Swedish programme for conifer conservation and breeding

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Outline

- Swedish forestry
- Use of bred material
- Breeding of forest trees
- Conservation in a breeding program
- Gain of tree breeding
- Deployment of improved material
- Summary

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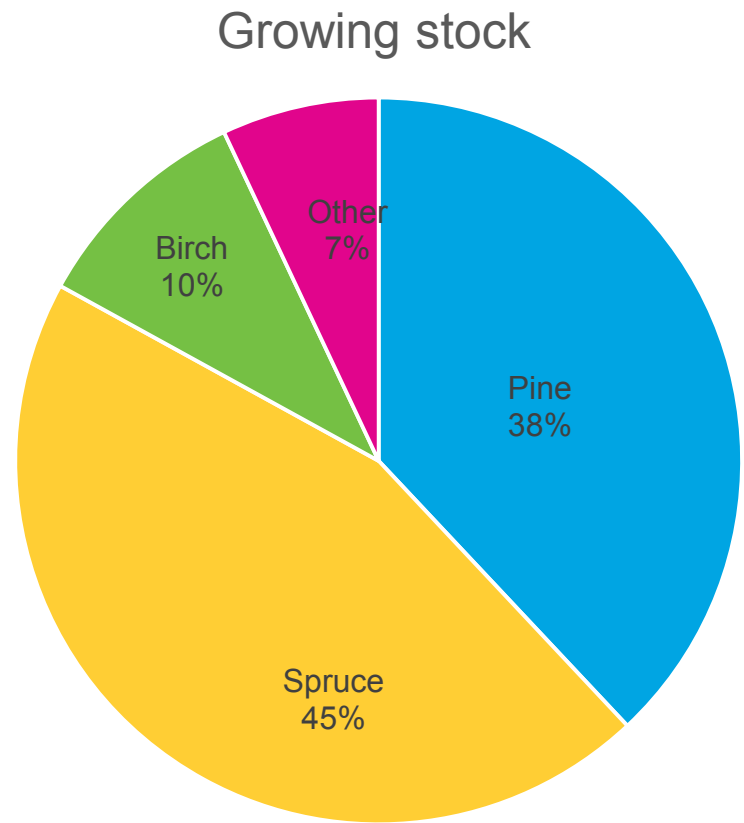
Breeding of forest trees

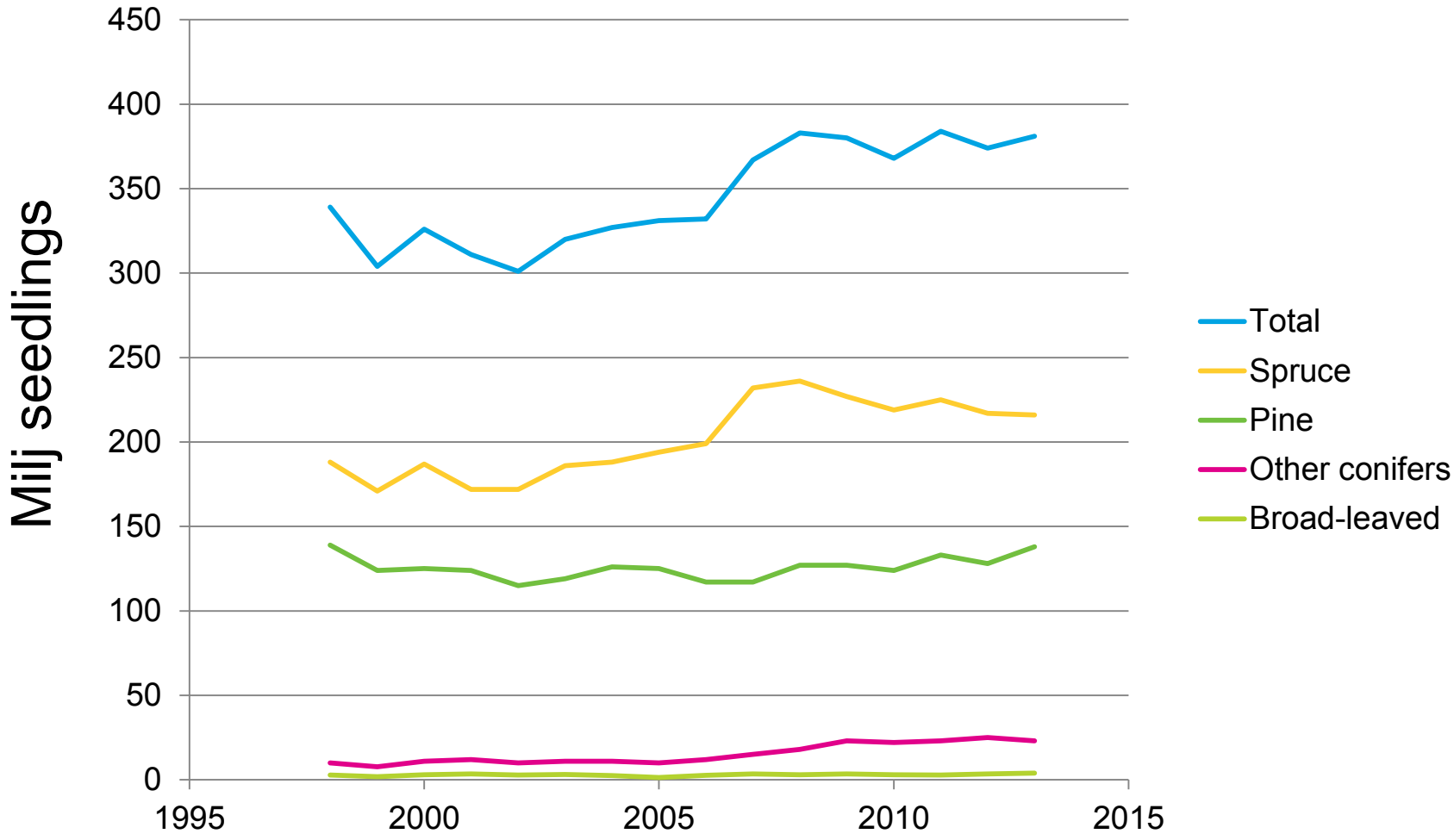
- Tree breeding has been under way for a number of decades
- Young in comparison with crops and animals
- Conservation often a parallell part to breeding and not integrated

Swedish forests

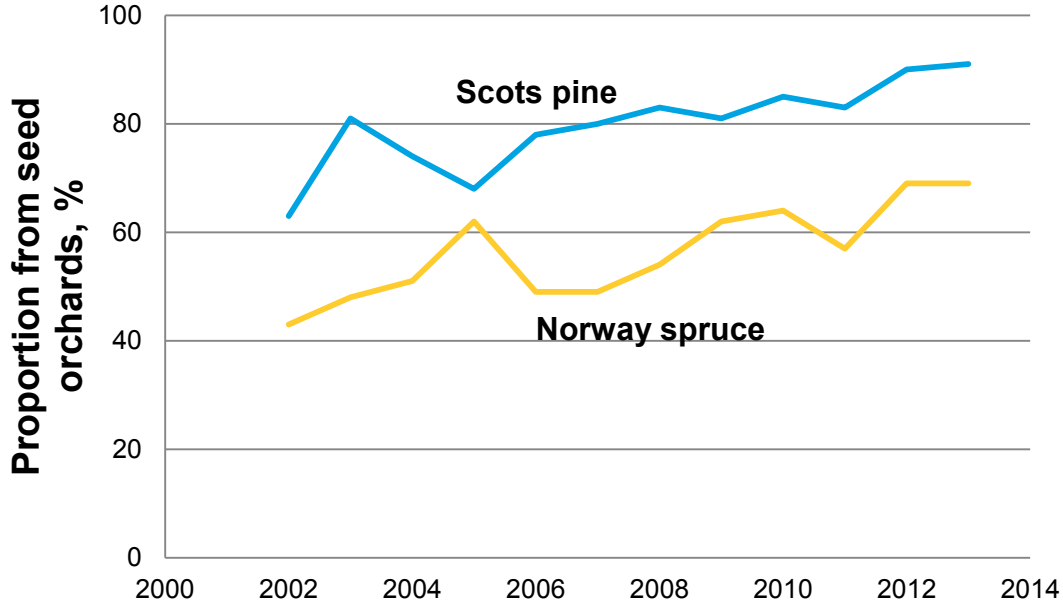
- Forest area
  23 milj ha (50% of total area)
- Annual growth
  110 milj m^3
- Harvest 95 milj m^3
- Rotation 60-120 yrs
- Annual harvest
  200 000 ha



Seedling production in Sweden



Proportion of seedlings from improved seed



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Forestry in society

- Renewable resource
- Forestry increases supply of bioenergy, biomaterials and biochemicals
- Climate change – CO2 sink
- Forestry become even more important

Who is responsible for conservation?

Swedish Forest Agency

- Plan to establish protected areas to conserve trees in site

Skogforsk

- In breeding programs

Breeding of trees

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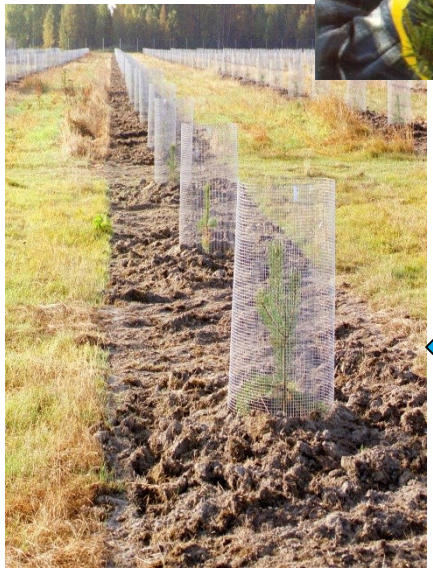
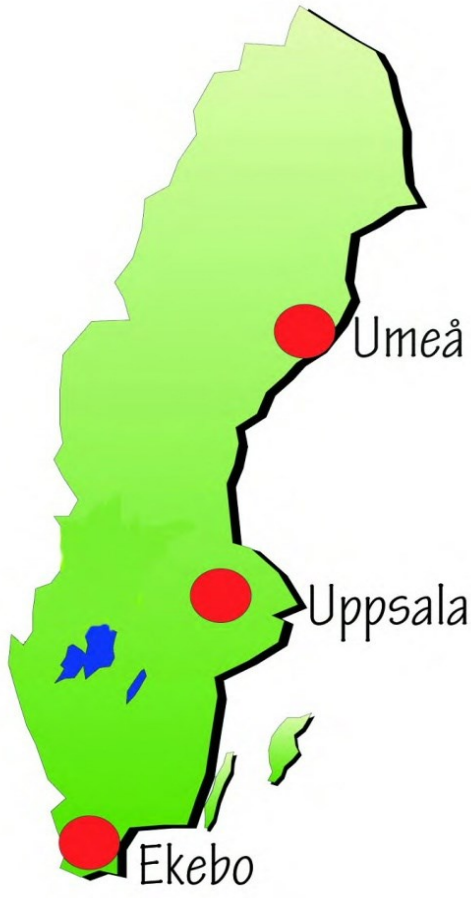


Forest tree breeding in Sweden



Skogforsk is responsible for all forest tree breeding in Sweden

Forest owners responsible for seed orchards

Species in breeding programs

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- Norway spruce
- Scots pine

- Birch
- Lodgepole pine

- Minor activities for other species
  e.g. larch, hybrid aspen, oak, ash, beech, cherry, sitka spruce, Douglas fir

Approach to long-term breeding

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To integrate:

- Increased value production
- Preparedness for future climatic changes
- Conservation of genetic resources

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Why conservation?

- Genetic diversity is a prerequisite for genetic improvement, survival and reproduction in a changing environment
- Important for managing risks
- Enough diversity for natural regeneration if forestry stops

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Components in conservation

- Objective – assure long-term adaptation
- Genetic variation and structure in population
- Methods
  - in situ (protected areas, gene reserve areas)
  - ex situ (e.g. clone archives, seed orchards, progeny tests and seed storage)

- In breeding programs

How can genetic variation be controlled in breeding populations?

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- Size of breeding population,(number of individuals)
- Low relationship to reduce inbreeding

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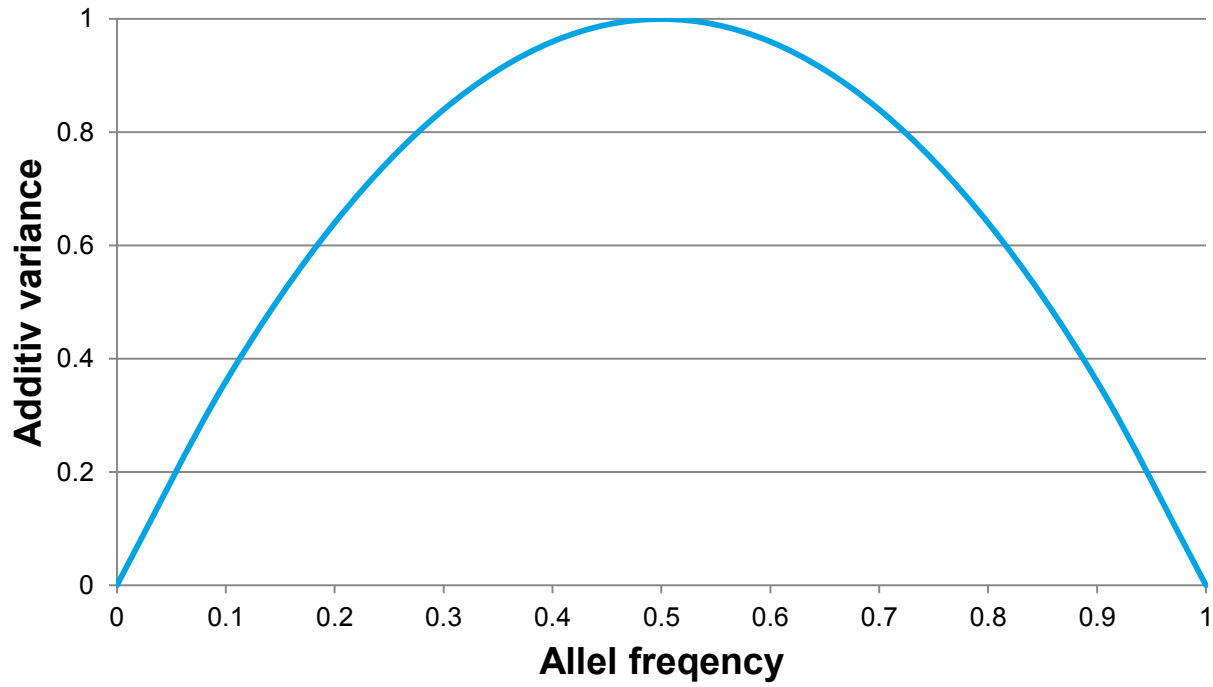
Rare alleles

The number of individuals in the population to keep all alleles at a locus with a given probability (from Gregorius 1980).

Frequency of rarest allele	Probability of keeping rarest alleles		
	95 %	99 %	99.9 %
20 %	21	28	39
10 %	51	66	88
5 %	117	149	194
1 %	754	916	1146

Genetic variation



Inbreeding

- $\Delta F=1/2Ne$
- Population size > 50
- Inbreeding 1% per generation

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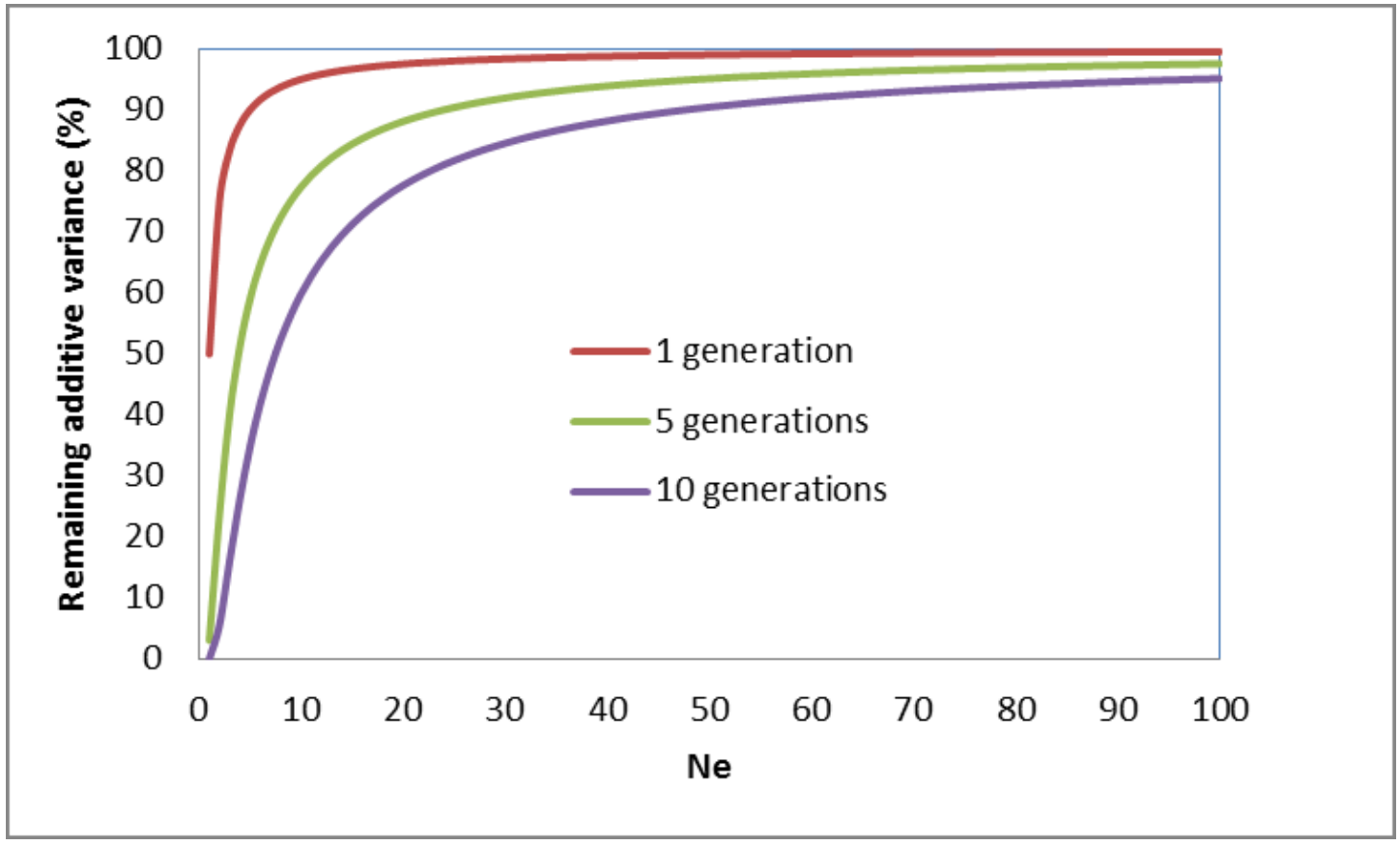
Remaining additive variation



Which traits will be important in the future?

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- Long rotation
- Industrial processes may change
- Use of wood may change
- Climate change

Objective traits should be general and long-term

High genetic diversity

Adaptation - climate change

- Bud burst
- Shoot elongation
- Growth cessation
- Bud set
- How to use this in breeding?

Breeding objective

Maximize the value production per hectare

While safeguarding a necessary diversity in the breeding populations, we concentrate on breeding for

- Vitality
- Adaptability
- Biomass production
- Stem and wood quality

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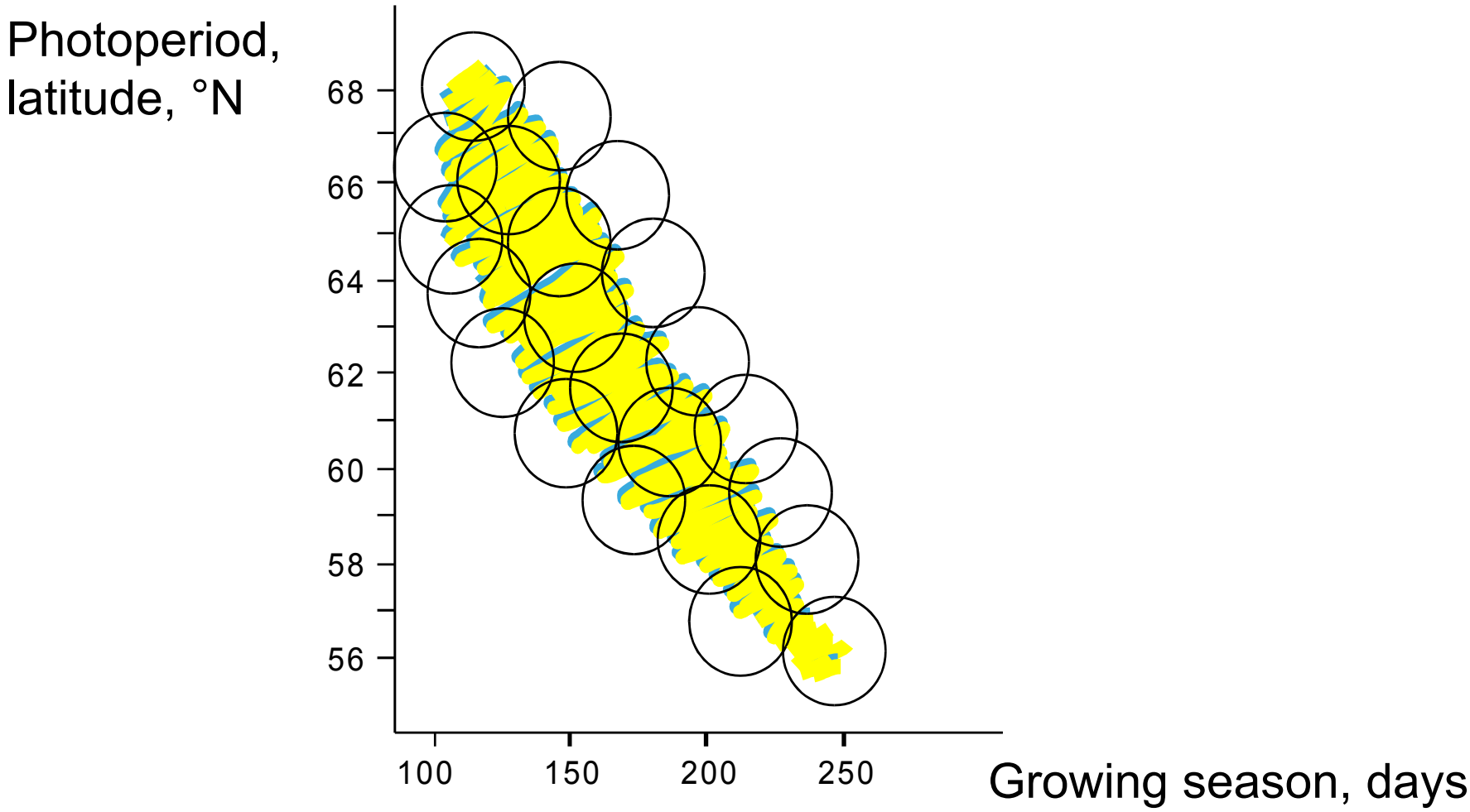
Principles for long-term breeding

- Multiple-population breeding system
- Some 50 individuals per sub-population
- Breeding within each sub-population
- Essentially within family selection
- Double-pair mating, when possible as positive assortative mating

Base material

Species	Size
Scots pine	6000 plus-trees
Norway spruce	6000 plus-trees 18000 clones
Lodgepole pine	200 plus-trees 1200 OP families
Birch	1450 plus-trees

Distribution of breeding populations



Where are we today?

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Plus tree selection

Propagation

Genetic testing

Selection

Mating

New generation

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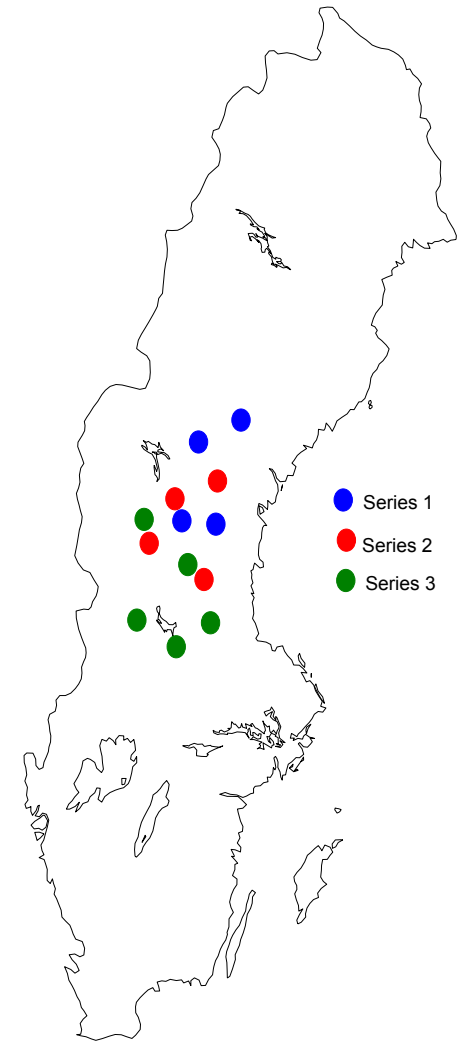
Mating design

Parent	1	2	3	4	5	…
26	x	x				
27		x	x			
28			x	x		
29				x	x	
30						
…						

Double-pair mating PAM if possible

Testing strategy

- Field tests 4-5 per population (100 tests per generation and species)
- Progeny or clone tests (also individual tree selection)
- Measured at ages 10-15 yrs (growth, survival, damage, quality)



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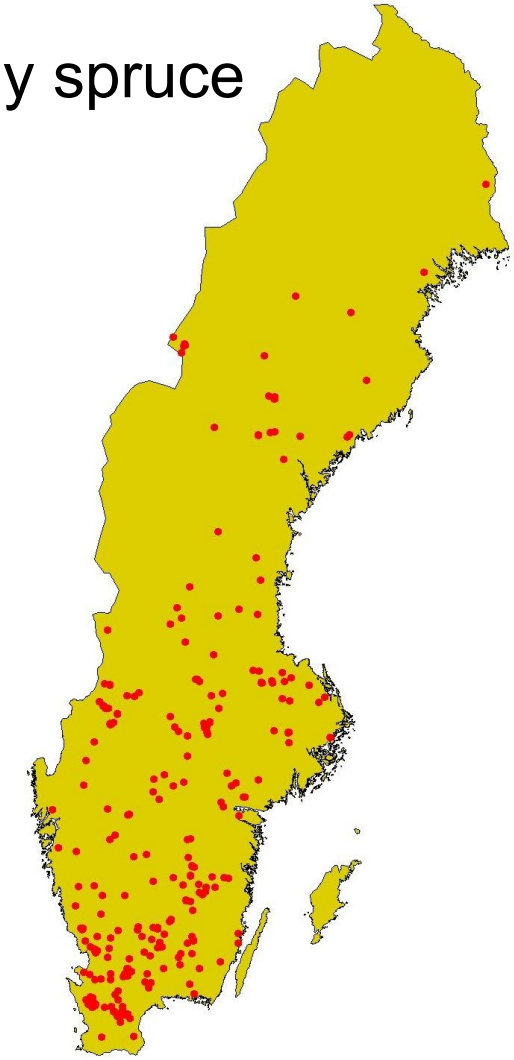
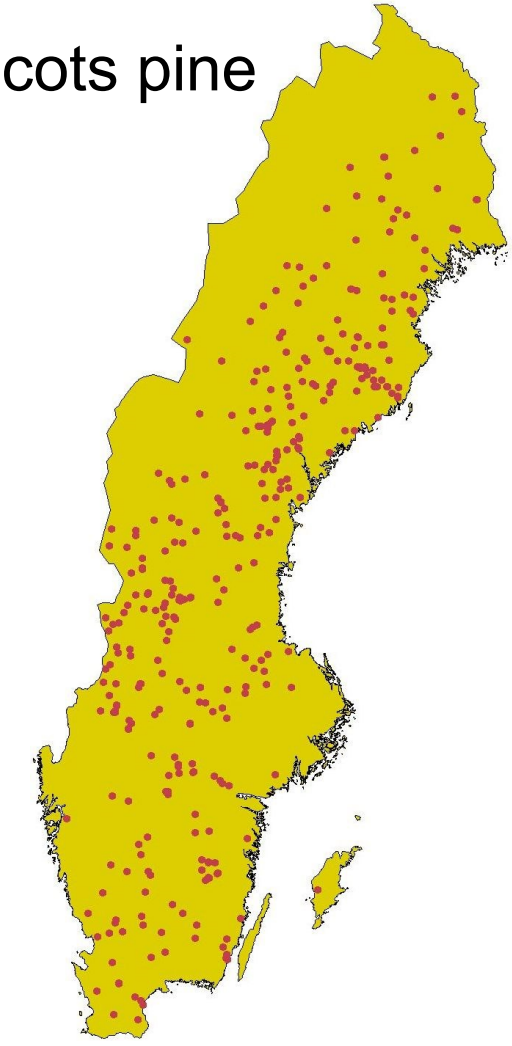
Field tests

Norway spruce



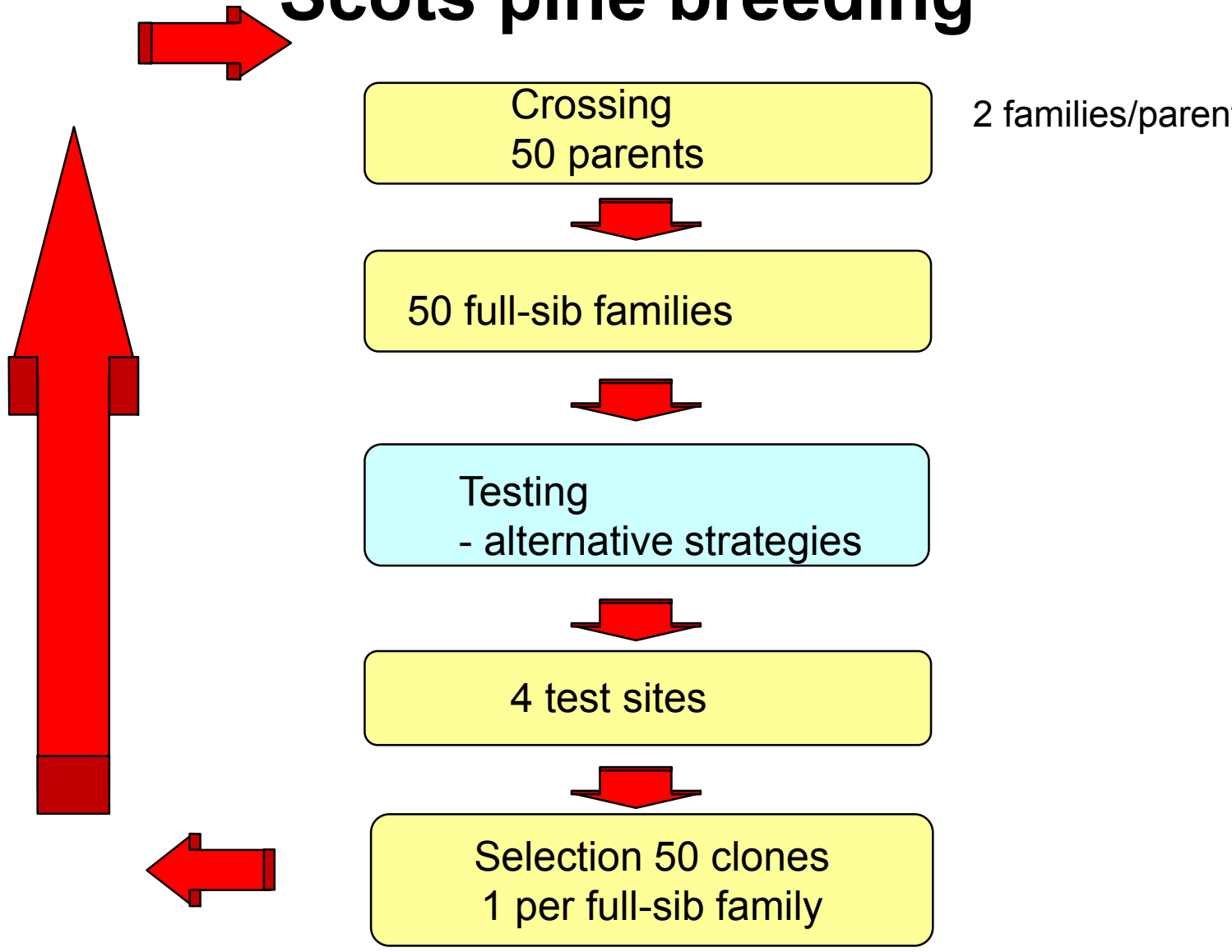
Scots pine



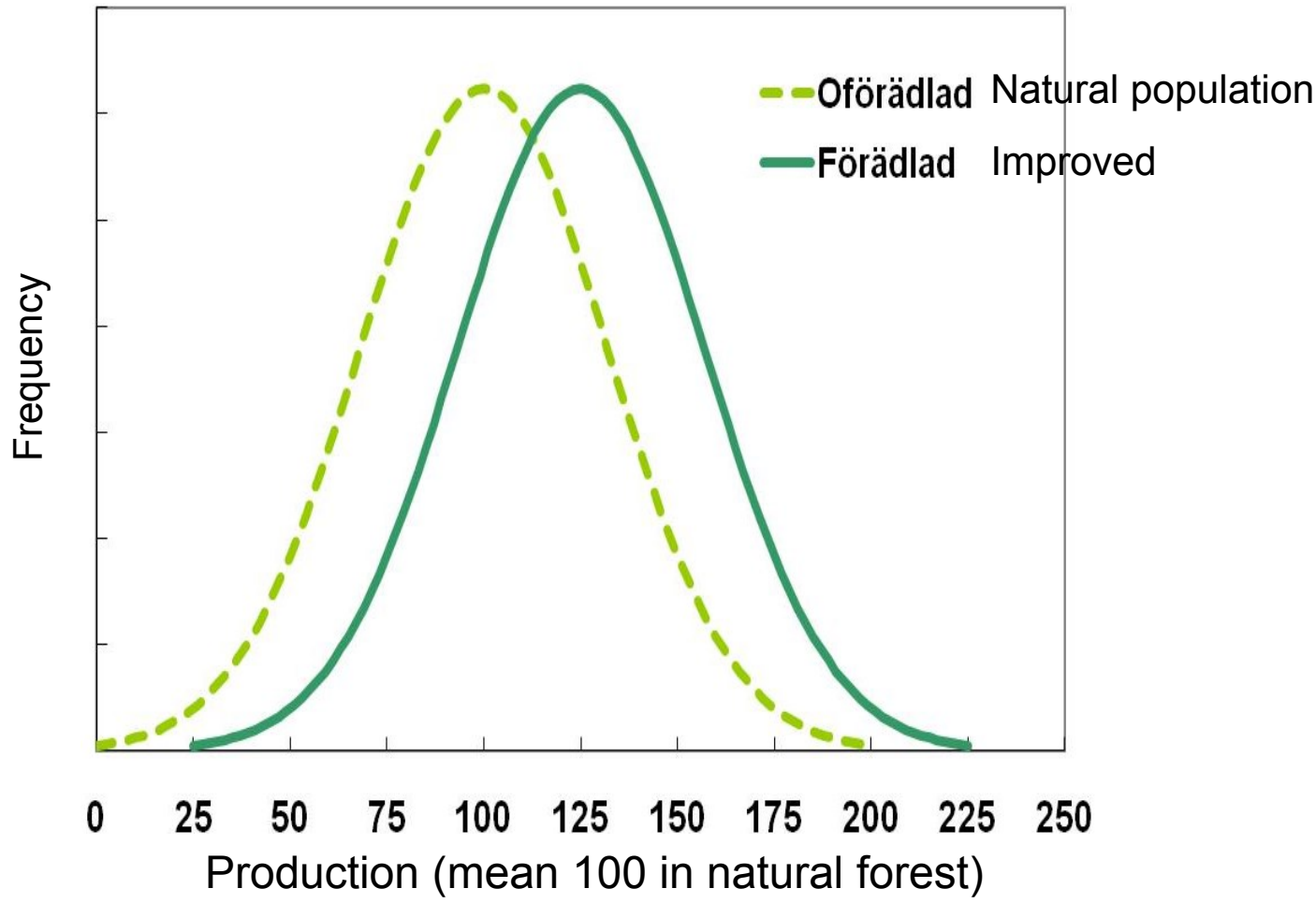
Tested genetic material

- Known genetic properties
- New genetic populations with known adaptive and wood-product properties
- Tested on different sites – generalists

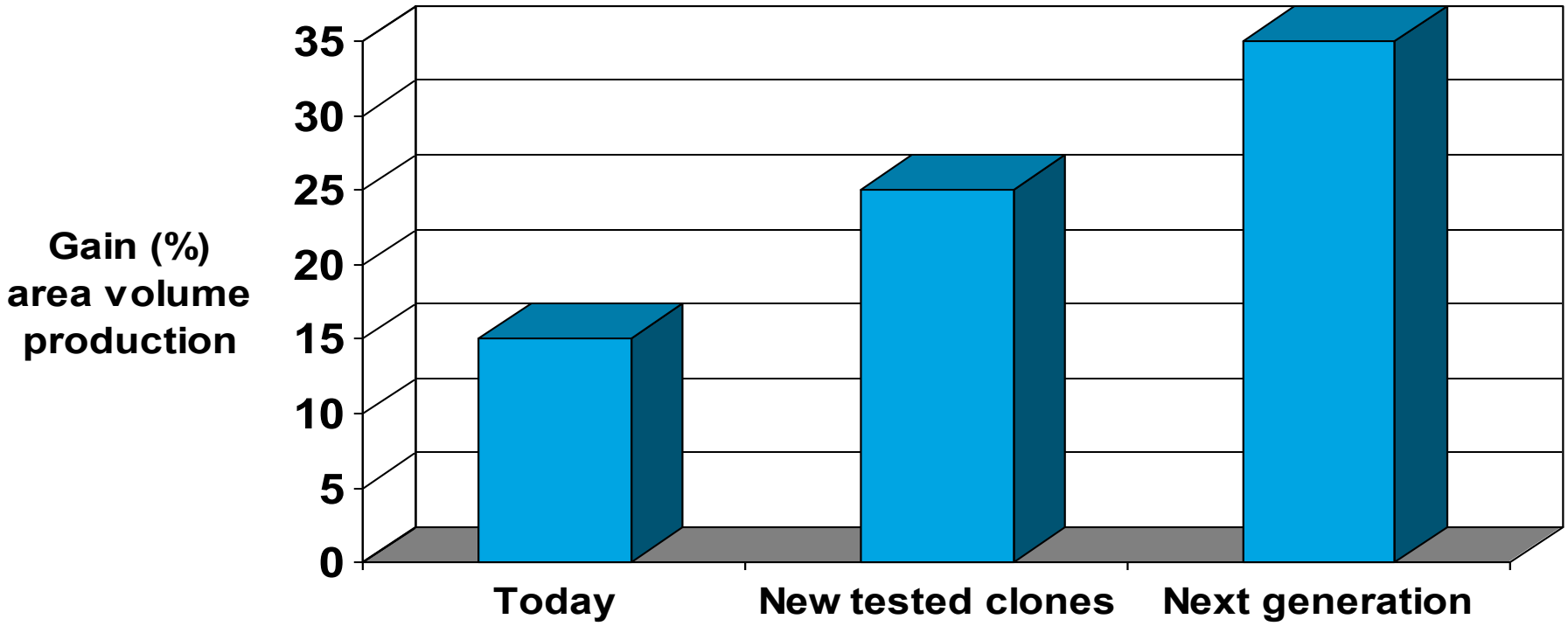
Scots pine breeding



Variation in tree size



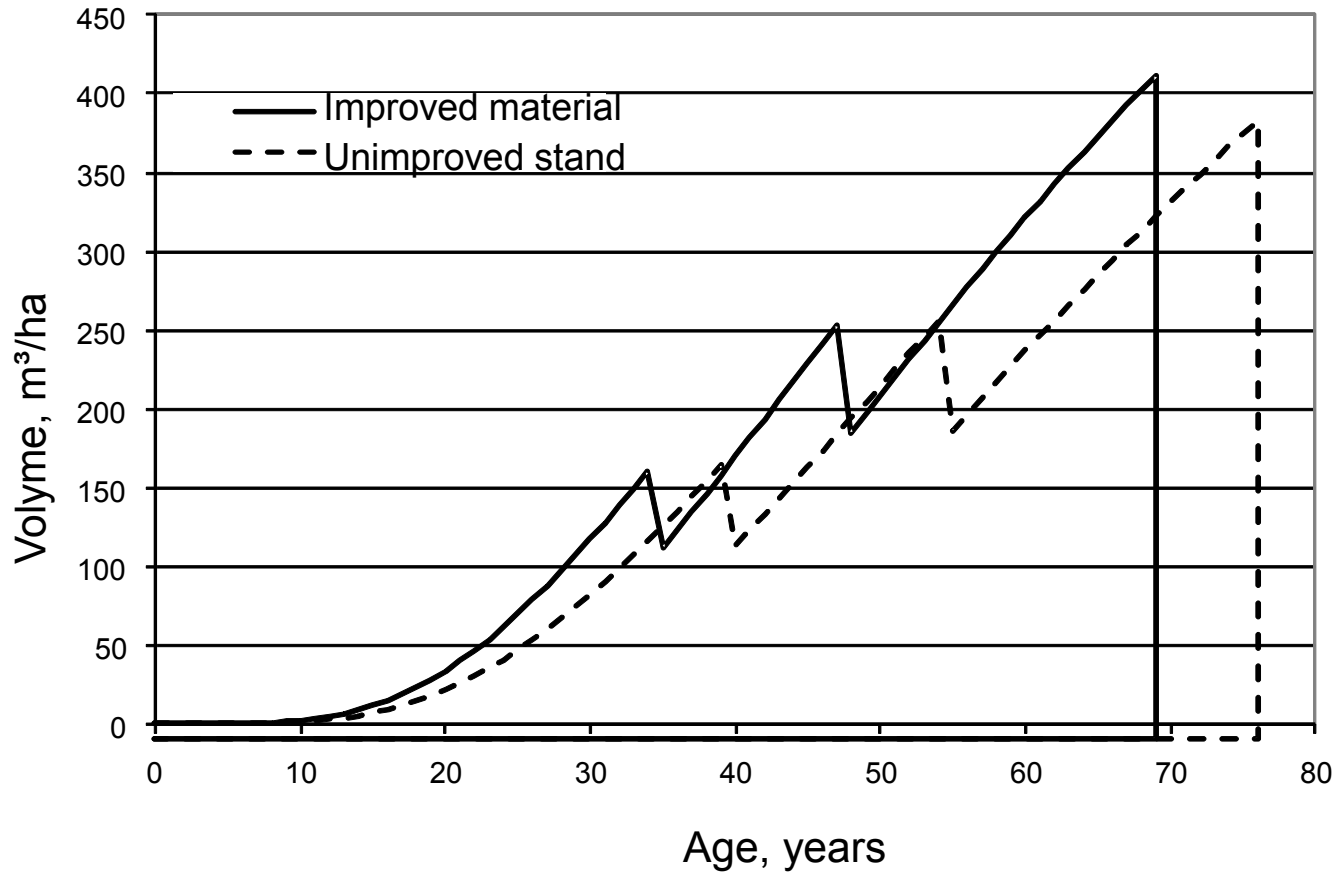
Expected genetic gain from seed orchards



Gain should be reduced for pollen contamination

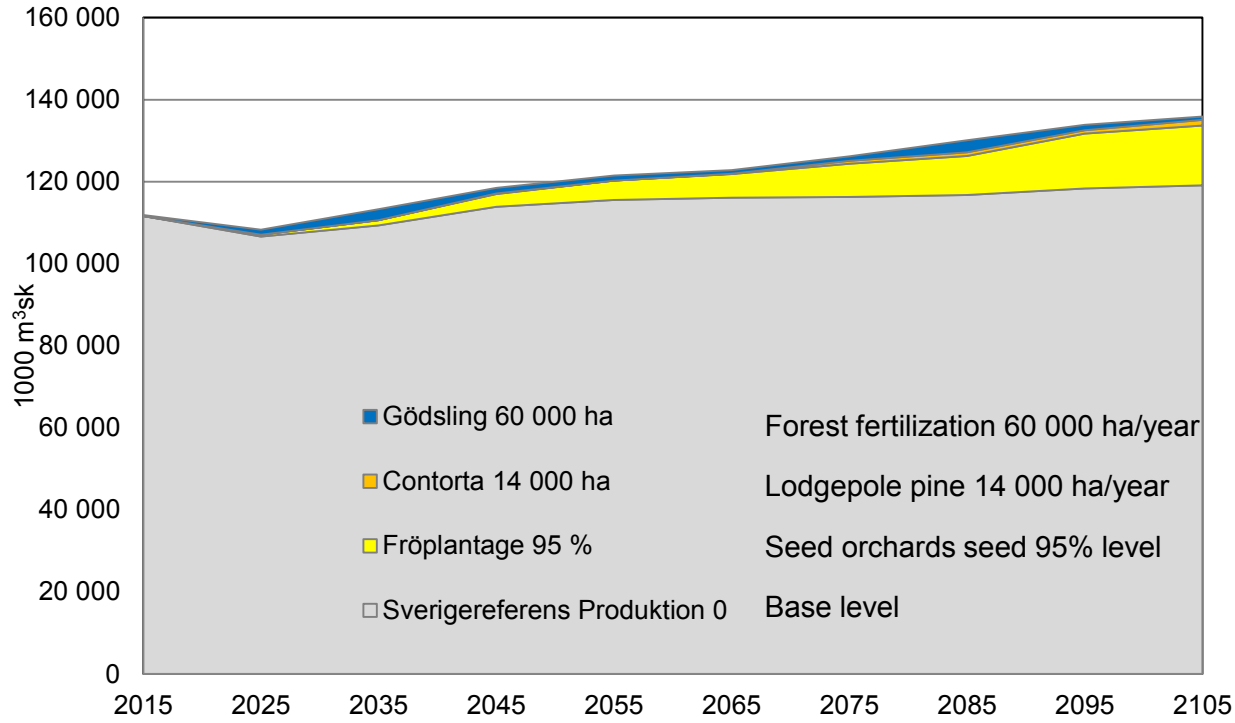
Yield and economy at stand level

Shorter rotation with improved material



(Rosvall 2010)

Yield at national level



(Rosvall 2010)

Selected site: Latitude: 61.732 Longitude: 16.084 Altitude: 191 (m)

Selected grid: Latitude: 61.747 Longitude: 16.052 Altitude: 290 (m)

Show orchards

http://wwwtest.skogforsk.se/PlantersGuide

Scenario: 1967-2007

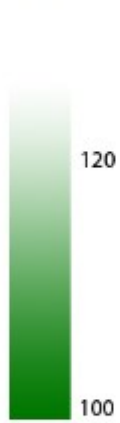
Local conditions: Average

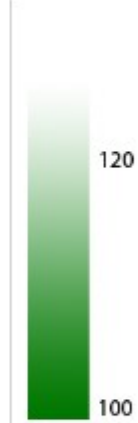
Change site | Show selected orchard(s)

Orchards:

No.	Name	Country	Index	Surv.	Growth	PC	Lat	Select
	Local origin		100	85	100		60	
FP-628	Drögsnäs	Sweden	113	85	114.9	40	60.7	
FP-610A	Hade T16:2 (Selectively harvested)	Sweden	111	85	112.3	40	60.5	
FP-612	Örberga	Sweden	110	85	111.3	40	60.1	
FP-610	Hade	Sweden	108	85	109.1	40	60.5	
FP-610B	Hade T16:2 (Selectively harvested)	Sweden	107	85	108.6	40	60.5	
FIN23	FIN23	Finland	107	85	108.5	95	61.2	
FIN21	FIN21	Finland	107	85	107.7	40	60.4	
FP-603	Lycksta	Sweden	106	85	107.5	40	60.7	
FP-617	Äxuln	Sweden	106	85	106.5	40	60.9	
FP-33	Skommarbo	Sweden	105	85	106	40	60.7	
FP-40	Dömle	Sweden	105	85	106	40	60.7	
FP-616	Sollerön	Sweden	104	85	104.5	40	61.1	

Name	Hade T16:2 (Selectively harvested)	Name
Country	Sweden	Country
Index	113	Index
Official ID	FP-610A	Official ID
Selection	Qualified	Selection
Altitude	55	Altitude
Area	13	Area
No clones	15	No clones
Owner	Bergvik 91%, Sveaskog 9%	Owner





How can genetic diversity be controlled in deployment?

- Seed from unimproved provenances or stands
- Open pollinated seed orchards
- Seed from selected full- or half-sibs (family forestry)
- Vegetatively propagated clones

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Summary

- High genetic diversity in breeding populations is important for an ‘unknown’ future
- Integrated properly into breeding conservation need not be especially demanding to maintain
- Deployment strategies and management affect the genetic diversity in our forests

Thanks for listening!

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