Spatial Distribution of Trees

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Purpose

- “Forest monitoring” are conducted in many forests for a long term.
- Most of these forests studies focused on tree distributions.
- We newly developed Echelon analysis as an analysis method from a hierarchic structure point of view.
- We developed patch detection in forest using Echelon Dendrogram.
Target Forest

- Data are in Forest Dynamics Data Base which had been compiled by the Forestry and Forest Products Research Institute.
- We focused on Ogawa Forest Reserve because this forest data have many information of trees.
- The site is a square of 300m × 200m (6ha).
- We focused on mature trees.

### Data

Table showing the coordinate data for different species along with their individual ID and girth.

<table>
<thead>
<tr>
<th>Species</th>
<th>X</th>
<th>Y</th>
<th>IND_ID</th>
<th>GBH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acer mono</td>
<td>12.08</td>
<td>197.97</td>
<td>2</td>
<td>97.8</td>
</tr>
<tr>
<td>Acer nikoense</td>
<td>10.35</td>
<td>185.42</td>
<td>16</td>
<td>16.5</td>
</tr>
<tr>
<td>Carpinus cordata</td>
<td>15.53</td>
<td>182.81</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>Swida controversa</td>
<td>17.90</td>
<td>182.99</td>
<td>20</td>
<td>132.9</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Quercus serrata</td>
<td>295.35</td>
<td>4.82</td>
<td>5885</td>
<td>62.1</td>
</tr>
</tbody>
</table>

About 5000
Data: GBH

- Girth at Breast Height
  - Each tree girth is measured at 1.3m.
- Advantage
  - There is an allometry equation between a breast height diameter and tree height.
  - “GBH” is used as a tree size.

\[
\frac{1}{H_{i,t}} = \frac{1}{\alpha_t D_{i,t}^{h_t}} + \frac{1}{H_{\text{max},t}}
\]

- \(H_{i,t}(m)\): \(i\) - th tree height of species \(t\)
- \(D_{i,t}(cm)\): \(i\) - th breast height diameter of species \(t\)
- \(\alpha_t, h_t, H_{\text{max}}\): each constant
**Forest Structure**

- The forest has two kinds of layers.
  - a upper layer, canopy; a under layer, understory
- There are gaps which divide layers of canopy and understory.
Voronoi Diagram

- Tree locations are point data. ➔ change to regional data using Voronoi diagram.
- This Voronoi Diagram made from canopy trees and trees in a gap.
- Each Voronoi region shows an occupied area by canopy tree. ➔ Canopy layers have no room except a gap.
Echelons are based on the areas of relative high and low values of response variables of spatial data.

The echelon approach gets together the areas in which the values have the same topological structure and makes hierarchically related structure of these areas.

Echelon Dendrogram is the graph that shows hierarchically the structure.
Patch Detection

- It takes about 50 years to change whole forest.
  - Small changes occur by fall-tree or grow-up tree.
  - We take notice of a patch.
- Patch definition (Forman et al., 1986)
  - A nonlinear surface area differing in appearance from its surroundings.
- Many kinds of forest consist of mosaic structure of patches. (Nakashizuka, 1987)
  - Patches detection by using Echelon Dendrogram is useful.
  - Existing method is not objective such as appearance check.
A patch is detected on the basis of bigger tree.

- Echelon Dendrogram is made based on neighboring information.

- [EN5] does not view a patch.

- A patch is too large.
Patch Detection
A forest has two layers. 

- Patches were detected in each layer.

- 10 patches were established based on larger trees in peaks.

- Patch shapes are irregular.
In general, a tree is classified according to shade tolerance. 

- **Shade-Intolerant**
- **Shade-Tolerant**

Shade-Tolerant tree biomass increases with time.
Shade tolerance is added in each patch.

Distributions of Shade-Tolerant trees and Shade-Intolerant trees were not regulation in patches.

This forest may be at transition stage.
20 patches are similarly detected in understory.

Most of trees are Shade-tolerant because of understory.
Comparing Patch: Canopy and Understory

- A part of overlapping gaps and Shade-Intolerant trees.
  - There were patch's Shade-Intolerant trees in gaps.
  - Shade-Intolerant trees grow up in sunlight area.
Comparing Patch: Canopy and Understory

- A part of overlapping Shade-Tolerant trees and Shade-Intolerant trees.
  - Shade-Intolerant trees don’t have thick leaves.
  - Shade-Intolerant trees of understory grow up under Shade-Intolerant trees of canopy.
Conclusion

- We developed patches detection methods using Echelon Dendrogram.
- Characteristics and heterogeneous characters of forest structure can be shown by using Echelon Dendrogram.
- We want to show a time series variation in the future.