HOW THE NATURE TEACHES US SILVICULTURE

we create the heterogenous forests for the future

MENDELU
Školní lesní podnik
Masarykův les
Křtiny

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We are the witnesses of largest catastrophy in the history of organized forestry in the Central Europe

Should not we to follow more natural processes?

<u>Two selected studies/examples</u>

Non-synchronous developmental dynamics of natural temperate forests

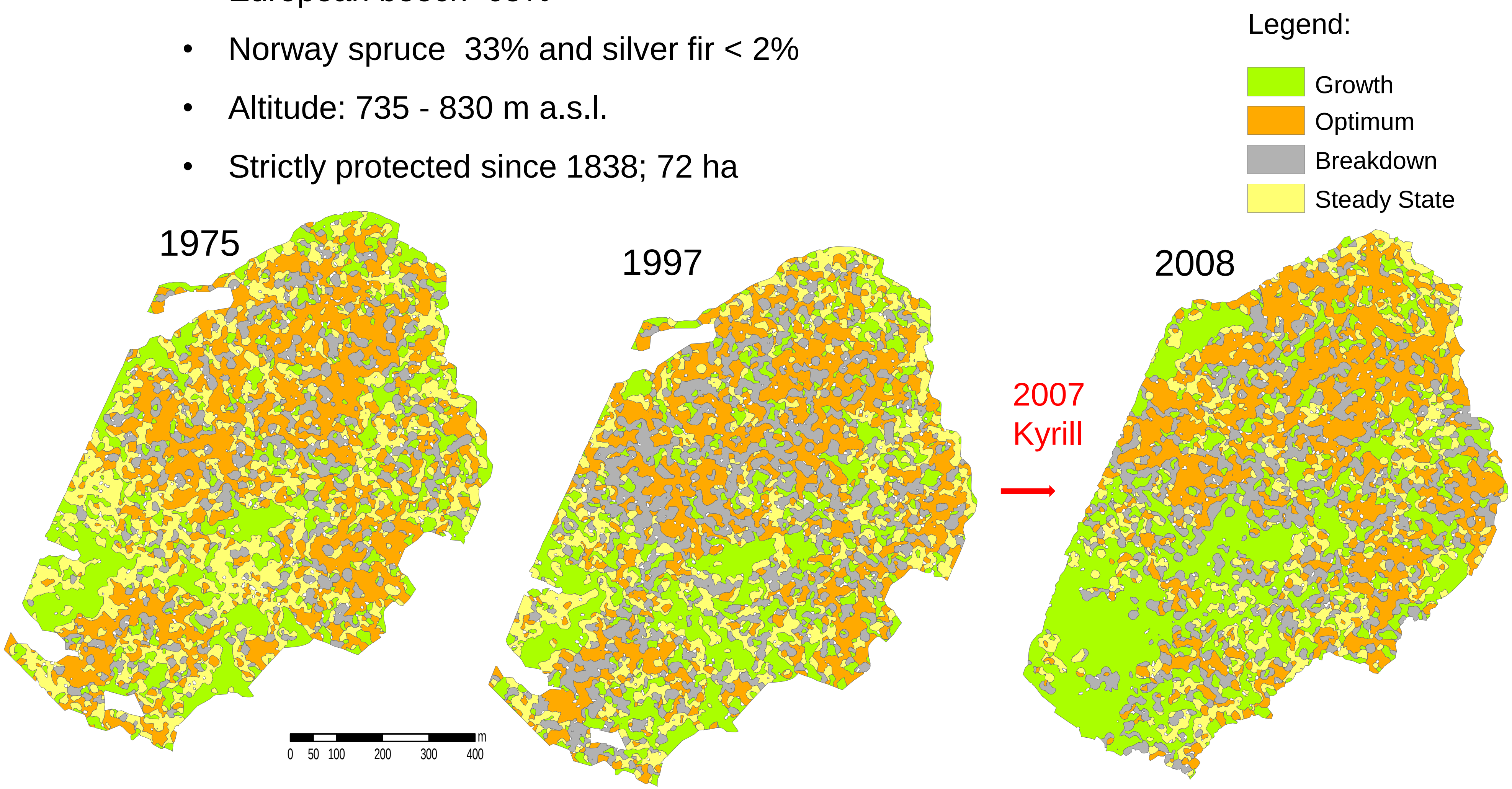
- What are the key developmental stages?
- Which trajectories are the most frequent?

How the bark-beetle teached us silviculture

- What are the limits of spruce admixture?
- Which trees are crucial to stop the bark-beetle?

Žofín

- European beech 65%
- Norway spruce 33% and silver fir < 2%
- Altitude: 735 - 830 m a.s.l.
- Strictly protected since 1838; 72 ha



Král K., Janík D., Adam D., McMahon S., Vrška T., 2014. Patch mosaic of developmental stages in Central European natural forests along an elevation and vegetation gradient. Forest Ecology and Management 330: 17-28.

Multi-temporal comparisons – transitions between stages and phases

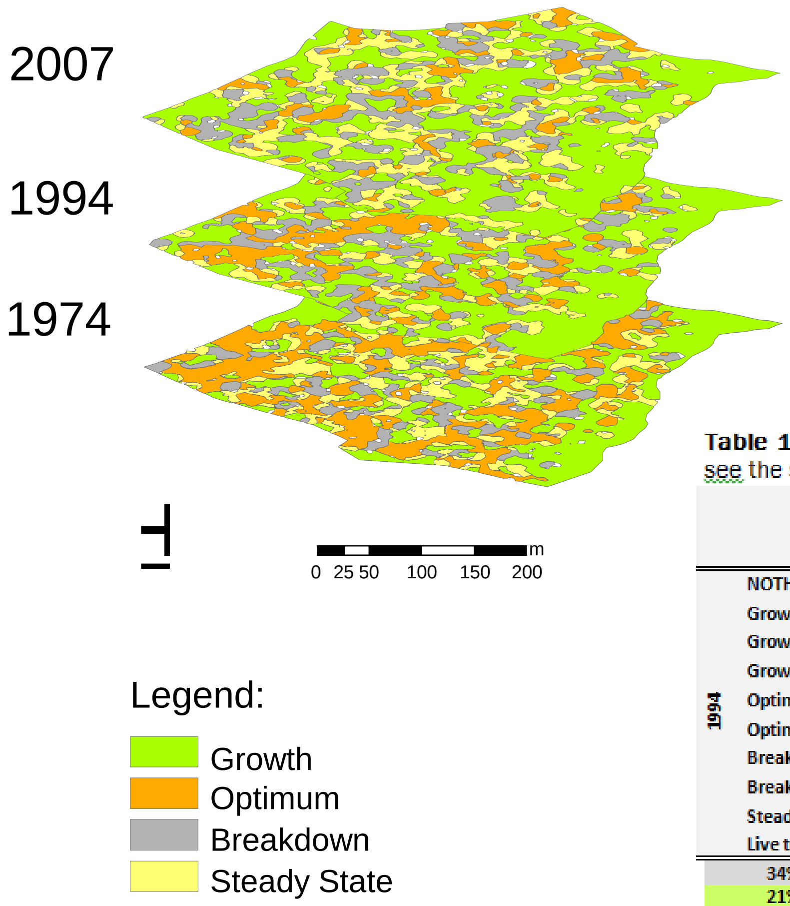


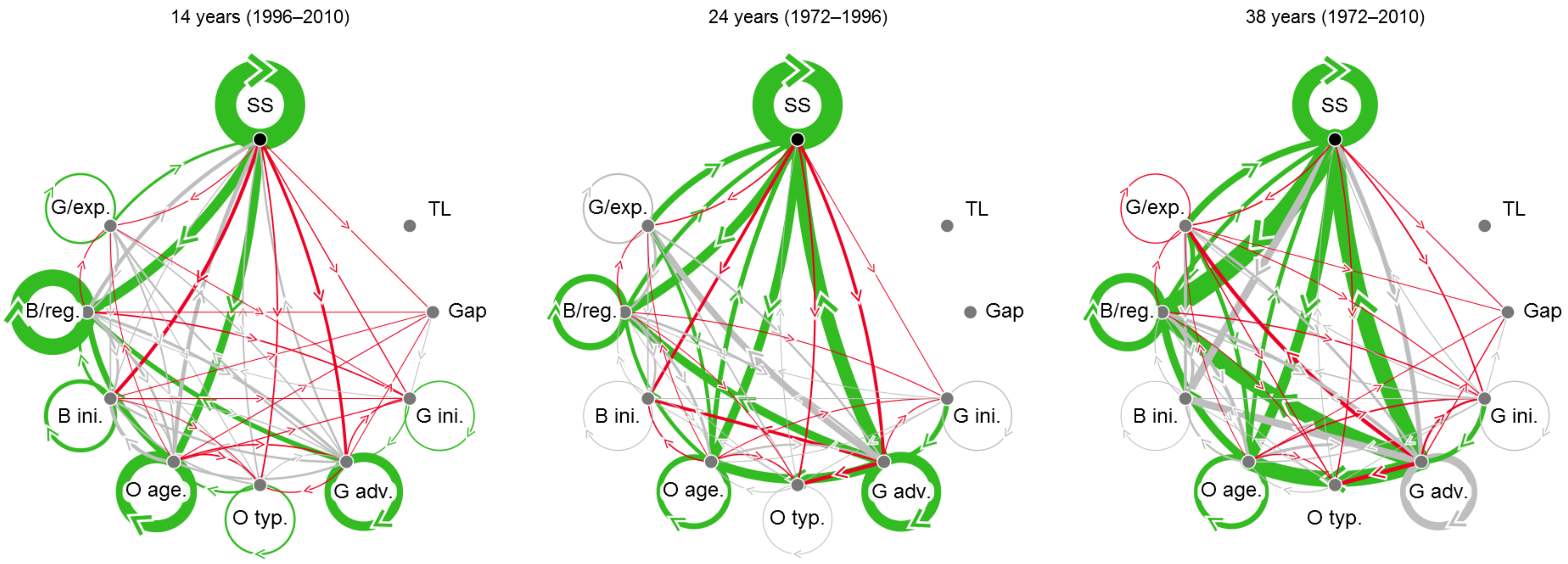
Table 1: Transitions (in ha) between developmental phases from 1973 to 1994 in Ranšpurk (21 years); see the summary and color key with explanation below the table.

	ha		1973 NO 0	G/ex. 1	G ini. 2	G adv. 3	O 4	O age. 5	B 6	B/reg. 7	SS 8	Gap 9
1994	NOTHING	0	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
	Growth/expiration	1	0.00	0.08	0.00	0.46	0.07	0.21	0.01	0.07	0.09	0.00
	Growth initial	2	0.04	0.00	0.22	0.09	0.04	0.04	0.01	0.02	0.02	0.02
	Growth advanced	3	0.12	0.03	1.02	2.06	0.37	0.51	0.17	0.22	0.27	0.03
	Optimum typical	4	0.00	0.07	0.01	0.43	0.98	0.34	0.09	0.04	0.17	0.00
	Optimum ageing	5	0.00	0.09	0.01	0.42	1.50	1.18	0.19	0.14	0.49	0.00
	Breakdown initial	6	0.00	0.02	0.00	0.16	0.52	0.34	0.31	0.08	0.39	0.00
	Breakdown/regeneration	7	0.00	0.02	0.00	0.21	0.40	0.42	0.27	0.37	0.39	0.00
	Steady State	8	0.00	0.13	0.00	0.61	1.10	1.27	0.12	0.21	1.58	0.00
	Live tree GAP	9	0.00	0.00	0.00	0.01	0.05	0.02	0.01	0.00	0.00	0.01

34%	No change
21%	progressive development (one phase)
8%	strongly progressive development (two phases)
7.3%	regressive development (one phase)
0.4%	strongly regressive development (two phases)
3%	stochastic, yet possible development (e.g. disturbances)
1.0%	unlikely development (possible misclassification)
26%	possible development, no clear trend (progressive/regressive)

Král K., Daněk P., Janík D., Krůček M., Vrška T., 2018. How cyclical and predictable are Central European temperate forest dynamics in terms of developmental phases? Journal of Vegetation Science 29 (1): 84-97.

example Boubín



Green – higher number of transitions than the null model
Red – lower number of transitions than the null model

Král K., Daněk P., Janík D., Krůček M., Vrška T., 2018. How cyclical and predictable are Central European temperate forest dynamics in terms of developmental phases? Journal of Vegetation Science 29 (1): 84-97.

Main ecological outputs

- in total about 65% of all observed phase-to-phase transitions were significantly more frequent than random switches between phases
- about 28% of observed transitions proceeded along pathways of random frequency
- only about 7% of observed transitions were realized through pathways significantly less frequent than random switches between phases

- the mean ratio of cyclic/acyclic transitions (2:3) was more or less stable throughout time

- in average only less than 40% of transitions between different developmental phases were classified as cyclic (following the model cycle), the majority of these transitions were realized through significantly frequent preferential pathways

Král K., Daněk P., Janík D., Krůček M., Vrška T., 2018. How cyclical and predictable are Central European temperate forest dynamics in terms of developmental phases? Journal of Vegetation Science 29 (1): 84-97.

Application in silviculture

- **Non-synchronous development** of individual phases gradually divides these patches into small micropatches **up to the level of individual trees** (Steady State).

- The **Steady State is more frequent** in the natural forests of **lower mountain areas**, as more coniferous species contribute to the dynamics, but this applies to a **ratio of about 1: 1 between conifers and deciduous trees**. Another important factor affecting the frequency of the presence of Steady State is the dependence on local species richness.

- Here we find **clear instructions for silviculture** - **individually mixed, structurally diversified, with beech, fir and spruce participation**. While the **representation of fir can be increased by silvicultural interventions** at the expense of more endangered (climate change) spruce. A suitable combination with small-scale patches for increasing the proportion of fir can be the use of irregular shelterwood system, which is a precursor of the so-called free style silviculture.

- **Similarly in lowland forests** it is possible to work with a more differentiated structure and **higher biological automation**, which, however, means a suitable choice of tree species - maples, hornbeams, lindens - and **not oaks**.

How the bark-beetle teached us silviculture

2007 – storm Kyrill in Žofín virgin forest (700-835 m a.s.l.) – **larger destroyed patches (up to 4 ha)** incl. fully destroyed peatbog patch in the central part of forest reserve.

2008 – **storm Emma in Boubín** virgin forest (900-1100 m a.s.l.) – no big patches but **many small-scale patches (up to 0,2 ha)** spreaded on the whole area of forest reserve.

We used stem-position maps to study the outbreak of Scolytidae – it was mapped 4/5 years – 2-times per year after every swarming of bark-beetles – to the end of outbreak. Observing of thousands .....trees

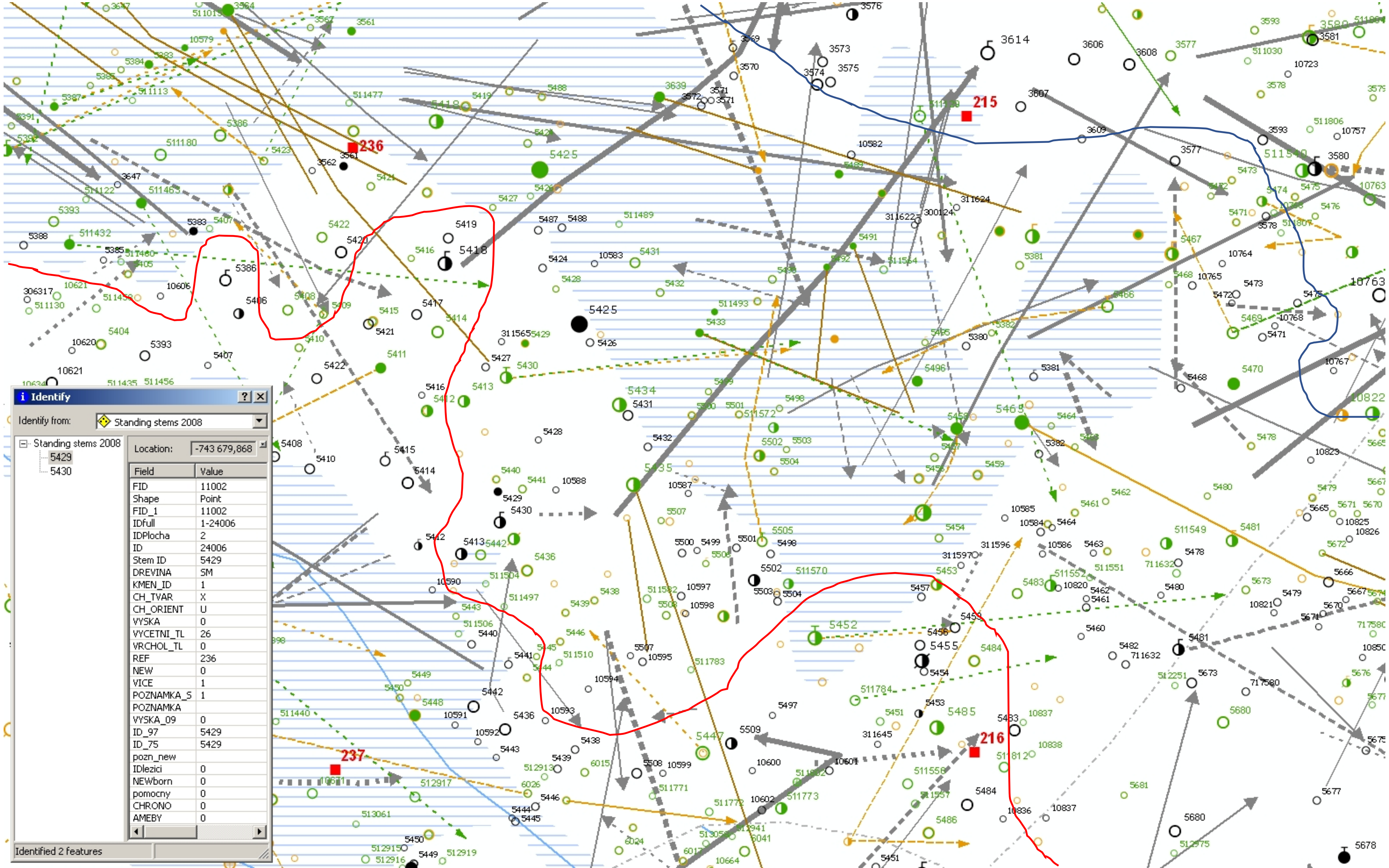
Spatial analysis of bark-beetle outbreak compared with the tree spatial patterns analysis, spatial stand strcuture analysis, tree species composition, tree sizes, deadwood amount, volumes of stems etc. (Bootstraping, Ripley's K function).

Spring 2007

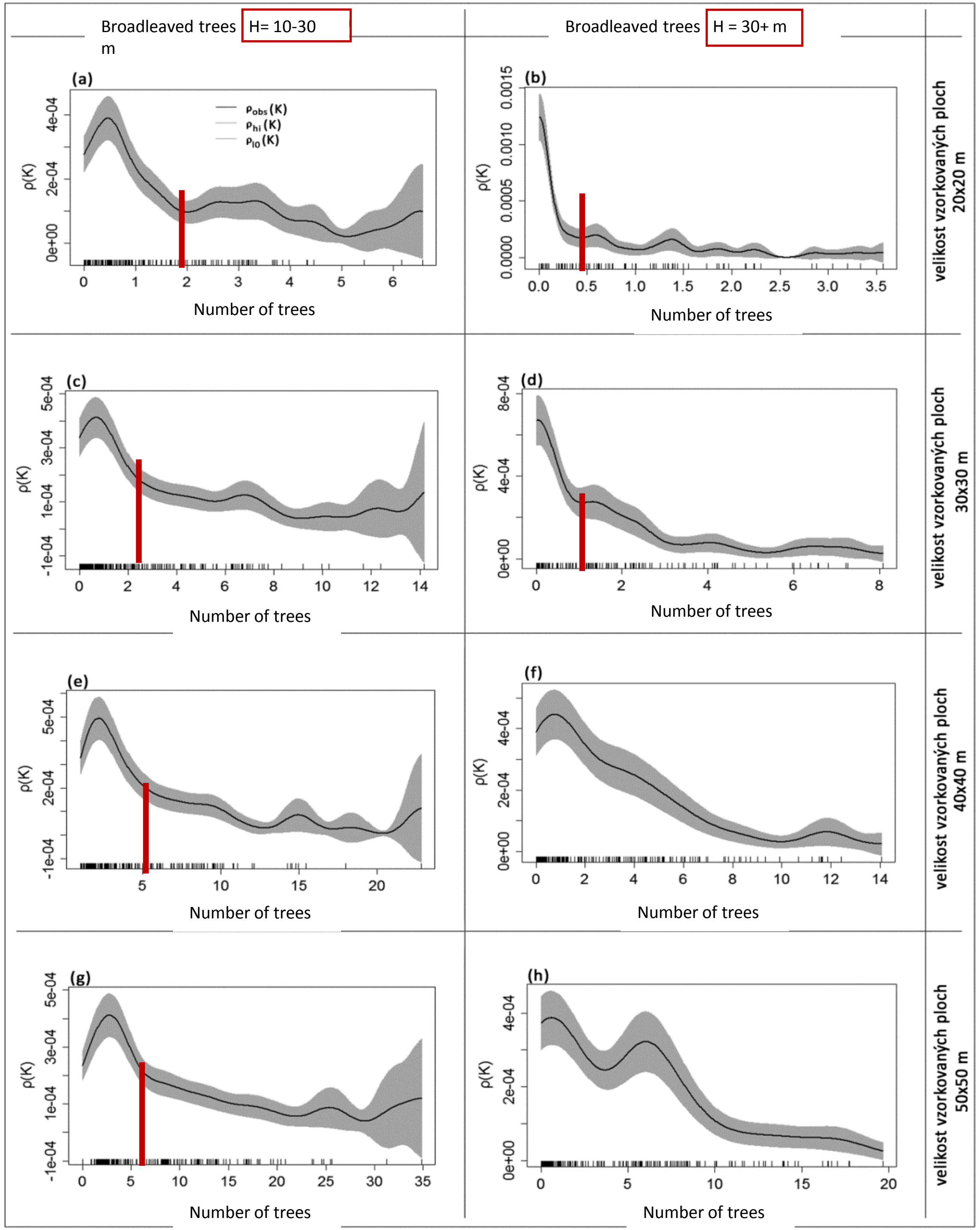
Žofín forest reserve after the storm Kyrill

Stem-position maps – Žofín – 75 ha, 22.000 trees DBH ≥ 10cm
Boubín – 46 ha, 16.500 trees DBH ≥ 10cm

May 2009



August 2009



Sampling scale

20x20 m

30x30 m

40x40 m

50x50 m

1) DEPENDENCY OF SPRUCES INFESTED BY BARK-BEETLES TO THE NUMBER OF DECIDUOUS TREES

All scales of sampling to 1ha:

- **32-36 deciduous trees**
- with well-developed crown and the height =10-30 m
- spatially randomly distributed (no clustered)

can significantly reduce the density of infested spruces

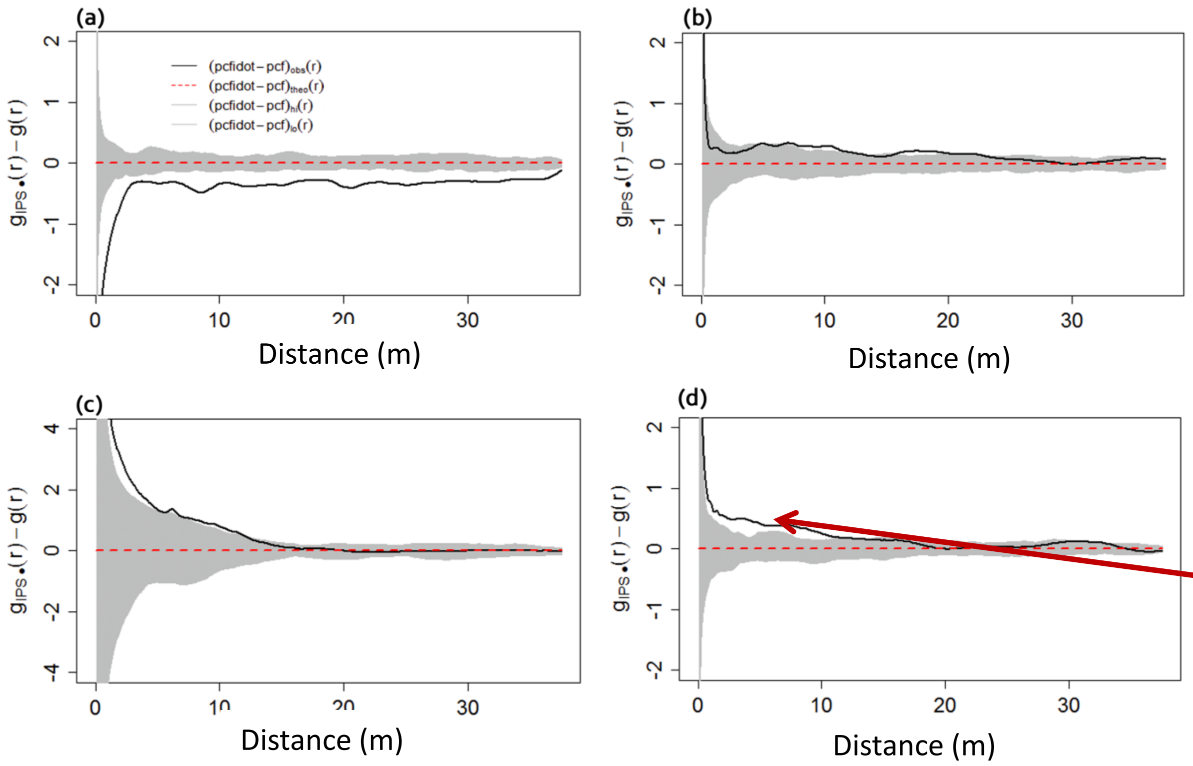
Only the partial effect of deciduous trees higher than 30 m.

Silviculture outputs:

- key point – the presence of shade-tolerant deciduous trees
- **systematical support of intermediate broadleaved trees**
- **single mixture of broadleaved and coniferous trees**

Vrška et al. 2015

2) SPATIAL RELATIONS BETWEEN FIT AND INFECTED TREES



ŽOFÍN	Number of spruces on the tested plots (per 2 ha)	
číslo plochy	Infected trees	Fit trees
1 (fig. a)	263	291
2 (fig. b)	86	69
3 (fig. c)	39	15
4 (fig. d)	73	17

Vrška et al. 2015

Positive spatial correlation of infected and fit spruces

- Spatial structure has the character of dispersion – in the mixture of spruce and beech
- Lower admixture of spruce = bark-beetle does not infect the nearest trees automatically
- Beech is inhibiting the spread of volatil substances
- Higher primary resistance of the spruce in the mixture with beech

<u>Silvicultural outputs for productive forests and buffer zones</u>:

- To reach 50% of broadleaved trees admixture minimally
- Single trees mixture or groups of coniferous and broadleved trees (spruce groups less than 0,10 ha)
- Spruce is not only the one coniferous tree species – restoration of silver fir is needed

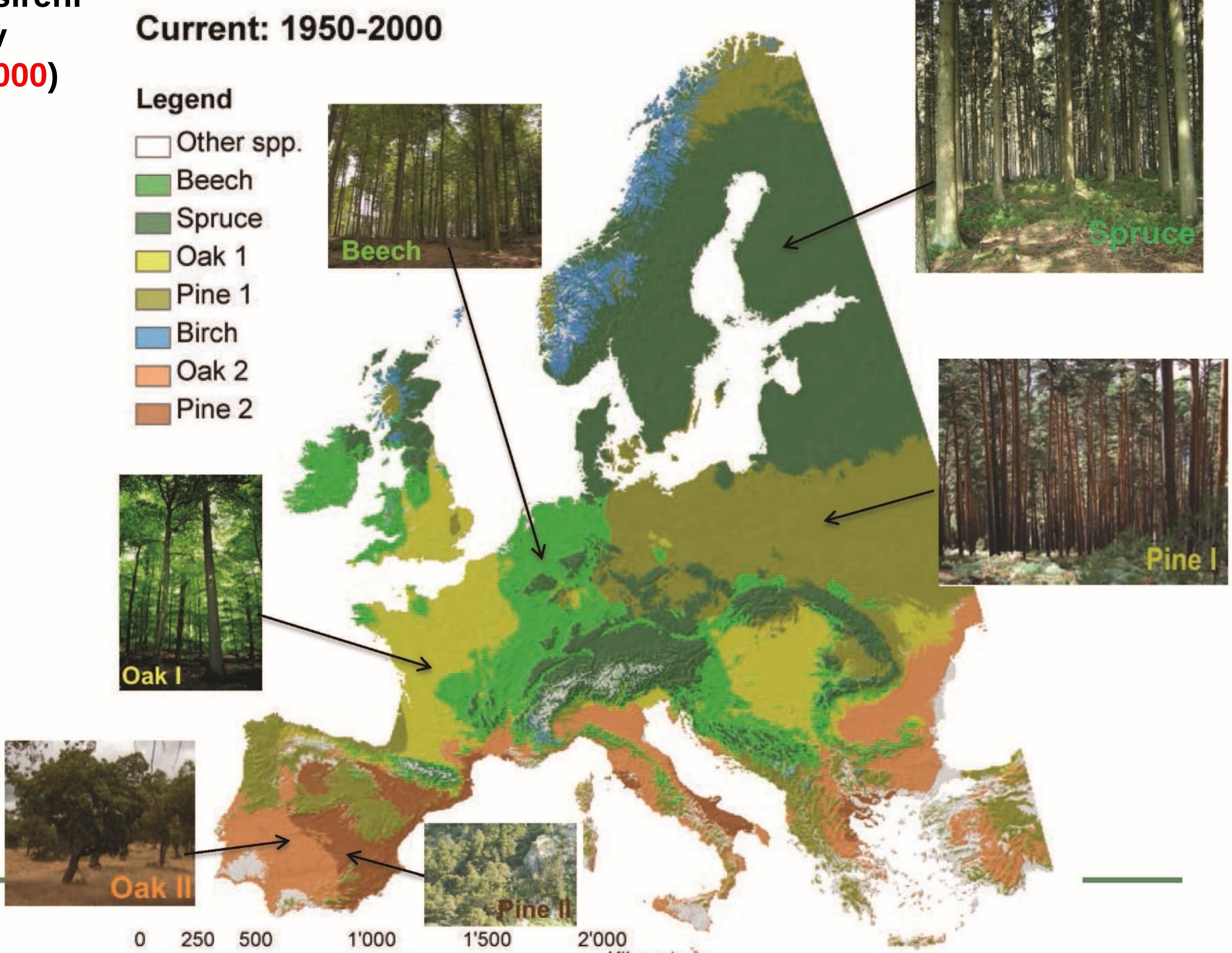
FOREST TRANSFORMATION = to change
i) tree species composition and
ii) spatial structure and
iii) silvicultural system

= 60 years (and to start latest in the 60 years of stand age)

It is slower than global climate change works!!!

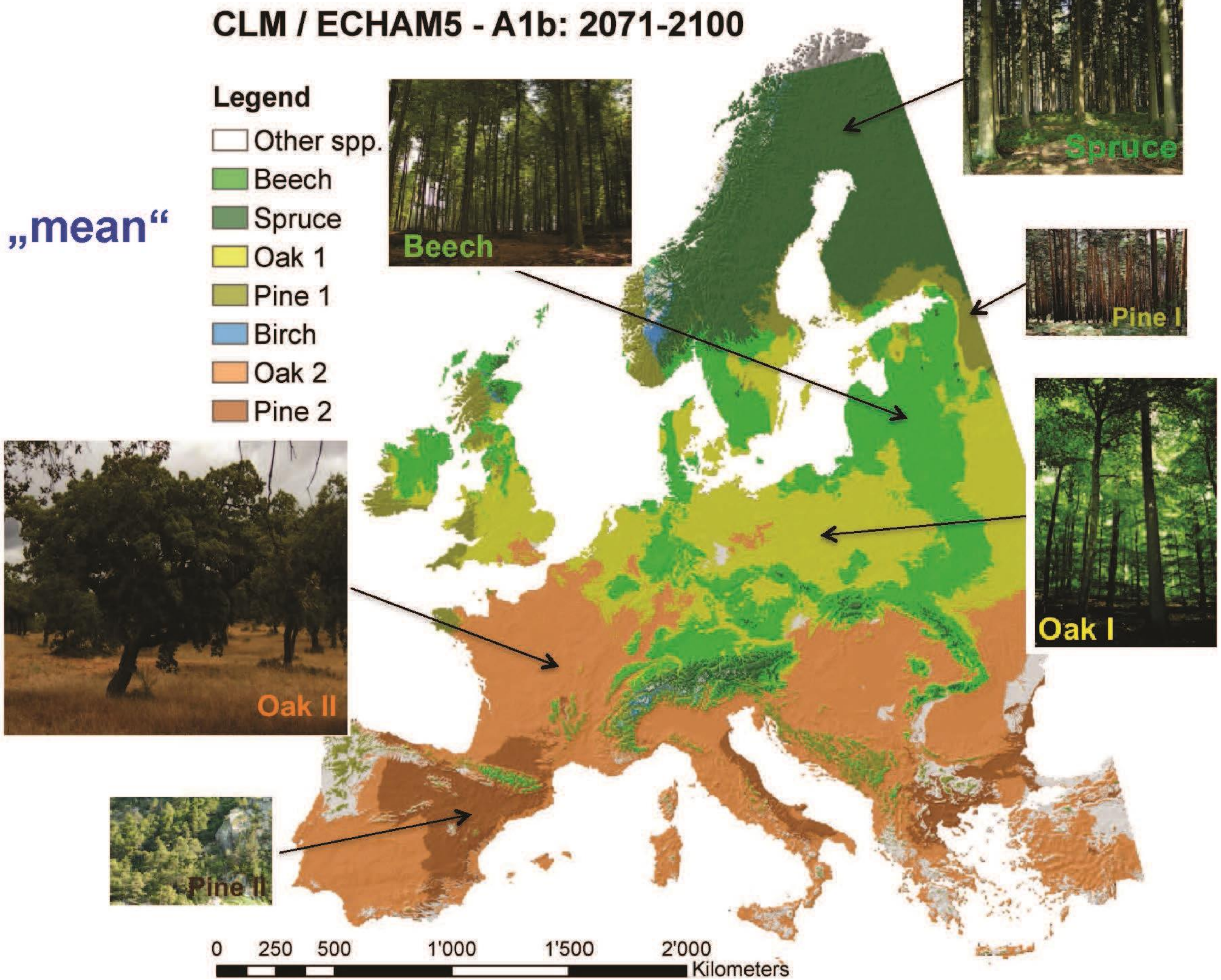
Potenciální rozšíření lesních dřevin v Evropě (1950-2000)

Hanewinkel et al. (2013) Nature Climate Change 3:204-27



Hanewinkel et al. (2013) Nature Climate Change 3:204-27

„mean“



Which affect resistence and resilience of forests in the era of climate change?

1) species composition - mixed forests with a higher proportion of deciduous trees and a higher number of species per unit area
2) type of mixing trees in stands - individual, clumps (up to 0,01 ha), groups (up to 0,10 ha) - important decision
3) spatial structure of stands - heterogeneous horizontal (DBH distribution) and vertical structure - better resistance to storms, greater variability of light conditions necessary for the existence of more tree species with different light requirements

General principles for the future silvicultural models:

1) to work with the lower number of trees per ha (physiology)
2) greater emphasis on working with specific trees - using selective principles
3) more focus on working with valuable deciduous trees and generally growing valuable assortments - (see future processing of wood) - branching, increasing representation
4) shorter rotation period in stands that cannot be adapted (e.g. spruce stands older than 60 years)

Question for the Norway spruce – where, how much and which type of mixing?

Restoration of stands after disintegration - pioneer tree species, partially underplantations of target tree species, safety of production

Heterogenous forests for the future?