CEPF FINAL PROJECT COMPLETION REPORT

I. BASIC DATA

Organization Legal Name: Wildlife Conservation Society

Project Title (as stated in the grant agreement): Annual Forest Cover Change Analysis and Change Detection Map for Sumatra

Implementation Partners for this Project: Conservation International, Ministry of Forestry

Project Dates (as stated in the grant agreement): April 1, 2005 – December 31, 2006

Date of Report (month/year): 01 March 2007

II. OPENING REMARKS

Provide any opening remarks that may assist in the review of this report.

Although the international community invested heavily over the last 20 years to monitor the rates of forest loss in Indonesia using satellite platforms the currently available maps of forest cover and of deforestation in Indonesia are inaccurate at the district level and below. Inaccurate forest maps resulted in fuzzy conservation planning at the Protected Area (PA), district and sub-district levels. For example, a conservation planner could overestimate deforestation rates and therefore recommend unjustified urgent anti-logging actions. Likewise, an artificial return of forest area could be observed in highly threatened areas.
A continuous monitoring of the patterns of loss, whether in shape, size, expansion rate and geographic location of forest clearance inside PAs, districts, sub-districts and villages is vital to enable conservation planners support a more accountable and transparent governance. Local government agents, such as park managers need detailed maps to plan better law enforcement strategies while local civil societies need detailed maps to accelerate the recognition of civil rights, for example to sue logging companies that operate illegally inside PAs and community forests.

This project was intended to fill the current gap of information. Here, we provide the first accurate baseline information of remaining forest cover and of forest loss in Sumatra at the district, sub-district and village levels (See Fig. 1).

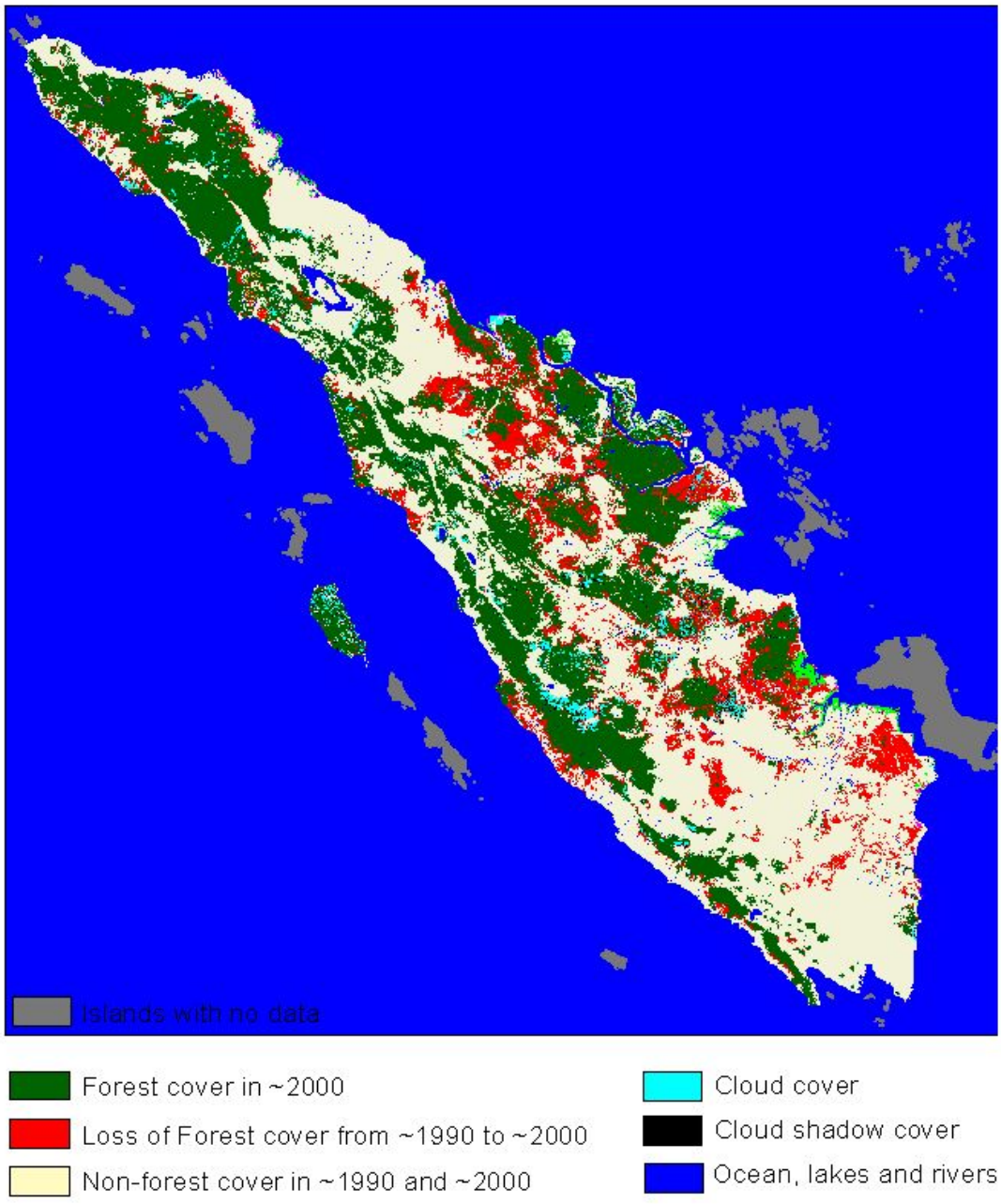

Fig. 1. Map of forest cover for 2000 and of deforestation for the period 1990 to 2000 across the main island of Sumatra and of Siberut.

III. ACHIEVEMENT OF PROJECT PURPOSE

***Project Purpose**:* Baseline information of the forest cover provided using remote sensing processes that can be applied to sustainable monitoring important natural resources.

Planned vs. Actual Performance

Indicator	Actual at Completion
Purpose-level:	
Government and local NGOs accept baseline information and understand how it can be used as a monitoring tool.	We are currently producing a manual to help stakeholders understand the map, its limitations, and how it can be used. The digital version of the map and associated manual will be sent to all relevant stakeholders. To this effect we are producing ~100 DVDs.
Local NGOs continue efforts to use remote sensing processing for producing annual low resolution change detection maps.	The World Bank has been leading an initiative (FOMAS) to improve good governance and transparency of Indonesia's Forests. One aspect of FOMAS is to enable local NGOS to access and use remote sensing data. WCS has been actively involved in the FOMAS forum and will continue for the years to come by providing assistance on remote sensing.

Describe the success of the project in terms of achieving its intended impact objective and performance indicators.

Over the last year, we have actively lobbied the government of Indonesia to ensure that the Ministry of Forestry will adopt the map as a mapping standard for Sumatra. We presented the map to the Minister of Forestry in person and at several key meetings at the Ministry of Forestry, including at the World Bank-led FOMAS initiative. The responses have been varied. On the one hand the Directorate General of Forest Protection and Nature Conservation (PHKA) have showed great interest in using the map. On the other hand, the Directorate General for Planning (BAPLAN) have expressed less enthusiasm.
In a move to improve good governance and transparency of Sumatra's forests, CI and WCS have agreed to disseminate the map in digital format to local government agencies as well as to local NGOs. We are currently preparing a manual to help stakeholders understand the map and its limitations, and we will send this information in 100 DVDs.

Were there any unexpected impacts (positive or negative)?

We haven't identified any unexpected impact.

IV. PROJECT OUTPUTS

***Project Outputs**: Enter the project outputs from the Logical Framework for the project*

Planned vs. Actual Performance

Indicator	Actual at Completion
Output 1. Forest cover change analysis and production of a change detection map (1990-2000) for Sumatra completed in collaboration with partners as part of the global Outcomes Monitoring protocol.	A map of forest cover for year 2000 and of forest loss for the period 1990 to 2000 has been successfully produced (Fig. 1) in collaboration with WCS, CI-CABS, CI-Indonesia, and the Ministry of Forestry.
1.1. WCS, CABS and CI-I assembled, initial imagery acquired, and validation options researched by month 2.	Assembled over 60 Landsat scenes.
1.2. Training of lead image analyst held by month 3.	CI-CABS's lead image analyst trained WCS's lead image analyst during 2 two-week sessions in June 2005, and December 2006.
1.3. Second and third analysts are trained and begin processing satellite data by month 4.	Three Indonesian Nationals, including two staff from the Ministry of Forestry have been trained in change detection technique from CI-CABS.
1.4. Image review work session with CABS and WCS by month 10.	CI-CABS carried out quality control of the map
1.5. Validation data collected using aerial surveys/high-resolution satellite data and ground data performed by team by month 11.	We collected 7 high-resolution satellite images to validate the map.
1.6. validation performed, and mosaicked wall to wall map created by month 16.	The overall accuracy for 2000 forest cover classification is p=95%, with kappa statistics of k=0.9.
1.7. Fragmentation and overlay analyses models run on data by month 18.	This task has been undertaken by CI-CABS.
1.8. Final Map production coordinated with CI-CABS by end of project.	In December 2006 CI-CABS's lead image analyst spent three weeks in Indonesia to coordinate final map production with WCS's lead image analyst.

Describe the success of the project in terms of delivering the intended outputs.

The following describes the method used to generate and validate the map (Fig. 1).

Estimation of forest cover and change

Time series satellite data

To generate the map of deforestation across the main island of Sumatra and the island of Siberut, we acquired Landsat-5 Thematic Mapper (TM) for ~1990, and Landsat-7 Enhanced Thematic Mapper (ETM+) for ~2000. For scenes with cloud cover greater than 25% we analysed additional cloud-free Landsat sub-scenes. Images collected in ~1990 and ~2000 were co-registered to NASA's Geocover, a set of ortho-rectified images from the 1990s. The Geocover orthorectification process uses Global Positioning System (GPS) data and accounts for elevation to produce an image set with a root mean square error (RMSE) of <50 m.

Definitions
We defined 'Deforestation' as the complete removal of forest cover over an area equivalent to ≥ 1 ha. We defined the 'forest' class as non-modified forest areas of old-growth vegetation dominated by closed-canopy tree cover (≥50%). We defined the Mangrove class as areas of forest on coastal areas. 'Non-forest' comprised a large continuum of land cover classes: human settlements, *Imperata cylindrica* grasslands, and re-growth areas dominated by shrubs and young forest trees, paddy fields and tree crops. Tree crops included coffee and pepper gardens, cinnamon, coconut, rubber, acacia and oil palm plantations, orchards and old-growth agro-forest dominated by *Shorea javanica*, rubber, mixed fruit gardens, benzoin and candlenut forests.

Classification strategy
We identified training sites (homogeneous areas) for forest and non-forest by visually analyzing the reflection of sunlight from the Earth's surface in three spectral regions: red, near infrared, and short wave infrared, corresponding to Band 3, 4 and 5 on the TM and ETM+ data. The red and infrared bands are scattered less by the atmosphere than the blue and green bands (Born and Wolf, 1975) and therefore produced the highest visible contrast between forest and non-forest areas of land.
We entered our training areas and respective spectral signatures into a tree-based classification algorithm, called SEE5 (http://rulequest.com/see5-win.html) to generate a classification of the study area into 'change' classes and 'non-change' classes. We were trained in SEE5 by researchers at Conservation International's Center for Applied Biodiversity Science (Justin Epting, personal communications, 2006).

Change classes were:
(a) Forest in ~1990 and Non-Forest in ~2000 (Deforestation of old growth forest)
(b) Mangrove in ~1990 and Non-Forest in ~2000 (Deforestation of Mangrove)
(b) Cloud in ~1990 and Forest in ~2000
(c) Cloud Shadow in ~1990 and Forest in ~2000
(d) Cloud in ~1990 and Non-Forest in ~2000
(e) Cloud Shadow in ~1990 and Non-Forest in ~2000
(f) Cloud in ~1990 and Cloud Shadow in ~2000
(g) Cloud Shadow in ~1990 and Cloud in ~2000

Non Change classes were:
(A) forest in ~1990 and forest in ~2000 (Remaining forest cover in 2000)
(B) Mangrove in ~1990 and Mangrove in ~2000 (Remaining Mangrove cover in 2000)
(C) Non forest in ~1990 and Non forest in ~2000
(D) Water in ~1990 and water in ~2000 (Lakes, the sea and largest rivers)
(E) Cloud in ~1990 and Cloud ~2000
(F) Cloud shadow in ~1990 and cloud shadow in ~2000

Note, we did not include any re-growth class in the analysis (Non-forest in ~1990 and Forest in ~2000) because it was technically impossible to measure by satellite alone. Indeed, re-growth produces similar reflectance values to those generated by smallholder tree crops and vice versa. In addition the 10 year time interval used here to measure change is too short to measure any substantial re-growth of the forest.

We filtered classification results to remove clumps of pixels whose corresponding size on the earth surface was < 2 ha. We edited classification results visually by on-screen digitizing in areas of haze and in areas of high topographic complexity, where the SEE5 algorithm often produced misclassification errors.

Finally, we digitized logging trails by on-screen digitizing. We digitized logging trails for ~1990 and for ~2000. Small-scale logging by local communities lacking heavy equipment remained undetected.

Accuracy assessment
We employed high-spatial resolution IKONOS and QUICKBIRD imagery as reference information to validate the accuracies of the LANDSAT ETM+-based ~2000 forest cover map. The reference imagery was acquired in ~2000 and within less than a year difference from the LANDSAT acquisition date (Table2). The reference imagery were scattered across 7 sites from north to south to encompass the primary forests and adjacent agricultural areas over Sumatra's full geographic range.
We generated a confusion matrix by assigning either forest or non-forest classes to 479 points on the LANDSAT-TM ~2000 forest map and the reference images (IKONOS/QUICKBIRD-based). These points were chosen randomly, but with a separation distance of 1000 m between two points to minimize the effects of spatial autocorrelation. From each confusion matrix, we calculated the overall accuracy, *p* and the kappa coefficient, *k*. We could not validate the accuracy of the ~1990 forest map because we did not possess reference information for that year.

Accuracy results
We have generated a map of forest cover and of deforestation at the very fine spatial scale of 1 ha with high classification accuracy (p=95.8%, kappa statistics, k=0.9) appropriate for analyzing fine scale changes in forest cover. Nevertheless, our accuracy assessments were conducted on just a 3-5% spatial subset, and therefore the accuracy presented in this study may vary across the study area.

Were any outputs unrealized? If so, how has this affected the overall impact of the project?

All outputs have been achieved

V. SAFEGUARD POLICY ASSESSMENTS

Provide a summary of the implementation of any required action toward the environmental and social safeguard policies within the project.

Non applicable

VI. LESSONS LEARNED FROM THE PROJECT

Describe any lessons learned during the various phases of the project. Consider lessons both for future projects, as well as for CEPF's future performance.

At the time of its release to stakeholders, the map is already 6-7 years out-of-date.
Future mapping projects may need to include provision for satellite data up to present so as to generate an up-to-date product at the end the project.

Project Design Process: (aspects of the project design that contributed to its success/failure)

The highly efficient change detection method used for this project and designed by CI-CABS has contributed to the success of this project.

Project Execution: (aspects of the project execution that contributed to its success/failure)

An excellent communication line between CI-CABS and WCS Indonesia has been instrumental to the success of this project.

VII. ADDITIONAL FUNDING

Provide details of any additional donors who supported this project and any funding secured for the project as a result of the CEPF grant or success of the project.

Donor	Type of Funding*	Amount	Notes

Additional funding should be reported using the following categories:

- ***A*** *Project co-financing (Other donors contribute to the direct costs of this CEPF project)*
- ***B*** *Complementary funding (Other donors contribute to partner organizations that are working on a project linked with this CEPF funded project)*
- ***C*** *Grantee and Partner leveraging (Other donors contribute to your organization or a partner organization as a direct result of successes with this CEPF funded project.)*
- ***D*** *Regional/Portfolio leveraging (Other donors make large investments in a region because of CEPF investment or successes related to this project.)*

Provide details of whether this project will continue in the future and if so, how any additional funding already secured or fundraising plans will help ensure its sustainability.

We are currently seeking funding to update the map till 2006-2007. We haven't secured any funding yet. Yet we hope that the World Bank will be interested to fund an update.

VIII. ADDITIONAL COMMENTS AND RECOMMENDATIONS

Several stakeholders from the government of Indonesia and from international organizations have asked why the project did not include provision to map forest cover and deforestation up till 2006-2007 so that the map would be useful for assessing outcomes/impact in the corridors which received CEPF investment?

VIII. INFORMATION SHARING

CEPF aims to increase sharing of experiences, lessons learned and results among our grant recipients and the wider conservation and donor communities. One way we do this is by making the text of final project completion reports available on our Web site, www.cepf.net, and by marketing these reports in our newsletter and other communications. Please indicate whether you would agree to publicly sharing your final project report with others in this way.

Yes

If yes, please also complete the following:

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