Native Species Restoration in Hong Kong, China

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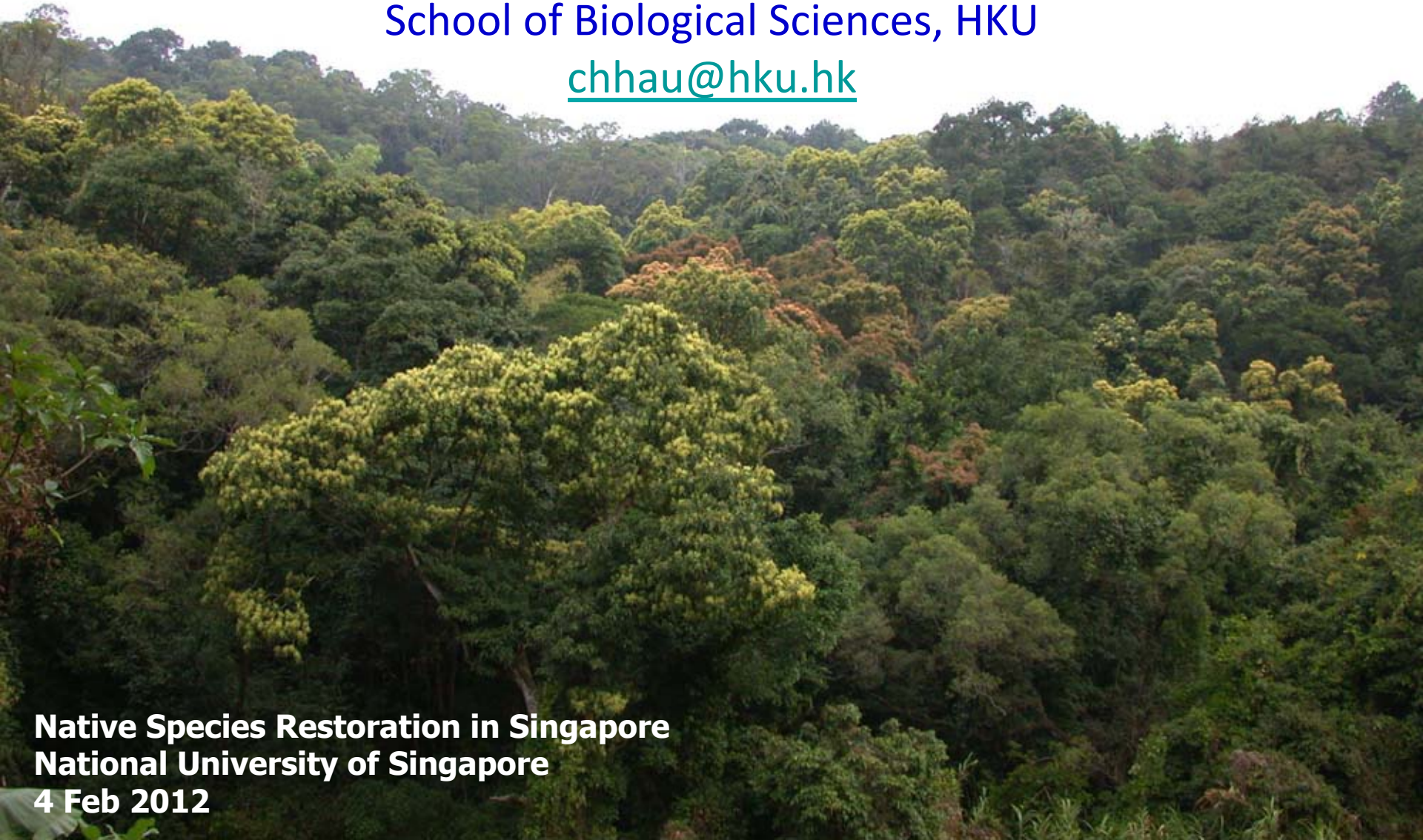
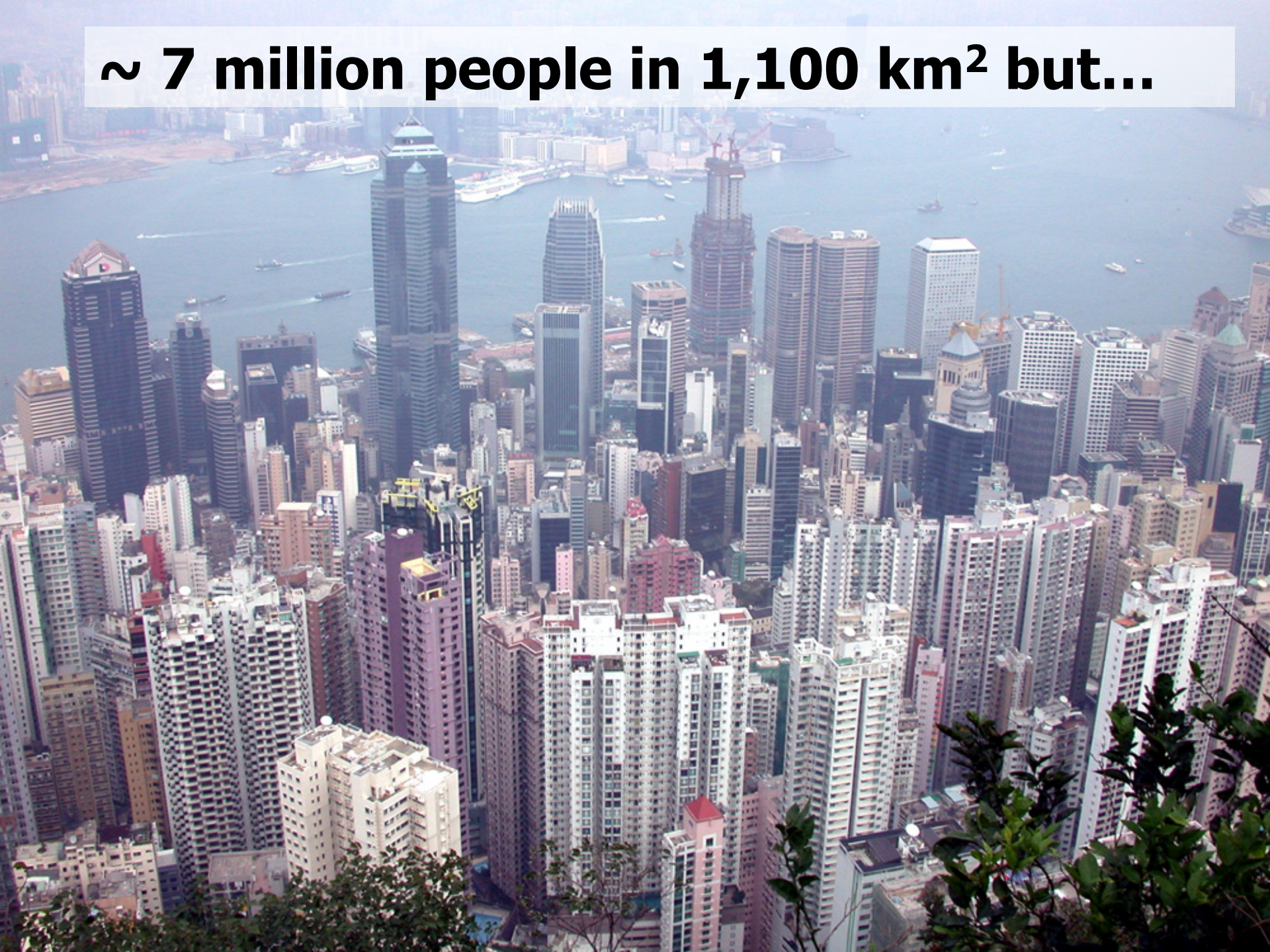
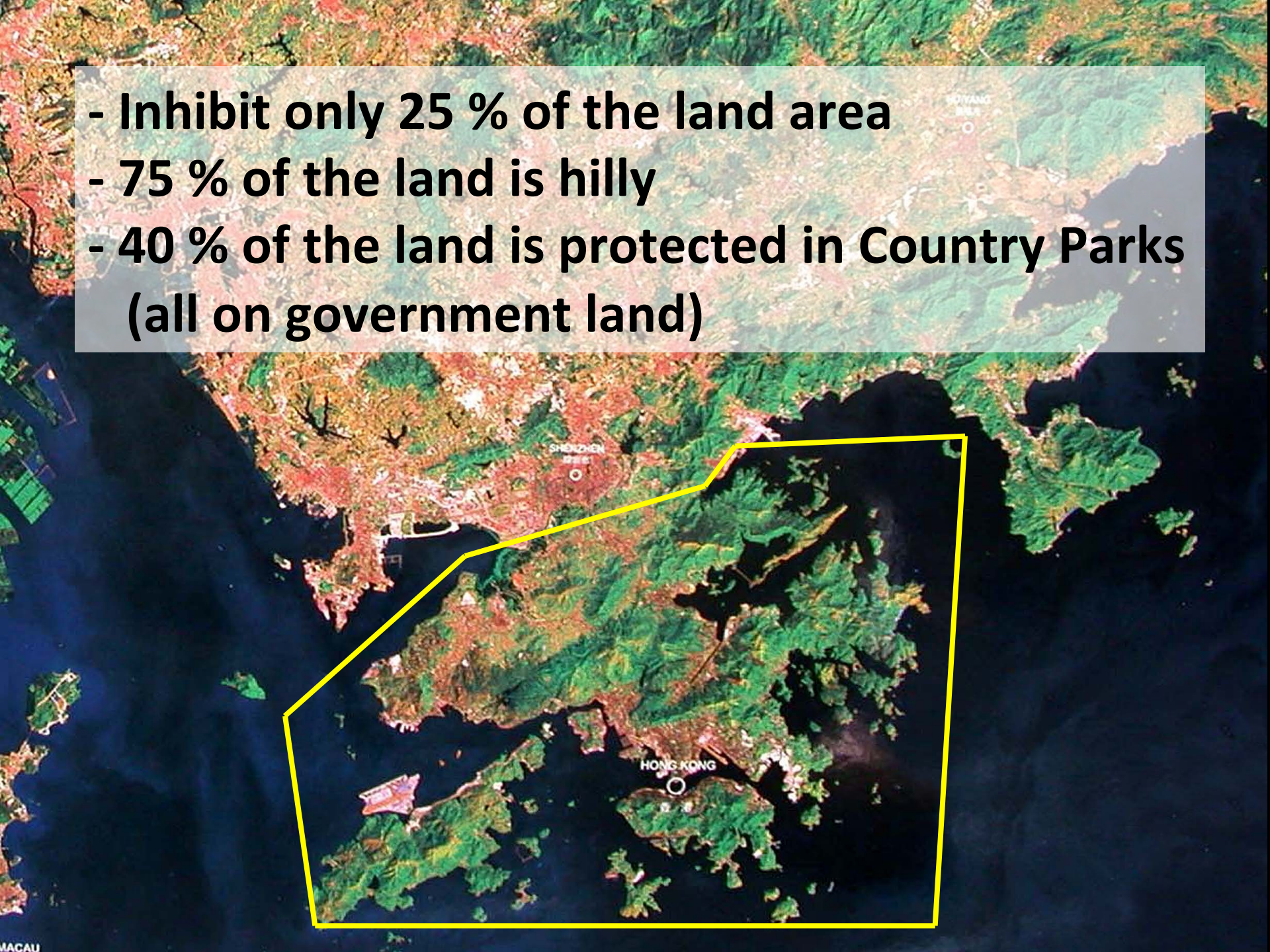
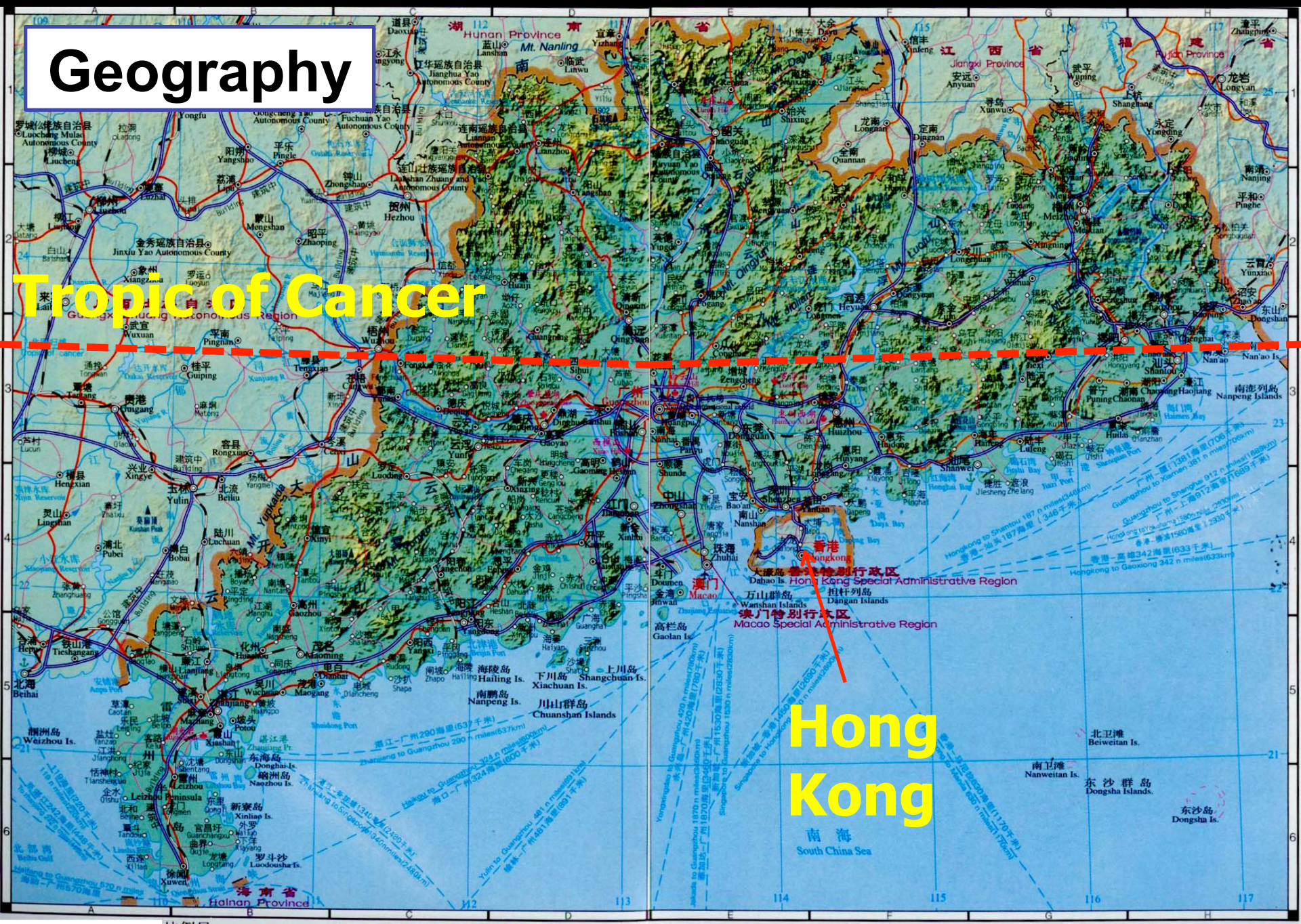


Native Species Restoration in Singapore
National University of Singapore
4 Feb 2012


~ 7 million people in 1,100 km^2 but…

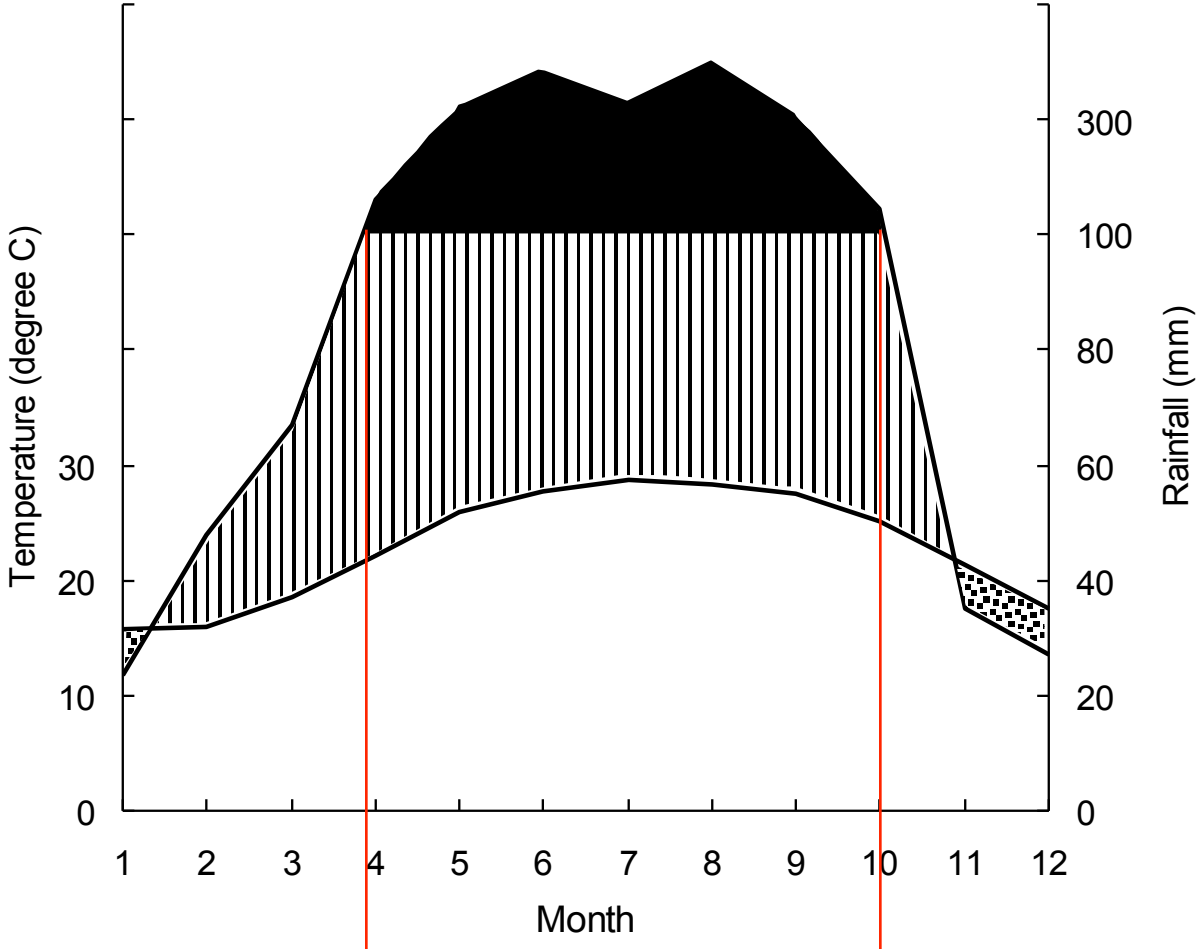

- Inhibit only 25 % of the land area
- 75 % of the land is hilly
- 40 % of the land is protected in Country Parks
(all on government land)
SHENZHEN
HONG KONG
MACAU

Geography


Tropic of Cancer
Hong Kong
Hunan Province
Mt. Nanling
Jiangxi Province
Fujian Province
Hong Kong Special Administrative Region
Macao Special Administrative Region
South China Sea
Hainan Province
比例尺 Scale 1:3 350 000
0 33.5 67.0 100.5千米 (km)

The Hong Kong Climate Diagram

1961-1990 averages: 23 °C / 2,214.3 mm



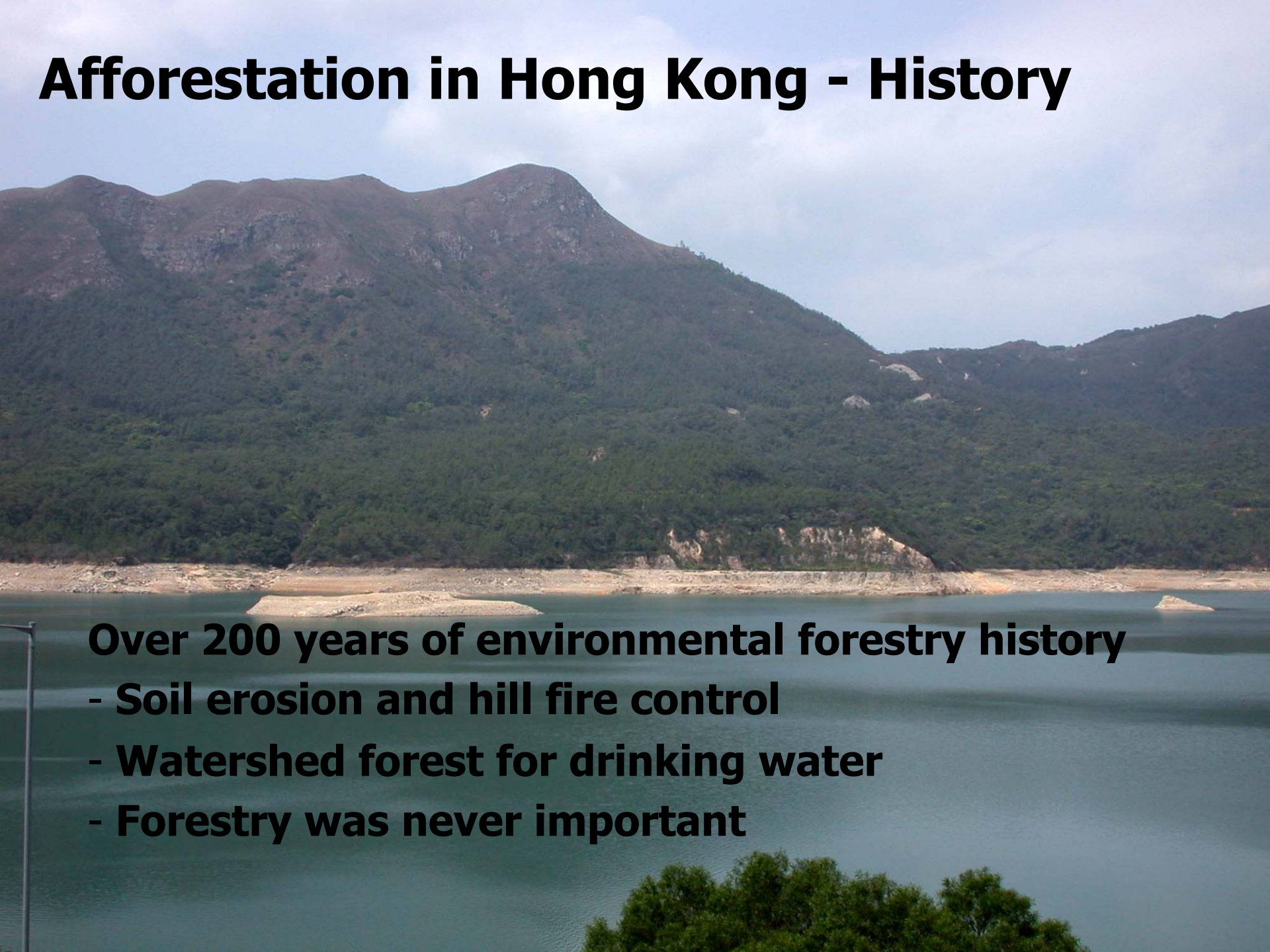
Hong Kong was once entirely covered in dense forest

Deforestation in Hong Kong – completed 500-800 yrs ago!

The last major territory-wide deforestation in HK happened in the Second World War

Hong Kong 1946 – 1967 (Stoke, 2005)

Afforestation in Hong Kong - History



Over 200 years of environmental forestry history

- Soil erosion and hill fire control
- Watershed forest for drinking water
- Forestry was never important

Reforestation in HK

Before World War II

- *Pinus massoniana*
- Native
- By aerial seeding
- A mixture of native and exotic species also tried.

Reforestation in Hong Kong

After World War II

-Mainly exotic species

Lophostemon confertus

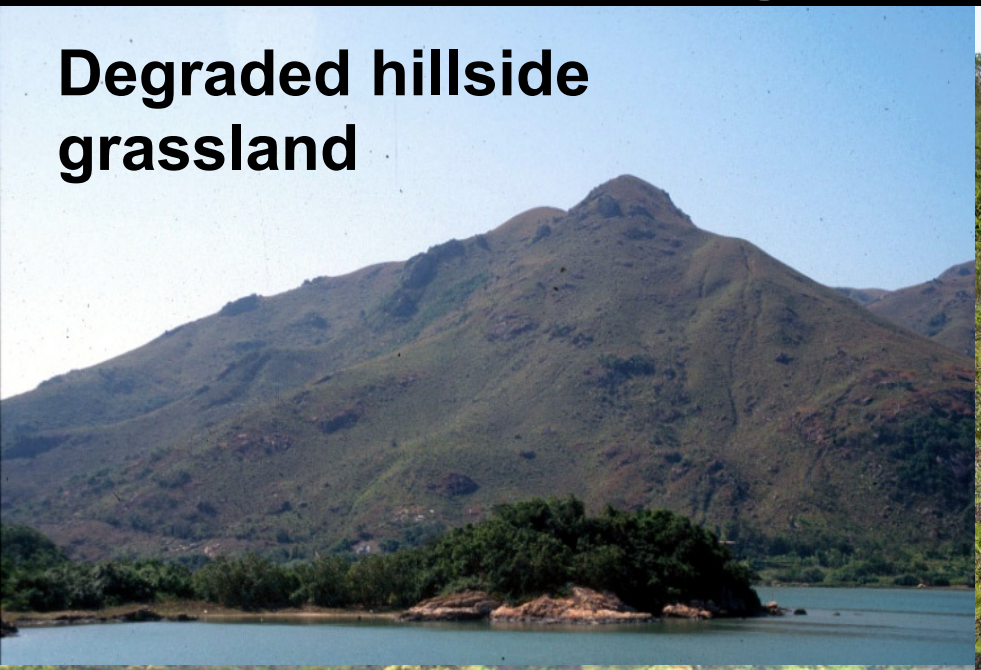
Acacia confusa

Melaleuca quinquenervia

Eucalyptus sp.

Monoculture of *Lophostemon confertus*

Current natural vegetation of Hong Kong



The vegetation cover of Hong Kong in the 90s

Vegetation cover	Area (km^2)	% of the total land area
Shrublands	396	37
Grasslands	177	16.5
Secondary forest	86	8
Plantation	62	5.8

(Dudgeon & Corlett 1994)

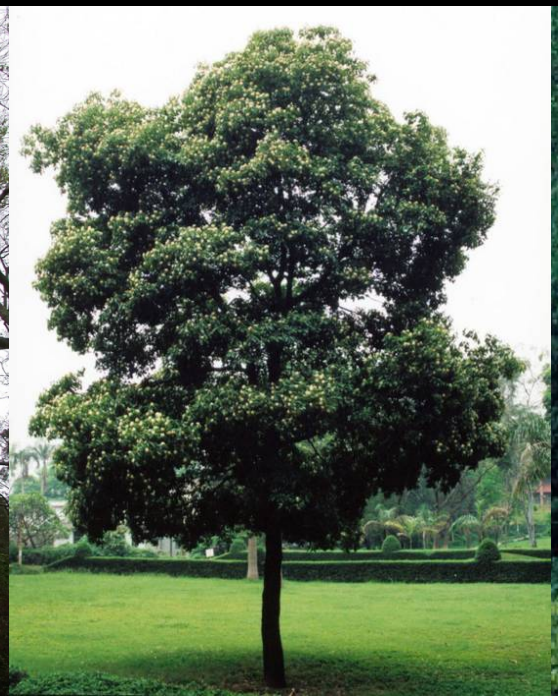
Public demand on using native species for biodiversity conservation was on the rise!!!

Only a few native species were used by the government since after the Second World War in low numbers

Castanopsis fissa

Liquidambar formosana

Schima superba



Machilus breviflora

Government's excuses then:

- Native tree species often failed to establish on exposed sites;
- Even if they survived, they grew slowly;
- Lack of seedling supply of native trees;
- Even if seedlings were available, they were expensive.

Many EIA planting projects in the 90s specified the use of native species but had to revert back to exotic species because of the lack of commercial supply of native tree seedlings

Yet, Hong Kong is rich in tree species

390 native species in 67 families and 192 genera (Fagaceae, Lauraceae)

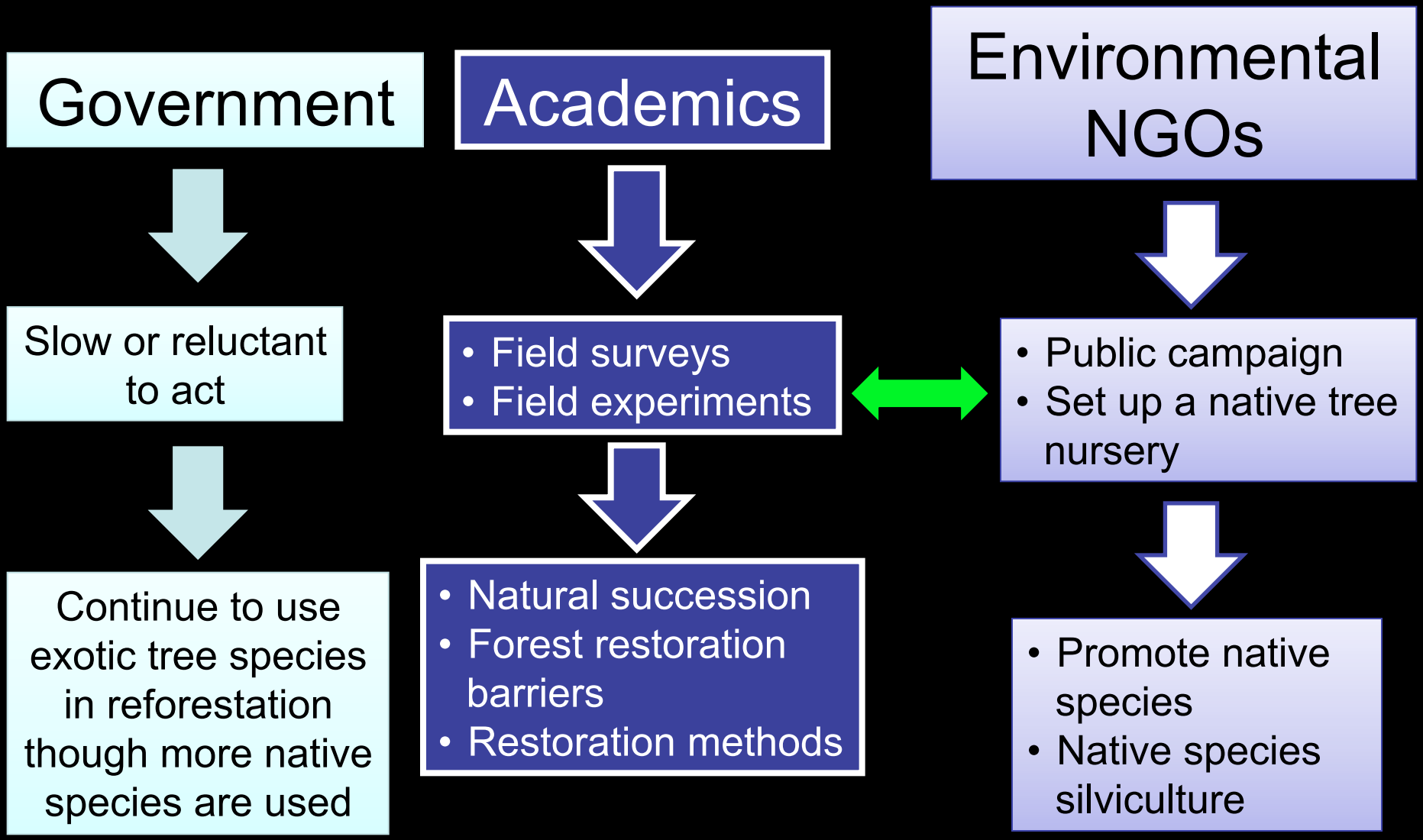
Up to the 1990s…

Little is known about the 390 native tree species in HK:

- Flowering and fruiting phenology
- Silvicultural information
- Seedling growth conditions in nursery and in the wild

Since the 1990s

Using native tree species for forest restoration in HK



Research

Natural forest succession in Hong Kong

Grassland

10 yrs

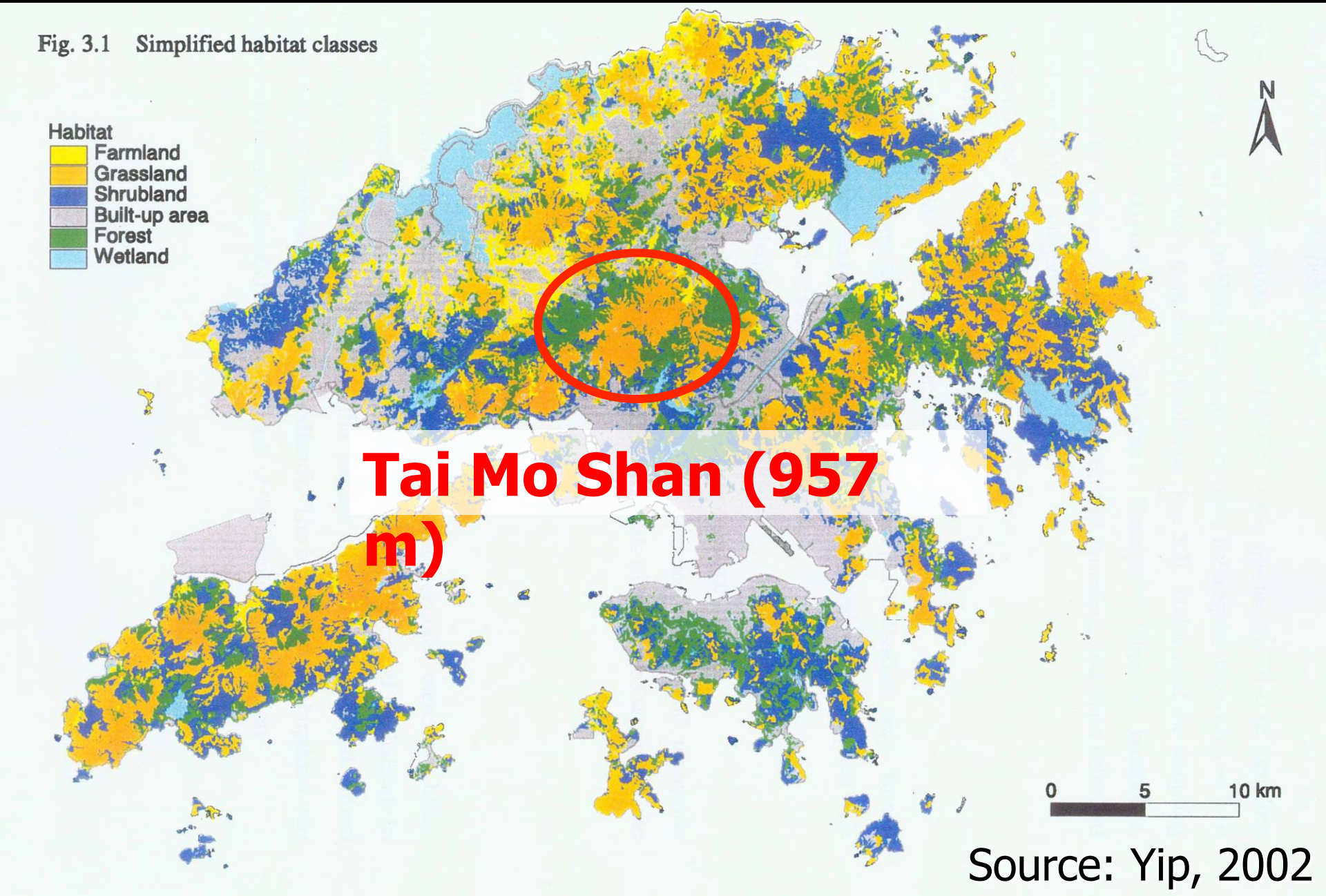
Shrubland

30-40 yrs

Secondary forest

(Chau 1994; Zhuang & Corlett, 1997)

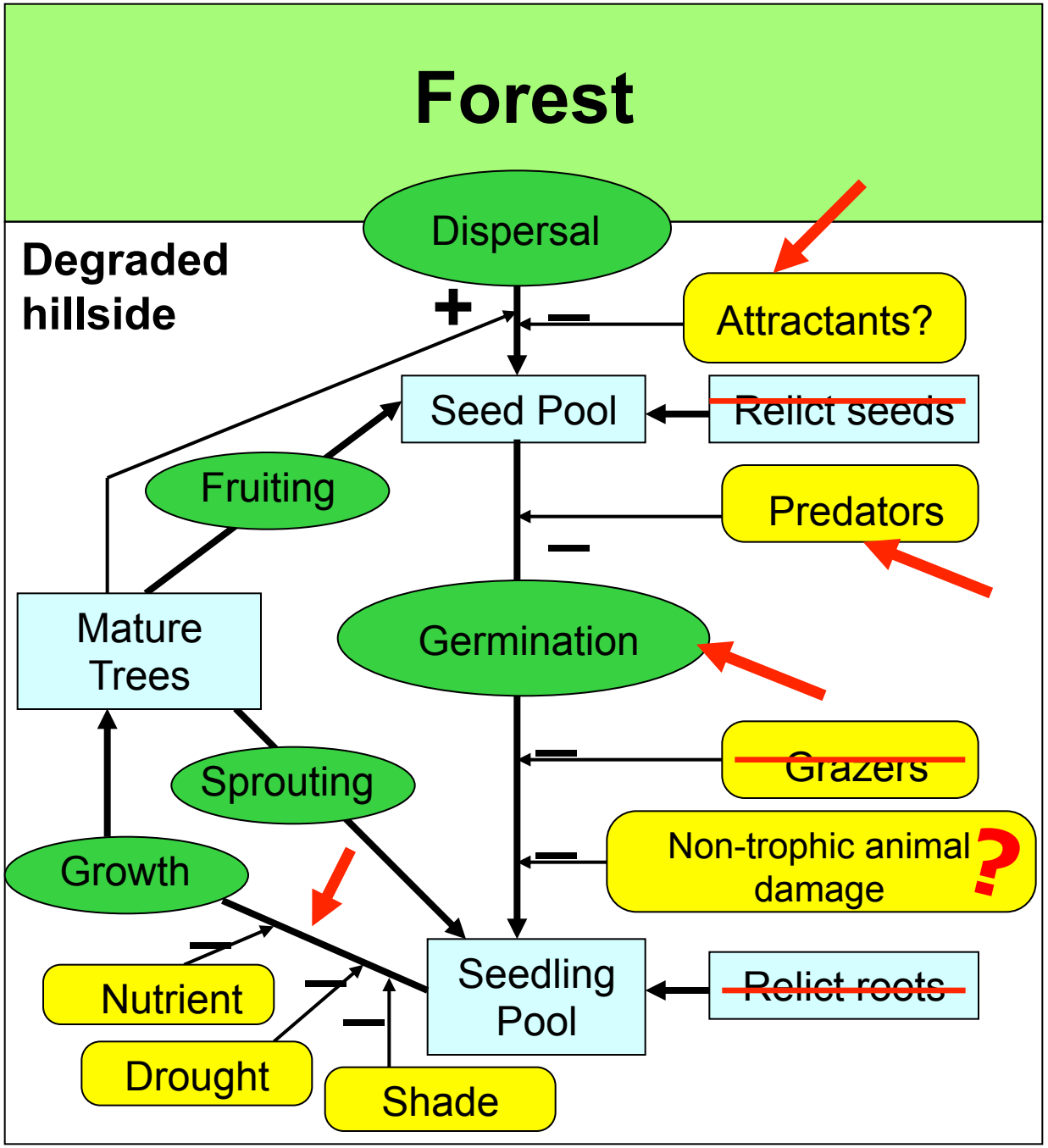
Research: Natural barriers to forest regeneration in HK



Source: Yip, 2002

Tai Mo Shan

Natural barriers to forest regeneration in HK



Modified from Nepstad *et al.* 1990

Natural barriers – seed dispersal

Au, Corlett & Hau 2006

- Compared seed dispersed into grassland, shrubland and forest of Tai Mo Shan for 2 years
- Results: seed input into grassland was surprisingly high
- Qualitative difference between habitats

Table 1. Seed rain of woody taxa into seed traps placed in six habitats in upland Hong Kong.

Sites	Seed number (seeds m^{-2} yr^{-1})	Fruit equivalents[a] (fruits m^{-2} yr^{-1})	Seed taxa	Taxa per 100 seeds
Grassland: open	47	5	9	19.2
Grassland: isolated trees	890	90	42	4.7
Grassland: female shrubs	6455	733	28	0.4
Grassland: male shrubs	611	52	15	2.5
Shrubland	558	213	59	10.6
Forest	129	59	42	32.6

[a] Number of seeds of each species in the seed rain divided by the mean number of seeds per fruit. Fleshy fruited species only.

Natural barriers – seed dispersal

Au, Corlett & Hau 2006

- Birds especially bulbuls are the major seed dispersers
- 85% of the taxa and >99% of the seeds trapped
- Estimated displacement is > 1 km in dry season (Weir & Corlett 2006)

Red-whiskered Bulbul
Pycnonotus jocosus

Light-vented Bulbul
Pycnonotus sinensis

Natural barriers – seed dispersal

Summary:

1. Only a sub-set of the local tree flora is dispersed naturally on the degraded hillside
2. The seed rain is adequate for the development of woody vegetation cover
3. Birds especially the bulbuls are the major seed dispersers

Natural barriers – seed predation

Hau, 1997; Chung 2006

- Compared both grassland & shrubland sites
- Rodents are the major seed predators (*Niviventer fulvescens*; *Rattus sikkimensis*)
- High temporal and spatial variations
- Predation rate could reach 100% in 2 weeks
- Predation rate in grassland is much lower than that in shrubland

Seed predation is patchy in space & time. It is also a selective barrier on forest regeneration but will not significantly reduce the availability of woody seeds for forest succession.

Natural barriers – seed germination

Chick, 2005

- Tested the germination of 23 common native tree species on Tai Mo Shan grassland
- Most species can germinate
- At least 6 species have germination rates higher than 60% and larger than 50% of the germinated seedlings survived after a year.

Adverse conditions in the field for germination such as drought; lack of shade again act as selective barriers only.

Natural barriers – seedling growth & survival

Hau & Corlett 2003

Tested 4 native tree species:

- below ground competition with grasses
- seasonal drought
- low soil fertility

All 3 factors can significantly impair seedling growth but that their relative importance differs among species.

Natural barriers - Seedling growth & survival

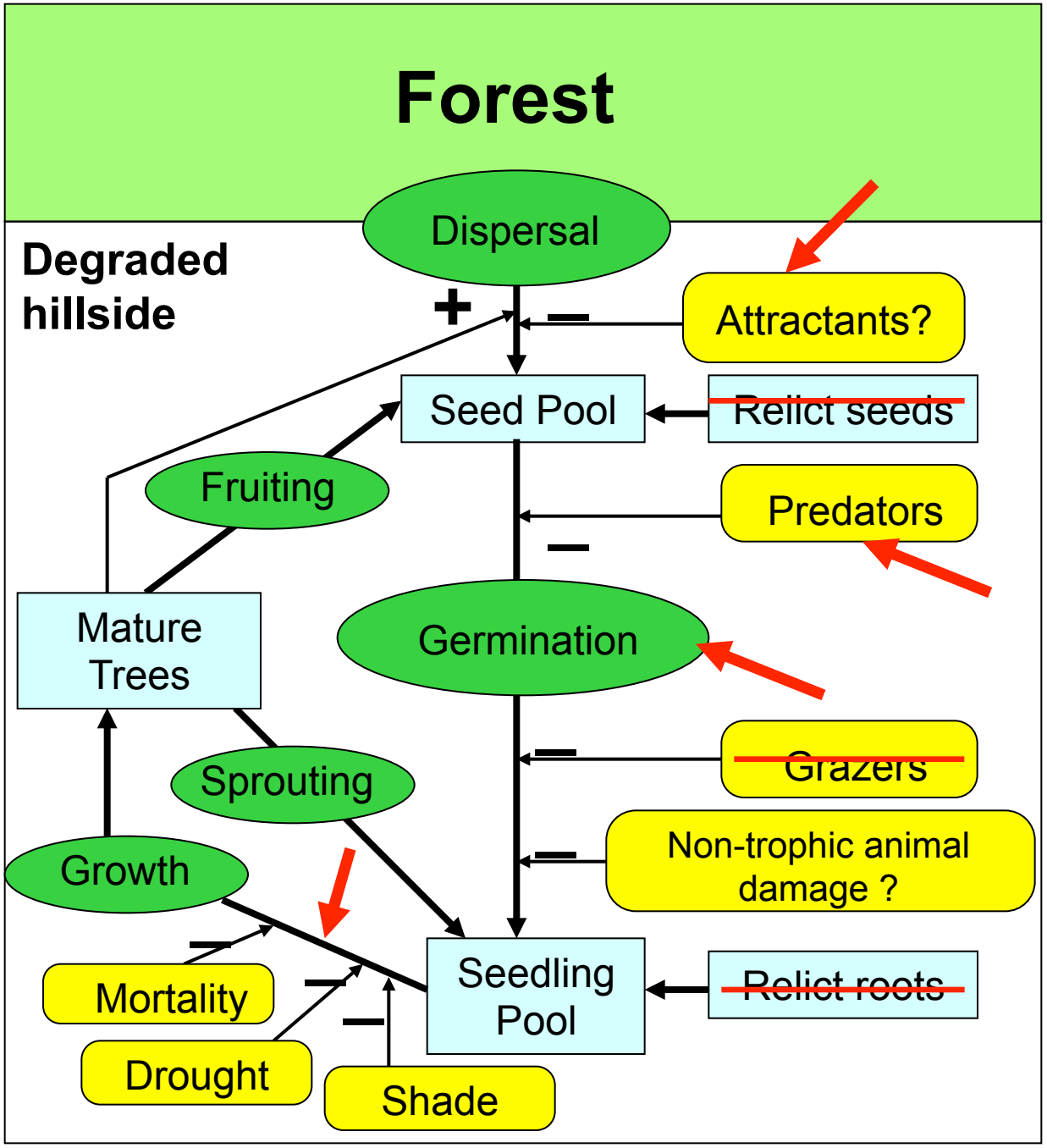
Hau & S0 2003

- Reported another 8 native species planted on a grassland at Tai Mo Shan in 2001
- Survival (2 year) between ~50 – 97% for all except one species.
- Reached 2 m in 2 years for most of the species

Feb 2001: A 7 m canopy is formed

Natural barriers

All natural barriers tested appears to be selective barriers only!



Modified from Nepstad *et al.* 1990

1997

Up to 50,000 seedlings/ year
Local seeds

Field planting trials

Since 1997…

- 200 native tree and some shrub species of over 200,000 seedlings produced.
- For use in voluntary, commercial and government reforestation projects
- Public education programmes
- Also used in supporting research works of local universities (8 MPhil projects and numerous undergraduate projects)
- And some basic research works

Germination tests

- > 121 species tested
- 75 species > 50 % germination rate
- plus 30 other species known to germinate well from past experiences

Nursery growth rate tests

- Around 90% of the species grown in the nursery could reach the transplanting size of 30-50 cm in 18 months.

Other research work in the nursery

Quality stock

Other research work in the nursery

- Mycorrhizas
- Genetic diversity
- Nitrogen-fixing native tree species

Ng and Hau 2009

- Examined the N-fixing ability of native legume species
- Attempted artificial inoculation in seedling production

More field planting works by the nursery

Hung Lung Hang
- 1500 seedlings of 21 native tree species in a 1 ha site.

Planting trial at Hung Lung Hang

15 August 2002

Planting trial at Hung Lung Hang

3 Jan 2011 - a 10 m canopy

More field planting works by the nursery

Nam Shan, Lantau Island

-10,000 seedlings of 23 native tree species

-with another 40,000 seedlings of exotic tree species

Planting trial at Nam Shan, Lantau Island

Research works in exotic plantations

Lee, Hau & Corlett 2005; 2008

- Natural regeneration in exotic tree plantations

Lee 2004; Yu 2007

- Enrichment planting/direct seeding of native species in exotic plantations

Hung 2010

- Thinning plus enrichment planting/direct seeding of native species in exotic plantations

From 57 native species in 8 planting trials:

Framework species criteria	Species (13 species)
Toughness	*Gordonia axillaris*; *Schefflera heptaphylla; Mallotus paniculatus*
Attractiveness to wildlife/ Early production of wildlife resources	*Schefflera heptaphylla*; *Mallotus paniculatus; Microcos paniculata; Ardisia crenata; Melicope pteleifolia; Aporosa dioica*
Regenerative ability	*Schefflera heptaphylla*; *Mallotus paniculatus; Microcos paniculata; Choerospondias axillaris; Machilus breviflora*
Keystone species	*Aporosa dioica*; *Litsea glutinosa, Ilex rotunda, Schefflera heptaphylla*
Architecture	*Mallotus paniculatus; Choerospondias axillaris*
Vigour	*Schefflera heptaphylla*; *Machilus breviflora; Gordonia axillaris*; *Cyclobalanopsis championii*
Species with limited dispersal mechanism	*Cyclobalanopsis championii*; *C. neglecta*; *C. edithiae*; *Lithocarpus harlandii*

Hau & So 2003

Propagating the framework tree species

Species	Family	Easy to propagate	Notes
Ardisia crenata	Myrsinaceae	No	Low growth rate
Choerospondias axillaris	Anacardiaceae	Yes	
Cyclobalanopsis championii	Fagaceae	Yes	Forming Ectomycorrhizas
Cyclobalanopsis neglecta	Fagaceae	Yes	Forming Ectomycorrhizas
Gordonia axillaris	Theaceae	No	Low germination & growth rates
Ilex rotunda	Aquifoliaceae	No	Low germination rate
Machilus breviflora	Lauraceae	Yes	
Mallotus paniculatus	Euphorbiaceae	Yes	
Melicope pteleifolia	Rutaceae	No	Low germination rate
Microcos paniculata	Tiliaceae	Yes	Medium germination rate
Schefflera heptaphylla	Araliaceae	Yes	
Schima superba	Theaceae	No	Low germination rate
Zanthoxylum avicennae	Rutaceae	Yes	Medium germination rate

Hau & So 2003

No. of trees planted in Hong Kong

Year	No. of trees planted in HK (million)
1999/00	1.5
2000/01	1.6
2001/02	1.8
2002/03	2.5
2003/04	3.2
2004/05	1.8
2005/06	2.3
2006/07	2.0
2007/08	1.6
2008/09	1.3
Total	**19.6**

On average, 90% were planted in hillside reforestation

Source: Development Bureau Greening Website
http://www.devb-wb.gov.hk/greening/en/index.htm

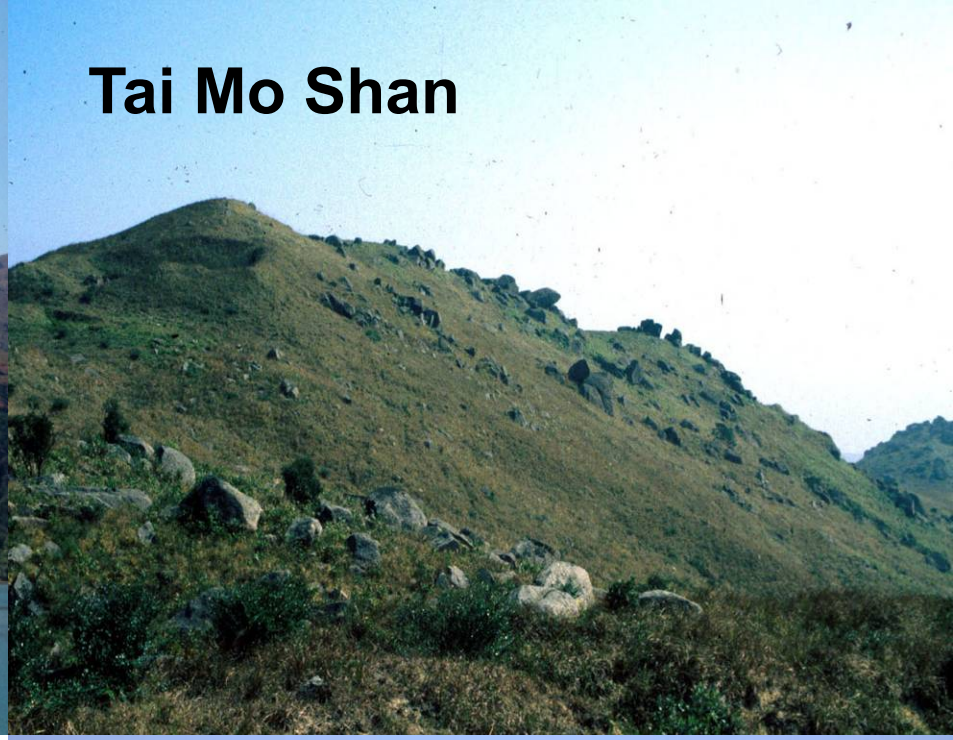
The vegetation cover of Hong Kong

	Dudgeon & Corlett 1994		ERM 2002	
Vegetation cover	Area (km^2)	% of the total land area	Area (km^2)	% of the total land area
Shrublands	396	37	224.5	20.1
Grasslands	177	16.5	347.8	31.1
Secondary forest	86	8	184.0	16.5
Plantation	62	5.8	1.8	0.16

Despite forest succession and active reforestation, the forest cover in Hong Kong is not increasing significantly in the last two decades.

North Lantau

Tai Mo Shan



Robin’s Nest (Hung Fa Leng)

Shek O

The impact of hill fire

The impact of hill fire

Hill fires in Hong Kong

- 1159 fires from 1993-2004 in Country Parks (on average 105 fires/yr)
- Most frequently burnt are grassland and shrubland
- Closed canopy forests do not burn
- There is no natural hill fire in HK

Anthropogenic hill fires

- Festival fires (Apr., Oct.)
- Accidental fires (careless visitors)
- Arson

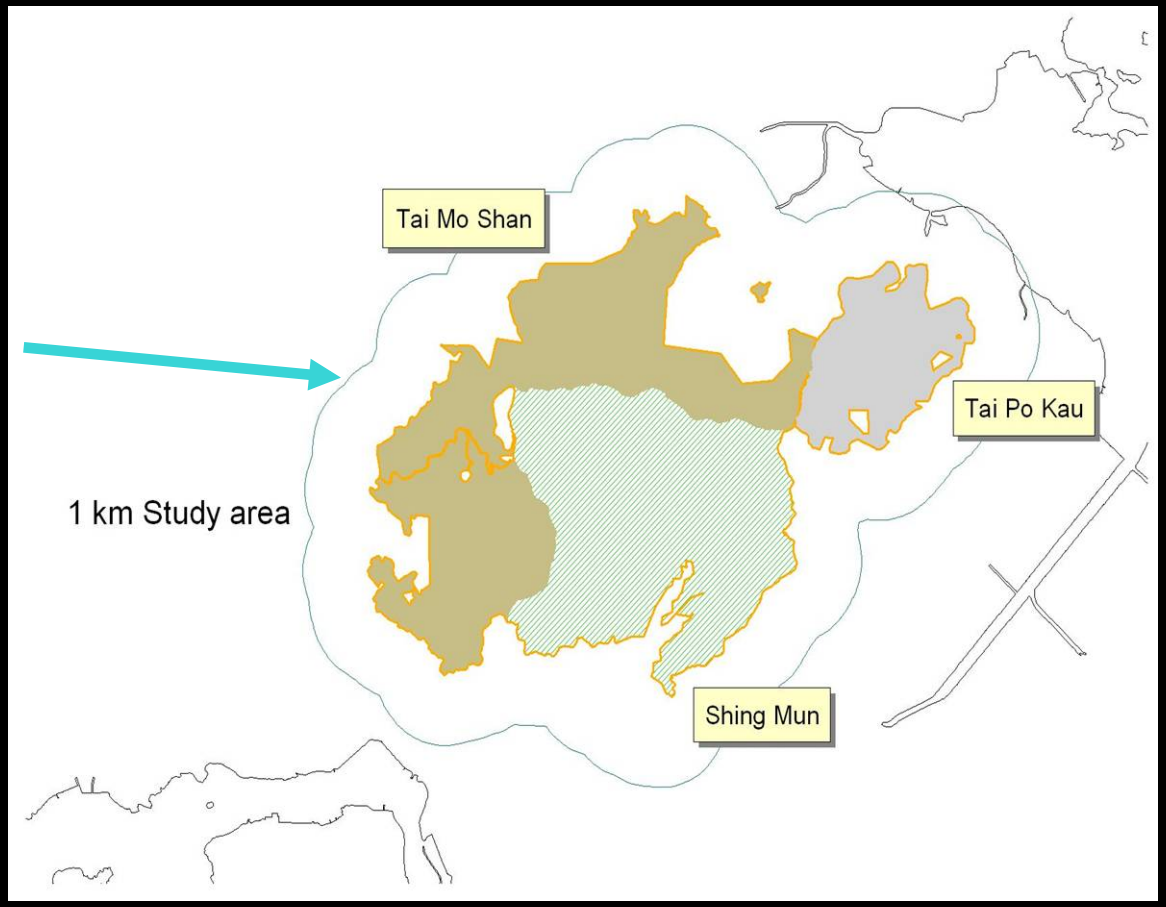
Ecological reforestation - The landscape approach

- The current afforestation approach on site by site basis in Hong Kong does not work!
- Many young planting sites have been destroyed by hill fires in the last decade costing millions of dollars
- A new reforestation approach on landscape level integrating fire prevention is needed

Forest reforestation - The landscape approach

A Feasibility Study of Hill Fire Management on Tai Mo Shan using GIS Analysis (Chan 2005)

1 km strip from the boundaries of the 3 Country Parks



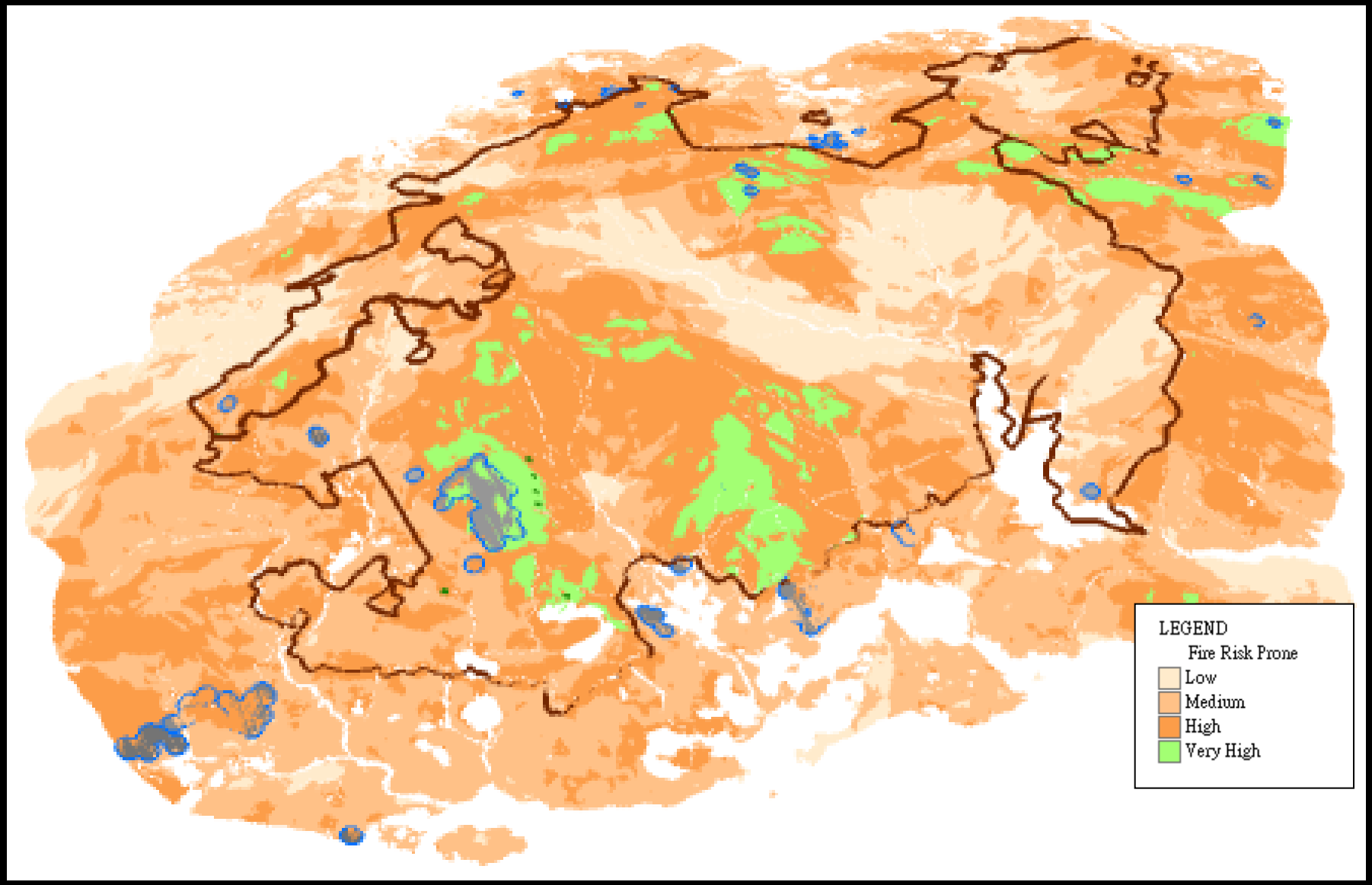
Forest reforestation - The landscape approach

a. Historical fire data (1993-2004) - from the government Fire Control Centre
b. Vegetation map - from ERM Hong Kong Ltd.
c. Geographical data - from Lands Department
d. Registered grave sites - from Lands Department

- **Historical fires**
  - **Fire frequency**
  - **Fire size**
- **Vegetation (fuel)**
  - **Close canopy forests**
  - **Shrubland**
  - **Grassland**
- **Topology**
  - **Slope**
  - **Aspect**
  - **Elevation**
- **Man-made structures**
  - **Grave sites**
  - **Roads & paths**
  - **Build-up areas**
  - **Villages**
- **Weather data**
  - **Wind**

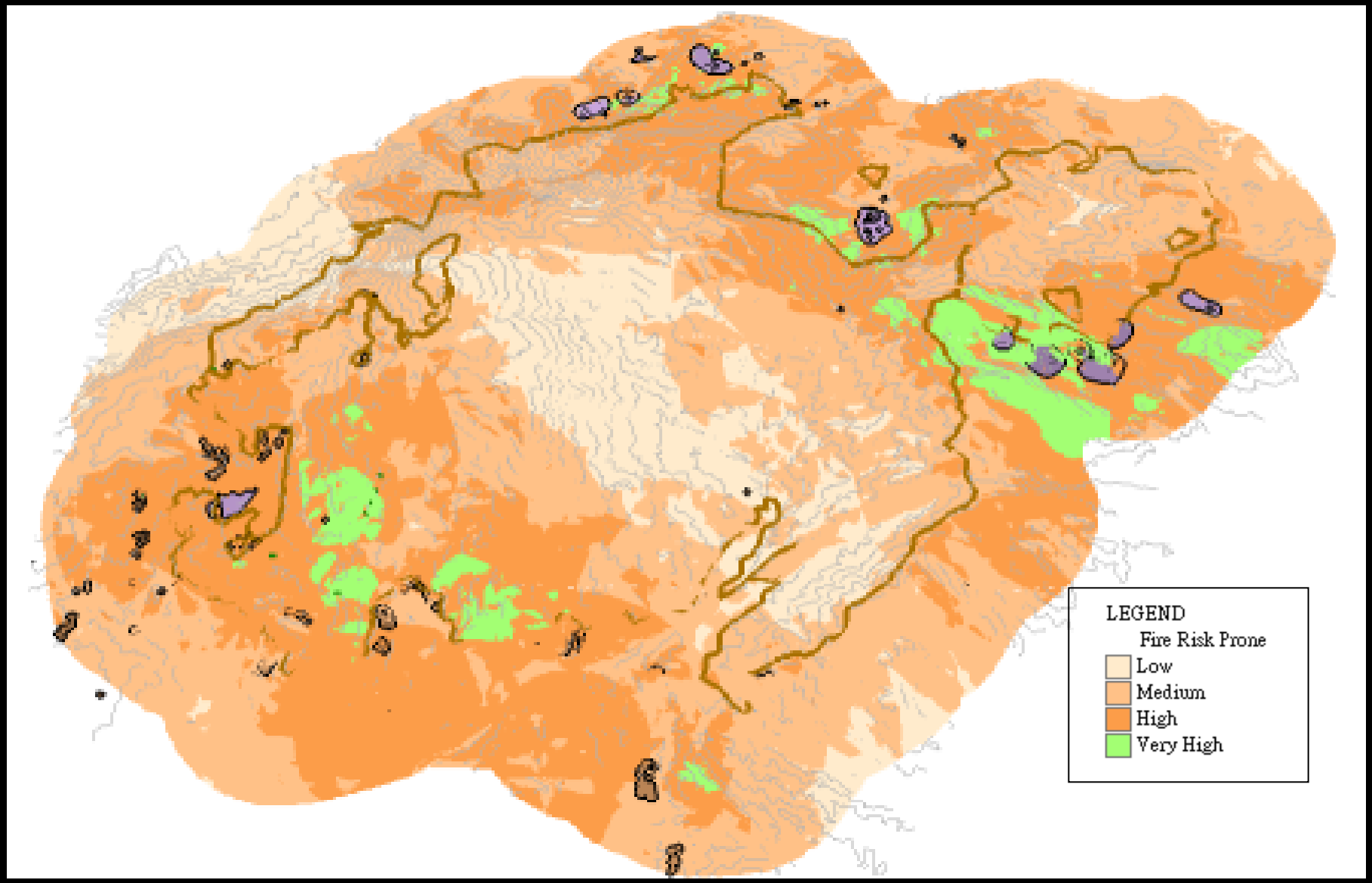
Forest reforestation - The landscape approach

RESULTS Festival fires: Fire sources and fire prone areas



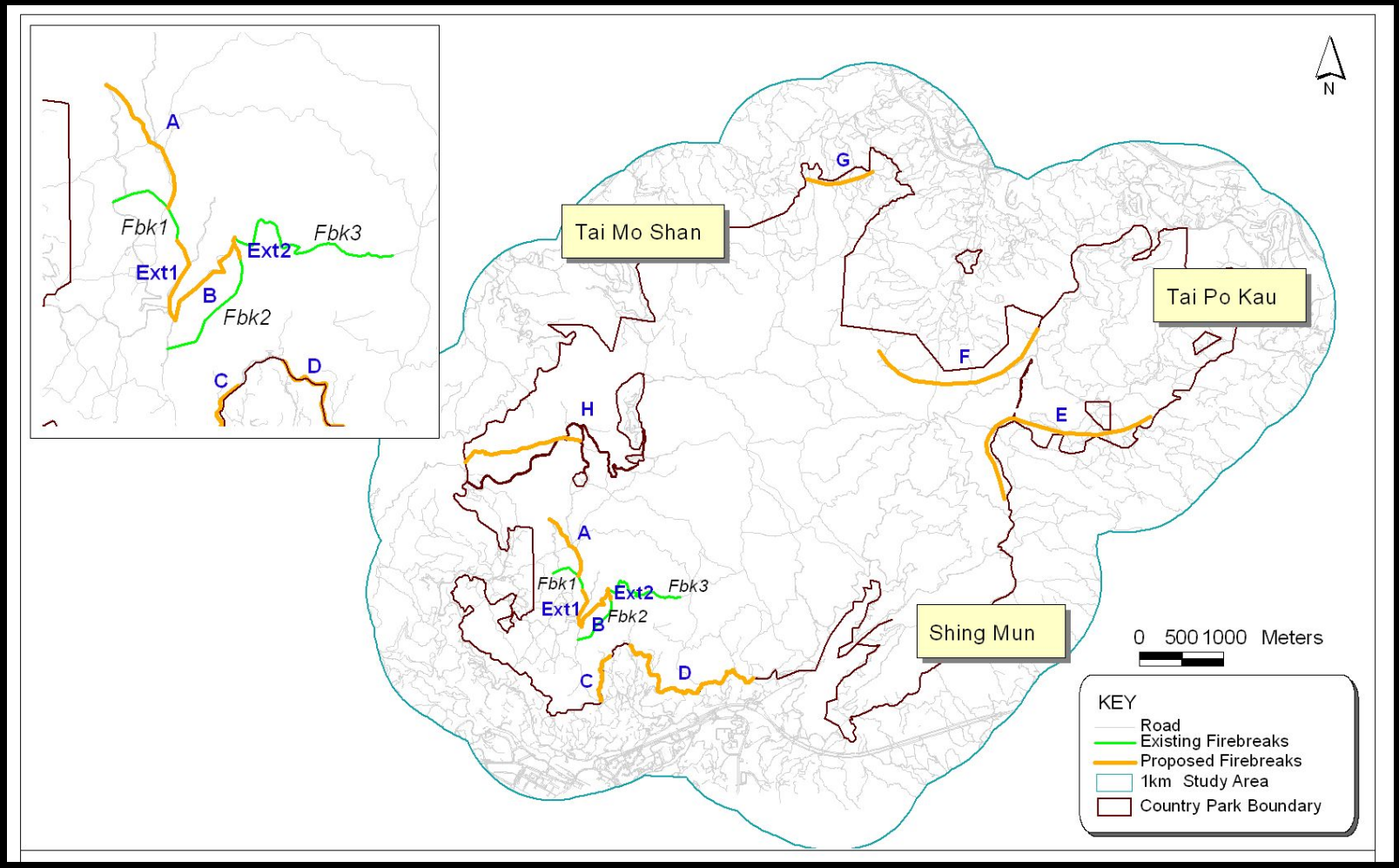
Forest reforestation - The landscape approach

RESULT Non-festival Fires: Fire sources and fire prone areas



Forest reforestation - The landscape approach

RESULT: Fire break design



Forest reforestation - The landscape approach

Conclusion for Tai Mo Shan

- First 10 years or so should focus on firebreak construction to isolate fire sources;

Forest reforestation - The landscape approach

Conclusion for Tai Mo Shan

- After the firebreaks become effective, allow natural succession to restore native biomass;
- Assist succession by adding plant diversity;
- Use cheaper methods such as direct seeding; planting island patches or corridors linking established forest patches to speed up succession.

This scheme could be applied to other parts of HK

On the government side

- Only one project in the 1990s (1993-1997)
- 60 ha hillside in Tung Chung, North Lantau
- 345,000 seedlings of over 50 native species

Since 2000, more native trees used in country parks reforestation. Up to 50% by now.

Recent years…

- The government is conducting large scale thinning and enrichment planting in exotic plantations;
- Commercial nurseries have steady supply of a limited number of native tree and shrub species (c. 20 species)
- The government is also planting more native tree and shrub species on roadside slopes
- The landscape level restoration approach is yet to be adopted by the government.

Experiences from Hong Kong

- Landscape level approach is needed for large scale reforestation
- Identify the real barriers (natural and artificial) to forest regeneration
- Reset priorities. In our case, fire prevention obviously has much higher priority.
- Natural succession alone can only restore native biomass, human intervention is needed to restore diversity.
- Lobbying the Government is important and there seems to be a significant lag time between research findings and government action.

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