Comparing Natural and Human Disturbance Parameters as a Reference for Multi-Functional Silviculture in Europe

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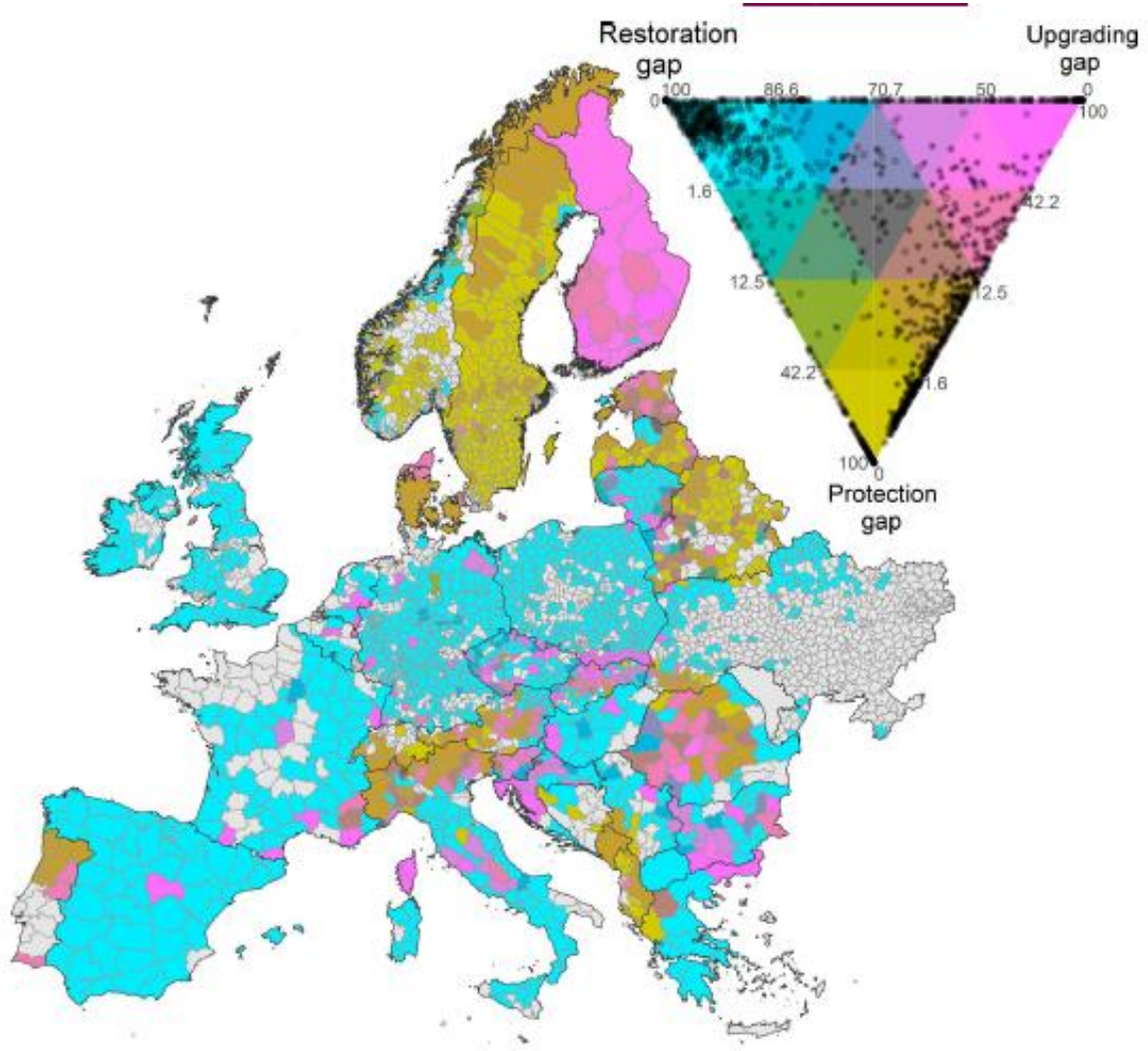
The Context



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Protection gaps and restoration opportunities for primary forests in Europe

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- Can we manage and restore older forest functions by emulating natural disturbance processes?
- Need new silvicultural approaches aimed at restoration of complex and resilient conditions.

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There are many questions…

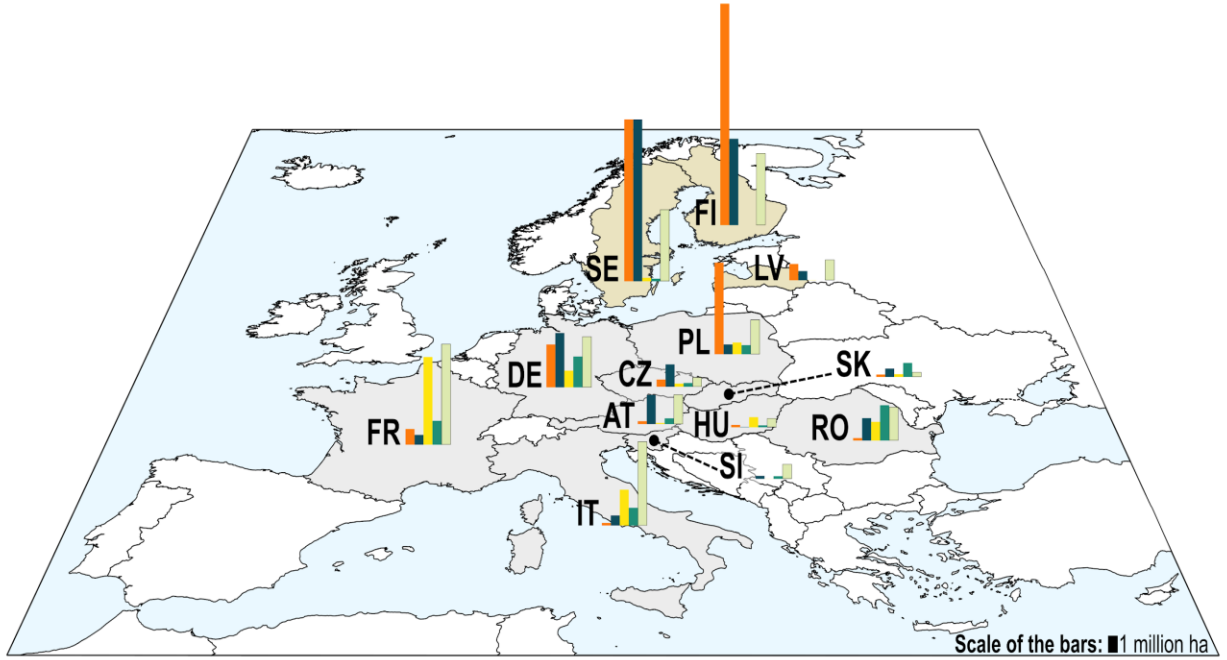
Can we use natural disturbance regimes as guide for sustainable forest management?

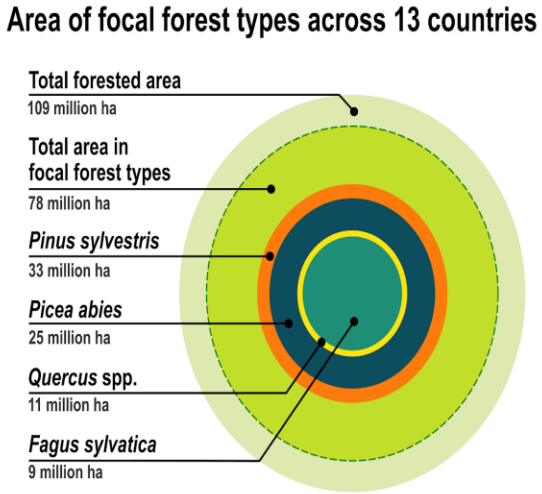
Is it even possible to compare this way in European forests? Can we even describe baseline natural disturbance dynamics?

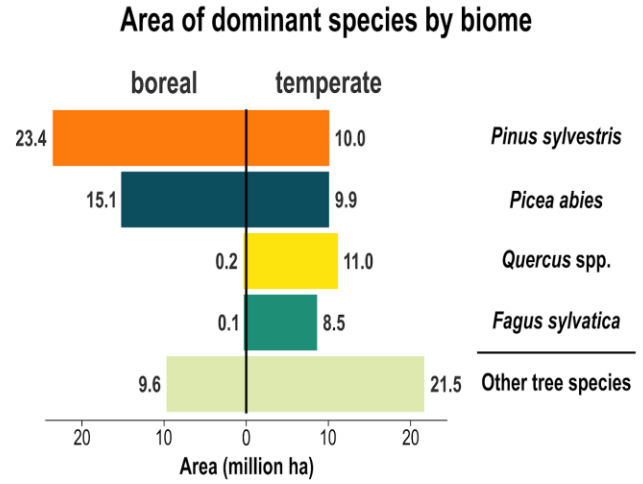
Would closer emulation of natural disturbance regimes provide adaptation benefits?

Would closer emulation of natural disturbance regimes help to restore old forest characteristics in managed forests?

What about climate change and altered disturbance regimes?







From: Aszalos, Thom…Keeton et al. 2022. Ecological Applications.

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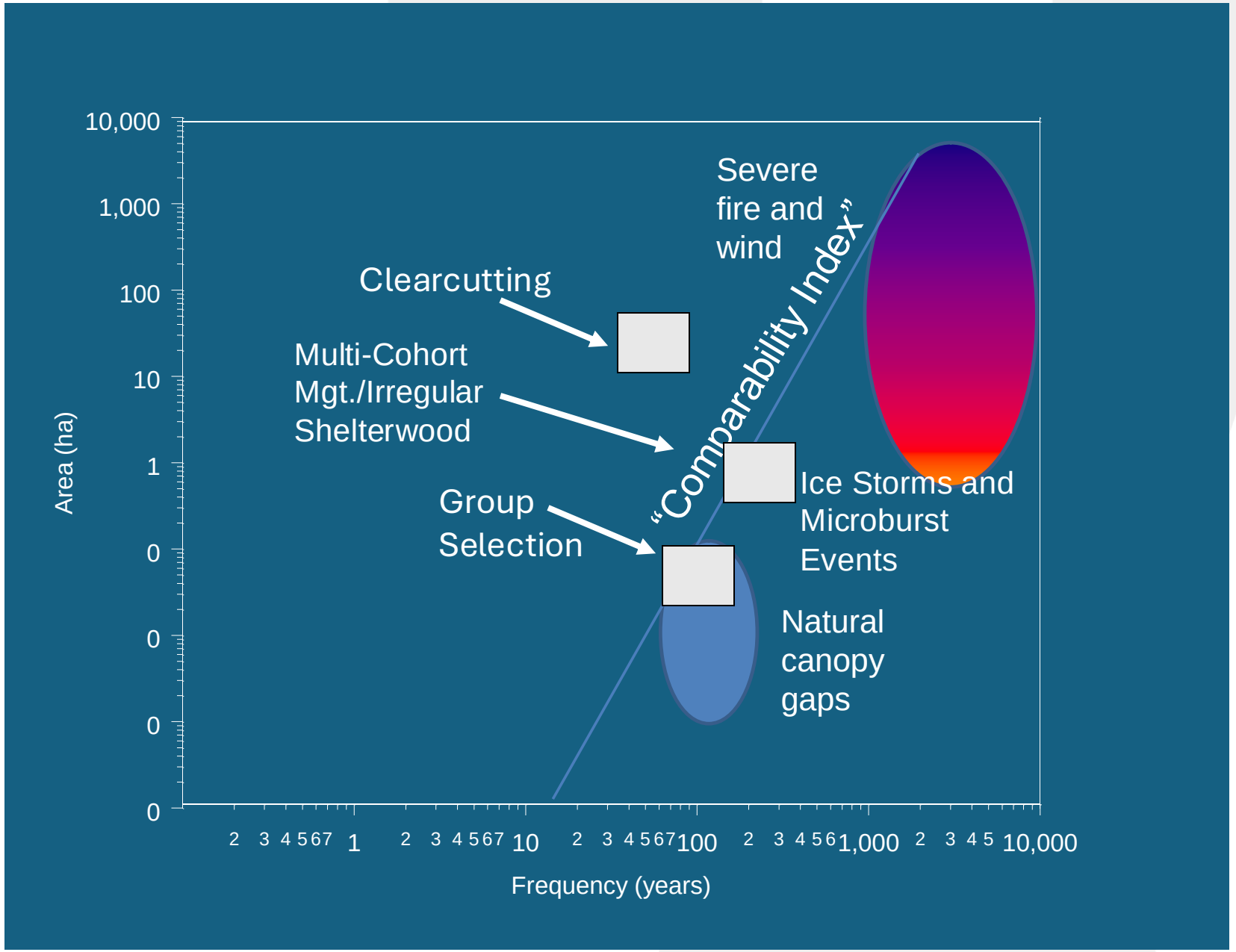
The Comparability Index: Comparing disturbance scales and frequencies

- First proposed by Seymour et al (2002) for the U.S. Northeast
- Later modified by North and Keeton (2008) to incorporate intermediate intensity disturbances

Modifications based on:

- Upper Midwest U.S. (Woods 2004, Hanson and Lorimer 2007)
- Northeast U.S. (Ziegler 2002, Curzon and Keeton, 2012); Meigs and Keeton (2018)
- Slovenia (Nagel et al. 2006)
- Czech and Slovak Republics (Svoboda et al., Mikolas et al. numerous)



Adapted from: Seymour et al. (2002). Forest Ecology and Management

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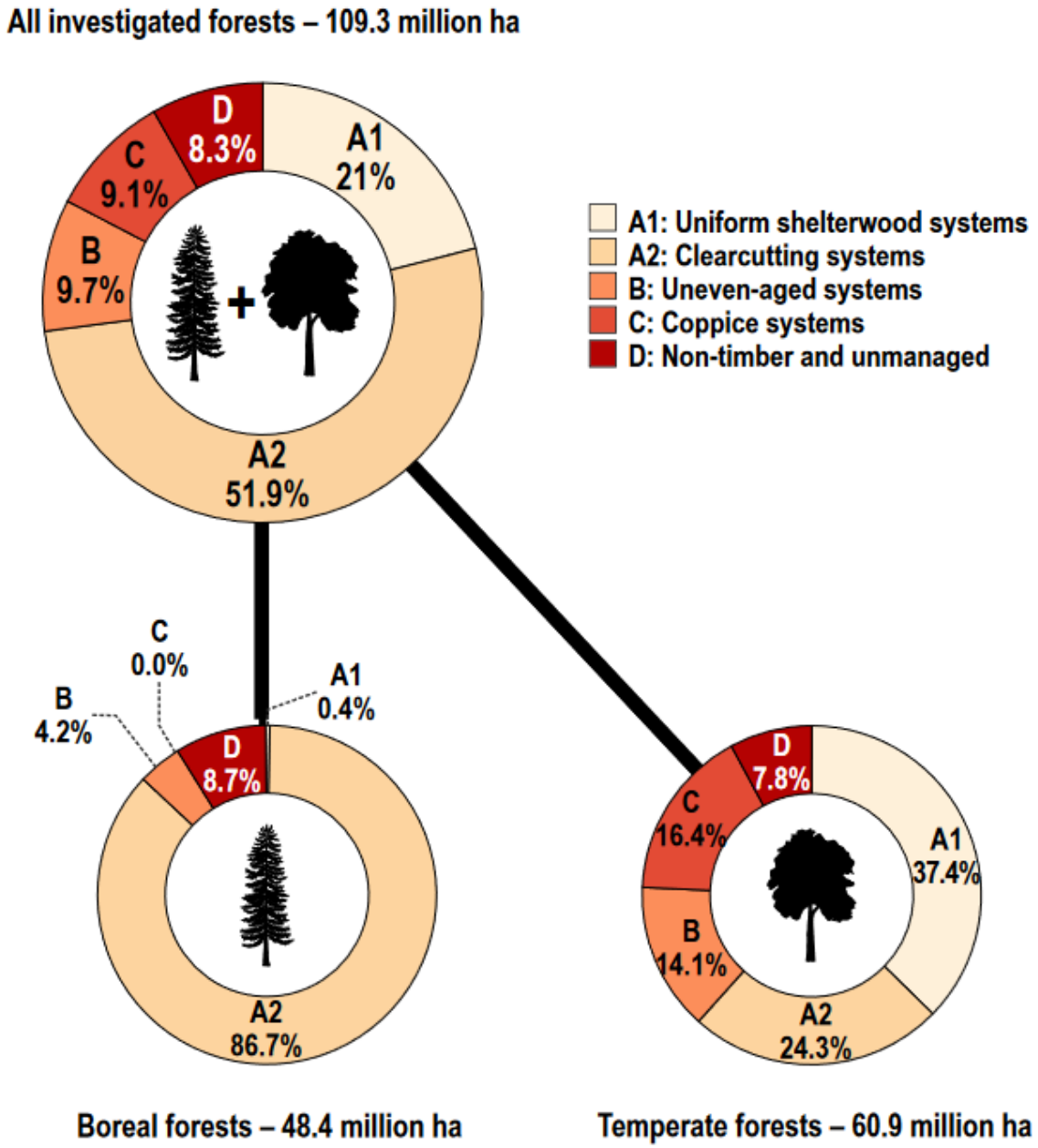
- Boreal and temperate: spruce, Scots pine, beech, oak, and mixed species

- Data by forest type from 13 countries:

  - Natural disturbance data: literature derived
  - Forest management data: expert opinion based on a standardized survey and protocol

- Standardization of definitions for major silvicultural systems



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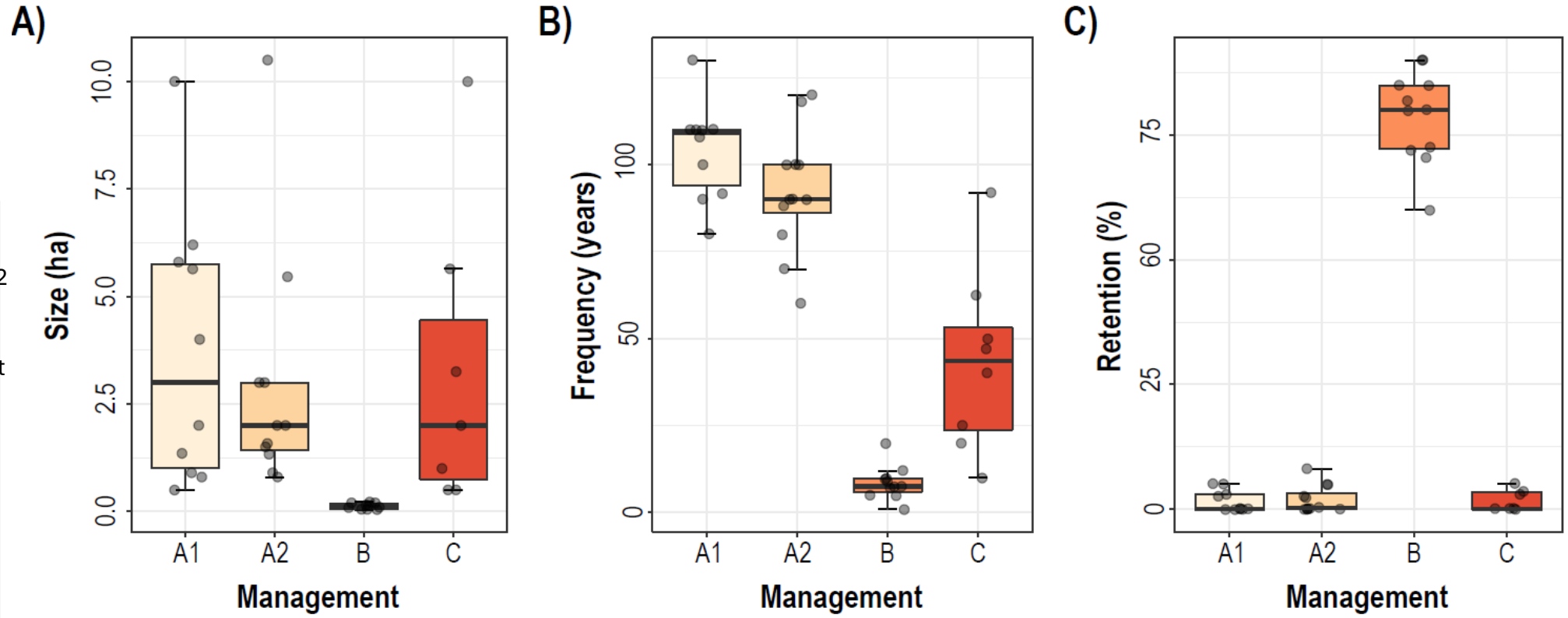
Literature and expert-based quantification of silvicultural systems according to size, frequency, and retention (residual structure)

A1: Shelterwood system
A2: Clearcutting system
A3: Short-rotation system
B: Uneven-aged management
C: Coppice systems

Dots indicate the national averages of the given attribute. Intervention size is the area of the final harvest in case of A1, A2 and C, and defined as the size of the canopy gaps created by the intervention in case of B. Harvest frequency is the rotation period for A1, A2, and C and entry cycles for B. Residual structure is defined as the percentage of living woody biomass volume (m3) post-harvest compared with the preharvest volume left on a 1 ha site



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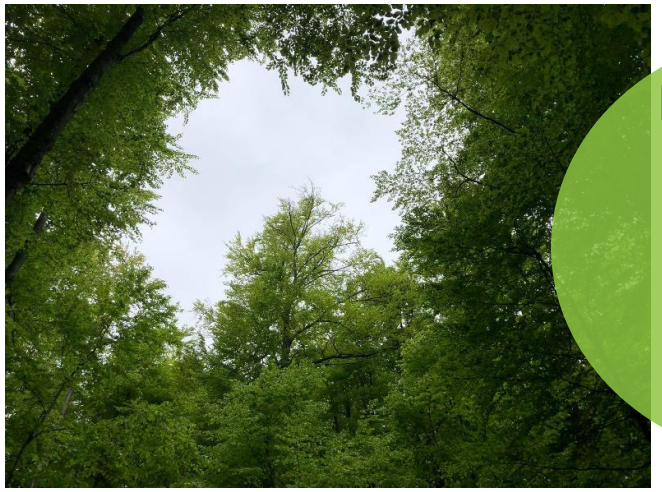
Classification of Natural Disturbance Regimes for Major European Forest Types



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

Intermediate severity disturbance 25-75%

Low severity, diffuse disturbance 75-90%

High severity disturbance 0-25%

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Attributes of natural forest disturbances in boreal and temperate Europe

Natural disturbance	Size (m^2)	Frequency (year)	Residual structure (%)*
Low severity, aggregated	20-200	1-10	80-85
Low severity, diffuse	200-10^6	10-100	75-90
Intermediate severity	200-10^6	100-500	25-75
High severity	10^4-10^7	150-1000	0-25

*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

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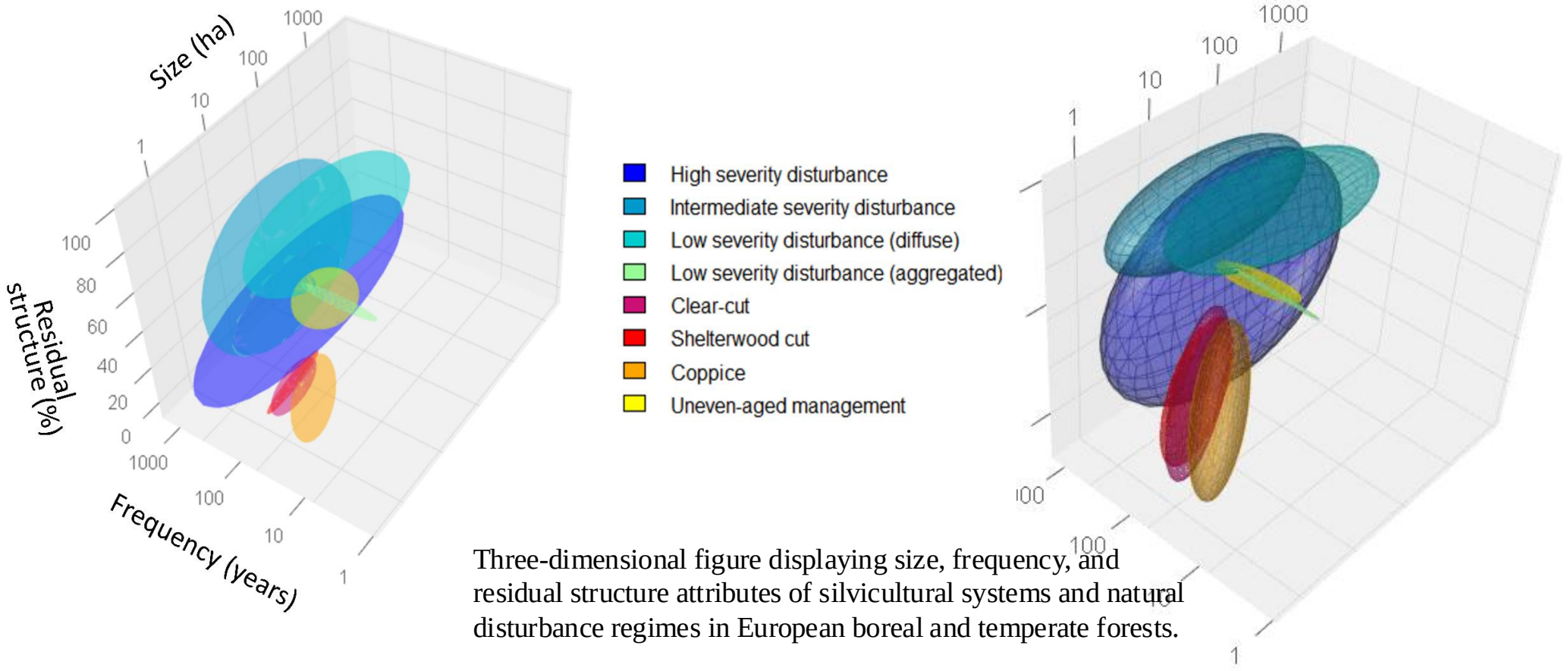
A “Comparability Index” to guide Natural Dynamics Silviculture in Europe



Three-dimensional figure displaying size, frequency, and residual structure attributes of silvicultural systems and natural disturbance regimes in European boreal and temperate forests.

From: Aszalos, Thom…Keeton et al. 2022. Ecological Applications.

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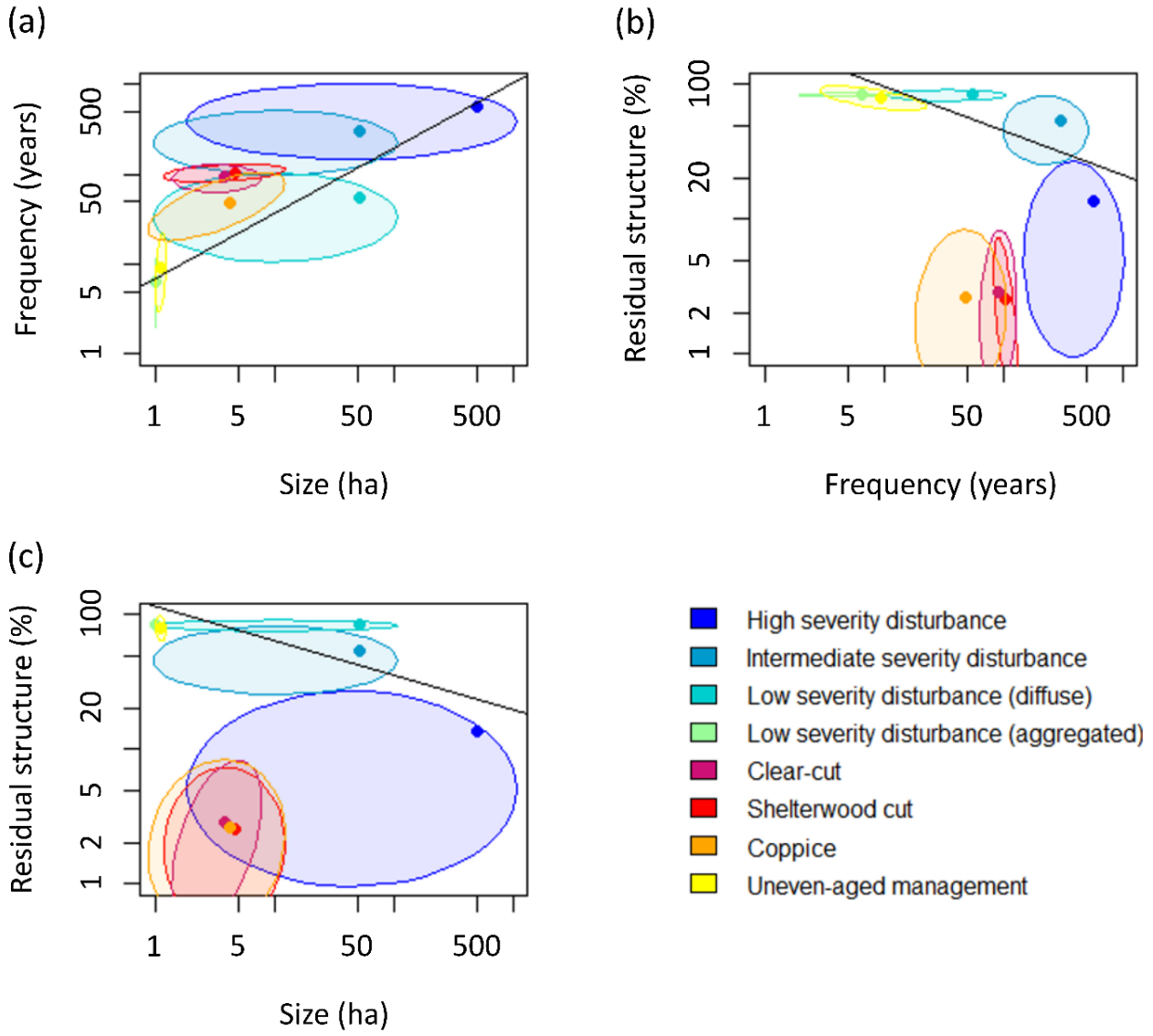
A *"Comparability Index"* for European forests

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. 2022. Ecological Applications



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Silviculture vs. Nat. Disturbances

Average size, frequency, and residual structure for silvicultural systems and natural disturbance regimes of European forests.

Silvicultural system	Size (ha)	Frequency (years)	Residual structure (%)
A1 Shelterwood system	3.72	103.98	1.56
A2 Clearcutting system	2.84	91.42	1.89
B Uneven-aged system	0.12	8.36	78.70
C Coppice system	3.27	48.04	1.66
Natural disturbance			
High severity	500.50	575.00	12.50
Intermediate severity	50.01	300.00	52.50
Low severity, diffuse effects	50.01	55.00	82.50
Low severity, aggregated effects	0.01	5.50	82.50

Comparability Index Values

Comparability Index (CI) values, representing the congruence between silvicultural systems and natural disturbance regimes.

CI	A1 Shelterwood	A2 Clearcutting	B Uneven-aged	C Coppice
Size relative to frequency	0.11	0.11	0.50	0.26
Size relative to residual structure	<0.01	<0.01	0.11	<0.01
Frequency relative to size	0.20	0.20	0.79	0.40
Frequency relative to residual structure	0.01	0.01	0.26	<0.01
Residual structure relative to size	0.03	0.04	0.70	0.03
Residual structure relative to frequency	0.06	0.06	0.80	0.05
Average	0.07	0.07	0.53	0.13

Substantial improvement needed

Room for improvement

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CONCLUSIONS

1 High variability of natural disturbances

We found that natural disturbances are highly variable in size, frequency, and severity, but European forest management fails to encompass this complexity

2 Even-aged systems dominate in Europe

Silviculture is skewed towards even-aged systems (73% of management), clearcutting systems have very high proportion (52%)

3 Significance of the third axis

The third axis, residual structure proved crucial in the comparison of natural disturbances and silvicultural systems – small overlap

4 Uneven-aged management

Uneven-aged silvicultural systems are closest to the comparability line with natural disturbances (only 10% of all management)

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Applying the Comparability Index: Example

How closely does European “Close-To-Nature” silviculture emulate natural disturbances?

- Gap processes
- Natural regeneration
- Conversion to site-endemic, mixed species composition
- Redevelopment of vertical structure

Opportunities for further modification?

- 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

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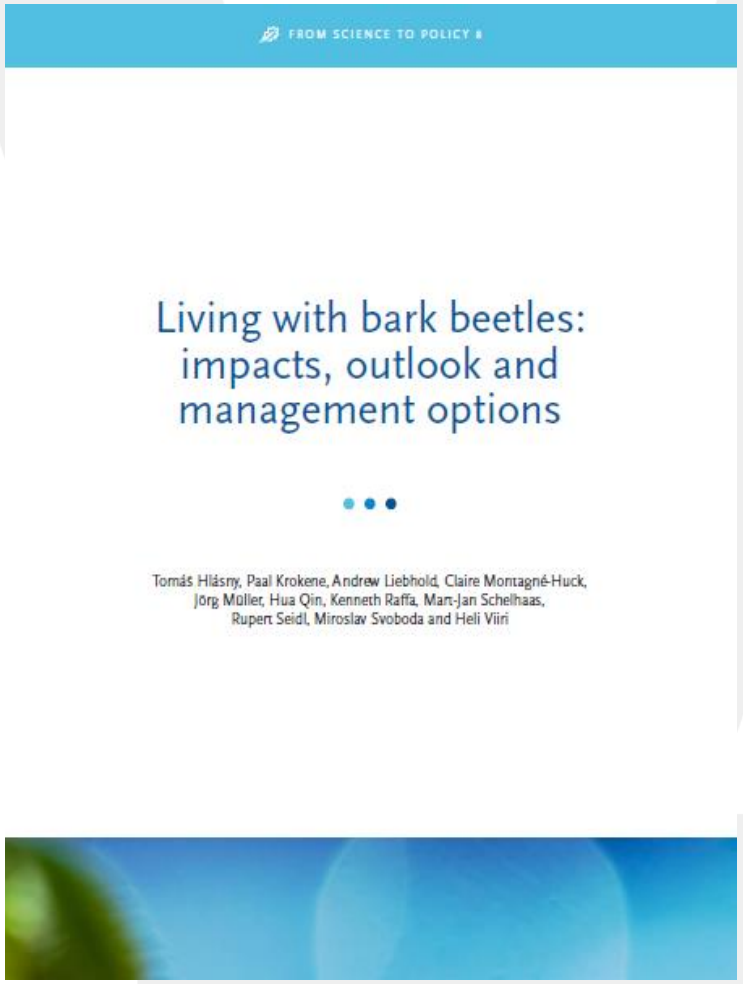
Close-to-Nature silvicultural demonstration at the Klokocna Forest, Czech Republic

Adoption of Natural Dynamics Silviculture is expanding, but must be adaptive to climate change and altered disturbance regimes

Recent reports from the European Forest Institute



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Implications for the Northern Forest Region

- In theory, the Comparability Index could be used anywhere, including the U.S. Northeast
- Need to add the third axis (retention)
- Downscaling and repopulate the index using localized data
- Consider shifting baselines for disturbance regimes with climate change

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Variable Retention Harvesting/ Irregular Shelterwood method in red pine (*Pinus resinosa*), Minnesota

Irregular Shelterwood method in mixed white pine (*Pinus strobus*) – northern hardwoods, Vermont

Acknowledgements

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Trust for Mutual Understanding

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USDA
United States Department of Agriculture
National Institute of Food and Agriculture

Koprova Valley, Slovak Republic, High Tatra Range of the Carpathian Mtns, June 2019