Natural disturbances as a guide for sustainable forest management in Europe

William S. Keeton, University of Vermont, USA

Reka Aszalos, Institute of Ecology and Botany, Hungary

Dominik Thom, Technical University of Munich, Germany

23 other co-authors from across Europe

High Tatras Mtns., Slovakia
Can we manage and restore older forest functions by emulating natural disturbance processes?

Challenge for Europe: Need new silvicultural approaches aimed at restoration of complex and resilient conditions. Not the same as retention forestry or “Close-to-Nature” forestry
Mimicking scale and frequency of disturbances

![Graph showing the relationship between frequency (years) and area (ha) for different disturbances types: Natural canopy gaps, Severe fire and wind, Clearcutting, Group Selection.](image)

Adapted from: Seymour et al. (2002). Forest Ecology and Management
Comparing Natural Disturbances to Forest Management

Supported by old-growth research in:
- Slovenia (Nagel et al. 2006)
- Czech and Slovak Republics (Svoboda et al., numerous)

Adapted from: Seymour et al. (2002). Forest Ecology and Management
Modified in: North and Keeton (2008). IUFRO
Natural disturbance regimes as a guide for sustainable forest management in Europe

Réka Aszalós¹ | Dominik Thom²,³,⁴ | Guntis Brūmelis⁸ | László Gálhidy⁹ | Ge...
• Database on forest management systems by major forest types

• Expert-based standardization of definitions for major silvicultural systems
Literature and expert-based quantification of silvicultural systems according to size, frequency, and retention (residual structure)
Classification of Natural Disturbance Regimes for Major European Forest Types

Low severity, aggregated (gap-dynamics) disturbance 80-85%

Low severity, diffuse disturbance 75-90%
Classification of Natural Disturbance Regimes for Major European Forest Types

Intermediate severity disturbance 25-75%

High severity disturbance 0-25%
# Attributes of natural forest disturbances in boreal and temperate Europe

<table>
<thead>
<tr>
<th>Natural disturbance</th>
<th>Size (m²)</th>
<th>Frequency (year)</th>
<th>Residual structure (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low severity, aggregated</td>
<td>20-200</td>
<td>1-10</td>
<td>80-85</td>
</tr>
<tr>
<td>Low severity, diffuse</td>
<td>200-10⁶</td>
<td>10-100</td>
<td>75-90</td>
</tr>
<tr>
<td>Intermediate severity</td>
<td>200-10⁶</td>
<td>100-500</td>
<td>25-75</td>
</tr>
<tr>
<td>High severity</td>
<td>10⁴-10⁷</td>
<td>150-1000</td>
<td>0-25</td>
</tr>
</tbody>
</table>

*Residual structure = 1/severity = percentage of post-disturbance live woody biomass volume (m³) compared with the pre-disturbance volume left on a 1 ha site.
Three-dimensional figure displaying size, frequency, and residual structure attributes of silvicultural systems and natural disturbance regimes in European boreal and temperate forests.

A “Comparability Index” for European forests

- Adapted from Seymour et al. (2002), later modified by North and Keeton (2008)
- Data from 13 countries:
  - Natural disturbance data: literature derived
  - Forest management data: expert opinion based on a standardized survey and protocol
- Boreal and temperate
- Four forest types: spruce, Scots pine, beech, and oak

Size, frequency, and residual structure attributes for natural disturbance regimes and silvicultural systems in Europe. Dots indicate the centroids of natural disturbance types and silvicultural systems. The **Comparability Index** is based on the centroids of all the natural disturbance types assessed.

From Aszalos, Thom…Keeton et al. (Ecological Applications)
### Average size, frequency, and residual structure for silvicultural systems and natural disturbance regimes of European forests.

<table>
<thead>
<tr>
<th>Silvicultural system</th>
<th>Size (ha)</th>
<th>Frequency (years)</th>
<th>Residual structure (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 Shelterwood system</td>
<td>3.72</td>
<td>103.98</td>
<td>1.56</td>
</tr>
<tr>
<td>A2 Clearcutting system</td>
<td>2.84</td>
<td>91.42</td>
<td>1.89</td>
</tr>
<tr>
<td>B Uneven-aged system</td>
<td>0.12</td>
<td>8.36</td>
<td>78.70</td>
</tr>
<tr>
<td>C Coppice system</td>
<td>3.27</td>
<td>48.04</td>
<td>1.66</td>
</tr>
</tbody>
</table>

### Natural disturbance

<table>
<thead>
<tr>
<th></th>
<th>High severity</th>
<th>Intermediate severity</th>
<th>Low severity, diffuse effects</th>
<th>Low severity, aggregated effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size (ha)</td>
<td>500.50</td>
<td>50.01</td>
<td>50.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Frequency (years)</td>
<td>575.00</td>
<td>300.00</td>
<td>55.00</td>
<td>5.50</td>
</tr>
<tr>
<td>Residual structure (%)</td>
<td>12.50</td>
<td>52.50</td>
<td>82.50</td>
<td>82.50</td>
</tr>
</tbody>
</table>

### Comparability Index Values

<table>
<thead>
<tr>
<th>CI</th>
<th>A1 Shelterwood</th>
<th>A2 Clearcutting</th>
<th>B Uneven-aged</th>
<th>C Coppice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size relative to frequency</td>
<td>0.11</td>
<td>0.11</td>
<td>0.50</td>
<td>0.26</td>
</tr>
<tr>
<td>Size relative to residual structure</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>0.11</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Frequency relative to size</td>
<td>0.20</td>
<td>0.20</td>
<td>0.79</td>
<td>0.40</td>
</tr>
<tr>
<td>Frequency relative to residual structure</td>
<td>0.01</td>
<td>0.01</td>
<td>0.26</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Residual structure relative to size</td>
<td>0.03</td>
<td>0.04</td>
<td>0.70</td>
<td>0.03</td>
</tr>
<tr>
<td>Residual structure relative to frequency</td>
<td>0.06</td>
<td>0.06</td>
<td>0.80</td>
<td>0.05</td>
</tr>
<tr>
<td>Average</td>
<td>0.07</td>
<td>0.07</td>
<td>0.53</td>
<td>0.13</td>
</tr>
</tbody>
</table>
CONCLUSIONS

1. High variability of natural disturbances
   Natural disturbances are highly variable in size, frequency, and severity, but European forest management fails to encompass this complexity.

2. Even-aged systems dominate
   Silviculture is skewed towards even-aged systems in Europe (73% of management); clearcutting most common regeneration method (52%).

3. Significance of residual structure
   Residual structure proved crucial in the comparisons, highlighting key differences between forest management and natural disturbances.

4. Uneven-aged management is closest
   Uneven-aged silvicultural systems have the highest Comparability Index values, but constitute only 10% of management in Europe.
Does European “Close-To-Nature” silviculture emulate natural dynamics?

Works well for:
• Gap processes
• Natural regeneration
• Conversion to site-endemic, mixed species composition
• Redevelopment of vertical structure

Opportunities for improvement:
• Large legacy trees
• Standing dead trees
• Large downed logs
• Tip-up mounds
• Spatial complexity within stands
• Diversification at landscape scales → resilience to disturbance
• Adaptation to climate change
Adoption of disturbance-based forestry practices is expanding, but must be adaptive to climate change and altered disturbance regimes.