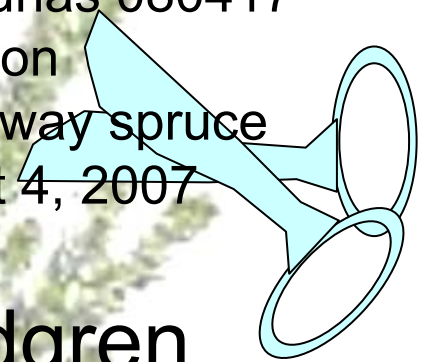
Norway spruce breeding in Sweden is based on clone testing

Presentation Kaunas 080417
based on
IUFRO WP Norway spruce
Poland, Sept 4, 2007



Dag Lindgren
Swedish University of Agricultural Sciences
Umeå, Sweden

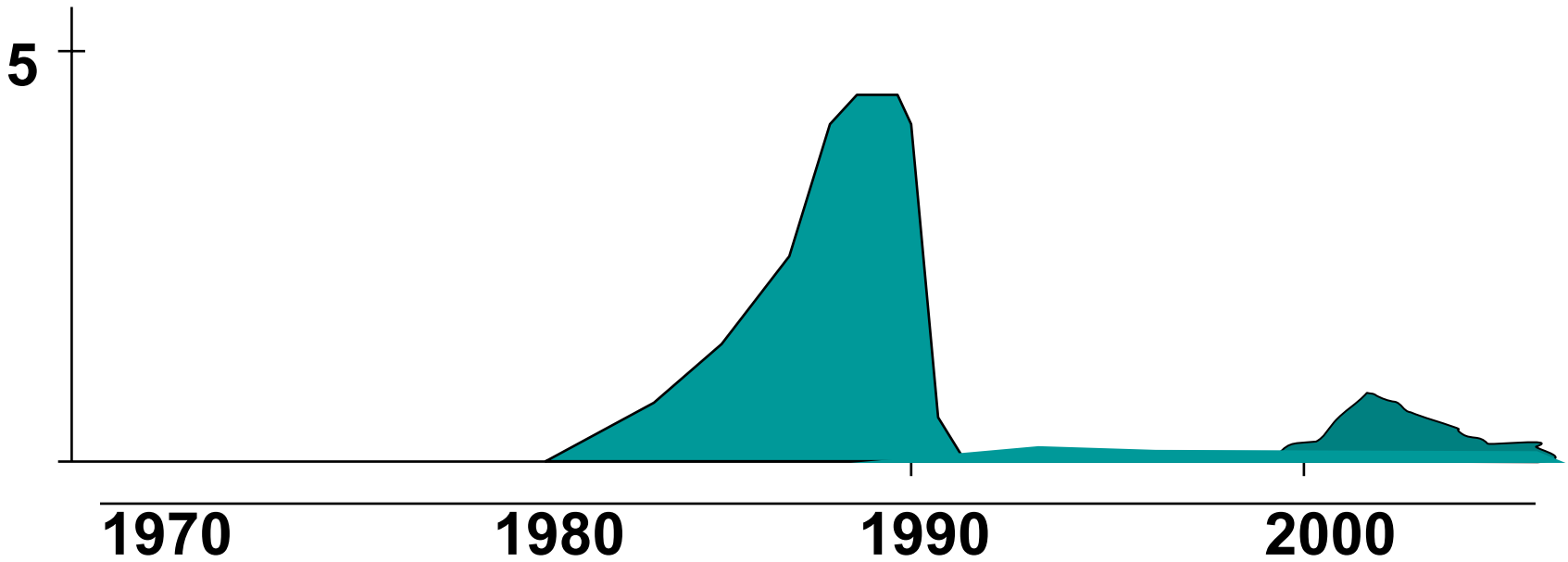
Norway spruce in Sweden

- Economically about as important species as all other combined.
- About 50% of plants from seed orchards, increasing.
- New seed orchards established now.
- Almost no clonal forestry (≈1/1000 of plants).

Swedish Norway spruce cuttings in forestry

Million cuttings annually

(of 180 million Norway spruce plants, breeding trials excluded)



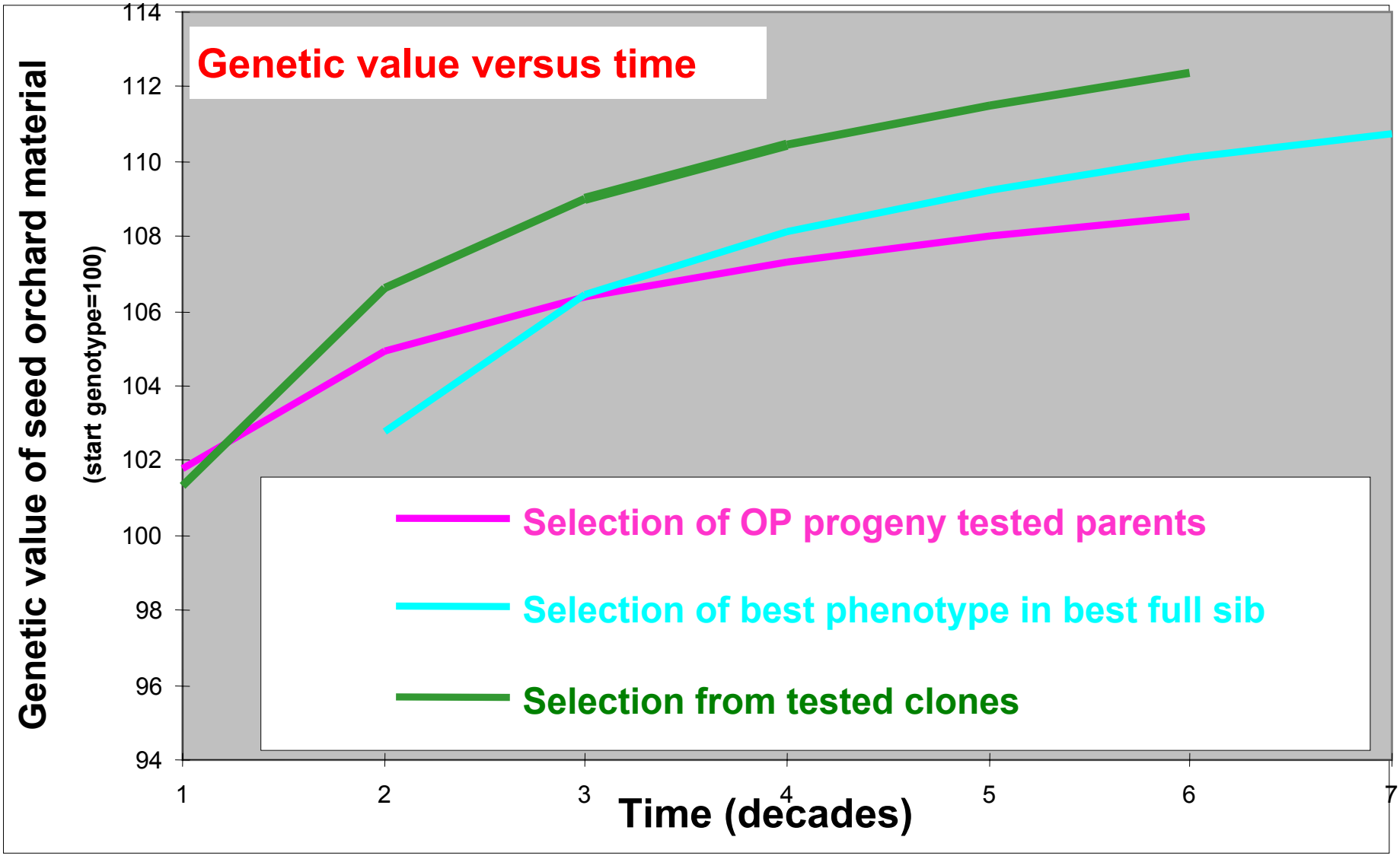
Based on Sonesson (2002)

Testing with cutting propagated clones

- Large efforts since long time to get operative clone forestry have failed
- But gave:
  - **Experience (know how)**
  - **Clone tests**

- Norway spruce flowers late, and has very irregular flowering. Therefore progeny tests with controlled crosses were established late. But plenty of clone tests existed, so it was natural to turn attention to them.
- Calculations in the end of the 80ies suggested that it was beneficial to combine progeny-testing and clone testing, thus to clone offspring to plus-trees before testing.
- This became a common praxis in the 90ies, and is now standard in Norway spruce breeding.

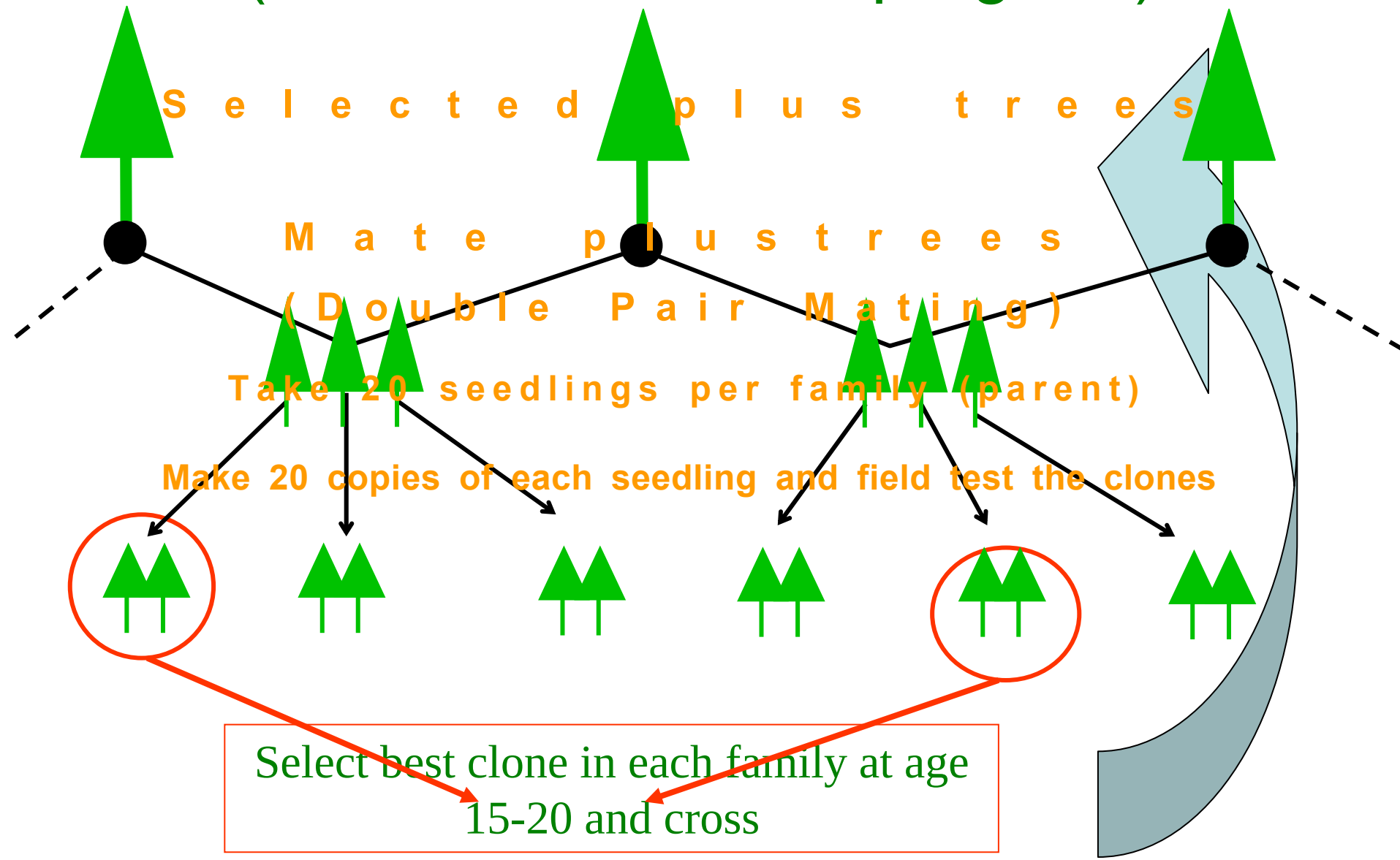
Gain in new seed orchard as a function of the time since plus tree (start genotype) selection (at the same cost) (based on Lindgren and Werner 1989)

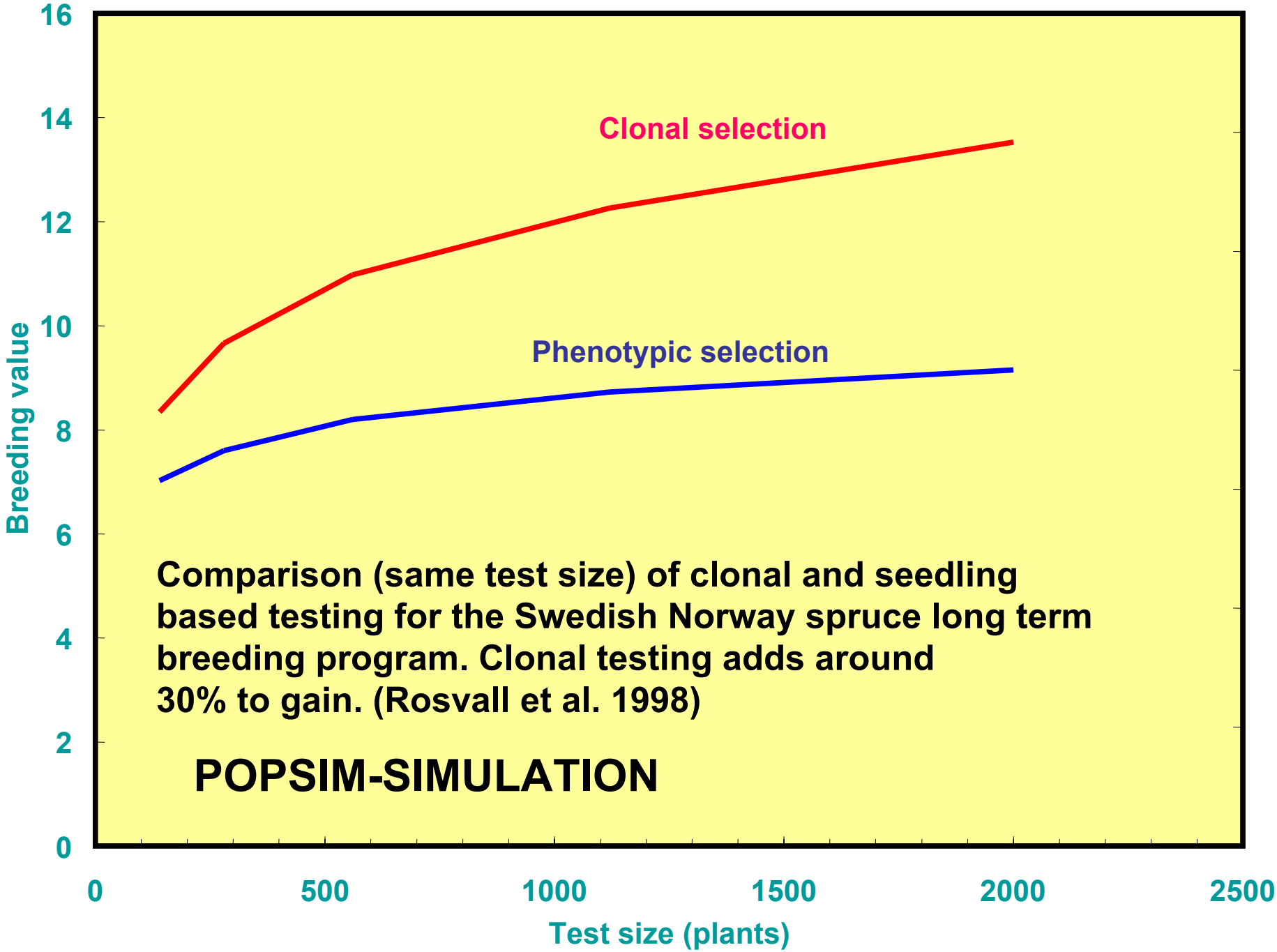


Clone-testing offer advantages:

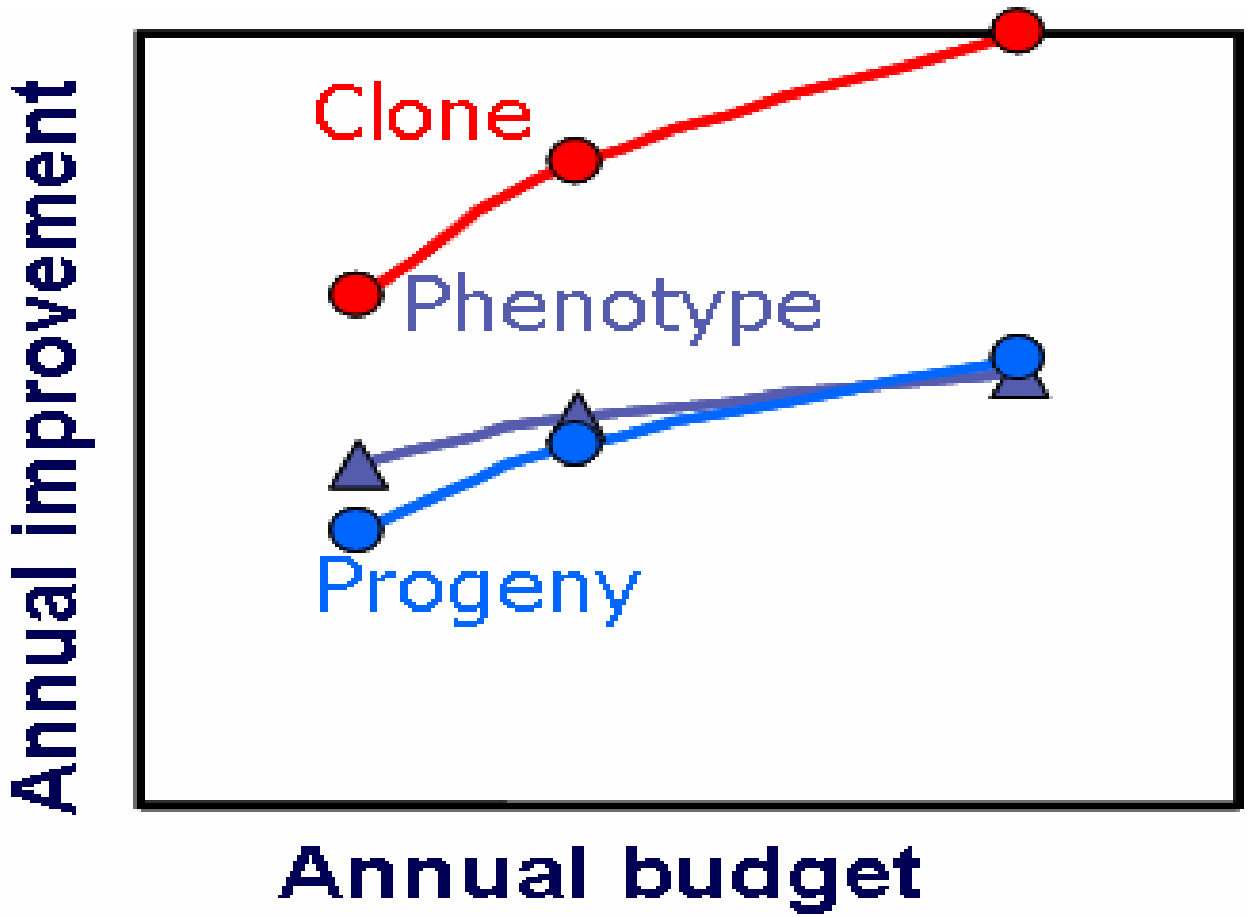
- Replications
- Reproducibility

Norway spruce breeding with clone test (Variant of Swedish program)



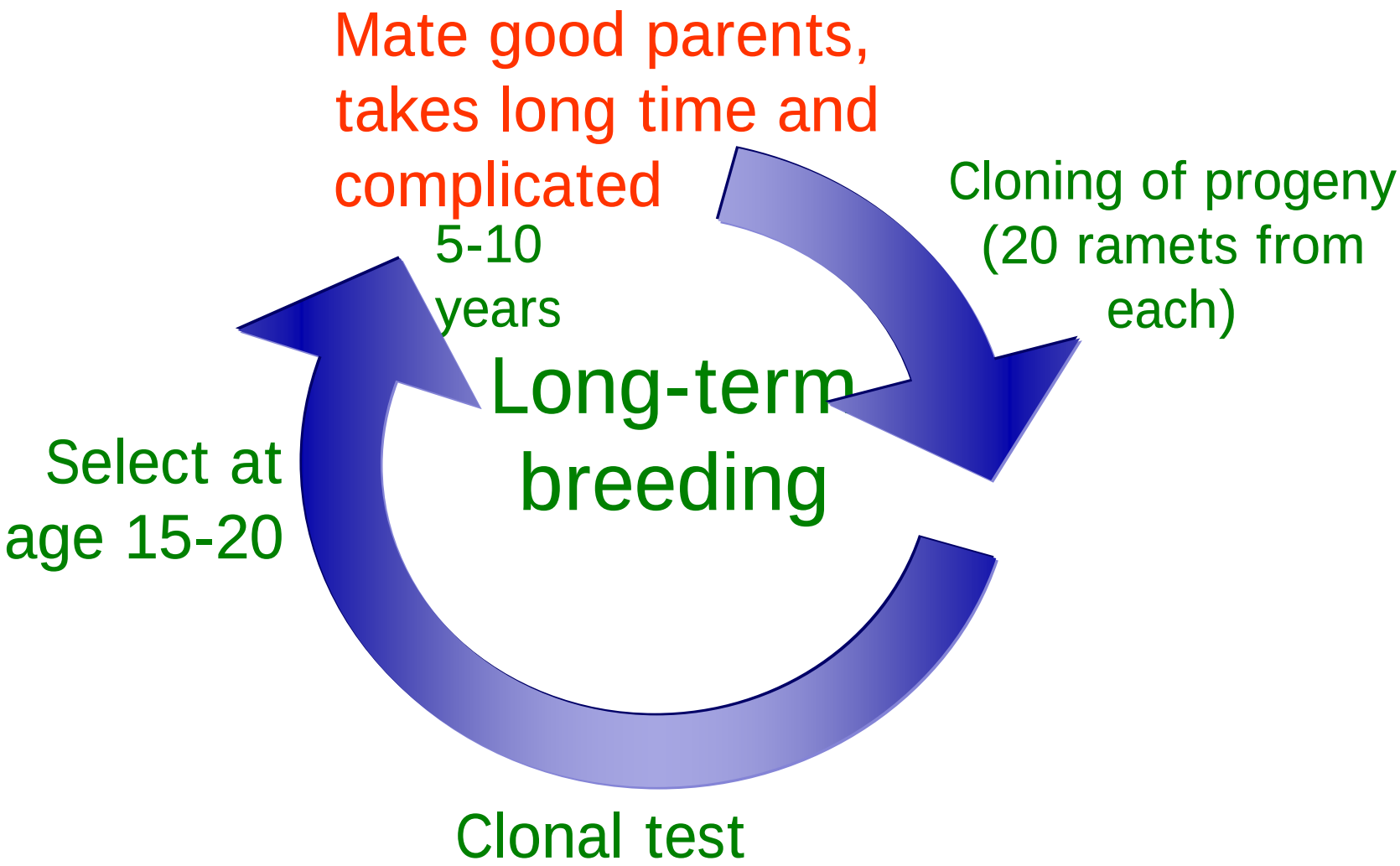

16
14
12
10
8
6
4
2
0
Breeding value
Clonal selection
Phenotypic selection
Comparison (same test size) of clonal and seedling based testing for the Swedish Norway spruce long term breeding program. Clonal testing adds around 30% to gain. (Rosvall et al. 1998)
POPSIM-SIMULATION
0
500
1000
1500
2000
2500
Test size (plants)

Clone test seems to result in almost double as high gain as alternatives. Simulation of Swedish breeding by breeding cycler, Danusevicius and Lindgren (2002)



New seed orchards are often established with cuttings of tested clones, but grafts of tested clones tested as cuttings works also.

“Conventional clone test” Norway spruce breeding cycle



Breeding without Breeding

- Concept coined by Yousry el Kassaby 2006 Documentation in electronic proceedings El-Kassaby et al (2007) and El-Kassaby & Lindgren (2007).
- Idea is to eliminate controlled crosses, and rely on open pollination and marker identification of the parent(s) instead.

Radicale new way of making forest tree breeding!

- Needed markers, marker competence and breeding theory competence!
- I like to be a part of the development of this concept in the research frontier! I push two projects in the area, here I talk about one of them.

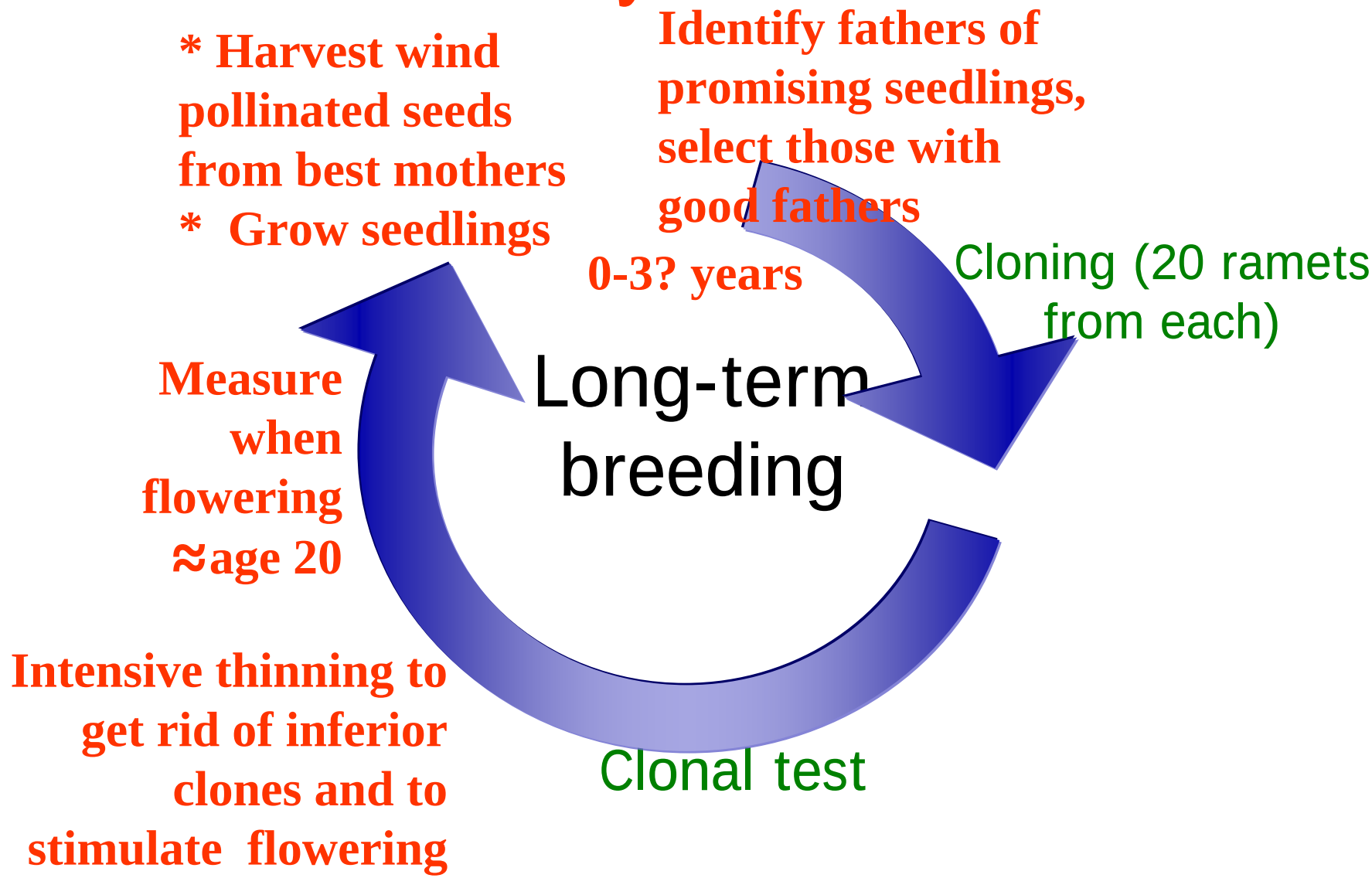
Idea

- Let Nature do the recombination!
- No controlled crosses in Tree breeding any more!
- Get pedigree by markers instead of crosses!

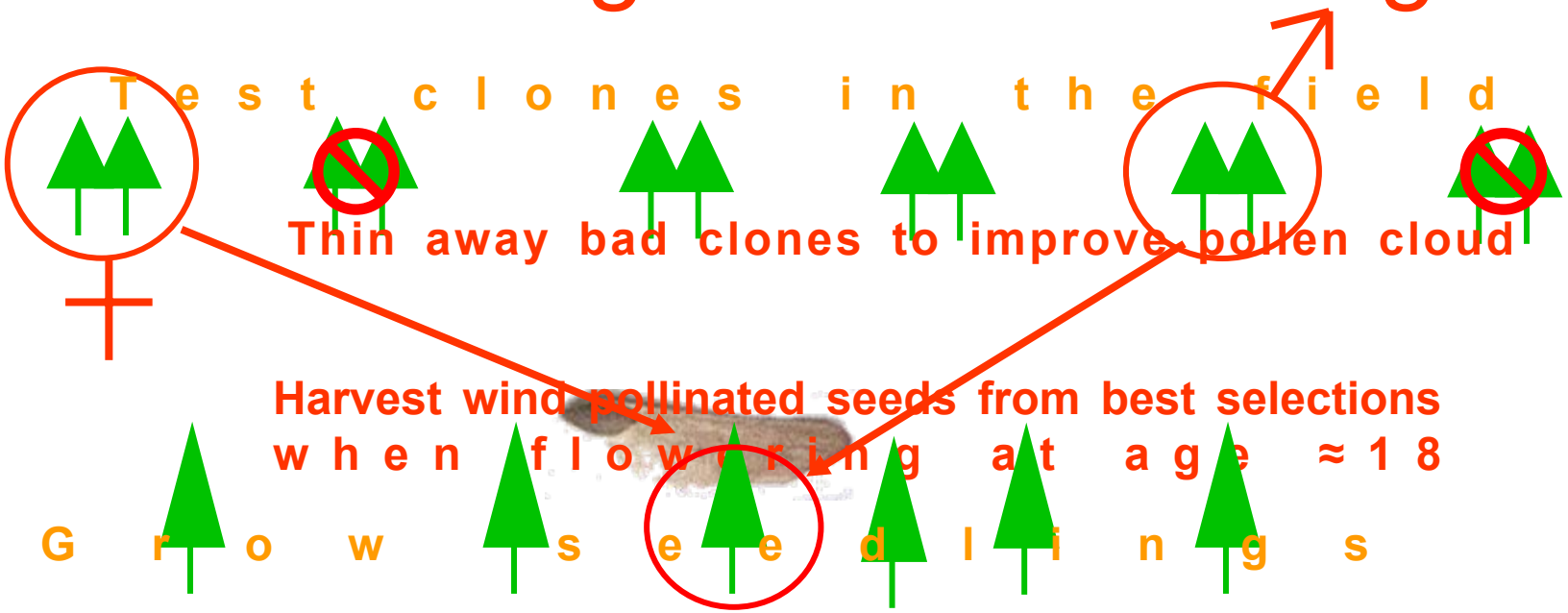
- Can be applied in a large scale immediatly after pilot study.
- No higher ”risk” than conventional breeding. Actually less as it eliminates a ”non-natural” element: *artificial* crosses.
- Brand new and fastly expanding research area!

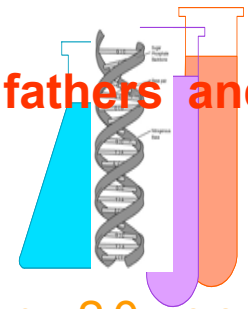
- Here I suggest an implementation of the concept to a breeding program with clonal testing of Norway spruce.

Possible breeding Without Breeding Cycle



Breeding without Breeding





Analyze seedlings for fathers and select some with good fathers

Multiply these in 20 copies and make a field trial

Advantages:

- No artificial crosses
- No clone archives, no top-grafting
- Robust, optimal testing design, little lost if BwB is never applied!
- Norway spruce flowers irregular, but nothing has to be done until a good cone set observed
- Intensive genetic thinning helps flowering and focus on good fathers
- Measurements done the seed maturation year, thus decisions made without delay, no unproductive wait!
- Clonal propagation takes some years, but most of the breeding cycle is used for the gain generating testing!
- The breeding cycle will be shortened.

Costs

- That it is clones with many copies makes the genotype number manageable.
- A good set of markers must be developed, BwB may require better and cheaper techniques, but molecular techniques improves contineously.
- If seedlings is too tough, female gamete and embryo assay improves safety.
- Marker analyses in this scenario is optimistically guessed to a third of all breeding costs after some development. High, but not forbiddingly high.
- The scenario is optimized for conventional breeding, but can be optimized for BwB instead.

- The markers cannot safely separate hundreds of fathers, thus only the best genotypes close to the mothers are genotyped and considered. A large fraction, say 90% of all tested seedlings will be rejected to achieve say 30% selection of fathers.
- For cost reasons more systems may be run on the say 15% of seedlings which are judged as maybe good father after the first cycle of analyses.
- The cost per selected genotype will be high and practical implementation may require cheaper marker methods than existing today.

Flowering

- The loss in breeding efficiency if flowering does not occur until 25 years may be rather small, but considerable if it takes longer time.
- Only a few seeds needed.
- Acceptable male flowering is prognosed to have developed after 20 years in cutting seed orchards, but in clone trials abundant male flowering may wait longer.
- Maybe male flowering can be triggered in the best males by hormone injections? Think on other methods to improve male flowering.
- Breeding clone trials in Sweden are repeated at 4-5 localities, the one with most abundant male flowering and earliest female flowering could be used.

Old clone tests

- BwB can be used to harvest the gains from existing old clone tests, it need not be planned in advance.

Collection of material at Ekebo

- At Ekebo (south Sweden) there is a clone archive with cuttings. It has been thinned rather intensively and partly genetic. It has been used for crosses and for setting up clonal seed orchards.
- Female and male flowering was good 2007.
- There are breeding value estimates of the clones (clone tested).
- Commercial seed collection has been done and thus we could get collection at a rather cheap price as the equipment is there.
- Clones grow in rows.
- We get seed samples from about 50 clones in an approximate 10*5 (square pattern).
- Of these, 12 clones in an approximate square pattern 3*5 with 3 ramets in each row are collected from each ramet.
- We go there and collect needle samples from test trees in end of May 2008.
- The material will give valuable information about pollination by neighbours (gene flow, neighbourhood size) besides the BwB information.
- We have got a small grant for getting the material, we have applied for a grant to do the analyses.