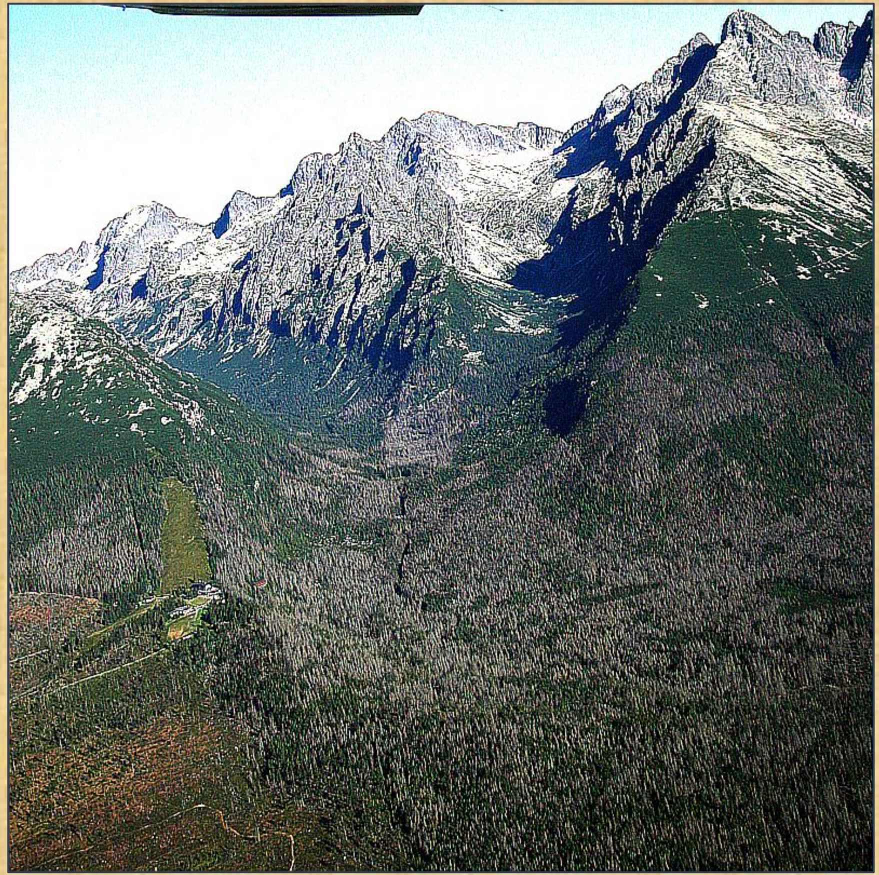
Impact of natural disturbances and forest management on mountain spruce ecosystems in theTatra National Park



Peter Fleischer

Research station and Museum of Tatra National Park, Tatranska Lomnica, SK

Technical University Zvolen, SK

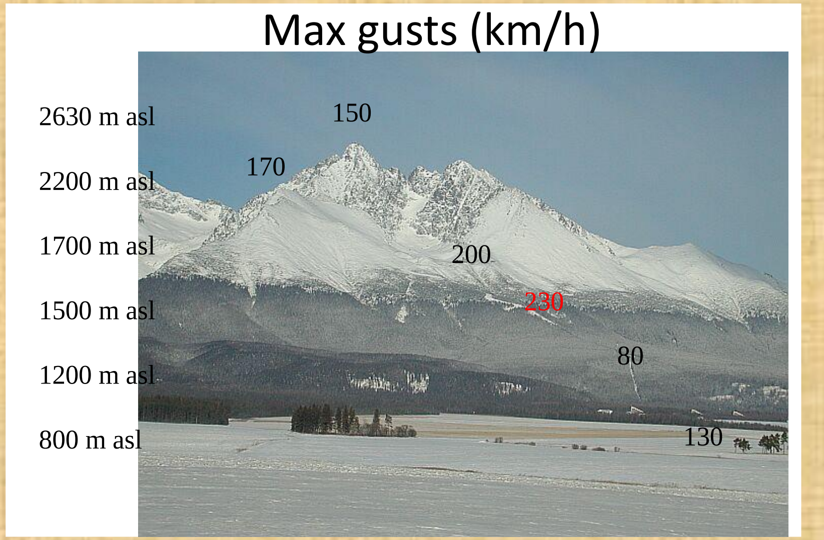
Windthrow 2004

Area: 12 000 ha

Volume: 2.5 mil m3

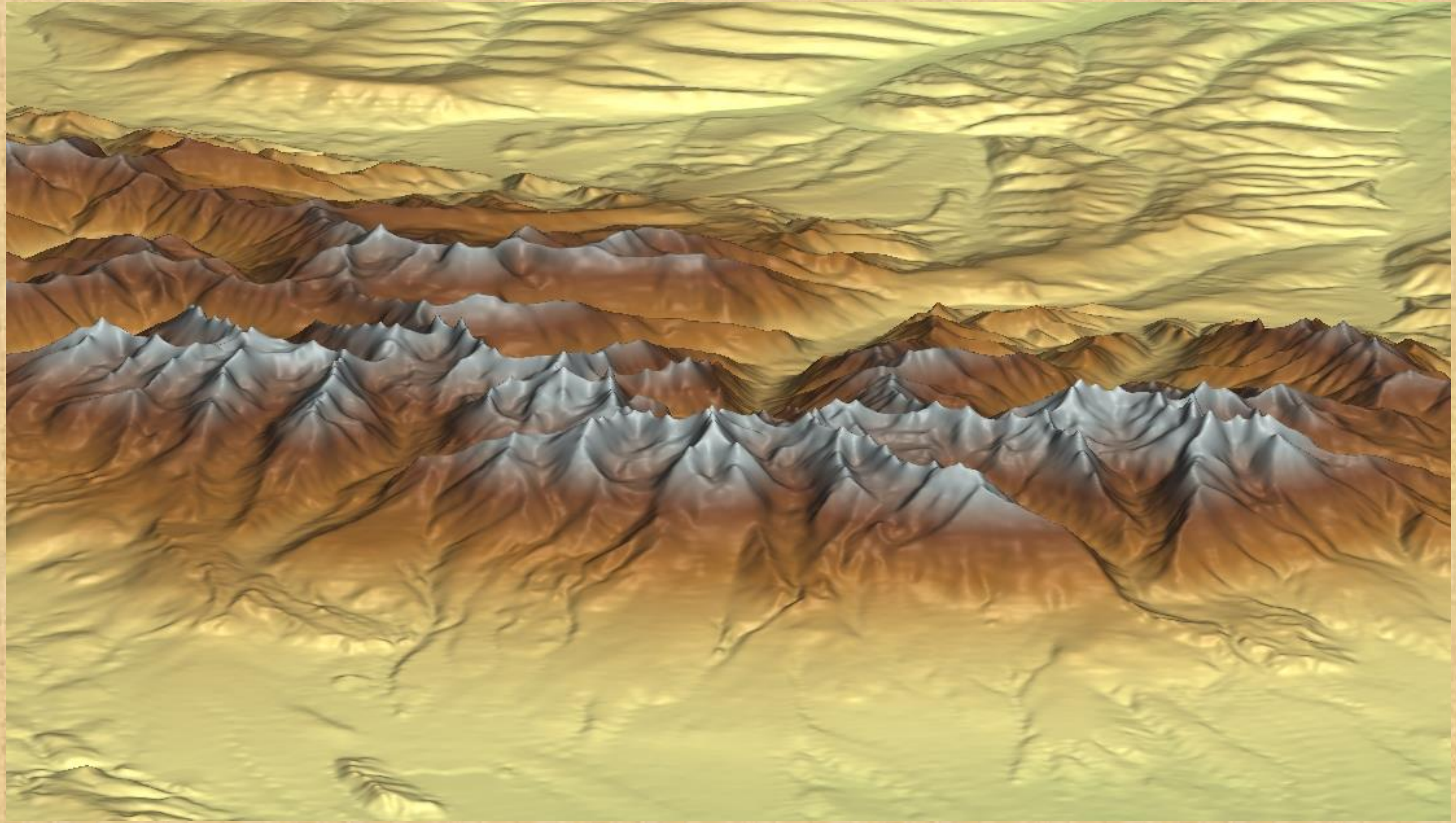
Community: mostly pine/larch-spruce stands

Wind gusts: 230 km/h



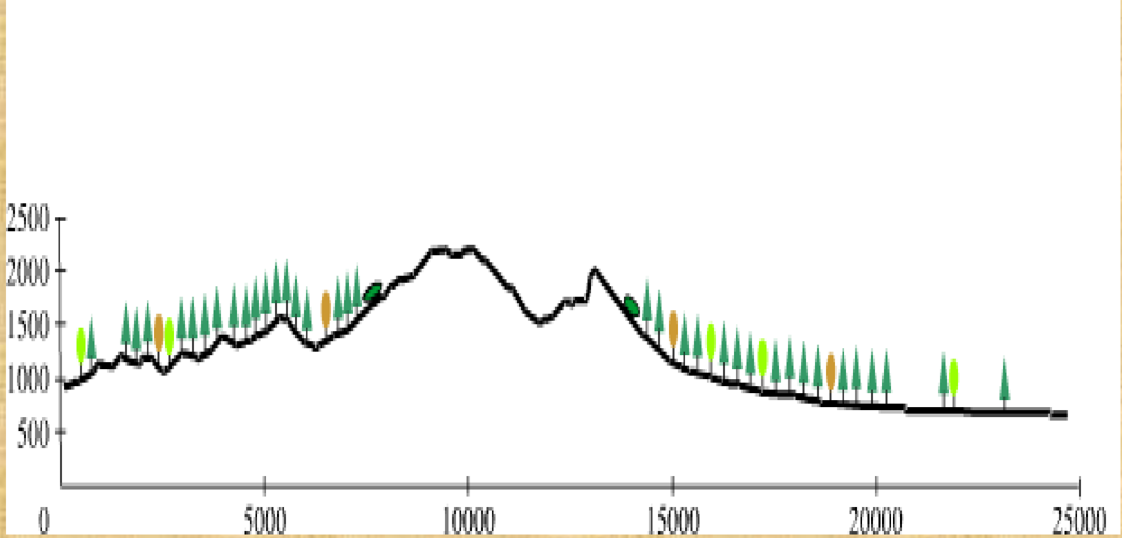
Geography and climate

Predisposition for destructive winds

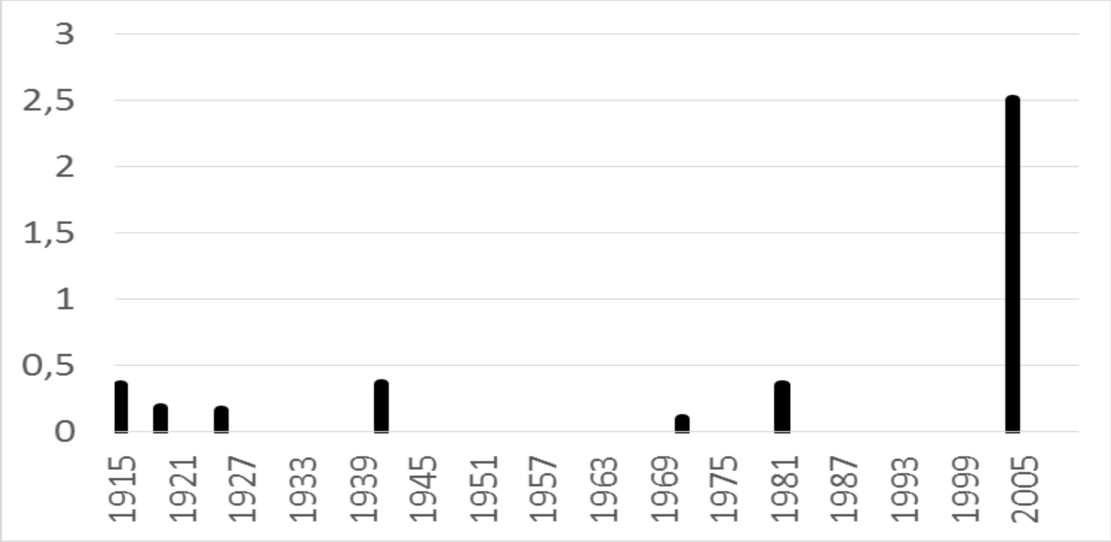


Wind - Permanent disturbance in the Tatra Mts

- main ridge oriented perp against prevailing strong winds
- wind above 150 km/h
- large air pressure gradient
- inversion layer above the ridge



History of large windthrows (in mil m3) according to forestry evidence



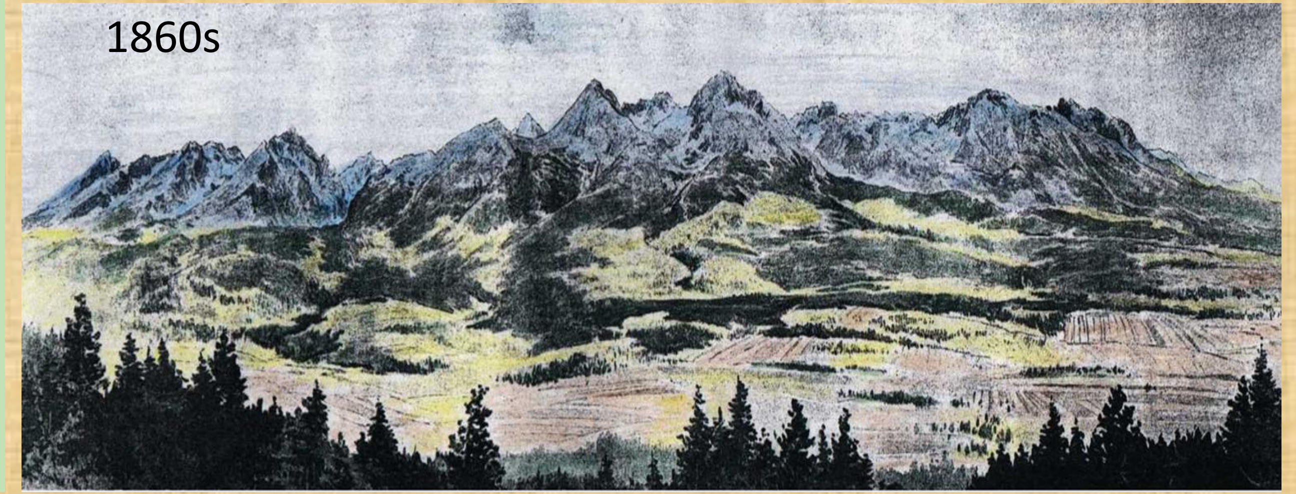
(*Koreň 2005*)

National Park –

since 1949 = protection and restoration

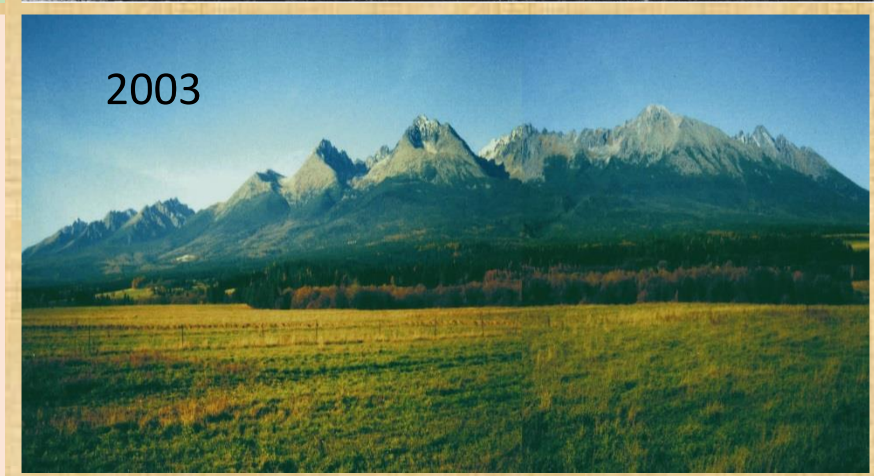
Protection of outstanding natural values:
- diversity
- endemism
- relicts
- rare species
- beauty

Reconstruction of
- overused resources in past (logging, grazing, mining)
- natural catastrophes)



The aim- multipurpose forestry providing vast array of ecosystem services:

- **Regulatory** -hydrology-floods,
  water quality,
  - erosion
  - mezoclimate
  - C sequestration
- **Cultura**l, social - health treatment
  - recreation
- **Habitat** – insect, mammals, birds,



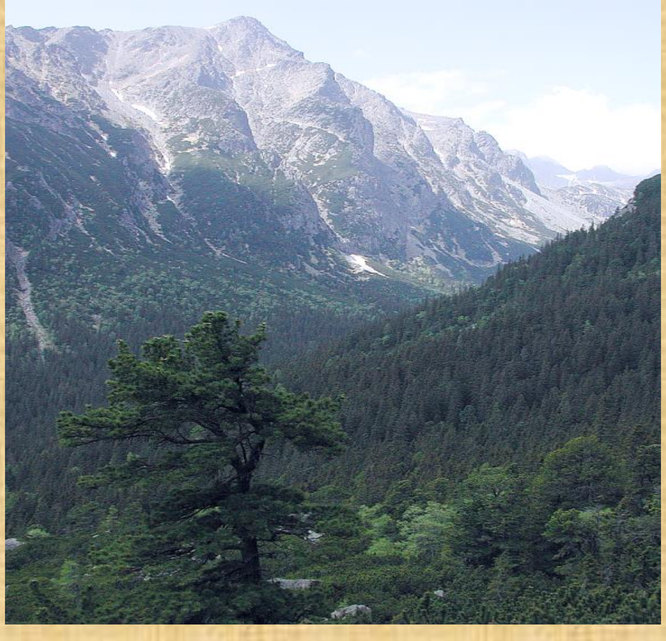
The Tatra Mts - forest

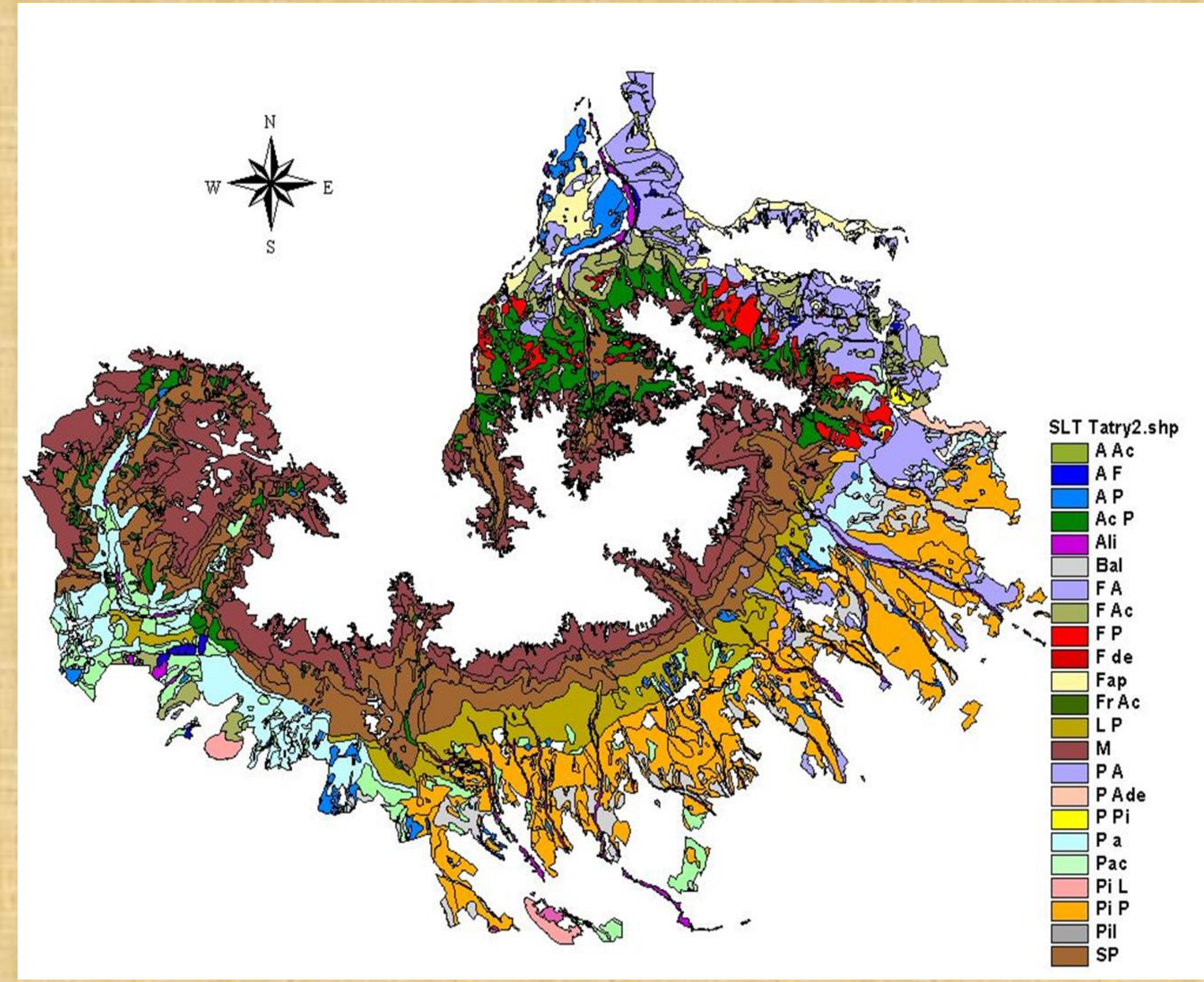
Forest cover: 40 000 ha
Forest span 700-1600 m a.s.l.

Dwarf pine: 1600-1800 (*Pinus mugo*)

Picea abies: 65%
Larix decidua:10%
Pinus sylvestris: 8%
Abies alba: 6%
Pinus cembra:+
Sorbus aucuparia:5%
Betula carpatica:5%

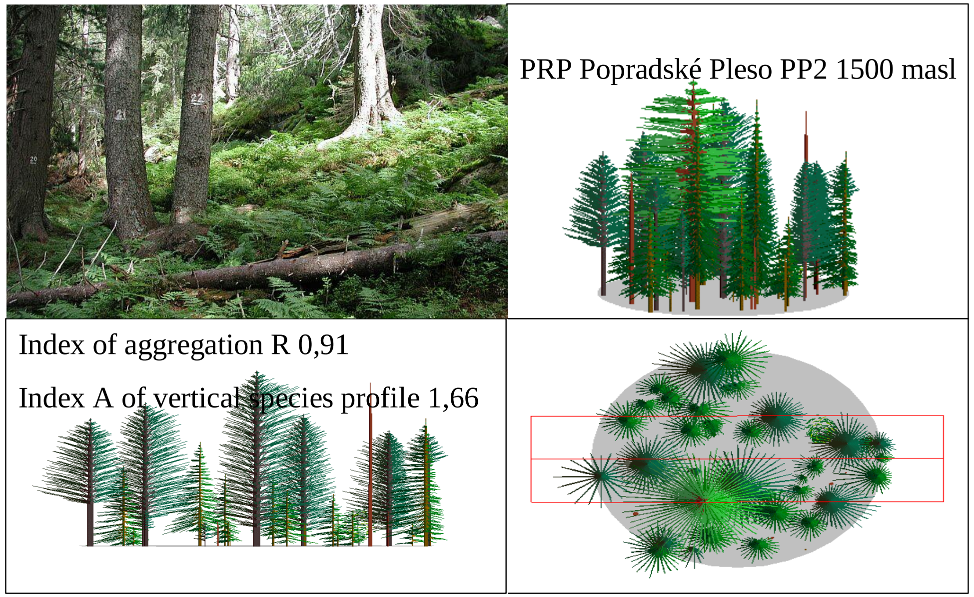
CE extrazonal taiga forest

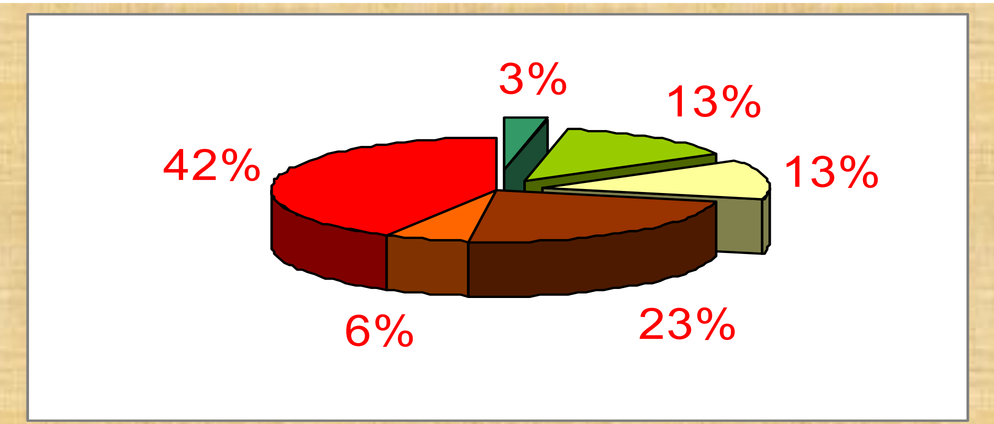




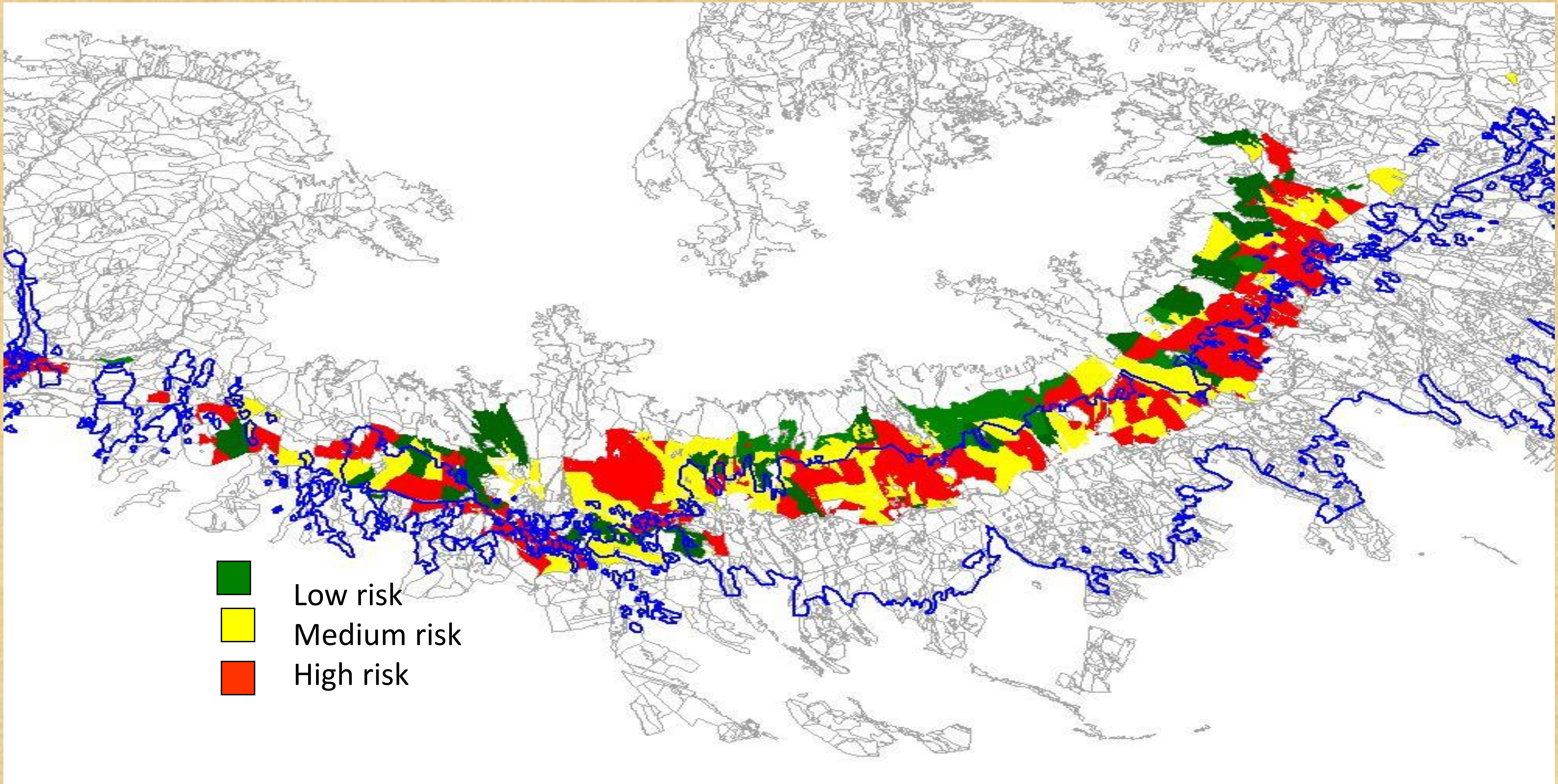
Potential forest vegetation

Risk assessment - criteria





Risk categories and the 2004 windthrow



Spracovať či ponechať kalamitu???

Argumenty za spracovanie

1. Riziko požiarov
2. Riziko záplav zo zablokovaných vodných tokov, ohrozenie kvality pitnej vody pre 20 000 ľudí
3. Riziko šírenia podkôrneho hmyzu (luxusné potravinové podmienky)

Skúsenosti 1931, 1942 s menežovaním kalamity

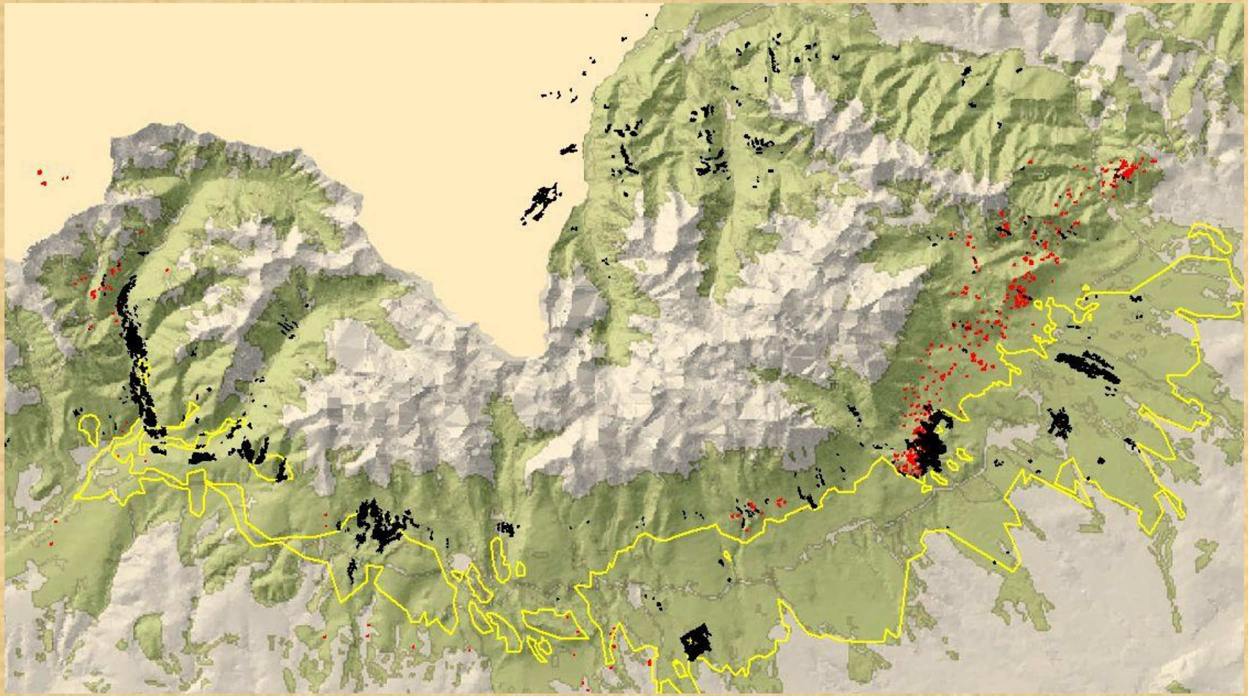
Argumenty proti spracovaniu

1. Devastácia krajiny
2. Erózia v dôsledku zmenených hydrických pomerov
3. Mikroklimatické extrémy
4. Živinový kolaps
5. Hospodárske využitie kalamitného dreva (NP a rezervácie)

Experiment so samovývojom

Vývoj po kalamite

- Kompromis v menežmente – diferencované spracovanie podľa priorít ochrany prírody



Nespracovaná (10% kalamity)

uhynuté stromy (stav 2006)

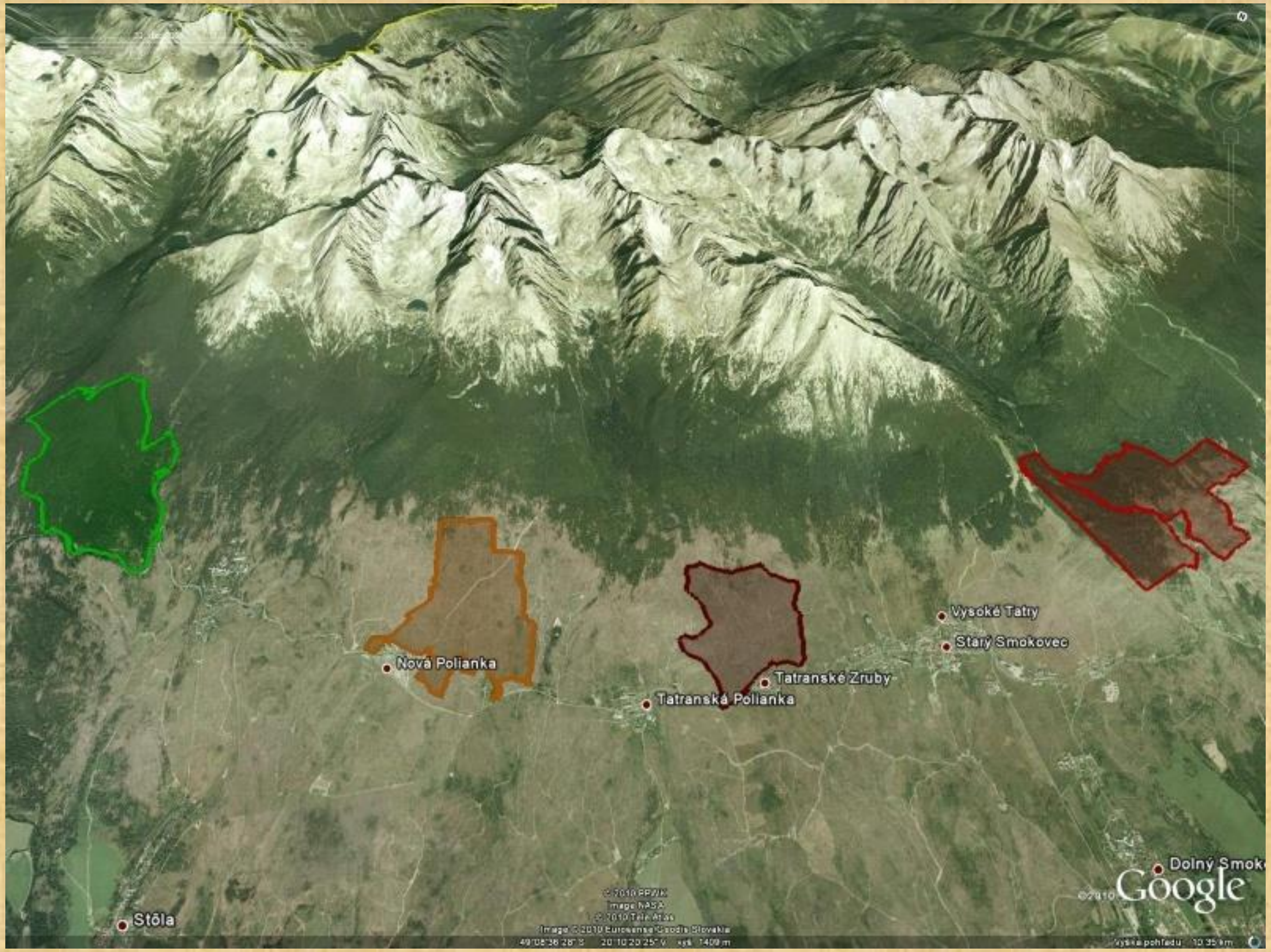
Vetrová kalamita 2004

Post-windstorm research

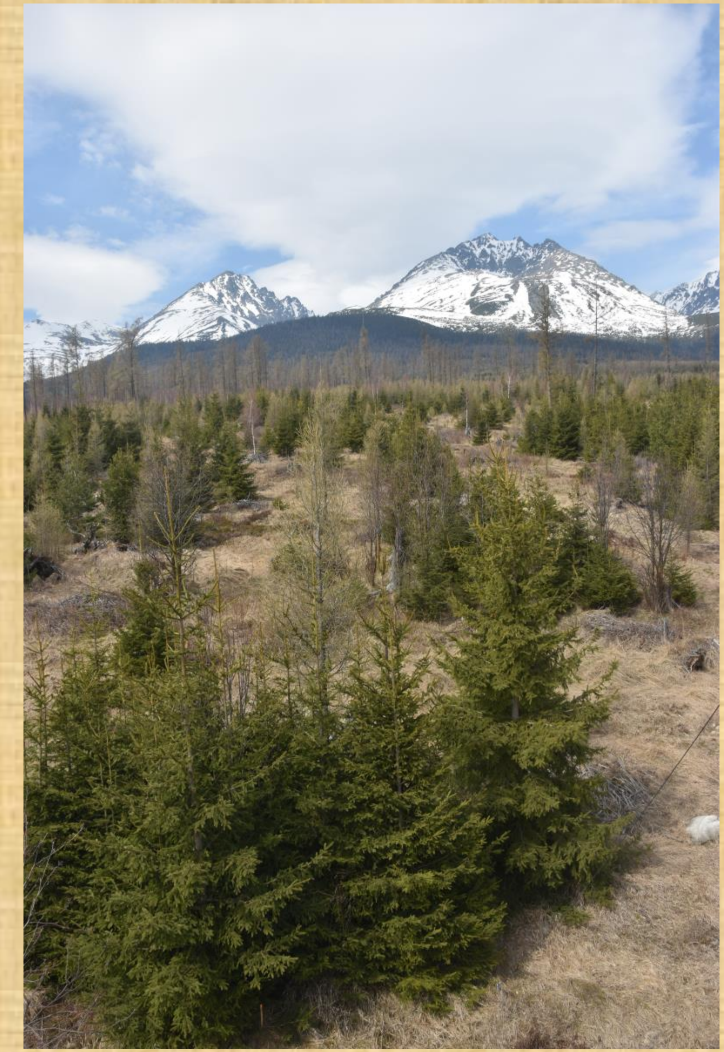
Consequences on:

- (micro) Climate
- Hydric conditions
- Energy balance
- Bioproduction
- Biogeochemical cycles
- Soil, humus
- Nutrient leaching and erosion
- Regeneration
- Succession
- Fungi, plant, animal communities
- Ecosystem services

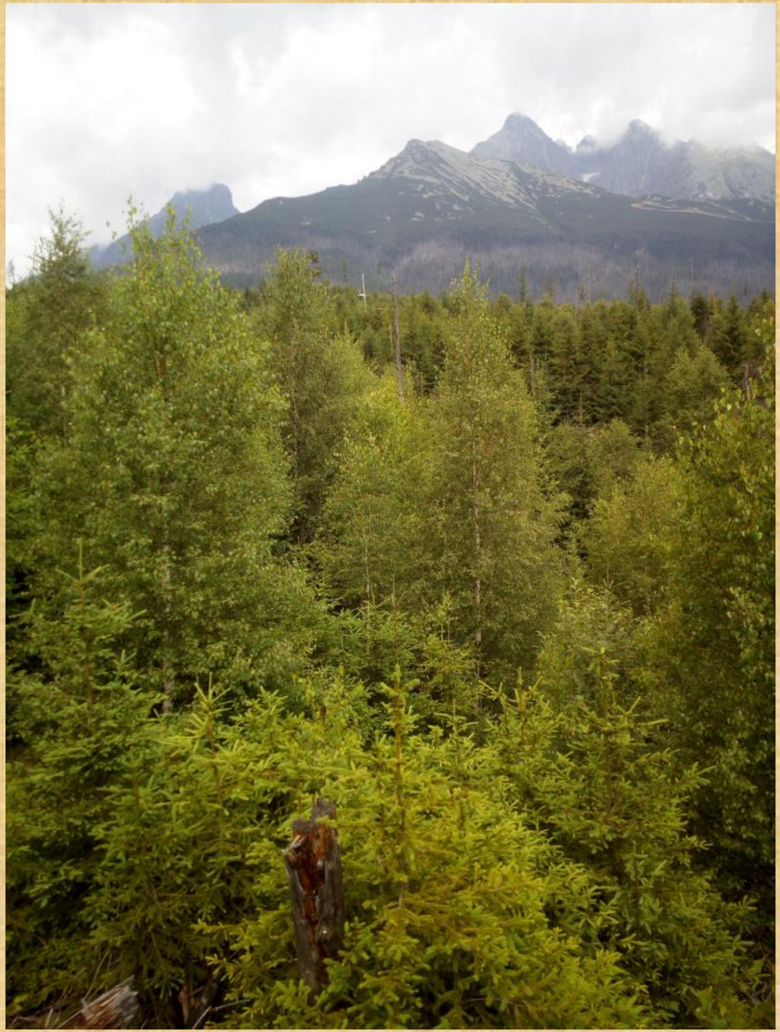
Partners



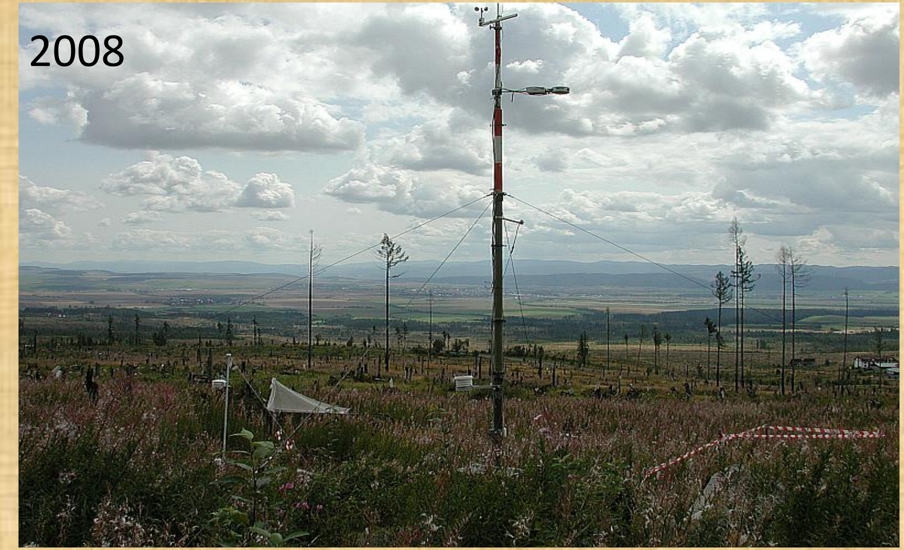
EXT – managed, wood extracted



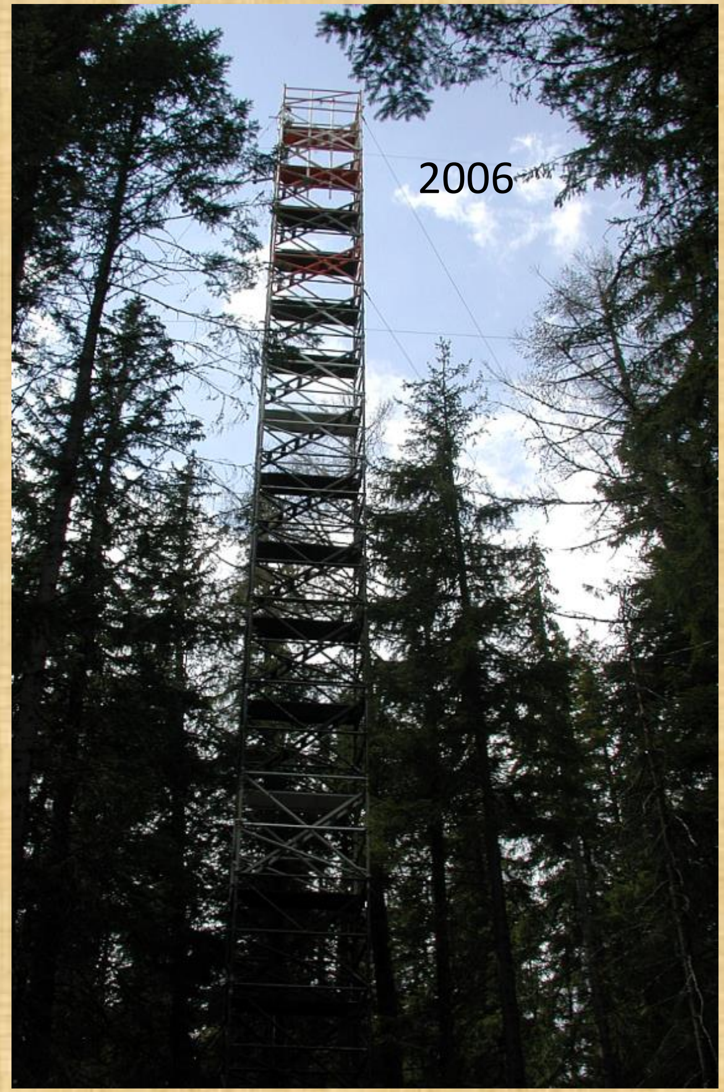
NEX – unmanaged, natural processes only



FIR – burnt site

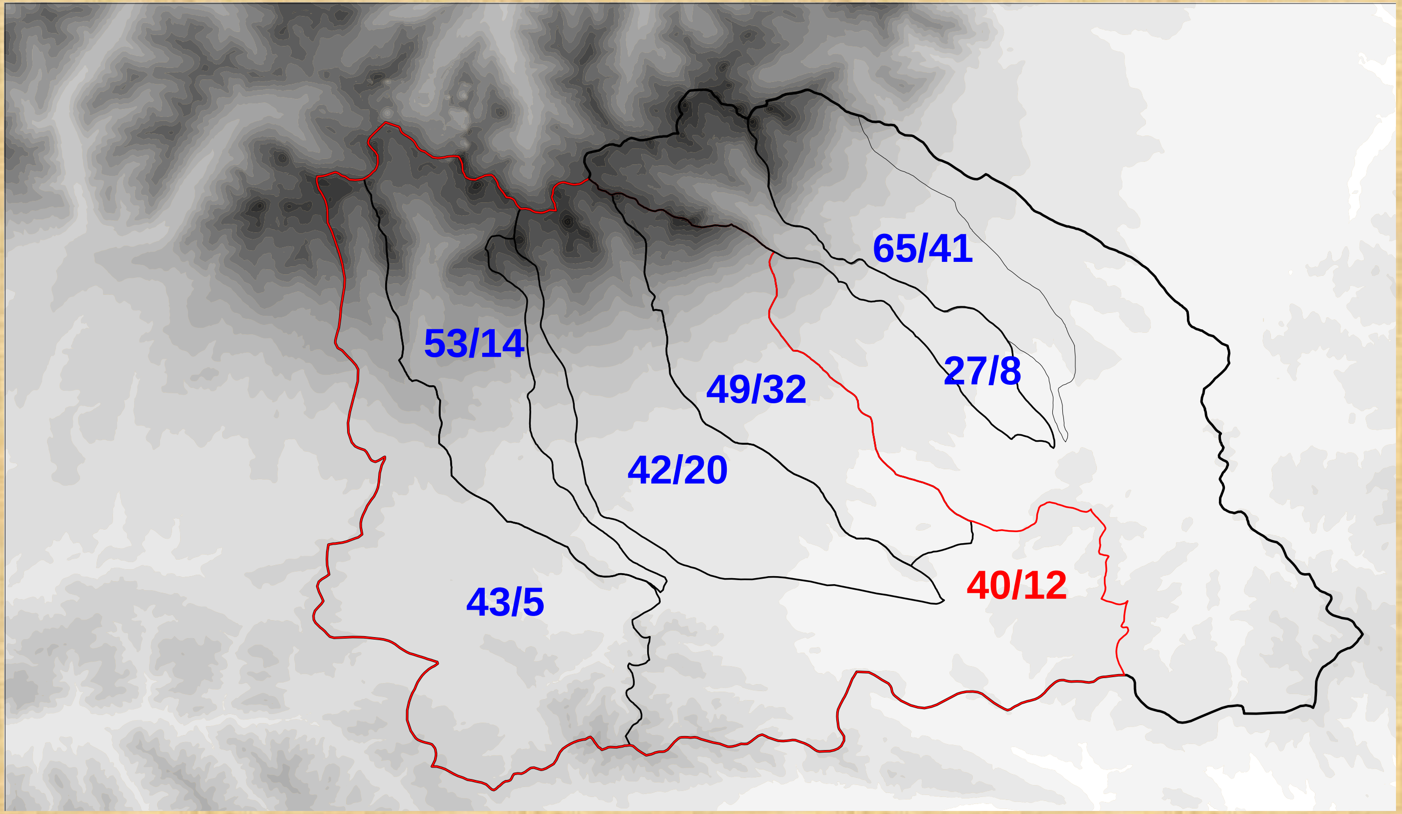


REF – undisturbed, reference site



Hydrological processes after disturbance 1 (wind) 1962-2007

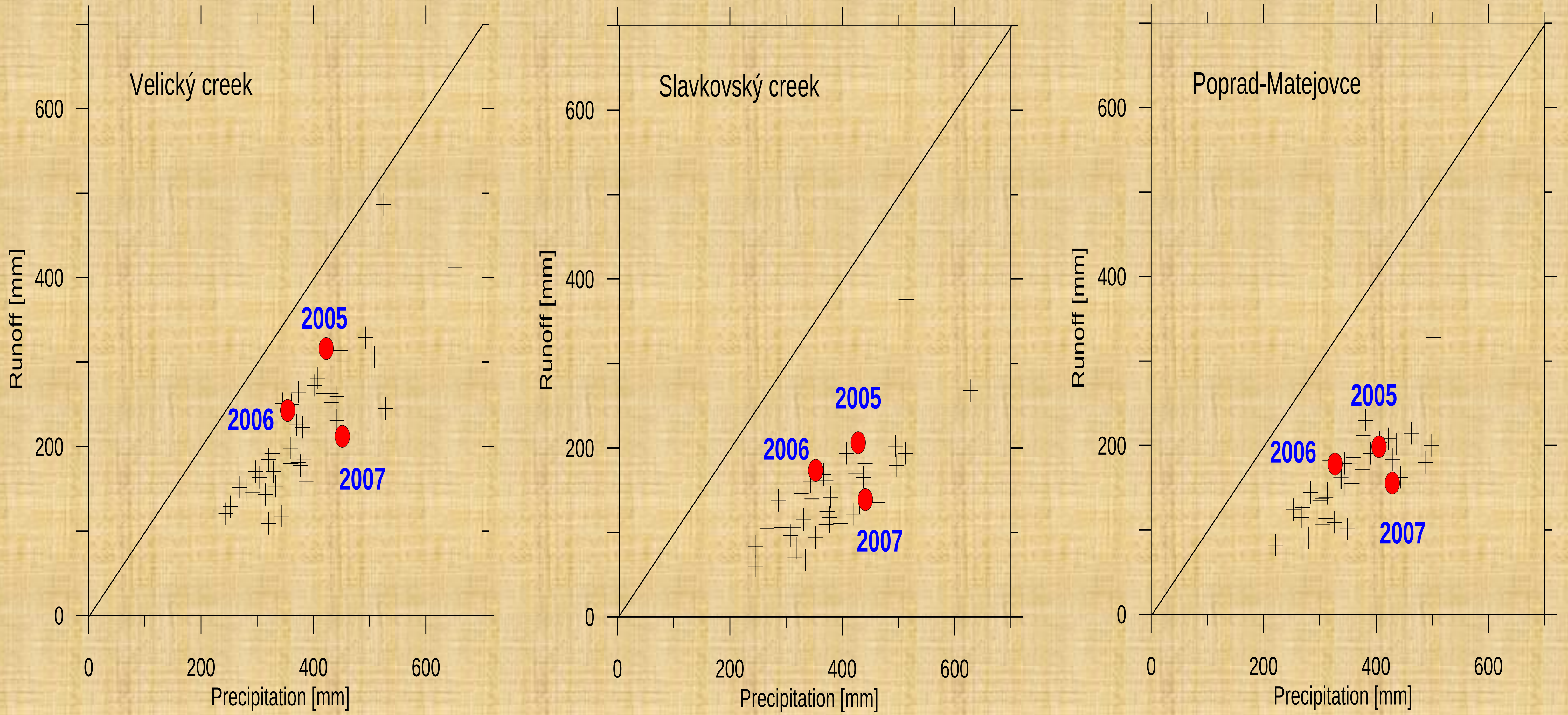
H0:
reduced retention
blocked rivers
floods
water erosion
nutrient leaching



Forest cover (%) before and after the windthrow:

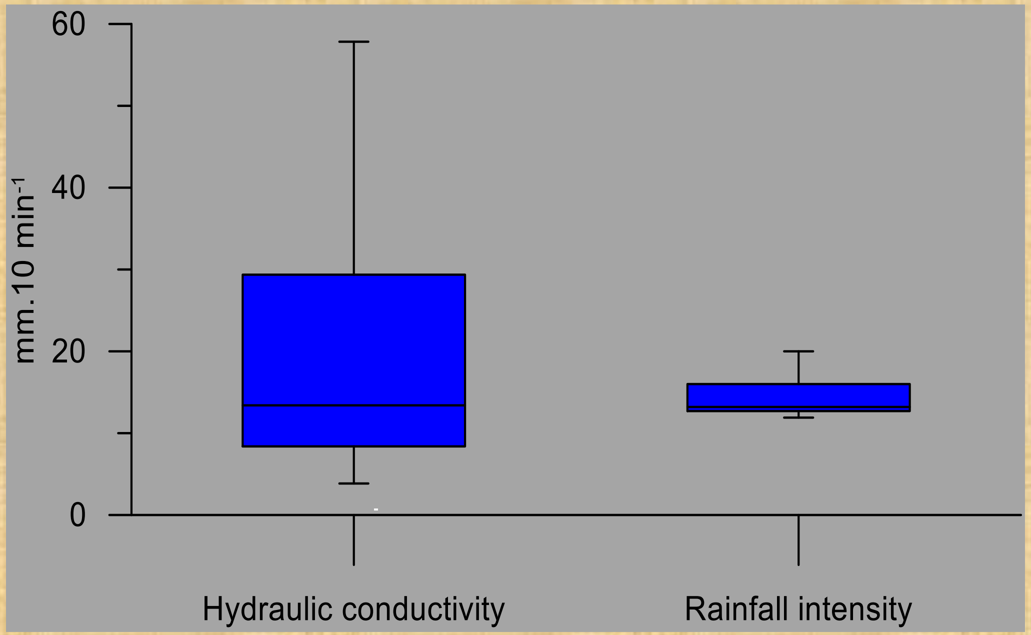
Hydrological processes – precipitation/runoff

1962-2007



Hydrological processes - soil/geological properties

Very high hydraulic conductivity (low probability for surface runoff) in sandy soils



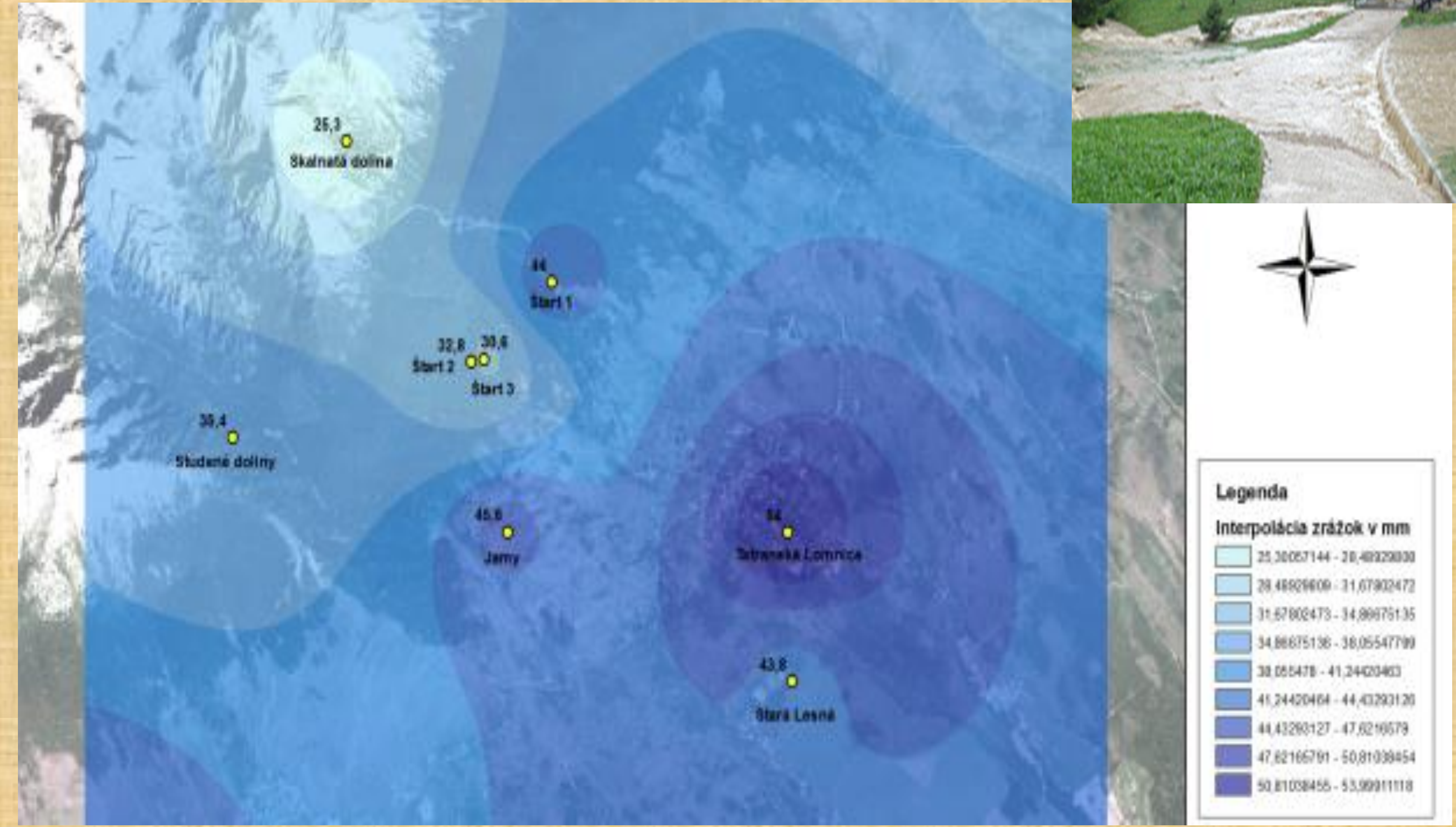
Extremely high water saturation in soil matrix (pores make 68% of soil volume)

Low compaction
Large content of rocks (= low retention)

10 cm	10%
20 cm	30%
40 cm	40%
50 cm	almost 50%

Holko 2015

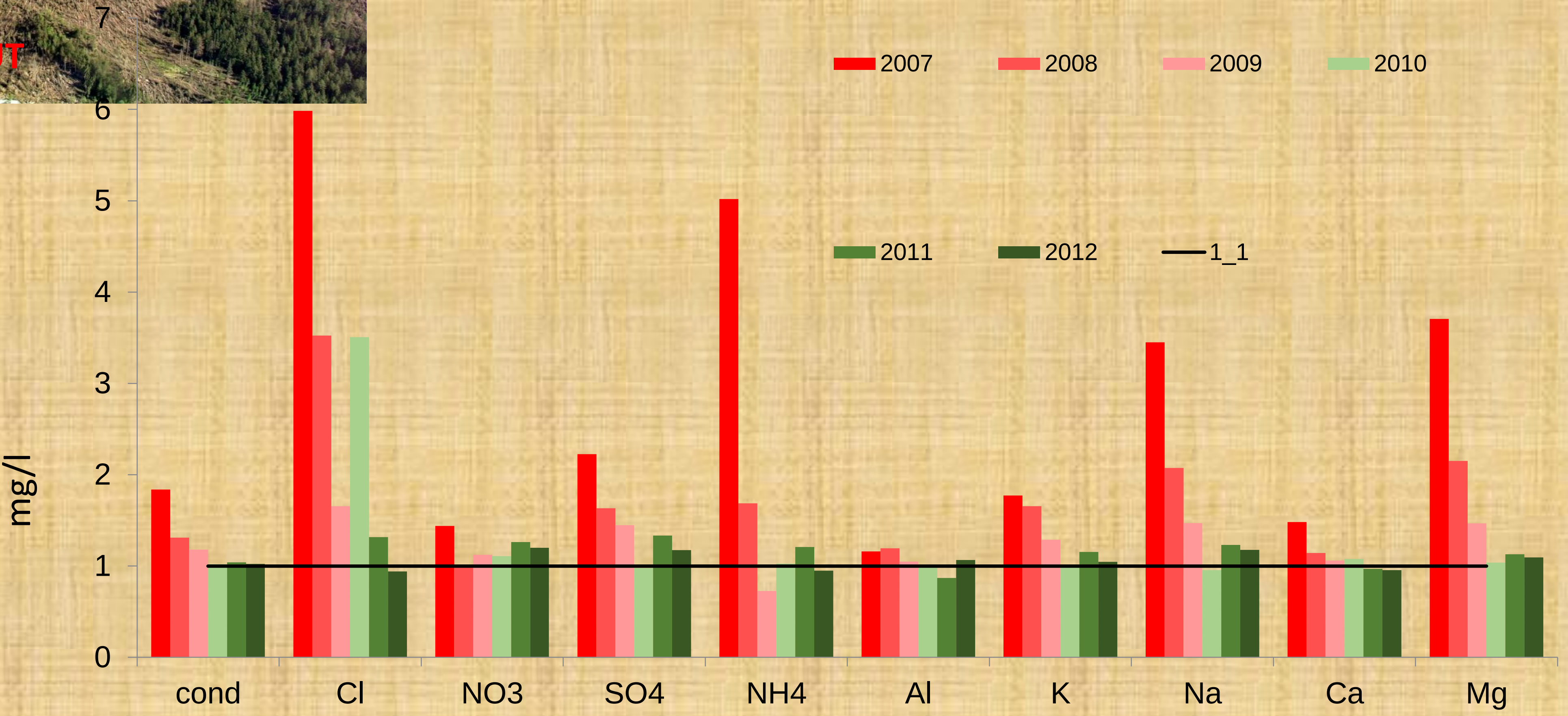
Hydrological processes after an extreme event



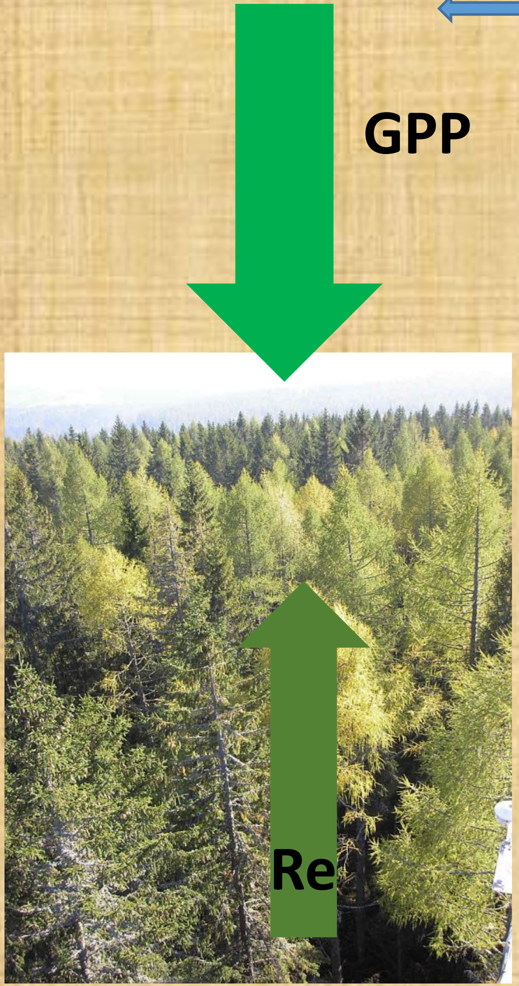
August 24, 2011 daily total 81 mm, 3-day 125 mm

Nutrient leaching and transport by stream water

$$I_{ob} = C_{out}/C_{IN}$$



Carbon balance before and after disturbance

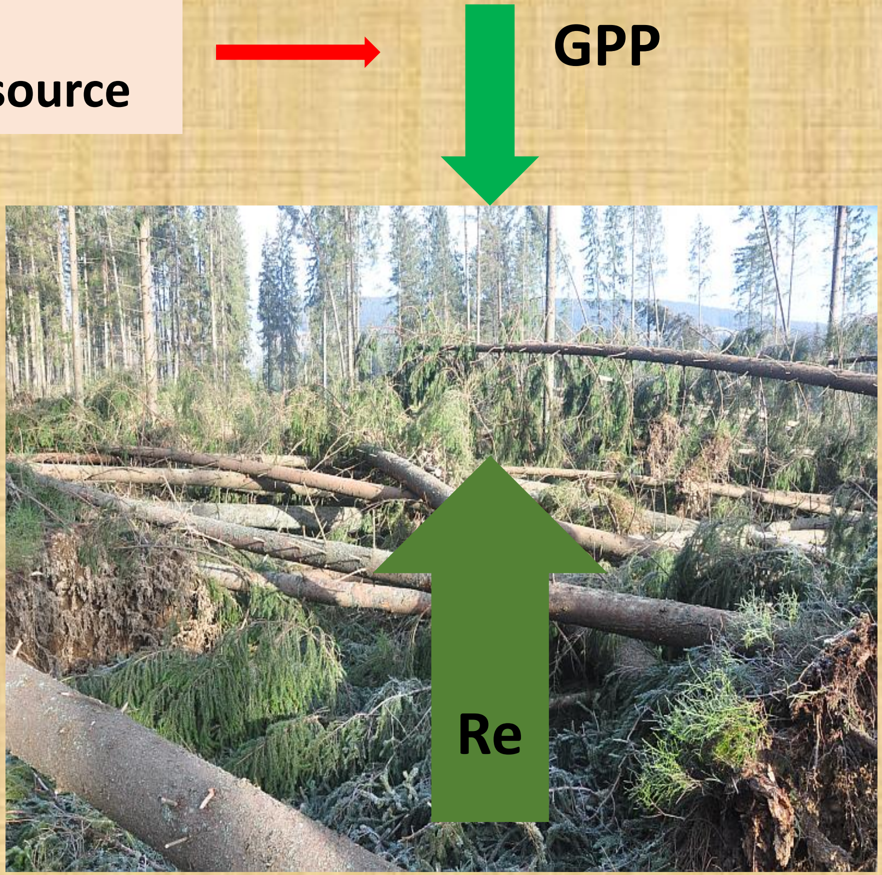


GPP > Re

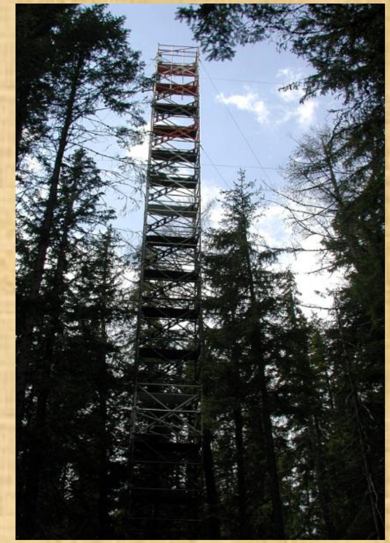
ecosystem acts as C sink

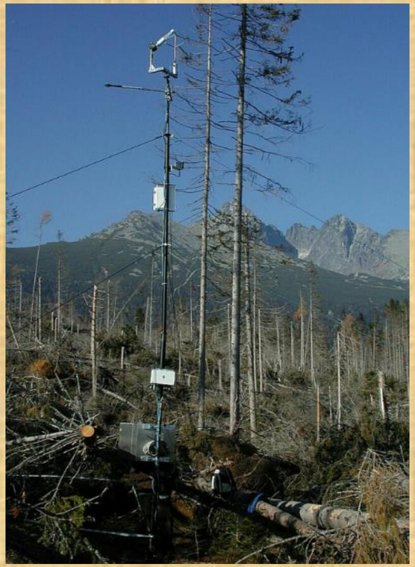
GPP < Re

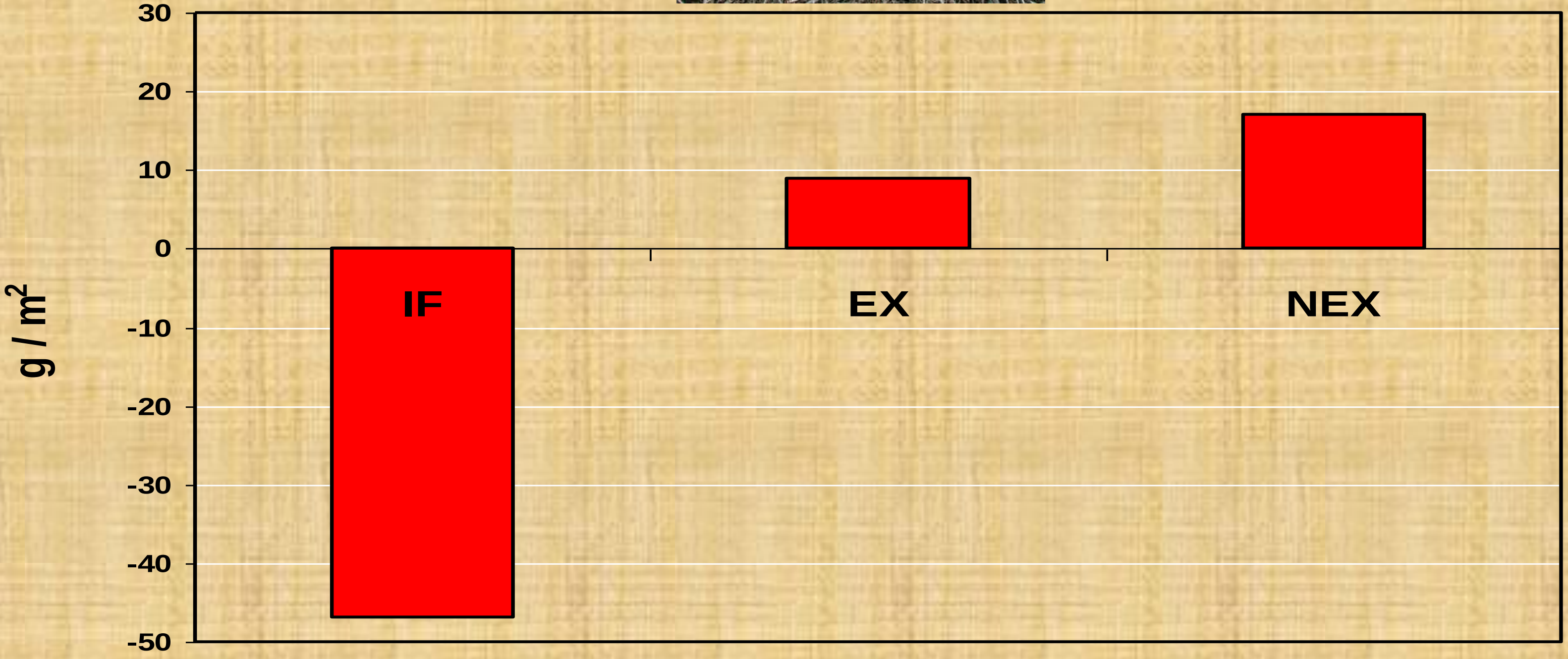
ecosystem acts as C source



C balance VIII-XI 2005 by EC





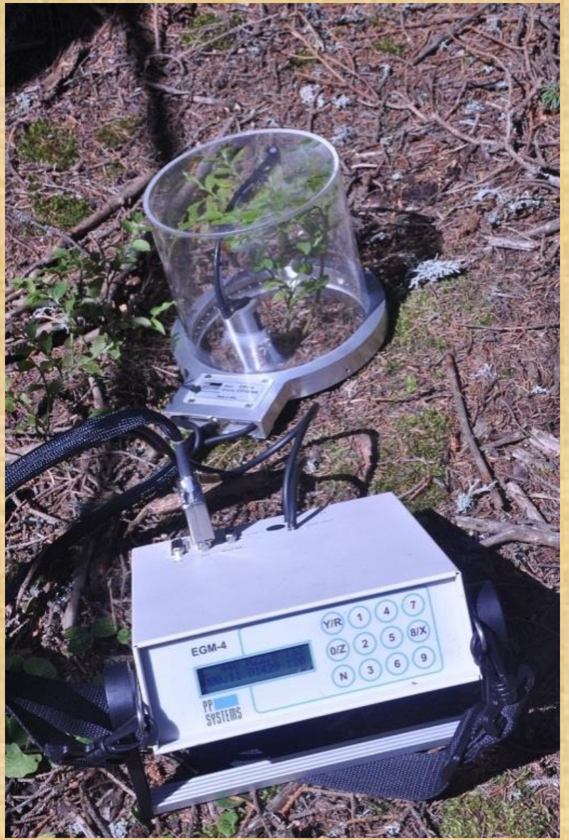


Meranie bilancie (NEE) CO2 komorovými metódami

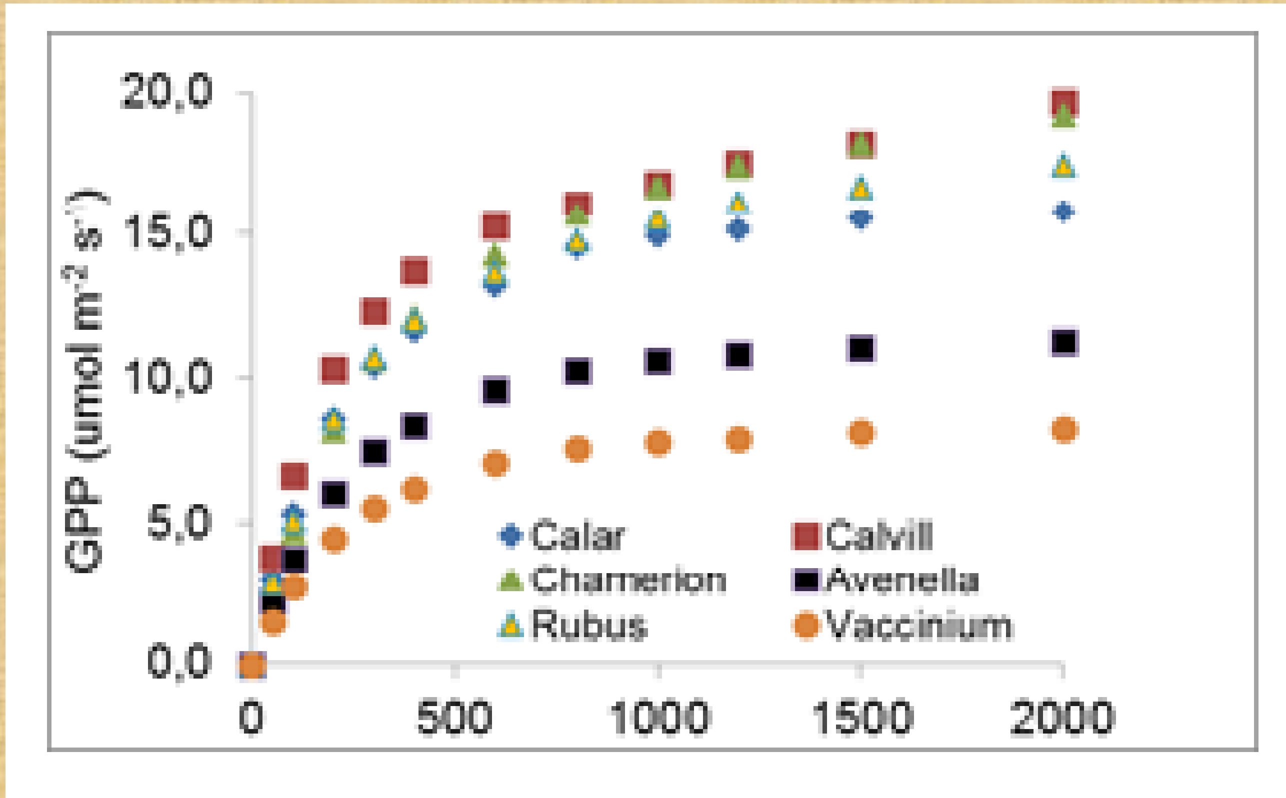
metóda komorová (od 2008, nízka vegetácia)

NEE=GPP-RE

RE = NEE (ak GPP=0, t.j bez pístupu svetla)



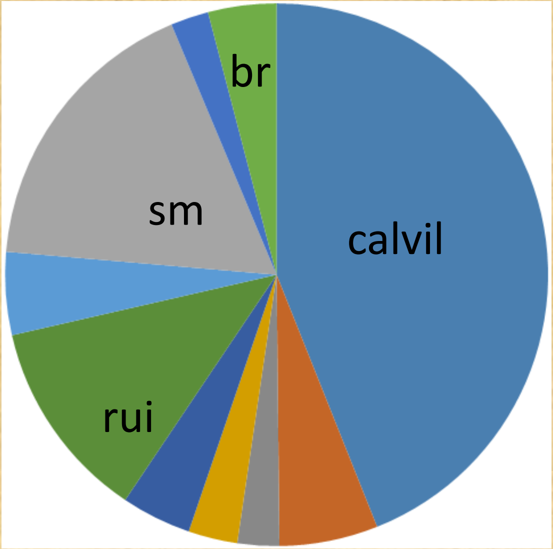
Species composition according to LAI
Species specific light courves (=



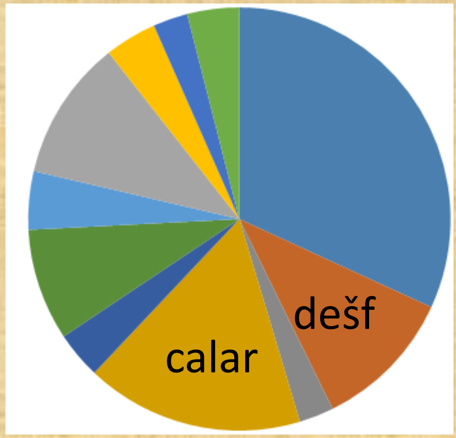
Druhová rozdielnosť, ale podobnosť svetelných kriviek, prípadne priebeh fenofáz eliminovali diferencie. LAI – kľúčový faktor

Species composition according to LAI

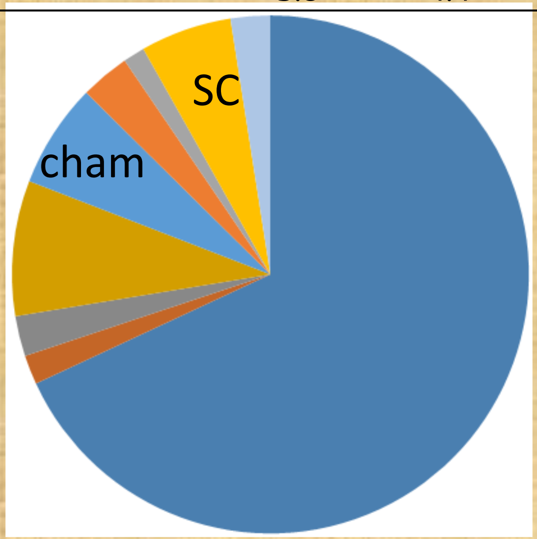
	M		U		REF
	EXT	FIR	NEX	BB	
Calamagrostis villosa	1.2 (1.6)	2.9 (2.2)	1.9 (2.1)	0.8 (1.5)	0.1 (0.3)
Avenela flexuosa	0.4 (0.7)	0.1 (0.4)	0.3 (0.6)	0.2 (0.3)	
Luzula nemorosa	0.1 (0.4)	0.1 (0.4)	0.1 (0.5)	0.2 (0.5)	
Calamagrostis arrundinacea	0.6 (1.8)	0.4 (1.7)	0.1 (1.3)		
Vaccinium myrtillus	0.1 (0.5)		0.2 (0.7)	0.1 (0.3)	0.2 (0.4)
Rubus ideaus	0.3 (0.9)		0.5 (1.4)	0.1 (0.6)	
Chamerion angustifolium	0.2 (0.3)	0.3 (0.4)	0.2 (0.4)	0.1 (0.4)	0.1 (0.2)
Picea abies	0.4 (0.8)	0.1 (0.1)	0.8 (1.4)	0.2 (0.5)	4.5 (0.9)
Larix decidua	0.2 (0.3)	0.3 (0.3)			
Sorbus aucuparia	0.1 (0.4)		0.1 (0.4)		
Betula verucosa	0.2 (0.3)		0.2 (0.4)		
Salix caprea		0.1 (0.2)			
other		0.1 (0.2)	0.1 (0.2)		0.1 (0.2)
Total	3.8	4.4	4.5	1.7	5.0



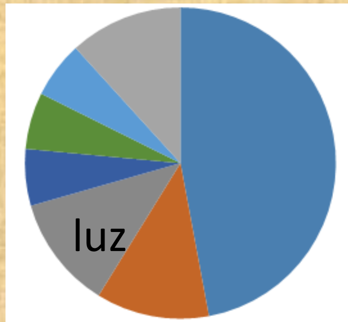
NEX 4,5



EXT 3,8

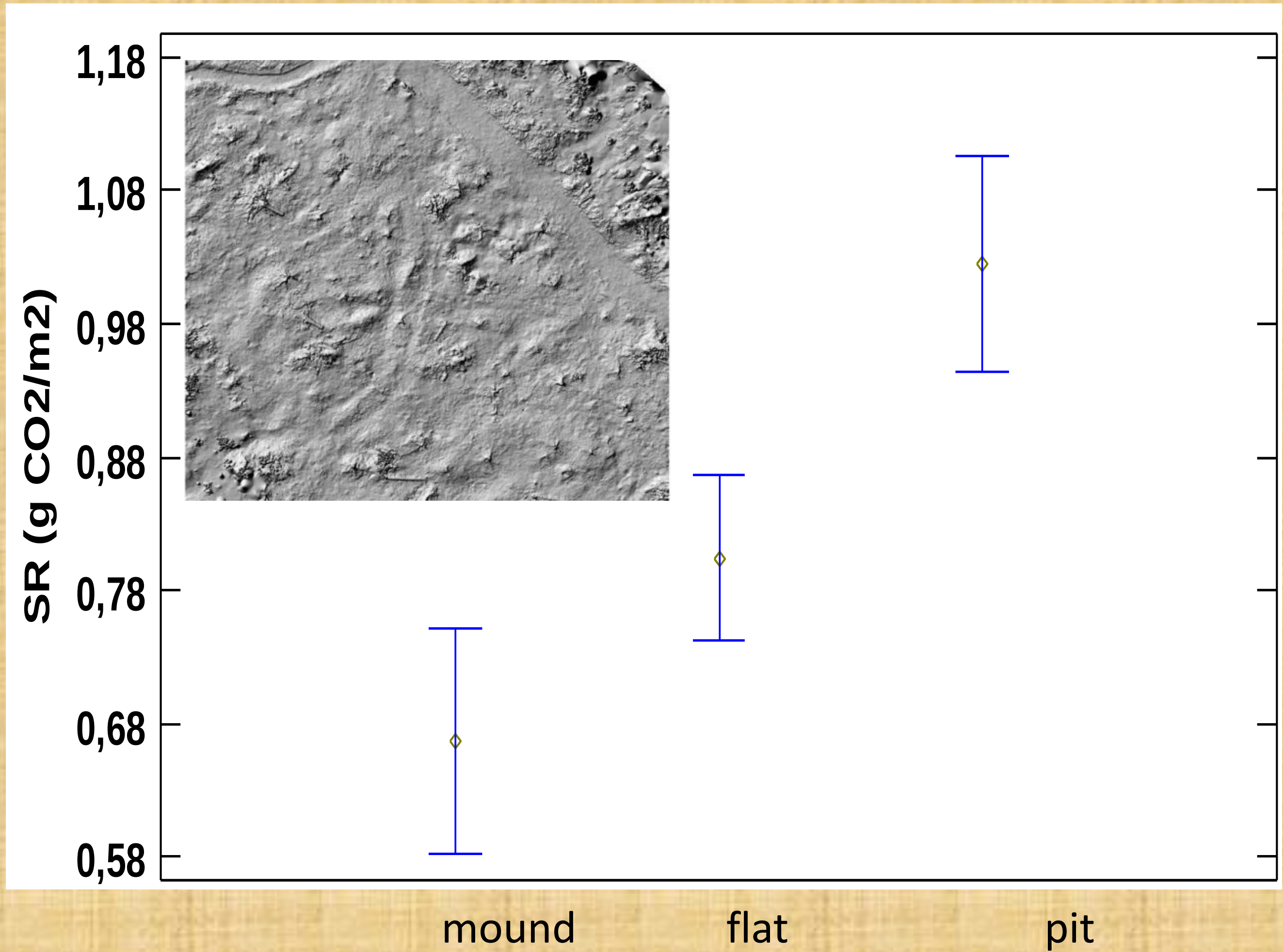


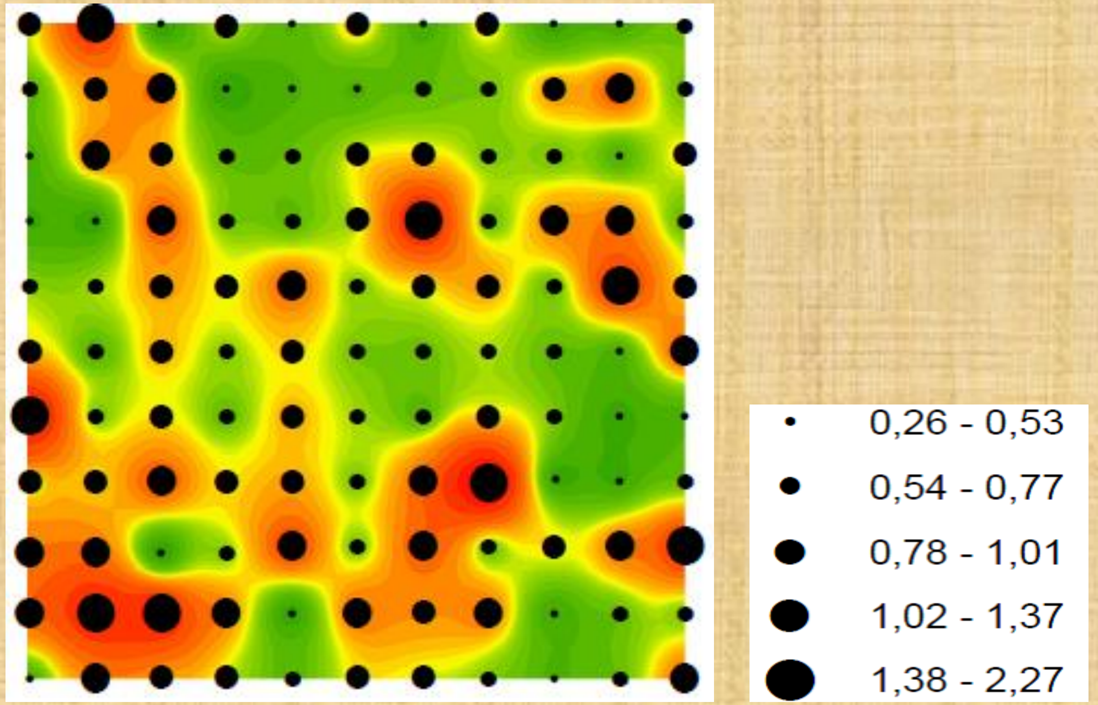
FIR 4,4



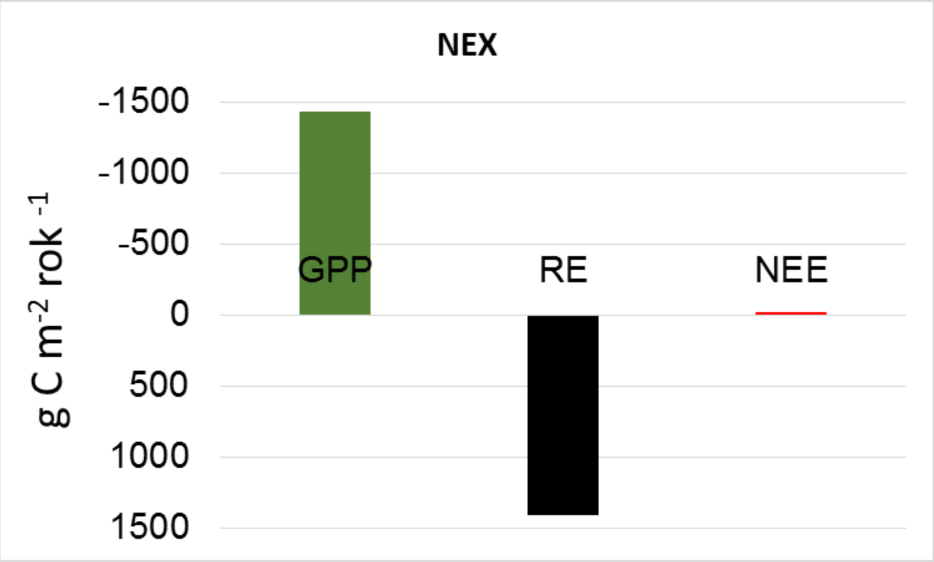
IPS 1,7

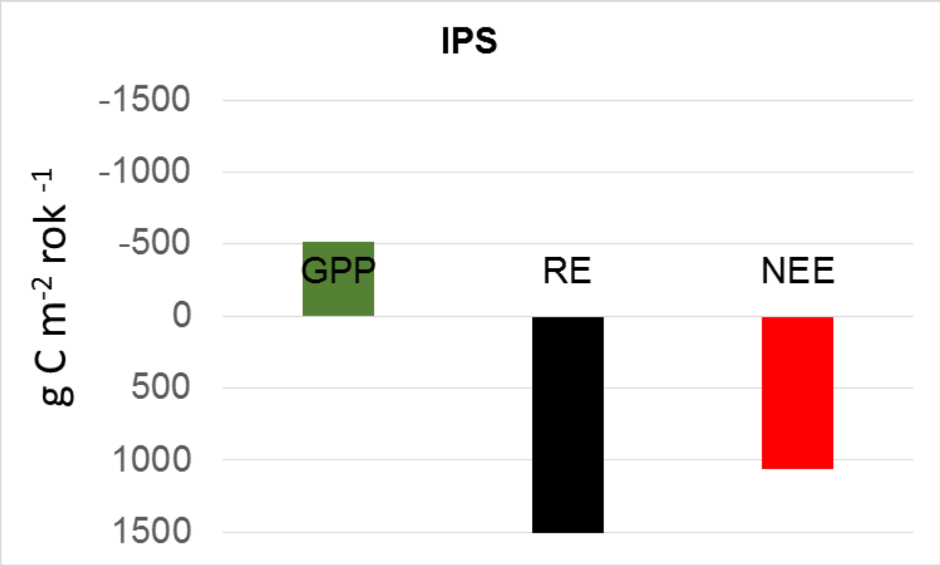
Soil respiration – microtopography as a factor



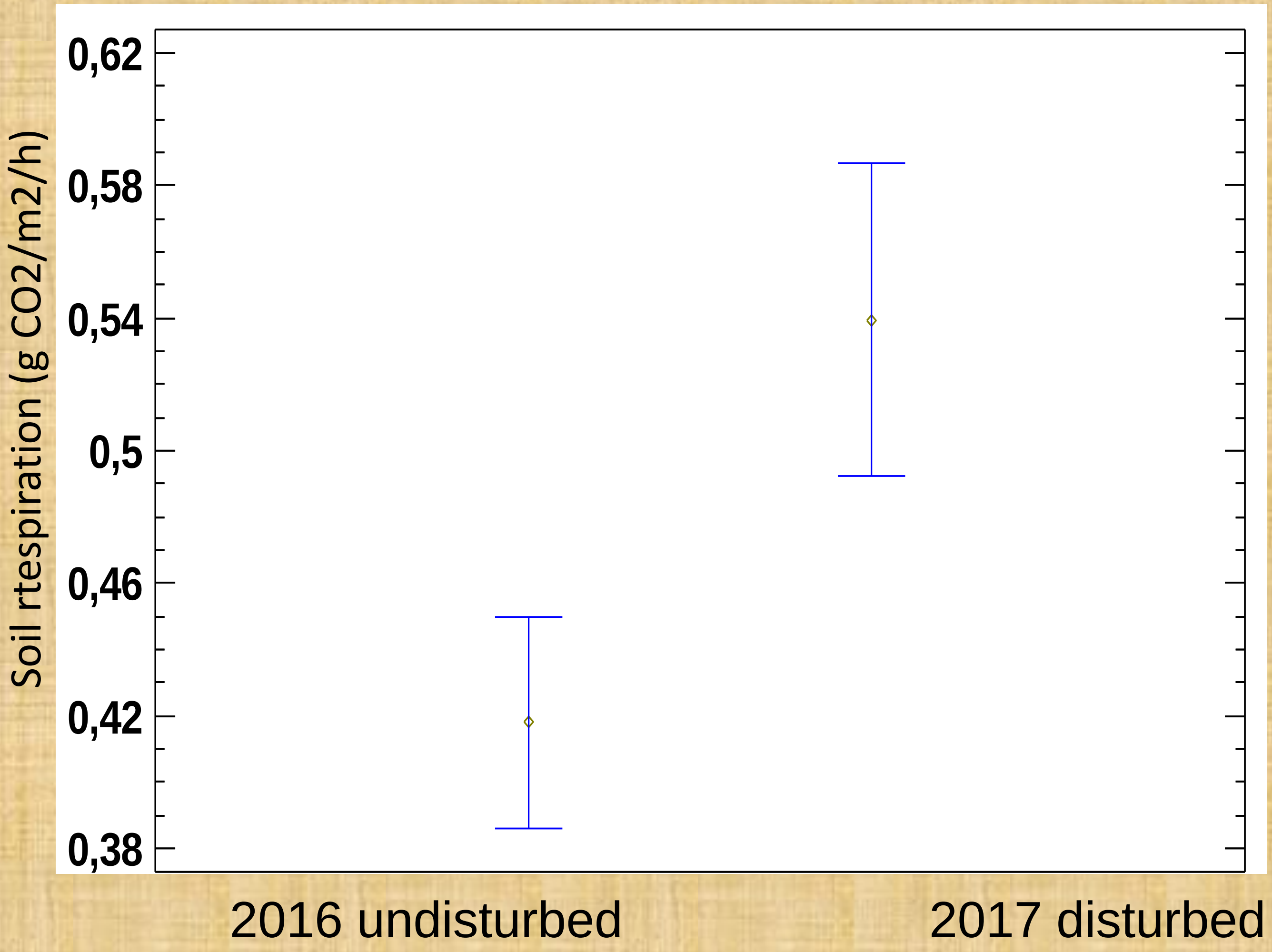


Carbon balance 10 y after disturbance

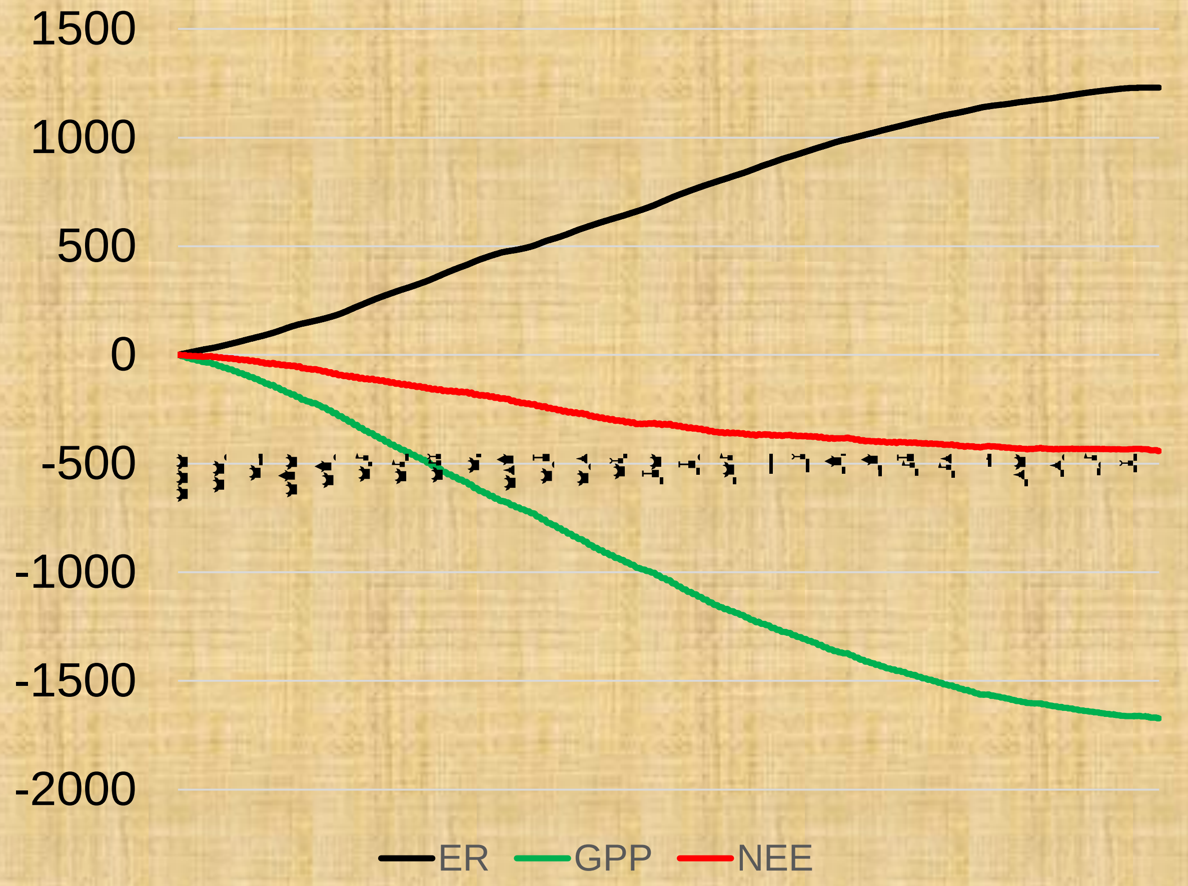




CO2 emission from disturbed forest by chamber



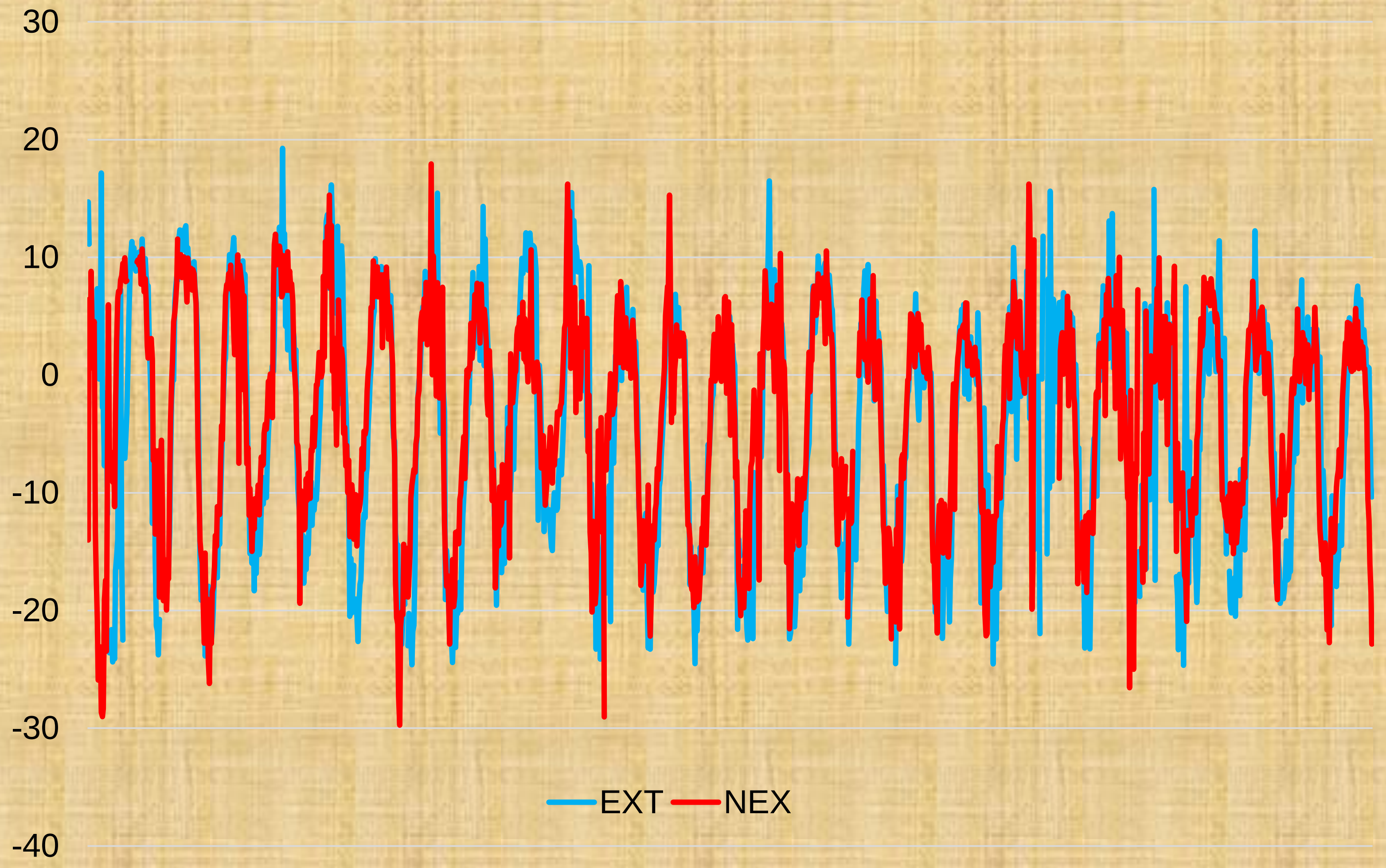
C balance on EXT (IV-XI 2018): -245 g C/m2



Interannual comparison (2.5. – 22.8)
2018: - 363 g C/m2
2019: - 249 g C/m2

Explanation:
Very dry spring 2019
Lower air temperature in 2019

C balance EXT vs NEX 2019 (21.6.- 18.7.)



EXT: - 109 g C/m2
NEX: - 94 g C/m2

?

- Similar LAI
- Similar SR

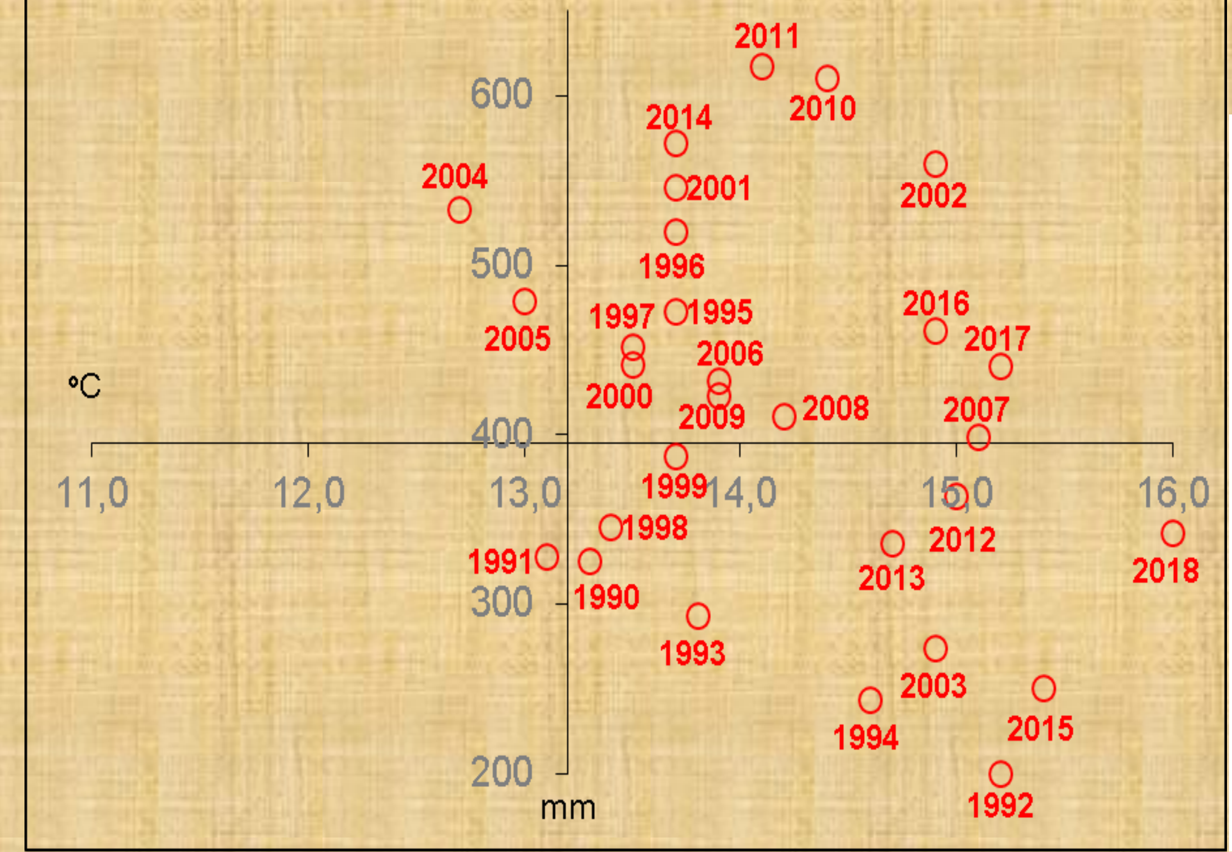
H:

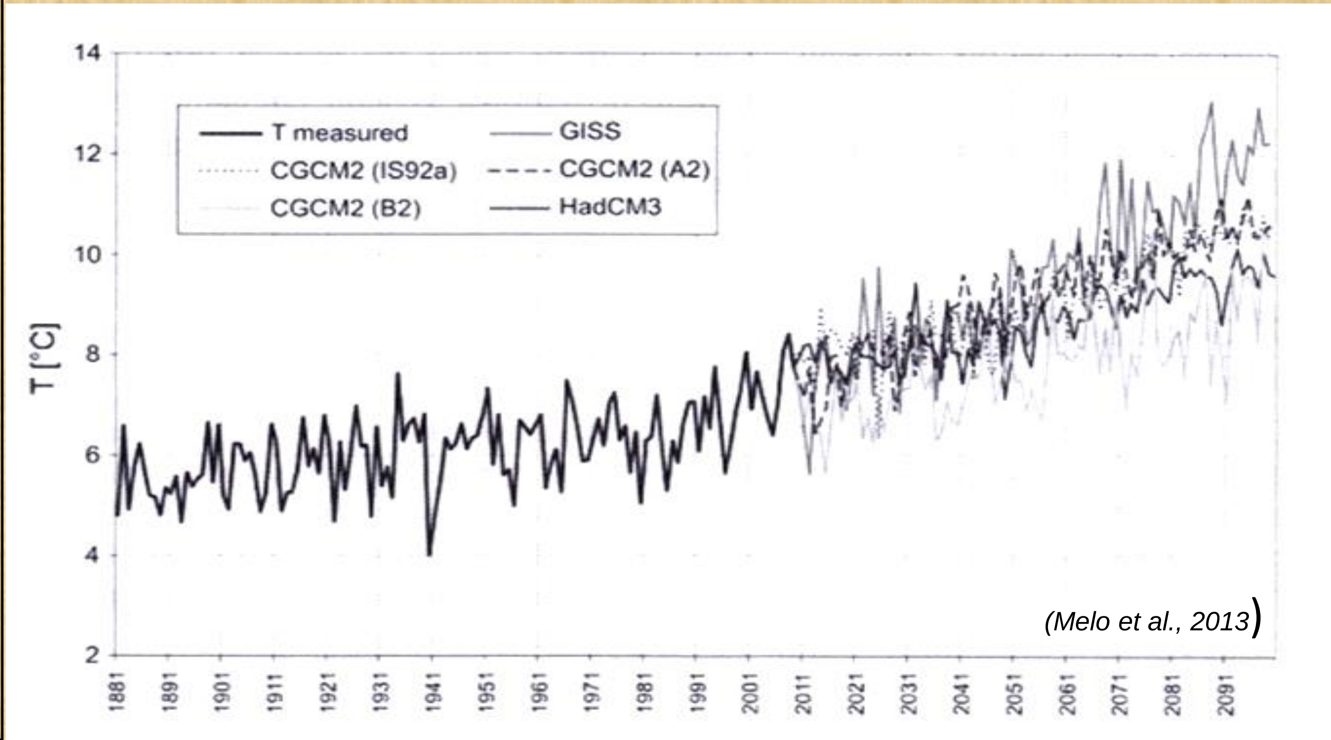
- Deadwood respiration

Mitigation and adaptation under CC

Teplota a zrážky vo vegetačnom období 1990-2018 (850 m n.m.)

warming and changes in precipitation pattern – evidence and projections

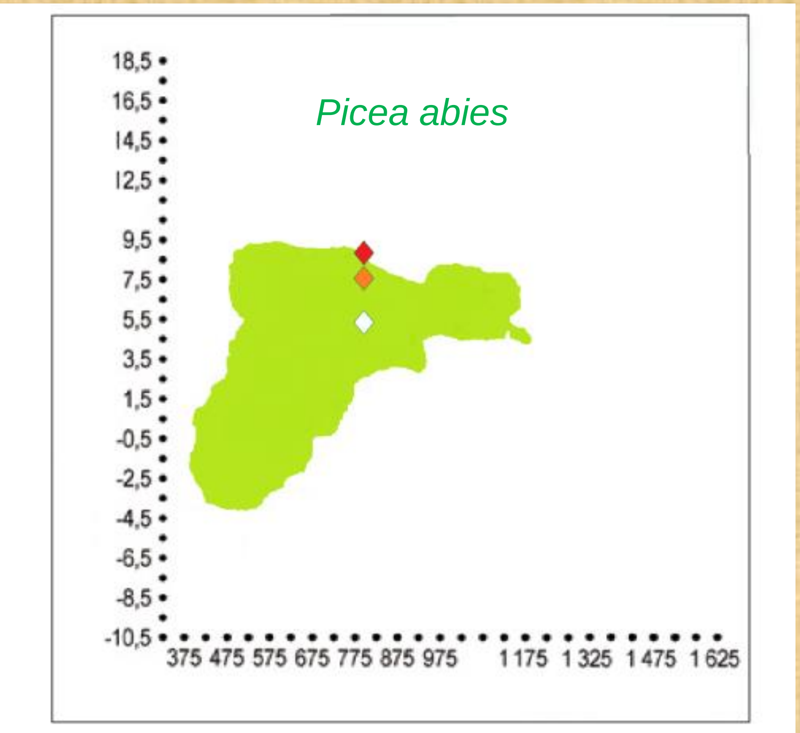


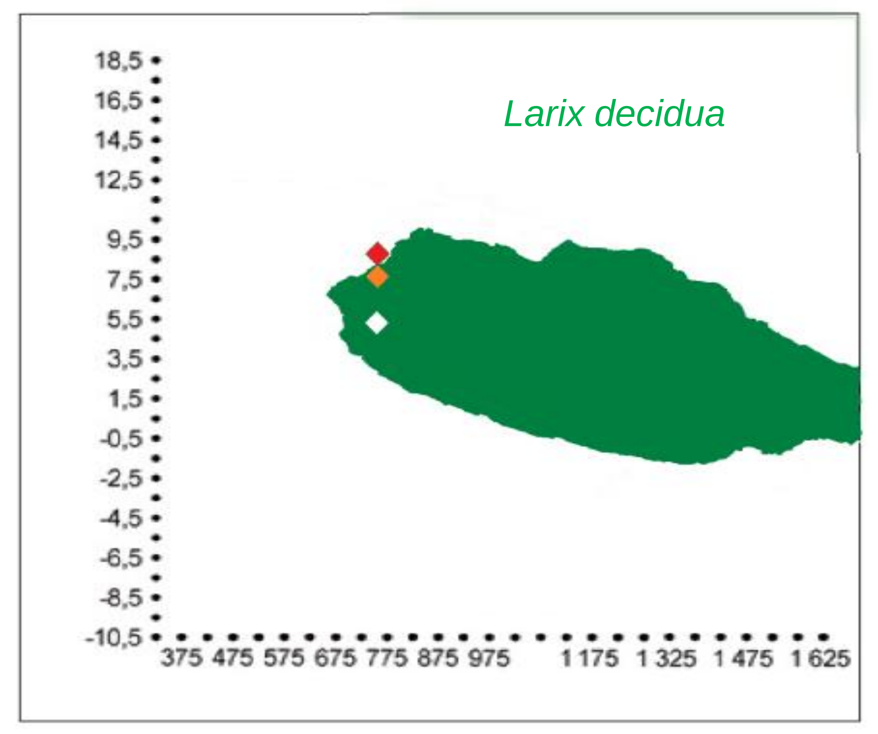


Teploty a zrážky V-VIII pre 1960-1990: 13,2 oC a 395 mm

Bioclimatic envelope –

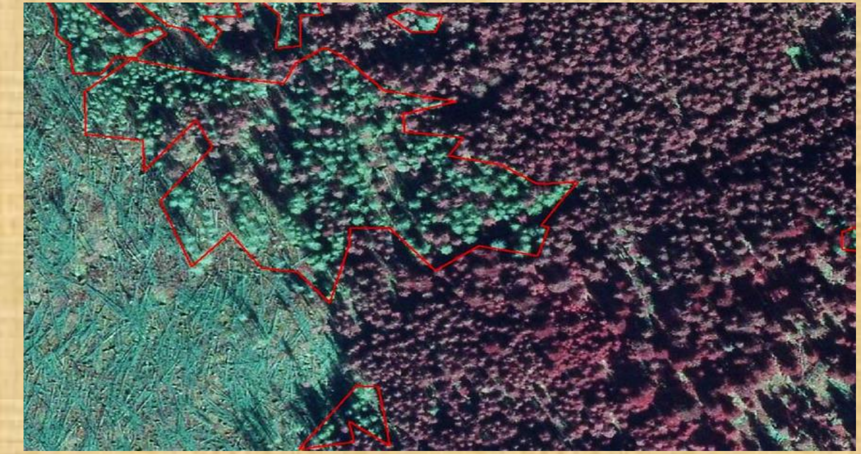
current and 2050 regional climate according to optimistic and pesimistic scenarios

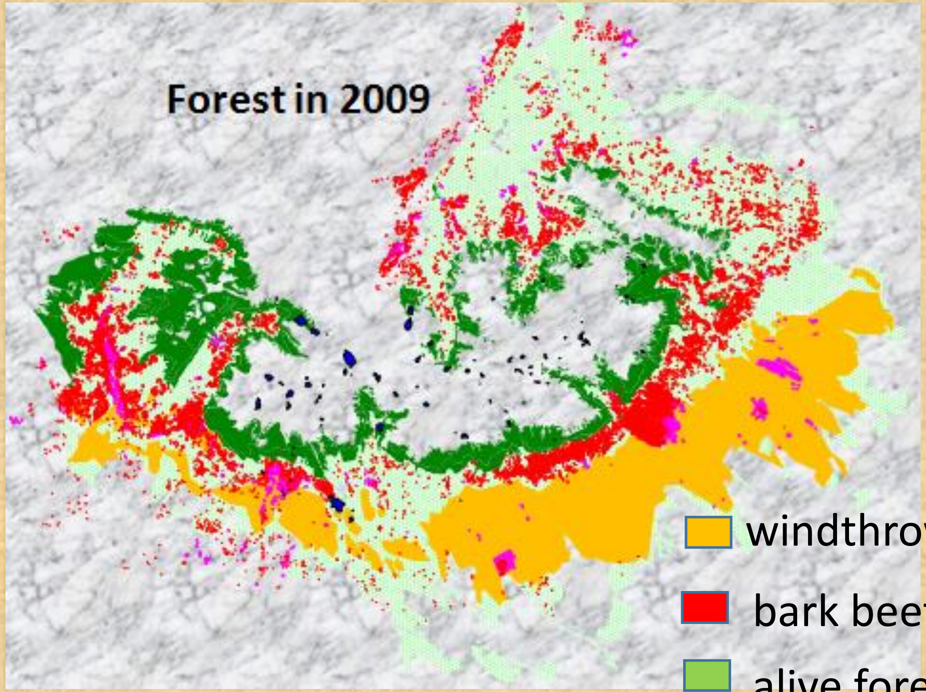


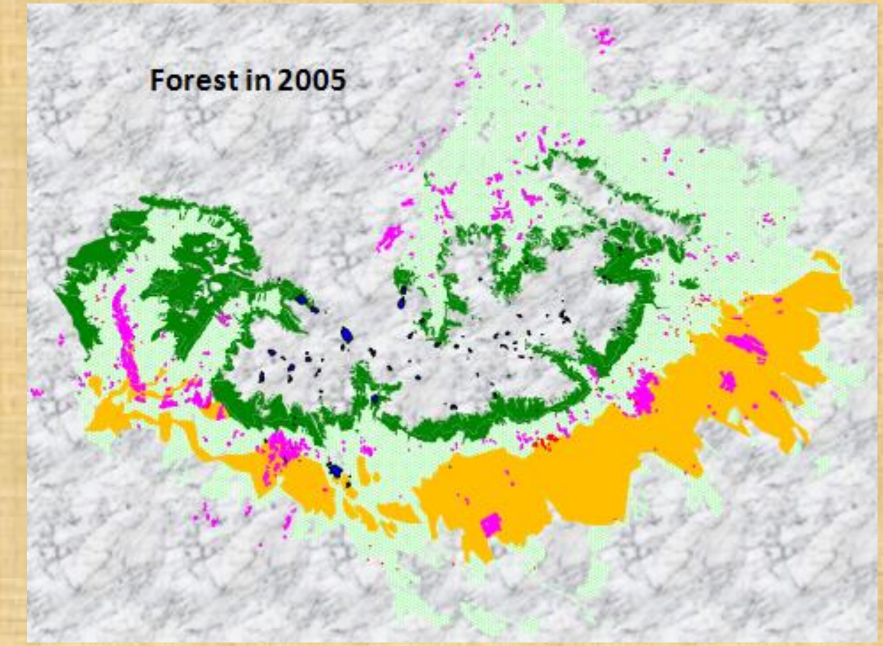


According *Kölling 2007*

Disturbance 2: Bark beetle







windthrow 2004

bark beetle 2007-2009

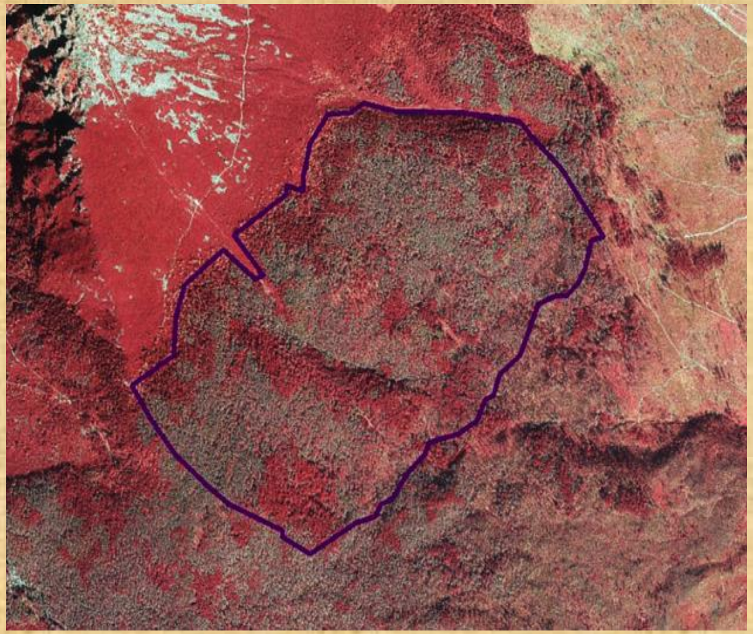
alive forest

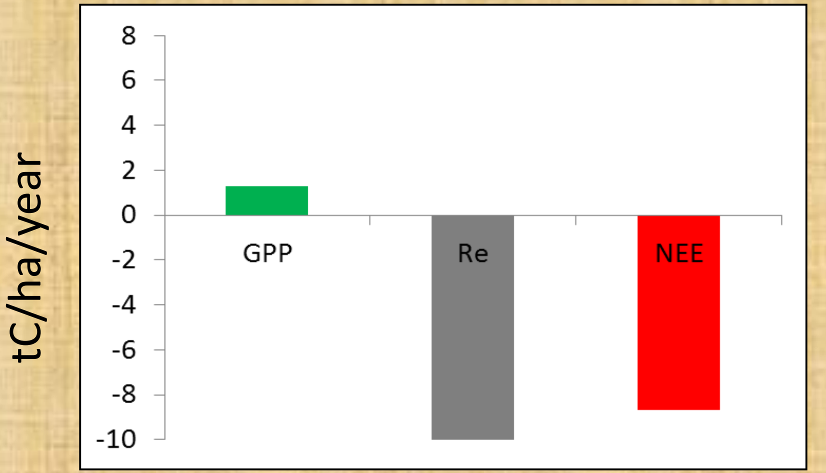
krumholz

Unmanaged windthrow (law restriction)

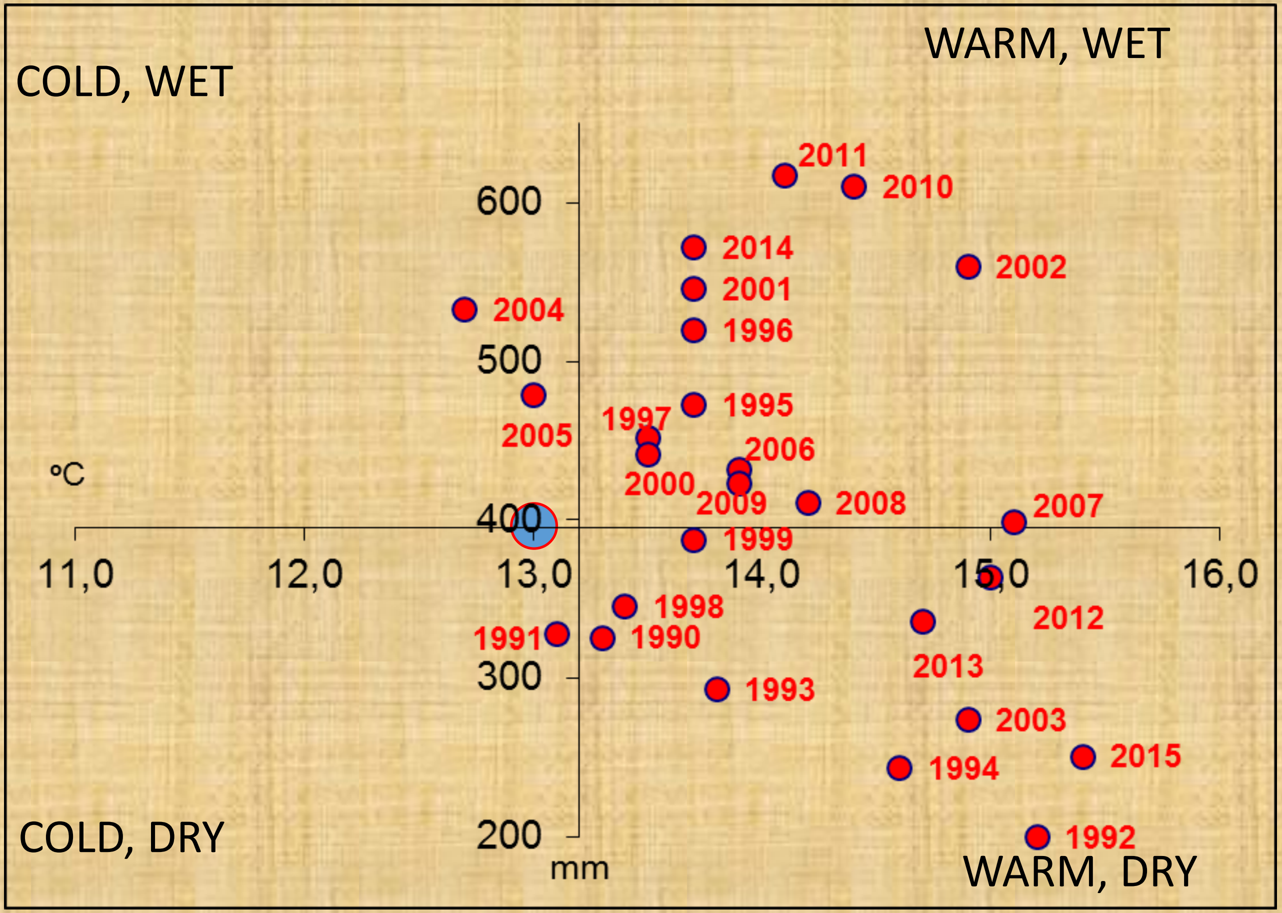
2005-2013: 7 000 ha killed by BB

Carbon sequestration on sites killed by bark beetle



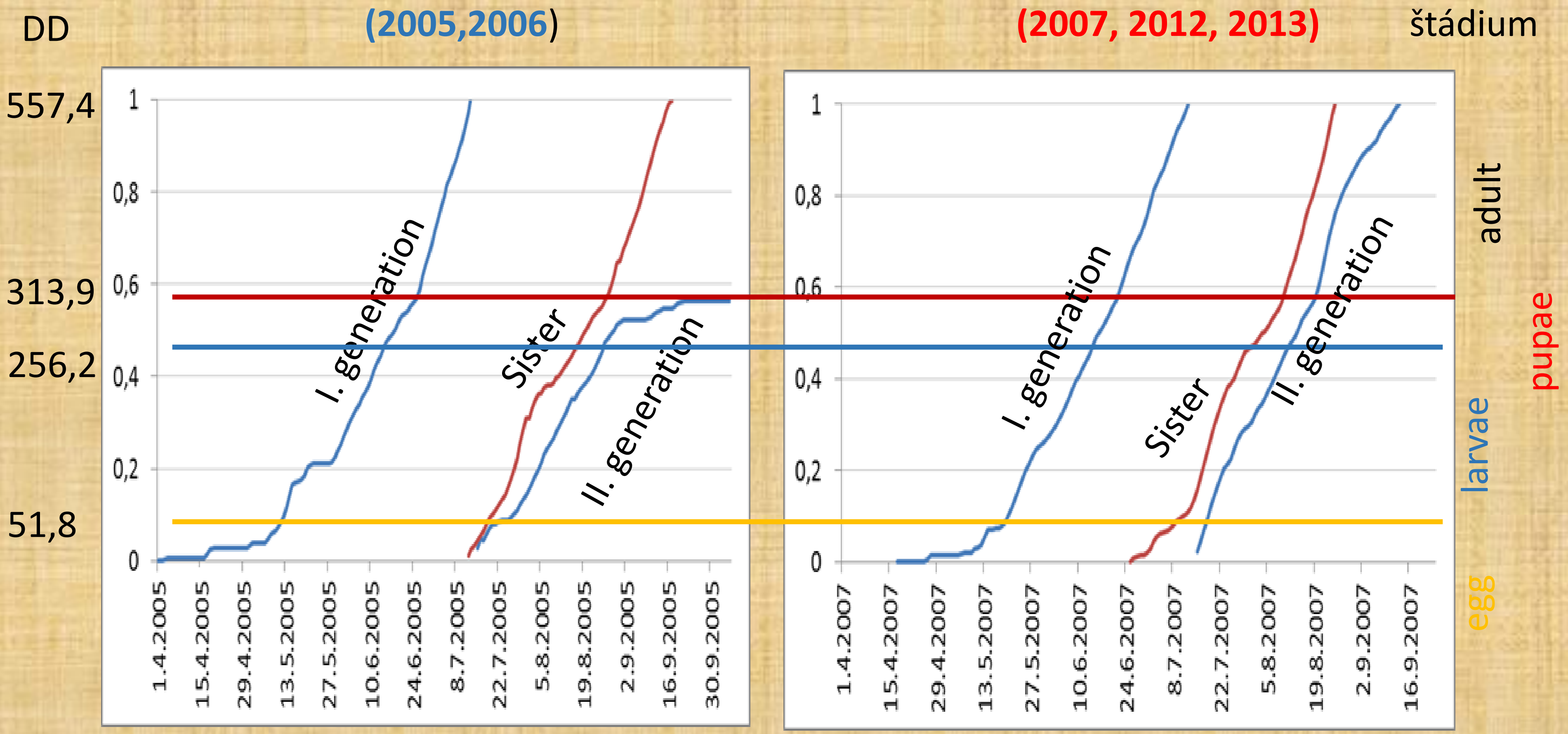


Air temperature and rain
during growing seasons (V-VIII)1990-2015



1930-1960: AT 13.2 °C
R 385 mm

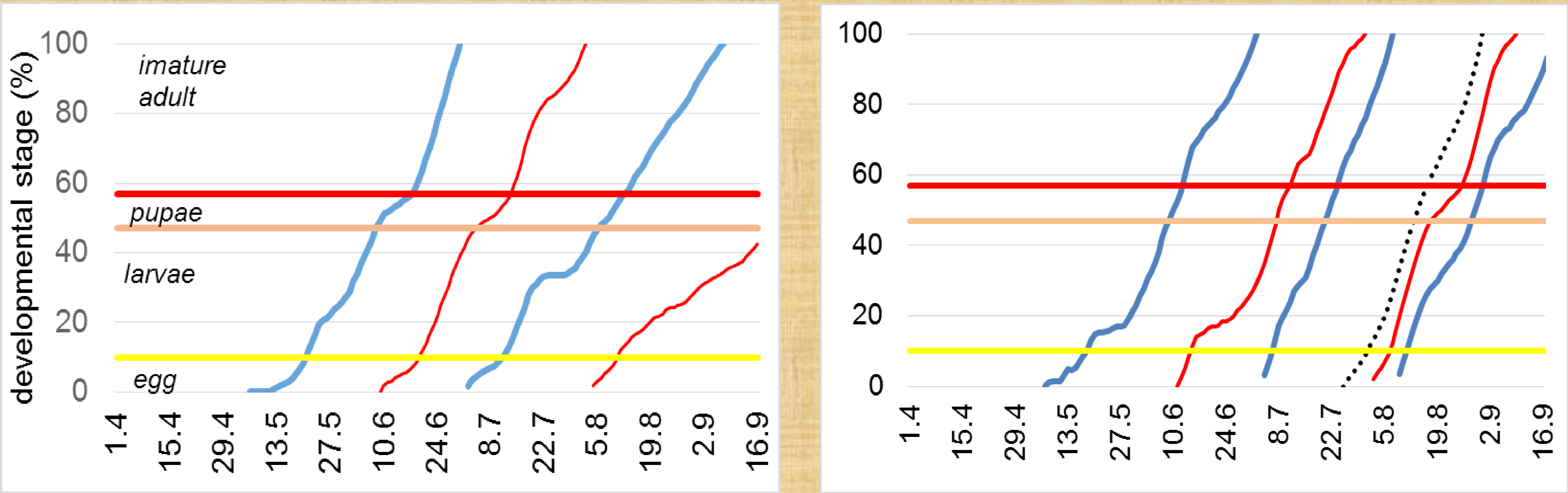
Insect: European bark beetle (Ips typographus) development in cold and warm year in 830 m a.s.l



Calculated by PHENIPS *(Baier et al., 2007)*

Klimatická zmena a podkôrny hmyz

Priebeh vývojových štádií lykožrúta na živých stromoch a vývratoch



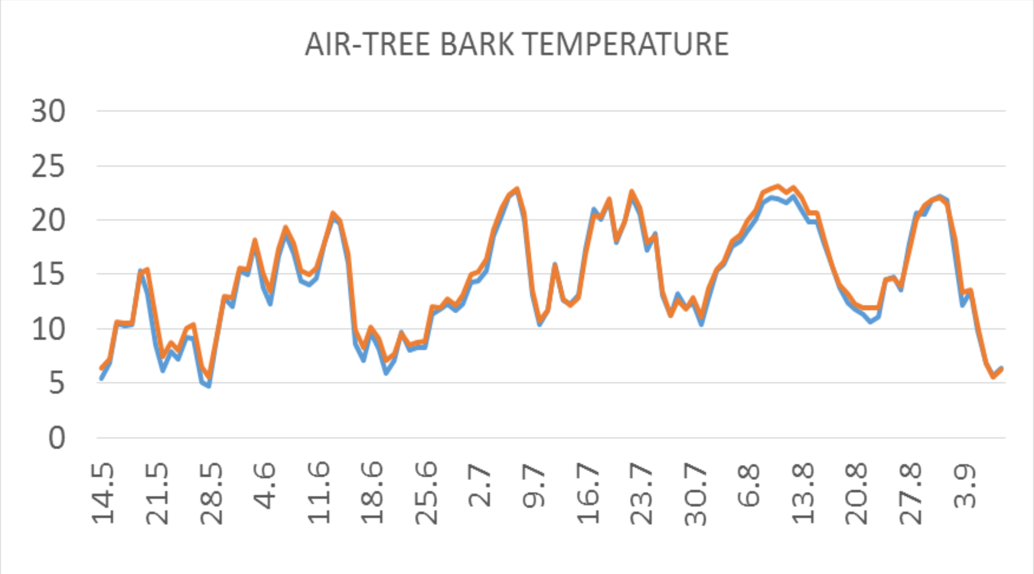
modrá-1. a 2. generácia, červená-prvá a druhá sesterská populácia, bodkovaná-fil.1.sestry

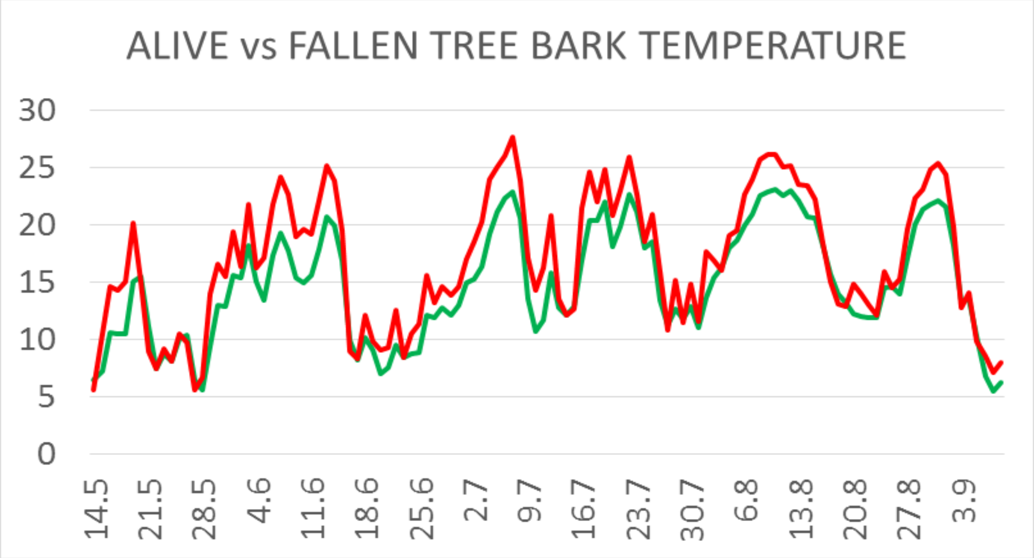
Unmanaged windtrow - bark beetle, bark temperature

BB phenology driven by bark temperature

Bark temperature depends on air temperature and radiation

Significantly higher bark temperature on fallen logs than on standing trees





Potential no. of IT generations : spatial distribution in 2014