PLANTING TRIAL AT YUEN TUN AND PERFORMANCE ASSESSMENT OF VEGETATION SPECIES ON 44 MAN-MADE SLOPES

GEO REPORT No. 248

K.C. Choi, R.Y.H. Chau & Halcrow China Limited

GEOTECHNICAL ENGINEERING OFFICE
CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT
THE GOVERNMENT OF THE HONG KONG
SPECIAL ADMINISTRATIVE REGION

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PREFACE

In keeping with our policy of releasing information which may be of general interest to the geotechnical profession and the public, we make available selected internal reports in a series of publications termed the GEO Report series. The GEO Reports can be downloaded from the website of the Civil Engineering and Development Department (http://www.cedd.gov.hk) on the Internet. Printed copies are also available for some GEO Reports. For printed copies, a charge is made to cover the cost of printing.

The Geotechnical Engineering Office also produces documents specifically for publication. These include guidance documents and results of comprehensive reviews. These publications and the printed GEO Reports may be obtained from the Government's Information Services Department. Information on how to purchase these documents is given on the second last page of this report.

R.K.S. Chan
Head, Geotechnical Engineering Office
September 2009

EXPLANATORY NOTE

This GEO Report comprises a Special Project Report covering two separate studies carried out by LPM Division 2, and a summary report of a special task under Consultancy Agreement No. CE 74/99 carried out by Halcrow China Limited and Dr Billy Hau of the University of Hong Kong under the management of LPM Division 2.

The reports are presented in two separate sections in this GEO Report. Their titles are as follows:

SECTION 1: IDENTIFICATION OF SUITABLE VEGETATION SPECIES FOR USE ON MAN-MADE SLOPES

K.C. Choi & R.Y.H. Chau

This report is largely based on GEO Special Project Report No. SPR 7/2004 produced in July 2004

FOREWORD

The Government of the Hong Kong Special Administrative Region has committed to making man-made slopes look as natural as possible, blending them with the surroundings and minimizing their visual impact on the built environment. Creating a well-established and sustainable vegetation cover on man-made slope is an essential step to achieve the commitment.

To establish sustainable vegetation covers, studies and trials have been undertaken by the Geotechnical Engineering Office of the Civil Engineering and Development Department (CEDD) to identify more vegetation species that are suitable for use on man-made slopes. This report presents the results of a planting trial of native small tree and shrub species on slopes 6SE-C/C630, C631 and C632 at Yuen Tun, Tai Lam Country Park. It also discusses the results of a study on performance assessment of vegetation species on slopes.

The planting trial was carried out in collaboration with the Kadoorie Farm & Botanic Garden Corporation (KFBG). Annual plant growth monitoring has been carried out since 2001. Erosion monitoring was carried out by Survey Division of CEDD. The valuable input from KFBG and Survey Division are gratefully acknowledged. Mr. K C Choi reported on the planting trial in Section 2 of this report with assistance from Mr. C H Chan under the supervision of Mr. K B Ling.

The performance assessment of vegetation species on slopes was carried out by Dr. Billy C H Hau of The University of Hong Kong. The study was overseen by a Working Group comprising representatives from various Government departments. Members of the Working Group are shown in Appendix D. The contributions of the members of the Working Group are gratefully acknowledged. Ms Rebecca Y H Chau, a member of the Working Group, reported on the study in Section 3 of this report under the supervision of Mr. K B Ling.

(Terence C F Chan)
Chief Geotechnical Engineer/LPM Division 2

ABSTRACT

To study the performance of vegetation establishment on steep man-made slopes, a planting trial of eight native small tree and shrub species was carried out at Yuen Tun, Tai Lam Country Park in collaboration with the Kadoorie Farm & Botanic Garden Corporation. Seedlings of *Zanthoxylum avicennae* (Prickly Ash, 簕欓), *Rhaphiolepis indica* (Hong Kong Hawthorn, 車輪梅), *Melicope pteleifolia* (Thin Evodia, 三椏苦), *Litsea rotundifolia* var. *oblongifolia* (Oblong-leaved Litsea, 豺皮樟), *Ardisia crenata* (Hilo Holly, 朱砂根), *Schefflera heptaphylla* (Ivy Tree, 鴨腳木), *Gordonia axillaris* (Hong Kong Gordonia, 大頭茶), and *Psychotria asiatica* (Wild Coffee, 九節) were planted on slopes with gradient of about 50° following hydroseeding. The trial commenced in July 2001. Monitoring of the vegetation growth has been carried out on a yearly basis. According to the vegetation monitoring results up to the end of 2003, the survival rate of the plants is over 70%. While all of the eight species have been establishing satisfactorily, *Gordonia axillaries*, *Schefflera heptaphylla*, and *Zanthoxylum avicennae* generally outperform the other species. The results from the trial provide useful data to study the sustainability of vegetation covers on slopes.

To identify more vegetation species that can successfully establish on steep man-made slopes, a study on the performance assessment of vegetation species on slopes was carried out since August 2002. Under this study, twenty well-vegetated, man-made cut slopes with gradient of 40° or above and completed for at least three years were surveyed. The performance of the vegetation species on the slopes was assessed based on their dominance, maturity, and general health condition. The healthy, naturally-occurring vegetation species recorded are considered the vegetation species that can successfully establish and self-sustain on steep man-made slopes. Of the 134 healthy, naturally-occurring vegetation species recorded, about 75% are tree or shrub species; 24 species are considered common and widespread, including 22 native species and two naturalised exotic species. The study also reveals that preserving mature, native trees enhances species diversity, natural succession and thus sustainability of the vegetation covers while the dense canopy of exotic tree plantation has an opposite effect.

Based on the findings of the study and the planting trial, and the experience gained from natural hillside afforestation projects by others, a number of recommendations for greening man-made slopes have been developed, with a view to establishing robust, cost-effective, and eco-friendly vegetation covers on man-made slopes. Amongst the recommendations, a list of native vegetation species that have been proven to be successful and reliable as planned vegetation is proposed for general use in greening slopes.

As part of the continuous improvement initiatives, a further study has been embarked on to identify more suitable vegetation species for use as planned vegetation on man-made slopes. Another study on the trial applications of bioengineering measures on natural terrain will also provide useful reference for achieving this target.

CONTENTS

1. INTRODUCTION

In the 2001 Policy Address, enhancing the appearance and aesthetics of engineered slopes (termed "man-made slopes" in this report) was identified as a new Key Result Area (KRA), in addition to six other KRAs, in the Policy Objective booklet on Slope Safety for All, for delivering the overall policy objective in slope safety. In this new KRA, the Government has committed to making the man-made slopes look as natural as possible, blending them with the surroundings and minimising their visual impact on the built environment. To meet this commitment, greening man-made slopes through the establishment of stable vegetation cover on slopes is the main aesthetic goal in slope works. Shotcrete cover is used on slopes only as a last resort on stability grounds and as emergency repairs to landslip scars.

In delivering the results of this new KRA, a number of initiatives and targets have since then been pursued by the Government. Improving the technology in greening slopes, which is the key to success in meeting the Government's commitment in enhancing slope appearance, is one of these initiatives. The targets of this initiative are to conduct trials of growing new vegetation mixes and applying new planting techniques on steep slopes by December 2003.

In pursuing the initiative of improving technology for greening slopes and its associated targets, the Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department has been undertaking a number of studies and trials. This report discusses the studies and trials undertaken in relation to the new vegetation mixes, while the studies and trials undertaken in relation to the new planting techniques are covered separately in Special Project Report No. SPR 6/2004 (Lui and Shiu, 2004).

The studies and trials undertaken by the GEO in relation to the new vegetation mixes aim to expand the range of vegetation types and species that are suitable for application as planned vegetation in the slope works and will sustain on the slope surfaces through self regeneration. It is hoped that the studies and trials will result in the establishment of self-regenerating vegetation covers on man-made slopes through enhancing the biological diversity and increasing the use of native vegetation species. Through the process of self regeneration the slope vegetation covers will eventually develop a stable ecological relationship with other elements in the surroundings, thus integrating harmoniously into the local ecosystem. In addition to fostering sustainability, the self-regenerating vegetation cover will also create stable, naturalistic landscape of minimal long-term maintenance requirements for man-made slopes, thus achieving cost-effectiveness in the slope works.

The sections below summarise the following studies and trials undertaken by the GEO in relation to the new vegetation mixes -

Section 2 Yuen Tun Planting Trial

Section 3 Performance Assessment of Vegetation Species on Slopes

Section 4 Further Studies

2. YUEN TUN PLANTING TRIAL

2.1 Background and Objective

2.1.1 Background

The GEO has been upgrading the stability of man-made slopes through the implementation of Landslip Preventive Measures (LPM) Programme. During the LPM works construction, existing vegetation will inevitably be affected. On completion of the slope stabilization works, new slope surface covers are provided to protect the soil slope surface from erosion. In the past, robust hard materials such as sprayed concrete and masonry facing were frequently used to protect the slopes. With the increasing awareness to improve the environment, vegetation covers gradually replace the hard surface covers. The Government of the Hong Kong Special Administrative Region has committed to making man-made slopes look as natural as possible, blending them with the surroundings and minimizing their visual impact on the built environment.

Creating vegetation cover on man-made slopes with gradient of less than 45º has not been a problem. However, establishing a vegetation cover on steeper slopes is difficult and its long-term sustainability is questionable. There is a need to get more in-depth understanding of the process of vegetation establishment on steep slopes where the ground is usually hard and the soil is infertile. Knowledge on the vegetation types, planting matrix of vegetation mixes, and their ability to self regenerate are essential for creating a stable vegetation cover that requires minimum long-term maintenance. In collaboration with Kadoorie Farm and Botanic Garden Corporation (KFBG), LPM Division 2 of the GEO carried out a planting trial on steep cut slopes located at Yuen Tun in Tai Lam Country Park.

2.1.2 Objective of the Trial

The main objective of the trial is to study the growth and establishment of native small trees and shrubs on steep slopes. To compare the effect of vegetation on the control of surface erosion, erosion monitoring on two control panels with bare soil surface was carried out. As a supplementary objective, commonly used erosion control mats were placed in selected trial panels to study their effect on the growth of vegetation. As a long-term goal, the results from the trial provide useful data to study the sustainability of vegetation covers on slopes.

2.1.3 Site Description

Soil cut slopes 6SE-C/C630 (826262N 823162E), 6SE-C/C631 (826230N 823160E) and 6SE-C/C632 (826175N 823207E) at Tai Lam Country Park were selected for the planting trial. The slopes are located near the junction of Tai Lam Nature Track and Yuk Sing Road, which is an access road to the Yuen Tun Camp of Civil Aids Services. The site is within Tai Lam Country Park and is about 1.2 km to the north of Tsing Lung Tau, Castle Peak Road. Figure 1 shows the location and the layout of the slopes.

The slopes are situated close to the ridgeline in the hilly terrain of the area. The crests of the slopes are very close to the hilltop. Feature 6SE-C/C630 is a northeast facing

cut slope, 50 m long 6 m high and standing at 60º. The slope surface was covered with chunam. Slope 6SE-C/C631 is connected with C630 but facing southeast. It was about 45 m long and 4 m high with a steep gradient of over 65º. The slope surface was bare with erosion gullies. Slope 6SE-C/C632 is about 50 m to the southeast of slope C630. It was about 65 m long 6 m high standing at about 55º. The slope surface was mostly bare with sparse vegetation. Surface erosion was noted on the bare slope faces and at the slope crest. Groundwater seepage was not observed on the slopes. The groundwater table is believed to be well below the slope toe. The general conditions of the slopes prior to the LPM and planting works are shown in Plate 1 to Plate 4.

Prior to the planting trial, the slopes were upgraded under the LPM programme. The LPM works carried out mainly involved trimming back the slopes to a flatter angle of 50º. The existing chunam surface cover on slope 6SE-C/C630 and erosion gullies on slopes 6SE-C/C631 and C632 were removed during slope trimming. The excavation and trimming were carried out mechanically by backhoe. The glazed bucket tooth marks formed during trimming were removed by scarifying the slope surface with hand tools. The finished slopes were divided into 13 panels by concrete access staircase. A brief description of the surface materials, the orientation and configuration of the panels are summarized in Table 1. Distribution of the panels is shown in Figure 1.

Panel 6 and Panel 8 were taken as control panels where no surface protection measure was provided. The soil surface was treated as with the other test panels and scarified in the same way. These two panels were used for surface erosion monitoring. Panels 1 to 5 and panel 7 were covered with erosion control mats (ECM). The mats, except the hessian fabric, are products commonly used in LPM works. The hessian fabric is the material used for making sandbags or for wrapping around tree trunks as protection measures in construction works. Photographs of ECM are shown in Plates 5 to 10. Details of the ECM used are summarized below: -

Panel No.	Product Name	Material	Notes
1	Soil Saver	Natural Jute	a)
2	Enkamat	3D Random Polyamide	b)
3	Tensarmat	3D Polyethylene	b)
4	Miramat	3D Polypropylene mono-filaments	a)
5	CMM Coir	Natural Coir	a)
7	N/A	Hessian Fabric	a)

Notes: a) The mat was laid after hydroseeding the slope surface.
b) Soil mix was sprayed on the mat before hydroseeding the slope surface.

In general, the slope forming material is described as light yellowish brown completely decomposed fine to medium grained granite. A few quartz veins are exposed on the trimmed slope surface. Classification tests and chemical analysis of soil samples trimmed from the slope have been carried out. The testing results are given in Table 2. According to the test results, the soil can be classified as coarse gravely clayey Sand with a trace of organic matter. The average pH value of the soil is 5.1 indicating that it is slightly acidic.

Concrete access stairways were constructed at about 10 m spacing to separate the slopes into 13 panels, and to assist close inspection of the vegetation during the planting trial. Cut off channels with concrete berm slabs were constructed along the slope crest to avoid

erosion due to concentrated surface storm water runoff. Along the slope toe, granite stone toe wall planters were constructed to increase planting opportunity and to improve the slope appearance. Appearances of the slopes shortly after completion of LPM works are shown in Plates 11 to 15.

2.2 Field Works

2.2.1 Planting

Hydroseeding was applied to panels 9 to 13 on 23 March 2001, and to panels 1 to 5 and panel 7 on 18 April 2001. The total surface area hydroseeded is about 850 m^2. Details of the materials forming the hydroseeding mix and the quantities used are given in Table 3.

In Panel 12, 100 g of shrub seeds *Gordonia axillaris* (Hong Kong Gordonia, 大頭茶) was evenly spread by hand on the slope surface immediately after hydroseeding. In Panel 13, tree and shrub seeds comprising 1 kg of *Gordonia axillaris* (Hong Kong Gordonia, 大頭茶), 40 g of *Melicope pteleifolia* (Thin Evodia, 三椏苦) and 60 g of *Reevesia thyrsoidea* (Reevesia, 梭羅樹) were added in the hydroseeding mix and sprayed on the soil surfaces. The seeds were provided by KFBG and soaked overnight before spreading on the slope surfaces.

After establishment of the grass cover on the hydroseeded slopes, seedling shrubs and small trees were planted at approximately 0.8 m horizontal and 0.6 m vertical spacing. The planting was carried out by KFBG in early July 2001. A total of 1241 seedlings comprising 8 native species namely, *Zanthoxylum avicennae* (Prickly Ash, 簕欓), *Rhaphiolepis indica* (Hong Kong Hawthorn, 車輪梅), *Melicope pteleifolia* (Thin Evodia, 三椏苦), *Litsea rotundifolia* var. *oblongifolia* (Oblong-leaved Litsea, 豺皮樟), *Ardisia crenata* (Hilo Holly, 朱砂根), *Schefflera heptaphylla* (Ivy Tree, 鴨腳木), *Gordonia axillaris* (Hong Kong Gordonia, 大頭茶), and *Psychotria asiatica* (Wild Coffee, 九節) were planted randomly on the 11 grassed panels. Fact sheets with photographs describing the botanical characteristics of the eight species are given in Appendix A. The quantity of seedling used in each of the panel together with the size of the seedlings in terms of stem height and basal diameter are tabulated in Table 4.

Panel No. 8, which is only 2 m high, was used as a control panel to monitor surface erosion. The monitoring was carried out from August 2001 to March 2003. As surface erosion on this panel is insignificant, it was decided to use it for trial planting of ferns. The ferns selected for the trial are *Blechnum orientale* (Oriental Blechnum, 烏毛蕨) and *Dicranopteris pedata* (Dichotomy Forked Fern, 芒萁). The method involved collection of mature ferns with spores beneath the fronds, shredding the dried fronds and removing the stipes and stock, mixing the broken fronds rich in spores with soil, then spreading the mixed materials on the slope surface. The slope surface was scarified and covered with two layers of coir erosion control mats. The mixed materials were evenly spread on the slope before and after laying of the mats.

Being located along the ridgeline in the area, the slopes are relatively dry. In the presence of crest channels, surface storm water from upslope is intercepted thus reducing infiltration into the ground through the slope surfaces. Watering was not carried out

throughout the trial planting period. Water for maintaining the growth and survival of the plants therefore essentially comes from precipitation. Other than removal of *Mikania micrantha* (Mikania, 薇甘菊) from the panels, establishment and maintenance works have not been carried out for the planting trial.

2.2.2 Vegetation Monitoring

Comprehensive vegetation monitoring covering every seedling planted on the slopes was carried out annually. The surveys were carried out by KFBG with assistance from LPM Division 2. The initial survey after planting was carried out on 21 August 2001, followed by annual monitoring on 5 July 2002 and 14 April 2003. Survey Division of Civil Engineering Department has carried out supplementary monitoring since December 2001 on plants that are located along the slope toe and easily accessible by the concrete stairways. The supplementary vegetation monitoring was carried out at bimonthly intervals up to the end of 2002, then quarterly in 2003. In the vegetation monitoring, the basal diameter and the stem height of the plants were measured. Conditions of the plants at the time of monitoring, such as missing, dead, broken, dry, sick or healthy were recorded.

2.2.3 Erosion Monitoring

Erosion monitoring on panel 6 and panel 8 was carried out by using a Geodimeter System 600S DR200+ to perform topographic survey to measure the extent and volume of erosion. The slope area of panel 6 and panel 8 is 50 m^2 and 20 m^2 respectively. The Geodimeter transmits and picks up reflected signals from points on remote surfaces without a reflector. Instrument setting allows points to be collected at uniform spacing within a fixed frame. Without the need to step on the slope and disturb the soil surface, this allowed more accurate monitoring of erosion subject only to natural weathering. By automatic scanning mode, similar points on the subject slope are surveyed every time at 0.2 m spacing. In each monitoring survey, a topographical model is formed for earthwork comparison with the initial data. The estimated error from the photogrammetric survey and the calculation of cut and fill is 0.3 m^3 and 0.1 m^3 for panel 6 and panel 8 respectively.

The erosion survey was carried out in conjunction with the supplementary vegetation survey. Erosion monitoring on panel 8 discontinued after the survey in February 2002, as the panel was used for trial planting of ferns.

2.3 Weather Conditions

The data from rain gauge No. N10 located at Emmanuel Primary School, Sham Tseng which is closest to the Yuen Tun trial site have been studied. The daily rainfall and the monthly total rainfall data from this rain gauge for the period between April 2001 and April 2004 were plotted in graph as shown in Figure 2. The average total monthly rainfall in rain gauge N10 for the last 20 years (1984 to 2004) and the monthly total rainfall at Hong Kong Observatory for 30 years (1961 to 1990) were also plotted in Figure 2 for comparison. From this figure, it is noted that the monthly total rainfalls in June and July 2001 are higher than the

average rainfall. Significant deviation was not observed in the rainfall in Year 2002 and 2003.

Splash action from raindrops and concentrated surface storm water flow cause erosion on soil slope surface. The degree of soil erosion on these slopes is related to the occurrence of highly intensive rainfall. The regional variation in extreme rainfall values is given in GEO Report No. 115 (GEO, 2001). The 24-hours extreme value for a 10-year return period is 367 mm in rain gauge N10 and 402 mm in the rain gauge at Hong Kong Observatory. Since April 2001, the highest daily rainfall recorded (on 5 May 2003) in rain gauge N10 was 307 mm and the other notable daily rainfalls were generally below 200 mm. Therefore, extreme daily rainfall did not occur during the trial planting period in Yuen Tun area.

The 30-years mean annual rainfall recorded at Hong Kong Observatory is 2214 mm. The weather condition at Yuen Tun in year 2001 is wetter than normal as the total annual rainfall in rain gauge N10 in the same year is 3337 mm. The total annual rainfall in rain gauge N10 in years 2002 and 2003 is 2270 mm and 2206 mm respectively.

Extreme high or low temperature could have detrimental effects on the vegetation growth. The average monthly temperatures at the Hong Kong Observatory from April 2001 to April 2004 are plotted in Figure 3. The average monthly temperatures for the last 20 years (1984 to 2004) are plotted on the same graph for comparison. Other than some minor deviations, the average monthly temperature during the trial planting period follows the normal weather pattern.

2.4 Surface Erosion

Soil erosion is the process by which water and gravity wear away the land surface. Vegetation intercepts rain and reduces the impact from raindrop splash. It slows the runoff on slope surface to reduce sheet erosion, and its root system reinforced the soil to keep the layer of looser but more fertile materials resting on sloping ground. Soil erosion process also depends on the hardness and density of the slope forming materials. Severe erosion could occur if the soils on slope were loosened and unprotected. To illustrate the typical erosion problem on slope, Plate 16 shows erosion on a soil slope without proper surface protection. The soil has been disturbed and the loose soil was not properly protected. Even if the slope is not as steep as the slope in Yuen Tun, severe erosion gullies were formed. Hydroseeding is a method to protect the slope from surface erosion, but erosion could occur before the grass is established. Plate 17 shows an eroded slope covered with a torn berm net indicating that hydroseeding had been carried out but the grass was not yet fully established as on the adjoining slopes.

For the vegetated slopes in Yuen Tun, no sign of erosion has been observed on the slope surfaces whether it has been covered with or without erosion control mats. For the control panels, the total erosion measured by the photogrammetric method using the Geodimeter System is about 0.3 m^3 to 0.5 m^3. Field inspections also confirm that there is no sign of erosion gullies on the slope surface of the control panels. The surface conditions of the control panels at various stages of the monitoring period are shown as Plates 18 to 21. As discussed in Section 2.3 above, there was no extreme rainfall occurred in Yuen Tun area

since April 2001. The slopes at Yuen Tun have not been subjected to splash action from extremely heavy raindrop or erosion due to concentrated surface water flow. In addition, the slope is composed of very dense highly decomposed granite which is less susceptible to erosion. Other than the washing away of the finer soil particles which were loosened during slope trimming, the hard materials stayed on the steep slope throughout the monitoring period.

2.5 Performance Assessment

2.5.1 Grasses

Performance of the hydroseeding is satisfactory as grass germination was observed on all the hydroseeded slope surfaces. For the slopes in Yuen Tun, the grasses grow well mainly in areas with finer and more friable soil. The steep gradient of the slopes and the hardness of the soil are the key factors that hinder the grass growth. During the early grass establishment period in June 2001, the grasses were attacked by grasshoppers. Within a short period of time, most of the green grasses on the slopes vanished. The grasses survived and regenerated on the slopes after a few weeks. Throughout the planting trial, it was found that stray cattle were consuming the grasses along the slope toe. As a result, the grasses thrived mainly on the upper portion of the slopes. The seasonal changes of the grasses were obvious. During the wet seasons, the grasses were green and long, whilst during the dry seasons they were brown and short.

Lolium species (Rye Grass, 黑麥草屬), *Paspalum notatum* (Bahia Grass, 百喜草) and *Cynodon dactylon* (Bermuda Grass, 狗牙根) were found on the slopes at the early stage of grass establishment period. *Lolium* species (Rye Grass, 黑麥草屬) is a winter grass, thus it disappeared soon in summer 2001. *Cynodon dactylon* (Bermuda Grass, 狗牙根) appears to be less competitive. By 2003, the predominant grass species that cover the slope is *Paspalum notatum* (Bahia Grass, 百喜草). Stolons of *Paspalum notatum* (Bahia Grass, 百喜草) that creep along the soil surface to develop roots and shoots can be found on the slopes.

Poorer grass covers are found at the lower portion of panels 4 and 5. This is mainly due to the extremely hard soil conditions at these parts of the slopes. Two other panels, panels 7 and 13 at the end of the slopes also have less satisfactory grass cover. This is due to disturbance from the stray cattle. The presence of footprints demonstrates that the grass together with the soil at these parts of the slopes have been frequently trampled by the cattle.

2.5.2 Trees and Shrubs

As mentioned in Section 2.2.1, native tree and shrub seeds *Gordonia axillaris* (Hong Kong Gordonia, 大頭茶), *Melicope pteleifolia* (Thin Evodia, 三椏苦) and *Reevesia thyrsoidea* (Reevesia, 梭羅樹) were applied to panels 12 and 13 during hydroseeding. However, there was no observable germination of these seeds throughout the vegetation monitoring period. The addition of seeds in hydroseeding mix for growing native trees and shrubs in this occasion is therefore considered not successful.

Performances of the tree and shrub seedlings are evaluated based on the survival rate, and the growth rates in terms of stem height and basel diameter of the plants. From the vegetation monitoring results up to April 2003, the average survival rates for each species and the average survival rates for all seedlings in each of the panel have been calculated and plotted as bar charts for comparison. Similarly, the average growth rates of the plants in respect of each species and panels have been prepared. The charts are included in Figures 4 to 7.

The seedlings were supplied and planted on the slope by KFBG with very high standard of workmanship. All seedlings were about the same size except *Rhaphiolepis indica* (Hong Kong Hawthorn, 車輪梅) which is relatively smaller and less sturdy. The performance of *Rhaphiolepis indica* therefore should be assessed separately. The survival rate of *Rhaphiolepis indica* is about 45% (Figure 4), which is much lower than the others, whilst the growth rate in terms of basal diameter is much higher because of the smaller original size.

In general, the survival rate of the other 7 seedlings is between 68% and 93%. In spite of the shrubs and small trees were planted on steep slope with poor soil and exposed conditions, the survival rates of the seedlings are unexpectedly high. Although watering was not carried out after the planting, the above average total rainfall in 2001, particularly around the planting period in July 2001, could have made significant contribution to the survival of seedlings. *Zanthoxylum avicennae* (Prickly Ash, 簕欓) has the highest survival rate whilst *Schefflera heptaphylla* (Ivy Tree, 鴨腳木) has the lowest. The lower survival rate for *Schefflera heptaphylla* (Ivy Tree, 鴨腳木) is due to disturbance from the strayed cattle. The cattle ate the young leaves of the plant and caused fatal damage to some of the seedlings particularly those along slope toe. Other than *Ardisia crenata* (Hilo Holly, 朱砂根) where the survival rate dropped from 83% to 72%, the change in survival rate for other species in year 2002/2003 as compared to year 2001/2002 is less than 4%. This indicates that once the seedlings are established on the slope, their survival capability is high. Survival rates of all seedlings in each of the panels have been compared (Figure 5). The survival rates in panel No. 7 and 13 are lower, and this is due to disturbance from the strayed cattle as the seedlings have been trampled while the cattle were consuming the grass on the slope surfaces.

The performance of the seedling species is assessed by comparing the average growth rates (Figure 7). As mentioned above, owing to the smaller original seedling size, the performance of *Rhaphiolepis indica* (Hong Kong Hawthorn, 車輪梅) should not be compared with the other trial species. Among the other 7 species, the average growth rate in terms of basal diameter is between 160% and 265%, and in terms of stem height between 100% and 235%. In general *Zanthoxylum avicennae* (Prickly Ash, 簕欓), *Schefflera heptaphylla* (Ivy Tree, 鴨腳木) and *Gordonia axillaris* (Hong Kong Gordonia, 大頭茶) appear to perform slightly better than the other species. Despite the smaller measured growth rates, *Ardisia crenata* (Hilo Holly, 朱砂根) actually grew quite well as many of the plants blossom in spring and produced plenty of fruits in autumn. *Psychotria asiatica* (Wild Coffee, 九節) is the least performing species in the trial. This species usually grows well under sheltered locations in lowland along forest margins. The exposed site conditions at Yuen Tun trial site are therefore not favourable for the growth of *Psychotria asiatica* (Wild Coffee, 九節).

For the supplementary vegetation monitoring that was carried out more frequently, the average monthly net growth in terms of basal diameter and stem height of the seedling have been calculated and plotted on a chart. The monthly total rainfall at rain gauge N10 and the average ambient temperature at Hong Kong Observatory were plotted as curves and added to the vegetation growth monitoring chart in Figure 8. From this chart, it is noted that growth rates varied according to the seasons. The seedling plants grow faster in warmer and wetter seasons, and the growth rate in year 2003 is less than year 2002.

Record photographs on the trial panels have been taken in regular intervals to keep track of the changes in surface cover conditions as well as the growth of vegetation. Photographs for each panel at initial stage, June 2002 and December 2003 are presented in Appendix B.

In addition to the planted vegetation, naturally recruited vegetation both native and exotic species have been found growing on the trial panels. Over 30 different kinds of tree, shrub, herb, climber, fern and fungus species have been identified. Photographs of some of the identified species are included in Appendix C. The naturally recruited vegetation increases bio-diversity to the restored vegetation system on the slopes. Some of the vegetation such as *Sapium discolor* (Mountain Tallow Tree, 山烏桕) and *Clerodendrum fortunatum* (Glorybower, 鬼燈籠) grow faster and stronger than the seedlings planted on the slope.

In Panel No. 8, the results of the fern planting trial by spreading spores on the slope surface are encouraging. Although germination of the fern is very slow and the coverage is poor, the trial confirmed that it is possible to propagate ferns by spreading spores collected from the fern. The spores were spread on the slope in April 2002 and signs of fern germination were noticed by October 2002. Notable patches of fern were found by July 2003. By December 2003, fern covered about 20% of the slope surface. There is more *Blechnum orientale* (Oriental Blechnum,烏毛蕨) germinating and growing on the slope than *Dicranopteris pedata* (Dichotomy Forked Fern, 芒萁). Some *Dicranopteris pedata* (Dichotomy Forked Fern, 芒萁) is naturally occurring as it existed before the spreading of spores.

2.5.3 Erosion Control Mats

Measures for the prescriptive use of vegetation cover for existing soil cut slopes of different gradients are given in GEO Report No. 56 “Application of Prescriptive Measures to Slopes and Retaining Walls” (GEO 1999). In addition to hydroseeding and planting of trees and shrubs, the report recommended the use of geosynthetic erosion control mats for slopes with gradients greater than 35°. Since the implementation of the control of visual impact of new slopes, more and more erosion control mats are placed on the slope surfaces. Irrespective of the soil and environmental conditions, attempts to vegetate slopes with gradients steeper than 50° are increasing. One of the objectives of the current trial is to study the effect of erosion control mat on the growth of vegetation. With regard to the performance of erosion control mats, a study was carried out in 2000 and the results are given in GEO Technical Note TN 4/2000 (GEO 2000).

The erosion control mats used in Yuen Tun can be divided into two categories, namely organic biodegradable mats and synthetic non-biodegradable mats. In terms of durability among the organic mats, coir mat is most durable followed by hessian fabric and then jute mat. By December 2003, deterioration of the coir mat is insignificant after having been placed on the slope for over two years. The hessian fabric began to deteriorate by December 2001 and essentially vanished by April 2003. For the jute mat, deterioration began soon after seedling planting in July 2001 and there is no trace of the jute materials on the slope surface by August 2002.

Installation of the three-dimensional polyamide and polyethylene synthetic geotextile mats involved spreading of soil mix on their surfaces before hydroseeding. Despite the higher than normal rainfall in June and July 2001, there was however no apparent bare spot on the slope surfaces, suggesting that the wash out of soil mix together with the hydroseeding mix from the mats was insignificant. According to the seedling growth monitoring and field observation, there is no indication to suggest that the vegetation covers in these two panels are more thriven than the other panels. However, there appears to be more naturally recruited vegetation growing in these two panels. It could be due to the coarse and thicker texture of the mats, which are more ready to trap the seeds that dropped on the slope surfaces.

The polypropylene geotextile mat was used in panel 4. By 2003, grasses grow only on the upper part of the slope where the gradient is flatter and the soil is richer. The material at the lower part of this panel is very dense highly to moderately decomposed granite that is not suitable for growing grass. Other than the seedling planted on the steep slope, there is very little vegetation to cover the geotextile materials. Appearance of panel No. 4 is the least natural among the 13 trial panels. Invasion of natural species in this panel is mainly found on the upper part of the slope.

2.6 Conclusions

A planting trial involving eight native shrub and small tree species has been carried out in Yuen Tun, Tai Lam Country Park. The planting works include hydroseeding followed by seedling planting on steep slopes. The slope forming material is decomposed granite of mainly very dense coarse silty gravelly sand. Throughout the planting trial, maintenance and establishment works including fertilizing and watering were not provided.

Weather conditions during the trial period have been studied. Other than the wetter year 2001, there was no significant deviation in the weather pattern during the trial planting period. The above average rainfall, particularly in the months following the planting, may have improved the survival rate of the seedlings planted on the steep slopes in Yuen Tun

Extremely heavy rainfall did not occur during the trial planting period and the slope forming materials are very dense highly decomposed granite. Monitoring results and field observations indicate that erosion is insignificant for the vegetated panels with or without erosion control mats as well as the control panels. The contribution of vegetation and erosion control mat on surface erosion could not be concluded in this trial.

Erosion control mats were used in selected trial panels. Among the organic mats, the coir mat is found to be more durable. For the synthetic mats, the 3D polyamide and 3D

polyethylene mats produced a more natural outlook than the polypropylene mat. According to the monitoring results, there is no discernable difference in the seedling growth and establishment of vegetation cover on panels with or without erosion control mats.

According to the monitoring results, the survival rate of the plants is over 70% and the seedlings have grown over 100% from its original size. At places with more favourable soil and environmental conditions, some seedlings have become small trees. Among the eight species used in the trial, *Zanthoxylum avicennae* (Prickly Ash, 簕欓), *Schefflera heptaphylla* (Ivy Tree, 鴨腳木) and *Gordonia axillaris* (Hong Kong Gordonia, 大頭茶) show better performance in terms of growth.

The vegetation on the trial panels is still mainly comprised of grass. The seedlings plants have not grown to create dense foliage cover to protect the slope surfaces. Although most of the seedlings have flowers and produce fruits, regeneration of the species from seed has not yet been observed. Other naturally recruited vegetation has invaded the trial panels to improve biodiversity of the vegetation system. A natural and sustainable vegetation system that requires minimum long-term maintenance can be anticipated.

3. PERFORMANCE ASSESSMENT OF VEGETATION SPECIES ON SLOPES

3.1 Background and Objective

The GEO has observed that certain vegetation species can successfully grow on steep man-made slopes. These vegetation species can be planned vegetation planted as part of the landscape treatment in the slope works or unplanned vegetation established through natural invasion. Steep man-made slopes present a particularly harsh growing environment for vegetation when compared with gentle slopes. Currently, the knowledge on the range of vegetation species that can successfully establish on steep man-made slopes as planned vegetation is still very limited.

To increase the exposure to the body of this knowledge and to research other issues related to slope greening technology, the GEO commissioned in August 2002 Dr. Billy C. H. Hau, Assistant Professor of the Department of Ecology & Biodiversity, The University of Hong Kong, to carry out a study titled "Performance Assessment of Greening Techniques and Vegetation Species on Slopes" (the Study). There are two Tasks under the Study. Task 1 focuses on the performance assessment of the new greening techniques that have been tried on man-made slopes, which is discussed separately in Special Project Report No. SPR 6/2004 (Lui and Shiu, 2004). Task 2 assesses the performance of the vegetation species found on steep man-made slopes, the discussion of which forms Section 3 of this report. Under Task 2, the healthy, naturally-occurring vegetation species recorded are considered the vegetation species that can self-sustain on steep man-made slopes. The findings of Task 2 form a useful knowledge base for further studies and site trials to find out which species can be and how they are applied successfully as planned vegetation for landscape use on man-made slopes.

To oversee the Study, a working group with representatives from the GEO and nine other government departments involved in slope works was established in September 2002. The membership of the working group is given in Appendix D.

3.2 Selection of Slopes

Twenty cut slopes with well-established vegetation covers were selected for inspection and performance assessment of the vegetation species under Task 2 of the Study. These slopes are of varying attributes in terms of geographical location, age, gradient, size, orientation, use of erosion control mat, and degree of isolation from natural vegetation. Table 5 sets out the 20 surveyed slopes and their respective slope attributes, and Figure 9 shows their geographical locations. Relatively old slopes (slopes with formation or upgrading works completed for at least 3 years) were selected in order that the assessment of the sustainability of the slope vegetation would be meaningful. As Task 2 focuses on steep slopes, all the slopes selected are with gradient of 40° or above.

3.3 Inspection and Assessment of Vegetation Performance

3.3.1 Inspection

The field inspections of the vegetation on the selected slopes were carried out in the months from September 2002 to January 2003 by a survey team led by the Primary Investigator, Dr. Billy C. H. Hau.

In the field inspections the slope surfaces were partitioned into quadrats of 5 m wide and about 7.5 m high along transects running longitudinally along the slope batters. An example of survey layout on a slope is given in Figure 10 (Hau and Leung, 2004). The vascular plants in each of the quadrats were then surveyed and assessed. This inspection method was applied to all slopes except Slopes No. 6SE-B/CR 72, No. 11SW-A/C 297, and part of No. 11NE-C/C 13 that are too high and steep for this method to be practicable. For these difficult slopes, the vegetation was surveyed and assessed by estimation using binoculars rather than by measurement. Owing to site constraints, field inspection was not applied to the whole of the slope surface for some of the surveyed slopes. The actual area that was surveyed for each of the surveyed slopes is shown in Table 6.

For assessing the vegetation performance on the slopes, the following information of each vegetation type in terms of growth habit (tree, shrub, climber, fern or grass) and each vegetation species in each vegetation type present on the slopes was collected -

(a) percentage coverage and quantities of plant individuals to indicate dominance and abundance respectively;

(b) size in terms of height and spread to indicate maturity; and

(c) general health condition.

In arriving at the quantities of plant individuals, only tree, shrub and climber species were covered. The quantities of tree and shrub species were counted whereas those of climber species were estimated if the climbers were in clumps and could not be counted exactly. For the measurement or estimation of plant size, only tree and shrub species were included.

Apart from identifying which vegetation types and which vegetation species have

better growth performance on the slopes, Task 2 of the Study aims to find out which vegetation species can self-sustain on the slopes. The sustainability of the vegetation species is assessed based on whether the species can self-regenerate. Generally, self-regenerating species are those species considered being able to occur naturally on the slopes. While the knowledge of local flora and of commercial availability of the species is useful in identifying whether the species are naturally-occurring, the survey team also collected the following information during field inspections to provide hints for the identification -

(a) distribution patterns of the species on the slopes (regular pattern indicates that the species are most likely planned vegetation while random pattern implies that the species are more likely naturally-occurring vegetation); and

(b) signs of natural regeneration such as flowering and/or fruiting.

To help analyse the survey data for the performance assessment of the vegetation growth, the information on slope attributes provided by the GEO (i.e. slope gradient, slope size, slope orientation, and degree of isolation from natural terrain or large woodland) was verified and the following additional environmental data was collected during the field inspections -

(a) slope altitude;

(b) presence of seepage on the slope;

(c) degree of shading of the slope by adjacent features;

(d) exposure of the slope to wind; and

(e) presence of natural stream courses near the slope.

Detailed discussion of the inspection method and the completed inspection forms for the surveyed slopes are given in Section 3 and Appendix 3 of the Final Summary Report on Task 2 of the Study respectively (Hau and Leung, 2004).

3.3.2 Assessment

Based on the vegetation survey data collected during field inspections, Task 2 of the Study assesses the growth performance of the vegetation on the surveyed slopes, focusing on the following aspects -

(a) the vegetation types in terms of growth form and the species that are healthy and are more dominant, abundant and mature, are considered having better growth performance;

(b) amongst the healthy vegetation species, those that are believed to have occurred naturally on the slopes, are

considered being able to self-establish and self-sustain on relatively steep man-made slopes; and

(c) amongst the healthy, naturally-occurring vegetation species, the more dominant and abundant ones are considered common and widespread species that are more adaptable to the environment of relatively steep man-made slopes.

In addition to the above, Task 2 of the Study also assesses the degree of natural succession of vegetation cover of each of the surveyed slopes and investigates whether and how natural succession of the vegetation covers on the surveyed slopes has been affected by the different environmental factors. The degree of natural succession is an important indicator of the ecological sustainability and stability of the vegetation cover. Generally, the higher the degree of natural succession, the more ecologically sustainable and stable is the vegetation cover. The assessment facilitates comparison of natural succession of the vegetation cover amongst the surveyed slopes, and the investigation helps identify factors which can promote ecological sustainability and stability of the slope vegetation cover, thereby minimising long-term maintenance commitments.

In assessing the degree of natural succession of vegetation cover of each of the surveyed slopes, the species diversity representing the community composition of the vegetation cover was studied. A vegetation community comprising a larger number of species with similar abundance amongst species is considered more diverse, more advanced in natural succession and more ecologically stable. Hence, the Shannon diversity index (H), a common quantitative index of species diversity, was applied to each of the surveyed slopes to provide further information on the vegetation community and hence species diversity of the slope in addition to abundance (A = the number of plant individuals present on the slope) and species richness (S = the number of vegetation species present on the slope). The slope with higher H value means its vegetation cover has higher species diversity and is more advanced in natural succession. An example showing the calculation of H is given in Appendix E (Hau and Leung, 2004).

In arriving at the A, S, and H values, only the woody species contributing to natural succession of the vegetation cover and with the quantities of plant individuals being able to be counted exactly were covered (Hau and Leung, 2004). In this case, only the woody native species and the woody naturalised exotic species that are non-invasive were included. The exotic species that are not naturalised, such as *Acacia confusa* (Taiwan Acacia, 台灣相思) and *Lophostemon confertus* (Brisbane Box, 紅膠木), were not considered because they are sterile and thus not long lasting. The naturalised exotic species that are invasive, such as *Leucaena leucocephala* (White Popinac, 銀合歡) and *Mikania micrantha* (Mikania, 薇甘菊), were also excluded because they tend to decrease the species diversity by killing or inhibiting the growth of other species and lead to a uniform community which is not ecologically stable. Where the woody climbers were found to be in clumps and therefore the quantities of plant individuals could only be estimated rather than counted exactly, the climber species concerned were not included as well. Herbaceous species such as the herbaceous climber, fern and grass species were not counted because they are not structure-building vegetation in the terrestrial ecosystem and will eventually be replaced or dominated by woody species in most cases.

To investigate whether and how natural succession of the vegetation covers

(represented by the H value) on the surveyed slopes has been affected by the different environmental factors presented by the slope attributes, the following two different statistical tests were run -

(a) for the environmental factors that are grouped into classes, including degree of shading of the slope by adjacent features, exposure of the slope to wind, and degree of isolation from natural vegetation, the one-way Analysis of Variances (ANOVA) was conducted, which was then checked by the Tukey's test; and

(b) for the environmental factors that are continuous, including slope age, slope gradient, slope orientation, and slope altitude, the simple linear correlation was used.

In addition to slope attributes, the following factors were also studied to investigate whether and how they have affected natural succession of the slope vegetation covers -

(a) coverage of dense canopy of exotic trees: percentage coverage of the exotic tree canopy on each of the slopes was determined, and its effect on natural succession of the slope vegetation covers was statistically tested by conducting ANOVA, which was then checked by the Tukey's test;

(b) existence of remnant mature, native trees: aerial photographs of the slopes one year prior to and after the completion dates of the slope formation or upgrading works were studied to identify whether the mature trees (plant individuals with a height larger than 5 m, a crown spread of over 5 m, and a trunk diameter at breast height greater than 20 cm) present on the slopes were the remnant vegetation retained during slope works; where the existence of remnant mature, native trees was ascertained, its effect on natural succession of the slope vegetation cover was also statistically tested by conducting ANOVA, which was then checked by the Tukey's test; and

(c) slope maintenance history: where available, the maintenance history of the surveyed slopes was reviewed to find out whether there had been removal or disturbance to the slope vegetation covers.

Detailed discussion of the assessment method and the computation of the species diversity indices as well as the application of the statistical tests for the surveyed slopes are given in Section 3 and Section 5 of the Final Summary Report on Task 2 of the Study respectively (Hau and Leung, 2004).

3.4 Key Findings

The following paragraphs summarise the findings of Task 2 of the Study. Brief summaries of the results of field inspection of each of the surveyed slopes and analysis of the results are set out in Section 4 and Section 5 of the Final Summary Report Task 2 of the Study respectively (Hau and Leung, 2004).

3.4.1 Composition of Slope Vegetation

A total of 9,983 healthy plant individuals of tree, shrub, and climber species that were believed to have occurred naturally on the surveyed slopes were recorded. The composition of these plant individuals is shown below.

Growth Habit	Native Plant	Naturalised Exotic Plant	Total
Tree	5,769 (57.8 %)	1,195 (12.0 %)	6,964(69.8 %)
Shrub	1,925 (19.3 %)	303 (3.0 %)	2,228 (22.3 %)
Woody climber	748 (7.5 %)	0 (0 %)	748 (7.5 %)
Herbaceous climber	28 (0.3 %)	15 (0.1 %)	43 (0.4 %)
Total	8,470 (84.9 %)	1,513 (15.1 %)	9,983 (100 %)

The recorded healthy, naturally-occurring plant individuals comprised 134 vegetation species, including 116 native species and 18 naturalised exotic species. Tables 7 and 8 list the recorded native vegetation species and the recorded naturalised exotic vegetation species respectively.

It is interesting to note that over 80% of the naturally-occurring trees and shrubs were found to be in the form of seedlings of 1.5 m high or less, demonstrating that these tree and shrub species were in the process of self-regeneration.

3.4.2 Common and Widespread Vegetation Species

Amongst the 134 naturally-occurring vegetation species recorded, some species are present on many of the surveyed slopes in high abundance. An arbitrary line has been drawn to define the common and widespread species as those species recorded on 8 or more of the surveyed slopes. According to this definition, there are 24 common and widespread species, which are listed in Table 9. These vegetation species generally exhibit strong pioneer characters in natural or disturbed forests, shrublands or grasslands, which is believed to be the reason for their successful establishment on man-made slopes.

3.4.3 Natural Succession of Slope Vegetation Cover

The 20 surveyed slopes vary considerably in the degree of natural succession of the vegetation cover, which is represented by the Shannon diversity index (H). Table 10 shows the H, A, and S values of each of the surveyed slopes, with the slopes listed in descending order of the H value.

The statistical test results reveal that while the exposure of the slope to wind, slope age, slope angle, slope orientation, and slope altitude do not seem to have any effect on natural succession, the factors discussed below generally have significant effect on the H value and amongst them coverage of dense canopy of exotic trees and existence of remnant mature, native trees appear to be more influential. It is rather surprising to note that the difference in the H value in relation to slope age is not prominent. This phenomenon may be due to the fact that all the surveyed slopes are relatively old and thus natural succession of the vegetation cover on all the slopes tends to slow down.

(1) Degree of Shading of the Slope by Adjacent Features. The statistical test results suggest that the slopes that are shaded by structures or buildings would have poorer natural succession, possibly due to low light illumination. Slope No. 11NE-D/C 79 (On Tin Street, Lam Tin), which is located close to the tall residential buildings of a public housing estate and has the lowest H value amongst the surveyed slopes, is an example. However, the results also indicate that there is no significant difference in the H value between slopes without shading and the slopes shaded by trees that are scattered on or adjacent to the slopes.

(2) Degree of Isolation from Natural Vegetation. The statistical test results imply that natural succession will likely be very slow on slopes that are completely isolated from any vegetation, whether planted or natural, whereas natural succession can be promoted if the slopes are directly connected to natural grassland, shrubland or woodland. Slopes No. 11 NE-D/C 79 (On Tin Street, Lam Tin) and No. 11NW-D/C 136 (Below Block 15, Valley Road Estate, Yan Fung Street), which are completely isolated from any vegetation and are ranked the two lowest in H value amongst the surveyed slopes, while Slopes No. 15NW-B/C 45 (Nam Long Shan Road, Aberdeen) and No. 11SW-D/C 378 (Tai Hang Road Service Reservoir), which have natural hillside shrubland and secondary woodland immediately behind them and are ranked the two highest in H value, are good examples.

(3) Coverage of Dense Canopy of Exotic Trees. The statistical test results indicate that slopes with large coverage of dense canopy of exotic trees have significantly lower H values than slopes with a low percentage of, or without, dense canopy cover of exotic trees. This implies that the large coverage of dense canopy of exotic trees, which were found to be in the form of monoculture tree plantations, inhibits natural succession, probably due to its tendency to limit suitable habitats for other vegetation species and seed-dispersing fauna. This can be exemplified by Slopes No. 6NE-A/C 2 (Au Tau Government Quarters, Yuen Long), No. 7SW-C/C 202 (Castle Peak Road, Shek Lei to Lai Yiu), No. 11NW-D/C 136 (Below Block 15, Valley Road Estate, Yan Fung Street), and No. 11SW-C/C 216 (Above No. 30, B2 Plunketts Road), which all have 80% or more of dense canopy cover of exotic trees and are ranked amongst the six lowest in H value amongst the surveyed slopes.

(4) Existence of Remnant Mature, Native Trees. The statistical test results show that slopes with remnant patches or individuals of mature, native trees have significantly higher H values than slopes that are without. The preservation of these remnant trees on man-made slopes plays an important role in enhancing species diversity of the vegetation cover because the trees act as species invasion foci by attracting avian seed dispersers which bring in seeds from nearby natural vegetation. The trees also provide a more protected micro-environment for other plant species to establish. Moreover, the topsoil preserved around the trees serves as a soil seed bank which enables rapid regeneration of other plants after the slope works. Examples of slopes that have mature, native trees, either in patches or of large individuals,

retained during previous slope works and are ranked high in H value amongst the surveyed slopes are Slopes No. 15NW-B/C 45 (Nam Long Shan Road, Aberdeen), No. 11SW-D/C 378 (Tai Hang Road Service Reservoir), No. 7NE-C/C 253 (100 M south of Chinese Music Archives, Chinese University, Tai Po Road - Ma Liu Shui), and No. 11SW-B/CR 25 (Wah Yan College, Hong Kong).

3.5 Conclusions and Recommendations

The list of healthy, naturally-occurring vegetation species recorded on the surveyed slopes under Task 2 of the Study gives a picture of which vegetation species can successfully establish and self-regenerate on relatively steep man-made slopes. The common and widespread species on the list provide useful hints on which vegetation species are particularly suitable for the environment of steep man-made slopes.

The results of the statistical tests on the degree of natural succession of slope vegetation cover in relation to different environmental factors cast light on ways to promote natural succession and hence ecological sustainability and stability of the vegetation covers on man-made slopes, thereby minimising their long-term maintenance requirements.

Apart from the findings of Task 2 of the Study, Hau and Leung (2004) made reference to the experience of the afforestation projects on natural hillsides in Hong Kong carried out by others, which bears similarities with the experience of greening man-made slopes in terms of site exposure, soil condition, planting requirements, post-planting management requirements, availability of seed source for natural succession, and aim of establishing vegetation cover that is ecologically sustainable and of minimal long-term maintenance requirements.

Hau and Leung (2004) also drew on the experience of two planting trials that are considered relevant to the greening of man-made slopes. One is the planting works on the exposed and compacted fill slopes in the Shek O Quarry rehabilitation project, and the other is the trial of planting native small tree and shrub species on steep man-made slopes at Yuen Tun, Tai Lam Country Park, which is discussed in detail in Section 2 of this report. While the results of the planting trial at Shek O Quarry are variable due to the very harsh environment for plant establishment, the generally satisfactory performance of the vegetation in the planting trial at Yuen Tun reinforces the findings of Task 2 of the Study in respect of the suitability of vegetation species on steep man-made slopes.

Based on the findings of Task 2 of the Study and the planting trials, and the experience gained from natural hillside afforestation projects by others, a number of recommendations for greening man-made slopes have been developed, with a view to establishing robust, cost-effective, and eco-friendly vegetation covers on man-made slopes.

3.5.1 Preserving Mature, Native Trees and Topsoil

In designing for the slope works, effort should be made to preserve the mature trees as far as possible, in particular the native or fleshy fruit-bearing ones so as to attract seed dispersers and increase seed input for natural regeneration of vegetation on the slopes. This applies particularly to the slopes highly isolated from natural seed sources such as the natural

terrain or large woodland. For enhancing preservation and protection of existing trees in slope works, both engineering considerations and arboricultural considerations should be looked into to explore measures to minimize construction impact on the existing trees and to enhance the resilience of the trees to construction damage.

Another possible seed source is the topsoil adjacent to the mature trees, in which the tree seeds may be embedded. Where possible, the topsoil adjacent to the mature trees should be preserved for re-use as topdressing material on the erosion control mats in the hydroseeding works. While some of the tree seeds in this source may be lost in the washout of the topsoil at the initial stage after hydroseeding when the grass cover has not yet established, some may be trapped by the erosion control mats, in particular the three-dimensional ones, thus enhancing natural regeneration of slope vegetation covers.

3.5.2 Increasing the Use of Self-regenerating Vegetation Species

In the past, certain fast-growing, hardy exotic tree species, such as *Acacia* species (Acacia, 金合歡屬), *Casuarina equisetifolia* (Horsetail Trees, 木麻黃), *Eucalyptus* species (Gum Trees, 桉屬), and *Lophostemon confertus* (Brisbane Box, 紅膠木), have been planted widely on man-made slopes, mainly in the form of tree seeds included in the hydroseeding mix and sometimes by pit-planting of container-grown seedlings. These few exotic tree species have quickly developed into plantations, forming dense canopies over the slopes.

While it is acknowledged that these exotic species are generally more effective than the native species in providing an initial vegetation cover and thus surface protection on slopes, their ecological value and sustainability are of great concern as there is no strong evidence to suggest that they can reproduce naturally in Hong Kong and at the same time they inhibit natural succession when they form dense canopies. As it is likely that the trees in the plantations comprising only these few exotic species will reach senescence and hence die in the same period, there will be a risk of wholesale loss of vegetation cover and a need for large-scale replanting sometime after the establishment of these exotic species, causing substantial adverse impact on the ecological value and visual amenity of the slopes.

In view of the drawback of the extensive use of these exotic, pioneering but sterile tree species, while it does not mean that they should be totally banned since they still perform a very effective greening function, particularly on large, exposed slopes, there is a need for improvement in species composition of the vegetation mixes when preparing the landscape design for the slope works. For enhancing biodiversity and ecological stability of slope vegetation covers, more native species of strong pioneer character or more non-invasive naturalised exotic species that are self-regenerating, should be included in the vegetation mixes to dilute the high percentage of these few exotic tree species. This again applies particularly where the slopes are highly isolated from natural seed sources.

Despite the need for increasing the use of self-regenerating vegetation species, in particular the native ones, the current range of these species that are proved suitable for use as planned vegetation on man-made slopes is still very limited. In the light of this limitation, more research into this area is recommended.

Whilst there is always a concern that the commercial supplies of the native species are

rather limited as not many of the native species have been propagated on a commercial scale, it is however considered that this limitation is not a serious problem for man-made slopes in view of the relatively small scale of the planting works involved when compared with afforestation projects. Currently, some of the native species in the form of seedlings may be available from the Kadoorie Farm and Botanic Garden and other commercial suppliers in Hong Kong and Mainland China. It is believed that once sufficient demand is generated, supplies on a commercial scale will eventually be available.

3.5.3 Increasing the Use of Shrub and Climber Species on Steep Slopes

To enhance biodiversity and ecological stability of the vegetation covers on man-made slopes, efforts should be made to plant more types of vegetation in addition to grass hydroseeding. For steep man-made slopes, while trees, in particular the large ones with dense crowns and shallow root systems, are considered not suitable due to their vulnerability to uprooting and toppling during rainstorms, introduction of suitable smaller plants such as shrub and climber species into the vegetation mixes should be encouraged. These smaller plants are not only less susceptible to wind damage but are also able to provide better protection to the slope surface against erosion as they generally can form dense, continuous vegetation cover close to the slope surface. The ground-covering growth habit of the smaller plants can also help maintain or even enhance the coverage of slope vegetation as their leaves and branches can trap plant seeds dispersed onto the slopes and prevent them from being washed away by rainwater.

Nevertheless, the increased use of shrub and climber species is also faced with difficulty as the current range of these species that have been proved suitable for use on man-made slopes as planned vegetation is also very limited. More research into this area is therefore also recommended.

3.5.4 Expanding the Range of Suitable Vegetation Species

In view of the need for increasing the use of self-regenerating vegetation species as well as shrub and climber species and the small plant palette currently available, limiting the use of these species as discussed in Sections 3.5.2 and 3.5.3, it is necessary to expand the range of suitable vegetation species that can be applied successfully as planned vegetation on man-made slopes, for the designers' reference.

Based on the list of healthy, naturally-occurring vegetation species, in particular the common and widespread ones, recorded under Task 2 of the Study, the species generally used in the natural hillside afforestation projects, and the species that performed satisfactorily in the planting trial at Yuen Tun, two recommended lists of native vegetation species for use in greening slopes have been developed (Hau and Leung, 2004).

The species in the first list (List A in Table 11), termed "core species" in Hau and Leung (2004), are suitable for general use in greening slopes. These species have been proven to be successful and reliable as planned vegetation in previous planting trials in Hong Kong. They are also generally easy to produce in nurseries in large quantities. Moreover, most of them provide fleshy fruit resources for seed dispersers and therefore can be included

in the landscape designs, particularly where the slopes do not have any existing mature, native trees to attract seed dispersers for increasing seed input for natural regeneration of vegetation on the slopes or where the slopes are highly isolated from natural seed sources.

Amongst the healthy, naturally-occurring species recorded under Task 2 of the Study and the species used in the afforestation projects, the performance of which as planned vegetation on slopes has not yet been tested with proper documentation in Hong Kong, some are believed to be more successful as planned vegetation than others. These species, termed "selective species" in Hau and Leung (2004), are included in the second list (List B in Table 12). They can be planted on selected sites as planting trials, for enriching the species diversity of the vegetation covers.

It should be noted that in both Lists A and B woody species rather than herbaceous species are included. Herbaceous species, as explained in the calculation of the Shannon diversity index in Section 3.3.2, are not structure-building vegetation in the terrestrial ecosystem and will eventually be replaced or dominated by woody species in most cases. In view of their characteristic of not being long-lasting due to natural succession, herbaceous species were not given priority in the recommendations.

3.5.5 Conducting More Planting Trials

The planting trial for the native small tree and shrubs species on steep slopes at Yuen Tun is the first that the GEO has conducted and documented in a systematic manner. Although a list of native vegetation species (List A) has been developed for general use in greening man-made slopes, additional planting trials to identify more suitable species, in particular those for use on steep slopes, are recommended. Where possible, studies to assess the long-term performance of the planned vegetation should also be considered.

Apart from conducting site trials for the species on List B, those other healthy, naturally-occurring species recorded under Task 2 of the Study and other afforestation species, which are not on both Lists A and B, could also be tried where appropriate. In future planting trials, priority should be given to the small tree, shrub and climber species, in particular those common and widespread ones recorded under Task 2 of the Study. However, it should be noted that the naturalised exotic species, *Mikania micrantha* (Mikania, 薇甘菊), is a very invasive weedy climber that could climb up other plants and eventually smother them by reducing their photosynthesis. As this species has been considered an ecological hazard in Hong Kong due to its plant-killing characteristic, it should not be used in greening slopes. Other invasive species such as *Leucaena leucocephala* (White Popinac, 銀合歡) and *Lantana camara* (Lantana, 馬纓丹), though being less damaging than *Mikania micrantha*, should also be used with caution.

As regards the herbaceous species, although they will eventually be replaced or dominated by woody species in most cases, planting trials are still worthwhile to explore alternatives or supplements to the grass species commonly used in hydroseeding, for providing the initial temporary protection to the slope surfaces against erosion before the successful establishment of the woody species. In addition to the non-invasive, naturally-occurring herbaceous climber species recorded under Task 2 of the Study, fern species commonly encountered during field inspections may also be considered for planting

trials. These fern species include *Blechnum orientale* (Oriental Blechnum,烏毛蕨), *Cyclosorus parasiticus* (Wood-fern, 華南毛蕨), *Dicranopteris pedata* (Dichotomy Forked Fern, 芒萁), *Pityrogramma calomelanos* (Silver Fern, 粉葉蕨), *Pteris semipinnata* (Semi-pinnated Brake, 半邊旗), and *Pteris vittata* (Ladder Brake, 蜈蚣草). These species, except *Dicranopteris pedata*, are shade-tolerant and therefore may be planted particularly in shaded areas, such as the slope surfaces under dense tree crowns, to supplement the surface protection function of hydroseeded grass species which normally do not perform well under shade.

In conducting planting trials, the feasibility of different planting methods, such as pit-planting of container-grown seedlings, hydroseeding of plant seeds or spore-bearing fern leaflets, and hydro-sprigging of herbaceous plants, should be explored. As discussed in Section 2, planting of *Blechnum orientale* and *Dicranopteris pedata* by mixing spore-bearing fronds with soil and spreading the mix on the slope surface was tried at Yuen Tun, and the results are encouraging. Further planting trials for these two fern species using other planting methods may be considered.

3.5.6 Enhancing Post-planting Management Practices

Where the specific slope characteristics and slope greening targets justify the extensive use of the exotic, pioneering but sterile, tree species, appropriate post-planting management of the vegetation cover is necessary in order to promote natural succession. In the circumstances, standard forestry improvement practices such as thinning of the exotic trees and enrichment planting of native species in between the exotic trees in the plantations should be considered. A list of recommended native species, which are generally hardier and more drought-tolerant, for enrichment planting is given in Table 13 (Hau and Leung, 2004). In order that the post-planting management practices are effective, it will be useful if field assessments are conducted to determine the extent of natural succession on all man-made slopes covered with exotic tree plantations.

4. FURTHER STUDIES

To pursue sustainable slope greening, the GEO is looking into the establishment of self-regenerating, ecologically stable vegetation covers that will result in naturalistic landscape of minimal long-term maintenance requirement. As part of the continuous improvement initiatives for achieving this target and as a follow-on to Task 2 of the Study discussed in Section 3, the GEO has embarked on a further study on the application of various vegetation species for landscaping of man-made slopes.

The key objectives of this further study are to expand the range of suitable vegetation species for landscape use on man-made slopes and to identify appropriate methods of application and maintenance requirements of the vegetation species. At the end of the study, recommendations including a user-friendly, extended plant selection matrix and necessary guidelines, will be developed to give clear guidance on the use of appropriate vegetation species on man-made slopes under different site conditions and landscape design intents.

The study commenced in October 2003. With the site trials involving planting works and one-year establishment works, which are scheduled for commencement in mid 2005 and

completion in late 2006, the study will end in 2007.

Another study by the GEO that may be of relevance to the identification of suitable vegetation species for use on man-made slopes is on the trial applications of bioengineering measures on natural terrain landslide scars, using predominantly native vegetation species. The findings of this study, like the experience of the afforestation projects on natural hillsides, will provide useful reference for building up the plant palette for use in greening man-made slopes.

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LIST OF TABLES

Table 1 - Configuration and Materials on the Trial Panels

Panel No.	Orientation	Slope Angle	Height (m)	Length (m)	Surface Material
1	NE	45^{o}	2.4	14	Brownish yellow fine to coarse silty sand. Top soil at slope crest
2	NE	47^{o}	4.9	9.8	Brownish yellow fine to coarse silty sand.
3	NE	47^{o}	6.4	10.8	Brownish yellow fine to coarse silty sand.
4	E	47^{o}	6.6	16.8	Yellow coarse silty sand with gravel. Soft rock with relict joint at toe
5	SE	47^{o}	7.3	10.2	Yellow coarse silty sand with gravel. Soft rock with relict joint at toe
6	SE	47^{o}	6.6	10.2	Yellow coarse silty sand with gravel. Soft rock with relict joint at toe
7	SE	48^{o}	4.5	14.6	Browish yellow coarse silty sand
8	NW	50^{o}	2.5	14.7	Brownish yellow fine to coarse silty sand. Quartz veins exposed.
9	NE	49^{o}	2.8	11.2	Brownish yellow fine to coarse silty sand. Quartz veins exposed.
10	NE	47^{o}	4.8	10	Brownish yellow fine to coarse silty sand. Quartz veins exposed.
11	NE	48^{o}	5.7	10	Yellow coarse silty sand. Quartz veins exposed.
12	NE	48^{o}	5.1	10	Yellow coarse silty sand. Quartz veins exposed.
13	NE	47^{o}	3.8	26.2	Reddish yellow fine to coarse silty sand.

Table 2 - Properties of Soil from Laboratory Testing Results

Laboratory Test	Sample No.				Average	After 2 years
	1	2	3	4		
Clay (%)	15	18	25	22	20	20
Silt (%)	18	14	8	8	12	15
Sand (%)	47	47	47	45	47	40
Gravel (%)	20	21	20	25	21	25
Liquid Limit (%)	53	51	59	60	56	55
Plastic Limit (%)	27	28	29	30	29	27
Plasticity Index (%)	26	23	30	30	27	28
Organic Matter Content (%)	1.5	1.6	1.6	1.5	1.55	2.6
Acidity pH value	5.9	6.2	4.2	4	5.1	4.1
Moisture Content (%)	11	8.8	8.1	7.4	8.8	-

Table 3 - Materials Forming the Hydroseeding Mix and Quantities Used

Materials	Rate of Application	Consumption C630 & C631	Consumption C632
Bermuda Grass Seed	15 g/m²	6.75 kg	6 kg
Bahia Grass Seed	10 g/m²	4.50 kg	4 kg
Rye Grass Seed	5 g/m²	Nil	2 kg
Fertilizer (NPK 15:15:15)	100 g/m²	45 kg	40 kg
Mulch (Gypsum)	200 g/m²	90 kg	80 kg
Water	1 liter/ m²	450 liters	400 liters
Soil Stabilizer	0.3 g/m²	135 g	120 g
Dye	0.2 g/m²	90 g	80 g

Table 4 - Summary of Seedlings Planted on Trial Panels (Sheet 1 of 3)

Panel	Seedlings	Total No.	Stem Height (cm)			Basal Diameter (mm)		
			Min.	Max.	Avg	Min.	Max.	Avg
1	Ardisia crenata	2	12	19	15.5	2.5	3.8	3.2
	Gordonia axillaries	20	17.5	27.5	21.9	1.7	4.6	2.9
	Litsea rotundifolia	19	17	35	23.5	1.5	3.4	2.2
	Melicope pteleifolia	4	15	22.5	19.5	2	3.5	3
	Psychotria asiatica	6	12.5	21	17.3	2.8	6.2	4.4
	Rhaphiolepis indica	2	10.5	15	12.8	0.5	0.8	0.7
	Schefflera octophylla	5	6	17	10.7	2.6	5.8	4.2
	Zanthoxylum avicennae	6	16	32.5	23.7	1.8	3.4	2.5
2	Ardisia crenata	9	11	23	19.5	2.3	4.9	3.3
	Gordonia axillaries	21	18	35	26.5	1.5	4.5	3.1
	Litsea rotundifolia	24	11	43	26.3	0.7	5.3	2.3
	Melicope pteleifolia	13	17	32	24.2	2.6	4.3	3.2
	Psychotria asiatica	8	21.5	31	26.9	4.5	7.8	6
	Rhaphiolepis indica	11	9.5	18.5	9.3	0.2	2.4	1.7
	Schefflera octophylla	8	5	29	18.2	4.4	7.5	5.8
	Zanthoxylum avicennae	8	30.5	55.5	39.6	3.1	4.1	3.6
3	Ardisia crenata	9	9	23.5	17.1	2.6	4	3.4
	Gordonia axillaries	18	14	28.5	21.4	2.2	5	3.1
	Litsea rotundifolia	17	14	42.5	26.5	1.7	3.9	2.7
	Melicope pteleifolia	13	12.5	33.5	23.3	2.1	5.5	3.6
	Psychotria asiatica	17	17	32.5	23.3	3.2	6.5	5
	Rhaphiolepis indica	9	7	22.5	9.7	0.4	2.2	0.7
	Schefflera octophylla	20	5	20.5	12.2	2.6	7.3	4.5
	Zanthoxylum avicennae	19	18	50.5	36.6	2.2	5.8	4.1
4	Ardisia crenata	10	10.5	20	16.6	2.8	4.7	3.7
	Gordonia axillaries	25	16	33	19.6	1.8	5.2	3.5
	Litsea rotundifolia	25	14	39.5	22.9	1.5	3.7	2.5
	Melicope pteleifolia	15	18	30.5	23.1	2.4	6.5	4.3
	Psychotria asiatica	10	22	38.5	28.5	4.8	7.2	6.1
	Rhaphiolepis indica	14	9.5	18.5	11.1	0.1	1.4	0.7
	Schefflera octophylla	10	11	23	14.4	4.9	6.8	5.4
	Zanthoxylum avicennae	10	17	54	31.2	1.8	5.7	3.8

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Table 4 - Summary of Seedlings Planted on Trial Panels (Sheet 2 of 3)

Panel	Seedlings	Total No.	Stem Height (cm)			Basal Diameter (mm)		
			Min.	Max.	Avg	Min.	Max.	Avg
5	Ardisia crenata	10	13	23	18.3	2.8	5.2	3.6
	Gordonia axillaries	25	16.5	31.5	23.8	1.6	5.1	3.4
	Litsea rotundifolia	25	11	39.5	24.9	1.4	4.8	2.7
	Melicope pteleifolia	15	18	41.5	23.9	2.5	6.6	2.6
	Psychotria asiatica	10	22	32	25.5	5.1	7.5	6.2
	Rhaphiolepis indica	14	10	27.5	17.1	0.3	2	1.1
	Schefflera octophylla	10	4.5	29.5	14.1	3.6	8.3	4.7
	Zanthoxylum avicennae	10	20	45.5	34.7	2.9	5.3	4.6
7	Ardisia crenata	9	10.5	16.5	13.4	2.3	4.8	3.2
	Gordonia axillaries	23	15	28	20.3	1.5	5	3.2
	Litsea rotundifolia	25	12.5	35.5	21.4	1.3	3.2	2
	Melicope pteleifolia	15	11	21.5	17.3	1.4	4.7	2.7
	Psychotria asiatica	8	18	23	19.8	4.3	5.7	5
	Rhaphiolepis indica	18	9.5	19	9.8	0.4	1.7	0.7
	Schefflera octophylla	15	7	18.5	11.7	3.5	5.8	4.5
	Zanthoxylum avicennae	15	13	29	20.9	1.2	3.8	2.5
9	Ardisia crenata	8	12	21	14.5	2.8	3.5	3.2
	Gordonia axillaries	15	13	27.5	21	1.4	4.4	3
	Litsea rotundifolia	13	9.5	22	16.1	1.4	3.6	1.8
	Melicope pteleifolia	11	13	28	19.3	1.8	4.3	3
	Psychotria asiatica	9	18	26	21.6	3.1	6.1	5
	Rhaphiolepis indica	12	7.5	24.5	14.2	0.2	2.8	1.4
	Schefflera octophylla	8	9	24.5	13.4	3.8	5.5	4.9
	Zanthoxylum avicennae	9	17.5	29.5	24.7	1.5	3.5	2.6
10	Ardisia crenata	10	15	21	18.5	2.3	4.5	3.1
	Gordonia axillaries	25	15.5	25.5	21.3	1.6	6.3	2.9
	Litsea rotundifolia	25	13	36.5	25	0.3	4.3	2.4
	Melicope pteleifolia	14	15	28	21	2.1	5.8	3.2
	Psychotria asiatica	10	20	29.5	23.6	4.2	6.4	5.3
	Rhaphiolepis indica	15	5	25	12.6	0.4	3.3	1
	Schefflera octophylla	10	11	25	15.3	4.7	8.2	5.8
	Zanthoxylum avicennae	10	14	37.5	26.5	2.2	3.6	2.8

Table 4 - Summary of Seedlings Planted on Trial Panels (Sheet 3 of 3)

Panel	Seedlings	Total No.	Stem Height (cm)			Basal Diameter (mm)		
			Min.	Max.	Avg	Min.	Max.	Avg
11	Ardisia crenata	11	9	21	14	2	5.8	2.9
	Gordonia axillaries	26	15.5	27	21.1	1.8	4.8	2.9
	Litsea rotundifolia	26	16	36	23.9	1.2	4.2	2.6
	Melicope pteleifolia	17	14.5	26.5	19.4	1.7	5	2.8
	Psychotria asiatica	12	18.5	28.5	22.7	3.8	8.2	5.6
	Rhaphiolepis indica	17	8.5	21.5	11.8	0.7	1.8	0.9
	Schefflera octophylla	10	8	19.5	12.8	3.8	7	5
	Zanthoxylum avicennae	11	17.5	39	26.7	2.2	5.2	3.5
12	Ardisia crenata	10	12	20	15	2.5	5.5	3.5
	Gordonia axillaries	25	20	43.5	29	2.5	5.8	4.2
	Litsea rotundifolia	25	13	33.5	24	1.4	4.3	2.2
	Melicope pteleifolia	15	18	34	22.8	2.6	5.3	3.3
	Psychotria asiatica	10	14	28	22.1	3.1	7.5	5.8
	Rhaphiolepis indica	14	7	20.5	11.5	0.2	1.5	0.6
	Schefflera octophylla	10	34	53	45.5	7.4	11	9.4
	Zanthoxylum avicennae	10	22.5	53.5	38.3	3.2	7.8	4.6
13	Ardisia crenata	12	9.5	17	13.3	2.4	3.5	2.9
	Gordonia axillaries	23	13.5	26	19.3	1.8	5	2.9
	Litsea rotundifolia	25	10	25.5	16.8	1	3.2	1.7
	Melicope pteleifolia	17	16.5	27.5	19.9	1.8	5.2	3.1
	Psychotria asiatica	20	16.5	23	20.4	2.7	6	4.7
	Rhaphiolepis indica	15	6	37.5	11.5	0.1	3.5	0.9
	Schefflera octophylla	11	5	17	10	2.5	5.2	4.1
	Zanthoxylum avicennae	11	12	32	19.9	1.6	4	2.5
Total for All Panels	Ardisia crenata	100	11.1	20.5	15.9	2.5	4.6	3.3
	Gordonia axillaries	246	16.0	30.5	22.3	1.8	5.1	3.2
	Litsea rotundifolia	249	12.9	35.7	23.0	1.2	4.0	2.3
	Melicope pteleifolia	149	15.4	30.0	21.3	2.1	5.3	3.2
	Psychotria asiatica	120	18.1	28.6	22.9	3.7	6.8	5.3
	Rhaphiolepis indica	141	8.0	23.4	11.9	0.3	2.2	0.9
	Schefflera octophylla	117	9.3	24.7	15.9	3.9	7.1	5.2
	Zanthoxylum avicennae	119	17.6	41.9	29.5	2.1	4.8	3.4

Table 5 - List of Slopes Surveyed for Performance Assessment of Vegetation Species on Slopes (Sheet 1 of 2)

Slope No.	Geographical Location	Slope Age [1] (Months)	Slope Gradient (Degree)	Slope Size [2] (M^2)	Slope Orientation (Degree)	Erosion Control Mat Used	Degree of Isolation from Natural Vegetation [3]	Remarks
6NE-A/C 2	Au Tau Government Quarters, Yuen Long	41	60	22,700	265	Not used	1	
6SE-B/C 6	Route Twisk	61	42	1,700	141	Soil Saver	1	
6SE-B/CR 72	Tsuen Wan West Low Level Fresh Water Service Reservoir	111	80	5,800	171	Not used	1	Partly rock slope
6SW-D/C 11	Access road to Marine Police Base, south of Siu Lam	> 294	45	1,600	343	Unknown	2	
7NE-C/C 253	100 M south of Chinese Music Archives, Chinese University, Tai Po Road - Ma Liu Shui	43	65	1,100	35	Tensar Mat	0	
7SW-C/C 202	Castle Peak Road, Shek Lei to Lai Yiu	69	56	3,600	302	Synthetic mat	0	
11NE-C/C 13	Jordan Valley Pumping Station	170	55	6,500	331	Not used	1	Partly rock slope
11NE-D/C 79	On Tin Street, Lam Tin	193	57	1,600	180-263	Not used	3	
11NW-A/C 56	Ching Cheung Road, Lai Chi Kok	129	40	21,700	228	Not used	0	
11NW-A/C 179	Lai Chi Kok Hospital, Castle Peak Road	136	50	2,700	245	Tensar Mat	0	
11NW-B/C 135	Lion Rock High Level No. 1 Fresh Water Service Reservoir	127	45	7,600	224	Tensar Mat, Miramat, Erolant, Enkamat	0	
11NW-D/C 136	Below Block 15, Valley Road Estate, Yan Fung Street	70	45	5,400	24	Soil Saver	3	Partly shotcrete
11SE-A/C 163	Fortress Hill MTR Station	165	50	3,900	313	Not used	3	
11SW-A/C 297	Mount Davis Service Reservoir	161	70	14,100	165-188	Not used	0	Partly rock slope
11SW-B/C 268	Behind 139-165 Wong Nai Chung Road, Causeway Bay	179	55	4,800	242	Tensar Mat	2	Partly shotcrete
11SW-B/CR 25	Wah Yan College, Hong Kong	134	50	2,800	330	Tensar Mat	2	
11SW-C/C 216	Above No. 30, B2 Plunketts Road	72	60	1,300	19	Soil Saver	0	
11SW-D/C 27	Lingnan Primary School & Kindergarten	117	50	2,700	22-90	Enkamat	1	
11SW-D/C 378	Tai Hang Road Service Reservoir	122	60	3,500	19	Tensar Mat	1	
15NW-B/C 45	Nam Long Shan Road, Aberdeen	60	50	600	262	Enkamat	0	

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Table 5 - List of Slopes Surveyed for Performance Assessment of Vegetation Species on Slopes (Sheet 2 of 2)

Notes:

1 Slope age means the time duration between the date of completion of slope formation or upgrading works and the date of slope inspection.

2 Slope size represents the slant area of the slope.

3 Degree of isolation from natural vegetation is ranked as follows -

0 = Directly connected to natural vegetation such as hillside grassland, shrubland and woodland.

1 = Connected to natural vegetation through vegetation corridors such as parks and gardens.

2 = Connected to vegetated parks and gardens larger than 1 ha.

3 = Completely isolated.

Table 6 - Slope Size and Actual Surveyed Area of Surveyed Slopes

Slope No.	Geographical Location	Slope Size [1] (M^2)	Actual Surveyed Area [2] (M^2)
6NE-A/C 2	Au Tau Government Quarters, Yuen Long	22,700	2,552
6SE-B/C 6	Route Twisk	1,700	1,228
6SE-B/CR 72	Tsuen Wan West Low Level Fresh Water Service Reservoir	5,800	4,475
6SW-D/C 11	Access road to Marine Police Base, south of Siu Lam	1,600	215
7NE-C/C 253	100 M south of Chinese Music Archives, Chinese University, Tai Po Road - Ma Liu Shui	1,100	764
7SW-C/C 202	Castle Peak Road, Shek Lei to Lai Yiu	3,600	648
11NE-C/C 13	Jordan Valley Pumping Station	6,500	1,074
11NE-D/C 79	On Tin Street, Lam Tin	1,600	1,546
11NW-A/C 56	Ching Cheung Road, Lai Chi Kok	21,700	1,225
11NW-A/C 179	Lai Chi Kok Hospital, Castle Peak Road	2,700	2,673
11NW-B/C 135	Lion Rock High Level No. 1 Fresh Water Service Reservoir	7,600	871
11NW-D/C 136	Below Block 15, Valley Road Estate, Yan Fung Street	5,400	1,640
11SE-A/C 163	Fortress Hill MTR Station	3,900	1,902
11SW-A/C 297	Mount Davis Service Reservoir	14,100	9,000
11SW-B/C 268	Behind 139-165 Wong Nai Chung Road, Causeway Bay	4,800	1,088
11SW-B/CR 25	Wah Yan College, Hong Kong	2,800	682
11SW-C/C 216	Above No. 30, B2 Plunketts Road	1,300	316
11SW-D/C 27	Lingnan Primary School & Kindergarten	2,700	810
11SW-D/C 378	Tai Hang Road Service Reservoir	3,500	885
15NW-B/C 45	Nam Long Shan Road, Aberdeen	600	570

Notes:
1 Slope size represents the slant area of the slope.
2 Actual surveyed area was calculated based on the area of quadrats set on the slope surface. This calculation method was applied to all surveyed slopes except those slopes that are too high and steep for this method to be practicable (Slopes No. 6SE-B/CR 72, No. 11SW-A/C 297, and part of No. 11NE-C/C 13). For these difficult slopes, the actual surveyed area was arrived at based on the estimated dimensions of the slope surface that was surveyed.

Table 7 - Naturally-occurring Native Vegetation Species Recorded on Surveyed Slopes
(Sheet 1 of 3)

Growth Habit	Botanical Name	Common Name	Chinese Name
Tree	*Acronychia pedunculata*	Acronychia	山油柑
	Adinandra millettii	Adinandra	黃瑞木
	Ailanthus fordii	Ailanthus	常綠臭椿
	Alangium chinense	Chinese Alangium	八角楓
	Antirhea chinensis	Chinese Antirhea	毛茶
	Aporusa dioica	Aporusa	銀柴
	Archidendron lucidum	Chinese Apea Ear-ring	亮葉猴耳環
	Bridelia tomentosa	Pop-gun Seed	土蜜樹
	Broussonetia papyrifera	Paper Mulberry	構樹
	Brucea javanica	False Sumac	鴉膽子
	Canthium dicoccum	Butulang Canthium	鐵矢米
	Celtis sinensis	Chinese Hackberry	朴樹
	Celtis timorensis	Philippine Hackberry	假玉桂
	Choerospondias axillaris	Hog Plum	南酸棗
	Cinnamomum parthenoxylon	Yellow Cinnamomum	黃樟
	Crateva sp.	Crateva	魚木屬
	Cratoxylum cochinchinense	Yellow Cow Wood	黃牛木
	Ficus fistulosa	Common Yellow Stem-fig	水同木
	Ficus hispida	Opposite-leaved Fig	對葉榕
	Ficus microcarpa	Chinese Banyan	細葉榕
	Ficus superba var. *japonica*	Superb Fig	筆管榕
	Ficus variegate var. *chlorocarpa*	Common Red-stem Fig	青果榕
	Glochidion lanceolarium	Large-leaved Abacus Plant	艾膠算盤子
	Glochidion wrightii	Wright's Abacus Plant	白背算盤子
	Gordonia axillaris	Hong Kong Gordonia	大頭茶
	Ilex viridis	Small-leaved Holly	亮葉冬青
	Itea chinensis	Itea	鼠刺
	Ligustrum sinense	Chinese Privet	山指甲
	Litsea glutinosa	Pond Spice	潺槁樹
	Litsea monopetala	Persimmon-leaved Litsea	假柿木薑子
	Macaranga tanarius	Elephant's Ear	血桐
	Machilus chekiangensis	Zhejiang Machilus	浙江潤楠
	Machilus pauhoi	Many-nerved Machilus	刨花潤楠
	Machilus velutina	Woolly Machilus	絨毛潤楠
	Mallotus paniculatus	Turn-in-the-wind	白楸
	Microcos nervosa	Microcos	破布葉
	Phyllanthus emblica	Myrobalan	餘甘子
	Rhus chinensis	Sumac	鹽膚木
	Rhus hypoleuca	Sumac	白背漆
	Rhus succedanea	Wax Tree	野漆
	Sapium discolor	Mountain Tallow Tree	山烏桕
	Schefflera heptaphylla	Ivy Tree	鴨腳木
	Scolopia saeva	Scolopia	廣東刺柊
	Sterculia lanceolata	Scarlet Sterculia	假蘋婆

Table 7 - Naturally-occurring Native Vegetation Species Recorded on Surveyed Slopes
(Sheet 2 of 3)

Growth Habit	Botanical Name	Common Name	Chinese Name
Tree (Cont'd)	*Styrax suberifolius*	Cork-leaved Snow-bell	紅皮
	Syzygium hancei	Hance's Syzygium	韓氏蒲桃
	Syzygium levinei	Levine's Syzygium	山蒲桃
	Tetradium glabrifolium	Melia-leaved Evodia	楝葉吳茱萸
	Trema tomentosa	India-Charcoal Trema	山黃麻
	Viburnum odoratissimum	Sweet Viburnum	珊瑚樹
	Zanthoxylum avicennae	Prickly Ash	簕欓
Shrub	*Alchornea trewioides*	Christmas Bush	紅背山麻杆
	Ardisia crenata	Hilo Holly	朱砂根
	Baeckea frutescens	Dwarf Mountain Pine	崗松
	Boehmeria nivea	Ramie	苧麻
	Boehmeria penduliflora var. *loochooensis*	Dense-Flowered False Nettle	密花苧麻
	Breynia fruticosa	Waxy Leaf	黑面神
	Callicarpa sp.	Beauty Berry	紫珠屬
	Clerodendrum fortunatum	Glorybower	鬼燈籠
	Croton sp.	Croton	巴豆屬
	Desmodium heterocarpon	False Groundnut	假地豆
	Eurya nitida	Shining Eurya	細齒葉柃
	Ficus hirta	Hairy Fig	粗葉榕
	Ficus variolosa	Varied-leaf Fig	變葉榕
	Glochidion eriocarpum	Hairy-fruited Abacus Plant	毛果算盤子
	Glochidion zeylanicum	Hong Kong Abacus Plant	香港算盤子
	Glochidion sp.	Abacus Plant	算盤子屬
	Helicteres angustifolia	Narrow-leaved Srewtree	山芝麻
	Homalium cochinchinense	Cochin-china Homalium	天料木
	Ilex asprella	Rough-leaved Holly	梅葉冬青
	Ilex pubescens	Downy Holly	毛冬青
	Inula cappa	Elecampane	羊耳菊
	Lasianthus sp.	Lasianthus	粗葉木屬
	Litsea cubeba	Fragrant Litsea	木薑子
	Litsea rotundifolia var. *oblongifolia*	Oblong-leaved Litsea	豺皮樟
	Melastoma candidum	Common Melastoma	野牡丹
	Melastoma sanguineum	Blood-red Melastoma	毛稔
	Phyllanthus cochinchinensis	Vietnam Leaf-flower	越南葉下珠
	Phyllanthus reticulatus	Reticulated Leaf-flower	小果葉下珠
	Psychotria asiatica	Wild Coffee	九節
	Rhaphiolepis indica	Hong Kong Hawthorn	車輪梅
	Rhodomyrtus tomentosa	Rose Myrtle	桃金娘
	Tadehagi triquetrum	Triquetrous Tadehagi	葫蘆茶
	Uraria crinita	Cat's Tail Bean	貓尾草
	Wikstroemia indica	Indian Wikstroemia	了哥王
	Unknown sp.		

Table 7 - Naturally-occurring Native Vegetation Species Recorded on Surveyed Slopes (Sheet 3 of 3)

Growth Habit	Botanical Name	Common Name	Chinese Name
Climber	*Asparagus cochinchinensis*	Wild Asparagus	天門冬
	Bauhinia championii [1]	Champion's Bauhinia	缺葉藤
	Cassytha filiformsis [1]	Cassytha	無根藤
	Cocculus orbiculatus [1]	Snail seed	木防己
	Dalbergia benthamii	Bentham's Rosewood	兩廣黃檀
	Dalbergia hancei	Scandent Rosewood	藤黃檀
	Desmos chinensis	Desmos	假鷹爪
	Dioscorea benthamii [1]	Bentham's Yam	大青薯
	Dioscorea sp. [1]	Yam	薯蕷屬
	Embelia leata	Twig-hanging Embelia	酸藤子
	Gnetum luofuense	Luofushan Joint-fir	羅浮買麻藤
	Gymnema sylvestre	Miracle Fruit	匙羹藤
	Hypserpa nitida	Shining Hypserpa	夜花藤
	Ipomoea biflora [1]	Hairy Morning Glory	心萼薯
	Maesa perlarius	Maesa	鯽魚膽
	Millettia nitida	Glittering-leaved Millettia	亮葉崖豆藤
	Mussaenda pubescens	Splash-of-white	玉葉金花
	Paederia scandens [1]	Chinese Fevervine	雞矢藤
	Puerarai lobata [1]	Kudzu	野葛
	Rosa laevigata	Cherokee Rose	金櫻子
	Rubus reflexus	Rusty-haired Raspberry	鏽毛莓
	Sageretia thea	Hedge Sageretia	雀梅藤
	Smilax china	Greenbrier	菝契
	Smilax glabra	Glabrous Greenbrier	土茯苓
	Smilax lanceifolia var. *opaca*	Opaque Greenbrier	暗色菝契
	Solena amplexicaulis	Clasping-stem Solena	茅瓜
	Stephania longa [1]	Long Stephania	糞箕篤
	Strophanthus divaricatus	Goat Horns	羊角拗
	Tetracera asiatica	Sandpaper Vine	錫葉藤
	Zanthoxylum nitidum	Shiny-leaved Prickly Ash	兩面針

Note: 1 Herbaceous species.

Table 8 - Naturally-occurring Naturalised Exotic Vegetation Species Recorded on Surveyed Slopes

Growth Habit	Botanical Name	Common Name	Chinese Name
Tree	*Bauhinia variegata*	Camel's Foot Tree	宮粉羊蹄甲
	Cassia sp.	Cassia	決明屬
	Cinnamomum burmannii	Batavia Cinnamon	陰香
	Cinnamomum camphora	Camphor Tree	樟樹
	Dimocarpus longan	Longan	龍眼
	Erythrina speciosa	Ivory Coral Tree	象牙花
	Leucaena leucocephala	White Popinac	銀合歡
	Melia azedarach	China-berry	苦楝
	Murraya paniculata	Orange Jasmine	九里香
	Syzygium jambos	Rose Apple	蒲桃
Shrub	*Lantana camara*	Lantana	馬纓丹
	Manihot esculenta	Cassava	木薯
	Nerium oleander	Oleander	夾竹桃
	Solanum torvum	Tetrongan	水茄
	Urena lobata	Rose Mallow	肖梵天花
Climber	*Mikania micrantha* [1]	Mikania	薇甘菊
	Passiflora foetida [1]	Passion Flower	龍珠果
	Passiflora suberosa [1]	Triangular Passion Flower	南美西番蓮

Note: 1 Herbaceous species.

Table 9 - Common and Widespread Naturally-occurring Vegetation Species Recorded on Surveyed Slopes

Growth Habit	Botanical Name	Common Name	Chinese Name
Native tree	*Bridelia tomentosa* [5, 7]	Pop-gun Seed	土蜜樹
	Celtis sinensis [5, 7]	Chinese Hackberry	朴樹
	Cratoxylum cochinchinense [3]	Yellow Cow Wood	黃牛木
	Ficus hispida [5, 7]	Opposite-leaved Fig	對葉榕
	Ficus variegata var. *chlorocarpa* [2, 7]	Common Red-stem Fig	青果榕
	Ligustrum sinense [2, 3]	Chinese Privet	山指甲
	Litsea glutinosa [2, 3, 7]	Pond Spice	潺槁樹
	Macaranga tanarius [5, 7]	Elephant's Ear	血桐
	Mallotus paniculatus [2, 3, 7]	Turn-in-the-wind	白楸
	Microcos nervosa [2, 3]	Microcos	破布葉
	Rhus succedanea [2, 3]	Wax Tree	野漆
	Sapium discolor [2, 3]	Mountain Tallow Tree	山烏桕
	Schefflera heptaphylla [3]	Ivy Tree	鴨腳木
	Sterculia lanceolata [2, 3, 7]	Scarlet Sterculia	假蘋婆
Native shrub	*Breynia fruticosa* [2, 3]	Waxy Leaf	黑面神
	Ficus hirta [2, 3]	Hairy Fig	粗葉榕
	Melastoma sanguineum [3]	Blood-red Melastoma	毛稔
	Psychotria asiatica [2]	Wild Coffee	九節
	Rhaphiolepis indica [3]	Hong Kong Hawthorn	車輪梅
Native climber	*Dalbergia benthamii* [2, 4]	Bentham's Rosewood	兩廣黃檀
	Embelia laeta [2, 3]	Twig-hanging Embelia	酸藤子
	Strophanthus divaricatus [2, 3]	Goat Horns	羊角拗
Naturalised exotic shrub	*Lantana camara* [5]	Lantana	馬纓丹
Naturalised exotic climber	*Mikania micrantha* [1, 5, 6]	Mikania	薇甘菊

Notes:
1 Herbaceous species.
2 Species common in forest or woodlands.
3 Species common in shrublands.
4 Species common in grasslands.
5 Species common in disturbed habitats, wastelands, or edges of woodlands or shrublands.
6 Species considered as an ecological hazard.
7 Species also recorded on slopes surveyed under Task 1 of the Study (Performance Assessment of Greening Techniques).

Table 10 - Species Diversity, Species Abundance, and Species Richness of Surveyed Slopes

Slope No.	Geographical Location	Shannon Diversity Index [1, 4] (H)	Species Abundance [2, 4] (A)	Species Richness [3, 4] (S)
15NW-B/C 45	Nam Long Shan Road, Aberdeen	**3.18**	782	**49**
11SW-D/C 378	Tai Hang Road Service Reservoir	3.00	432	37
7NE-C/C 253	100 M south of Chinese Music Archives, Chinese University, Tai Po Road - Ma Liu Shui	2.87	96	25
11NW-B/C 135	Lion Rock High Level No. 1 Fresh Water Service Reservoir	2.73	299	30
11SW-B/CR 25	Wah Yan College, Hong Kong	2.72	299	26
6SE-B/C 6	Route Twisk	2.70	80	20
11NE-C/C 13	Jordan Valley Pumping Station	2.68	754	39
6SW-D/C 11	Access road to Marine Police Base, south of Siu Lam	2.67	293	30
11NW-A/C 56	Ching Cheung Road, Lai Chi Kok	2.50	205	26
11SW-D/C 27	Lingnan Primary School & Kindergarten	2.38	136	21
11SW-A/C 297	Mount Davis Service Reservoir	2.27	545	25
11SW-B/C 268	Behind 139-165 Wong Nai Chung Road, Causeway Bay	2.19	1,039	32
6SE-B/CR 72	Tsuen Wan West Low Level Fresh Water Service Reservoir	2.17	188	15
11NW-A/C 179	Lai Chi Kok Hospital, Castle Peak Road	2.10	1,539	36
6NE-A/C 2	Au Tau Government Quarters, Yuen Long	1.98	284	20
11SE-A/C 163	Fortress Hill MTR Station	1.77	**1,685**	22
11SW-C/C 216	Above No. 30, B2 Plunketts Road	1.65	377	18
7SW-C/C 202	Castle Peak Road, Shek Lei to Lai Yiu	1.62	63	9
11NW-D/C 136	Below Block 15, Valley Road Estate, Yan Fung Street	1.35	97	9
11NE-D/C 79	On Tin Street, Lam Tin	1.34	127	9

Notes:

1 Shannon diversity index (H) represents the species diversity of the vegetation cover on the slope. It is calculated based on species abundance (A) and species richness (S), using the equation as illustrated in the example in Appendix E. The slope with higher H value means its vegetation cover has higher species diversity and is more advanced in natural succession.

2 Species abundance (A) represents the number of plant individuals [4] present on the slope.

3 Species richness (S) represents the number of vegetation species [4] present on the slope.

4 In arriving at the A, S, and H values, only the woody species contributing to natural succession of the vegetation cover (woody native species and woody non-invasive, naturalised exotic species) and with the quantities of plant individuals being able to be counted exactly were covered (Hau and Leung, 2004).

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Table 11 - Recommended List A of Native Vegetation Species for Use in Greening Slopes [1]

Botanical Name	Common Name	Chinese Name	Growth Habit [9]
Ardisia crenata [3, 4, 6, 8]	Hilo Holly	朱砂根	Shrub
Bridelia tomentosa [2, 5, 6, 7]	Pop-gun Seed	土蜜樹	Shrub or small tree
Gordonia axillaris [3, 4, 5, 6]	Hong Kong Gordonia	大頭茶	Shrub or small tree
Litsea rotundifolia var. *oblongifolia* [3, 4, 6]	Oblong-leaved Litsea	豺皮樟	Shrub
Mallotus paniculatus [2, 5, 6, 7]	Turn-in-the-wind	白楸	Medium tree
Melastoma sanguineum [2, 5, 6]	Blood-red Melastoma	毛稔	Shrub
Melicope pteleifolia [4, 6]	Thin Evodia	三椏苦	Shrub or small tree
Microcos nervosa [2, 6]	Microcos	破布葉	Medium tree
Psychotria asiatica [2, 4, 5, 6, 8]	Wild Coffee	九節	Shrub or small tree
Rhaphiolepis indica [2, 4, 5, 6]	Hong Kong Hawthorn	車輪梅	Shrub or small tree
Rhodomyrtus tomentosa [3, 5, 6]	Rose Myrtle	桃金娘	Shrub
Schefflera heptaphylla [2, 4, 5, 6]	Ivy Tree	鴨腳木	Shrub or small tree
Sterculia lanceolata [2, 5, 6, 7]	Scarlet Sterculia	假蘋婆	Large tree
Zanthoxylum avicennae [3, 4, 6]	Prickly Ash	簕欓	Shrub or small tree

Notes:

1 The species on the list are suitable for general use in greening slopes. However, planting of medium or large tree species on slopes with gradient greater than 45° is not recommended for safety reason.

2 Common and widespread species amongst the naturally-occurring species recorded on the surveyed slopes.

3 Species amongst the naturally-occurring species recorded on the surveyed slopes but not on the list of common and widespread species.

4 Species planted in the planting trial at Yuen Tun, Tai Lam Country Park.

5 Species commonly planted in natural hillside afforestation projects.

6 Species bearing flowers, fruits, and/or seeds that are attractive to wildlife.

7 Species recorded on slopes surveyed under Task 1 of the Study (Performance Assessment of Greening Techniques) and tried in afforestation projects with certain degree of success.

8 Shade-tolerant species that can be used particularly on heavily-shaded slopes.

9 Tree species are arbitrarily classified into the following groups according to their normal sizes in the wild -

Large tree = Tree with a normal height greater than 10 m and with a large crown.

Medium tree = Tree with a normal height much greater than 3 m but with a small crown.

Small tree = Tree with a normal height around 3 m.

Table 12 - Recommended List B of Native Vegetation Species for Use in Greening Slopes [1]

Botanical Name	Common Name	Chinese Name	Growth Habit [7]
Alangium chinense [3, 5]	Chinese Alangium	八角楓	Medium tree
Aporusa dioica [3, 5]	Aporusa	銀柴	Medium tree
Celtis sinensis [2, 5, 6]	Chinese Hackberry	朴樹	Large tree
Cinnamomum parthenoxylon [3]	Yellow Cinnamomum	黃樟	Large tree
Cratoxylum cochinchinense [2, 5]	Yellow Cow Wood	黃牛木	Small tree
Eurya nitida [3, 5]	Shining Eurya	細齒葉柃	Shrub
Ficus hirta [2, 5]	Hairy Fig	粗葉榕	Shrub
Ficus hispida [2, 5, 6]	Opposite-leaved Fig	對葉榕	Small tree
Ficus superba var. *japonica* [3, 5]	Superb Fig	筆管榕	Medium tree
Ligustrum sinense [2, 5]	Chinese Privet	山指甲	Small tree
Litsea glutinosa [2, 4, 5, 6]	Pond Spice	潺槁樹	Medium tree
Macaranga tanarius [2, 5, 6]	Elephant's Ear	血桐	Medium tree
Machilus breviflora [4, 5]	Short-flowered Machilus	短序潤楠	Medium tree
Machilus chekiangensis [3, 4, 5]	Zhejiang Machilus	浙江潤楠	Large tree
Melastoma candidum [3, 5]	Common Melastoma	野牡丹	Shrub
Myrsine seguinii [5]	Rapaena	密花樹	Shrub or small tree
Reevesia thyrsoidea [4, 5]	Reevesia	梭欒樹	Small tree
Rhus succedanea [2, 5]	Wax Tree	野漆	Small tree
Schima superba [4, 5]	Schima	木荷	Large tree

Notes:

1 The species on the list can be planted on selected sites as planting trials. However, planting of medium or large tree species on slopes with gradient greater than 45° is not recommended for safety reason.

2 Common and widespread species amongst the naturally-occurring species recorded on the surveyed slopes.

3 Species amongst the naturally-occurring species recorded on the surveyed slopes but not on the list of common and widespread species.

4 Species commonly planted in natural hillside afforestation projects.

5 Species bearing flowers, fruits, and/or seeds that are attractive to wildlife.

6 Species recorded on slopes surveyed under Task 1 of the Study (Performance Assessment of Greening Techniques).

7 Tree species are arbitrarily classified into the following groups according to their normal sizes in the wild -

Large tree = Tree with a normal height greater than 10 m and with a large crown.

Medium tree = Tree with a normal height much greater than 3 m but with a small crown.

Small tree = Tree with a normal height around 3 m.

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Table 13 - Recommended Hardy, Drought-tolerant Native Vegetation Species for Enrichment Planting in Exotic Tree Plantations on Slopes [1]

Botanical Name	Common Name	Chinese Name	Growth Habit [7]
Breynia fruticosa [2, 6]	Waxy Leaf	黑面神	Shrub
Bridelia tomentosa [2, 5, 6]	Pop-gun Seed	土蜜樹	Shrub or small tree
Celtis sinensis [2, 6]	Chinese Hackberry	朴樹	Large tree
Cyclobalanopsis championii [6]	Champion's Oak	嶺南青岡	Small tree
Cyclobalanopsis myrsinifolia [6]	Small-leaved Oak	小葉青岡	Small tree
Cyclobalanopsis neglecta [6]	Bamboo-leaved Oak	竹葉青岡	Large tree
Desmodium heterocarpon	False Groundnut	假地豆	Sub-shrub
Gordonia axillaris [3, 4, 5, 6]	Hong Kong Gordonia	大頭茶	Shrub or small tree
Litsea glutinosa [2, 5, 6]	Pond Spice	潺槁樹	Medium tree
Litsea rotundifolia var. *oblongifolia* [3, 4, 6]	Oblong-leaved Litsea	豺皮樟	Shrub
Macaranga tanarius [2, 6]	Elephant's Ear	血桐	Medium tree
Machilus breviflora [5, 6]	Short-flowered Machilus	短序潤楠	Medium tree
Mallotus paniculatus [2, 5, 6]	Turn-in-the-wind	白楸	Medium tree
Melastoma sanguineum [2, 5, 6]	Blood-red Melastoma	毛稔	Shrub
Rhodomyrtus tomentosa [3, 5, 6]	Rose Myrtle	桃金娘	Shrub
Sapium sebiferum [5, 6]	Chinese Tallow Tree	烏桕	Medium tree
Schefflera heptaphylla [2, 4, 5, 6]	Ivy Tree	鴨腳木	Shrub or small tree
Sterculia lanceolata [2, 5, 6]	Scarlet Sterculia	假蘋婆	Large tree

Notes:
1 Planting of medium or large tree species on slopes with gradient greater than 45° is not recommended for safety reason.
2 Common and widespread species amongst the naturally-occurring species recorded on the surveyed slopes.
3 Species amongst the naturally-occurring species recorded on the surveyed slopes but not on the list of common and widespread species.
4 Species planted in the planting trial at Yuen Tun, Tai Lam Country Park.
5 Species commonly planted in natural hillside afforestation projects.
6 Species bearing flowers, fruits, and/or seeds that are attractive to wildlife.
7 Tree species are arbitrarily classified into the following groups according to their normal sizes in the wild -
Large tree = Tree with a normal height greater than 10 m and with a large crown.
Medium tree = Tree with a normal height much greater than 3 m but with a small crown.
Small tree = Tree with a normal height around 3 m.

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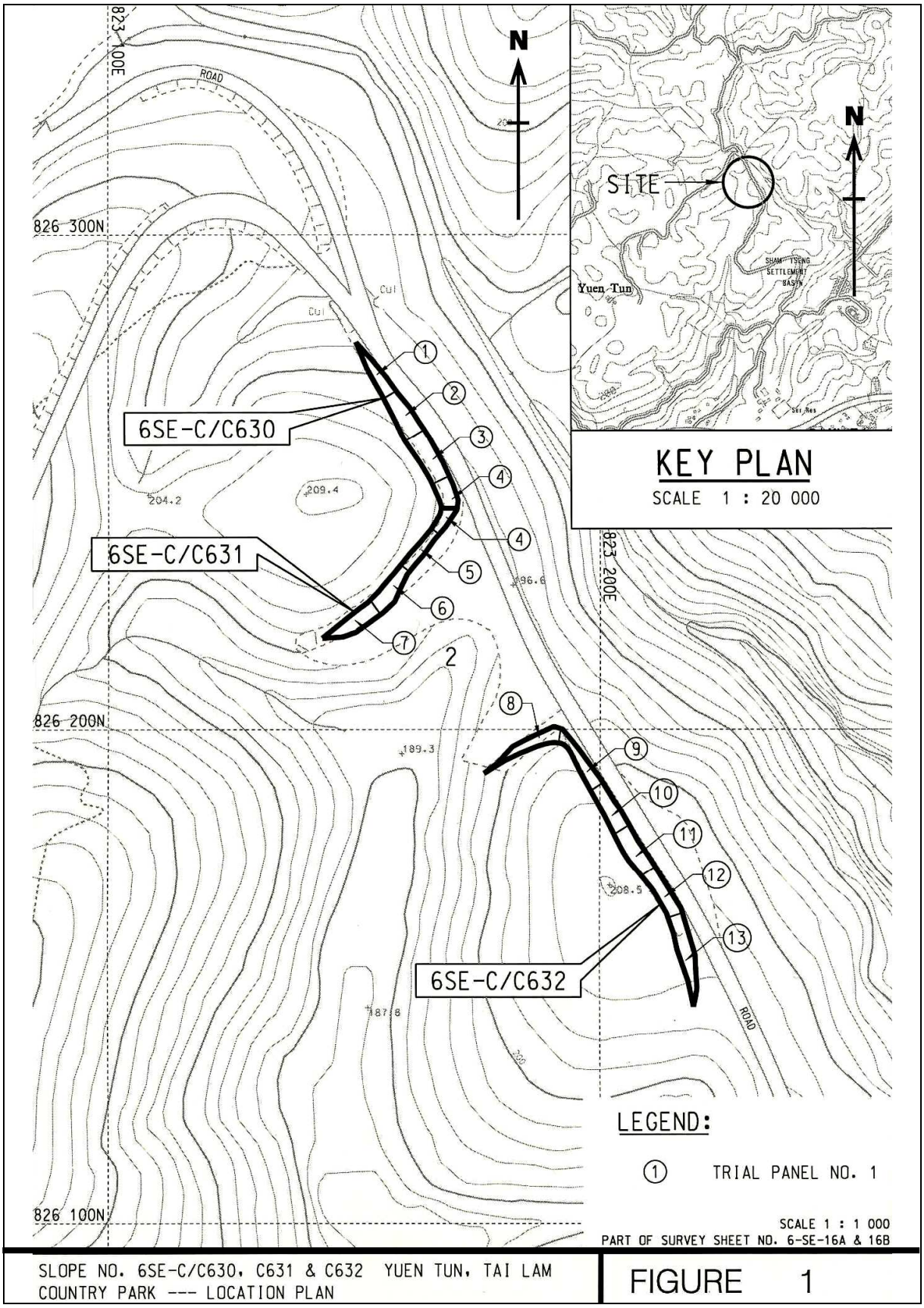

Figure 1 - Location Plan

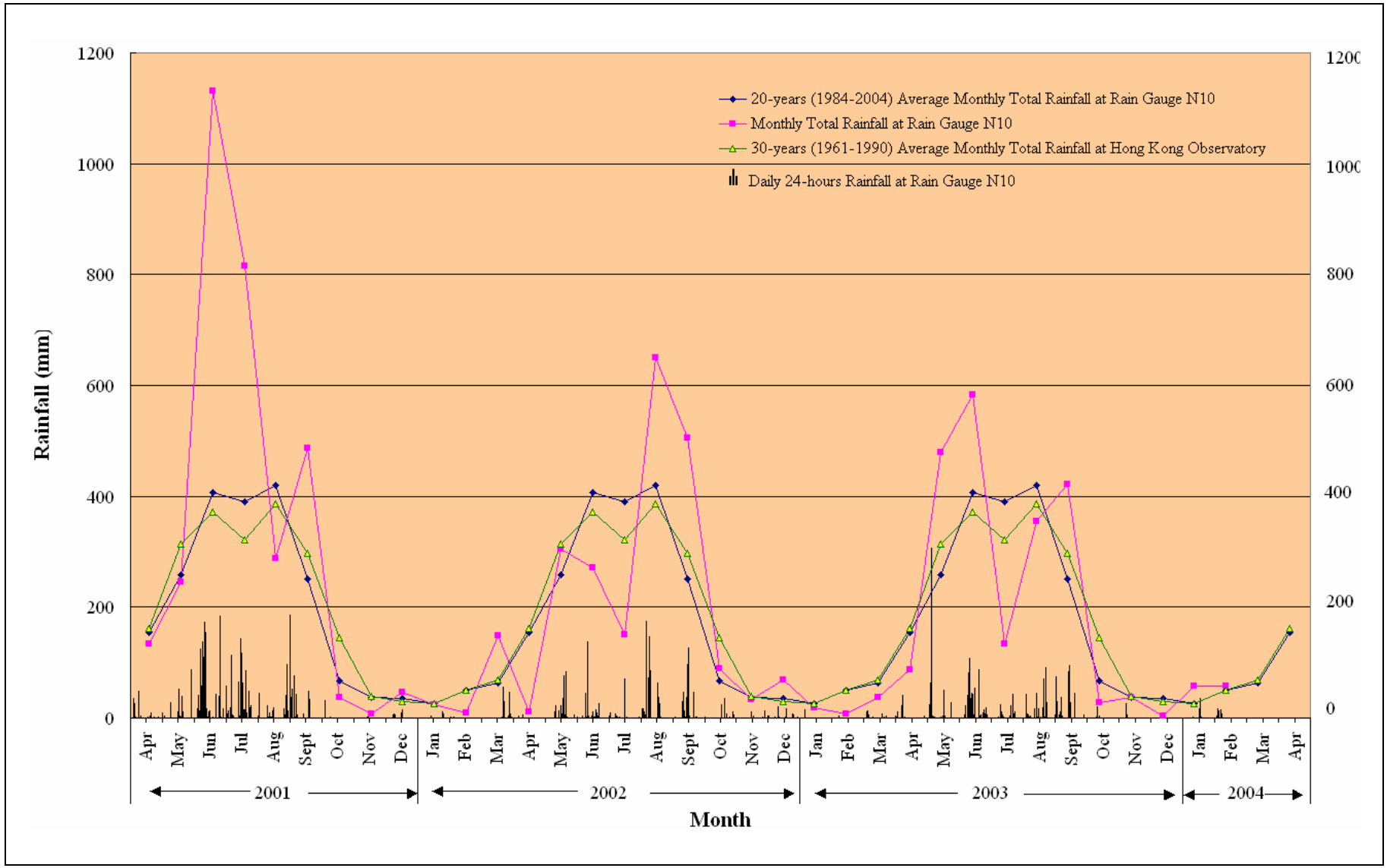

Figure 2 - Rainfall for the Period April 2001 to April 2004

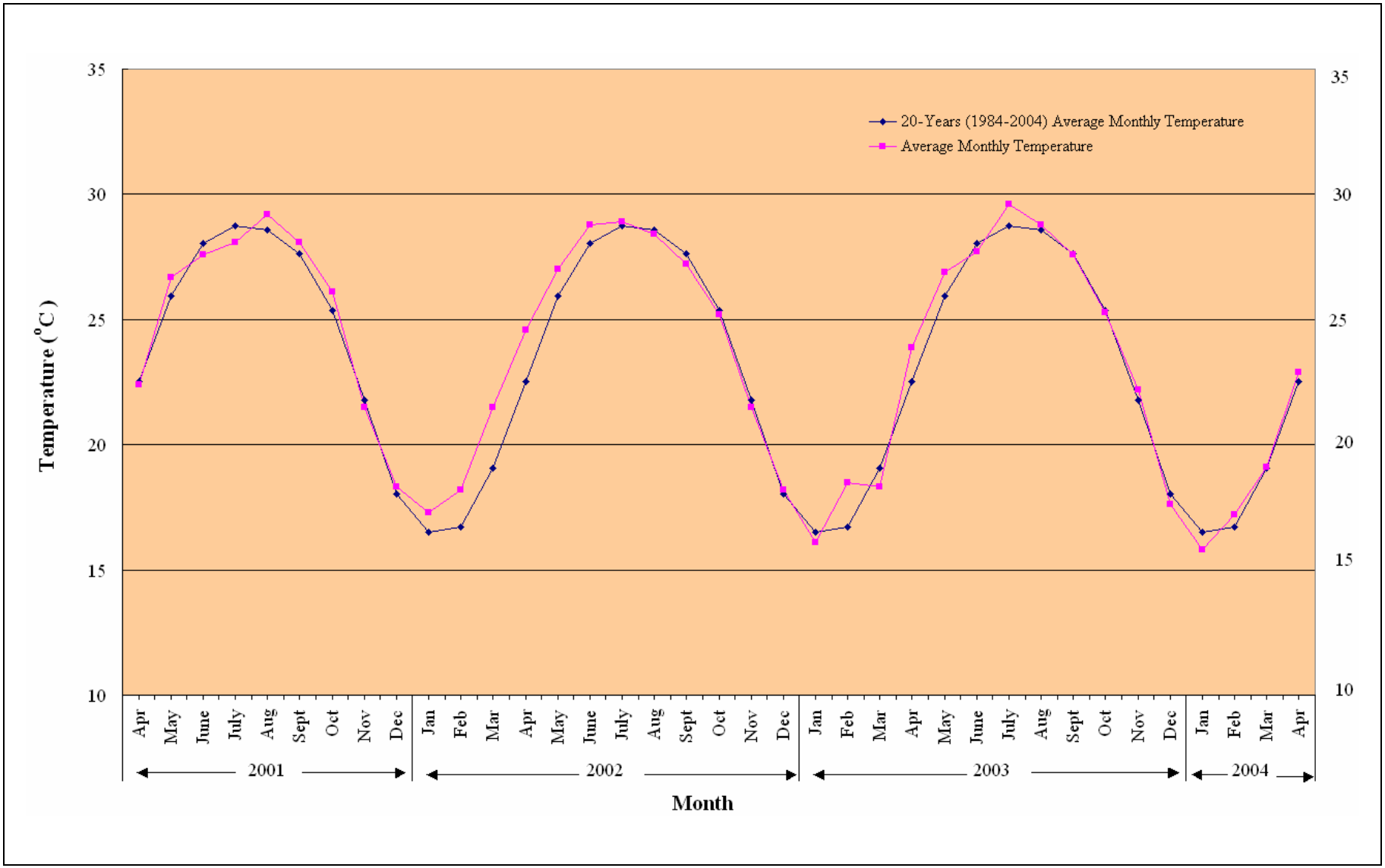

Figure 3 - Ambient Temperature for the Period April 2001 to April 2004

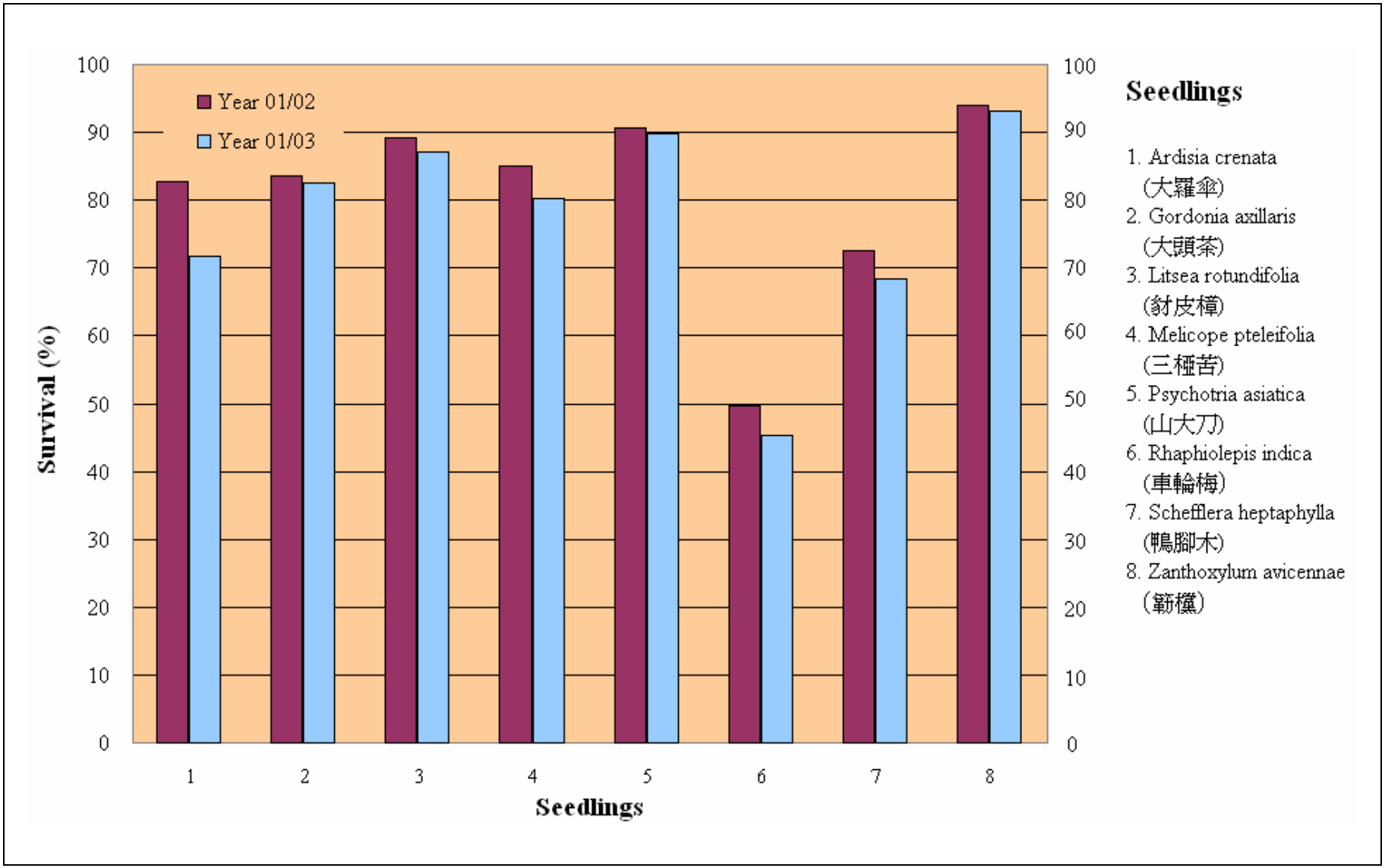

Figure 4 - Survival Rate of Seedlings Species for all Panels

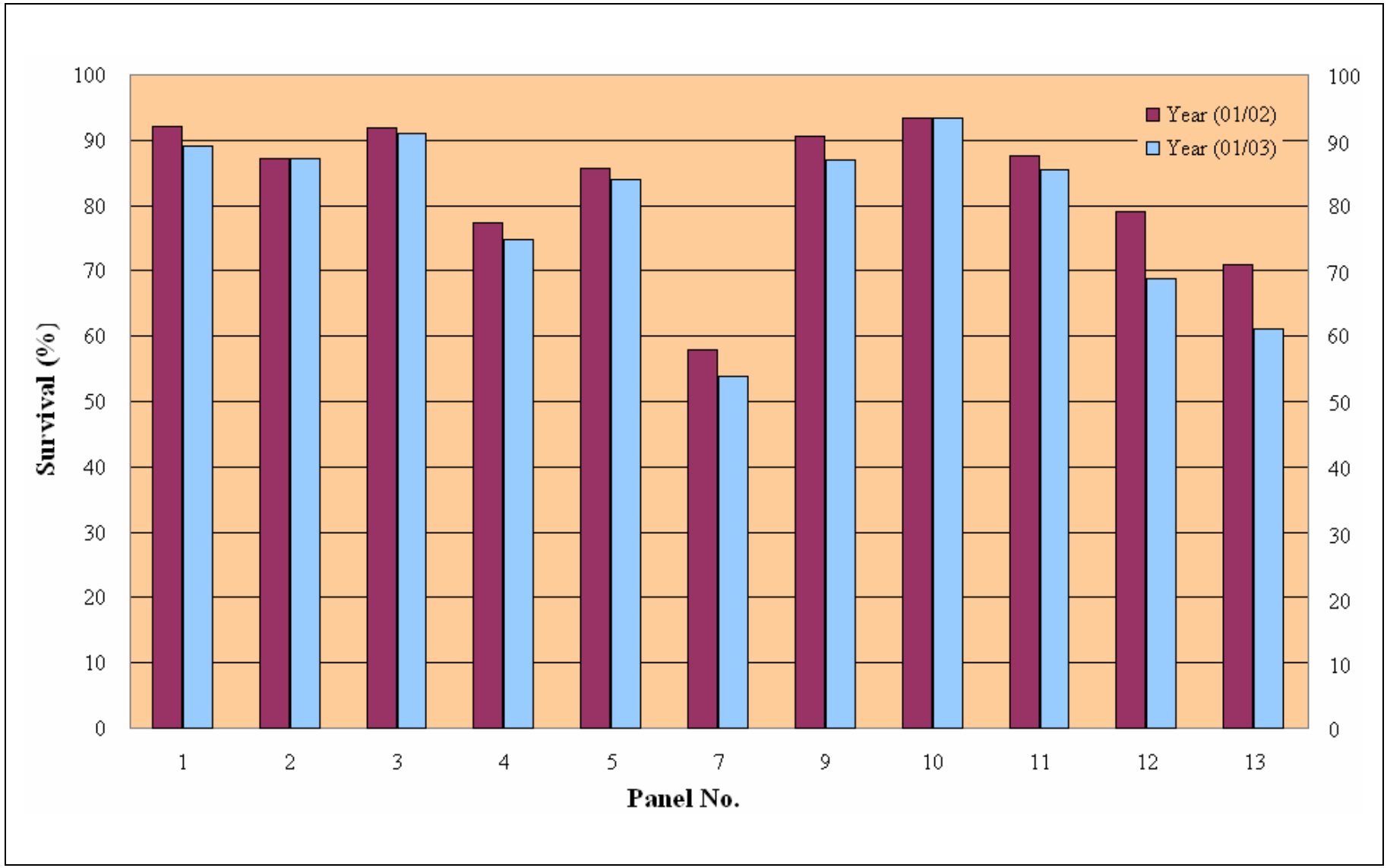

Figure 5 - Survival Rate of all Seedlings in the Trial Panels

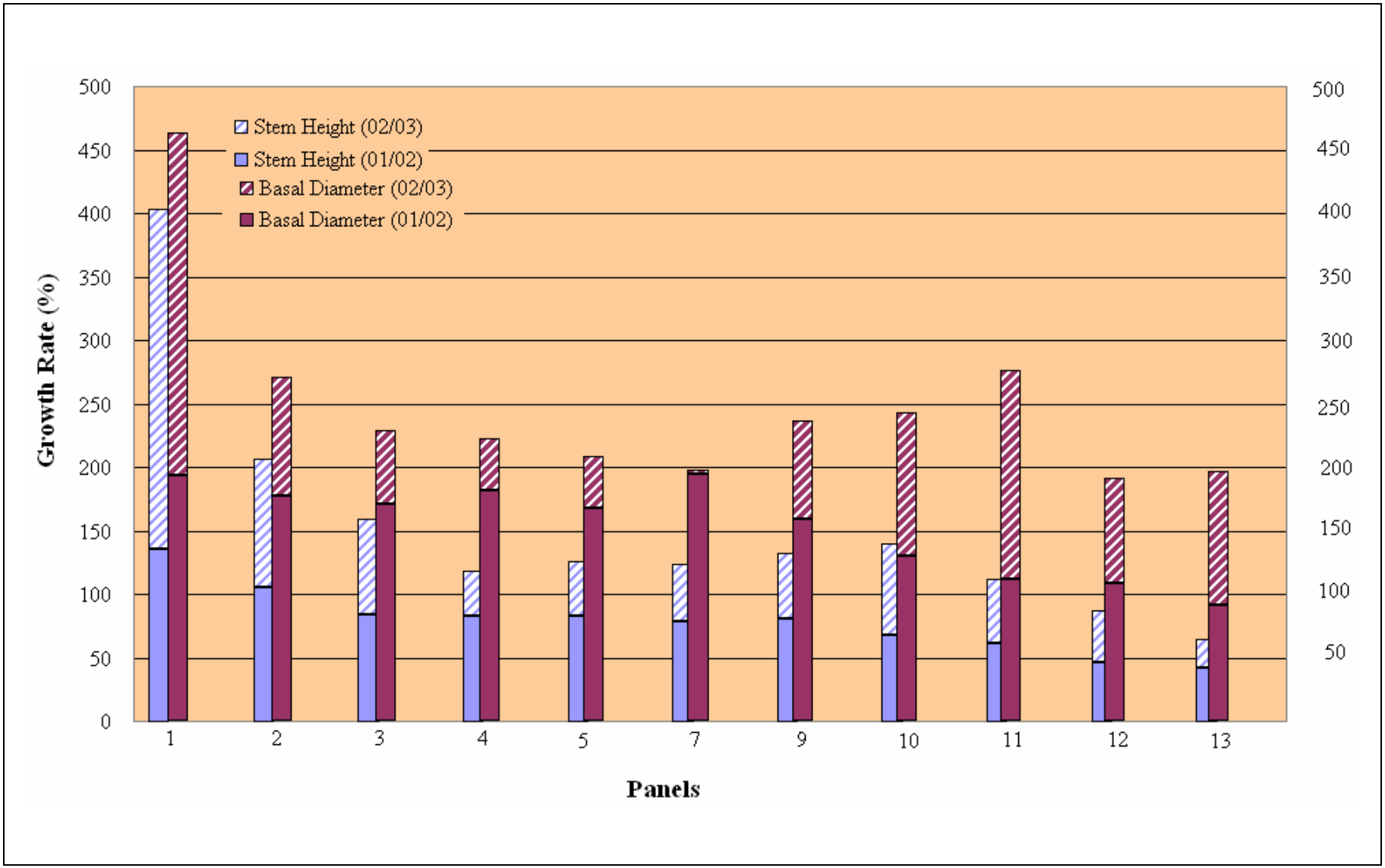

Figure 6 - Average Growth Rate of Seedlings in the Trial Panels

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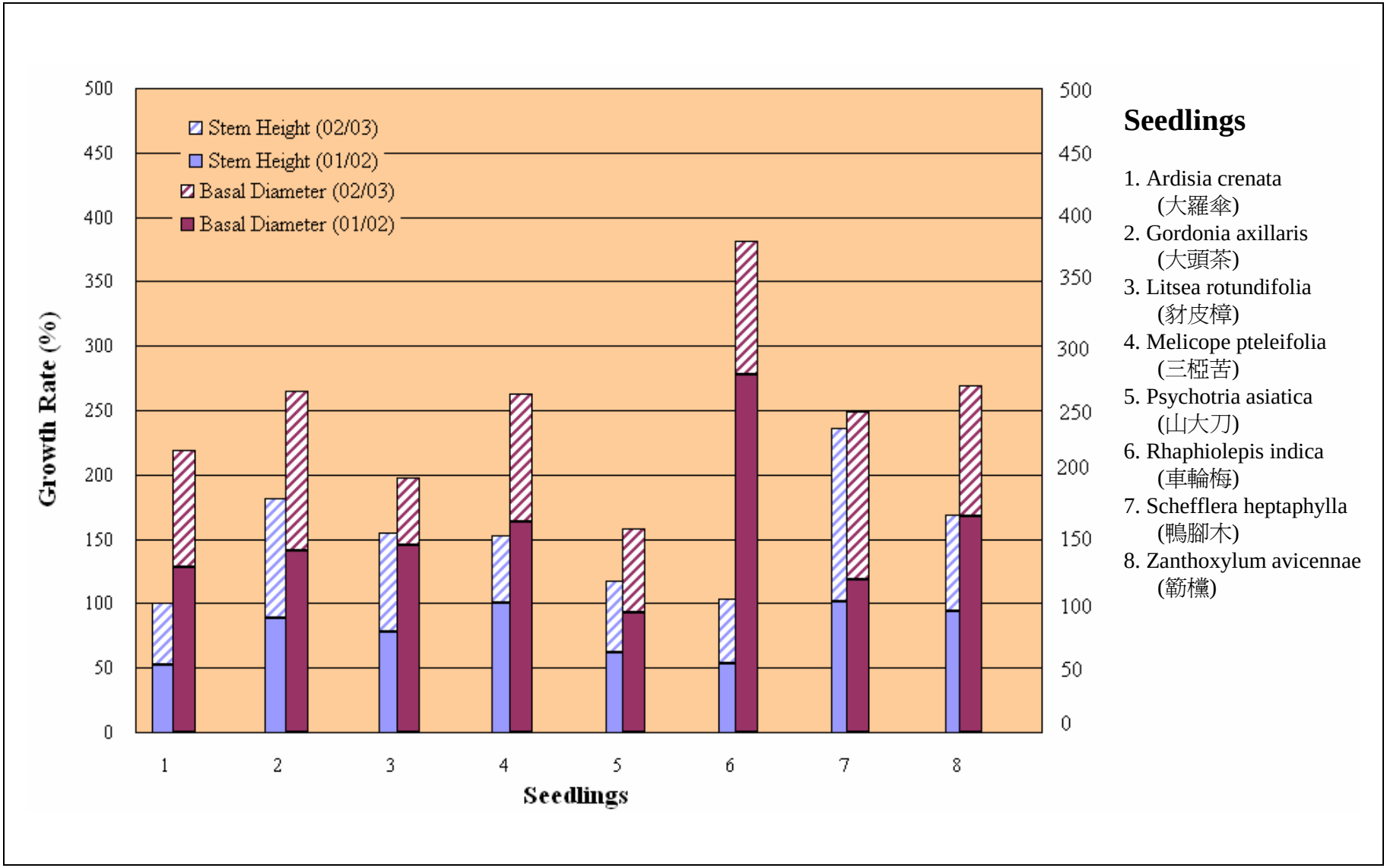


Figure 7 - Average Growth Rate of Seedlings Species for all Panels

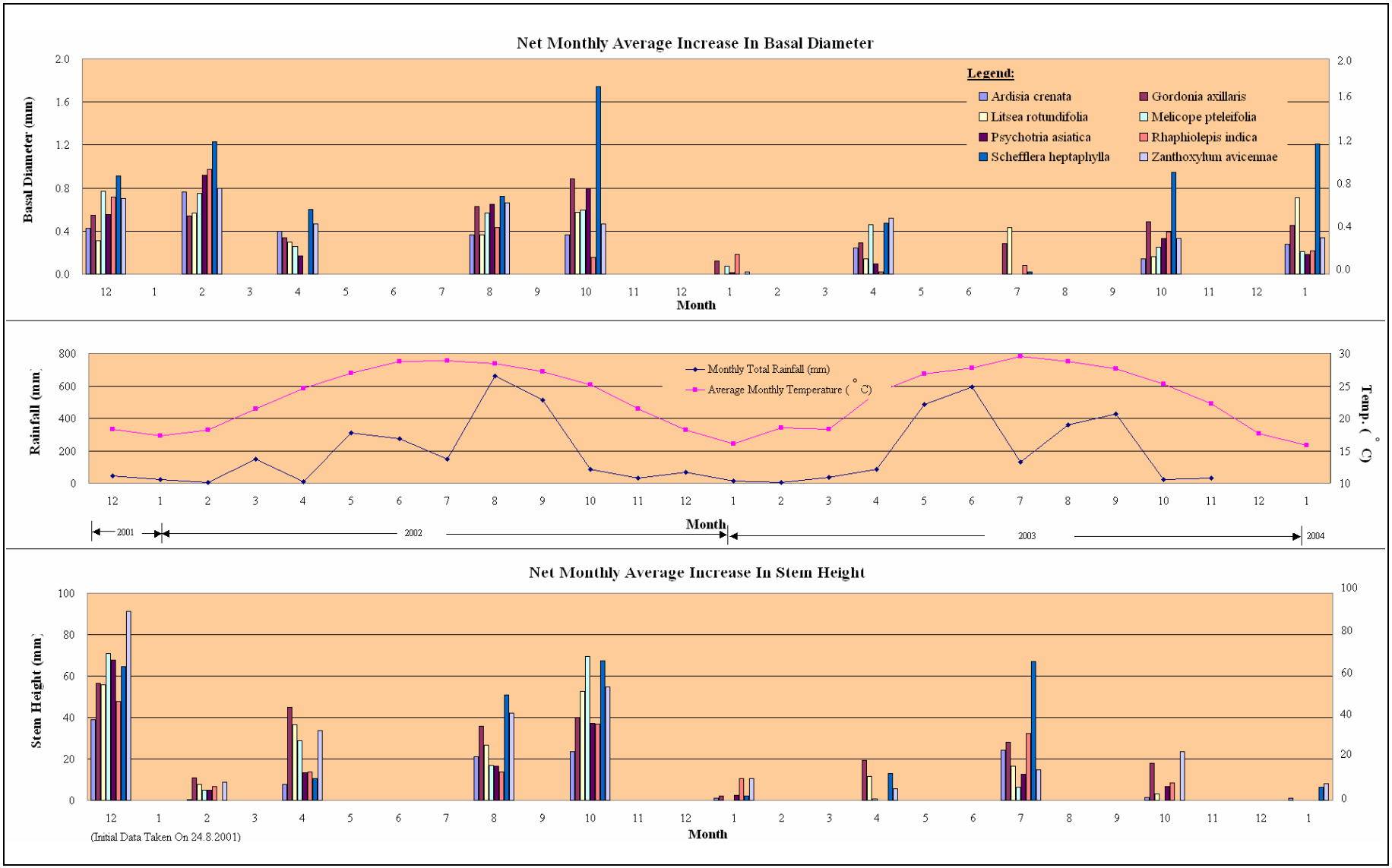


Figure 8 - Seedling Growth and Weather Conditions

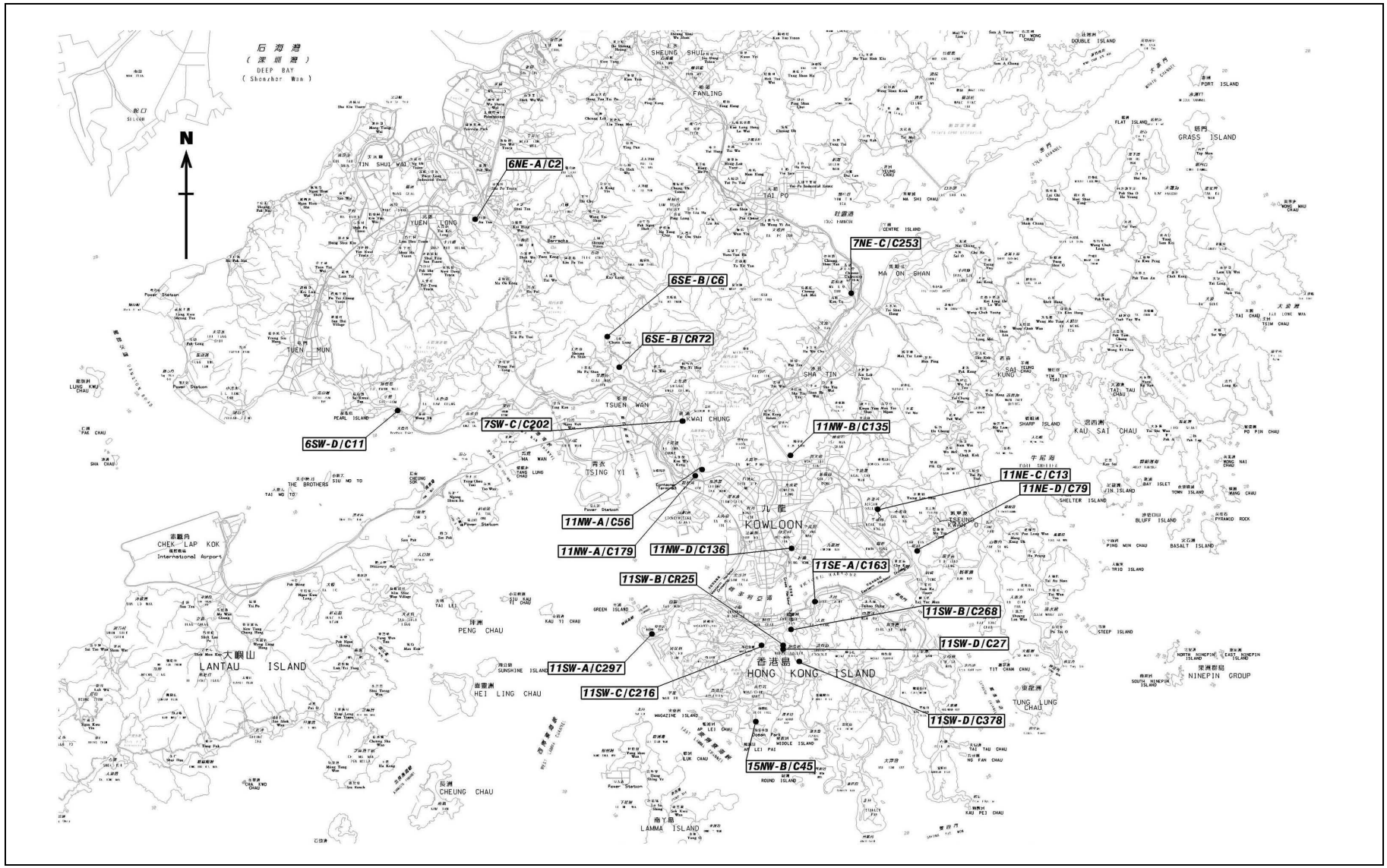
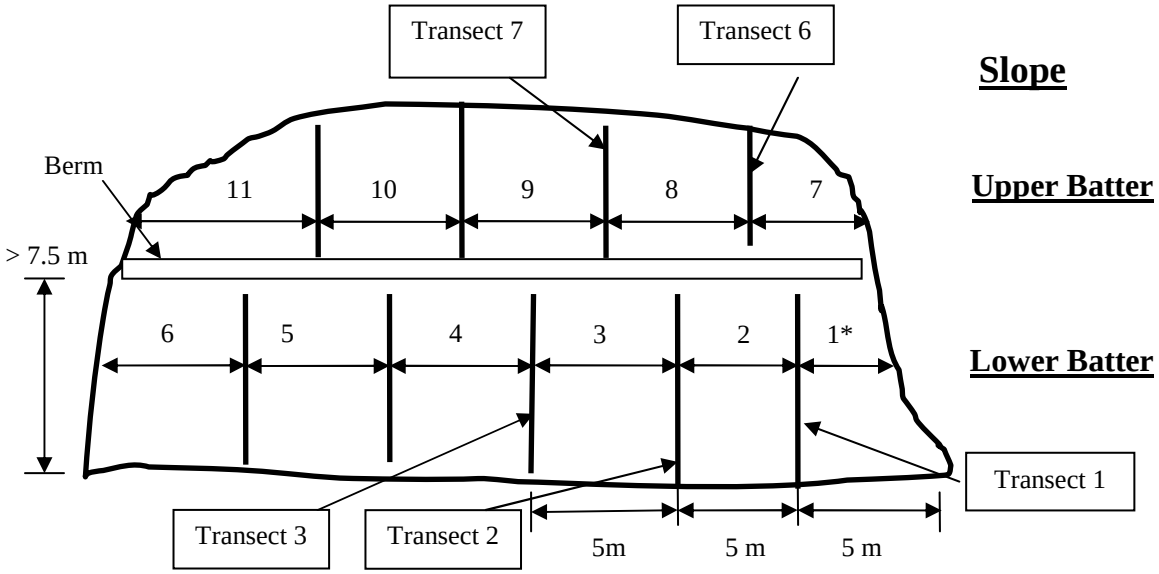


Figure 9 - Geographical Locations of Surveyed Slopes



* Quadrat number: 1-11

Figure 10 - Survey Layout on a Slope

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Plate 1 - Southern View of the Slope No. 6SE-C/C630 (before LPM Works)

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Negative Nos. DE\2000\258\04 - 06

Plate 2 - General View of the Slope No. 6SE-C/C631 (before LPM Works)

Negative No. DE\2000\283\04

Plate 3 - Northern View of the Slope No. 6SE-C/C632 - Yuen Tun (before LPM Works)

Negative No. DE\2000\SEP\114.JPG

Plate 4 - Southern View of the Slope No. 6SE-C/C632 - Yuen Tun (before LPM Works)

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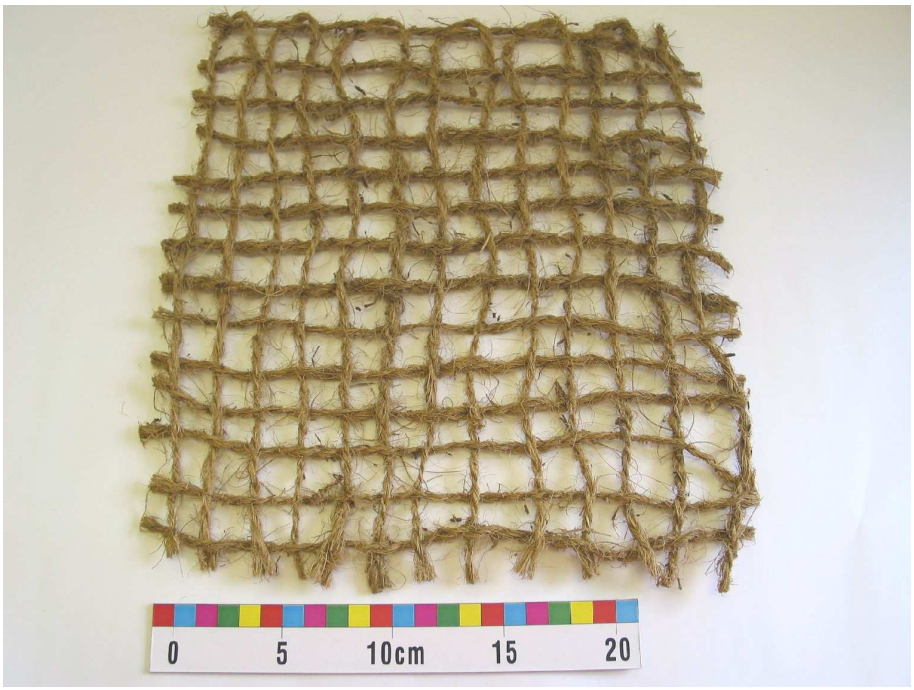
Negative No. DE\2003\NOV\0244.JPG

Plate 5 - Erosion Control Mats - Hessian Fabric



Negative No. DE\2003\NOV\0240.JPG

Plate 6 - Erosion Control Mats - Natural Coir

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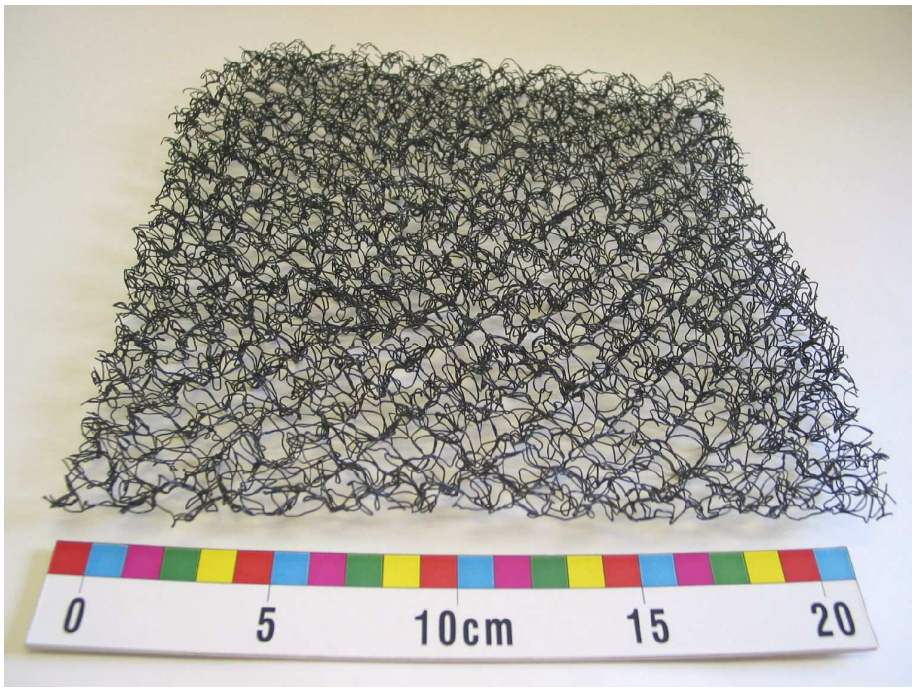
Negative No. DE\2003\NOV\0236.JPG

Plate 7 - Erosion Control Mats - Natural Jute



Negative No. DE\2003\NOV\0234.JPG

Plate 8 - Erosion Control Mats - 3D Random Polyamide Mat

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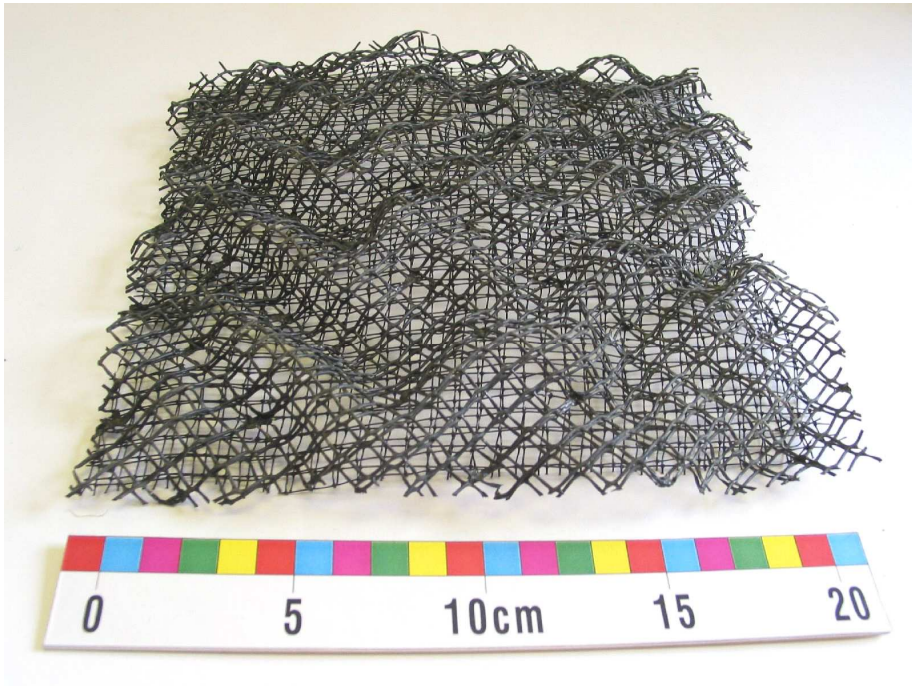
Negative No. DE\2003\NOV\0250.JPG

Plate 9 - Erosion Control Mats - 3D Polypropylene Mono-filaments Mat



Negative No. DE\2003\NOV\0253.JPG

Plate - 10 - Erosion Control Mats - 3D Polyethylene Mat

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Taken on 14.6.2001

Plate 11 - Northern View of the Slope No. 6SE-C/C630 (after Completion of LPM Works)

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Plate 12 - Southern View of the Slope No. 6SE-C/C630 (after Completion of LPM Works)

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Taken on 14.6.2001

Plate 13 - General View of the Slope No. 6SE-C/C631 (after Completion of LPM Works)

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Plate 14 - Northern View of the Slope No. 6SE-C/C632 (after Completion of LPM Works)

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Plate 15 - Southern View of the Slope No. 6SE-C/C632 (after Completion of LPM Works)

Negative No. ME89/150/17

Plate 16 - Gully Erosion on Slope in a Construction Site

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Plate 17 - Gully Erosion on Slope before Grass Establishment

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Negative Nos. DE\2001\APR\0286-0291.JPG

Plate 18 - Surface Conditions of Panel No. 6 of the Slope No. 6SE-C/C631 - Yuen Tun in April 2001

Negative Nos. DE\2003\DEC\0792-0794.JPG

Plate 19 - Surface Conditions of Panel No. 6 of the Slope No. 6SE-C/C631 - Yuen Tun in December 2003

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Plate 20 - Surface Conditions of Panel No. 8 of the Slope No. 6SE-C/C632 - Yuen Tun in March 2001

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Plate 21 - Surface Conditions of Panel No. 8 of the Slope No. 6SE-C/C632 - Yuen Tun in February 2002

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APPENDIX A

FACT SHEETS OF THE YUEN TUN TRIAL PLANTING SPECIES

Ardisia crenata
Hilo Holly
朱砂根

A fast-growing evergreen shrub that is native to Hong Kong and South China. It can grow up to 2 m in height. It is common in lowland forest. The attractive reddish, shining fruits increase the value of using this species in landscaping projects.

Leaves are alternate, simple, elliptical, 7 - 12 cm long, and about 2 - 2.5 cm broad. Leaf apex is acute or tapering, base cuneate and the texture leathery. The leaf margin is wavy. Leaf stalk is up to 1 cm long.

Flowers in clusters of umbel, bisexual and white in color. Flowering from May to June.

The fruit is a reddish berry, round, and about 0.6 to 0.8 cm across. The fruit ripens from October to December. Seed is almond, globular in shape and about 0.4 to 0.5 cm in diameter. The fleshy fruit is attractive to birds and seeds are dispersed mainly by birds.

(Flora Conservation Department,
Kadoorie Farm and Botanic Garden,
September 2001)

Flower

Fruit

Tree Form

Gordonia axillaris
Gordonia
大頭茶

A fast-growing evergreen tree that is native to Hong Kong and South China. It usually grows as shrub in HK but can grow up to 9 m in height. It is very common in hillside slopes in Hong Kong, especially on Hong Kong Island. It can grow in very poor soil and exposed environments.

Leaves are alternate, simple, oblong 6 to 14 cm long, about 2.5 to 4 cm wide. Leaf apex is blunt or slightly notched, base tapering, margins entire. Texture is rather stiff and hard, shining green above, smooth and hairless. Leaf stalks is thick. 1 to 5 cm long.

Flowering in October to December. Flowers are single or a few together, terminal or axillary, bisexual, 5 - 7 cm across. White petals with bright yellow stamens.

Fruit is a woody capsule, 2.5 to 3.5 cm long, brown in color, open in 5 valves at the top to release winged seeds. Fruiting in November to December. Seeds are dispersed by wind, 1.5 to 2 cm long, dark brown in colour.

Flowers are attractive to insect pollinators such as bees and wasps. Ants are often found nesting on Gordonia.

(Flora Conservation Department,
Kadoorie Farm and Botanic Garden,
September 2001)

Flower

Leave

Fruit

Fruit with open valves

Litsea rotundifolia var. *oblongifolia*
Long-leafed Litsea
豹皮樟

A fast growing evergreen shrub or small tree that is native to Hong Kong and South China. It can grow up to 15 m in height but seldom higher than 6 m in Hong Kong. It is a locally common species and can be found easily in shrubland and young secondary forest. This species grows well in exposed sites and is a suitable pioneer species for planting on slopes and degraded sites for land rehabilitation.

Leaves are alternate, simple, petiole 0.3 to 0.5 cm. Leaf blade is oval. 2.5 to 5.5 cm long, 1 to 2.2 cm wide, rather stiff, base tapering. Leaf apex is bluntly pointed and the margin is entire.

Flowering in summer. Flowers are small, yellowish, in clusters of umbel, attaching on the leaf axils and unisexual.

Fruits are drupes, round, 0.6 cm across. It turns from green to black when ripe. Fruiting in September to November. Seeds are round, 0.4 to 0.5 cm across, light brown in colour. Fruits are eaten by birds. It is an adult food source for some moths and butterflies species, like the *Pazala* spp.

(Flora Conservation Department,
Kadoorie Farm and Botanic Garden,
September 2001)


Flower


Leave


Green Fruit


Ripe Fruit

Melicope pteleifolia
Evodia
三椏楛

A fast growing evergreen tree that is native to Hong Kong and South China. It can grow up to 8 m in height. It can be found in shrubland and young secondary forests and is very common in Hong Kong. This species grows well under semi-sheltered locations, but could also grow on exposed sites and in poor soils.

Leaves are opposite, compound with three leaflets, petiole up to 10 cm long. Leaflet is elliptic, 6 to 20 cm long, 2 to 8 cm wide, slightly wavy, base tapering, apex acute, margin entire.

Flowering from April to June. Flowers are small, numerous, yellowish or white in color, in axillary panicles and unisexual.

Fruit is a yellow capsule, containing 1 seed, open to release the seed when ripe. Seed is round, black and shining, 0.3 to 0.6 cm across. Fruiting from July to October. It is the larval food plant for various moths and butterflies such as *Paralebeda plagifera* and Paris Peacock. Seeds are highly attractive to birds such as Japanese White-eye.

(Flora Conservation Department,
Kadoorie Farm and Botanic Garden,
September 2001)


Flower


Leave


Green Fruit


Ripe Fruit

Psychotria asiatica
Wild Coffee
九節

A fast growing evergreen shrub or small tree that is native to Hong Kong and South China. It is 0.5 to 5 cm in height. It is very common in Hong Kong and can be easily seen in lowland secondary forest and forest margin. It grows well under sheltered locations, but could also grow on not too exposed sites.

Leaves are opposite, petiole 0.7 to 5 cm long. Leaf blade is thick, elliptic. 5 to 23 cm long, 2 to 9 cm wide, base cuneate, apex tapering and margin entire.

Flowering over the year. Flower is small, numerous, white, in panicle or umbel clusters and unisexual.

Fruit is a drupe, round or global, 0.5 to 0.7 cm long, 0.4 to 0.7 cm wide, yellow first than changing to red when ripe. Each fruit contains 2 seeds, also fruiting over whole year. Seed is light brown, semi-global, around 0.4 cm across.

(Flora Conservation Department,
Kadoorie Farm and Botanic Garden,
September 2001)


Flower


Flower


Fruit (yellow to red)


Leave

Rhaphiolepis indica
Hong Kong Hawthorn
車輪梅

An evergreen shrub or small tree that is native to Hong Kong and South China. It can grow up to 5 m in height but usually around 1.5 to 2 m. It can be found in grasslands, shrublands, young secondary forests and forest edges. It grows well in exposed sites and in poor soils. It has good potential for planting on slopes and degraded sites for land rehabilitation.

Leaves are alternate and simple. Leaf blade is varying from broad-oval to narrow-elliptic, 2 to 8 cm long. Leaf apex is acute to blunt, base tapering and extending to petiole. Margin is toothed, the upper surface is dark green, and the vein net on the lower surface makes this species easy to identify. Petiole is around 0.5 to 1.8 cm long.

Flowering in spring. Flowers are white or pale pink and in panicle cluster, making them very attractive.

Fruiting from October to January. Fruit is a drupe, round, about 0.5 cm across. Ripe fruit changes color from green to purplish black. Seed is also rounded in shape, about 0.4 cm across, light-brown in color. Fruits are attractive to birds.

(Flora Conservation Department,
Kadoorie Farm and Botanic Garden,
September 2001)


Flower


Leave


Tree Form


Ripe Fruit

Schefflera heptaphylla

Ivy Tree

鴨腳木

A fast-growing evergreen tree that is native to Hong Kong and South China. It can grow up to 18 m in height. It is commonly used in landscaping projects and sometimes used in reforestation projects. It is common and can be easily found in low land secondary forests as well as Fung Shui woods in Hong Kong. This species grows well on sheltered sites with good soil condition, but can also grow on exposed sites.

Leaves are alternate, palmate, compound with 6 to 11 leaflets. Leaflets is various in shape and size, from oval to lanceolate. 9 to 17 cm long and 3 to 5 cm wide. Leaf apex is shortly pointed, rarely round, base tapering, cuneate or blunt. Margins are entire but toothed in seedling stage. Leaf stalk is 15 to 30 cm long, and leaflet stalk is 1.5 to 5 cm.

Flowering from November to December. Flowers are small, in a large terminal panicle, 20 to 30 cm long, unisexual.

Fruits are fleshy berries, round, about 0.5 cm across, green at first and black finally, containing 5 to 6 seeds. Fruits ripen in December and January. Seeds are brown, semi-circular and 0.5 cm long. This species is able to fruit when they are three-year old and the fleshy fruits are eaten by many bird species. It is thus highly valuable in forest restoration.

(Flora Conservation Department,
Kadoorie Farm and Botanic Garden,
September 2001)

Flower

Flower

Fruit (green to black)

Leave

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Zanthoxylum avicennae

Prickly Ash

鼸箭櫟

A fast growing evergreen small tree that is native to Hong Kong and South China. It can grow up to 8 m in height but usually around 2 to 4 m. It can be found in shrublands and forests. This species grows well on exposed sites and in poor soils. It is thus suitable for habitat restoration.

Leaves are alternate, compound with pinnate leaves. There are a lot of prickles on the branches and leaves of the young stands. In the seedling stage, the number of leaflets can be up to 31, but normally is 11 to 21. Leaflet is opposite, oval to oblong and somewhat asymmetric, always broadly oval in the seedling stage, 2.5 to 7 cm long, and 1 to 3 cm across. Leaflet apex is blunt or suddenly pointed, base tapering, margin entire or with shallow blunt teeth on the upper side of the leaflet. Leaflet stalk is about 0.3 cm and leaf stalk can up to 12 cm long.

Flowering from June to August. Flowers are white, unisexual, in axillary panicle.

Fruiting from October to December. Fruit is a drupe, round, about 0.4 to 0.5 cm across, with gland-dots on the surface. Ripe fruit changes color from green to purple. Seed is also rounded in shape, about 0.3 to 0.4 cm across, black and shinning. Fruits are attractive to birds. It is also the adult and larval food plant of some swallowtail butterflies (*Papilio* spp.).

(Flora Conservation Department,
Kadoorie Farm and Botanic Garden,
September 2001)

Flower

Fruit

Tree Form

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APPENDIX B

RECORD PHOTOGRAPHS OF THE TRIAL PANELS

FEATURE NO. 6SE-C/C630, Yuen Tun Panel No. 1

Apr 2001 (18/04/2001)

Aug 2002 (30/08/2002)

Dec 2003 (19/12/2003)

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FEATURE NO. 6SE-C/C630, Yuen Tun Panel No. 2

Apr 2001 (18/04/2001)

Aug 2002 (30/08/2002)

Dec 2003 (19/12/2003)

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FEATURE NO. 6SE-C/C630, Yuen Tun Panel No. 3

Apr 2001 (18/04/2001)

Aug 2002 (30/08/2002)

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FEATURE NO. 6SE-C/C630, Yuen Tun Panel No. 4

Apr 2001 (18/04/2001)

Aug 2002 (30/08/2002)

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FEATURE NO. 6SE-C/C630 & 631, Yuen Tun Panel No. 5

Apr 2001 (18/04/2001)

Aug 2002 (30/08/2002)

Dec 2003 (19/12/2003)

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FEATURE NO. 6SE-C/C631, Yuen Tun Panel No. 6

Apr 2001 (18/04/2001)

Aug 2002 (30/08/2002)

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FEATURE NO. 6SE-C/C631, Yuen Tun Panel No. 7

Apr 2001 (18/04/2001)

Aug 2002 (30/08/2002)

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FEATURE NO. 6SE-C/C632, Yuen Tun Panel No. 8

Mar 2001 (23/03/2001)

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FEATURE NO. 6SE-C/C632, Yuen Tun Panel No. 9

Mar 2001 (23/03/2001)

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FEATURE NO. 6SE-C/C632, Yuen Tun Panel No. 10

Mar 2001 (23/03/2001)

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FEATURE NO. 6SE-C/C632, Yuen Tun Panel No. 11

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FEATURE NO. 6SE-C/C632, Yuen Tun Panel No. 12

Mar 2001 (23/03/2001)

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FEATURE NO. 6SE-C/C632, Yuen Tun Panel No. 13

Mar 2001 (23/03/2001)

Aug 2002 (30/08/2002)

Dec 2003 (19/12/2003)

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APPENDIX C

PHOTOGRAPHS OF NATURALLY RECRUITED VEGETATION FOUND IN YUEN TUN TRIAL

Naturally Recruited Vegetation Found in Yuen Tun Trial

Sapium discolor Tree
山烏桕

Mallotus paniculatus Tree
白楸

Rhus hypoleuca Tree
白背漆

Lophostemon confertus Tree
紅膠木

Acacia mangium Tree
大葉相思

Bauhinia sp. Tree
羊蹄甲屬

Naturally Recruited Vegetation Found in Yuen Tun Trial

Rhodomyrtus tomentosa Shrub
桃金孃

Melastoma sanguineum Shrub
毛棯

Clerodendrum fortunatum Shrub
鬼燈籠

Phyllodium pulchellum Shrub
排錢草

Phyllanthus cochinchinensis Shrub
越南葉下珠

Breynia fruticosa Shrub
黑面神

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Naturally Recruited Vegetation Found in Yuen Tun Trial

Helicteres augustifolia Herb
山芝蔴

Dianella ensifolia Herb
山菅蘭

Polygonum glabrum Herb
光蓼

Mimosa pudica Herb
含羞草

Liriope spicata Herb
麥門冬

Urena lobata Herb
梵天花

Naturally Recruited Vegetation Found in Yuen Tun Trial

Mussaenda pubescens Climber
玉葉金花

Strophanthus divaricatus Climber
羊角拗

Smilax china Climber
拔葜

Smilax glaber Climber
光葉拔葜

Embelia laeta Climber
酸藤果

Tetracera asiatica Climber
錫葉藤

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Naturally Recruited Vegetation Found in Yuen Tun Trial

Rubus reflexus Climber
蛇泡簕

Pityrogramma calomelanos Fern
紛葉蕨

Lycopodium cernuum Fern
鋪地蜈蚣

Scleroderma sp. Fungus
硬皮馬勃

Scleroderma polyrhizum Fungus
多根硬皮馬勃

Scleroderma bovista Fungus
大孢硬皮馬勃

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APPENDIX D

MEMBERSHIP OF THE WORKING GROUP

The members of the working group to oversee the study titled "Performance Assessment of Greening Techniques and Vegetation Species on Slopes" include -

Post	Representative	Affiliation
Chairman	Mr W K Pun	Civil Engineering and Development Department
Members	Mr C K Chan	Agriculture, Fisheries and Conservation Department
	Mr K M Poon	Architectural Services Department
	Mr Y K Shiu	Civil Engineering and Development Department
	Ms Rebecca Y H Chau	Civil Engineering and Development Department
	Mr K K Yung	Drainage Services Department
	Mr C P Choi	Highways Department
	Mr Peter C Y Yung	Highways Department
	Mr Eddy Leung	Housing Department
	Mr Norman Woods	Lands Department
	Mr S P Ng	Territory Development Department
	Dr Billy C H Hau	The University of Hong Kong
	Mr Andy H C Lam	Water Supplies Department
Secretary	Ms Becky L S Lui	Civil Engineering and Development Department

APPENDIX E

EXAMPLE SHOWING CALCULATION OF SHANNON DIVERSITY INDEX

The calculation of the Shannon diversity index (H) [1] is illustrated below (Hau and Leung, 2004).

H is calculated on the basis of species richness (S) [1] and species abundance (A) [1] and is the sum of the proportion of individuals that each species contributes to the total in the sample, i.e. the proportion is Pi for the ith species by (Begon et al. 1996) -

$$H = -\sum_{i=1}^{S} Pi \ln Pi$$

where S = the number of vegetation species present in the sample;

A = the number of plant individuals present in the sample;

Pi = the number of plant individuals (A) of the ith species in the sample / the total number of plant individuals (A) in the sample.

The calculation of H of a hypothetical slope with 5 species is shown below as an example -

Species (S):	1	2	3	4	5	Total
Abundance (A):	50	60	50	70	90	320
Pi =	50/320 = 0.16	60/320 = 0.19	50/320 = 0.16	70/320 = 0.22	90/320 = 0.28	
Pi x lnPi =	-0.29	-0.31	-0.29	-0.33	-0.36	

H = -[(-0.29) + (-0.31) + (-0.29) + (-0.33) + (-0.36)] = 1.58

Note:

1. In arriving at the A, S, and H values, only the woody species contributing to natural succession of the vegetation cover (woody native species and woody non-invasive, naturalised exotic species) and with the quantities of plant individuals being able to be counted exactly were covered (Hau and Leung, 2004).

SECTION 2:

AGREEMENT NO. CE 74/99 & SUPPLEMENTARY AGREEMENT NO. 1 GEO - 10 YEAR EXTENDED LPM PROJECT

REVIEW OF LANDSCAPE CONDITIONS OF MAN-MADE SLOPES ALONG SOUTH LANTAU ROAD AFTER LPM WORKS - SUMMARY REPORT

Halcrow China Limited

This report was originally produced in September 2007

Halcrow China Limited
AGREEMENT NO. CE 74/99 &
SUPPLEMENTARY AGREEMENT NO. 1
GEO - 10 YEAR EXTENDED LPM PROJECT
Review of Landscape Conditions of Man-made Slopes
along South Lantau Road after LPM Works
- Summary Report
September 2007

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Review of Landscape Conditions of Man-made Slopes
along South Lantau Road after LPM Works
- Summary Report

September 2007

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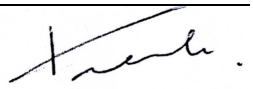
1	0	First issue	September 2007	

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1. INTRODUCTION

Enhancing the ecological value of man-made slope has been one of the key elements of the Landslip Preventive Measures (LPM) programme in recent years (GEO 2007). Various proprietary products for slope greening and environmental improvement have been tried on shotcreted slopes in Hong Kong in the last 10 years. However, they were found to be not very cost-effective (Lui and Shiu 2004). Slope greening on recently upgraded soil slopes still relied on the traditional method of hydroseeding using commercial grass species such as *Cynodon dactylon* (狗牙根) and *Paspalum notatum* (百喜草) and exotic tree seeds such as those of *Acacia confusa* (臺灣相思) were sometimes added to the hydroseeding mix on less steep slopes (Choi and Chau 2004). In addition, creepers, especially *Wedelia trilobata* (三裂葉蟛蜞菊), are sometimes planted on the slope surface as well.

Twenty-four man-made slopes along the Mui Wo to Pui O Section of South Lantau Road were upgraded under CED Contract no. GE/2001/06 from December 2001 to October 2004. These 24 slopes were all soil slopes with landscape treatment applied on part or whole of the slope surface. Halcrow China Limited (HCL) was commissioned by GEO/LPM 2, CEDD, to carry out ecological surveys for these 24 slopes at about 6-month intervals, starting from August 2005 to December 2006 (altogether 4 times). The aims were to review and monitor the growth and survival of native and exotic plant species planted or established naturally on these features. The requirements of this assignment included:

(a) A qualitative comparison of the growth and survival of the plants at different period of time;

(b) A review and assessment of the performance of ecological rehabilitation of the features and to correlate, if possible, the performance of these plant species on slopes under different environmental conditions.

2. METHODOLOGY

The 24 studied slopes are all along the South Lantau Road between Mui Wo and Pui O (Table 1). Four field surveys were planned covering two dry and two wet seasons respectively in this study. In the field surveys, all vascular plant species including ferns, herbs, climbers, shrubs and trees on the slopes were identified and recorded. For unidentified species on site, specimens were collected for further identification in the laboratory. All plants that were flowering or fruiting were also recorded and photographed. The relative abundance of each species found on each slope was determined as “Present” (in

low numbers), “Common” and “Very Common”. For animal species, notably birds, amphibians and reptiles, and insects, all species found on the slopes were counted, identified and recorded. If these animals were observed utilizing the resources e.g. flower nectar available on the slope, notes were taken.

For vegetation cover of the planted species, photo quadrats (1 m × 1 m) were set up on each of the feature at randomly selected parts of the slope and a photo was taken for each quadrat set during each survey. The number of quadrats set on each slope (ranging from 1 to 9) depended on the size and the planted vegetation cover of the slope. Photos taken in the same quadrat between the four surveys were compared. In addition to the photo quadrats, landscape pictures of each slope were also taken in each survey to compare the overall greening effect of each slope between the different surveys.

Finally, environmental data including weather condition, description on the adjacent vegetation, slope orientation and type of erosion control mat used were recorded during the first survey. The original planting plan was checked prior to the first survey so as to determine if a particular species was planted or naturally occurring. Floristic changes could thus be assessed as well. When we decided on the original of the plant species recorded on the slope, we had also taken into consideration our knowledge on the local flora, the general plant lists of the commercial landscaping field and the spatial patterns of the species on the slopes (planted species usually appear in a regular pattern).

2.1 Data Analysis

The number of species recorded in each survey was represented graphically for the comparison of changes over time. In addition, the plant communities between the slopes were compared by Bray-Curtis similarity (Clarke and Warwick 2001). The relative abundance record of each species on each slope was first converted to present “1” or absent “0” and then the plant communities between the slopes in each survey was compared using Primer Version 6 (Primer-E Ltd., 6 Hedingham Gardens, Roborough, Plymouth PL6 7DX, UK, http://www.primer-e.com). The non-metric multidimensional scaling (MDS) ordination was used to create a graphical representation of similarities of plant communities between sites. MDS plot is constructed by successively refining the positions of the points on the plot until they satisfy as closely as possible the similarity (or dissimilarity) relations between samples. A cluster analysis was also conducted to show the level of similarities between the studied slopes.

Table 1 - General Information of the 24 Slopes Covered in this Study

No.	Feature No.	Location	*Length (m)	*Height (m)	**Estimated Area (m^2)	***Slope Facing ($0-360^o$)
1	10SW-C/C1	Adjacent to the Roundabout at Mui Wo, South Lantau Road, Lantau Island	58	17	986	93
2	10SW-C/C2	Near the Roundabout at Mui Wo, South Lantau Road, Lantau Island	46	17	782	93
3	10SW-C/FR70	Below House No. 3 of Fu Kong Shan, South Lantau Road, Lantau Island	17	11	187	162
4	10SW-C/C64	Below House No. 4 of Fu Kung Shan, South Lantau Road, Lantau Island	100	6	600	160
5	10SW-C/C67	Near M.S. ¼ of South Lantau Road, Lantau Island	130	7	910	173
6	10SW-C/C68	Near M.S. ¼ of South Lantau Road, Lantau Island	65	8	520	338
7	10SW-C/C12	Near M.S. ¼ of South Lantau Road, Lantau Island	80	13	1,040	338
8	10SW-C/C104	Near M.S. ½ of South Lantau Road, Lantau Island	95	18	1,710	230
9	10SW-C/C125	Near M.S. ½ of South Lantau Road, Lantau Island	60	14	840	238
10	10SW-C/C45	Near M.S. ½ of South Lantau Road, Lantau Island	80	8	640	270
11	10SW-C/FR11	Near M.S. ½ of South Lantau Road, Lantau Island	225	9	2,025	240
12	10SW-C/C119	Near M.S. ¾ of South Lantau Road, Lantau Island	40	7	280	350
13	10SW-C/C118	Near M.S. ¾ of South Lantau Road, Lantau Island	27	10	270	310
14	10SW-C/C117	Near Lai Chi Yuen, South Lantau Road in Lantau Island	38	10	380	310
15	10SW-C/C116	Near Lai Chi Yuen, South Lantau Road in Lantau Island	20	37	540	310
16	10SW-C/C20	Near Lai Chi Yuen, South Lantau Road in Lantau Island	50	17	850	340
17	10SW-C/C209	Near M.S. ¾ of South Lantau Road, Lantau Island	62	19	1,178	337
18	10SW-C/FR32	Near M.S. ¾ of South Lantau Road, Lantau Island	20	12	240	355
19	10SW-C/C21	Near M.S. 1 of South Lantau Road, Lantau Island	200	11	2,200	290
20	10SW-C/C193	Near M.S. 1 of South Lantau Road, Lantau Island	195	15	2,925	320
21	10SW-C/C187	Near Nam Shan Barbeque Area, South Lantau Road, Lantau Island	180	15	2,700	170
22	10SW-C/C199	Near M.S. 1½ of South Lantau Road, Lantau Island	70	13	910	123
23	10SW-C/C198	Near M.S. 1½ of South Lantau Road, Lantau Island	90	24	2,160	93
24	10SW-C/C165	Near M.S. 1½ of South Lantau Road, Lantau Island	145	13	1,885	103

* Source: April 2001, Mouchel Halcrow; Slope Information System (http://hkss.cedd.gov.hk/hkss/chi/slopeinfo/index.htm), CEDD

** Calculated by using the length times height of the slope

*** Measured during the first field survey

3. RESULTS

Four surveys were conducted to cover two wet and two dry seasons as planned and the detailed monitoring report of each survey was submitted to the GEO after each survey (Table 2). It should be noted that this summary report has summarized the results from the 4 monitoring reports and comparisons were made. For detailed information about each survey, the monitoring reports should be consulted.

Table 2 - Field Survey Dates and Seasons and the Month/year of the Submission of Monitoring Reports

Survey	Survey Dates	Season	Monitoring Report Submitted In:
First	25/8/2005; 27/8/2005; 9/9/2005; 14/9/2005	Wet	December 2005
Second	1/2/2006; 17/2/2006	Dry	March 2006
Third	14/6/2006; 15/6/2006; 16/6/2006; 6/7/2006; 7/7/2006	Wet	December 2006
Fourth	9/12/2006; 15/1/2007; 27/1/2007	Dry	June 2007

3.1 Plants

3.1.1 Changes in Species Richness Over Time

The relative abundance of the plant species recorded in each survey is shown in Appendix A. In general, the number of plant species (or species richness) recorded on each slope was gradually increasing, though to a different extent, from the first survey to the fourth survey (Table 3). The percentage increment in plant species richness ranged from 17% (10SE-C/C118) to 131% (10SW-C/C116). Four slopes with a natural slope face i.e. with an undisturbed slope surface even after the upgrading work (10SW-C/C21; 10SW-C/C193; 10SW-C/C187 and 10SW-C/C198) had much higher species richness in the end of the study period than other slopes (Figure 1). Slopes with no or only a small increase in species richness over time (e.g. 10SW-C/FR70; 10SW-C/C68; 10SW-C/C118 and 10SW-C/C199) were dominated by the planted *Wedelia trilobata* (三裂葉蟛蜞菊) which appeared to inhibit natural regeneration (Table 3; Figure 1). Finally, the data showed that the number of species increment during the first wet and dry seasons was low. However, the increment in the second wet and dry season was obviously higher. In addition, most of the naturally regenerated species were found and recorded in the second dry season survey (i.e. the fourth survey).

Table 3 - Number of Species Recorded in the Four Vegetation Surveys

No.	Features	Number of Species Recorded in Different Surveys				Overall % Increment
		First (wet season)	Second (dry season)	Third (wet season)	Fourth (dry season)	
1	10SW-C/C1	30	34	51	57	90%
2	10SW-C/C2	33	33	40	41	24%
3	10SWC/FR70	28	25	25	33	17%
4	10SW-C/C64	19	25	31	28	47%
5	10SW-C/C67	37	39	47	49	32%
6	10SW-C/C68	21	24	29	25	19%
7	10SW-C/C12	31	30	38	39	25%
8	10SW-C/C104	15	15	26	37	106%
9	10SW-C/C125	19	19	31	34	79%
10	10SW-C/C45	23	26	30	40	74%
11	10SW-C/FR11	23	27	34	35	52%
12	10SW-C/C119	36	36	45	54	50%
13	10SW-C/C118	20	20	21	20	0%
14	10SW-C/C117	29	31	38	37	27%
15	10SW-C/C116	16	21	33	37	131%
16	10SW-C/C20	18	23	33	33	83%
17	10SW-C/C209	34	35	37	47	38%
18	10SW-C/FR32	16	16	24	21	31%
19	10SW-C/C21	56	59	60	82	46%
20	10SW-C/C193	45	51	68	86	91%
21	10SW-C/C187	62	64	70	85	37%
22	10SW-C/C199	28	28	31	34	21%
23	10SW-C/C198	45	45	67	75	66%
24	10SW-C/C165	35	38	44	48	37%

3.1.2 Changes in Abundance Over Time

The abundance of most herbaceous plant species, whether planted or naturally occurring, fluctuated between the wet and dry season. It is natural that most perennial herbs will die in the winter dry season and grow back in the summer wet season e.g. 10SW-C/FR11 (see the pictures in the final monitoring report). This change in abundance is more obvious with the hydroseeded grass species, *Paspalum notatum* (百喜草) which gave most of the slopes a brown colour in the dry season. In some slopes e.g. 10SW-C/C1 (see the pictures in the final monitoring report), recovery of this planted grass in the wet season was poor. The change in abundance of the woody species, whether planted or naturally occurring, over the seasons was not obvious.

3.1.3 Naturally Occurring Plant Species

A total of 190 plant species with 14 ferns, 40 climbers, 42 herbs, 38 shrubs and 56 trees were recorded as naturally occurring on the 24 slopes (Appendix 1). Of these, 2 climber, 11 herb, 2 shrub and 9 tree species were exotic. The most common species was the exotic herbaceous climber *Mikania micrantha* (薇甘菊), which was recorded on all 24 slopes. Another common herbaceous species was *Emilia sonchifolia* (一點紅), which was found on 18 slopes. *Mallotus paniculatus* (白楸), *Trema tomentosa* (山黃麻) and *Sterculia lanceolata* (假蘋婆) were the most common tree species, which were found on 22, 19 and 18 slopes respectively. The fern species *Cyclosorus parasiticus* (華南毛蕨) and *Pteris vittata* (蜈蚣草) were the most common which were recorded on 20 slopes.

In terms of growth habit, more tree species were recorded in all but 3 slopes 10SW-C/FR70; 10SW-C/C125 and 10SW-C/C209 (Figure 2). More herbaceous species was recorded on these three slopes than that of tree species.

3.1.4 Species and Area Relationship

It appears that larger slopes have higher plant species richness in this study (Figure 3). Features 10SW-C/C1 (986 m^2), 10SW-C/C67 (910 m^2), 10SW-C/C21 (2,200 m^2), 10SW-C/C193 (2,925 m^2), 10SW-C/C187 (2,700 m^2), 10SW-C/C198 (2,160 m^2) and 10SW-C/C165 (1,885 m^2) have larger slope surface areas and relatively higher species richness. Features 10SW-C/FR70, 10SW-C/C64, 10SW-C/C68, 10SW-C/C118, 10SW-C/FR32 have smaller areas and lower species richness. Exceptional cases were 10SW-C/C104 (1,710 m^2), 10SW-C/FR11 (2,025 m^2) and 10SW-C/C119 (280 m^2). The former two slopes are large but had relatively low species richness. The latter was small but had high species richness.

3.1.5 Comparison of the Plant Communities between Slopes

The similarity (Bray-Curtis similarity) of the plant communities of the 24 studied slopes in each survey was represented on 2-dimensional MDS plots (Figure 4) with superimposed clusters from Figure 5 at an arbitrary level of 50% similarity.

The results show that Sites 6 (10SW-C/C68) and 11 (10SW-C/FR11) are rather dissimilar to all other slopes in all 4 surveys. They both have rather low species richness and are facing west. 10SW-C/C68 was more or less covered by a uniform layer of *Wedelia trilobata* (三裂葉蟛蜞菊). 10SW-C/FR11 was under the shade of some mature *Acacia confusa* (臺灣相思) trees on the slope crest. It was dominated by the native grass *Lophatherum gracile* (淡竹葉) especially in the middle part of the slope.

Other clusters formed at 50% similarity level between surveys are rather variable except that sites 1, 2, 3, 4 and 19, 20, 21, 23, 24 often come under the same cluster in different surveys respectively. The cluster with sites 1 to 4 (10SW-C/C1; 10SW-C/C2; 10SW-C/FR70 and 10SW-C/C64) are next to each other near Mui Wo. They all had similar landscape treatment with *Wedelia trilobata* (三裂葉蟛蜞菊) and hydroseeded *Papalum noatum* (百喜草)

as the ground cover with some woody species planted at the toe planter. The cluster with sites 19, 20, 21, 23 and 24 (10SW-C/C21; 10SW-C/C193; 10SW-C/C187; 10SW-C/C198 and 10SW-C/C165) are also next to each other. They are relatively large slopes and have at least part of the slope face not disturbed during the slope upgrading work. The plant species richness on these slopes is also higher (see Table 3).

3.1.6 Performance of the Planted Species on the Slopes

Thirty-six plant species appeared to be planted on the slopes studied (Table 4). The most common planted species were *Wedelia trilobata* (三裂葉蟛蜞菊) and *Paspalum notatum* (百喜草). As mentioned earlier, *P. notatum* (百喜草) performed badly as most of them could not recover from the winter dry season. On the other hand, *W. trilobata* (三裂葉蟛蜞菊) performed very well which often inhibited natural regeneration. Other poorly performing species include *Catharanthus roseus* (長春花), *Murraya paniculata* (九里香) and *Parthenocissus dalzielii* (異葉爬山虎). The fern *Nephrolepis hirsutula* (毛葉腎蕨) was found establishing and growing very well on the slope which often gave the slope the green effect even during the winter dry season. A few other shrub species including *Lantana* spp. (馬纓丹屬), *Ligustrum sinense* (山指甲), *Pittosporum tobira* (海桐花) and *Rhaphiolepis indica* (石斑木(車輪梅)) were also doing well on most of the slopes. Not many trees were planted on these 24 slopes. Yet, *Acacia auriculiformis* (耳果相思) and *Syzygium jambos* (蒲桃) were the most common and they did well on slopes. On 10SW-C/FR32, a number of native tree species were planted (it looked like a field trial) which covered the whole slope surface. Among the species planted, *Cinnamomum camphora* (樟) was comparatively better than *Cetlis sinensis* (朴樹), *Gordonia axillaris* (大頭茶), *Mallotus paniculatus* (白楸), *Machilus breviflora* (短序潤楠) and *Sapium discolour* (山烏桕). It should be noted that the trees planted on this not very steep slope were all growing very well and a canopy layer of about 2 m is being formed.

Table 4 - Performance of the Planted Species on the 24 Slopes

Species	Family	Chinese Name	Origin*	Form	Performance**
Parthenocissus dalzielii	Vitaceae	異葉爬山虎	E	Climber	+
Paspalum notatum	Poaceae	百喜草	N	Herb	+
Catharanthus roseus	Apocynaceae	長春花	E	Shrub	+
Murraya paniculata	Rutaceae	九里香	E	Shrub	+
Epipremnum aureum	Araceae	綠蘿	E	Climber	++
Ficus pumila	Moraceae	薜荔	N	Climber	++
Allamanda cathartica	Apocynaceae	軟枝黃蟬	E	Shrub	++
Melastoma candidum	Melastomataceae	野牡丹	N	Shrub	++
Rhododendron sp.	Ericaceae	杜鵑屬	N	Shrub	++
Rhodomyrtus tomentosa	Myrtaceae	桃金娘(崗棯)	N	Shrub	++
Acacia confusa	Mimosaceae	臺灣相思	E	Tree	++
Aporusa dioica	Euphobiaceae	銀柴	N	Tree	++
Cassia surattensis	Caesalpiniaceae	黃槐	E	Tree	++
Celtis sinensis	Ulmaceae	朴樹	N	Tree	++
Ficus microcarpa	Moraceae	細葉榕	N	Tree	++
Litsea glutinosa	Lauraceae	潺槁樹 ***	N	Tree	++
Lophostemen confertus	Myrtaceae	紅膠木	E	Tree	++
Mallotus apelta	Euphobiaceae	白背葉	N	Tree	++
Mallotus paniculatus	Euphobiaceae	白楸 ***	N	Tree	++
Michelia x *alba*	Magnoliaceae	白蘭	E	Tree	++
Sapium discolor	Euphobiaceae	山烏桕	N	Tree	++
Sapium sebiferum	Euphobiaceae	烏桕	N	Tree	++
Philodendron cordatum	Araceae	心葉喜樹蕉	E	Climber	+++
Wedelia trilobata	Asteraceae	三裂葉蟛蜞菊	E	Climber	+++
Nephrolepis hirsutula	Nephrolepidaceae	毛葉腎蕨	N	Fern	+++
Lantana camara	Verbenaceae	馬纓丹	E	Shrub	+++
Lantana camara cv. *Flava*	Verbenaceae	黃馬纓丹	E	Shrub	+++
Lantana montevidensis	Verbenaceae	小葉馬纓丹	E	Shrub	+++
Lantana sp.	Verbenaceae	馬纓丹屬	E	Shrub	+++
Ligustrum sinense	Oleaceae	山指甲	N	Shrub	+++
Pittosporum tobira	Pittosporaceae	海桐花	N	Shrub	+++
Acacia auriculiformis	Mimosaceae	耳果相思	E	Tree	+++
Cinnamomum camphora	Lauraceae	樟	N	Tree	+++
Pinus massoniana	Pinaceae	馬尾松	N	Tree	+++
Rhaphiolepis indica	Rosaceae	石斑木(車輪梅)	N	Tree	+++
Syzygium jambos	Myrtaceae	蒲桃	E	Tree	+++

* N = Native / E = Exotic

** "+" = poor performance, "++" = medium performance", "+++" = good performance in terms of both growth and establishment

*** Most individuals found were suspected to be natural but some must be planted according to the landscape plans. However, it was very difficult to differentiate the planted and the naturally occurring individuals in the field as these two species were planted in small numbers.

3.2 Animals

A total of 17 bird species were recorded on the studied slopes in this study (Appendix B) but the number of species recorded on each slope is low which is mostly 0, 1 or 2 with a few exceptions (Table 5). Many of these birds were seen on the trees on these slopes either on the slope face or at the slope crest or toe. Most of the individuals recorded might be just passing through the site. Only the Greater Coucal, Common Tailor Bird, Japanese White-eye, Grey-backed Thrush and White-rumped Munia were seen foraging among the vegetation on the slopes. The Besra and Greater Coucal are of some conservation concern as they are considered rare. All other species recorded are common and widespread in Hong Kong. In view of the relatively small size of the slopes to birds and the relatively simple vegetation on these slopes, they would unlikely form very important habitats for birds.

A total of 48 butterfly species were recorded on these slopes (Appendix B) with a mean value of 8.8 species per slope (Table 5). Most of the butterfly species (and the bees and wasps) were seen utilizing the nectar sources i.e. flowers growing on the slopes. Across all the animal groups recorded, the studied slopes appear to be the most important in providing resources for butterflies. The most common nectar sources on the slopes include the exotic *Lantana camara* (馬纓丹); *Ageratum conyzoides* (藿香薊); *Wedelia trilobata* (三裂葉蟛蜞菊); *Mikania micrantha* (薇甘菊); *Boehmeria nivea* (苧麻) and *Rhododendron* sp. (杜鵑屬) and the native *Ligustrum sinense* (山指甲); *Rhaphiolepis indica* (石斑木(車輪梅)). On the other hand, some butterfly larval foodplants (e.g. were also recorded on the slopes which indicate that the slopes are potentially suitable for the larvae of some butterfly species. For example, *Strophanthus divaricatus* (羊角拗), *Litsea glutinosa* (潺槁樹), *Schefflera heptaphylla* (鵝掌柴), *Tetradium glabrifolium* (棟葉吳茱萸), *Boehmeria nivea* (苧麻) and *Lantana camara* (馬纓丹). In fact, the caterpillar of the Blue-Spotted Crow was found on *Strophanthus divaricatus* (羊角拗) on 10SW-C/C199 in the third survey.

Table 5 - The Number Animal Species Recorded on Each Slope. For the Animal Survey, 10SW-C/C12; 10SW-C/C104 and 10SW-C/C125 were Treated As One Slope. Likewise, 10SW-C/C117; 10SW-C/C116 and 10SW-C/C20 were Treated As One Slope

Slope	Birds	Butterflies	Dragonflies	Other insects	Spiders	Snails	Amphibians & reptiles	Total
10SW-C/C1	6	17	0	1	1	1	0	26
10SW-C/C2	7	17	0	8	1	0	0	33
10SWC/FR70	6	12	0	2	0	1	0	21
10SW-C/C64	3	10	0	5	0	0	0	18
10SW-C/C67	5	8	1	5	1	0	0	20
10SW-C/C68	1	3	1	0	1	0	0	6
10SW-C/C12; 104; 125	2	15	3	7	2	1	0	30
10SW-C/C45	1	4	0	3	0	1	0	9
10SW-C/FR11	2	9	2	5	1	0	1	20
10SW-C/C119	1	9	0	5	0	0	0	15
10SW-C/C118	1	8	0	0	0	0	0	9
10SW-C/C117; 116; 20	3	11	2	7	0	0	0	23
10SW-C/C209	0	3	2	3	0	0	0	8
10SW-C/FR32	1	9	3	2	0	0	0	15
10SW-C/C21	2	10	2	4	1	0	1	20
10SW-C/C193	3	5	1	0	0	0	1	10
10SW-C/C187	3	5	0	5	2	1	1	17
10SW-C/C199	1	5	1	4	1	0	0	12
10SW-C/C198	4	7	0	6	1	0	0	18
10SW-C/C165	1	6	0	2	1	1	0	11
Mean	2.7	8.8	0.9	3.7	0.7	0.3	0.2	17.2
s.d.	2.0	4.2	1.1	2.4	0.7	0.5	0.4	7.4

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A total of 47 species of insects were grouped under “Other insects” in this study which included bees, wasps, grasshoppers etc (Appendix B). On the other hand, 4 spider, 3 snail and 3 reptile species were also recorded on the slopes. These animals are likely utilizing the resources provided by the vegetation of the slopes such as nectar. The predatory species like the spiders must be hunting on other insect on the slopes. Whilst all of these species are common and widespread in Hong Kong, these slopes are nonetheless acting as the habitats for these wildlife species.

The diversity and abundance of the wildlife recorded on the slopes were higher during the wet season, especially the second wet season (Appendix B). This is natural as most of the wildlife species recorded on these slopes was insects.

Lastly, 10SW-C/C1 and 10SW-C/C2 have the highest animal species richness among all slopes. This was largely attributable to the flowering *Rhododendron* sp. (杜鵑屬) which attracted many butterflies in the beginning of the wet season and the flowering *Mikania micrantha* (薇甘菊) at the beginning of the dry season. Being right next to the round about garden and roadside planters of Mui Wo had also contributed to the butterfly richness at these two slopes.

4. DISCUSSION

4.1 Natural Regeneration on the Studied Slopes

The gradual increase in plant species richness at all 24 slopes over the study period clearly suggests that natural plant regeneration at the 24 studied slopes is taking place. However, like all recently disturbed lands, the plant communities are still dominated by the invasive alien species including *Mikania micrantha* (薇甘菊), *Bidens alba* (白花鬼針草) and *Ageratum conyzoides* (藿香薊). Yet, the occurrence of many woody native species indicates there are rich supplies of seeds and propagules at these slopes. The naturally occurring native plant species recorded on these 24 slopes are very similar to those recorded in Choi and Chau (2004; Table 7) on 20 old soil slopes in Hong Kong. This clearly shows that soil slopes would allow natural regeneration to take place. Yet, the results of this study (both in the MDS and species richness) agree with Lui and Shiu (2004) that a dense ground cover of *Wedelia trilobata* (三裂葉蟛蜞菊) could delay or prevent natural regeneration. Also, the failure of the hydroseeded grass *Paspalum notatum* (百喜草) to persist on the slopes for a longer term may be beneficial to natural regeneration. Thus, for slopes with good supplies of natural seeds such as those slopes surrounded by natural vegetation in the countryside or within country parks, planting *W. trilobata* (三裂葉蟛蜞菊) may not be desirable. On the other hand, *W. trilobata* (三裂葉蟛蜞菊) may be used in isolated or sites with very bad soil where natural regeneration will be very slow.

The fact that 190 plant species were recorded in these 24 slopes that were more or less in the same hillside area over the 134 species recorded in 20 old slopes scattered in various parts of Hong Kong (Choi and Chau 2004) reiterate the importance of seed sources in natural regeneration. Some of the slopes reported in Choi and Chau (2004) are pretty isolated from any natural vegetation. The higher composition of shrub and tree species in the plant communities on these 24 slopes also show that natural regeneration is heading towards the formation of more complex vegetation.

The result of this study shows that larger slopes appear to have richer plant regeneration. Yet, a properly designed study may be needed to verify this finding.

The cluster formed in terms of the similarity of the plant communities of several large slopes with at least some parts of the slope surface undisturbed clearly shows that in-situ vegetation could further enhance the supply of plant propagules for natural regeneration (Choi and Chau 2004).

According to the photo quadrats, hydroseeded grass species, *Paspalum notatum* (百喜草) and some weeds grew well at the beginning of the study. Starting from the second survey, *P. notatum* (百喜草) and some of the weeds dried and could not regenerate after the first dry season (the second survey). Although those dried individuals could not provide satisfactory greening effect, it could still cover the slope surface as mulch and contribute to the modification of soil and the micro-environment for other plants to establish. This may explain the slower increment on plant species and abundance during the first two surveys and a significant increment in the last two surveys.

Slope orientation was measured and compared with the number and abundance of plants recorded. No obvious relationship was found from this study, thus slope orientation may not be a critical factor affecting plant establishment.

4.2 Naturally Regenerated Tree Species on the Studied Slopes

Like similar studies in Hong Kong (Choi and Chau 2004; Lui and Shiu 2004), natural regeneration on slopes in this study is also dominated by bird dispersed tree and shrub species. This is in fact the characteristic of forest and shrub land types in Hong Kong as almost all of the larger vertebrate seed dispersers have disappeared from Hong Kong due to prolonged human disturbance (Hau et al. 2005; Lee et al. 2005; Au et al. 2006). Frugivorous birds are the major fauna traversing different vegetation types in Hong Kong.

The total number of plant species was generally increasing from the first to the last survey especially trees and shrubs. In most cases, tree species recorded in the first survey could be recorded in the remaining surveys. This shows that tree is an important component contributing to the stability of the vegetation. In this study *Mallotus paniculatus* (白楸), *Trema tomentosa* (山黃麻), *Sterculia lanceolata* (假蘋婆), *Zanthoxylum avicennae* (簕欓), *Ficus hispida* (對葉榕), *Sapium discolour* (山烏桕), *Ficus hirta* (粗葉榕), *Rhus succedanea* (木蠟樹(野漆)), *Microcos paniculata* (破布葉), *Macaranga tanarius* (血桐), *Cratoxylum cochinchinense* (黃牛木), *Cinnamomum parthenoxylon* (黃樟) and *Celtis sinensis* (朴樹) were found at least 50% of the studied slopes. This suggests that these species may be considered to be used on slope greening on less steep slopes in the future.

4.3 Planted Species on the Studied Slopes

The performances of those planted native shrub species was satisfactory. *Ligustrum sinense* (山指甲), *Pittosporum tobira* (海桐花) and *Rhaphiolepis indica* (石斑木(車輪梅)) performed very well. The performance of *Rhodomyrtus tomentosa* (桃金娘(崗棯)),

Rhododendron sp. (杜鵑屬) and *Melastoma candidum* (野牡丹), in terms of growth and survival rate was also satisfactory. However, *Catharanthus roseus* (長春花) and *Murraya paniculata* (九里香) grew poorly on the slopes, which showed that these species may not be suitable on man-made slope. However, it should be noted that their poor performances might be due to poor seedling quality or planting treatment, which could not be verified in this study.

The performances of planted native tree species, *Aporusa dioica* (銀柴), *Pinus massoniana* (馬尾松), *Cinnamomum camphora* (樟), *Ficus microcarpa* (細葉榕), *Litsea glutinosa* (潺槁樹), *Mallotus apelta* (白背葉), *Mallotus paniculatus* (白楸), *Sapium discolor* (山烏桕) and *Sapium sebiferum* (烏桕) were also satisfactory. All except *P. massoniana* (馬尾松) and *M. apelta* (白背葉) could attract birds or fruit bats which can further enhance the ecological value of the slopes. In addition, the planted exotic tree species, *Acacia confuse* (臺灣相思), *A. auriculiformis* (耳果相思), *Cassia surattensis* (黃槐) (on toe planter), *Lophostemen confertus* (紅膠木), *Michelia x alba* (白蘭) (on toe planter) and *Syzygium jambos* (蒲桃) also performed very well. *S. jambos* (蒲桃) was recently found to be invading natural forest along undisturbed streams in Hong Kong (Leung 2006), it should not be planted in Hong Kong anymore until its invasive potential will be further studied.

Finally, the planted fern and herb species *Nephrolepis hirsutula* (毛葉腎蕨), *Lantana* sp. (馬纓丹屬), *Philodendron cordatum* (葉喜樹蕉) and *Wedelia trilobata* (三裂葉蟛蜞菊) were all growing well on the slope. However, the use of *W. trilobata* (三裂葉蟛蜞菊) should be cautioned as noted earlier.

4.4 Tree Planting Trial on Feature 10SW-C/FR32

Large numbers (288 individuals) of 6 different native tree species had been planted on 10SW-C/FR32 obviously with the aim of setting up a woodland on this slope. Although only 3 species (*Cinnamomum camphora* (樟), *Mallotus paniculatus* (白楸) and *Sapium discolour* (山烏桕)) could be found during the surveys, the good performance of these 3 tree species, especially *C. camphora* (樟) have started to form a closed canopy (already reaching 2 m). The understory was cleared of weeds and grass in the 4th survey. This is a good site trial to show that planting native species woodland is possible on man-made slopes.

4.5 Effect on Weedy Species on Natural Regeneration and Regular Maintenance Works

Mikania micrantha (薇甘菊) was the most common weed species that were found on all studied slopes. During the surveys, it was observed that the growth of *M. micrantha* (薇甘菊) slowed down in dry season. However, *M. micrantha* (薇甘菊) could recover and the coverage could become even more extensive once entering the wet season again. Young trees were frequently seen to be strangled or even killed by *M. micrantha* (薇甘菊). In addition to *M. micrantha* (薇甘菊), native climbers *Pueraria lobata* (野葛) and *Lygodium* spp. (海金沙屬) could also strangle and kill seedlings. Regular clearing of these weeds may be needed. However, many non-weedy species were seen to be damaged or cut obviously

during maintenance clearing of unwanted vegetation (see the monitoring reports). Contractors should be reminded to be more vigilant in regular maintenance.

Slopes that are extensively covered by ground covering plants, such as *M. micrantha* (薇甘菊), *P. lobata* (野葛) and *Wedelia trilobata* (三裂葉蟛蜞菊) were recorded to have low plant species richness. This is because these plants densely covered the slope surface and seeds would be difficult for other plants to establish even if seeds could find their ways through. Regular removal or thinning of these plants with intensive care of those young seedlings of other plant species is recommended.

In general, arboricultural works were found to be good during the surveys, except those for the planters at some slopes, which need further improvement (see the monitoring reports). Improper pruning works and inadequate supporting were common problems found in toe planters. Moreover, in most cases, toe planters are too small to provide adequate root growing space for the planted tree species. If root development is restricted, it will result in poor growth and health condition, as well as poor self-supporting. This may explain why most of the toe planter trees are still supported by bamboos frames even several years after planting. It is suggested that shrubs or small trees should be planted rather than large trees, if space for the planters is limited. In addition, improper pruning works was found on some of the features and young trees were just topped to control their growth. However, improper pruning works, like topping will result in internal decay. In such a case, the tree may die or become a hazard in the future. Proper pruning works should be carried out by qualified tree workers or arborists.

4.6 Wildlife on the Studied Slopes

The results of this study show that man-made slopes could be attractive to wildlife provided that there are food resources available to them. For the relatively simple vegetation on slopes, nectar resources, whether native or exotic, could be very attractive to insects, especially butterflies. This study also found some predatory insect species and lizards on the slope which showed that an ecosystem is being developed on these slopes. The results show that planting the right species to promote natural regeneration would indeed increase the attractiveness of man-made slopes to wildlife.

4.7 Recommendations

According to the findings of this study, several recommendations are proposed:

(a) Disturbance to the original vegetation on the slope should be minimized during upgrading work i.e. in-situ vegetation should be retained as far as is practicable.

(b) Hydro-seeding of grass species could continue be done on man-made slopes especially those with higher potential in natural regeneration.

(c) To enhance ecological value, especially in country side, native plants with better performance, such as (shrubs) *Ligustrum sinense* (山指甲), *Melastoma candidum* (野牡丹), *Pittosporum tobira* (海桐花), *Rhaphiolepis indica* (石斑木 (車輪梅)); *Rhodomyrtus tomentosa* (桃金娘(崗棯)), *Rhododendron* sp. (杜鵑屬) and (trees) *Aporusa dioica* (銀柴), *Cinnamomum camphora* (樟) (naturalized), *Ficus microcarpa* (細葉榕), *Litsea glutinosa* (潺槁樹), *Mallotus apelta* (白背葉), *Mallotus paniculatus* (白楸), *Pinus massoniana* (馬尾松), *Sapium discolor* (山烏桕) and *Sapium sebiferum* (烏桕) should be considered.

(d) Although *Wedelia trilobata* (三裂葉蟛蜞菊) is very promising in slope greening, it may hinder the regeneration of other plants. Careful consideration should be made prior to using this species.

(e) Planting of *Syzygium jambos* (蒲桃) in Hong Kong should be suspended in view of its invasive potential and unknown ecological impacts.

(f) Planting native woodlands on suitable man-made slopes may be a sustainable way to minimize maintenance cost in the long term.

(g) Weed species have to be removed regularly and carefully.

(h) The quality of arboricultural works on slopes should be improved.

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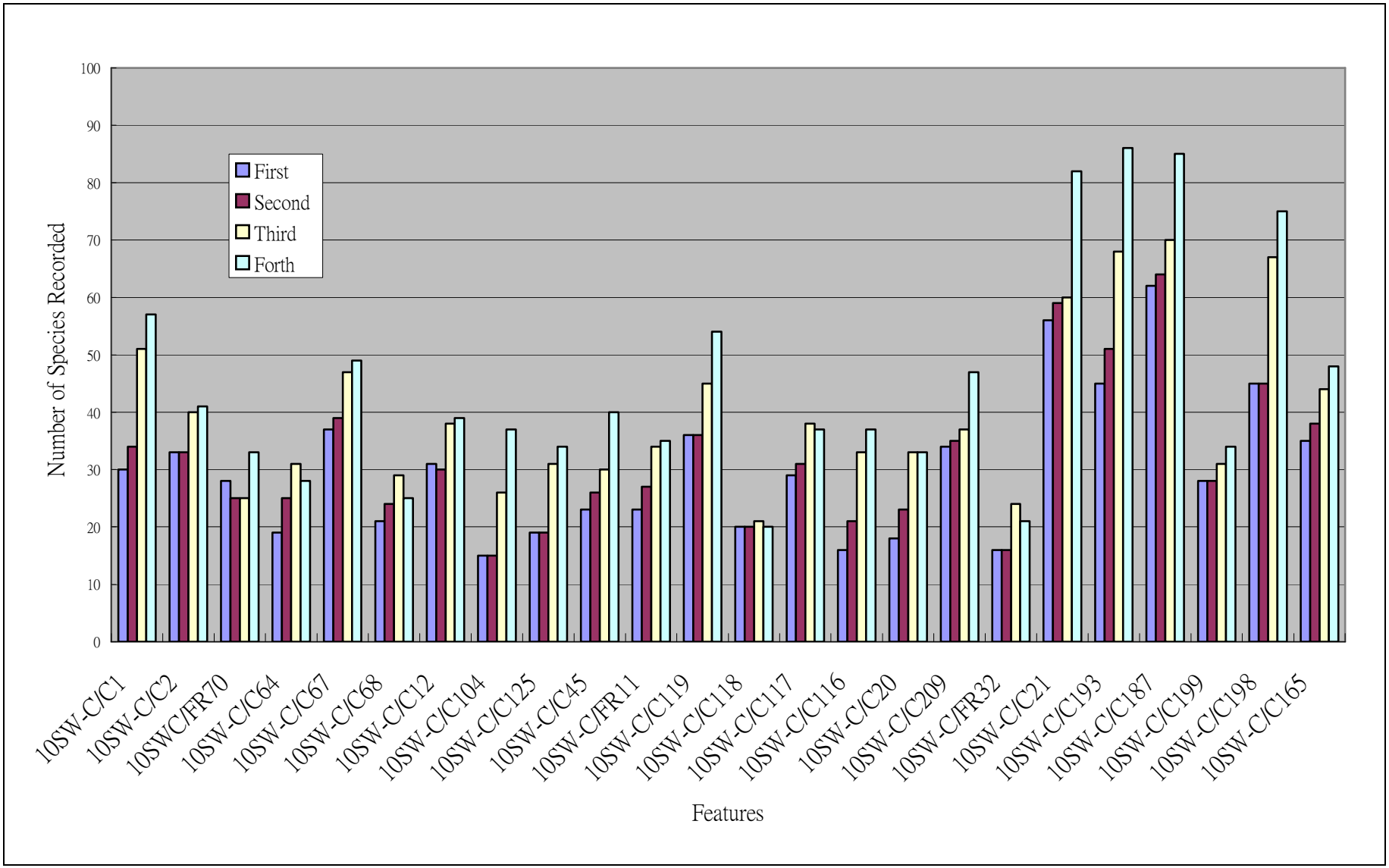

Figure 1 - The Total Number of Species Recorded on Each Slope in Each Survey

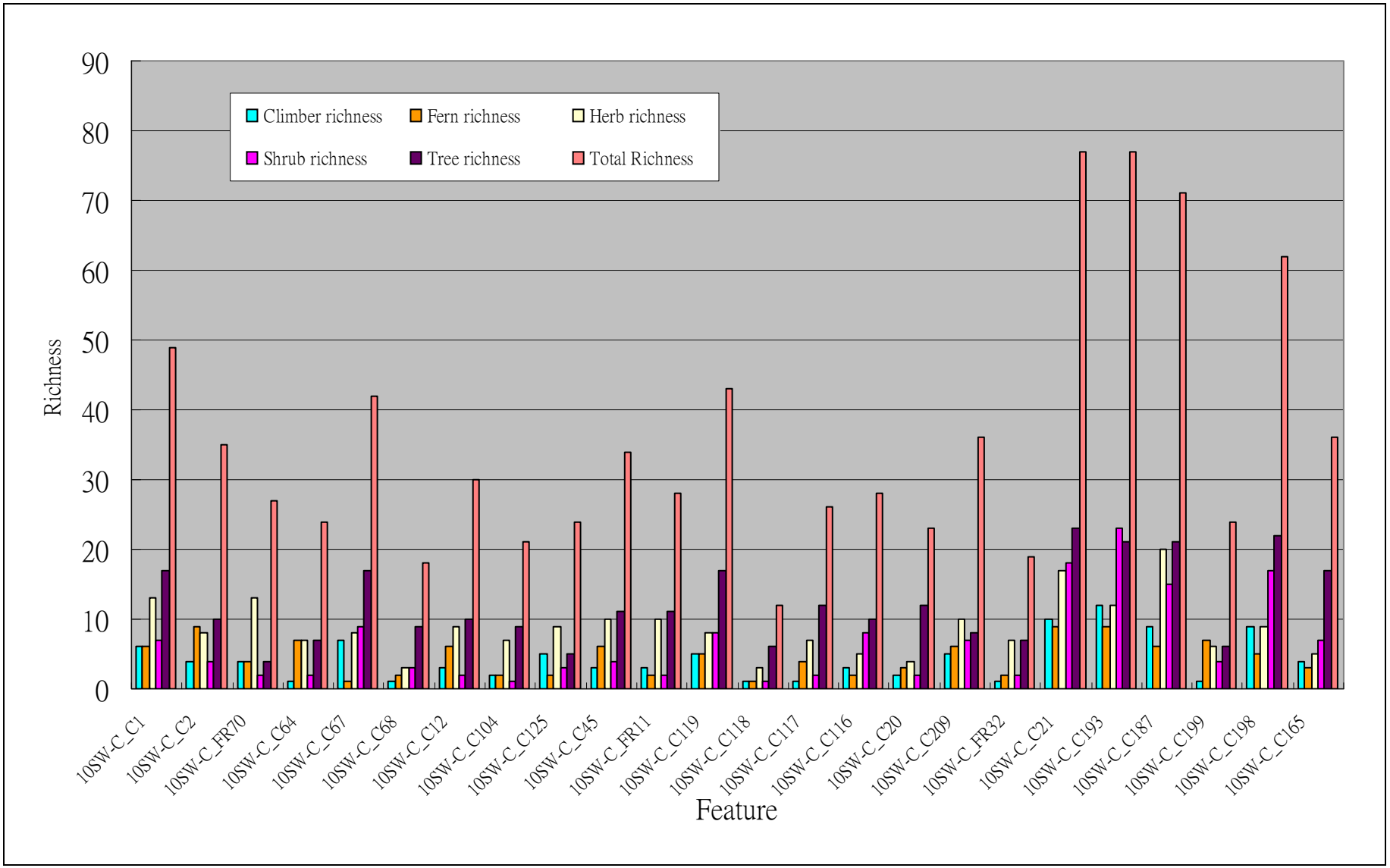

Figure 2 - The Species Richness of Different Plant Groups Recorded on the 24 Studied Features

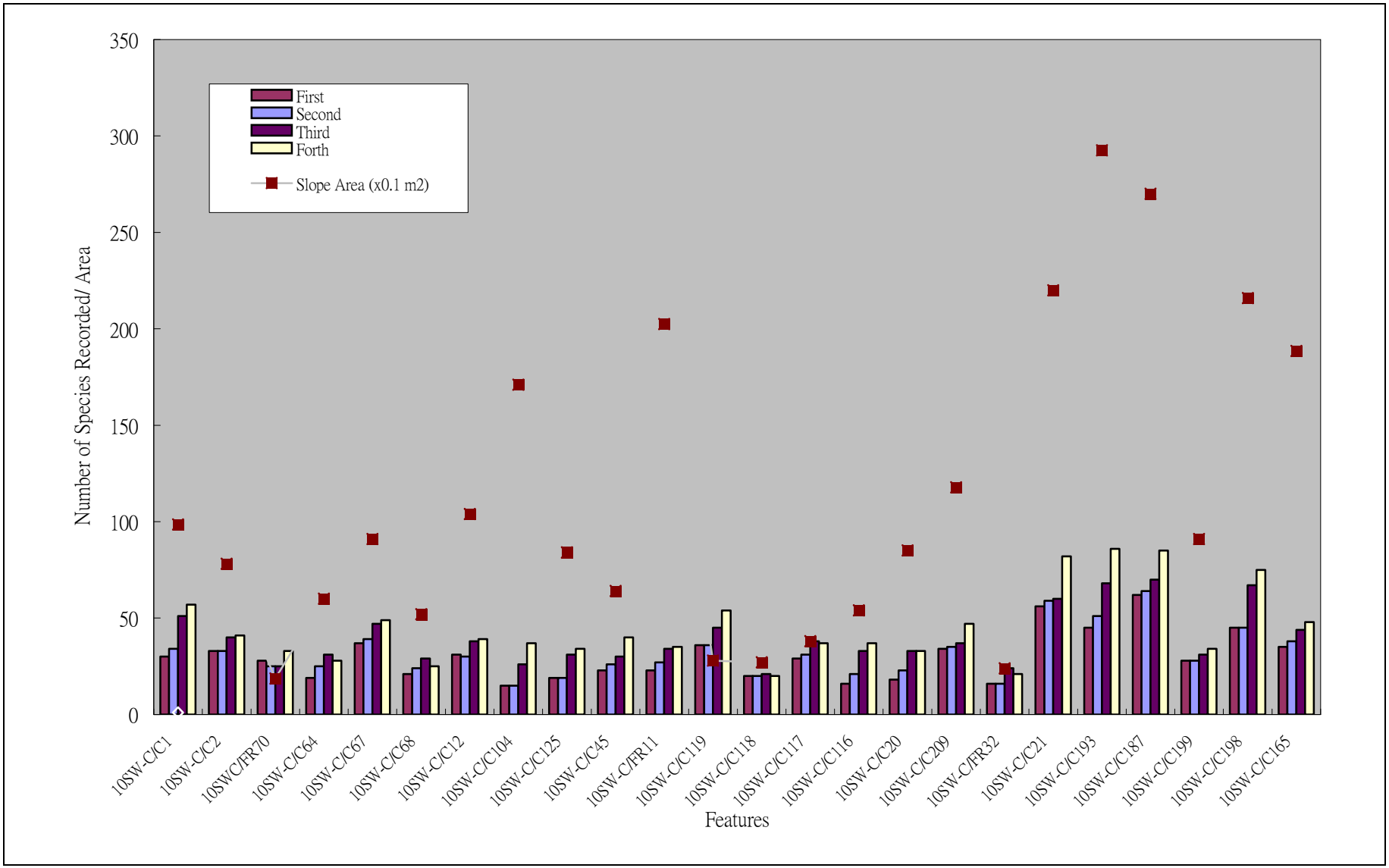

Figure 3 - Diagram Showing the Relationship between Numbers of Species Recorded and Slope Area on Different Features

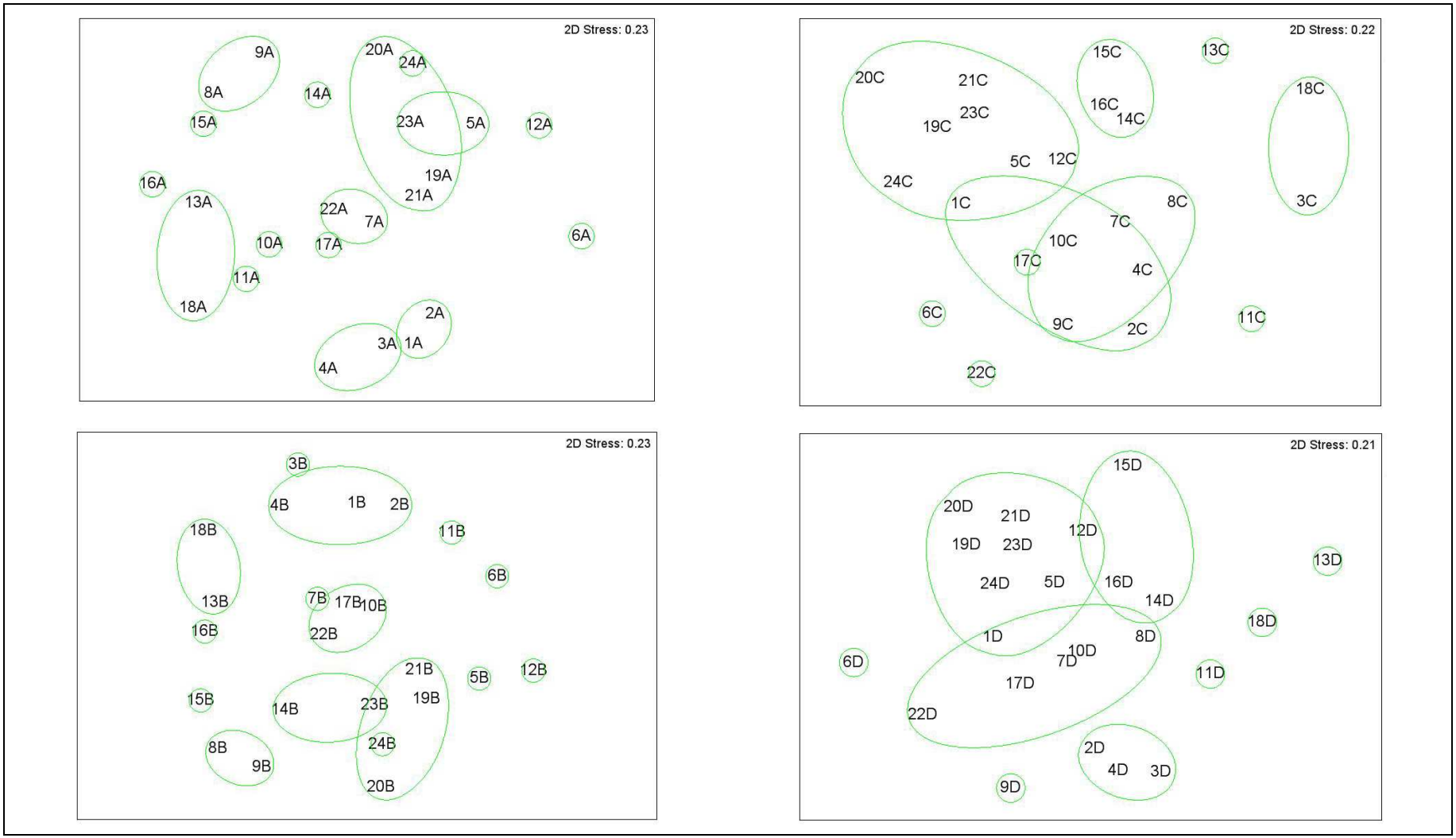

Figure 4 - The MDS Plots Showing the Similarity of the Plant Communities between Slopes. Cluster Formed at the Arbitrary Level of 50% is Superimposed on the 2-D MDS. A to D Represent the First to Fourth Survey Respectively. The Slope Number is According to the Sequence on Table 1.

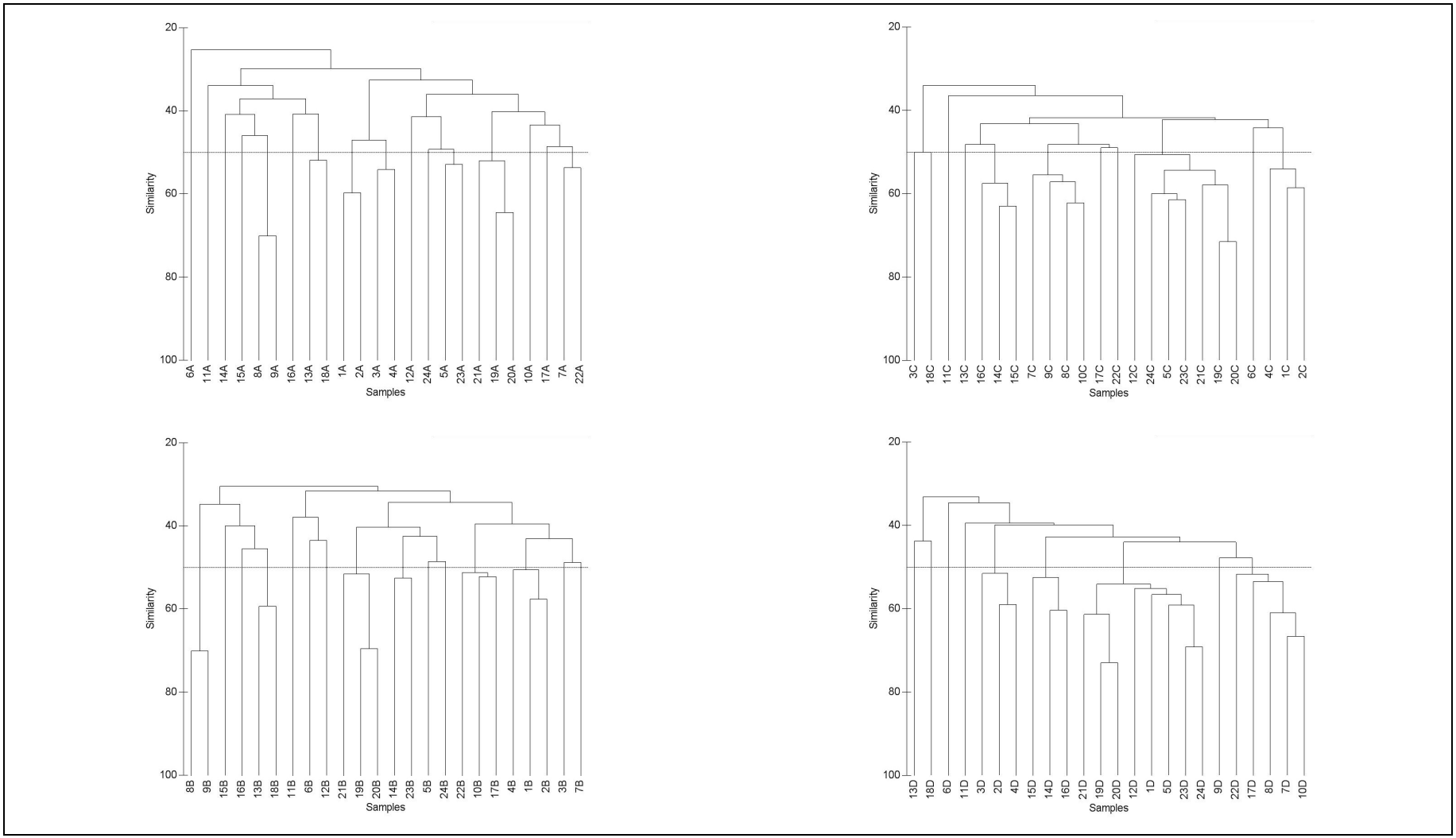

Figure 5 - Dendrograms of the 24 Slopes, Using Group Average Clustering from Bray-Curtis Similarities on Present and Absent Data. A to D Represent the First to Fourth Survey Respectively. The Slope Number is According to the Sequence on Table 1

APPENDIX A

THE RELATIVE ABUNDANCE OF THE PLANT SPECIES RECORDED IN EACH SURVEY

Appendix A: The Relative Abundance of the Plant Species Recorded in Each Survey

Scientific name	Family	Chinese name	Slope No. Form	Slope No. Origin [2]	Abundance [1] 10SW-C_C1 1st	2nd	3rd	4th	10SW-C_C2 1st	2nd	3rd	4th	10SW-C_FR70 1st	2nd	3rd	4th	10SW-C_C64 1st	2nd	3rd	4th	10SW-C_C67 1st	2nd	3rd	4th	10SW-C_C68 1st	2nd	3rd	4th	10SW-C_C12 1st	2nd	3rd	4th	10SW-C_C104 1st	2nd	3rd	4th	10SW-C_C125 1st	2nd	3rd	4th	10SW-C_C45 1st	2nd	3rd	4th	10SW-C_FR11 1st	2nd	3rd	4th	10SW-C_C119 1st	2nd	3rd	4th
PTERIDOPHYTES																																																				
Nephrolepis cordifolia	Nephrolepidac	腎蕨	Fern	P, N																																																
Nephrolepis hirsutula	Nephrolepidac	毛葉腎蕨	Fern	P, N	*	*	**	***	***	***	*	**							***	***							*	*	*	**									*	*		*							*			
Adiantum capillus-veneris	Adiantaceae	鐵線蕨	Fern	N																																												*	*		*
Blechnum orientale	Blechnaceae	烏毛蕨	Fern	N	**	**	*	**			*	*	*						*	*					*	*	*														*	*							*	*		
Cyclosorus parasiticus	Thelypteridac	華南毛蕨	Fern	N	*	*	*	*	**	*	*	**	**	*		*	*	*	*	*			*		*	*	*	*	*	*	*			*				*	*	*	*	*	*	*	*			*	**
Dicranopteris pedata	Gleicheniacea	芒萁	Fern	N																																															
Lindsaea sp.	Lindsaeaceae	鱗始蕨屬	Fern	N								*																																							
Lygodium flexuosum	Lygpdiaceae	曲軸海金沙	Fern	N					**	**	*	*																																							
Lygodium japonicum	Lygpdiaceae	海金沙	Fern	N	*	*	**		***	**	*	**	**		*	*	**	**	*	*	**		**	**			*		*	*	*	**						*			*	*	*			**	**	**	**
Microlepia sp.	Dennstaedtiac	鱗蓋蕨	Fern	N	*	*	*	*			*																																							
Pityrogramma calomelanos	Hemionitidace	粉葉蕨	Fern	N	*	*		*	*	*	*	*	*				*	*	*	*																					*										
Pteris ensiformis	Pteridaceae	劍葉鳳尾蕨	Fern	N															*	*										*	*																			
Pteris semipinnata	Pteridaceae	半邊旗	Fern	N	**	**	**	**	**	**	**	*	*	*		*	*	*	*	*					*				*	*	*	*										*	*					*	*	*	**
Pteris vittata	Pteridaceae	蜈蚣草	Fern	N	*	*	**	*	***	*	**	**	***	*	*	*	***	**	**	**			*			*	*		**	*	*												*	*								
Pyrrosia lingua	Polypodiacea	石韋	Fern	N							*	*																																							
Sphenomeris chinensis	Lindsaeaceae	烏蕨	Fern	N																																															
ANGIOSPERMS																																																			
Ficus pumila	Moraceae	薜荔	Climbe	P, N																													*	*	*	*	*	*	*	*	*	*	*								
Ligustrum sinense	Oleaceae	山指甲	Shrub	P, N									**	**	**	**	*	*			**	**	**	**	*	*	*	*					*	*	*	*	*	*	*	*	*	*	*								
Pittosporum tobira	Pittosporacea	海桐花	Shrub	P, N																									*	*	*	*	*	*	*	*	*	*	*	*											*
Rhodomyrtus tomentosa	Myrtaceae	桃金娘(崗棯)	Shrub	P, N											*																																			*	*	*	*
Aporusa dioica	Euphobiaceae	銀柴	Tree	P, N			*	*													*	*	*	*	*	*	*	*							*	*	*	*	*	*			*	*			*	*	*	*
Mallotus apelta	Euphobiaceae	白背葉	Tree	P, N																																																
Rhaphiolepis indica	Rosaceae	石斑木	Tree	P, N																					*	*	*	*															*	*	*	*							
Parthenocissus dalzielii	Vitaceae	異葉爬山虎	Climbe	P, E															*	*																											*	*	*	*			
Philodendron cordatum	Araceae	葉喜樹蕉	Climbe	P, E																																													*	*	*			
Wedelia trilobata	Asteraceae	三裂葉蟛蜞菊	Climbe	P, E			*	*					*	*	***	***	***	***	***	***	***	***	***	***	**	**	**	***	*	*	*	*	***	**	***	***	*	*	*		***	***	***	***					*	*	*	***
Epipremnum aureum	Araceae	綠蘿	Herb	P, E									***	*	*																																					
Paspalum notatum	Poaceae	百喜草	Herb	P, E	*	*	*	*	**	*	*	*	***	*	*	*	**	*	**	**	***	*	**		***	*	*	*	***	*	**	*	**	*	*	*	**	*	*	*	***	*	**	*	***	*	*	*	***	*	***	**
Allamanda cathartica	Apocynaceae	軟枝黃蟬	Shrub	P, E																																															
Lantana camara	Verbenaceae	馬纓丹	Shrub	P, E	*	*	*	*			*	*	***	**	*	*					***	***	**	**					***	*	***	**										*					*	*	*	*
Lantana camara cv. Flava	Verbenaceae	黃馬纓丹	Shrub	P, E																									***	*																				
Lantana montevidensis	Verbenaceae	小葉馬纓丹	Shrub	P, E																									***	*			**	**	*	**	**	*	*	*									*	*
Lantana sp.	Verbenaceae	馬纓丹屬	Shrub	P, E																																			*	*										
Rhododendron sp.	Ericaceae	杜鵑屬	Shrub	P, E																													*	*	*	*	*	*	*	*									*	*	*	*
Cassia surattensis	Caesalpiniace	黃槐	Tree	P, E																																															
Michelia x alba	Magnoliaceae	白蘭	Tree	P, E																																															
Murraya paniculata	Rutaceae	九里香	Tree	P, E																																															
Syzygium jambos	Myrtaceae	蒲桃	Tree	P, E																																														*	*	*	*
Abrus mollis	Fabaceae	毛相思子	Climbe	N														*																																		
Asparagus cochinchinensis	Liliaceae	天門冬	Climbe	N			*	*																																											
Bauhinia gluca	Caesalpiniace	粉葉羊蹄甲	Climbe	N								*																																							
Berchemia floribunda	Rhamnaceae	多花勾兒茶	Climbe	N																																															
Byttneria aspera	Sterculiaceae	刺果藤	Climbe	N																																			*	*	*	*	*	*	*	*						
Caesalpinia crista	Caesalpiniace	華南雲實	Climbe	N				*																							*											*								*
Capparis sp.	Capparaceae	槌果藤	Climbe	N																										*																			
Cassytha filiformis	Lauraceae	無根藤	Climbe	N																																														
Cocculus orbiculatus	Menispermac	木防己	Climbe	N															*	*																														
Dabergia benthamii	Fabaceae	兩廣黃檀	Climbe	N																	*	*	*	*													*	*												
Dabergia hancei	Fabaceae	藤黃檀	Climbe	N																																														
Dendrotrophe frutenscens	Santalanceae	寄生藤	Climbe	N																																														
Dioscorea bulbofera	Dioscoreacea	黃獨	Climbe	N																																														
Eleutherococcus trifoliatus	Araliaceae	白簕	Climbe	N																																														
Embelia laeta	Myrsinaceae	酸藤子	Climbe	N																																														
Embelia ribes	Myrsinaceae	白花酸藤子	Climbe	N																																														
Gnetum luofuense	Gnetaceae	羅浮買麻藤	Climbe	N																																														
Heterosmilax japonica var.gaudichaudia	Smilacaceae	肖菝葜	Climbe	N																																														
Hiptage bengalensis	Malpighaceae	風筝果	Climbe	N																																														
Ipomoea caririca	Convolvulace	五爪金龍	Climbe	N																																														
Ipomoea obscura	Convolvulace	小心葉薯	Climbe	N																																														
Millettia reticulata	Fabaceae	雞血藤	Climbe	N			*	*						*	*									**																										
Mussaenda pubescens	Rubiaceae	玉葉金花	Climbe	N																																														
Paederia scandens	Rubiaceae	雞矢藤	climber	N							*	*						*		*																														
Psychotria serpens	Rubiaceae	蔓九節	Climbe	N																																														
Pueraria lobata	Fabaceae	野葛	Climbe	N					***	*	*	***	*	*	***	***					*	*	*	*																												
Pueraria phaseoloides	Fabaceae	三裂葉野葛	Climbe	N													***	***	*																																
Rosa laevigata	Rosaceae	金櫻子	Climbe	N																																														
Rubus leucanthus	Roaceae	白花懸鉤子	Climbe	N																																														
Rubus reflexus	Roaceae	纏毛莓	Climbe	N																									*	*																				
Smilax china	Smilacaceae	菝葜	Climbe	N																																														*
Smilax glabra	Smilacaceae	土茯苓	Climbe	N																									*	*	*	*											*	*		*				
Solena amplexicaulis	Cucurbitacea	茅瓜	Climbe	N	*	*	*	*																																										
Stephania hernandifolia	Menispermac	蕺菜薕	Climbe	N			*	*															*	*			*	*	*	*																	*	*		*
Strophanthus divaricatus	Apocynaceae	羊角拗	Climbe	N				*							*						*	*	*	*	*	*	*	*																			*	*		
Tetracera asiatica	Dilleniaceae	錫葉藤	Climbe	N																	*	*																													
Uvaria grandiflora	Annonaceae	大花紫玉盤	Climbe	N																	*	*																											*	*	*	*
Vitis flexuosa	Vitaceae	葛藟葡萄	Climbe	N																																														

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Appendix A: The Relative Abundance of the Plant Species Recorded in Each Survey

Scientific name	Family	Chinese name	Form	Slope No. Origin [2]	10SW-C_C118 1st	2nd	3rd	4th	10SW-C_C117 1st	2nd	3rd	4th	10SW-C_C116 1st	2nd	3rd	4th	10SW-C_C20 1st	2nd	3rd	4th	10SW-C_C209 1st	2nd	3rd	4th	10SW-C_FR32 1st	2nd	3rd	4th	10SW-C_C21 1st	2nd	3rd	4th	10SW-C_C193 1st	2nd	3rd	4th	10SW-C_C187 1st	2nd	3rd	4th	10SW-C_C199 1st	2nd	3rd	4th	10SW-C_C198 1st	2nd	3rd	4th	10SW-C_C165 1st	2nd	3rd	4th
PTERIDOPHYTES																																																					
Nephrolepis cordifolia	Nephrolepidac	腎蕨	Fern	P, N																											*	*	**	**																			
Nephrolepis hirsutula	Nephrolepidac	毛葉腎蕨	Fern	P, N	*	*	*	*	*	*	*	**	*	*	*	*	*	*	*	*	*	*	**	***					*	*	*	**													*	*	*	*	*	*	*	*	***	***	***	***
Adiantum capillus-veneris	Adiantaceae	鐵線蕨	Fern	N																										*	*	*	*	*	*	*	**																		
Blechnum orientale	Blechnaceae	烏毛蕨	Fern	N																		*	*						*	*	*	*	*	*	*	*					*	*	*	*			*	*			*	*
Cyclosorus parasiticus	Thelypteridac	華南毛蕨	Fern	N						*	**			*	*			*	*		*	*	**	**				*	*	*	*					*	*	*	**	*	*	*	*		**	*					
Dicranopteris pedata	Gleicheniacea	芒萁	Fern	N																									**	**	**	**	*	*	*	*							*										
Lindsaea sp.	Lindsaeaceae	鱗始蕨屬	Fern	N																									**	**	*	**	*	*	*	*															*	*		
Lygodium flexuosum	Lygpdiaceae	曲軸海金沙	Fern	N																																																
Lygodium japonicum	Lygpdiaceae	海金沙	Fern	N					*	*	*	**					*	*	*	*	*	*	**	*					*	*	*	*	*	*	*	*	**	*	*	*	*	*	*	*	**	*	**	**	*	*	*	*
Microlepia sp.	Dennstaedtiac	鱗蓋蕨	Fern	N																																															
Pityrogramma calomelanos	Hemionitidace	粉葉蕨	Fern	N																	*	*	*	*						*	*	*	*	*							*	*	*	*								
Pteris ensiformis	Pteridaceae	劍葉鳳尾蕨	Fern	N																											*								*	*	*	*								
Pteris semipinnata	Pteridaceae	半邊旗	Fern	N							*	*											*																*	*	*	*				*						
Pteris vittata	Pteridaceae	蜈蚣草	Fern	N		*	*	*	*	*	*	**			*	*	*	*	*	*	***	**	*	**	*	*	*	*	***	**	**	**	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			*	*
Pyrrosia lingua	Polypodiacea	石韋	Fern	N																																															
Sphenomeris chinensis	Lindsaeaceae	烏蕨	Fern	N																															*	*															*			
ANGIOSPERMS																																																					
Ficus pumila	Moraceae	薜荔	Climbe	P, N																													*	*	*	*	*	*	*	*														
Ligustrum sinense	Oleaceae	山指甲	Shrub	P, N																	**	**	*	*									*	*	*	*	*	*	*	*														
Pittosporum tobira	Pittosporacea	海桐花	Shrub	P, N																					*	*							*	*	*	**																
Rhodomyrtus tomentosa	Myrtaceae	桃金娘(崗棯)	Shrub	P, N			*	*													*	*	*	*					*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			*	*
Aporusa dioica	Euphobiaceae	銀柴	Tree	P, N					*	*		*	*	*	*	*			*	*									*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	***	***	***	***
Mallotus apelta	Euphobiaceae	白背葉	Tree	P, N	**	*			*	*	*	*									*	*	*	*	*	*	*	*					*	*																				
Rhaphiolepis indica	Rosaceae	石斑木	Tree	P, N						*	*				*	*		*	*	*		*	*	*					*	*	*	*		*	*	*	*	*	*	*									*		*	*
Parthenocissus dalzielii	Vitaceae	異葉爬山虎	Climbe	P, E																									*	*	*	*					***	***	***	***														
Philodendron cordatum	Araceae	葉喜樹蕉	Climbe	P, E																																																	
Wedelia trilobata	Asteraceae	三裂葉蟛蜞菊	Climbe	P, E	***	***	***	***	***	**	***	***	*	*	*	*	*	*	***	***									***	**	***	***					***	***	***	***	***	***	***	***			***	***	*	*	***	***
Epipremnum aureum	Araceae	綠蘿	Herb	P, E																																																
Paspalum notatum	Poaceae	百喜草	Herb	P, E	***	**	*	*	***	**	***	**	***	**	**	**	***	**	**	**	***	**	**	**	***	**	**	**	*	*	*	*	*	*	*	*	**	*	*	*	***	**	***	**	***	**	**	**	***	**	***	***
Allamanda cathartica	Apocynaceae	軟枝黃蟬	Shrub	P, E					*	*	*	*					*	*		*	*	*	*	*																												
Lantana camara	Verbenaceae	馬纓丹	Shrub	P, E	*	*	*				*	*													*	*	**	**	*	*	*	*															*	*		*	*	*	*	*
Lantana camara cv. Flava	Verbenaceae	黃馬纓丹	Shrub	P, E				*				*																																								
Lantana montevidensis	Verbenaceae	小葉馬纓丹	Shrub	P, E			*	*			*				*	*			*	*																									*	*	*	*	*	*	*	*	*	*	**	*
Lantana sp.	Verbenaceae	馬纓丹屬	Shrub	P, E																																																	
Rhododendron sp.	Ericaceae	杜鵑屬	Shrub	P, E																																																	
Cassia surattensis	Caesalpiniace	黃槐	Tree	P, E																																																	
Michelia x alba	Magnoliaceae	白蘭	Tree	P, E																																																	
Murraya paniculata	Rutaceae	九里香	Tree	P, E																	*	*	*	*					*	*	*	*													**	**	**	**								
Syzygium jambos	Myrtaceae	蒲桃	Tree	P, E					*	*	*	*			*	*	*	*	*	*																													*	*	*	*				
Abrus mollis	Fabaceae	毛相思子	Climbe	N																																	*	*	*	*														
Asparagus cochinchinensis	Liliaceae	天門冬	Climbe	N																																	*																	
Bauhinia gluca	Caesalpiniace	粉葉羊蹄甲	Climbe	N																																																	
Berchemia floribunda	Rhamnaceae	多花勾兒茶	Climbe	N																																																	
Byttneria aspera	Sterculiaceae	刺果藤	Climbe	N																																																
Caesalpinia crista	Caesalpiniace	華南雲實	Climbe	N																	*	*	*	*																									*	*		*				*
Capparis sp.	Capparaceae	槍果藤	Climbe	N																																																	
Cassytha filiformis	Lauraceae	無根藤	Climbe	N																																																
Cocculus orbiculatus	Menispermac	木防己	Climbe	N																																															
Dabergia bentharnii	Fabaceae	兩廣黃檀	Climbe	N																																																
Dabergia hancei	Fabaceae	藤黃檀	Climbe	N																																																
Dendrotrophe frutenscens	Santalanceae	寄生藤	Climbe	N																																																
Dioscorea bulbofera	Dioscoreacea	黃獨	Climbe	N																																																
Eleutherococcus trifoliatus	Araliaceae	白簕	Climbe	N																																																
Embelia laeta	Myrsinaceae	酸藤子	Climbe	N													*	*																																		
Embelia ribes	Myrsinaceae	白花酸藤子	Climbe	N	*	*																															*	*	*	*												
Gnetum luofuense	Gnetaceae	羅浮買麻藤	Climbe	N																		*											*		*																
Heterosmilax japonica var.gaudichaudia	Smilacaceae	肖菝葜	Climbe	N																																															
Hiptage bengalensis	Malpighaicea	風筝果	Climbe	N																																															
Ipomoea caririca	Convolvulace	五爪金龍	Climbe	N																																															
Ipomoea obscura	Convolvulace	小心葉薯	Climbe	N																																															
Millettia reticulata	Fabaceae	雞血藤	Climbe	N																																															
Mussaenda pubescens	Rubiaceae	玉葉金花	Climbe	N																																															
Paederia scandens	Rubiaceae	雞矢藤	climber	N																																															
Psychotria serpens	Rubiaceae	蔓九節	Climbe	N																																															
Pueraria lobata	Fabaceae	野葛	Climbe	N	*	*	*	*			*	*						**	**							***	*	*	***																				*	*		
Pueraria phaseoloides	Fabaceae	三裂葉野葛	Climbe	N																**																																	
Rosa laevigata	Rosaceae	金櫻子	Climbe	N																																															
Rubus leucanthus	Roaceae	白花懸鉤子	Climbe	N																		*																														
Rubus reflexus	Roaceae	纏毛莓	Climbe	N																									*	*		*	*	*			*																
Smilax china	Smilacaceae	菝葜	Climbe	N																													*	*															*	*		
Smilax glabra	Smilacaceae	土茯苓	Climbe	N									*	*	*		*		*										*	*	*	*	*	*	*													*	*	*	*	*	*
Solena amplexicaulis	Cucurbitacea	茅瓜	Climbe	N						*																																											
Stephania hernandifolia	Menispermac	蔓茘藤	Climbe	N																	*	*							*	*		*	*	*		*													*	*	*	*		
Strophanthus divaricatus	Apocynaceae	羊角拗	Climbe	N																		*										*	*			*	*													*	*	*	*	*	*
Tetracera asiatica	Dilleniaceae	錫葉藤	Climbe	N										*	*																	*				*	*														*	*		
Uvaria grandiflora	Annonaceae	大花紫玉盤	Climbe	N																												*	*					*	*												
Vitis flexuosa	Vitaceae	葛藟葡萄	Climbe	N																																																

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Appendix A: The Relative Abundance of the Plant Species Recorded in Each Survey

Scientific name	Family	Chinese name	Slope No. Form	Origin [2]	Abundance [1] 10SW-C_C1 1st	2nd	3rd	4th	10SW-C_C2 1st	2nd	3rd	4th	10SW-C_FR70 1st	2nd	3rd	4th	10SW-C_C64 1st	2nd	3rd	4th	10SW-C_C67 1st	2nd	3rd	4th	10SW-C_C68 1st	2nd	3rd	4th	10SW-C_C12 1st	2nd	3rd	4th	10SW-C_C104 1st	2nd	3rd	4th	10SW-C_C125 1st	2nd	3rd	4th	10SW-C_C45 1st	2nd	3rd	4th	10SW-C_FR11 1st	2nd	3rd	4th	10SW-C_C119 1st	2nd	3rd	4th
Abrus cantoniensis	Fabaceae	雞骨草	Herb	N																																																
Alocasia odora	Araceae	海芋	Herb	N			*	*	*	*	*	*							*	*					*	*	*	*																*	*	*						
Aplinia sp.	Zingiberaceae	山薑屬	Herb	N																																								*	*	*	*					
Artemisia indica	Asteraceae	五月艾	Herb	N		*	*	**			*	*			*	*			*	*			*	*			*	*	*	*	*	*	*	*	*	*					*	*	*	*			*		
Blumea lacera	Asteraceae	見霜黃	Herb	N																																															
Centotheca lappacea	Poaceae	假淡竹葉	Herb	N																																															
Crassocephalum crepidioides	Asteraceae	野茼蒿	Herb	N																																								*								
Cynodon dactylon	Poaceae	狗牙根	Herb	N																																															
Desmodium candatum	Fabaceae	山螞蝗	Herb	N									*	*	*	*																																			
Desmodium heterocarpon	Fabaceae	假地豆	Herb	N												*					**	*	*	*																											
Dianella ensifolia	Liliaceae	山菅蘭	Herb	N					*	*																																										
Dicranopteris pedata	Gleicheniacea	芒萁	Herb	N																																															
Emilia sonchifolia	Asteraceae	一點紅	Herb	N	*	*	*	*	*	*	*	*				*		*	*	*	*	*	*	*			*	*	**	*		*				*	*	*	*	*	*	*	*			*		
Hedyotis acutangula	Rubiaceae	金草	Herb	N												*																																			
Imperata koenigii	Poaceae	絲茅(白茅)	Herb	N			*	*				*				*				*									*							*														
Inula cappa	Asteraceae	羊耳菊	Herb	N																																														
Ischaemum barbatum	Poaceae	粗毛鴨嘴草	Herb	N																																	*	*							*	*	*	*					
Ischaemum sp.	Poaceae	鴨嘴草	Herb	N			*	*																																											
Ixeris japonica	Asteraceae	剪刀股	Herb	N																									*	*																					
Lophatherum gracile	Poaceae	淡竹葉	Herb	N				*	*	*						*							*	*																				***	***	*	***	***	**	*	*	*
Mariscus umbellatus	Cyperaceae	磯子苗	Herb	N																	*	*	*						*	*	*	*			*	*			*	*							*	*		
Miscanthus floridulud	Poaceae	五節芒	Herb	N					*	*	*	*	**	*	**	**		**	*	*			*	*			*			*	*	*	*			**			*	*						*	*		*	*
Miscanthus sinensis	Poaceae	芒	Herb	N																																														
Oxalis sp.	Oxalidaceae	酢漿草	Herb	N			*	*																	*	*			*																			*	*	***	*
Palhinhaea cernua	Lycopodiacea	鋪地蜈蚣	Herb	N																																														
Piper sarmentosum	Piperaceae	假蒟	Herb	N																																														
Pogonatherum crinitum	Poaceae	金絲草	Herb	N																																														
Scleria ciliaris	Cyperaceae	緣毛珍珠茅	Herb	N																																															
Sonchus arvensis	Asteraceae	苣買菜	Herb	N	*	*	*	*	*	*	*		*	*	*				*			*			*	*					**	*				*										*	*		*
Uraria crinita	Fabaceae	貓尾草	Herb	N									*	*		*	**	*					*	*					*	*	*																*	*		
Urena lobata	Malvaceae	肖梵天花	Herb	N									*	*		*				*																													*	*		
Acanthus ilicifolius	Acanthaceae	老鼠簕	Shrub	N			*																																												
Adina pilulifera	Rubiaceae	水團花	Shrub	N																																														
Antirhea chinensis	Rubiaceae	毛茶	Shrub	N																																														
Aralia decaisneana	Araliaceae	黃毛楤木	Shrub	N					*	*	*	*							*	*																											*				
Ardisia crenata	Myrsinaceae	朱砂根(大羅傘)	Shrub	N																																														
Baeckea frutescens	Myrtaceae	崗松	Shrub	N																																														
Breynia fruticosa	Euphobiaceae	黑面神	Shrub	N	*	*	*	*															*	*																									*	*	*	*
Brucean javanica	Smaroubacea	鴉膽子	Shrub	N																	*	*	*	*																											
Callicarpa formosana	Verbenaceae	杜虹花	Shrub	N																																														
Callicarpa kochiana	Verbenaceae	枇杷葉紫珠	Shrub	N																*																															
Clerodendrum canescens	Verbebacae	灰毛大青	Shrub	N																																														
Clerodendrum fortunatum	Verbebacae	白花燈籠	Shrub	N																			*						*	*	*	*															*				
Daphniphyllum oldhamii	Daphniphyllur	虎皮楠	Shrub	N																																														
Desmos chinensis	Annonaceae	假鷹爪	Shrub	N																			*																									*	*		*
Dichroa febrifuga	Hydrangeacea	常山	Shrub	N																	*	*																													
Diospyros vaccinioides	Ebenaceae	小果柿	Shrub	N				*													*	*																													
Eurya nitida	Theaceae	細齒葉柃	Shrub	N																						*																								
Ficus hirta	Moraceae	粗葉榕	Shrub	N	*	*	*	*			*	*					*	*	*				*	*													*	*	*	*									*
Ficus variolosa	Moraceae	變葉榕	Shrub	N																																														
Gardenia jasminoides	Rubiaceae	梔子	Shrub	N																																														
Glochidion eriocarpum	Euphorbiacea	毛果算盤子	Shrub	N																																														
Glochidion zeylanicum	Euphorbiacea	香港算盤子	Shrub	N																																														
Helicteres angustifolia	Sterculiaceae	山芝麻	Shrub	N					*	*																																								
Ilex asprella	Aquifoliaceae	梅葉冬青	Shrub	N			*	*															*	*																									*	*		*
Ilex pubescens	Aquifoliaceae	毛冬青	Shrub	N																																														
Litsea rotundifolia	Lauraceae	豺皮樟	Shrub	N																											*	*																	*
Maesa perlarius	Myrsinaceae	鯽魚膽	Shrub	N																																														
Melastoma candidum	Melastomatac	野牡丹	Shrub	N									*	*	*	*					**	*	**	**	*	*	*	*																					
Melastoma sanguineum	Melastomatac	毛稔	Shrub	N		*	*	*																																										
Melicope pteleifolia	Rutaceae	三極苦	Shrub	N																																														
Phyllanthus cochinchinensis	Euphobiaceae	越南葉下珠	Shrub	N	*	*	**	**	*	*	*	*									*	*			*	*	*	*																			*	*		
Psychotria asiatica	Rubiaceae	九節	Shrub	N			*	*													*	*	*	*	*	*	*	*																				*	*
Tadehagi triquetrum	Fabaceae	葫蘆茶	Shrub	N					*	*		*									*	*	*	*																										*	
Vitex negundo var. *cannabifolia*	Verbenaceae	牡荊	Shrub	N																																														
Wikstroemia indica	Thymelaeacei	了哥王	Shrub	N																																													
Zanthoxylum nitidum	Rutaceae	兩面針	Shrub	N																																													*	*		*
Acronychia pedunculata	Rutaceae	山油柑(降真香)	Tree	N																																														
Adinandra millettii	Theaceae	黃瑞木	Tree	N																																														
Alangium chinense	Alangiaceae	八角楓	Tree	N			*	*													*	*	*	*	*	*	*	*																	*	*	**	*	*	*	*
Antidesma bunius	Euphobiaceae	五月茶(五味子)	Tree	N																																													*			*
Aquilaria sinensis	Thymelaeacei	土沉香	Tree	N																																															
Archidendron lucidum	Mimosaceae	亮葉猴耳環	Tree	N																			*	*	*	*																								*	*
Bischofia javanica	Euphorbiacea	秋楓	Tree	N																																														
Bombax ceiba	Bombacaceae	木棉	Tree	N																	*	*	*	*																										
Bridelia tomentosa	Euphobiaceae	土蜜樹	Tree	N	*	*	*	*	*	*	*	*	**	**	*	*	**	**	*	*	**	**	*	*																									*	*		
Celtis sinensis	Ulmaceae	朴樹	Tree	N	*	*	*	*					*	*	*	*	*	*	*	*			*	*																											
Cerbera manghas	Apocynaceae	海芒果	Tree	N	*	*	*	*	*	*	*	*																																							
Choerospondias axillaris	Anacardiacea	南酸棗	Tree	N																																														*
Cinnamomum camphora	Lauraceae	樟	Tree	N																																														
Cinnamomum parthenoxylon	Lauraceae	黃樟	Tree	N																	*	*	*	*																									*	*		*
Cratoxylum cochinchinense	Clusiaceae	黃牛木	Tree	N				*													**	**	**	**			*	*	*	*	*	*					*	*	*	*		*	*	*						

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Appendix A: The Relative Abundance of the Plant Species Recorded in Each Survey

Scientific name	Family	Chinese name	Slope No. Form	Origin [2]	10SW-C_C118 1st	2nd	3rd	4th	10SW-C_C117 1st	2nd	3rd	4th	10SW-C_C116 1st	2nd	3rd	4th	10SW-C_C20 1st	2nd	3rd	4th	10SW-C_C209 1st	2nd	3rd	4th	10SW-C_FR32 1st	2nd	3rd	4th	10SW-C_C21 1st	2nd	3rd	4th	10SW-C_C193 1st	2nd	3rd	4th	10SW-C_C187 1st	2nd	3rd	4th	10SW-C_C199 1st	2nd	3rd	4th	10SW-C_C198 1st	2nd	3rd	4th	10SW-C_C165 1st	2nd	3rd	4th
Abrus cantoniensis	Fabaceae	雞骨草	Herb	N							*	*																																						
Alocasia odora	Araceae	海芋	Herb	N					*	*																																							
Aplinia sp.	Zingiberaceae	山薑屬	Herb	N																																													
Artemisia indica	Asteraceae	五月艾	Herb	N	*	*							*	*	*	*					*	*		*	*	*	*	*					*	*		*	*	*	*	*					*	*	*	**	*	*		*
Blumea lacera	Asteraceae	見霜黃	Herb	N																	*	*			*	*	*	*	*	*	*		*	*			*	*		*					*	*						
Centotheca lappacea	Poaceae	假淡竹葉	Herb	N																																	*	*	*	*												
Crassocephalum crepidioides	Asteraceae	野茼蒿	Herb	N							*							*					*	*					*													*	*								
Cynodon dactylon	Poaceae	狗牙根	Herb	N																																														
Desmodium candatum	Fabaceae	山螞蝗	Herb	N																																													
Desmodium heterocarpon	Fabaceae	假地豆	Herb	N																							*	*								*		*												
Dianella ensifolia	Liliaceae	山菅蘭	Herb	N																		*												*	*														
Dicranopteris pedata	Gleicheniacea	芒萁	Herb	N																																													
Emilia sonchifolia	Asteraceae	一點紅	Herb	N	*	*	*				*	*			*		*	*	*	*	*	*		*	*	*			*	*	*	*			*	*	*	*	*	*	*	*	*	*	*	*			*	
Hedyotis acutangula	Rubiaceae	金草	Herb	N																									*	*		*			*	*														
Imperata koenigii	Poaceae	絲茅(白茅)	Herb	N								*					*	*	*	*	*	*	*	*					*	*	*	*	*	*	*	*	*	*	*	*					*	*	*	*	*	*
Inula cappa	Asteraceae	羊耳菊	Herb	N																																	*	*	*	*								*				*
Ischaemum barbatum	Poaceae	粗毛鴨嘴草	Herb	N																																														
Ischaemum sp.	Poaceae	鴨嘴草	Herb	N																																													
Ixeris japonica	Asteraceae	剪刀股	Herb	N																									*	*		*	*	*		*	*	*												
Lophatherum gracile	Poaceae	淡竹葉	Herb	N				**			*	*	*	*	*	*											*	*	*	*	*						*	*	*	*											
Mariscus umbellatus	Cyperaceae	磚子苗	Herb	N									*	*							*										*						*	*		*											
Miscanthus floridulud	Poaceae	五節芒	Herb	N	*	*	*	*	*	*	*	*	*	*	*	*							*	*	*	*	*	*	*	*	**	*	*	*	*	*	*	*											
Miscanthus sinensis	Poaceae	芒	Herb	N																																														
Oxalis sp.	Oxalidaceae	酢漿草	Herb	N																																			*	*											
Palhinhaea cernua	Lycopodiacea	鋪地蜈蚣	Herb	N																									*			*																		
Piper sarmentosum	Piperaceae	假蒟	Herb	N																																	*	*	*	*					*	*					
Pogonatherum crinitum	Poaceae	金絲草	Herb	N																									*	*	*	**	*	*	*	*												*			
Scleria ciliaris	Cyperaceae	緣毛珍珠茅	Herb	N																																	*	*	*	*											
Sonchus arvensis	Asteraceae	苦買菜	Herb	N							*	*			*							*							*	*	*	*					*	*	*	*	*	*	*	*			*				
Uraria crinita	Fabaceae	猫尾草	Herb	N																																														
Urena lobata	Malvaceae	肖梵天花	Herb	N																	*	*	*	*			*	*	*	*	*	*																		
Acanthus ilicifolius	Acanthaceae	老鼠簕	Shrub	N																																														
Adina pilulifera	Rubiaceae	水團花	Shrub	N																																			*	*											
Antirhea chinensis	Rubiaceae	毛茶	Shrub	N																											*																			
Aralia decaisneana	Araliaceae	黃毛楤木	Shrub	N							*				*																																		
Ardisia crenata	Myrsinaceae	朱砂根(大羅傘)	Shrub	N																																			*	*											
Baeckea frutescens	Myrtaceae	崗松	Shrub	N																											*	*		*																
Breynia fruticosa	Euphobiaceae	黑面神	Shrub	N																	*	*	*	*					*	*	*	*		*	*	*	*	*	*	*					*	*		*	*	*
Brucean javanica	Smaroubacea	鴉膽子	Shrub	N																																														
Callicarpa formosana	Verbenaceae	杜虹花	Shrub	N																											*	*																		
Callicarpa kochiana	Verbenaceae	枇杷葉紫株	Shrub	N																																														
Clerodendrum canescens	Verbebacae	灰毛大青	Shrub	N																														*	*														
Clerodendrum fortunatum	Verbebacae	白花燈籠	Shrub	N																																													
Daphniphyllum oldhamii	Daphniphyllur	虎皮楠	Shrub	N																																													
Desmos chinensis	Annonaceae	假鷹爪	Shrub	N																																												
Dichroa febrifuga	Hydrangeacea	常山	Shrub	N																																												
Diospyros vaccinioides	Ebenaceae	小果柿	Shrub	N																	*	*		*																									
Eurya nitida	Theaceae	細齒葉柃	Shrub	N																											*	*		*															
Ficus hirta	Moraceae	粗葉榕	Shrub	N											*			*	*										*	*	*	*		*	*														
Ficus variolosa	Moraceae	變葉榕	Shrub	N																											*			*	*														
Gardenia jasminoides	Rubiaceae	梔子	Shrub	N																														*	*														
Glochidion eriocarpum	Euphorbiacea	毛果算盤子	Shrub	N											*														*	*	*	*		*	*														
Glochidion zeylanicum	Euphorbiacea	香港算盤子	Shrub	N																																														
Helicteres angustifolia	Sterculiaceae	山芝麻	Shrub	N																																													
Ilex asprella	Aquifoliaceae	梅葉冬青	Shrub	N					*	*	*	*																	*	*	*	*	*	*	*	*	*	*	*	*					*	*	*	*	*	*
Ilex pubescens	Aquifoliaceae	毛冬青	Shrub	N																																														
Litsea rotundifolia	Lauraceae	豺皮樟	Shrub	N											*	*					*								*	*	*						*	*	*	*											
Maesa perlarius	Myrsinaceae	鯽魚膽	Shrub	N																									*	*		*					*	*	*	*											
Melastoma candidum	Melastomatac	野牡丹	Shrub	N											*			*	*	*	*								*	*	*	*	*	*	**	**							*	*	*	*	*				
Melastoma sanguineum	Melastomatac	毛稔	Shrub	N											*														*	*	*	*	**	**	**	**	*	*	*	*			*		*	*	*	*	*	*	*
Melicope pteleifolia	Rutaceae	三桠苦	Shrub	N																															*	*			*											
Phyllanthus cochinchinensis	Euphobiacea	越南葉下珠	Shrub	N																																*			*											
Psychotria asiatica	Rubiaceae	九節	Shrub	N									*		*			*	*										*	*							*	*	*	*									*	*
Tadehagi triquetrum	Fabaceae	葫蘆茶	Shrub	N	*		*	*													*	*	*	*				*				*					*	*	*	*	*	*	*	*		**	*	*	*	*	*
Vitex negundo var. *cannabifolia*	Verbenaceae	牡荊	Shrub	N																									*	*																		*	*				
Wikstroemia indica	Thymelaeacea	了哥王	Shrub	N																									*	*		*	*	*	*	*	**	**	**	**											
Zanthoxylum nitidum	Rutaceae	兩面針	Shrub	N									*	*		*											*	*																				*	*			
Acronychia pedunculata	Rutaceae	山油柑(降真香)	Tree	N																																														*	*	*	*
Adinandra millettii	Theaceae	黃瑞木	Tree	N					*	*							*																																		
Alangium chinense	Alangiaceae	八角楓	Tree	N																					*	*	*	*	*	*							*	*	*	*									*	*	**	*
Antidesma bunius	Euphobiacea	五月茶(五味子)	Tree	N																																													*	*	*	*
Aquilaria sinensis	Thymelaeacea	土沉香	Tree	N					*	*					*	*															*	*															*	*	*	*
Archidendron lucidum	Mimosaceae	亮葉猴耳環	Tree	N																																														
Bischofia javanica	Euphorbiacea	秋楓	Tree	N																																													
Bombax ceiba	Bombacaceae	木棉	Tree	N																																													
Bridelia tomentosa	Euphobiacea	土蜜樹	Tree	N																											*	*																		
Celtis sinensis	Ulmaceae	朴樹	Tree	N					*	*	*	*			*	*			*	*			*	*	*	*								*	*														
Cerbera manghas	Apocynaceae	海芒果	Tree	N																																	*	*	*	*											
Choerospondias axillaris	Anacardiacea	南酸棗	Tree	N																																													
Cinnamomum camphora	Lauraceae	樟	Tree	N																							*	*	**	**																		
Cinnamomum parthenoxylon	Lauraceae	黃樟	Tree	N	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*							*	*	*	*	*	*	*	*					*	*	*	*								
Cratoxylum cochinchinense	Clusiaceae	黃牛木	Tree	N																	*	*	*	*					*	*	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	**	**

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Appendix A: The Relative Abundance of the Plant Species Recorded in Each Survey

Scientific name	Family	Chinese name	Slope No. Form	Origin [2]	Abundance [1] 10SW-C_C1 1st	2nd	3rd	4th	10SW-C_C2 1st	2nd	3rd	4th	10SW-C_FR70 1st	2nd	3rd	4th	10SW-C_C64 1st	2nd	3rd	4th	10SW-C_C67 1st	2nd	3rd	4th	10SW-C_C68 1st	2nd	3rd	4th	10SW-C_C12 1st	2nd	3rd	4th	10SW-C_C104 1st	2nd	3rd	4th	10SW-C_C125 1st	2nd	3rd	4th	10SW-C_C45 1st	2nd	3rd	4th	10SW-C_FR11 1st	2nd	3rd	4th	10SW-C_C119 1st	2nd	3rd	4th
Ficus esquiroliana	Moraceae	黃毛榕	Tree	N																																															
Ficus hispida	Moraceae	對葉榕	Tree	N	*	**	*	*	*	*	*	**					*	*	*								*	*			*	*																		
Ficus microcarpa	Moraceae	細葉榕	Tree	N	*	*	*	*	*	*	*	*																																							
Ficus superba var. *japonica*	Moraceae	筆管榕	Tree	N	*	*	*	*																																										
Ficus variegata	Moraceae	青果榕	Tree	N	*	*	**	**	*	*	*	**								*				*				*	*	*	*																	*	*	
Garcinia oblongifolia	Glusiaceae	嶺南山竹子	Tree	N																																														
Gleditsia australis	Caesalpiniace	小果皂莢	Tree	N																									*																					
Gmelina chinensis	Verbebaceae	石梓	Tree	N	*	*	*	*	*	*	*	*									*	*	*	*											*	*			*	*									
Homalium cochinchinensis	Flacourtiacea	天料木	Tree	N																																													
Itea chinensis	Grossulariace	老鼠刺	Tree	N																																													
Litsea glutinosa	Lauraceae	潺槁樹	Tree	N				*	*	*	*	*											*	*					**	*	*	*	*	*	*	*	*	*	*	*				*			*	*
Macaranga tanarius	Euphobiaceae	血桐	Tree	N	*	*	*	*	**	**	*	*			*					*	*	*	*	*							*	*	*	*	*	*	*	*							**	*	*	*
Machilus chekiangensis	Lauraceae	浙江潤楠	Tree	N																																												*	*	*	*
Mallotus paniculatus	Euphobiaceae	白楸	Tree	N	*	*	*	*	**	**	**	**					*	*	*	*	***	**	**	**	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Melia azedarach	Meliaceae	楝	Tree	N																																													
Microcos paniculata	Tiliaceae	破布葉	Tree	N			*	*					*	*					*		*	*	*	*	*	*	*	*	*	*	*	*			*	*							*	*	*	*	*	*	**	**
Pavetta hongkongensis	Rubiaceae	香港大沙葉	Tree	N																																													
Phyllanthus emblica	Euohobiaceae	油甘子	Tree	N			*	*																																									
Pinus massoniana	Pinaceae	馬尾松	Tree	N																																													
Rhus chinensis	Anacardiacea	鹽膚木	Tree	N																																	*							*	*				
Rhus hypoleuca	Anacardiacea	白背漆	Tree	N																						*	*																						
Rhus succedanea	Anacardiacea	木蠟樹(野漆)	Tree	N																	*	*	*	*					*	*	*	*	*	*	*	*							*	*	*	*				
Sapindus saponaria	Sapindaceae	無患子	Tree	N																																													
Sapium discolor	Euphobiaceae	山烏桕	Tree	N															*	*				*									*	*									*	*	*	*			*	*
Sapium sebiferum	Euphobiaceae	烏桕	Tree	N																																													
Saurauia tristyla	Actinidiaceae	水冬哥	Tree	N																																													
Schefflera heptaphylla	Araliaceae	鵝掌柴	Tree	N																																												*	*	*	*
Scolopia chinensis	Flacourtiacea	刺柊	Tree	N					*	*	*	*													*	*	*																							
Sterculia lanceolata	Sterculiaceae	假蘋婆	Tree	N				*	*	*	*	*									*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	**	*	*	*		*	*		*	*	*	*	*	*
Tetradium glabrifolium	Rutaceae	楝葉吳萸蒴	Tree	N																																													
Trema tomentosa	Ulmaceae	山黃麻	Tree	N			*	*					*	*	*	*			*	*	**	**	*	*				*		*	*	*	*	*	*	*	*	*	***	***	**	*						*
Zanthoxylum avicennae	Rutaceae	簕欓	Tree	N			*	*													*	*		*			*	*			*	*															*	*		*
Macroptilium atropurpureum	Fabaceae	紫花大翼豆	Climbe	E																																													
Passiflora foetida	Passifloracea	龍珠果	Climbe	E							*	*	***	*	*	*																																
Ageratum conyzoides	Asteraceae	藿香薊	Herb	E	**	*	**	*			*	*	***	*	*	*	*	*	*				*		*	*			*	*	**	*	**	*	**	*			*			*	*	*	***			*	
Bidens alba	Asteraceae	白花鬼針草	Herb	E	*	*	*	*					**	*	*							*							*	*	*	**			*	**			*				*	*			*	*		*
Eupatorium odoratum	Asteraceae	飛機草	Herb	E															*																				*							*					
Euphorbia sp.	Euphorbiacea	飛揚草	Herb	E			*	*			*	*				*																														*				
Gynura bicolor	Asteraceae	風鳳菜	Herb	E							*																																				*	*	*		*
Mikania micrantha	Asteraceae	薇甘菊	Herb	E	**	*	***	***	***	**	***	***	***	*	***	***	*	*	**	*	*	*	*	*		*	*	*	*	*	**	**	*	*	**	**	*	*	*	*	*	*	*	*	***	*	***	***	**	*	*	***
Mimosa pudica	Mimosaceae	含羞草	Herb	E													*	*																													*	*		*	
Panicum maximum	Poaceae	大黍	Herb	E																																													
Pilea microphylla	Urticaceae	小葉冷水花	Herb	E	*	*	*	*																																									
Rhynchelytrum repens	Poaceae	紅毛草	Herb	E																																												
Thysanolaena agrostis	Poaceae	粽葉薗	Herb	E																																												
Boehmeria nivea	Urticaceae	苧麻	Shrub	E											*	*																													**	**	*	*	*	*	*	*
Catharanthus roseus	Apocynaceae	長春花	Shrub	E																																													
Acacia auriculiformis	Mimosaceae	耳果相思	Tree	E																																												
Acacia confusa	Mimosaceae	臺灣相思	Tree	E	*	*	*	*									*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			*				*					*	*	*	*	*	*	*	*
Bauhinia sp.	Caesalpiniace	羊蹄甲屬	Tree	E																																													
Casuarina equisetifolia	Casuarinacea	木麻黃	Tree	E		*	*	*																																								
Delonix regia	Caesalpiniace	鳳凰木	Tree	E																																												
Dimocarpus longan	Sapindaceae	龍眼	Tree	E																																												
Leucaena leucocephala	Mimosaceae	銀合歡	Tree	E																																												
Lophostemen confertus	Myrtaceae	紅膠木	Tree	E																																												
Vernicia montana	Euphobiaceae	木油桐	Tree	E																																												

Notes:

[1] Abundance: * = present; ** = common; *** = very common

[2] Origin: N = native; E = exotic; P = planted (otherwise naturally occurring)

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Appendix A: The Relative Abundance of the Plant Species Recorded in Each Survey

Scientific name	Family	Chinese name	Slope No. Form	Origin [2]	10SW-C_C118 1st	2nd	3rd	4th	10SW-C_C117 1st	2nd	3rd	4th	10SW-C_C116 1st	2nd	3rd	4th	10SW-C_C20 1st	2nd	3rd	4th	10SW-C_C209 1st	2nd	3rd	4th	10SW-C_FR32 1st	2nd	3rd	4th	10SW-C_C21 1st	2nd	3rd	4th	10SW-C_C193 1st	2nd	3rd	4th	10SW-C_C187 1st	2nd	3rd	4th	10SW-C_C199 1st	2nd	3rd	4th	10SW-C_C198 1st	2nd	3rd	4th	10SW-C_C165 1st	2nd	3rd	4th
Ficus esquiroliana	Moraceae	黃毛榕	Tree	N																																															
Ficus hispida	Moraceae	對葉榕	Tree	N	*	*	*	*			*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				*									*	*	*	*				
Ficus microcarpa	Moraceae	細葉榕	Tree	N																																													*	*
Ficus superba var. *japonica*	Moraceae	筆管榕	Tree	N																									*	*	*	*	*	*		*															
Ficus variegata	Moraceae	青果榕	Tree	N																	*	*	*	*					*	*	*	*	*	*	*	*	*	*	*	*										
Garcinia oblongifolia	Glusiaceae	嶺南山竹子	Tree	N																													*	*		*															
Gleditsia australis	Caesalpiniace	小果皂莢	Tree	N																																														
Gmelins chinensis	Verbebaceae	石梓	Tree	N								*																							*											*	*	*	*
Homalium cochinchinensis	Flacourtiacea	天料木	Tree	N																																												*	*		
Itea chinensis	Grossulariace	老鼠刺	Tree	N																																		*												
Litsea glutinosa	Lauraceae	潺槁樹	Tree	N	*	*	*	*	*	*		*											*	*					*	*	*	*	*	*			*	*							*	*	**	*	*	*	**	**
Macaranga tanarius	Euphobiaceae	血桐	Tree	N					*	*		*							*	*									*	*															*	*	*	*				*
Machilus chekiangensis	Lauraceae	浙江潤楠	Tree	N			*	*	*	*	*	*						*	*	*																*	*	*	*							*	*	*	*				
Mallotus paniculatus	Euphobiaceae	白楸	Tree	N	*	*	*	*	*	*	*	*	**	**	**	*	*	*	**	**	*	*	*	*							*	*			*	*	*	**	*	*	*	*	*	*	*	*	*	*	**	**
Melia azedarach	Meliaceae	楝	Tree	N																																												*	*		
Microcos paniculata	Tiliaceae	破布葉	Tree	N																										*							*	*	*	*			*	*	*	*	*	*	**	**
Pavetta hongkongensis	Rubiaceae	香港大沙葉	Tree	N																									*	*		*																			
Phyllanthus emblica	Euohobiaceae	油甘子	Tree	N																									*	*	*	*	*	*	*	*			*	*			*	*	*	*	*	*	*	*
Pinus massoniana	Pinaceae	馬尾松	Tree	N					*	*	*	*		*	*	*	*	*	*	*																	*	*												
Rhus chinensis	Anacardiacea	鹽膚木	Tree	N																																*	*	**	**												
Rhus hypoleuca	Anacardiacea	白背漆	Tree	N																											*	*																		
Rhus succedanea	Anacardiacea	木蠟樹(野漆)	Tree	N	*	*	*	*									*	*	*	*									***	***	*	**	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*
Sapindus saponaria	Sapindaceae	無患子	Tree	N																																												*	*	*	*
Sapium discolor	Euphobiaceae	山烏桕	Tree	N					*	*	*	*							*	*	*	*	*	*							*	*	*	*														*	*
Sapium sebiferum	Euphobiaceae	烏桕	Tree	N	*	*			**	*	*	*			*	*																			*	*														
Saurauia tristyla	Actinidiaceae	水冬哥	Tree	N																											*																		
Schefflera heptaphylla	Araliaceae	鵝掌柴	Tree	N							*	*																	*	*	*	*	*	*	*	*			*	*								*	*	*	*
Scolopia chinensis	Flacourtiacea	刺柊	Tree	N																											*	*																		
Sterculia lanceolata	Sterculiaceae	假蘋婆	Tree	N					*	*	*	*			*	*				*			*	*					*	*	*	*	*	*	*	*	*	*	*	*					*	*	**	*	*	*	**	**
Tetradium glabrifolium	Rutaceae	楝葉吳茱萸	Tree	N																											*																		
Trema tomentosa	Ulmaceae	山黃麻	Tree	N			*				**		*	*	*	*	*	*	**	*	*	*	*				*	*	*	*	*	*	*	*	*	*	*	*	**	*	*	*	*			*	*	*	*	*	*
Zanthoxylum avicennae	Rutaceae	簕欓	Tree	N					*	*	*	*			*	*			*	**	*	*	*	*			*	*	*	*	*	*			*	*	*	*					*	*	*	*	*	*	*	*
Macroptilium atropurpureum	Fabaceae	紫花大翼豆	Climbe	E													***	*	**								*																							
Passiflora foetida	Passifloracea	龍珠果	Climbe	E																																														
Ageratum conyzoides	Asteraceae	藿香薊	Herb	E	*	*			*	*	*		*	*	*		**	*	*	*	**	*	*	*	*	*	**		***	*	**	*	*	*	*	*	*	*	*	*	*	*	*	*		*				
Bidens alba	Asteraceae	白花鬼針草	Herb	E					*	*																	*	*	*	*	*	*				*	*	*	*							*	*				
Eupatorium odoratum	Asteraceae	飛機草	Herb	E																																															
Euphorbia sp.	Euphorbiacea	飛揚草	Herb	E																																														
Gynura bicolor	Asteraceae	風鳳菜	Herb	E																	*	*	*													*	*		*											
Mikania micrantha	Asteraceae	薇甘菊	Herb	E	**	*	*	*	*	*	***	***	**	*	***	***			*	**	*	*	**	**	**	**	**	*	*	**	**	***	*	***	*	**	*	**	**	*	*	*	**	**	*	**	**	*	*	*	*
Mimosa pudica	Mimosaceae	含羞草	Herb	E			*				*																																							
Panicum maximum	Poaceae	大黍	Herb	E										*	*	*																																		
Pilea microphylla	Urticaceae	小葉冷水花	Herb	E																																														
Rhynchelytrum repens	Poaceae	紅毛草	Herb	E																					*						*																		
Thysanolaena agrostis	Poaceae	粽葉薷	Herb	E																											**		**			*		*								*	*				
Boehmeria nivea	Urticaceae	苧麻	Shrub	E																									*	*	*	**																		
Catharanthus roseus	Apocynaceae	長春花	Shrub	E	*	*	*																																											
Acacia auriculiformis	Mimosaceae	耳果相思	Tree	E										*	*	*	*	*	**	**	**	**	**	**																								**	**	**	**				
Acacia confusa	Mimosaceae	臺灣相思	Tree	E					**	**	**	**	*	*	*	*	*	*	*	*	*	*	*	*					*	*	*	*	*	*	*	**											*				*	*
Bauhinia sp.	Caesalpiniace	羊蹄甲屬	Tree	E																																														
Casuarina equisetifolia	Casuarinacea	木麻黃	Tree	E																																														
Delonix regia	Caesalpiniace	鳳凰木	Tree	E																																													
Dimocarpus longan	Sapindaceae	龍眼	Tree	E																																													
Leucaena leucocephala	Mimosaceae	銀合歡	Tree	E																																													
Lophostemen confertus	Myrtaceae	紅膠木	Tree	E																																													
Vernicia montana	Euphobiaceae	木油桐	Tree	E				*																																									

Notes:

[1] Abundance: * = present; ** = common; *** = very common

[2] Origin: N = native; E = exotic; P = planted (otherwise naturally occurring)

Table of Contents (Section 2)

Table of Contents (Section 2)

APPENDIX B

ANIMAL SPECIES RECORDED ON THE STUDIED SLOPES

Appendix B: Animal Species Recorded on the Studied Slopes

Species Name	Common Name	Chinese Name	Photo
BIRDS			
Accipiter virgatus	Besra	松雀鷹	
Acridotheres cristatellus	Crested Mynah	八哥	
Aethopyga christinae	Fork-tailed Sunbird	叉尾太陽鳥	
Centropus sinensis	Greater Coucal	褐翅鴉鵑	
Copsychus saularis	Oriental Magpie Robin	鵲鴝	
Eudynamis scolopacea	Common Koel	噪鵑	
Garrulax pectoralis	Greater Necklaced Laughingthrush	黑臉噪鶥	
Turdus hortulorum	Grey-backed Thrush	灰背鶇	Y
Orthotomus sutorius	Common Tailorbird	長尾縫葉鳥	Y
Parus major	Great Tit	大山雀	
Prinia flaviventris	Yellow-bellied Prinia	灰頭鷦鶯	
Pycnonotus jocosus	Red-whiskered Bulbul	紅耳鵯	
Pycnonotus sinensis	Chinese Bulbul	白頭鵯	
Streptopelia chinensis	Spotted Dove	珠頸斑鳩	
Lanius schach	Long-tailed Shrike	棕背伯勞	
Lonchura maja	White-rumped Munia	白腰文鳥	
Zosterops erythropleurus	Japanese White-eye	暗綠繡眼鳥	Y
BUTTERFLIES			
Hesperiidae			
Astitcopterus jama	Forest Hopper	腌翅弄蝶	Y
Iambrix salsala	Chestnut Bob	雅弄蝶	Y
Odontoptilum angulatum	Chestnut Angle	角翅弄蝶	Y
Parnara guttata	Common Straight Swift	直紋稻弄蝶	
Papilionidae			
Byasa alcinous	Chinese Windmill	麝鳳蝶	
Graphium agamemnon	Tailed-Green Jay	統帥青鳳蝶	
Graphium doson	Common Jay	木蘭青鳳蝶	
Graphium sarpedon	Common Bluebottle	青鳳蝶	
Papilio demoleus	Lime Butterfly	達摩鳳蝶	
Papilio helenus	Red Helen	玉斑鳳蝶	
Papilio memnon	Great Mormon	美鳳蝶	
Papilio paris	Paris Peacock	巴黎翠鳳蝶	
Papilio polytes mandane	Common Mormon	玉帶鳳蝶(白帶型)	Y
Papilio polytes polytes	Common Mormon	玉帶鳳蝶(白斑型)	
Papilio protenor	Spangle	藍鳳蝶	
Pieridae			
Delias pasithoe	Red-base Jezebel	報喜斑粉蝶	Y
Catopsilia pomona	Lemon Emigrant	遷粉蝶	Y
Catopsilia pyranthe	Mottled Migrant	梨花遷粉蝶	
Cepora nerissa	Common Gull	黑脈園粉蝶	
Eurema hecabe	Common Grass Yellow	寬邊黃粉蝶	Y
Hebomoia glaucippe	Great Orange Tip	鶴頂粉蝶	Y
Pieris canidia	Indian Cabbage White	東方菜粉蝶	
Lycaenidae			
Acytolepis puspa	Common Hedge Blue	鈕灰蝶	Y
Spindasis lohita	Long-banded Silverline	銀線灰蝶	
Zizeeria maha	Pale Grass Blue	酢醬灰蝶	Y
Zizeeria otis	Lesser Grass Blue	毛眼灰蝶	Y
Riodinidae			
Abisara echerius	Plum Judy	蛇目褐蜆蝶	
Zemeros flegyas	Punchinello	波蜆蝶	
Satyridae			
Elymnias hypermnestra	Common Palmfly	翠袖鋸眼蝶	
Melanitis phedima	Dark Evening Brown	睇暮眼蝶	
Mycalesis mineus	Dark-band Bush Brown	小眉眼蝶	
Mycalesis zonata	South China Bush Brown	平頂眉眼蝶	Y
Amathusiinae			
Discophora sondaica	Common Duffer	鳳眼方環蝶	
Nymphalisae			
Ariadne ariadne	Angled Castor	波蛺蝶	Y
Athyma nefte	Colour Sergeant	相思帶蛺蝶	Y
Athyma selenophora	Staff Sergent	新月帶蛺蝶	
Cupha erymanthis	Rustic	黃襟蛺蝶	
Euthalia phemius	White-edged Blue Baron	尖翅翠蛺蝶	
Junonia hierta	Yellow Pansy	黃裳眼蛺蝶	Y
Junonia lemonias	Lemon Pansy	蛇眼蛺蝶	
Limenitis sulpitia	Five-dot Sergeant	殘鍔線蛺蝶	
Neptis hylas	Common Sailor	中環蛺蝶	Y
Rohana parisatis	Black Prince	羅蛺蝶	Y
Symbrenthia lilaea	Common Jester	散紋盛蛺蝶	
Danaidae			
Danaus genutia	Common Tiger	虎斑蝶	Y
Euploea core	Common Indian Crow	幻紫斑蝶	
Euploea midamus	Blue-spotted Crow	藍點紫斑蝶	Y
Ideopsis similis	Ceylon Blue Tiger	擬旖斑蝶	Y
DRAGONFLIES			
Diplacodes trivialis	Blue Percher	紋藍小蜻	
Neurothemis fulvia	Russet Percher	網脈蜻	
Orthetrum glaucum	Common Blue Skimmer	黑尾灰蜻	Y
Orthetrum luzonicum	Marsh Skimmer	呂宋灰蜻	
Orthetrum pruinosum neglectum	Common Red Skimmer	赤褐灰蜻	
Orthetrum sabina	Green skimmer	狹腹灰蜻	
Trithemis festiva	Indigo Dropwing	慶褐蜻	Y

Species Name	10SW-C_C1				10SW-C_C2				10SW-C_FR70				10SW-C_C64				10SW-C_C67			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
BIRDS																				
Accipiter virgatus																				
Acridotheres cristatellus	*				*															
Aethopyga christinae						*				*										
Centropus sinensis	*				*															
Copsychus saularis												*								
Eudynamis scolopacea									*				*							
Garrulax pectoralis																		*		
Turdus hortulorum																				
Orthotomus sutorius	*	*	*		*	*	*		*	*	*		*						*	
Parus major																				*
Prinia flaviventris																				
Pycnonotus jocosus			*				*					*						*		
Pycnonotus sinensis																				
Streptopelia chinensis		*	*			*	*													
Lanius schach																				
Lonchura maja																				
Zosterops erythropleurus	*	*	*		*	*	*					*			*		*	*		*
BUTTERFLIES																				
Hesperiidae																				
Astitcopterus jama																				
Iambrix salsala																			*	
Odontoptilum angulatum																				
Parnara guttata																				
Papilionidae																				
Byasa alcinous																				
Graphium agamemnon																	*			
Graphium doson									*				*							
Graphium sarpedon																				
Papilio demoleus																				
Papilio helenus			*				*													
Papilio memnon		*													*					
Papilio paris																				
Papilio polytes mandane			*				*				*				*					
Papilio polytes polytes	*				*		*		*				*							
Papilio protenor																				
Pieridae																				
Delias pasithoe												*								*
Catopsilia pomona			*				*				*								*	
Catopsilia pyranthe	*				*				*				*							
Cepora nerissa																				
Eurema hecabe			*				*												*	
Hebomoia glaucippe	*		*		*		*										*			
Pieris canidia			*				*				*									
Lycaenidae																				
Acytolepis puspa			*						*				*							
Spindasis lohita																				
Zizeeria maha			*																	
Zizeeria otis							*													
Riodinidae																				
Abisara echerius																				
Zemeros flegyas																				
Satyridae																				
Elymnias hypermnestra	*				*		*								*					
Melanitis phedima		*																		
Mycalesis mineus																				
Mycalesis zonata							*													
Amathusiinae																				
Discophora sondaica							*													
Nymphalisae																				
Ariadne ariadne							*													
Athyma nefte																			*	
Athyma selenophora																				
Cupha erymanthis			*				*		*				*							
Euthalia phemius																				
Junonia hierta																			*	
Junonia lemonias																				
Limenitis sulpitia									*				*							
Neptis hylas	*		*		*		*		*				*						*	
Rohana parisatis																				
Symbrenthia lilaea																				
Danaidae																				
Danaus genutia																			*	
Euploea core																				
Euploea midamus	*				*															
Ideopsis similis			*				*				*									
DRAGONFLIES																				
Diplacodes trivialis																				
Neurothemis fulvia																			*	
Orthetrum glaucum																				
Orthetrum luzonicum																				
Orthetrum pruinosum neglectum																				
Orthetrum sabina																				
Trithemis festiva																				

Species Name	10SW-C_C68				10SW-C_C12; 104;105				10SW-C_C45				10SW-C_FR11				10SW-C_C119			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
BIRDS																				
Accipiter virgatus							*													
Acridotheres cristatellus																				
Aethopyga christinae																				
Centropus sinensis																				
Copsychus saularis																				
Eudynamis scolopacea																				
Garrulax pectoralis																				
Turdus hortulorum																				
Orthotomus sutorius									*											
Parus major													*					*		
Prinia flaviventris																				
Pycnonotus jocosus																				
Pycnonotus sinensis																				
Streptopelia chinensis																				
Lanius schach																				
Lonchura maja																				
Zosterops erythropleurus	*						*						*							
BUTTERFLIES																				
Hesperiidae																				
Astitcopterus jama			*																	
Iambrix salsala																				
Odontoptilum angulatum							*													
Parnara guttata					*															
Papilionidae																				
Byasa alcinous																			*	
Graphium agamemnon					*		*						*		*					
Graphium doson																				
Graphium sarpedon							*													
Papilio demoleus							*													
Papilio helenus											*								*	
Papilio memnon			*														*			
Papilio paris							*										*			
Papilio polytes mandane															*					
Papilio polytes polytes																				
Papilio protenor															*					
Pieridae																				
Delias pasithoe																				
Catopsilia pomona			*		*		*				*				*					
Catopsilia pyranthe					*										*					
Cepora nerissa																				
Eurema hecabe					*		*				*									
Hebomoia glaucippe							*													
Pieris canidia					*		*													
Lycaenidae																				
Acytolepis puspa																				
Spindasis lohita									*											
Zizeeria maha													*				*		*	
Zizeeria otis																				
Riodinidae																				
Abisara echerius																				
Zemeros flegyas																				
Satyridae																				
Elymnias hypermnestra																				
Melanitis phedima																				
Mycalesis mineus																				
Mycalesis zonata																				
Amathusiinae																				
Discophora sondaica																				
Nymphalisae																				
Ariadne ariadne							*													
Athyma nefte																				
Athyma selenophora																				
Cupha erymanthis							*												*	
Euthalia phemius							*													
Junonia hierta																				
Junonia lemonias																			*	
Limenitis sulpitia																				
Neptis hylas													*		*					
Rohana parisatis																				
Symbrenthia lilaea															*					
Danaidae																				
Danaus genutia							*												*	
Euploea core															*					
Euploea midamus	*																		*	
Ideopsis similis							*								*					
DRAGONFLIES																				
Diplacodes trivialis					*															
Neurothemis fulvia																				
Orthetrum glaucum							*													
Orthetrum luzonicum							*								*					
Orthetrum pruinosum neglectum			*																	
Orthetrum sabina																				
Trithemis festiva															*					

Species Name	10SW-C_C118				10SW-C_C117; 116; 20				10SW-C_C209				10SW-C_FR32				10SW-C_C21			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
BIRDS																				
Accipiter virgatus																				
Acridotheres cristatellus																				
Aethopyga christinae																				
Centropus sinensis																				
Copsychus saularis																				
Eudynamis scolopacea																				
Garrulax pectoralis																				
Turdus hortulorum																				*
Orthotomus sutorius																				
Parus major			*		*		*													
Prinia flaviventris																		*		
Pycnonotus jocosus																				
Pycnonotus sinensis							*													
Streptopelia chinensis																				
Lanius schach																				
Lonchura maja																				
Zosterops erythropleurus								*								*				
BUTTERFLIES																				
Hesperiidae																				
Astitcopterus jama																				
Iambrix salsala																				
Odontoptilum angulatum																				
Parnara guttata																				
Papilionidae																				
Byasa alcinous			*				*													
Graphium agamemnon																				
Graphium doson																				
Graphium sarpedon																				
Papilio demoleus																				
Papilio helenus													*							
Papilio memnon															*				*	
Papilio paris			*							*					*				*	
Papilio polytes mandane															*					
Papilio polytes polytes					*		*													
Papilio protenor					*								*		*					
Pieridae																				
Delias pasithoe																*				
Catopsilia pomona			*				*								*				*	
Catopsilia pyranthe																				
Cepora nerissa			*				*													
Eurema hecabe			*				*													
Hebomoia glaucippe							*													
Pieris canidia																				
Lycaenidae																				
Acytolepis puspa																				
Spindasis lohita																				
Zizeeria maha															*				*	
Zizeeria otis																				
Riodinidae																				
Abisara echerius																		*	*	*
Zemeros flegyas																				
Satyridae																				
Elymnias hypermnestra																				
Melanitis phedima																				
Mycalesis mineus					*								*							
Mycalesis zonata																				
Amathusiinae																				
Discophora sondaica																				
Nymphalisae																				
Ariadne ariadne																			*	
Athyma nefte																			*	
Athyma selenophora																			*	
Cupha erymanthis			*		*		*													
Euthalia phemius																				
Junonia hierta																				
Junonia lemonias							*													
Limenitis sulpitia																			*	
Neptis hylas			*																	
Rohana parisatis											*									
Symbrenthia lilaea																				
Danaidae																				
Danaus genutia																				
Euploea core																				
Euploea midamus			*				*		*				*				*			
Ideopsis similis			*				*				*						*			
DRAGONFLIES																				
Diplacodes trivialis																				
Neurothemis fulvia															*					
Orthetrum glaucum					*		*		*		*				*					
Orthetrum luzonicum							*				*				*				*	
Orthetrum pruinosum neglectum																				
Orthetrum sabina																	*			
Trithemis festiva																				

Species Name	10SW-C_C193				10SW-C_C187				10SW-C_C199				10SW-C_C198				10SW-C_C165			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
BIRDS																				
Accipiter virgatus																				
Acridotheres cristatellus																				
Aethopyga christinae																				
Centropus sinensis																				
Copsychus saularis															*					*
Eudynamis scolopacea																				
Garrulax pectoralis																				
Turdus hortulorum												*				*				
Orthotomus sutorius		*																		
Parus major																				
Prinia flaviventris																				
Pycnonotus jocosus															*					
Pycnonotus sinensis						*		*							*					
Streptopelia chinensis																				
Lanius schach				*																
Lonchura maja								*												
Zosterops erythropleurus		*			*															
BUTTERFLIES																				
Hesperiidae																				
Astitcopterus jama																				
Iambrix salsala																				
Odontoptilum angulatum																				
Parnara guttata																				
Papilionidae																				
Byasa alcinous																				
Graphium agamemnon							*													
Graphium doson																				
Graphium sarpedon																				
Papilio demoleus																				
Papilio helenus							*								*				*	
Papilio memnon											*				*				*	
Papilio paris																				
Papilio polytes mandane															*					
Papilio polytes polytes																				
Papilio protenor											*									
Pieridae																				
Delias pasithoe				*				*				*								*
Catopsilia pomona															*				*	*
Catopsilia pyranthe																				
Cepora nerissa																				
Eurema hecabe			*																	
Hebomoia glaucippe											*									
Pieris canidia																				
Lycaenidae																				
Acytolepis puspa																				
Spindasis lohita																				
Zizeeria maha																				
Zizeeria otis																				
Riodinidae																				
Abisara echerius				*				*											*	
Zemeros flegyas			*													*				
Satyridae																				
Elymnias hypermnestra																				
Melanitis phedima																				
Mycalesis mineus																				
Mycalesis zonata																				
Amathusiinae																				
Discophora sondaica																				
Nymphalisae																				
Ariadne ariadne																				
Athyma nefte																				
Athyma selenophora																				
Cupha erymanthis																				*
Euthalia phemius																				
Junonia hierta																				
Junonia lemonias																				
Limenitis sulpitia																				
Neptis hylas		*	*																	
Rohana parisatis															*					
Symbrenthia lilaea																				
Danaidae																				
Danaus genutia																				
Euploea core																				
Euploea midamus					*				*						*					
Ideopsis similis					*		*				*				*				*	
DRAGONFLIES																				
Diplacodes trivialis																				
Neurothemis fulvia																				
Orthetrum glaucum			*																	
Orthetrum luzonicum											*									
Orthetrum pruinosum neglectum																				
Orthetrum sabina																				
Trithemis festiva																				

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Appendix B: Animal Species Recorded on the Studied Slopes

Species Name	Common Name	Chinese Name	Photo	10SW-C_C1				10SW-C_C2				10SW-C_FR70				10SW-C_C64				10SW-C_C67				10SW-C_C68				10SW-C_C12; 104;105				10SW-C_C45				10SW-C_FR11				10SW-C_C119				10SW-C_C118				10SW-C_C117; 116; 20				10SW-C_C209				10SW-C_FR32				10SW-C_C21				10SW-C_C193				10SW-C_C187				10SW-C_C199				10SW-C_C198				10SW-C_C165			
				1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
OTHER INSECTS																																																																																			
Ceracris fasciata		黑翅竹蝗	Y																									*																								*								*										*													
Ceracris sp.		蝗	Y																			*								*												*										*																																
Cicinclela aurulenta	Blue-spotted Tiger Beetle	金斑虎甲	Y																																																																					*								
Cosmoscarta heros	Spittlebug	沫蟬	Y											*																																																																		
Cryptocephalus trifasciatus	Three-banded Leaf Beetle	三帶隱頭葉甲	Y							*																																																																									
Cryptotympana holsti	Large brown cicada	南蚱蟬	Y			*				*												*																										*																																
Delta pyriforme	Common Potter Wasp																											*																																																					
Ducetia japonica		黑條螽	Y																																			*																																							*	
Entoria sp.	Stick insect	竹節蟲	Y																																																																								*					
Gryllidae	Cricket																																			*																																												
Julus sp	Round Millipede	馬陸	Y																											*																																																	
Liliocerus sp.	Lily leaf-beetle		Y																																			*																																									
Opisthoplatia orientalis	Oriental Litter Cockroach	短翅蟑螂																																												*																																			
Apis cerana	Chinese Honey Bee	東方蜜蜂	Y												*																																																																	
Parapolybia nodosa		叉胸側異胡蜂	Y																																																					*																	*								
Parapolybia varia		變側異腹胡蜂	Y																																																																					*				*				
Polistes gigas	Large Brown Paper Wasp	棕馬蜂				*				*																																				*								*		*																		*						
Polistes olivaceus	Common Paper Wasp	果馬蜂				*																																												*																															
Polyrachis dive	Black Tree Ants	雙齒多刺蟻			*									*																*																																																			
Teleogryllus mitratus	Field Cricket	油葫蘆/黑蟋蟀																																																*								*																							
Tetrix sp.	Pygmy Grasshopper	蚱																												*																		*										*																							
Tricondyla pulchripes	Wingless Black Tiger Beetle	長胸缺翅虎甲																																																																								*					
Trilophidia annulata		疣蝗																																														*																																	
Xylocopa nasalis	Bamboo carpenter bee	竹木蜂	Y											*								*														*														*																																
Blosyrus herthus	Sweet Potato Black Weevil	卵圓圓腹象																																																																									*					
	unknown ants																													*																																																			
	unknown beetle 3																											*																																																						
	unknown bug									*																																																																								
	unknown bug																																																																		*																	
	unknown cricket																																																																		*									*					
	unknown grasshopper																																										*																																									
	unknown grasshopper																																										*																																									
	unknown grasshoppper2																																							*																																													
	unknown bug																																																																										*									
	Wood Cockroach																																																												*																							
Cyclosia sp.	Moth caterpillar-Catocalinae		Y																																								*																																									
	Moth caterpillar-Catocalinae																					*																																																															
	unknown moth-caterpillar 2		Y																																																																		*																	
	unknown moth 2		Y																																					*																																												
	unknown moth 3		Y																																																																	*																	
	unknown moth 4		Y																																																																																		*	
	unknown moth caterpillar		Y																											*												*																																											
SPIDERS																																																																																				
Araneus sp.			Y			*				*																												*																																															
Nephila pilipes	Giant Wood Spider	大木林蜘蛛	Y																	*		*		*				*		*																														*						*		*				*				*				*	
Oxyopes sp.	Lynx Spider		Y																											*																																																				
	unknown jumping spider (blue)		Y																																																																	*																	
SNAILS																																																																																				
Achatina fulica	Giant African Snail			*																														*																																																		
Bradybaena similaris	Asian Trampsnail		Y									*																		*																																																		*	
Cryptosoma imperator																																																																				*																	
Reptiles and Amphibians																																																																																				
Hemidactylus bowringii	Bowring's Gecko	原尾蜥虎	Y																																																									*	*									*																	
Calotes versicolor	Changeable Lizard	變色樹蜥																																																																*																							
Sibynophis chinensis	Chinese Mountain Snake	黑頭劍蛇																																						*																																																	

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GEO PUBLICATIONS AND ORDERING INFORMATION
土力工程處刊物及訂購資料

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MAJOR GEOTECHNICAL ENGINEERING OFFICE PUBLICATIONS
土力工程處之主要刊物

GEOTECHNICAL MANUALS

Geotechnical Manual for Slopes, 2nd Edition (1984), 300 p. (English Version), (Reprinted, 2000).

斜坡岩土工程手冊(1998)，308頁(1984年英文版的中文譯本)。

Highway Slope Manual (2000), 114 p.

GEOGUIDES

Geoguide 1	Guide to Retaining Wall Design, 2nd Edition (1993), 258 p. (Reprinted, 2007).
Geoguide 2	Guide to Site Investigation (1987), 359 p. (Reprinted, 2000).
Geoguide 3	Guide to Rock and Soil Descriptions (1988), 186 p. (Reprinted, 2000).
Geoguide 4	Guide to Cavern Engineering (1992), 148 p. (Reprinted, 1998).
Geoguide 5	Guide to Slope Maintenance, 3rd Edition (2003), 132 p. (English Version).
岩土指南第五冊	斜坡維修指南，第三版(2003)，120頁(中文版)。
Geoguide 6	Guide to Reinforced Fill Structure and Slope Design (2002), 236 p.
Geoguide 7	Guide to Soil Nail Design and Construction (2008), 97 p.

GEOSPECS

Geospec 1	Model Specification for Prestressed Ground Anchors, 2nd Edition (1989), 164 p. (Reprinted, 1997).
Geospec 3	Model Specification for Soil Testing (2001), 340 p.

GEO PUBLICATIONS

GCO Publication No. 1/90	Review of Design Methods for Excavations (1990), 187 p. (Reprinted, 2002).
GEO Publication No. 1/93	Review of Granular and Geotextile Filters (1993), 141 p.
GEO Publication No. 1/2000	Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls (2000), 146 p.
GEO Publication No. 1/2006	Foundation Design and Construction (2006), 376 p.
GEO Publication No. 1/2007	Engineering Geological Practice in Hong Kong (2007), 278 p.
GEO Publication No. 1/2009	Prescriptive Measures for Man-Made Slopes and Retaining Walls (2009), 76 p.

GEOLOGICAL PUBLICATIONS

The Quaternary Geology of Hong Kong, by J.A. Fyfe, R. Shaw, S.D.G. Campbell, K.W. Lai & P.A. Kirk (2000), 210 p. plus 6 maps.

The Pre-Quaternary Geology of Hong Kong, by R.J. Sewell, S.D.G. Campbell, C.J.N. Fletcher, K.W. Lai & P.A. Kirk (2000), 181 p. plus 4 maps.

TECHNICAL GUIDANCE NOTES

TGN 1	Technical Guidance Documents