence, we intend to produce a GIS database and analysis for all of Sumatra's forest habitat where tigers live or potentially could live. Berbak and Kerinci Seblat National Parks will follow the Way Kambas GIS database model.

The Sumatran Tiger Project is designed to develop a conservation strategy for the long-term management of wild Sumatran tigers across all of Sumatra. This cannot be done without a GIS approach, because Sumatra is too vast, the remaining forests where tigers live are too fragmented, and the remaining tiger populations are too isolated. These factors have stymied a comprehensive approach to tiger conservation by the Indonesian Ministry of Forestry because it is a complex and convoluted situation. There is no standardized database that incorporates all of

the variables that are necessary to assess what needs to be done to protect tigers. A GIS database has the potential to eliminate much of this confusion by creating a "tiger map" of Sumatra showing where and what kinds of forests still remain, their protected status, their suitability for tiger viability, their proximity to human settlements and potential for human-tiger conflict, and a number of other variables. Such a "tiger map" will be a powerful tool in creating the overall of where tigers are and what needs to be done to protect them in the future. The identification of important tiger conservation regions (Tiger Conservation Units – TCU) will contribute to the global conservation effort to save as many tigers as possible across all of Asia.

Objectives: Sumatra-Wide GIS Database

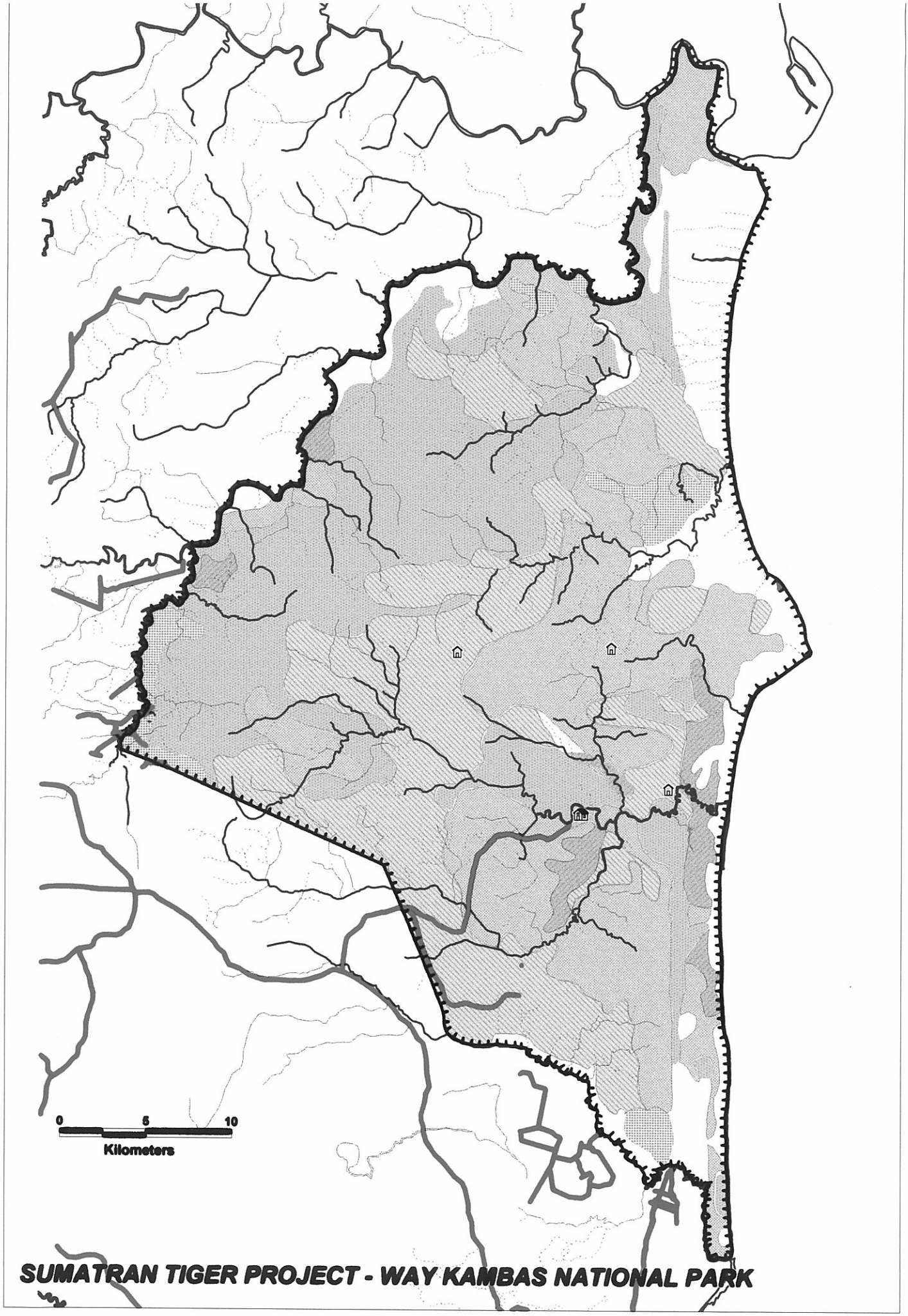
- On a local level such as a national park, some of these GIS features would include: analysis of corridor configuration and feasibility; utility of buffer zones versus core conservation areas; human population modelling and future impact analysis; analysis of multiple ecological layers: tiger distribution, prey abundance, habitat type, local climate and rainfall, other species, disturbance factors, potential threats (fire, flood, poachers); and integration of satellite imagery and input from GPS ground-truth teams

- One of the features that GIS will provide the Sumatran Tiger Project is its ability for questions to be asked about different parameters and their positive or negative impact for tiger conservation.

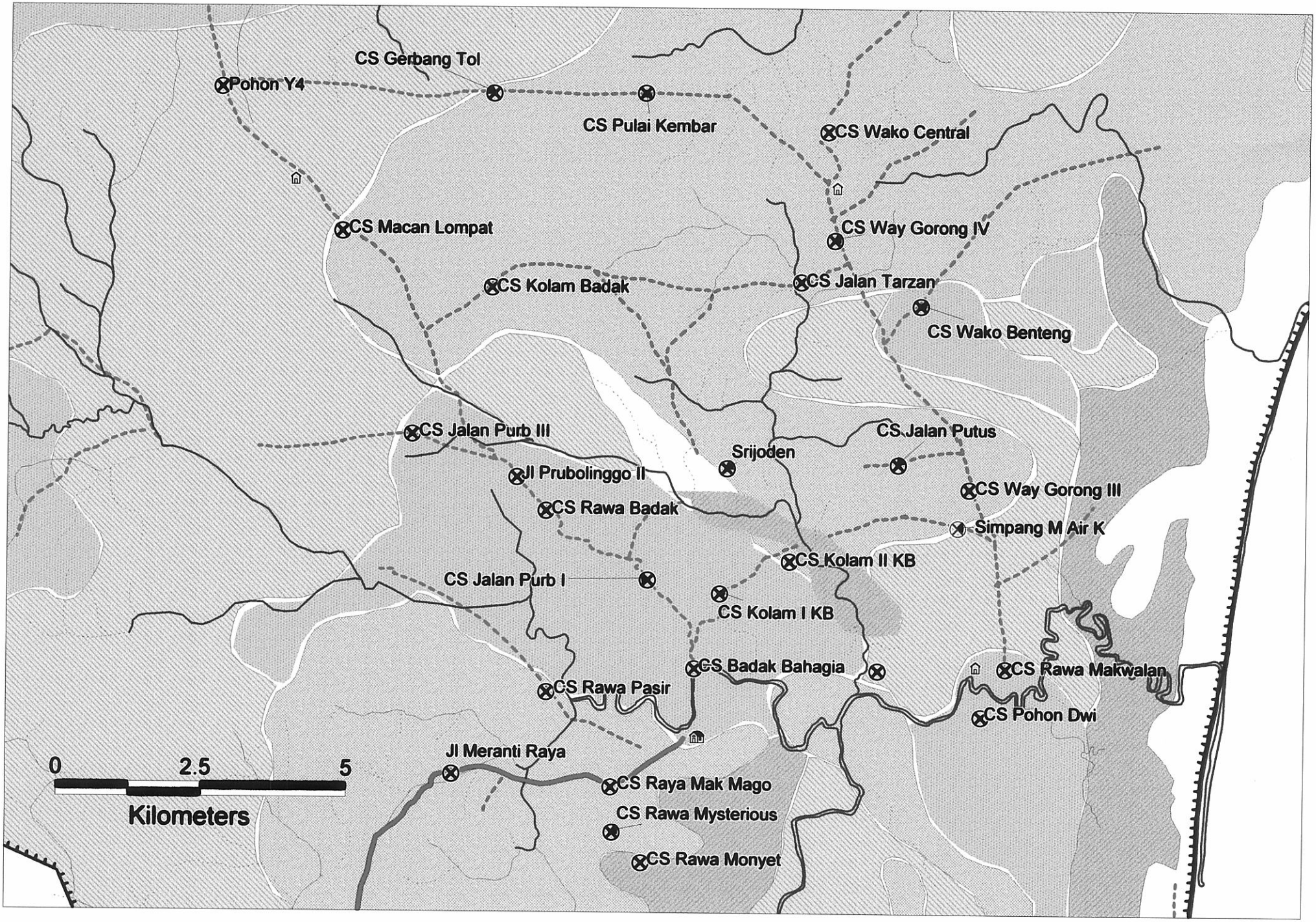
- This analysis will permit the identification of possible tiger conservation units (TCU) and the GIS analysis will allow the prioritization of these TCUs for conservation action. The TCUs will be linked on a global scale with all Asian tiger range states, and will place Indonesia at the forefront of this global effort to prioritize the conservation needs for the Sumatran tiger.

- Another feature is that it will provide the project with the ability to generate reports complete with multiple charts. The ability for GIS to visually represent different conservation scenarios will be a powerful and persuasive tool in discussions with the Ministry of Forestry on how best to save tigers for the future.

These GIS maps will be based upon the ERDAS and ArcInfo software, allowing them to conform with the current systems that have been developed by PHPA and LIPI.



SUMATRAN TIGER PROJECT - WAY KAMBAS NATIONAL PARK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Pohon Y4
CS Pulai Kembar
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CS Macan Lompat
CS Way Gorong IV
CS Kolam Badak
CS Jalan Tarzan
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CS Jalan Purb III
CS Jalan Putus
Srijoden
Jl Prubolinggo II
CS Way Gorong III
CS Rawa Badak
Simpang M Air K
CS Kolam II KB
CS Jalan Purb I
CS Kolam I KB
CS Badak Bahagia
CS Rawa Makwalan
CS Rawa Pasir
CS Pohon Dwi
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CS Raya Mak Mago
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Zone 1
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Zone 3