Tree Population Dynamics of Large-scale Mature Urban Forest in Kyoto city, Japan

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Important roles of Urban Forests

- Improvement of urban environment
- Recreation space for urban residents
- Wildlife Habitat

And more….

But most urban forests has been disappeared
And remnants has been fragmented each other
Preserved Forest in Urban Area of Japan

In Japanese traditional religion, Natural deities have been greatly worshiped.

Trees in shrines have been protected.

Intact woods in urban area remains as shrine forests.

Shimogamo-Jinja is the oldest shrine in Kyoto city. It is surrounded by vast forest, Tadasu-No-Mori.
Tadasu-No-Mori Forest
Location of Study site - Kyoto city -

- Located in western Japan 35° 02’ N, 135° 46’ E
- Mean annual temperature: 15.6°C
- Highest temperature in July (23.5°C)
- Lowest temperature in January (1.9°C)
- Warm Index: 132.6 °C-month

- Located in the warm temperate zone
- Climax Forest Phase: Evergreen Broad-Leaved Forests
- Mean annual precipitation: 1545.4 mm
Tadasu-No-Mori Forest

- Whole Area: 12.4 ha
  (woods area only: 9.08 ha)
- Registered as the World Heritage of UNESCO in 1994
- Dominant Species:
  *Ulmacea* deciduous broadleaved
  - *Aphananthe aspera*
  - *Celtis sinensis*
  - *Zelkova serrata*
Why had Tadasu-No-Mori been *Ulmaceae*, deciduous broad-leaved forest?

- Located in the riparian flood plain
- Tadasu-No-Mori Forest
- Disturbed by floods many times
- Stopped to reach climax phase

Maintain the state dominated by *Ulmaceae* species
Frequency of floods of Kamo River adjoining Tadasu-No-Mori Forest for every 50 years

(Nakajima, 1983)
The Latest Disturbance in Tadasu-No-Mori Forest

- Major typhoon had struck in 1934
- Massive flood had occurred in 1935

Most trees in Tadasu-No-Mori Forest had fallen
The State of Tadasu-No-Mori Forest after 5 Years since the Latest Disturbance

All woody stems larger than or equal to 100cm GBH were censused (Ikeda, 1939)

- Number of stems: 97
- Stem density: 10.6 (/ha)
- Number of species: 18
- Total basal area: 0.08%
The Structure of Tadasu-No-Mori Forest in 1939

**Basal Area**

- *Aphananthe aspera*
- *Zelkova serrata*
- *Celtis sinensis*
- Others

**Stem Number**

- *Aphananthe aspera*
- *Zelkova serrata*
- *Celtis sinensis*
- Others

Relative Rate(%)
Human Impact on Tadasu-No-Mori Forest

After the latest disturbance

- Removal of natural disturbance process
- Improvement of Rivers

- Introduction of non-native plant or competitive species against *Ulmaceae* species
  - *Cinnamomum camphora* (non-native plant, evergreen broad-leaved)
  - *Quercus glauca* (evergreen broad-leaved)
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Census Methods

All woody stems larger than or equal to 10cm DBH (Except for Climbers)

- DBH (1.3 m above ground)
- Height
- Location
- Species

1st measurement: 1991
2nd measurement: 2002
### Structural Parameters

<table>
<thead>
<tr>
<th></th>
<th>1991</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Species</td>
<td>56</td>
<td>59</td>
</tr>
<tr>
<td>Number of Stems</td>
<td>3416</td>
<td>3433</td>
</tr>
<tr>
<td>Stem Density (N/ha)</td>
<td>376.2</td>
<td>378.1</td>
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<tr>
<td>Basal Area (%)</td>
<td>0.37</td>
<td>0.40</td>
</tr>
</tbody>
</table>

(larger than or equal to 10cm DBH)
## Mortality and Recruitment Rate

<table>
<thead>
<tr>
<th>Species</th>
<th>Mortality Rate (%/yr)</th>
<th>Recruitment Rate (%/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td><em>Quercus glauca</em></td>
<td>1.2</td>
<td>2.0</td>
</tr>
<tr>
<td><em>Aphananthe aspera</em></td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td><em>Celtis sinensis</em></td>
<td>1.3</td>
<td>0.3</td>
</tr>
<tr>
<td><em>Cinnamomum camphora</em></td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td><em>Zelkova serrata</em></td>
<td>1.5</td>
<td>0.2</td>
</tr>
</tbody>
</table>

(larger than or equal to 10cm DBH)
Change of Total Basal Area

About 4 times increased in 63 years

(> 100cm GBH)
Change of Stem Density

Stem Density (N/ha)

About 13 times increased in 63 years

(> 100cm GBH)
Relative Rate of Basal Area

(larger than or equal to 10cm DBH)

- 1991:
  - Aphananthe aspera
  - Cinnamomum camphora
  - Celtis sinensis
  - Zelkova serrata

- 2002:
  - Cinnamomum camphora
  - Aphananthe aspera
  - Celtis sinensis
  - Zelkova serrata

Relative Basal Area (%)
Comparison of Traits among four main species

- *Cinnamomum camphora* (*Lauraceae*, Evergreen)
- *Aphananthe aspera* (*Ulmaceae*, deciduous)
- *Celtis sinensis* (*Ulmaceae*, deciduous)
- *Zelkova serrata* (*Ulmaceae*, deciduous)

Growth Rate and Mortality Rate of these species were compared with each other
Relation Between Size and Growth Rate

- **Cinnamomum camphora**
- **Aphananthe aspera**
- **Celtis sinensis**
- **Zelkova serrata**
Relation Between degree of suppression and Growth Rate

- **Cinnamomum camphora**
- **Aphananthe aspera**
- **Celtis sinensis**
- **Zelkova serrata**

![Graph showing the relation between degree of suppression and growth rate for different species of trees.](image-url)
Relation Between Size and Mortality Rate

- **Cinnamomum camphora**
- **Aphananthe aspera**
- **Celtis sinensis**
- **Zelkova serrata**

**Plot Details:**
- **Y-axis:** Mortality Rate (%/11yr)
- **X-axis:** DBH class (cm)
- Mortality rate decreases as DBH class increases.
Relation Between Degree of Suppression and Mortality Rate

Basal Area of Neighborhood Upper Trees (%)

Mortality Rate (%/11yr)

- Cinnamomum camphora
- Aphananthe aspera
- Celtis sinensis
- Zelkova serrata
DBH Frequency Distribution in 2002

- **Cinnamomum camphora**
- **Aphananthe aspera**
- **Celtis sinensis**
- **Zelkova serrata**
DBH Frequency Distribution in 2002

Quercus glauca

Reversed J-shaped
Stem Density  (larger than or equal to 10cm DBH)

```
1991
Quercus glauca  Cinnamomum camphora  Celtis sinensis  Aphananthe aspera  Zelkova serrata

2002
Quercus glauca  Cinnamomum camphora  Celtis sinensis  Aphananthe aspera  Zelkova serrata
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Summary

- *Cinnamomum camphora*, non-native species, will maintain the most dominant position for the time being
- In the further future, *Quercus glauca* will take the place of *Cinnamomum camphora*.

Future plans

- We continue to census in this site at regular intervals and examine the influences of human activity on this forest