Seed Use Efficiency:

From the Forest to the Forest

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Acknowledgements

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Collaborators: MoF&R, PRT, Forest Industry
Research Associates, PDFs and Graduate Students


Science
AAAS

Mild	Hot	Very Hot
 Hungarian	 Cayenne	 Habanero
 Anaheim	 Serrano	 Thai

Outline

- Background: The Bigger Picture
- Tree Improvement Delivery System:
  - Seed orchard genetics
  - Seed production
  - Clonal "personality":
    - Reproductive output
    - Germination behaviour
- Interaction between Biology and Production
  - Can we find a happy compromise?
- Mathematics of Germination
- The "Status quo" Syndrome!
- The Way Forward:
  - We need your help!!

Background: The Bigger Picture

Tree Improvement Delivery System

Biological Constraints

End-Product

Natural Populations → Plus-trees

Selection
Breeding
Testing
→ Advanced generations

Phenology
Fertility variation
Contamination
→ Seed orchards → Seeds

Seed issues →

Germination
Dormancy
Thinning
Culling
→ Nurseries → Seedlings

Regeneration → Plantations

Tree Improvement Delivery System

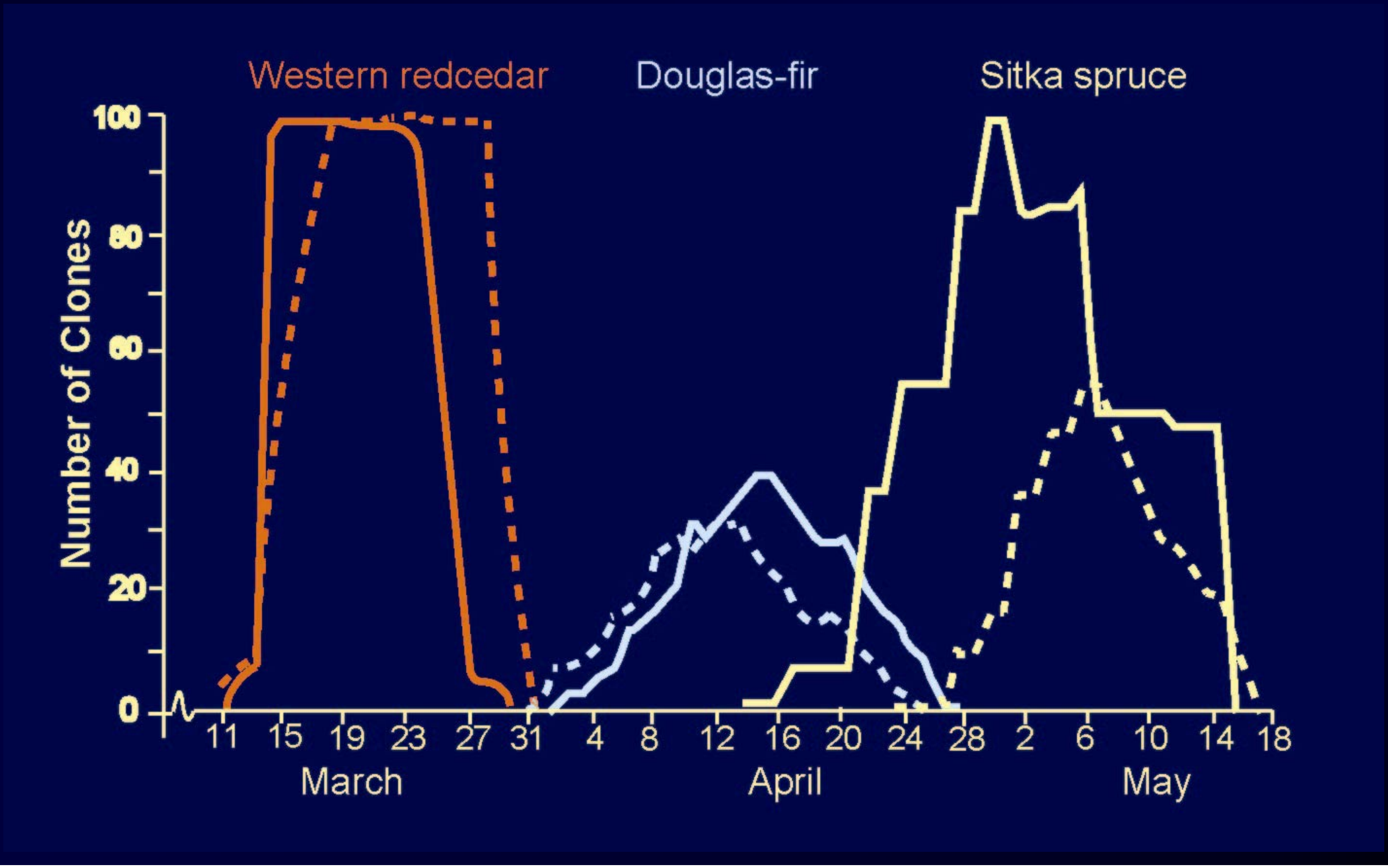
Tree Improvement = Breeding + Delivery

Maximize gain per unit time, effort, cost

Rate of conversion to high gain

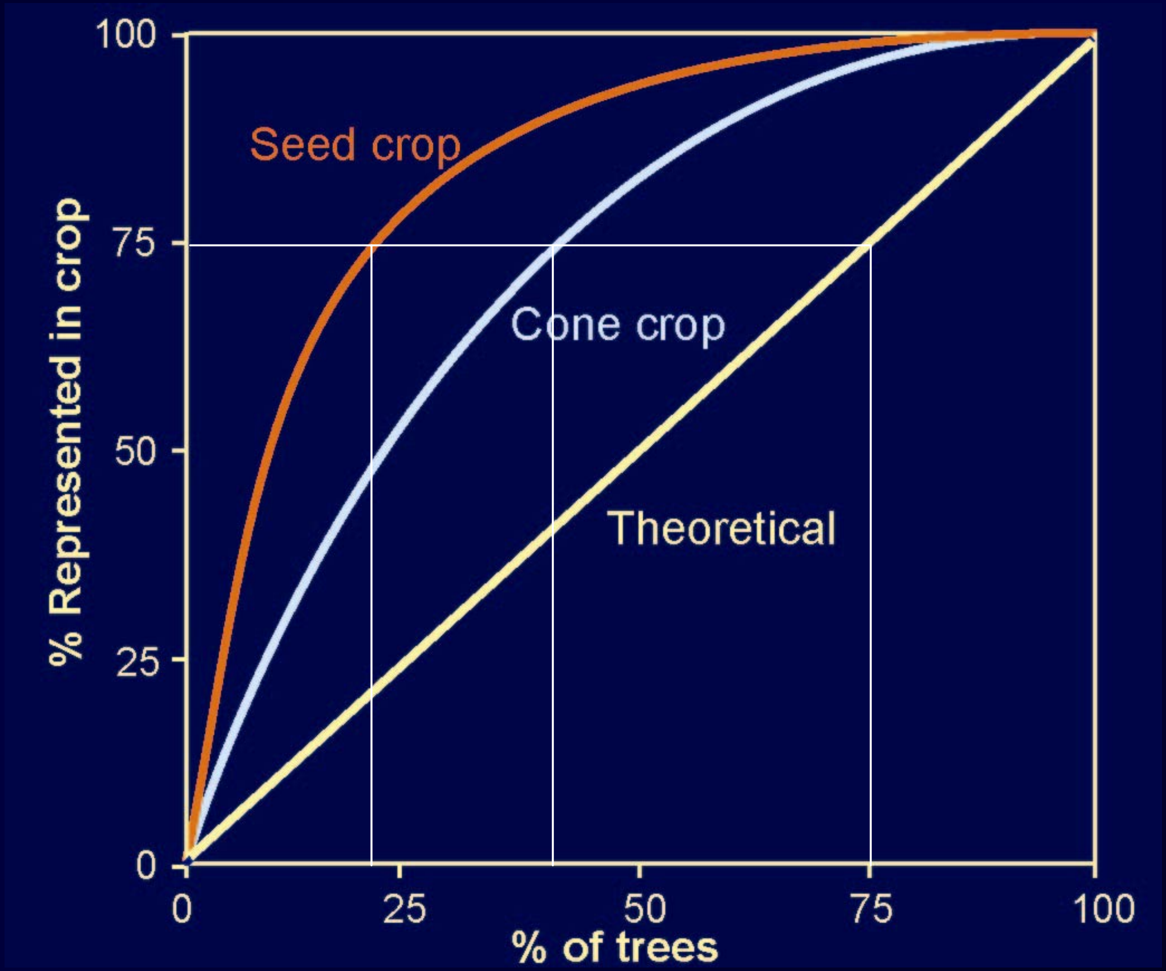
Seed Orchard Genetics

Reproductive Phenology



Seed Orchard Genetics

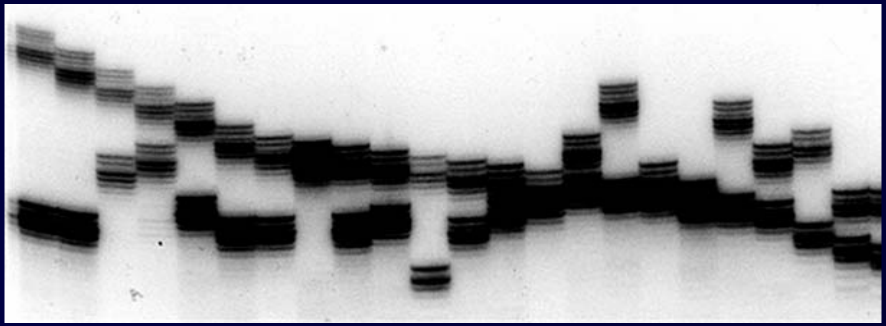
Reproductive output: energy vs. success

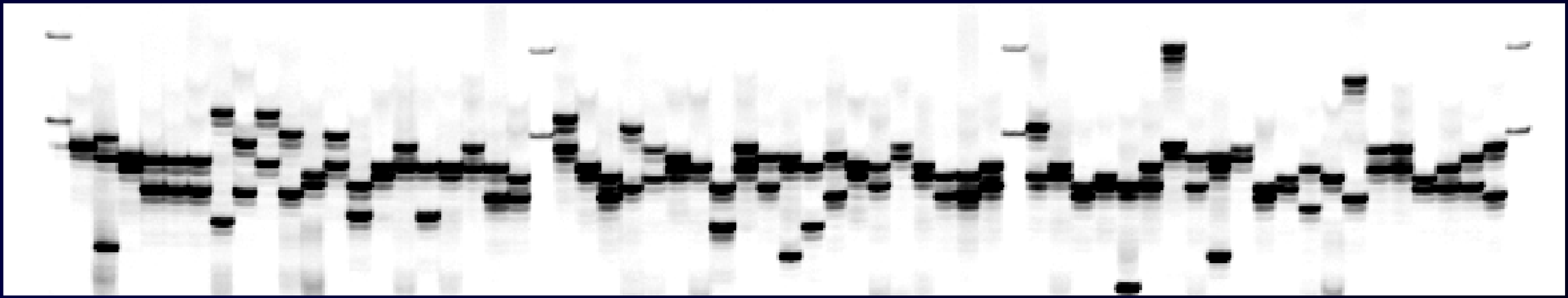


Seed Production

Who is doing what to whom and When?

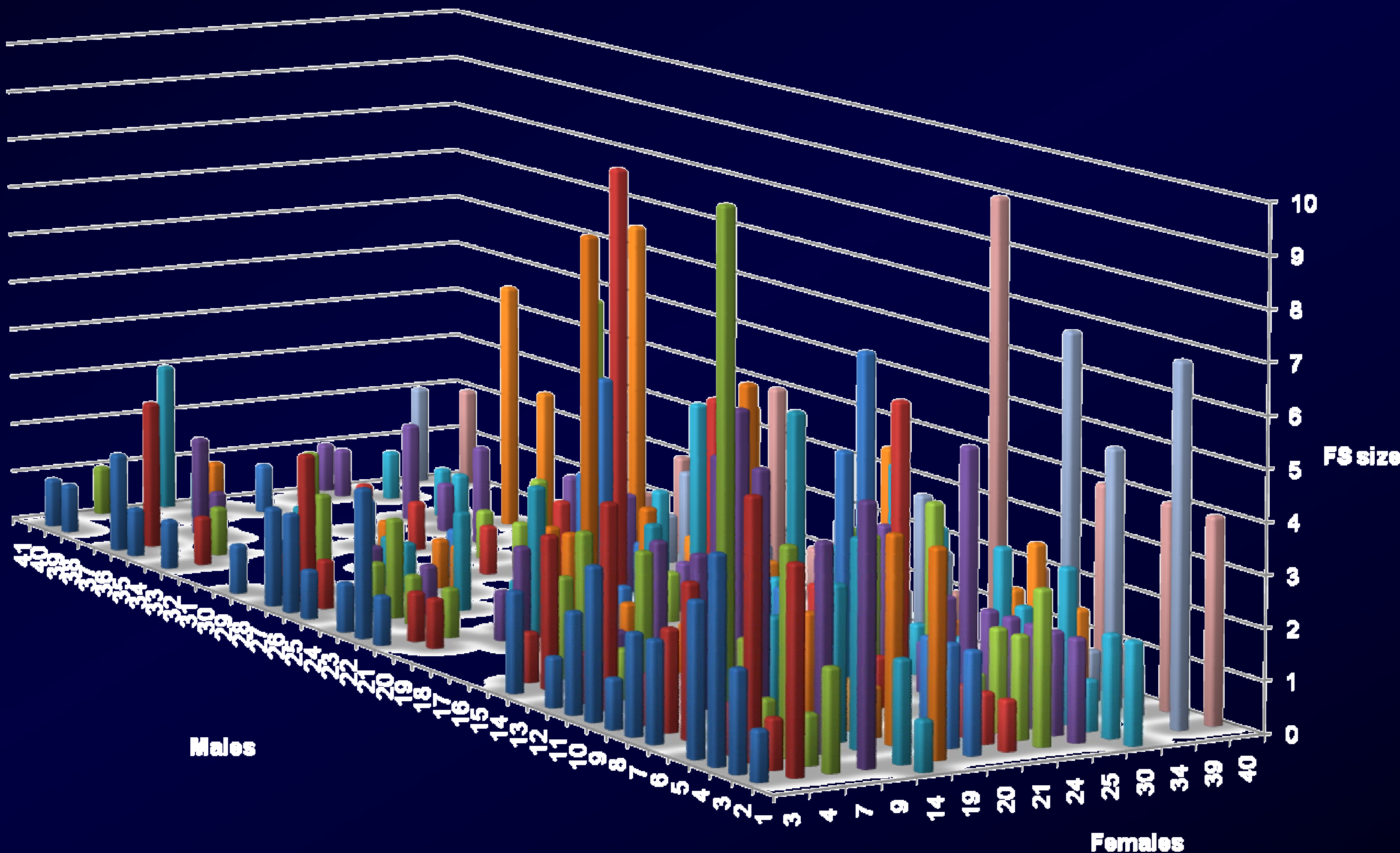
- Molecular markers
- Pedigree reconstruction



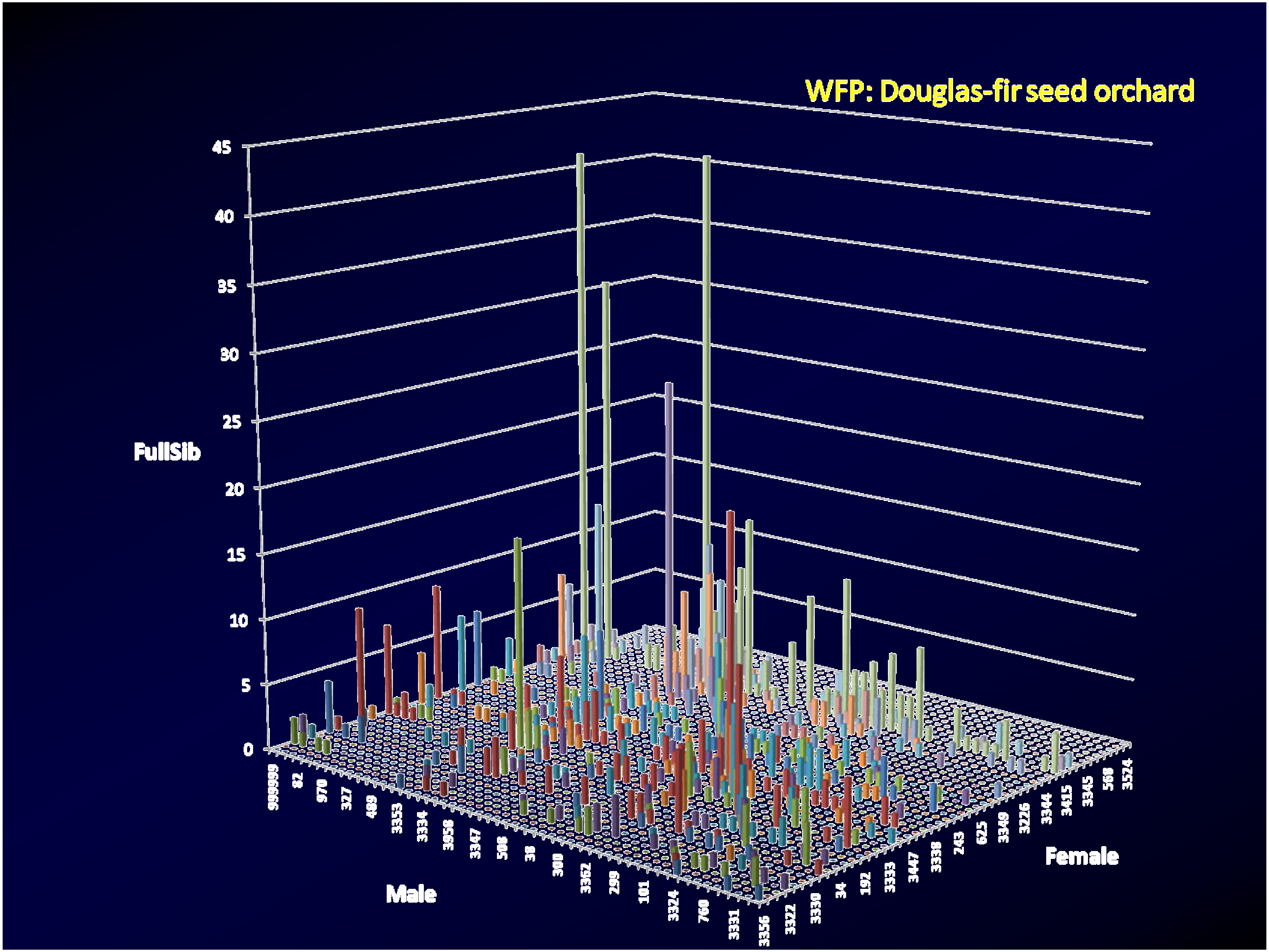


PRT: Lodgepole pine seed orchard

Identifying Pollen Donors



TIB: Western larch seed orchard



WFP: Douglas-fir seed orchard
FullSib
45
40
35
30
25
20
15
10
5
0
Male
999999
82
970
327
489
3353
3334
3958
3347
508
38
300
3362
299
101
3324
760
3331
3356
Female
3322
3330
34
192
3333
3447
3338
243
625
3349
3226
3344
3415
3345
568
3524

Extracting seedlots' genetic parameters

1- Genetic worth:
    Volume = 10.5%
    Wood density = -1.2%

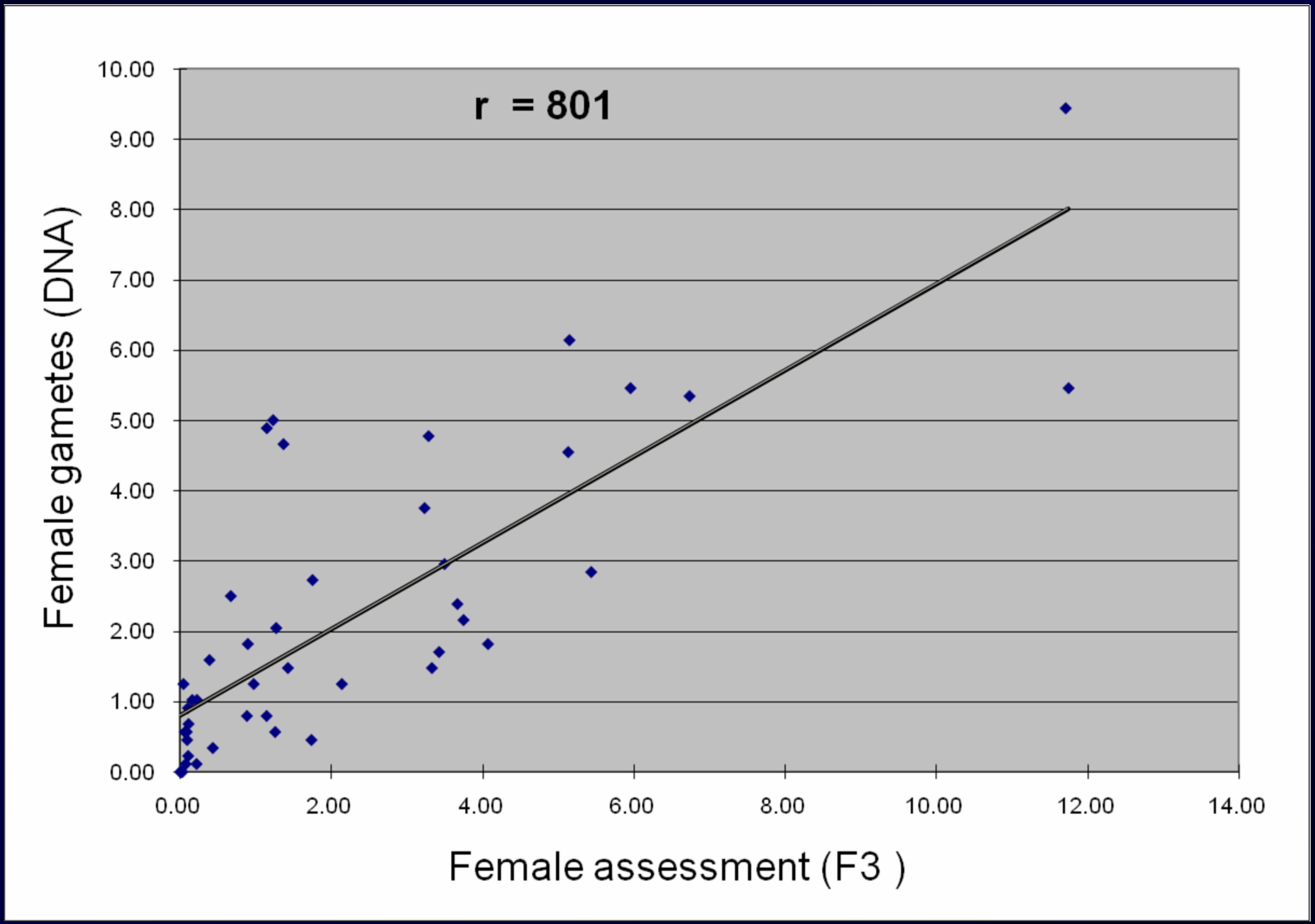
2- Effective population size (N_e) = 17.99

3- Contamination rate = 10.9%

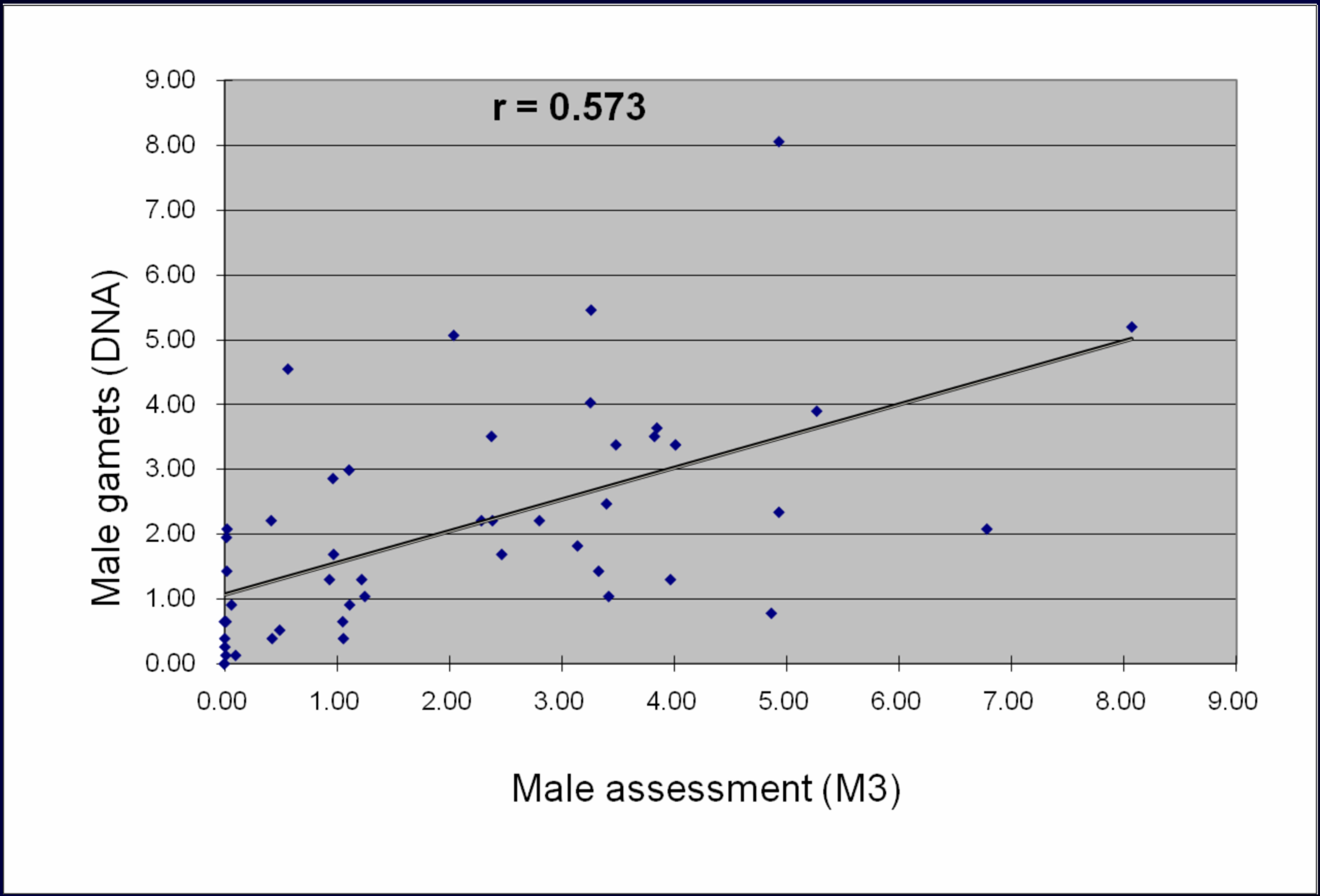
4- SMP success rate:
    Parents in orchard = 25.6%
    Parents outside = 7.4%

5- Selfing rate = 16.7%

Streamlining the Process

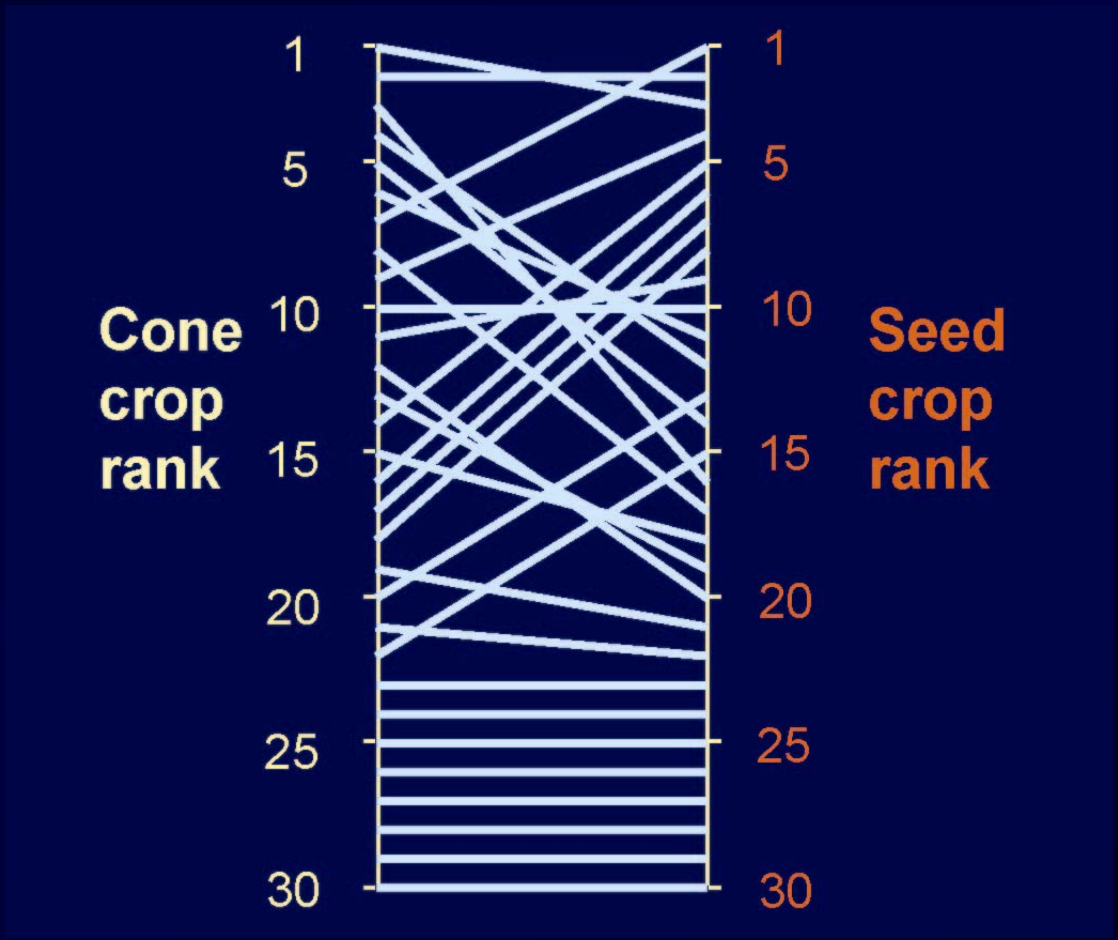


Streamlining the Process



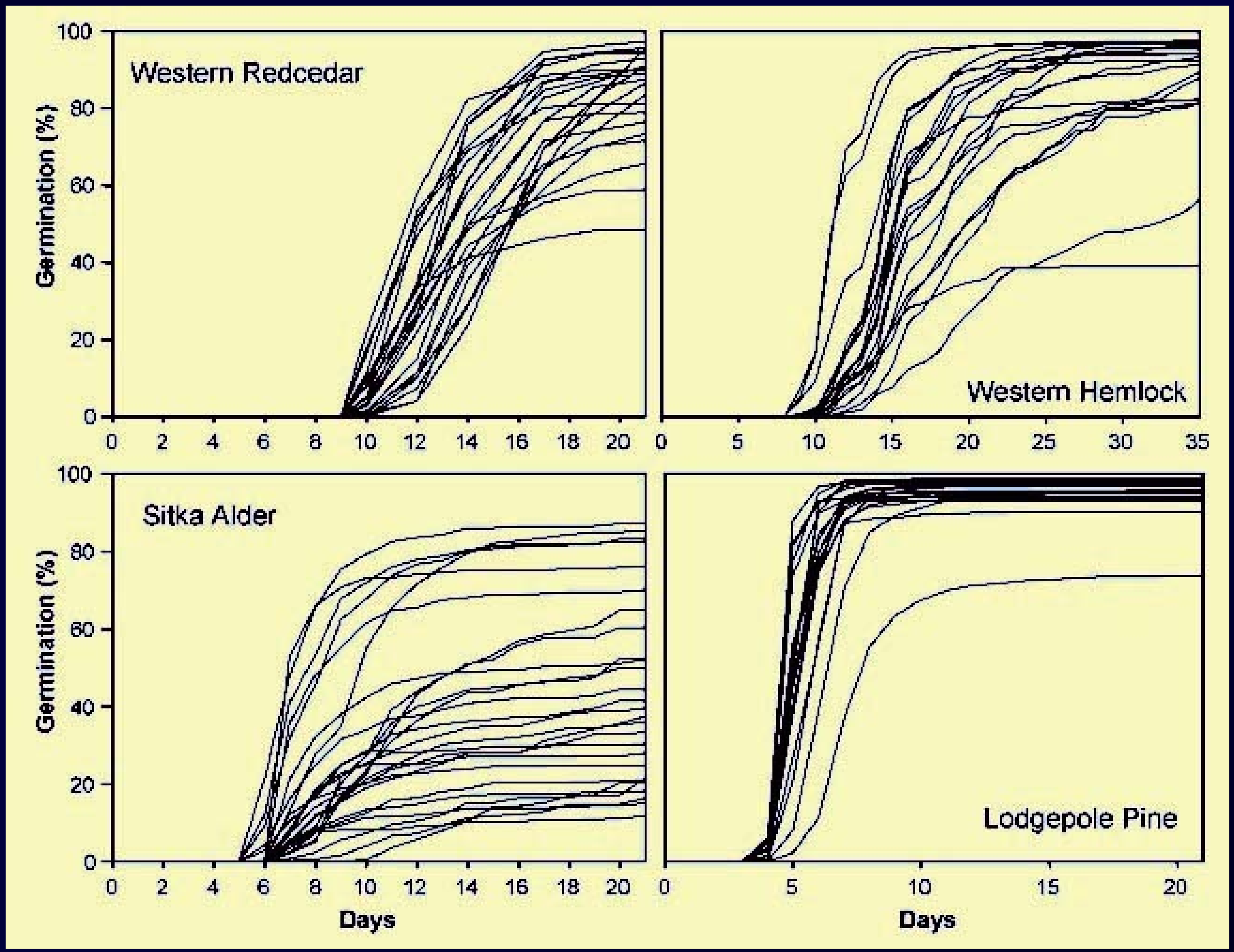
Clonal Individuality

Cone vs. seed count



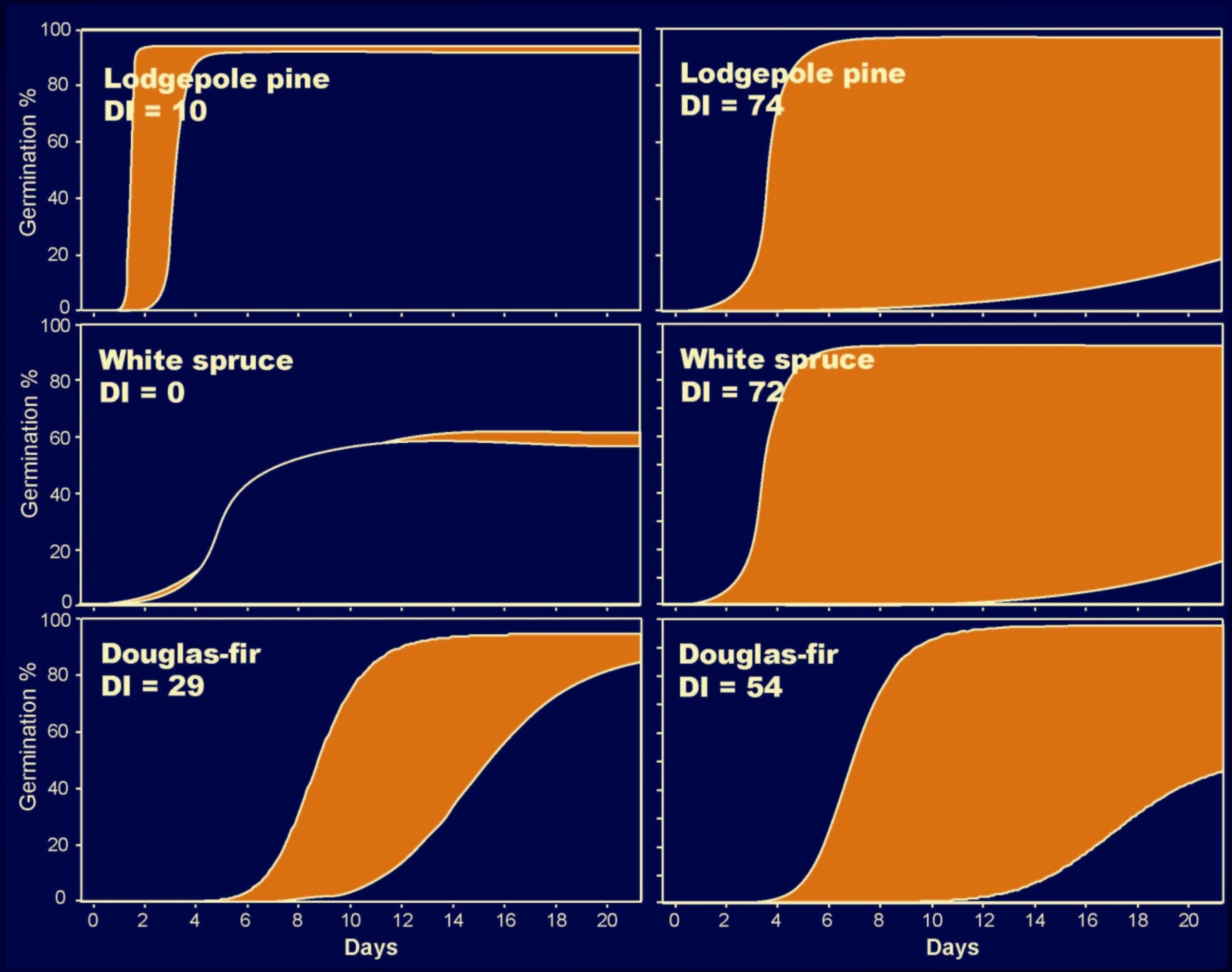
Clonal Individuality

Germination Behaviour



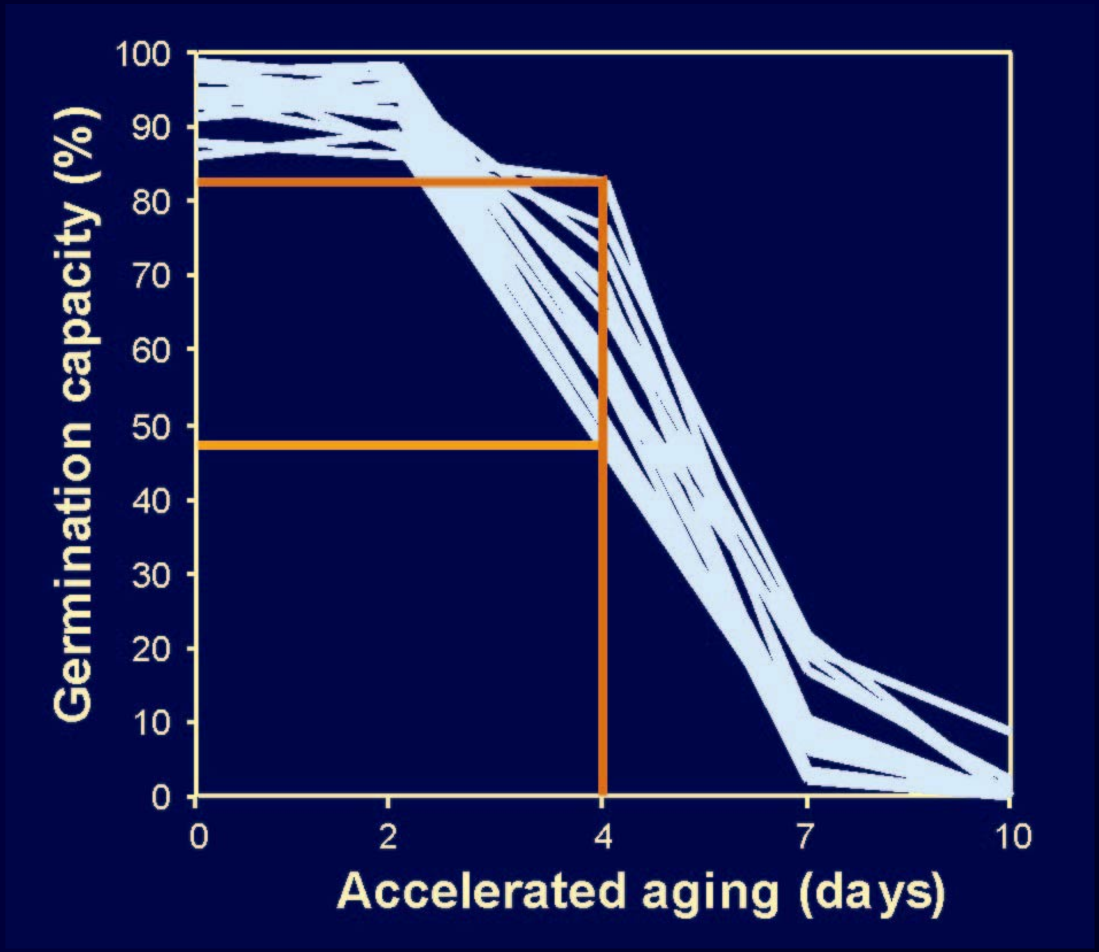
Clonal Individuality

Dormancy



Clonal Individuality

Aging



Clonal Individuality

Germination parameters' genetic control

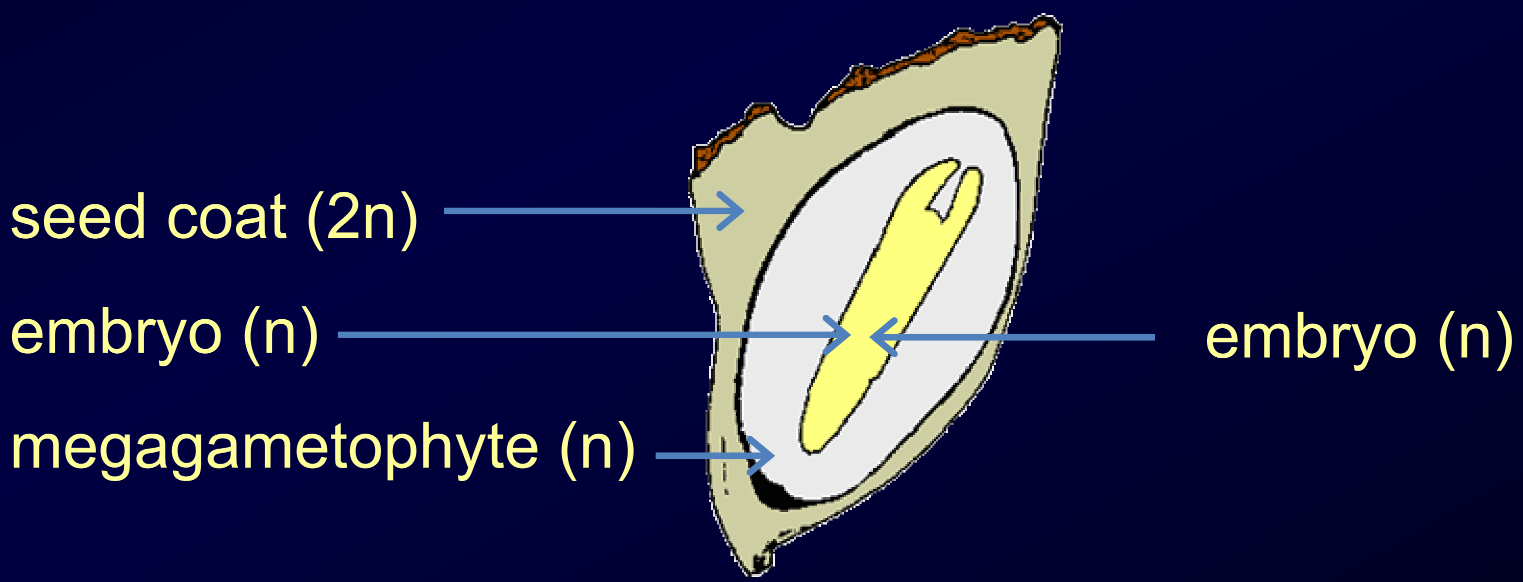
Species	GC	R_{50}'	PV	GV
Douglas-fir	0.92		0.91	0.93
Lodgepole pine	0.98	0.99	0.99	0.99
Pacific silver fir	0.70			0.72
Sitka spruce	0.74		0.78	0.74
Western hemlock	0.88	0.91	0.91	0.92
Western redcedar	0.79		0.78	0.80
Paper birch	0.90	0.92	0.87	0.91
Sitka alder	0.96	0.94	0.78	0.97

Clonal Individuality

Why such high genetic control?

Seed parent → Contribution ← Pollen parent

Gymnosperm seed



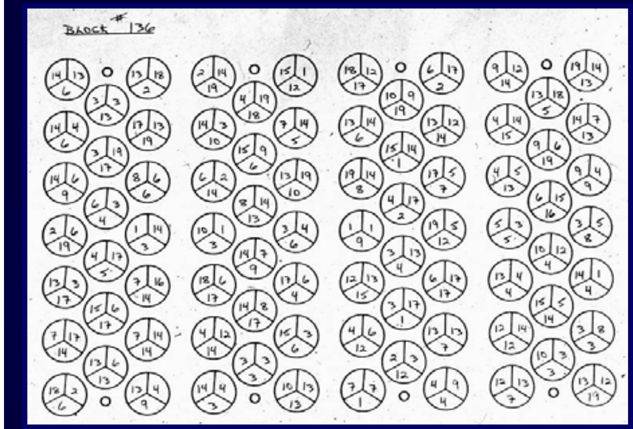
Clonal Individuality

2nd gen. Bulkley FS Pl families

Interaction between Biology and Production

Nursery Genetics

- 15 parents, equal contribution
- Fd, Hw each with 26,000 seeds
- 1, 2, 3 seeds/cavity and family blocks
- Randomized, each seed tracked



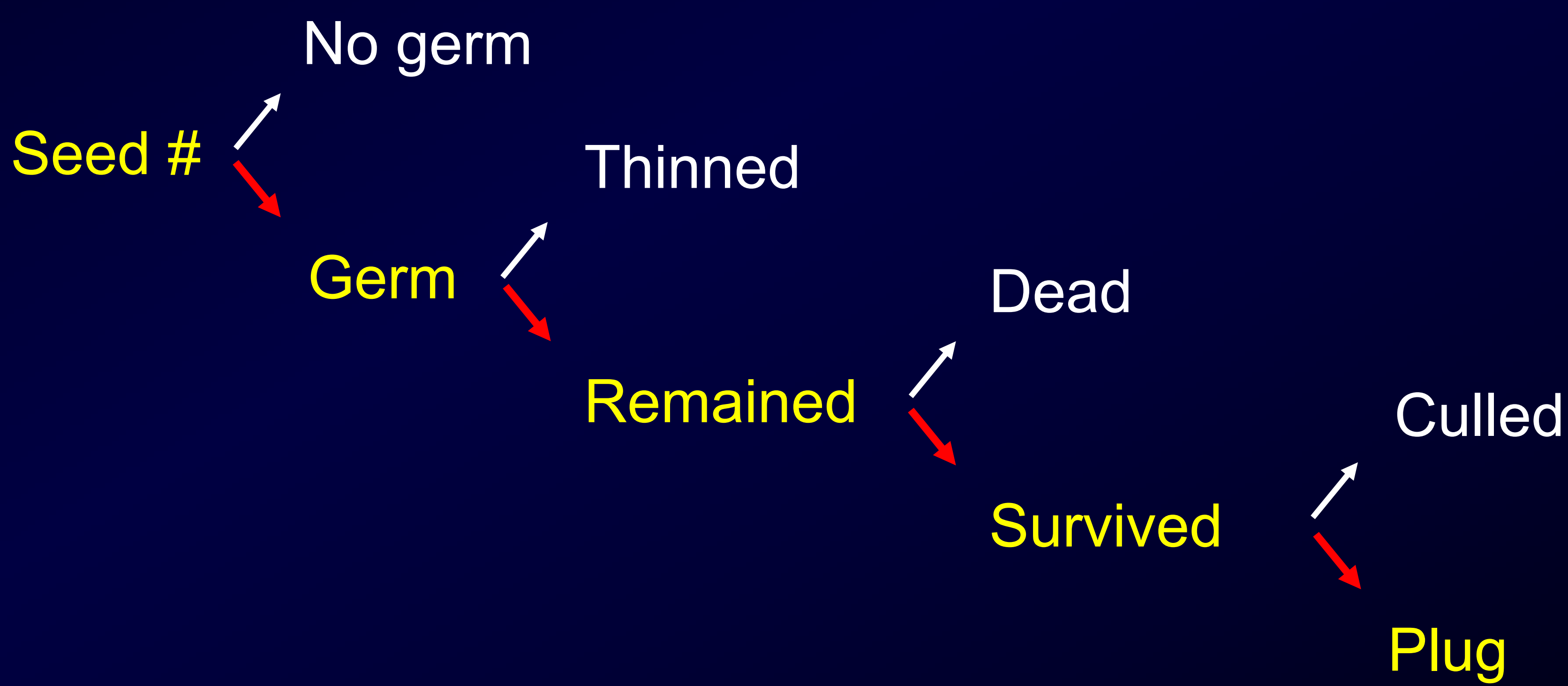
Interaction between Biology and Production

Nursery Genetics

Interaction between Biology and Production

Nursery Genetics

Chain of custody



Interaction between Biology and Production

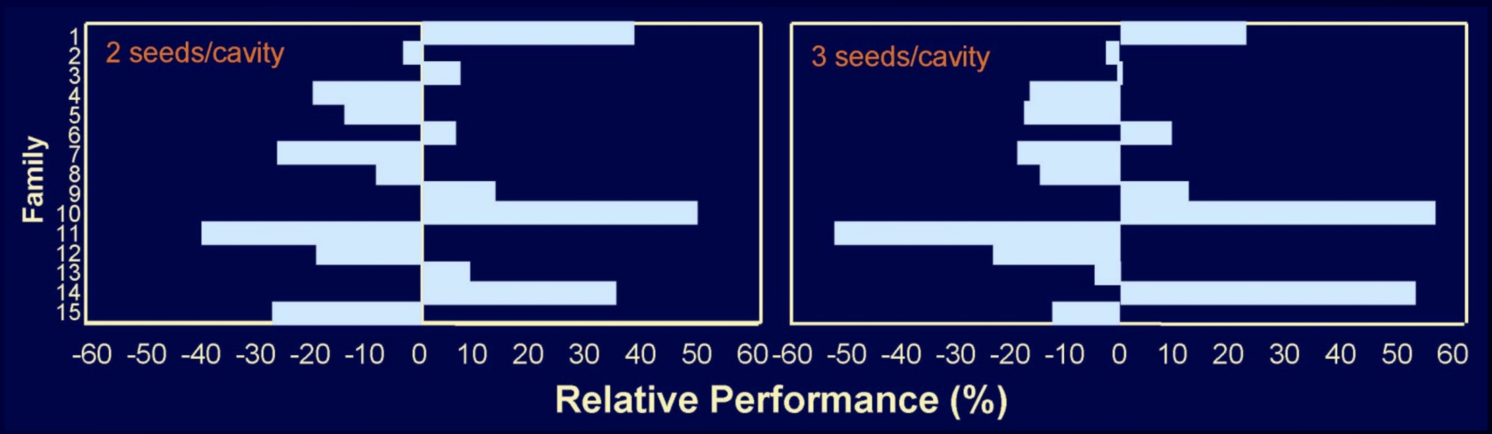
Germination Speed (R_{50}')

Family #	Douglas-fir	Western hemlock
1	8.5	21.5
2	9.9	21.7
3	10.2	22.8
4	9.7	22.1
5	11.2	21.8
6	9.5	19.9
7	10.3	24.7
8	10.8	23.1
9	11.2	23.0
10	11.4	20.9
11	10.0	20.6
12	11.1	21.3
13	11.4	21.3
14	11.1	21.0
15	10.3	21.6

Interaction between Biology and Production

Multiple sowing

	% of Variation			
Df	Germination	Thinning	Survival	Culling
2 seeds/cavity	9	91	0	0
3 seeds/cavity	4	95	0	1
Hw				
2 seeds/cavity	6	83	1	10
3 seeds/cavity	7	85	1	7



Interaction between Biology and Production

Single sowing

1 seed/cavity	% of Variation			
Df	Germination	Thinning	Survival	Culling
Random	65	n/a	4	31
Family block	20	n/a	18	62
Hw				
Random	19	n/a	12	69
Family block	8	n/a	0	92

Reduced productivity

Specs!

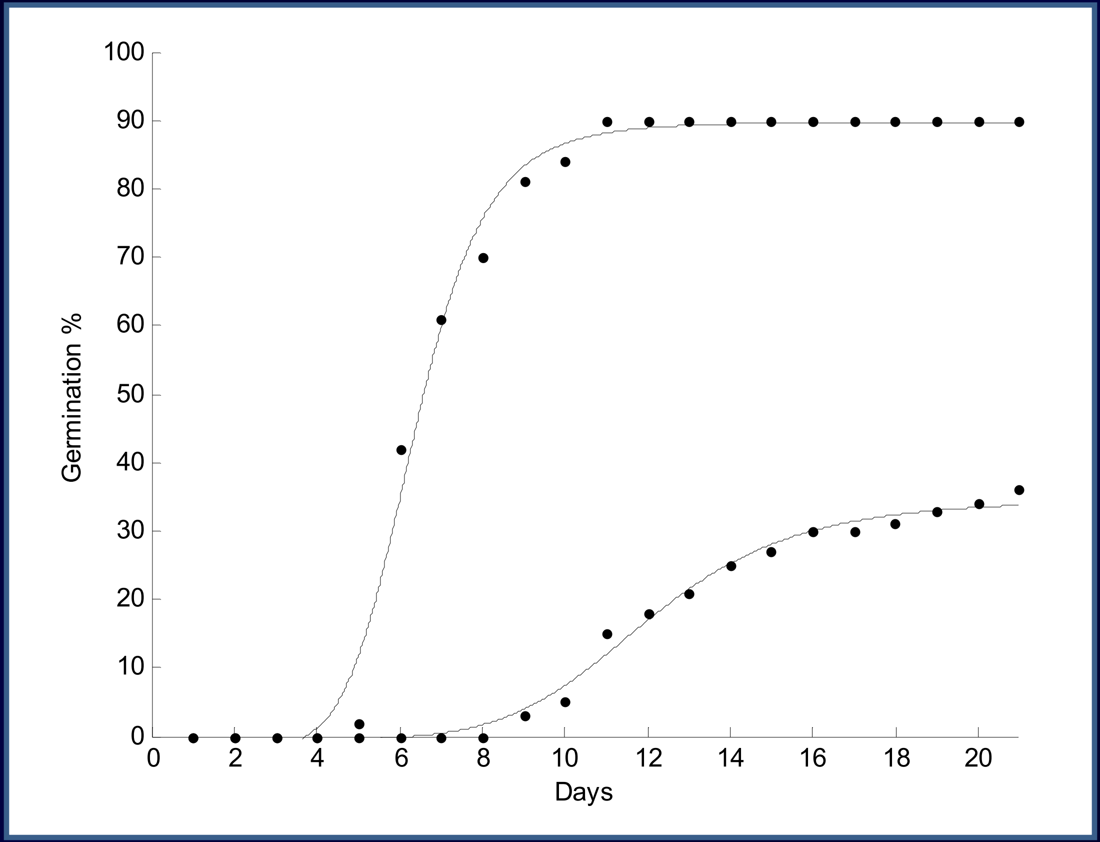
Species-specific growth habits

Interaction between Biology and Production

The Perfect Solution → Mini-plug

Mathematics of Germination

The 4-parameters Hill function



a = germination capacity (GC)
b = representative of shape and steepness of the germination curve
c = germination speed (R_{50}')
Lag = time at germination onset

The “Status quo” Syndrome

Edwards, D. G. W. and El-Kassaby, Y. A. (1995), *Seed Sci. & Technol.*, **23**, 771–778

Douglas-fir genotypic response to seed stratification

D. G. W. EDWARDS[2] and Y. A. EL-KASSABY[1,3]

[2] Canadian Forest Service, Pacific Forestry Centre, 506 West Burnside Rd., Victoria, B.C. V8Z 1M5, Canada
[3] Pacific Forest Products Ltd., Saanich Forestry Centre, 8067 East Saanich Rd., Saanichton, B.C. V8M 1K1, Canada

ISTA’s recommendation → 3 wks stratification

Un-stratified > 3wks > 5wks > 7wks*

Should we follow ISTA rules?

The "Status quo" Syndrome

DOUGLAS-FIR GENOTYPIC RESPONSE

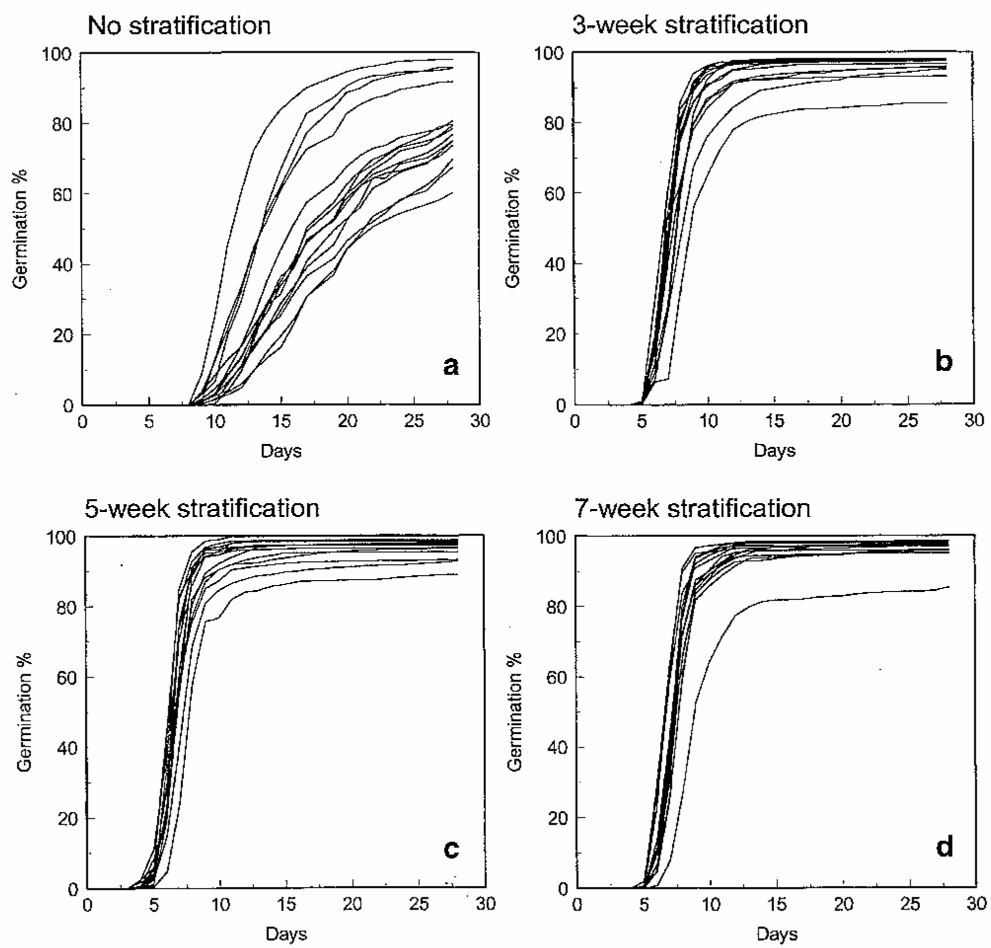
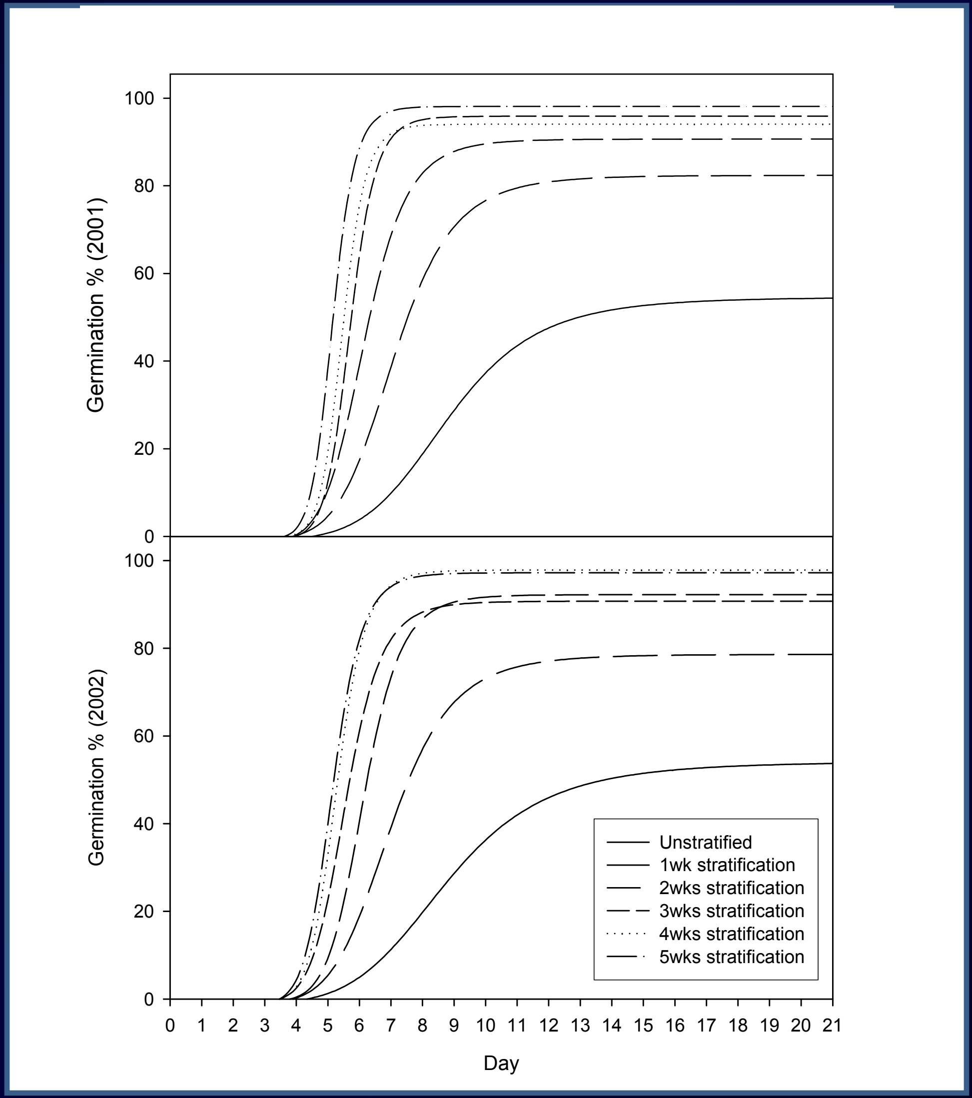


Figure 1. Germination course of 15 Douglas-fir clones. (a, unstratified seeds, and following stratification: b, 3 weeks; c, 5 weeks; d, 7 weeks).

The “Status quo” Syndrome

Logepole pine seed shortage



The "Status quo" Syndrome

Logepole pine seed shortage

1- Challenged ISTA's seed pretreatment prescriptions

2- Extended stratification from 3wks → 5wks

3- ≈ 2% increase in germination

4- 2007 sowing request: 115.4M seedlings

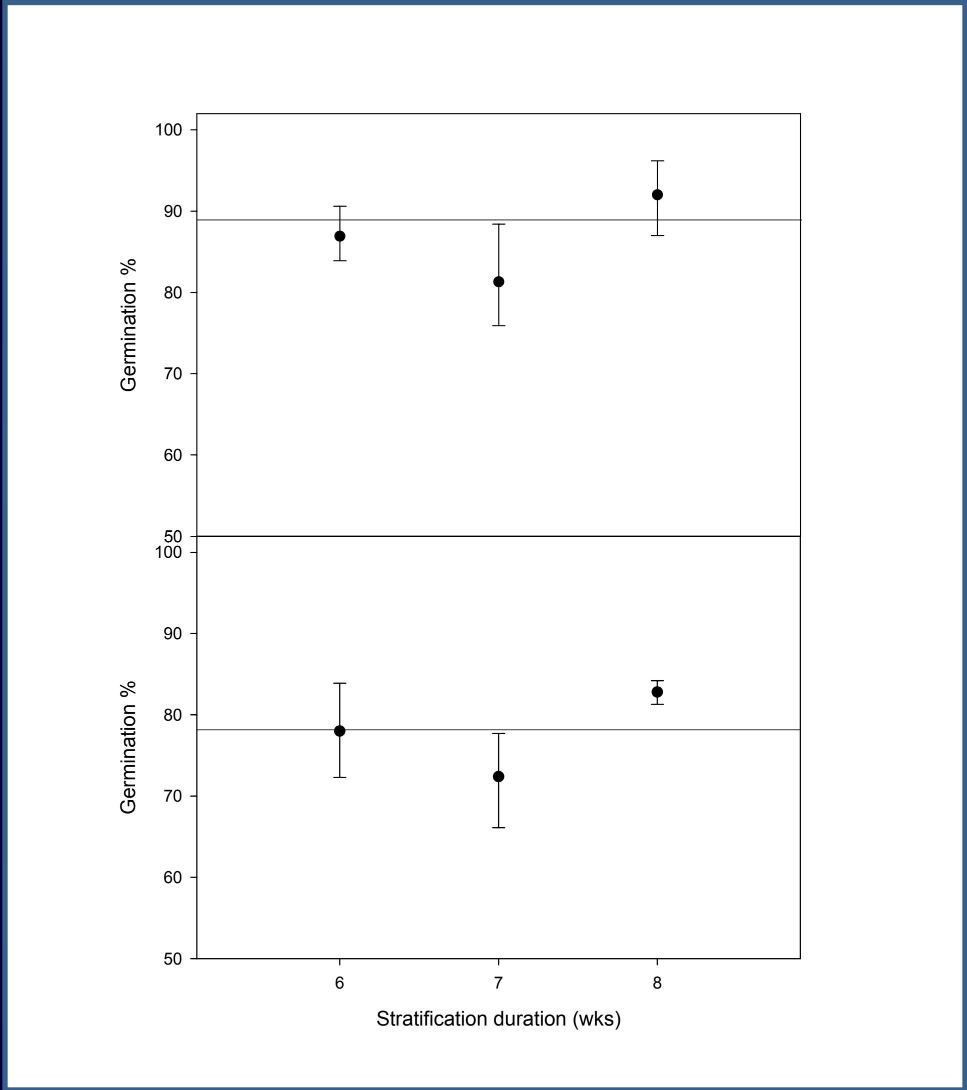
5- Factor 2% ↑ → 126.5M → +11M seedlings

6- Increased utilization of 9.6%

7- Additional 6,900 ha (@1,600/ha)

The "Status quo" Syndrome

Logepole pine seed shortage



The "Status quo" Syndrome

Logepole pine seed shortage

- Lessons from the nursery trial:
  - Inconclusive test (timing differences)
  - Sowing factor = original lab germination
  - Germination improvement ≠ increase in seedling production
- Next step:
  - Volunteers/collaborators
  - Multiple sites – multiple seedlots
  - Willingness to alter sowing factors to reflect improved germination

The "Status quo" Syndrome

Logepole pine seed shortage

- Dual approach (lab and nursery)
- 2-3 seedlots/site
- 3 sites
- 20 blocks/treatment (control and various strat times)
- Change sowing factor (based on germination improvement level)
- Collect germination data
- Collect seedling recovery/block/treatment
- Funds may be available to compensate for additional work

Questions