A Global Analysis of Temperate Old-Growth Forests

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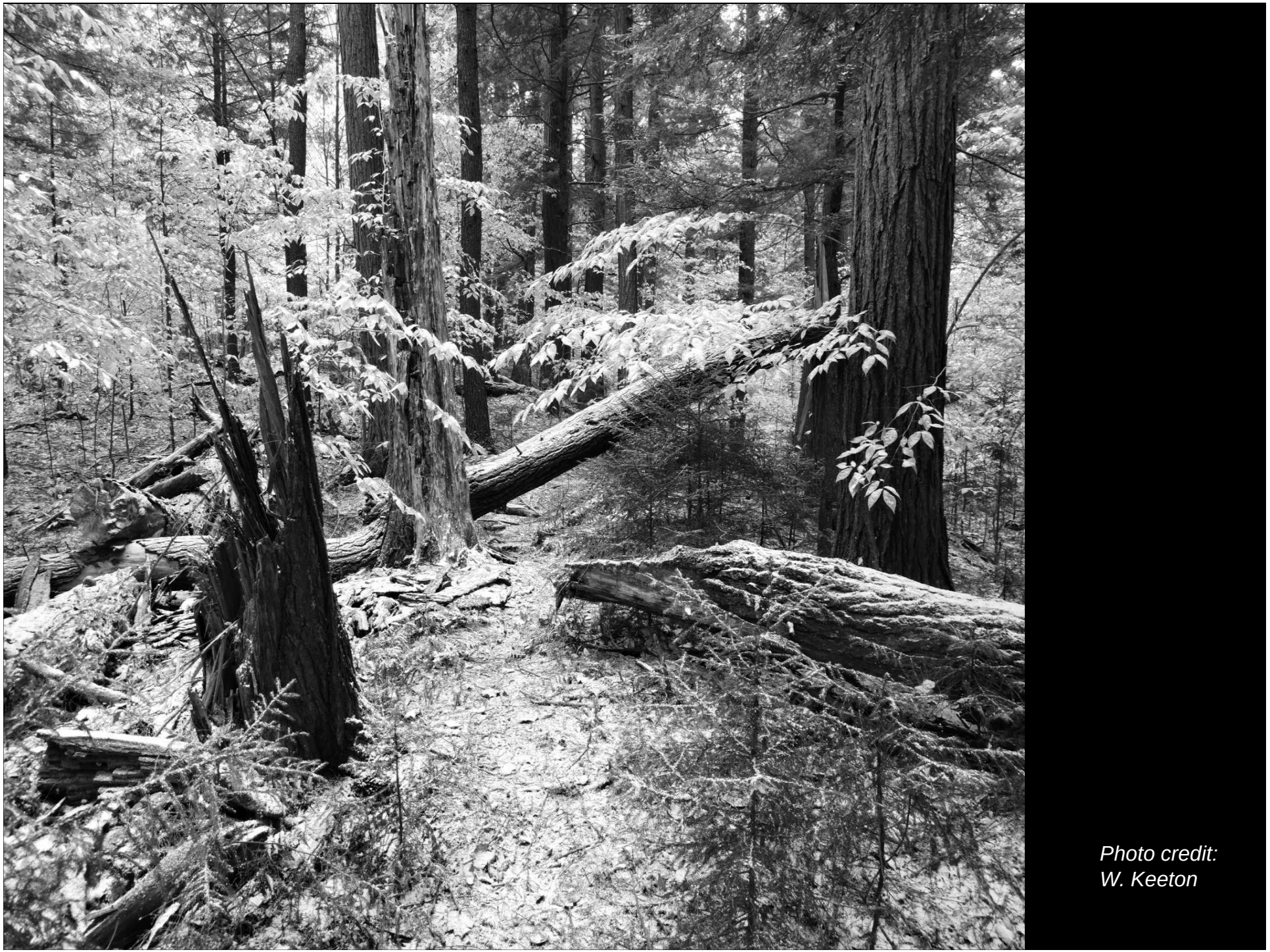

Photo credit:
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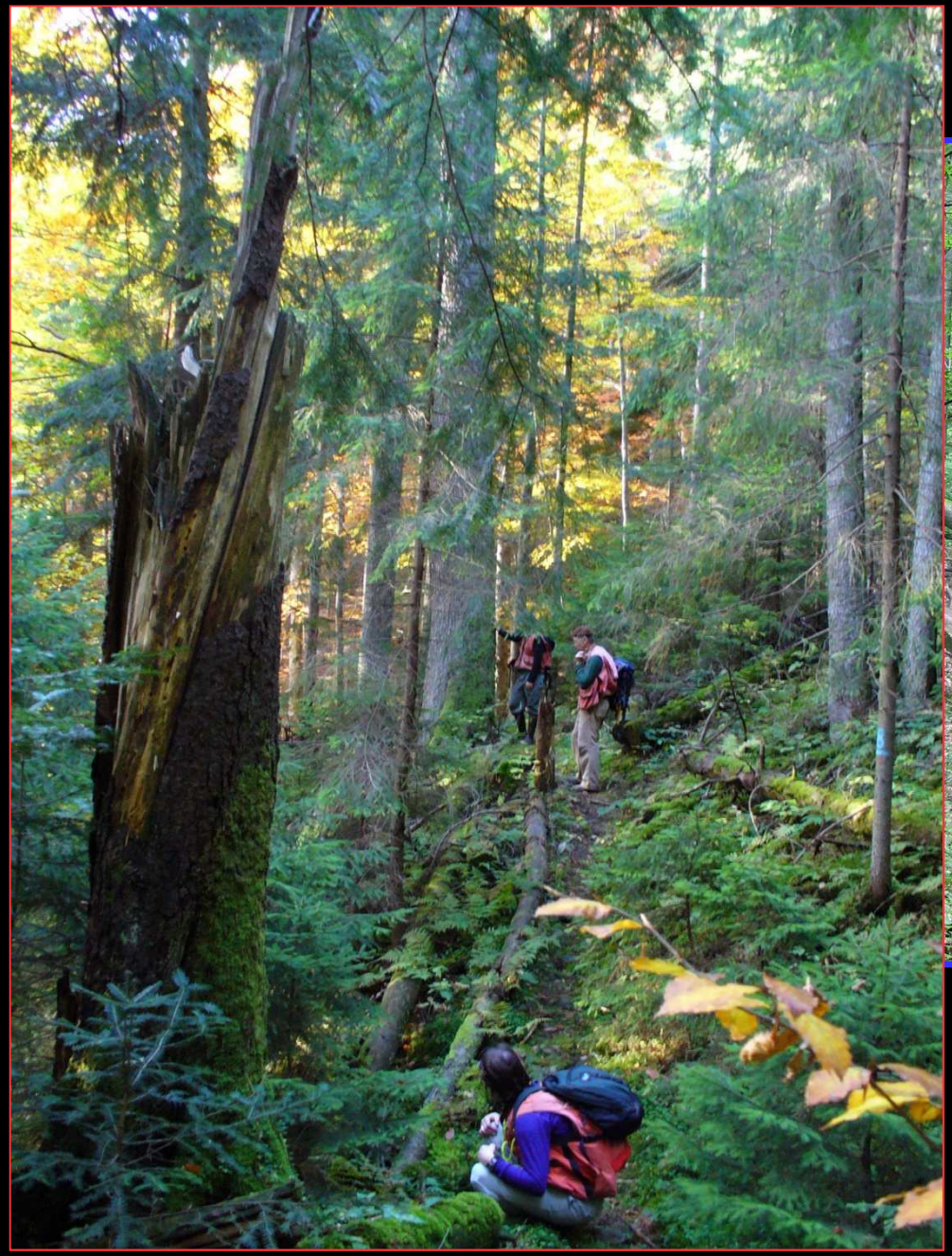
Nothofagus spp. forests,
Tierra Del Fuego, Chile

Eucalyptus delegatensis,
Tasmania, Australia

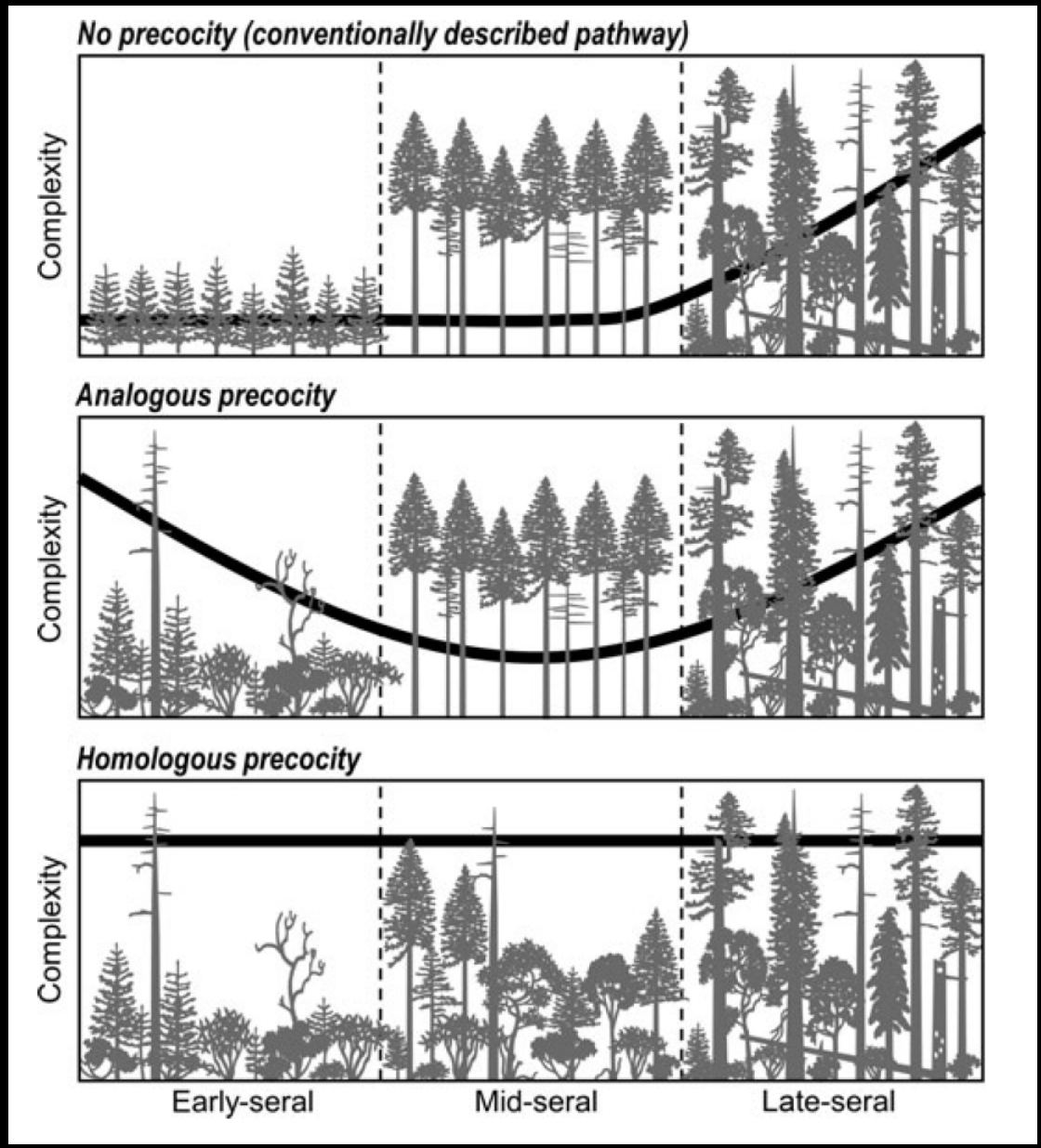


Carpathian Mountains, Ukraine

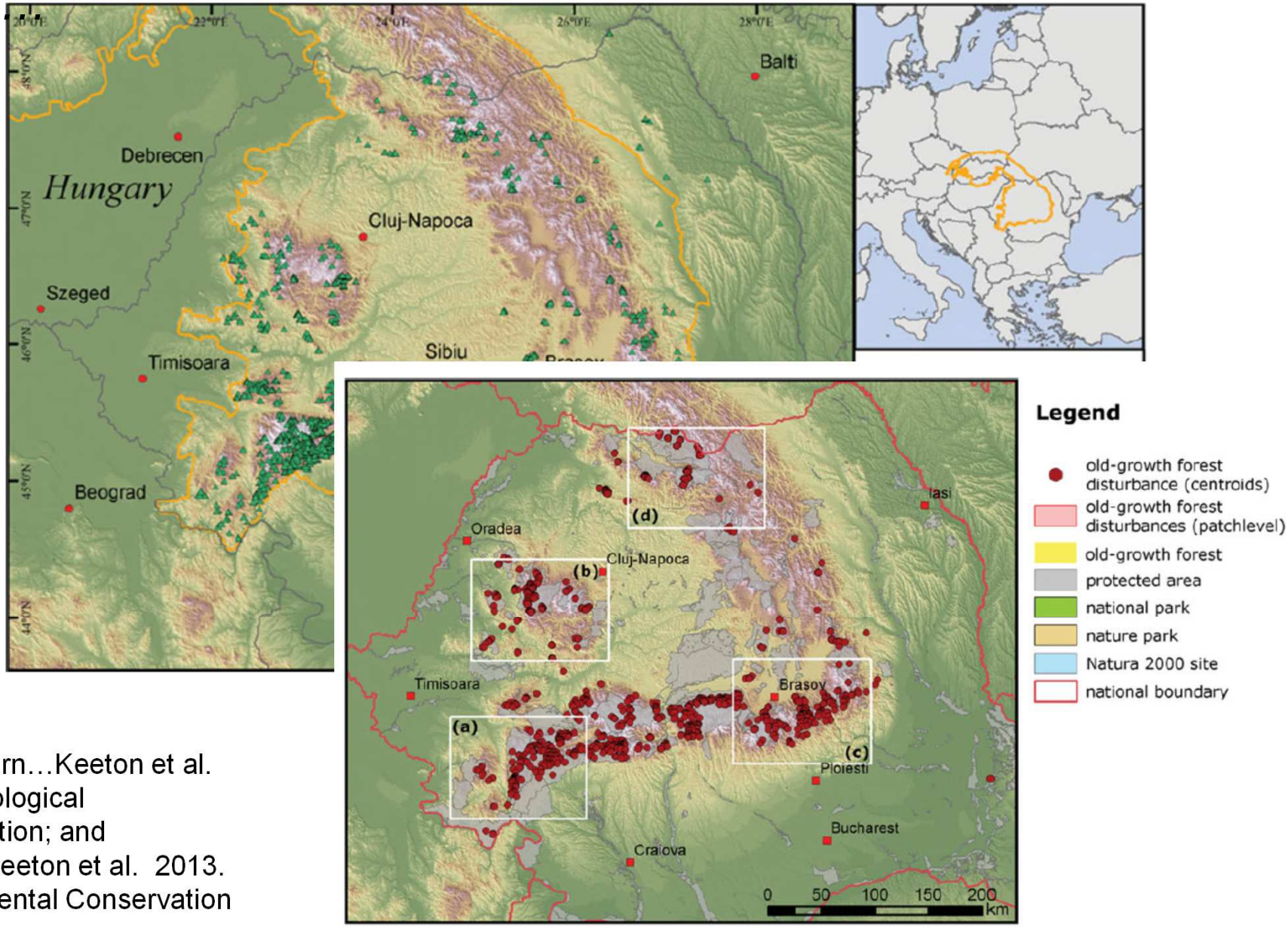
Photo credits: W. Keeton

Alternate pathways of forest development

From Donato et al. 2012. Journal of Vegetation Science



Old-growth distribution and disturbance trends in Romania



From Knorn…Keeton et al. 2012. Biological Conservation; and Knorn…Keeton et al. 2013. Environmental Conservation

Research Questions

- Universal structural characteristics?
  - How variable?
  - Differences reflective of regional ecology and disturbance regimes?

- Potential for carbon storage and other co-varying ecosystem services?

Global distribution of temperate forests by latitude

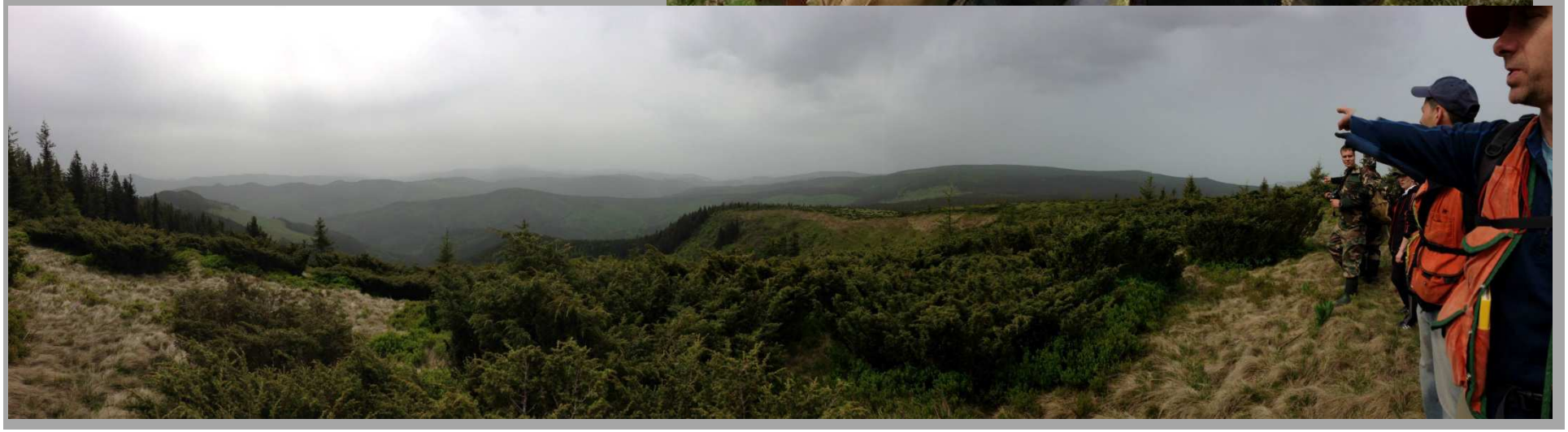
Global Analysis of Temperate Old-growth Forests

Total N = 501 sites
Carpathians N = 99 (32 OG, 67 Mature);
Poland, Ukraine, Slovakia, Romania

Getting there…

Our ride: “Mama”…

Final preparations…



Crash training in forest inventory and carbon estimation techniques

Data collection…

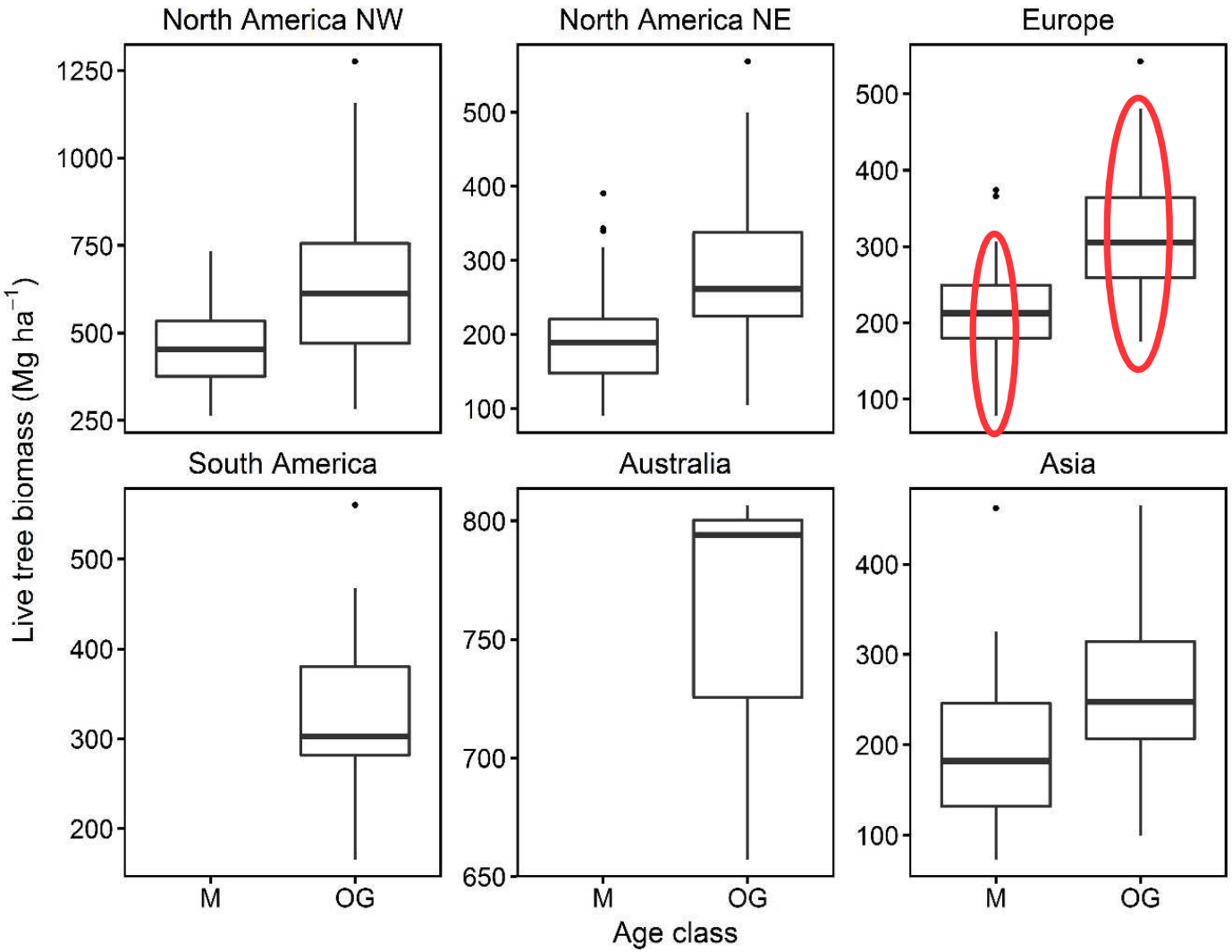
Key Structural Metrics

- *n* varies by analysis from 212 to 341
- *n* = 501 for biomass data

CATEGORY	VARIABLE
Stocking (live and dead)	Total basal area (m^2 ha^{-1})
	Live basal area (m^2 ha^{-1})
	Dead basal area (m^2 ha^{-1})
	Total stem density (trees ha^{-1})
	Live stem density (trees ha^{-1})
	Dead stem density (trees ha^{-1})
	Relative density (Curtis index)
Biomass	Total aboveground biomass (Mg ha^{-1})
	Live aboveground biomass (Mg ha^{-1})
	Dead aboveground biomass (Mg ha^{-1})
Tree diameter distributions	Q factor
	Medial diameter (cm)
	Quadratic mean diameter (cm)
Large tree structure	Total large tree density (trees ha^{-1} > 50 cm dbh)
	Live large tree density (trees ha^{-1} > 50 cm dbh)
	Dead large tree density (trees ha^{-1} > 50 cm dbh)
Gap mosaics	Gap area (ha^2, gaps > 10 m^2)
	Mean gap size (m^2)
Canopy /vertical structure	Canopy height (m)
	Tree height diversity index (*H'*)
Downed Coarse Woody Debris	Forest LWD vol. (m^3 ha^{-1})
	Large log density (logs >50 cm max d., #/ha)

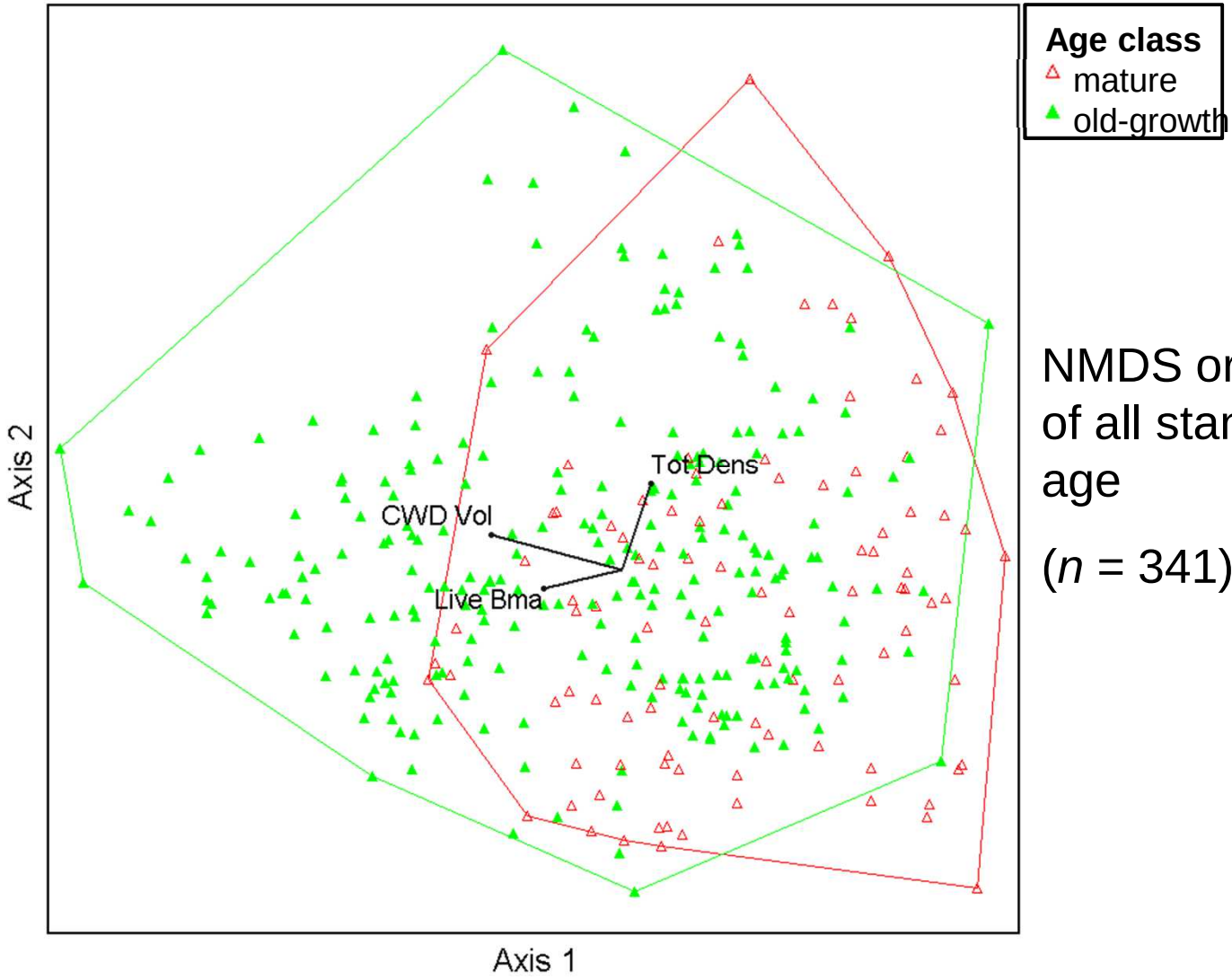
Commonality in old-growth structure globally?

- Old-growth values often higher than mature forest
- BUT high degree of variability within and among systems



M = Mature
OG = Old-growth

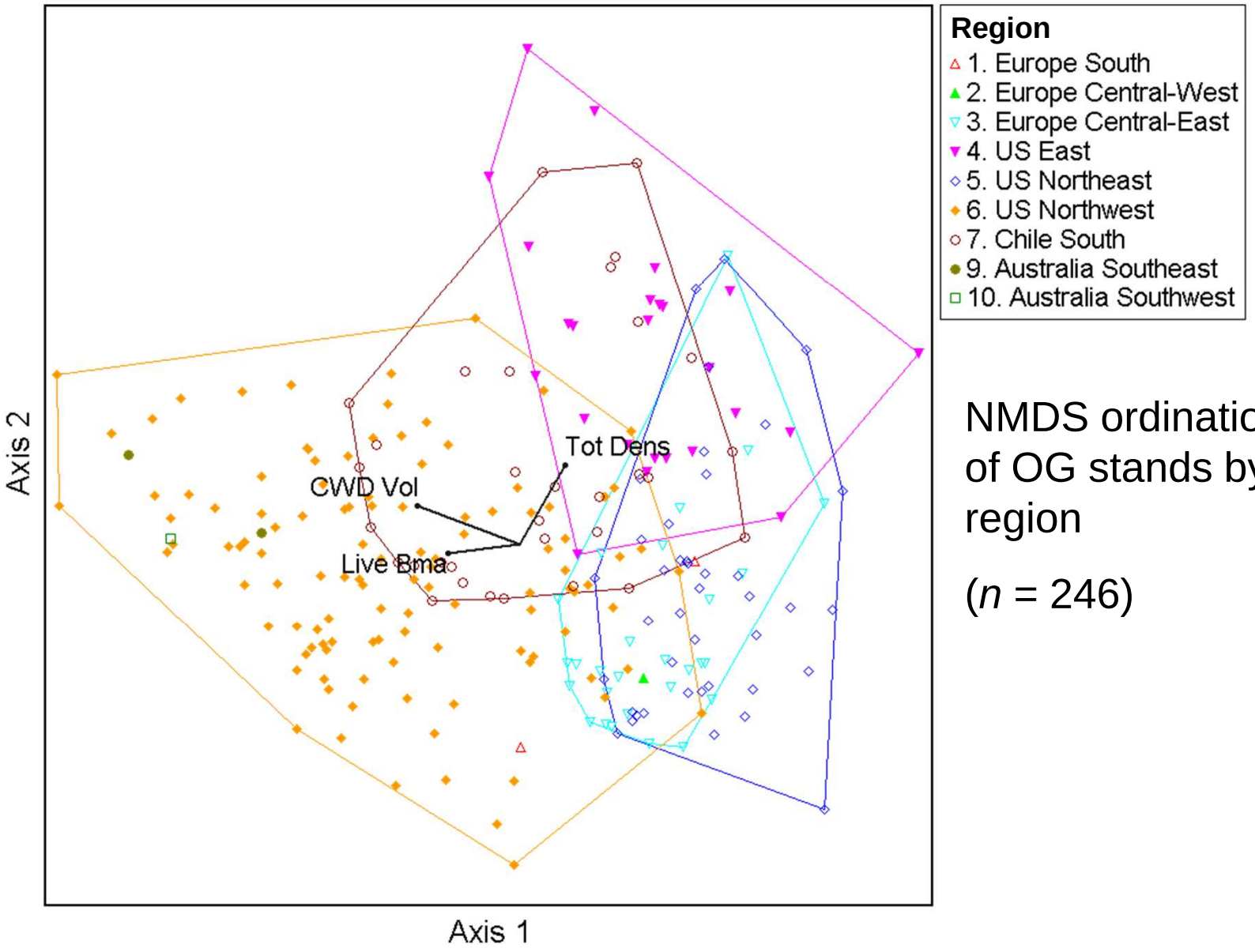
High degree of variability and overlap between age classes when data are viewed at the global scale



NMDS ordination of all stands by age

(*n* = 341)

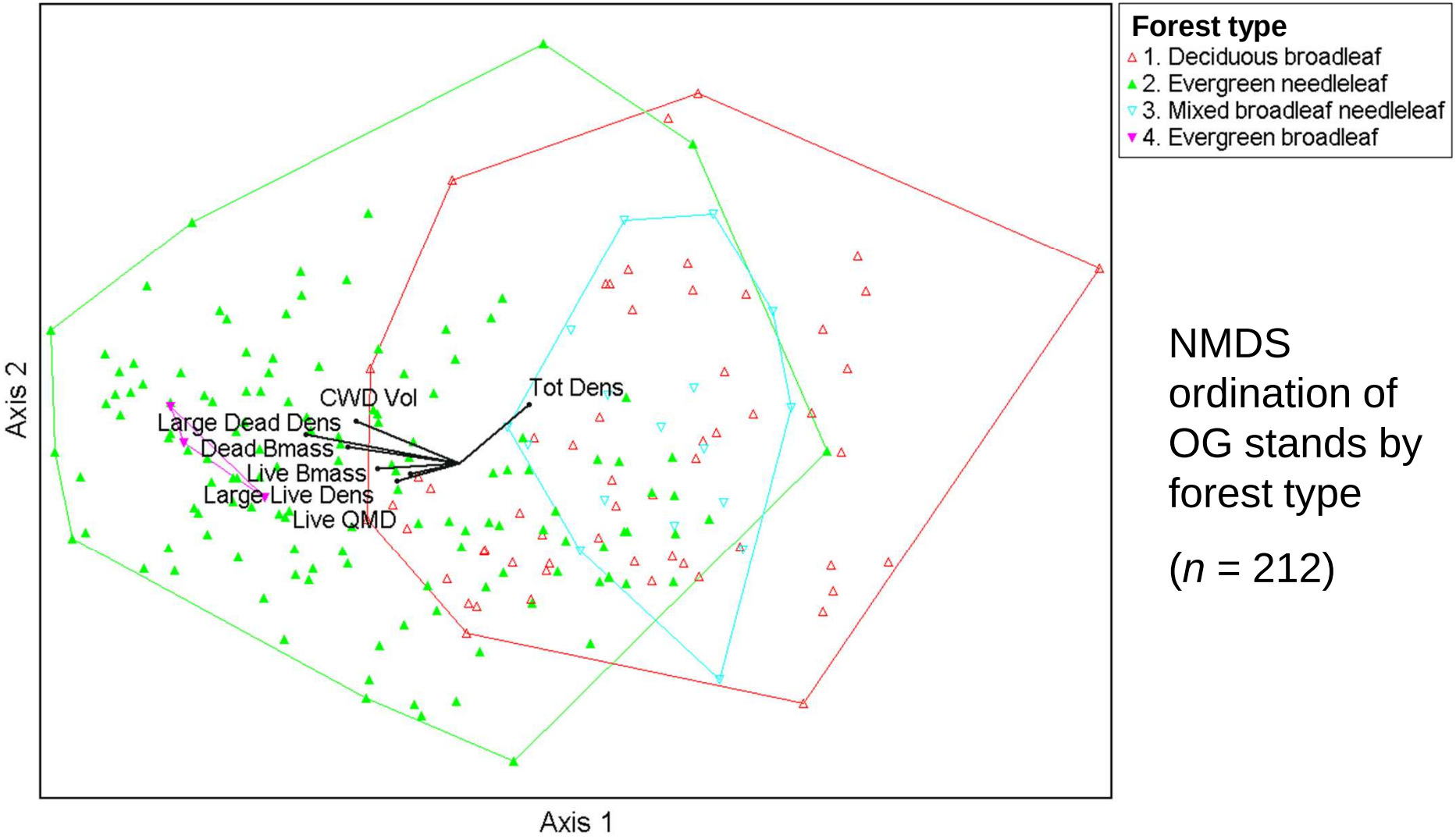
Old-growth forests in different regions exhibit different structure, except for the NE US and Central Europe



NMDS ordination of OG stands by region

(*n* = 246)

Additional structural variables help differentiate forest types along a needleleaf-broadleaf gradient



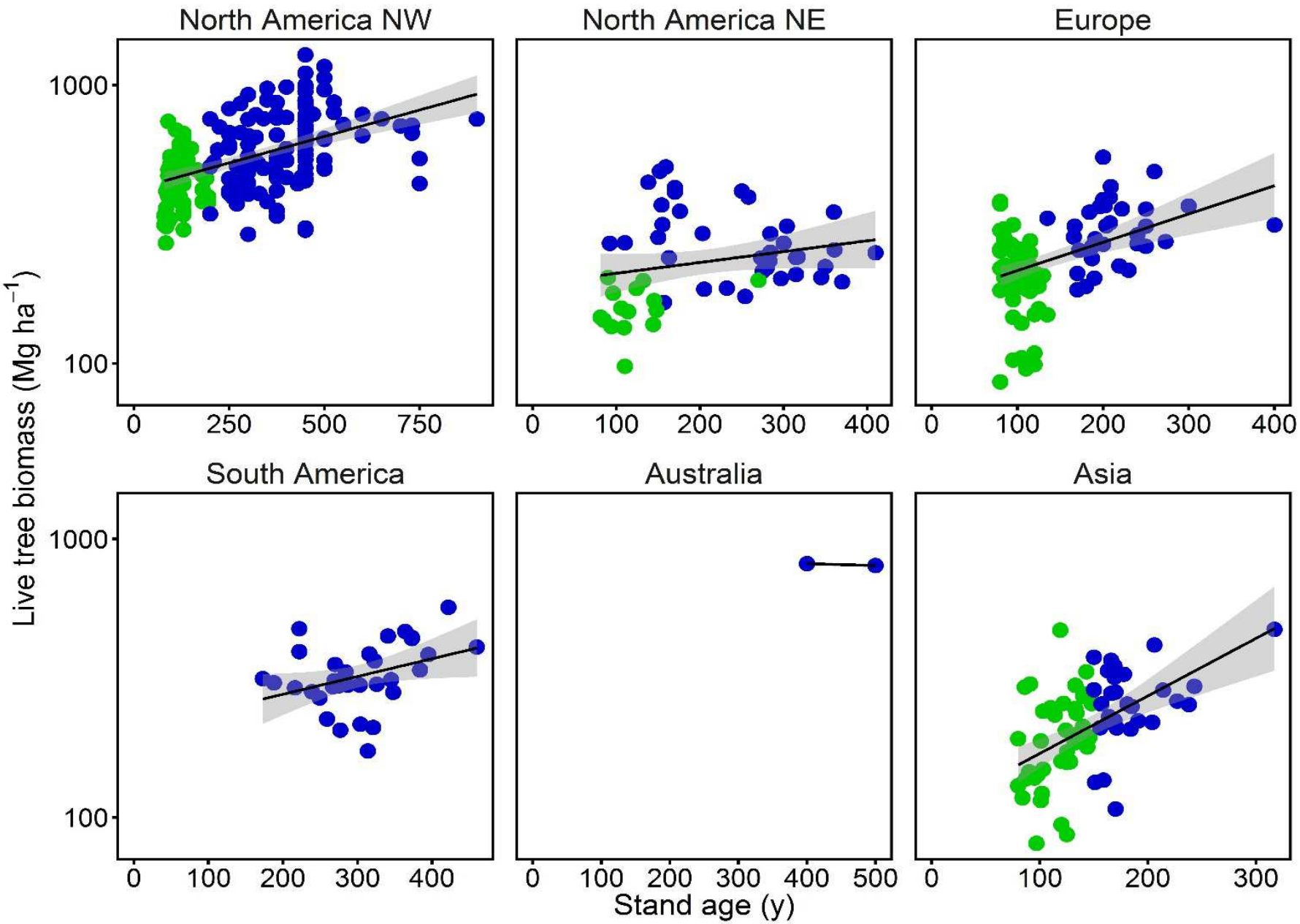
NMDS ordination of OG stands by forest type

(*n* = 212)

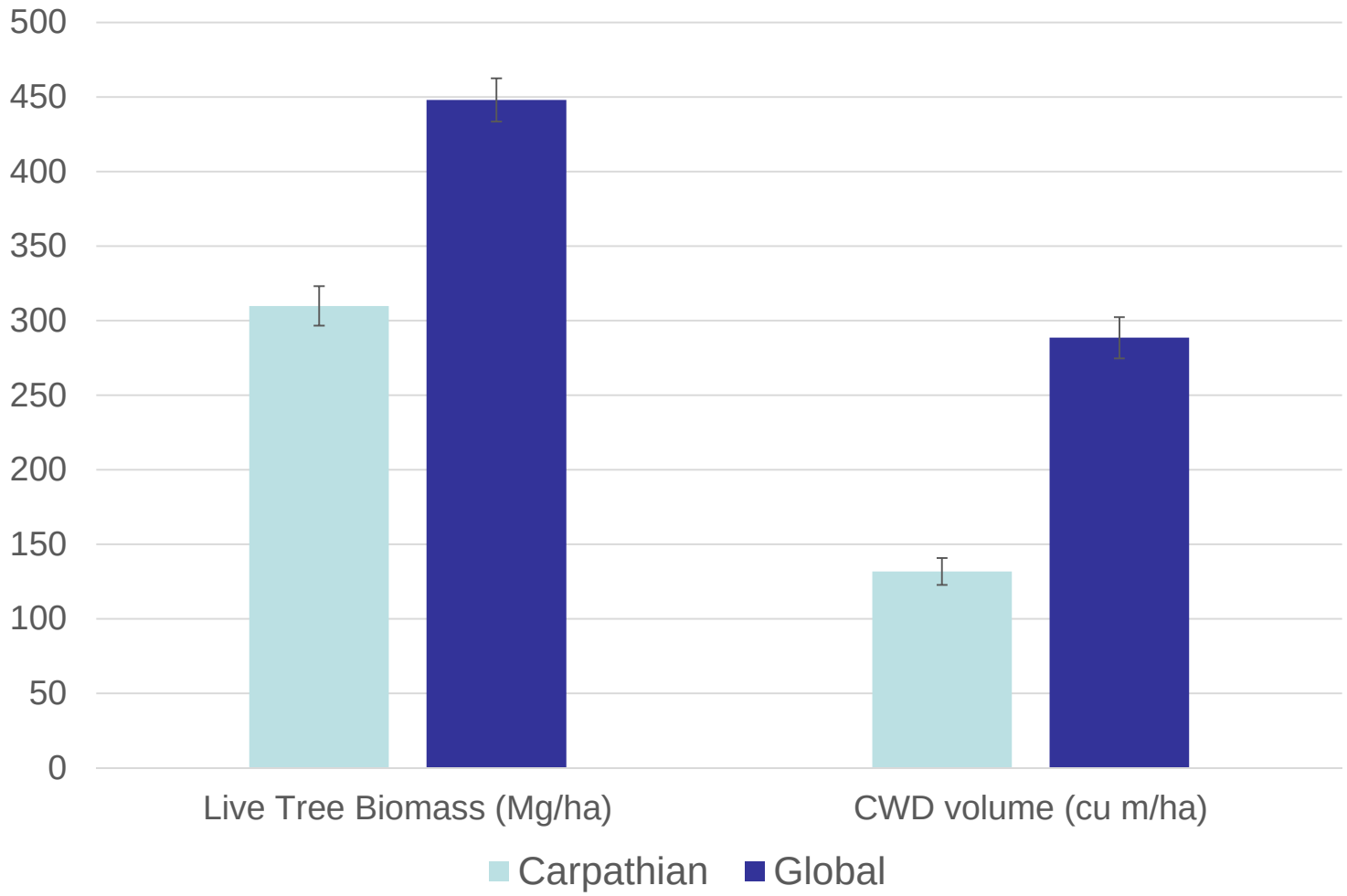
Kendall's Tau (Ranked Correlation)

	Axis 1			Axis 2		
	r	r-sq	tau	r	r-sq	tau
BA_Live	,734	,539	**,559**	,628	,394	**,451**
STEMDENS	-,517	,268	-,346	,698	,487	**,546**
LAB	,865	,748	**,705**	,389	,151	,311
DAB	,523	,274	,360	,413	,171	,405
Height	,608	,369	**,561**	,138	,019	,150
QMD	,585	,342	,504	-,072	,005	-,060
LLT	,692	,480	,512	,313	,098	,243
LDT	,616	,379	,510	,357	,128	,332
CWD	,628	,394	,468	,504	,254	**,471**

LAB = Live Aboveground Biomass

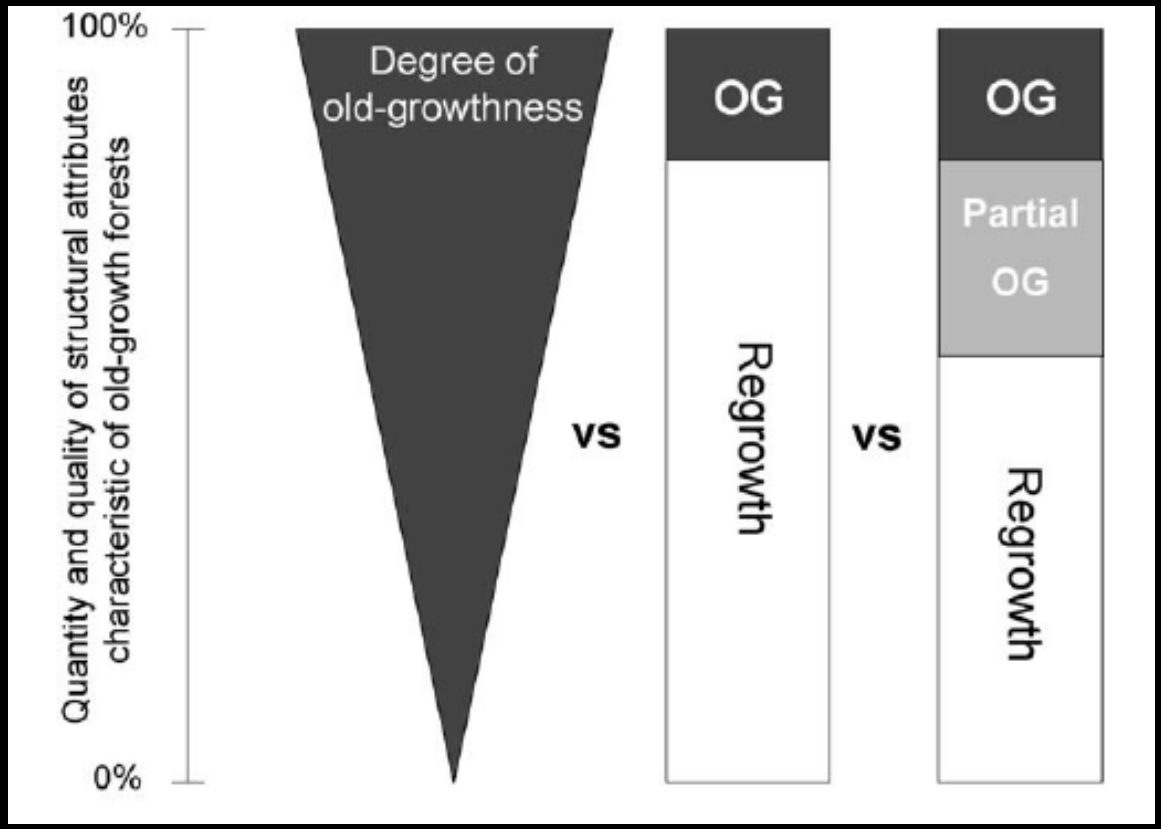

North America NW
North America NE
Europe
South America
Australia
Asia
Live tree biomass (Mg ha^{-1})
Stand age (y)
1000
100
0
250
500
750
100
200
300
400
500

How do Carpathian old-growth forests compare?



Broadening our perspective about “primary forests” and old-growth

- Recognizing variability
- Expansion of primary and old-growth forest definitions
- Multiple pathways of development
- Incorporate dynamics



From: Bauhus, J., Puettmann, K., Messier, C., 2009. Silviculture for old-growth attributes. Forest Ecology and Management 258: 525-537.

Criteria for Identification of Virgin Forests – Accommodating of Variability

CRITERIA & INDICATORS FOR SELECTION OF VIRGIN FORESTS IN THE CARPATHIANS

A1	Criterion:	Naturalness
	Indicators:	**Defining:**
A.1.1.	Species composition	Forests formed of native/autochtonous tree species according to potential natural forest types.
A1.2	Structure	Cyclic ecosystems with complex structures, which include all stages of small development circles (some phases may be present only in small areas) in a mosaic structure (horizontal) and vertically layered, according to the natural type of forest. Range of tree ages proved by biometric characteristic.
		Occurrence of trees with exceptional dimensions according to the site conditions and species, and signs of physiological decline.
A1.3	Deadwood	Presence of deadwood (lying and standing) at all stages of degradation and all over the forest surface.
A1.4	Human activities which influenced the development, structure and dynamic of the	**Infrastructure:** No documented evidence and no visible traces of forest exploitation infrastructure (e.g. absence of remnants of facilities of wood water transport supporting walls, regulating facilities roads, trails, dams, cable systems, etc.) or other forestry machinery recent traffic. Limited traces of pedestrian activities are allowed (pathways not wider than 1 m).

From:http://www.carpathianconvention.org/tl_files/carpathiancon/

Emulating natural disturbances and managing for old-growth characteristics

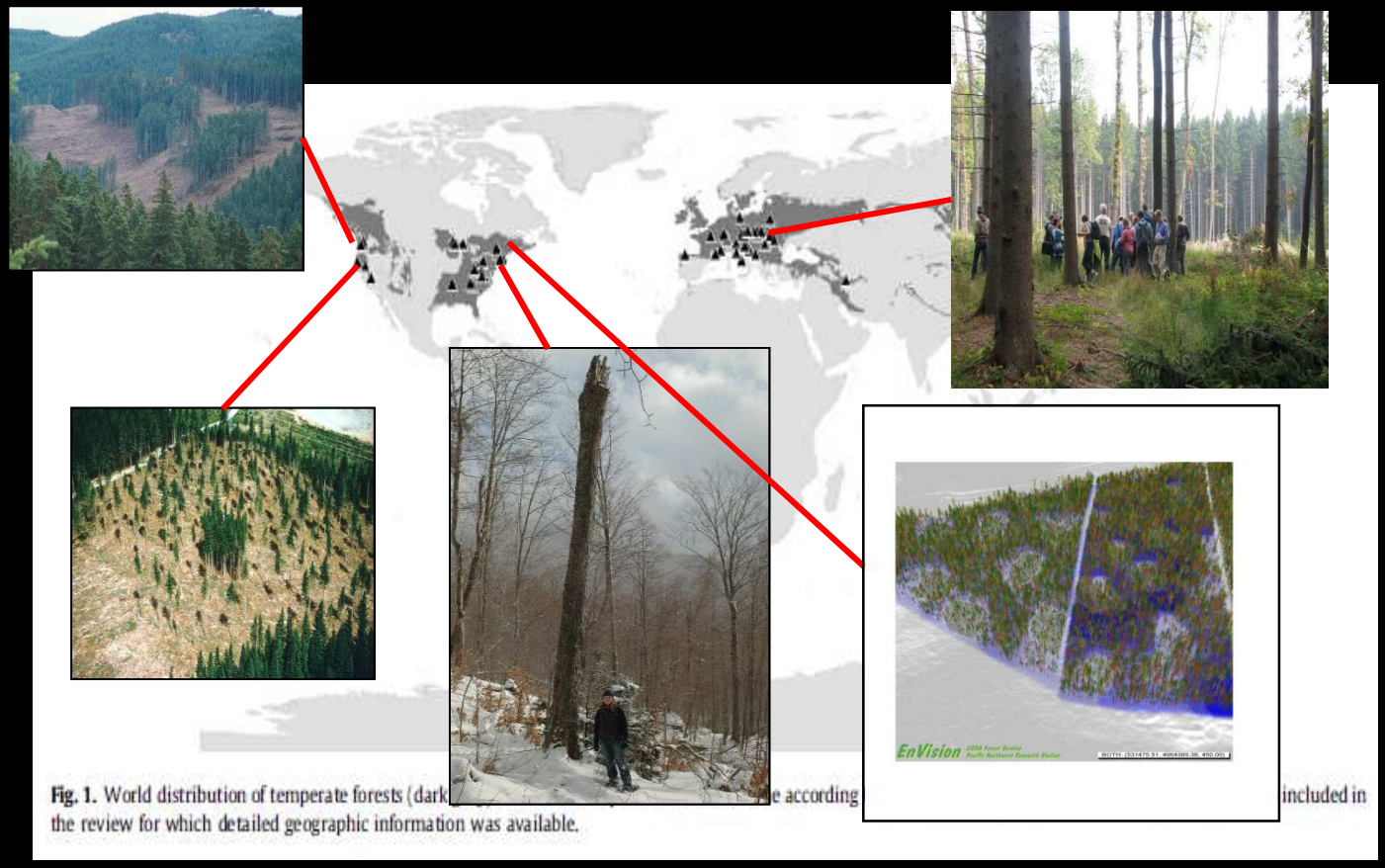


Fig. 1. World distribution of temperate forests (dark … e according … included in the review for which detailed geographic information was available.

From: Burrascano, S., W.S. Keeton, F.M. Sabatini, and C. Blasi. 2013. Commonality and variability in the structural attributes of moist temperate old-growth forests: A global review. Forest Ecology and Management 291:458–479.

Conclusions

- **Carpathian old-growth forests are intermediate in structural complexity, but share characteristics deemed of universal ecological value.**
- **Aboveground biomass (live and dead), large tree densities, and CWD volumes are universally predictive of stand age, but there is high variability within and among systems.**
- **Criteria for defining and mapping old-growth need to accommodate variability in developmental pathways and forest structure.**
- **Conservation of the world's remaining old-growth forests, including those in the Carpathians, will maintain an important carbon storage reservoir, while providing co-varying ecosystem services.**

- National Science Foundation
- USDA CSREES National Research Initiative
- Northeastern States Research Cooperative
- USDA McIntire-Stennis Forest Research Program
- U.S. Fulbright Scholarship Program
- Trust for Mutual Understanding