6th framework programme
Research Infrastructures Action
Integrating activity

Treebreedex

Large forest tree provenance experimental networks: their advantages, limitations and importance for future experiments

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Sachsenforst
Wald braucht Zukunft

Table of contents

1. History of provenance research

- Since middle age deforestation, exploitation and devastation of forests in Central Europe
- Development of sustainable forestry and reforestation
- Large scale seed transfer with no consideration of the origin of seed esp. Norway spruce, Scots pine

➔ Decrease of yield, poor quality, high susceptibility to pest and diseases

➔ Ban on different species

➔ Consideration of local seed sources

➔ Increasing interest in provenance research

History of provenance research

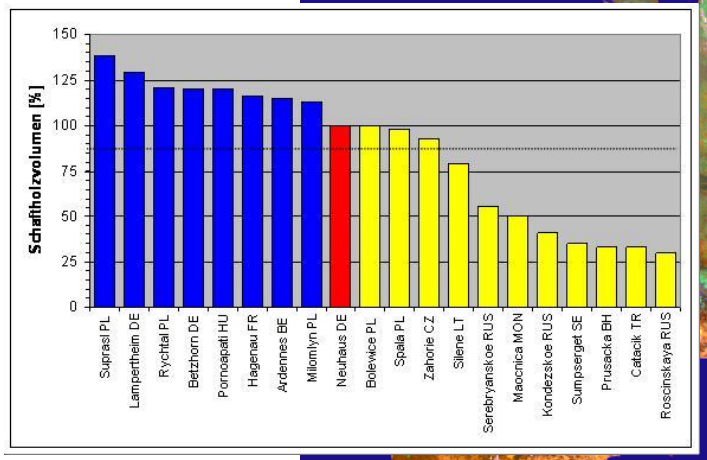
- 18th century:
  - Observations on correlations between provenance and site or provenance and quality respectively (Duhamel du Monceau)
- 19th century :
  - 1821: First provenance trials established in France (A. de Vilmorin)
  - 1893: IUFRO-congress in Vienna „Importance of seed origin in silviculture"
- 20th century :
  - 1906: Conference of German Forest Association in Dansk „Significance and obtaining of good forest seeds and plants"
  - 1907: Establishment of the first international provenance trial with Scots pine

2. Examples: IUFRO-Provenance experiments

Species	Year	Number of seed-lots	Number of trial plots	Participating countries
Pinus sylvestris (Giertych, Oleksin 1992)	1907	13	20	7
	1938	55	25	12
	1939	23	2	2
	1982	20	11	5
Picea abies (Krutzsch 1992)	1938/39	36	26	14
	1964/1968	1.100	20	13
	1972	20	43	10

IUFRO-Scots pine provenance experiment 1982

age 28



(Schneck & Liesebach 2010)

(Schneck & Liesebach 2010)

-65%
-70%
-59%
-44%
-21%
+13%
+20%
+38%
-0%
+15%
+21%
-2%
+29%
+16%
-7%
+20%
-67%
-50%
-67%

Two IUFRO-Norway spruce provenance tests

(Krutzsch 1992)

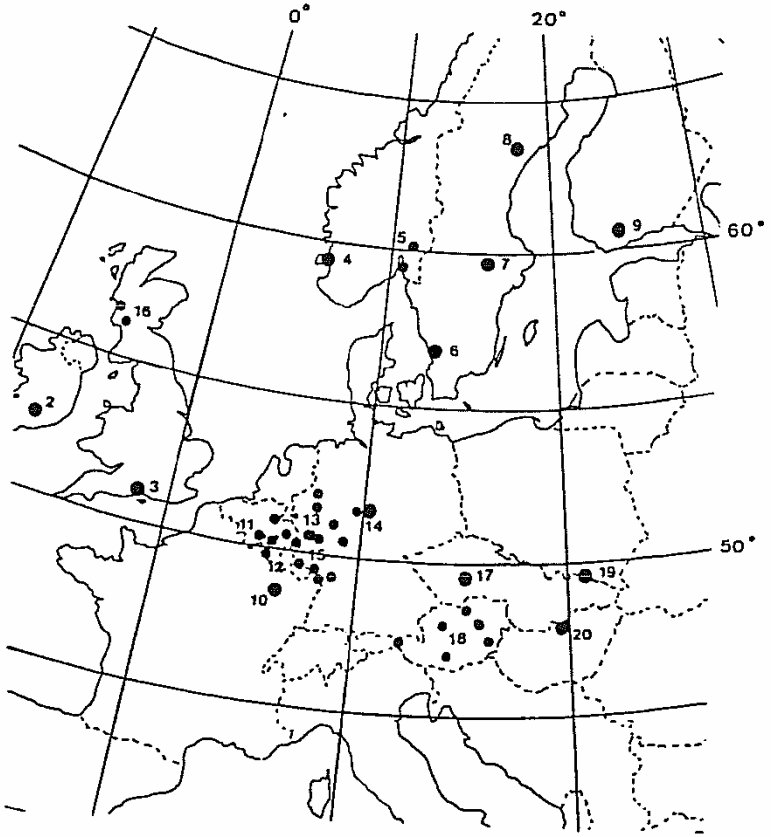


Figure 2. — International Provenance Test with Norway spruce IUFRO 1964/1968, Test sites.

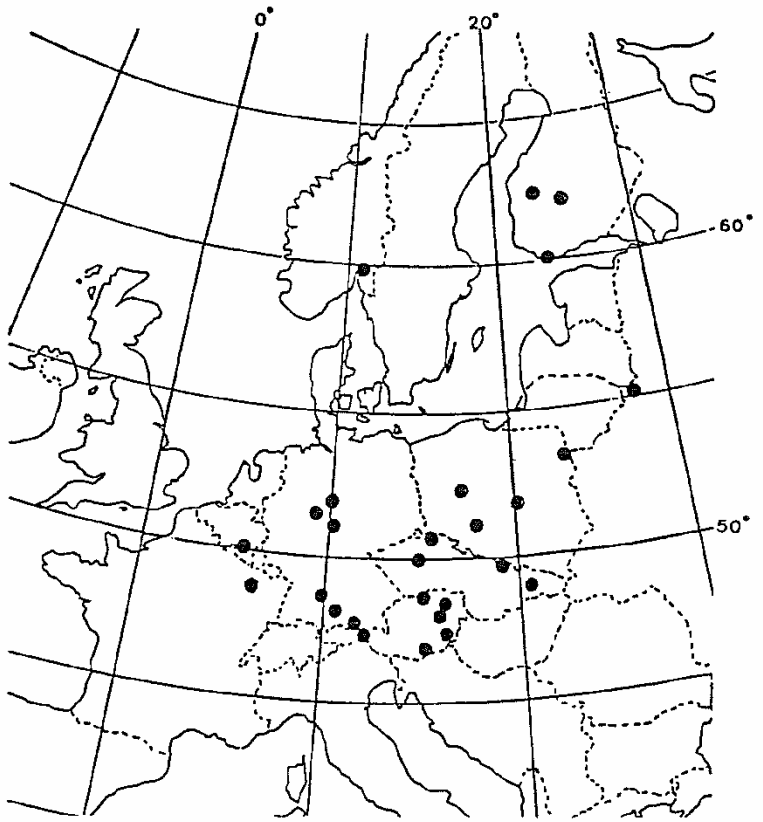


Figure 3. — International Provenance Test with Norway spruce IUFRO 1972, Test sites.

IUFRO-Provenance experiments

Species	Year	Number of seed-lots	Number of trial plots	Participating countries
Larix decidua (Weisgerber, Sindelar 1992)	1944	48	23	12
	1957/58	63	75	15
Pseudotsuga menziesii (Kleinschmit, Bastien 1992)	1973/78	182	60	36

3. Research in IUFRO-provenance tests

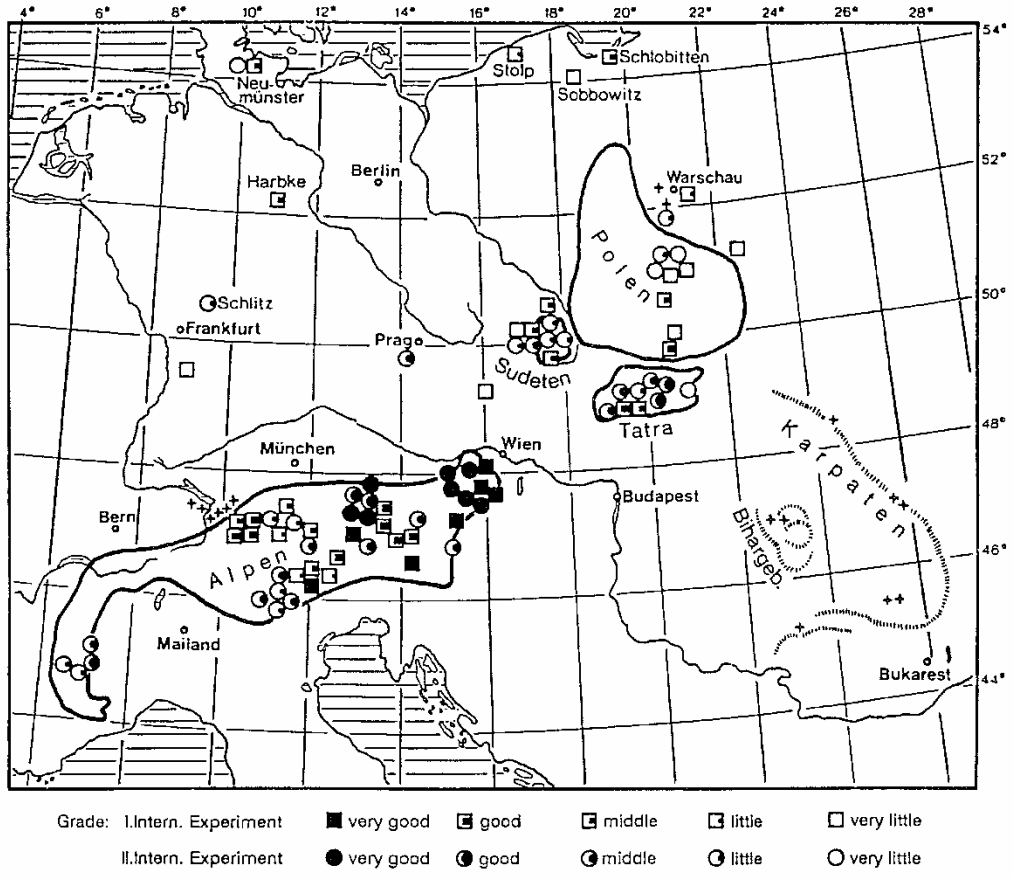


Figure 2. — Stem shape of provenance samples of European larch. From the 1st International Trial, sub-trial Neuhof, at age 23 and also as the mean of 24 sub-trials of the 2nd International Trial at the age of up to 20 years. Proportion of straight and slightly bent stems (1st Trial) and straight stems (2nd Trial) in the total number of stems, according to grades (from SCHOBER, 1981, 1985).

European larch

Traits:

- Growth
- Stem straightness
- Larch cancer
- Cultivation value

Stem shape of provenance samples of European larch (Weisgerber, Sindelar 1992)

EU-Provenance/progeny experiments

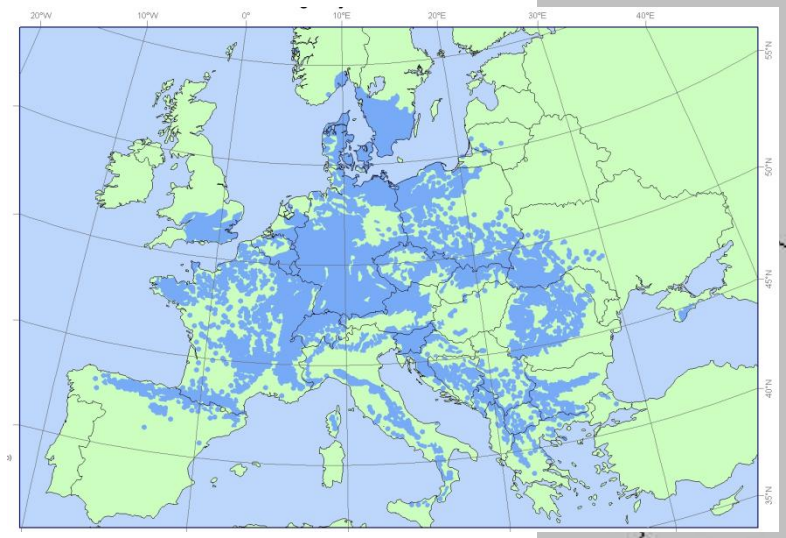
Species	Year	Number of seed-lots	Number of trial plots	Participating countries
Fagus sylvatica	1993/95	126	23	18
	1996/98	61	26	17
Larix eurolepis, *Larix lepteuropea*, *Larix* sp.	1999	25	18	7
…				

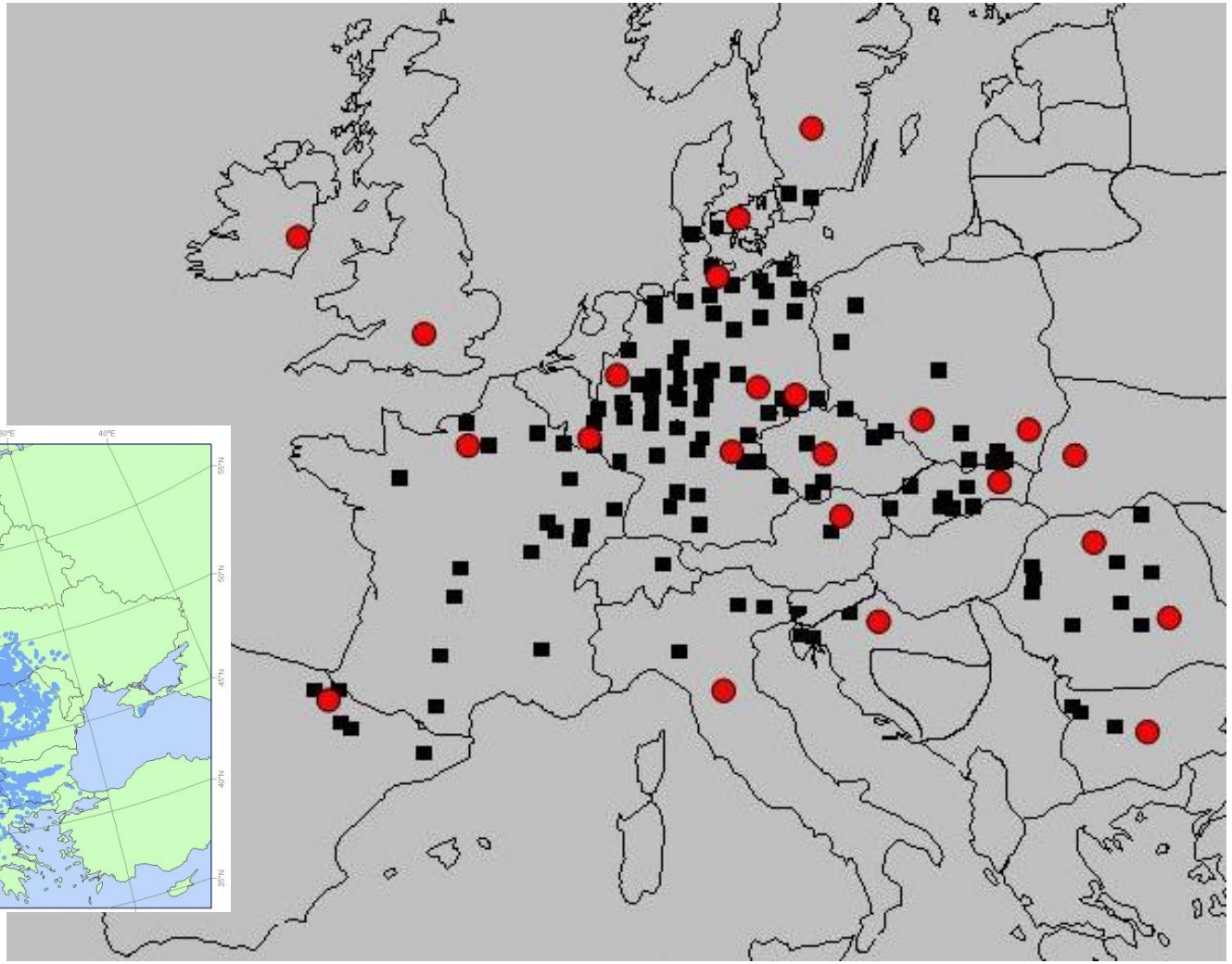
International Beech Provenance Experiment 1993/95

23 trial sites

126 provenances

(26) 36-49 or 100 provenances per site





Research in IUFRO-provenance tests

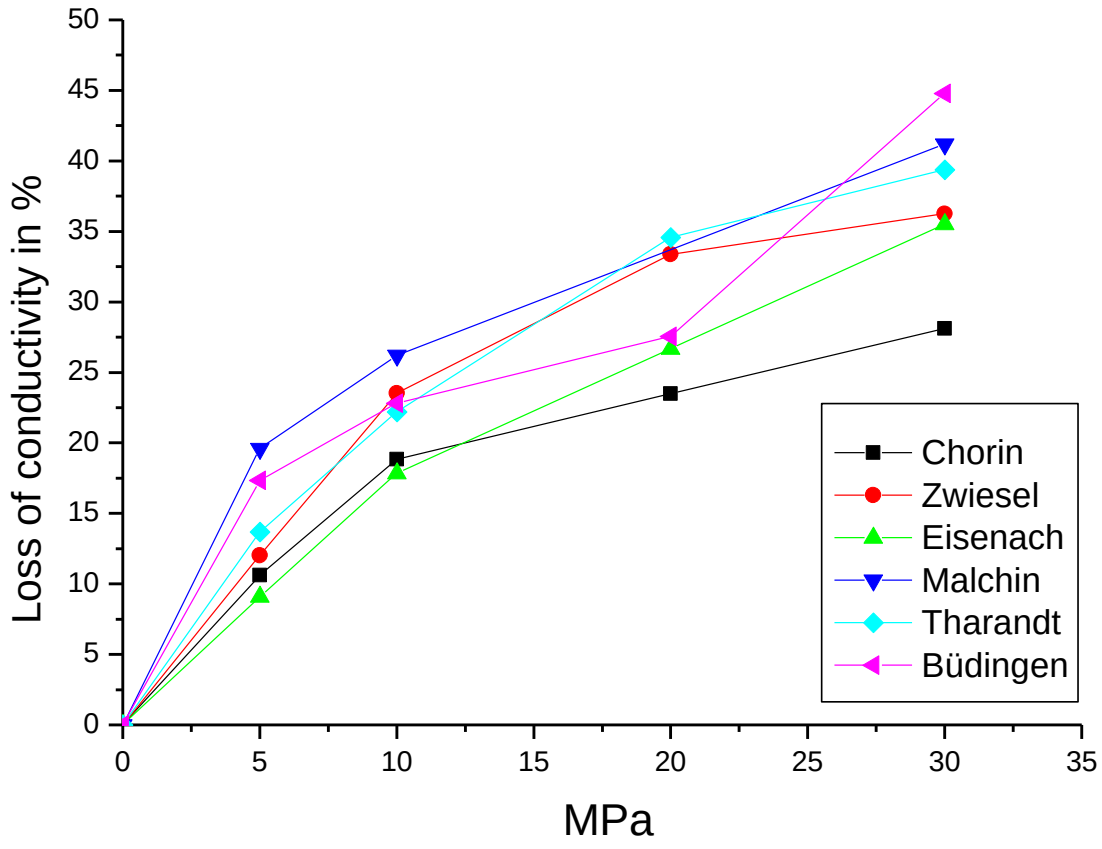
- Scots pine
  - Evaluation of provenances` growth
  - Relations to climate of origin
  - Correlation with geographic coordinates
- Norway spruce
  - Genecological studies
  - Time of flushing and bud cessation
  - Growth capacity
- Douglas fir
  - Cone and seed morphology
  - Phenology
  - Frost sensitivity
  - Growth capacity and quality

Research in EU-provenance tests

- European beech
  - Survival
  - Growth and quality
  - Morphological and anatomical traits
  - Physiological traits
- Larch-hybrids
  - Survival
  - Growth and quality
  - Wood quality

Research in EU-provenance tests

European beech



Assessment of loss of conductivity 2005 using provenances of Malter trial plot (DE-SN)

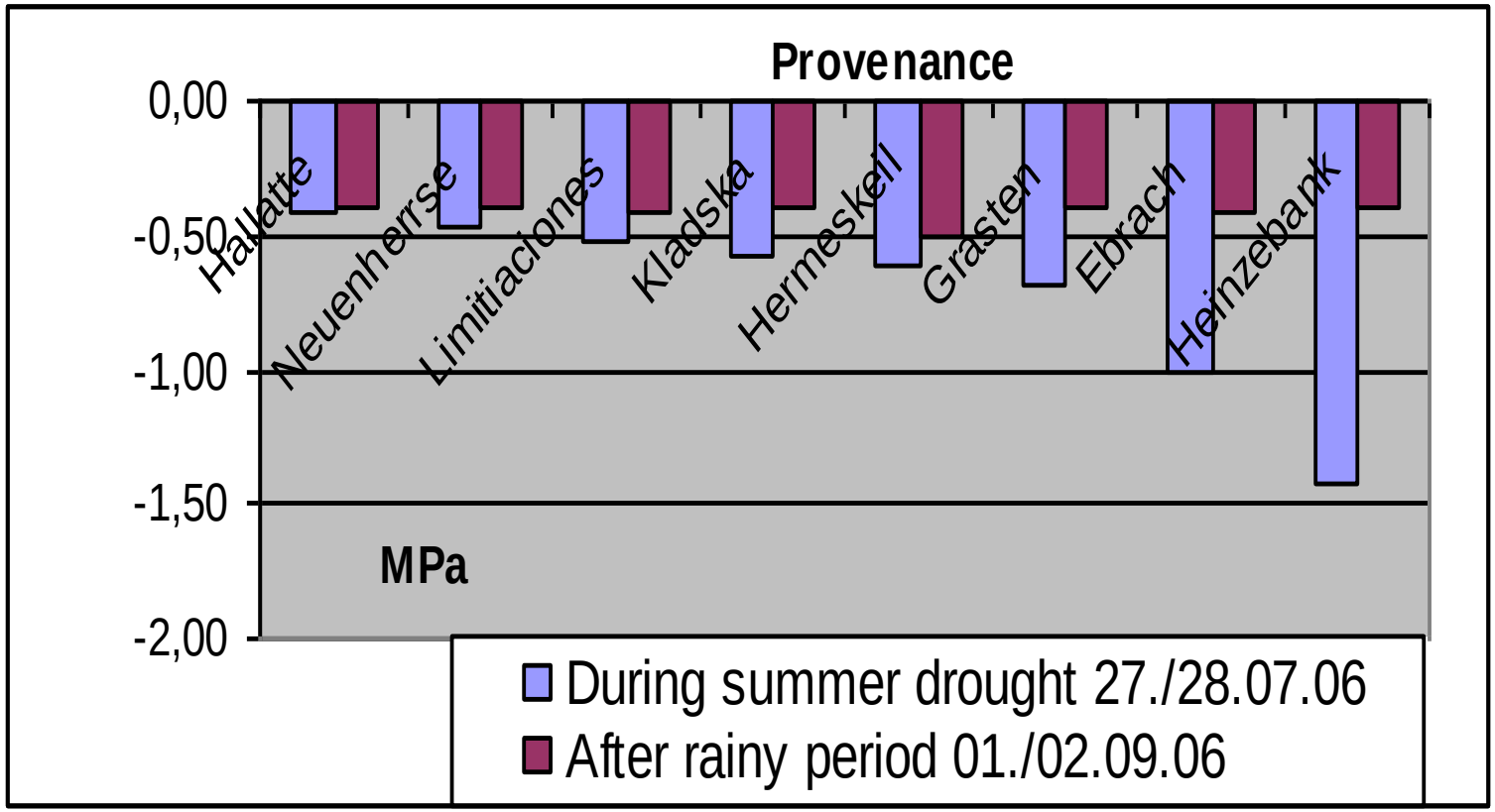
Significant correlation between “Colouring” in Graupa and PLC30 in Malter:

rs=0,943

Research in EU-provenance tests

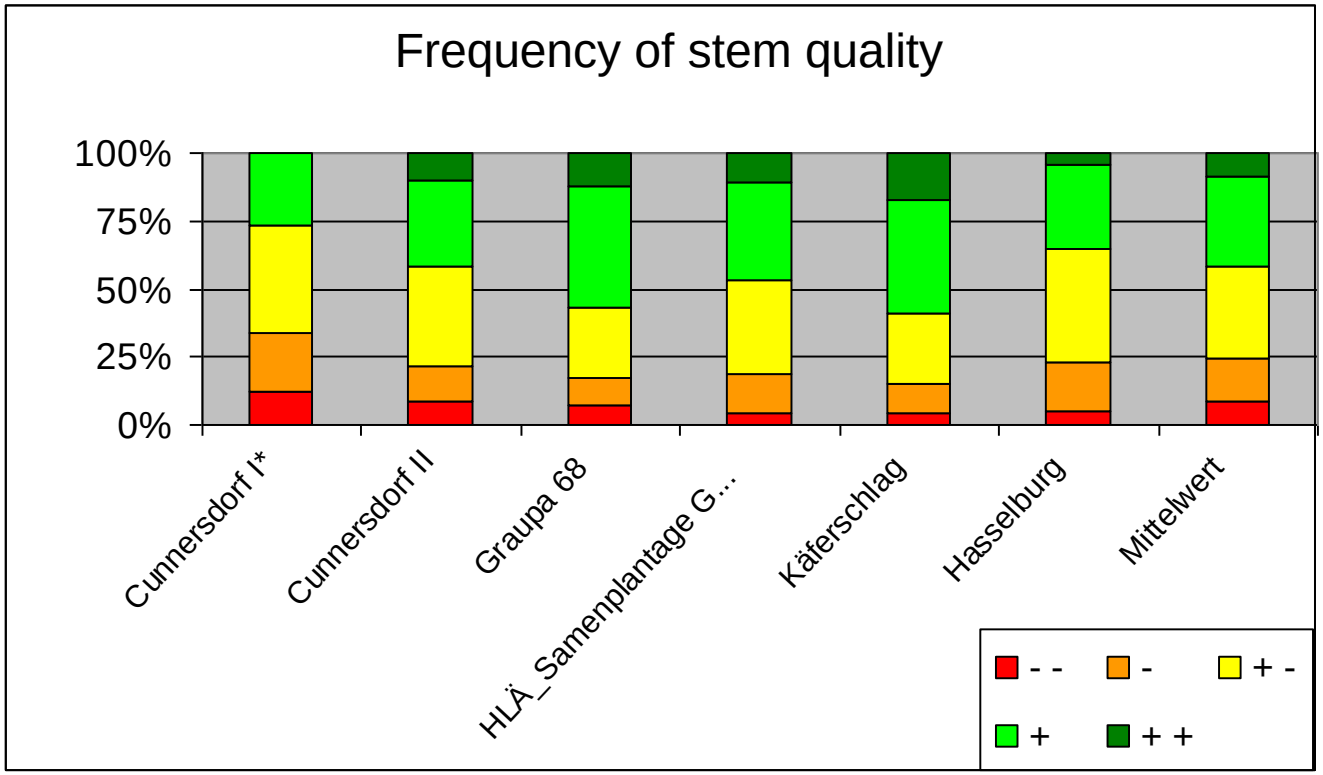
European beech

Assessment of predawn water potential 2006 using provenances of Malter trial plot



Research in EU-progeny tests

Hybrid-larch progeny test 1999



Research results - credit

- Main conifer species and broadleaved species covered by provenance tests
- Assessment of cultivation value with main emphasis on growth, quality and resistance
- More or less sound knowledge on the variation of provenances of species investigated under existing climate conditions
- Systematic screening of material approved as tested on European level just started with Hybrid-larch

Research results - debit

- Rare and/or valuable tree species under-represented
- Related to participation still regional gaps where no direct results are available
- Assessment of morphological, anatomical or physiological traits related to adaptability to climate change done more or less accidentally
- Material approved as tested on regional level can be traded on European level without constraints
- General approach for systematic screening of material on the European level e. g. Poplar still to be developed

4. Advantages and limitations

- Practical approach to study the variation of provenances as well as genecological and clinal correlations
  - Survival
  - Morphological, phenological, physiological traits
  - Growth, quality, resistance traits
- Scientific base for the delineation of regions of provenance
- Practical approach to develop recommendations for the use and the planting of provenances
- Scientific base for the delineation of deployment and breeding zones

Advantages and limitations

- Representivity of experiments depends on
  - Selection of provenances in relation to natural distribution area
  - Balancing dissimilarities in flowering and fruiting among regions
  - Set of standard provenances
  - Number of participating countries
  - Distribution of trial plots in relation to soil and climate
- Reliability of experiments depends on
  - Comparable seed collection procedures (intensity of flowering and fruiting, number of trees, distances among mother trees, amount of seeds collected per tree)
  - Comparable spacing, planting, tending and thinning procedures
  - Comparable assessment methods

Advantages and limitations

- Continuity of experiments depends on
  - Stability of institutional infrastructure
  - Availability of labour and finances
  - Long term accessibility of trial plots
- Analysis of experiments depends on
  - Reliable data collection
  - Completeness of data
  - Long term data storage
  - Data accessibility
  - Ability to cope with missing values

5. Importance for future experiments

- Research on the response of species and their provenances to changing climate
  - Growth response of provenances
  - Change of productivity of provenances
  - Suitability of emerging species and provenances
- Advanced breeding work
  - Systematic testing of improved and approved material in different environments as the test environment
  - Development of breeding zones
  - Selection of trees and their vegetative propagation by TC
  - Provenance and species crossing

Importance for future experiments: Example “Growth response to changing climate”

Pinus contorta Dougl. ex Loud. provenances (Wang et al. 2006)

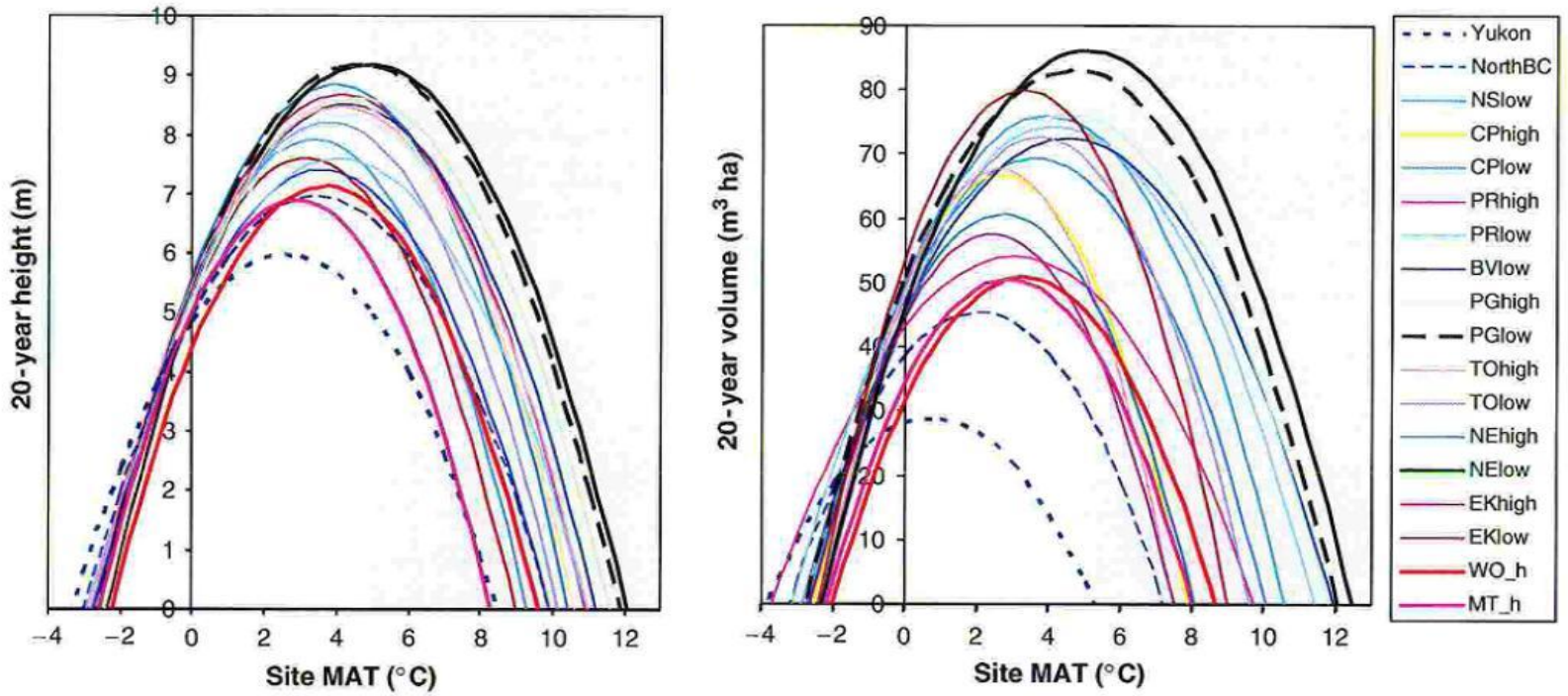


Fig. 6 Growth response curves of seed planning unit populations and regions for 20-year height and volume per hectare against mean annual temperature (MAT) at each population's optimum annual heat:moisture index (AHM). Shaded areas are extrapolations beyond the MAT range of test sites.

Importance for future experiments: Example “Growth response to changing climate”

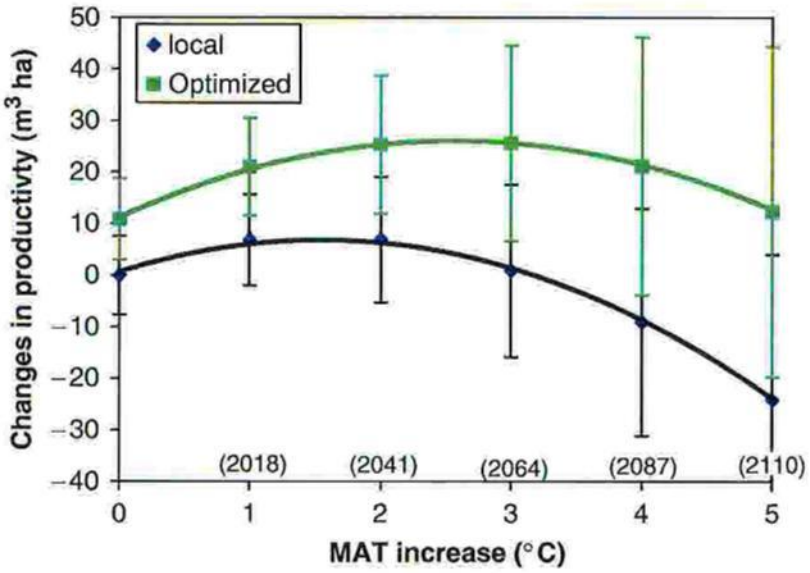


Fig. 8 Predicted changes in productivity of lodgepole pine across all seed planning units in BC for local seed vs. most productive seed source for future climates. Each increase of 1 °C in mean annual temperature (MAT) is accompanied by an increase of 1.8% increases in mean annual precipitation. Error bars indicate the 90% confidential interval for predicted means.

Pinus contorta Dougl. ex Loud. provenances

(Wang et al. 2006)

6. Conclusions

- Large forest tree provenance experimental networks
  - Source for basic and general knowledge on the variation as well as on the cultivation value of provenances of species investigated in existing climate conditions
  - Base for on-going research on the adaptability of the material in question under climate change
  - Important tool for the assessment of cultivation value of emerging species and their provenances under existing climate conditions as well as under future climate conditions
- Tools for the assessment of cultivation value of material in question in climate change to be improved and made suitable for systematic screening

Conclusions

- Large forest tree provenance experimental networks
  - Difficult to manage in the long term
  - Time and labour consuming
  - Full of problems related to every step of the experiment as well as related to the involvement of different institutions with different mentalities, different background, different budgets

- However, it is the only and practical way to explore the possibilities and limitations of genetic resources until something better is developed.

Thank you for your attention!