Ministry of Environment
and Food of Denmark
Nature Agency

Forest tree breeding and Gene conservation in Denmark

NordGen
Akureyri, April 2018

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Introduction:
- The Nature Agency
- Danish Forest area
- Institutions

Breeding programmes:
- Forest trees
- Examples
- Achievements and Implementation

Gene conservation:
- Objectives
- Status
- Protection

The Danish Nature Agency

State forests represents 18% of the forest area

…to create the greatest possible value for society in terms of good conditions for outdoor recreation, nature protection and efficient operation of the agency's forests…

Close to nature forestry
Natural regeneration and planting

The Danish Nature Agency
…use of forest reproductive material

- Breeding and seed sources
- Continuous seed supply
- Gene conservation
- Seedlings, provenance requierments:
  - Material from seed orchards
  - Tested > Qualified > Selected
  - Genetic diversity
- Information
  - Non-scientific papers
  - Descriptions of seed sources
  - Thematic days
  - Plantevalg.dk

The Danish forest area

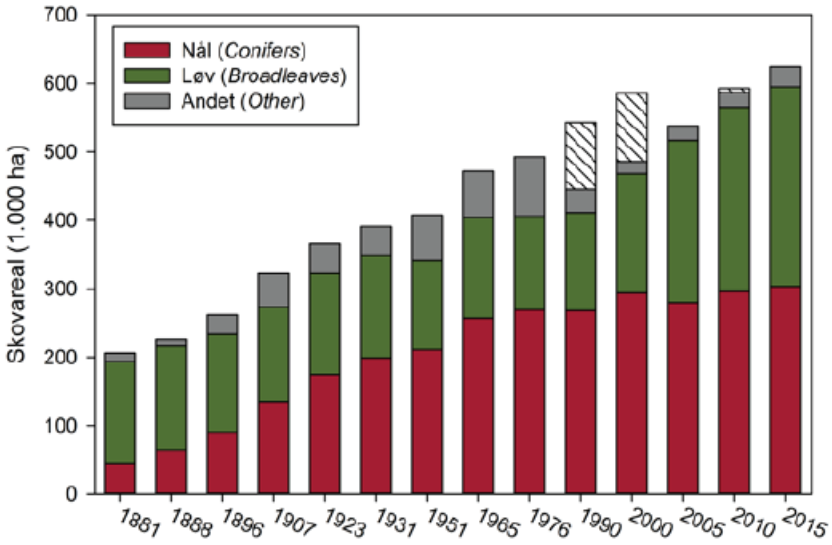
2015: 14.5 % of area
625.000 ha.

The afforested area is increasing

Species distribution:

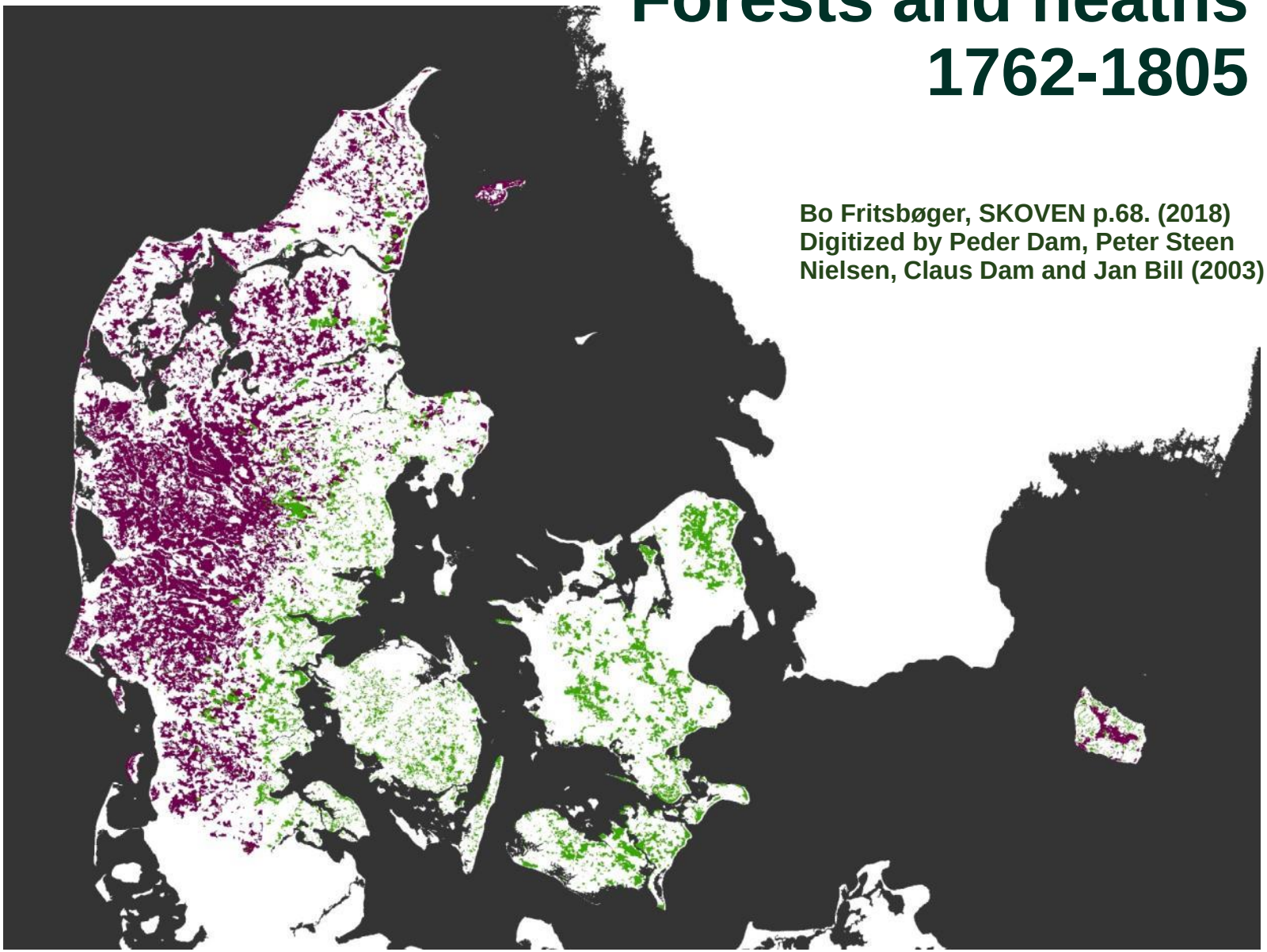
- **Norway spruce 15 %**
- **Beech 14 %**
- **Pine sp. 11 %**
- **Oak sp. 10 %**
- **Birch sp. 7 %**
- **Sitka spruce 6 %**
- **Nordmann fir 5 %**

- **The main species covers almost 70 % of the forest area**



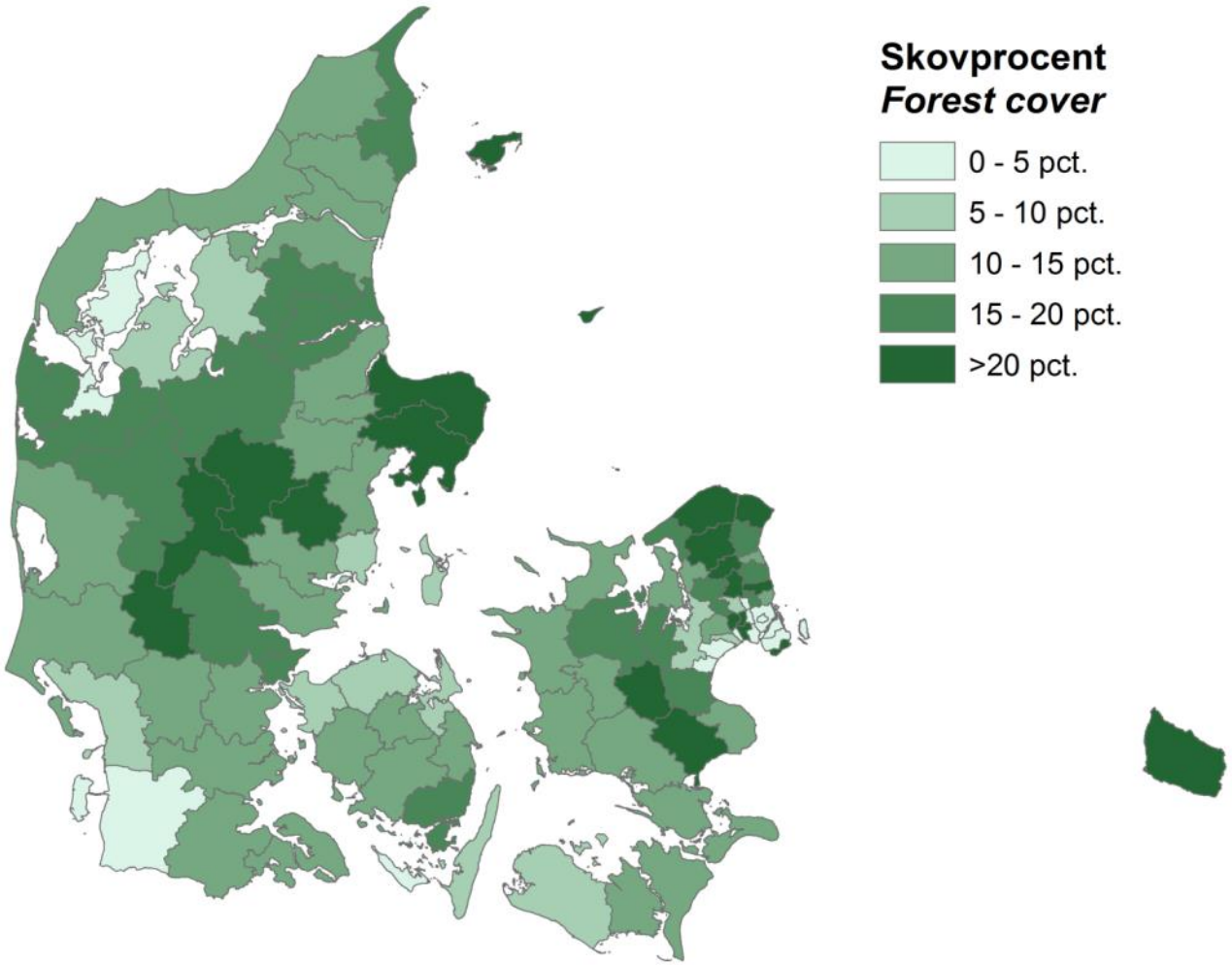
Forest Statistics 2015

Forests and heaths 1762-1805



Bo Fritsbøger, SKOVEN p.68. (2018)
Digitized by Peder Dam, Peter Steen Nielsen, Claus Dam and Jan Bill (2003)

Forest cover 2016



Thomas Nord-Larsen et al. (2017): Skove og plantager 2016, Institut for Geovidenskab og Naturforvaltning, Københavns Universitet, Frederiksberg. 104 s. ill.

A little history

1832 forestry education in DK

1901 State Forest Research institution 1901
Species- and provenance trials

1936 The Arboretum
1946 Tree Improvement Station

Selection, hybridisation and breeding
Larch, Douglas fir, Scotc pine
Propagation and Seed orchards

1990 Forest tree program
2000 Landscape program
2017 Climate robust species

Danish Nature Agency
HedeDanmark
University of Copenhagen (IGN)

Forest breeding program

Purposes
- **Seed supply**
- **Tree improvement**

Seemingly simple…to improve tree performance

- ❖ **Select trees with desirable traits**
- ❖ **Test if the traits are heritable**
- ❖ **Produce offspring**

In reality, many challenges…
Time, changing demands, resources, knowledge
CSO or SSO?

Examples: Sitka spruce, Douglas fir, ash

Sitka spruce

Planted in Denmark since 1860.

27 Provenance trials 1918-1992
Suitable provenances identified

Origins:
Washington and British Columbia

Breeding 1960-2000
- ***Plus trees from seed stands***
- ***Plus trees from seedlings***

Seed supply 1996-2014:
87 % Seed orchards
22 % Seed stands
1 % Import

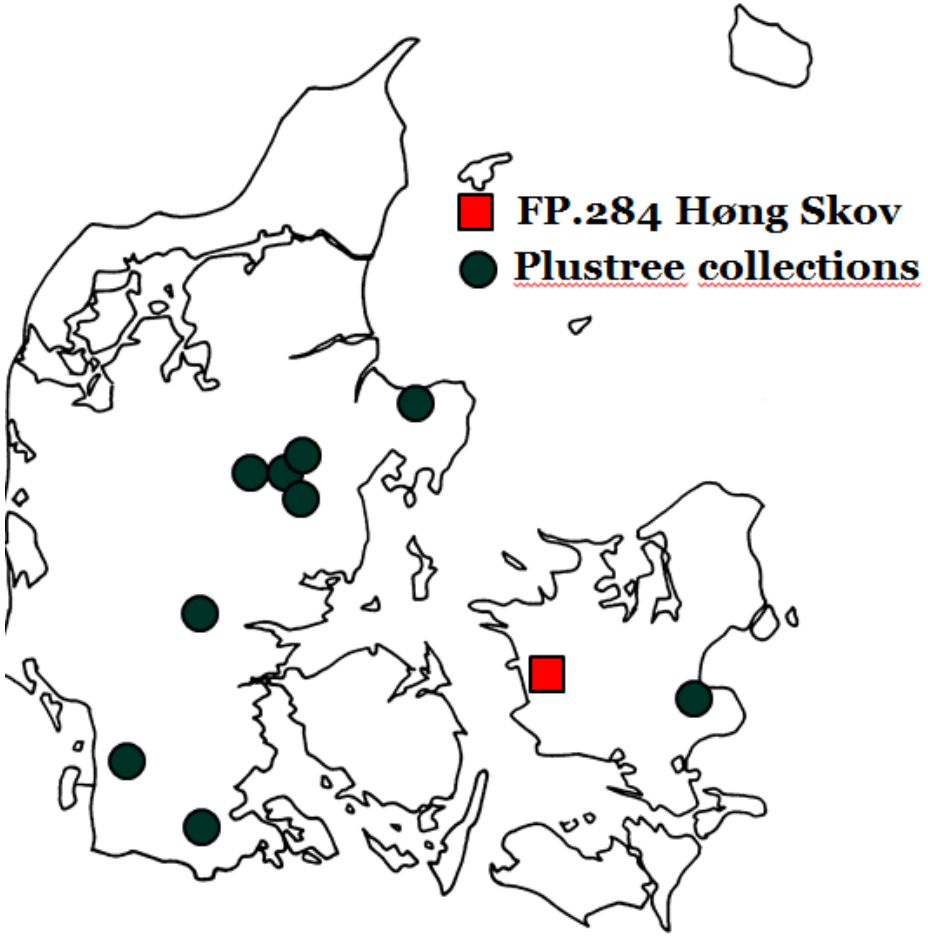
Sitka spruce

Seed sources:
- 7 Seed orchards
- 2 Seed stands

Improved:
Volume production, wood density, stem straightness, spiral grain, frost hardiness, aphid tolerance.

No new trials

2006-2015
5 new seed orchards
Improved:
- Stem straightness,
- 12–50 % increased production



“The future Douglas fir seed sources – better growth and higher quality”

Hansen et al.
SKOVEN 5 2016

First generation seed orchards focus on stem straightness and health (1950-1970)
In second generation also focus on growth and diversity (1990-2010)

Seed Orchard	Present performance compared to stands	Expected performance afther thinning
FP.262 Sønderskovgård Established 1994	Later flushing Straight trees + 24% Diameter -9%	Later flushing Straight trees **+ 24%** Diameter **0%**
FP. 277 Tuse Næs Established 1999	Straight trees + 11% Diameter 0%	Straight trees **+ 21%** Diameter 0%
FP. 278 Sebberup Established 1997	Later flushing Straight trees + 22% Diameter 0%	Later flushing Straight trees **+ 24%** Diameter **8%**

Ash *Fraxinus excelsior*

European ash dieback 2003

All Seed Orchards infested

Variation in susceptibility
1-5% healthy trees

Selection for low susceptibility
Forestry qualities as second priority

Diversity
1 tree per stand
Older than 55 years

2012-14: 214 plustrees:
4 new Clonal Seed Orchards
(35-105 clones)

Seed production in 2025

The future of ash?

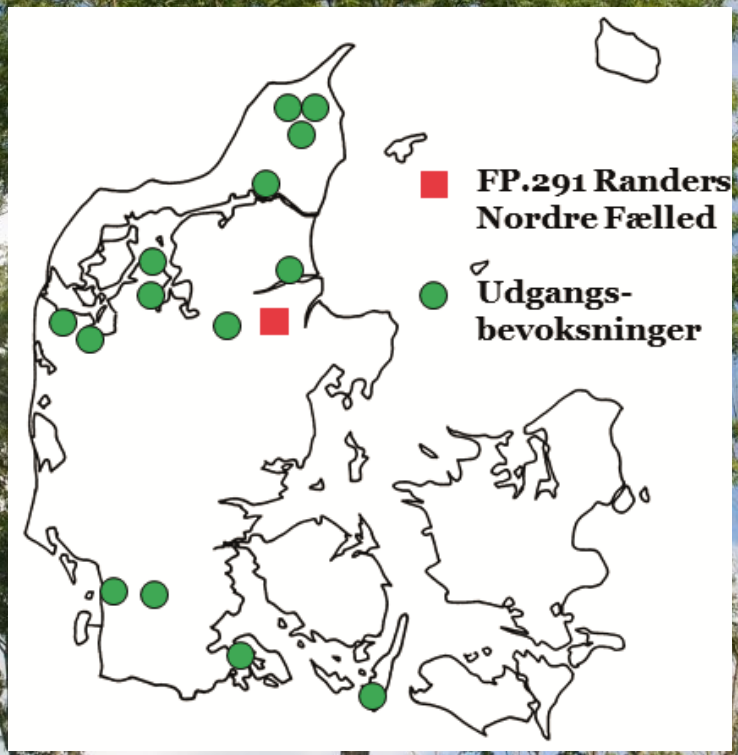
1 seed orchard approved in 2017
Selected for low susceptibility

Replanting desirable

Genetic diversity?

The emerald ash borer
***Agrilus planipennis*,**

…spreading from Asia, reached european Russia in 2005 and USA in 2002.



Breeding implemented?

Seed supply dominated by Danish seed sources:

- *Fagus sylvatica*
- *Picea abies*
- *Picea sitchensis*
- *Pinus sylvestris*
- *Alnus glutinosa*
- *Betula sp.*
- *Abies procera*

Acces
Institutions
Forest program

Seed supply dominated by imported seeds:

- *Quercus sp.*
- *Abies nordmanniana*
- *Abies alba*
- *Pseudotsuga menziesii*

Gene conservation of trees and shrubs

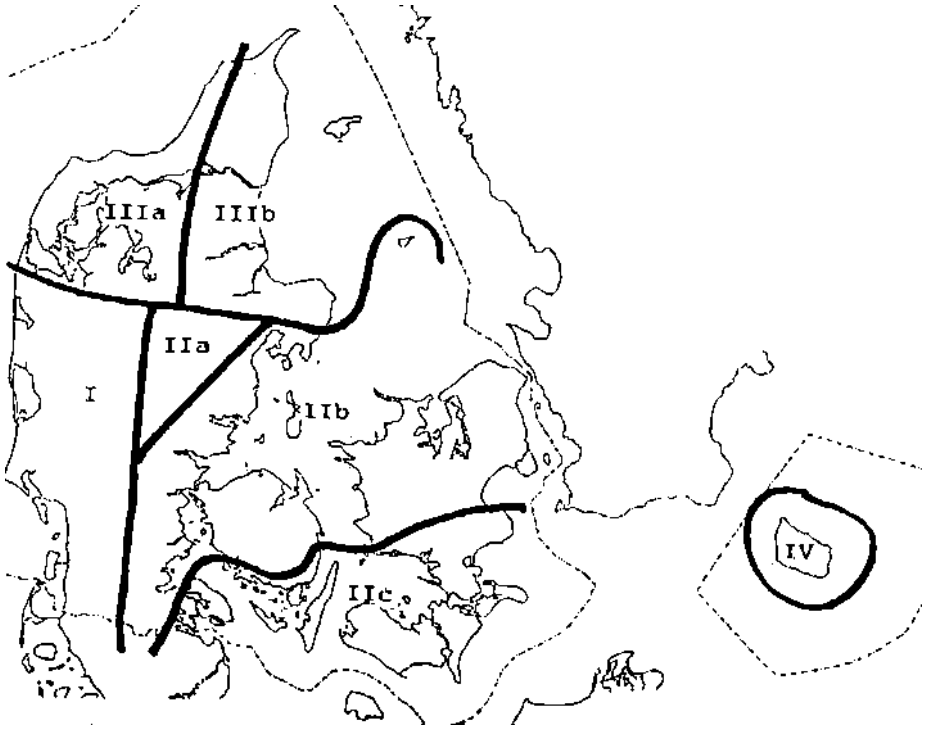
The Danish strategy is from 1994:

- **Evolutionary conservation**
- **75 species**
- **Knowledge is expected to increase**
- **Strategy is adjustable**
- **Implementation in 10 years**

The strategy is implemented on areas owned by the state forestry.

***In situ* is used for native species, and should cover different ecological zones.**

***Ex situ* is used for native and introduced species.**



Gene-ecological zones 1994

Conservation objectives

1. Genetic variation of actual or potential value

2. Buffer; changing environment

3. Building blocks; breeding

The good question:
What is the value of trees in future?

Conservation contributes to the Danish biodiversity strategy

Gene conservation status

82 species are included

18 deciduos trees
20 coniferous trees
44 shrubs

Designation is implemented in the operative plans for state forests (Revised regulary)

In situ protection

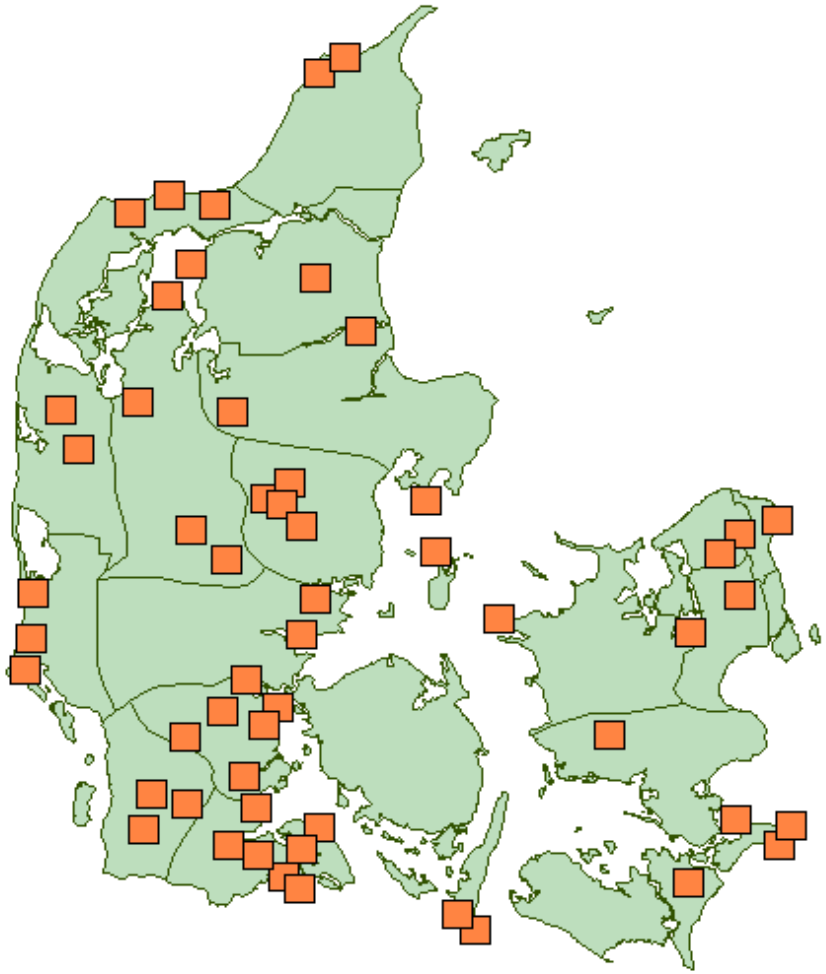
58 species / 89 areas / 2880 ha

Each species is represented at 1-28 sites.
Forest trees typical at 8-15 sites

Areas often covered of other kinds of protection:
- **Natural forest**
- **Natural conservation**

Guidelines emphasizes
Natural regeneration
Isolation zone

Continues until other decisions are made



Ex situ

Covering 53 species

98 seed stands, seed orchards etc. 1200 ha

Clonal archives in breeding programmes of conifers

Ex situ protection

Managed for seed production

Clonal archives are a temporary conservation

In all cases decision about regeneration / renewal must be made after each rotation

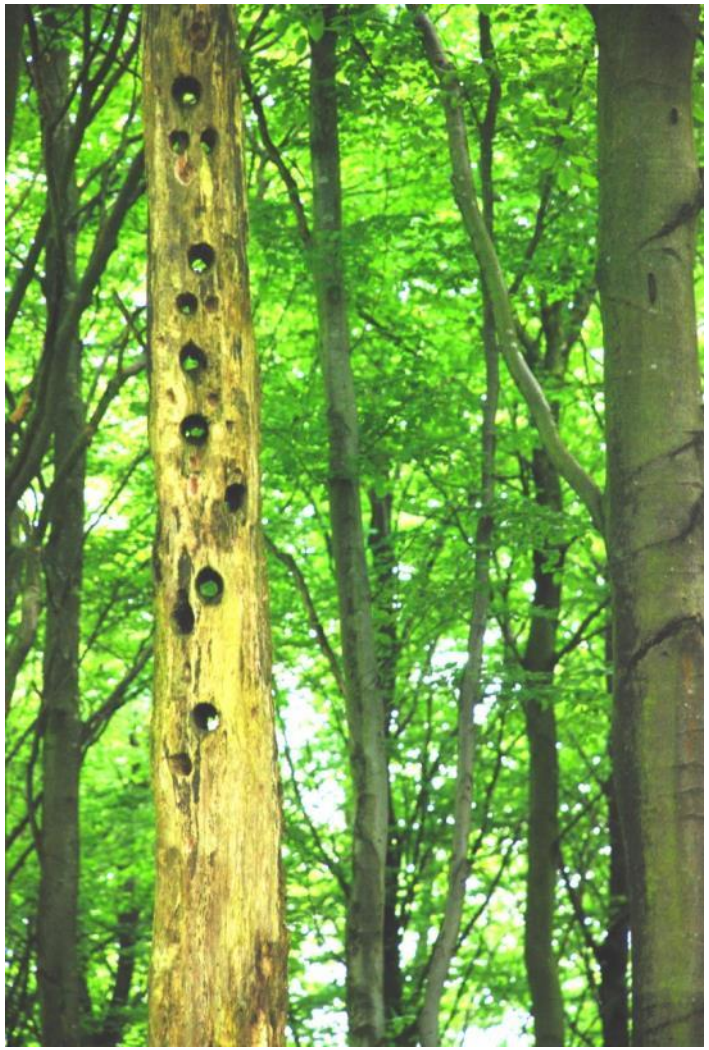
The *ex situ* gives conservation “by use” And covers material of actual value

How good is the protection?

Will natural evolution be able to occur in the cultural forms of forests? Or will we rush in with management at first sign of any bottleneck?

Gene flow is probably much more abundant than any isolation zone can handle.
But is it a problem?

How about disasters as forest fire?
…or ash dieback?
…or fast changing environment?

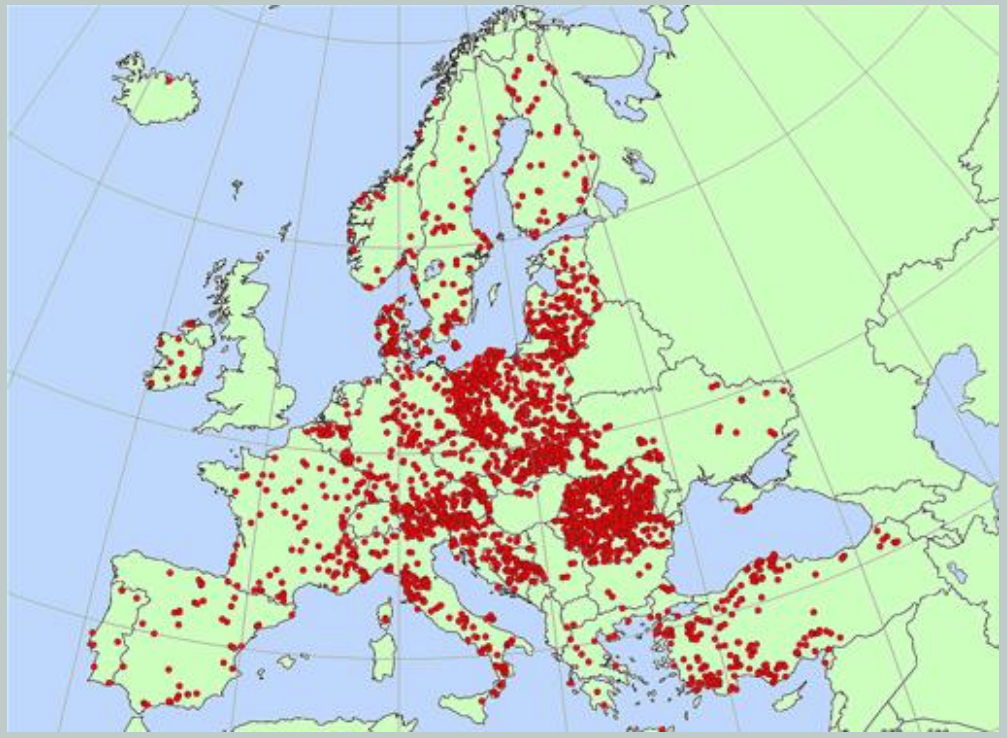


Climate change and benefit sharing

If growing conditions are changing…

Perhaps future use of FRM must rely on gene conservation programmes in other countries

Need for European cooperation, and sharing of knowledge and FRM is increasing



EUFGIS Pan-European gene conservation

Thank you

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