

Primary forests

- Represent some of the last pristine wilderness areas of temperate Europe

What are primary forests?

- Forests that develop free of direct human intervention
- Natural stand composition, broad distribution of tree ages, presence of veteran trees, high proportion of old canopy trees, diversity of horizontal and vertical structure, and a significant amount and diversity of standing and downed dead trees in different stages of decomposition
- Developed under a natural disturbance regime. In addition to late-successional forests, primary forests include all developmental phases including early seral stages and young forests that originated after natural disturbances









Foto: Karol Kaliský





- 1.4 M ha mapped
- 32 countries
- 0.7% of Europe's forest area
- ~89% protected (any)
- 46% Strictly protected (IUCN I)

Received: 20 September 2017 | Accepted: 19 April 2018
 DOI: 10.1111/ddi.12778




BIODIVERSITY REVIEW

WILEY Diversity and Distributions













Where are Europe's last primary forests?

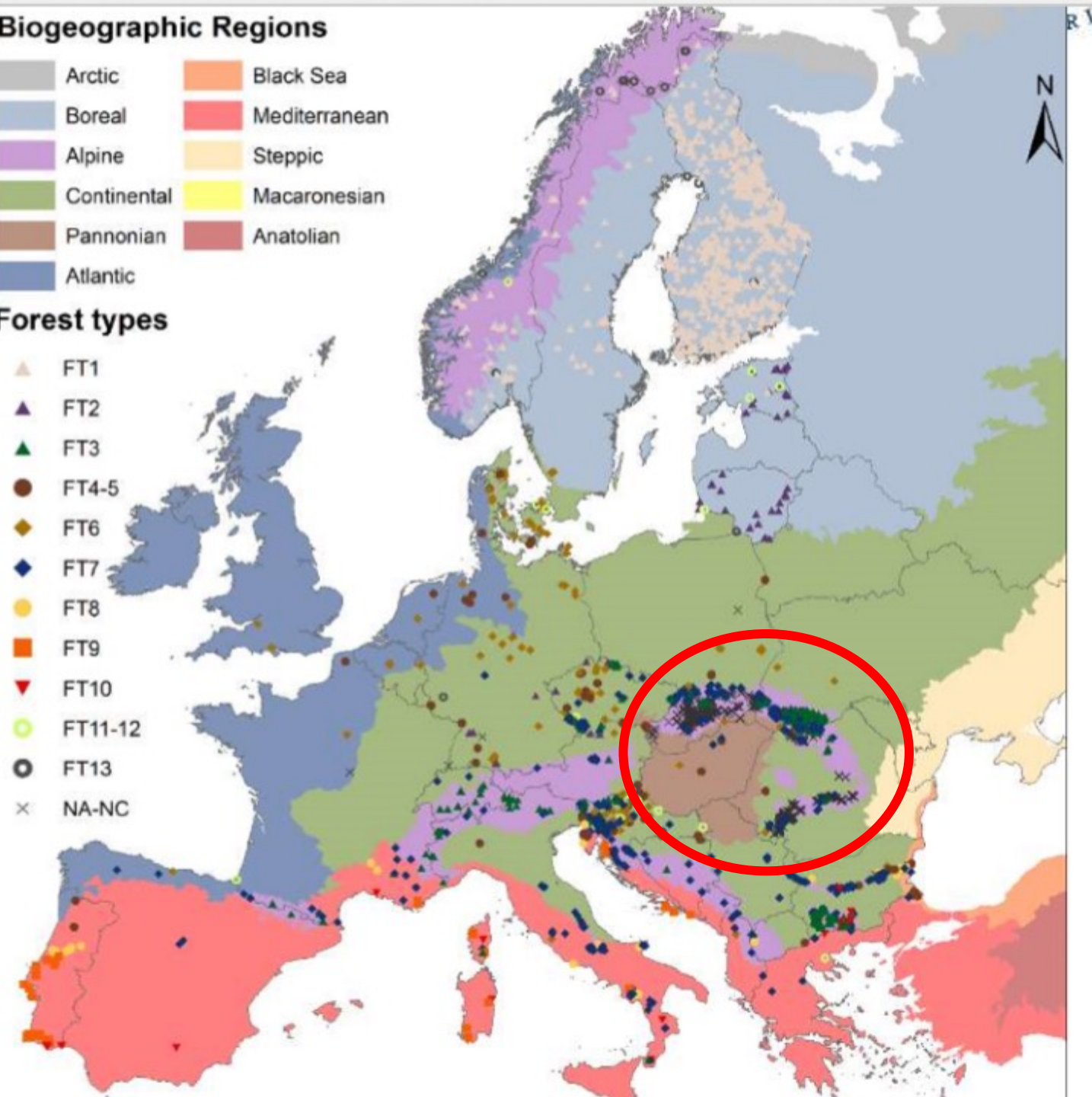
Francesco Maria Sabatini¹  | Sabina Burrascano² | William S. Keeton³ |
 Christian Levers¹  | Marcus Lindner⁴ | Florian Pötzschner¹ | Pieter Johannes Verkerk⁵ |
 Jürgen Bauhus⁶ | Erik Buchwald⁷ | Oleh Chaskovsky⁸ | Nicolas Debaive⁹ |
 Ferenc Horváth¹⁰ | Matteo Garbarino¹¹ | Nikolaos Grigoriadis¹² | Fabio Lombardi¹³ |
 Inês Marques Duarte¹⁴  | Peter Meyer¹⁵ | Rein Midteng¹⁶ | Stjepan Mikac¹⁷ |
 Martin Mikoláš¹⁸ | Renzo Motta¹¹ | Gintautas Mozgeris¹⁹ | Leónia Nunes^{14,20} 

Biogeographic Regions

- | | |
|---|---|
|  Arctic |  Black Sea |
|  Boreal |  Mediterranean |
|  Alpine |  Steppic |
|  Continental |  Macaronesian |
|  Pannonian |  Anatolian |
|  Atlantic | |

Forest types

-  FT1
-  FT2
-  FT3
-  FT4-5
-  FT6
-  FT7
-  FT8
-  FT9
-  FT10
-  FT11-12
-  FT13
-  NA-NC



**However, many
primary forests are
still not mapped and
identified...**



Sambata valley,
Romania





Ucisoara valley, Romania

Ucea Mare,
Romania

Unmapped primary forests

just few meters from the road (45° 39.521'N, 24° 42.494'E). Presence of the Ural owl (*Strix uralensis*) was documented in the unmapped primary forests .







A wide-angle photograph of a mountain slope covered in a dense forest. The trees are mostly green, but some are beginning to turn yellow and orange, indicating the start of autumn. The forest extends to the top of the mountain, where a valley is visible in the distance. The sky is a clear, pale blue.

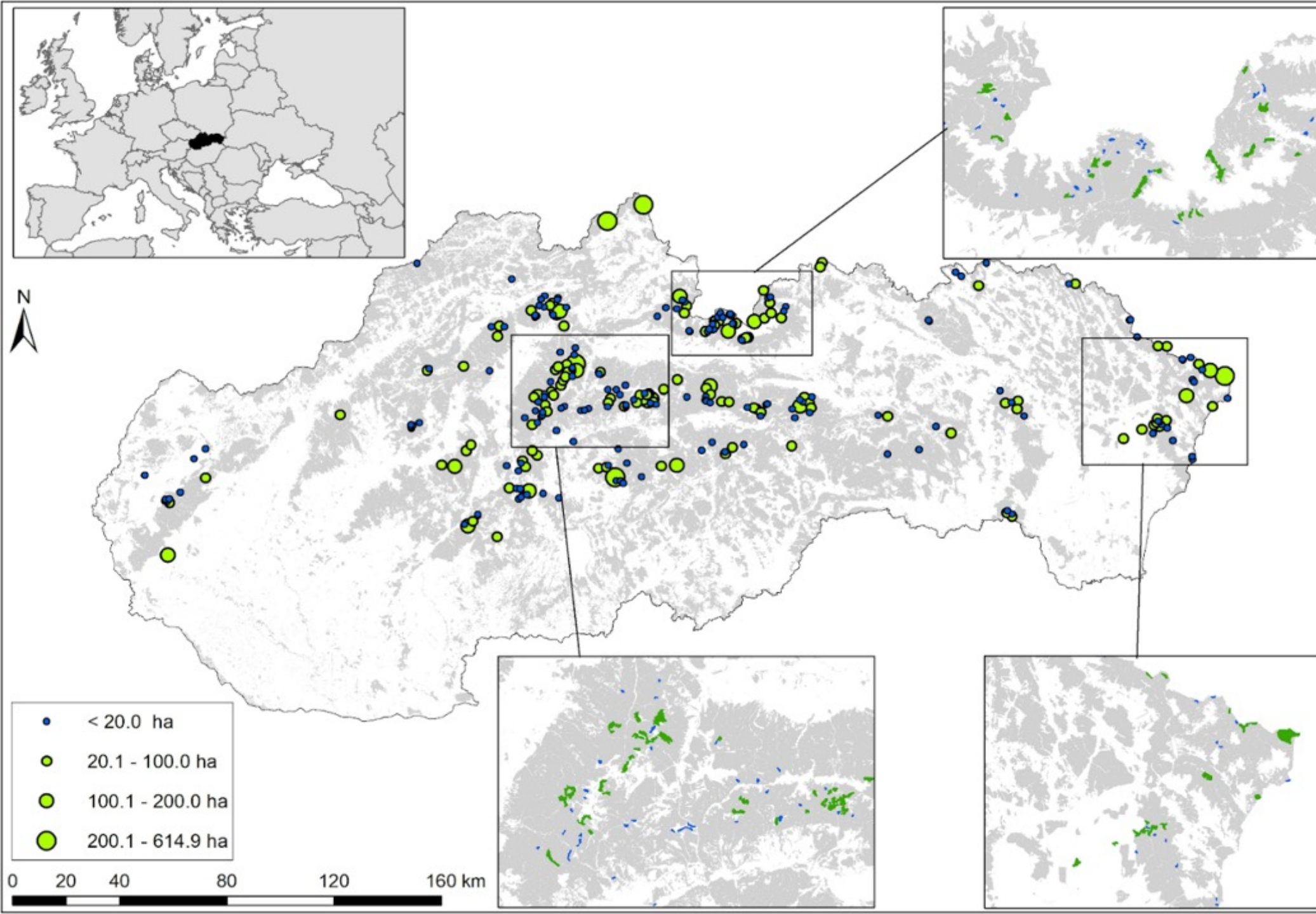
**Boia Mica,
Fagaras Mountains,
Romania**





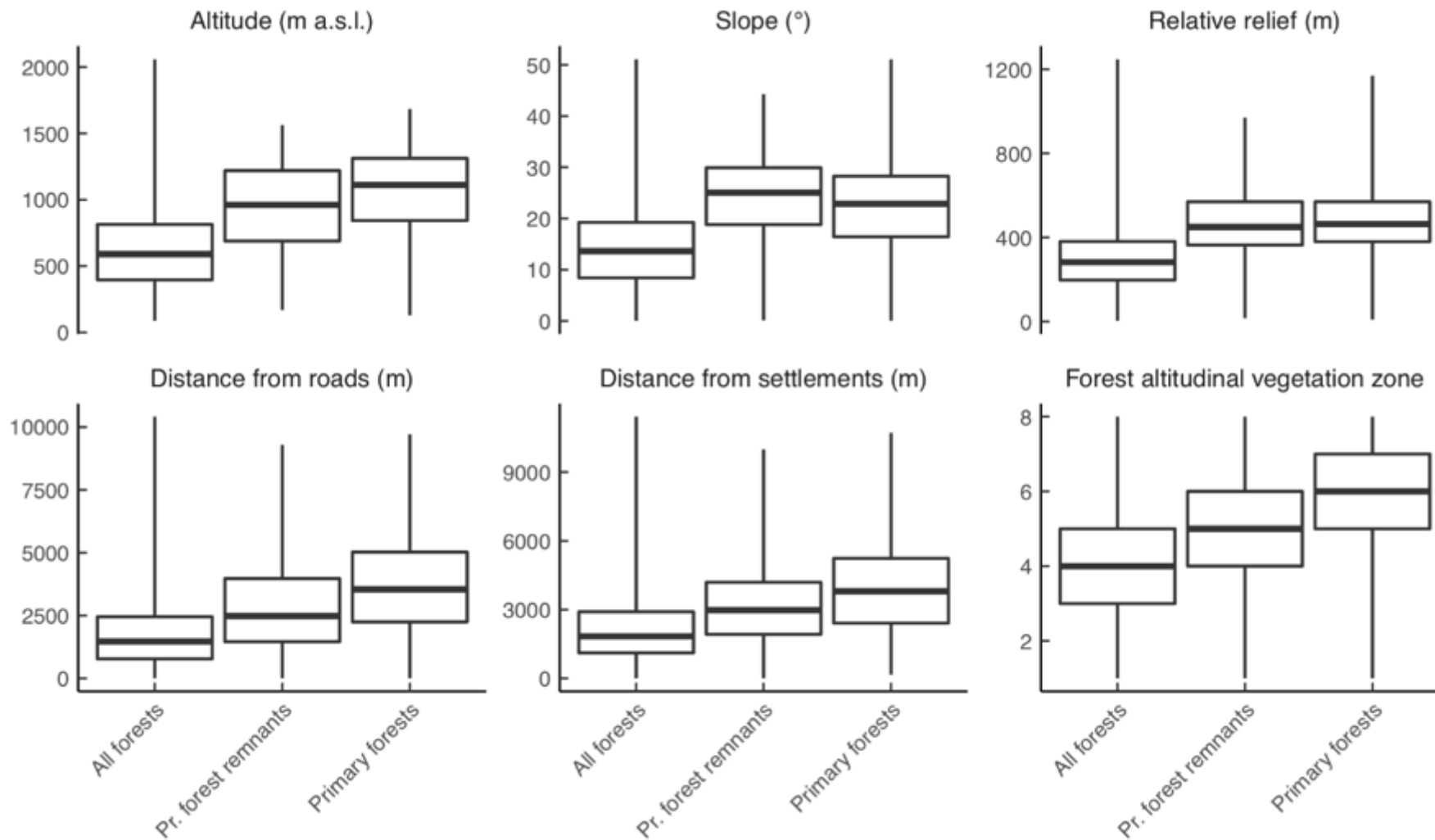
Boia Mica

- Almost 10 % of cored beech trees are older than 300 years
- In one plot, 17 trees older than 300 years



Slovakia

- 261 primary forest localities
- Only 0.47% of the total forested area
- 0.21% of the study landscape
- Spatial pattern of primary forests was clustered



Primary forests have tended to **avoid clearing** on sites with:

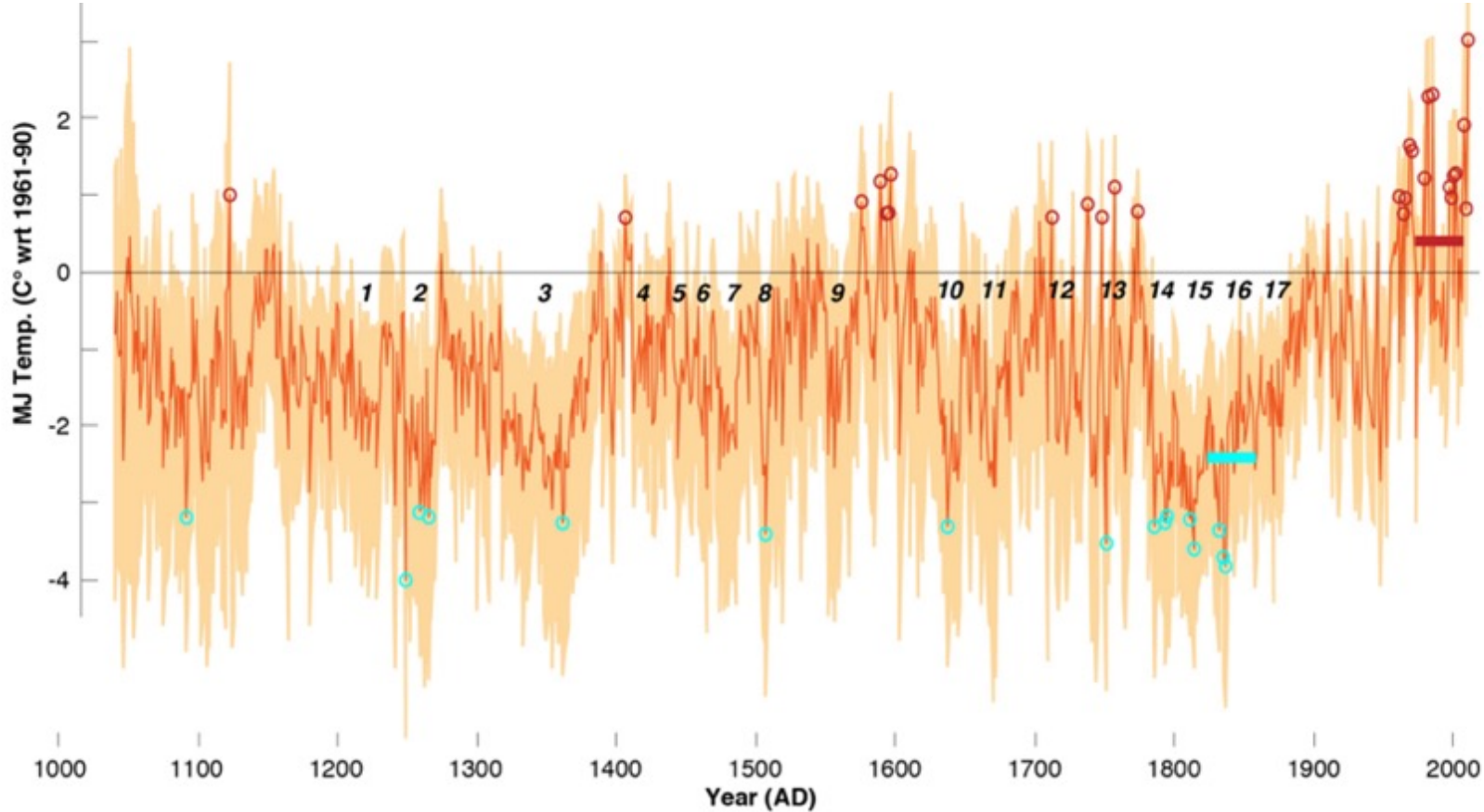
- Higher elevation
 - Steeper slopes
 - Rugged terrain
 - Greater distances from roads and settlements
- = Remote locations**

Comparison of landscape characteristics between all forest, primary forests remnants (5–20 ha), and primary forests (≥ 20 ha). The central line of each box refers to the median value, box height refers to the interquartile range, and vertical lines above and below the box indicate the maximum and minimum values, respectively.



**Primary forests = living laboratories
valuable reference sites for foresters
- remote project**

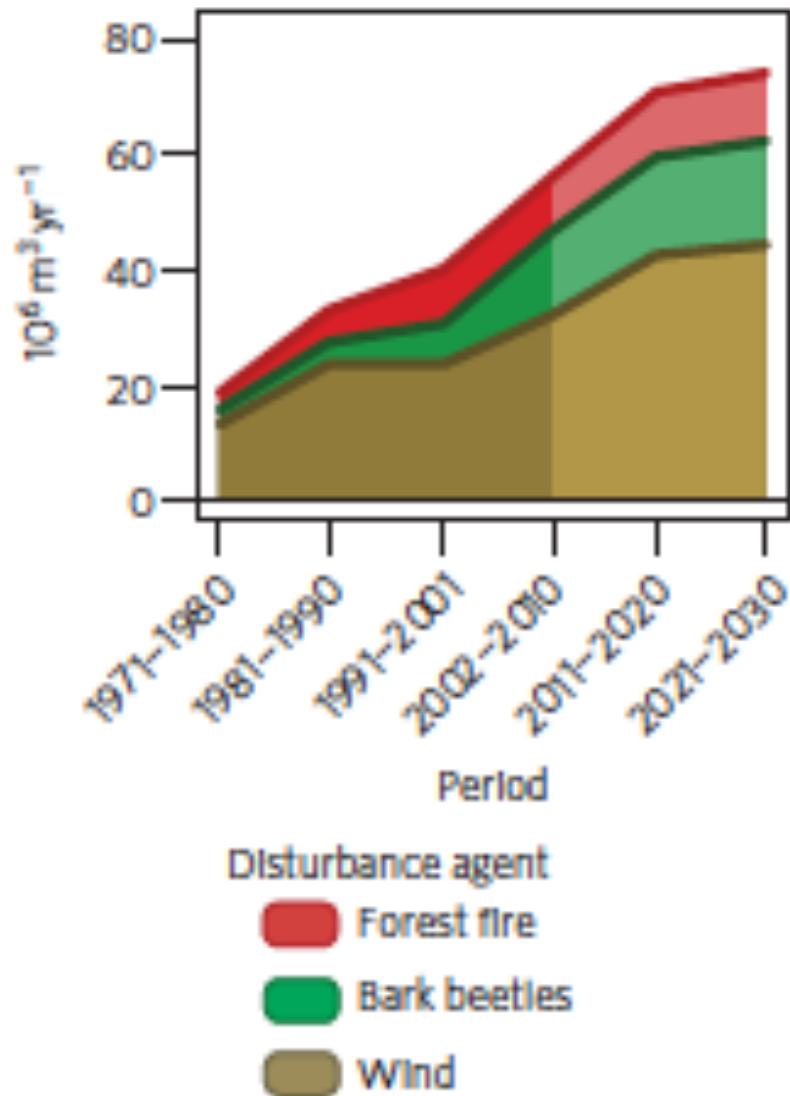
Climate change - many uncertainties



Buntgen et al. 2013 PNAS

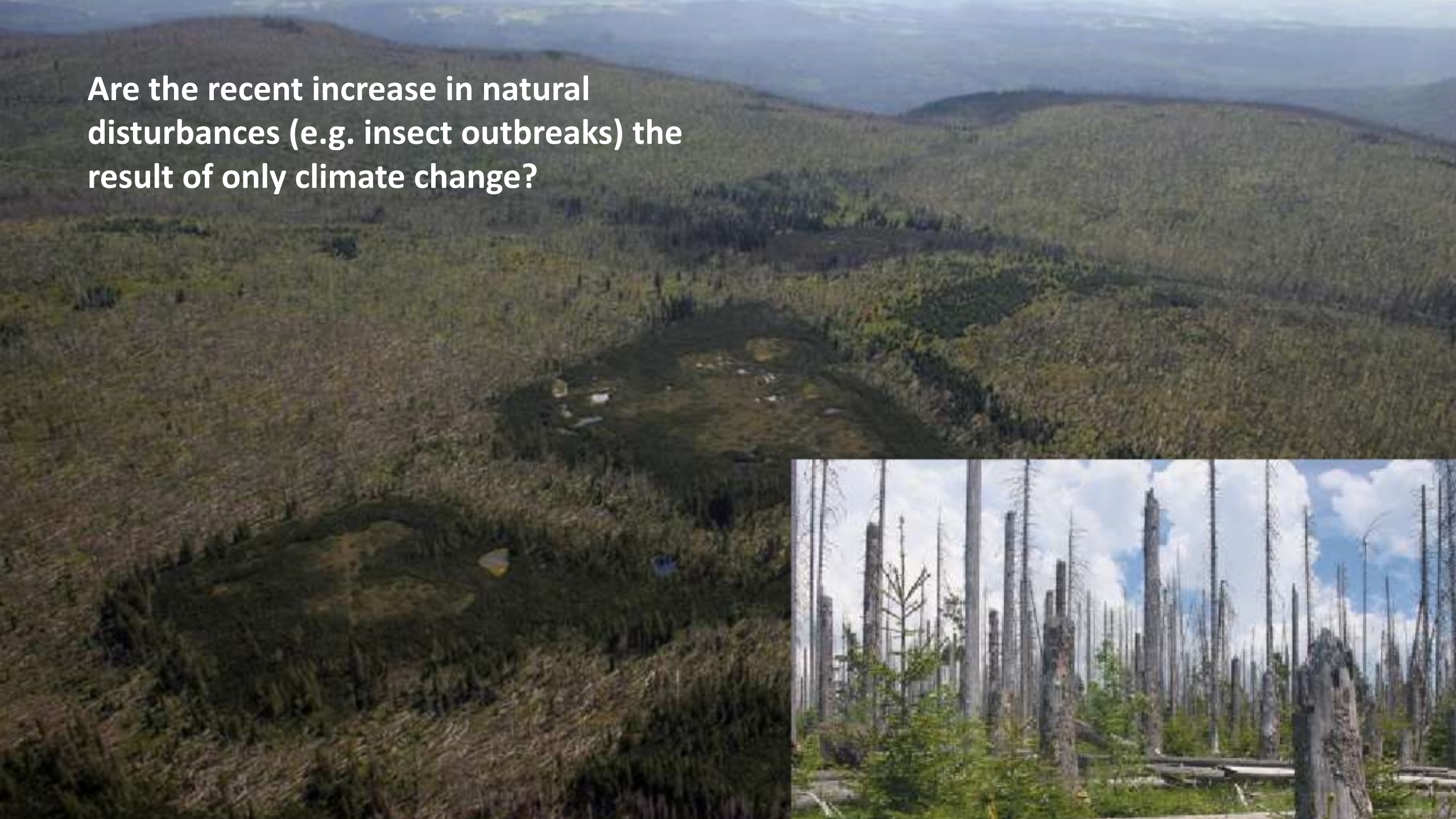
Increasing forest disturbances in Europe and their impact on carbon storage

Rupert Seidl^{1*}, Mart-Jan Schelhaas², Werner Rammer¹ and Pieter Johannes Verkerk³



Forest disturbance damage in Europe 1971-2030. Predictions (light hues) assume a continuation of business-as-usual forest management (reference strategy) and represent the median over an ensemble of scenarios of future climate and forest growth.

Are the recent increase in natural disturbances (e.g. insect outbreaks) the result of only climate change?





Primary forests of Europe's temperate zone play an important role in providing key ecosystem functions to our society. Primary forests also provide habitat for many species that help maintain biodiversity. Institutions and individuals behind the REMOTE (REsearch on MOUNTAIN TEMperate) Primary Forests project help enhance our understanding of unique primary forests over long periods of time by means of various activities including research, public outreach, and education.

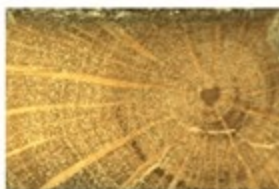
Our research

IV. ANNUAL DENDROCHRONOLOGICAL CONFERENCE

03.10.2018

Department of Forest Ecology Faculty of Forestry and Wood Sciences Czech University of Life Sciences Prague is organizing Dendroforum 2018 IV. annual dendrochronological conference. The conference is in the form of an informal meeting. Accepted papers will be presented orally. In case of interest...

[Read more](#)



WHERE ARE EUROPE'S LAST PRIMARY FORESTS?

16.05.2018

Agriculture and forestry have transformed much of Europe – but truly wild places still exist! Researchers from the Geography Department of Humboldt-Universität zu Berlin led the creation of the first map of Europe's last wild forests, including more than 1.4 million hectares in 34 European...

[Read more](#)

NEW RESEARCH PLOTS IN PRIMARY FORESTS OF SLOVAKIA

23.06.2018

During one week in June 2018 we established seven new research plots for a biodiversity survey in a beech dominated primary forest reserve Kundračka (Great Fatra Mountains). Again, it was



Our project: Remoteforests (www.remoteforests.org)

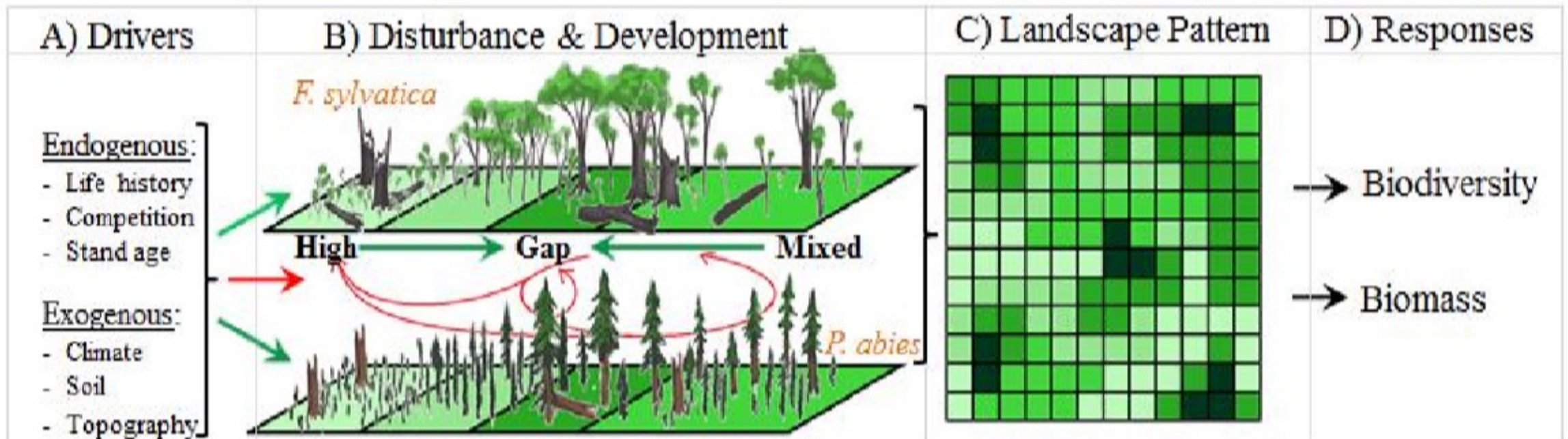


REMOTE

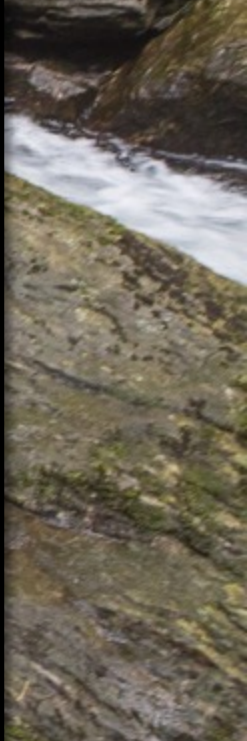
Primary Forests

Research on Mountain Temperate Primary Forests

Main objectives:



- Drivers of disturbance dynamics
- Tree growth history and forest carbon
- Stand structural diversity and biodiversity







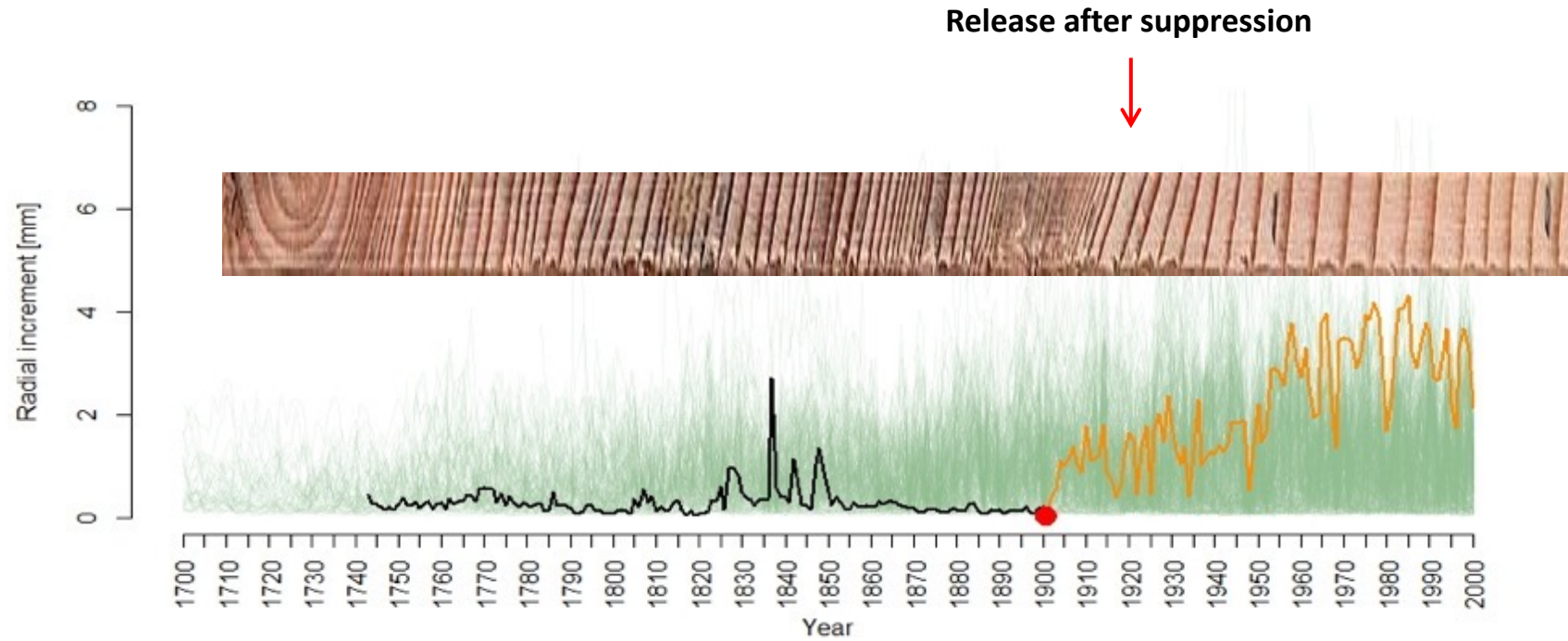





The largest dendrochronological database of temperate primary forests in Europe

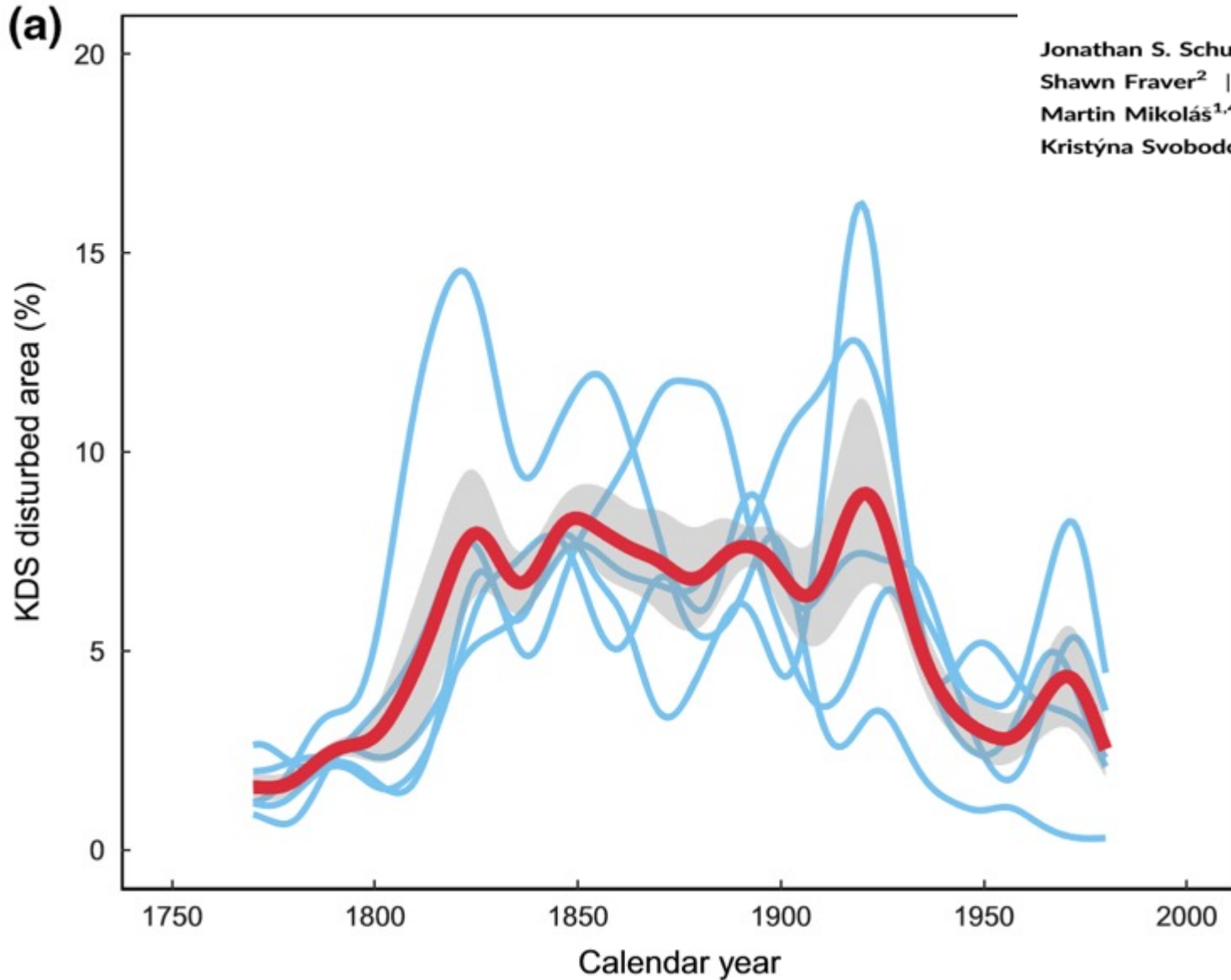


Disturbance history reconstruction



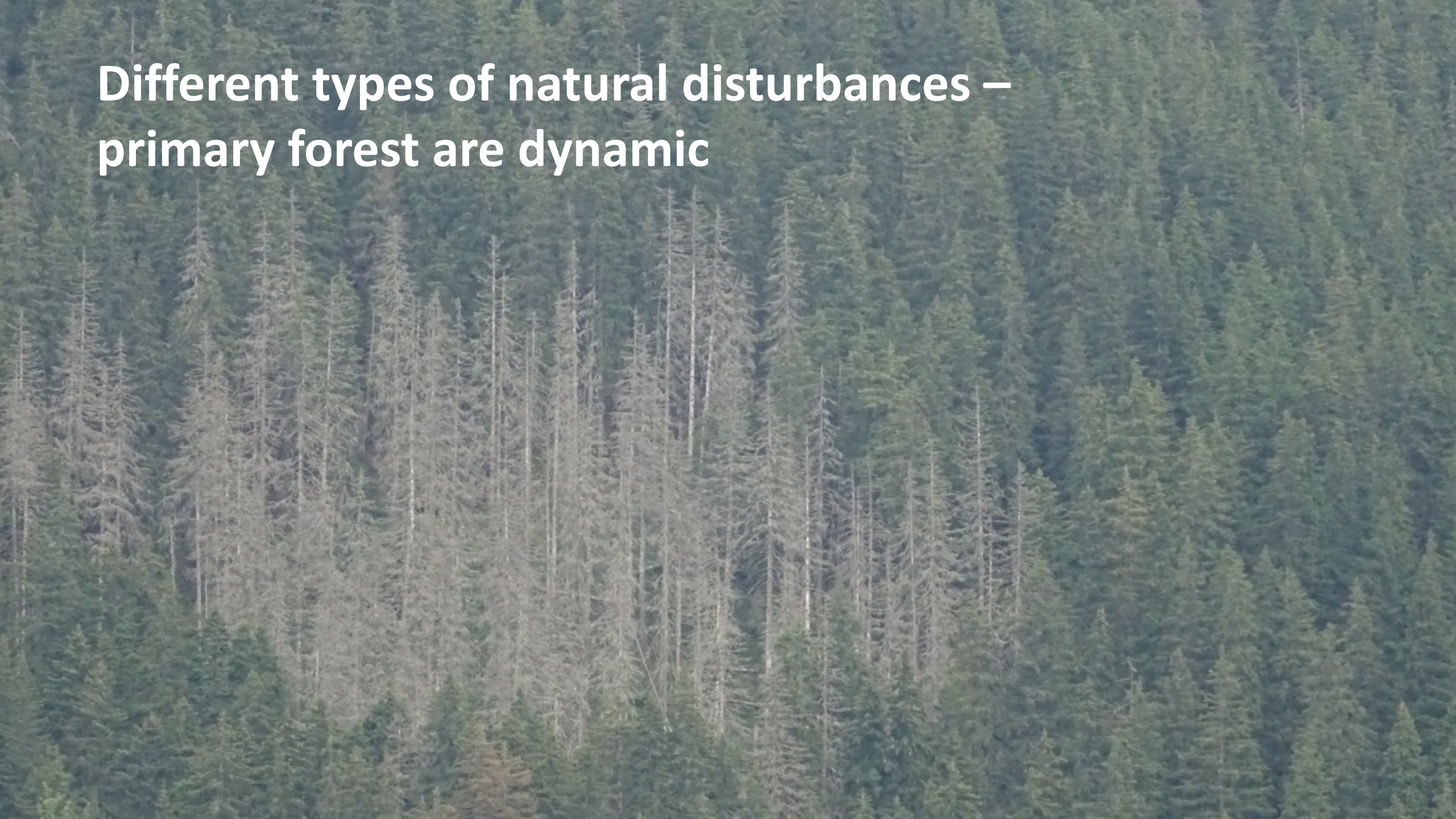
Large-scale disturbance legacies and the climate sensitivity of primary *Picea abies* forests

Jonathan S. Schurman^{1*}  | Volodymyr Trotsiuk^{1*} | Radek Bače¹ | Vojtěch Čada¹ | Shawn Fraver² | Pavel Janda¹ | Dominik Kulakowski³ | Jana Labusova¹ | Martin Mikoláš^{1,4} | Thomas A. Nagel^{1,5} | Rupert Seidl⁶ | Michal Synek¹ | Kristýna Svobodová^{1,7} | Oleh Chaskovsky⁸ | Marius Teodosiu⁹ | Miroslav Svoboda¹



- Approximately 75% of current canopy area recruited prior to 1900.
- Reduced disturbance rates since 1920 - a potential legacy of high 19th century disturbance rates - have contributed to a recent region-wide increase in disturbance susceptibility.
- High severity disturbances are a natural process within these primary forest ecosystems.

**Different types of natural disturbances –
primary forest are dynamic**







Semenic – Izovarele Nerei (2023)





**Primary forests are also young
forests after disturbance**





18

24

25





Environmental characteristics
e.g. climate, soil – regional level influence

Natural disturbance history
Windthrow
Bark beetle

Gradient of multiple disturbance components

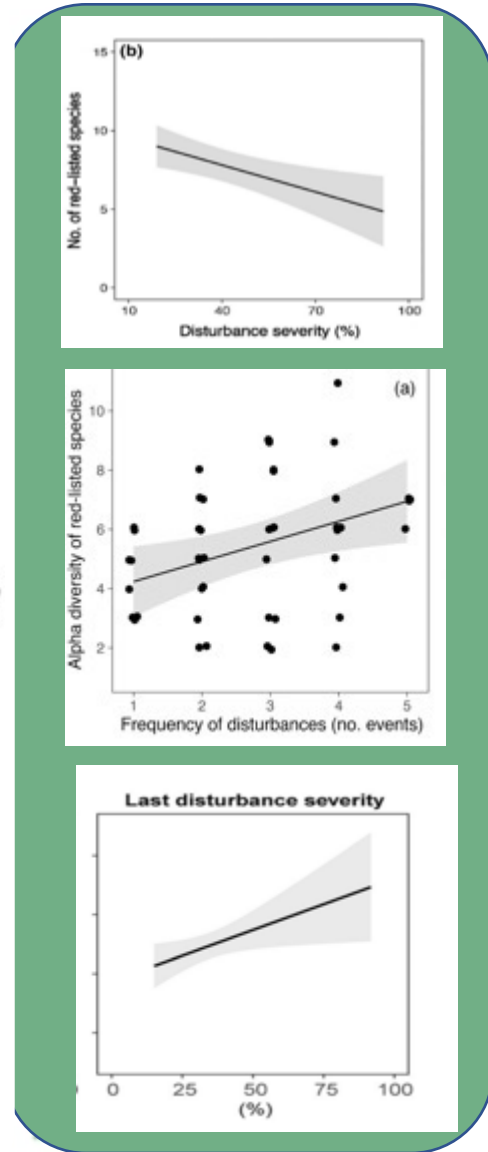
- Time since disturbance
- Disturbance severity
- Disturbance frequency

Long term disturbance history determines present-day biodiversity

Deadwood amount and canopy openness play key roles

Different groups respond to different disturbance characteristics

Disturbance effects are diverse across temporal scales



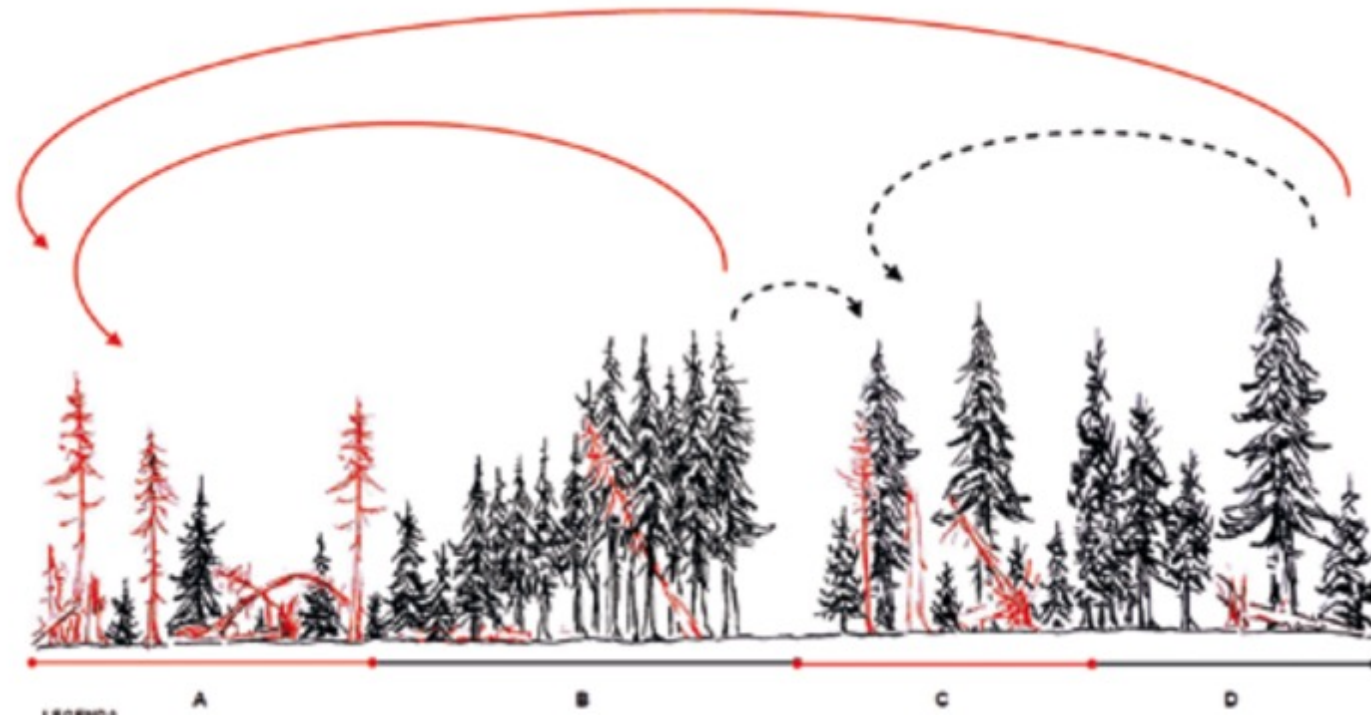
Langbehn et al. 2021
JVS

Ferenčík et al. 2022
FEM

Kozák et al. 2021
Ecosystems

Management implications

- The importance of setting aside **large areas** (strictly protected forest landscapes) where a wide range of disturbance timing and severity can act and create a **heterogeneous environment** that can support a full array of **biodiversity**
- Disturbances are a critical part of natural forest dynamics and are an important rewilding tool



Salvage logging of primary and old-growth forests



Logging and planned logging in our research plots (especially Romania and Ukraine)

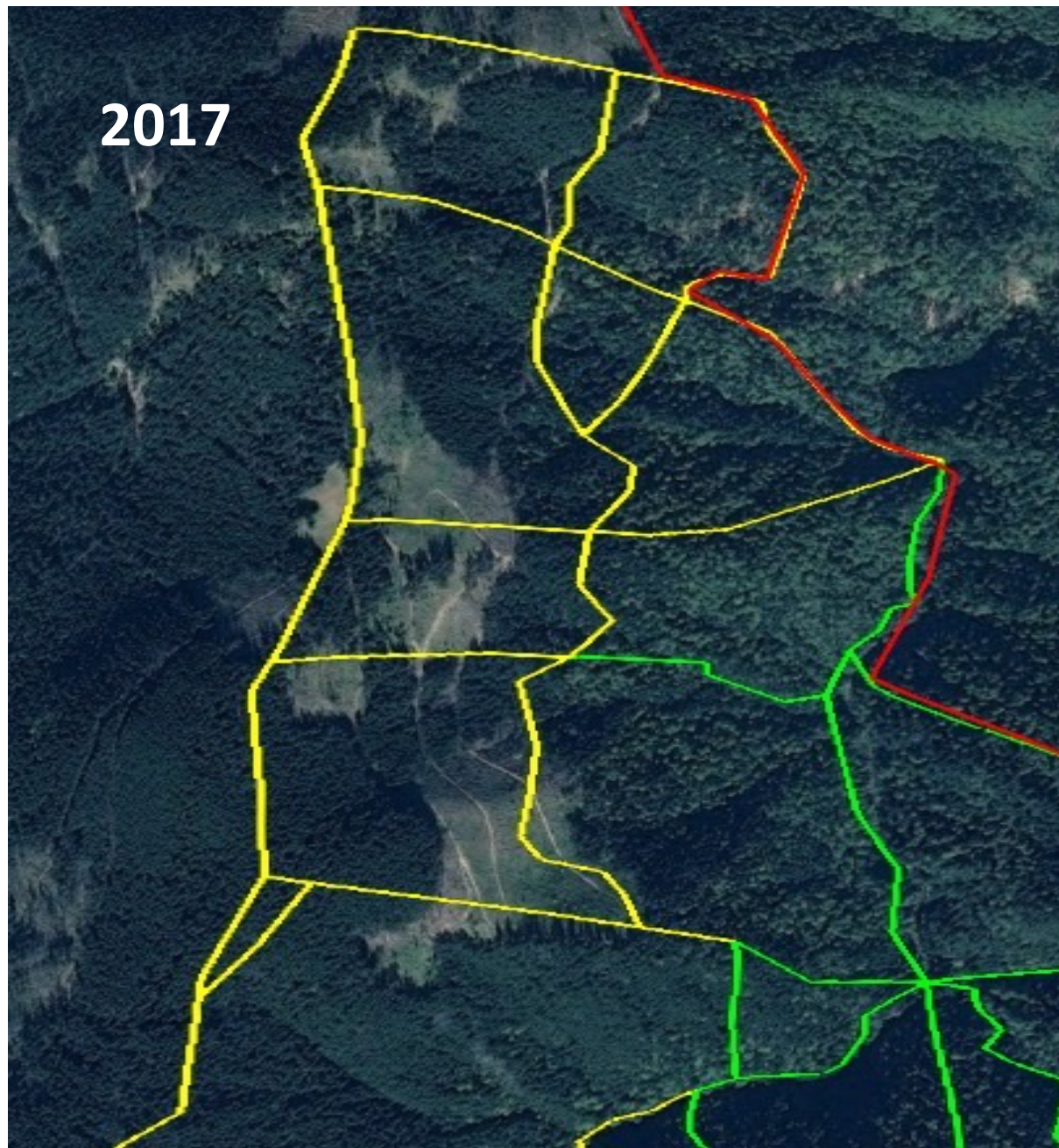
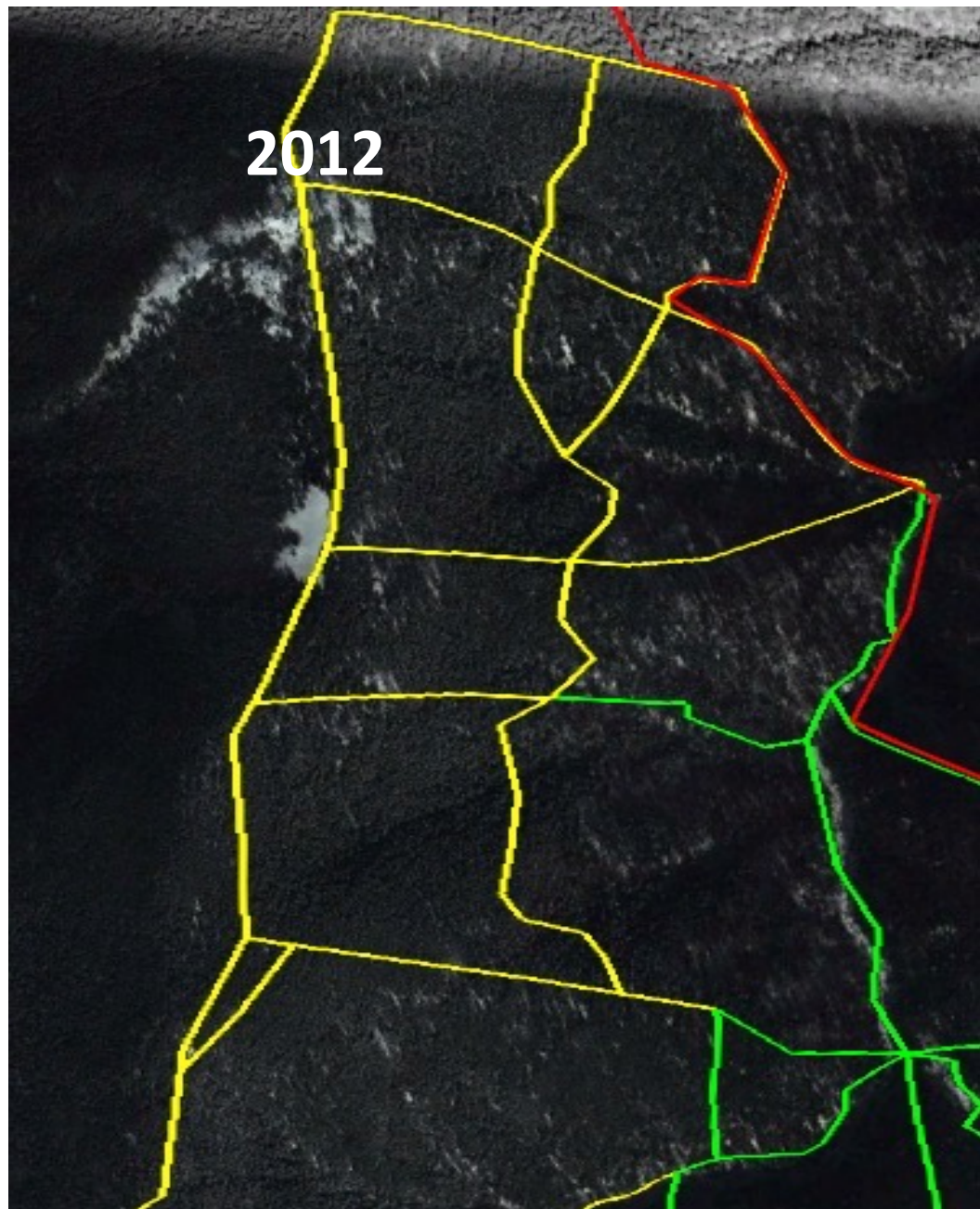




300 years old trees were cut down in this plot











Unprotected old-growth forests in Ucea Mare, Fagaras Mountains, Romania





Legenda

- - APROBAT
- - AUTORIZAT
- - PREDAT
- - REPRIMIT
- - PREGATIT PENTRU PREDARE
- - PREGATIT PENTRU REPRIMIRE
- - RETRAS
- - ISTORIC

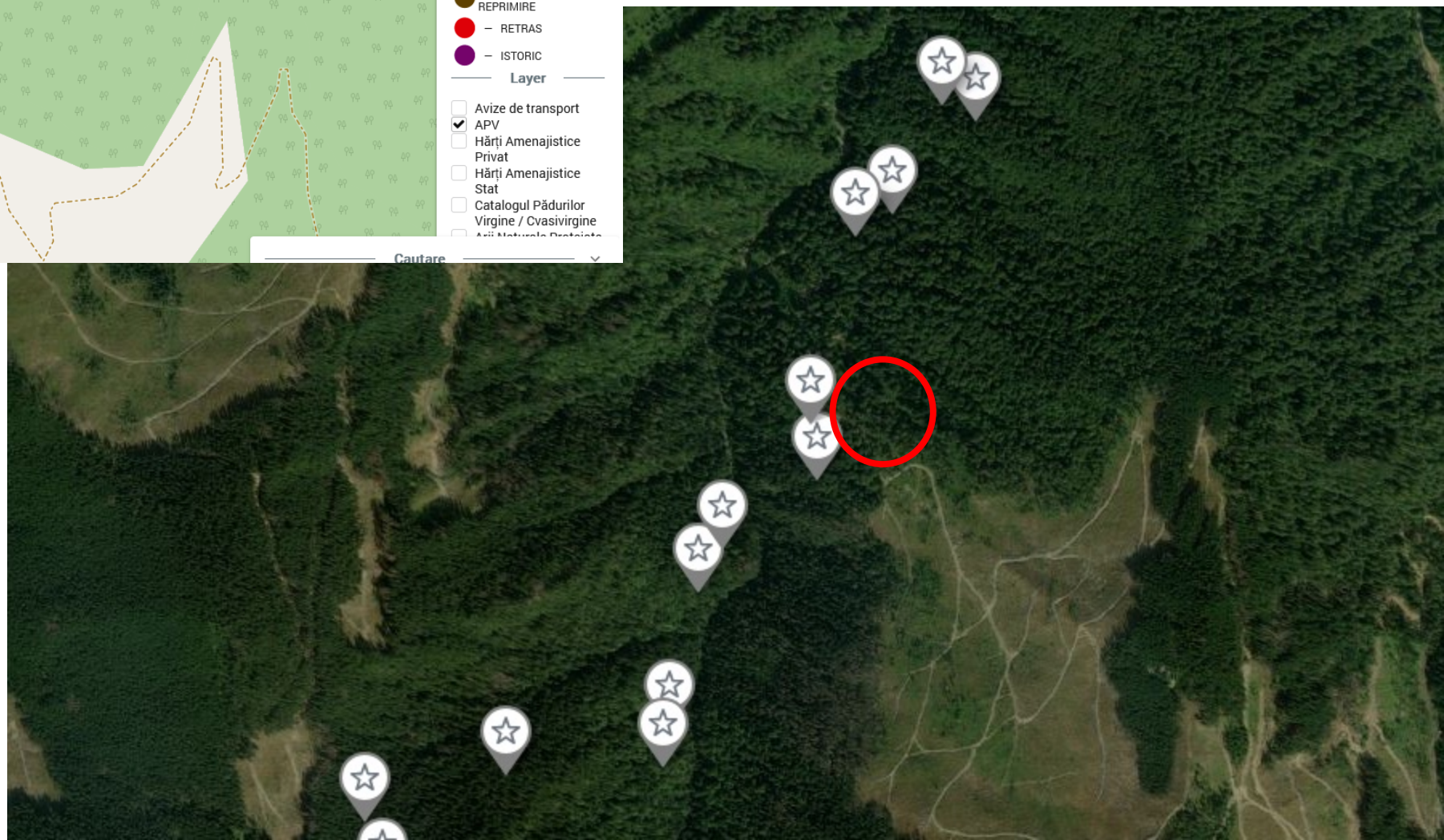
Layer

- Avize de transport
- APV
- Hărți Amenajistice Privat
- Hărți Amenajistice Stat
- Catalogul Pădurilor Virgine / Cvasivirgine
- Așii Naturala Protecție

Cautare

Ucea mare, Fagaras Mountains

45.6569089N, 24.7066903E







The consequences of logging primary and old growth forests on biodiversity in the Carpathians

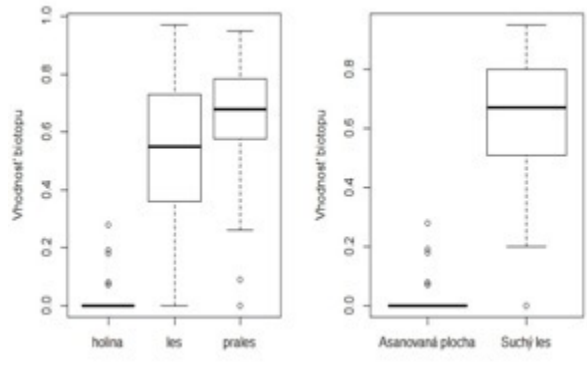


Capercaillie – umbrella species – its protection will protect many other rare species

- It requires in average **550 ha** of suitable habitats (Storch 1995).
- Effective connectivity is up to 10 km distance.
- Minimum viable population requires 250-500km² of suitable habitats.



- **Structure of suitable habitats:**
 - Low canopy closure
 - Rich ground vegetation cover
 - Low branched trees
- **Such structures are very typical for natural mountain forests.**

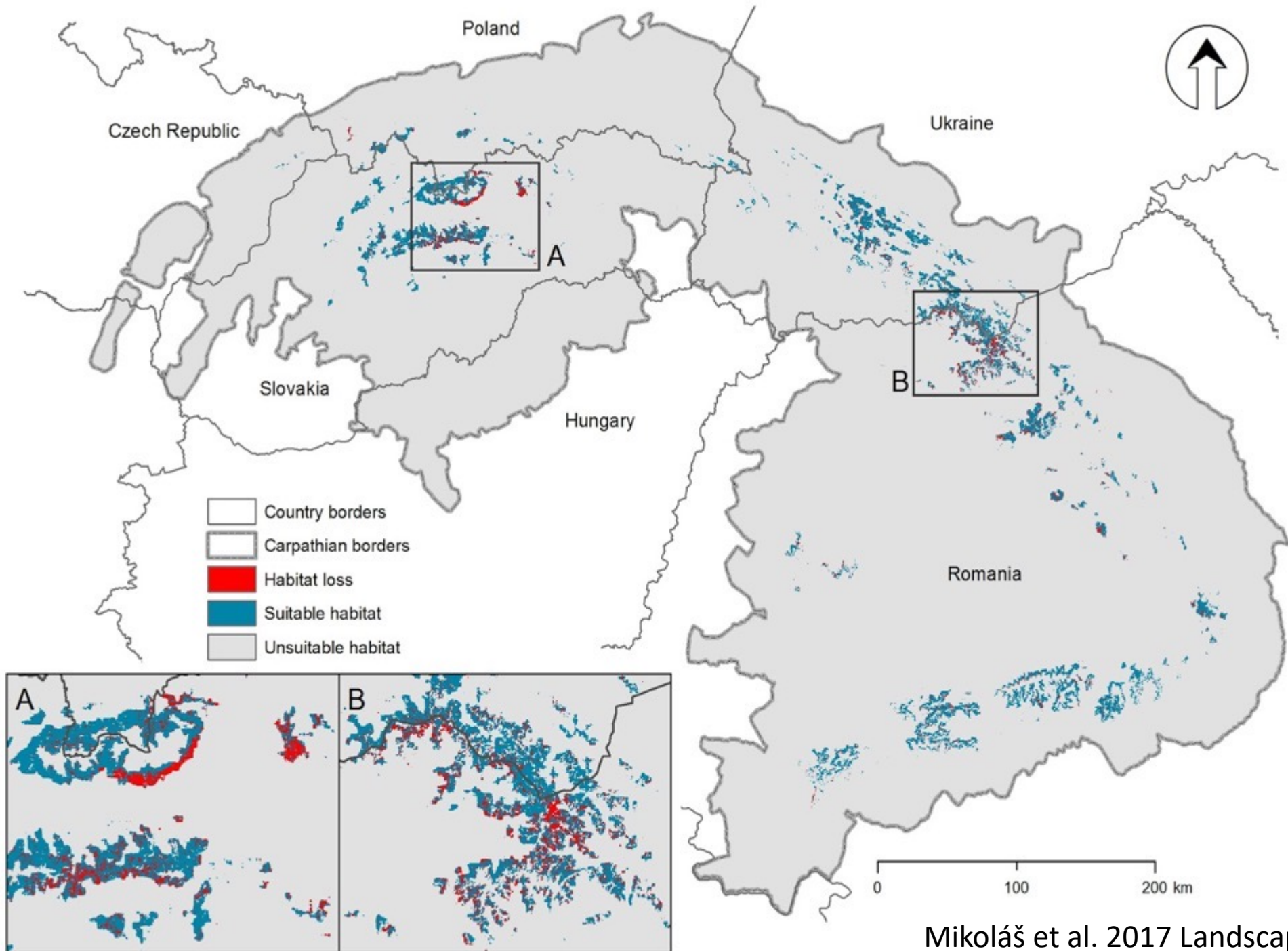


Commercially managed forests lead to unsuitable habitat structures:

- Dense canopy, no ground vegetation, no hiding possibilities...
- Clearcut: long-term loss of habitat







A. Low Tatra Mts. National Park, Slovakia

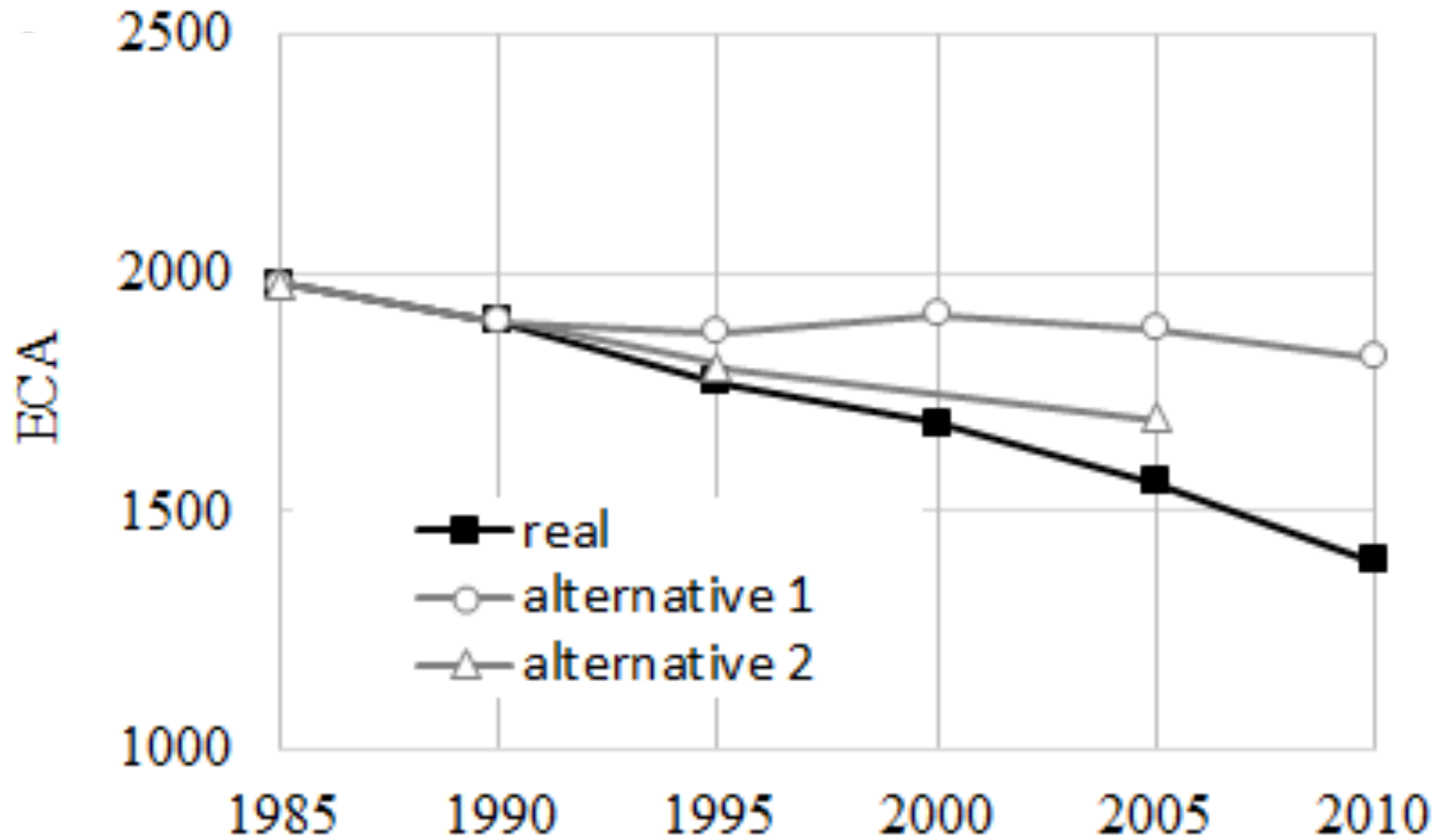


B. Maramures National
Park, Romania



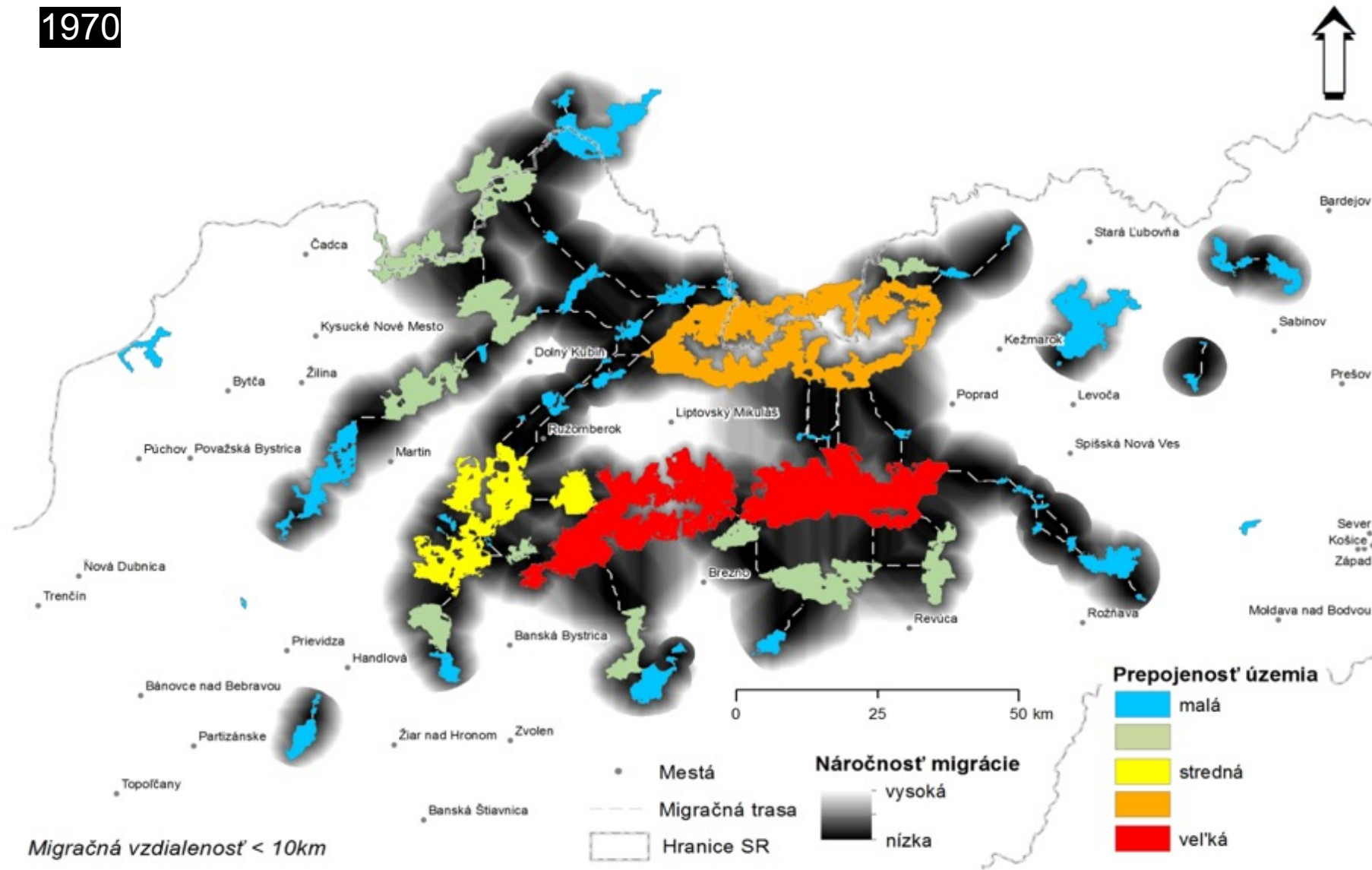
	Capercaillie suitable habitat (km2)				Loss of capercaillie suitable habitat (km2)			
	PAs	SPAs	Unprotected	Total	<u>PAs</u>	<u>SPAs</u>	<u>Unprotected</u>	Total
Czech Republic	9	9	0	9	1	1	0	1
Hungary	0	0	0	0	0	0	0	0
Poland	305	97	32	350	33	10	4	39
Romania	1,142	1,469	1,964	3,720	233	273	260	565
Slovakia	1,483	1,380	133	1,797	256	211	18	325
Ukraine	498	NA	1135	1,633	48	NA	131	180
<u>Total</u>	<u>2,939</u>	<u>1,713</u>	<u>2,129</u>	<u>7,510</u>	<u>571</u>	<u>495</u>	<u>413</u>	<u>1,109</u>

- Protected areas do not ensure the protection of threatened species and their habitats in the Carpathian region
- Priority in protected areas is timber production rather than the conservation of biodiversity and non-extractive ecosystem services

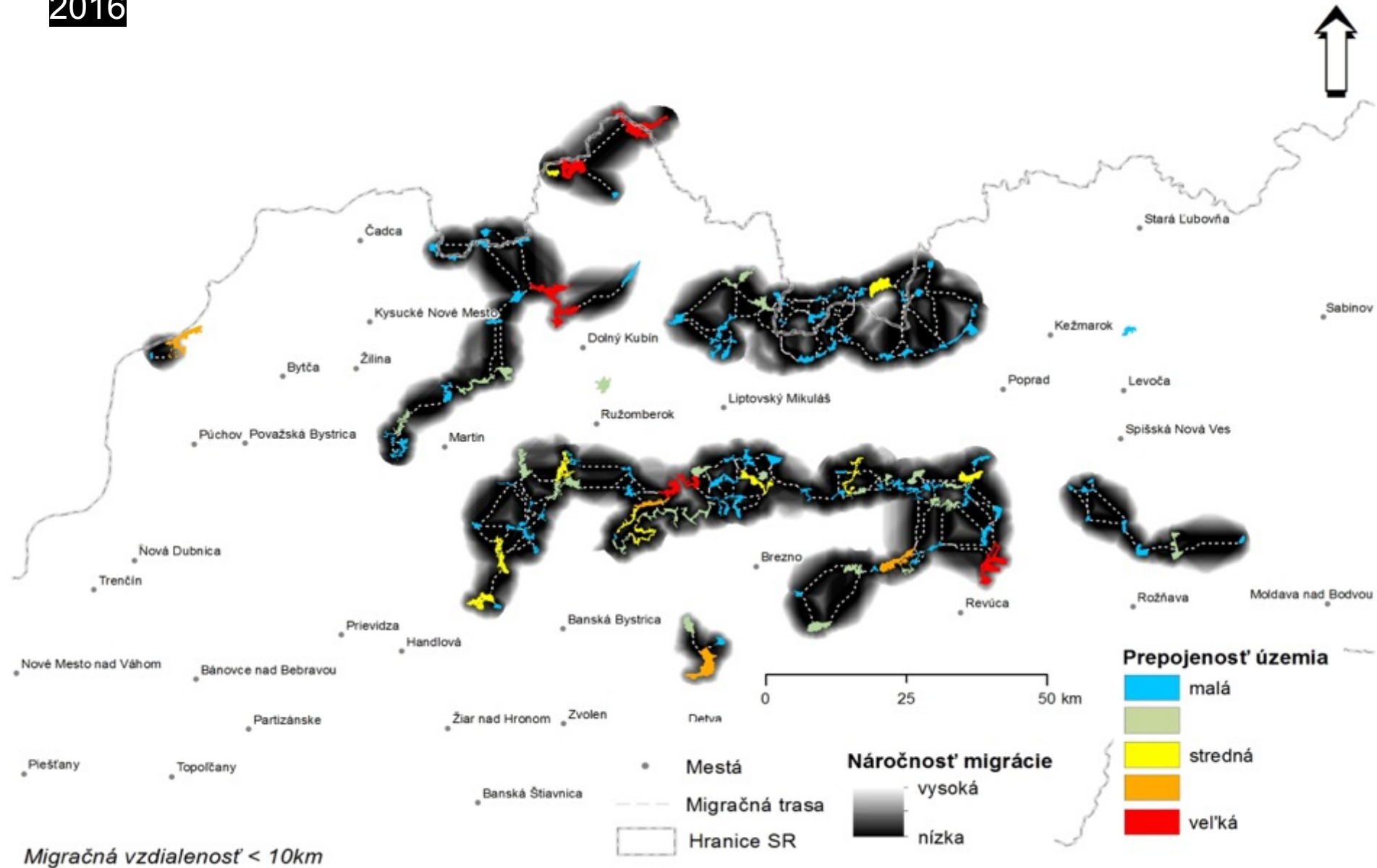


- **Connectivity change (Equivalent Connected Area (ECA) index.): decrease of habitats by 15 % decreased the overall connectivity by 30 %**

1970



2016



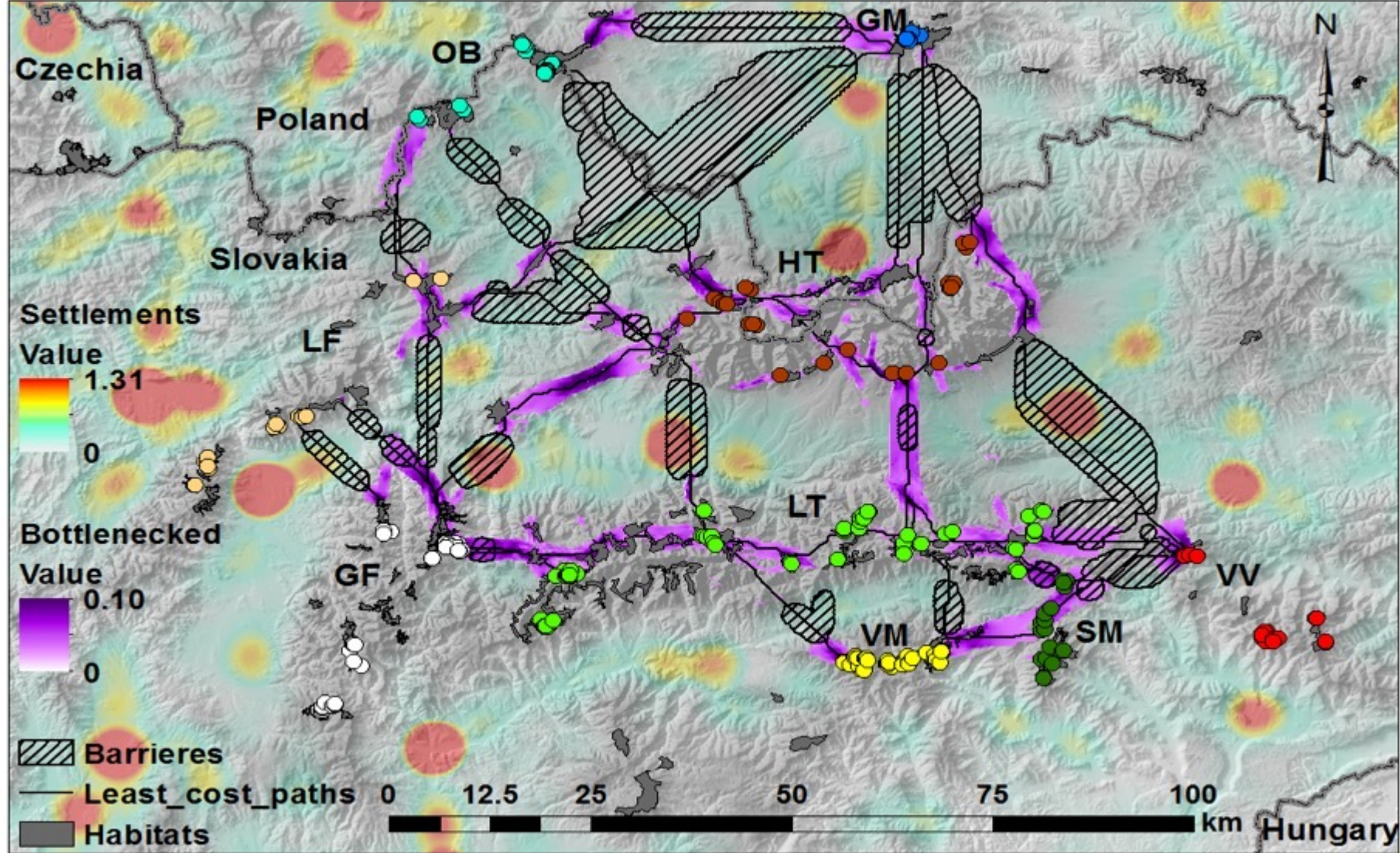
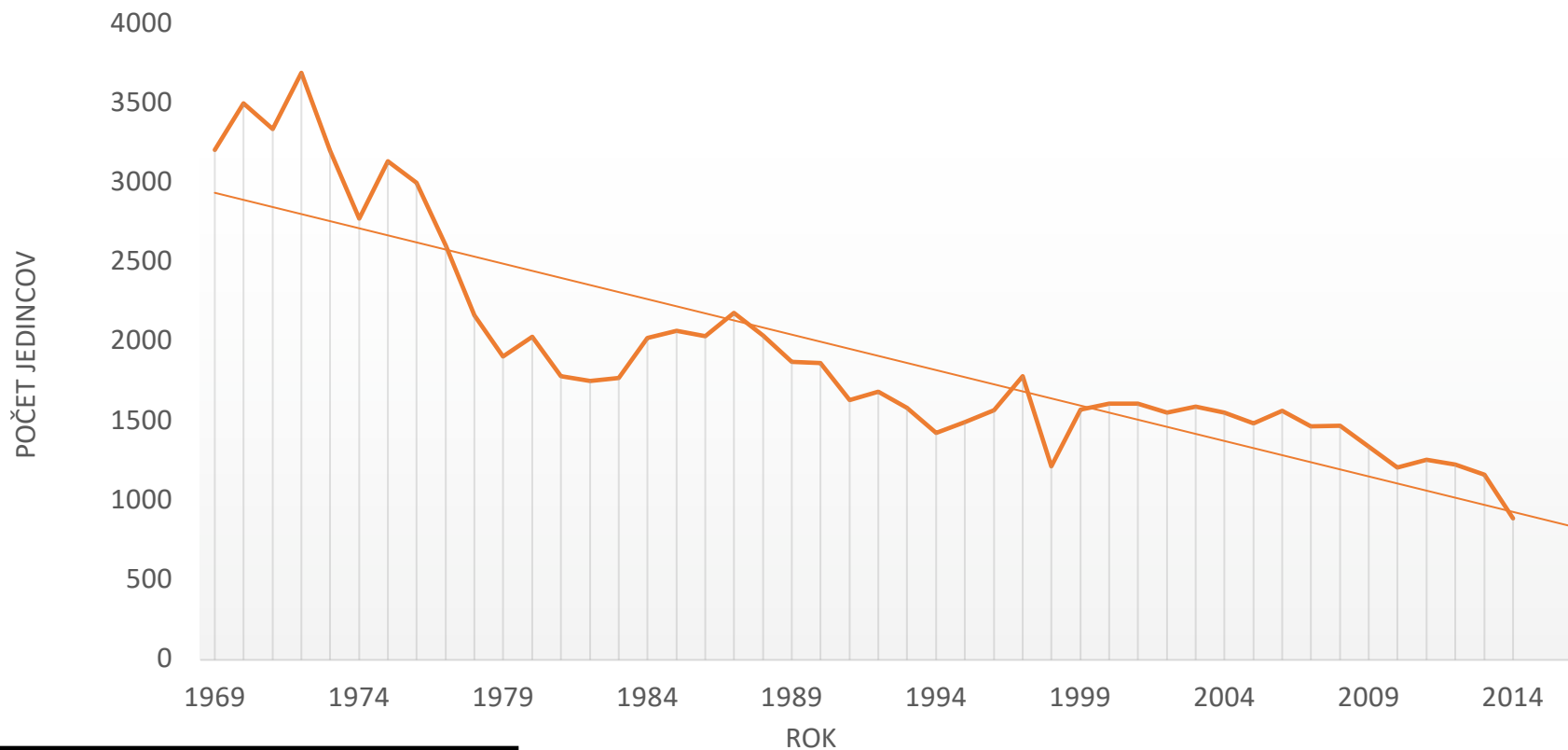
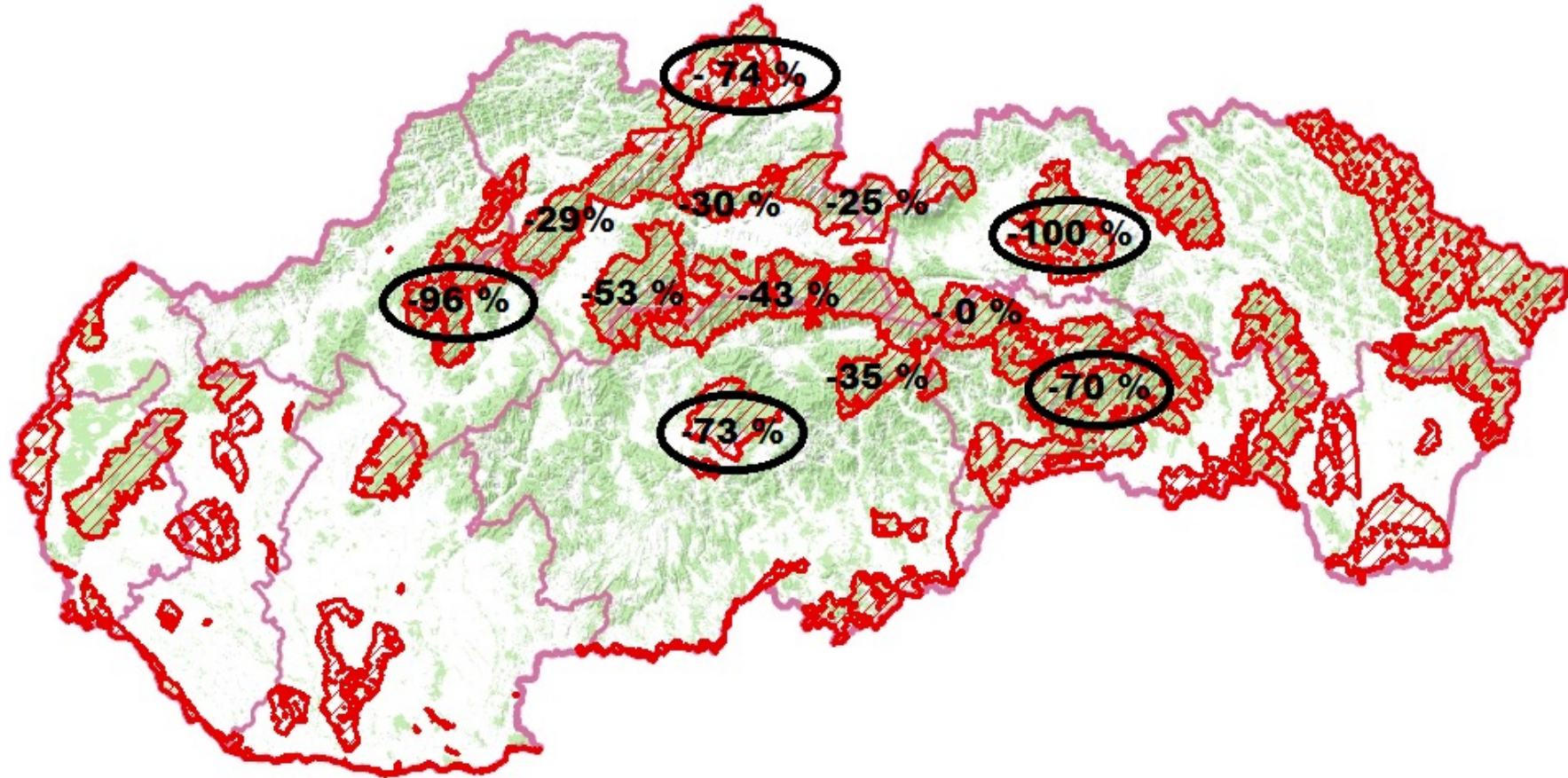


Figure 1 Patchily distributed subpopulations identified by the colouring of sample sites, computed least cost paths (solid lines), barriers (shaded polygons), and bottlenecked corridors (increased orange colouring and value indicates more narrowed or bottlenecked corridor) across a landscape of the Western Carpathians, Slovakia.



Capercaillie population declined by 76% since 1972 in the Western Carpathians, Slovakia

Percentual decrease of capercaillie population in SPAs (NATURA 2000 sites)



Gúgh J., Trnka A., Karaska D. & Ridzoň J. 2015: Zásady ochrany európsky významných druhov vtákov a ich biotopov. – Štátna ochrana prírody Slovenskej Republiky, Banská Bystrica, 333 str.

**September 2018 – Low Tatras
National Park**







Kráľová hoľa







**Western Tatras, Slovakia
2014-2015**





Salvage logging in capercaillie forests lead to the complete destruction of its habitat.



1:16 655
0 100 200 400 600 800
Meters

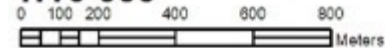
NAPANT lokalita Kráľova Hoľa juh
Biotop Hlucháňa 2004-2006 / reálny stav lesov 2003

Digitalna ortofotomapa, DTM
(c) EUROSENSE s.r.o.





1:16 655



NAPANT lokalita Kráľova Hoľa juh
Biotop Hlucháňa 2004-2006 / reálny stav lesov 2006



Digitalna ortofotomapa, DTM
(c) EUROSENSE s.r.o.

Building of new forest roads:

- Change in soil-water regime
- Creation of new sun-exposed forest walls

All these stress factors caused by salvage logging may speed up bark beetle population growth rates



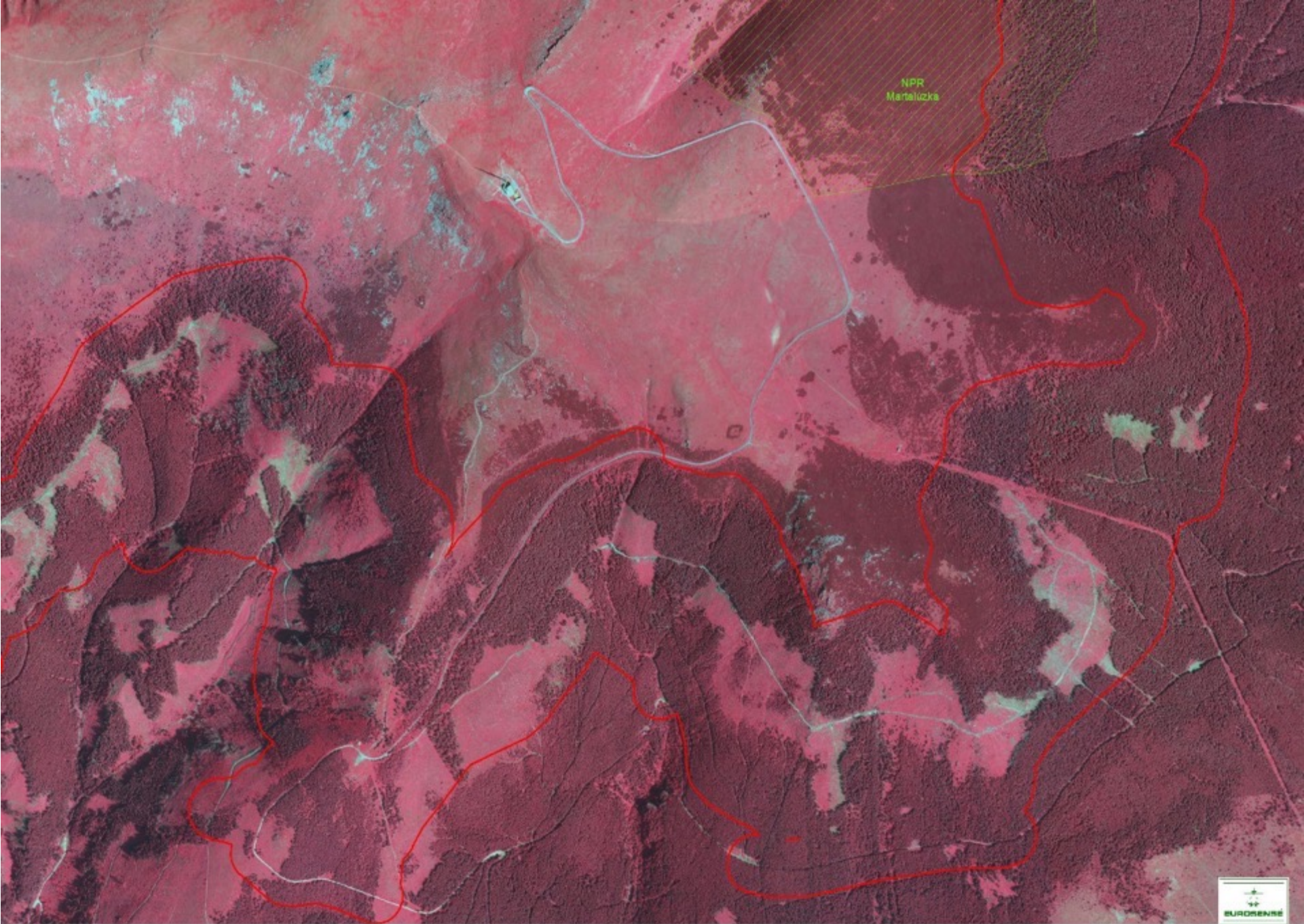
1:16 655

0 100 200 400 800 800
Mete

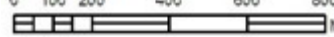
NAPANT lokalita Kráľova Hoľa juh

Biotop Hlucháňa 2004-2006 / reálny stav lesov 2009 infračervená ortofotomapa

Digitalna ortofotomapa, DTM
(c) EUROSENSE s.r.o.



1:16 655



Biotop Hlucháňa 2004-2006 / reálny stav lesov jul 2012 infračervená ortofotomapa

NAPANT lokalita Kráľova Hoľa juh



Digitalna ortofotomapa, DTM
(c) EUROSENSE s.r.o.



1:16 655
0 100 200 400 600 800
Meters

NAPANT lokalita Kráľova Hoľa juh
Biotop Hlucháňa 2004-2006 / reálny stav lesov jul 2015

Digitalna ortofotomapa, DTM
(c) EUROSENSE s.r.o.



- Note that result of salvage logging is not necessarily „green forest“.
- Large scale salvage logging lead to complete destruction of capercaillie habitats...
 - this is case from national park



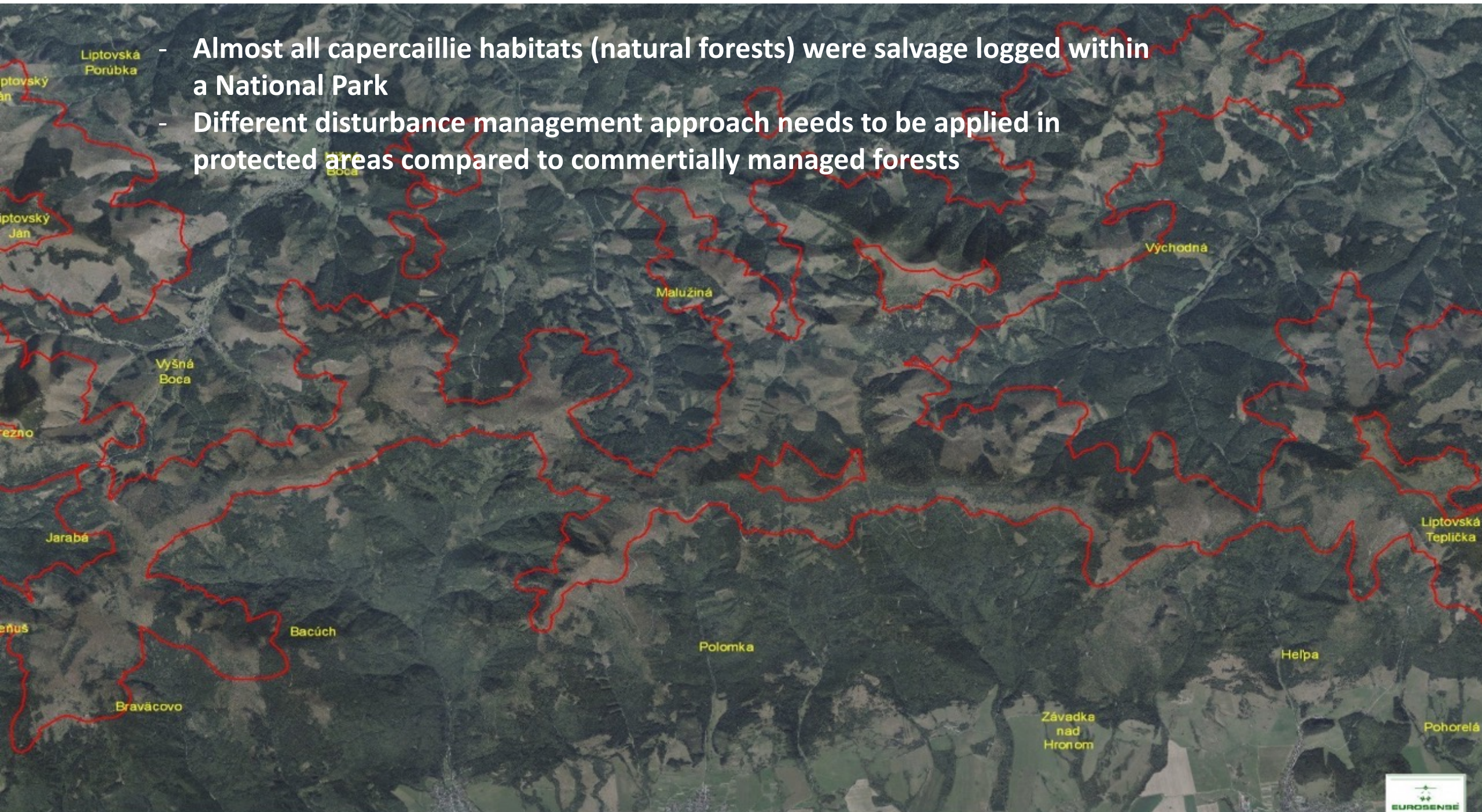
1:16 655
0 100 200 400 600 800
Meters

NAPANT lokalita Kráľova Hoľa juh
Biotop Hlucháňa 2004-2006 / realny stav lesov september 2018

Digitalna ortofotomapa, DTM
(c) EUROSENSE s.r.o.



- Almost all capercaillie habitats (natural forests) were salvage logged within a National Park
- Different disturbance management approach needs to be applied in protected areas compared to commercially managed forests



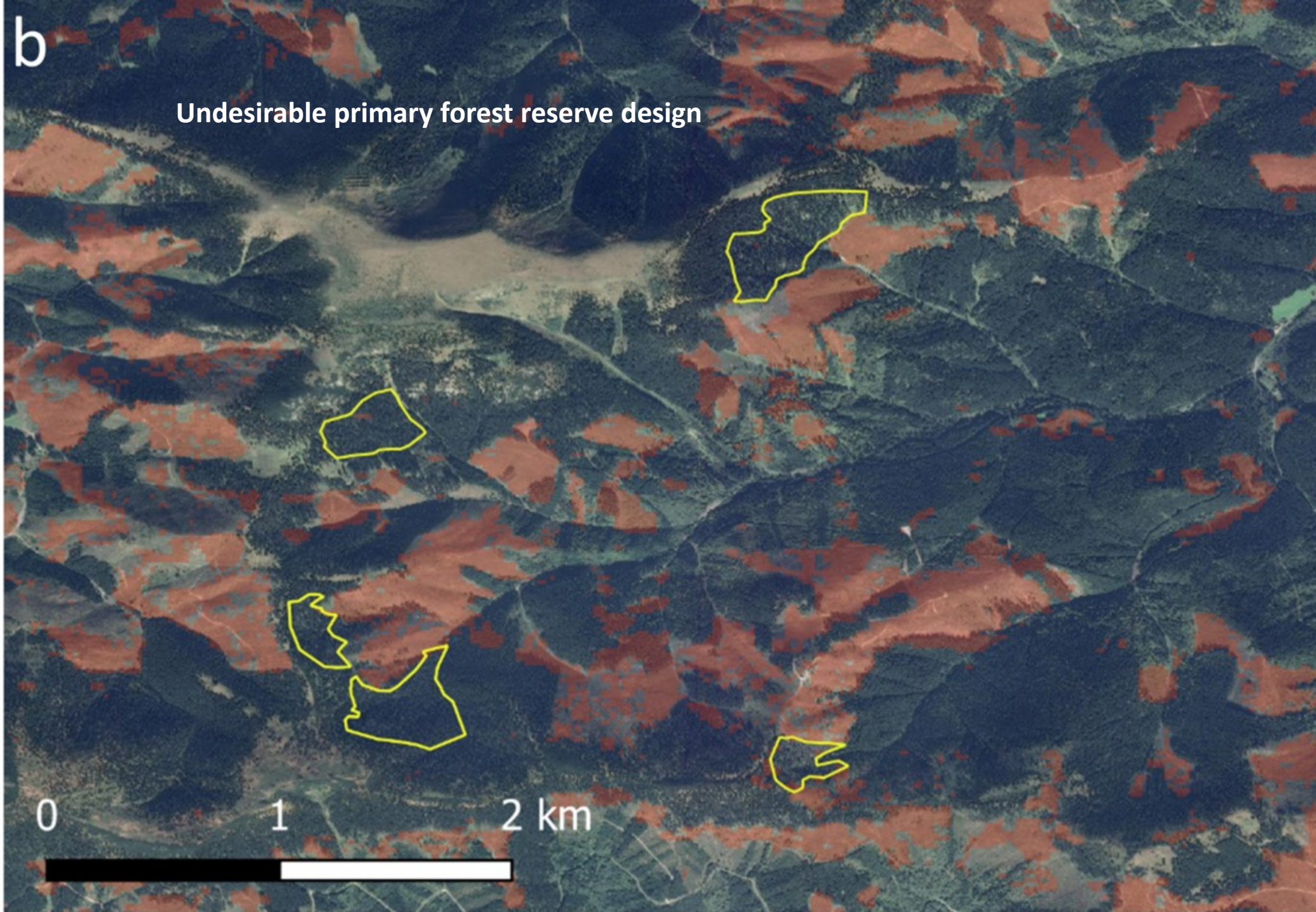
Undesirable primary forest reserve design

- Protects only fragmented patches (tens of ha) of the existing primary forest and the surrounding area is subjected to harvests.
- Specialist forest species populations in such isolated islands of primary forest patches are often suffering from extinction debt
- **Extinction debt:** delayed species extinctions expected as a consequence of habitat loss and fragmentation

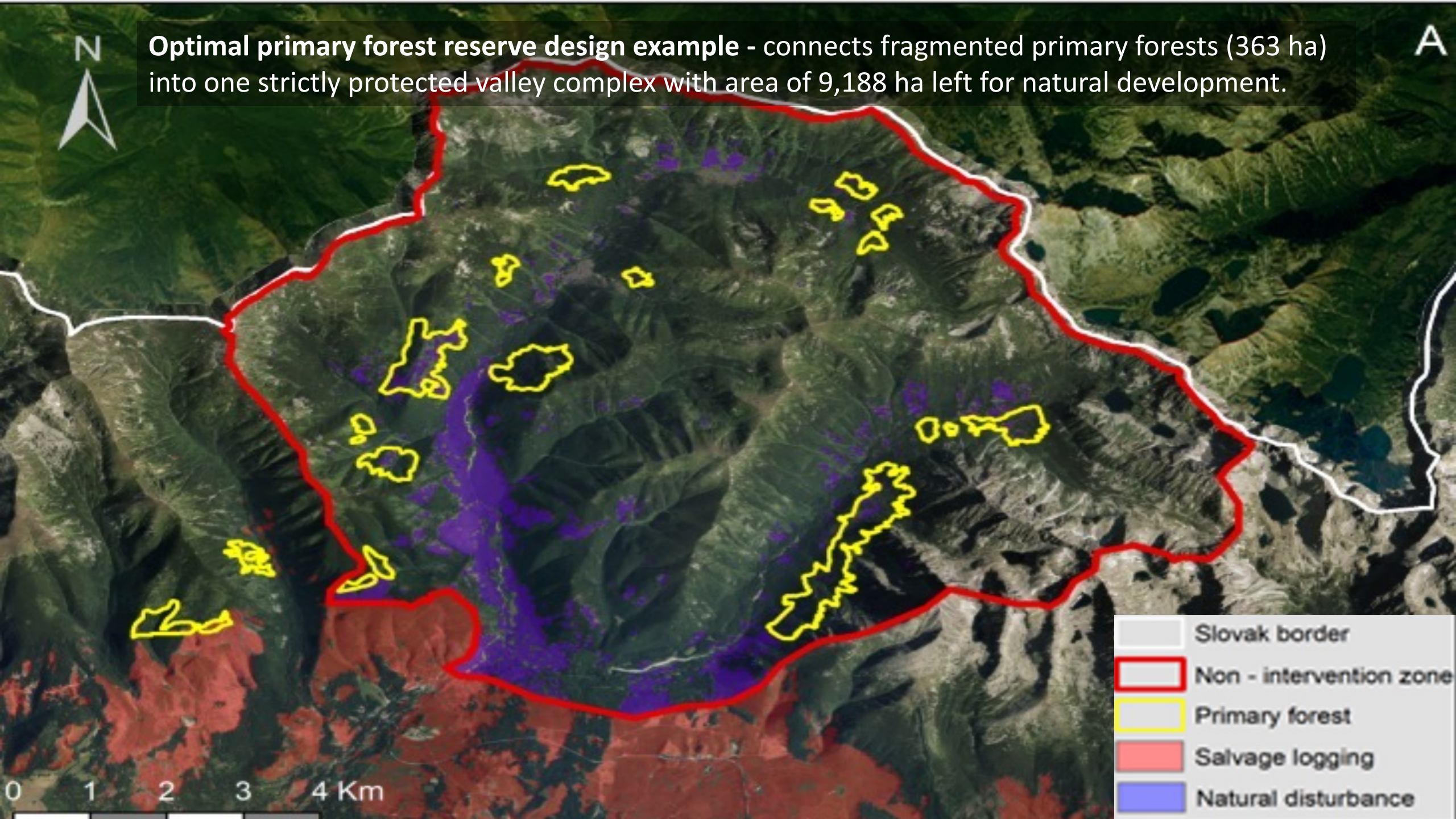


b

Undesirable primary forest reserve design



Optimal primary forest reserve design example - connects fragmented primary forests (363 ha) into one strictly protected valley complex with area of 9,188 ha left for natural development.



-  Slovak border
-  Non - intervention zone
-  Primary forest
-  Salvage logging
-  Natural disturbance

0 1 2 3 4 Km

Conclusions

- **Natural disturbances** such as windthrow and bark beetle outbreaks are natural part of the **forest dynamics** that support and maintain **biodiversity**
- **Conservation** of primary and old-growth forests is **slow**, many primary forests are still **not mapped**, many primary forests are **not protected** in Europe
- Conservation of only primary forests stands is insufficient; **conservation targets** should be also the **natural forests, valley systems, secondary old-growth forests** and **habitats** of protected species if biodiversity conservation and carbon sequestration is the objective