



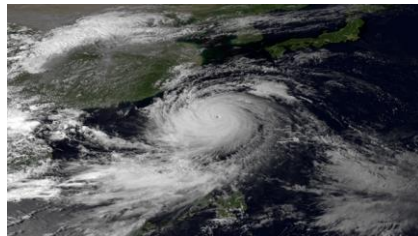
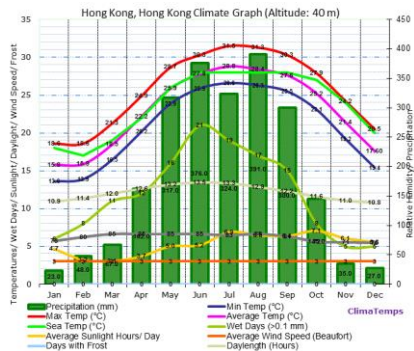
The challenge of planting trees on slopes in Hong Kong

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The Challenge

Establishing trees on hill slopes in HK have always been a problem

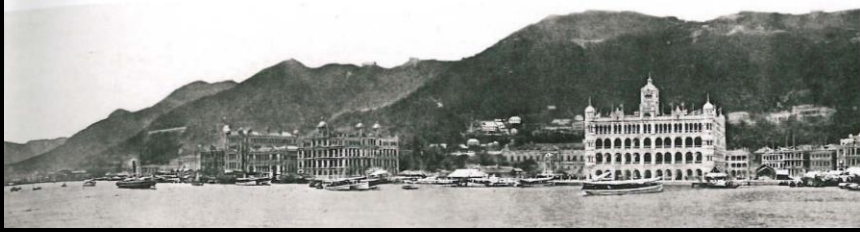
- High levels of climatic exposure
- Shallow, nutrient poor soils
- Typhoons
- Landslides and erosion



Images. (left) Climatmaps.com, (bottom) HK Observatory

Effect of climate on pattern of natural vegetation in Hong Kong

The 'Barren Rock'



View of Hong Kong Island, 1890



View of Kowloon, 1860

Images. HK Museum of History



Austin Hotel, Peak, 1900



Bethany, Pokfulam, 1880



Taikoo Sanatorium, 1895



Peak Sanatorium, 1867

Images. HK Gwulo

History of planting on slopes in Hong Kong

Repeated attempts to green the 'barren rock' from 1850's onwards,

- to provide timber for burning and house building (Chinese Fir),
- but also for health effects and visual improvement.



Happy Valley Racecourse, 1890

Image. HK Museum of History



Happy Valley, 1870



Slopes above East Point, 1880

Tree planting / Afforestation departments established in 1872, under Charles Ford.

- Slope planting based on seed of native species collected from the more remote hill slopes imported exotics brought in from Australia
- Grown on in Government Nurseries, and planted out as seedlings



Hong Kong Herbarium

Images. LCSD, HKGwulo.com



Chuen Lung Forestry Station



Peak Gardens, 1880

Image. HK Museum of History

Many hill slopes now covered in dense woodland suggests that the barren slope problem was largely man-made.



Braemar Hill

Failures

Human factors resulted in loss of many trees

- clearance for firewood
- theft
- hill fires
- poor species choice
- poor planting practice



Woodland clearance



Woodland clearance, hill fires, and early planting practice

Image. Unknown, HK Museum of History

Species Selection

Research into tree planting on slopes has tended to concentrate on species selection



Chuen Lung Forestry Station

Image. HKGwulo.com

R.T. Corlett/Forest Ecology and Management 116 (1996) 93-105 101

| Species | Family | Source | Success |
|--|----------------|------------|---------|
| 1871-1900 | | | |
| <i>Albizia lebbekii</i> (L.) Benth. | Mimosaceae | trop. Asia | # |
| <i>Alnus mollis</i> (L.) Willd. | Fagaceae | SE Asia | # |
| <i>Arucaria cunninghamii</i> D.Don | Arucariaceae | E Aus | # |
| <i>Bauhinia javanica</i> Bl. | Bauhinia | native | # |
| <i>Caesalpinia coriaria</i> (Jacq.) Willd. | Caesalpinaceae | S Am. | # |
| <i>C. ferrea</i> Dal. | Caesalpinaceae | Brazil | # |
| <i>Camellia hongkongensis</i> Seem. | Theaceae | native | # |
| <i>C. oleifera</i> Abel | Theaceae | native? | # |
| <i>Casuarina fissa</i> Rehd. & Wils. | Fagaceae | native | ## |
| <i>Casuarina equisetifolia</i> L. | Casuarinaceae | SE Asia | ## |
| <i>Cedrela odorata</i> L. | Meliaceae | trop. Am. | # |
| <i>Cedrus deodora</i> (D.Don.) G.Don.f. | Pinaceae | N India | # |
| <i>Celtis sinensis</i> Pers. | Ulmaceae | native | # |
| <i>Ceratonia stliqua</i> L. | Caesalpinaceae | Arabia | # |
| <i>Chorospandus axillaris</i> Bartt. & Hill | Anacardiaceae | native | # |
| <i>Cinnamomum camphora</i> (L.) Presl. | Lauraceae | China | ## |
| <i>C. aromaticum</i> Nees | Lauraceae | Burma | # |
| <i>Cryptomeria japonica</i> (L.F.) D.Don | Taxodiaceae | Japan | # |
| <i>Cunninghamia lanceolata</i> (Lamb.) Hk. | Taxodiaceae | China | # |
| <i>Eucalyptus alba</i> Bl. | Myrtaceae | N Aus. | # |
| <i>E. citriodora</i> Hk. | Myrtaceae | NE Aus. | ## |
| <i>E. gumifera</i> Hochst. | Myrtaceae | E Aus. | # |
| <i>E. globulus</i> Labill. | Myrtaceae | SE Aus. | # |
| <i>E. haemastoma</i> Sm. | Myrtaceae | SE Aus. | # |
| <i>E. moluccana</i> Roxb. | Myrtaceae | E Aus. | # |
| <i>E. marginata</i> Sm. | Myrtaceae | SW Aus. | # |
| <i>E. maculata</i> Hk. | Myrtaceae | E Aus. | # |
| <i>E. microcorys</i> F. Maell. | Myrtaceae | E Aus. | # |
| <i>E. pitulata</i> Sm. | Myrtaceae | E Aus. | # |
| <i>E. resinosa</i> Sm. | Myrtaceae | E Aus. | # |
| <i>E. robusta</i> Sm. | Myrtaceae | E Aus. | ## |
| <i>E. siderophloia</i> Benth. | Myrtaceae | E Aus. | # |
| <i>E. brigitiana</i> R.Baker | Myrtaceae | SE Aus. | # |
| <i>E. tereticornis</i> Sm. | Myrtaceae | E Aus. | # |
| <i>Ficus microcarpa</i> L.F. | Moraceae | native | # |
| <i>Glyptostrobus pensilis</i> K.Koch | Taxodiaceae | SE China | # |
| <i>Grevillea robusta</i> R.Br. | Proteaceae | E Aus. | # |
| <i>Hura crepitans</i> L. | Euphorbiaceae | S Am. | # |
| <i>Homenara cuneata</i> L. | Caesalpinaceae | S Am. | # |
| <i>Juniperus bermudiana</i> L. | Cupressaceae | Bermuda | # |
| <i>Liquidambar formosana</i> Hance | Hamelidaceae | native | ## |
| <i>Libocarpus harlandii</i> Rehd. | Fagaceae | native | # |
| <i>Livistona chinensis</i> R.Br. | Palmae | S China | # |
| <i>Lophocarpus confertus</i> Wils. & Waterh. | Myrtaceae | E Aus.### | # |
| <i>Mallotus paniculatus</i> Maell.Arg. | Euphorbiaceae | native | # |
| <i>Melaleuca quinquenervia</i> S.T. Blake | Myrtaceae | E Aus./NG | ## |

List of tree species used in afforestation "Environmental forestry in Hong Kong: 1871-1997" (R. Corlett).

Species

Large number of exotic species, were imported
- *Eucalyptus*, *Casuarina*, *Melaleuca* (1870-1900)
- *Acacia*, *Leucaena* (1900-1950)



Exotics used in slope re-vegetation

Species mix

Planting mixes that have include exotics,
have ended up being dominated by them.



Acacia spp. and Casuarina
sp. dominating slope
planting schemes

Species competition

Intended native tree species get out competed in the long term by fast growing (and allelopathic) exotics

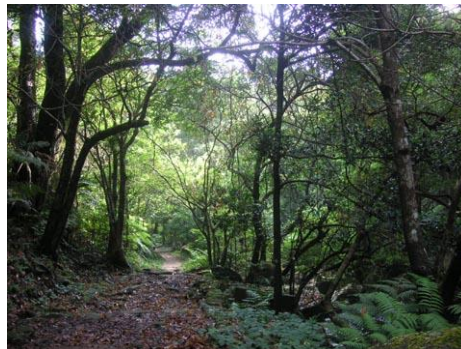


Image. SCMP.com

Exotic species not matching the natural landscape

Exotic vs native

Natives very much slower to become established, but often are more tenacious and will come through given enough time



Native tree species at Tai Po Kau and in the New Territories

Vegetation management

Long term maintenance of vegetation on slopes is rare
Clearance of vegetation is undertaken only where it is blocking
accesses or drainage channels, or poses a safety hazard



Maintenance of vegetation on slopes

Vegetation management

Thinning of planted slope vegetation (as part of long-term
management strategy) has never successfully been implemented
(for contractual / logistical reasons)



Thinning of woodland stands is standard practice in
Europe and North America

Image. doomsteadliner.net

Nature

Failure to understand the natural / ecological successional process of vegetation on the hillside



Yuen Shan, Tai Kong Po, Kamtin

Key questions

What species are there already?



Regenerating scrub and woodland vegetation on slopes at Mt Parker

Key questions

What would Nature do (what if we did nothing)?



Types of natural vegetation on slopes of HK Island

If there are adjacent areas of natural vegetation, thousands of seeds will naturally be carried into the site



Natural scrub vegetation on slopes

Planting design

In the past we have tended to have an overly aesthetic approach to planting design on slopes

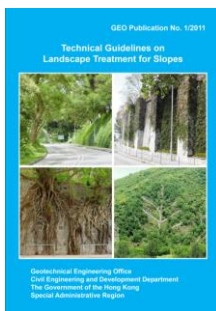
Exotic species used to achieve a rapid greening response



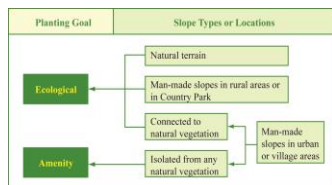
Artificial patterns of vegetation, Sai Kung, SENT Landfill

Ecological planting

Ecological approaches, based on use of native species to replicate vegetation on site / surrounding areas, have become more prevalent and successful in the last 10 years



Replanting of Anderson Road Quarry



GEO1/2011 recommends predominant use of native species

Images. CEDD, Janet Forbes

Planting technique

Most species used in hill slope re-vegetation can grow successfully on in the extreme climatic and physical conditions.

Plant failures are mainly due to short term technical planting issues.

Key factor in plant survival is water, and how newly planted seedlings can take up water fast enough to survive.



Images. Canon.com.hk (upper), Brother (lower),

Corporate sponsored volunteers undertaking hill slope planting work

Planting technique

High percentage of initial failures immediately following planting. Slow root establishment associated with exposure results in desiccation.

- Losses in planting trials 20-100%.
- Similar in practice.

Planting April-June has much higher chances of survival, due to high soil and atmospheric humidity.



Planting failures, Shek O Road

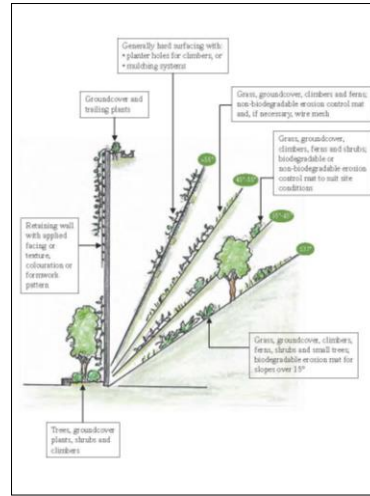
Nature of the slope influences plant establishment

In addition to geographic / geometric features plants are affected by:

- slope orientation
- slope angle
- altitude
- surrounding land use
- ecological context



Re-planted slope, Sai Kung



Slope Gradient, planting type diagram from GEO 1/2011

Nature of Cut slopes

In-situ soils can be thin, stony, nutrient poor, difficult to dig. Some are cut entirely in soil, some are predominantly rocky.



Vegetation on mixed soil / rock slopework



Natural soils are often very rocky

Capacity of the soil to support new growth also varies considerably

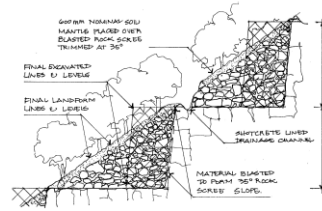


Slope planting, Sai Kung

Nature of Fill slopes

For geotechnical reasons placed soil layers placed over rock fill tend to be thin (as little as 150mm deep), so have a propensity for drying out.

- Placed soil can be highly compacted.
- Addition of cement to surface layers can make plant establishment even more difficult.



Cover soil layer at Shek O Quarry, Detail from the Landscape Masterplan



Re-vegetated slope

Image. (top) Pioneer Quarries



Slope works at Anderson Road

Nursery seedlings

Persistent problems with poor nursery stock (quantity over quality)



Tree production nurseries in Guangzhou

Poor root stock

Narrow Root system, due to rooting condition, lack of biomass volume (to support re-growth)

Poor root branching, not undercut / root pruned to promote the growth of fine absorbing roots



Seedling trees with soil removed from their root balls to reveal extent of root system

Seedling size

Shorter specimens (300 high) are reportedly much more successful than 900 high

Taller plants often sold due to inefficiencies in the nursery production system (not enough volume, plants kept too long in the nursery)



Seedlings planted in landfill restoration works at SENT



Seedling trees in Shunde nursery

Seedling size



Range of tree seedling sizes, nurseries in Guangzhou

Specimens grown too close together, to create height (considered more valuable by the industry)

Taller plants have narrow canopy, immature branching structure, poor stem taper, high crown ratio

Plant failures

Plants grown in sheltered / shaded nurseries, crowded with other plants and regularly watered, have no chance to be acclimatized when planted out on the hill side



Seedlings failing immediately after planting, SENT landfill restoration works

Wind burn is very common, reduces plant vigor and allows in insects and diseases

Root ball volume

- Root balls too small to retain enough moisture
- 300-600 high seedling will normally come with a 100mm dia (0.785 ltrs) black plastic root ball
- should be at least 200 dia x 200 deep (6.2 ltrs)



Need to maximize root ball size, but that is very expensive in terms of handling



Seedling trees in Guangzhou nurseries

Poor quality root ball soil

Use of hydric mud as a root medium in the production of seedlings, as it holds together better during transportation (and it is cheap) does not have good soil moisture



Hydric mud used for root balls, Guangzhou nurseries

Handling

Problem with root ball quality and size are compounded by damage due to poor handling



Standard approach to packing seedling trees for delivery

In packaging of plant stock for transportation, many plants crushed (differential between weight of root ball and delicacy of stem and canopy)



Accessibility

Access nearly always by foot, up steep steps.

- Moving plant and other materials especially difficult due to their weight
- Key problem is the importation of water, if not directly available on site.



Hill slope planting by Kadoorie Farm on Tai Mo Shan



Images. (left) SCMP

Working on slopes

Planting work on slopes is laborious

- forming planting pit,
- mixing soil conditioner with the back fill,
- planting, backfilling,
- firming in, watering



Problems of working on slopes
SENT landfill restoration works

Working on slopes

Cutting / repairing erosion control matting and wire mesh

Geotextile erosion control matting



Coir erosion control matting



Wire mesh

Image (top left) Halcrow China

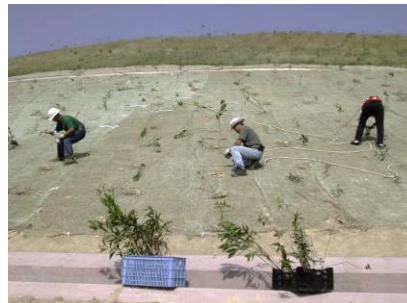
Working on slopes

Moving on steep sloping ground is difficult and dangerous

Most planted slopes are 27-35 degrees. Safety standards require the use of anchored ropes, making movement very slow and time consuming.



Problems of working on slopes
SENT landfill restoration works



Dragging ropes can damage newly planted trees

Image (right). James Walker

Planting pits

Bigger planting pits are better for transplant recovery, but creates greater potential for erosion

- angle of excavation with respect to slope
- placement of excavated soil above the excavated hole



Pit planning
SENT landfill restoration works

Soil moisture

Watering thoroughly beforehand is effective in raising success rates,

- watering the planting pit after planting is ineffectual
- complete immersion of the root ball prior to planting, is much better.



Planting in remote hill slope locations, Penny's Bay Development, by helicopter

The 'seedling' model for re-vegetation

Growing and preparing the seedling, planting layout and species matrices, forming planting pit, amelioration of soil, watering, cutting of surrounding vegetation – all artificial constructs, that are contractually difficult to achieve, and problematic for long term management / maintenance

.... is a lot of effort to produce a poor facsimile of nature,



Slope planting



Single species plantations

Images (left to right). Sinopec, AFCD, Halcrow China

Re-vegetation objective

- a sustainable, ecologically relevant vegetative cover?
- or
- just green?



Images (left to right). Urbis Limited, Getty Images, Janet Forbes

Planting of restored quarry at Shek O

Alternative approaches to re-vegetation

What if we did nothing ?



Natural succession of vegetation on hill slopes



Seeding

- Grass hydroseeding (native species) for erosion control
- Direct seeding of shrub and tree seeds and active management to facilitate plant establishment



Grass and tree seed hydroseeding

Images. (top left, bottom left) Halcrow China, (bottom right) MTS Fibromat Sdn Bhd

Conclusion

Complex challenges in establishing plants on slopes demand specific rather than prescriptive approaches.



Re-vegetated slopes
in New Territories

Conclusion

Essential to know the nature of the site and slope, and look to replicate what is existing as far as possible

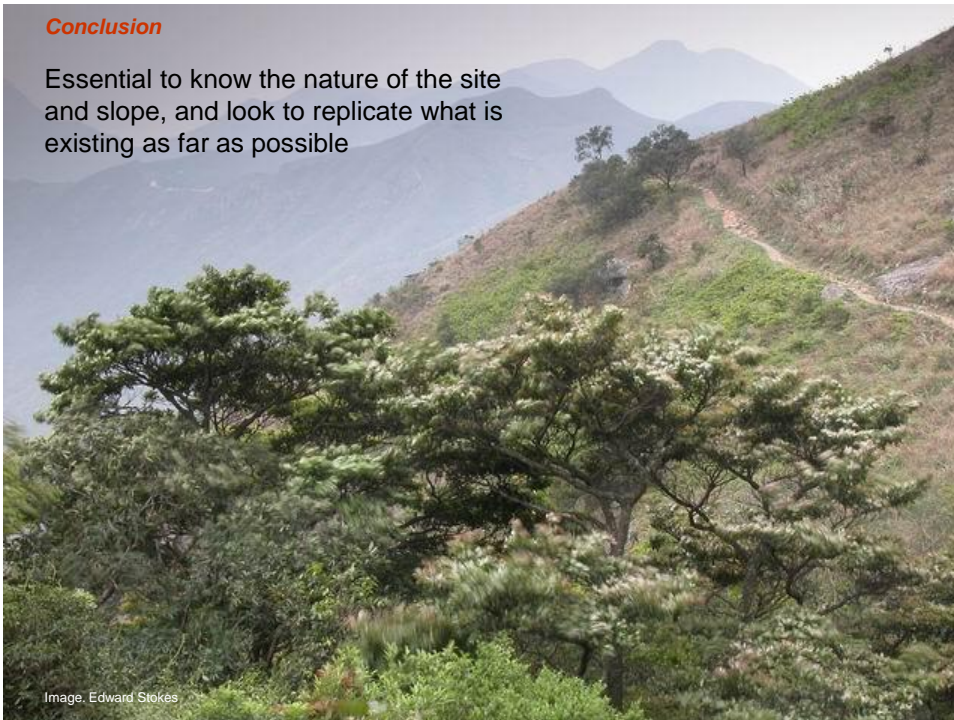


Image: Edward Stokes

7th Annual International Arboriculture Summit - Hong Kong, November 2014

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Mt Parker

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