Spatial variations in forest succession rates revealed from multi-temporal habitat maps using Landsat imagery in subtropical Hong Kong

Ivan H. Y. Kwong*, Derrick Y. F. Lai, Frankie K. K. Wong, Tung Fung *(*Email: khoyinivan@link.cuhk.edu.hk)*
Department of Geography and Resource Management, The Chinese University of Hong Kong, Hong Kong

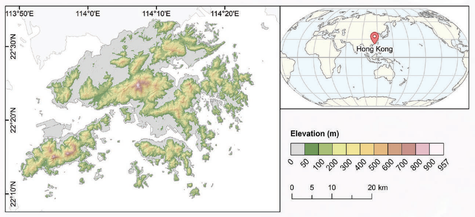
EGU General Assembly 2025
Vienna, Austria & Online | 27 April–2 May 2025
Link to abstract:
https://meetingorganizer.copernicus.org/EGU25/EGU25-2667.html

Introduction

Forest succession and driving forces
- Secondary succession is a major process in forest habitat restoration across degraded landscapes
- Multiple factors (e.g., biotic, abiotic, anthropogenic) are involved in the dynamics of vegetation changes over time and require comprehensive investigations of many variables

Effective use of remote sensing tools
- Repeated observations from remote sensing imagery can discern habitat patterns across spatial and temporal scales
- The Landsat satellite mission since 1972 has been increasingly used in time-series analyses, but an effective processing framework combining multi-temporal imagery is lacking

Study area
Hong Kong, in the northern Asian tropics with rich biodiversity but constant concerns about forest regeneration over decades



Research objectives
1. Integrate Landsat time series to produce multi-temporal habitat maps in 1973-2022
2. Evaluate classification accuracies across habitat classes and temporal periods
3. Examine forest succession patterns and their correlations with underlying factors

Results

1. A single classification model could be developed using all images acquired by multiple Landsat sensors across years, including the earliest Landsat 1–5 MSS data
- 90.1% overall accuracy, >86% and 88% when considering individual classes and mapping periods respectively *(Figures 1 & 2)*

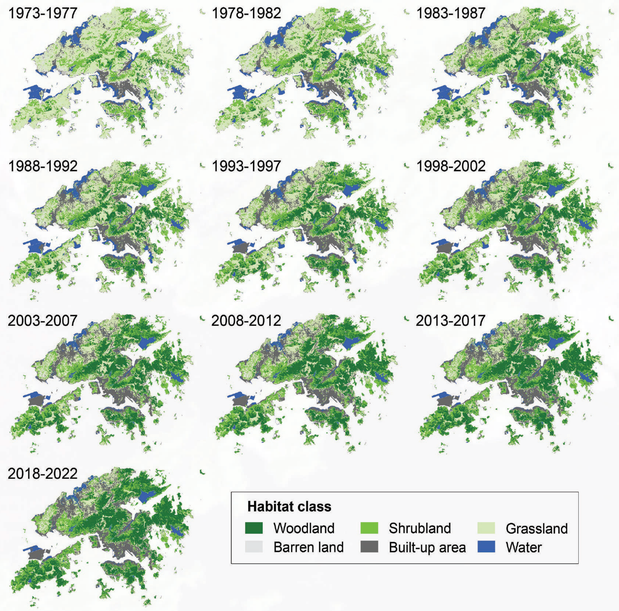


Figure 1: Habitat maps in different years produced in this study

2. Incorporating more images in the classification model enhanced overall accuracy, and the best performance was achieved when all images were included
- Earlier years (e.g., 1973-1982) and transitional classes (e.g., shrubland) often had lower accuracies and were more vulnerable to reduced proportion of input images *(Figure 2)*

3. The natural landscape in Hong Kong gradually transformed from being grassland-dominated in the 1970s to woodland-dominated in the 2010s
- Grasslands took a **median time of 21 years** to become shrublands and another **29 years** to become woodlands, but the **first quartiles of 7 and 10 years** respectively indicate a high spatial variability *(Figure 3)*
- **Hill fire** and increasing **distance from seed sources** were important factors positively correlated with the transition time (restricting forest succession), while **precipitation** and **protected area designation** produced the highest negative correlations (accelerating the process) *(Figure 4)*

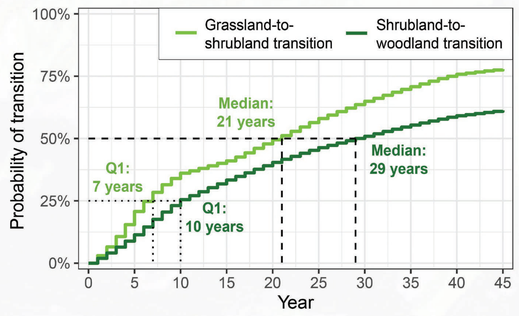


Figure 3: Kaplan-Meier survival curves of grassland-to-shrubland (light green) and shrubland-to-woodland (dark green) transitions

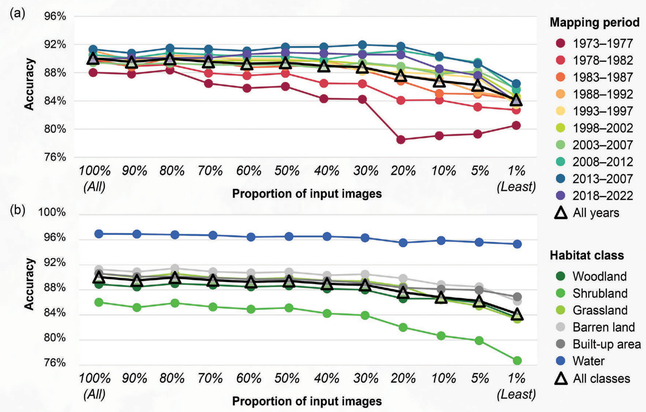


Figure 2: Classification accuracies by proportion of input images and (a) mapping periods and (b) habitat classes

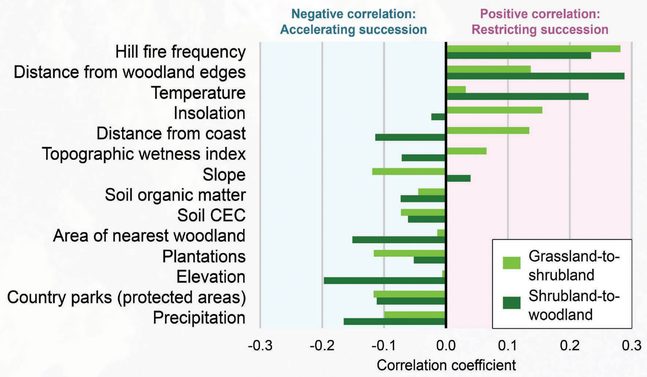
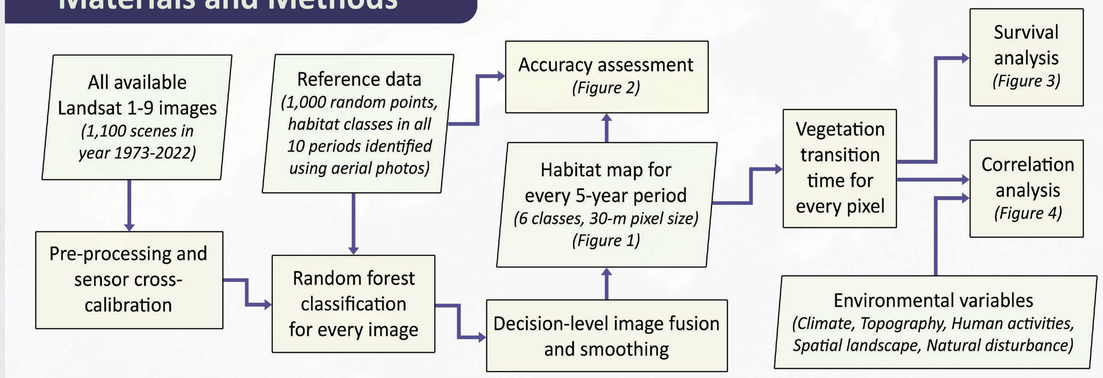


Figure 4: Kendall rank correlation coefficient between variables and vegetation transition times (number of years required)

Materials and Methods



Discussion

Recommendations on using Landsat time series
- This study included Landsat 1-5 MSS data which is crucial in extending the temporal baseline but often ignored in existing studies
- A single classification model can be developed to obtain consistent results from multiple satellites across different periods
- Increasing observations over time bring benefits in utilising temporal information in image dataset

Implications on forest succession and restoration
- This study incorporated a holistic set of spatial layers related to various aspects
- Habitat distribution was an overall result of many positive and negative factors enhancing spatial heterogeneity
- Relative importance of different mechanisms can be quantified to help allocate conservation resources and optimise locations of management activities

Conclusion

- This study demonstrated the value of connecting the Landsat time series with human impacts and management practices to produce spatially explicit ecological insights
- It took advantage of the multi-temporal observations which could not be revealed using traditional analysis of individual plots or chronosequence at a single time
- The experience of forest regeneration in Hong Kong will benefit the increasing interest in forest protection and restoration in the wider tropical region

Supplementary information:
https://github.com/ivanhykwong/Habitat-Type-Quality-HK