



1. INTRODUCTION

1.1 Background

In 1998, Environmental Baseline Surveys were commissioned by the Planning Department under a Supplementary Agreement to the Study on Sustainable Development for the 21st Century in Hong Kong (SUSDEV 21 Study). One of the key tasks of the SUSDEV 21 study, completed in 2000, involved delineating terrestrial habitats on the basis of satellite images and aerial photographs, and assigning a conservation/ecological value to each of these habitats based on field survey findings and existing information (2000 Study). A Terrestrial Habitat and Ecological Baseline Database, a Terrestrial Habitat map and a Conservation Assessment map were produced from the 2000 Study and incorporated into the Computer-Aided Sustainability Evaluation Tool (CASET). Subsequently in 2002, the Sustainable Development Unit (SDU) of the Chief Secretary for Administration's Office of the Hong Kong Special Administrative Region Government (HKSARG) commissioned a study, which was completed in 2003, on Terrestrial Habitat Mapping and Ranking Based on Conservation Value (2003 Study) to update the findings of the 2000 Study. The 2000 Study and the 2003 Study, collectively, are hereafter referred to as the Previous Studies.

In October 2004, SDU commissioned a study (**this Study**) to update the terrestrial habitat mapping and ranking for Hong Kong based on conservation value using the latest remote sensing data (including satellite images and aerial photographs), as well as other geospatial data and field truthing surveys.

2. KEY TASKS

The key tasks of this Study are as follow:

- Task 1: Review of Previous Studies
- Task 2: Remote Sensing Analysis and Desktop Truthing
- Task 3: Field Truthing Surveys
- Task 4: Analysis of Information Collected Including Conservation Evaluation

2.1 Review of Previous Studies

The methodologies employed and the procedures used for data analysis in the Previous Studies in developing the terrestrial habitat and ecological baseline database, the terrestrial habitat map as well as the conservation assessment map were reviewed in this Study.

Habitat Categorisation Method

The 2000 Study classified the land area of Hong Kong into 25 habitat categories (please see Table 1), which included nine natural terrestrial habitats, ten natural/artificial freshwater and intertidal habitats, two disturbed areas which provide some habitat and four disturbed areas which provide little if any habitat.

**Table 1. 25 Habitat Types used in the 2000 Study**

Habitat Type		Mapping Category
A. Natural Terrestrial Habitats	1	Bare Rock or Soil
	2	Grassland
	3	Shrubby Grassland
	4	Mixed Shrubland
	5	Baeckea Shrubland (subsumed under Shrubby Grassland in 2003 Study)
	6	Fung Shui Forest
	7	Montane Forest
	8	Lowland Forest
	9	Plantation or Plantation/Mixed Forest
B. Natural / Artificial Freshwater and Intertidal Habitats	1	Freshwater / Brackish Wetland
	2	Natural Watercourse
	3	Modified Watercourse
	4	Fishpond / Gei wai
	5	Mangrove
	6	Intertidal Mudflat
	7	Seagrass Bed
	8	Sandy Shore
	9	Rocky Shore
	10	Artificial Rocky / Hard Shoreline
C. Disturbed Areas which Provided Some Habitats	1	Cultivation
	2	Golf Course, Urban Park
D. Disturbed Areas which Provide Little if any Habitat	1	Rural Industrial Storage / Containers
	2	Quarry
	3	Landfill
	4	Others

In the 2003 Study, the definitions of habitat categories were not modified in general, except that the definition of “shrubby grassland” was revised to include “baeckea shrubland”, because “baeckea shrubland” showed a comparatively low mapping accuracy, the majority of the “baeckea shrubland” identified were actually “mixed shrubland” or “shrubby grassland”, and all these classes had the same indicative ecological value. The definition of “fung shui forest” was also revised to incorporate the “fung shui” elements in the 2003 Study.

Conservation Ranking System

A conservation ranking system incorporating ecological, heritage, recreation and landscape conservation components was proposed in the 2000 Study. There were four rankings, namely high, medium, low and negligible conservation values (please refer to Table 2.). In addition to the conservation value rankings, the conservation map also included an asterisk to indicate that the area had one or more unique features which distinguished it from other areas in the same category. This conservation ranking system was retained in the 2003 Study without any change.



Table 2. Conservation Ranking System in the Previous Studies

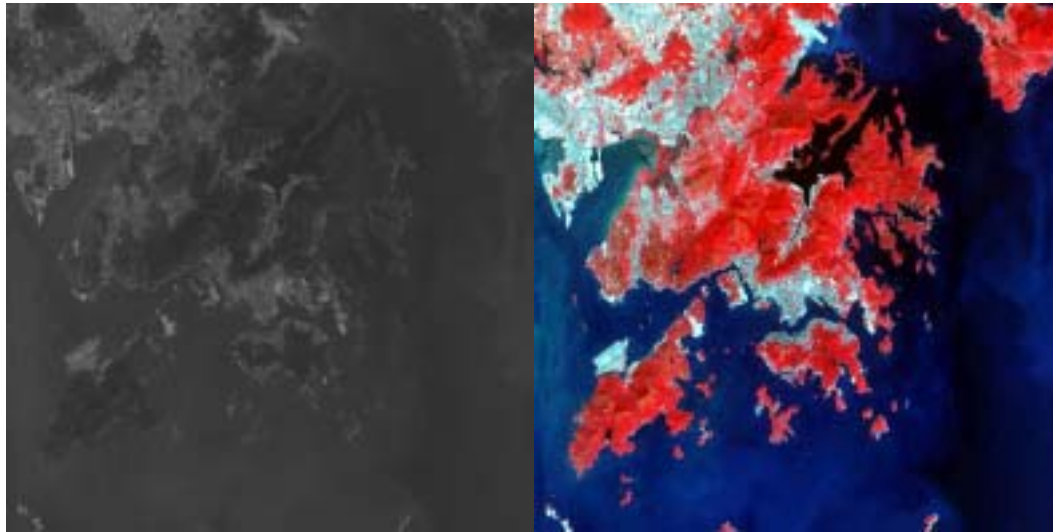
High Value Ecological Habitat	
	■ Fung Shui Forest
	■ Montane Forest
	■ Lowland Forest
	■ Mixed Shrubland
	■ Freshwater / Brackish Wetland
	■ Natural Watercourse
	■ Mangrove
	■ Seagrass Bed
	■ Intertidal Mudflat
Medium Value Ecological Habitat	
	■ Shrubby Grassland (including Baeckia Shrubland)
	■ Plantation or Plantation / Mixed Forest
	■ Fishpond / Gei Wai
	■ Sandy Shore
	■ Rocky Shore
	■ Cultivation
Low Value Ecological Habitat	
	■ Bare Rock or Soil
	■ Grassland
	■ Modified Watercourse
	■ Artificial Rocky / Hard Shoreline
	■ Golf Course / Urban Park
	■ Quarry
Negligible Value Ecological Habitat	
	■ Rural Industrial Storage / Containers
	■ Landfill
	■ Other

2.2 Remote Sensing Analysis and Desktop Truthing

A preliminary habitat map was developed using remote sensing data including satellite images and aerial photos, as well as other geospatial data. High-resolution satellite images taken on 18 October, 2003 were purchased and used for land cover and habitat mapping (please refer to Figure 1). The satellite images provide an ideal source of land cover and vegetation for mapping at 1:20,000 scale.



Figure 1. Satellite Images of Hong Kong taken on 18 October, 2003



A two-step process was taken to develop a detailed habitat map. Firstly, nine general land cover types that were more spectrally distinct were classified using satellite images. Table 3 lists the nine land cover classes derived from the satellite images.

Table 3. General Land Cover Classes Derived from Satellite Images

1.	Grasslands
2.	Forest (including low and high land forest and other type of trees)
3.	Shrubby Grassland (grassland with some shrubs)
4.	Mixed Shrubland (tall and low shrublands)
5.	Natural and Artificial Wetlands (including fishpond, costal wetlands and other lands with water or saturated soils)
6.	Mangrove
7.	Cultivation
8.	Bare and Modified lands (all bare ground with different land use)
9.	Water (natural and man-made)

The second step refined and split the nine general land cover classes into 24 habitat types using a suite of ancillary data. The methods used for mapping each of the 24 habitat types are presented in Table 4.



Table 4. Habitat Mapping Processing Methods

Habitats Type	Spatial Data Sources	Method for Processing
<i>Bare Rock or Soil</i>	*Aerial photos (2001-2004, 50 cm resolution) from the LandsD * Satellite images (SPOT 2003)	Bare surfaces identified from satellite images and visual interpretation of aerial photos.
<i>Quarry</i>	*Aerial photos (2001-2004, 50 cm resolution) from the LandsD. *Digital map data (2003, 1:20K) from the LandsD * Satellite images (SPOT 2003)	Quarry features were located from digital map data with reference to bare surfaces identified from satellite images.
<i>Landfill</i>	*Aerial photos (2001-2004, 50 cm resolution) from the LandsD * Land utilization map (2003) from PlanD * Satellite images (SPOT 2003)	Landfill class was identified based on the previous studies. Revisions were made using the land utilization map. Aerial photos and bare surfaces identified from satellite images were used in manual editing and refinement.
<i>Other (Urban or Other Highly Modified Area)</i>	* Satellite images (SPOT 2003)	Bare surfaces identified from satellite images less Bare Rock/Soil, Quarry and Landfill classes.
<i>Fung Shui Forest</i>	*Fung Shui wood class from the previous studies * Satellite Images (SPOT 2003)	Class was determined by using data from previous studies and the forest classes identified from satellite images.
<i>Plantation/Mixed Forest</i>	* Data from the AFCD * Satellite images (SPOT 2003)	Class was determined by using data from AFCD and the forest classes identified from satellite images.
<i>Fishpond/Gei Wai</i>	*Aerial photos (2001-2004, 50 cm resolution) from the LandsD *Digital map data (2003, 1:20K) from the LandsD * Land utilization map (2003) from PlanD * Fishpond data from the previous studies * Satellite images (SPOT 2003)	Manual interpretation of the data sources with reference to aerial photos and water classes identified from satellite images.
<i>Natural Watercourse</i>	*Digital map data (2003, 1:20K) from the LandsD *Watercourse data from the previous studies *Satellite images (SPOT 2003)	Manual interpretation of the data sources with reference to aerial photos and water classes identified from satellite images.
<i>Modified Watercourse</i>	*Digital map data (2003, 1:20K) from the LandsD *Watercourse data from the previous studies * Satellite images (SPOT 2003)	Manual interpretation of the data sources with reference to aerial photos and water classes identified from satellite images.



Habitats Type	Spatial Data Sources	Method for Processing
<i>Rocky Shore</i>	*Aerial photos (2001-2004, 50 cm resolution) from the LandsD *Satellite images (SPOT 2003)	Visual interpretation of aerial photos and bare surfaces identified from satellite images.
<i>Artificial Rocky/Hard Shoreline</i>	*Aerial photos (2001-2004, 50 cm resolution) from the LandsD *Satellite images (SPOT 2003)	Visual interpretation of aerial photos and bare surfaces identified from satellite images.
<i>Intertidal Mudflat</i>	*Aerial photos (2001-2004, 50 cm resolution) from the LandsD *Digital map data (2003, 1:20K) from the LandsD *Data from the AFCD *Satellite images (SPOT 2003)	Manual interpretation of the data sources with reference to aerial photos and bare surfaces and water classes identified from satellite images.
<i>Sandy Shore</i>	*Aerial photos (2001-2004, 50 cm resolution) from the LandsD *Digital map data (2003, 1:20K) from the LandsD *Sandy shore area from the previous studies *Satellite images (SPOT 2003)	Manual interpretation of the data sources with reference to aerial photos and bare surfaces and water classes identified from satellite images.
<i>Seagrass Bed</i>	*Aerial photos (2001-2004, 50 cm resolution) from the LandsD	Manual interpretation of the data sources with reference to aerial photos.
<i>Golf Course/Urban Park</i>	*Aerial photos (2001-2004, 50 cm resolution) from the LandsD *Digital map data (2003, 1:20K) from the LandsD *Satellite images (SPOT 2003)	Manual interpretation of the data sources with reference to aerial photos and satellite images.
<i>Rural and Industrial Storage/Containers</i>	*Aerial photos (2001-2004, 50 cm resolution) from the LandsD *Land utilization map (2003) from PlanD *Satellite images (SPOT 2003)	Manual interpretation of the data sources with reference to aerial photos and satellite images.
<i>Cultivation</i>	*Aerial photos (2001-2004, 50 cm resolution) from the LandsD *Land utilization map (2003) from PlanD *Satellite images (SPOT 2003)	Manual interpretation of the data sources with reference to aerial photos and satellite images.
<i>Grassland</i>	*Satellite images (SPOT 2003)	The grassland class identified from satellite images less the cultivation class.
<i>Shrubby Grassland</i>	*Satellite images (SPOT 2003)	The shrubby grassland class identified from satellite images less the cultivation class.
<i>Mixed Shrubland</i>	*Satellite images (SPOT 2003)	The mixed shrubland class identified from satellite images less the cultivation class.



Habitats Type	Spatial Data Sources	Method for Processing
<i>Mangrove</i>	* Aerial photos (2001-2004, 50 cm resolution) from the LandsD * Satellite Images (SPOT 2003) * Data from the AFCDD	Manual interpretation of the data sources with reference to aerial photos and satellite images.
<i>Freshwater/Brackish Wetland</i>	* Aerial photos (2001-2004, 50 cm resolution) from the LandsD * Data from the previous studies * Satellite images (SPOT 2003)	Manual interpretation of the data sources with reference to aerial photos and satellite images.
<i>Montane Forest</i>	* Aerial photos (2001-2004, 50 cm resolution) from the LandsD * Digital elevation model (DEM 2003) from the LandsD * Satellite images (SPOT 2003)	Identification of forest areas from the aerial photos and satellite images that are above 600 metres.
<i>Lowland Forest</i>	* Aerial photos (2001-2004, 50 cm resolution) from the LandsD * Digital elevation model (DEM 2003) from the LandsD * Satellite images (SPOT 2003)	Identification of forest areas from the aerial photos and satellite images that are below 600 metres.

2.3 Field Truthing Surveys

Field truthing surveys were conducted at 370 sites over a period from 17 December 2004 to 5 February 2005. The field truthing survey teams verified the preliminary habitat mapping results and assessed the conservation value of the sites based on field observation. The accuracy of the preliminary habitat map was estimated. The accuracy rate was calculated by dividing the number of sites correctly mapped in the preliminary habitat map as verified in the field truthing surveys by the number of sites surveyed for each habitat category times 100.

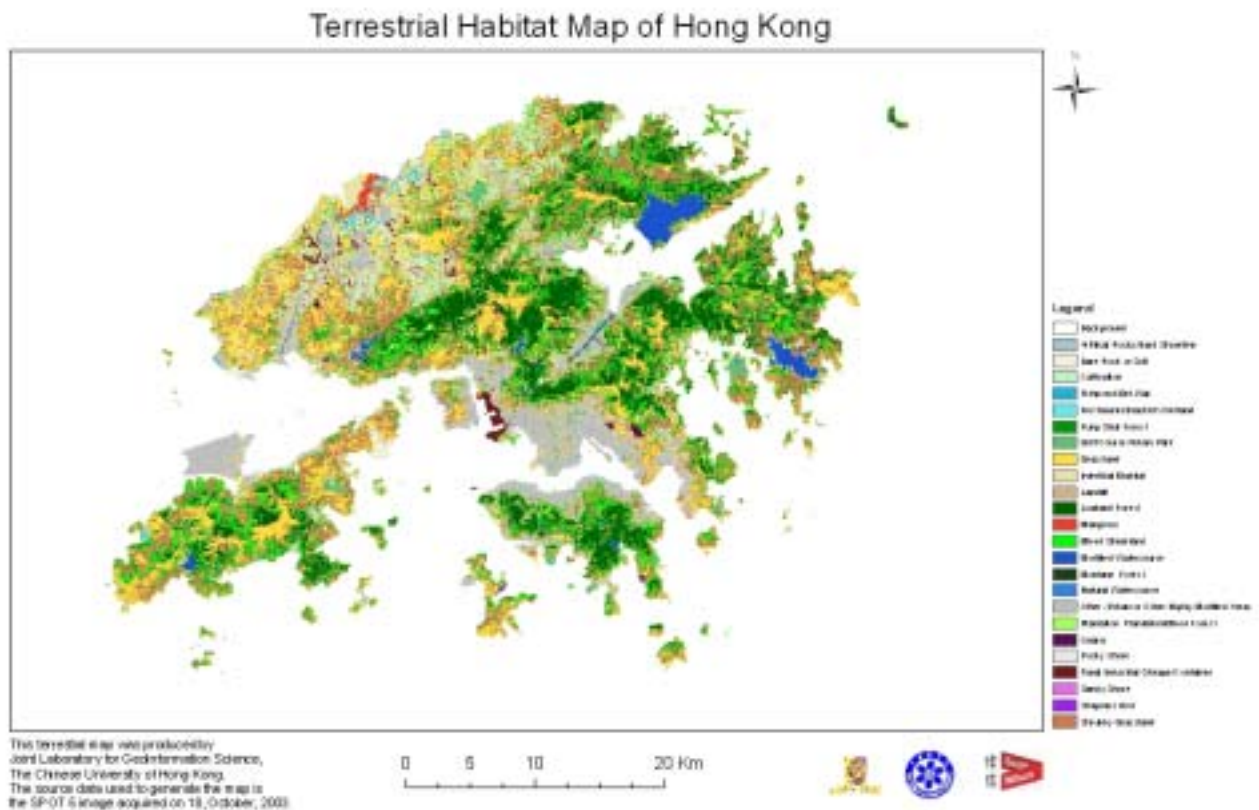
Table 5. Mapping Accuracy of Each Surveyed Habitat Category

Habitat Type	No. of Sites verified (accuracy rate in %)
Fung Shui Forest	9 (88)
Lowland Forest	98 (70)
Mixed Shrubland	47 (67)
Freshwater/Brackish Wetland	45 (64)
Natural Watercourse	34 (24)
Mangrove	9 (89)
Intertidal Mudflat	8 (100)
Shrubby Grassland	60 (67)
Sandy Shore	7 (29)
Rocky Shore	7 (71)
Cultivation	27 (78)
Plantation	19 (57)



One of the main purposes of the field truthing survey was to collect field data for verifying the information and quality of the preliminary habitat map. After field truthing surveys, sites that show differences between the habitat map label and the field data were examined with reference to satellite images and the aerial photos. Any disagreements caused either by the classification error or time difference between the satellite data acquisition and the field truthing surveys (over a year's difference) were then rectified. Through this process a final habitat map was generated (Please refer to Figure 2).

Figure 2. Terrestrial Habitat Map of Hong Kong



2.4 Analysis of Information Collected Including Conservation Evaluation

As revealed in Table 6, shrubby grassland which occupies a total area of 24,675 ha, is the most dominant habitat class in terms of spatial extent among the 24 habitat classes. The second dominant habitat class is grassland which covers approximately 21,573 ha and 19.4% of the total area mapped.

The total area mapped for lowland forest is 18,318 ha and is equivalent to 16.5% of the total mapped area whereas mixed shrubland occupies an area of 15,197 ha which covers 13.7% of the total area. Only 417 ha of land is identified as plantation that comprises only 0.4% of the total mapped area. The two non-lowland forest habitats, fung shui forest and montane forest are observed to have small spatial extent of 106 ha and 123 ha respectively. A comparatively larger portion of area that accounts for 11.4% of the total land area is mapped as urban or highly modified area.



Spatially rare habitat classes mapped in this Study comprises of seagrass bed (5.4 ha), sandy shore (180 ha), rocky shore (94 ha), and wetland (130 ha). Compared to the total area mapped as modified watercourse (2,384 ha), the fishpond/gei wai habitat constitutes a smaller extent which covers only 1032 ha.

Other mapped classes of small to medium spatial extent include golf course / urban park (1,398 ha), quarry (169ha), landfill and rural industrial storage / containers (1,783 ha). The land areas identified for mangrove and intertidal mudflat, which cover an area of 343 ha and 656 ha respectively, fall into the middle range.

Table 6. Area Mapped for Each Habitat Type

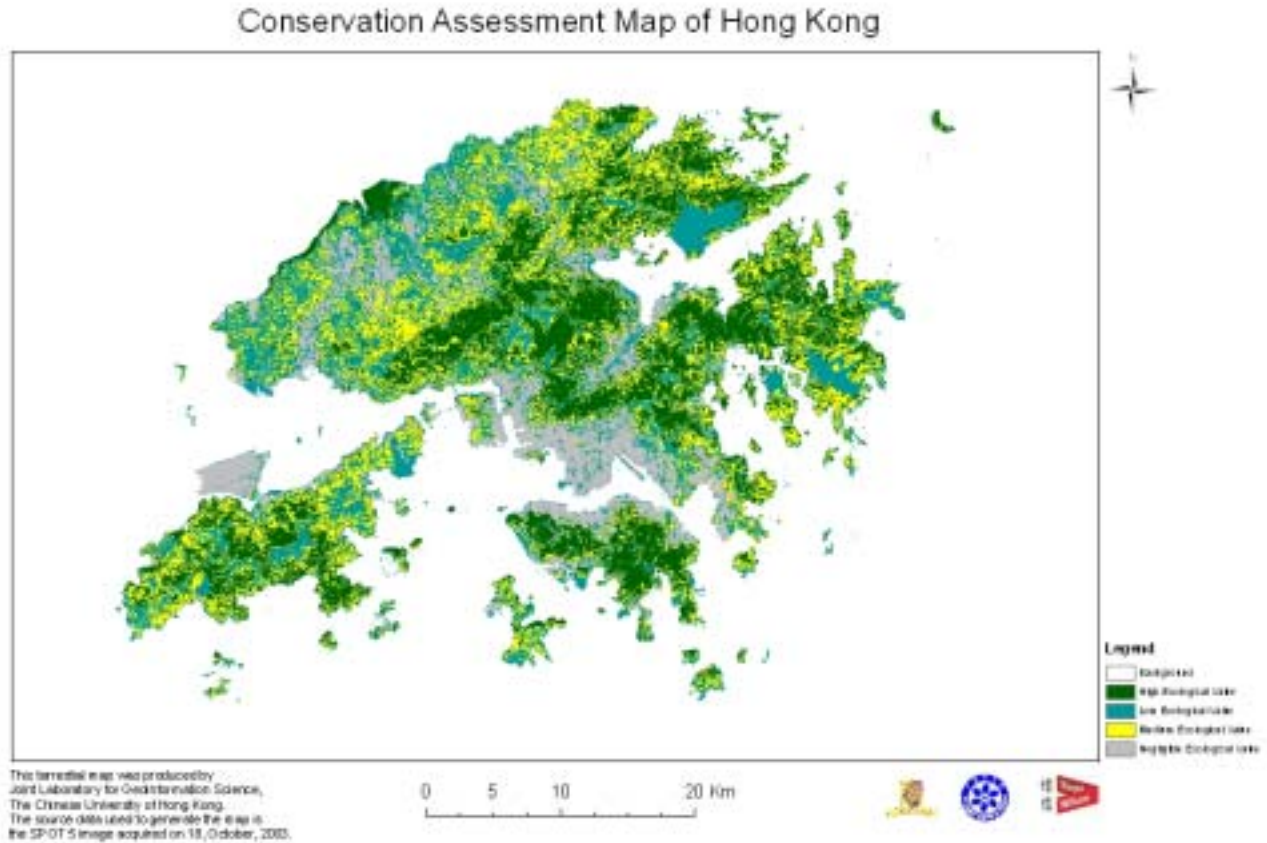
Type	Area (ha)	% of Total
Bare Rock or Soil	5101.8	4.6
Quarry	168.6	0.2
Landfill	404.3	0.4
Other (Urban or Other Highly Modified)	12656.3	11.4
Fung Shui Forest	106.3	0.1
Plantation or Plantation/Mixed Forest	417.0	0.4
Fishpond/Gei Wai	1031.7	0.9
Natural Watercourse	803.9	0.7
Modified Watercourse	2384.1	2.1
Rocky Shore	94.2	0.1
Artificial Rocky/Hard Shoreline	315.4	0.3
Intertidal Mudflat	656.1	0.6
Sandy Shore	179.6	0.2
Seagrass Bed	5.4	0.0
Golf Course/Urban Park	1398.3	1.3
Rural Industrial Storage/Containers	1379.2	1.3
Cultivation	3838.3	3.5
Grassland	21572.7	19.4
Shrubby Grassland	24674.8	22.2
Mixed Shrubland	15196.5	13.7
Mangrove	343.1	0.3
Freshwater/Brackish Wetland	130.1	0.1
Montane Forest	123.4	0.1
Lowland Forest	18318.3	16.5
Total	111299.4	100.00

Conservation Assessment

The conservation map for this Study was prepared with the use of the conservation ranking system, which was developed in the Previous Studies. An updated conservation assessment map is presented in **Figure 3**.



Figure 3 Conservation Assessment Map of Hong Kong



As stated in the previous section of this report, to maintain consistency and compatibility the conservation ranking system developed in the Previous Studies was adopted. The ranking system provides a standard against which the conservation values of different areas can be assessed. Following this system, a 2004 conservation map has been generated and is presented in **Figure 3**.

As shown in **Table 7** below, the conservation ranking based on 2004 conservation assessment map indicates that one third of the total area mapped are habitats of high ecological value. A little over one quarter of the habitats mapped have a medium ecological value. Twenty eight percent of the habitats mapped have a low ecological value and almost thirteen percent of area is occupied by habitats with negligible ecological value.

Table 7 Area of spatial habitats by ecological values

Ecological Value	Total Area (ha)	Percentage Cover (%)
High	35683	32.1
Medium	30236	27.2
Low	30941	27.8
Negligible	14440	13.0



3. CONCLUSIONS

3.1 Review of previous studies

A comprehensive review of the Previous Studies was undertaken by the Consultants. This review helped identify experience and key issues from the Previous Studies and set a stage for formulating a strategy for this Study. The primary conclusions of the review include: to adopt the habitat classification scheme and the conservation ranking system developed in the Previous Studies to maintain consistency and continuity; to improve habitat mapping accuracy and efficiency by using high resolution data and an advanced computerized classification method; and to improve accuracy by using a probability sampling of desktop truthing and field truthing surveys.

3.2 Habitat mapping

Updated terrestrial habitat map (24 habitat types) and conservation assessment map of four rankings (high, medium, low and negligible) were generated. The habitat and conservation maps were produced using a combination of satellite imagery, aerial photos, and other geospatial data. The habitat map was developed by a two-step approach. First, a map showing nine general land cover classes was derived. Second, a map of 24 habitat classes was derived from the nine general land cover classes using ancillary data. Subsequent refinements were made to improve the accuracy of the habitat map through post-classification manual interpretation, screen editing and desktop truthing.

3.3 Desktop Truthing

In order to assess the quality of the habitat map, a probability based accuracy assessment was conducted to obtain the accuracy estimates for the habitat map. The methodology used for the assessment consisted of three primary components: 1) a sampling design for determining the spatial locations from which reference data were obtained; 2) evaluative interpretation of the reference data; and 3) an analysis of the accuracy estimates. A total of 480 samples were collected to assess the accuracy of the 24 classes (20 samples per habitat class) based on a stratified sampling procedure. As revealed in the desktop truthing, the overall mapping accuracy of the 24 habitat classes was 81%. The mapping accuracy for each specific class ranges from 40% to 100%. Classes including Bare Rock, Rocky Shore, Sandy Shore, Grassland, and Lowland Forest were identified to have relatively low mapping accuracy, ranging from 40% to less than 60%.

3.4 Field Truthing Surveys

The objectives of the field truthing survey were to verify the habitat mapping quality, and to verify the conservation assessment map. A methodology for field truthing survey, site selection and effort-allocation was developed and implemented. A total of 370 sites for 12 habitat classes with a pre-defined high and medium conservation value were visited. A total of 50 days were spent on collecting field data from all sites. The field truthing surveys comprised of three key tasks:

- to identify habitat types, major vegetation composition and characteristics of each habitat;
- to locate sample sites by using Global Positioning System (GPS) and 360 degree panoramic digital photograph for each survey site; and
- to collect information on conservation value, dominant species and species of conservation importance.



3.5 Revision of Habitat and Conservation Assessment Maps

The field truthing survey provided critical data that allowed verification of habitat classification and conservation assessment. Information collected from the field truthing survey also helped revise the preliminary habitat map and refine the conservation value ranking. The updated habitat map covers a total land area (above low tide mark) of 111,299.4 ha. Among the 24 habitat classes mapped on the habitat map, Shrubby Grassland is identified to be the most extensive habitat whereas Seagrass Bed occupies the smallest land cover.

The conservation ranking indicates that one third of the total areas mapped are habitats with high conservation value. Approximately one quarter of the habitats mapped have a medium conservation value. Twenty eight percent of the total mapped area is assigned with a low conservation value. The remaining area which covers thirteen percent of the total mapped area is identified as habitats with negligible conservation value.

3.6 Major Contributions of this Study

This Study provides the most updated information with regard to habitat types in Hong Kong and their conservation values. The habitat map, as one of the key deliverables of the project, allows for quantification and assessment of existing natural habitats and study of its status and trends when compared with the habitat maps developed from the Previous Studies. The conservation ranking map for each habitat portrays in detail the areas with various levels of conservation status, and provides useful information for sustainability assessment. Combination of the high resolution habitat map and conservation map facilitates identification of important areas for conservation. The accuracy estimates of the habitat map derived from a scientifically defensible design provides critical information on the quality of the data.

The information compiled from field truthing survey provides a valuable and detailed database for 370 sites with medium and high conservation value throughout Hong Kong. The database not only includes information on habitat types and status, but also detailed information on plant species and communities and the importance regarding conservation of different habitat types. The 360-degree panoramic photos with GPS location provide a first-hand dataset for each site surveyed.

3.7 Recommendations

To achieve a sustainable and effective function of the habitats in Hong Kong, it is recommended that:

- the status and trend of terrestrial habitats and the associated ranking based on conservation values shall be updated on a regular basis, say every 2 years, using high resolution remote sensing and geospatial data;
- the computerized classification methodologies as developed in this Study is recommended to be adopted as the basis for future land cover and habitat classification; and
- additional field truthing surveys shall be conducted to further enhance the representation of the habitat map and the accuracy of the assessed conservation values.