CHAPTER 15

Habitat Enhancement for Slope Stabilisation at Kent Ridge Park

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Introduction

Kent Ridge Park is part of the Southern Ridges, which is located in the southwest of Singapore and includes Mount Faber Park, Telok Blangah Hill Park, HortPark, and Labrador Nature Reserve. The vegetation type found in this park is largely Adinandra belukar ('belukar' is the Malay word for 'secondary forest'), characterised by disturbed young secondary forest with a canopy dominated by Tiup Tiup (*Adinandra dumosa*). Given the history of disturbance within this forest, the canopy is more open, the forest is much drier, and the soil quality is much poorer than a mature rainforest. The forests within the Southern Ridges are also quite isolated from mature forest patches that could act as a seed source. This has resulted in the floristic diversity remaining at a very low level.

When the slope along the mountain biking trail in Kent Ridge Park failed in December 2015, there was an immediate need for it to be stabilised. Given Kent Ridge Park's status as a nature area and a popular site for nature lovers, this slope failure was seen as an opportunity by the National Parks Board (NParks) to increase the biodiversity of this site by habitat enhancement after the works had been completed, instead of merely re-turfing the slope (which is the standard practice for newly stabilised slopes). The planting palette was chosen to include plants found in mature forest areas including those in Singapore's Central Catchment Nature Reserve. Care was taken to ensure that plants chosen would be able to survive in harsh open conditions characteristic of the post-stabilisation environment, could establish on sloped terrain, and were sustainable from an operational and maintenance point of view. For this reforestation project, we aimed to increase the floristic diversity of this area, so as to provide a seed source to the surrounding forest, thus allowing it to progress to a more mature ecological succession stage.

As such, the objectives of the Kent Ridge Park slope habitat enhancement project were as follows:

1. Creating slope stability, especially at the steepest portion of the slope
2. Restoring ecosystem diversity and structure from a degraded site
3. Ensuring sustainability through frequent and consistent monitoring and management of the planted area

Methodology

How the incident happened

In early December 2015, a section of a southward facing slope within the Kent Ridge Park Mountain Bike Trail failed and a landslide resulted (Fig. 1). The affected area covered a total area of approximately 0.3 hectares (3,000 square metres) (Fig. 2), measuring about 100 metres long and 30 metres wide with an elevation difference of about 30 metres. The area had a dense vegetation of predominantly secondary forest species such as *Adinandra dumosa*, *Cyrtophyllum fragrans*, *Dillenia suffruticosa*, and *Macaranga heynei*.

The incident was detected on 11 December 2015 but subsequent investigations showed that the mountain bikers had first spotted the slope failure as early as 5 December 2015. Several supporting facilities were dislodged as a result. NParks closed off the mountain bike trail, and a slope consultant and a slope stabilisation contractor were engaged to survey the extent of the affected area and propose methods to stabilise the area.

Fig. 1. Slope failure at Kent Ridge Park, Mountain Bike Trail in December 2015.

Fig. 2. Approximately 3,000 square metres of area was affected.

Slope engineering and slope stabilisation method

Waterproof canvas sheets were laid over the bare exposed areas to protect them from further water erosion and to minimise water seepage into the ground (Fig. 3).

Figs. 3. Large canvas sheets were laid over to prevent the saturation of soil, which might lead to further slope failure.

Mackintosh test and borehole rigs were installed on site for soil investigation to gather geotechnical information on the subsoil conditions at the site for the design of stabilisation methods. However, immediate mitigation measures were put in place to safeguard the site in view of the progressive erosion observed on site, compounded by the rain which was typical of the weather pattern at the end of the year.

After analysing the results, the final stabilisation method chosen for the area was the soil nail with grid beam method (Fig. 4). Soil nails each measuring up to 12 metres in length were inserted perpendicularly into the ground. Subsequently, concrete grid beams were cast around each of the nail in the shape of a square which were filled up by soil and turf. In addition, the previous bike trail had to be reinstated. Each of the grid beam measured around 3 metres by 3 metres to provide sufficient planting space for small trees, where possible, and shrubs. The depth of soil added was roughly 0.3 metre for the grid beam section.

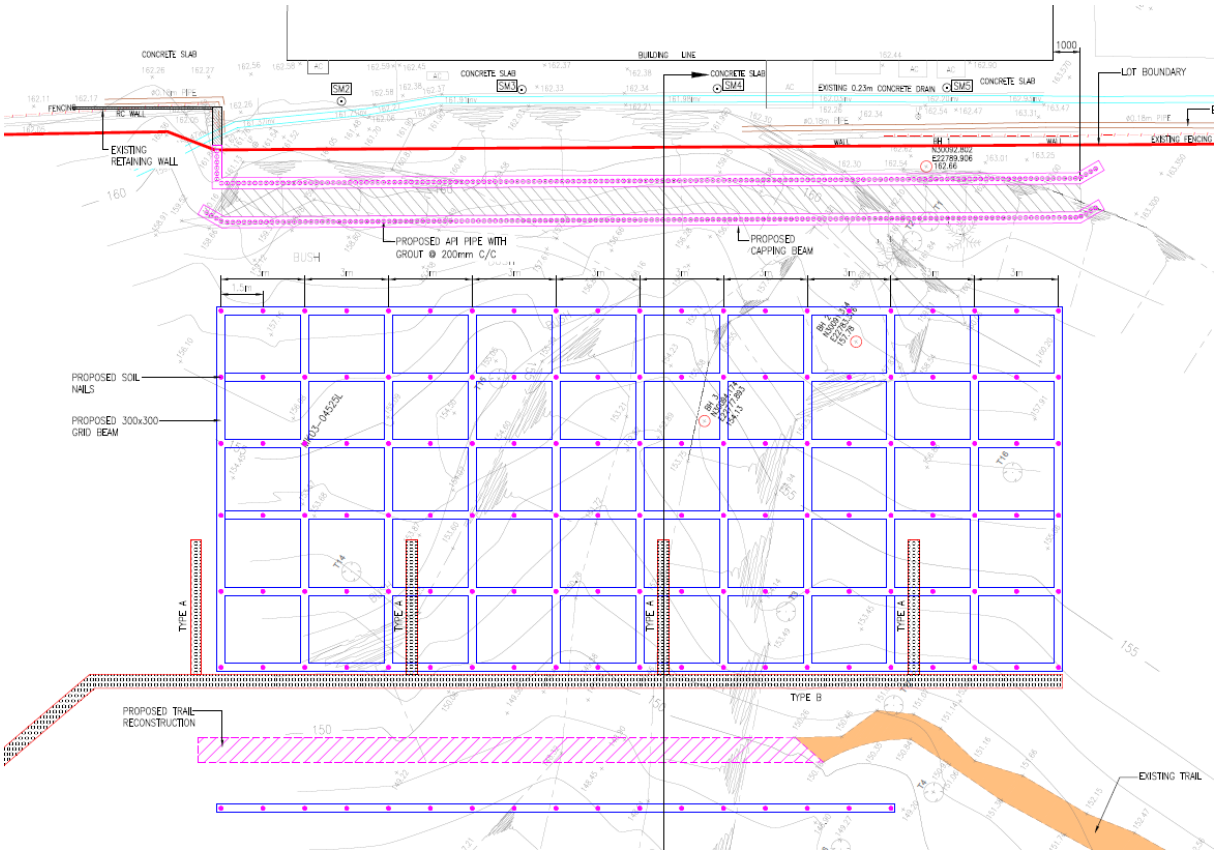

Fig. 4. Grid beams layout plan.

Timeframe

- December 2015 to February 2016: Immediate mitigation measures, soil investigation and submissions
- March 2016 to December 2016: Slope stabilisation (through the soil nail with grid beam method), drain constructions and trail reinstatement (Fig. 5)
- January 2017 to February 2017: Soil top-up, planting and establishment period (Fig. 6–10)

Fig. 5. Construction of grid beams in October 2016.

Fig. 6. Backfilling of soil in January 2017.

Fig. 7. Planting of turf at end January 2017.

Fig. 8. Planting of native shrubs (*Melastoma malabathricum*) on Area 1 in February 2017.

Fig. 9. Differentiation of planting at Area 1 (shrubs) and 2 (trees and larger shrubs) in February 2017.

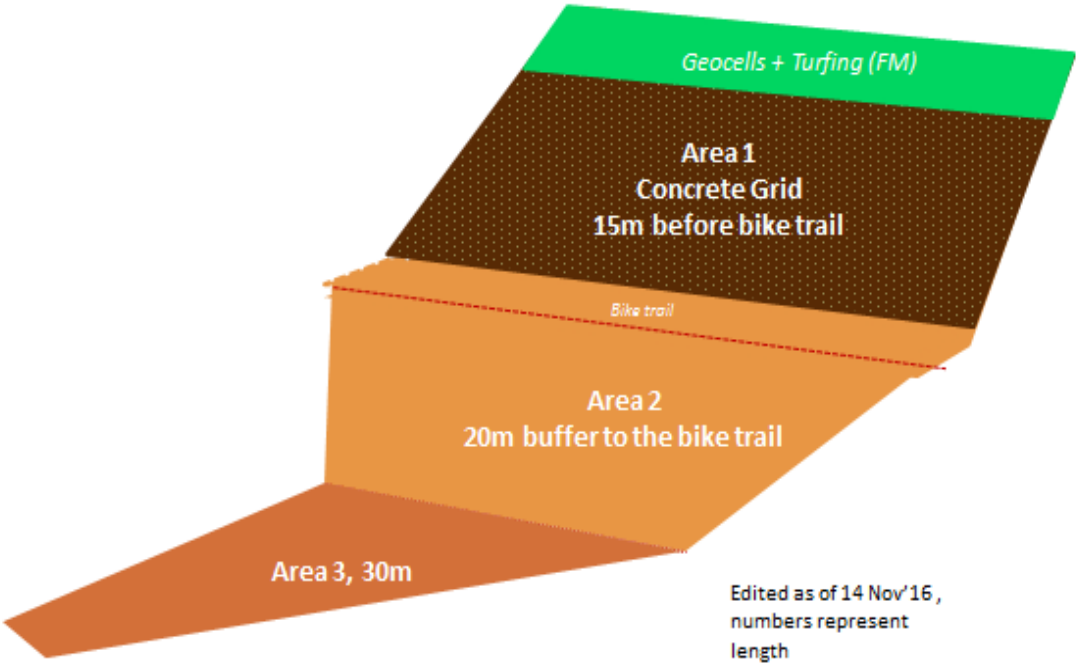

Fig. 10. The 3 distinct slope areas, with reference to the indicative mountain bike trail track.

Formation of a workgroup formed for the project

A habitat enhancement workshop was organised on 10 October 2016 by National Biodiversity Centre (NBC) and the Centre for Urban Greenery and Ecology (CUGE). A workgroup, comprising eight members from different NParks divisions, was formed to look at enhancing habitats at potential sites within parks with a range of biodiversity found in Singapore. Within Kent Ridge Park, the slope was also identified to be a case study with actual implementation as the slope stabilisation works were nearing completion.

The group held two investigation site visits to survey the surroundings and document the existing environment conditions, vegetation and fauna observed (Fig. 11). Following the visit, the group worked with the data and eventually came up with a planting palette that was suitable for the various soil depths found at the different sections (Table 1).

Fig. 11. A site visit for a rapid survey in February 2017.

Planting palette

Table 1: Planting palette for slope stabilisation habitat enhancement

Area 1	**Area 2**	**Area 3**
Melastoma malabathricum (plant extensively)	*Dillenia suffructicosa* (minimal)	*Koompassia malaccensis*
Leea rubra	*Ficus grossularioides*	*Shorea curtisii*
Ardisa crenata	*Ficus aurata*	*Alstonia angustiloba*
Ardisia elliptica	*Caryota mitis*	*Archidendron clypearia*
Cheilocostus speciosus	*Adinandra dumosa*	*Archidendron jiringa*
Ficus deltoidea	*Ploiarium alternifolium*	*Syzigium zeylanicum*
Tristellateia australasiae	*Rhodamnia cinerea*	*Horsfieldia irya*
Rhodomyrtus tomentosa	*Macaranga heynei*	*Parkia speciosa*
	Macaranga hypoleuca	*Sindora wallichii*
	Macaranga gigantea	*Palaquium obovatum*
	Bauhinia semibifida	*Macaranga bancana*

Results and monitoring

Monitoring

In February 2017, a mixture of six species of trees and shrubs (Table 2), numbering about 70, were planted at Area 2 and 3 where the deeper soil depth allowed for larger trees to be planted. The soil was also from the original site. They were planted at approximately 2-metre gaps to allow for subsequent growth.

Table 2: Tree species that were planted on Feb 2017.

1) *Horsfieldia irya*
2) *Horsfieldia polyspherula*
3) *Ploiarium alternifolium*
4) *Rhodamnia cinerea*
5) *Sindora wallichi*
6) *Syzygium zeylancium*

Survival rate

During the survey of January 2019, many of the original species that were planted survived although some did not establish well (Fig. 12). This could be due to the soil conditions where they were planted in. The soil at Kent Ridge Park was tested and found to be acidic with a pH level of 5 to 5.5. The lack of substantial organic matter on the ground surface, as only young trees were planted, was not enough to improve the soil condition and pH level.

Fig. 12. Most of the tree saplings survived, as seen during a visit to the site in February 2017.

Height, outlook, and appearance

Some of the trees such as *Horsfieldia irya*, were observed to be doing better than others such as *Sindora wallichii*, where they were showing signs of yellowing in their leaves which could be caused by a variety of health problems such as nutrient deficiency in the soil and lack of water (partially due to the drier weather conditions in January 2019).

Presence of Spontaneous Recruitment

Several spontaneous species such as *Muntingia calabura* and *Adenanthera pavonina* were observed to have established in the plot (Annex A). The seeds of these species were likely to be dispersed by birds which was a positive sign, indicating that fauna had visited the area. A single specimen of *Cecropia pachystachya*, a pioneer tree species that could spread rapidly and invasively in disturbed forests, was also observed. It was removed to a depth of 0.1 metre below surface so that as much of its root system was removed to inhibit its regeneration.

Site utilisation

Butterflies, including the Common Mormon (*Papilio polytes romulus*) and Chocolate Pansy (*Junonia hedonia ida*), and odonata species including the Common Parasol (*Neurothemis fluctuans*) and Scarlet Grenadier (*Lathrecista asiatica*), were frequently seen fluttering in this site. The fauna sighted so far had been common species that were also found in other parts of Kent Ridge Park. It is likely that more species will utilise the site as vegetation establishes and grows in height and density.

Subsequent management of area

The habitat enhancement site, located more than 400 metres from the start of the mountain bike trail, is within the Adinandra belukar secondary forest. Quarterly maintenance programmes to remove invasive species such as *Mikania micrantha*, *Cecropia pachystachya* and *Acacia auriculiformis* was needed for the planted species to establish and grow quickly. The slopes were left to self-regenerate after the initial assistance given at the beginning.

Results of the habitat restoration and enhancement initiatives

Figures 13 and 14 show how habitat restoration and enhancement works can transform a slope failure and degraded site to a stable slope with enriched niches for flora and fauna, leveraging on nature-based solutions. This project demonstrates that nurturing a suitable environment would lead to self-recruitment of flora and fauna, hence, leading to a long-term regeneration of natural ecosystems. Monitoring the site would enable NParks to learn how ecological succession occurs in parks that are near highly urbanised areas and how the state of a park can become closer to that of more pristine natural ecosystems.

Fig. 13. View from top (towards the east) photographed in 2019.

Fig. 14. View from top (towards the south) photographed in 2019.

Annex A

January 2019 – Observations of spontaneous seedlings.

Muntingia calabura

Stachytarpheta indica

Ficus grossularioides

Adenanthera pavonina

Adenanthera pavonina closeup

Cecropia pachystachya

January 2019 – Conditions of original trees/shrubs planted in February 2017.

Cheilocostus speciosus

Syzygium zeylanicum

Sindora wallichi

Horsfieldia irya