

Ī Genetics in a Commercial Conifer Nursery and Practicing ForestryĪ

Kurt Ramskogler, LIECO



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Content

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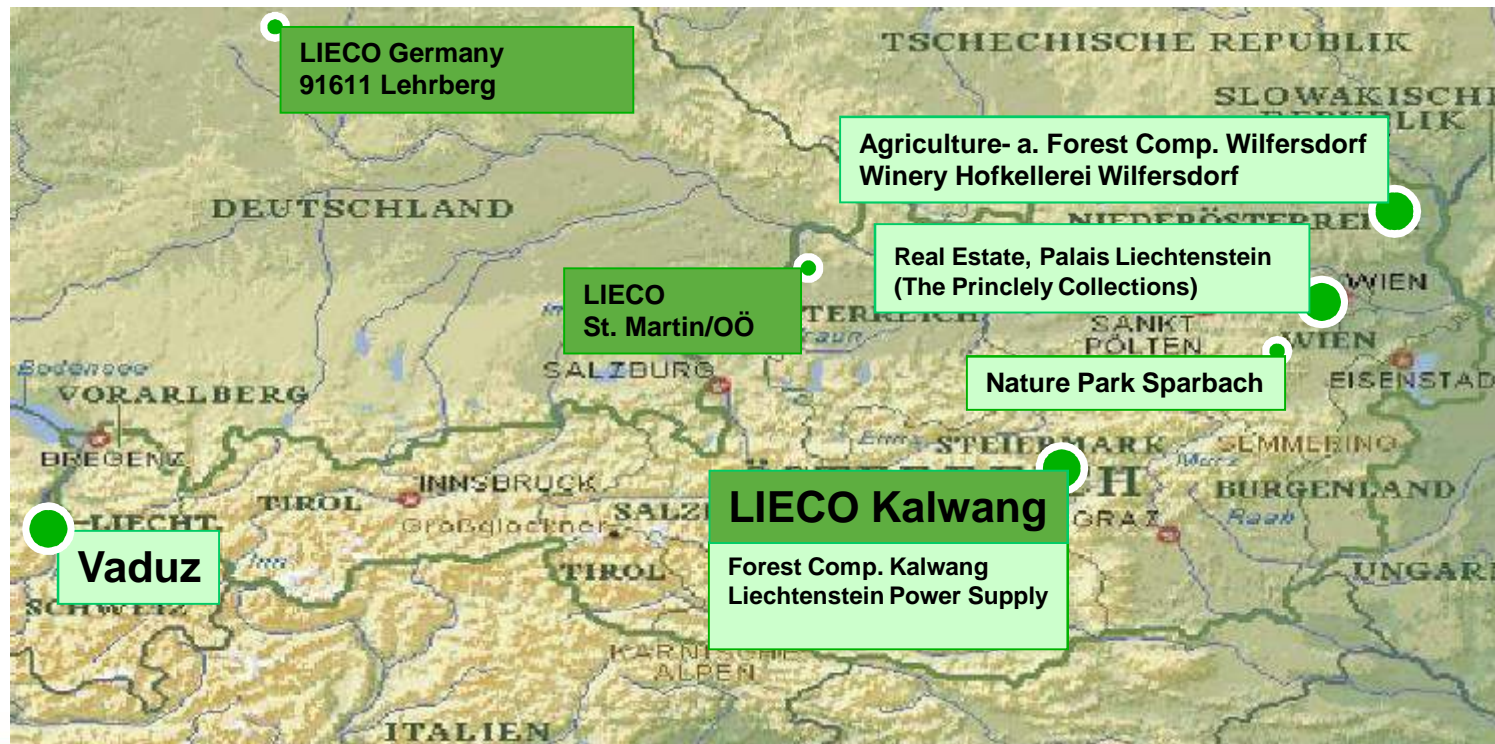


- 1) Introduction LIECO
- 2) Forest History
- 3) Silviculture / Provenances
- 4) Current Situation
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The property-area in Austria is around 20.000 ha



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SUCCESSFUL AFFORESTATION

- “ An enterprise of the sPrince of Liechtenstein Foundation%o
- “ Pioneer for containerized forest seedlings in Middle Europe
- “ Market leader for forest seedlings in Austria
- “ 30 years R&D
- “ Technology- and know-how leader at least in Middle Europe

Company goal

Research, development, production and sale of high quality containerised forest seedlings for a site adapted sustainable forestry as well as expansion at least in Europa



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LIECO . A Company with Visions

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Production site St. Martin

Production site Kalwang (Head office)



Area: 12 ha



Area: 9,5 ha



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The LIECO System stands for

- ✓ the selection of the best available provenances
- ✓ a wide range of seeds / seed sources
- ✓ best production technology
- ✓ best quality of forest seedlings
- ✓ the leading conifer producer; broad leaf share max. 10%
- ✓ best logistics
- ✓ optimized planting system

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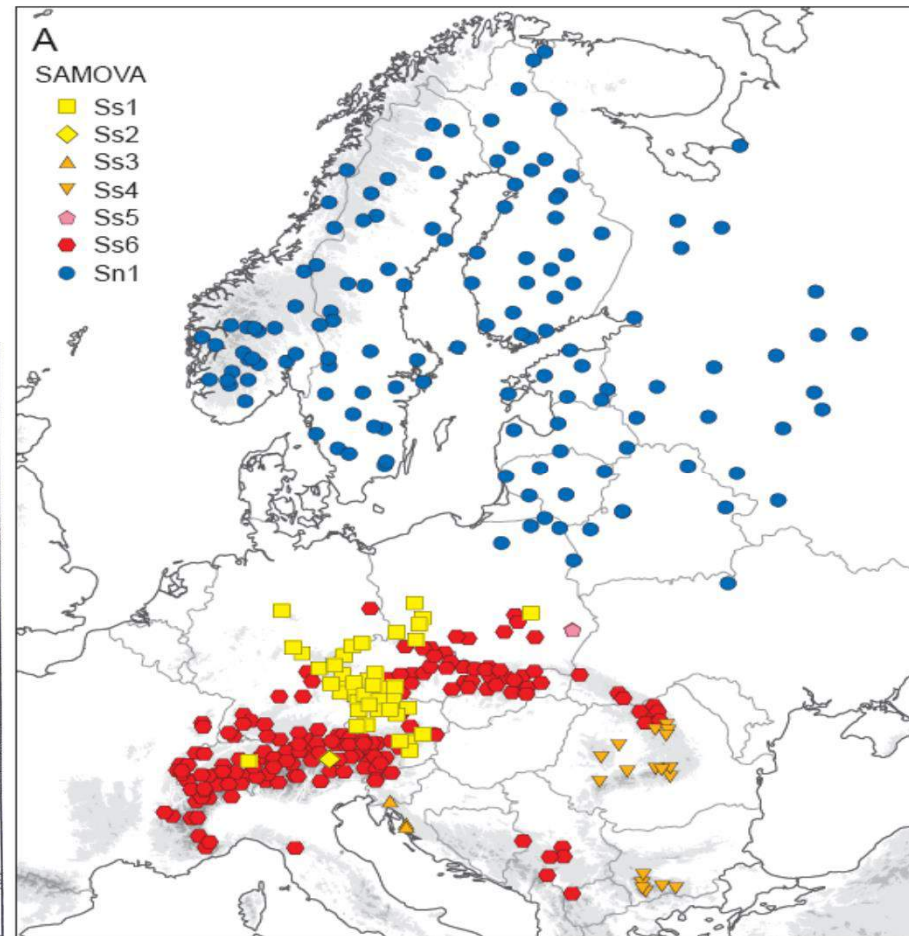
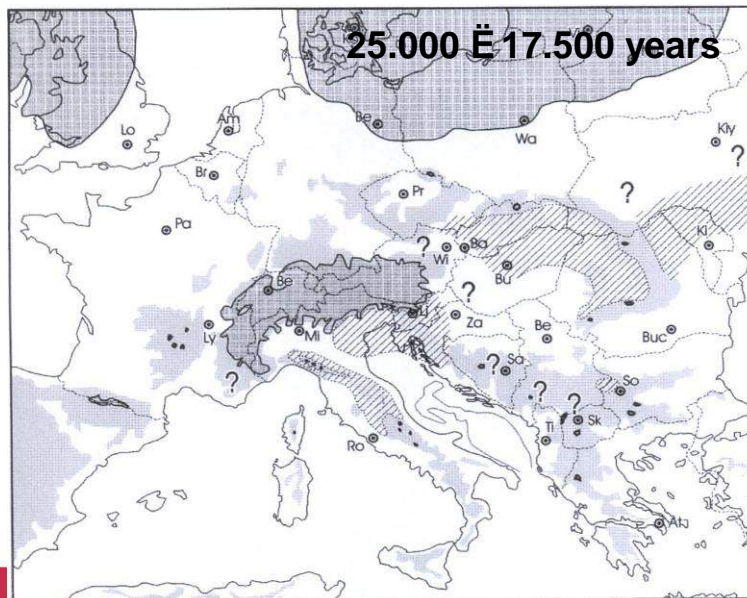
Genetics & Immigration History

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“ Glacial history / immigration history → different haplotypes (Example spruce)



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Source: Green Heritage & Trees for the future

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Genetics & Forest History

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- “ Forest history / anthropogenic impact
→ Large clear-cuts, seed sources, ð



Source: Green Heritage & Trees for the future



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- “ **Systematic regeneration since introduction of the various forest regulations / laws** (ö .., 1524 %Salzburgs+first forest regulations . archbishop Matthäus Lang von Wellenberg, regulation of the Bavarian and Austrian Forest Law 1852, ö ..)
- “ **1791: First silviculture standard work** Timber production instructions for forest techniciansí -> Georg Ludwig Hartig
1817: Heinrich Cotta published his Silviculture instructionsí , the first global silviculture book

Selective silviculture: Í Breeding in a wider senseî → Selection of provenances, seed stands, seed trees, plus trees (selective thinnings), Õ

Cone section

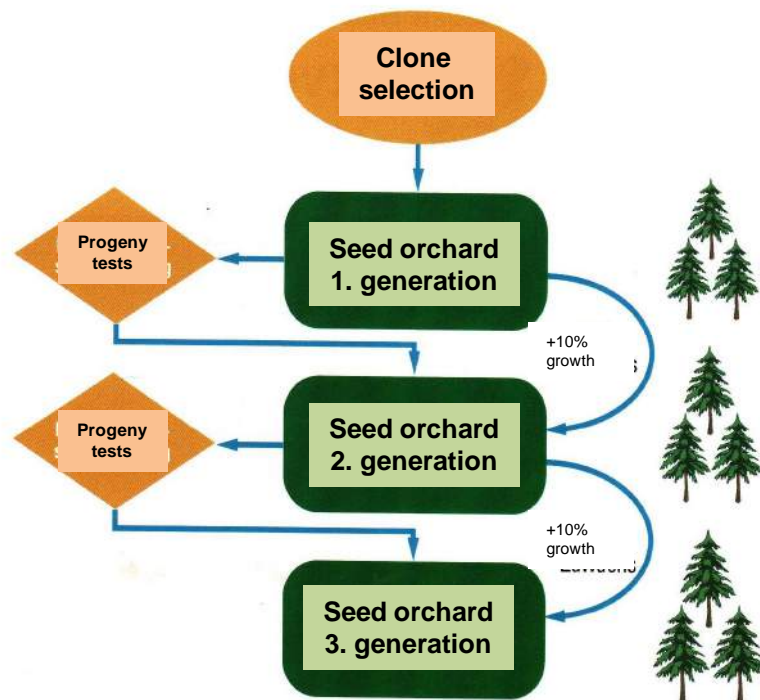
Nr. 1 + 2
Bad quality

Nr. 3
Middle quality
→ **Partial mast**

Nr. 4 - 7
Good quality
→ **Full mast**



Í Proper breedingÎ → Repeated selection of plus-trees and testing them, to produce in artificial populations seeds with an improved value. Goal also to secure sustainably an optimized seed supply from seed orchards with the best provenances and genetics for practicing forestry



Provenances

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Origin / genetics decides about the progeny characteristics



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Provenances

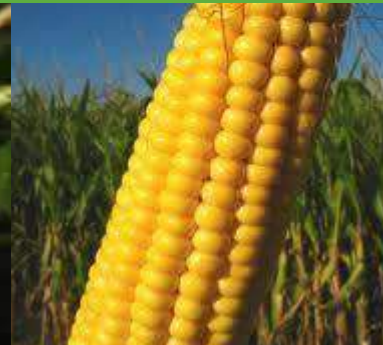
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For animals and agricultural plants
the importance of genetics is well known



Within forestry ???



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Provenances

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The proper genetics / origin decides about quality, stability and vitality of our stands and therefore also about the timber proceeds



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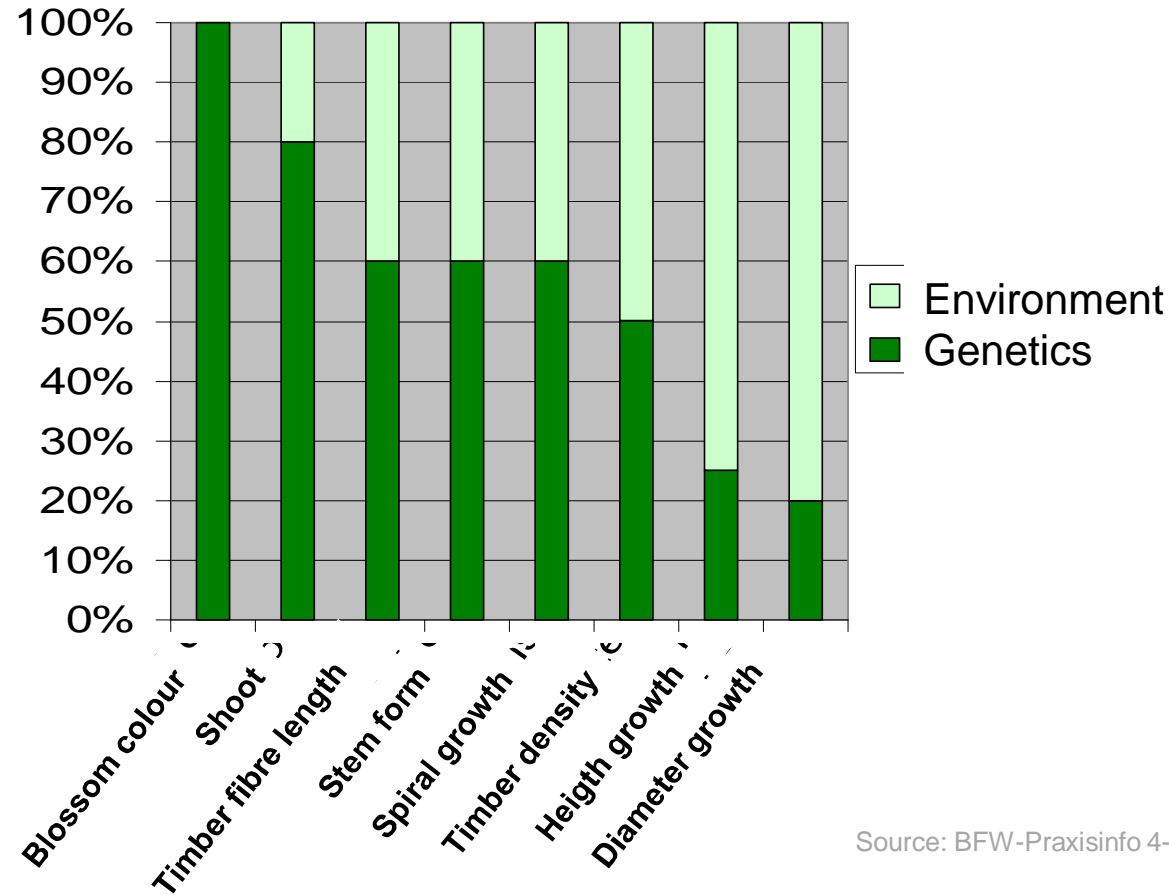


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Phenotypic Appearance

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Source: BFW-Praxisinfo 4-2004, T. Geburek



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Choice of suitable Provenances

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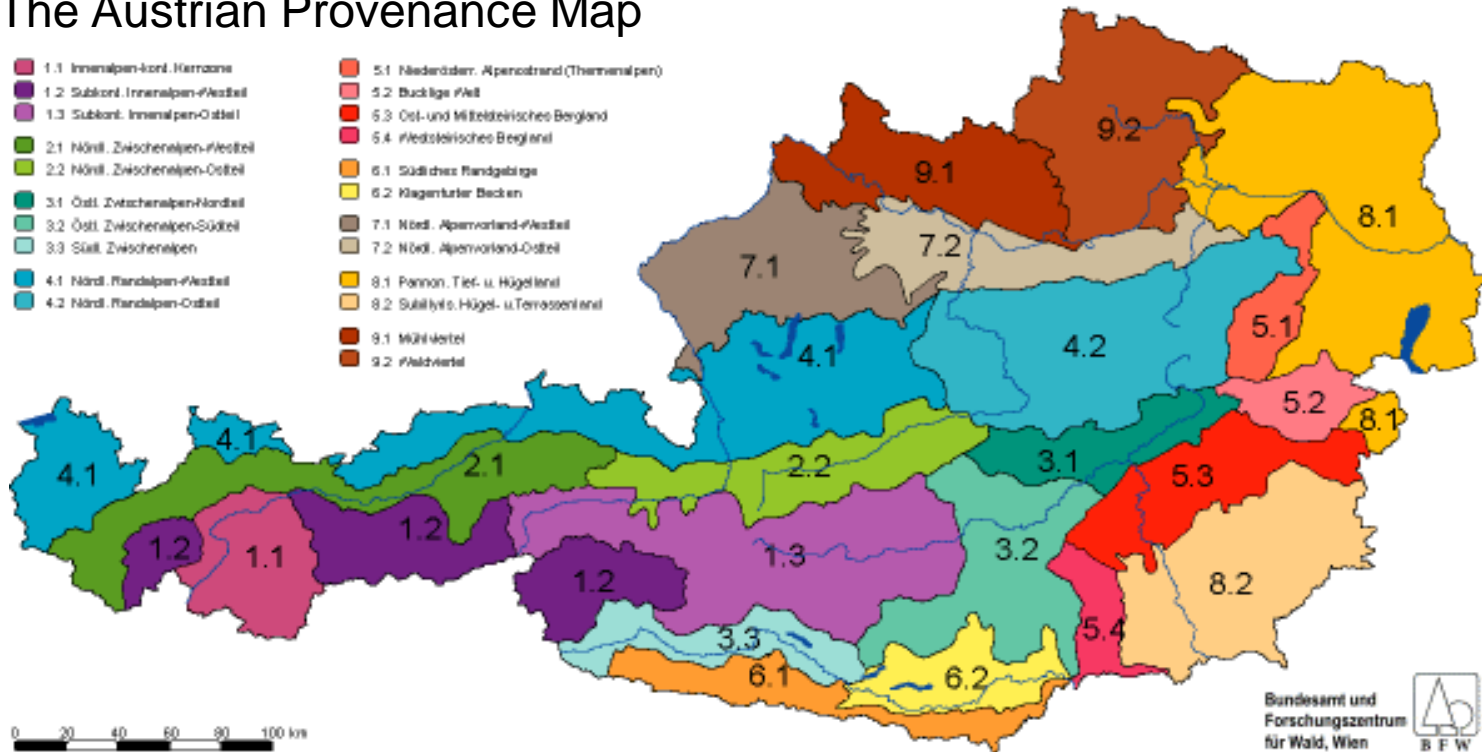


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The Austrian Provenance Map



- | | |
|-----------------------------------|---|
| 1.1 Inneralpen-inkl. Harzzone | 5.1 Niederöster. Alpenstrand (Thermalalpen) |
| 1.2 Subkont. Inneralpen-Westteil | 5.2 Bucklige Welt |
| 1.3 Subkont. Inneralpen-Ostteil | 5.3 Ost- und Mittelsteirisches Bergland |
| 2.1 Nördl. Zwischenalpen-Westteil | 5.4 Weststeirisches Bergland |
| 2.2 Nördl. Zwischenalpen-Ostteil | 6.1 Südliches Randgebirge |
| 3.1 Östl. Zwischenalpen-Nordteil | 6.2 Klagenfurter Becken |
| 3.2 Östl. Zwischenalpen-Südteil | 7.1 Nördl. Alpenvorland-Westteil |
| 3.3 Süd. Zwischenalpen | 7.2 Nördl. Alpenvorland-Ostteil |
| 4.1 Nördl. Randalpen-Westteil | 8.1 Pannon. Tief- u. Hügelland |
| 4.2 Nördl. Randalpen-Ostteil | 8.2 Subillyris. Hügel- u. Terrassenland |
| | 9.1 Mühlviertel |
| | 9.2 Waldviertel |



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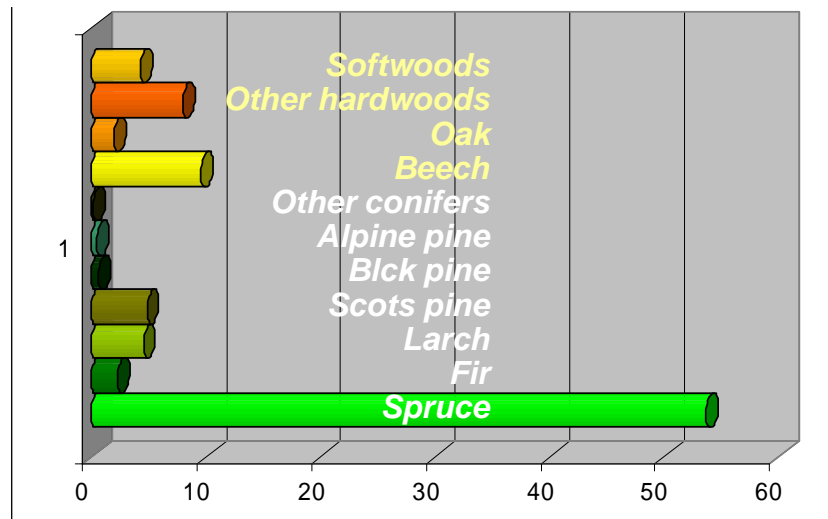
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Current Situation

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47,6% of Austria is covered with forests



WaldBericht, BMLFUW and ÖWI

11% of the forests = bareness, openings and shrubs

25% of the forests = broad leaves

64% of the forests = conifers
51% spruce = dominating

→ Spruce is and remains the most important tree species in Austria

→ The provenance has an essential influence on the stand-quality and -stability

Current Situation – Questions?

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- ✓ Too low growth ð ?
- ✓ Too low wood qualityð ?
- ✓ Too long rotation periods ð ?
- ✓ Too low resistance against environmental impacts, insects, fungi, ð ?
- ✓ Too low knowledge about the history of forestry and forests, genetics in common, genetic adaptability of various tree species and geographical characteristics, provenances, biodiversity in common and diversity within tree species, ð ?



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Current Situation – Questions?

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- ✓ Too little seed orchards for improved seeds ò ?
- ✓ Too little lab capacity for seed and molecular analyses for individual trees ò ?
- ✓ Too little availability of high quality seedlings (root development) and from improved genetic material (seed orchards) ò ?
- ✓ Too little knowledge about new standards in seedling production ò ?

Current Situation & Questions?

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- ✓ Too little knowledge about the genotypes σ ?
 - The knowledge of the foresters analyzing stands for harvesting seeds / plus tree selection / selective thinnings is mainly based on the phenotype, because the DNA as an analyzing tool (genetic markers) is not available yet in Middle- / Central-Europe in a sufficient dimension



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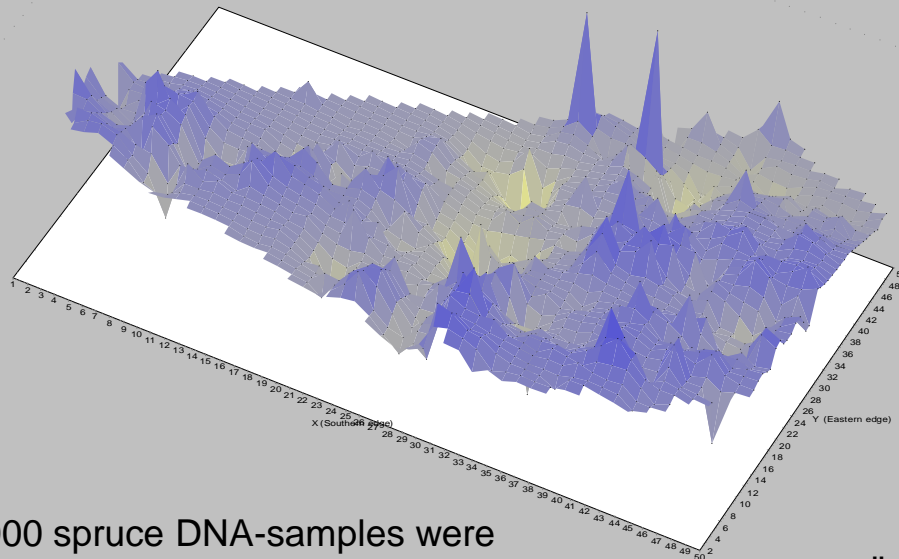
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- ✓ Genetic landscape for spruce based on microsatellites

Source: Green Heritage  Trees for the future



Result: Higher genetic heterogeneity in some parts of Austria = regions with obviously non-resident provenances detected and confirmed

More than 3.000 spruce DNA-samples were gathered and analyzed through the last Austrian Forest Inventory (ÖWI)



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- ✓ Seeds for the seedlings production are mainly coming from seed stands, approved by state experts according to the various provenance maps and phenotype
- ✓ Seed orchards were mainly established to secure gene resources for biodiversity reasons (Austria, Germany) and not primarily to produce improved seeds to increase the biomass production
 - Austria: 68 seed orchards are existing (131 ha)
 - Example SCA-Skog Sweden (about 2 mio. ha productive forests): Access to about 120 ha seed orchards

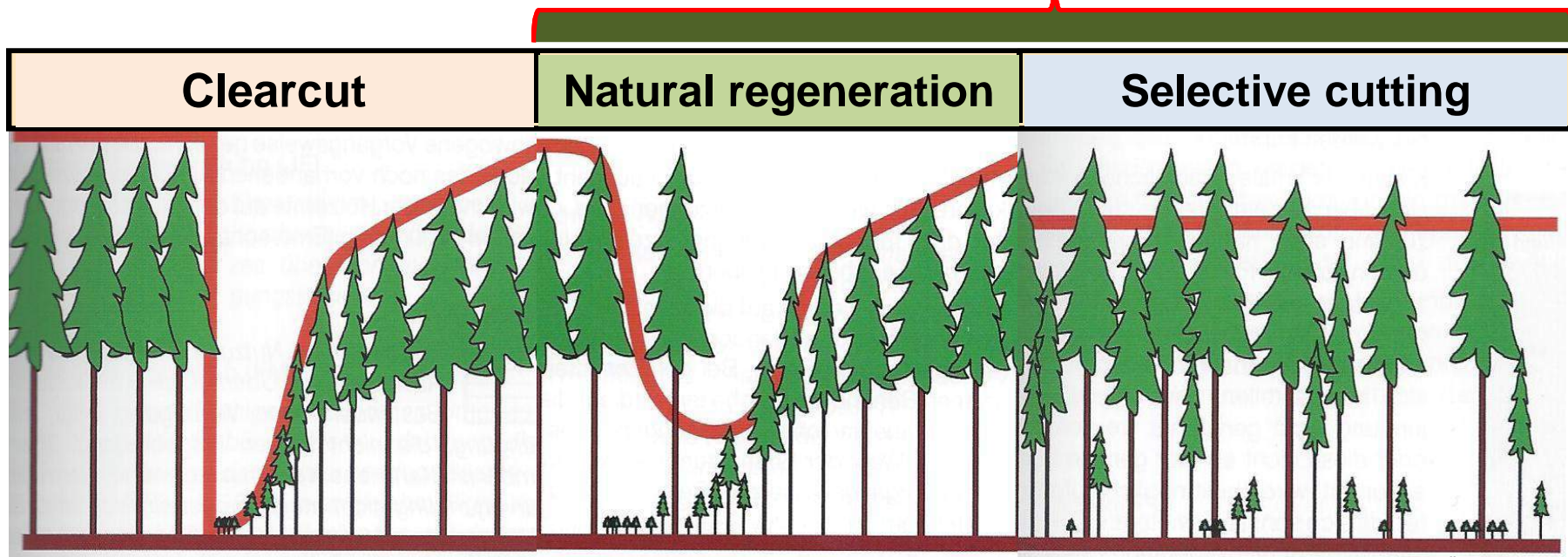


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- ✓ High focus on natural regeneration and naturalistic silviculture



Source LK-Ö / LFI 2013

— Impact of the silvicultural system on the increment



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- ✓ Only a few forest companies established own seed orchards for their main species, kept their own forest seedlings production and are engaged in cuttings production and $\tilde{\circ}$. \rightarrow positive examples
Liechtenstein, Mayr-Melnhof (A), Hohenzollern, Bavarian State Forest, $\tilde{\circ}$ (D)+
- ✓ The seedlings production know-how is declining \rightarrow young seedlings for lining out / transplanting are more and more produced through order productions in the big European nursery centres (Northern Germany, Netherlands, Hungary, $\tilde{\circ}$)

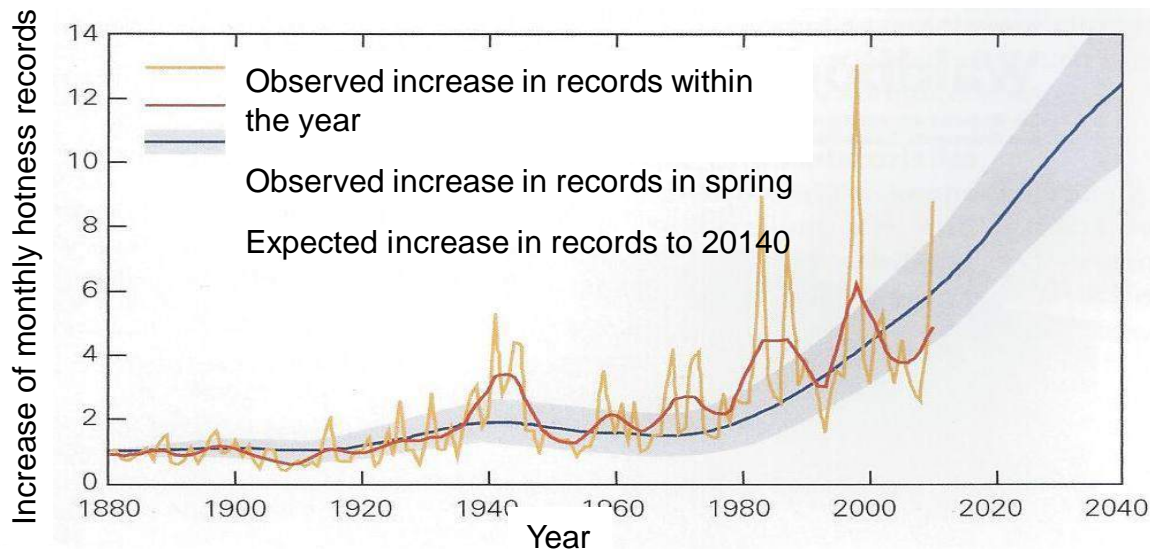
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- ✓ Trees which are planted today, probably have to endure till they are harvested, strong changes. Thereby a temperature increase is not absolutely crucial. The in the last decades observed increase of hotness and drought periods are seen more critical, especially for conifers like spruce
- ✓ More and more studies show an ongoing climate change



Trough climate change hotness records are today about 5x more frequent as they could be expected without global warming
(off Coumou et.al., Climate Change 2013)

Current Situation

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- ✓ Forecasts about local climate changes and their impacts on forests are still foreseen with huge inaccuracies
- ✓ Elongation of the vegetation period in Middle Europe within the last 40 years: about 10 days (Menzel et al. 2006)
- ✓ Sweden: Changes since 1960 show for identical clones on 60 different sites on average a 11 days longer vegetation period, a 6 days earlier bud flash and a 5 days later loss of the leaves

Current Situation

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- ✓ Higher temperatures lead to positive and negative effects



- > Higher photosynthesis
- > Prolongation of the vegetation period and therefore more growth and higher productivity



- > Earlier bud bursting and more frost damages
- > Increased water demand / higher evaporation rate, which means that there is less water available even if the precipitation distribution and amount does not change
- > Regional more drought damages / heavy rains / storms ?
- > Increase of forest pests, because their development time is temperature steered

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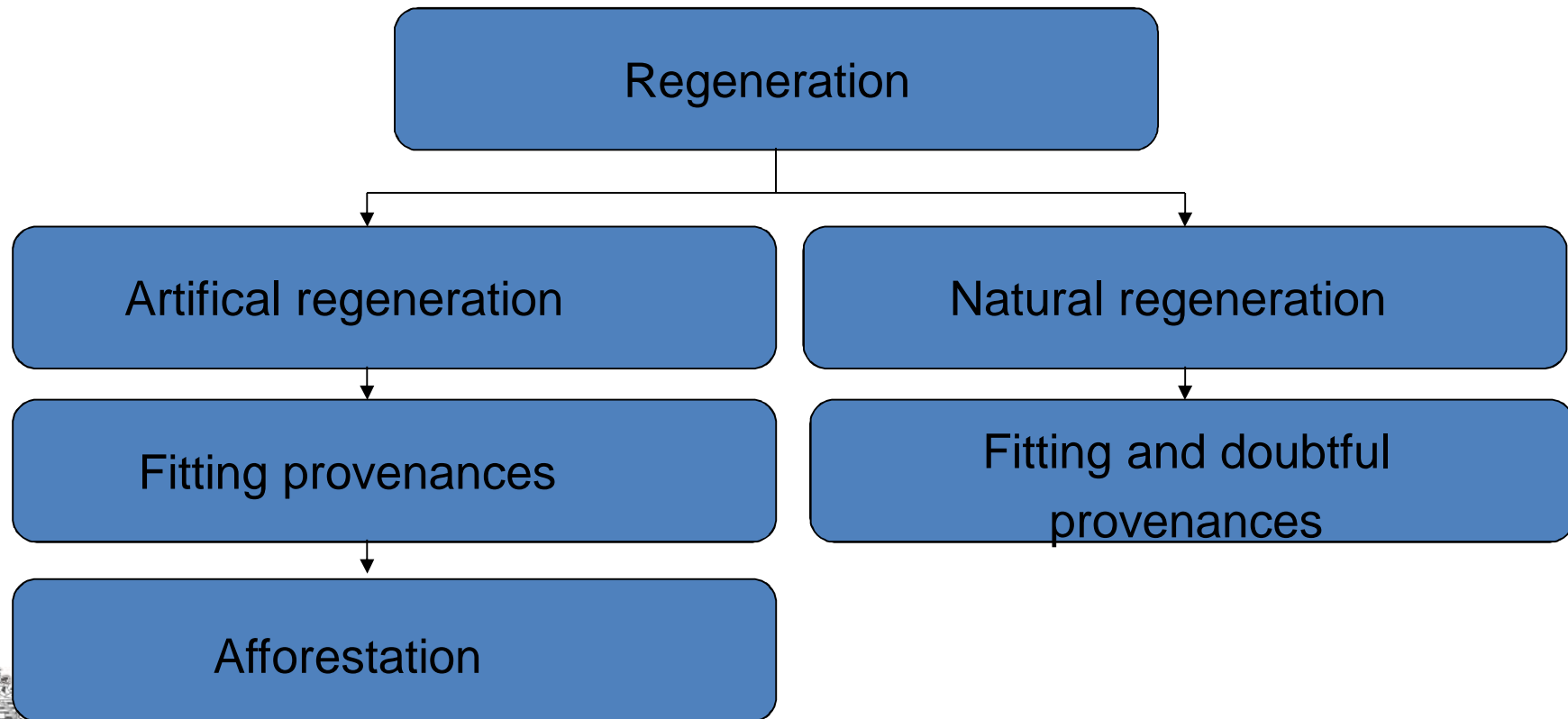
- ✓ European countries like Sweden, Ireland, Poland, etc. are far better developed in conifer genetics
 - availability of gene markers for specific traits (e.g. drought resistance), yield increase oriented breeding programs through improved seeds from seed orchards (OP . MCP . Varieties = increased genetic certainty), practical use of somatic embryogenesis, ...
 - Clear goals are missing like e.g.: Conservation and improvement of the genetic resources, breeding, search and maintenance of the genetic material on an adequate quantitative and qualitative level for regeneration (Poland 2011-20135)+

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Regeneration decision process



Improved Genetics

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OPPORTUNITIES

- “ Resistance increase / more stable forests (incl. protection forests)
- “ Yield and productivity increase
- “ Quality increase
- “ Conservation of endangered species and provenances
- “ More security respectively risk-minimization through improved provenance recommendations
- “ Improvement of the competitiveness
- “ Job preservation
- “ Sustainable intensification of forestry

RISKS

- “ Missing knowledge and willingness of forestry to deal with genetic issues / yield increase
- “ Missing target definitions of forestry
- “ NGOs are against a sustainable intensification of forestry
- “ Political perception about a sustainable intensification of forestry
- “ Too little money for R&D
- “ Loss of competitiveness
- “ ð



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Goals?

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% Conservation and improvement of the genetic production level for the main tree species under consideration of the expected / ongoing climate change and

a sustainable increase of the quantitative and qualitative timber harvesting potential of the managed forests and

the conservation of the forestry competitiveness+

% Securing biodiversity, diversity within a tree species and yield increase as well as conservation of the genetic adaptation potentials for the main tree species+

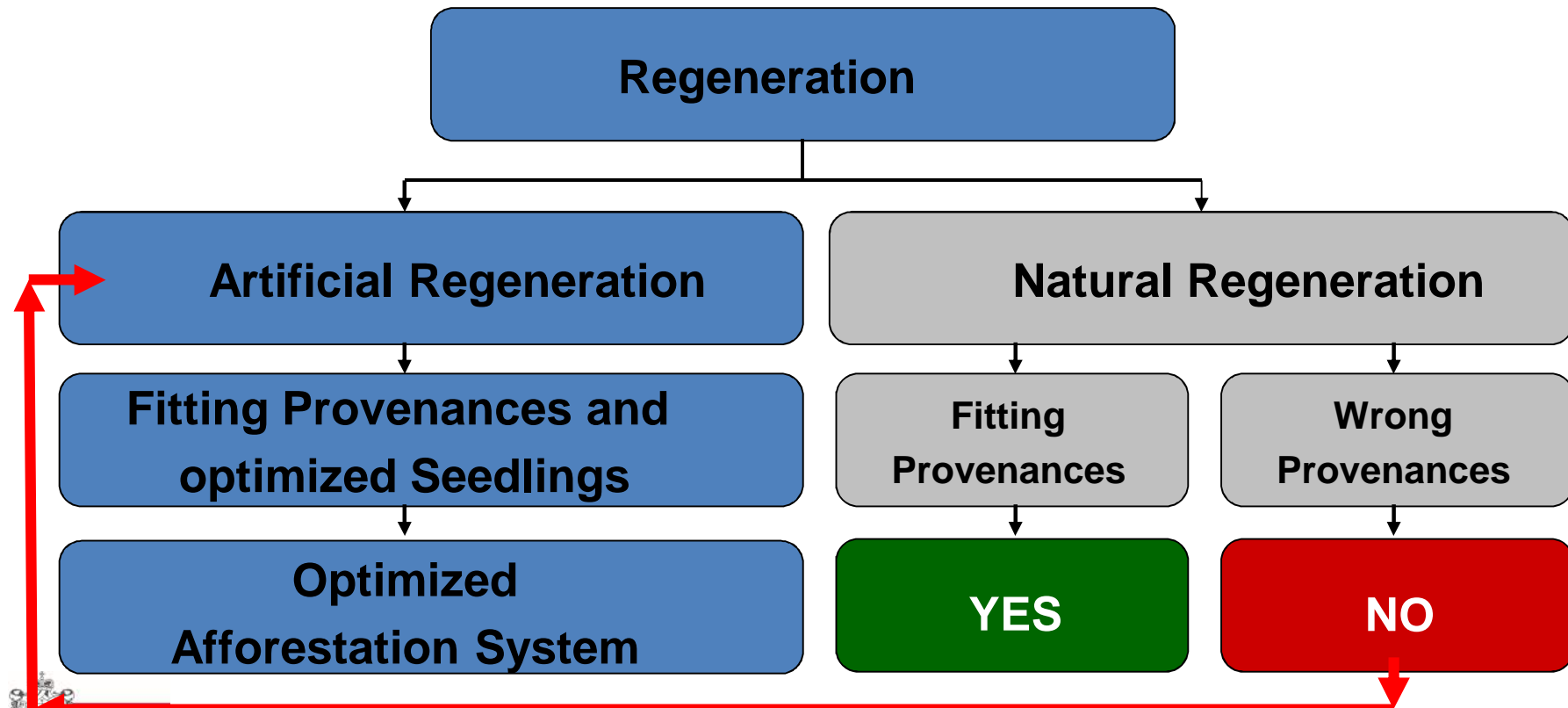
Requirements

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Regeneration decision process in future (Balance between natural and artificial afforestation, referring to the particular company goals)



►Maintenance of the genetics / yield increase?!



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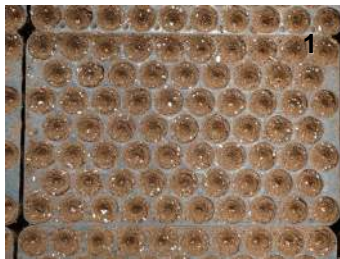
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“ **Forestry needs nurseries which are producing forest seedlings on state of the art.** They should be produced in one nursery preferably from the seed to the plantable seedling!



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Requirements

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→ Seedlings with the best genetics and a root system, those who secures even in drought periods highest growth- / survival rates



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2009

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- “ **Afforestation system** -> a closed cycle from seed harvesting . seed processing . seedlings production linked to the demand . seedlings delivery logistics . planting system linked to the seedlings and site demand (with or without soil preparation, δ). The planting has to be planned well by forest experts and the planting work and success of the regeneration aim monitored strictly



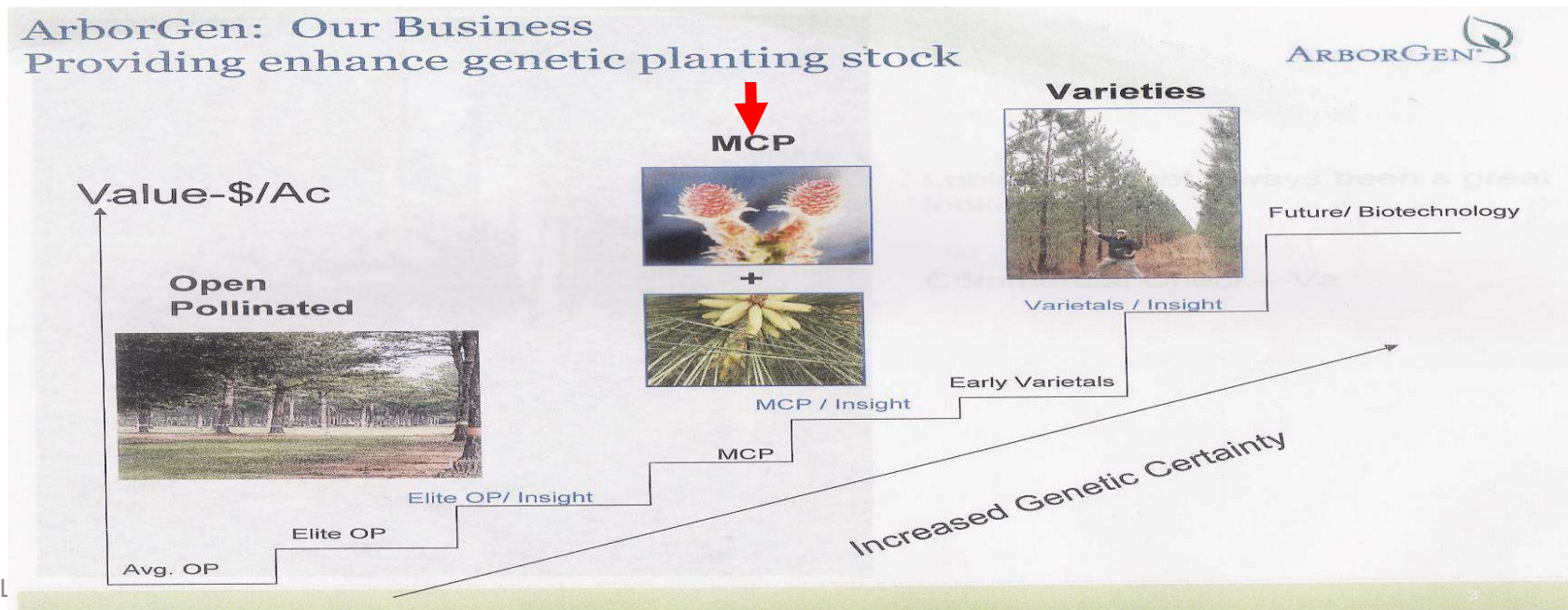
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- “ The **approval of seed stands, seed testing** has to be kept and improved according to the future needs -> lab capacity ?
- “ (Middle European) Forestry needs **more seed orchards** for improved seeds especially for the main tree species and best provenances . > OP -> MCP -> \tilde{o} .



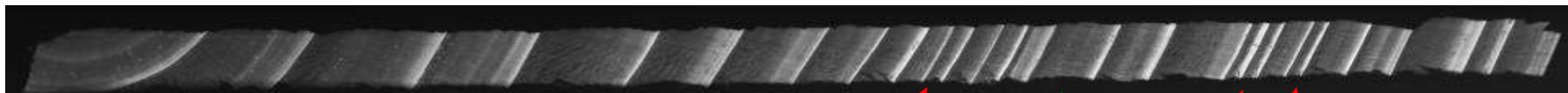
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- “ (Middle European) Forestry needs **more R&D support** to find the best provenances and genetics according to yield, defined characteristics / traits and stability -> Gen marker development for special characteristics like drought resistance, $\tilde{\sigma}$



Deutsch Gerisdorf
Altitude: 350 m
Precipitation: 685 mm
May+June: 179 mm
Temperatur: 8,3°C

1993
340 mm

1998
560 mm

2001
320 mm

2003
230 mm

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Example Spruce in Austria

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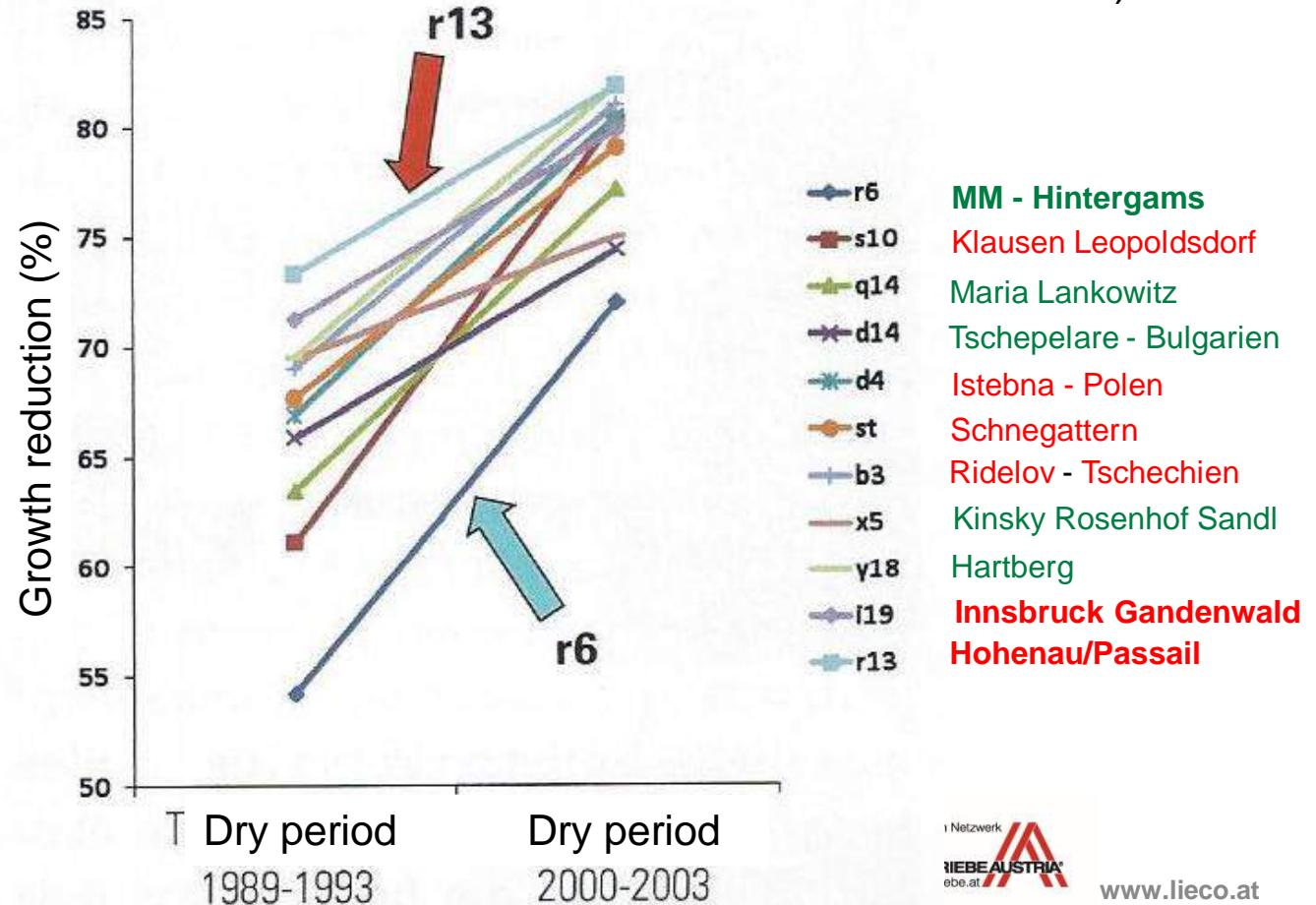


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- ✓ Drought resistance → Platicity of various provenances (1989-93 → growth reductions 54% to 73% and 2000-03 → reductions 72% to 82%)

Porrau:
Altitude: 250 m
Precipitation: 515 mm;
Mai+Juni: 137 mm
Temperature: 9,8°C

Source: Green Heritage Ę
Trees for the future



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- “ (Middle European) Forestry needs **more applicable R&D results** according to biodiversity, diversity, seed quality, provenances in general, drought resistance, cuttings, somatic embryogenesis, ð
- “ Adaption of the various **provenance recommendations** always under consideration of the current knowledge (eg. in Austria www.herkunftsberatung.at)

Requirements

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- “ To generate within practicing forestry **more interests in genetics and regeneration in general** -> newly planned: certification training for regeneration and tending generation through the BFW Training Centre Ort+
- “ To generate **more knowledge about seedlings production and breeding programs** -> as better as the improved genetic material is, as higher is the demand for high quality containerized seedlings produced on state of the art (international trend)

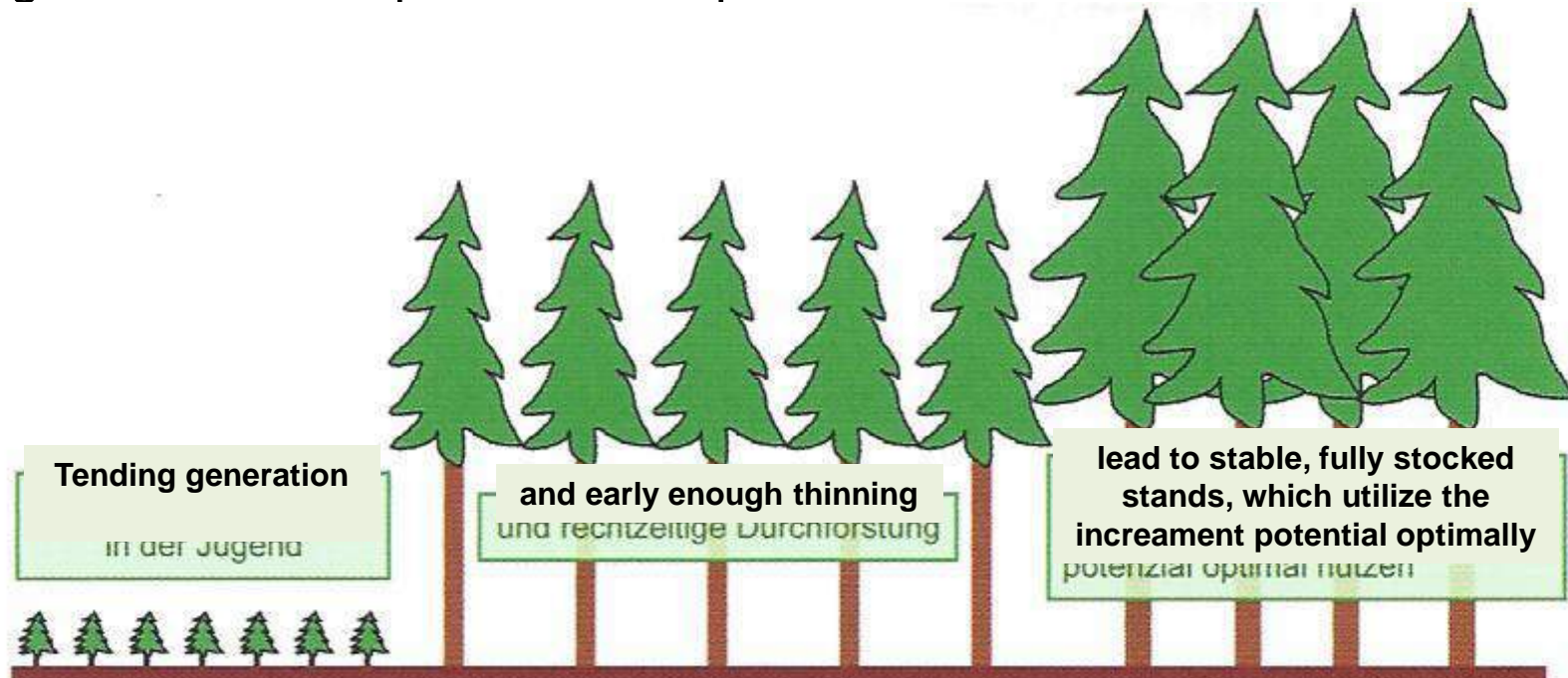
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- “ **Intense focus in the forest management on spacing and optimized rotation periods** -> trees need space for an optimal growth and adequate rotation periods



Source LK-Ö / LFI 2013

Requirements

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- “ **Proper tree species selection** -> %As many economic important tree species as possible and as many as ecological important as necessary+
- “ The installation of a **Genotyp-provenance data base** is in future essential for practicing forestry to have always the knowledge about the best provenances and genetics available
- “ A **higher yield / productivity** in our forests means that worldwide natural / native forests will be better protected
- “ **Clear goals and visions**

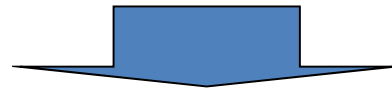
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Climate effects are modified through the site ➡ in all regional and local forecasts have to be considered that climate factors always act together with other site factors (Soil & water holding capacity, exposition, inclination)



Therefore the site, genetics and silviculture decides significantly, if and which tree species will be worth to be grown under the expected climate conditions

Caution: Often quoted climate envelope models are mainly based on two dimensional frequency distributions (average annual temperature and precipitation) and the actual appearance; growth, genetics / vitality, potential pests, \tilde{o} are not considered

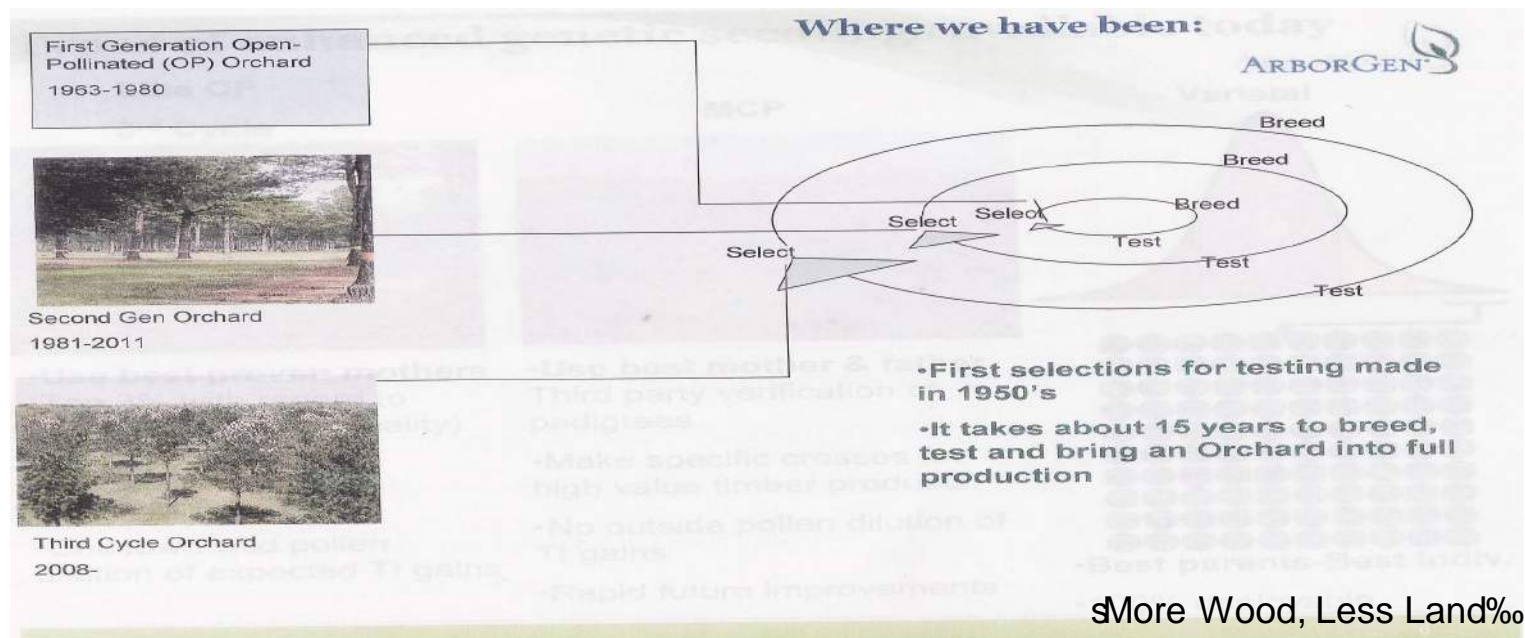
Conclusions

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Through targeted breeding a substantial yield increase can be expected. Factors like drought tolerance should be considered, to be successful due to climate change and to secure stable and productive forests. To realize breeding goals needs R&D years →



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Conclusions

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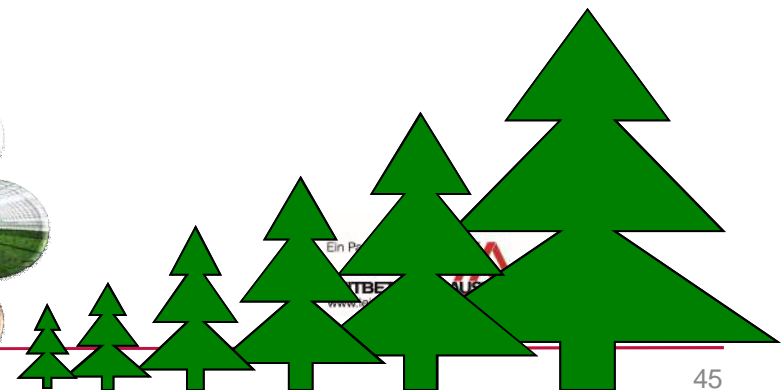
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Through a proper provenance choice in conifer based forestry a yield, quality and stability increase can be realized, if they are grown on suitable sites and if the silviculture management is at best.

Our Í Conifer-Breadtrees (Spruce, Larch, Fir, Pine, Å)Î will be also important in future and will ensure our forest companies and the companies along the whole value added chain Í Forestry Æ TimberÎ sustainably



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Thanks for your
attention

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