



## **A Preliminary Assessment of High Conservation Value Forest in the Green Corridor, Thua Thien-Hue Province, Viet Nam**

### ***Milestone 6 Report***

#### **Earth Observation Support for Traditional Ecological Mapping and Biodiversity Conservation in Viet Nam (EO-STEM) Project Work Package No. 2**

**August 2006**

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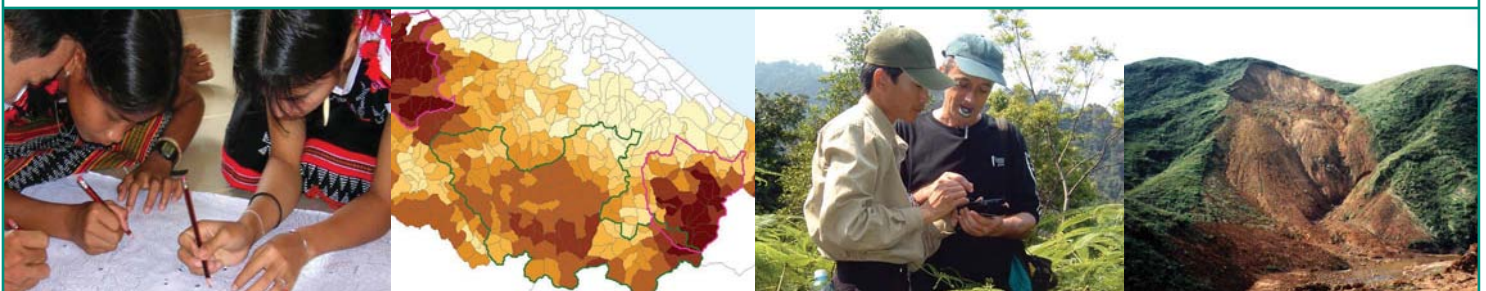
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**A PRELIMINARY ASSESSMENT OF HIGH  
CONSERVATION VALUE FOREST  
IN THE GREEN CORRIDOR,  
THUA THIEN-HUE PROVINCE, VIET NAM**

**MILESTONE 6 REPORT**

**EARTH OBSERVATION SUPPORT FOR TRADITIONAL  
ECOLOGICAL MAPPING AND BIODIVERSITY  
CONSERVATION IN VIET NAM (EO-STEM) PROJECT**

(CONTRACT NO. 9F028-4-5007/01)

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## LIST OF ACRONYMS

<u>ACRONYM</u>	<u>DESCRIPTION</u>
CSA	Canadian Space Agency
CTS	Central Truong Son
DARD	Department of Agriculture and Regional Development
EO	Earth Observation
EOADP	Earth Observation Application Development Program
FIPI	Forestry Inventory and Planning Institute
GCP	Green Corridor Project
GEF	Global Environment Fund
GIS	Geographic Information Systems
HCVF	High Conservation Value Forest
Lao PDR	Lao People's Democratic Republic
MARD	Ministry of Agriculture & Rural Development
NTFP	Non-Timber Forest Products
SNV	Stichting Nederlandse Vrijwilligers (Dutch International Development Agency)
SPOT	Système Pour l'Observation de la Terre
TEK	Traditional Ecological Knowledge

## ACKNOWLEDGEMENTS

The *Green Corridor Project (GCP): meeting global conservation targets in a productive landscape* is a four-year initiative that commenced in June 2004 with funding through the World Bank - Global Environment Facility (GMOA5301). The GCP also receives co-funding from the WWF Greater Mekong Programme, Thua Thien-Hue Provincial People's Committee and SNV (Dutch International Development Agency).

The Earth Observation Support to Traditional Ecological Mapping and Biodiversity Conservation in Viet Nam (EO-STEM) Project is funded by the Canadian Space Agency (CSA) Earth Observation Application Development Program (EOADP).

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The EO-STEM Project team would like to thank Mr. Hoang Ngoc Khanh, Director of Thua Thien-Hue Provincial Forest Protection Department, Dr. Chris Dickinson and Ms. Tran Minh Hien, WWF, for their support and input to the EO-STEM Project.

## 1.0 INTRODUCTION

This report presents results from activities undertaken as part of the Earth Observation Support for Traditional Ecological Mapping and Biodiversity Conservation in Viet Nam (EO-STEM) Project. The main objective of the EO-STEM Project is to provide technical support to the Government of Viet Nam through the Green Corridor Project (GCP), which is being implemented in Thua-Thien Hue (TT-Hue) Province by WWF and TT-Hue Forest Protection Department (FPD). The goals of the EO-STEM Project are directly linked with those of the GCP, which aims to maintain and sustain the rich biodiversity of the Green Corridor area in TT-Hue Province. A key output and focus of the project is the demonstration of the application of Earth Observation (EO) data for biodiversity conservation and management for WWF, TT-Hue Province and other partners.

### 1.1 AIM OF THE CONSERVATION VALUE ASSESSMENT

The forests of the Green Corridor are largely under-surveyed for most plant and animal groups, and the knowledge biodiversity is far from complete. In addition, the existing landscape-level forest habitat information is considered out-of-date, too coarse for effective conservation planning, and of undocumented accuracy, which introduces a degree of uncertainty and potential for error.

The aim of the assessment of high conservation value forest (HCVF) is to integrate new information produced by the GCP and EO-STEM projects to identify potential areas of conservation priority. The outputs of this preliminary assessment will provide inputs to for Provincial decision-making related to conservation zonation.

The activities required in order to meet the overall aim are:

- Identification of the factors that influence landscape conservation value;
- Identification of landscape-level data for each factor;
- Develop a flexible model for conservation value assessment that includes the concepts of rating and weighting of input factors;
- Application of the model and production of a preliminary conservation value assessment;
- Interpretation of landscape conservation value, identifying opportunities for decision-makers to influence (weight) individual inputs to address the needs and desires of the planning process; and
- Critique of the model, in order to identify uncertainties and potential areas for improvement.

## 1.2 STRUCTURE OF THE DOCUMENT

Following the introduction and background, the report includes five main sections:

- *Section 3* introduces the landscape-level approach to conservation zonation analysis that was used in this project;
- *Section 4* outlines the methods used to perform the conservation zonation analysis, including Geographic Information System (GIS) and Earth Observation (EO) tools that were employed, and description of the data and criteria used in the analysis;
- *Section 5* presents the results of the conservation zonation analysis and introduces supporting contextual data that could be used by decision-makers when developing a final zonation; this process would determine the areas of HCVF to be protected;
- *Section 6* discusses the results of the conservation zonation analysis and reviews the process of weighting criteria with decision makers, thus taking into account additional considerations and priorities; and
- *Section 7* presents possible future work activities.

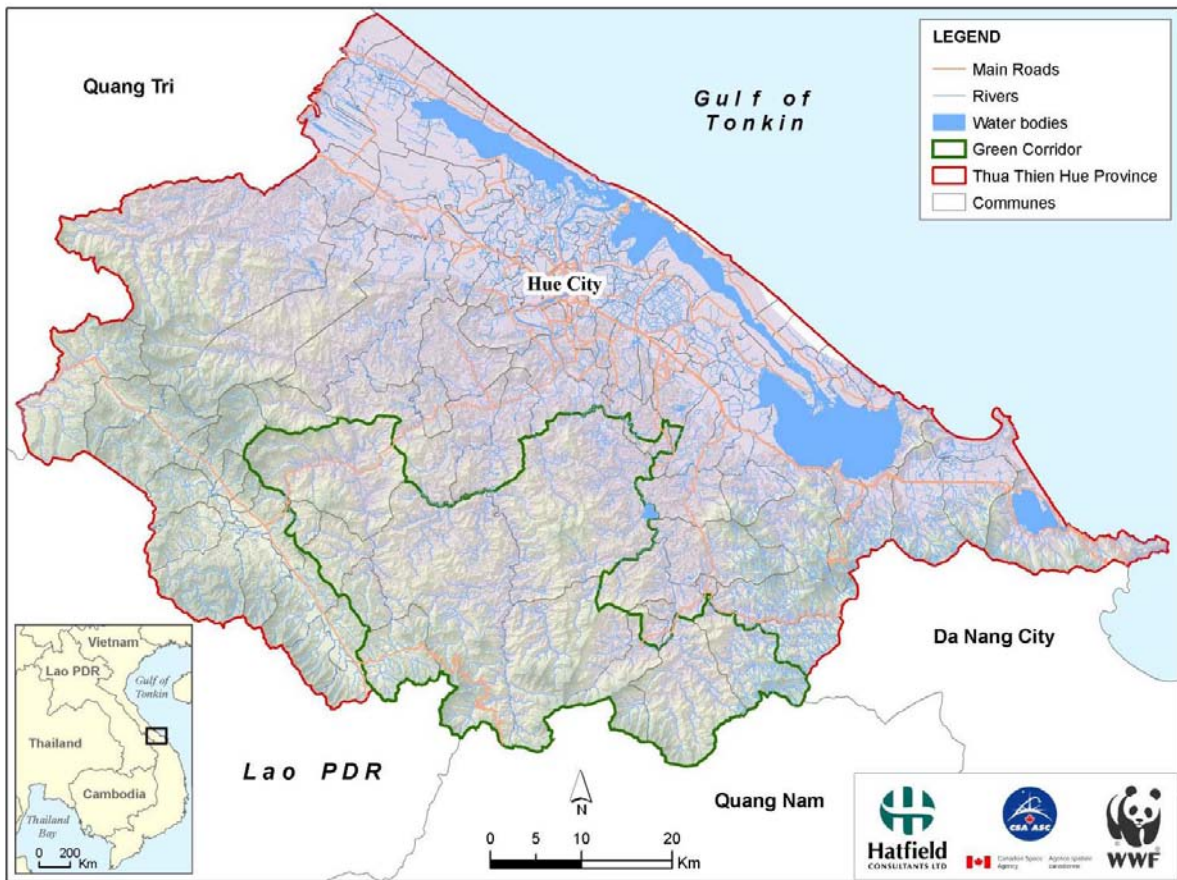
This report is supported by a set of appendices provided at the end of the main document.

## 2.0 BACKGROUND

### 2.1 THE GREEN CORRIDOR

The Green Corridor area has been identified through systematic conservation landscape assessments as one of the highest conservation priorities in the Central Truong Son (CTS) mountain range, since it supports some of the last remaining lowland forests in Viet Nam and harbors a wide range of endemic and endangered species such as the Saola (*Pseudoryx nghetinhensis*) (Tordoff *et al.* 2003, IUCN, 2006). The concept of the Green Corridor originally linked a larger area from coastal forest in TT-Hue Province to the Xe Sap Biological Conservation Area in Lao PDR; however, the Green Corridor was eventually defined as comprising eleven Communes in Nam Dong, Huong Thuy and A Luoi Districts. The Green Corridor covers an area over 135,000 hectares, stretching between Bach Ma National Park and Phong Dien Nature Reserve (Figure 1).

**Figure 1** Thua Thien-Hue Province and the Green Corridor Project area.



## **2.2 GREEN CORRIDOR PROJECT**

The GCP is a four-year initiative that started in June 2004, which is implemented by WWF Greater Mekong Programme and TT-Hue Province FPD. The project receives funding from the World Bank (Global Environmental Facility), WWF, TT-Hue Provincial Peoples' Committee and SNV (Dutch International Development Agency).

The primary objective of the GCP is to protect and maintain the biodiversity rich forests of the Green Corridor forest landscape, which comprises parts of three districts of TT-Hue Province (Figure 1). The Green Corridor is under extreme threat from illegal logging, hunting, and the impacts of unsustainable development.

The secondary objective of the GCP is to establish a replicable model for protection and maintenance of high global conservation values in multiple-use forest landscapes of strategic importance for biodiversity conservation. The GCP develops methodologies for achieving multiple benefits from forest management in productive landscapes, and conducts urgently needed direct interventions to combat the threats to the biodiversity of the Green Corridor. To achieve this, the GCP works with forest managers, local communities and provincial government, including sectoral development planners.

The GCP takes a landscape-level approach and envisages a network of protected areas, production and protection forest, and community forests to ensure that the biodiversity unique to the area is conserved. This approach is different to a traditional protected area approach to biodiversity conservation, which aims to delineate areas for strict protection and to establish a zone around the isolated forest in which use is minimized. Through systematic assessment of landscape biodiversity value, a key output of the GCP is a conservation zonation plan and participatory conservation agreements reduce conflicting plans and strategies and will ensure that conservation goals are achievable. Ultimately, the GCP aims to develop a productive landscape in which local communities benefit from improved conservation and resource management and are not adversely impacted by inappropriate development actions at district, provincial or national level.

## **2.3 EO-STEM PROJECT**

The EO-STEM Project is funded by the Canadian Space Agency (CSA), through the Earth Observation Application Development (EOADP) Program. Hatfield Consultants Ltd. leads the EO-STEM Project with assistance from a number of Canadian partners, including Strata360 & ÆRDE Environmental Research.

The objectives of the EO-STEM Project are:

1. Provide the WWF and the Government of Viet Nam (GoVN) with a spatial framework for efficient conservation management and planning;
2. Demonstrate proven Canadian Earth Observation (EO) technologies to produce products to support the Government of Viet Nam's and WWF's biodiversity conservation in the Green Corridor of Viet Nam through the Green Corridor Project (GCP);
3. Use participatory processes to document traditional ecological knowledge (TEK);
4. Develop a (spatial) framework for integrating EO into on-going biodiversity and forest conservation monitoring and evaluation (M&E) systems;
5. Ensure long-term sustainability of the project by providing capacity building and training in EO technologies to District, Provincial and National biodiversity conservation personnel; and
6. Produce a replicable model for integrating EO into regional biodiversity and conservation management, through the effective demonstration of EO and GIS-based biodiversity products.

This document summarises activities conducted for EO-STEM Work Package No. 2: *Develop and Demonstrate Earth Observation Products and Services for Biodiversity Conservation Planning*. The report was prepared to fulfill obligations as per Hatfield Consultants Ltd's contract with the Canadian Space Agency (Contract No. 9F028-4-5007/01).

### **3.0 GREEN CORRIDOR CONSERVATION VALUE ASSESSMENT**

There are many methods for prioritizing land for conservation or social importance. Forests are defined as having high conservation value where environmental or socioeconomic values are considered to be significant. The concept of HCVF in Viet Nam was reviewed by Pollard (2004); the review defines conservation value as:

*Related to the function of a forest at a local, regional or global scale. These may be clear functions, such as watershed protection or the maintenance of a food resource for local people. But these functions also include more intrinsic elements such as a community of endemic species which may have no clear economic value but are important for the maintenance of the diversity of life.*

The ideas covered in HCVF provide a relatively simple framework for combining environmental and social factors into one value; however, implementation of a HCVF assessment is not straightforward given the range of data involved and the requirement for integration. The Biological Assessment of the CTS (Tordoff *et al.* 2004), which originally defined the Green Corridor as a conservation priority, also presented an approach for the integration of various datasets for conservation value assessment; the CTS Biological Assessment did not make explicit reference to the HCVF concept.

Section 3.1 describes the overall approach taken to assess conservation value for the Green Corridor; Section 3.2 describes the tools used; and Section 3.3 to 3.6 describe important assessment factors and the methodology in more detail.

#### **3.1 OVERALL APPROACH FOR GREEN CORRIDOR ASSESSMENT**

Conservation action undertaken by the GCP must be based on systematic conservation value analysis. The approach developed by the EO-STEM team to assess conservation value in the Green Corridor is based upon the practice of multi-criteria (decision support) analysis, which is often conducted using computer-based Geographic Information Systems (GIS). Multi-criteria analysis provides a formal mechanism for integration and processing of information 'layers' to derive optimal recommendations for confronting complex questions; for more details, see Malczewski (1999).

An example of a multi-criteria assessment is the CTS Biological Assessment (Tordoff *et al.* 2003); the EO-STEM assessment for the Green Corridor is similar to the CTS Biological Assessment, but the spatial scale of the EO-STEM assessment is more detailed and additional analyses are undertaken. The Green Corridor assessment also attempts to be aligned with the concept of HCVF and to address the conservation values in the HCVF framework. Further, an attempt is made to ensure that the steps in the Green Corridor assessment are very clearly defined, to allow for stakeholder engagement and modification.

The Green Corridor assessment is based on two main groups of factors:

1. Biophysical landscape descriptors – describe biological and physical aspects of landscape processes that are important to maintain landscape integrity; and
2. Zonation modifiers – a group of factors that represent human value judgments regarding the relative importance of components of the landscape, conservation values and management priorities.

In addition to these factors, conservation zonation decisions are also based on threats – factors that are anthropogenic in nature and pose a threat to identified conservation value. These threat factors are mainly related to proximity to human influence (agricultural encroachment and the influence of roads) are also introduced for context.

## **3.2 TOOLS FOR LANDSCAPE-LEVEL ASSESSMENT**

### **3.2.1 Geographic Information Systems**

GIS have a wide variety of applications in natural resource management, but one of the key strengths of GIS is spatial modelling. Modern GIS software allows the user to describe geographic features using both vector and raster data models. Vector data models allow the user to represent discrete and thematic features using points, lines and polygons. Raster data models use grid-based images to represent continuous and thematic data as layers or surfaces of numerical values.

Raster layers can be used in numerical modelling, where layers can be processed using functions and operators in a raster calculator or map algebra framework. This powerful and efficient processing capability is extremely useful when analysing landscape features. In the context of conservation and biodiversity management, it is possible to assign a rating of high, medium and low *conservation value* to individual layers, weight them according to their importance, and combine them to derive output layers that can be used to guide decision-making in the zonation processes. An additional benefit of this approach is that weights can be modified during the decision-making process in order to test and demonstrate different scenarios.

GIS is known as a very effective tool for spatial modelling for landscape-level conservation assessment and zonation; however, the integration of different data requires careful consideration and planning.

### **3.2.2 Remote Sensing**

Remote sensing provides a unique perspective of the Earth's surface. Remote sensing can provide images over wide areas, irrespective of administrative borders. Modern optical satellite sensors capture imagery in digital format in several parts of the electro-magnetic spectrum (different reflected energy levels)

creating images with more information that the human eye can see. This information can be analysed and processed to create maps of land cover that, with field validation, can be very accurate and cost-effective compared to large-scale field surveys for the same area.

Remote sensing was used as part of the EO-STEM Project to develop a classification of forest cover in the Green Corridor; as described in subsequent sections, this classification is valuable as an input to the conservation value assessment.

### **3.3 BIOPHYSICAL LANDSCAPE DESCRIPTORS**

For the Green Corridor assessment, the Hatfield team defined a set of Biophysical Landscape Descriptors, which aim to determine specific aspects of landscape conservation value. There are four biophysical landscape descriptors, which are discussed in more detail below:

- Watershed protection;
- Integrity of surface water resources;
- Forest integrity; and
- Biodiversity value.

#### **3.3.1 Watershed Protection**

Forests provide ecosystem services in terms of regulating climate and hydrology; in particular, forests play a significant role in stabilizing soils. Vegetation cover can reduce direct erosion from rainfall, and the binding of roots and plant matter can secure soils, contributing to the prevention of landslides. This watershed protection function of forests can be viewed at two scales: a local scale where forest cover may prevent landslides and the erosion of farming or residential land; and, a large scale where erosion and the silting up of river systems can affect agriculture, fisheries and coastal and marine ecosystems.

The value of forests for maintaining watershed integrity depends on the particular physical characteristics of the landscape. The spatial data required to assess watershed integrity value include:

- Elevation - land at higher elevations may be more susceptible to erosion;
- Slope - steeper slopes are naturally more susceptible to erosion and landslides;
- Soil type - certain soil types are more erodable; and
- Rainfall - high rainfall or high frequency of extreme rainfall events can increase the risk of erosion and landslides.

### 3.3.2 Integrity of Surface Water Resources

The biodiversity value of natural forest close to a river may be considered greater than forest further away. Forests can protect local water supplies and enhance the biodiversity of river and lake ecosystems, and hence riparian areas have considerable value for conservation.

To determine the landscape-level value forests in ensuring integrity of surface water resources, spatial data required includes rivers and natural forest; subsequently, spatial analysis to determine the proximity of the forest to rivers is an essential element to assess conservation value.

### 3.3.3 Forest Integrity

Deforestation in South East Asia is an important conservation concern, and large landscape-level forests are becoming increasingly rare. Pollard (2004) identified the value of 'large forests' that may contain viable populations of all (or most) species. This conservation value is concerned less with species and more with the value of large-scale forests; it aims to identify forest that is still in a natural state, i.e., forest that is relatively undisturbed by recent anthropogenic activities such as plantations, industrial harvesting of timber, farming encroachment, and road building. Larger blocks of forest are intrinsically more important for conservation than blocks of similar forest that are smaller in size; however, this assessment is strongly influenced by the scale of available forest data.

The basis of the descriptor used in the Green Corridor assessment is that *any* forested area may form important component of larger forest landscape, and provide important connectivity between blocks of natural forest; any local forested areas may have higher conservation value as a component of a larger forest landscape.

The spatial data required for characterizing landscape forest integrity include information on natural forest cover and non-forested areas that represent the 'landscape matrix'. Spatial analysis is essential to determine the context of each forested location and the degree to which it forms part of a continuous larger forested area (i.e., the local level of forest connectivity in the surrounding landscape).

### 3.3.4 Biodiversity Value

Forest containing globally, regionally or nationally significant concentrations of biodiversity values is considered to be a high conservation priority. The emphasis should be on globally significant biodiversity that is rare or endangered, as defined by the most recent IUCN Redlist of Rare and Endangered Species.

Biodiversity value may be determined through *direct* information (e.g., through spatially distributed information on biodiversity from biodiversity surveys),

where location information for each positive observation of individual species was recorded. An alternative *indirect* way of assessing landscape biodiversity value is through an assessment of forest habitats, for example mapped using remote sensing imagery.

The spatial data used to assess biodiversity values are either biodiversity survey data (with location data for each observation), or forest habitat maps that distinguish between ‘biodiversity rich’ natural forest types.

### **3.4 ZONATION MODIFIERS**

Three conservation value Zonation Modifiers were developed by the Hatfield team for the Green Corridor assessment:

- Forest elevation;
- Protected areas; and
- Community use value.

In addition, data concerning threats were also developed, including the important threat caused by access to an area by road.

#### **3.4.1 Forest Elevation**

The CTS biological assessment (Tordoff *et al.* 2003) identified lowland forest habitats (less than 300m) as a conservation priority, based on the judgment that certain rare forests (in terms of elevation) have higher value. For the Green Corridor assessment, a similar approach was defined to add additional conservation value to lowland forests across different ranges of elevations.

To define conservation values for lowland forest, the required data are the area of natural forest cover and elevation.

#### **3.4.2 Protected Areas**

Practical conservation management considerations may increase the value of forest if it is close in proximity to existing protected areas; this may be related to costs of enforcing protection and the advantages of buffer areas. Subsequently, forest has increased value based on proximity to existing protected areas.

The spatial data required to create this modifier is the boundaries of existing protected areas. In addition, spatial analysis is required to determine proximity to protected areas.

#### **3.4.3 Community Use Values**

According to the HCVF framework, forest areas that are fundamental to meeting basic needs of local communities may be judged to have higher conservation

value; these areas protect the basic subsistence and security of local communities. The needs should be related to sustainable use of forest for essential food, fuel, and medicine.

For the Green Corridor assessment, there is a range of local statistics that would be useful for defining this zonation modifier, for example income and proportion of household income from forest; however, such statistics can be difficult to obtain. In addition, in the Green Corridor, many rural Communes cover relatively large areas, in which there is likely considerable variation in community forest value.

If data is unavailable from local governments, or unsuitable, an approach to collect required data is to conduct participatory mapping assessments with local communities in order to collect 'traditional knowledge' related to the history of settlement, community land use, and community biodiversity use; these mapping assessment may enable the identification of areas of forest that are fundamental to meeting the needs of local communities.

## **3.5 THREATS**

The remaining factors in the Green Corridor assessment are threats to conservation value. Threats are important considerations for a conservation zonation planning process, but are not descriptors of actual conservation value. For the Green Corridor, selected *Threat Factors* are listed below, but were not integrated into the Green Corridor conservation value assessment; these factors can be used in the decision-making process to assist in the determination of weighting values.

### **3.5.1 Threat from Roads**

The proximity of roads to HCWF is an important consideration for decision-makers; depending on their judgments, road proximity may increase or decrease an area as a conservation priority in the zonation process. Threat from the improved access to the forest that a road provides may increase the costs of surveillance and lead to a decision to focus protection on other areas. Alternately, the priority for conservation might be to actively mitigate the impact of roads, considering that areas that are difficult to access are already protected by their isolation.

The spatial data used to describe this modifier are:

- Existing roads – with differences among different types of road (e.g., paved and unpaved); and
- Planned roads.

### 3.5.2 Other Threats

A range of other threats that maybe considered by decision-makers; depending on data availability, other threats may include:

- Hydroelectric developments;
- Logging and mining activities;
- Hunting intensity;
- Opening of agricultural land; and
- Population density.

## 3.6 SYNTHESIS OF CONSERVATION VALUE FACTORS

This section describes the analytical model developed for the Green Corridor conservation value assessment, which integrates the available data for the factors above to provide an overall conservation value. A description of the **rating** of each factor is provided, and also the potential opportunity for prioritization of factors through **weighting**. Finally, technical details regarding the methods used to create the input factors used in the model are provided.

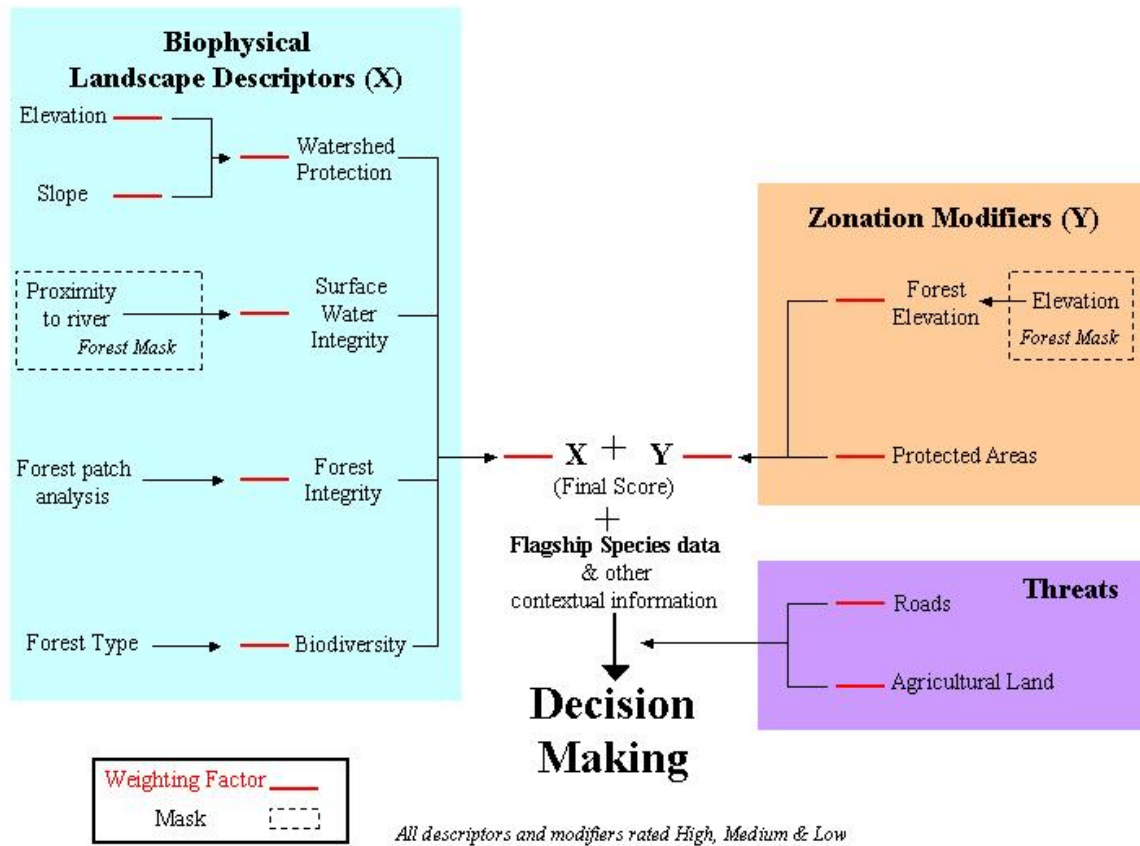
### 3.6.1 Conservation Value Assessment Model

A graphical overview of the synthesis of the Biophysical Landscape Descriptors and Zonation Modifiers used in the Green Corridor conservation value assessment is provided in Figure 2. The overall conservation value for each location in the Green Corridor is the sum of the scores obtained for each factor. Factors are **rated** High, Medium or Low in terms of conservation value, which provide scores of 3, 2, and 1 respectively; a location can also score zero for a particular factor.

The relative importance of each factor in the assessment is important for the decision making process; therefore, the assessment model is designed in to allow the **weighting** of individual factors or weighting of each class of factors (Biophysical Landscape Descriptors and Zonation Modifiers). The red lines indicate the opportunities for stakeholders to apply weightings to different parts of the model, thus increasing the importance or relevance of that factor - weightings are not applied in the current analysis.

Biophysical Landscape Descriptors (X) and Zonation Modifiers (Y) are the core of the model, which are the combination of the set of factors. The Biodiversity Data collected for the Green Corridor Project is used to provide additional context and are important during the decision making process. Some factors were subject to a mask, which eliminates certain areas (i.e. allocates zero value) based on a threshold. For example, for the Forest Elevation factor, all areas above a certain elevation are masked from the analysis.

**Figure 2 Green Corridor HCVF assessment model.**



NOTE: **Rating** of each factor into high, medium, and low scores and a **weighting** of each factor during integration can be changed; the final ratings and weightings can be established in consultation with stakeholders.

Threats reveal areas that are at greatest risk of negative impacts. Where threats data can be represented as maps, they can be used with the overall conservation value to provide additional perspectives on conservation value in consultation with stakeholders.

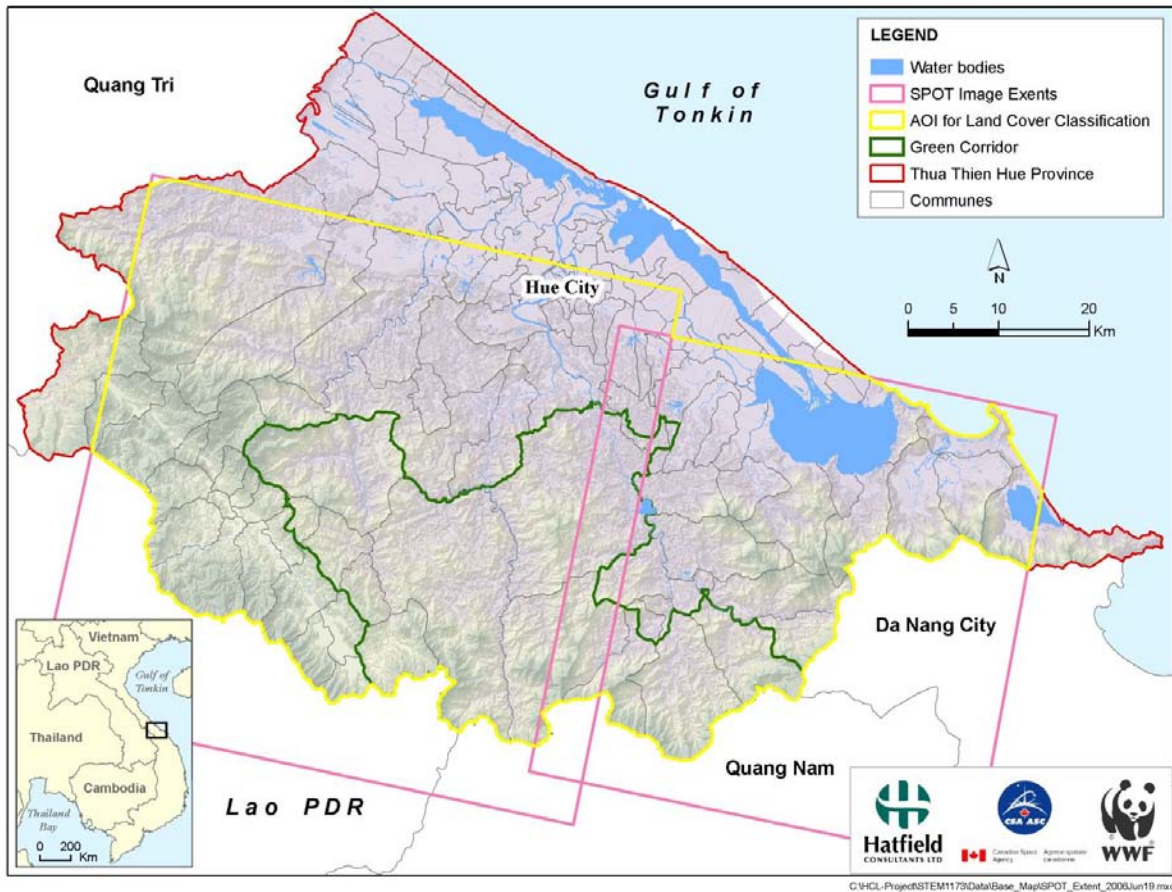
### 3.6.2 Data Availability

For the Green Corridor assessment, there were some limitations in the available data for use in the model; Table 1 provides a description of the available data. With the exception of the satellite imagery and its derived products, descriptions of the source, age, and accuracy of the data are not known for the Provincial datasets; this uncertainty has to be considered when interpreting the model outputs. The original mapping scale of most of the data is not known, so the scale of the elevation model (20 m) was used as a 'base scale' for the purposes of integration using raster-based GIS analysis.

Also, geographic coverage of some data layers is not complete for the whole province. The coverage of SPOT-5 satellite data acquired by the EO-STEM Project covered the Green Corridor and most of the Province, but some areas are not included in the forest map. Three areas were omitted from the analysis: one small area in the far east of the province, to the north east of Da Nang City; a second small area in the far West of the province, along the border with Quang Tri Province; and, a larger lowland area to the north and west of Hue City, which is mostly non-forest. These areas are illustrated in Figure 3.

Table 1 lists the data available used in the conservation value assessment, including details of a data provider, the mapping scale used in its creation, and a short description of the data layer.

**Figure 3 The Green Corridor area and coverage of SPOT-5 imagery, EO-STEM Project.**



**Table 1 Summary of available data and use for green Corridor HCVF assessment.**

<b>Data Layer</b>	<b>Provider</b>	<b>Scale</b>	<b>Description / Assessment</b>
Forest cover	EO-STEM	1:50,000	Classification of natural forest, plantation and non-forest land-use using 2004 and 2005 SPOT-5 satellite imagery. <ul style="list-style-type: none"> <li>• Accuracy assessment</li> </ul> See EO-STEM technical document for details (Hatfield 2006)
Land use	Province	1:50,000	Production, Protection and Special-use forest. <ul style="list-style-type: none"> <li>• Age of dataset unknown (data set to be re-evaluated by the Province by end of June 2006)</li> </ul>
Hydrology	Province	1:50,000	Rivers, streams, lakes <ul style="list-style-type: none"> <li>• Original source and age of dataset unknown</li> <li>• Rivers do not form a connected network – river and stream data merged so that hydrological network is complete</li> </ul>
Roads	Province	1:50,000	Existing roads only <ul style="list-style-type: none"> <li>• Original source and age of dataset unknown</li> <li>• Classification of roads unclear</li> </ul>
Socio-economic	EO-STEM	1:50,000	Socio-economic statistics at Commune-level provided from the Department of Natural Resources and Environment: <ul style="list-style-type: none"> <li>• No. of villages</li> <li>• Total of households</li> <li>• Population</li> <li>• % Poverty</li> <li>• Non-Timber Forest Products (NTFP) potential (high, medium, low)</li> <li>• Forest use/dependence (high, medium, low)</li> </ul>
Elevation	EO-STEM	1:50,000	Digital Elevation Model (DEM) created from Province digital contour data. Some processing and editing required. <ul style="list-style-type: none"> <li>• Original source and age of dataset unknown</li> <li>• Quality issues related to disconnected contours</li> </ul>
Slope	EO-STEM	1:50,000	Calculated from DEM Slope in degrees at each grid location
Rainfall	Prov.	N/A	Tabular data of monthly average rainfall for 3 Provincial meteorological stations. <ul style="list-style-type: none"> <li>• No coordinates for station locations</li> </ul>
Biodiversity data	GCP	N/A	Locations of area of biodiversity surveys and species lists for: birds, plants and trees, primates, amphibians, and butterflies. <ul style="list-style-type: none"> <li>• No coordinates for location of individual observations</li> <li>• Lack of presence and absence data</li> </ul>
Forest units	Prov.	1:50,00	Forest management units <ul style="list-style-type: none"> <li>• Age of dataset unknown</li> </ul>

### 3.6.3 Rating of Factors for the Green Corridor

Individual input factors were rated based on expert judgment; reference to Tordoff et al. (2003) for Forest Elevation. The ratings for each landscape descriptor and zonation modifier are provided in Table 2; each input factor was rated as **High**, **Medium** or **Low** in terms of conservation value.

**Table 2 Landscape descriptor and conservation zonation modifier ratings.**

Value	Units	Note	Rating			
			High (3)	Medium (2)	Low (1)	None (0)
<b>Landscape Descriptor</b>						
Elevation	meters (above mean sea level)		493-1,780	170-493	18-170	0-18
Slope	degrees		25-88	14-25	2-14	0-2
Watershed Integrity (elevation + slope rating)			5-6	3-4	0-2	0
Integrity of Surface Water Resources (proximity to river)	meters	Natural forest mask	0-500	500-1,500	1,500-3,000	>3,000
Forest Integrity	% forest cover					
Biodiversity (forest cover)	N/A		Rich	Medium	Poor	Other
<b>Zonation Modifier</b>						
Forest Elevation <sup>3</sup>	meters (above mean sea level)	Natural forest mask	<300	300-700	700-1200	>1,200
Protected area	meters		0-1000	1,000-2,500	2,500-5,000	>5,000
Roads (distance from)	meters	Main roads	0-500	500-1500	1,500-3,000	>3,000
		Minor roads	-	-	0-500	-
Other threats	meters	Non-forest land mask	0-500	500-1500	1,500-3,000	>3,000

All input factors were assumed equally important in this assessment and no weightings were applied to each factor.

In order to rate specific factors, GIS analysis was required, as described below:

#### ***Watershed Protection:***

Watershed integrity is the sum of the elevation rating and slope rating. Although it was intended to use the official MARD watershed classification system to define this parameter, soil data and rainfall values were not included. Soils data are currently not available for the study area and rainfall values for the three weather stations in TT-Hue Province are in the 'high' class according to MARD watershed classification methodology (Do Xuan Lan, FIPI, pers. comm.); therefore, rainfall scores would not change across the entire study area.

***Integrity of Surface Water Resources:***

This factor was created using GIS analysis of the proximity to rivers and streams, which were then rated (see values in Table 2). This value is only applicable within the natural forest area, so the extent of natural forest as determined in the EO-STEM forest classification (Hatfield 2006) was used to mask, or remove, all non-natural forest areas.

***Forest Integrity:***

This integrity value was created by calculating the proportion of natural forest and non-forest within a 'local landscape area', aiming to define the extent to which an area of natural forest forms part of a larger landscape forest. Using GIS analysis, the percentage coverage of natural forest within a 250m radius of each raster cell was calculated.

***Biodiversity:***

The EO-STEM forest classification (Hatfield 2006) was reclassified using GIS to present forest type as a proxy for biodiversity. According to the typical classification of MARD forest types (Do Xuan Lan, FIPI, pers. comm.), rich, medium and poor natural forest were allocated conservation high, medium and low ratings; all other classes have zero biodiversity value.

***Forest Elevation:***

The EO-STEM forest classification (Hatfield 2006) was used to mask all areas that are not natural forest. As this factor gives higher value to lowland forest, and GIS was used to rate natural forest with higher values for lowland forest based on the elevation data (Table 2).

***Protected Areas:***

Proximity to existing protected area boundaries was determined using GIS analysis; the result was rated as high, medium and low according to the thresholds in Table 2.

***Threats:***

Proximity to roads was calculated using GIS software techniques, which took into account the different impacts of main roads and smaller minor roads/trails. The two types of road were rated using different criteria (Table 2).

Additional contextual threat maps were produced, including commune-level population density based on statistics provided by WWF, and non-forest land derived from the EO-STEM forest classification (Hatfield 2006), which can also be used as an indicator of development pressure.

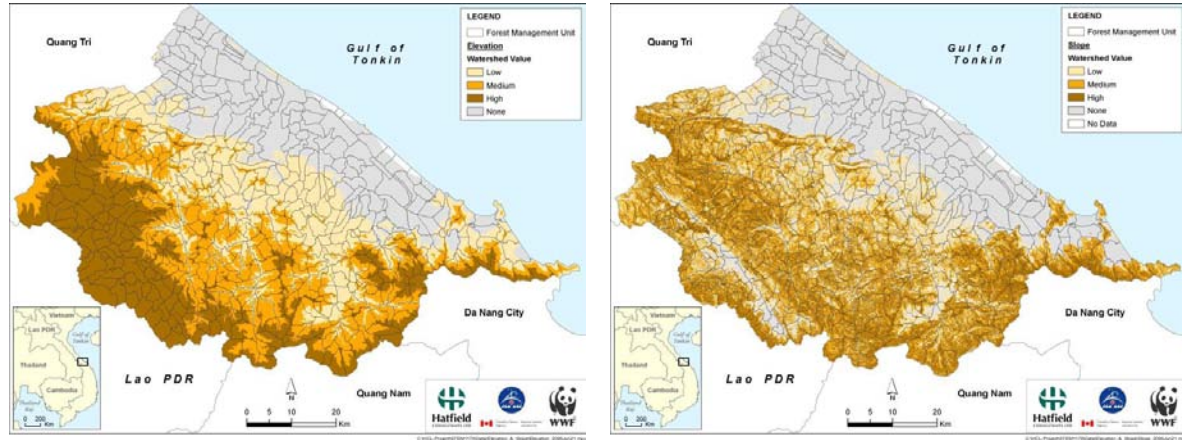
## 4.0 RESULTS

This section provides a summary of the results of the conservation value assessment. The results are presented as individual maps for each factor in the model (Biophysical Landscape Descriptors and Zonation Modifiers) and a map of the final output.

Refer to Figure 4 to Figure 13 for the Biophysical Landscape Descriptors and Zonation Modifiers. Figure 13 is the combined result for the Biophysical Landscape Descriptors (X) and Figure 14 is the combined result for the Zonation Modifiers (Y). Figure 15 is the combined final result, obtained by combining Biophysical Landscape Descriptors and Zonation Modifiers.

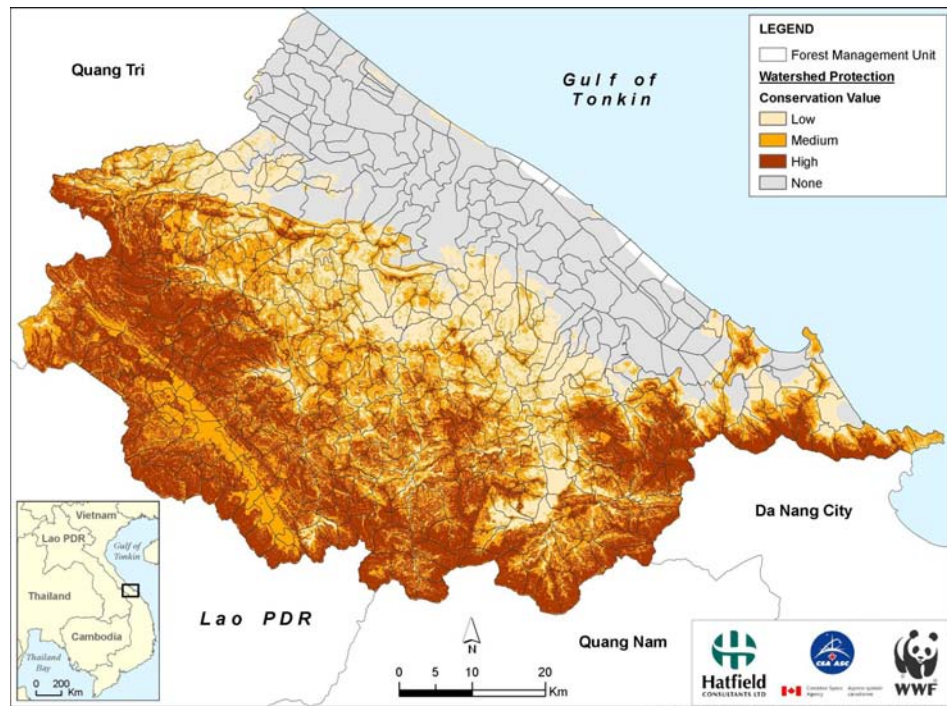
## 4.1 BIOPHYSICAL LANDSCAPE DESCRIPTORS

Figure 4 Conservation value rating for a) Elevation; b) Slope; and c) Watershed Protection, Thua Thien-Hue Province, Viet Nam.



a) Elevation

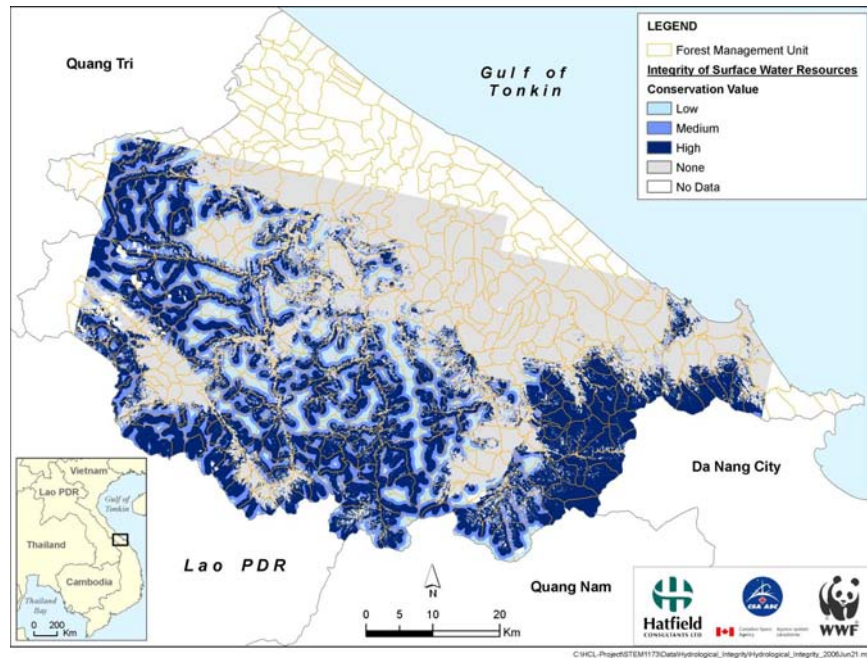
b) Slope



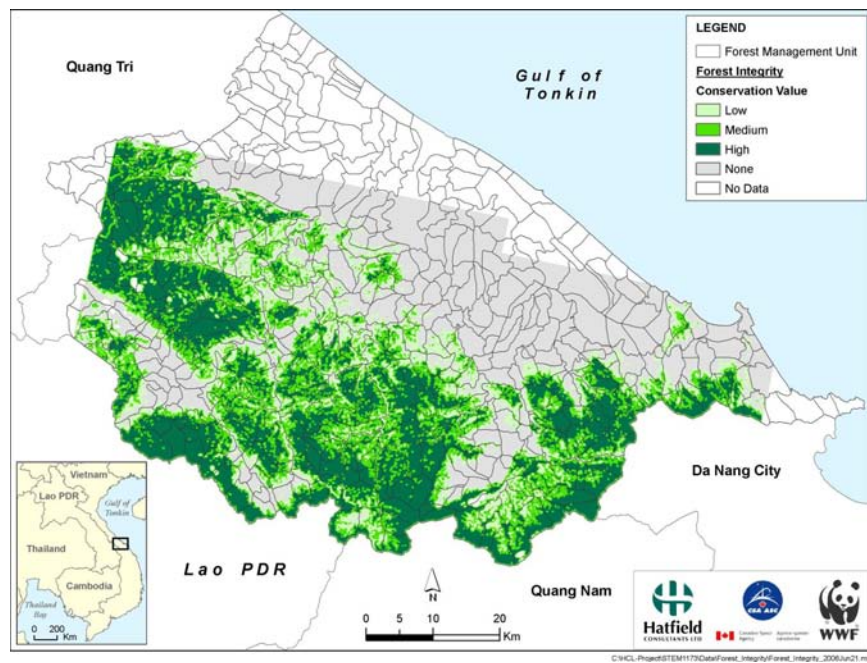
c) Watershed Protection

Watershed integrity = elevation rating + slope rating: low = 0 to 2; medium = 3 to 4; and high = 5 to 6

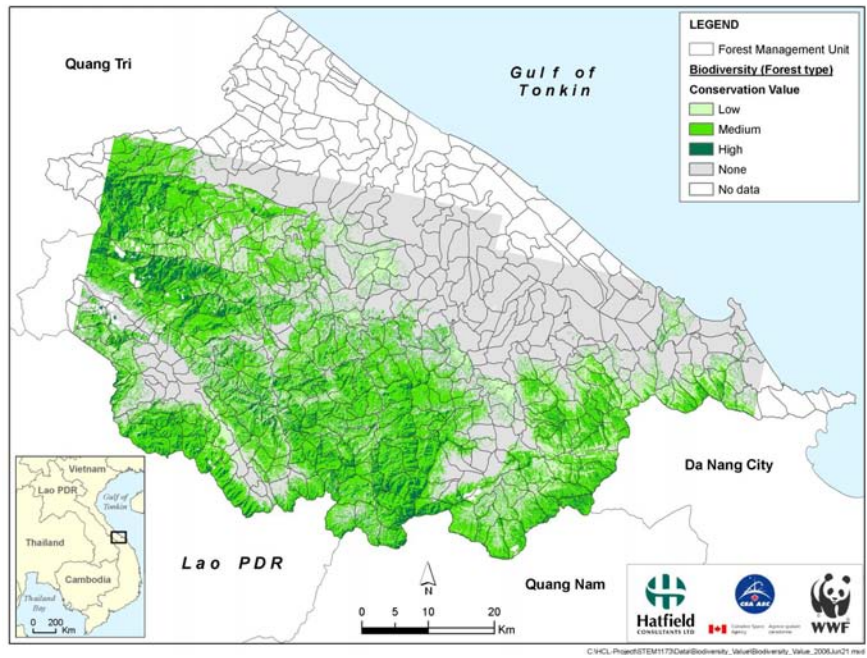
**Figure 5 Conservation value rating for Integrity of surface water resources, Thua Thien-Hue Province, Viet Nam.**



**Figure 6 Conservation value rating for Forest Integrity, Thua Thien-Hue Province, Viet Nam.**

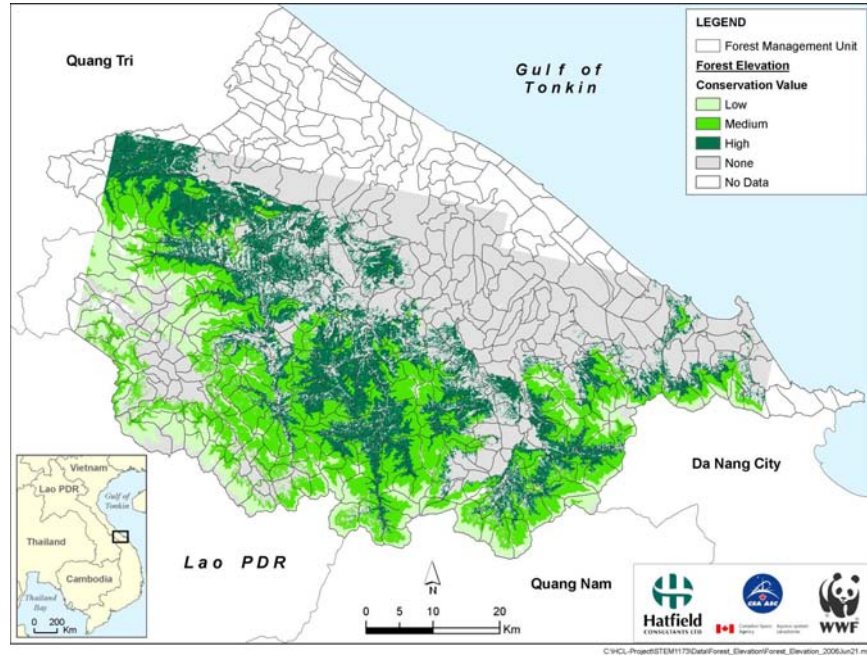


**Figure 7 Conservation value rating for Biodiversity (based on forest type), Thua Thien-Hue Province, Viet Nam.**

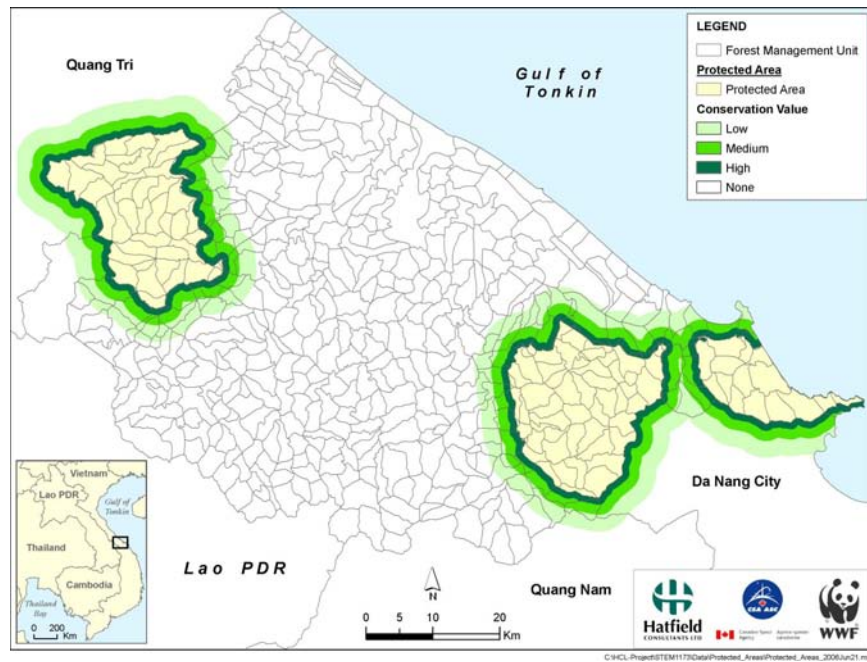


## 4.2 ZONATION MODIFIERS

**Figure 8 Conservation value rating for Forest Elevation, Thua Thien-Hue Province, Viet Nam.**

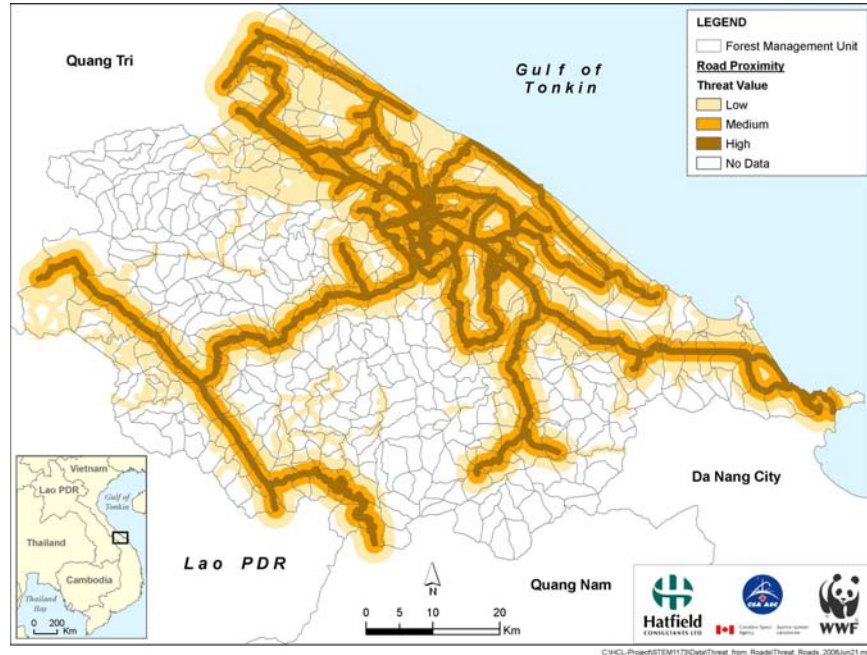


**Figure 9 Conservation value rating for Protected Areas proximity, Thua Thien-Hue Province, Viet Nam.**



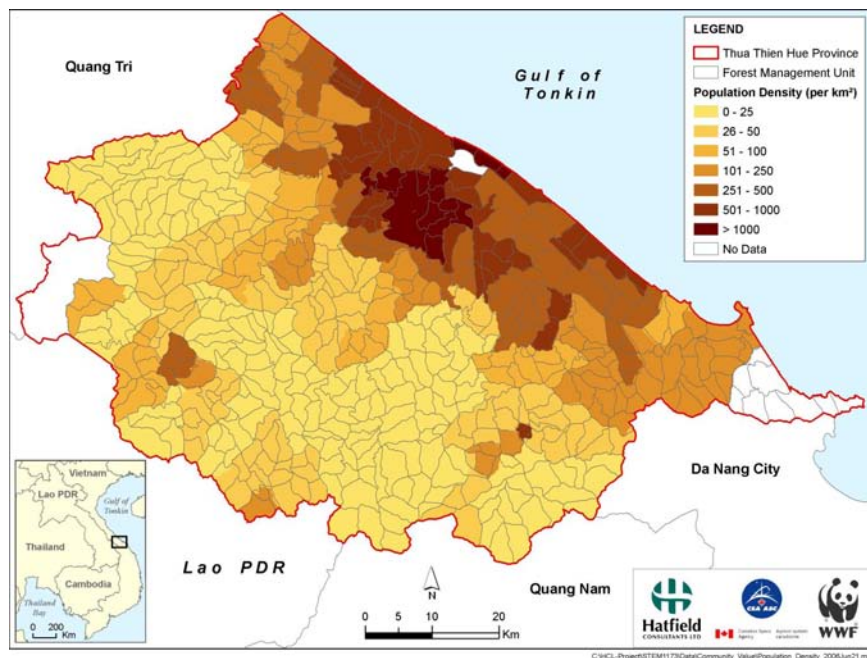
### 4.3 THREATS

**Figure 10 Potential threat to HCVF from roads, Thua Thien-Hue Province, Viet Nam.**



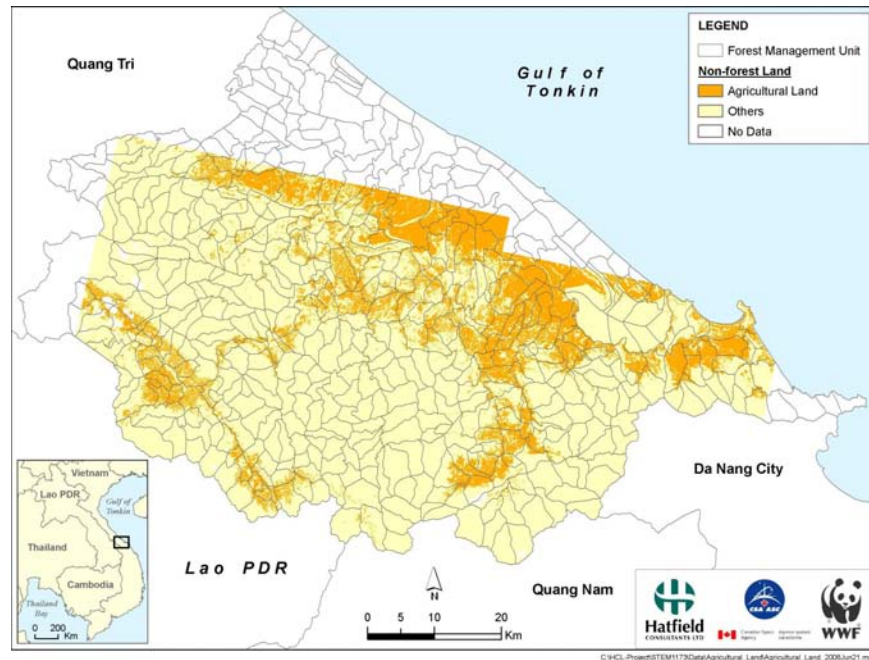
Note: Provided as contextual information for the conservation value assessment.

**Figure 11 Population density, which represents a potential threat to HCVF, Thua Thien-Hue Province, Viet Nam.**



Note: Provided as contextual information for the conservation value assessment.

**Figure 12** Non-forest land, which represents a potential threat to HCVF, Thua Thien-Hue Province, Viet Nam.

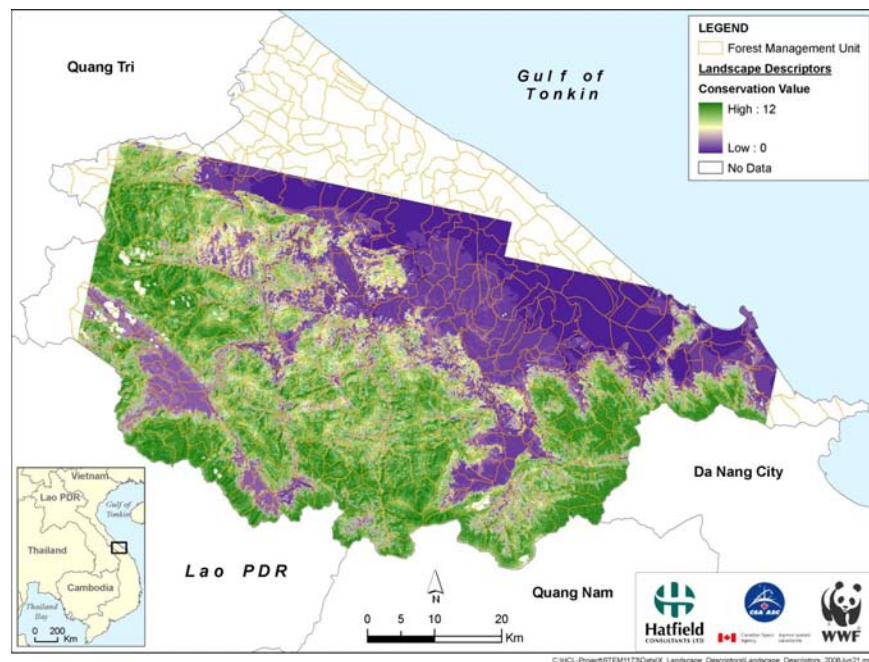


Note: Provided as contextual information for the conservation value assessment.

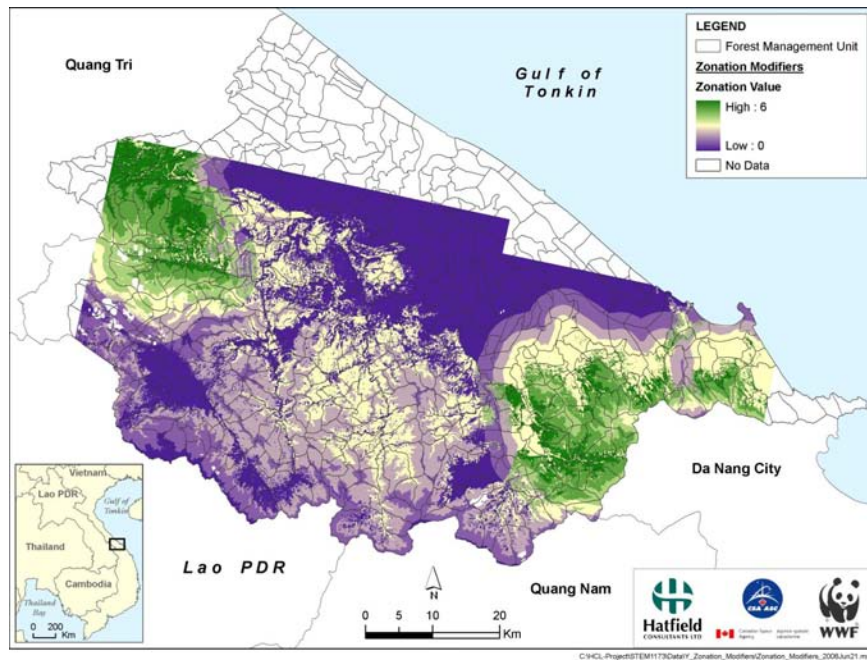
#### 4.4 INTEGRATION OF FACTORS

The biophysical landscape descriptors were integrated by summing the ratings for the individual input descriptors in Table 2; the result is shown in Figure 13, where no weightings have been applied to individual input descriptors. Similarly, the zonation modifiers were summed without weighting of individual modifiers, as shown in Figure 14. The final result is the summation of biophysical landscape descriptors and zonation modifiers without weightings, as shown in Figure 15.

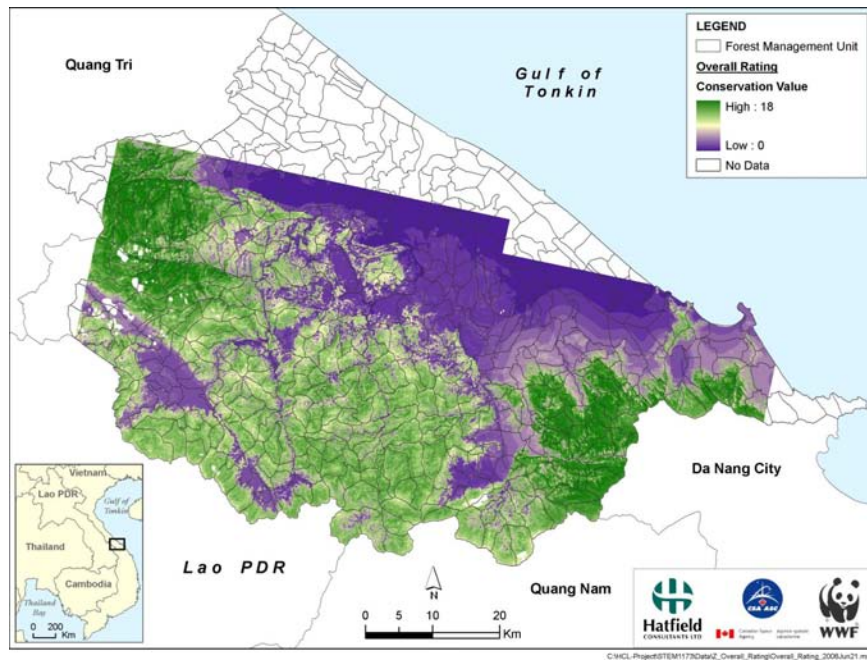
**Figure 13 Total conservation value based on sum of scores for Biophysical Landscape Descriptors, Thua Thien-Hue Province, Viet Nam.**



**Figure 14** Total conservation value based on sum of scores for Zonation Modifiers, Thua Thien-Hue Province, Viet Nam.



**Figure 15** Total conservation value based on sum of scores for Biophysical Landscape Descriptors and Zonation Modifiers, Thua Thien-Hue Province, Viet Nam.



## 4.5 SUMMARY OF THE RESULTS

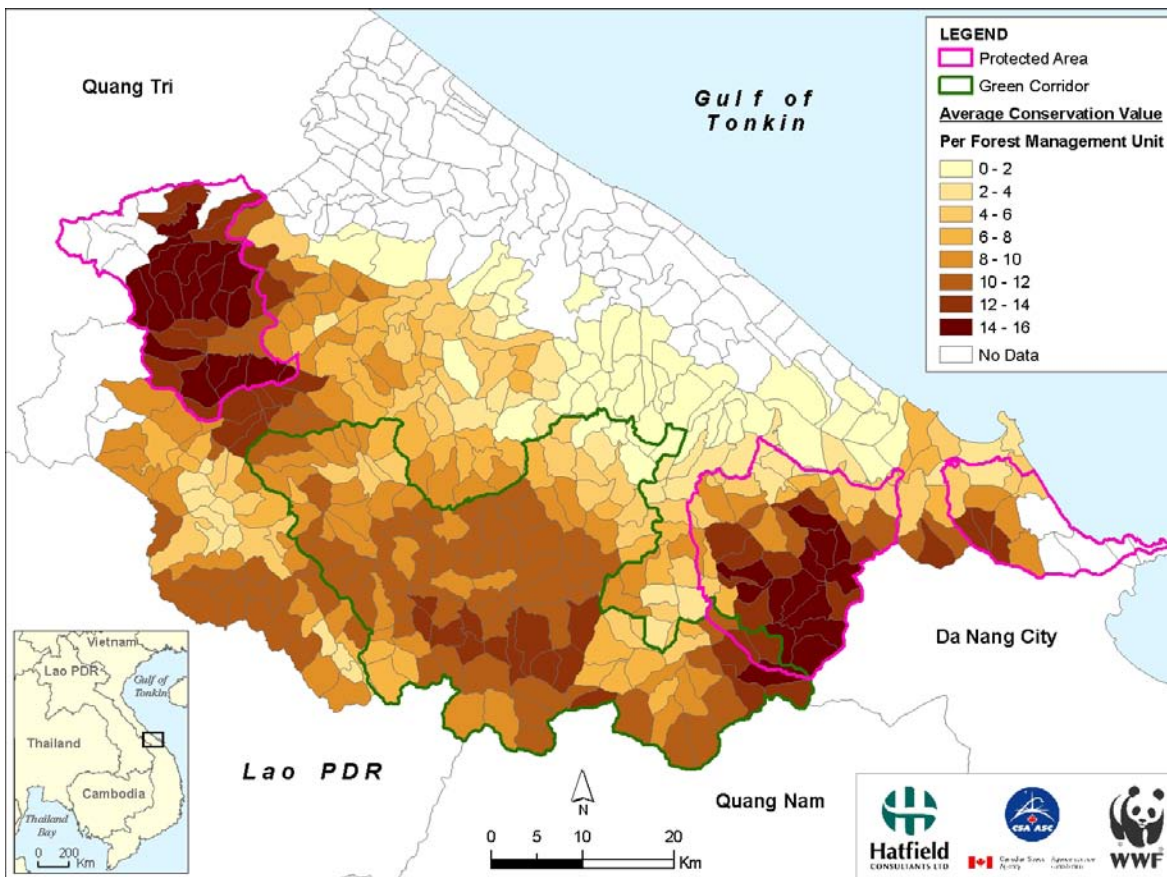
The implementation of the assessment model to combine the Biophysical Landscape Descriptors and Zonation Modifiers produced an overall rating of **conservation value**; this overall conservation value has a range of values from Low (0) to High (18).

A useful way to present results to aid interpretation of results for Provincial planning purposes is to summarise conservation values by Commune or Forest Management Unit. The ultimate goal of the assessment of HC VF is to define areas for increased protection; therefore, presenting the results based on Forest Management Unit should assist decisions about priority areas for conservation action.

Figure 16 illustrates the average conservation value for each Forest Management Unit. As part of this summary, it is important to pay attention to the coverage of the SPOT imagery for the Forest Management Units; the entire Green Corridor is covered by the SPOT imagery, but there is not complete coverage for the entire Province.

Table 3 presents the average conservation value for all Green Corridor Communes; in Appendix A1, the same statistics are provided for all Communes that have SPOT coverage greater than 75% of the Commune area. In terms of conservation value, it is clear that the Green Corridor has Communes containing significant forest cover, in particular the Communes of Thoung Lo, Huong Nguyen, and Thuong Quang.

**Figure 16 Total conservation value summarized by Forest Management Unit Thua Thien-Hue Province, Viet Nam.**



Note: Summary by Forest Management Unit completed using a free extension for ArcGIS called *Hawth's Analysis Tools* ([www.spatial ecology.com](http://www.spatial ecology.com)), specifically the *Zonal Statistics (by Polygon)* tool.

**Table 3**      **Average conservation value for Communes that form the Green Corridor Project area, Thua Thien-Hue Province, Viet Nam.**

<b>Commune</b>	<b>Average Conservation Value</b>	<b>Standard deviation</b>
Thoung Lo	13.7	2.8
Huong Nguyen	10.7	3.0
Thuong Quang	10.7	3.5
Huong Phong	10.2	3.0
Thuong Nhat	9.4	3.7
Hong Ha	9.2	4.0
Huong Lam	9.2	4.1
A Roang	9.1	4.2
Thuong Long	8.6	4.3
Phu Vinh	8.4	3.6
Duong Hoa	7.5	4.6
Phu Son	1.3	0.5
Thuy Phu	0.6	0.6

## 5.0 DISCUSSION

The objective of this activity was to integrate a range of spatial data to identify HCVF for TT-Hue province; this provides the basis for a landscape-level conservation zonation by TT-Hue Province and the GCP. The development of the model using a GIS framework allowed the integration of variety of datasets in a transparent model.

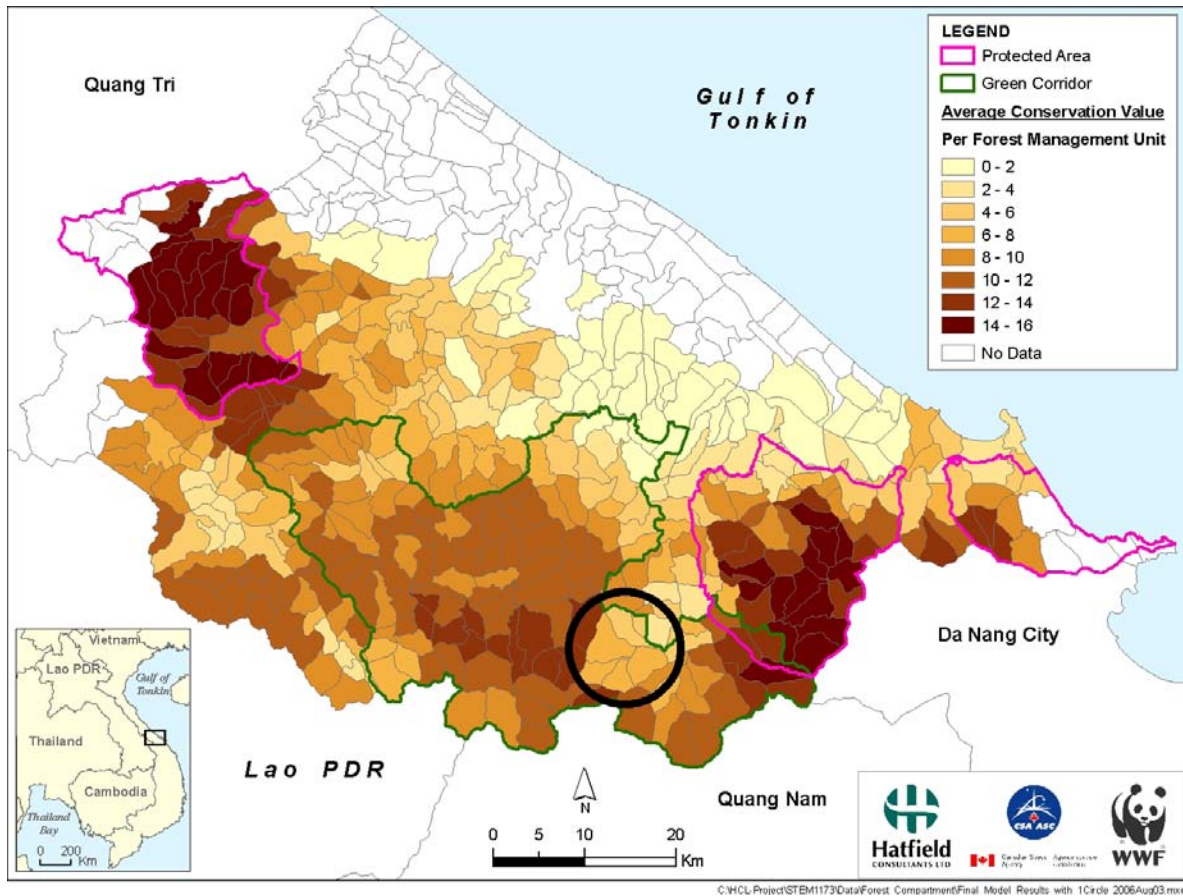
### 5.1 INTERPRETATION OF CONSERVATION VALUE

The maps presented in Section 4.0 for the Biophysical Landscape Descriptors and Zonation Modifiers provide visual information regarding the conservation value of the landscape, according the analysis completed. The conservation value should be evaluated the in conjunction with the contextual information, the most important of which is the **biodiversity survey data** that was gathered during the field surveys that were conducted as part of the GCP; a map of the 2005 biodiversity survey data is included in Appendix A2. In addition, the conservation value should be compared to the maps of Threats (Figure 10 to Figure 12).

The final map of total conservation value (Figure 15) provides a clear illustration that the most important factor determining conservation value is the distribution of natural forest in TT-Hue Province. This is due to the use of forested area data in the Biodiversity, Forest Elevation, and Integrity of Surface Water Resources factors. Another significant influence on the total conservation value is Watershed Protection, which is based on landform. The influence of Watershed Protection on the model results is interesting; even though a number of areas achieve low conservation value for most factors, the Watershed Protection score is high enough to raise the overall conservation value for several Forest Management Units – one particular area is identified in Figure 17.

High-scoring Forest Management Units are mostly located within the boundaries of existing protected areas (Figure 16); however, a number do exist outside of these areas.

**Figure 17** Area of the Thua Thien-Hue identified as having relatively high conservation value, despite predominantly non-forest cover.

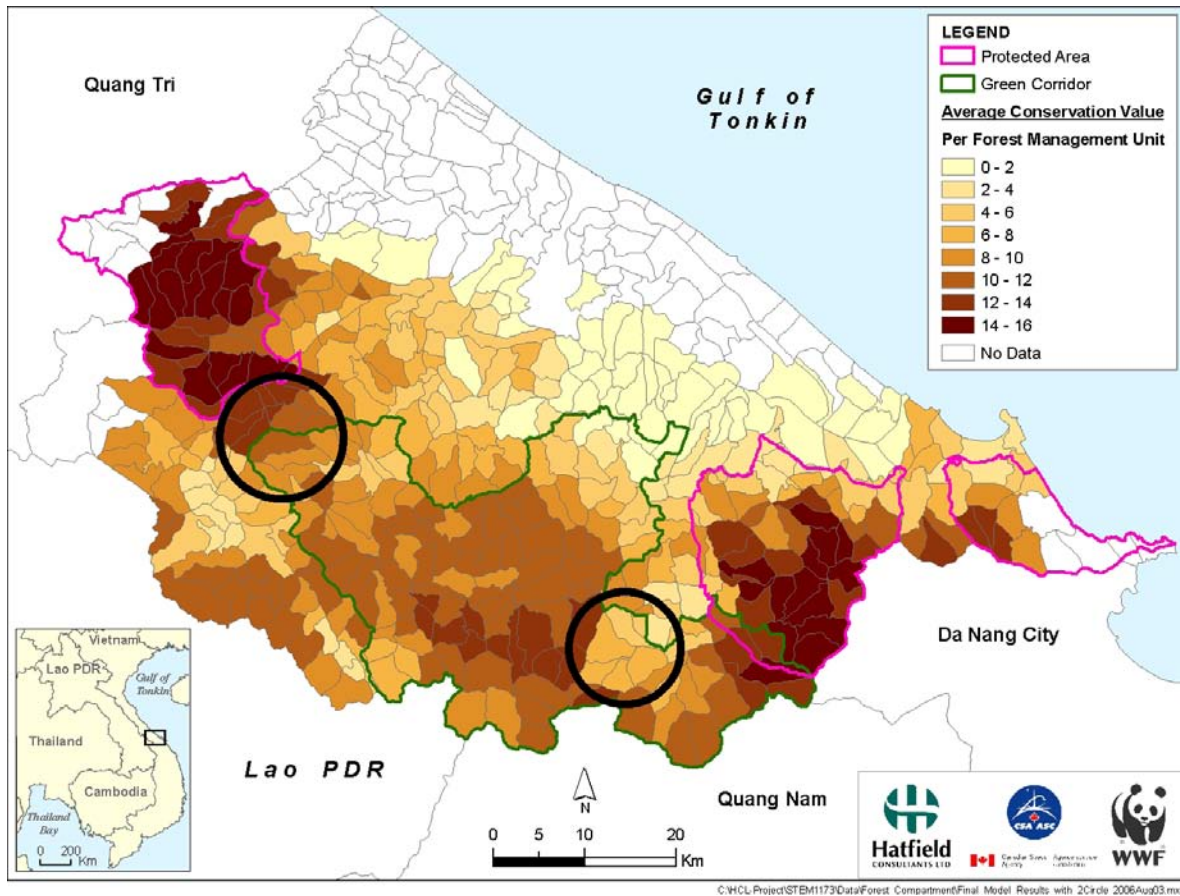


## 5.2 POTENTIAL CONSERVATION ACTION

The evaluation of conservation values, biodiversity survey data and threats provides decision-makers with information on which to base conservation zonation decisions. Example actions based on the results are:

1. Forest Management Units bordering the southeast boundary of the Phong Dien Protected Area are classified as HCVF; this information could potentially be used as justification to extend the boundary to include this area;
2. To maintain or enhance the corridor western and eastern protected areas, attention needs to be paid to the connectivity of the Green Corridor landscape. The two areas identified in Figure 18 provide corridor access between areas of HCVF and the current protected areas; these areas could be the focus of community forest management activities and preference given to reforestation with native species.

**Figure 18** Areas of Thua Thien-Hue identified as potentially important from an ecological corridor perspective.



### 5.3 LIMITATIONS

A number of limitations are inherent in any landscape assessment that aims to integrate and analysis multiple spatial datasets.

The methodology developed and implemented in the Green Corridor assessment aimed to minimize potential errors and uncertainties by conducting simple GIS analysis and carefully evaluating the suitability of data; however, the assessment was still limited by the available data.

The conservation assessment could be strengthened with improvements to data available, including:

- Biodiversity surveys – the data provided by WWF broadly characterized the biodiversity of certain areas of TT-Hue Province, but due to the lack of detailed positional information for individual survey observations, the data could not be directly used in the GIS analysis;

- Elevation - data provided to the project team was in the form of contours, containing a number of areas of non-continuous contour lines and open areas with no values. These factors contributed to the creation of a DEM that included some errors and incorrect values. Updated elevation data would strengthen watershed protection analysis;
- Provincial road network - while a road network for the province was made available to the project, the information did not include a classification of road type; therefore, roads were classified into major and minor roads based on the best judgment of the EO-STEM and GCP team;
- Road building plans - proposed improvements or extensions of the Provincial road network do not affect the assessment of conservation value; however, they are crucial for decision-making related to conservation zonation; and
- Community forest dependence - additional data on the community use of the forest are important to determine HC VF, including the traditional cultural value of the forest.

The general availability of more up-to-date or comprehensive datasets in certain parts of the assessment would also increase confidence levels in the outputs of the model. This in turn would have a positive impact on the decision-making process, which would be based on more robust assessments of conservation value; however, the assumptions made in the analysis are considered reasonable, and no dataset was considered unsuitable for inclusion in the analysis.

## 6.0 FUTURE WORK

This document represents the first steps towards defining HCVF within the Green Corridor landscape. The next stage is to conduct a series of stakeholder consultations (workshops) to discuss the landscape and conservation values, criteria, and weighting that could be used to make refinements to the conservation assessment. A further use of this methodology is that it allows decision makers to develop and compare scenarios for zonation.

The GCP will conduct provincial and district level workshops to discuss and modify the assessment model. The GCP will also present the results of the Green Corridor biodiversity surveys, which evaluate the area and its biodiversity importance on a regional and national level scale. It is expected that this process will also complement the finalization of the current provincial level processes in SFE reform, forest classification and extension to Bach Ma National Park. The workshops will also enable conservation zonation to be discussed in light of other planning processes, in particular the classification of Protection, Production and Special Use forest in the province, and the Bach Ma National Park extension.

The Province could use the conservation value assessment to:

- Determine whether any further Special Use forest should be designated; in particular to evaluate the proposed Bach Ma National Park extension and the proposed Saola Nature Reserve, and to take into account any community issues;
- Use the data for assisting the Protection Forest Management Boards in producing environmental service management plans;
- Identify key areas of fragmentation and potential corridors that should both be the focus of strategic protection and forest landscape restoration planning; and
- Use the data as a baseline for monitoring and measuring the state of the environment in the Province.

## 7.0 REFERENCES

- Hatfield. 2006. Remote Sensing Classification of Forest Cover in Thua Thien-Hue Province, Viet Nam. Milestone 7 Report, Earth Observation Support For Traditional Ecological Mapping And Biodiversity Conservation In Viet Nam (EO-STEM) Project. Hatfield Consultants Ltd., West Vancouver, Canada.
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- IUCN. 2006. IUCN Red List of Threatened Species. Retrieved on 11 May 2006.

## 8.0 CLOSURE

We trust the above information meets your requirements. If you have any questions or comments, please contact the undersigned.

**Hatfield Consultants Ltd.:**

Approved by:



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Thomas G. Boivin, Project Director

August 18, 2006

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Date

Approved by:



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Dr. Andy Dean, Project Manager

August 18, 2006

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Date

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## **APPENDICES**

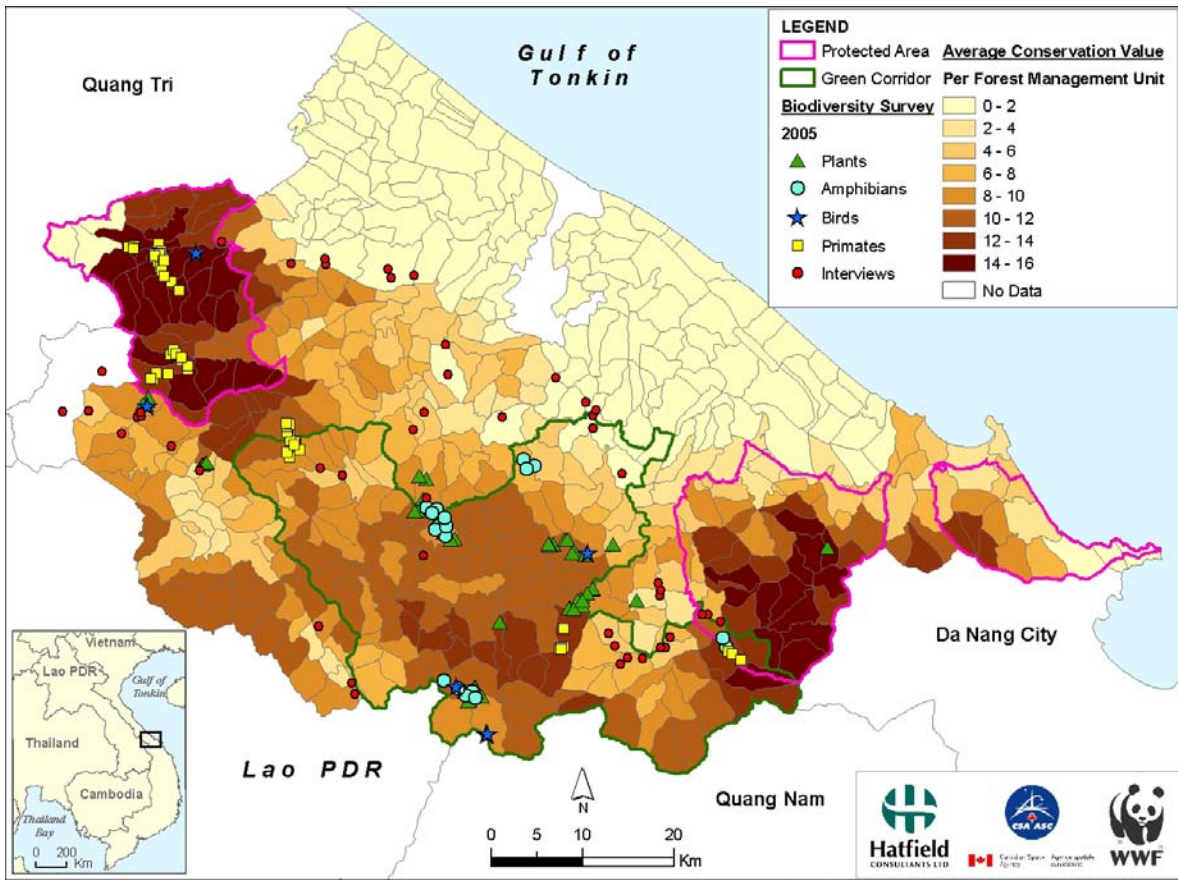
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**Appendix A1**  
**Biodiversity Survey Data**

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Figure A1.1 2005 biodiversity survey data.



NOTE: This map shows the location of surveys, not the location of actual incidence of the biodiversity groups. The red dots indicate locations of surveys on the presence of flagship species performed in villages and communities.

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**Appendix A2**

**Average Conservation Values  
for Communes of Thua Thien-Hue  
Province, Viet Nam**

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**Table A2.1 Average conservation value for Communes with over 75% SPOT coverage, Thua Thien-Hue Province, Viet Nam.**

<b>Commune</b>	<b>Area (Ha.)</b>	<b>Average Conservation Value</b>	<b>Standard Deviation</b>	<b>% SPOT Coverage</b>
Thoung Lo	10587	13.7	2.8	100
Huong Loc	6624	13.5	3.7	100
Phong My	39361	12.4	4.7	78
Hong Kim	4136	11.3	3.7	100
Huong Phu	7998	10.9	4.9	100
Huong Nguyen	28155	10.7	3.0	100
Thuong Quang	15839	10.7	3.5	100
Hong Thai	6944	9.7	3.5	100
Phong Xuan	15607	9.6	5.4	100
Thuong Nhat	11339	9.4	3.7	100
Hong Ha	18288	9.2	4.0	100
Huong Lam	5062	9.2	4.1	100
A Roang	5714	9.1	4.2	100
Hong Trung	6566	9.0	3.9	100
Loc Tri	6291	9.0	5.5	100
Hong Thuong	3992	8.9	4.2	100
Dong Son	2639	8.6	4.1	100
Thuong Long	5122	8.6	4.3	100
Phu Vinh	2861	8.4	3.6	100
Loc Dien	11416	8.3	5.9	100
Loc Thuy	6970	8.1	5.1	100
Hong Van	4129	7.8	4.5	79
Loc Tien	5410	7.7	5.0	100
Huong Son	4107	7.5	4.5	100
Duong Hoa	26224	7.5	4.6	100
Hong Bac	3132	7.2	4.1	100
A Dot	1747	7.0	4.5	100
Bac Son	1041	6.7	3.9	100
Loc Hoa	3215	6.5	4.1	100
Binh Dien	11793	6.4	4.3	100
Thi Tran A Luoi	1356	6.3	4.2	100
Son Thuy	1583	5.9	4.0	100
A Ngo	871	5.9	4.0	100
Binh Thanh	6483	5.8	4.4	100
Nham	3790	5.7	4.0	100
Phong Son	11638	5.7	4.9	100
Huong Van	6134	5.3	4.6	96
Xuan Loc	4629	5.2	3.5	100
Thi Tran Khe Tre	425	5.0	2.3	100
Hong Tien	2221	4.5	3.9	100
Huong Hoa	1101	4.3	3.1	100
Loc Binh	2996	4.0	4.1	100
Huong Binh	6334	4.0	3.7	100
Thi Tran Phu Loc	2767	3.9	2.9	100

**Table A2.1 (Cont'd.)**

<b>Commune</b>	<b>Area (Ha.)</b>	<b>Average Conservation Value</b>	<b>Standard Deviation</b>	<b>% SPOT Coverage</b>
Loc Vinh	3274	3.5	2.4	100
Huong Giang	771	3.4	2.7	100
Huong Huu	987	3.1	3.2	100
Huong Ho	3333	3.1	3.7	100
Huong Tho	4768	2.5	3.2	100
Loc An	2534	2.4	1.1	100
Hong Quang	545	2.3	0.5	100
Loc Son	1926	2.0	1.1	100
Phu Son	3076	1.3	0.5	100
Loc Bon	3281	1.3	1.2	100
Thuy Bang	2298	1.0	0.4	100
Thuy Xuan	768	0.8	0.4	100
Thuy Phuong	2683	0.8	0.5	100
Vinh Hien	2106	0.7	0.8	100
Huong Chu	1554	0.7	1.5	99
Thuy Duong	1388	0.7	0.5	100
Huong Van	2251	0.7	1.5	96
Thi Tran Phu Bai	1552	0.7	0.6	100
Thuy An	1482	0.7	0.6	100
Thuy Phu	3605	0.6	0.6	100
Huong An	1054	0.5	0.9	100
Thuy Chau	1797	0.5	0.7	100
P. An Cuu	252	0.4	0.6	100
Ving Giang	1852	0.2	0.4	100
Thuy Biew	643	0.1	0.4	100
Vinh Ha	2995	0.1	0.3	98
P. Truong An	192	0.1	0.3	100
P. Phuoc Vinh	110	0.1	0.3	100
Phuong Duc	141	0.1	0.2	100
Huong Long	760	0.0	0.1	100
Thuy Tan	795	0.0	0.0	76
P. Via Da	203	0.0	0.0	93
P. Thuan Loc	140	0.0	0.0	100
P. Phu Thuan	114	0.0	0.0	100
P. Tay Loc	139	0.0	0.0	100
P. Phu Hoa	66	0.0	0.0	100
P. Phu Cat	54	0.0	0.0	100
P. Thuan Thanh	147	0.0	0.0	100
P. Kim Long	238	0.0	0.0	100
P. Xuan Phu	188	0.0	0.0	100
P. Thuan Hoa	104	0.0	0.0	100
P. Phu Hoi	101	0.0	0.0	100
P. Phu Nhuan	75	0.0	0.0	100
P. Vinh Ninh	149	0.0	0.0	100