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

The UNIVERSITY of VERMONT

Carbon Dynamics Lab
University of Vermont
Rubenstein School of Environment and Natural Resources

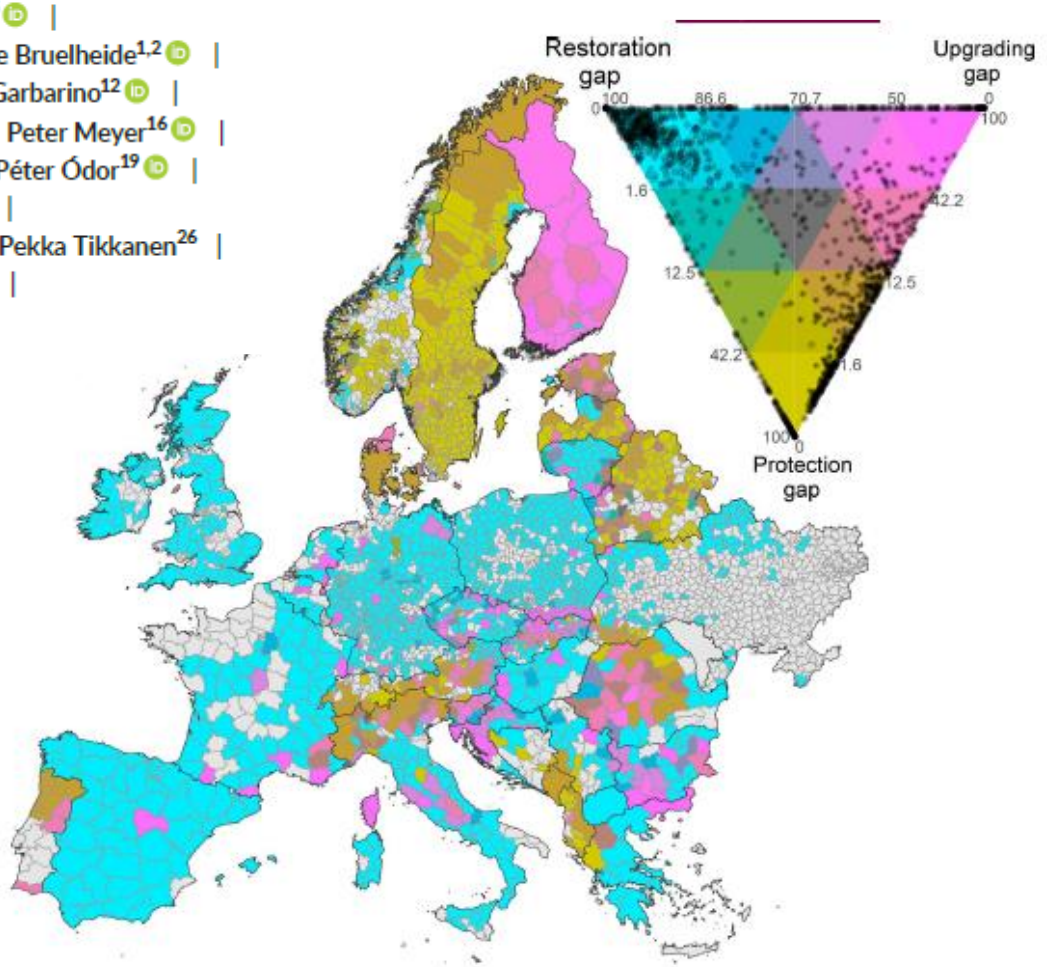
Received: 26 March 2020 | Revised: 30 July 2020 | Accepted: 18 August 2020
DOI: 10.1111/ddi.13158

BIODIVERSITY RESEARCH

Diversity and Distributions WILEY

Protection gaps and restoration opportunities for primary forests in Europe

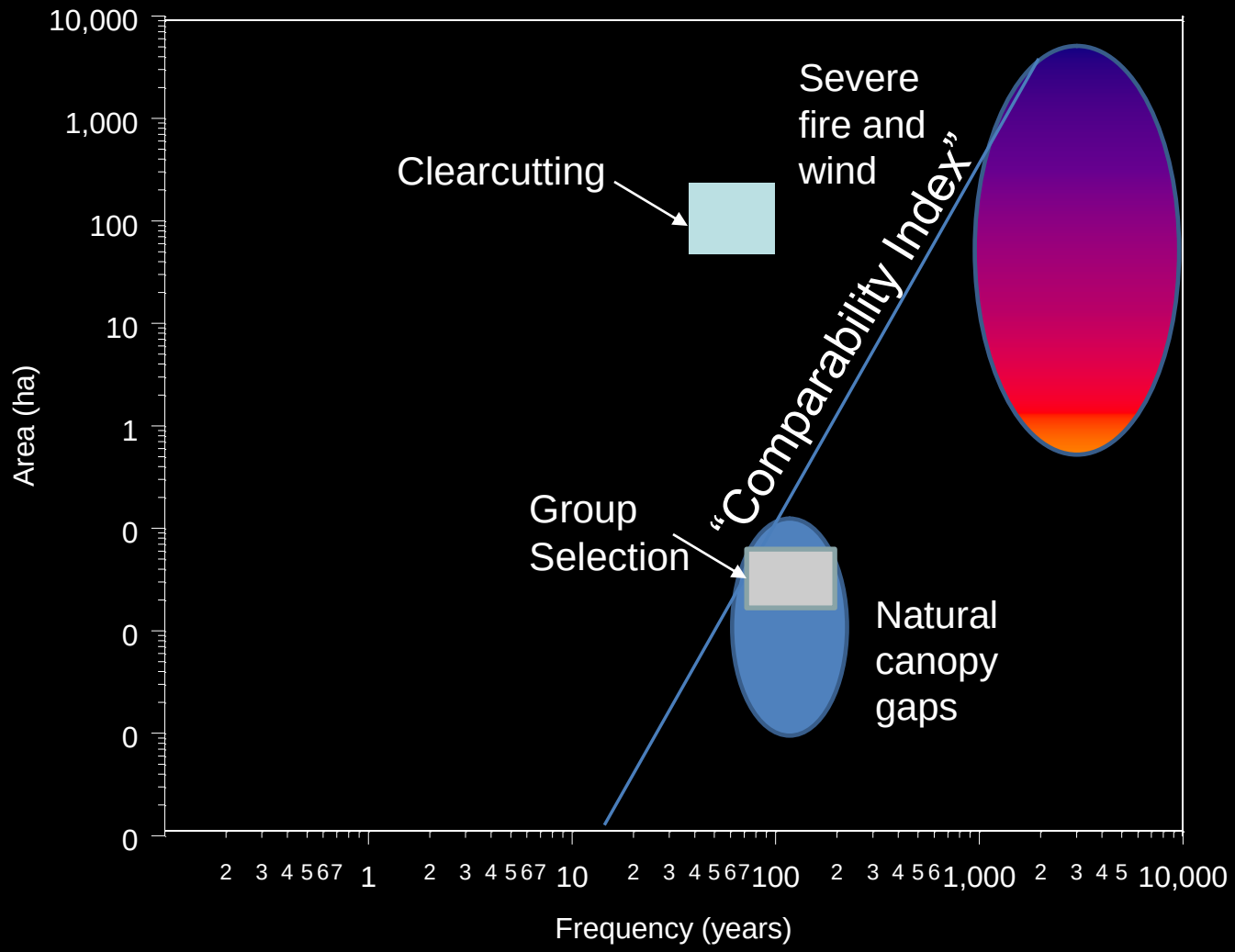
Francesco M. Sabatini[1,2,3] | William S. Keeton[4] | Marcus Lindner[5] | Miroslav Svoboda[6] | Pieter J. Verkerk[7] | Jürgen Bauhus[8] | Helge Bruelheide[1,2] | Sabina Burrascano[9] | Nicolas Debaive[10] | Inês Duarte[11] | Matteo Garbarino[12] | Nikolaos Grigoriadis[13] | Fabio Lombardi[14] | Martin Mikoláš[6,15] | Peter Meyer[16] | Renzo Motta[12] | Gintautas Mozgeris[17] | Leónia Nunes[11,18] | Péter Ódor[19] | Momchil Panayotov[20] | Alejandro Ruete[21] | Bojan Simovski[22] | Jonas Stillhard[23] | Johan Svensson[24] | Jerzy Szwagrzyk[25] | Olli-Pekka Tikkanen[26] | Kris Vandekerkhove[27] | Roman Volosyanchuk[28] | Tomas Vrska[29] | Tzvetan Zlatanov[30] | Tobias Kuemmerle[3,31]



Can we manage and restore older forest functions by emulating natural disturbance processes?

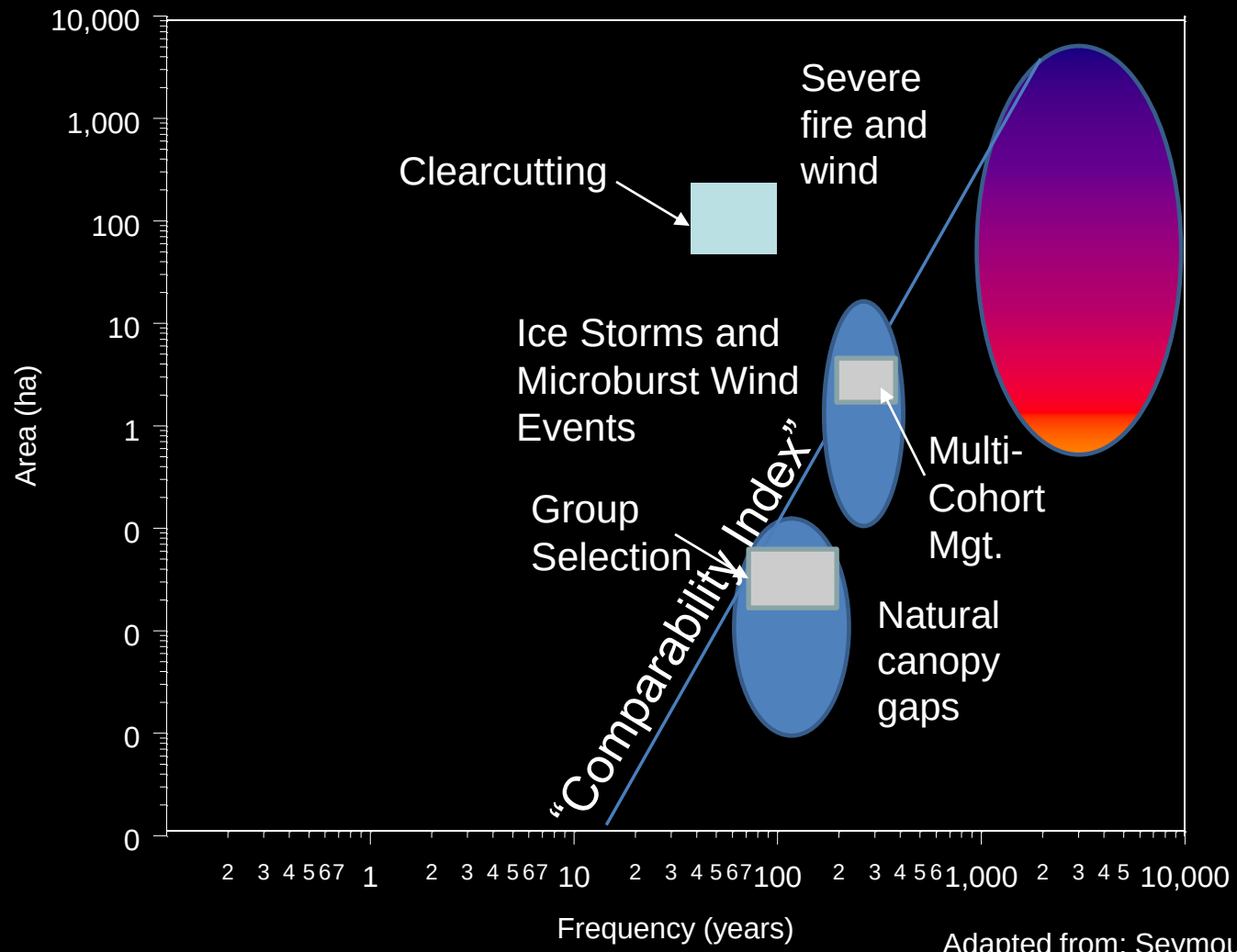
Challenge for Europe: Need new silvicultural approaches aimed at restoration of complex and resilient conditions. Not the same as retention forestry or “Close-to-Nature” forestry

Mimicking scale and frequency of disturbances



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

Comparing Natural Disturbances to Forest Management



Supported by old-growth research in:

- Upper Midwest U.S. (Woods 2004, Hanson and Lorimer 2007)
- Northeast U.S. (Ziegler 2002, Curzon and Keeton, 2012); Meigs and Keeton (in review)
- 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

Received: 1 July 2021 | Revised: 13 November 2021 | Accepted: 1 December 2021

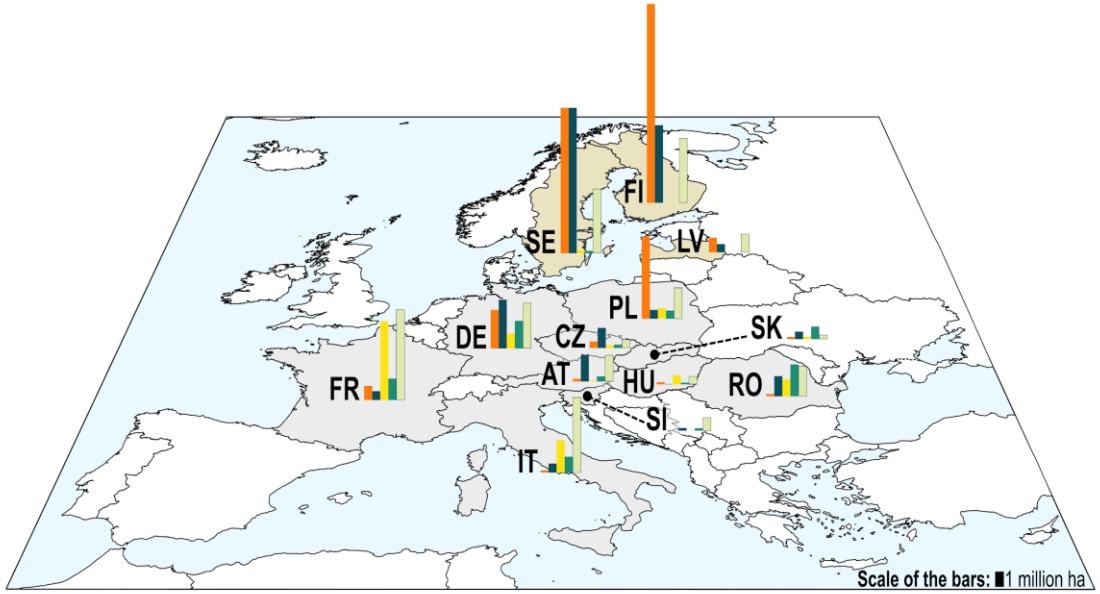
DOI: 10.1002/eap.2596

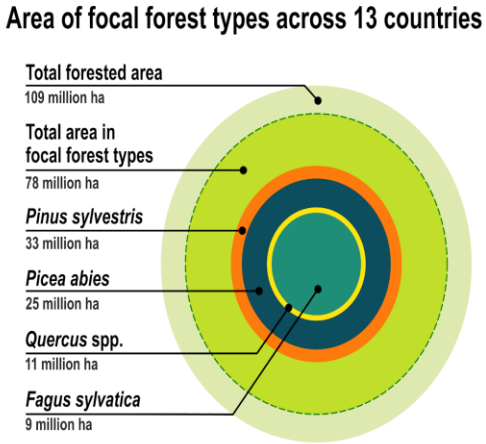
ARTICLE

ECOLOGICAL APPLICATIONS
ECOLOGICAL SOCIETY OF AMERICA

Natural disturbance regimes as a guide for sustainable forest management in Europe

Réka Aszalós[1] | Dominik Thom[2,3,4] |
Guntis Brūmelis[8] | László Gálhidy[9] | Geo
Klaus Katzensteiner[10] | Bence Kovács[1] |
Laurent Larrieu[13,14] | Renzo Motta[15] |
Péter Ódor[1] | Dušan Roženbergar[18] | Yoa
Tibor Standovár[21] | Miroslav Svoboda[11] |
Philipp Toscani[23] | William S. Keeton[3,24]





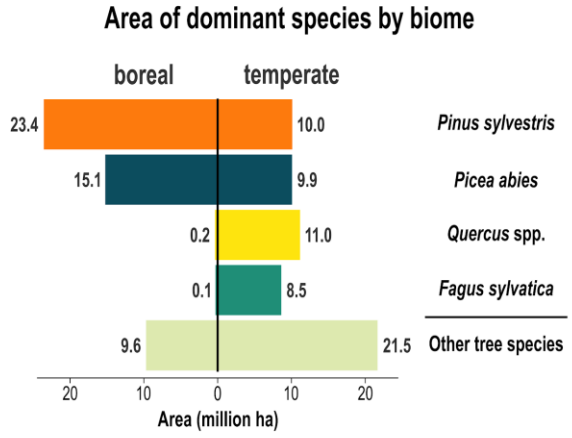
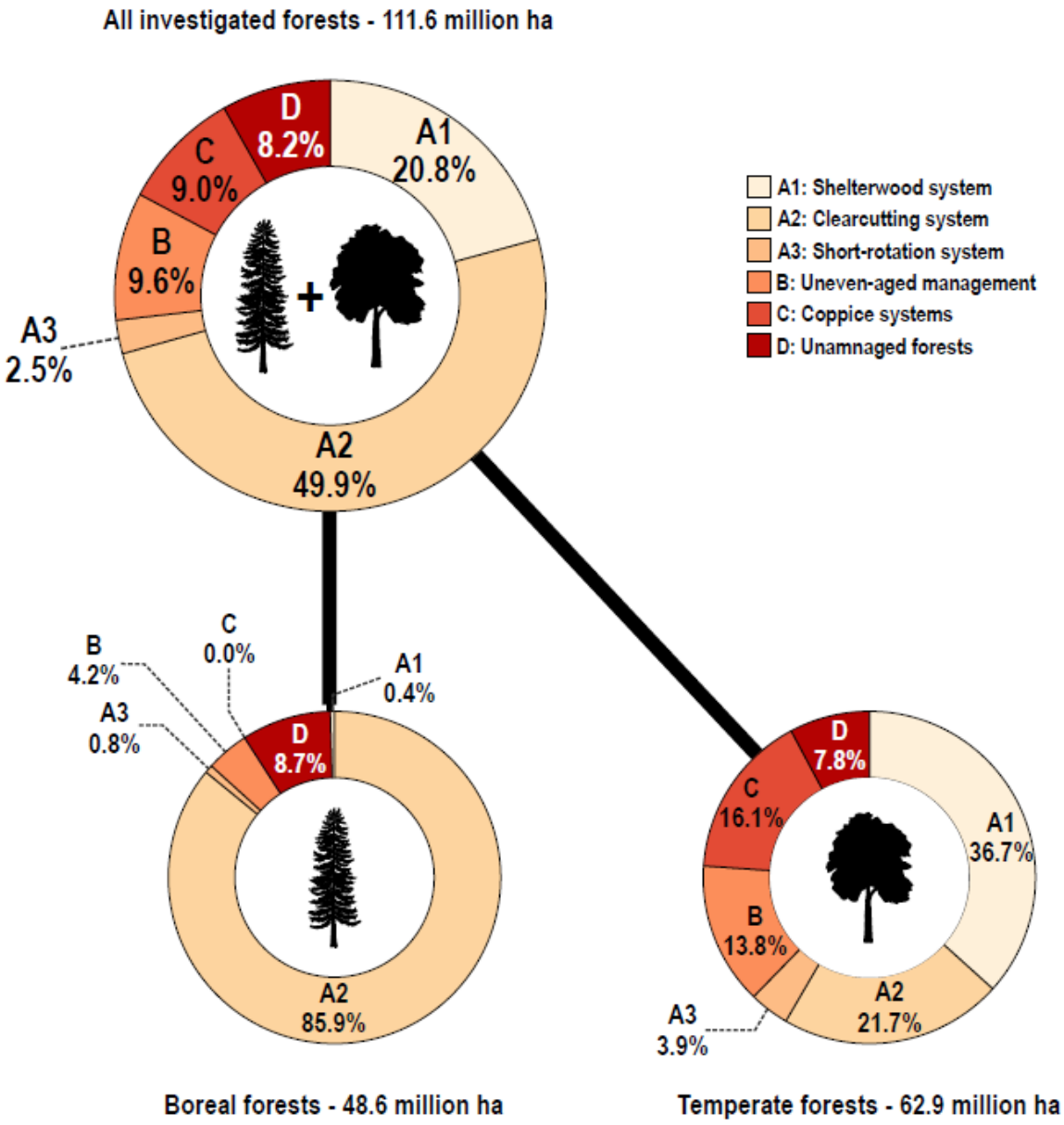
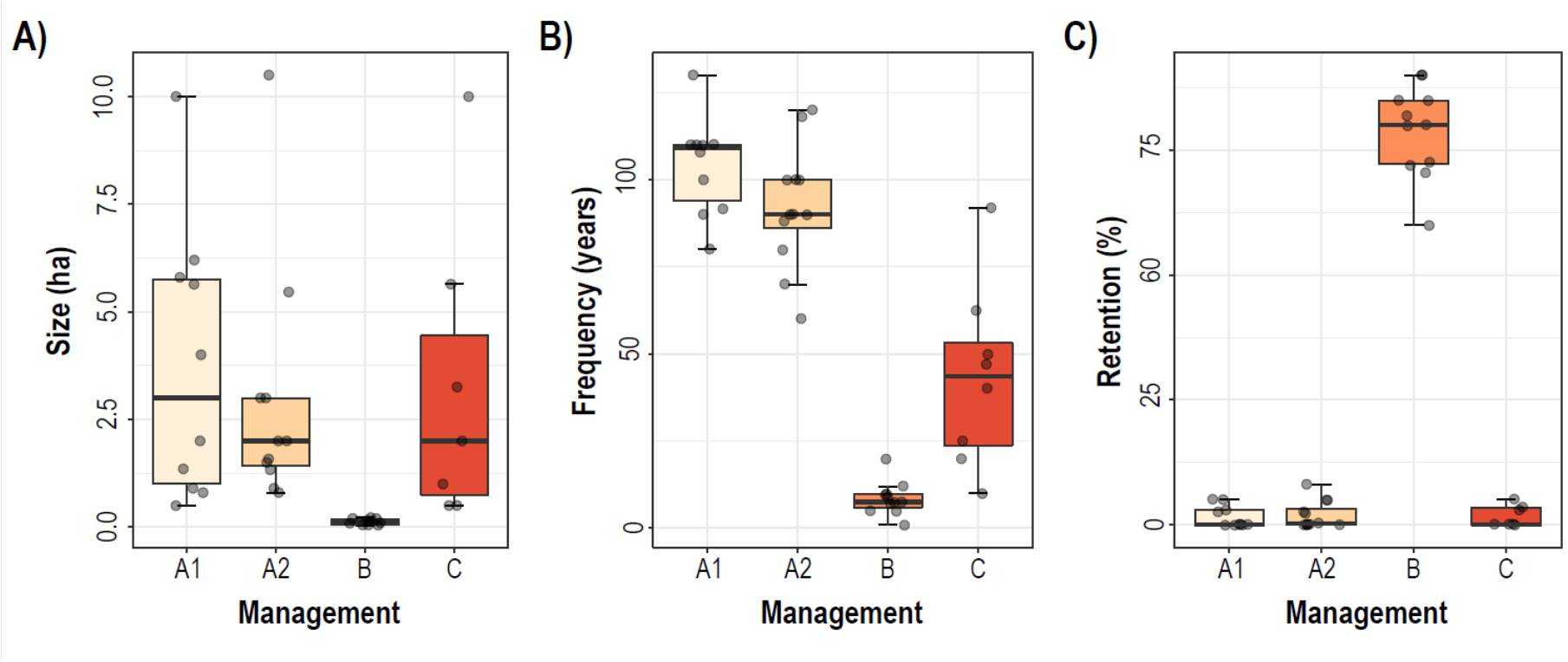


Figure. Area and proportion of the four forest types within the scope of this study by country and region

- 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

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

A “Comparability Index” for Sustainable Forest Management in Europe

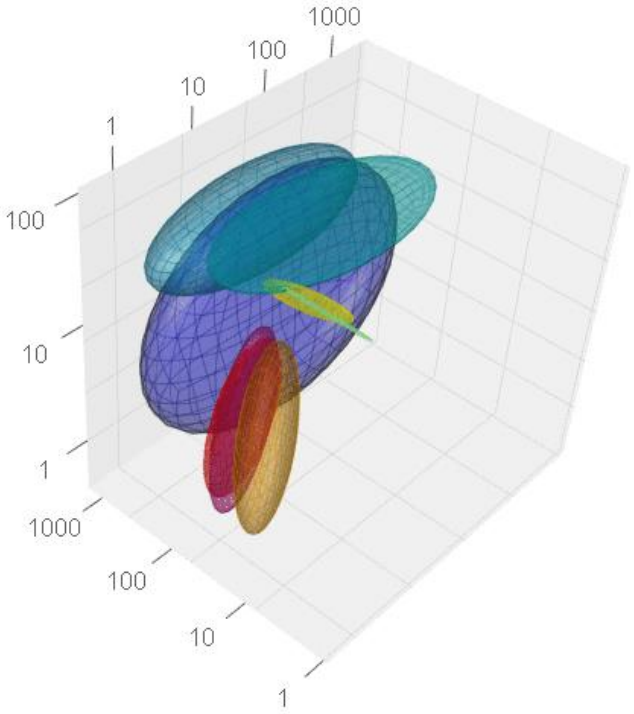
There are many questions…

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

Is it even possible to compare this way in European forests?

Would closer emulation of natural disturbance regimes provide adaptation benefits?

Climate change and altered disturbance regimes?



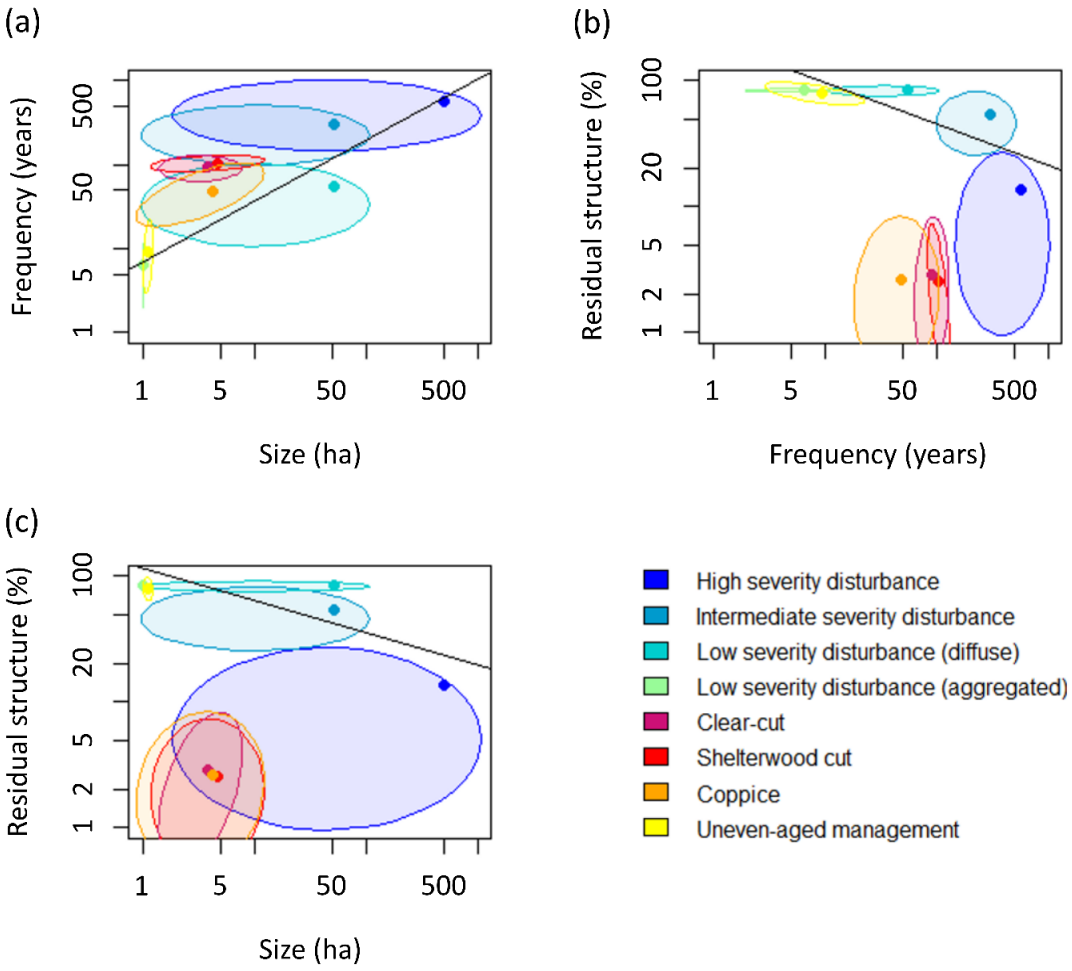
High severity disturbance
Intermediate severity disturbance
Low severity disturbance (diffuse)
Low severity disturbance (aggregated)
Clear-cut
Shelterwood cut
Coppice
Uneven-aged management

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.

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)

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

CONCLUSIONS

High variability of natural disturbances

Natural disturbances are highly variable in size, frequency, and severity, but European forest management fails to encompass this complexity

1

2

Even-aged systems dominate

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

Significance of residual structure

Residual structure proved crucial in the comparisons, highlighting key differences between forest management and natural disturbances

3

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?

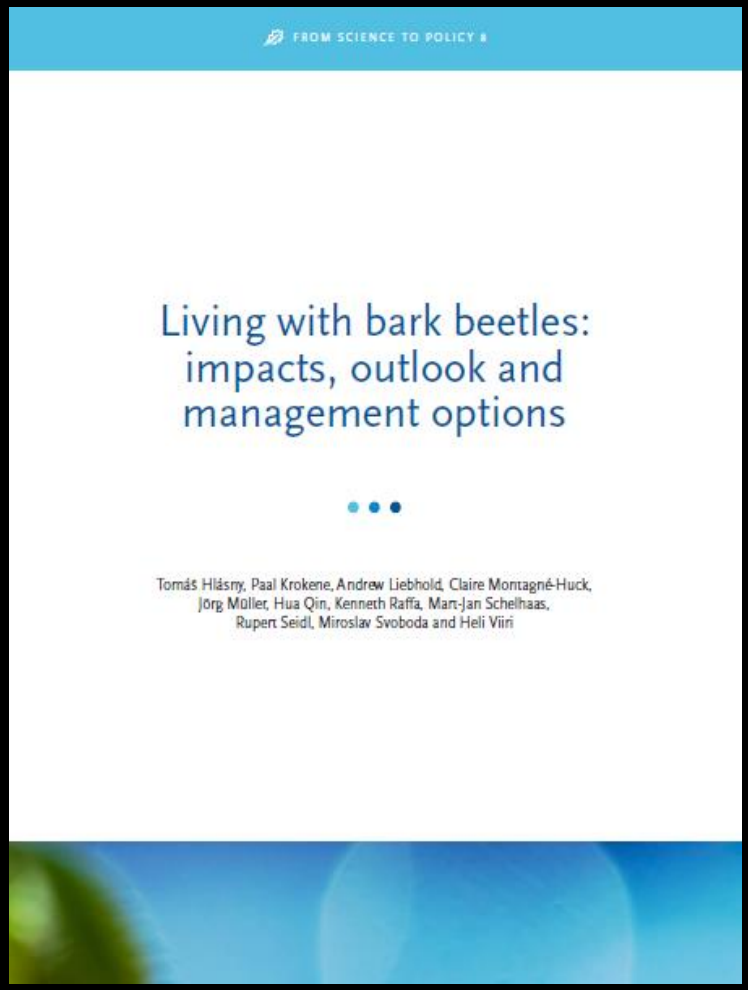
Works well for:

- 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



Acknowledgements

FULBRIGHT

Trust for Mutual Understanding

FULBRIGHT Hungary
CELEBRATING OUR 25TH ANNIVERSARY

Life4Oak Forests

fulbrightaustria

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

Koprova Valley, Slovak Republic, High Tatras Mtns, June 2019