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<th><strong>Title</strong></th>
<th>Fragmentation and rehabilitation of urban forests in relation to new town development</th>
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<tr>
<td><strong>Author(s)</strong></td>
<td>Jim, CY</td>
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<tr>
<td><strong>Citation</strong></td>
<td>The 18th European Forum on Urban Forestry (EFUL 2015), Brussels, Belgium, 9-13 June 2015.</td>
</tr>
<tr>
<td><strong>Issued Date</strong></td>
<td>2015</td>
</tr>
<tr>
<td><strong>URL</strong></td>
<td><a href="http://hdl.handle.net/10722/218235">http://hdl.handle.net/10722/218235</a></td>
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Fragmentation and rehabilitation of urban forests in relation to new town development

European Forum on Urban Forestry 2015
Brussels, 9-13 June 2015

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Introduction
Research context

Enhancing urban forest in the course of urbanization

Strategy

- Planned synergy: between nature and city
- Town plan: sympathetic to pre-urbanization ground truth
- Urban green infrastructure: inherited (remnant or relict) and created
- Geometry of forest cover: pattern and distribution
- Proximity and accessibility: between city (people) and nature
- Distribution and connectivity: peri-urban and intra-urban forests

Aims

- Quality of life and environment
- Ecosystem services
- Sustainable and smart cities
- Compact cities: more critical concern and need
- Compact cities: more physical and institutional constraints
Study objectives

**Effects of new town development on urban forest**

- Case study: Tai Po new town in Hong Kong
- Track changes before and after urbanization
- Map spatial pattern and distribution of forest
- Assess forest condition and performance
- Explore factors and processes leading to modifications
- Apply findings to nature conservation in new town development and urban growth in developing countries
II
Hong Kong: Contrast between City and Countryside
City contrasting with countryside

- Small area: 1108 km$^2$
- Rugged topography
- 80% >100 masl
- 25% developed
- Population 7.2 million
Extremely compact city

Ultra-compact and vertical city
  High building density
  High population density
  High road & vehicular density
  High human-land ratio
  Limited open and plantable space
Scenic, bucolic & serene countryside
Comprehensive & extensive protected-area system

Extensive coverage
~40% of land area

IUCN Category V Protected Areas (PA)
- Semi-natural and managed ecosystems
- Co-existence of protection, normal economic activities, recreation and tourism
New town in former rural and undeveloped land
III
Study Area
Tai Po New Town: location

New Towns Programme from 1970s
Transferred >2M people from old core
Tai Po New Town established in 1979
In New Territories (rural hinterland)
Tai Po old market towns (1945 map)

Sleepy old market town founded in 1672
Surrounded by villages and farmlands
Wet paddy cultivation and fishing
Tai Po location: aerial photo

Conservation by concentration
Tai Po: oblique aerial view

Compact development
High density
High rise
Green belt in urban fringe
IV
Forest Canopy Changes
Evaluation of peri-urban and intra-urban forest cover

Macro-scale forest canopy cover

Scope

- Pre-urbanization (3 phases) and post-urbanization (2 phases) periods from 1950s to 2000s
- Reconstruction of forest cover in landmark years
- Size, shape, continuity and fragmentation of forest patches
- Town core area (intra-urban) and hinterland envelope (peri-urban)

Data sources

- Large-scale sequential aerial photographs
- Topographic maps of different years
- Land use maps
- Government documents and records
- Field studies
Forest canopy in 1956

- Low total cover
- Small patches
- Scattered
-Disconnected
Forest canopy in 1969

- Increase in cover
- Coalescence into larger patches
- More connected
Some cover losses and fragmentation due to development
Forest canopy in 1986

Further cover losses and fragmentation due to development
Forest canopy in 1998

Notable increase in cover and continuity enveloping the...
## Forest canopy changes through time

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (km$^2$)</th>
<th>Change between periods (%)</th>
<th>Change from 1956 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-new-town scenario</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1956</td>
<td>3.7</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>1969</td>
<td>8.5</td>
<td>+129.7</td>
<td>129.7</td>
</tr>
<tr>
<td>1978</td>
<td>9.0</td>
<td>+5.9</td>
<td>143.2</td>
</tr>
<tr>
<td><strong>Post-new-town-scenario</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>7.7</td>
<td>-14.4</td>
<td>108.1</td>
</tr>
<tr>
<td>1998</td>
<td>15.5</td>
<td>+101.3</td>
<td>318.9</td>
</tr>
</tbody>
</table>
### Forest canopy changes in configuration

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Year</th>
<th>Farmland</th>
<th>Village</th>
<th>Market (Present C/R)</th>
<th>Road</th>
<th>Hillslope</th>
<th>Residential</th>
<th>Industrial</th>
<th>Open space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-new-town</td>
<td>1956</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1969</td>
<td>Increased</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1978</td>
<td>Increased</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-new-town</td>
<td>1986</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Pre-new-town**
  - 1956: Forest canopy changes in configuration start with base conditions.
  - 1969: Farmland increased, village increased, market density increased, road increased.
  - 1978: Farmland increased, village increased, market density increased, road increased.

- **Post-new-town**
  - 1986: Most trees were cleared with agriculture decline and urban expansion.
  - 1998: Farmland increased, village increased, market density increased, road increased.

- **Key Observations**
  - Some peri-urban areas zoned as village type development with increased road density.
  - More highways and roads were built designated as greenbelts, country parks, or SSSI.

- **Note:** These land use zones did not exist at the pre-new-town stage.
Forest canopy changes in distribution pattern

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Year</th>
<th>Farmland</th>
<th>Village</th>
<th>Market (Present C/R)</th>
<th>Road</th>
<th>Hillslope</th>
<th>Residential</th>
<th>Industrial</th>
<th>Open space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-new-town</td>
<td>1956</td>
<td>Dispersed, piecemeal</td>
<td>Scattered, small</td>
<td>Isolated, discontinuous</td>
<td>Elongated, narrow</td>
<td>Scattered, fragmented</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1969</td>
<td>Clustered, larger in size</td>
<td>Clumped, larger in size</td>
<td>Isolated, discontinuous</td>
<td>Elongated, narrow</td>
<td>N: continuous S: scattered</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1978</td>
<td>More connected</td>
<td>Continuous</td>
<td>Isolated, discontinuous</td>
<td>Elongated, narrow</td>
<td>N: smaller, connected S: larger, continuous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Some peri-urban areas zoned as village type development</td>
<td>More highways and roads were built</td>
<td>Designated as greenbelt, country park or SSSI</td>
<td>These land use zones did not exist at the pre-new-town stage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-new-town</td>
<td>1986</td>
<td>Most trees were cleared with agriculture decline and urban expansion</td>
<td>Broken up into a few clustered tree patches</td>
<td>Isolated, discontinuous</td>
<td>Rectilinear</td>
<td>Connected but scattered</td>
<td>Isolated, small</td>
<td>Scant tree planting (area under construction)</td>
<td>Piecemeal</td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td></td>
<td>Few pieces of continuous woodlands</td>
<td>Isolated, discontinuous</td>
<td>Rectilinear</td>
<td>Extensive, dense and continuous</td>
<td>Dense, clustered into small groups</td>
<td>Linear, scattered</td>
<td>Clumped, larger</td>
</tr>
</tbody>
</table>
V

Synopsis of findings
Initial drop followed by significant enhancement

After 30 years of intensive new town development

- ~3 times increase against 1956 baseline
- ~1.5 times increase against 1979 (initiation of new town)
- Maturity and stability: town plan and fabric, greenery cover

New town area at 3500 ha

- Total urban forest cover at 1550 ha (44.3% of new town area)
- Peri-urban forest alone at 1220 ha
  - 34.9% of new town area
  - 78.9% of total urban forest area

Critical contribution of urban fringe slope

- Green belt
- Conservation area (country park and SSSI)
Syncopacy of spatial changes in forest cover

Enhanced urban-forest attributes and functions

Geometric aspects
- Coverage
- Patch size
- Patch connectivity (linkage)
- Patch coalescence (aggregation)
- Tree size and biomass volume

Ecological and landscape aspects
- Vegetation structural complexity
- Species richness and diversity
- Ecological value
- Ecosystem services
- Landscape and scenic quality
Main losses and fragmentation of pre-urbanization vegetation

Former farmlands in lowlands
- Few trees were preserved in new-town fabric
- Un-accommodating grade raising to form development land

Lower slopes at town fringe
- Earth fill borrow areas (can be rehabilitated)
- Urban incursion (permanent loss)
Successful *green infilling*

**Human input**
- Afforestation in urban-fringe slopes
- Enrichment planting in simple or degraded forests (assisted succession)
- Planting in urban parks and greenspaces
- Planting at roadsides

**Natural process**
- Forest succession
- Continued growth of inherited trees

**Urban-forest configuration**
- Penetration and permeation of forest in urban matrix
- Allocating planting spaces with appropriate size, shape and location
- More tree cover than previous rural landscape
Ecological engineering of afforestation

Two-stage ecological-engineering approach to afforestation

- **Harsh initial site conditions**: eroded skeletal soil, moisture and nutrient deficit, hot and dry microclimate, windy exposure
- **Start with exotic pioneer species**: resistance to drought, fire, nutrient deficiency; nitrogen-fixing; fast-growing; high survival rate
- **Seedling planting method**: rather than direct seeding
- **Silvicultural input**: initial watering and weeding; thinning
- **Fast establishment** of woodland cover
- **Nursing crop**: trigger self-sustaining improvement in nutrient-capital accumulation, water-holding capacity, and microclimate conditions
- **Replacement of weaklings**: enrichment or fill planting by native equilibrium species; natural seed rain from proximal source areas
- **Simple exotic-pioneer floristic to diverse relay native floristic**
- **Enhance forest restoration**: pace, quality and diversity
The End
Thank You
Questions and Comments are Welcome