University College Dublin; 29th April 2019
Dublin, Ireland

CONVERSION TO CONTINUOUS COVER FORESTRY (CCF): *An adaptive forest management strategy within the context of global climate change (GCC)*

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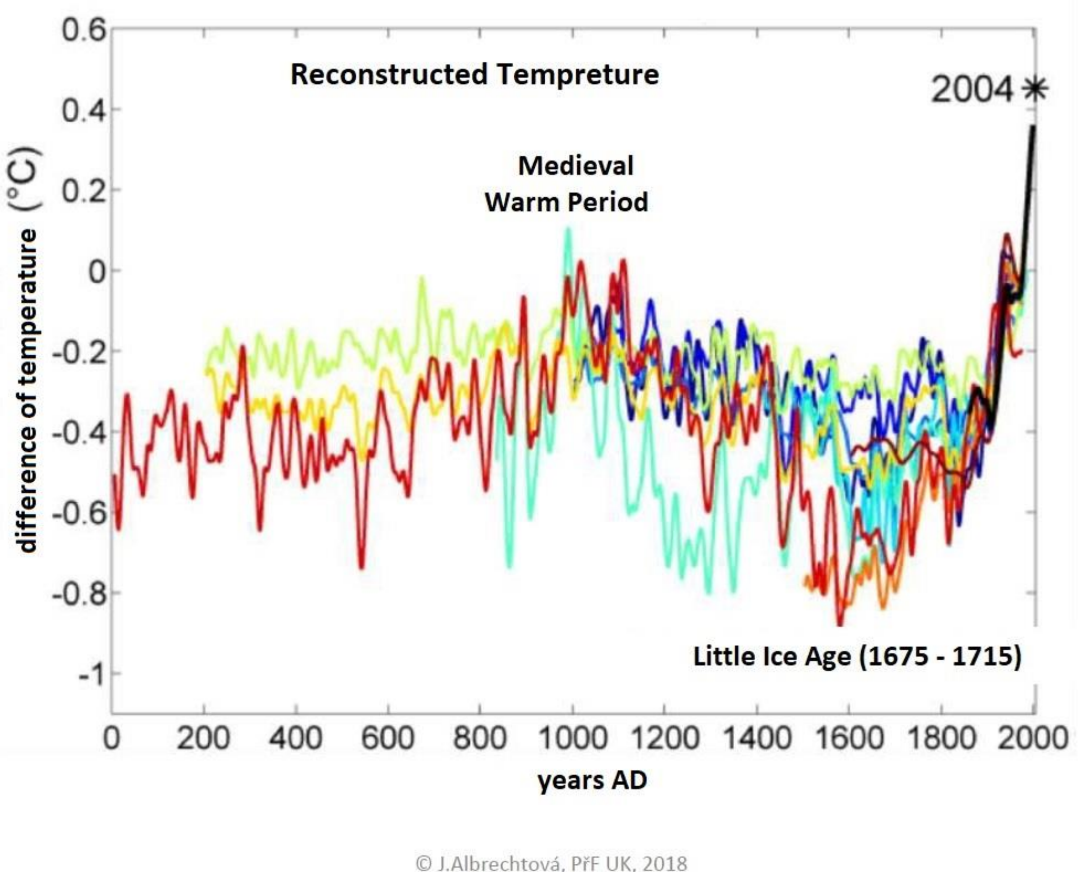
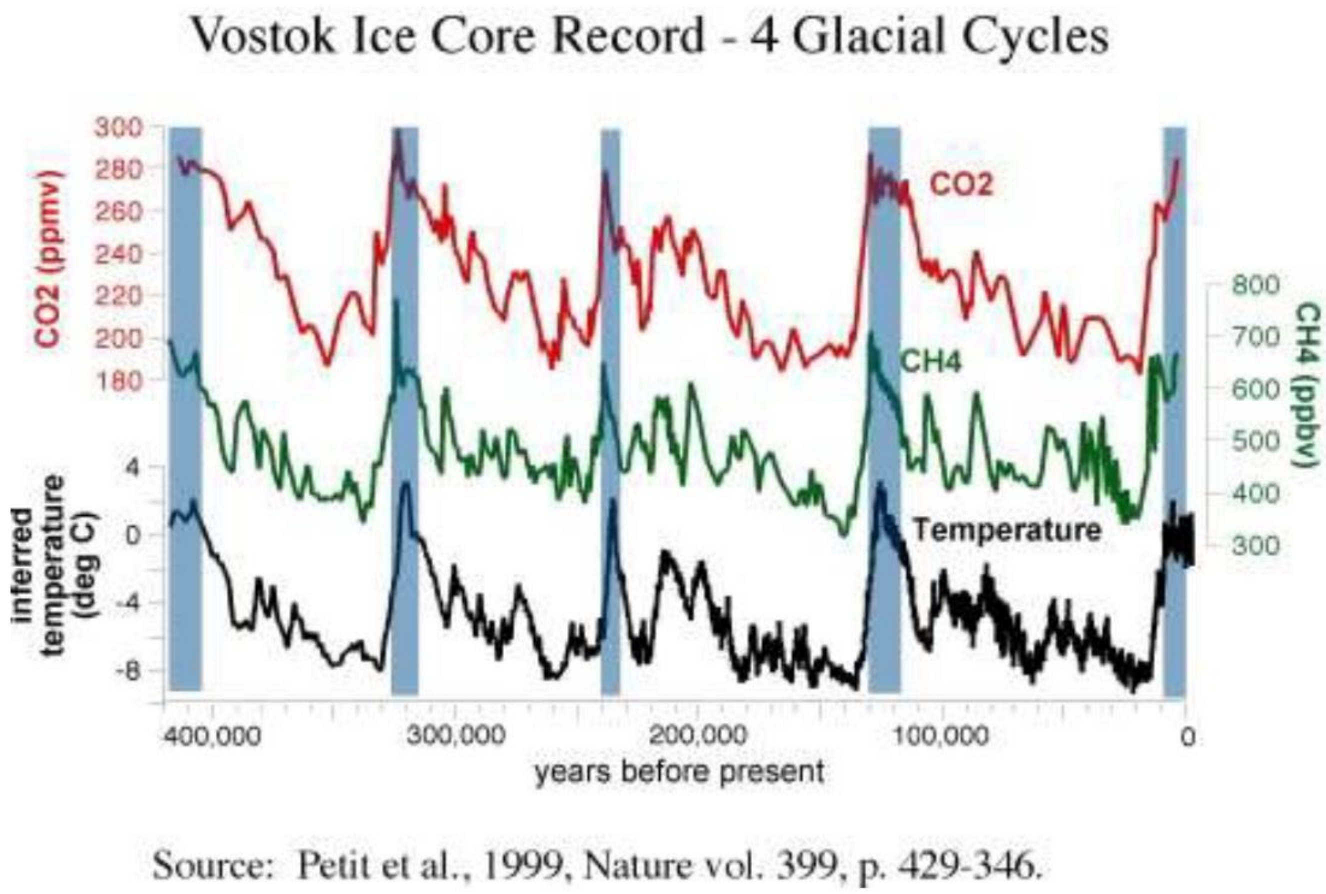
Global Climate Change

Temerature; CO2 (CH4) concentration; precipitation; EXTREMES





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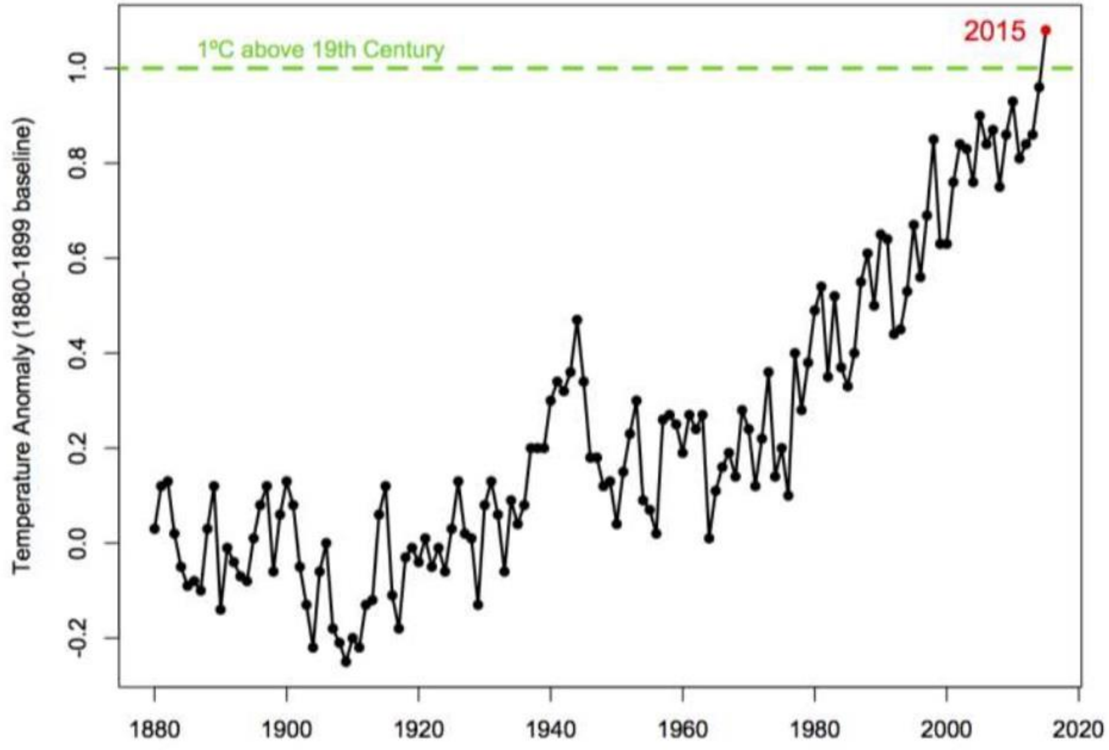
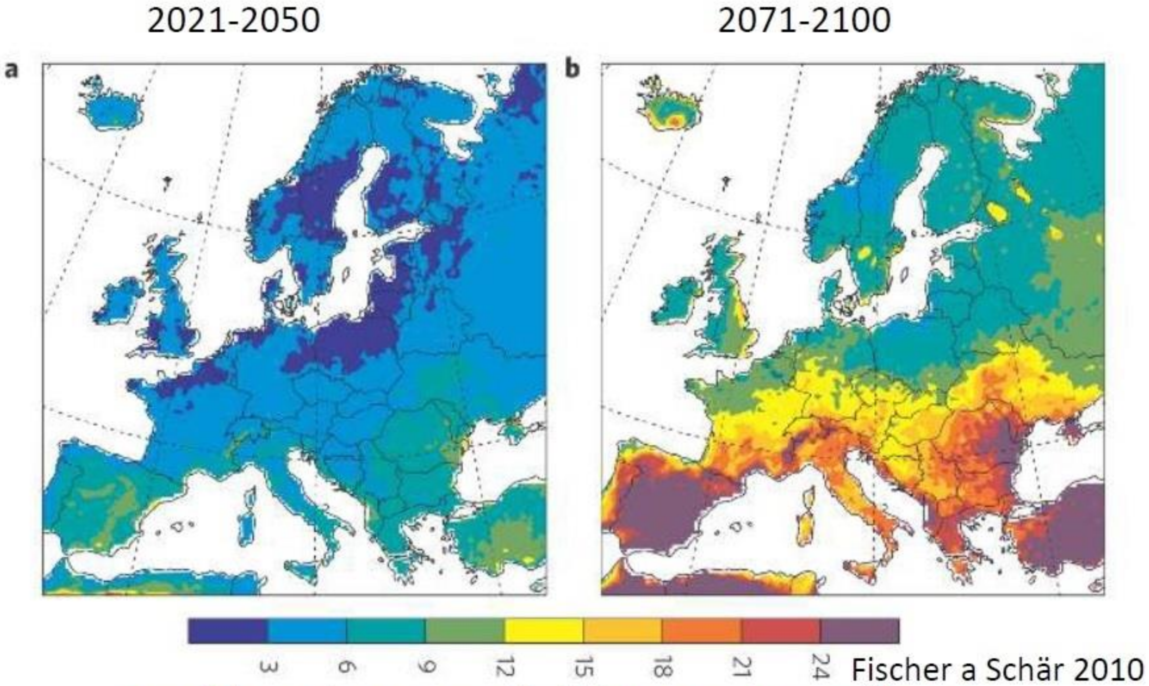


NASA, 2016

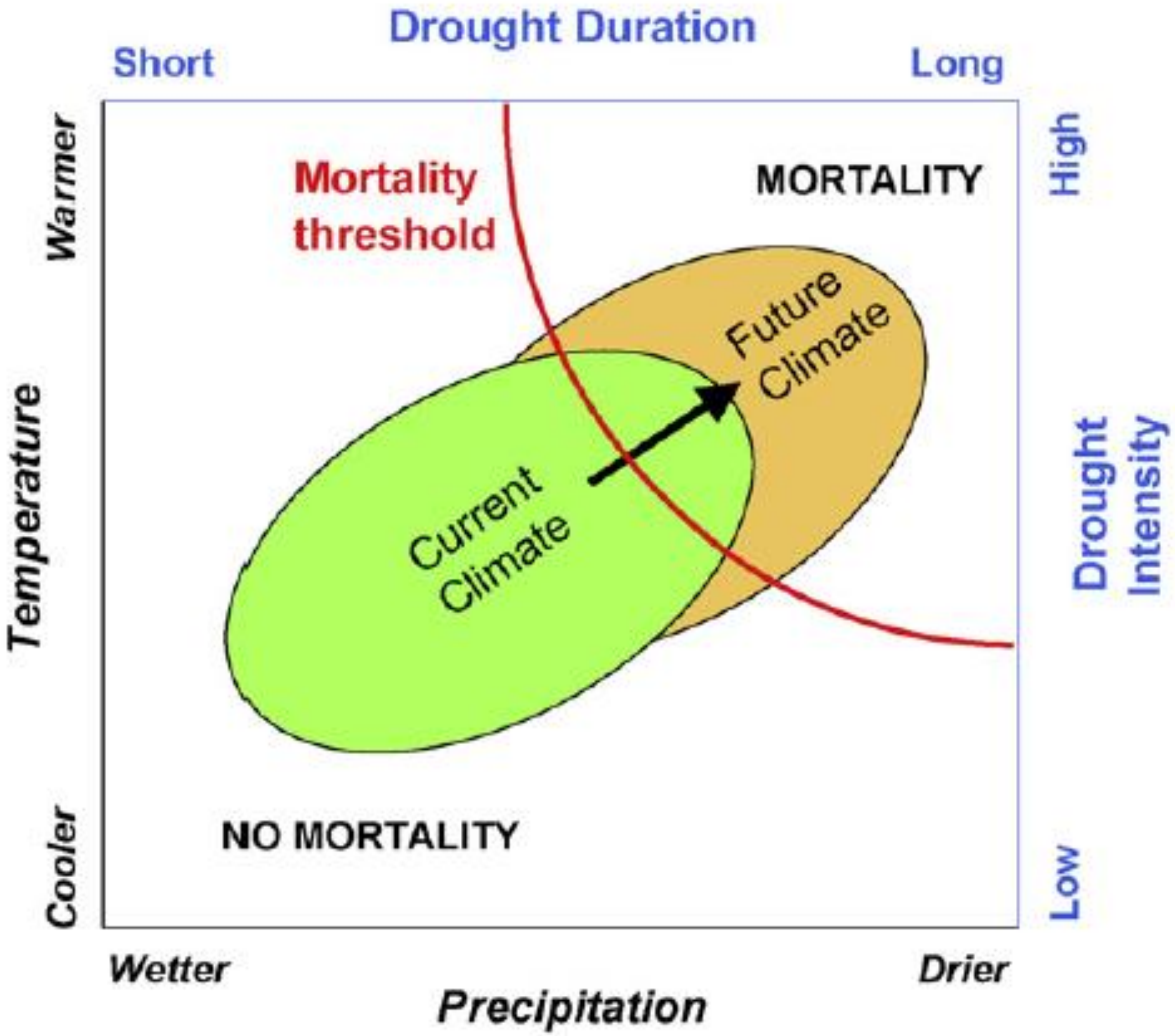


Fischer a Schär 2010

No. of days when extremelly high temperatures will occur

Consequences for FORESTRY

GCC – Temperature and distribution of precipitation



Allen et al., 2010

Consequences for FORESTRY

GCC – temperature and distribution of precipitation

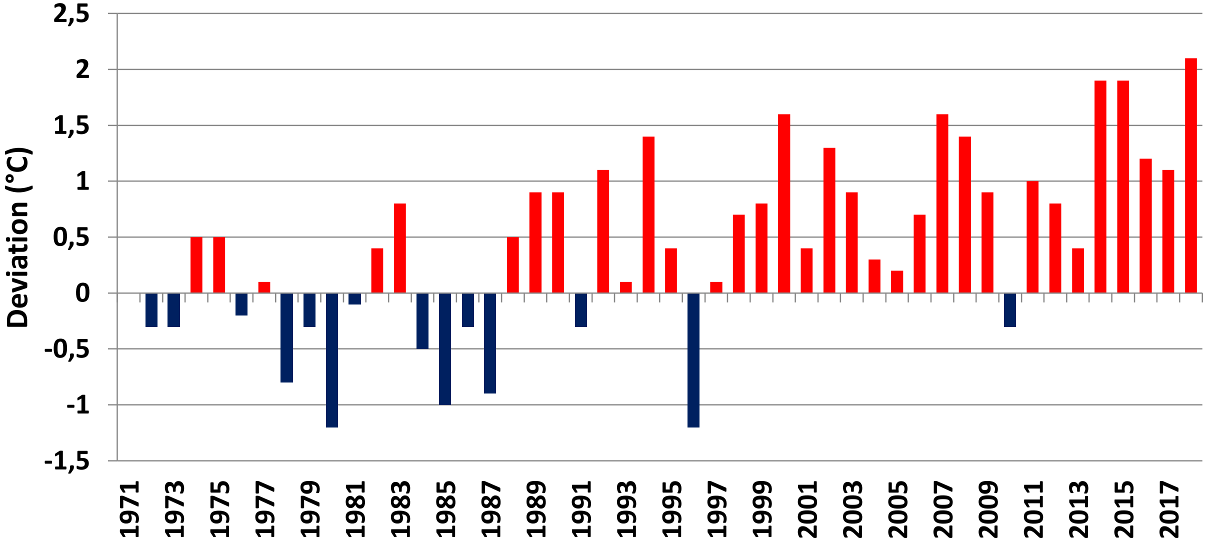
- ***Despite the fact that the total annual amount of precipitation is not changing too much, a distribution of precipitation is changing rapidly. This means:***
    - ***Increase in the extreme events***
    - ***Availability of water during growing season is decreasing***
    - ***Options for vegetation utilizing the water are limited due to extremes***

Consequences for FORESTRY

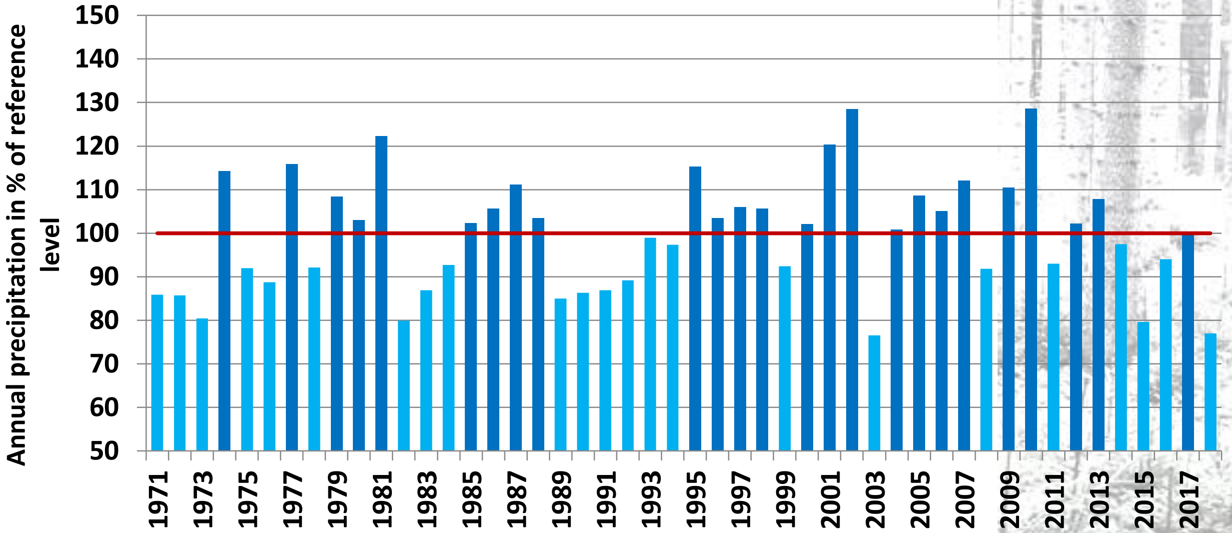
GCC – Temperature and distribution of precipitation

increment of annual temperatures

Deviations of annual temperature from long-term average of temperatures (period of 1961-1990) in the Czech Republic



Annual amount of precipitation expressed in % of long-term average (1961-1990) in the Czech Republic



No clear trend of changes at the level of TOTAL ANNUAL amount of precipitation => changes occure at the level of distribution of precipitation within the year

graphs from Lubojacký 2019; FGMRI

Consequences for FORESTRY

GCC – temperature and distribution of precipitation

Large-scale disturbance by bark beetle

- ***Secondary disturbance agent***

  (*Ips typographus; Ips duplicatus; Pityogenes chalcographus*)

- ***Primary caused by impact of GCC – due to serious long-term (at least from 2015) physiological stress in combination with other reasons:***
  - ***tree species composition***
  - ***forest structure***
  - ***forest management systems***

Consequences for FORESTRY

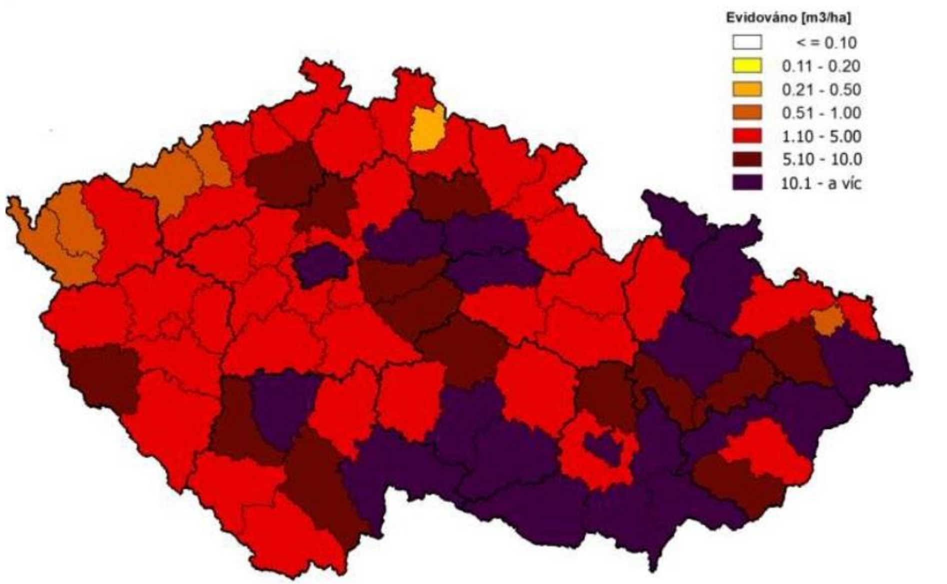
Salvage fellings in 2018 (Czech Rep.)

- ***14.6 million m3 (2017 – 12 mil. m3; 2016 – 9.4 mil. m3)***
- ***Biotics factors – 8.4 mil. m3 (2017 – 4.1 mil. m3; 2016 – 3.6 mil. m3; 2015 – 1.8 mil. m3)***
- ***95% of biotic damages caused by bark beetles***

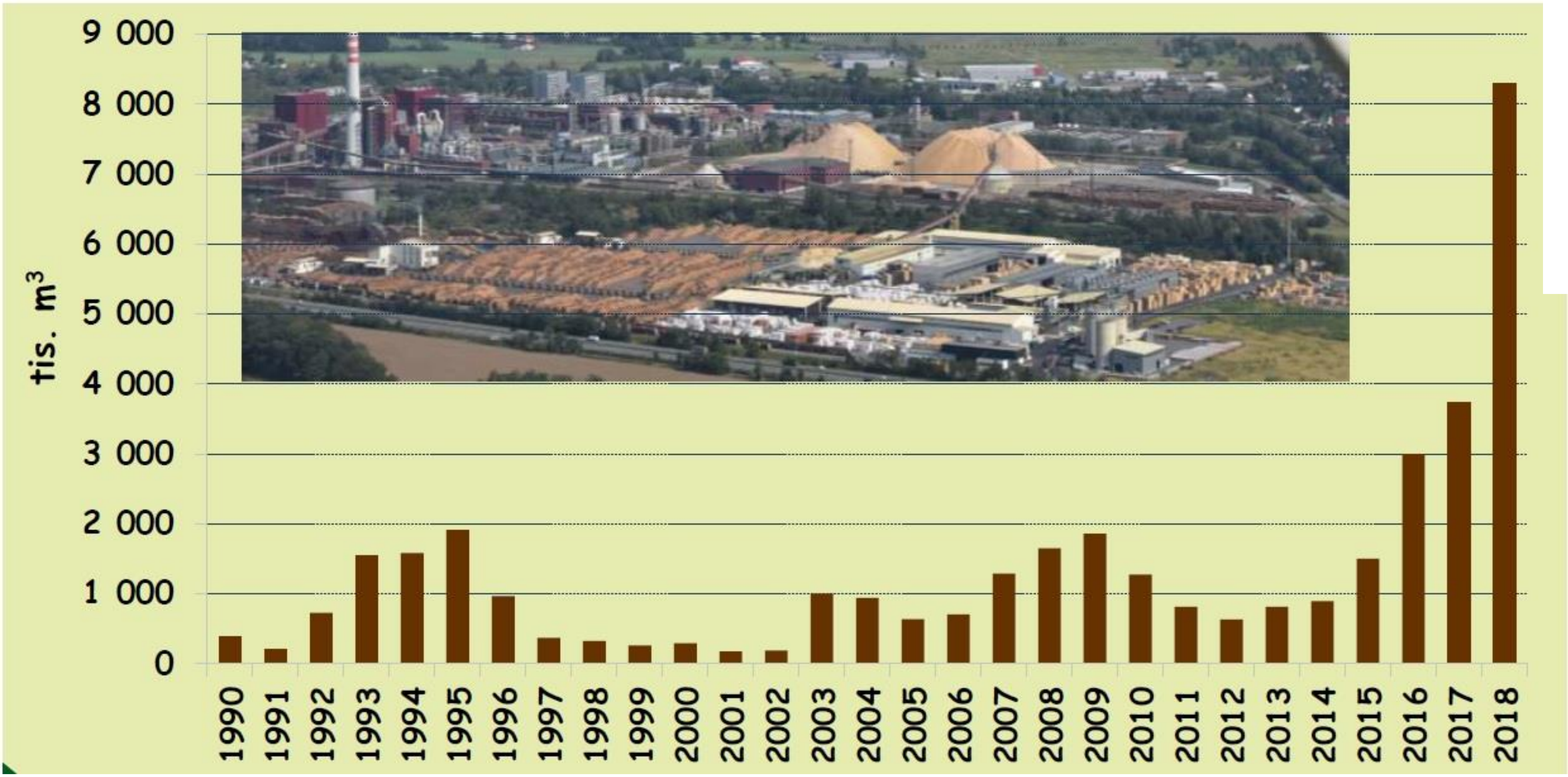
FGMRI; 2019

Consequences for FORESTRY

Volume of bark beetle salvage felling per 1 hectare of Norway spruce stand (in 2018)



A volume of salvage felling of Bark beetle wood in the Czech Republic (period of 1990 - 2018)



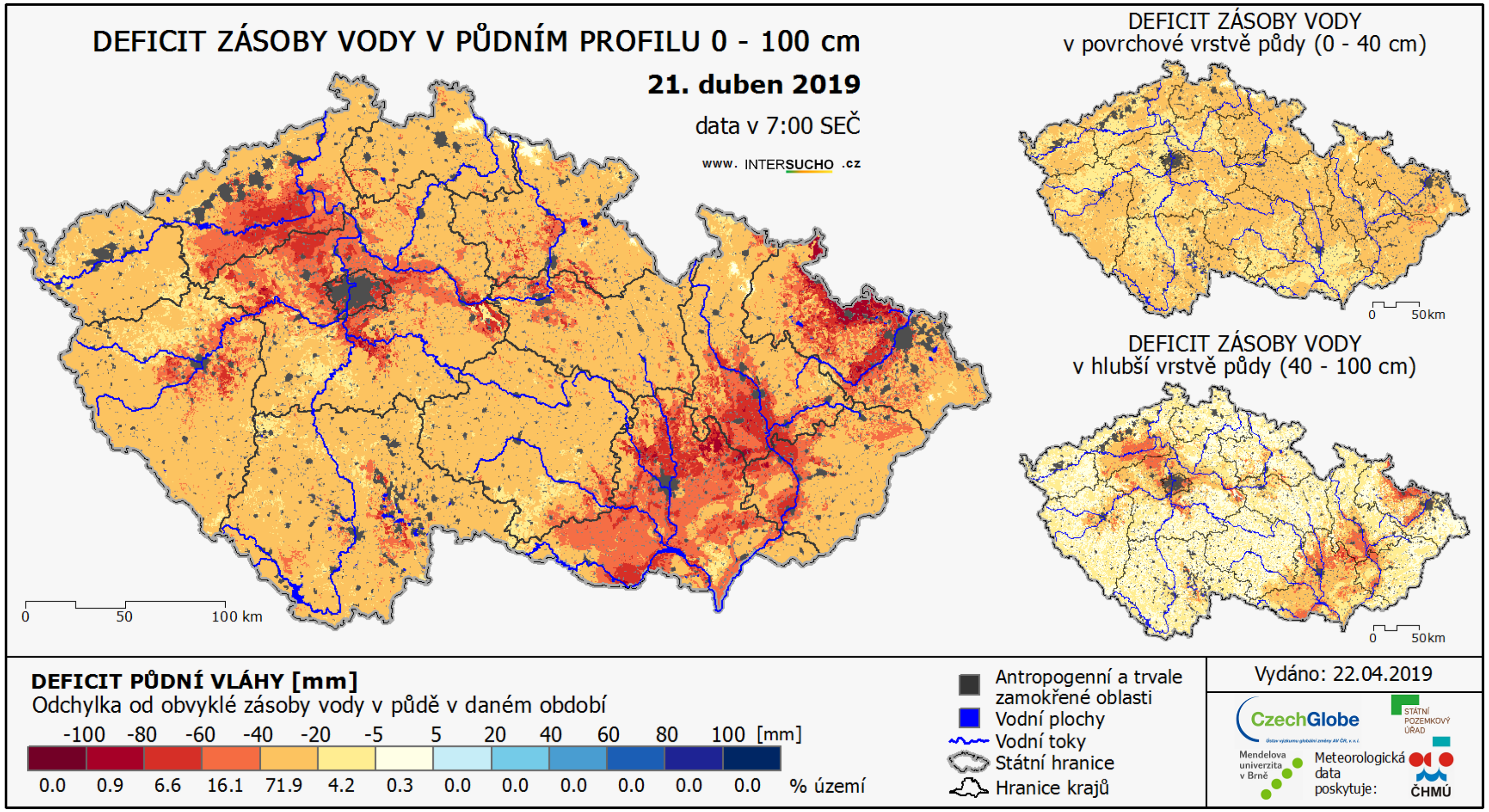
Lubojacký 2019; FGMRI

Consequences for FORESTRY

Deficit of soil water: 0 – 100 cm; 0 – 40 cm; 40 – 100 cm;

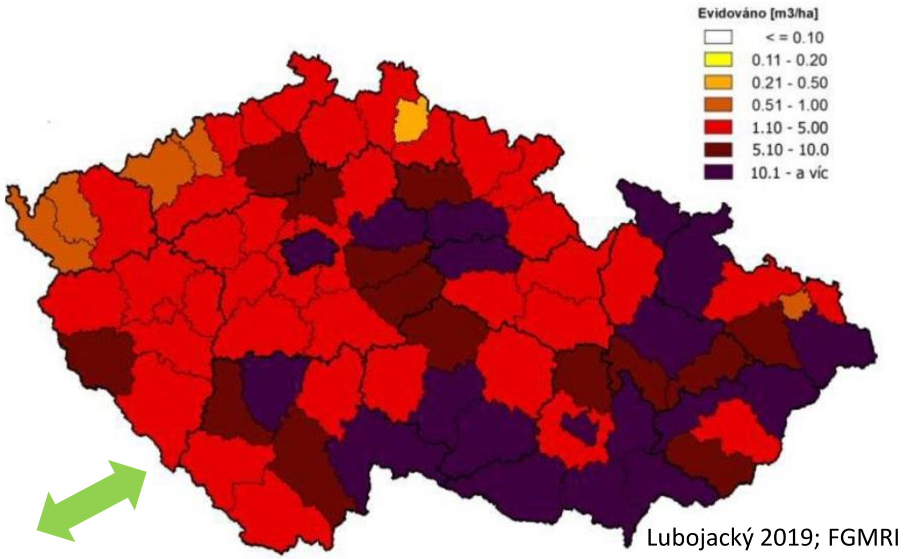
expresed as a difference (mm) of current water supply to long-term water supply (taken on a set date):

***21st April 2019**; the most often is a lack of 20 - 40 mm (71.9% of area)*



https://www.intersucho.cz

Volume of bark beetle salvage felling per 1 hectare of Norway spruce stand (in 2018)



Lubojacký 2019; FGMRI

Consequences for FORESTRY

FGMRI, 2018

Consequences for FORESTRY

FGMRI, 2018

Consequences for FORESTRY

FGMRI, 2018

Consequences for FORESTRY

FGMRI, 2018

Consequences for FORESTRY

2019 Perspective (pictures from video)…

Video from 20th April 2019;

(showing situation in a pheromone trap);

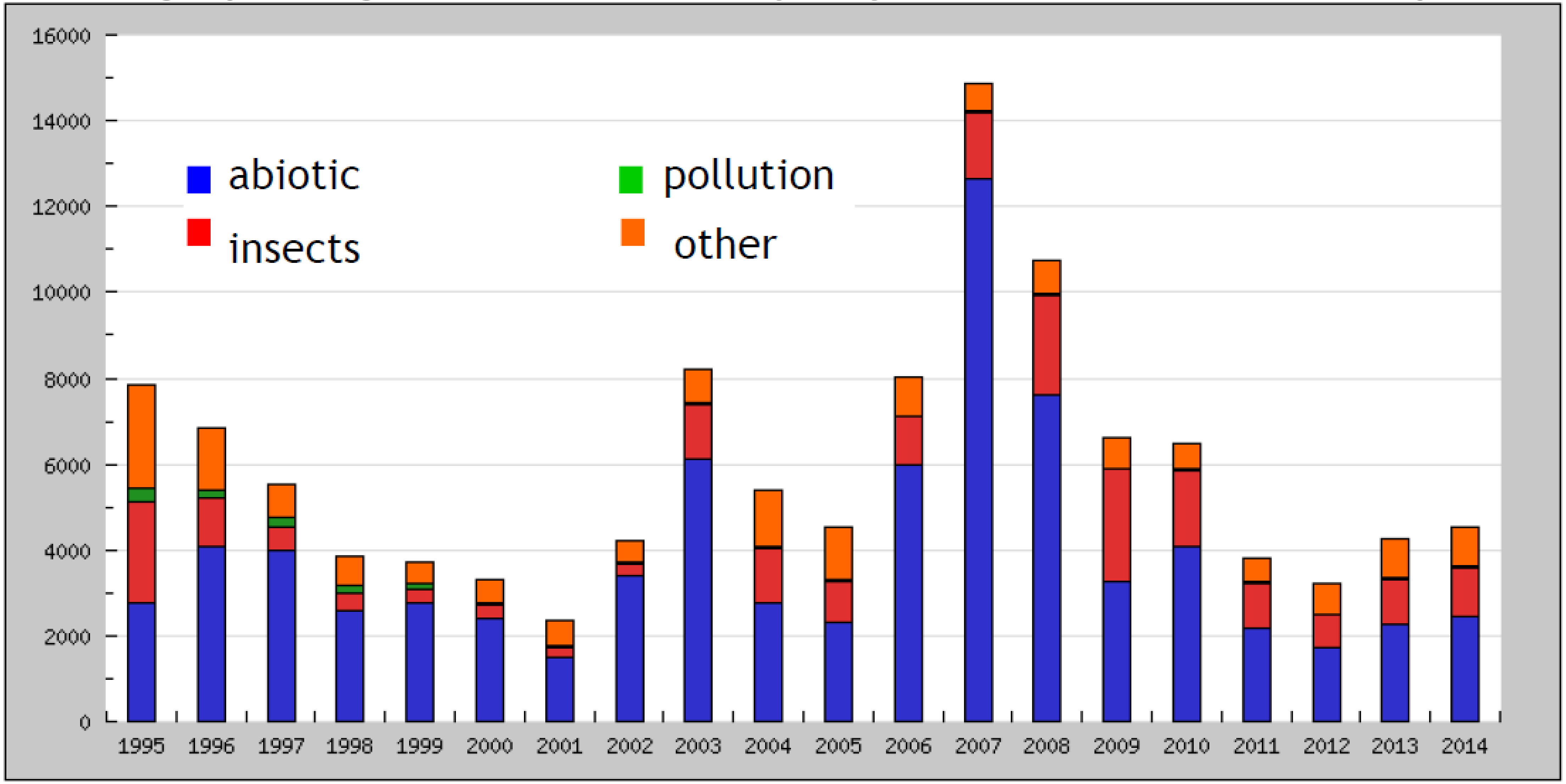
current situation in the Czech Republic…

Norway spruce:

- Within all of **Europe** there are **6 – 7 mil. ha** of secondary pure Norway spruce monocultures outside of its origin territory (Teuffel et al. in Spiecker et al. 2004)
- In the **Czech Republic** N. spruce represents **51.4%** of total forest cover while within natural forest its share was approx. **11.2%**
- ***Before a bark beetle disaster windfalls often occurred:***

Before bark beetle disaster windfalls (and other abiotic agents) often occurred as the main disturbance agent:

Salvage felling in the Czech Rep. by reasons (thousand of m3)



Pokorný 2018;
MENDELU in Brno



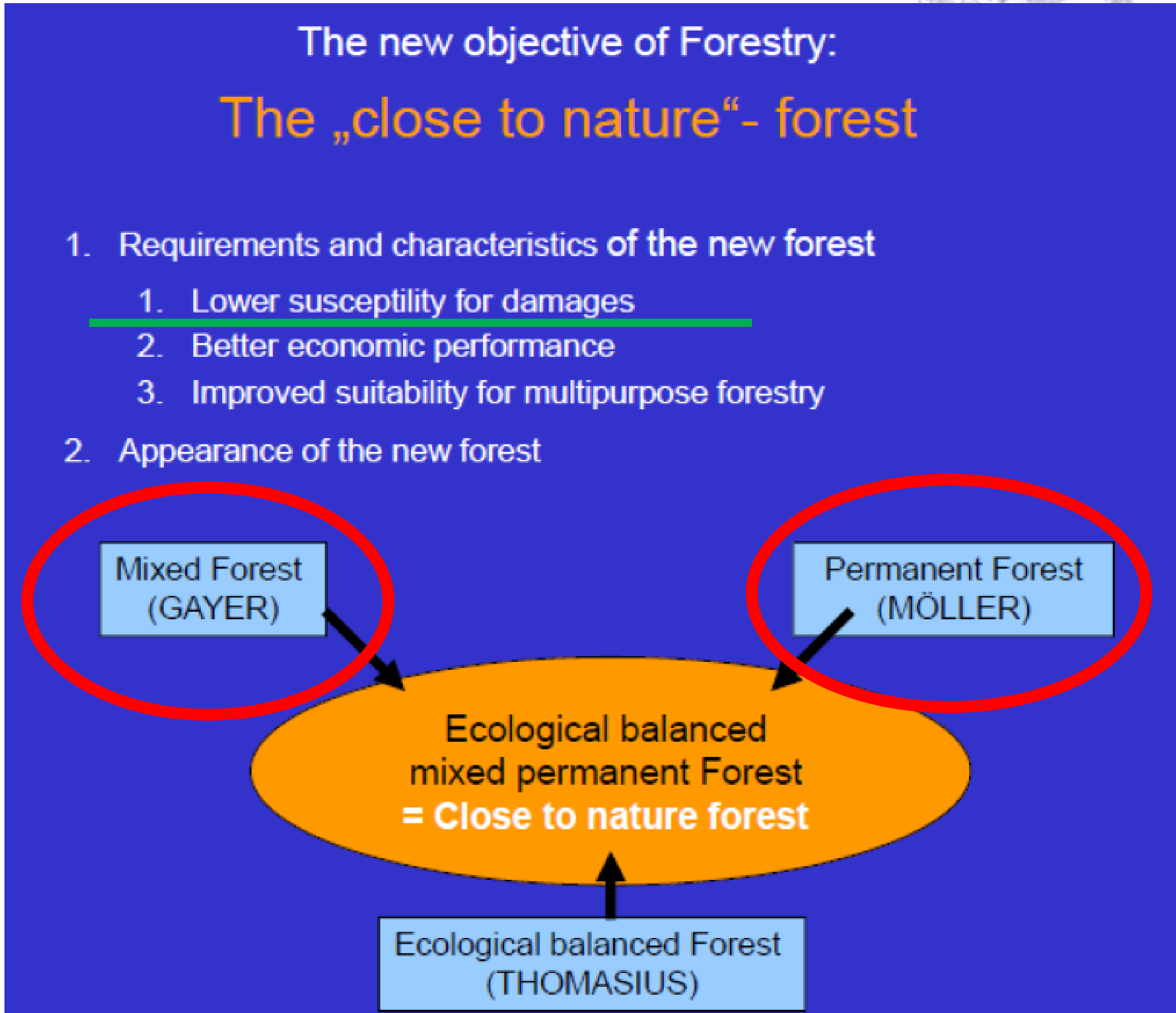

Bednář, 2009 + 2018; FGMRI

Continuous Cover Forestry (CCF)

- *Is it a solution?*
- *How does adoption of CCF prevent or mitigate described scenarios (i.e. large-scale disturbances of managed forests)?*
- *Through which entities does it deal with forest threats and outbreaks?*

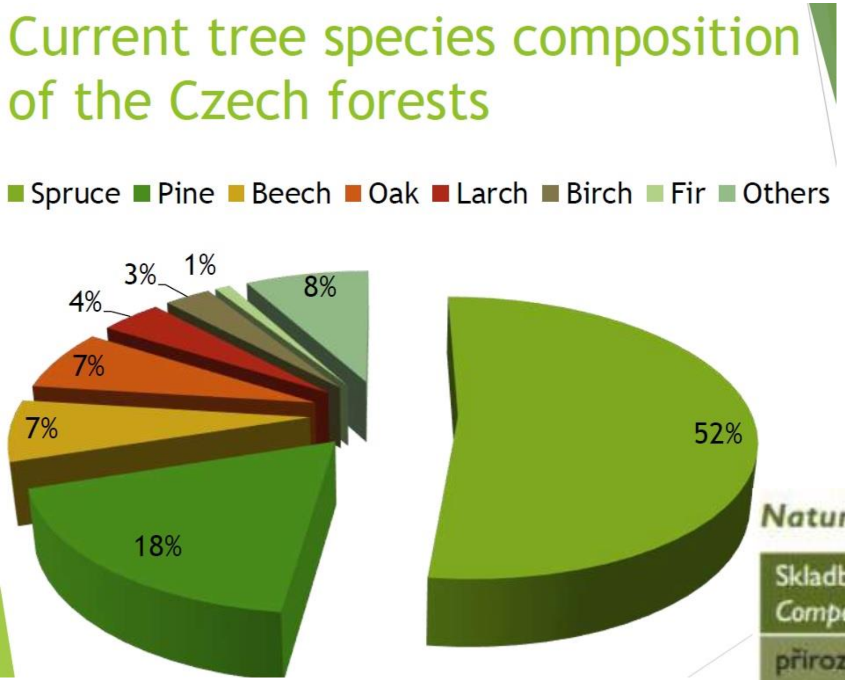
CONVERSION of tree species composition

TO MAKE FORETS STANDS STABLE



scheme from Tikvić 2016; SUMFAK in Zagreb

Tree species composition – Necessity for CONVERSION



Current

vs. recommended (mid-term target)

vs. natural

Natural and current composition of tree species, % of forest land area

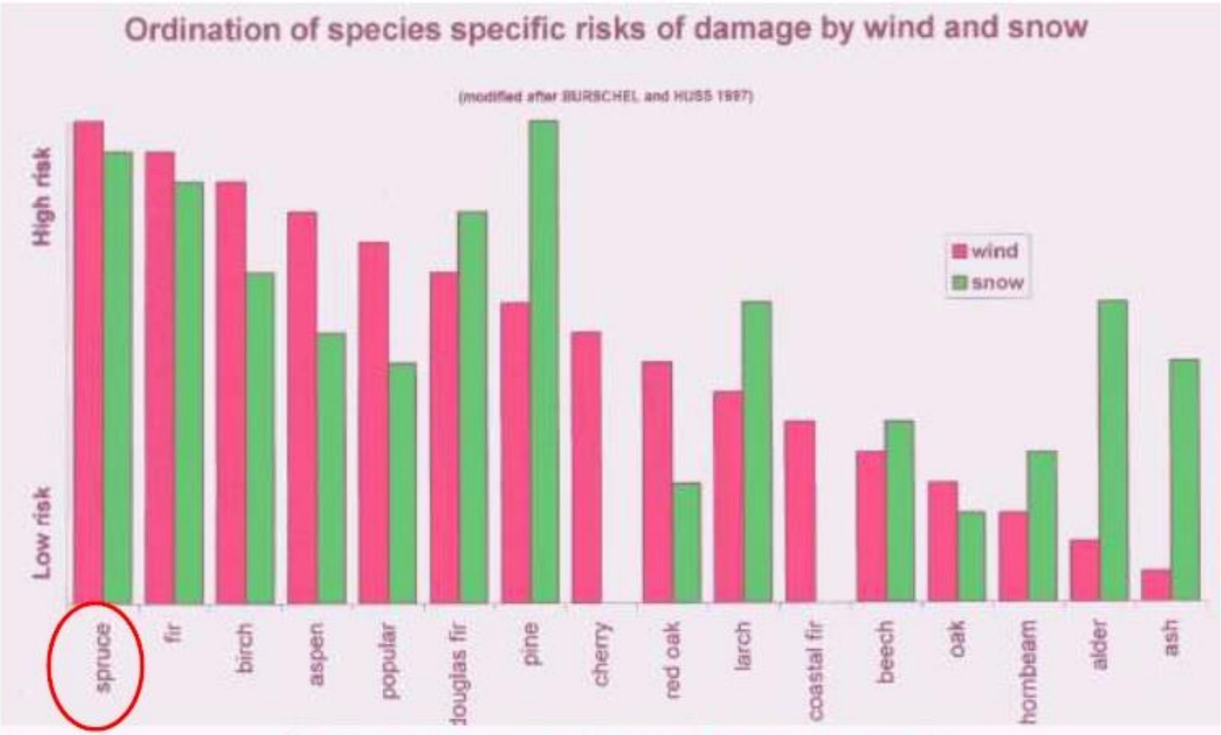
Skladba lesů *Composition*	smrk *spruce*	jedle *fir*	borovice *pine*	modřín *larch*	ostatní jehličnaté *other conifers.*	Sa jehličnaté *total conifers*	dub *oak*	buk *beech*	habr *hornbeam*
přirozená *natural*	11,2	19,8	3,4	0,0	0,3	34,7	19,4	40,2	1,6
současná *current*	51,4	1,0	16,7	3,9	0,3	73,2	7,0	7,7	1,3
doporučená *recommended*	36,5	4,4	16,8	4,5	2,2	64,4	9,0	18,0	0,9

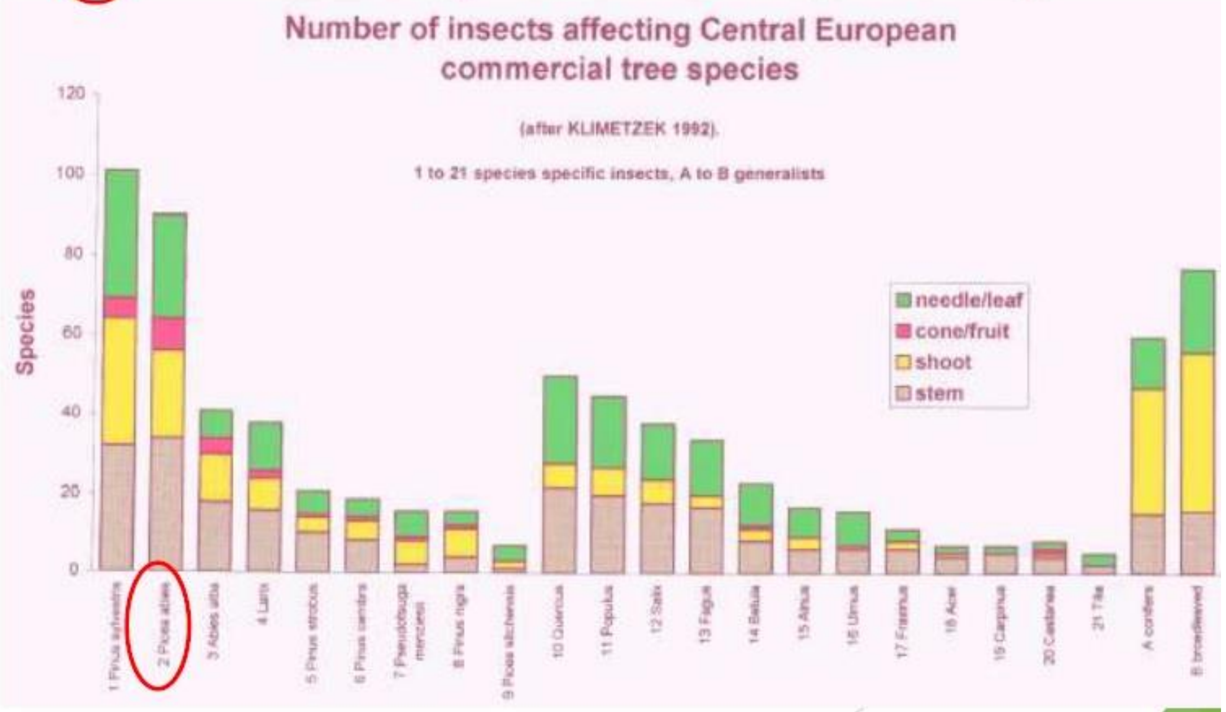
	jasan *ash*	javor *maple*	jilm *elm*	bříza *birch*	lípa *linden*	olše *alder*	ostatní listnaté *other broadleaves*	Sa listnaté *broadleaves total*	holina *unstocked area*
přirozená *natural*	0,6	0,7	0,3	0,8	0,8	0,6	0,3	65,3	0,0
současná *current*	1,4	1,3	0,0	2,7	1,1	1,6	1,6	25,6	1,2
doporučená *recommended*	0,7	1,5	0,3	0,8	3,2	0,6	0,6	35,6	0,0

Pramen: ÚHÚL
Source: *FMI*

Tree species composition

Vulnerability of tree species to both biotic and abiotic agents

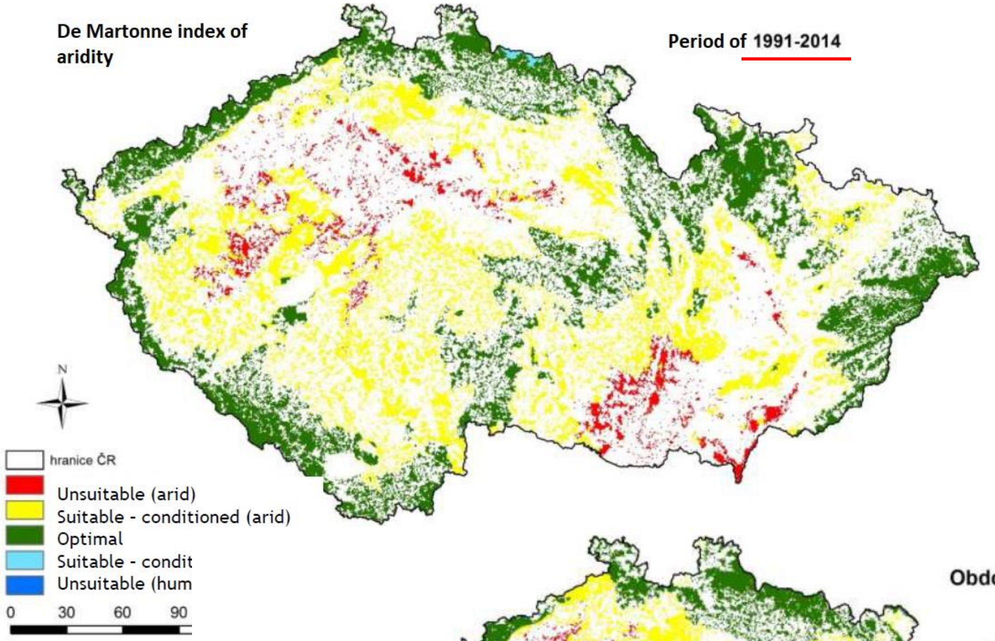


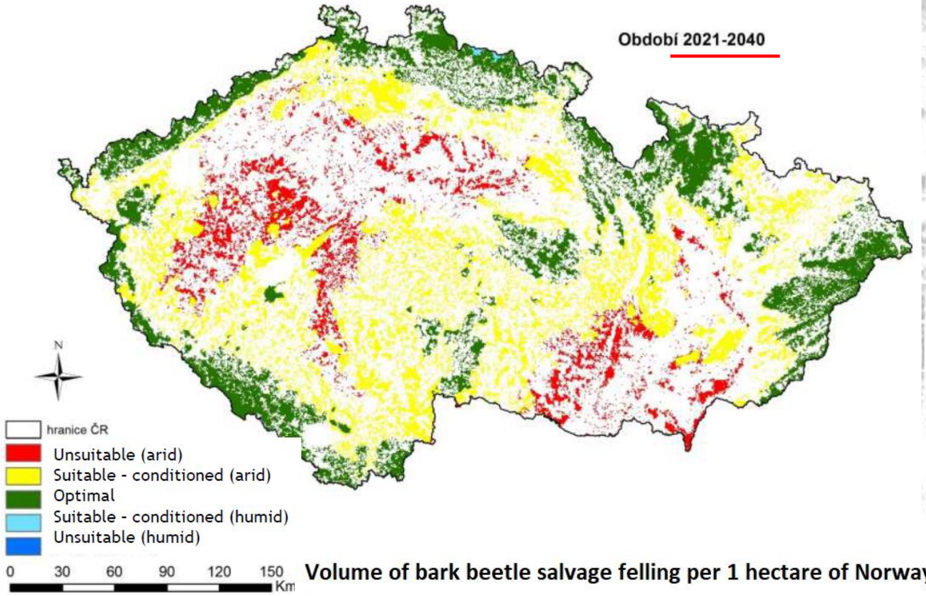


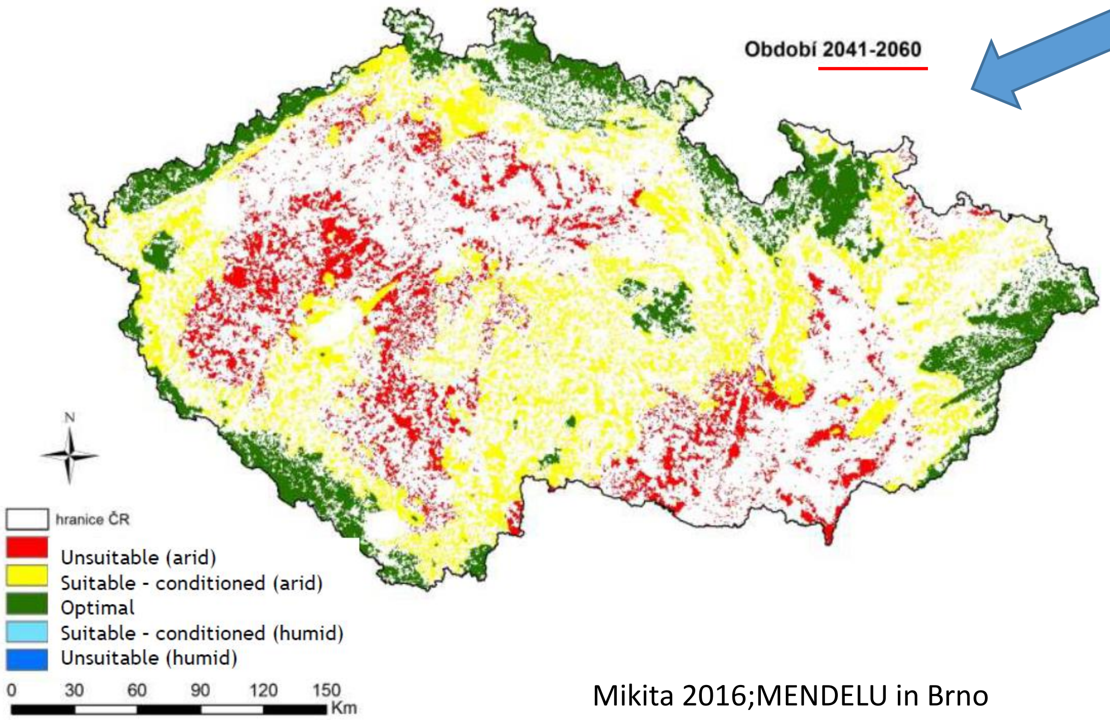
Tree species composition:

Norway spruce

Prediction under GCC

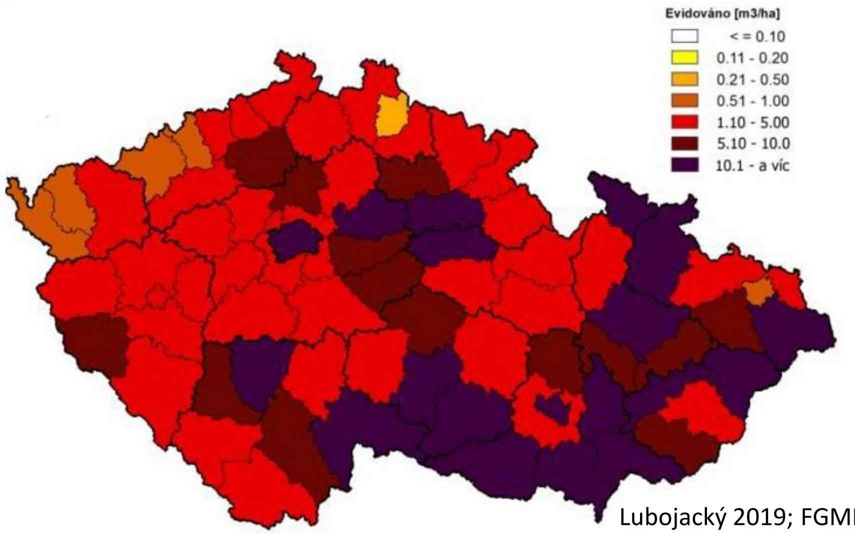






Mikita 2016;MENDELU in Brno

Volume of bark beetle salvage felling per 1 hectare of Norway spruce stand (in 2018)



Lubojacký 2019; FGMRI

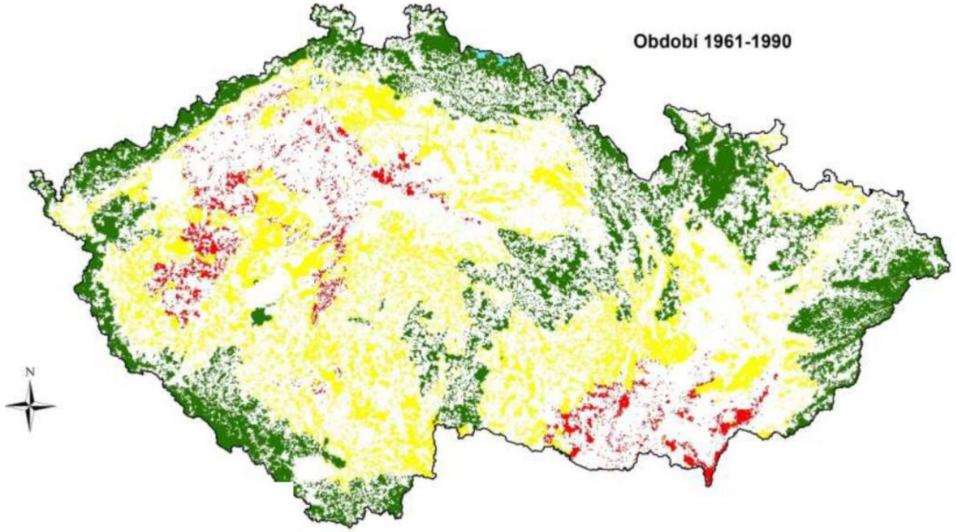
Tree species composition

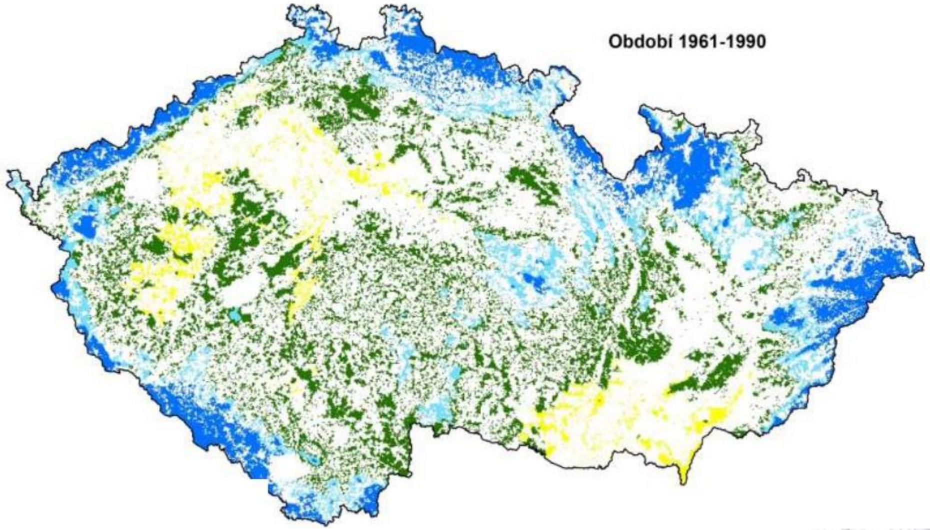
Prediction under GCC

Norway spruce

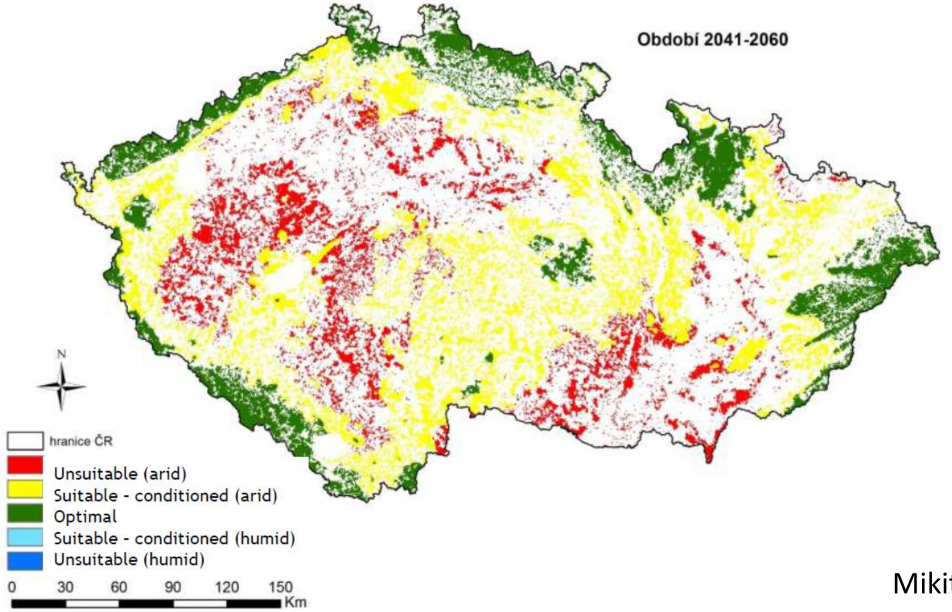
Sessile Oak

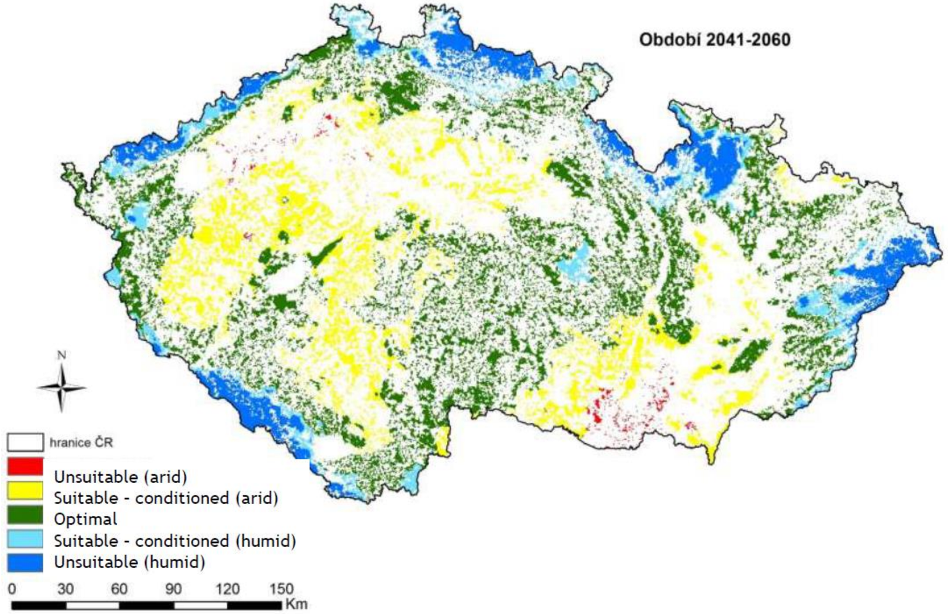
1961 - 1990





2041 - 2060





Mikita 2016; MENDELU in Brno

Tree species composition

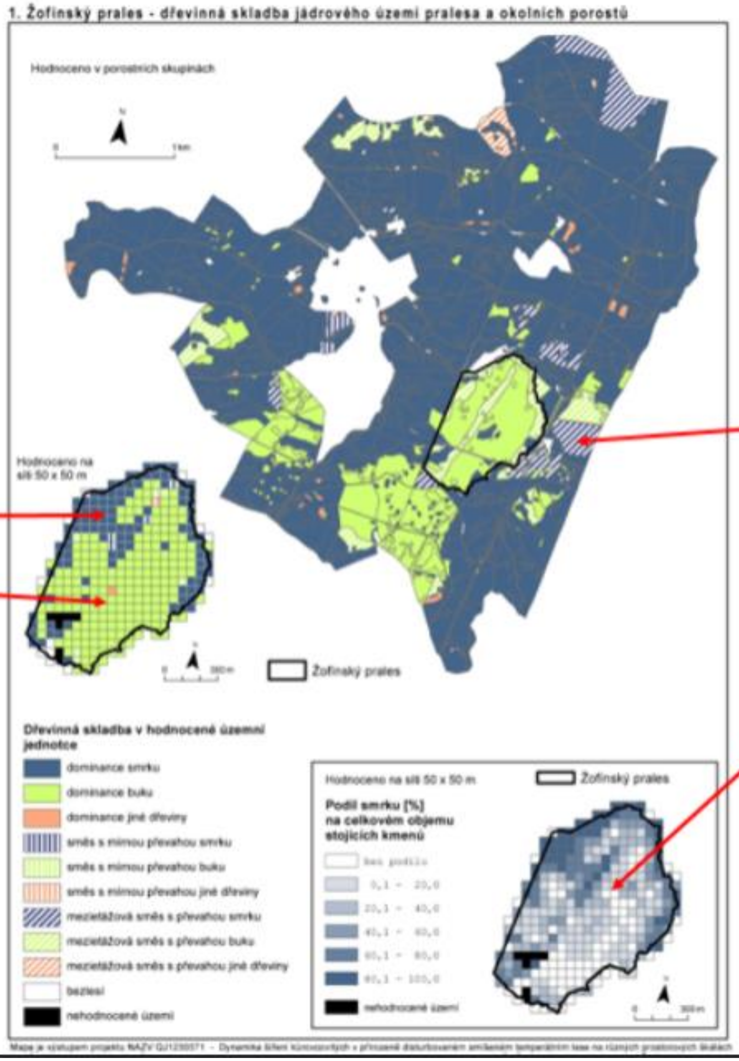
Importance of mixture to prevent bark beetle outbreaks

Spring 2007
Žofín forest reserve after the storm Kyrill

Vrška et al. 2018; Silva Taroucy - VUKOZ and MENDELU in Brno

Tree species composition

Importance of mixture to prevent bark beetle outbreaks



Spruce with admixed beech

Spruce dominates

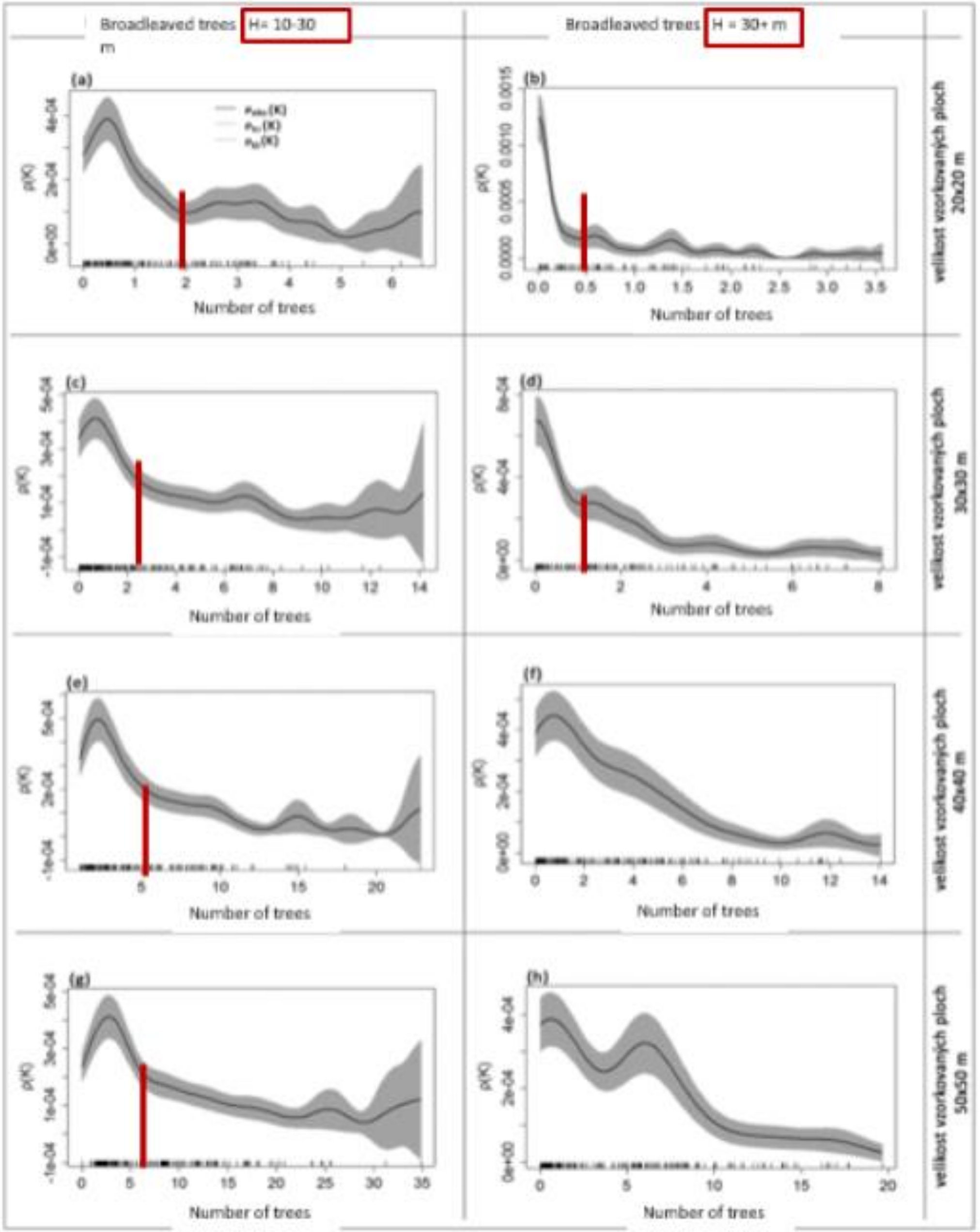
Beech dominates

portion of spruce on the total volume of standing stems

Adam et al. 2015

Vrška et al. 2018; Silva Taroucy - VUKOZ and MENDELU in Brno

Tree species composition: *Importance of mixture to prevent bark beetle outbreaks*



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

importance of mixture

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

importance of structure

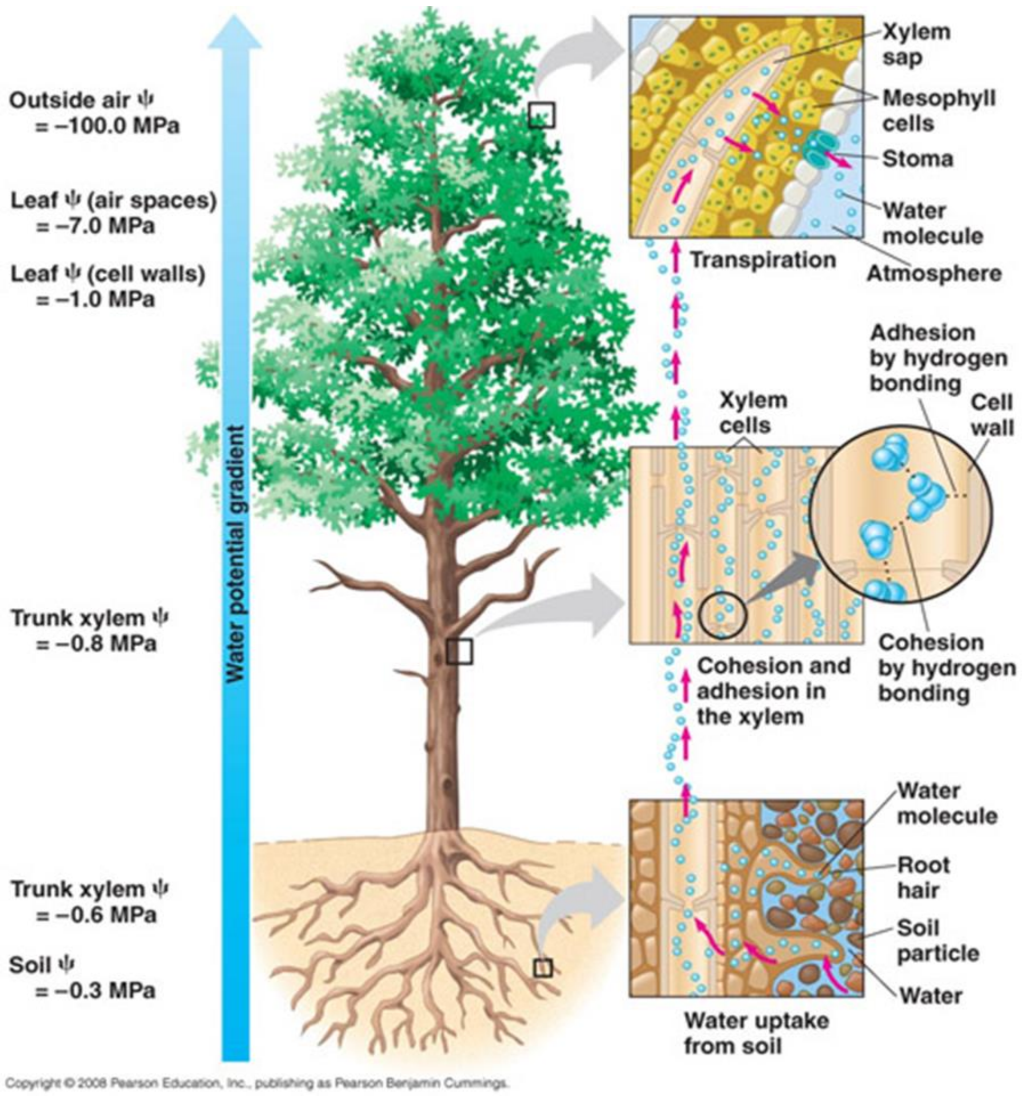
Silviculture outputs:

- 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

Drought stress - Consequences for FOREST STRUCTURE

Water in the soil-plant-atmosphere continuum



Water balance of trees

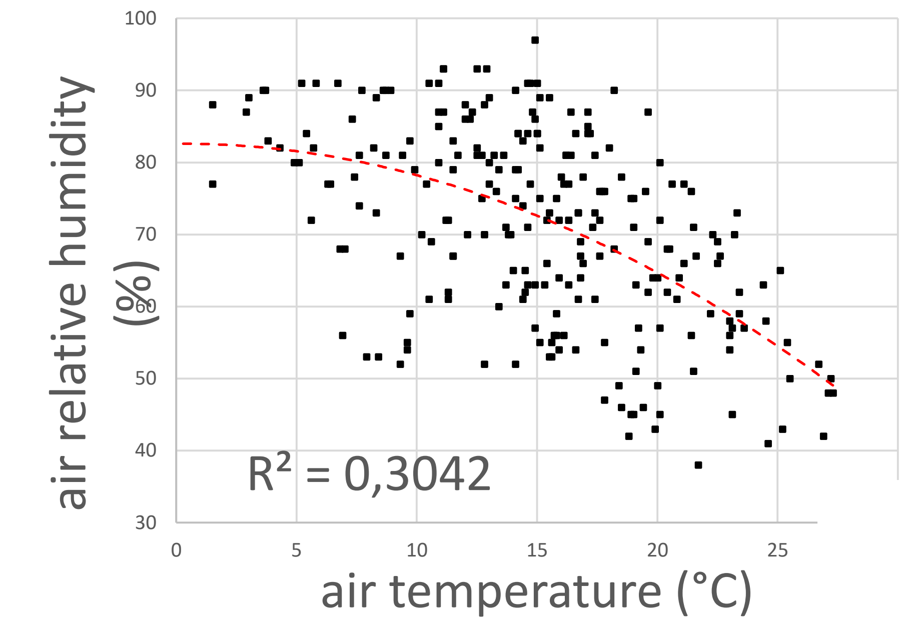
Water movement from leaves to the atmosphere

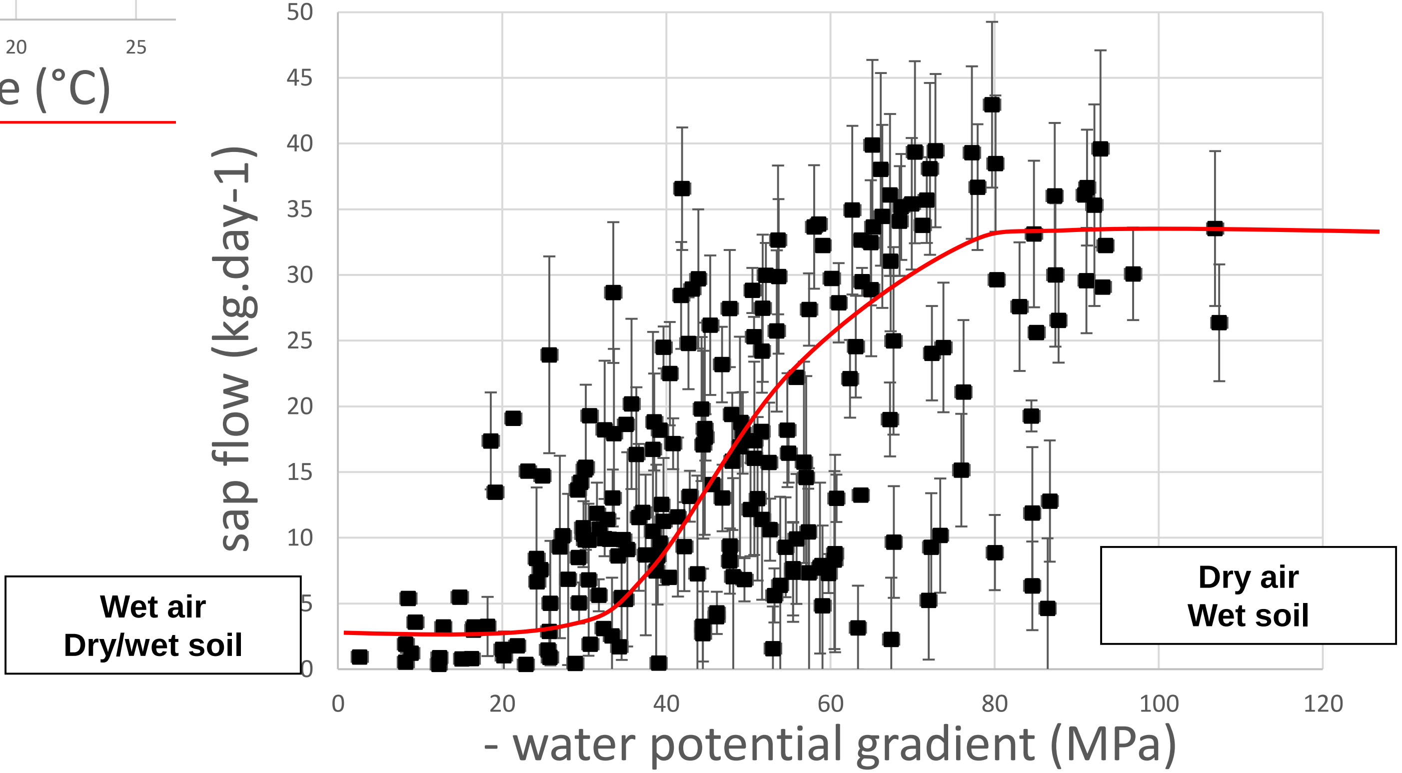
Water transport through the xylem

Water absorption by roots

Horáček et al. 2018; CzechGlobe

Drought stress - Consequences for FOREST STRUCTURE





Horáček et al. 2018; CzechGlobe

Drought stress - Consequences for FOREST STRUCTURE

General mechanism and driving forces of water regime in trees, when an extreme position of the regime is a drought stress

Mechanisms and driving forces operating on water transport (a) within the tree and (b) between the tree and its environment = **water potential gradient**

The main factors are

(a) air temperature and relative humidity,
(b) wind speed,
(c) soil moisture

Horáček et al. 2018; CzechGlobe

Drought stress - Consequences for FOREST STRUCTURE

Within the same conditions there are huge differences between tree species and even between different growth stages of the same tree species

	Transpiration	Soil WP	Air WP
Pine, mature	low	dry	dry
Spruce, mature	high	dry	dry
Spruce, young	low	dry	dry

Horáček et al. 2018; CzechGlobe

Drought stress - Consequences for FOREST STRUCTURE

… **tree adaptation to the environment** …

1. ***Transpiration*** is very sensitive to ***environmental conditions***.
2. ***Soil moisture – key importance*** (*Point of Reduced Availability* - Soil Water Potential = - 0.5 MPa).
3. If SWP **bellow - 0.5** MPa, than *actual transpiration is very limited*

clear cuts = decrease of air humidity!

4. **Air humidity determines the *potential transpiration***

   while

   soil moisture regulates the *actual transpiration*

   as different they are as high stress acts

5. ***N. spruce*** is highly predisposed for ***drought sensitivity*** (compared to e.g. Scotts pine) - it is due to different requirements of species for the soil water content (+ ontogenetic development).
6. To ***increase the resistence*** of N. spruce to drought = ***to reduce its transpiration*** = growing in **mixtures**

Horáček et al. 2018; CzechGlobe

Drought stress - Consequences for FOREST STRUCTURE

Proposal of adaptation treatment to mitigate the impact of drought stress in conifers …

1. Prevailing **wind** direction and speed, **relative air humidity** and **soil moisture:**

   the most important microclimatic conditions

   necessity to avoid clear cuts!

1. The **circulation of dry air increases the transpiration more than the air temperature**.

2. <u>*To mitigate long-term drought stress:*</u>

   to support trees with treatments (silviculture interventions) ***leading to*** **increasing humidity in the crown layer**

1. **The crucial need of 'microclimate care':**

   a) forest structure = key parameter for the forest stand microclimate (to avoid clear fells)

   b) heterogenity of canopy surface = air flow (speed) reduction and/or the reduction of evapotranspiration

   c) tree dimensions´ and tree species modification = different vulnerability for drought stress both for different tree species and different sizes (ontogenetic stages)

Horáček et al. 2018; CzechGlobe

Drought stress - Consequences for FOREST STRUCTURE

The importance of tree species mixture - *Hydraulic lift*

results from analyses of 22 dry periods

Volume soil moisture (%) at soil depth (cm)	*Young N. spruce stand*			*Young E. beech stand*		
	Average (%)	Standard deviation	Variation coefficient (%)	Average (%)	Standard deviation	Variation coefficient (%)
W5	13,1	3,1	24	17,1	4,6	27
W20	18,5	3,1	17	15,8	3,6	23
W50	22,9	1,3	6	16,3	2,1	13

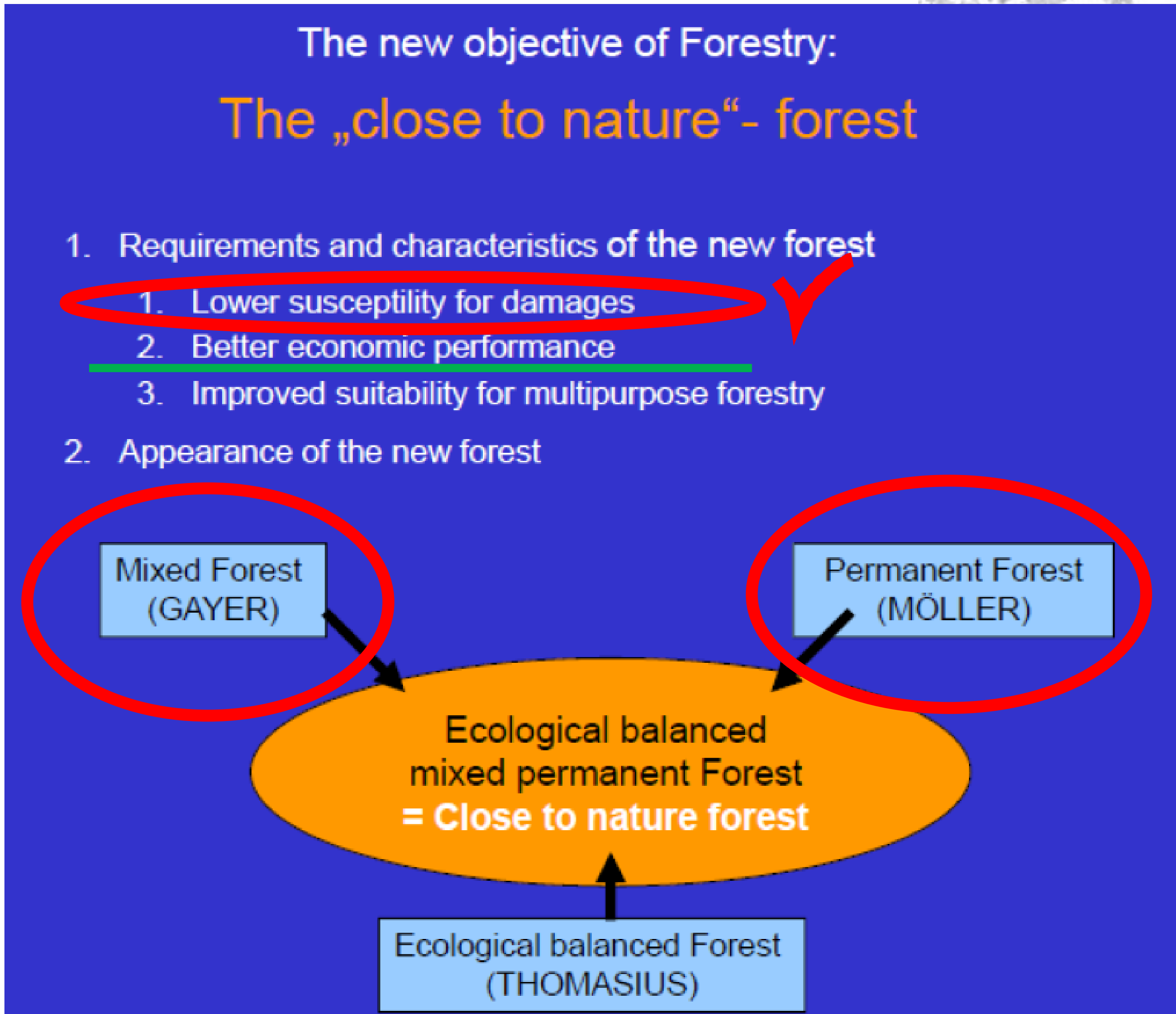
Modelling process:

30% admixture of European beech into the **Norway spruce stand** increased volume soil moisture (VSM) of the upper soil layer (0–10 cm) in dry periods above the range of ***Decrease Availability of soil water for plants*** (4–11% of VSM):

i.e. mitigation of drought stress for N. spruce through admixture of E. beech

Šach, Černohous, 2015; FGMRI

scheme from Tikvić 2016; SUMFAK in Zagreb

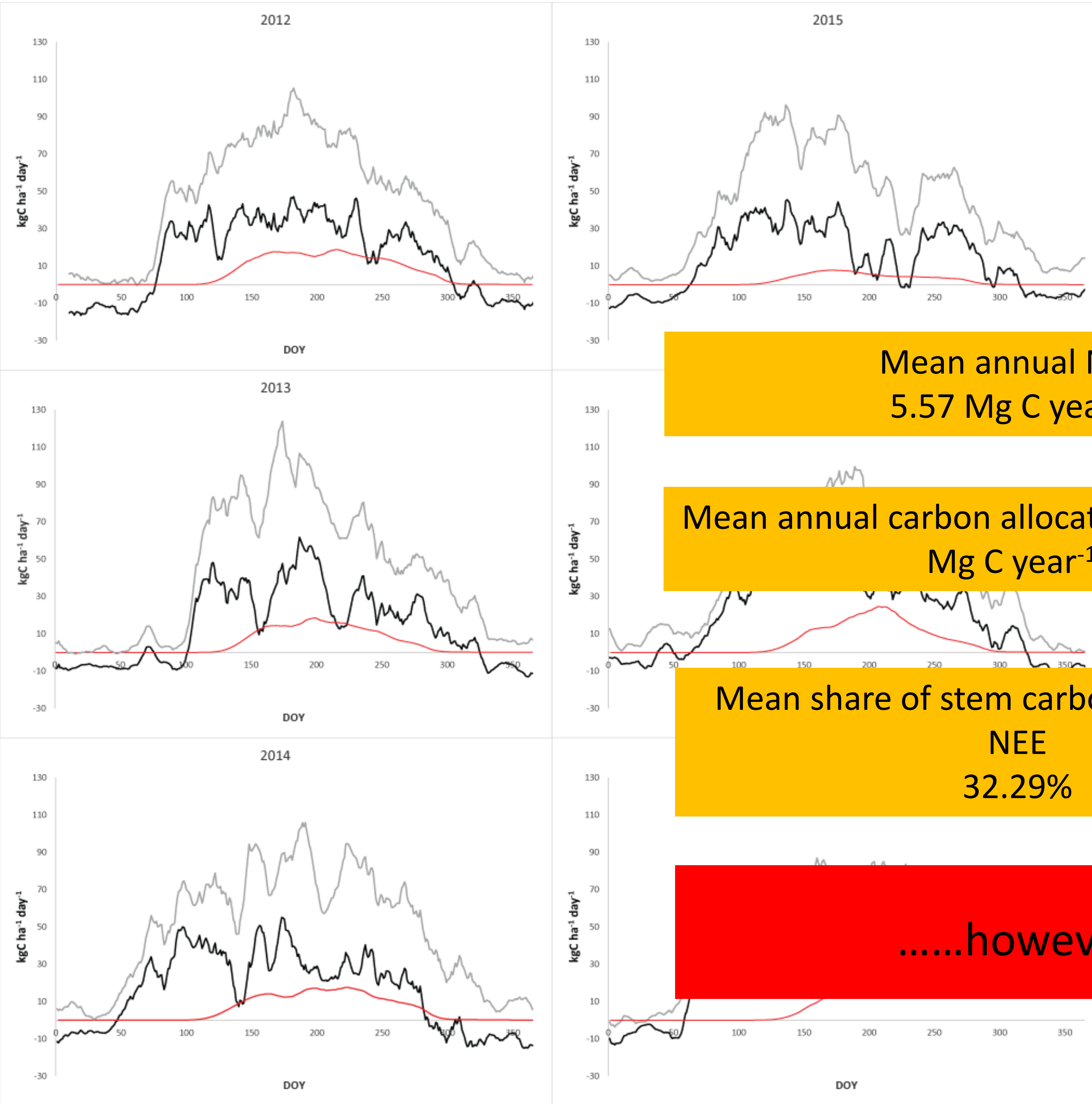


Forest production - Consequences of drought stress

example of:

pure eve-aged mature N. spruce stand

(permanent research plot Rájec)



Mean annual NEE
5.57 Mg C year^{-1}

Net Ecosystem Exchange

Mean annual carbon allocation to stem 1.80 Mg C year^{-1}

All data per hectare

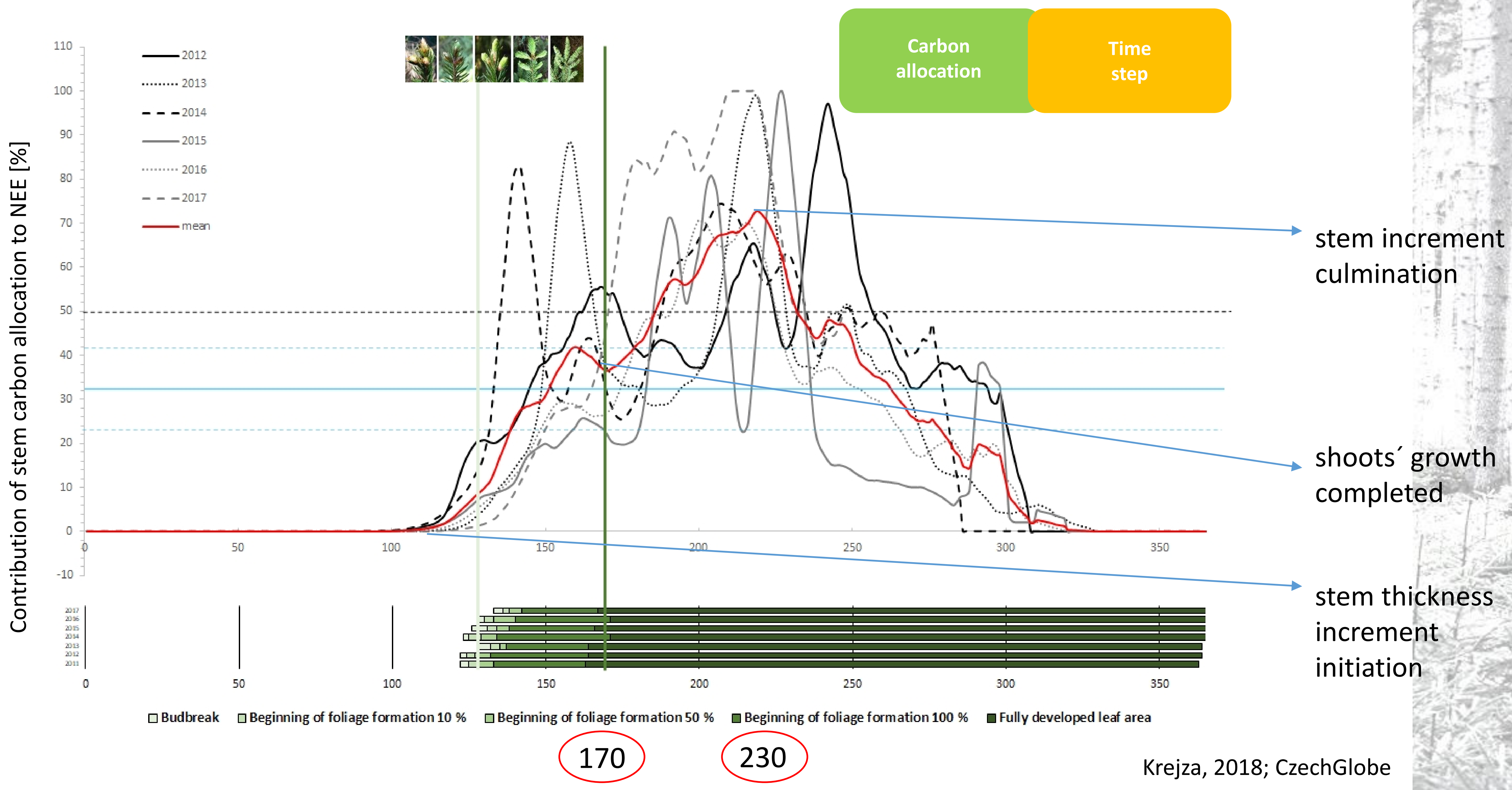
Mean share of stem carbon allocation to NEE
32.29%

……however

Krejza, 2018; CzechGlobe

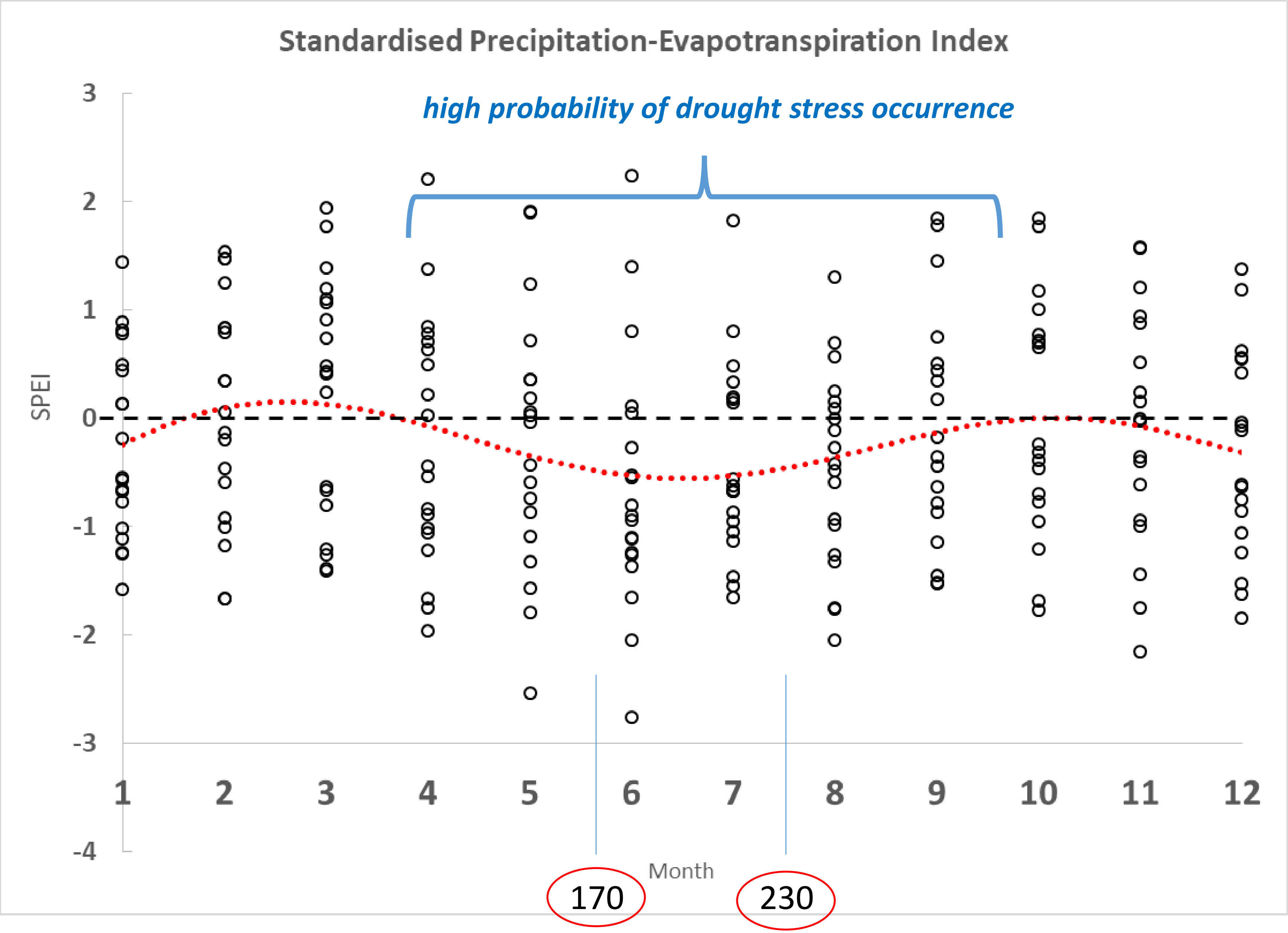
Forest production - *Consequences of drought stress*

Permanent research plot Rájec



Krejza, 2018; CzechGlobe

Forest production - Consequences of drought stress



Permanent research plot Rájec

Pure eve-aged mature

N. spruce stand

Krejza, 2018; CzechGlobe

Forest production - Consequences of drought stress

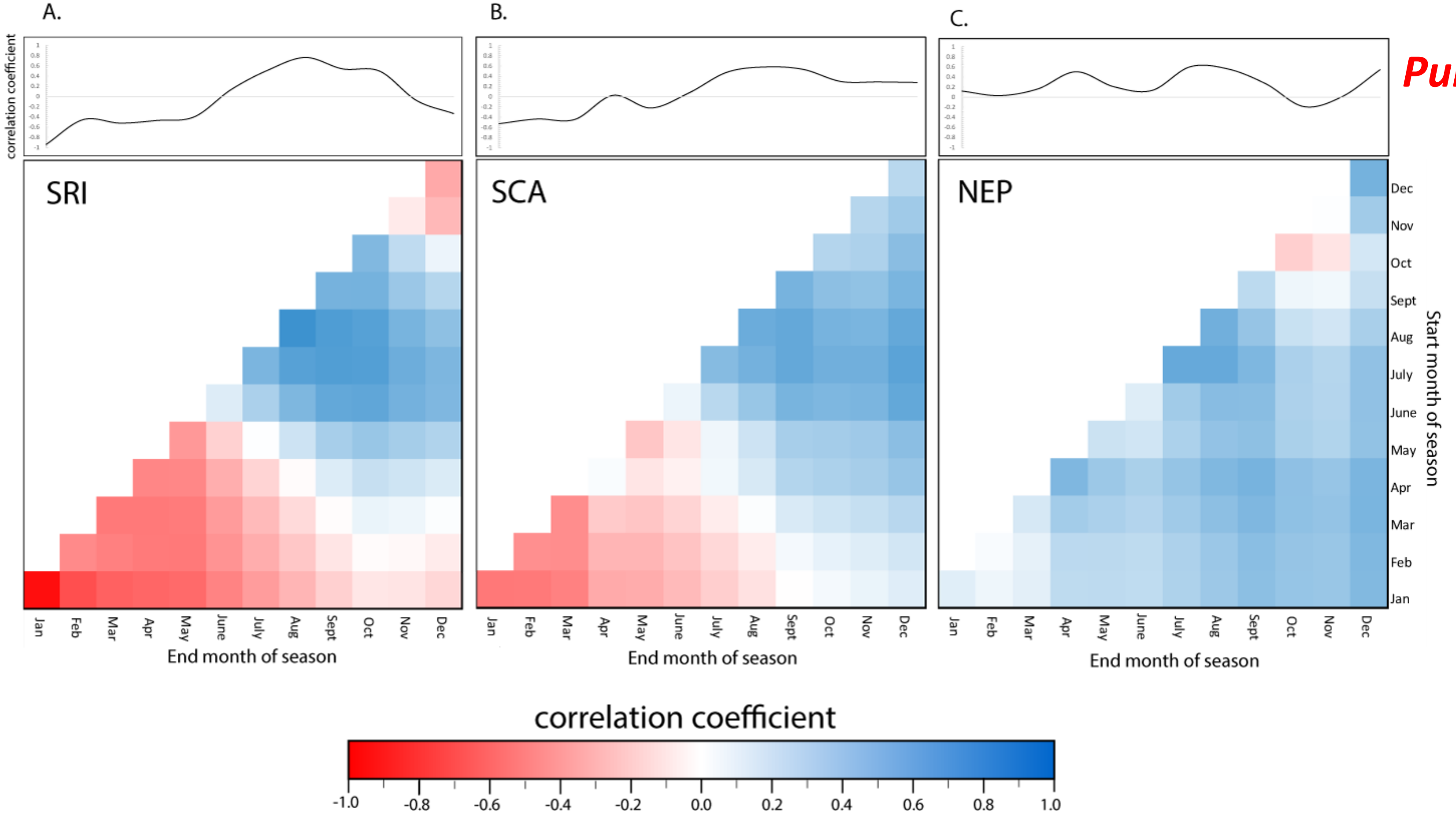
Permanent research plot Rájec

Pure eve-aged mature N. spruce stand

SRI: annual stem radial increment *(more dependent on radial growth of cells)*

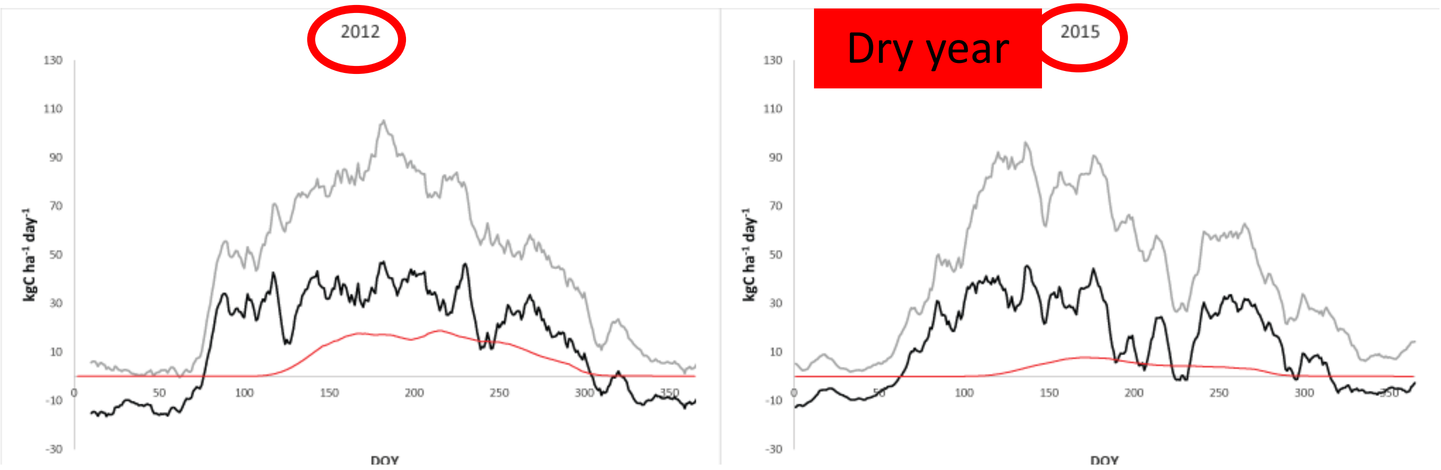
SCA: annual stem carbon allocation (more dependent on cells´ walls thickening)

NEP: annual net ecosystem production



Correlation coefficient of linear regression between the (SPEI) ***Standardized Precipitation and Evaporation Index*** (from monthly (1st diagonal) to annual scale (the last value in right bottom)) and ***(A.) annual stem radial increment (SRI)***, ***(B.) annual stem carbon allocation (SCA)*** and ***(C.) annual net ecosystem production (NEP)***.

Krejza, 2018; CzechGlobe



Forest production - Consequences of drought stress

Permanent research plot Rájec

Pure eve-aged mature N. spruce stand

Net Ecosystem Exchange

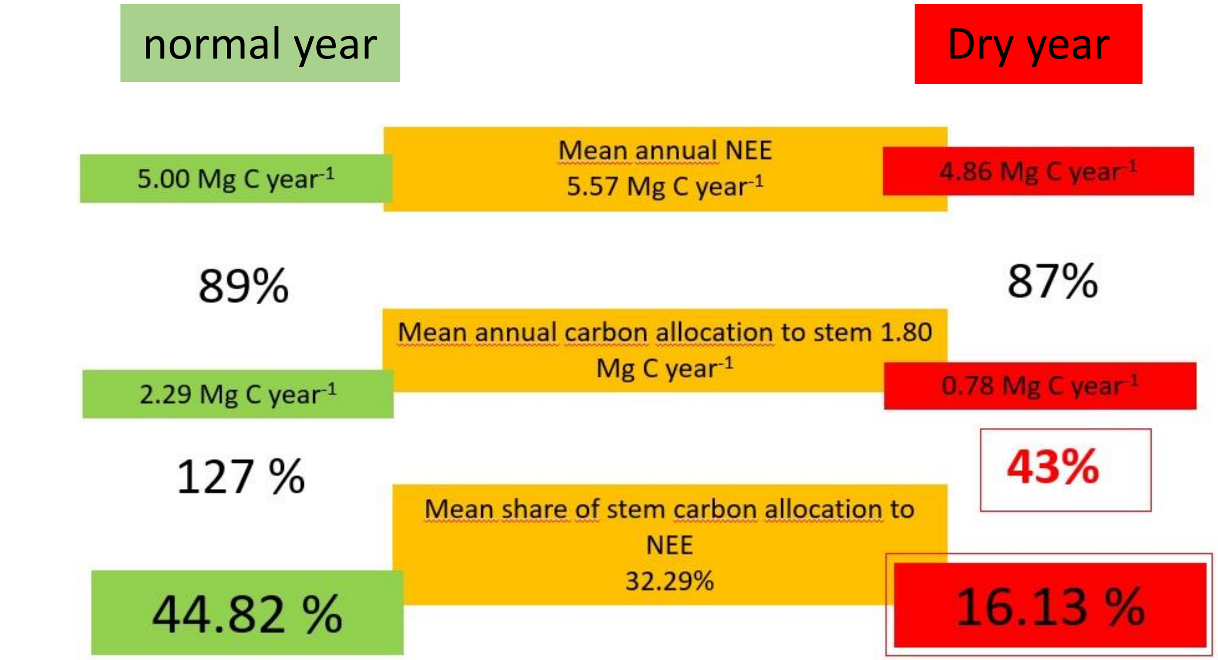
All data per hectare

2012	Mean	2015 (Dry year)
5.00 Mg C $year^{-1}$	Mean annual NEE 5.57 Mg C $year^{-1}$	4.86 Mg C $year^{-1}$
89%		87%
2.29 Mg C $year^{-1}$	Mean annual carbon allocation to stem 1.80 Mg C $year^{-1}$	0.78 Mg C $year^{-1}$
127 %		**43%**
44.82 %	Mean share of stem carbon allocation to NEE 32.29%	16.13 %

Krejza, 2018; CzechGlobe

Forest production:

Consequences of drought stress



Krejza, 2018; CzechGlobe

*Example of **pure eve-aged mature N. spruce stand** under drough stress*

DROUGHT STRESS:

NOT ONLY AN ISSUE OF VITALITY AND SURVIVAL, BUT ALSO AN ISSUE OF THE FOREST PRODUCTION AND OF AN ABILITY TO FULLFIL ECOSYSTEM SERVICES (LIKE CARBON STORAGE IN FORESTS).

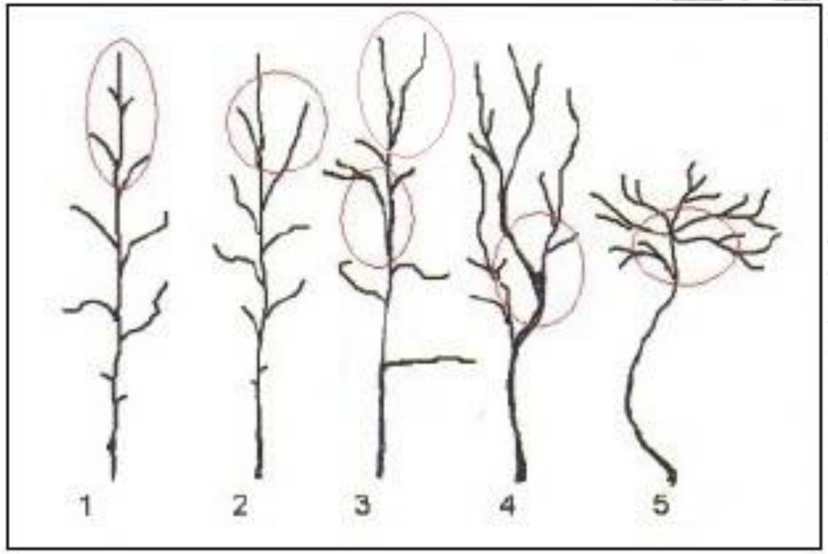
Forest tree species composition, forest structure and all particular silvicultural measures (interventions) have to lead to minimize drought stress also for reasons of higher forest production and better fulfilling of ecosystem services.

Forest production - NATURE AUTOMATION

A. Positive effect of overstorey on growth, stability and quality development of understorey

∑ 6121 individuals at the age of 5 - 20 years

- *height*
- *DBH*
- *quality* →
- HDR ratio
- RHG
- RRG
- hemispherical photos



in total: 37 research plots

plus other issues

ID of research plot	yars after planting: 20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5
Cl	14	14	14	14		33	33	33	33	33		20	20	20	20	20
Cl		34	34	34		36	36	36					25	25	25	
SCl	5	5	5	5		34	34	34					16	16	16	
SCl		35	35	35		37	37	37		31	31	31	31	23	23	
SCl													18	18	18	18
GP		21	21	21	21	21	29	29	29	29	29		19	19	19	
GP							13	13	13		17	17	17	17	17	
GP			30	30	30	30	30				22	22	22			
GP						32	32	32	32	32			15	15	15	
GP											24	24	24	24		
SW-C	7x	7x	7x	7x						4zz	4zz	4xz			2x	2x
SW-C		6x	6x	6x			3zz	3xz	3xz			26x	26x	26x	26x	
SW-C				8x	8x	8x			27x	27x	27x	27x				
SW-C				9x	9x	9x	9x			28x	28x	28x	28x			
SW-C						11x	11x	11x		1zz	1zz	1xz				
SW-C					12x	12x	12x	12x								
SW-C					10x	10x	10x	10x								

SW-C - shelter-wood cut; GP - gap cut; SCl - small clearing; Cl - large clearing

Bednář, 2016; FGMRI

Forest production - NATURE AUTOMATION

A. Positive effect of overstorey on growth, stability and quality development of understorey

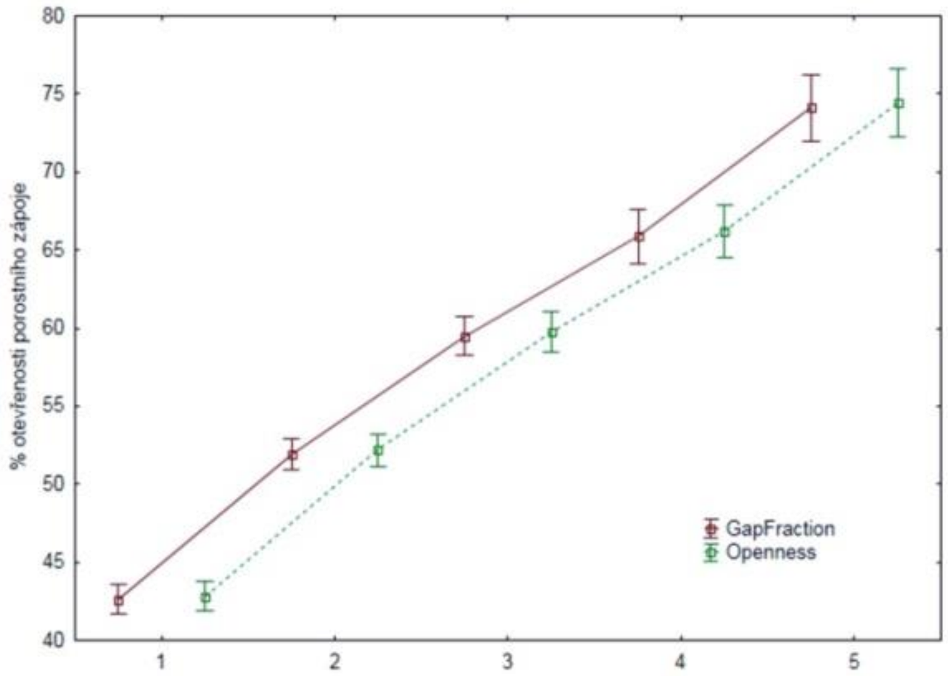
Observed and compared regeneration fellings:

- shelter-wood cut
- gap cut *(0.05 – 0.12 ha)*

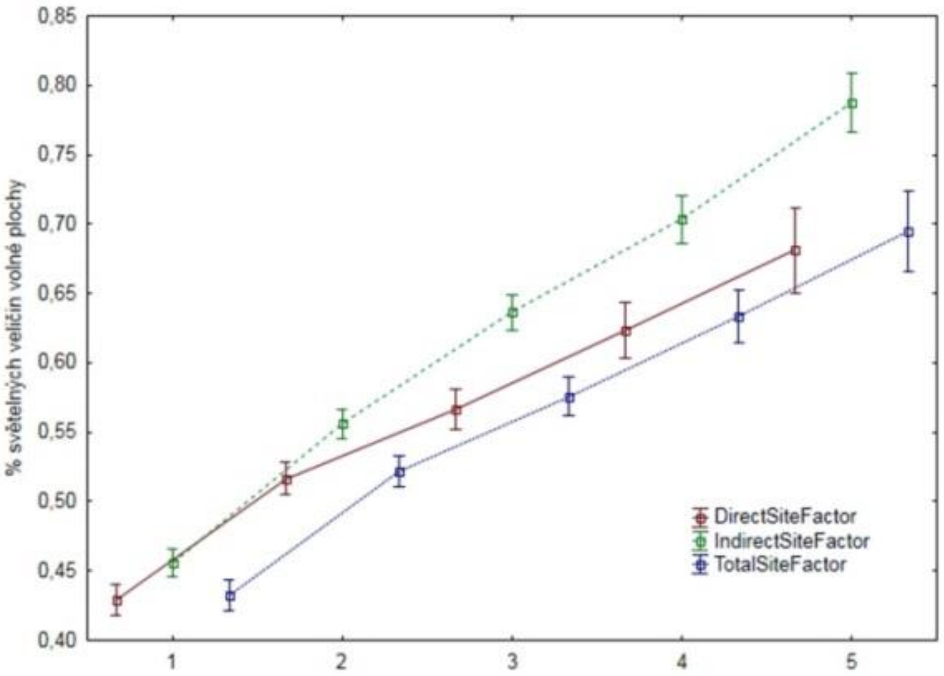
} **CCF**

- small clering *(0.25 – 0.33 ha)*
- large clearing *(0.5 ha +)*

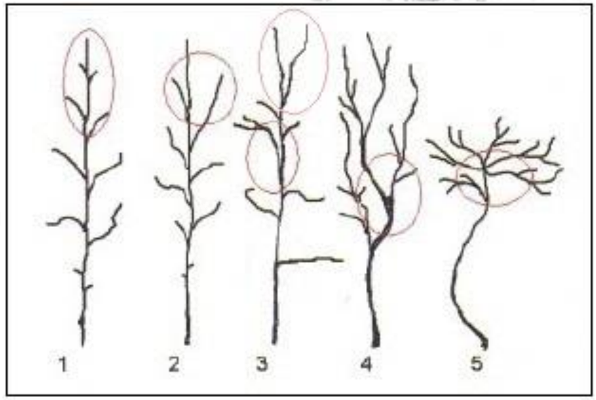
- SIGNIFICAN INFLUENCE OF LIGHT CONDITIONS ON MORPHOLOGICAL QUALITY OF E. BEECH (DECIDUOUS T.S.)



quality class



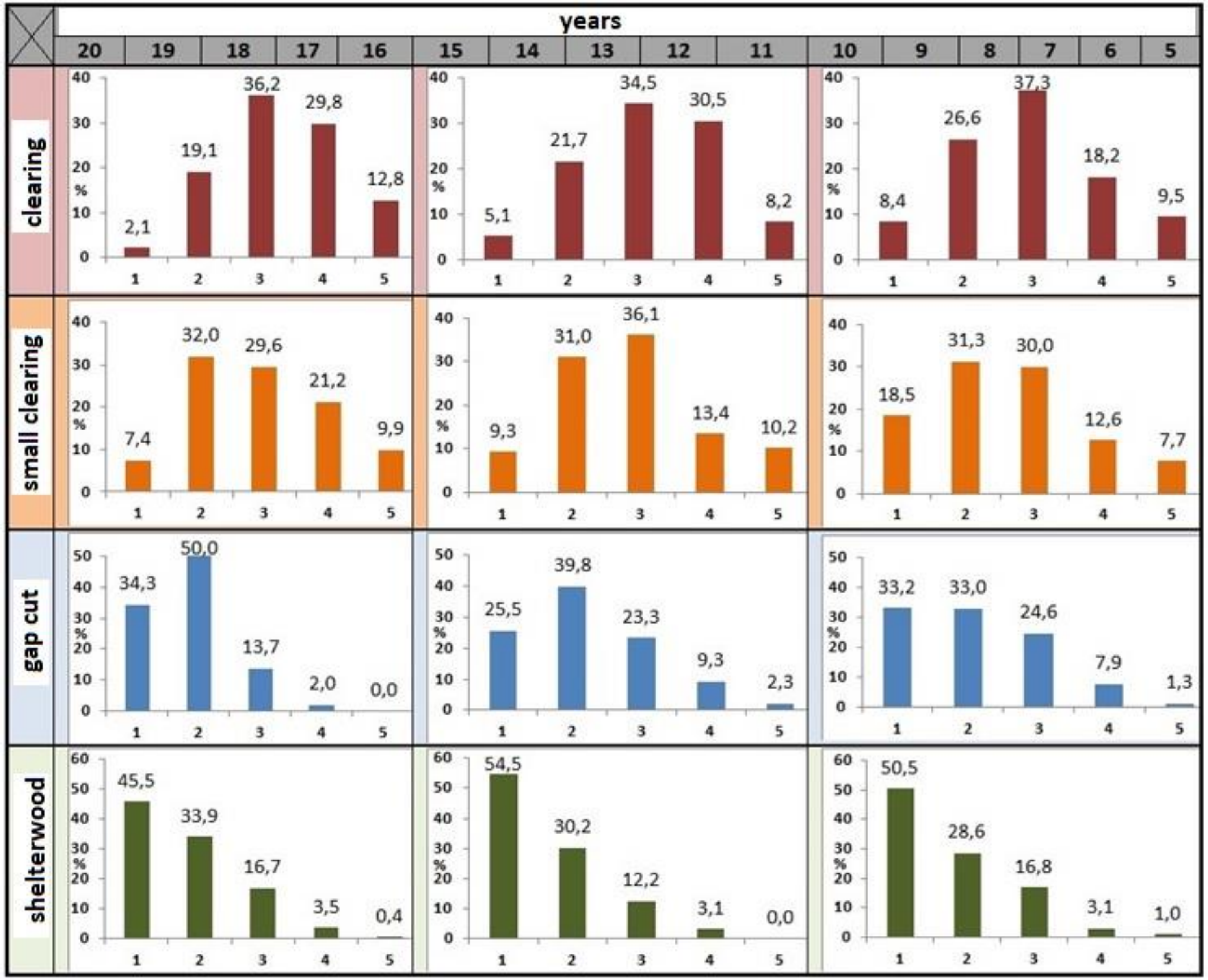
quality class



Bednář, 2016; FGMRI

Forest production - NATURE AUTOMATION

A. Positive effect of overstorey on growth, stability and quality development of understorey

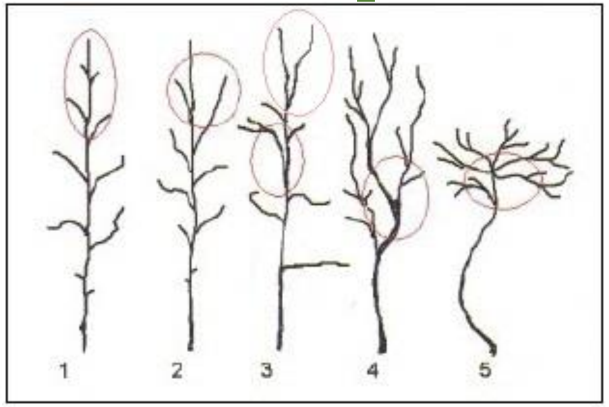


Share (%) of particular quality classes within different regeneration fellings and within different periods after planting

- *All stands were established by the same density of samplings:*

10 thousand/hectare (spacing 1 m x 1 m)

- *Quality class 1 and 2 give preconditions of future high quality development*



Bednář, 2016; FGMRI

Forest production - NATURE AUTOMATION

A. Positive effect of overstorey on growth, stability and quality development of understorey

Destructions

- **96** juveniles harvested
- at the age of ***10*** and ***15 years***

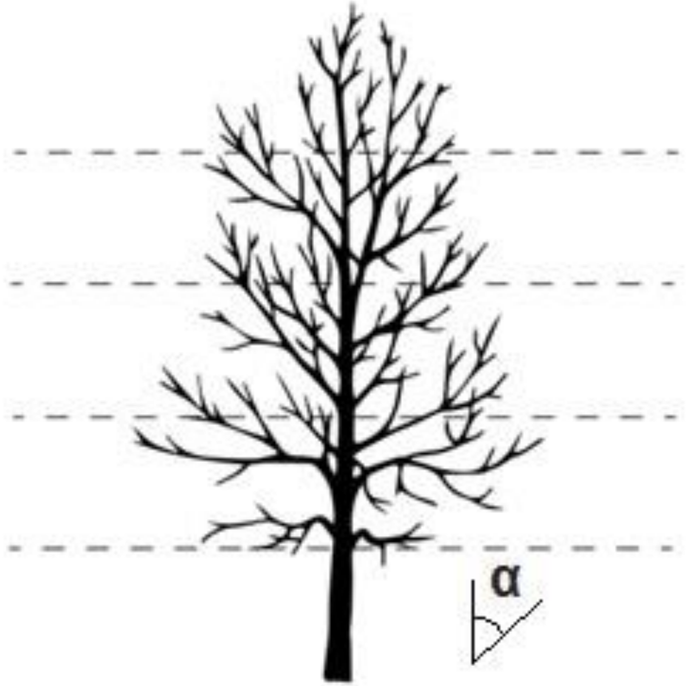
48 + 48

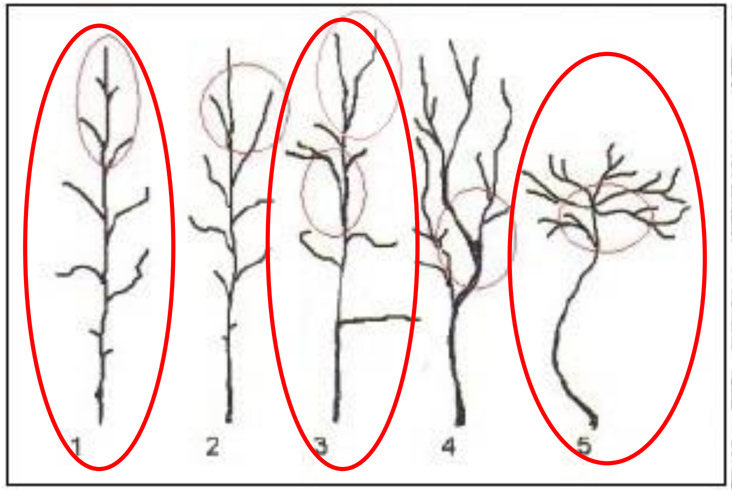
24 + 24 + 24 + 24

gap cut | shelterwood c. | small clearing | clearing

- Selection: 1/3 + 1/3 + 1/3

8 - top q. | 8 - average q. | 8 - low q.





Bednář, 2016; FGMRI

Forest production - NATURE AUTOMATION

A. Positive effect of overstorey on growth, stability and quality development of understorey

No signifficant differences about Branch-Stem-Ratio

Signifficant differences within branch zenith angle

	Branch zenith angle [°] μ ± σ	signifikance
gap cut	68,2 ± 12,5	A
shelterwood	59,1 ± 9,6	B
small clearing	46,1 ± 15,7	C
clearing	45,2 ± 14,5	C

i.e. two individuals reaching currently the same quality class, but growing within two different regeneration fellings have different perpectives of future quality development

	Branch zenith angle [°] μ ± σ	signifikance
shelterwood	65,2 ± 10,1	A
gap cut	62,9 ± 11,7	A
small clearing	54,9 ± 9,8	B
clearing	41,4 ± 15,3	B

i.e.within both clearings there is higher probability of quality decrease (even when particular individual is currently exhibiting sufficient quality)

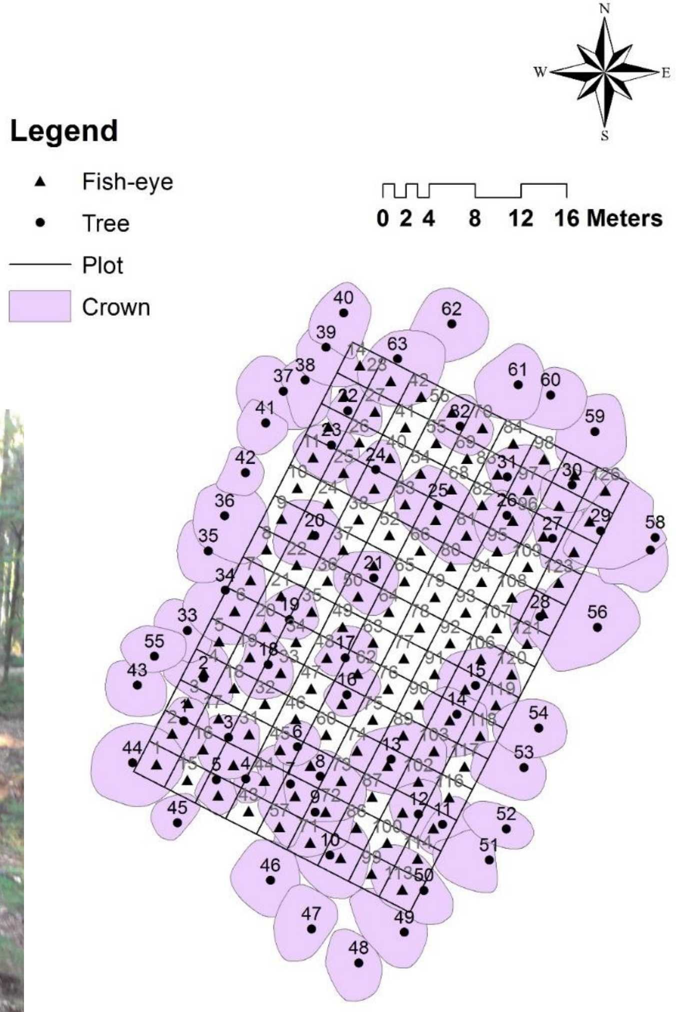
Bednář, 2016; FGMRI

Forest production - NATURE AUTOMATION

B. Positive effect of overstorey on growth, stability and quality development of understorey

Photomorphological plasticity of N. spruce natural regeneration and its growth

- *3 reseach plots*
- *166 sub-plots; 1263 juveniles measured (height range: 10 - 431 cm)*
- *measured: 7 morphological parametres + density*



Bednář, 2016; FGMRI

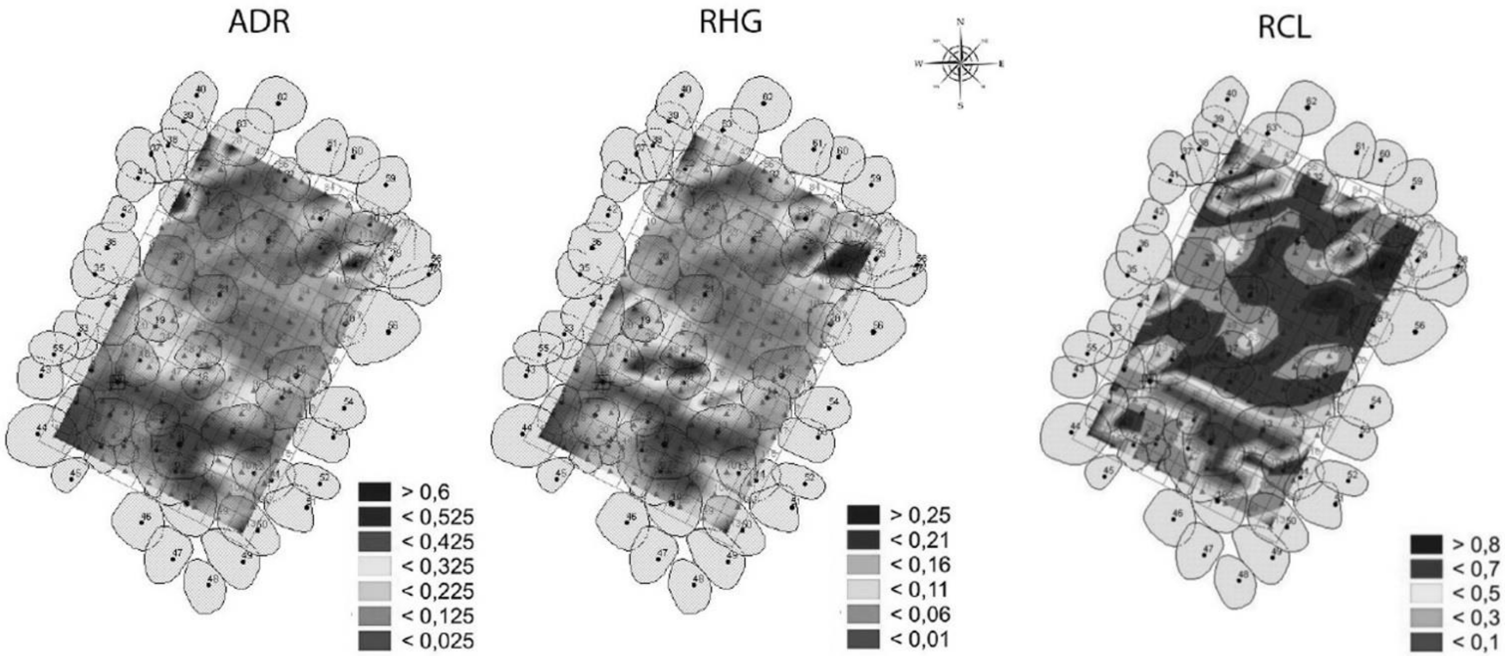
Forest production - NATURE AUTOMATION

B. Positive effect of overstorey on growth, stability and quality development of understorey

Photomorphological plasticity of Norway spruce natural regeneration and its growth dynamic

*There were proved **huge predispositions for photomorphological plasticity** (the levels of height growth; lateral crowth and live crown length - **RHG, ADR, RCL**)*

can be effectivelly used for forest structure initiation and encouragement



POSITIVE DEVELOPMENT OF HDR - ***under shelter HDR is lower*** (height growth suppresed while D is not correlating with light conditions when in open area height growth is intensive while D increment does not correlate with light)

NO NEGATIVE EFFECT OF SHELTER ON DENSITY
(density does not correlate with light conditions)

Bednář, 2016; FGMRI

Forest production - NATURE AUTOMATION

C. Positive effect of shelter-wood cut on forest production and stability of mature N. spruce overstorey

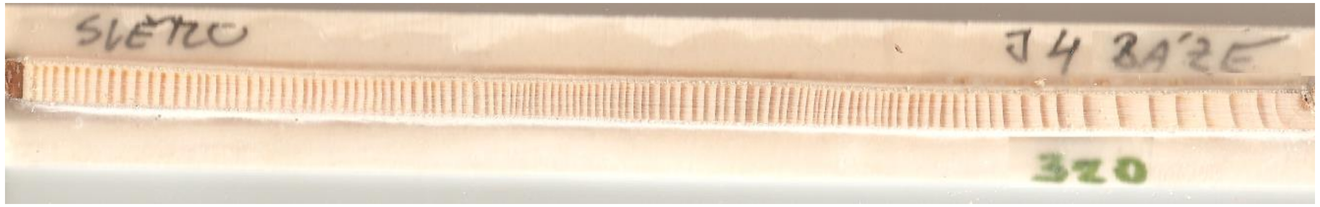
DENDROCHRONOLOGICAL ANALYSES

- 3 vertical levels

- different cardinal points (N x S x W x E)

In total 480 core dendrochronological samples

↳ ***from 80 trees***



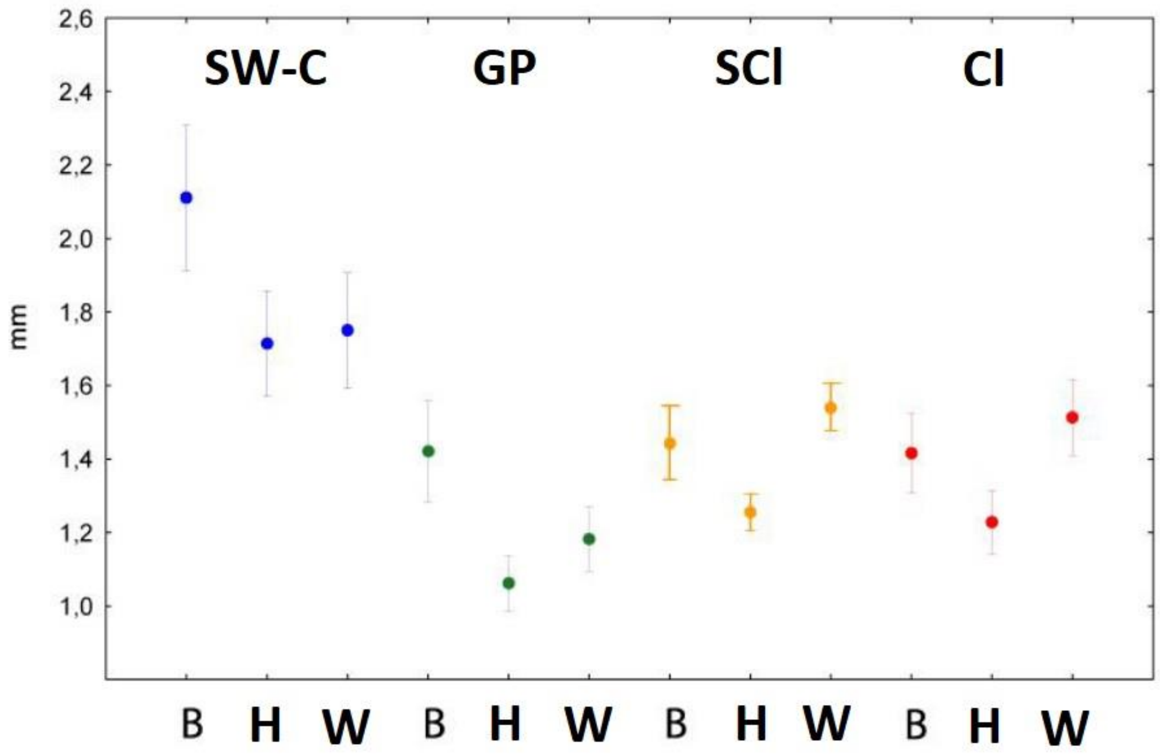
Bednář, 2016; FGMRI

Forest production - NATURE AUTOMATION

C. Positive effect of shelter-wood cut on forest production and stability of mature N. spruce overstorey

Within shelter-wood cut and around gap cut: allocation of increment onto basal part of stem (making convergent shape of stem)

Around small clearing and clearing: increment into higher parts of stem - first live whorl (making cylindric shape of stem)



⬇

Changes within position of centre of gravity = changes of mechanical stability/lability

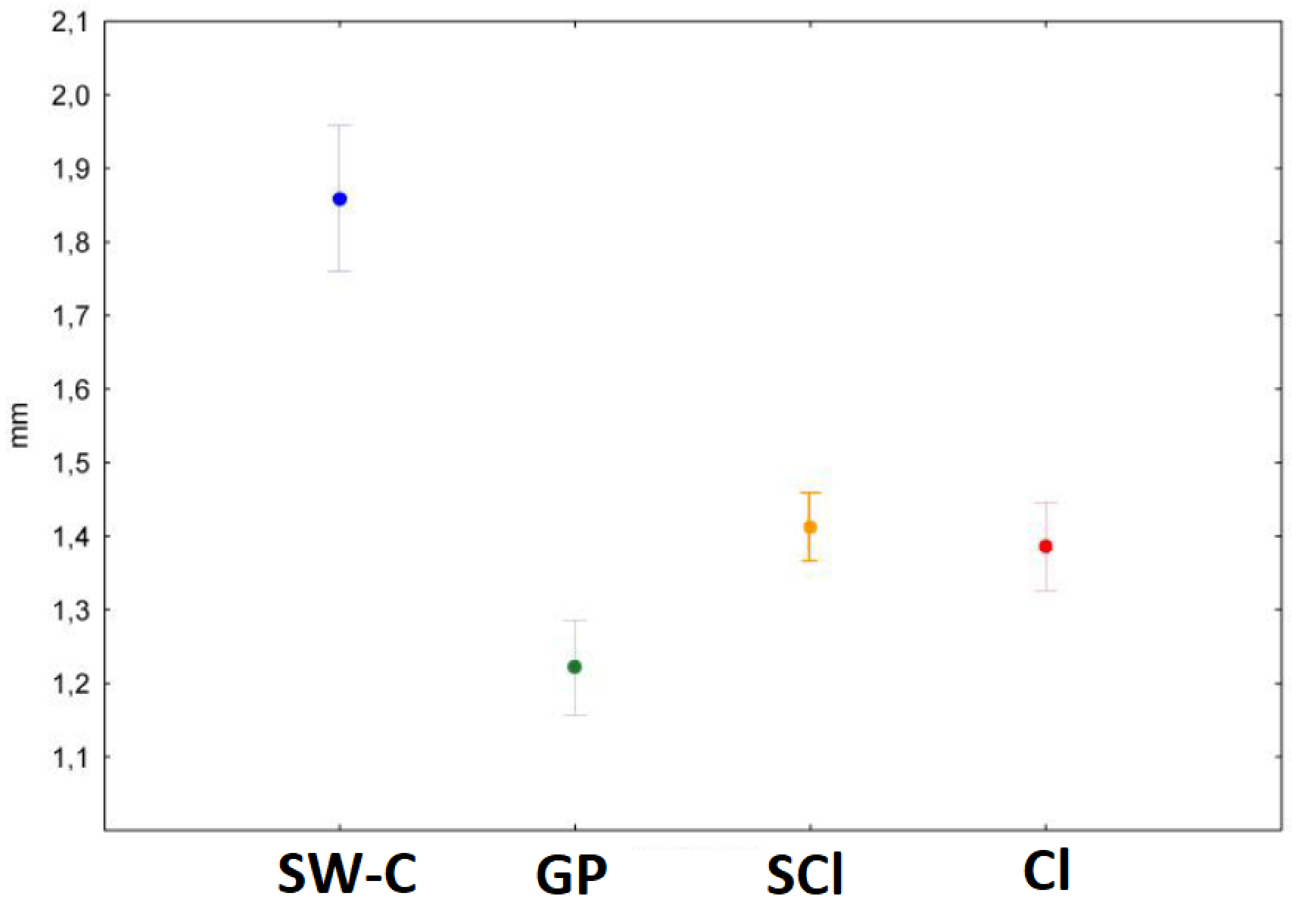
SW-C: *shelter-wood cut;* ***GP:*** *gap cut;* ***SCl:*** *small clearing;* ***Cl:*** *clearing;* ***B:*** *base (DBH);* ***H:*** *half of stem;* ***W:*** *first live whorl (live crown base)*

Bednář, 2016; FGMRI

Forest production - NATURE AUTOMATION

C. Positive effect of shelter-wood cut on forest production and stability of mature N. spruce overstorey

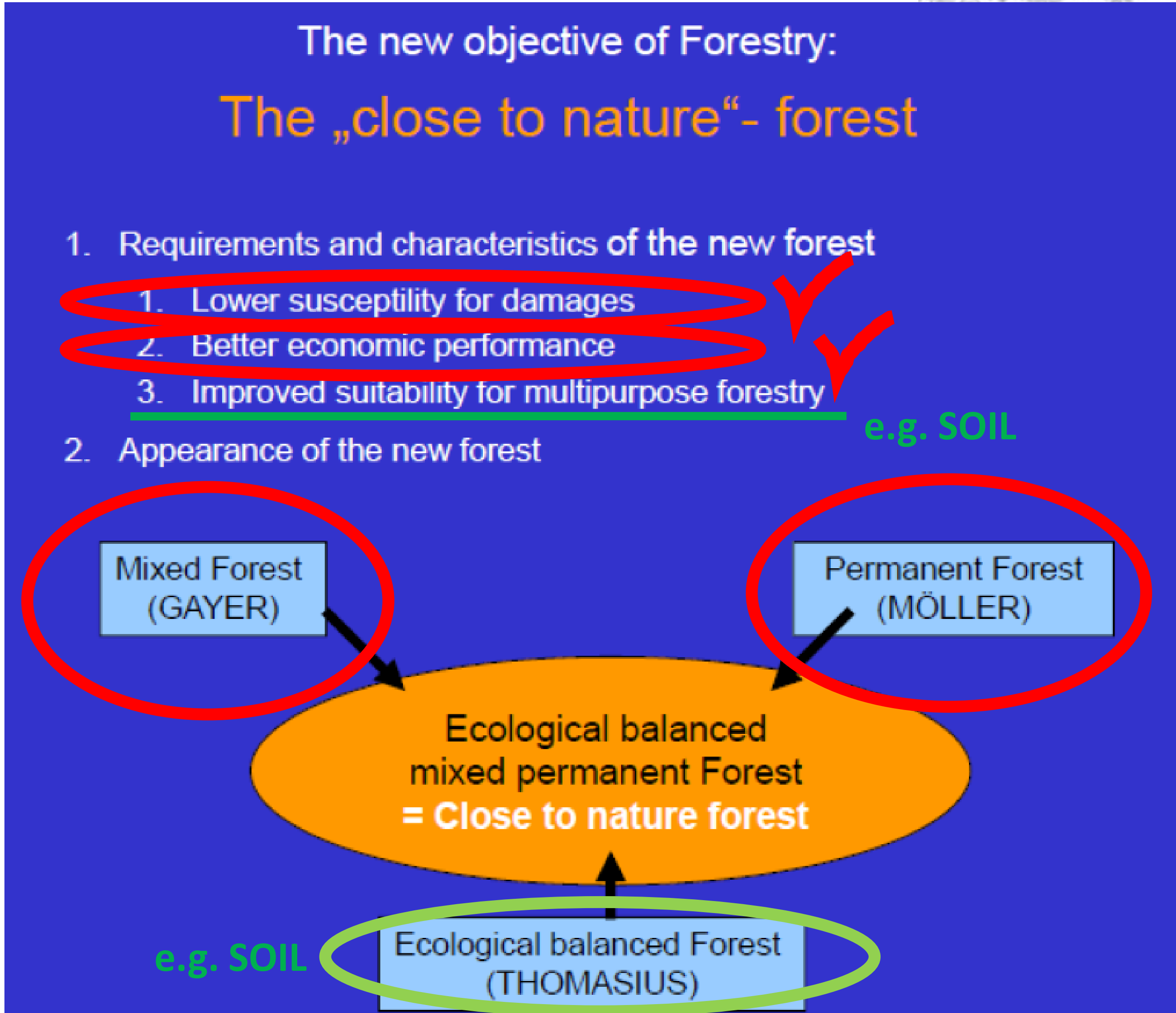
- *The highest increment (tree ring width) was significantly proved wihin shelterwood cut*
- *In adition, when increment of value would be considerent, an advantage of shelter-wood cut would be even bigger (due to allocation into basal part of a stem)*
- *Within shelter-wood cut and around gap cut the stability was improved also due to allocation on the side of the stem according to prevailing direction of wind (non-presendted data)*



***SW-C:** shelter-wood cut; **GP:** gap cut; **SCl:** small clearing; **Cl:** clearing*

Bednář, 2016; FGMRI

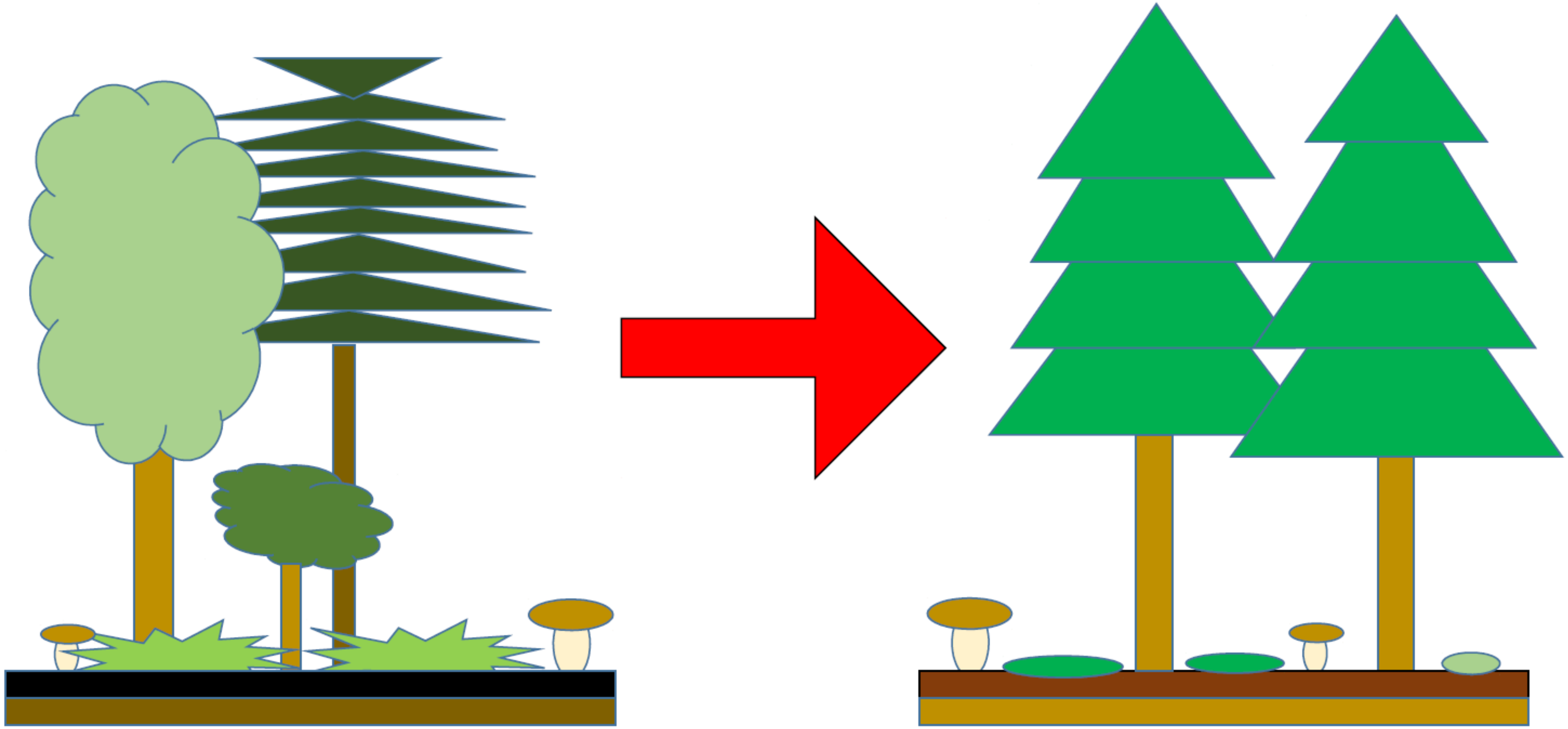
scheme from Tikvić 2016; SUMFAK in Zagreb



Forest SOIL - “The Breadbasket for forest ecosystem“

Changes in soil chemistry and humus accumulation,

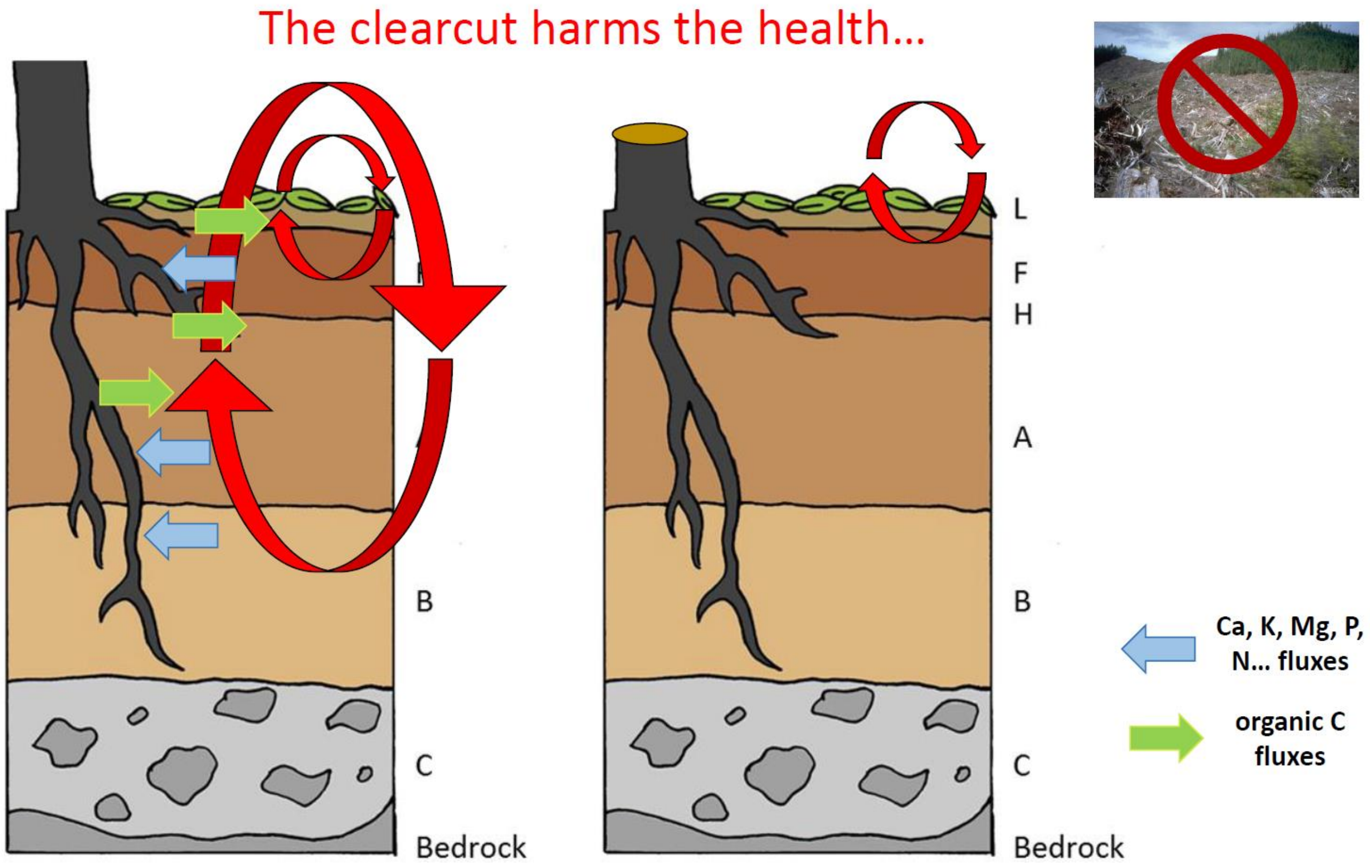
Slow acidification of stands on sites previously occupied by mixed forests



Rotter 2018; Silva Taroucy - VUKOZ

Forest SOIL - “The Breadbasket for forest ecosystem “

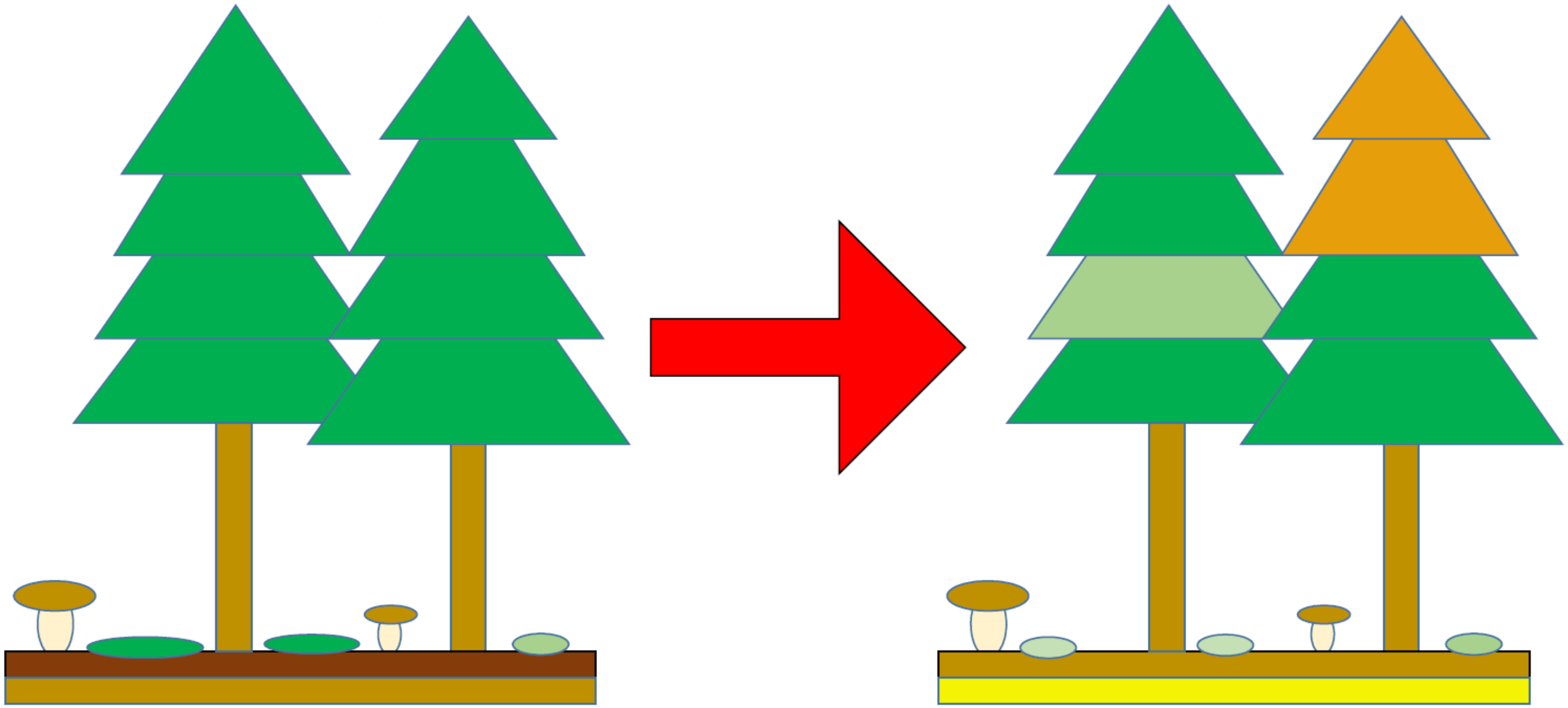
<u>Basic ions are migrating deeper</u> into soil <u>or out</u> from the ecosystem; <u>mycorrhiza is replaced</u> by saprophytic species; <u>loss of litterfall</u> after clearcuts



Rotter 2018; Silva Taroucy - VUKOZ

Forest SOIL - “The Breadbasket for forest ecosystem “

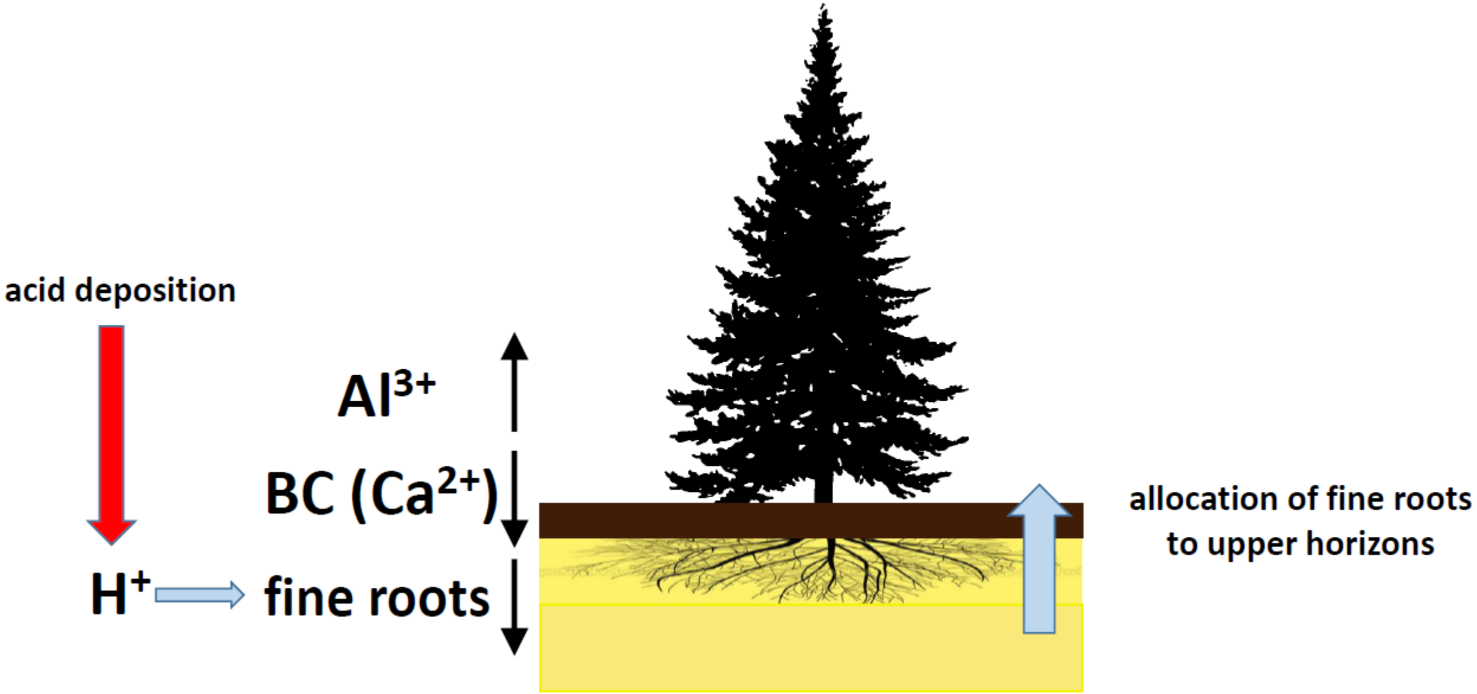
Deep chronic changes in soils: *the loss of base ions, mobilization/releasing (from complexes) of free Al3+ damaging fine roots (acts toxically), suppression of microbial activity* =**soil is increasingly poorer in terms of nutrients**



Rotter 2018; Silva Taroucy - VUKOZ

Forest SOIL - “The Breadbasket for forest ecosystem “

Sensitivity to drougth stress is incresing (accumulation of fine roots in upper soil horizonts)

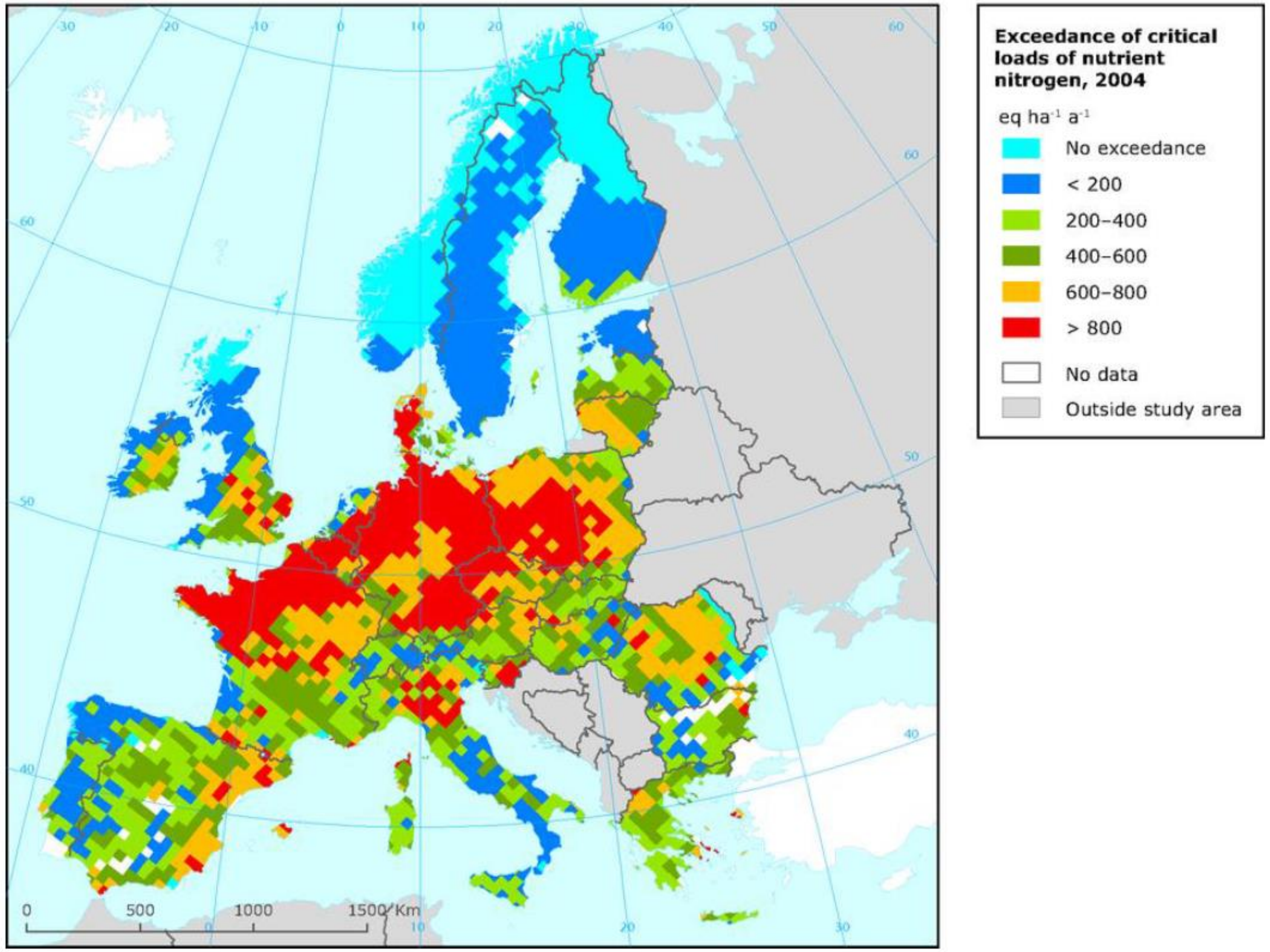


In aditions, there will be further problems, mainly N deposition.

Rotter 2018; Silva Taroucy - VUKOZ

Forest SOIL - “The Breadbasket for forest ecosystem “

Exceedance of critical loads…

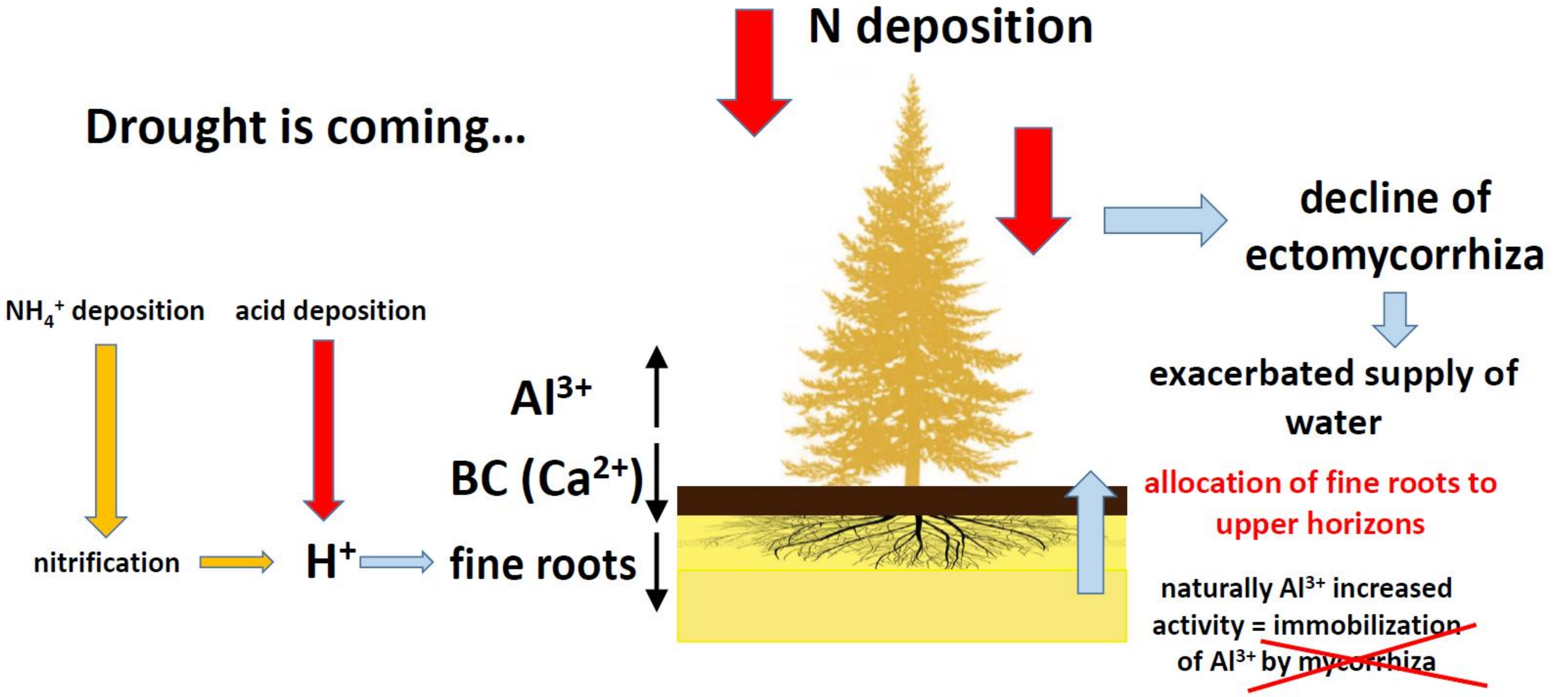


European Environment Agency

Rotter 2018; Silva Taroucy - VUKOZ

Forest SOIL - "The Breadbasket for forest ecosystem "

Synergisms between deterioration of soil and climate change



Carter et al., *Ecosphere* (2017); Brunner et al., *Frontiers in plant science* (2013)

Forest SOIL - "The Breadbasket for forest ecosystem "

- ***Mixed tree species composition can help also here***

Mycorrhiza differs in its sensitivity to nitrogen deposition

low sensitivity to N deposition

arbuscular mycorrhizal fungi (AM) + rapid litter decomposition

maple, elm, ash, cherry-tree, rowan

both of AM and EM + mediate litter decomposition

linden, poplar

beech, oak, hornbeam, birch

ectomycorrhizal fungi (EM) + slow litter decomposition

fir, spruce

pine

high sensitivity to N deposition

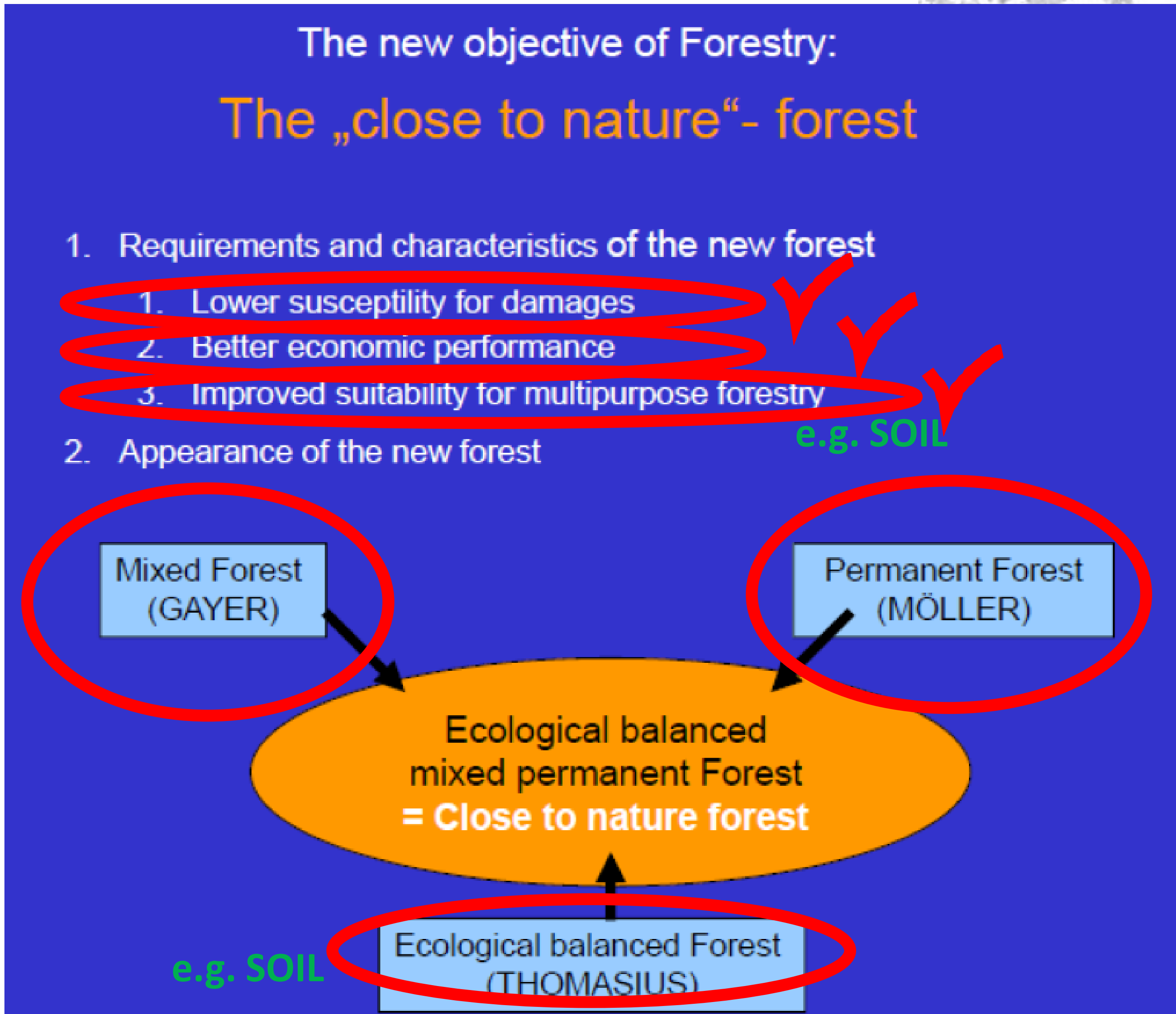
Rotter 2018; Silva Tarouncy - VUKOZ

Forest SOIL - "The Breadbasket for forest ecosystem "

To care about the health of soil... key pre-condition for forest existence under GCC

- *To avoid clear-cuts to avoid losses of mycorrhizal network and subsequent loss of nutrients*
- *To avoid pure coniferous forest stands causing gradual soil acidification and subsequent losses of basic ions*
- *To use broadleaves especially those with deep rooting systems and appropriate character of litter (e.g. linden, maple etc.)*
- *To take into account the vulnerability of trees to current nitrogen deposition in Europe: what is useful is an admixture of tree species with arbuscular mycorrhizy to mitigate the effect of N deposition*
- *To leave the branches etc. after cutting on the site for decomposition*

Rotter 2018; Silva Tarouçy - VUKOZ



scheme from Tikvić 2016; SUMFAK in Zagreb


Thank you!
ACKNOWLEDGEMENT:
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Czech forestry - Basic description:

Current Czech forestry:

- *Forest cover **– 34% (2,7 million ha)***
- ***Continual increment** of the forest cover **for last decades***
- *Within 2016 **– 1500 ha increment of forest area***
- *Total harvest in 2016: **17,6 million m3** (in 2017: 19 million m3; in 2018: 25,7 million m3)*
- ***9% increment of harvest in 2016** (2016 – third highest total harvest in history, but total harvest both in 2017 and 2018 exeeded 2016)*

Czech forestry - Basic description:

- ***79%*** *of the harvest represented* ***Norway spruce*** *- in 2016*
  (vs. Scots pine – 8 % and European beech – 4 %)

Wood industry narrowly aimed at mainly conifers´ wood processing

- ***State is the biggest forest owner:***
  - *nearly* ***60 %*** *of the Czech forests*
  - *the main State Forest Enterprise = LČR – 48%; VLS – 5% - military areas; Natinal Parks – 5%*