The Irish Sitka spruce breeding programme: an overview

Acknowledgements: David Thompson, Alistair Pfeifer, John Fennessy, Mick Keane, Henry Phillips

Kevin Black, Director FERS Ltd

Species

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Provenance →

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Family

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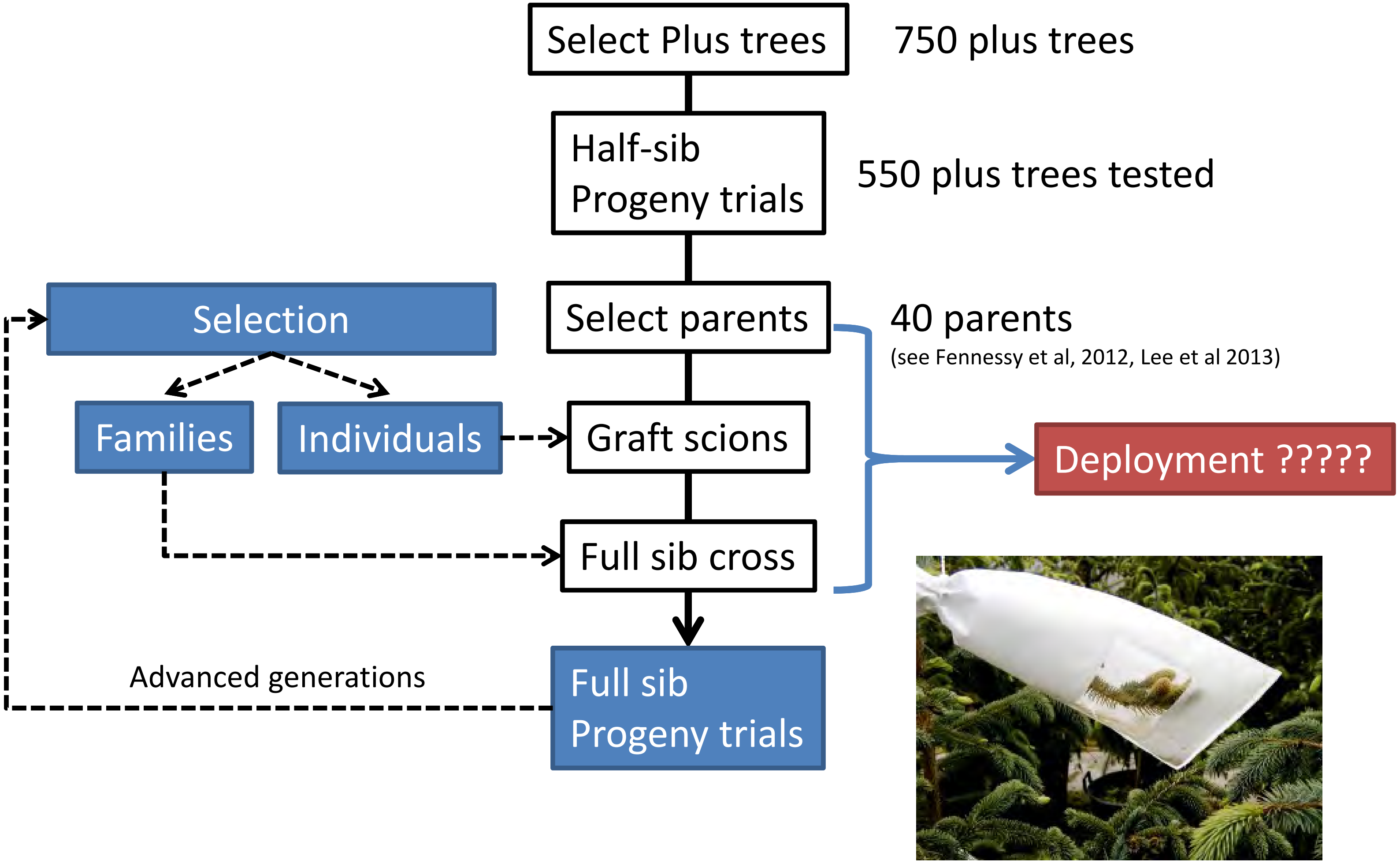
Individuals

Provenance	Top H m	DBH (cm) cm	YC $m^3\ ha^{-1}\ yr^{-1}$	Standing Vol $m^3\ ha^{-1}$	Assortment LL/SLL/P	Price £/Ha
QCI	13.9	19.1	22	315.7	27/44/29	6,246
N. Washington	14.9	20.7	24	389.6	38/40/22	8,843
S. Washington	**15.9**	**21.4**	**24+**	**430**	**40/41/19**	**10,180**
N. Oregon	15.1	20.6	24	399.6	37/43/20	9,110
S. Oregon	15.4	20.9	24	434.3	33/45/22	9,456

Thompson et al., 2005

- **Washington been recommended for years but foresters are reluctant to change**
- N. Farrelly, maybe Oregon is better in some regions (based on new data)
- Site interaction- i.e. select provenance for specific sites
- More than one climatic eco-zone in Ireland based on ESC
  - Cool Wet (<0.01%), Warm Wet (>5%), **Warm moist**, and Warm Dry (7 in UK)
- G x E not to be underestimated

Breeding and selection strategy

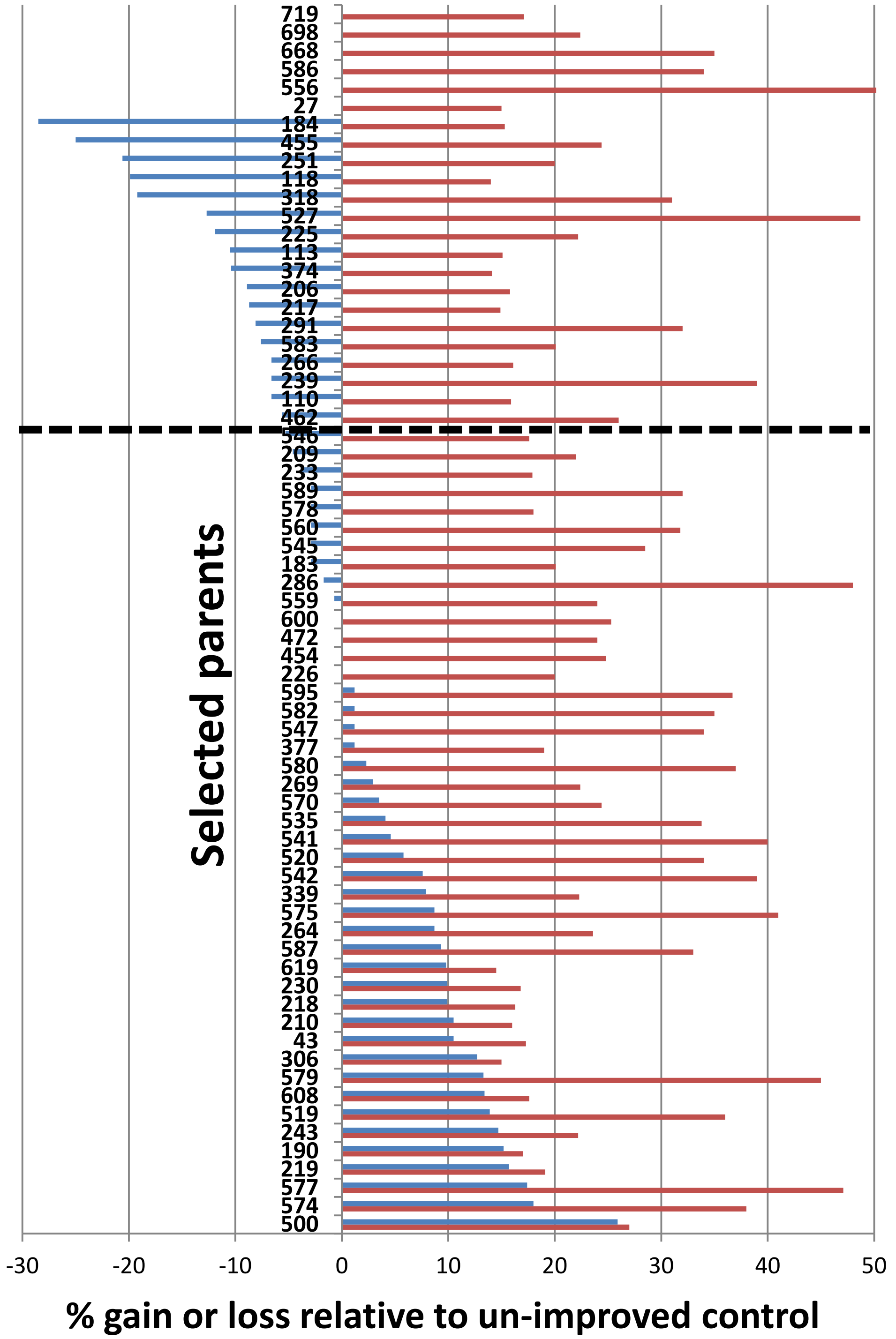


Half-sib progeny trials

- **Objectives**
  - Select parents with superior growth, form and wood quality (mainly Washington)
  - High heritability
  - Determine G vs E and breeding value

- **Progress**
  - **Current selection only based on H and wood density at 15 years**
    - High genetic correlation (0.6) between H @ 11 and DBH @ 30 years (Lee et al , 2013)
    - But negative correlation between wood quality and vigour
  - DBH measurements at ca. 30 years now available- **analysis required urgently**
  - Genetic distance selected between parents not well defined **(inbreeding risk)**
  - **No estimation of heritability of traits in selected families**

- **Sitka spruce genetics (limitations and potentials)**
  - Narrow sense heritability (h_2) for H, and DBH low to marginal (0.4 to 0.6)
  - Higher h_2 for wood density and elasticity and fibril angle (see Lee et al, 2013)
  - High family h_2 (0.72) for *Elatobium* resistance (Jensen, 1997)
  - Low family h_2 (0.4) for shoot weevil resistance (King et al. 2002)



Step 1: selected parents with 15%
Increase in H relative to control

Step 2 : selected parents with 15%
Increase in H relative to control
& < -5% decline in **wood density**

- Preliminary mean family h_2 = 0.47 (2 trials)??
- Mean H inc. 27%
- No change in wood density
- 40 parents in 8 broad un-related breeding groups (need molecular analysis)
- **Must re select parents based on h_2 of DBH and volume at 30 years**
- **ID new breeding parents**

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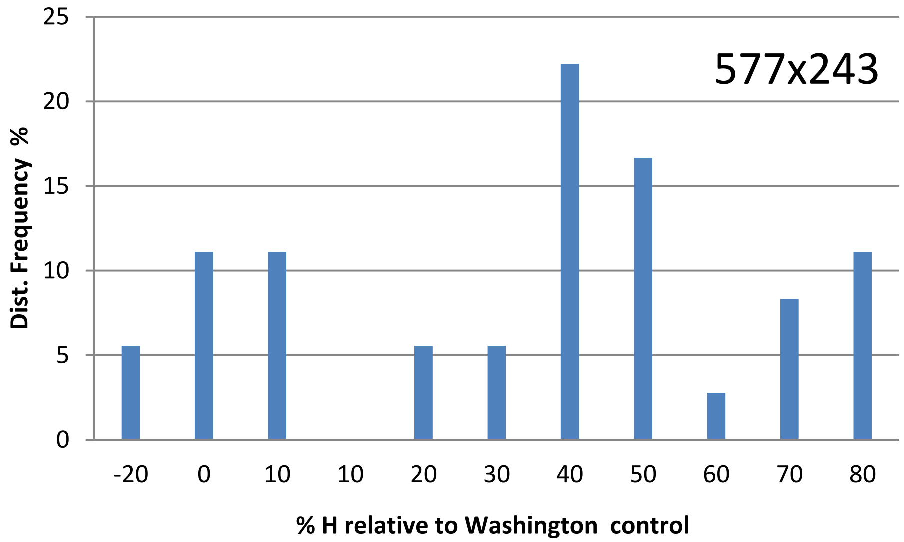
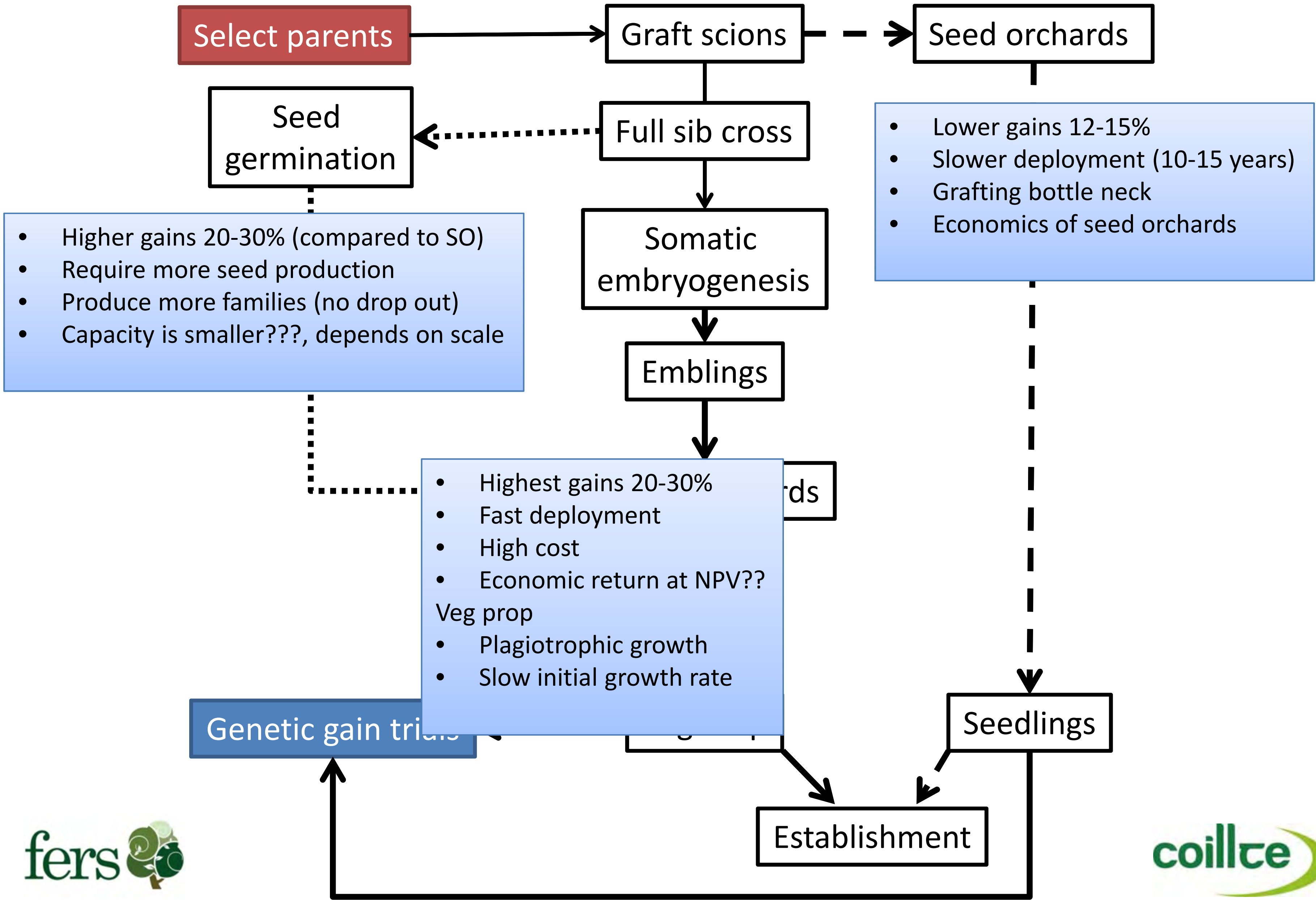
Full sib progeny trials

- Not designed for h2, H2 studies (i.e. no site replication)
- Limited to select superior clones or families (E effect may be underestimated)
- Early data suggests a 30 % gain in H relative to a control
- As an example BNO1508 trial (5yr H) 34 full-sib crosses
  - 24 families (71%) are 10% taller and control
  - For selected families (e.g. 577x243)
    - 70% individuals 20% taller than control
    - 30% individuals are 50% taller than controls



Deployment strategies



Veg prop

- Plagiotropic growth
- Lower investment in photosynthetic tissue
- Lower initial growth rate
- Lower RCD (Production issue) higher susceptibility to weevil)

Improved veg prop performance?

Improved VP cuttings vs unimproved transplants

Exp	County	Soil	Age	Height	DBH	Tree vol
				% difference relative to control		
NMT0896	Cork	Peaty Gley	1	-4.7ns		
BGR0597	Galway	Brown earth	2	-4.0ns		
HFD0802	Tipp.	Brown posdsol	2	**-7.6***		
NMT0896	Cork	Peaty Gley	3	2.0ns		
NMT0896	Cork	Peaty Gley	4	6.7ns		
HFD0803	Tipp.	Brown posdsol	4	-3.6ns		
NMT0896	Cork	Peaty Gley	6	**6.8***		
CAL1405	Kilkenny	Acid BE	7	**7.2****	-1.0ns	
HFD0804	Tipp.	Brown podsol	7	-4.2ns		
RDF0405	Cork	Podsol	7	2.4ns	**8.0***	
BSO0502	Galway	Gley	12	-2.8ns	-4.4ns	-1.7ns
HFD0802	Tipp.	Brown posdsol	12	**4.7***	**7.6****	**18.9****
BGR0597	Galway	Brown earth	15	**5.9****	**5.9****	**21.0*****
NMT0896	Cork	Peaty Gley	16	**10.4*****	**7.4****	**26.6*****

- Site and age interaction
- Only observe significant differences at ca. 8 yrs. Onwards
- **20-25**% increase in tree vol by 15-16 yrs (**assumed gain for economic analaysis**)
- **Need to use unimproved cutting as control (VP gain-clonal trials)**
- **Early selection using full sib seeds compared to Washington control seed**

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Economic feasibility of veg prop deployment

Discounted net benefit

Yield	Rotation Type	Rotation Age	% Improved Planting Stock 33%	40%	50%	100%
12 to 14	Standard	48	1.63	1.77	1.79	1.12
	0.7 m^3	52	1.75	2.16	2.27	1.27
	21m	49	1.20	1.34	1.35	0.87
14 to 16	Standard	46	2.13	2.13	2.28	1.31
	0.7 m^3	46	1.73	2.13	2.28	1.12
	21m	44	2.05	2.04	2.04	1.10
16 to 18	Standard	44	2.46	2.45	2.61	1.46
	0.7 m^3	41	1.42	1.49	1.77	0.97
	21m	40	2.12	2.08	2.05	1.12
18 to 20	Standard	42	2.98	2.98	3.00	1.62
	0.7 m^3	37	2.27	2.27	2.22	1.15
	21m	36	1.58	1.63	1.76	1.15
20 to 22	Standard	40	2.51	2.52	2.67	1.50
	0.7 m^3	34	1.44	1.47	1.62	1.03
	21m	34	1.44	1.47	1.62	1.03
22 to 24	Standard	39	2.99	2.99	3.27	1.94
	0.7 m^3	32	1.21	1.22	1.44	0.91
	21m	31	1.21	1.22	1.44	0.91

So is there an economic case for a SS breeding programme?

Assessed breeding & deployment options:

1. Stop the current breeding and production of improved SS- gain based on already deployed material

2. Continue the **SS** breeding work and the production of improved material by **both** VP and SO (seed orchards)

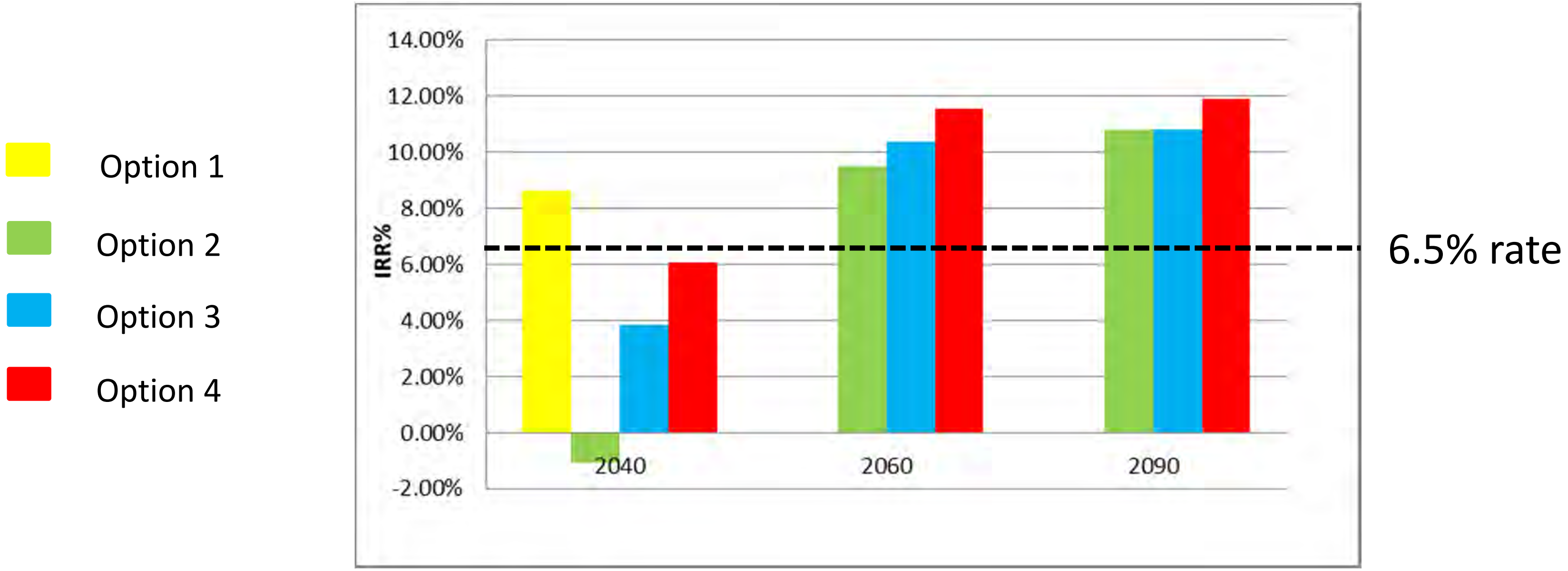
3. Continue the **SS** breeding work, but stop VP production. Concentrate effort producing new improved SS material using SO.

4. Stop both the SS breeding and VP work and concentrate **only** on grafting existing material for SO (**no further improvement**)

Assumptions:

- 6.5 % discount rate
- Historic costs are sunk
- 12% increase in gain for SO v.s. 20% for VP
- Rotation at shortened rotation (current practice)
- Use H. Phillips model at 50:50 mix for VP
- Seed orchard production and economics based on new seed orchard data
- Must run on long term projection to realise cost benefit
- Include costs of current Sitka spruce breeding programme

Economic & Strategic considerations



- Must have long term view : Option 1 no sense in long term
  - Improved seed security (rely on other programmes)
- Option 4 most favourable economically, but there are strategic risks
  - No further improvements
  - Maladaptation risk
  - Loss of capacity (cant switch breeding programme on /off)
- Option 2 and 3 similar returns in the long term
  - Lower gains for option 3 off set by lower establishment cost
  - Option 2 carries higher risk if prescribed silviculture not adhered to

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Seed orchard deployment is a no regret option

- VP production is limited to ca 2.5 M plants per year
- High reliance on improved seed from other programmes has disadvantages
- Improved seed orchards in production but scale too small
- Need to establish 10-30 ha **Irish** improved seed orchard
  - In combination with VP deployment
- Support from forest service under section 10 of the strategy-grants??
- Seed registration and standards
- Must demonstrate gain for every seed orchard established
- Still flowering/seed production challenges to overcome
  - Grafting selected scions material is a bottleneck

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Conclusions

- **Species and provenance first** (we still can not get this right)
- **Large historic investment in the SS programme which can yield good economic return**
- **Deployment strategies should include seed orchards**
- **Decision process in crossing/selection is undermined by:**
  - Quantitative genetics poorly explored
  - Incomplete analysis of progeny trials
  - Poor design of some trials to include E effect
  - Inability for early selection and appropriate controls
  - Failure to use new technologies such as molecular techniques
  - No long term academic/research partnerships
- **What do we select for in the future ???**
  - Stress resistance (greatest threat to forestry)
    - Can we select for broad stress tolerance (see Alfaro et al, 2005)
  - Yield
  - Wood quality
    - Currently no economic incentive

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