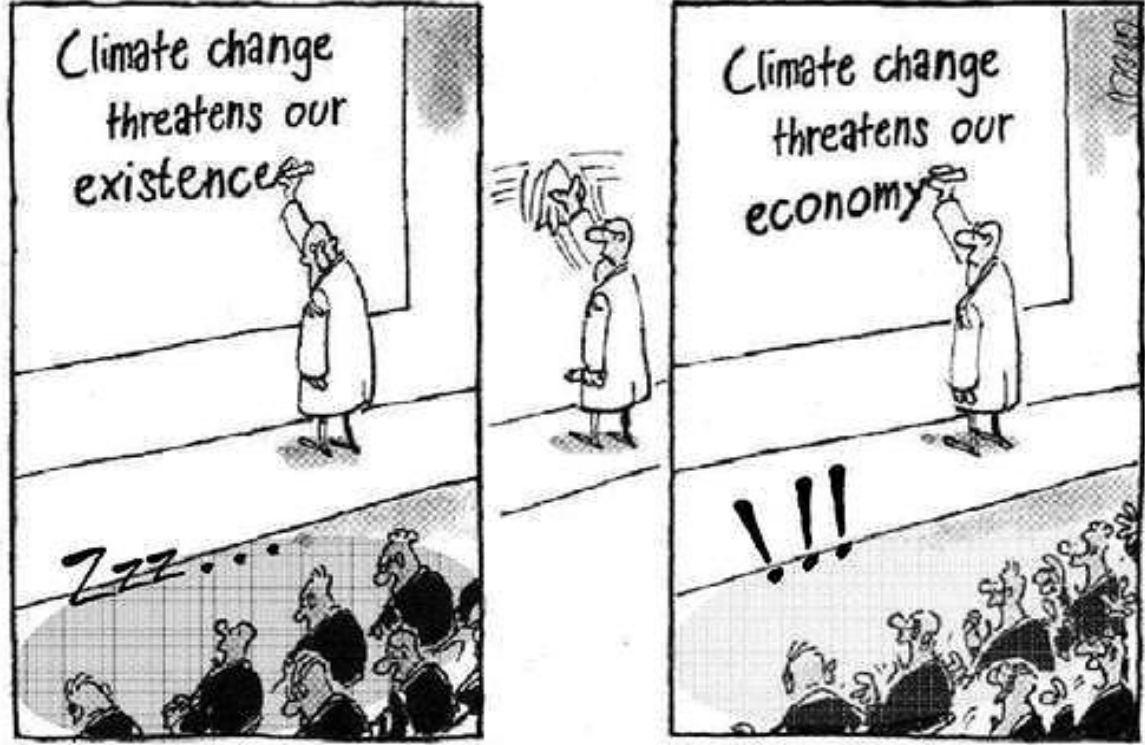
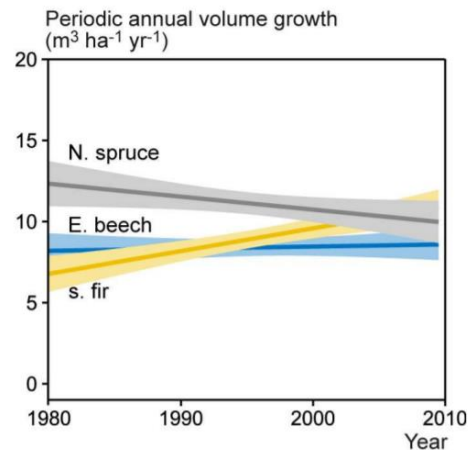
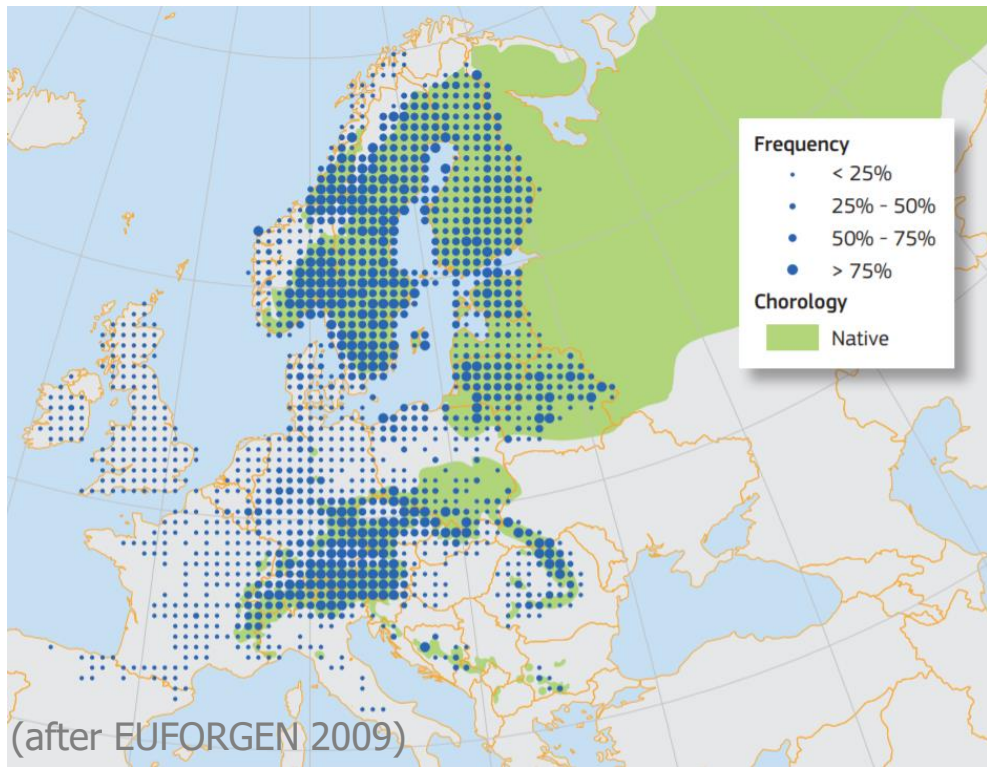


# ADAPTIVE FOREST MANAGEMENT IN SLOVENIAN SPRUCE FORESTS

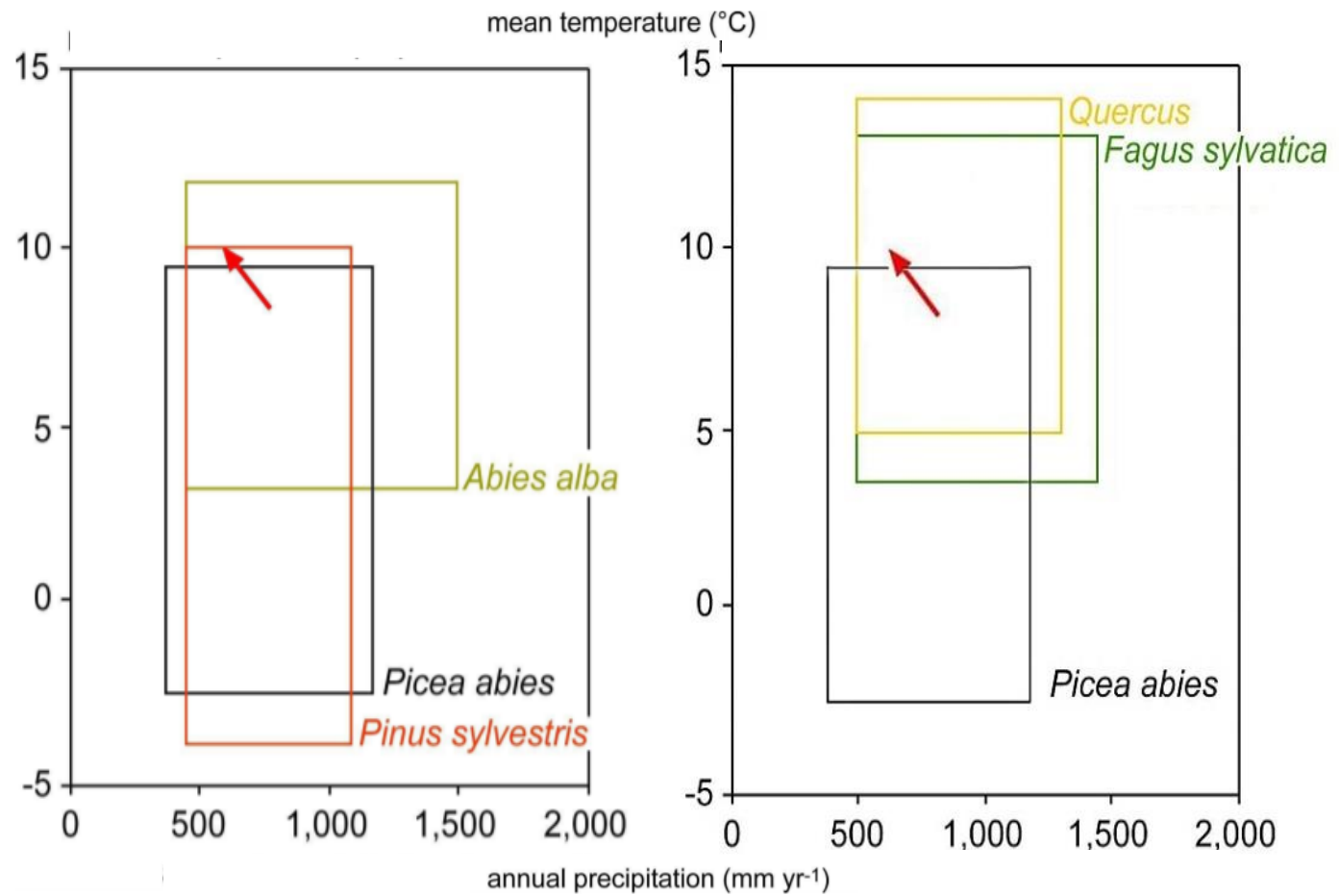
Matjaž Čater, Aleksander Marinšek, Tom Levanič, Primož Simončič







Pretzsch, Steckel, 2019



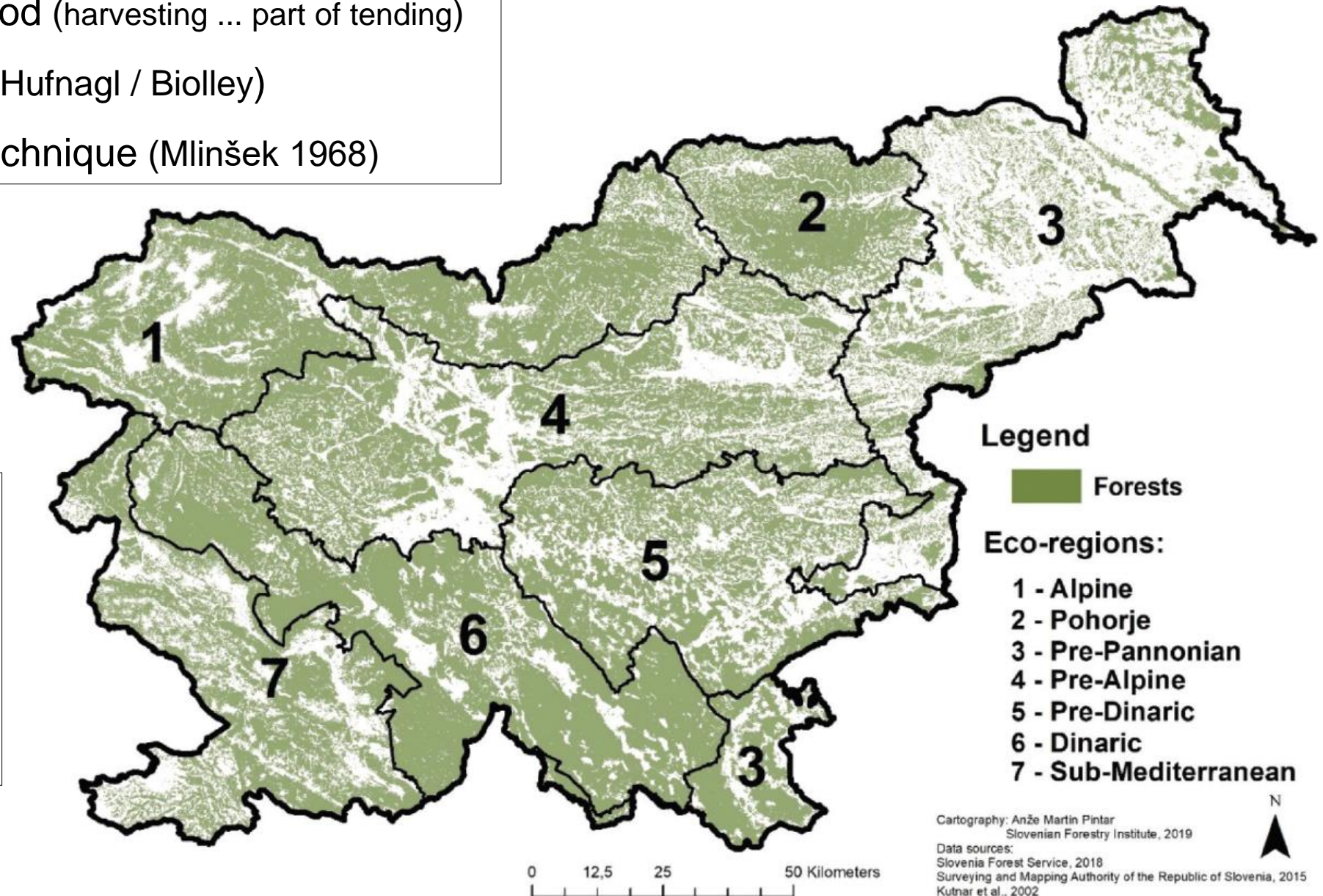
## Silvicultural systems:

- Irregular shelterwood (harvesting ... part of tending)
- Selection system (Hufnagl / Biolley)
- Free silvicultural technique (Mlinšek 1968)

## Principles:

Sustainable  
Close-to nature  
Multi-purpose

Predominant natural regeneration



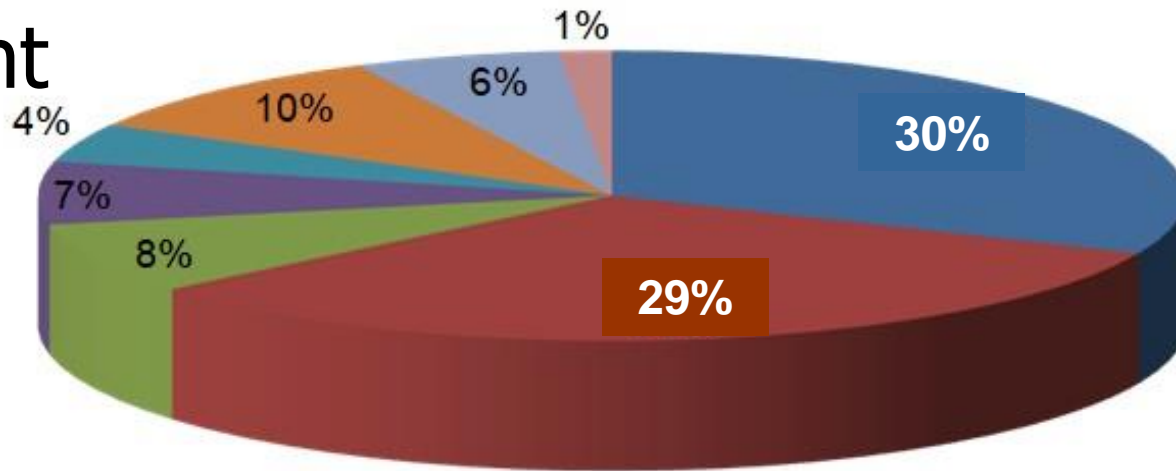
Forest area	1 177 240 ha	58,1%
Forest reserves	9 508 ha	
Protective forests	98 762 ha	

	unit	conifers	broadleaves	Σ
Living stock	m <sup>3</sup>	168 346 000	217 790 000	386 136 000
	m <sup>3</sup> /ha	143	186	329
Increment*	m <sup>3</sup> /year	4 226 000	5 262 000	9 488 000
	m <sup>3</sup> /ha, year	3.42	4.44	7.86

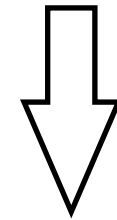


Species		[m <sup>3</sup> /ha]	%
<i>Fagus sylvatica</i> L.	European beech	109.7	33.4
<i>Picea abies</i> (L.) Karst.	Norway spruce	94.3	28.7
<i>Abies alba</i> Mill.	European silver fir	25.9	7.9
<i>Quercus petraea</i> (Matt.) Liebl.	sessile oak	17.5	5.3
<i>Pinus sylvestris</i> L.	Scots pine	13.0	3.9
<i>Acer pseudoplatanus</i> L.	Sycamore maple	12.0	3.7
<i>Carpinus betulus</i> L.	common hornbeam	7.8	2.4
<i>Castanea sativa</i> Mill.	sweet chestnut	5.3	1.6
<i>Pinus nigra</i> Arnold	Austrian pine	5.2	1.6
<i>Ostrya carpinifolia</i> Scop.	hop hornbeam	4.7	1.3
other		33.3	10.2
	Σ	328.7	100.0

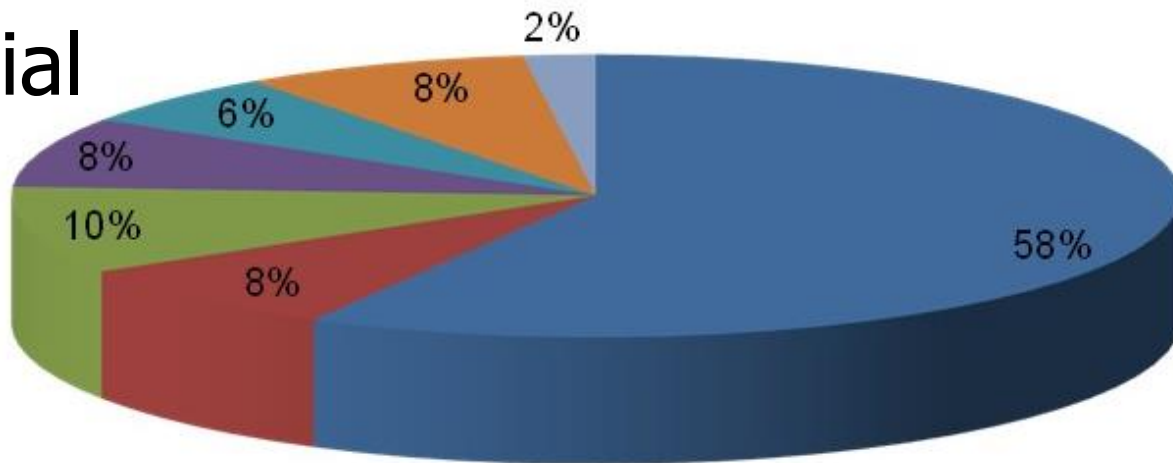
# Present



N. spruce...29%  
beech...30%



# Potential



N. spruce... 8%  
beech...52%

- Beech
- Fir
- Decid. tree sp. of high value
- Pine species
- Spruce
- Oak species
- Other decid. trees

# Content

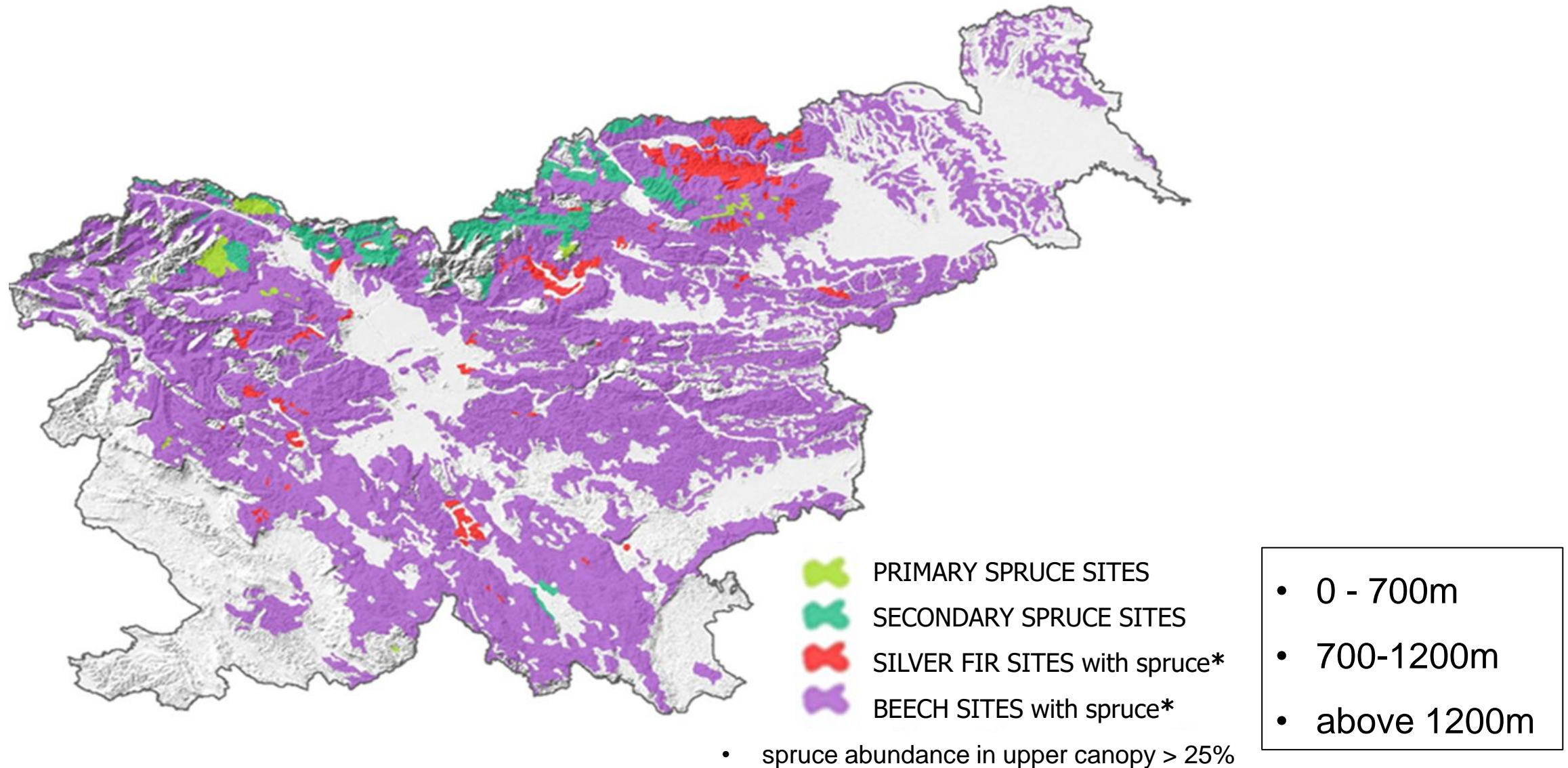
young

- 1) natural regeneration - various sites and elevations;
- 2) light response: damaged vs. undamaged stand;
- 3) natural vs. planted response, extreme post-disturbance sites

adult

- 4) growth response - different sites and elevations
- 5) future scenarios.

# 1. Natural regeneration: various sites and elevations







primary spruce sites

abundance of various tree species increases with altitude, more in shrub than in herb layer



secondary spruce sites

similar pattern, highest abundance in altitudes 700-1200m



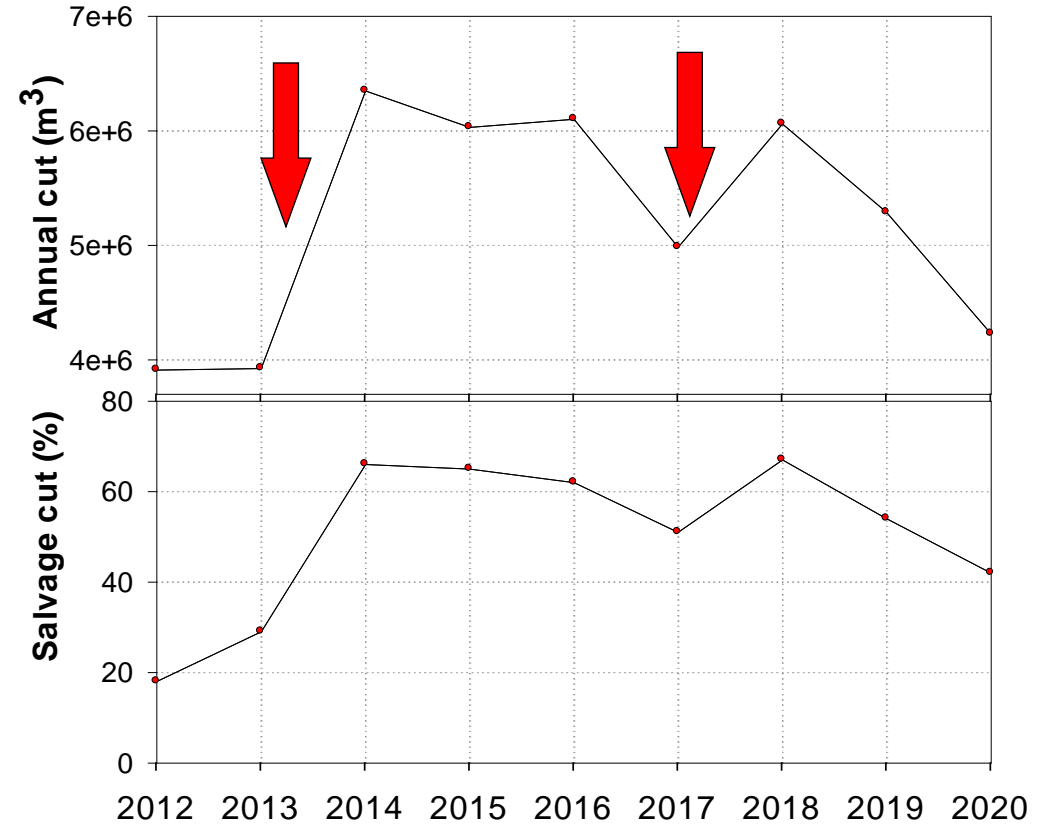
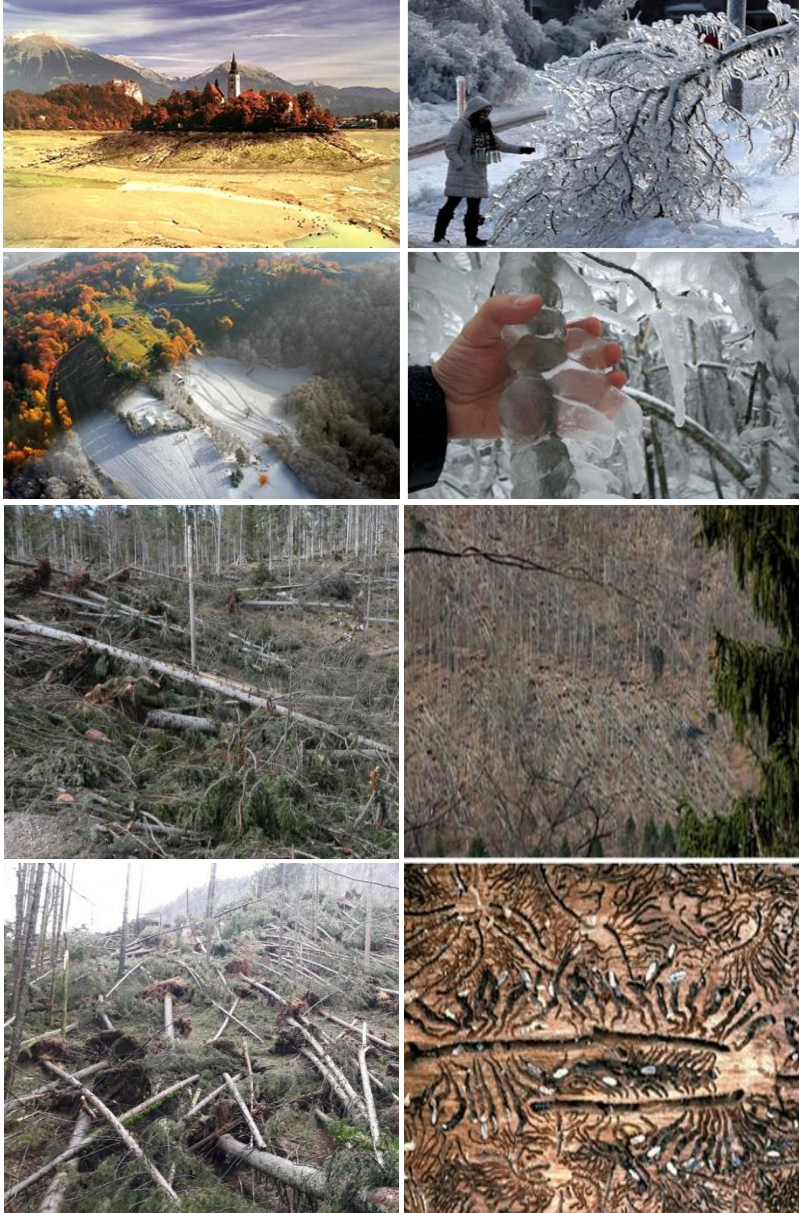
fir and beech sites with more than 25% spruce



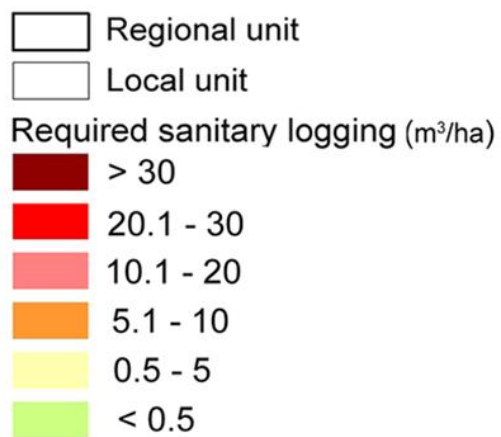
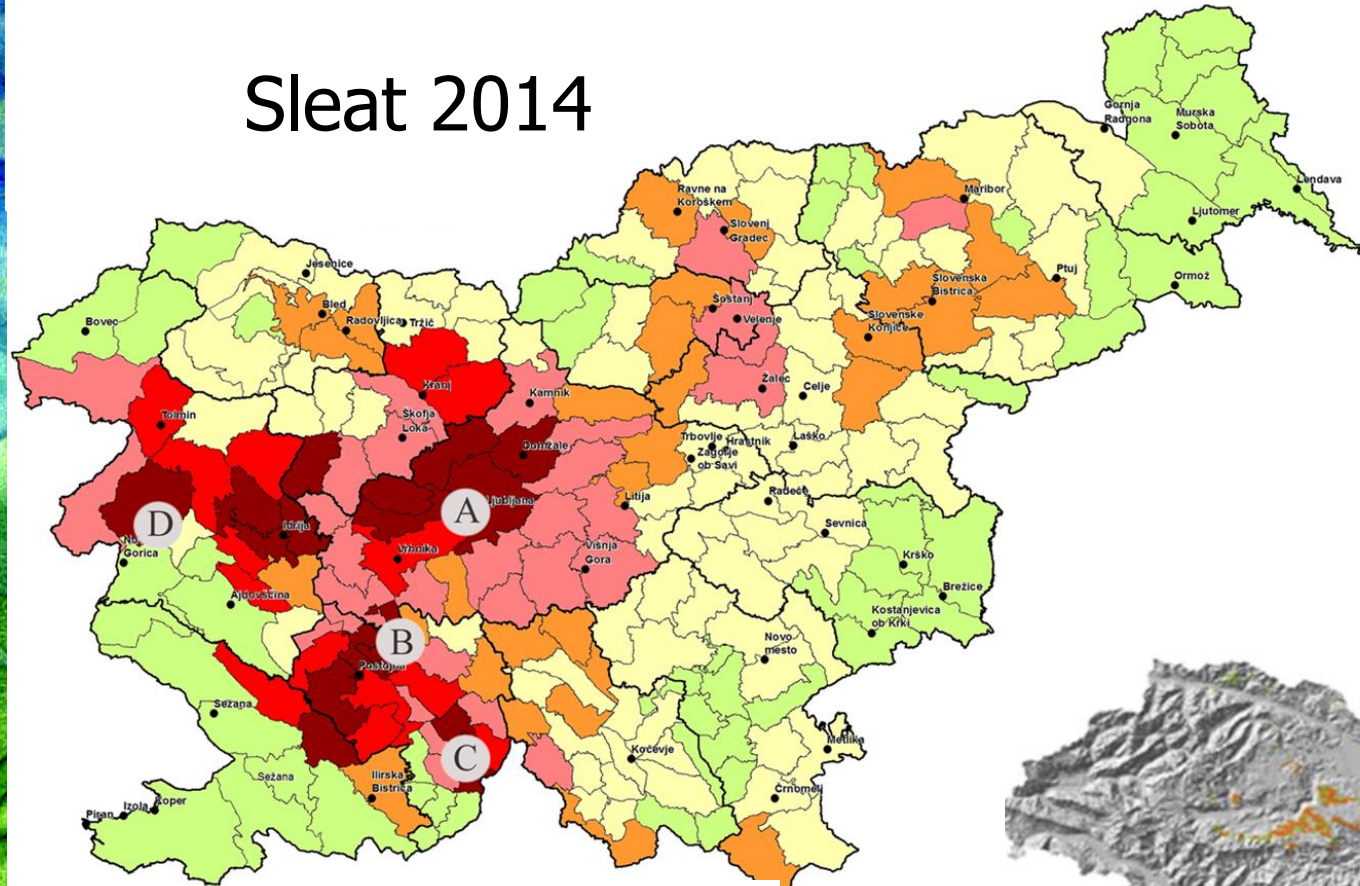
reversed pattern, highest abundance of all categories in lower altitudes, decreases with altitude

# 2. Light response: damaged vs. undamaged stands

Extreme weather events



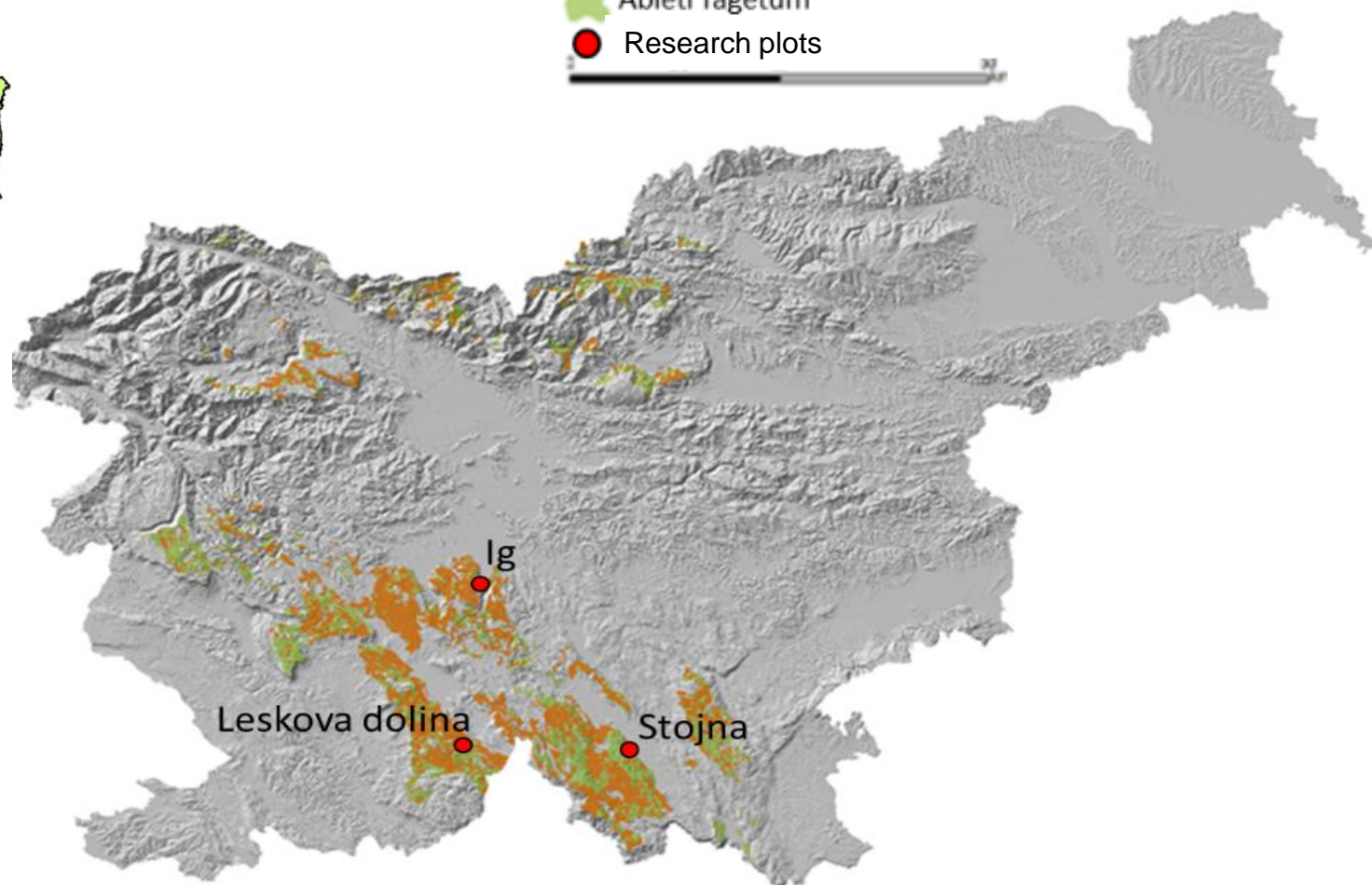
# Sleat 2014



# Windstorm 2017

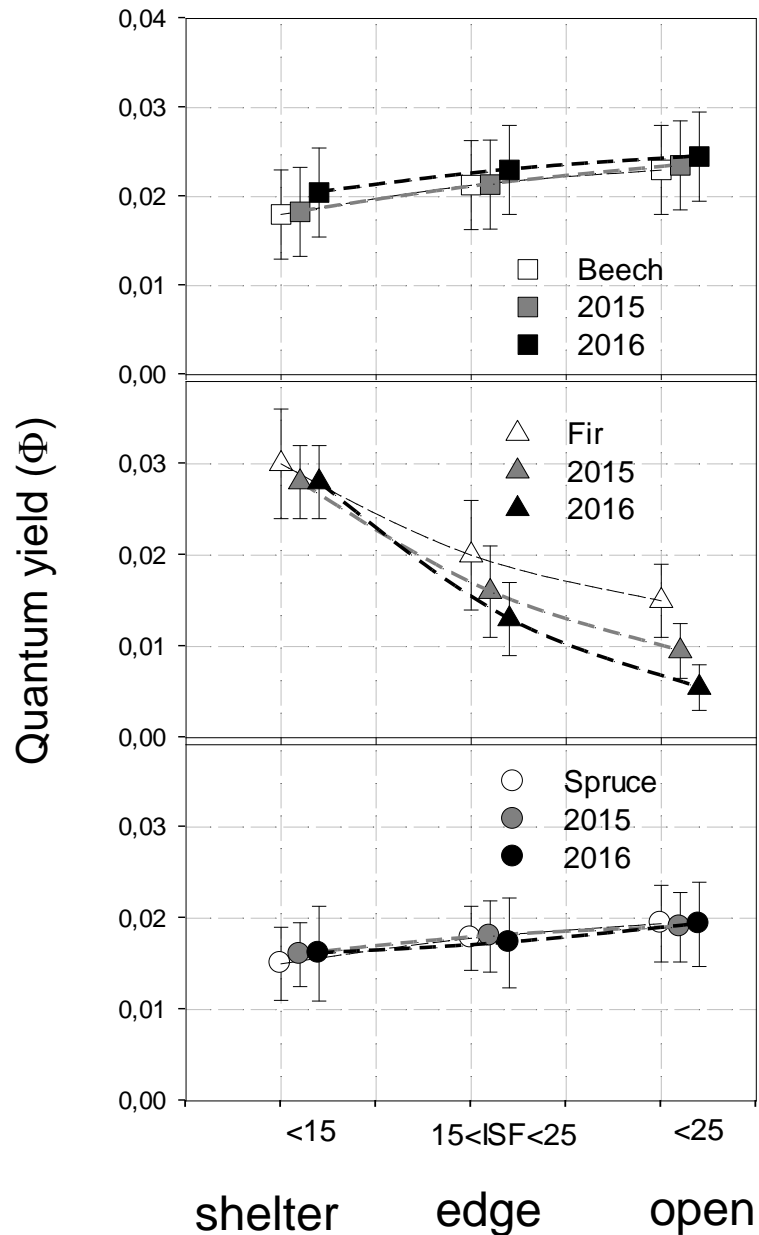
## Legend

- Abieti fagetum (damaged)
- Abieti fagetum
- Research plots





Response after rapid exposure to light

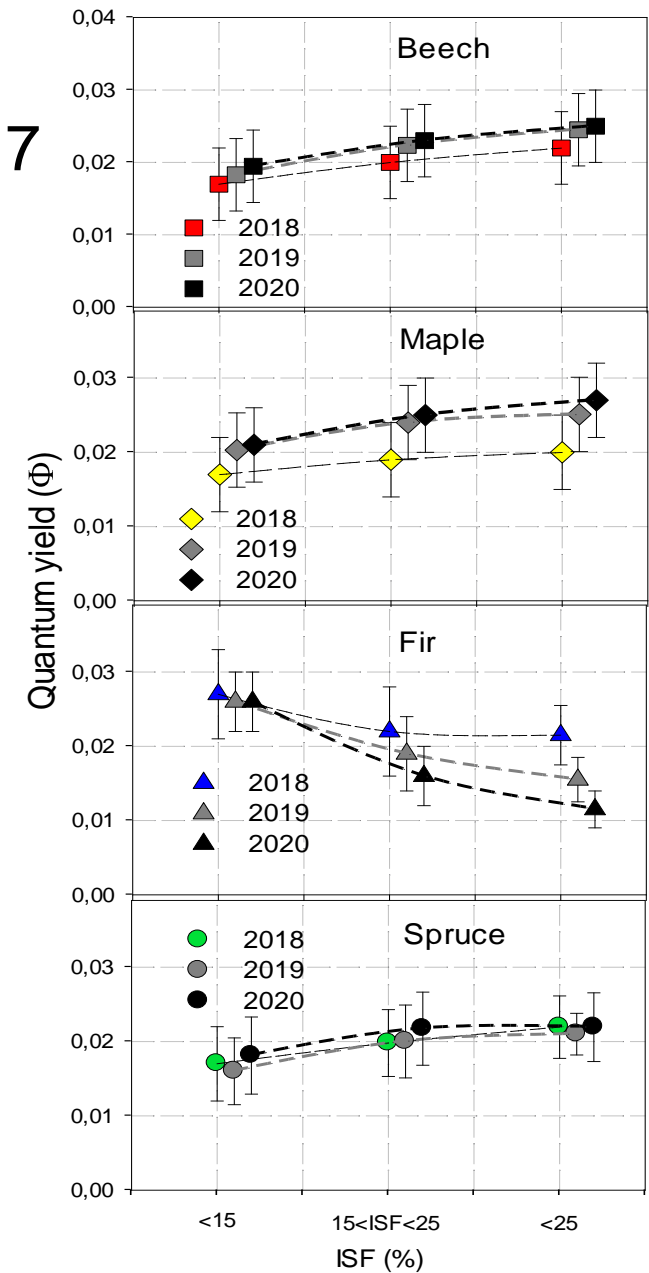


Sleat 2014

Windstorm 2017

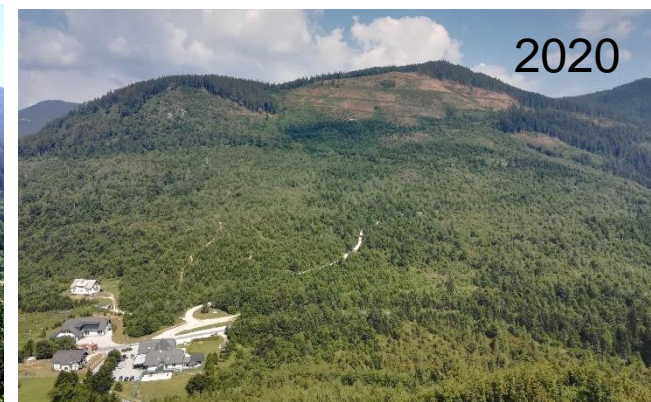
### Efficiency

- increases in broadleaves
- decreases in fir
- no effect in spruce



### 3. Natural vs. planted: extreme post-disturbance sites

- three extreme sites (slope, exposure)
- natural vs. planted spruce regeneration
- observations: several years



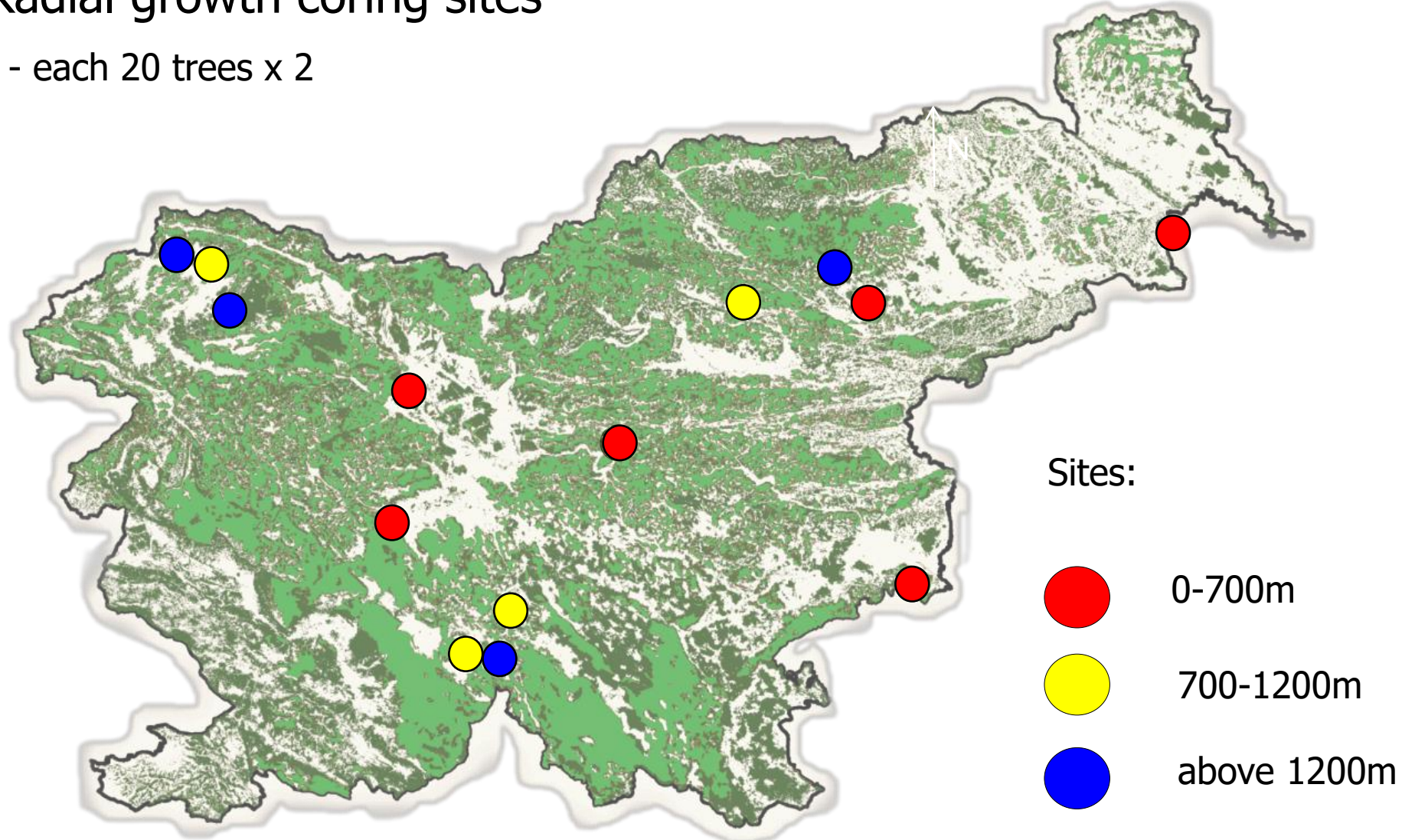
best performance on moderate, flat sites; poor on steep slopes  
(assimilation, water utility, growth, competition, survival)

best response in natural, weak in planted spruce

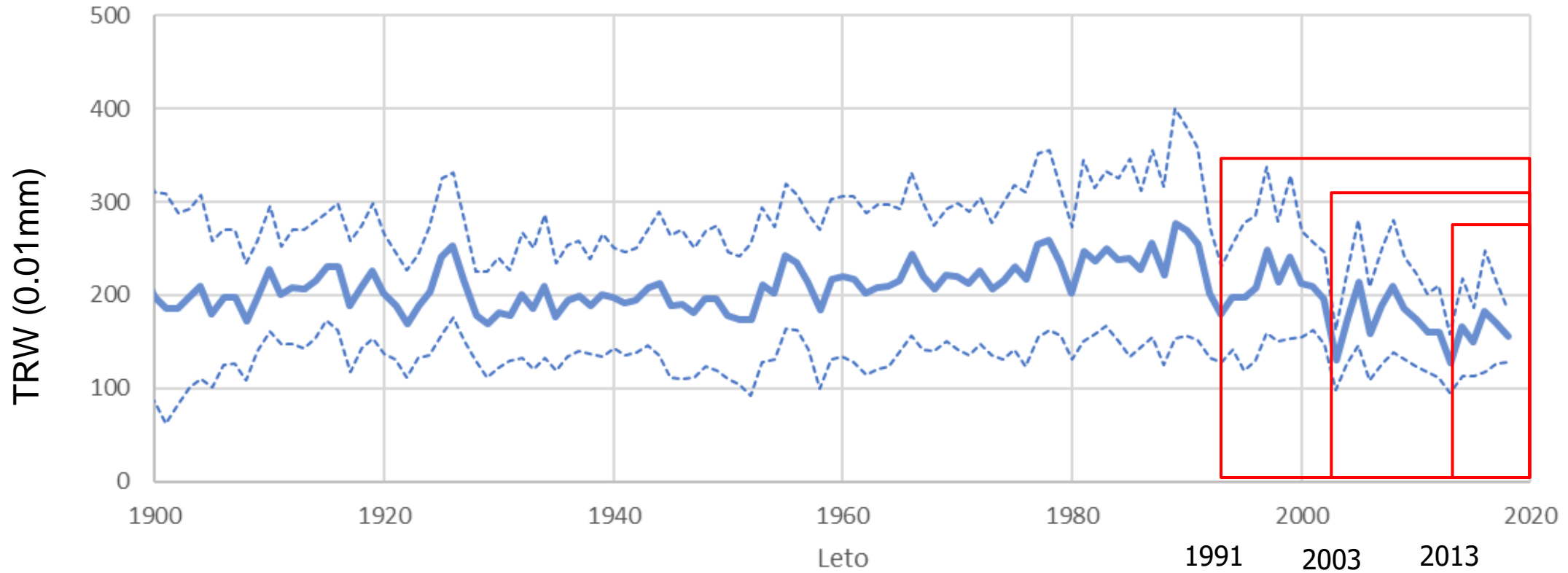
# 4. Growth response - different sites and elevations

## Radial growth coring sites

- each 20 trees x 2



# Average radial growth



reduction of radial growth and st. dev.

# Response of radial growth to climate - altitude belts

		Precipitation									Temperature										
		J	F	M	A	M	J	J	A	S	O	J	F	M	A	M	J	J	A	S	O
above 1200m	Pokljuka			-											+	+					
	Sviščaki											No response									
	Pohorje																				
	Vršič 1300m			-												+	+				
700 - 1200m	Ravnik			+	+	+												-			
	Mašun				+	+												-			
	Vitanje				+	+	+	+									-	-	-		
	Vršič 800m			+	+	+										-	-				
below 700m	Verd				+	+											-	-	-		
	Dole pri Litiji				+	+	+												-		
	Sorško polje				+	+						+	+	+			-	-			
	Loče			+	+	+										-	-				
	Brežice			+	+	+										-	-	-			
	Apače			+	+	+										-					



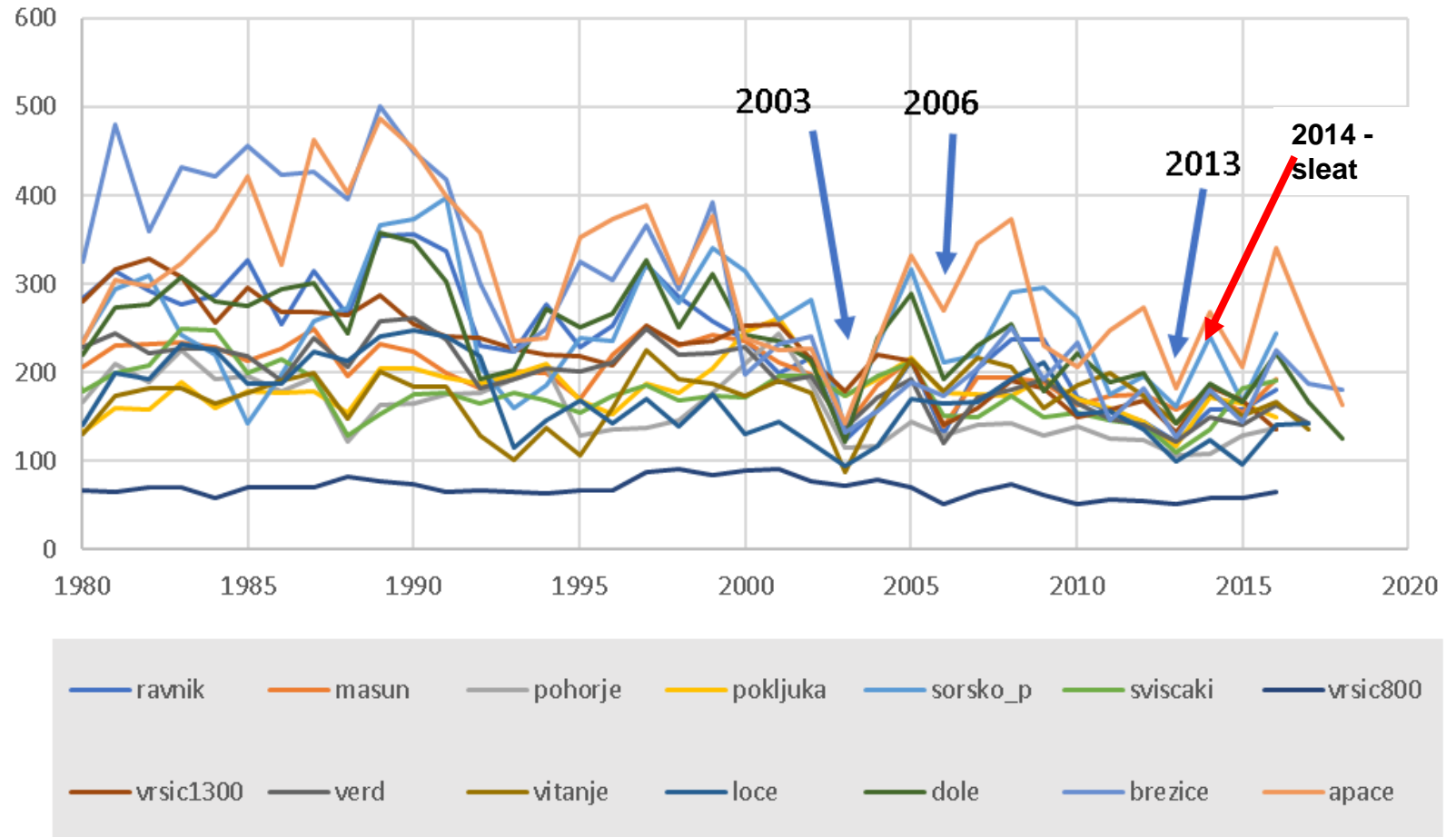
# Negative and positive pointer years

**2003** – very warm year, precipitatio deficit in spring and summer

**2006** – very warm year, little precipitation in growing season

**2013** – extremely warm spring and summer, big precipitation deficit

**2014** – sleat in February, warm year, above average precipitation



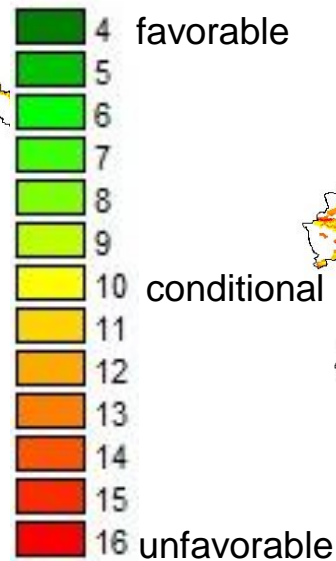
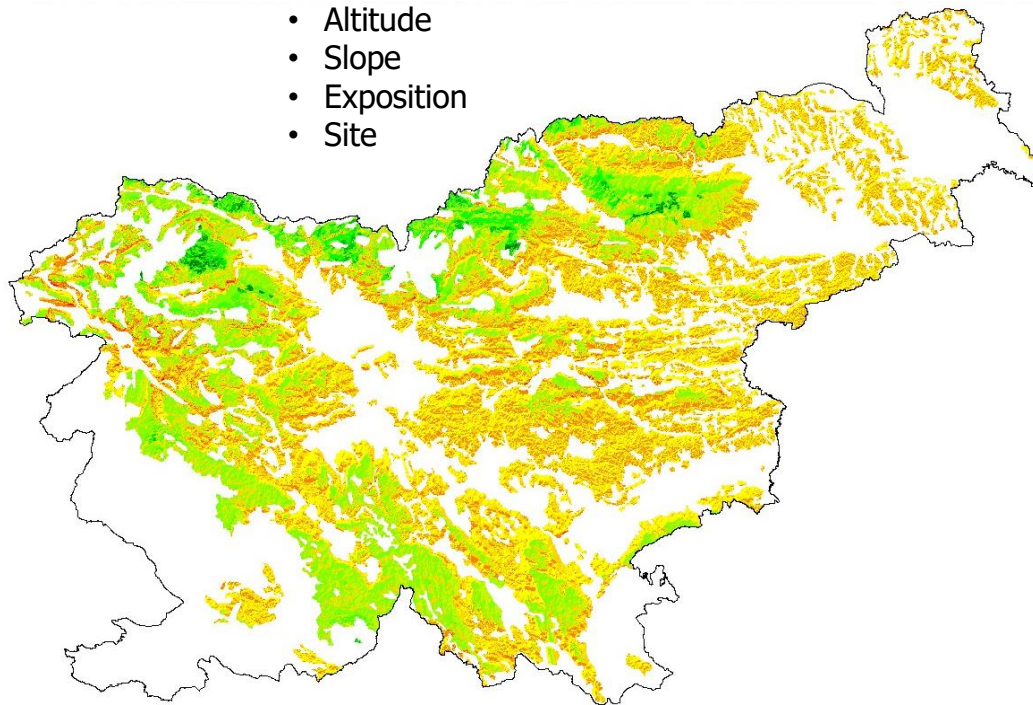
Coherent response on all sites regardles to the location

# 5. Model scenario: suitability of sites for the spruce (until 2070)

## Optimistic

**Included:**

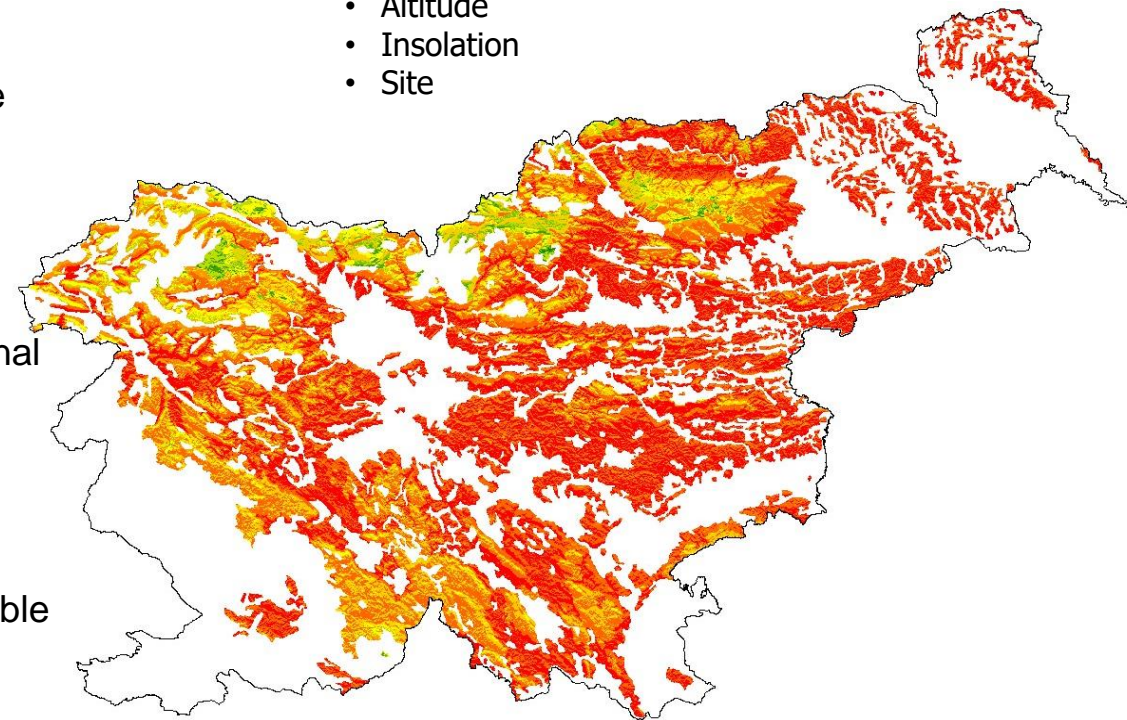
- Altitude
- Slope
- Exposition
- Site



## Pesimistic

**Included:**

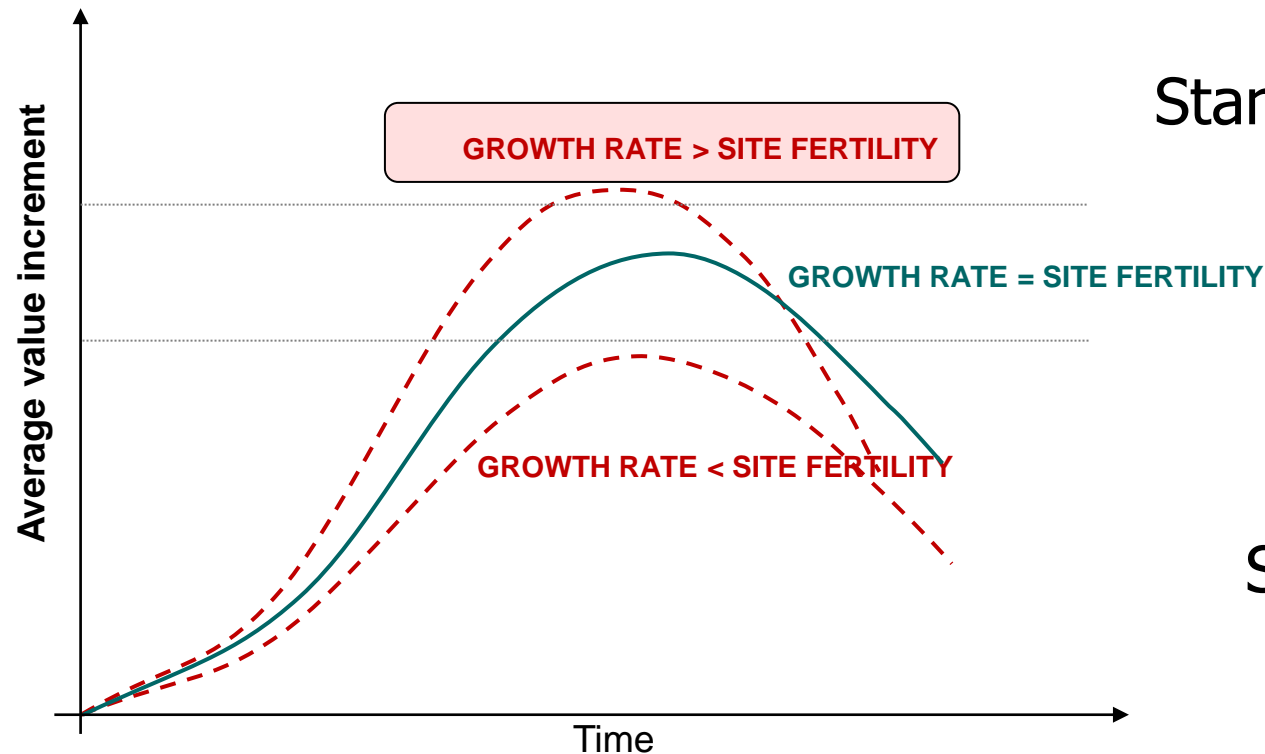
- Altitude
- Insolation
- Site



On sites below 700m spruce will be gone (both scenarios)

# Conclusions

## 1. Preserving balance between growth potential and site productivity




Stand: density / silvicultural system structure  
slenderness ( $h/d_{1.3}$ )  
species admixture  
???

Site: water availability  
soil characteristics  
altitude



## **2. Sufficient natural regeneration**

- regeneration should follow (potential) site conditions
- advantage of natural over artificial (planted) regeneration
- focus on silver fir
- Douglas fir? (Natura 2000 sites)



### **3. Reduction of (predictable) risks**

- rather mixed than pure forest stands
- slenderness  $< 70$  on poor and  $< 80$  on rich sites
- sites with average annual precipitation  $> 600\text{mm}$
- avoiding shallow soils, steep and southern slopes
- lower living stock, shorter rotation
- gradual replacement of spruce on sites below 700m
- respecting future scenarios

## 4. Conversion



CONVENTIONAL FORESTRY

Clearcutting of Spruce plantation



CLOSE-TO NATURE FORESTRY

Conversion of Spruce monocultures

Risk  
Suitability



Site

Stand

Climate and soil

Root & light competition



### **Aims**

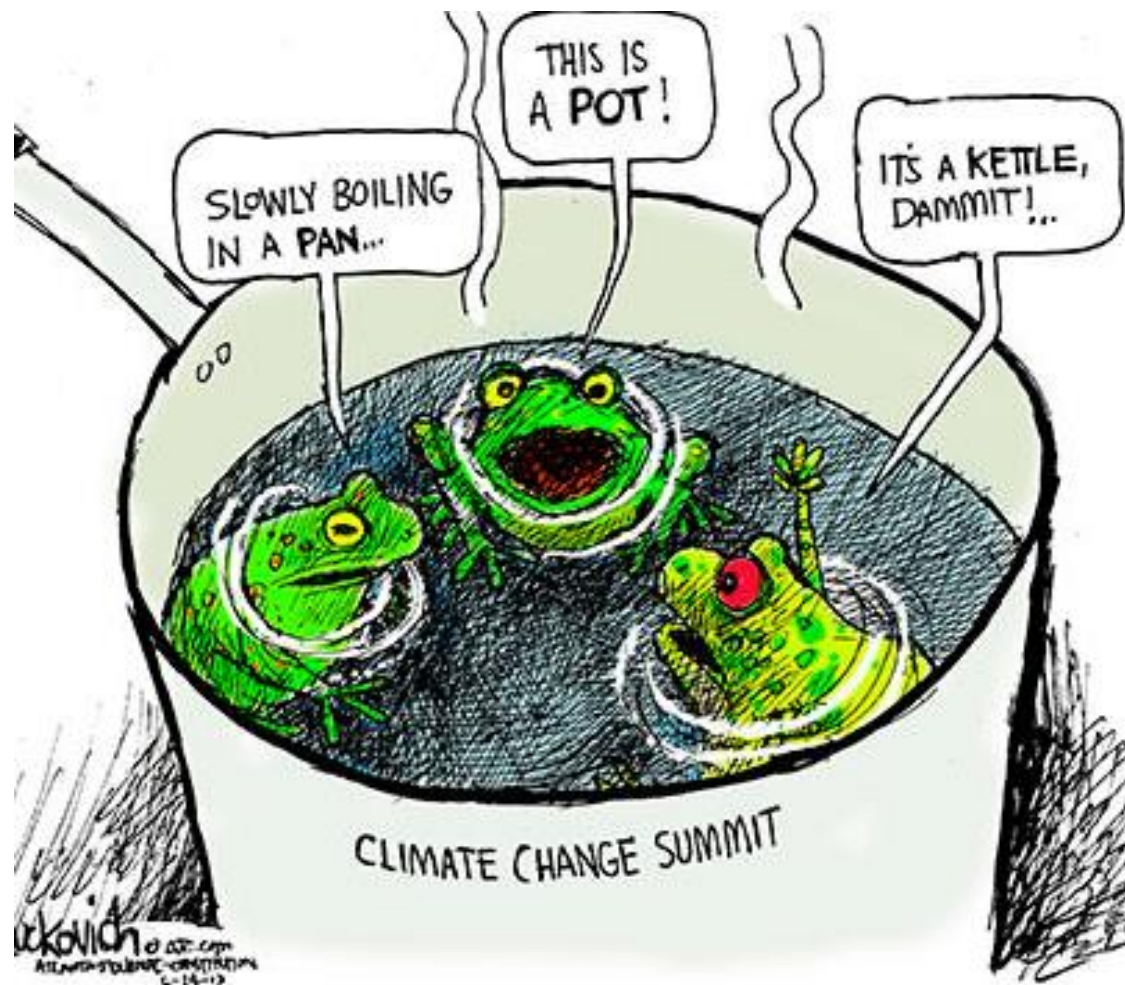
- Wood production
- Non timber products
- Maintain /rehabilitate site productivity

### **High/low resource input**

- Regeneration measures
- Canopy management
- Shelterwood harvesting

### **Output**

- Survival & growth
- Wood quality



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V4-1820 Causes and effect of December 2017 windthrow on further development of European beech and Silver fir stands in Slovenian Forests

V4-1614 Adaptive management in spruce forests in Slovenia