Management of Scots pine (*Pinus sylvestris*) for resilience - a Central European perspective

Eberswalde University for Sustainable Development

IUFRO

centro PINUS

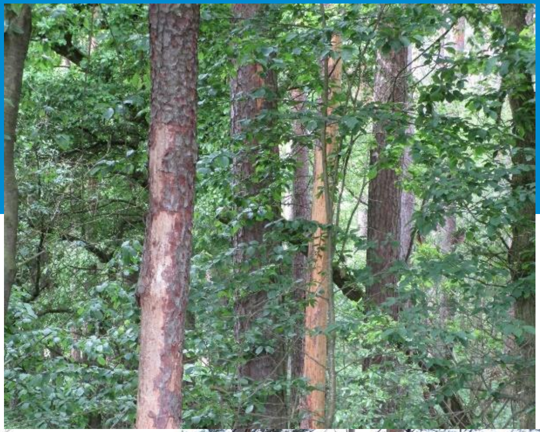
Prof. Dr. Peter Spathelf

March 10, 2022

Ukraine

Protected oak in Scots pine stand, Brandenburg

History




Georg Ludwig H
1764 - 1837
Leiter der preußischen Staatsforst
1811 - 1837
Begründer nachhaltiger Forstw

Outline

- Introduction
- Features of Scots pine forest management in Germany
  - Ecology, growth and robustness
  - Silvicultural systems
  - The question of high-value timber production
- Continuous-Cover Forestry with Scots pine
- Resilient Scots pine forests and management for diverse ecosystem services

https://de.wikipedia.org/wiki/Berlin-Brandenburg

Features of Scots pine forest management in Germany
I. ecology, growth and robustness

Mixed pine forest, city forest of Berlin

Pinus sylvestris: a Eurasian tree species

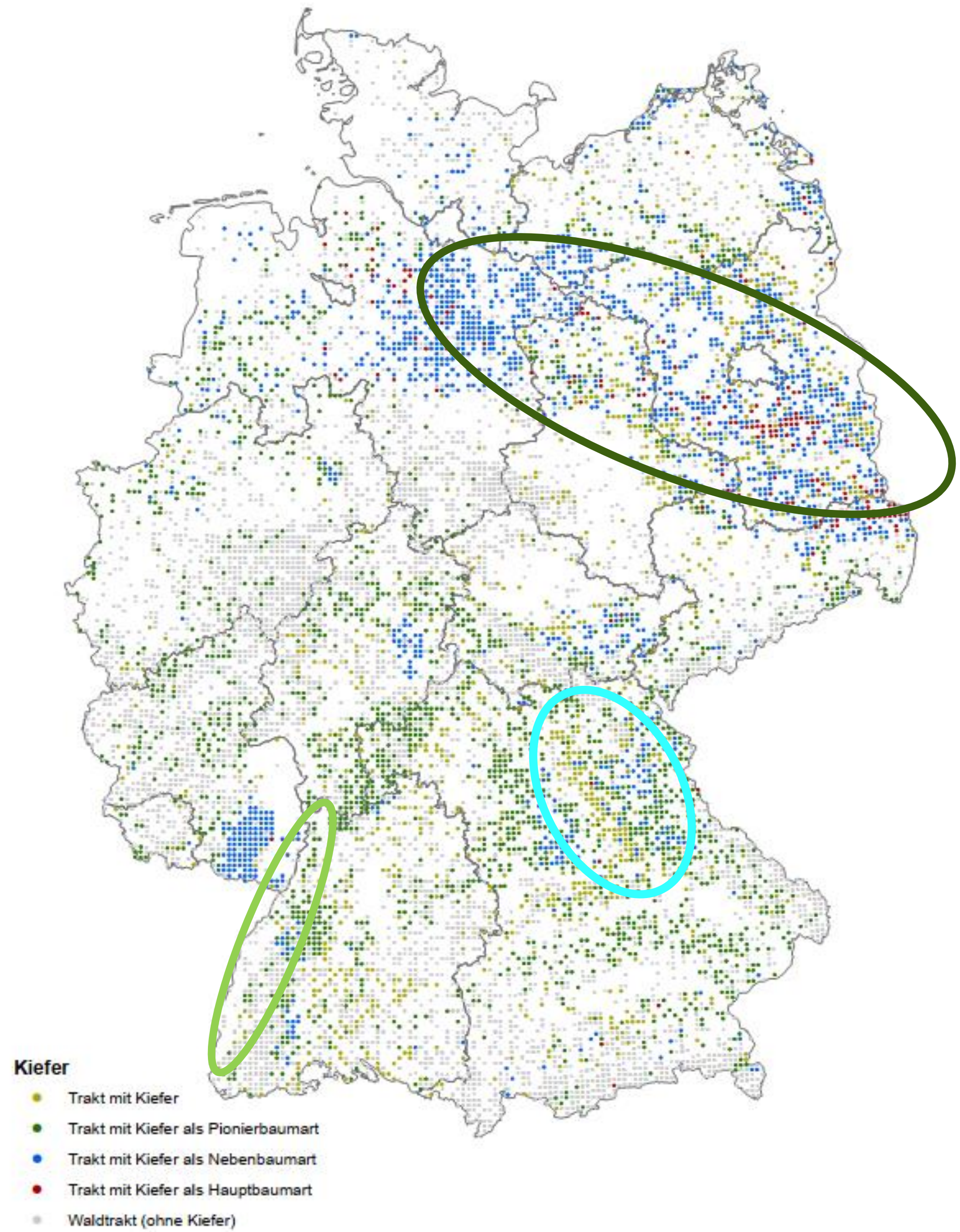
Scots pine:
the most widely distributed pine species in the World!

Source: http://www.euforgen.org/species/pinus-sylvestris/

Pinus sylvestris in Germany

Source: ***https://literatur.thuenen.de*** ***/digbib_extern/dn055892.pdf***

- Northeast Germany (40-70 %)
- Valley of the Rhine river
- Center and northeast of Bavaria
- …



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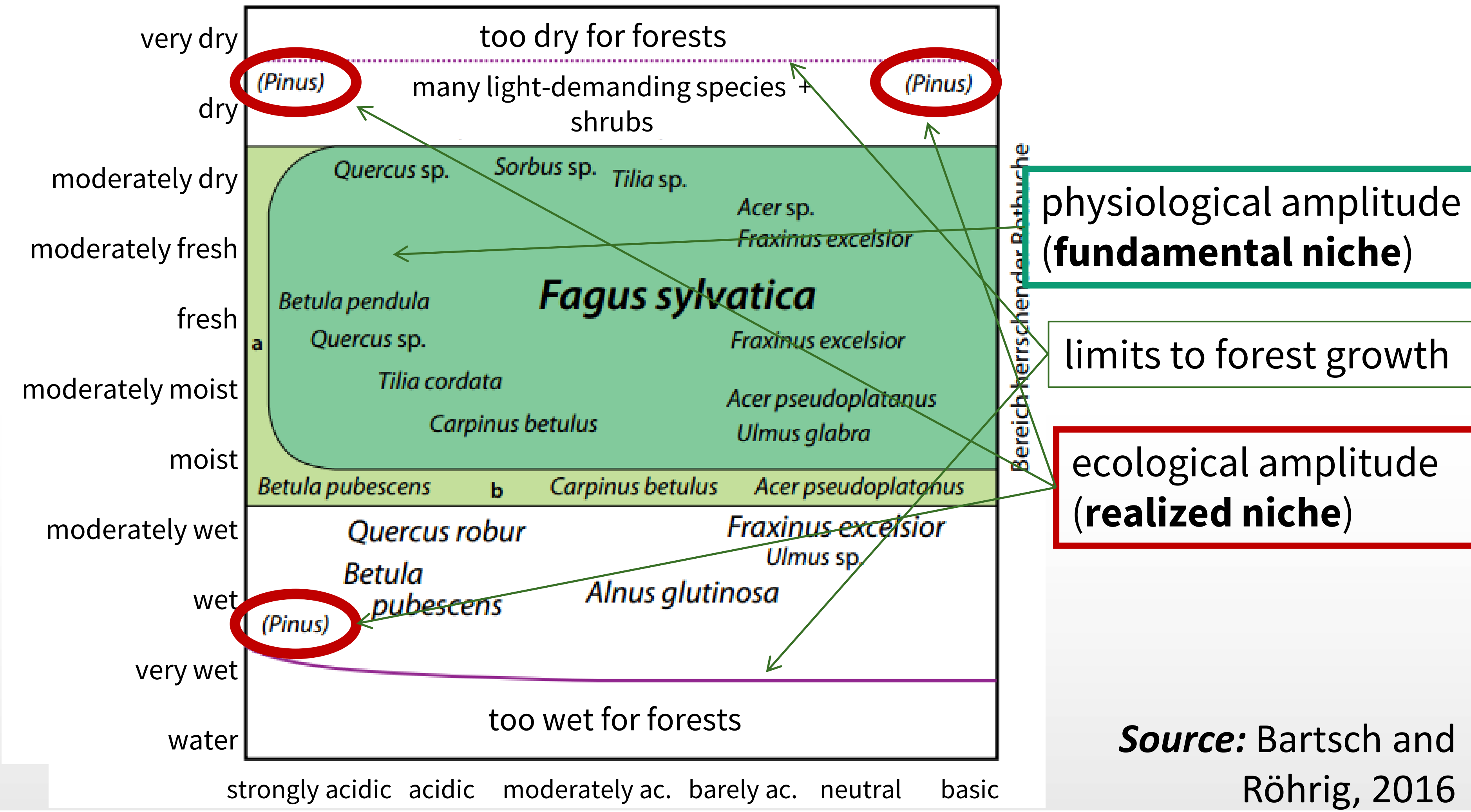
Scots pine: *fundamental* and *realized* ecological niche



Source: Bartsch and Röhrig, 2016

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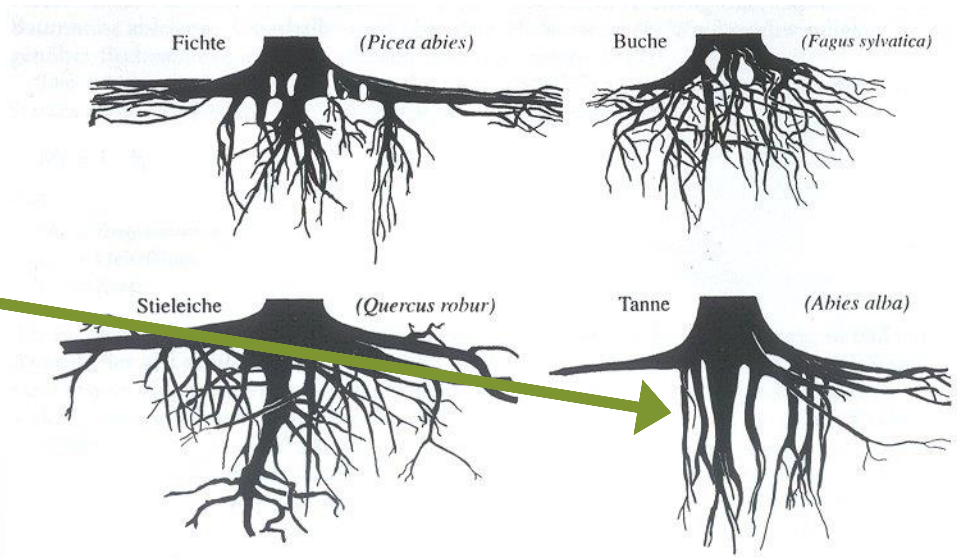
Regeneration guilds

Light demanding vs. shade tolerant tree species

Light requirements	Tree species	Characteristics
Very light demanding	Birch, Larch, **Scots pine**, Aspen, Wild cherry, Black alder, Pedunculate oak	Light demanding tree species Pioneer tree species
Light demanding	Mountain pine, Black pine, White elm, European ash, Sessile oak, Walnut	Semitolerant tree species Pioneer tree species
Intermediate	**Swiss stone pine**, Mountain ash, Norway maple, Field maple, Broad-leaved lime	Intermediate tree species
Shade tolerant	Hornbeam, Mountain elm, Sycamore maple, Chestnut, Small-leaved lime, Norway spruce	Semitolerant tree species Tree species of climax stage
Very shade tolerant	Beech, **Silver fir**, Grand fir, Jew tree, Western red cedar, Western hemlock	Shade tolerant tree species Tree species of climax stage

Root development

From: Schütz, 2002

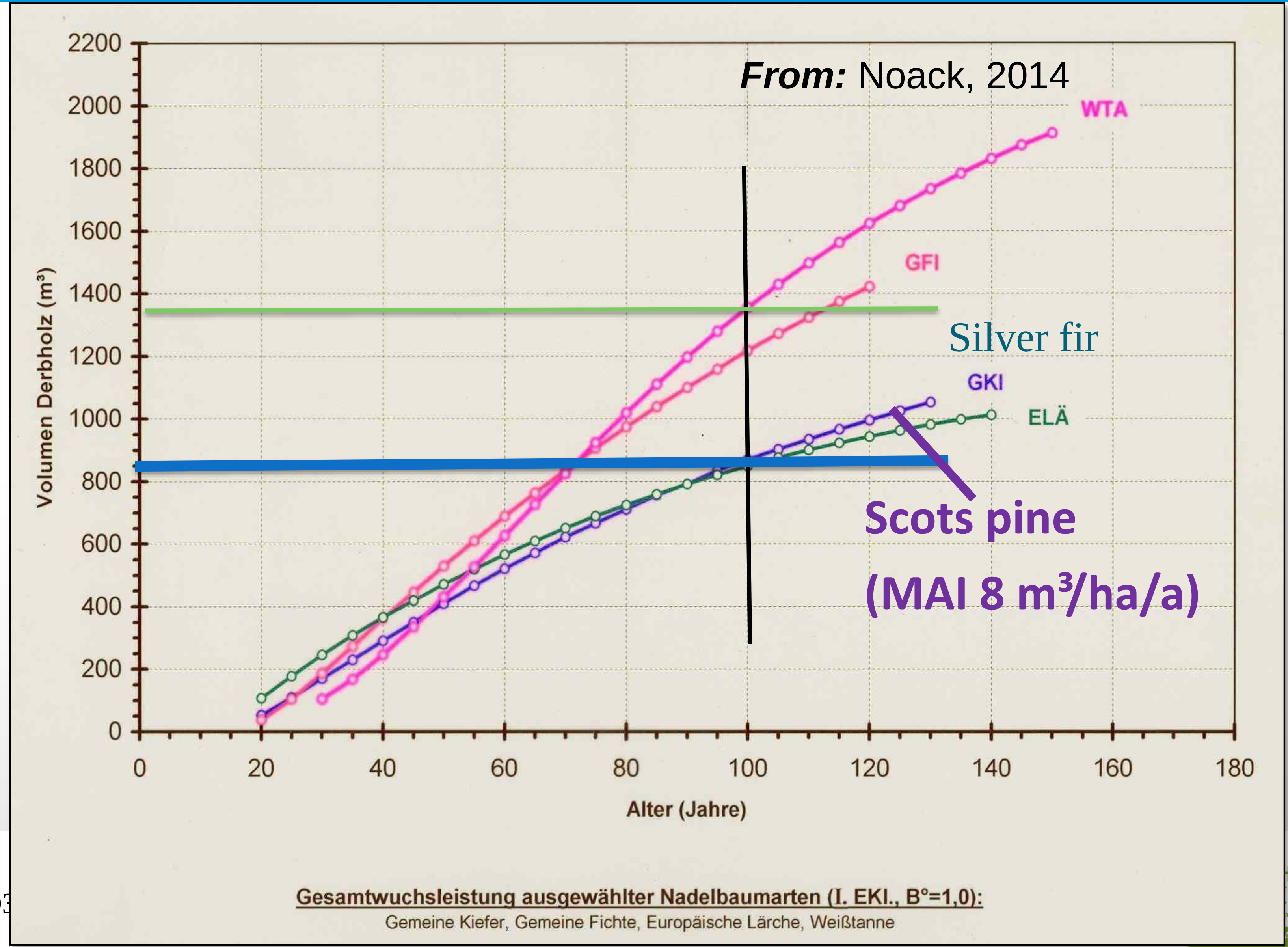


Scots pine

Tree species with moderate root energy:

- often with tap root (up to 8 m deep) ***= resistant to storm;***
- more shallow roots on clay soils, when ground water level is high ***= vulnerable to storm***

Total production of Scots pine in the Northeastern German lowlands



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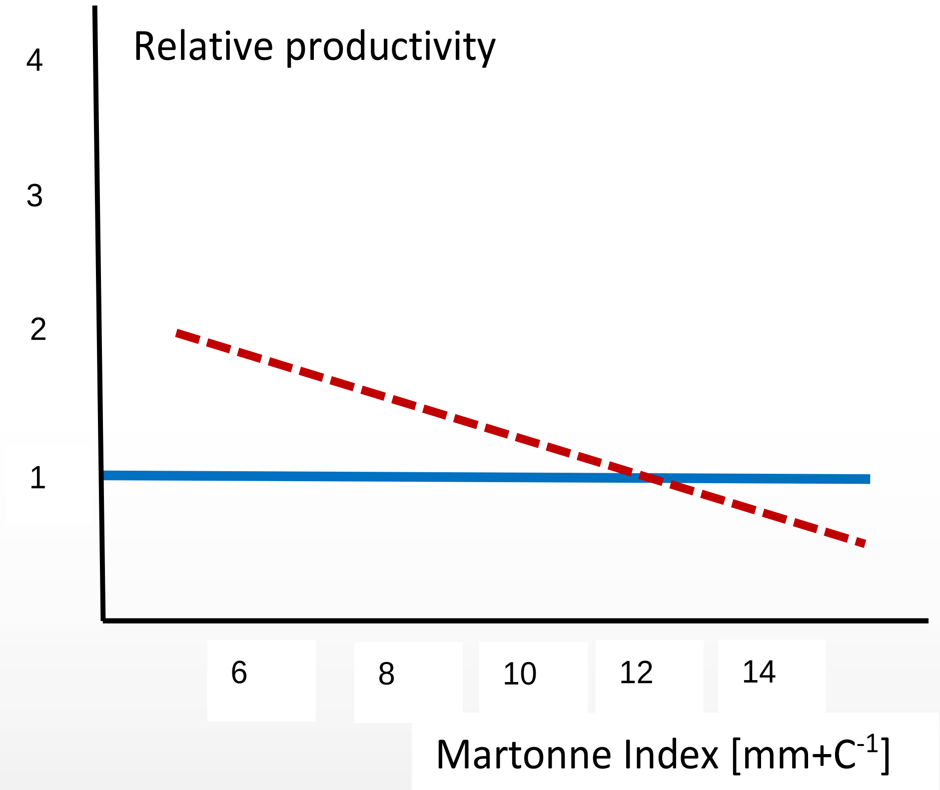
Overyielding in Scots pine and European beech forests

Results

- Standing volume +12 %, stand density +20 %, stand volume growth +8 %, compared to the weighted mean of the neighboring monocultures

➢ *Mixed stands carry more trees of a given size*

➢ *Influence of site factors?*



Results from: Pretzsch et al., 2016 (triplet analyses); Pretzsch & Forrester, 2017

Biodiversity - productivity relationship

→ *facilitation* and *niche complementarity*

Eur J Forest Res

Fig. 9 Essential results of this study in schematic representation: **a** change from facilitation dominated interactions to competition along the gradient from low- to high-productivity sites and **b** observed site-dependent relationships between productivity and species richness (*broken lines A, B, C* for poor, mediocre and rich sites) and expected relationship (*solid saturation curve*) according to Körner (2002)

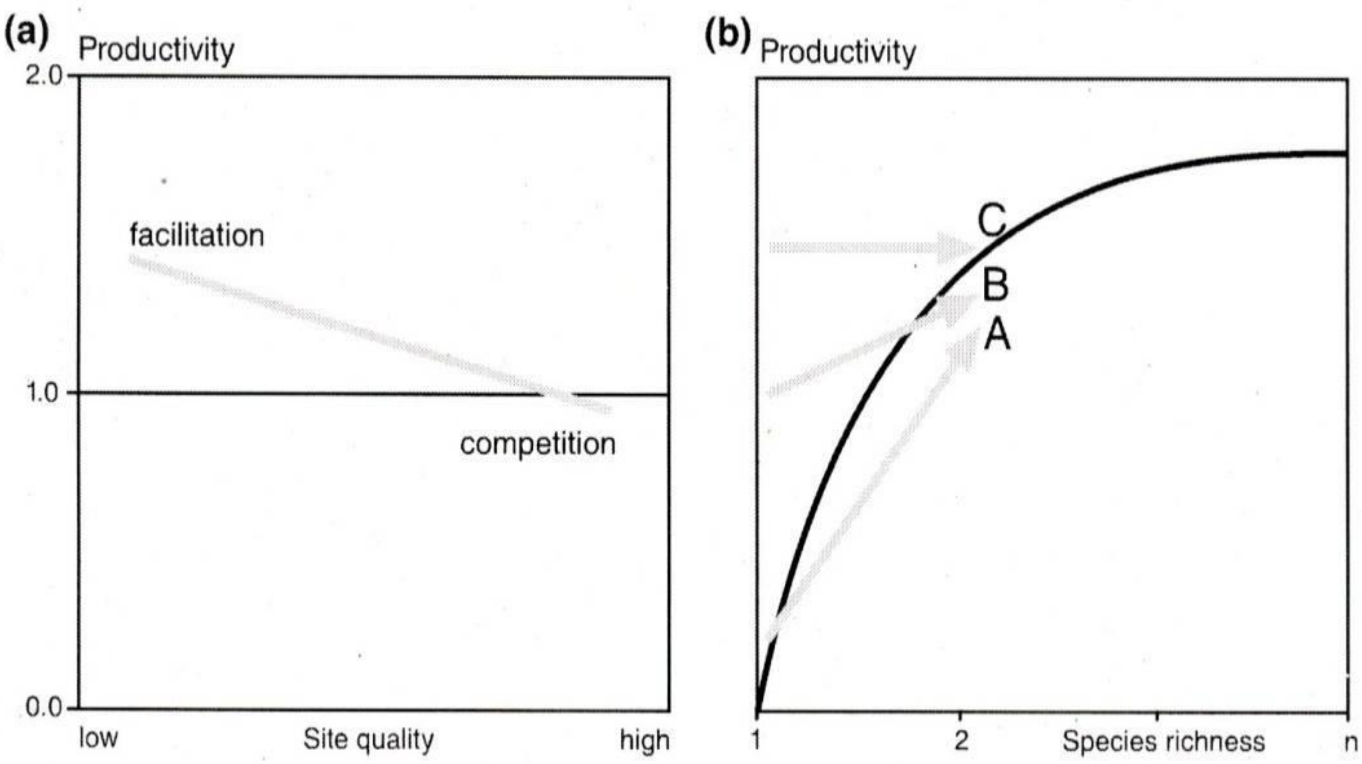


Figure from Pretzsch et al., 2013

Growth of other pines elsewhere

Tree species	Region		Productivity	
	trop./subtrop.	temp. regions	iv [m³/ha/yr]	rotation cycle[yr]
Eukalyptus	Brazil, Uruguay	Chile, SW of Europe	12 - 30	7 - 10 (15)
Eukalyptus clone	Brazil		40 - 80	6 - 8
Pinus elliottii + taeda	Brazil, USA		15 - 25	15 - 25
Acacia mangium	South East Asia		8 - 20	7 - 10
Tectona grandis	Costa Rica, Ivory Coast, India		4 - 18	25 - 60
Populus		Italy, France	8 - 25	7 - 15
Pinus radiata		New Zealand	18 - 24	15 - 25

diverse sources

Thinning response

What is the response of pine stands after density reduction?

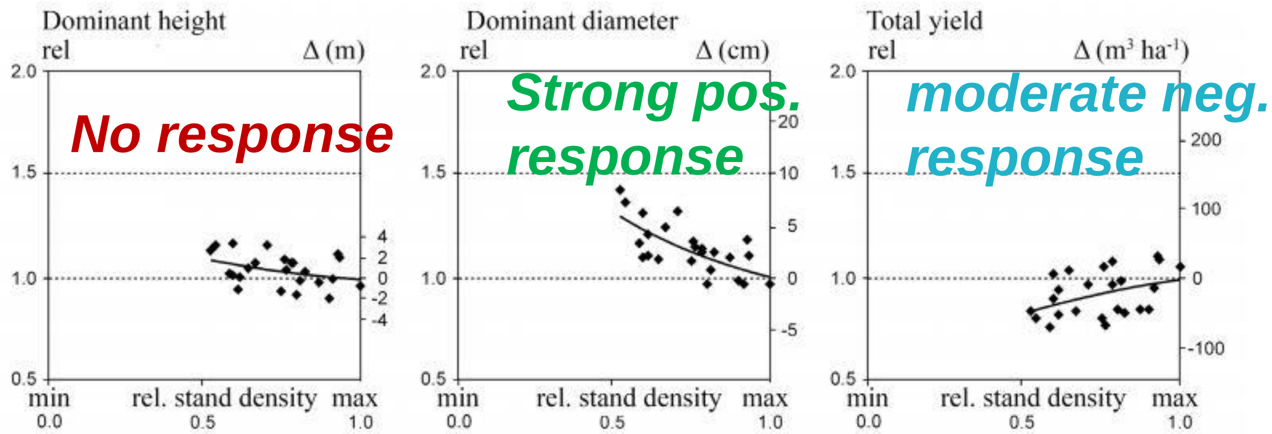


Figure 1. Reduction of stand density to 50 % below the maximum density (from relative density of 1.0 to 0.5) by spacing and thinning from above significantly increases the height and diameter of the 100 tallest trees per ha but reduces the total yield (from left to right) on the combined spacing and thinning experiments Weiden 611 in Scots pine till the stand age of 40 years (Nickel *et al.*, 2007). The x-axis displays the relative stand density (maximum=1.0 was 43 m^2/ha), the left y-axis shows the relative growth reactions (characteristics for fully stocked stands set to 1.0), and the right y-axis displays the absolute benefit and loss, respectively, in terms of height (m), diameter (cm) and total yield (m^3/ha) in thinned compared with unthinned stands.

'thinning response hypothesis' (also called Assmann's theory)

Source: del Rio et al., 2017

Pine wood utilization

Good for

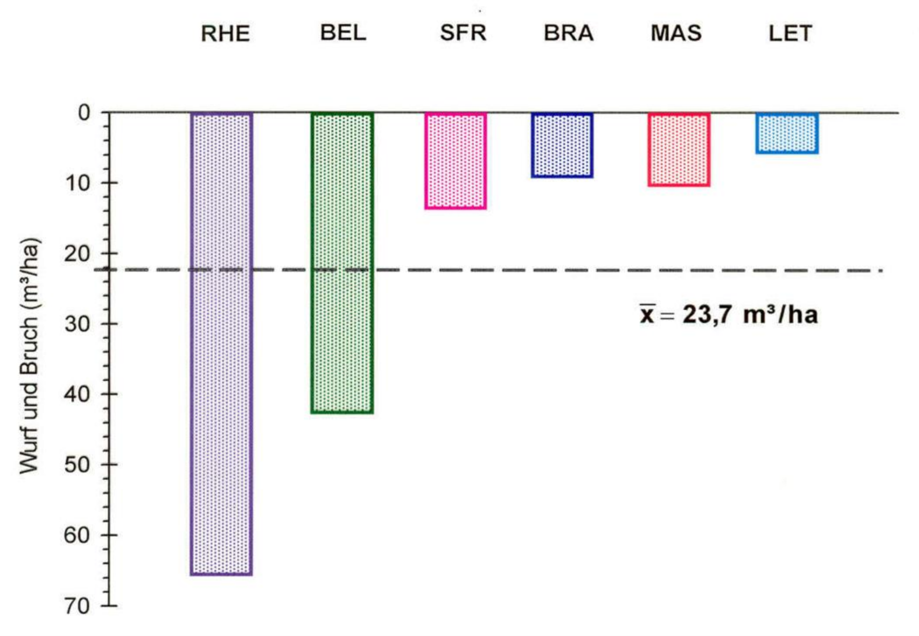
- pulp and paper, fibre boards
- furniture
- building and construction (engineered wood)

Stem disk, ***source:*** HNE Eberswalde

Medium density fibreboard

Glued laminated timber;
source: Klenk AB, Oberrot, Germany

Provenances



1. Storm damage 13.11.1972 (Noack, 2014)

2. Quality and growth of provenances

3. Not shown: drought resistance

International provenance trial Chorin 85

Vulnerability of pine: aspects and case studies

Pine tree lappet moth, South Brandenburg; ***source:*** HNEE

Drought: Bavaria, near Nürnberg

Key process: resistance and resilience to drought

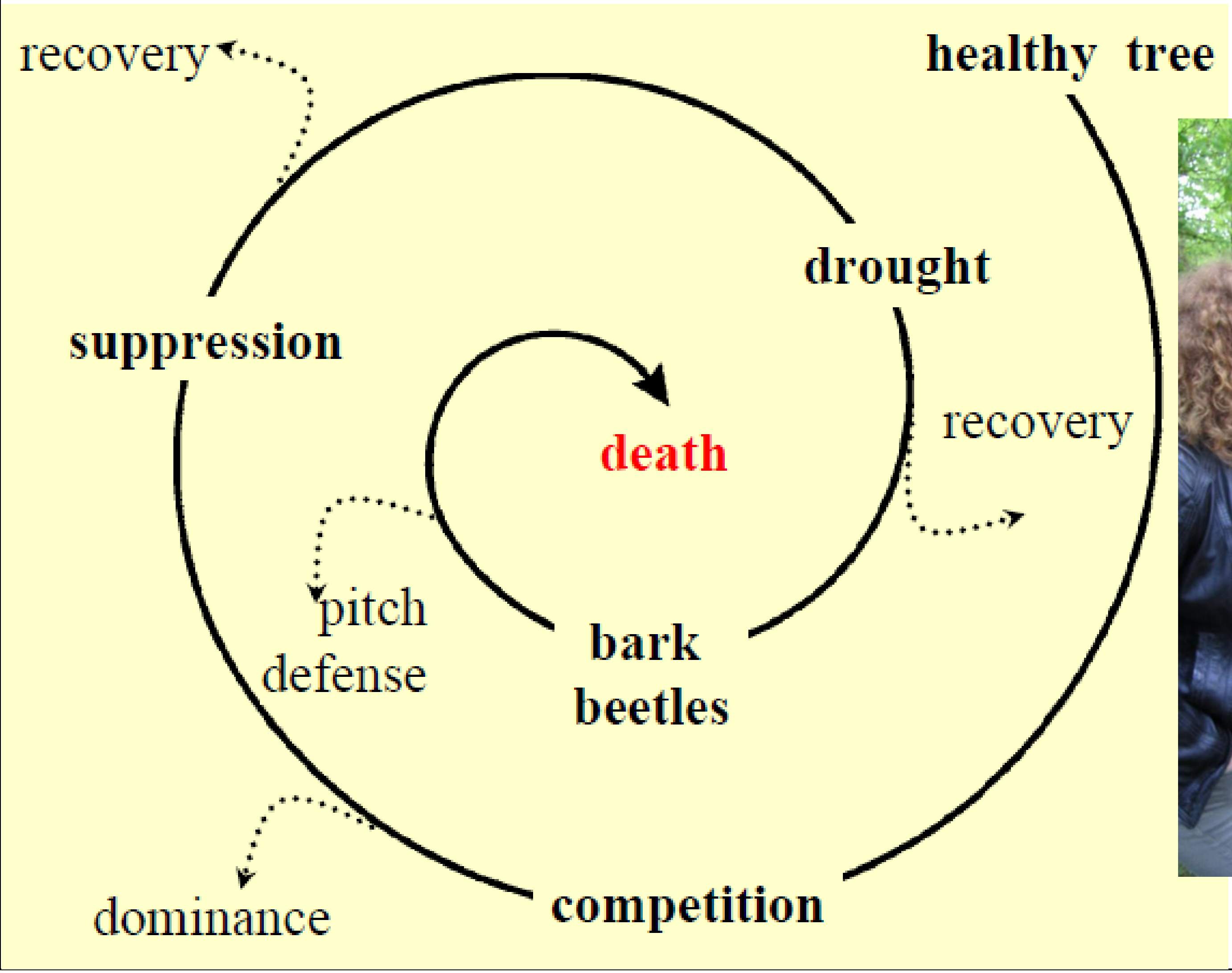
What do we know?

- *isohydric species*
- *role of ground vegetation*
- *epigenetics (results Pfynwald, CH)*

Photo: Rigling, WSL

Spiral model of tree decline

acc. to Franklin, 1987



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Scots pine in Germany: is fire a necessary factor for rejuvenation?

No, because

- fire not necessary for ecosystem development (decomposing humus on natural pine sites)
- fires are man-made (> 95 % of burnt forests)
- number of fires drecreasing (exceptions: hot and dry years such as 2003 or 2018) due to *recognition and combat + forest conversion*

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Large forest fire (near Berlin)

II. Silvicultural systems

Pine regeneration after forest fire, South Brandenburg

Silvicultural systems and Scots pine

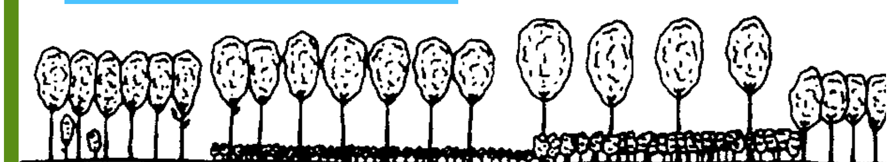
Even-aged

Uneven-aged (CCF systems)

Source: Larsen, 2008

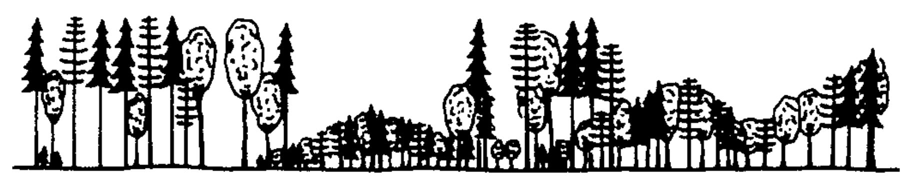
Clearcut

Shelterwood cut



Strip cut

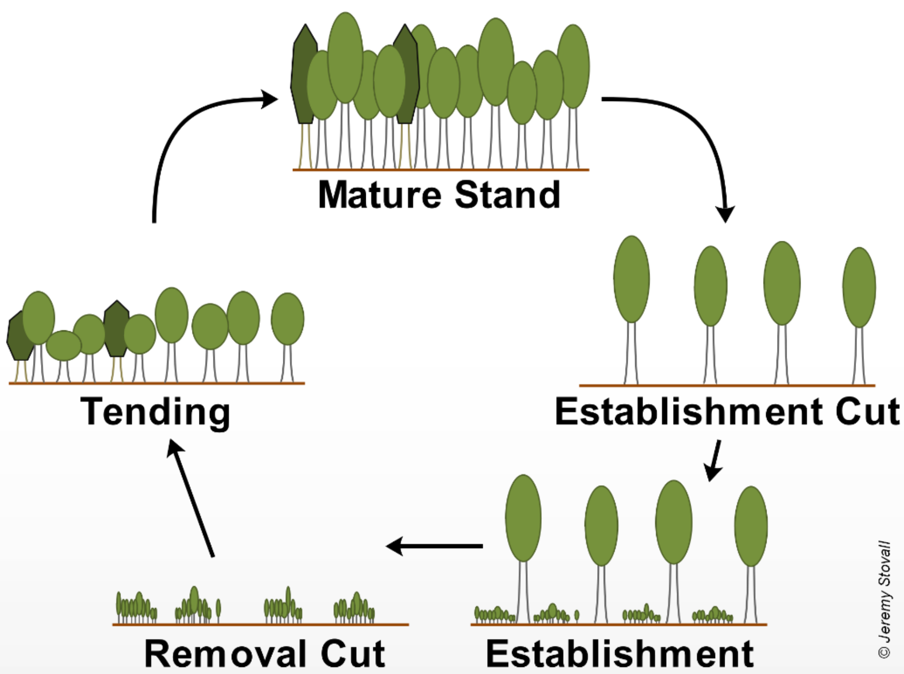
Irregular shelterwood cut



Selection cut (forest)


Mecklenburg-Vorpommern,
Northeast Germany
Clear or strip cut

Shelterwood cut



Near Eberswalde

Pine grows well and regenerates naturally in the valleys of Lake Inari. The seedtree method and light soil preparation are suitable silvicultural methods. The climate in the area is favourable owing to the proximity of the Gulf Stream and the temperature-moderating effect of the large lake basin.

Scots pine:
a tree species with service functions

Source: Pommerening & Murphy, 2004

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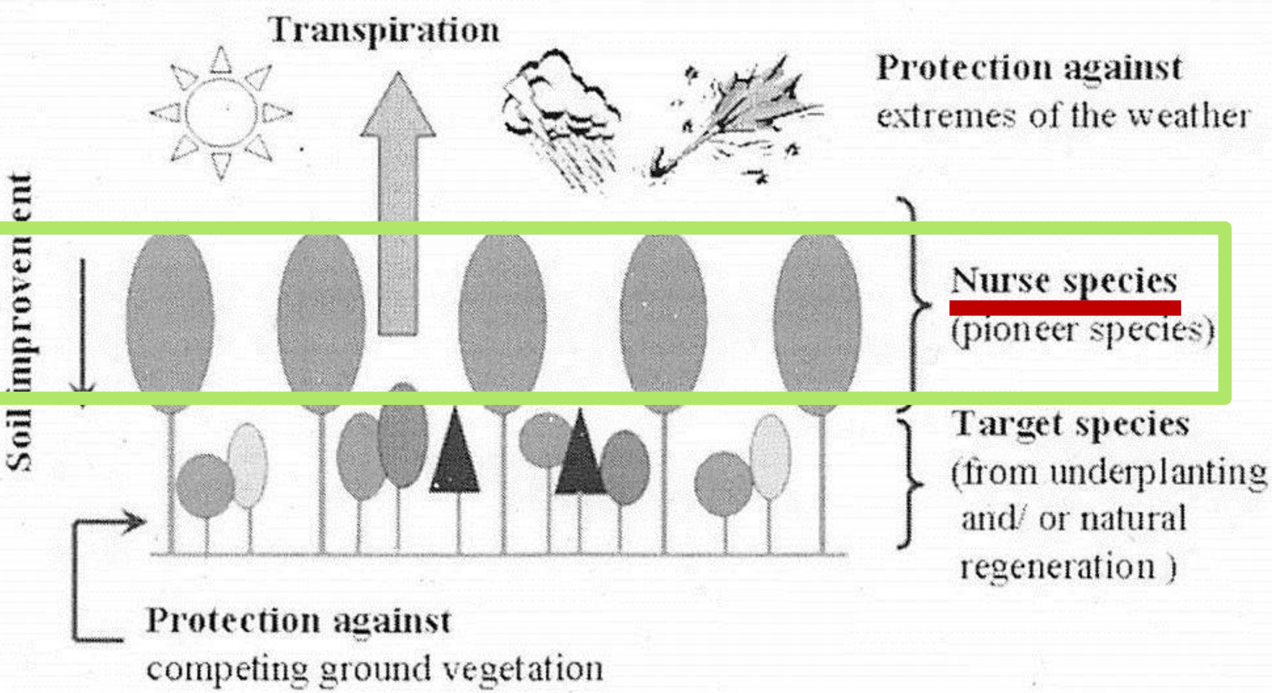

Figure 4. The nature and functions of a nurse crop used in afforestation.

Retention principle

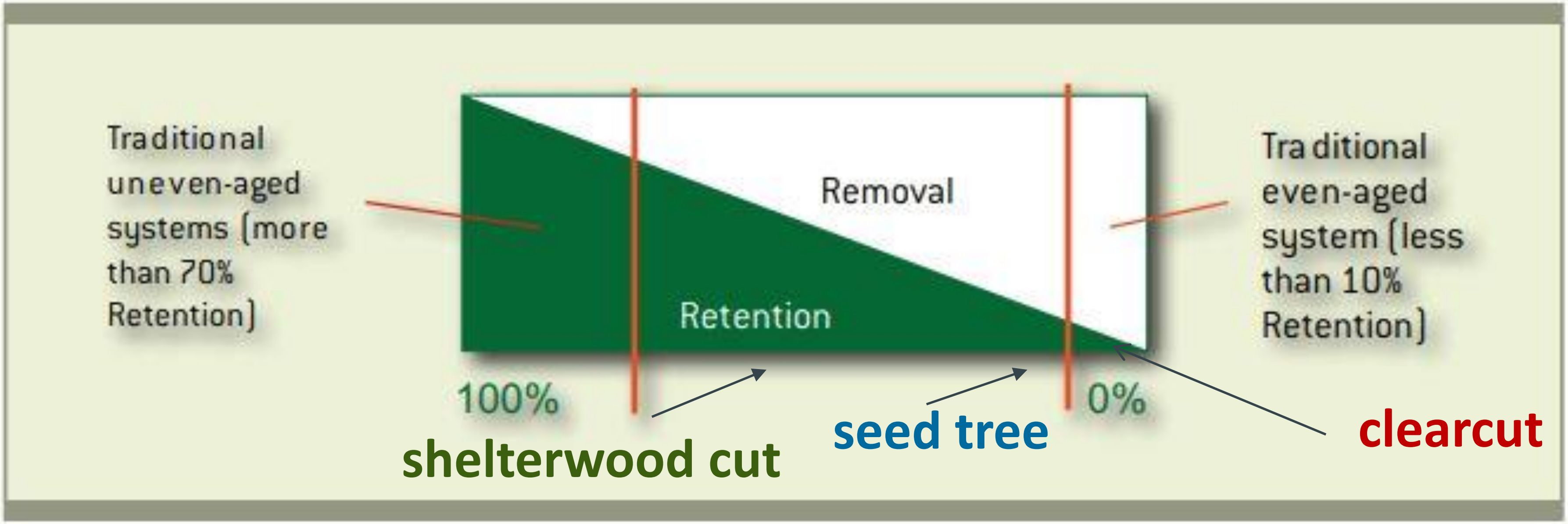

Figure 20. In forestry there is a wide variation in the amount of trees removed at harvest. Traditional uneven-aged management implies that most trees are left (approx. >70%), while in traditional clearcutting almost all trees are removed (approx. <10% are left). Retention forestry embraces typically a gradient of retention between 10% and 70%. Source: Modified from Franklin et al. (1997).

<u>Case study:</u> natural regeneration of Scots pine in NE Germany

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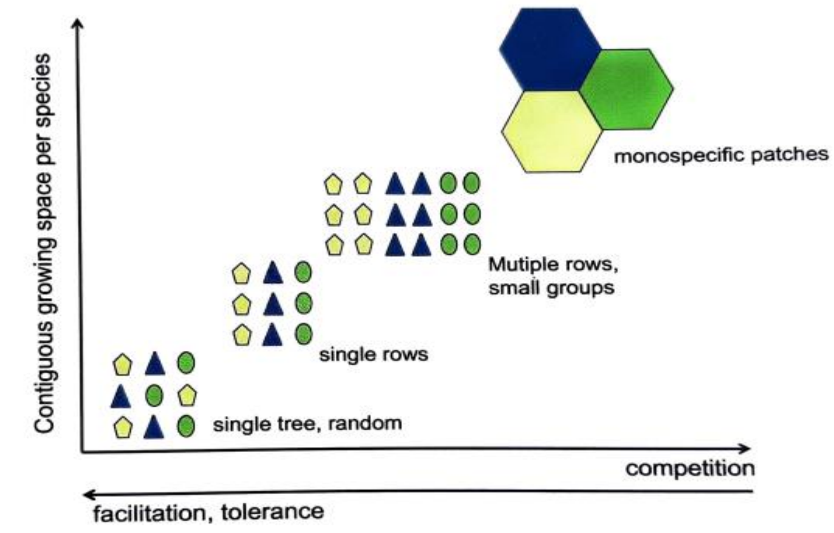
Excursus: mixed-species forests
(Bauhus et al., 2017)

- Intimate mixtures / single-tree mixtures
- Spatial mixtures (small monospecific patches)
- Vertical mixtures (Plenter forest)
- Admixed species with service functions
  - ➢ *Trainer trees*
  - ➢ *Nurse crops*

❖ Mixtures often do increase stand productivity and enhance ecological resilience



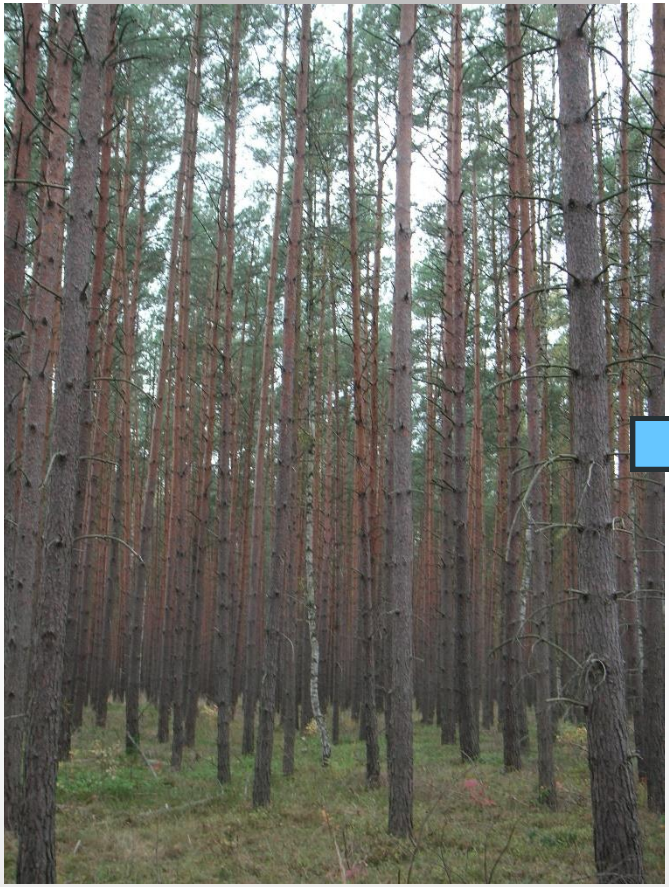
✓ *Good compromise: small-scale mixtures of tree species patches !*

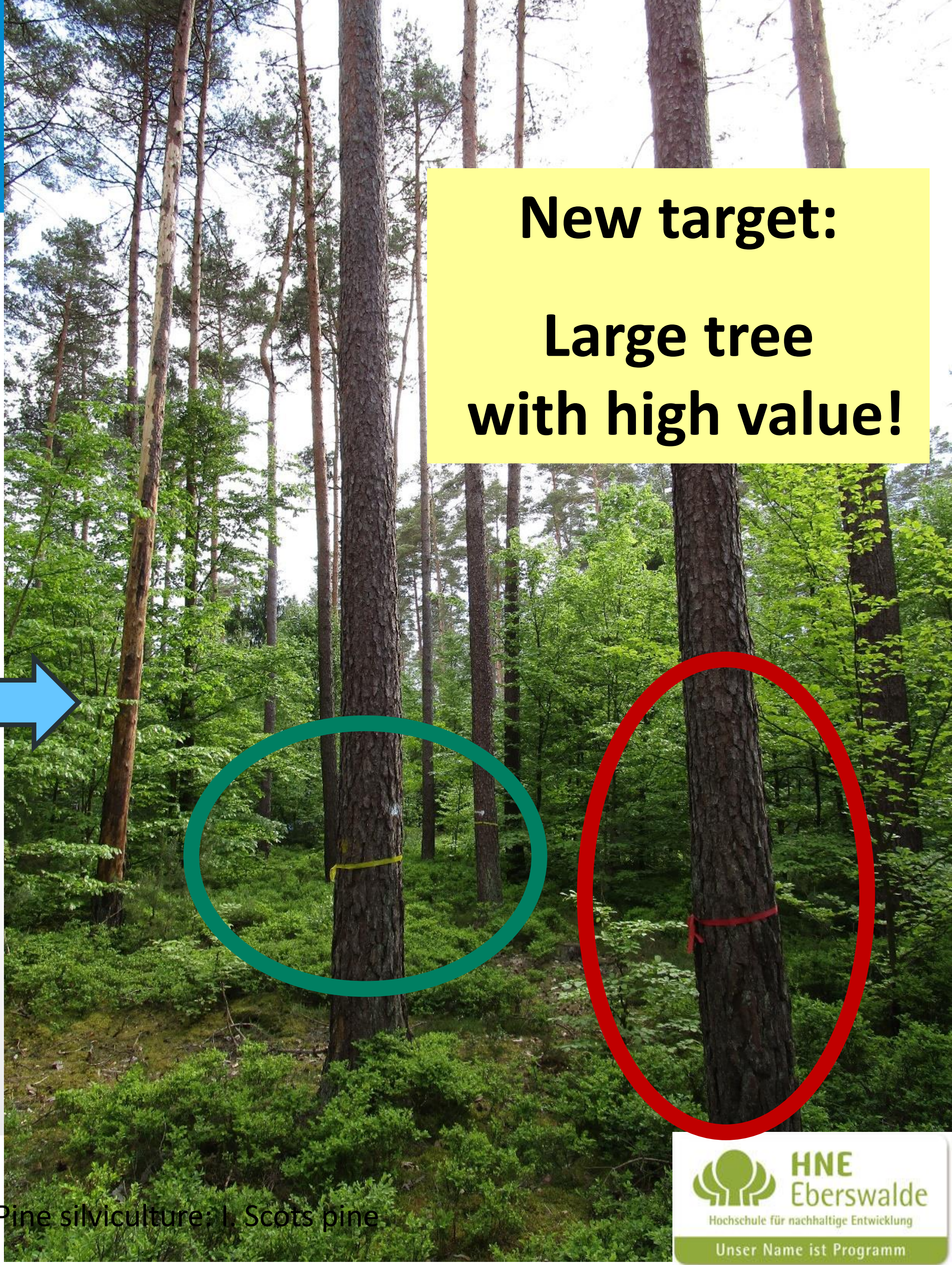
III. The question of high-vaulue timber production

Pine forest, Burglengenfeld, Bavaria

Production strategies

Mass production

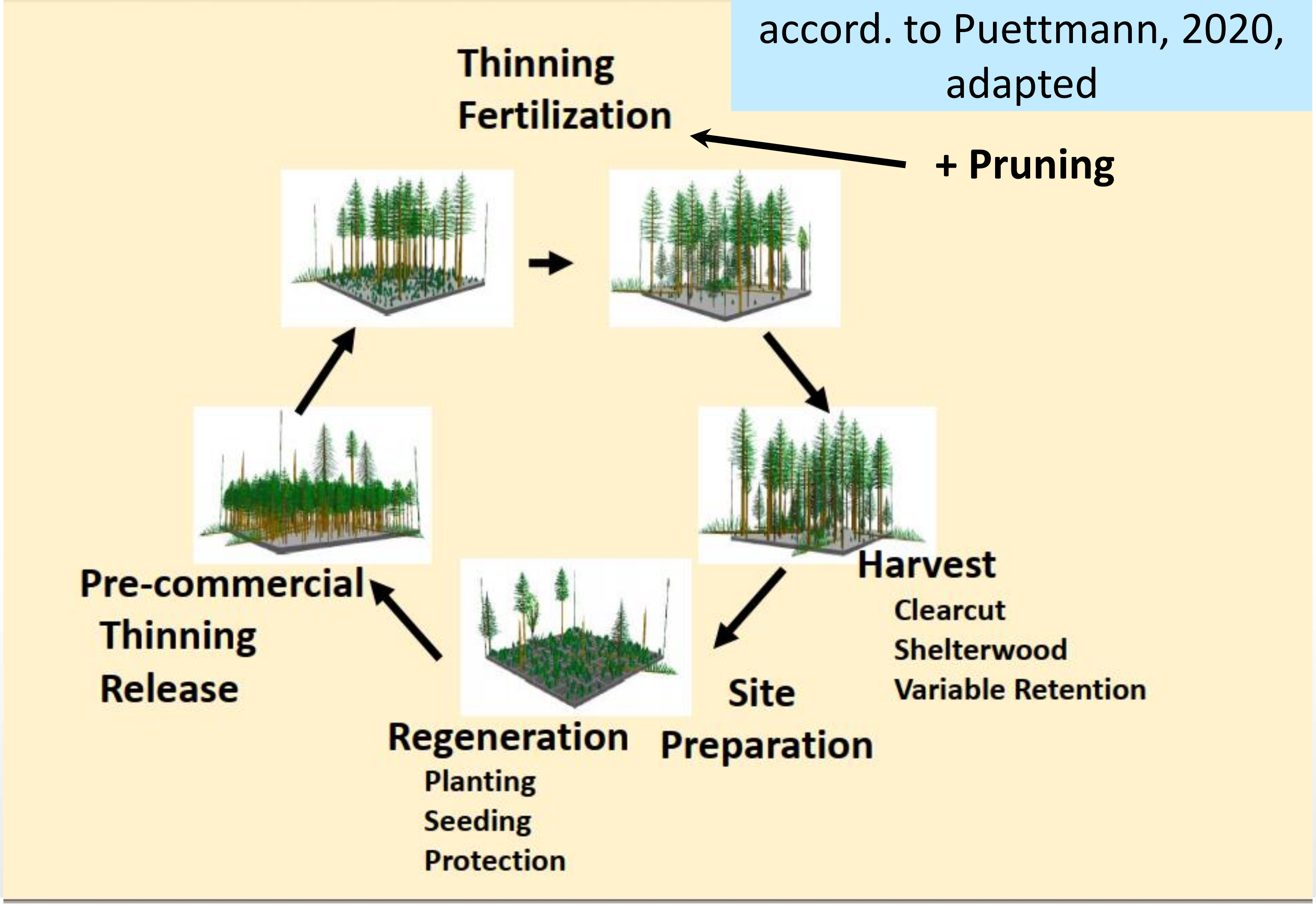




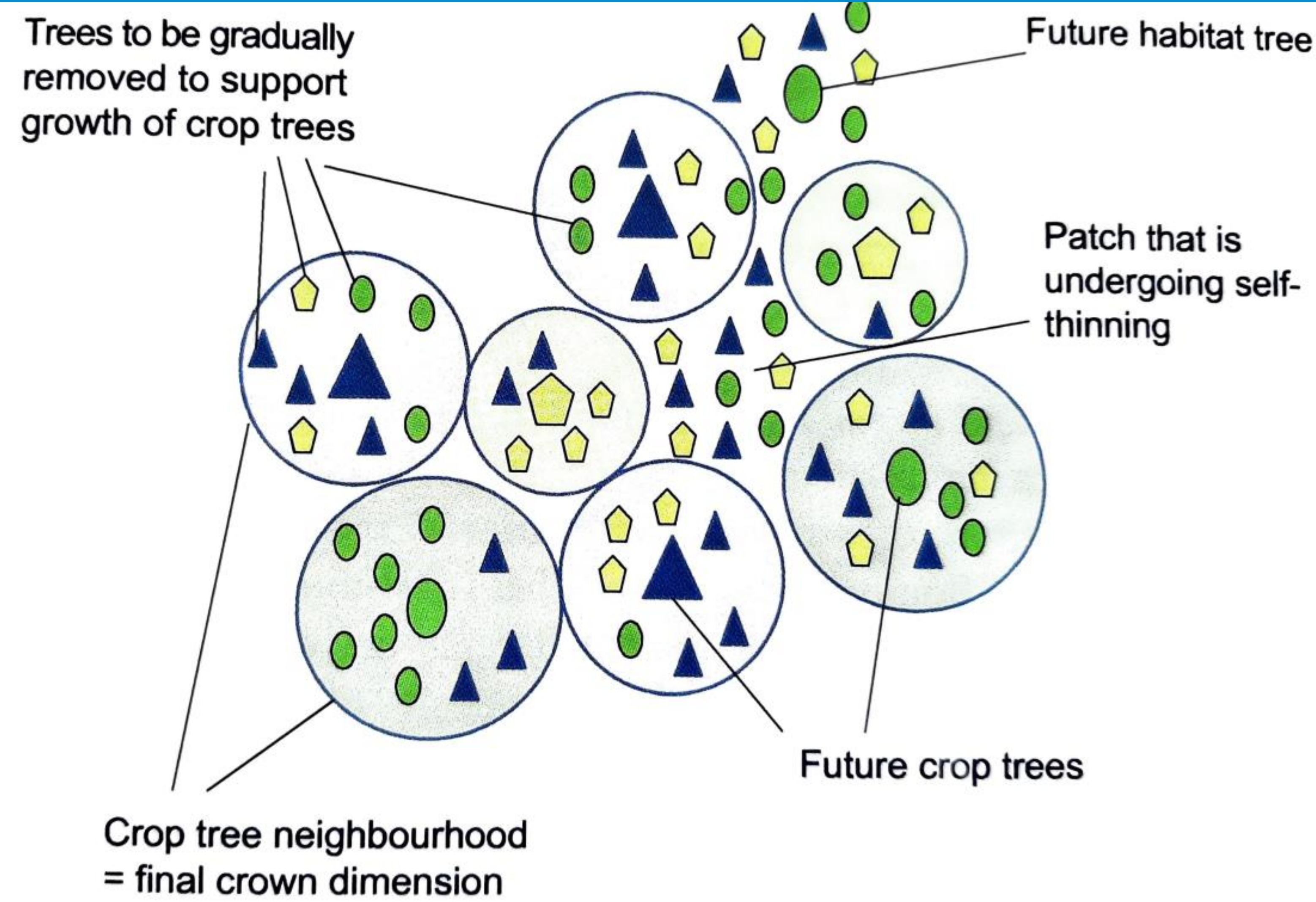
New target:

Large tree with high value!

Silvicultural practices



Crop tree concepts



From: Bauhus et al., 2017

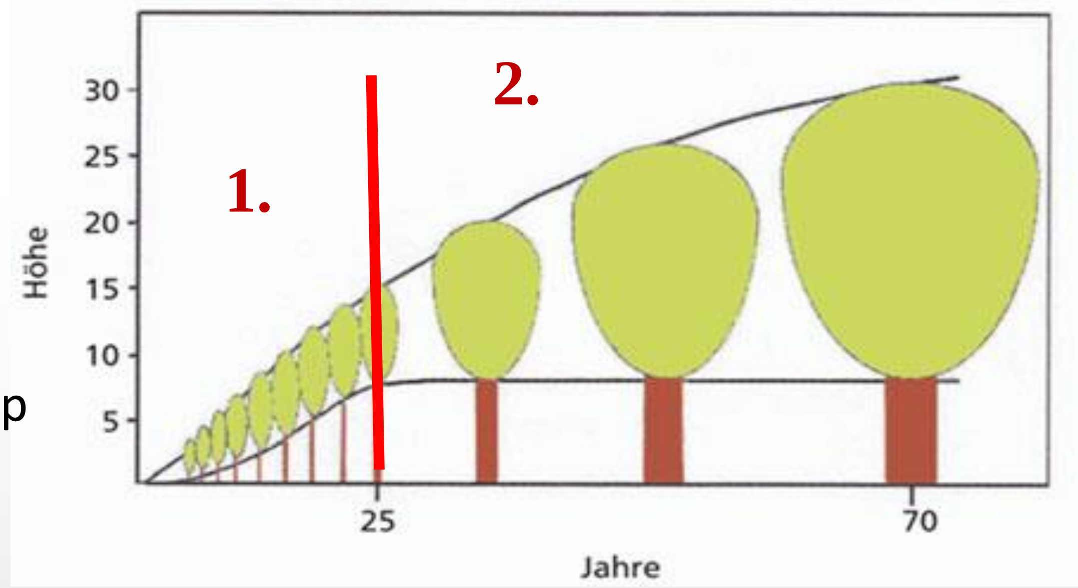
‘Two-phase strategy’ for high-value timber production

I. Scots pine is a species with low apical dominance and strong plagiotropic crown expansion ⇒ ***two quality strategies possible***

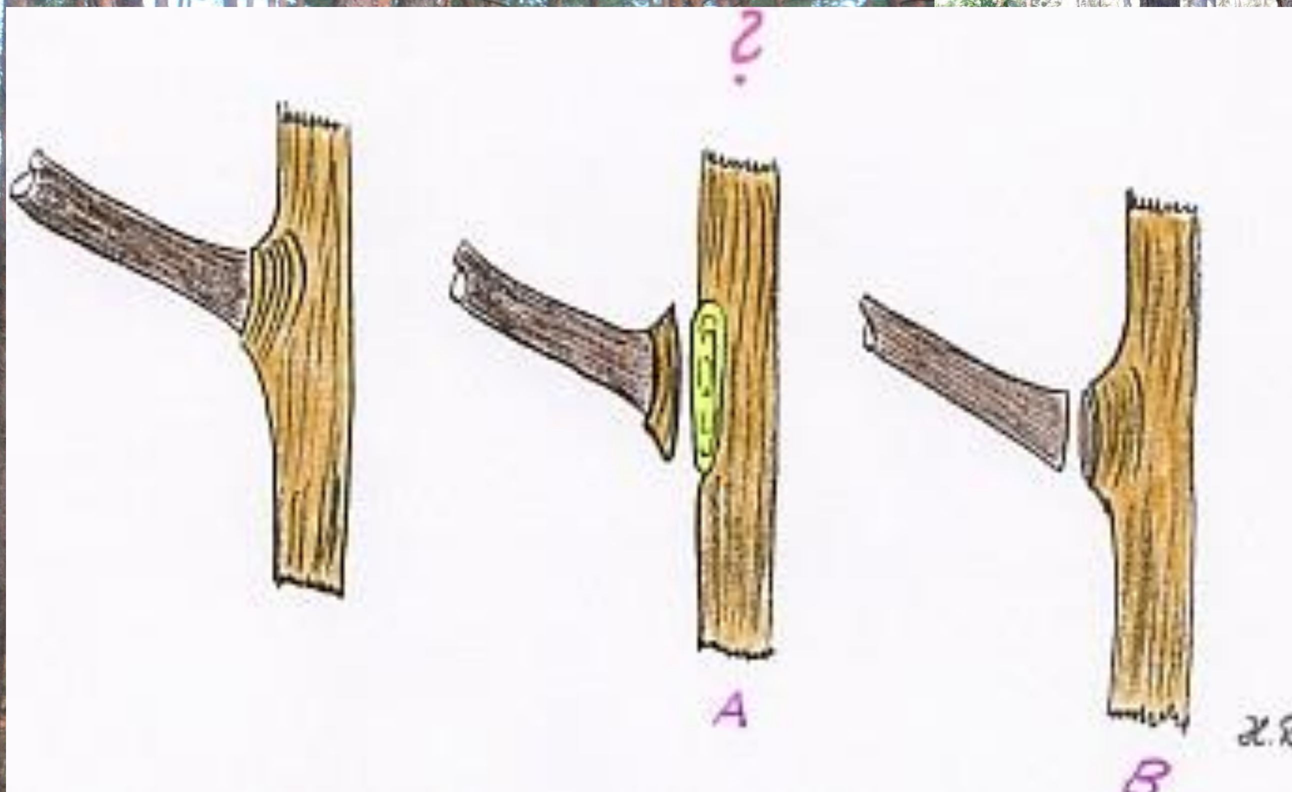
II. For a tradeoff establish two consecutive stages:

1. ***Precommercial thinning:*** dense stand for reducing knottiness
   focus on quality
2. ***Release stage:*** selection and thinning of e.g. 50-70 future crop trees per ha (selective/crown thinning)
   focus on diameter growth

From: Schuster, 2009



High-value timber production through pruning



B is correct!

Figure acc. to Rieger

Reduced-impact logging

Source: report for KWF ‚Holzernte in Wäldern mit Verjüngung unter Schirm', 2017

Break !

10‘

Continuous-Cover Forestry with Scots pine – an impossibility?

CCF with Scots pine, Lorch

The way to CCF:
forest conversion

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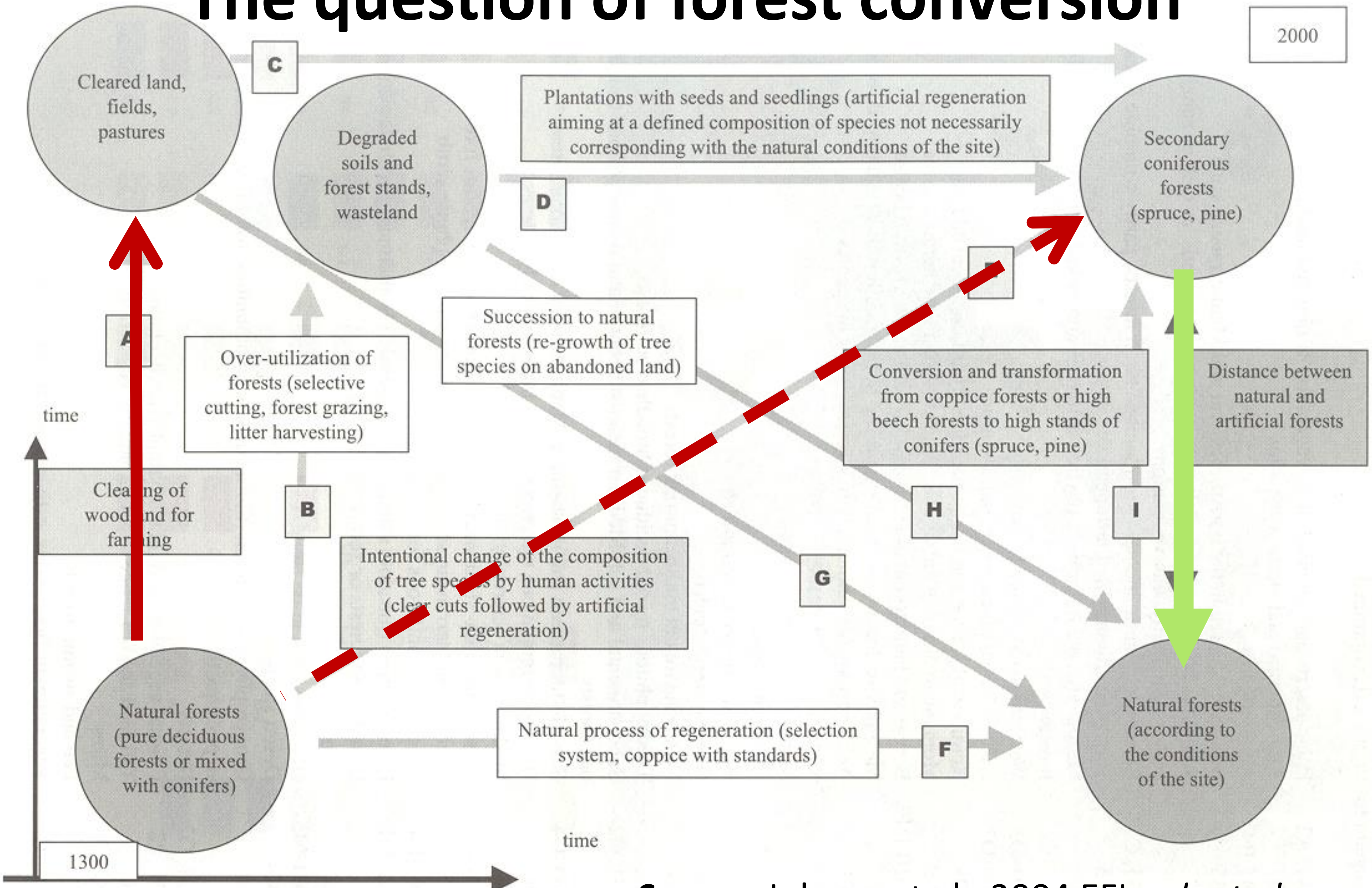
Hochschule für nachhaltige Entwicklung
Unser Name ist Programm

The question of forest conversion



Source: Johann et al., 2004 EFI, *adapted*

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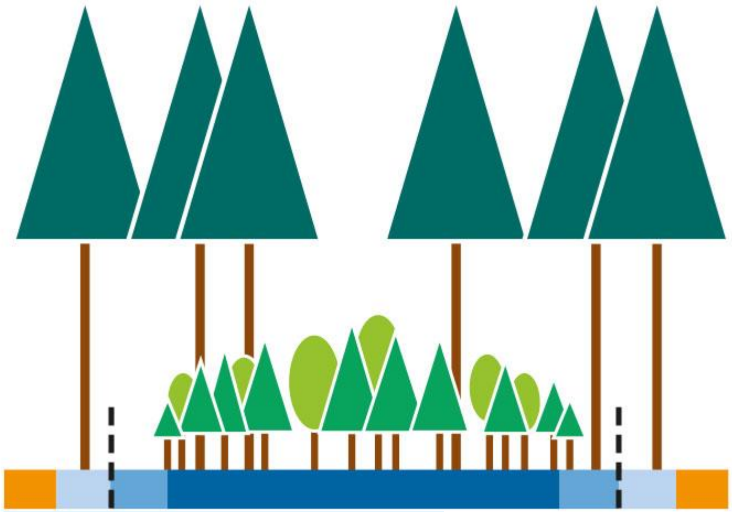
Mainstream forestry, since decades
‚GDR forestry‘

Advanced regeneration in gaps


beech,
underplanted
Underplanting and natural
regeneration
oak,
dispersed by jay

Forest conversion

Conversion of a pure Scots pine stand into a mixed stand



Source: LWF, 2011

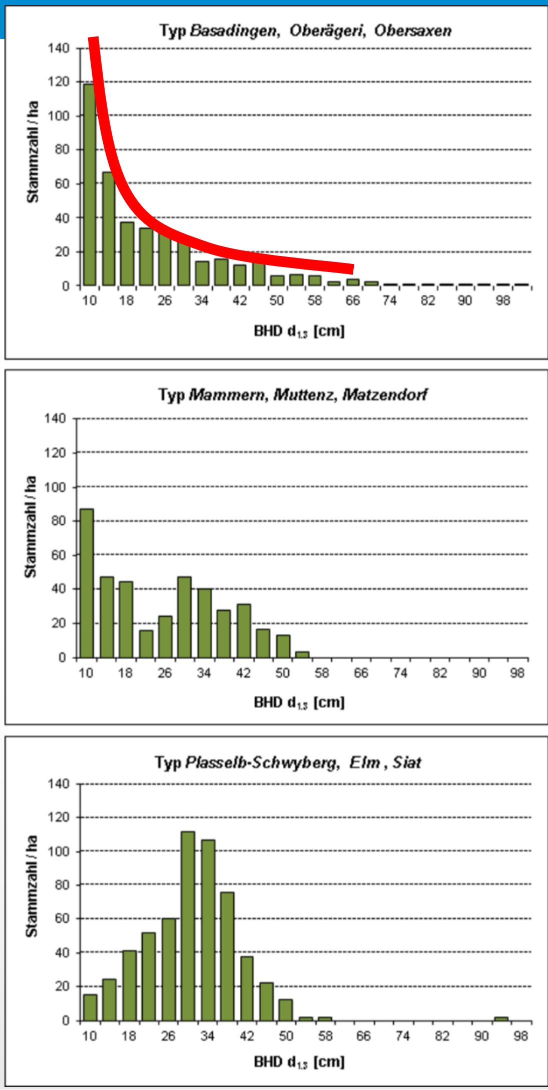
<u>Per ha:</u>

- *3 groups of beech, 1 group of Silver fir with 0.1 ha, in a spacing of 2 x 2 m*
  750 plants x € 2 = € 1,5 k
- *protection fence*
  4 x 100 m fence = 400 x € 10 = € 4 k
- *slight soil scarification*
  soil scar. = € 0,5 k

Total: € 6 k

What are the costs for 1 ha of underplanting?

Ba-diam-q approach

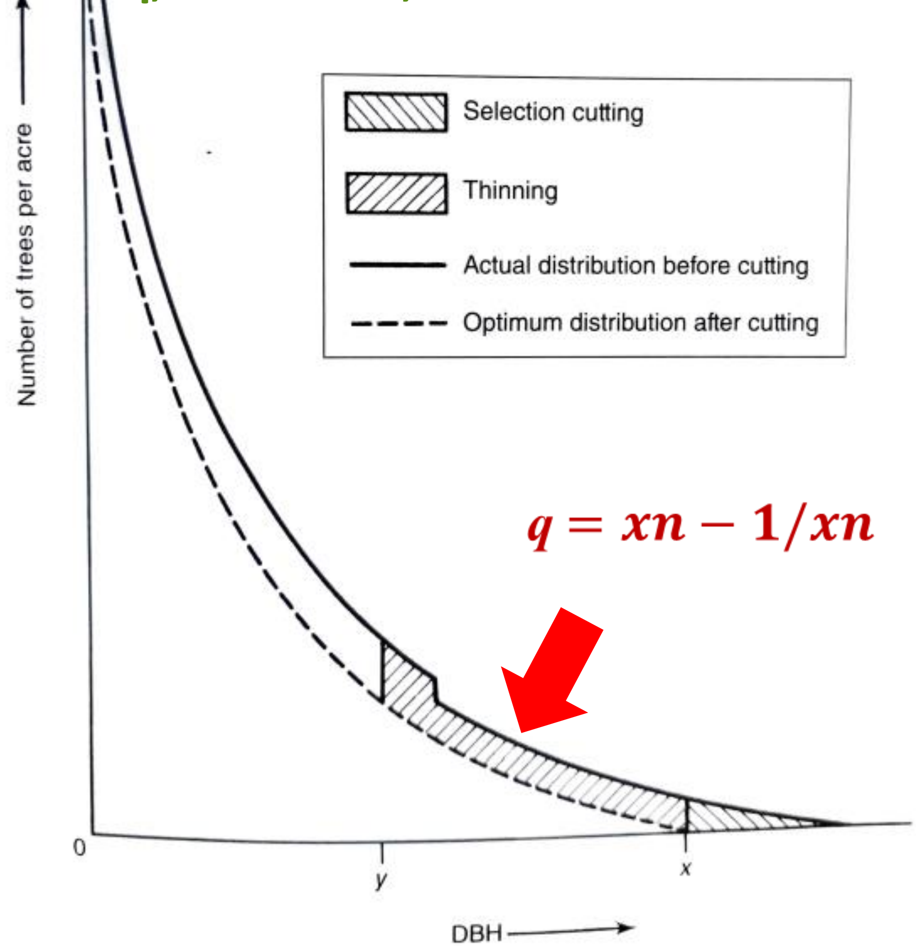


Source:
Zingg, 2012

Thinning according to target diameter distribution curve

<u>Parameters required:</u>

q, basal area, dbh max



$$q = xn - 1/xn$$

acc. to Ashton & Kelty, 2018

Basic precondition for CCF!

Maintenance of ecologically compatible wild deer populations

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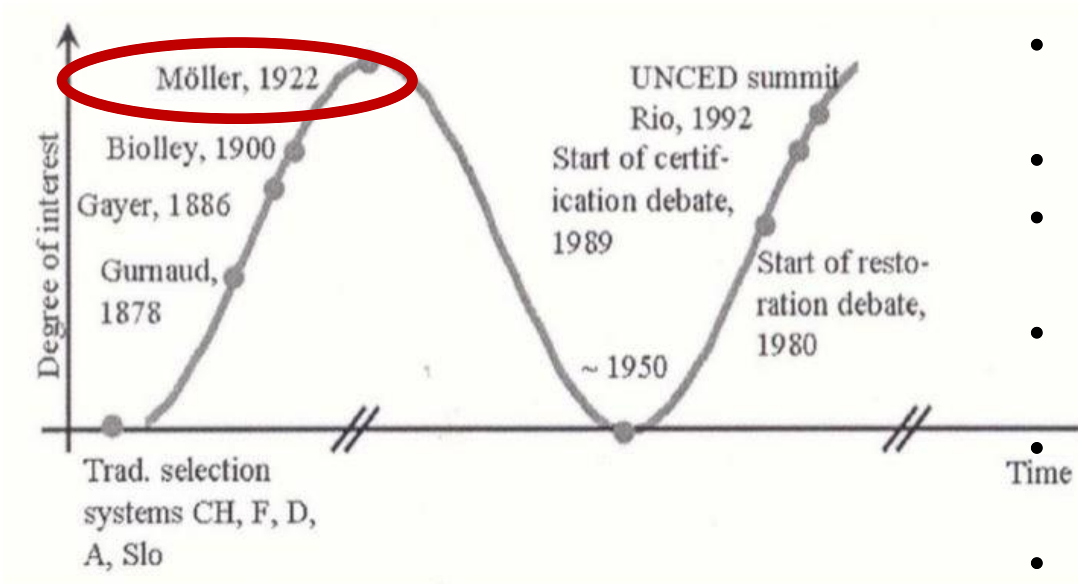
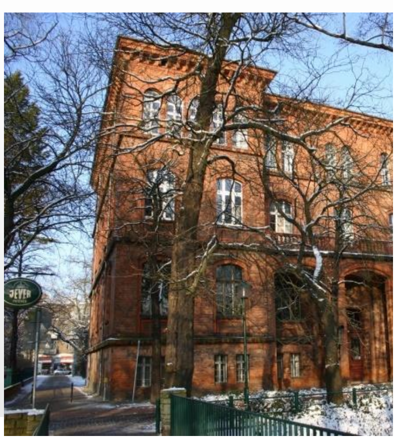
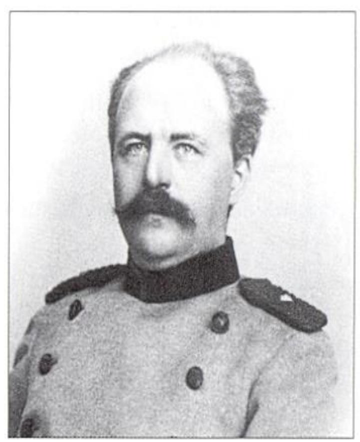
CCF

History (Pommerening & Murphy, 2004)



- Selection of species of the natural forest cover
- Creation of mixed stands
- No clear cut, promotion of natural regeneration
- Relevance of thinning, maintenance of stable forests
- Reduction of damages on soils and the remaining stand
- Retention of stand legacies





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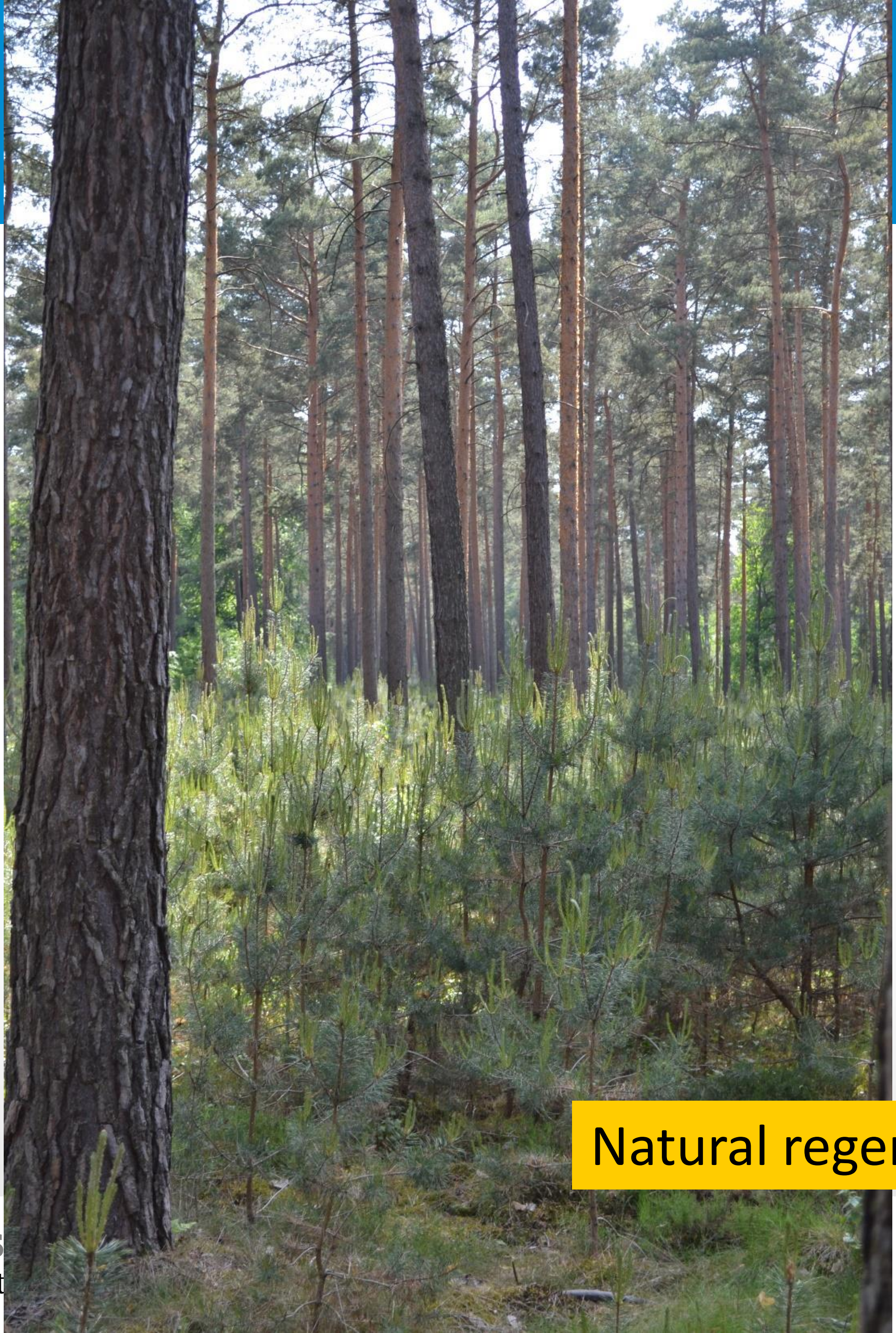
Von Kalitsch – godfather of pine CCF


Bärenthoren (south of Berlin): two-storey stand



Natural regeneration

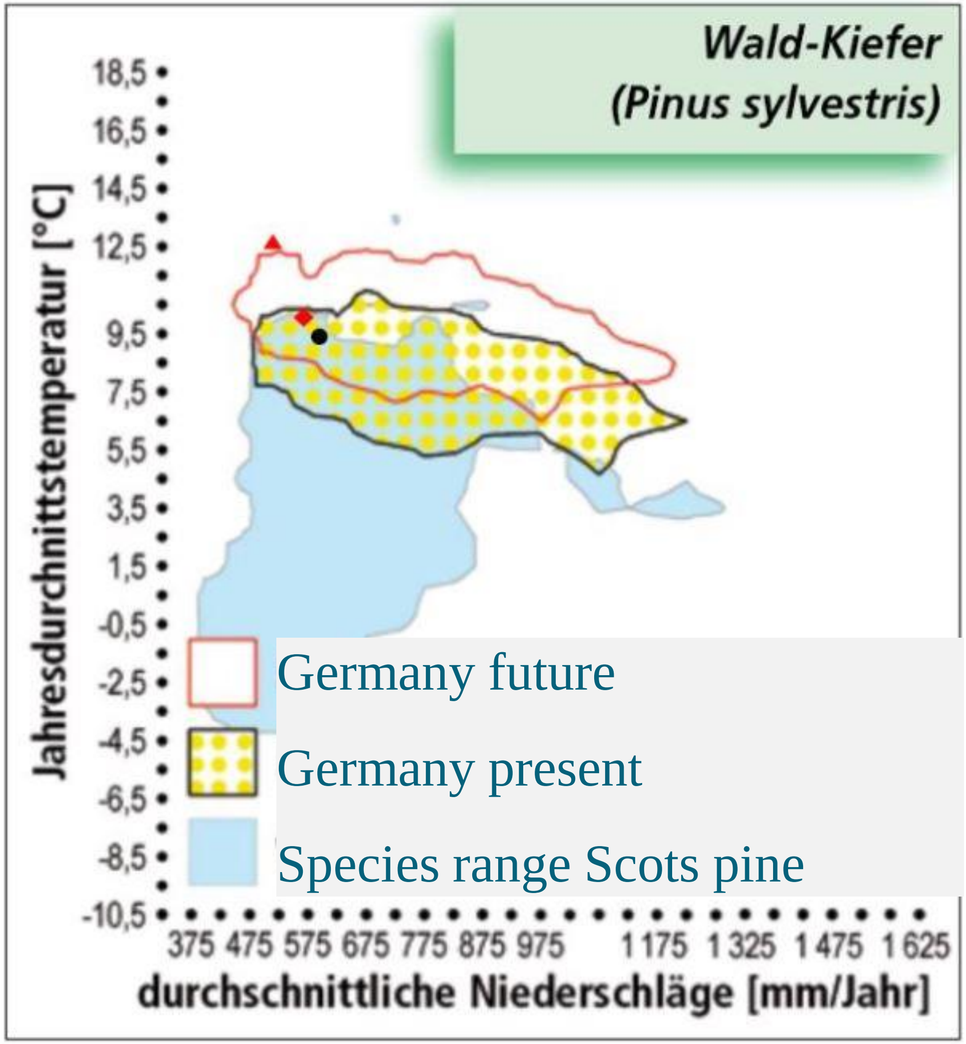
Multi-storey pine stand


Holdover trees

Resilient Scots pine forests and management for diverse ecosystem services

Pine reforestation after calamity, south of Berlin

Climatic robustness



Climatic envelope

Scots pine in Germany

From: Petretschek, 2019, adapted from Kölling, 2007

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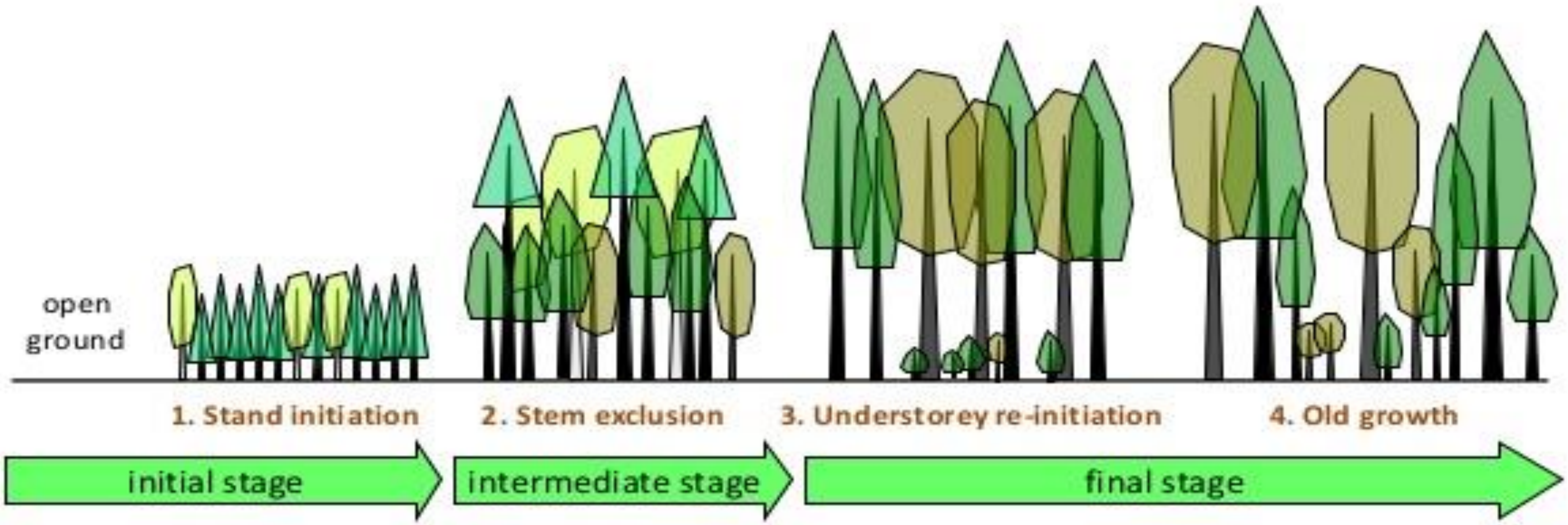
Strategies for Enhancing Forest Resilience

Development stages in a natural forest



Intervention Options linked to Enhanced Resilience

Species choice
- genetics/provenance

New species introduced

Wider use of "minor" species

Mixed species

Assisted migration of native species

Modify thinning regimes

Modify harvesting systems

Extended "rotations"

Diversify stand structures (i.e., CCF)

Source: Wilson and Leslie, 2008

Diagram based on Oliver and Larsen 1996
Adapted from graphic by Jens Haufe

Forestry Advance Access published May 20, 2014

Forestry An International Journal of Forest Research

Institute of Chartered Foresters

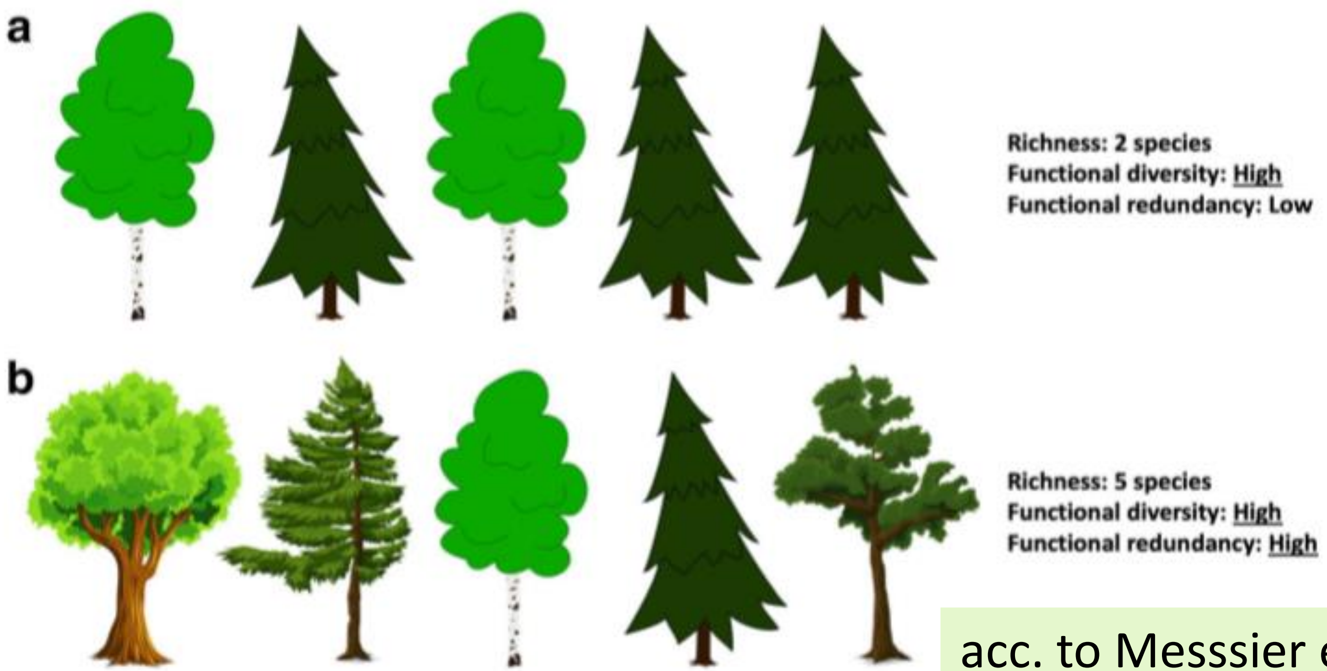
Forestry 2014; **0**, 1–12, doi:10.1093/forestry/cpu018

Suitability of close-to-nature silviculture for adapting temperate European forests to climate change

Peter Brang[1]*, Peter Spathelf[2], J. Bo Larsen[3], Jürgen Bauhus[4], Andrej Bončina[5], Christophe Chauvin[6], Lars Drössler[7], Carlos García-Güemes[8], Caroline Heiri[1], Gary Kerr[9], Manfred J. Lexer[10], Bill Mason[11], Frits Mohren[12], Urs Mühlethaler[13], Susanna Nocentini[14] and Miroslav Svoboda[15]

- Increase of species richness and structural diversity
- Maintenance of genetic diversity of stands
- Increase of ecological resilience and resistance of tree species
- Reduction of rotation and target diameter, respectively

Functional species diversity and resilience



acc. to Messsier et al., 2019

Fig. 1 Diagram illustrating in a simplified way the notions of functional diversity and redundancy within two stands. **a** Although it consists of only two tree species, the upper stand has a high functional diversity because these two species have very different functional traits: e.g., one species is an angiosperm, the other a gymnosperm. However, because of the large difference in the functional traits between these two species, the functional redundancy is weak and if a species disappears, several particular functional traits will be lost. **b** The lower stand also has a high functional diversity because it is composed of five different species, two gymnosperms and three angiosperms with relatively similar traits. Functional redundancy is however high in this case and if a species disappears, functional traits will be maintained in the stand

⇒ Principle of *ecological insurance*

Assisted migration

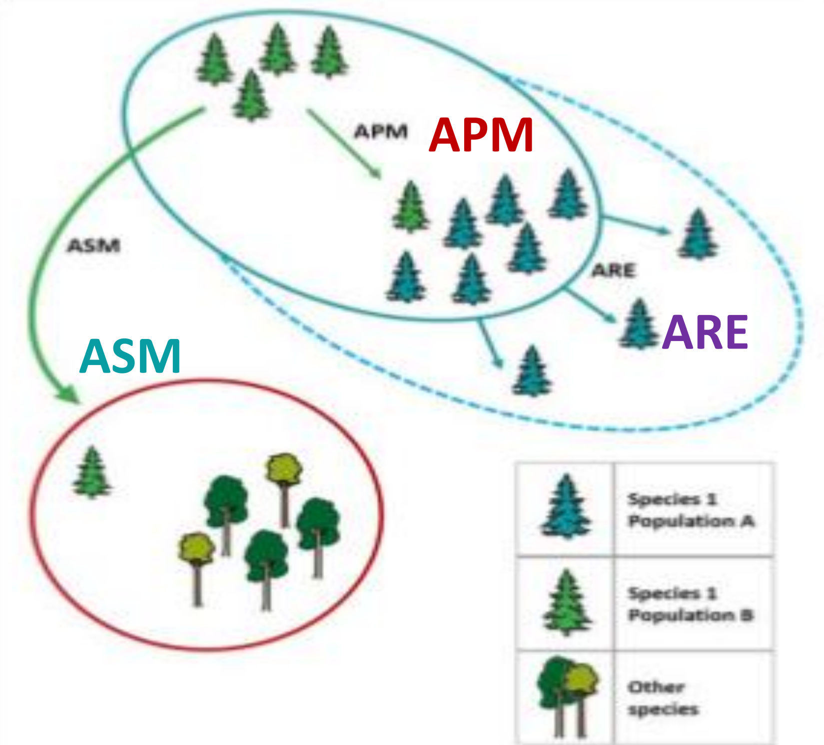


Fig. 2 Conceptualization of the different forms of assisted migration (Park and Talbot 2018). The movement of populations within the current range of a species is generally defined as assisted population migration (APM) while moving individuals of a target species just outside its range to cope with changing environmental conditions is termed as assisted range expansion (ARE). Assisted species migration (ASM) occurs when a species is moved far outside its current distribution range. Less controversial than ASM, APM and ARE have already been adopted in seed transfer guidelines in many regions of the world (Pedlar et al. 2011; Konnert et al. 2015). Although it may involve substantial changes in policy and public perceptions, ASM might be a viable option to introduce specific functional traits and increase resilience in particular forest regions

Assisted migration
 = *planned migration of tree species or provenances into climatically more suitable regions*

Examples with pine in Europe:

APM: Scots pine provenances from southern to central Europe

ARE: Scots pine, on most sites in Germany

ASM: P. ponderosa, as an introduced pine species from abroad

Source: Messier et al., 2019

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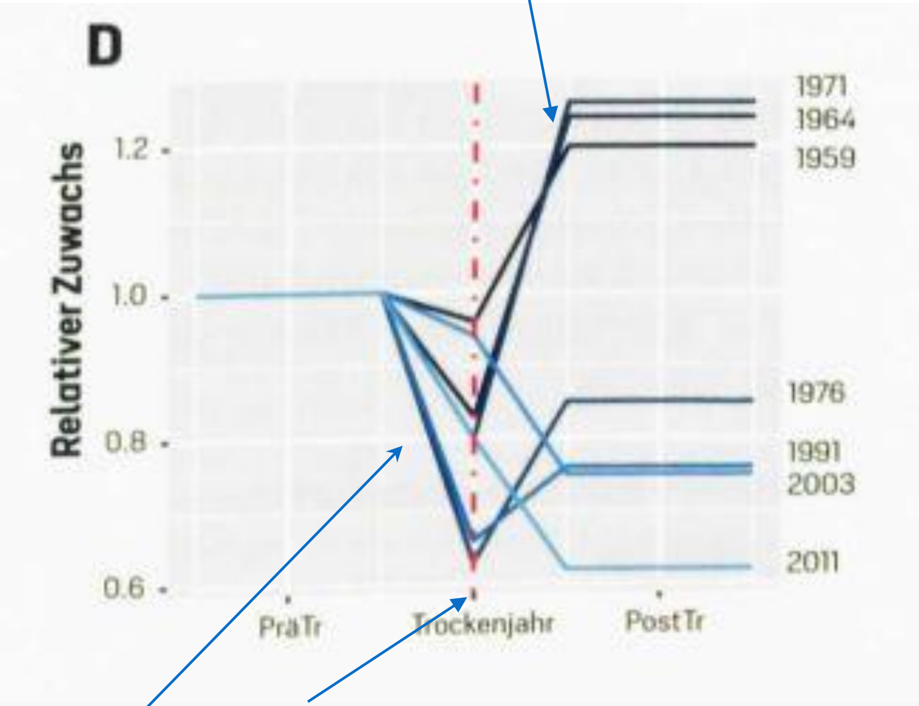
Response of Scots pine to drought and thinning

resilience



drought year, e.g. 2003

resistance

Resistance and resilience of Scots pine, after **drought**

Preliminary results:

- *low resistance in 1976 and 1991*
- *higher ecological resilience at young ages (correlated with thinning intensity)*
- *decreasing resilience after several drought years*

Source: Stubenazy et al., 2020

Reforestation after damage, under difficult conditions:

- *mixtures*
- *natural regeneration > direct seeding > planting*
- *soil scarification*
- *consideration of nature conservation aspects*


No chance for self-renewal?


Soil tillage and planting


Leaving stand legacies
(deadwood)
10.03.2022


Enrichment planting, also with non-native tree species

Management for diverse ecosystem services

- NTFP: e.g. resin, mushrooms, berries
- Soil fixation on dunes
- Water infiltration
- Soil nutrient sustainability
- C storage
- Biodiversity
- Recreation
- …

Other relevant pine species in Central Europe

- P. strobus ?
- Mountain pine ?
- Cembra pine ?
- Austrian pine ~
- Ponderosa pine ?
- …

Lessons learnt about Scots pine

1. Second most important conifer species in Germany (Central Europe), pioneer tree species, less competitive
2. Susceptible to biotic pests in pure stands, recently declining robustness due to drought
3. Future in mixed forests with oak, E. beech and Douglas-fir: further conversion of pure stands needed
4. Management option: from a mass product to high-value timber, other ecosystem services
5. Difficult to manage in CCF or retention systems

Thank you!

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