

Inter-variatal Hybrid Douglas-Fir

Growth Potential of Coastal Sources and Winter Hardiness of Interior Sources

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Key Management Point:

- Hybrid Douglas-fir is outperforming interior and coastal parent sources in Northern Idaho.

Outline

- Background on Hybrid Douglas-fir
- Overview of published research
- Current work



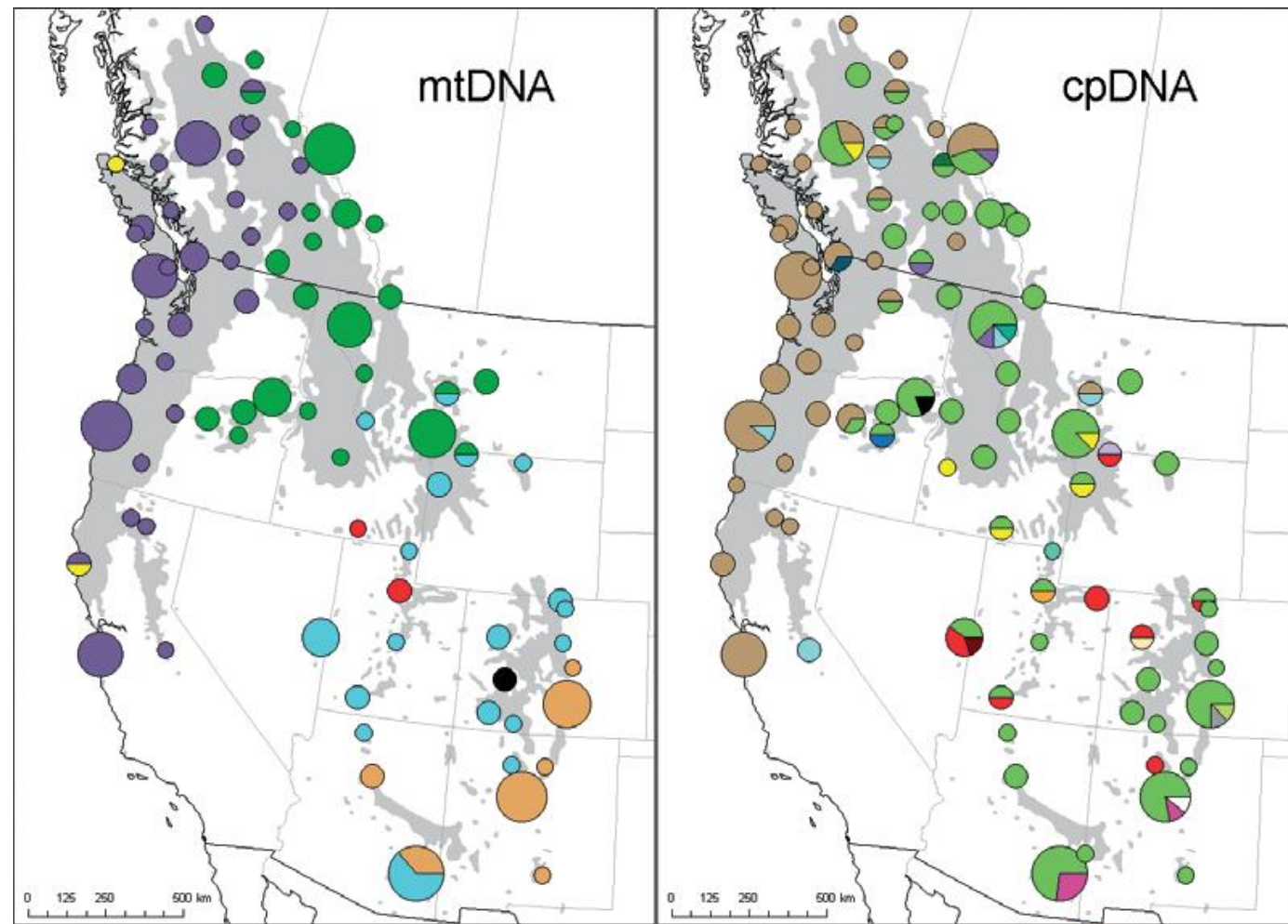
Douglas-Fir Varieties



	Coastal	Interior
Growth ^a	✓	
<i>Rhabdocline pseudotsugae</i> Tolerance	✓	
Cold Hardiness		✓
Drought Hardiness		✓
Shade Tolerance ^a		✓

- Coastal Douglas-fir: Second tallest Conifer
- Interior Douglas-fir: - 40 ° C
- Varieties are completely interfertile

Genetic Structure of Douglas-Fir



MOLECULAR ECOLOGY

Molecular Ecology (2010) 19, 1877–1897

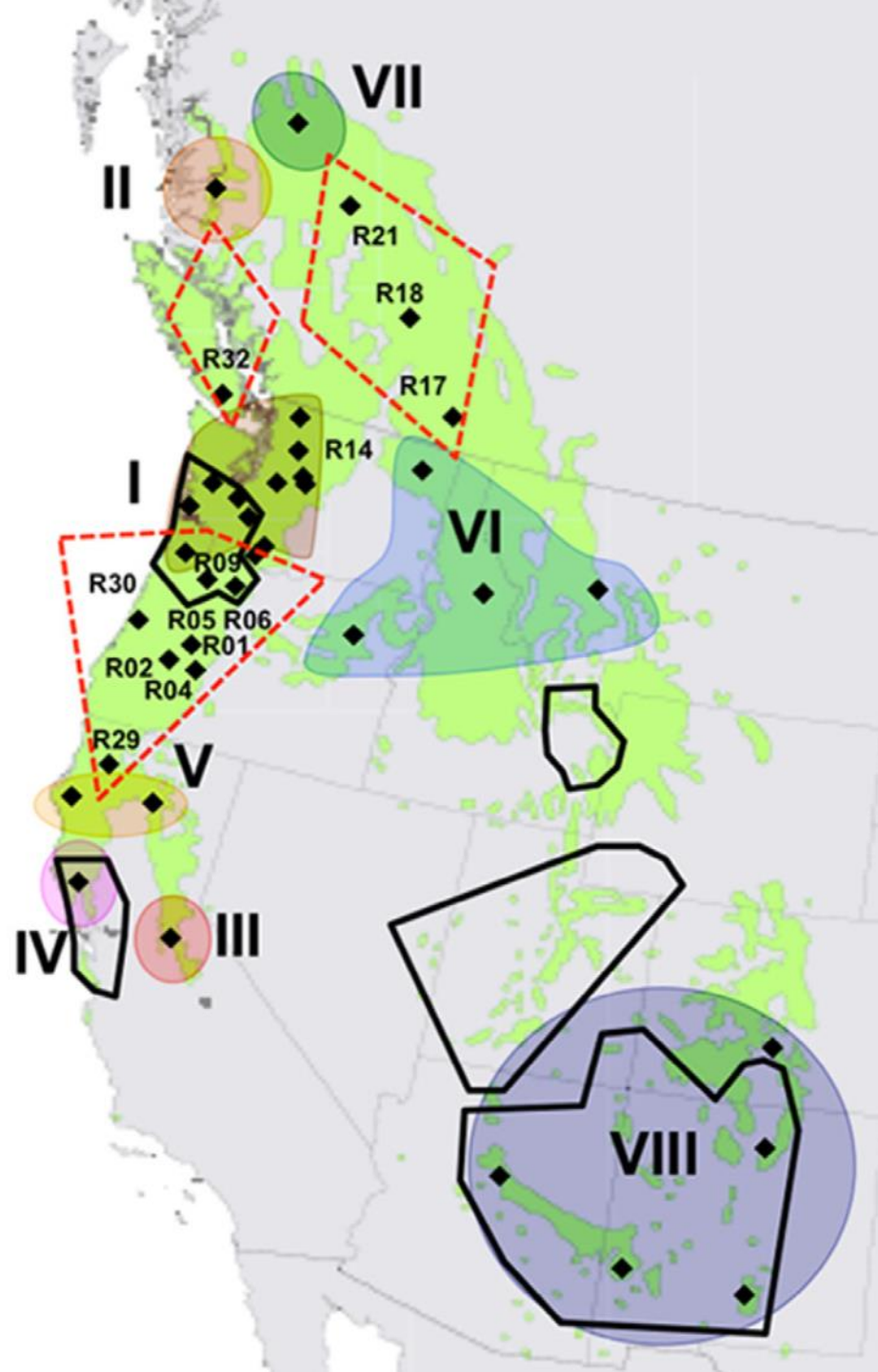
doi: 10.1111/j.1365-294X.2010.04622.x

Phylogeography of Douglas-fir based on mitochondrial and chloroplast DNA sequences: testing hypotheses from the fossil record

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Genetic Structure of Douglas-Fir

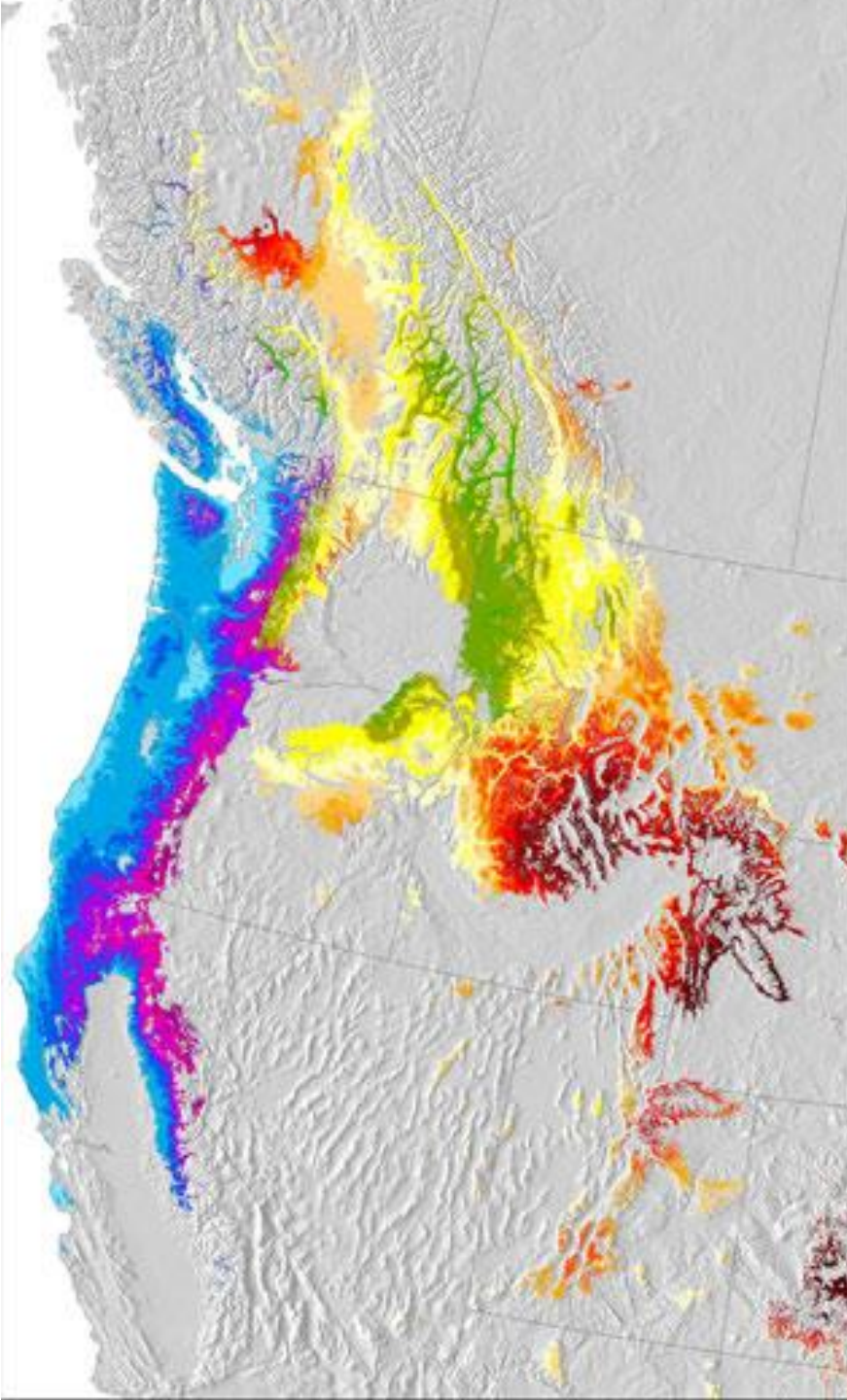


Ecology and Evolution

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Intervarietal and intravarietal genetic structure in Douglas-fir: nuclear SSRs bring novel insights into past population demographic processes, phylogeography, and intervarietal hybridization

Marcela van Loo^{1,†}, Wolfgang Hintsteiner^{1,2,†}, Elisabeth Pötzelsberger¹, Silvio Schüler³ & Hubert Hasenauer¹



Genetic Structure of Douglas-Fir

- Clinal Variation in Growth Potential

Forest Ecology and Management 324 (2014) 138–146



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Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco



Comparative genetic responses to climate in the varieties of
Pinus ponderosa and *Pseudotsuga menziesii*: Clines in growth potential



Gerald E. Rehfeldt ^{a,*}, Laura P. Leites ^b, J. Bradley St Clair ^c, Barry C. Jaquish ^d, Cuauhtémoc Sáenz-Romero ^e,
Javier López-Upton ^f, Dennis G. Joyce ^g



Jerry Rehfeldt

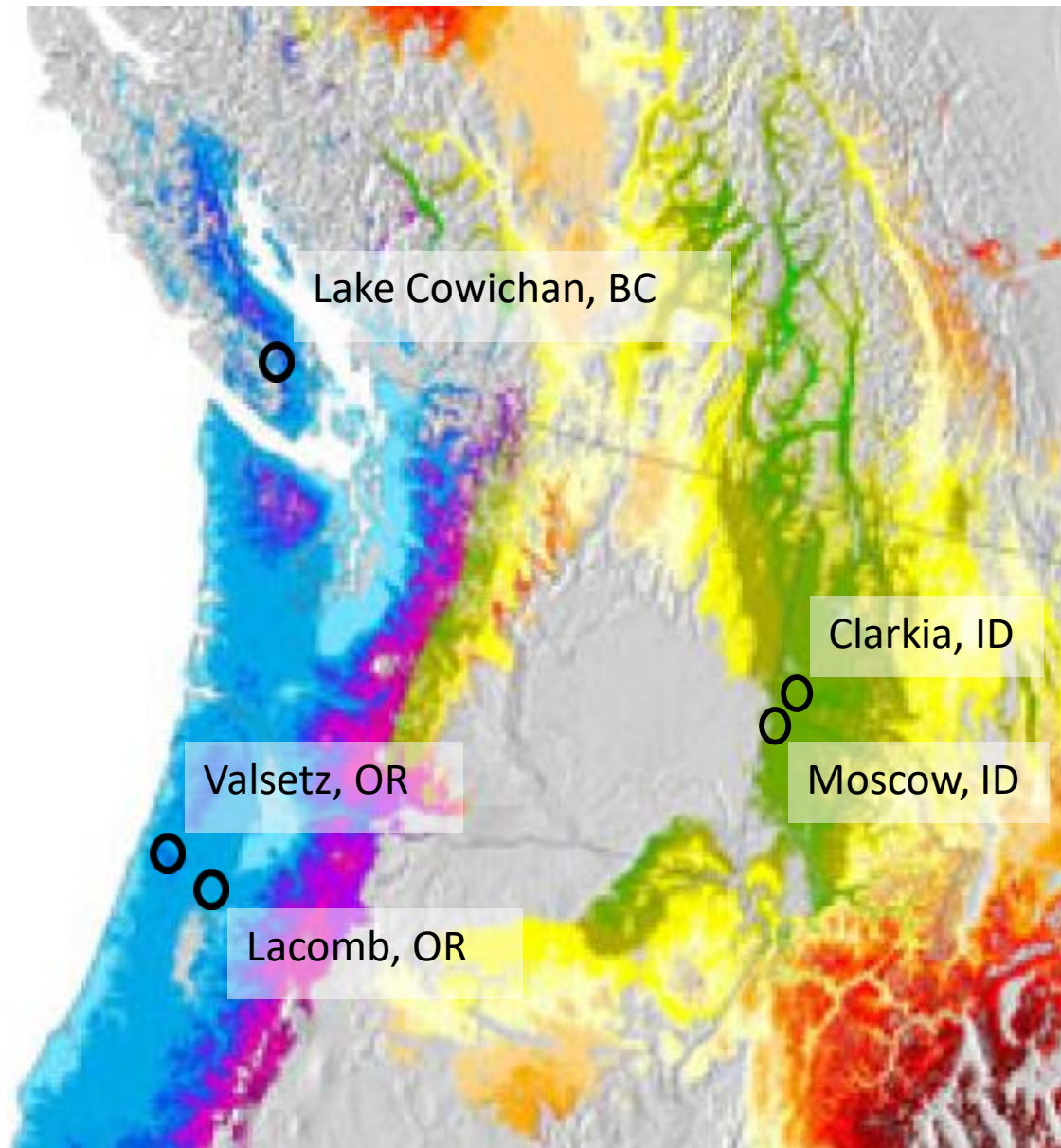
Management opportunities:

- Increased climatic resilience
- Increased productivity

“...Thus it seems likely that planting stock combining specific site adaptation and rapid growth can be produced by racial crossing.

– Duffield, 1950

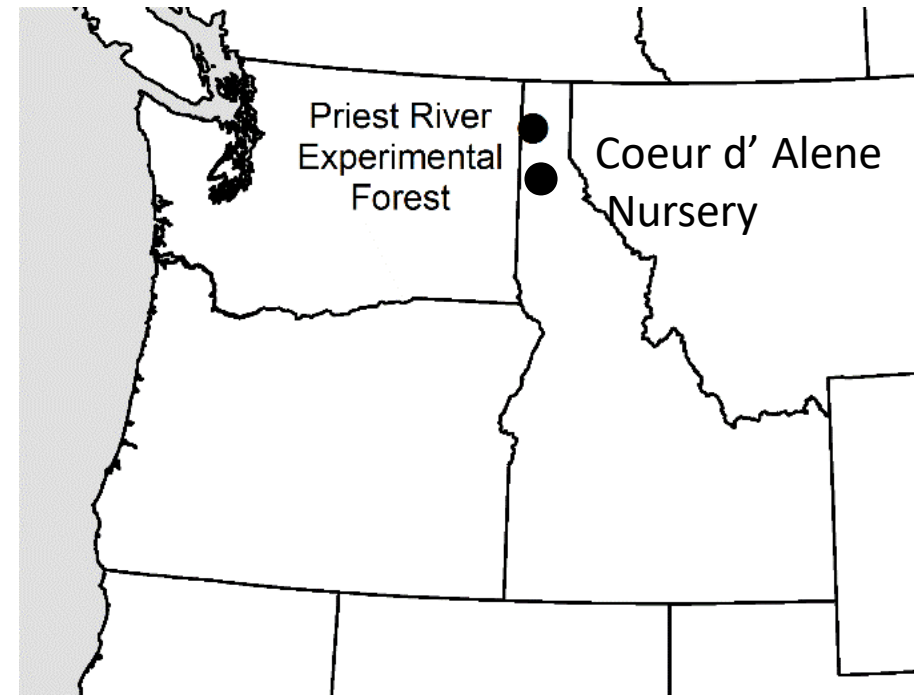
Growth and Cold Hardiness Testing of Inter-varietal Hybrid Douglas-fir



- **Coastal Douglas-fir**
 - 15 Paternal half-sib families
- **Interior Douglas-fir**
 - 18 Maternal half-sib families

Hybrid Douglas-fir Test Results

- Planted as seed in 1971
- 70 full-sib hybrid families
- 33 half-sib families from parental lines



Hybrid Douglas-fir Test Results

- Winter drought in 1972
 - as low as - 26 °C
 - Interior: 44% Survival
 - Hybrid: 44% Survival
 - Coastal: 9% Survival
- Traits
 - Specific Combining effects
 - Weak additive for Growth Potential
 - Intermediate for other adaptive traits

Theor. Appl. Genet. 50, 3-15 (1977)



Growth and Cold Hardiness of Intervarietal Hybrids of Douglas-fir

G.E. Rehfeldt

Research Geneticist, Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Ogden, Utah (U.S.A.)

Summary. Potentials for improvement of the interior variety of Douglas-fir (*Pseudotsuga menziesii* var. 'glauca') by hybridization with the coastal variety (*P.m.* var. 'menziesii') were explored. The primary objective was to assess possibilities for increasing growth potentials of the interior variety while maintaining adaptation to relatively cold inland environments. Seventy full-sib hybrid families and their half-sib parental lines were grown in two contrasting environments common to the interior variety. Nine traits related to growth, phenology, and freezing tolerance in 4-year-old trees were compared.

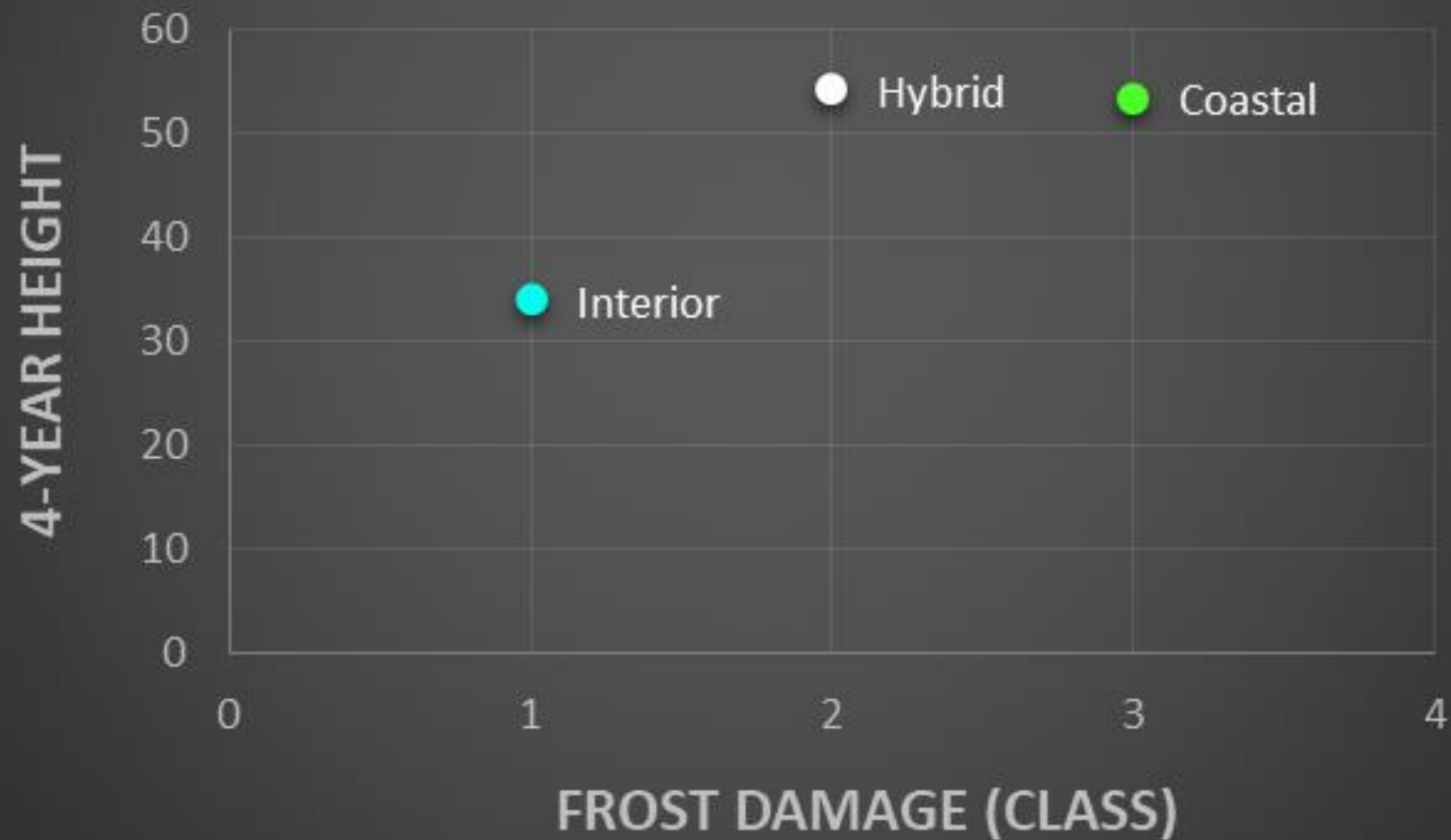
For traits related to growth (height and diameter) in the inland environment, hybrids equaled the growth of the coastal variety and exceeded the interior variety by 40 percent. For traits related to adaptation (bud burst, bud set, frost damage, tree form, and freezing tolerance), hybrids were intermediate but approached levels characteristic of the interior variety. Survival of hybrids equaled that of the interior variety and was superior to that of the coastal variety.

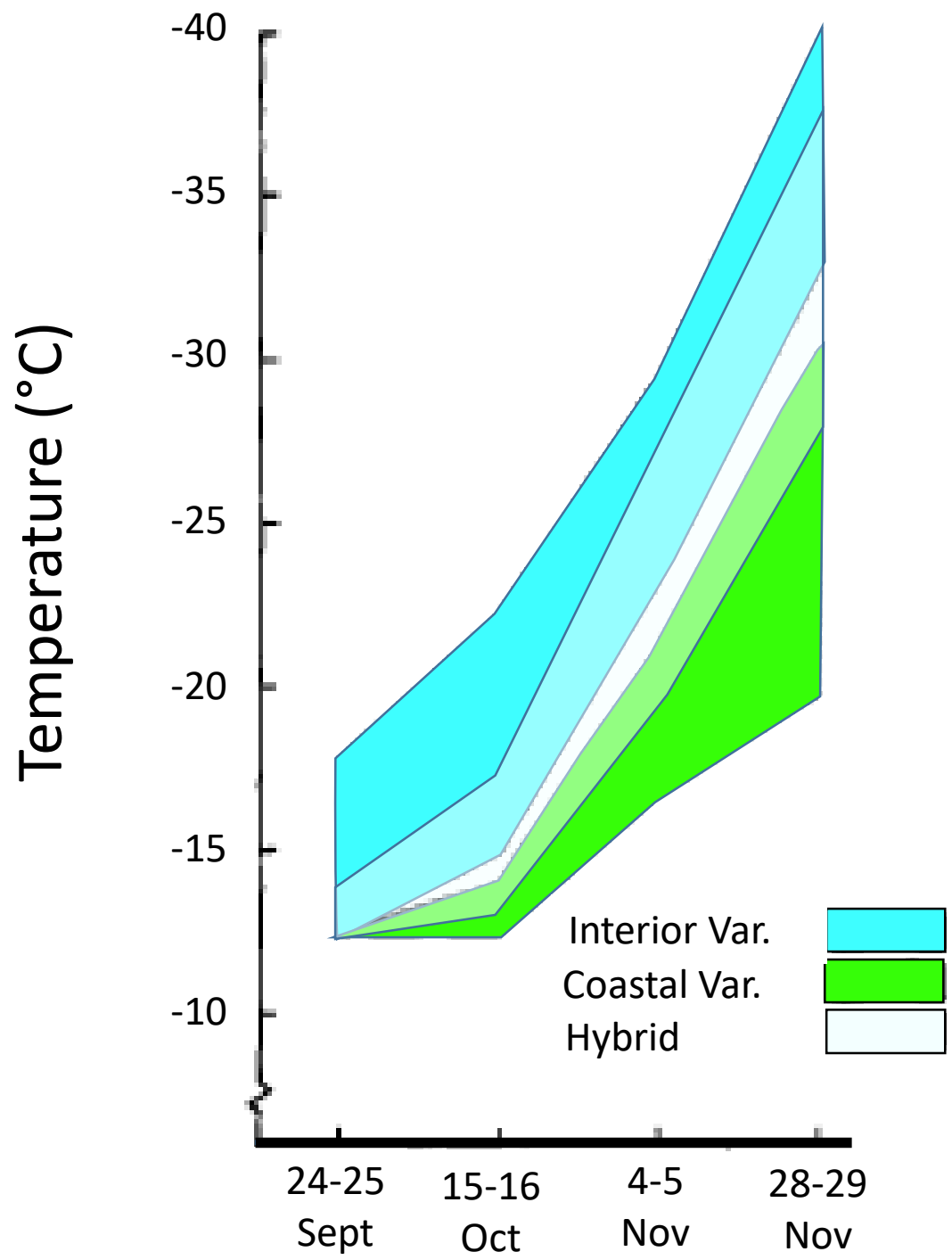
Hybrid characters could not be predicted reliably from those of parental lines. Yet, quantitative genetic analyses suggest that expression of characters related to growth depends on nonadditive genetic effects, but expression of those related to adaptation is somewhat dependent on additive effects.

Realization of the tremendous potential of hybridization for improvement of the interior variety will require at least one backcross generation or additional crosses utilizing introgressed populations.

Key words: *Pseudotsuga menziesii* - Douglas-fir - Hybridization - Cold Hardiness - Physiologic Adaption - Growth Pattern

4-Year Old Seedling Performance at Coeur d' Alene and Priest River Experimental Forest Nurseries





Cold Hardiness Development Through Fall

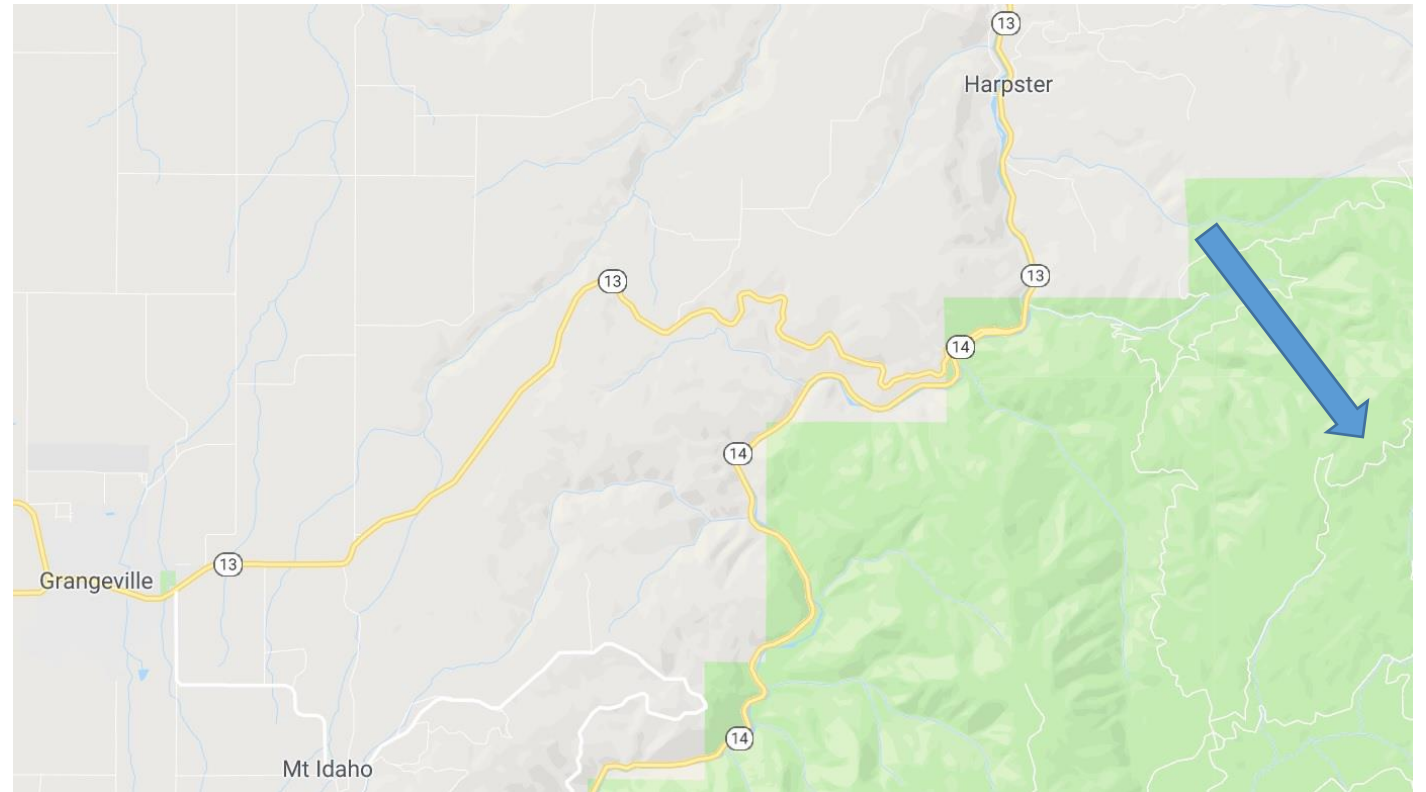
Green Creek Field Test

Elevation : 3400 feet

Latitude: 46 degrees

Longitude:116 degrees

- 3 year-old (1-2) stock planted in 1975
- 70 full-sib hybrid families
- Fewer than 33 half-sib families from parental lines



Green Creek Field Test

- 10 year field trial:
 - Hybrid survival = interior parents
 - Hybrid height was ~ 2 x height of interior parents


United States
Department of
Agriculture

Forest Service

Intermountain
Research Station
Ogden, UT 84401

Research Note
INT-355

March 1986



Performance of Douglas-fir Intervarietal Hybrids After 10 years of Field Testing

G. E. Rehfeldt¹

ABSTRACT

After 10 years of field testing, Douglas-fir intervarietal hybrids have equaled the survival of inland parental lines, but doubled their height. Both hybrids and inland lines surpassed the survival and height of coastal parental lines. The performance of hybrid families seemed to reflect specific rather than general combining abilities, and variation within hybrid families was high.

KEYWORDS: *Pseudotsuga menziesii*, progeny tests, interprovenance hybridization

Hybridization offers the possibility of combining the growth potential of the coastal variety of Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*) with the winter hardiness of the inland variety (*Pseudotsuga menziesii* var. *glauca*). Such hybrids would increase the productivity of the inland variety while maintaining adaptation to severe environments. In an assessment of this possibility, Rehfeldt (1977) analyzed traits reflecting growth potential, morphology, phenology, and freezing tolerance of 4-year-old hybrid families. For all traits, hybrids were intermediate between parental lines, but freezing tolerance was more similar to that of the inland line than to that of the coastal line.

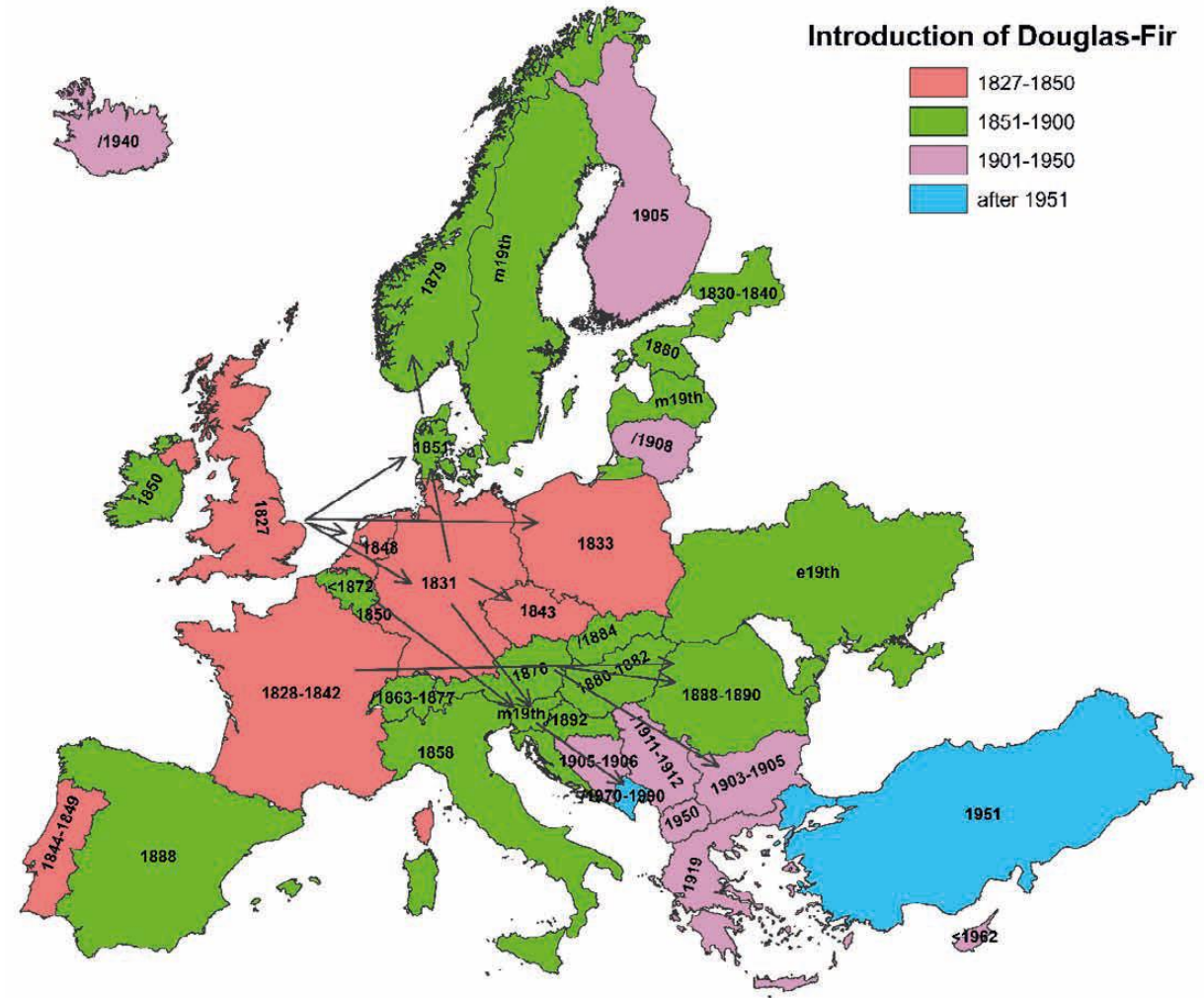
In the present paper, the performance of intervarietal hybrids is assessed after 10 years of field testing. Whereas an earlier report (Rehfeldt 1977) concerned genetic variation in single traits, this report assesses performance, the integration of numerous traits that produce the phenotype on a given site.

METHODS

As described previously (Rehfeldt 1977), hybrids had been developed on 20 maternal trees from two inland provenances by using pollen from 25 coastal trees representing four provenances (table 1). Each parental tree also was represented in the test by seedlings derived from wind pollinations in their native stands. Seedlings were grown for 3 years (1-2) at a nursery on the Priest River Experimental Forest where September frosts heavily screened all coastal lines and some hybrid

Naturalization in Europe

- Douglas-fir introduced/naturalized in > 30 European countries
- intraspecific genetic admixture contributes significantly to the invasive success of non-native species
- Increased pool of raw material for adaptive evolution



(by T. Eckhart)
(Spiecker *et al.*, 2019)

Douglas-fir Breeding in Saxony

By H. BRAUN

Saxon State Institute for Forestry, D-01827 Graupa, Germany

(Received 24th April 1998)

Summary

Due to its high productivity as well as good ecological and silvicultural characteristics, Douglas-fir plays a special role among the introduced species in Germany. A decisive factor in successful stand establishment is the genetic suitability of the plants for the specific plantation site. Therefore, in Graupa the investigations done were focused on provenance research as well as on studies of locally selected stands and on the supply

2. Progeny Testing of Native Stands and Using the Results

In 1981 and 1982, 21 Douglas-fir stands were selected in cooperation with the local forest service. The selected stands as well as the subsequent progeny trials and the two seedlings seed orchards are located on the map in *figure 1*.



Fig. 9. – Location of the trial plots.

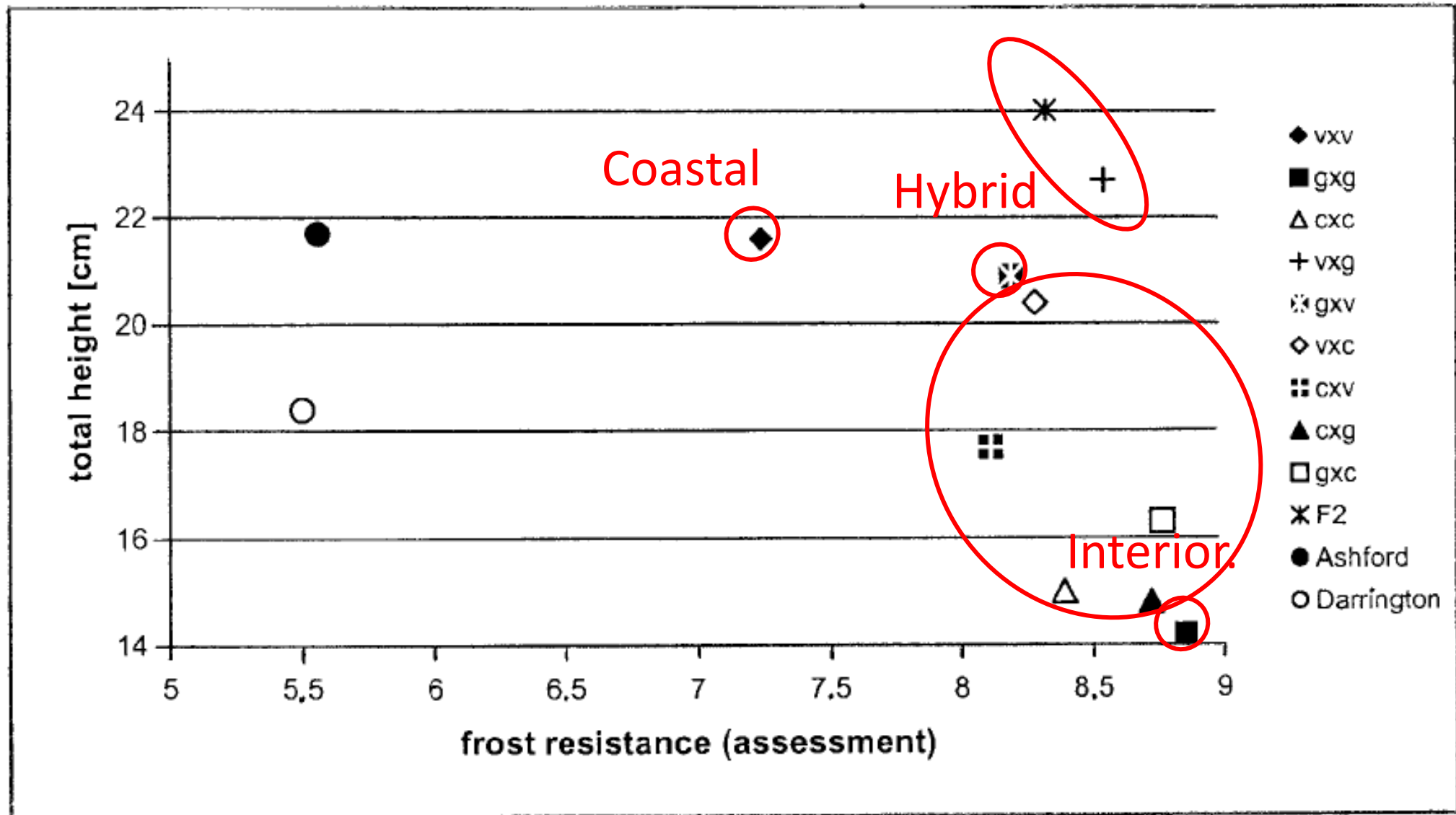


Fig. 10. – Progeny test of Douglas fir hybrids, age 1/1, nursery results (frost resistance – 9 – no damage).

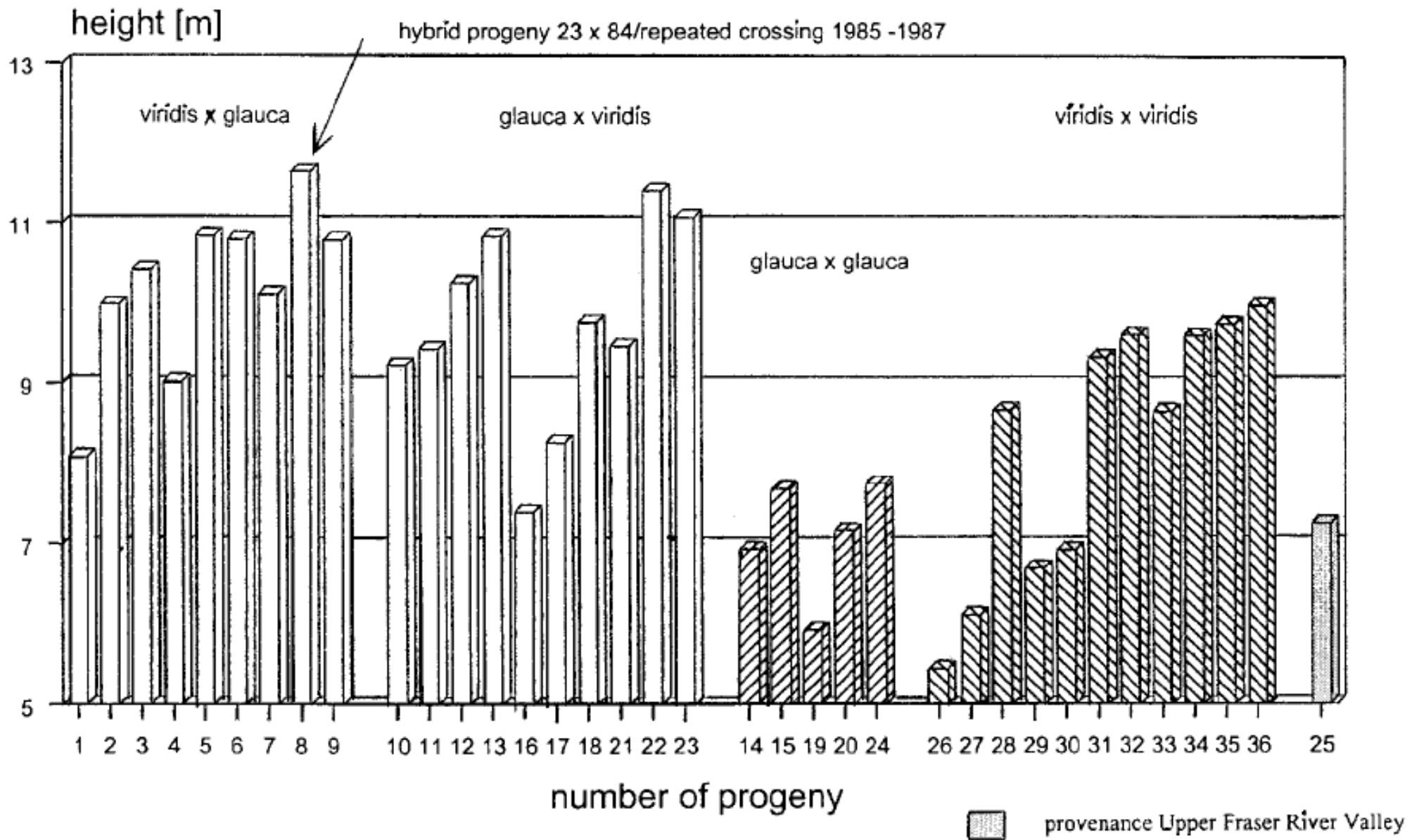


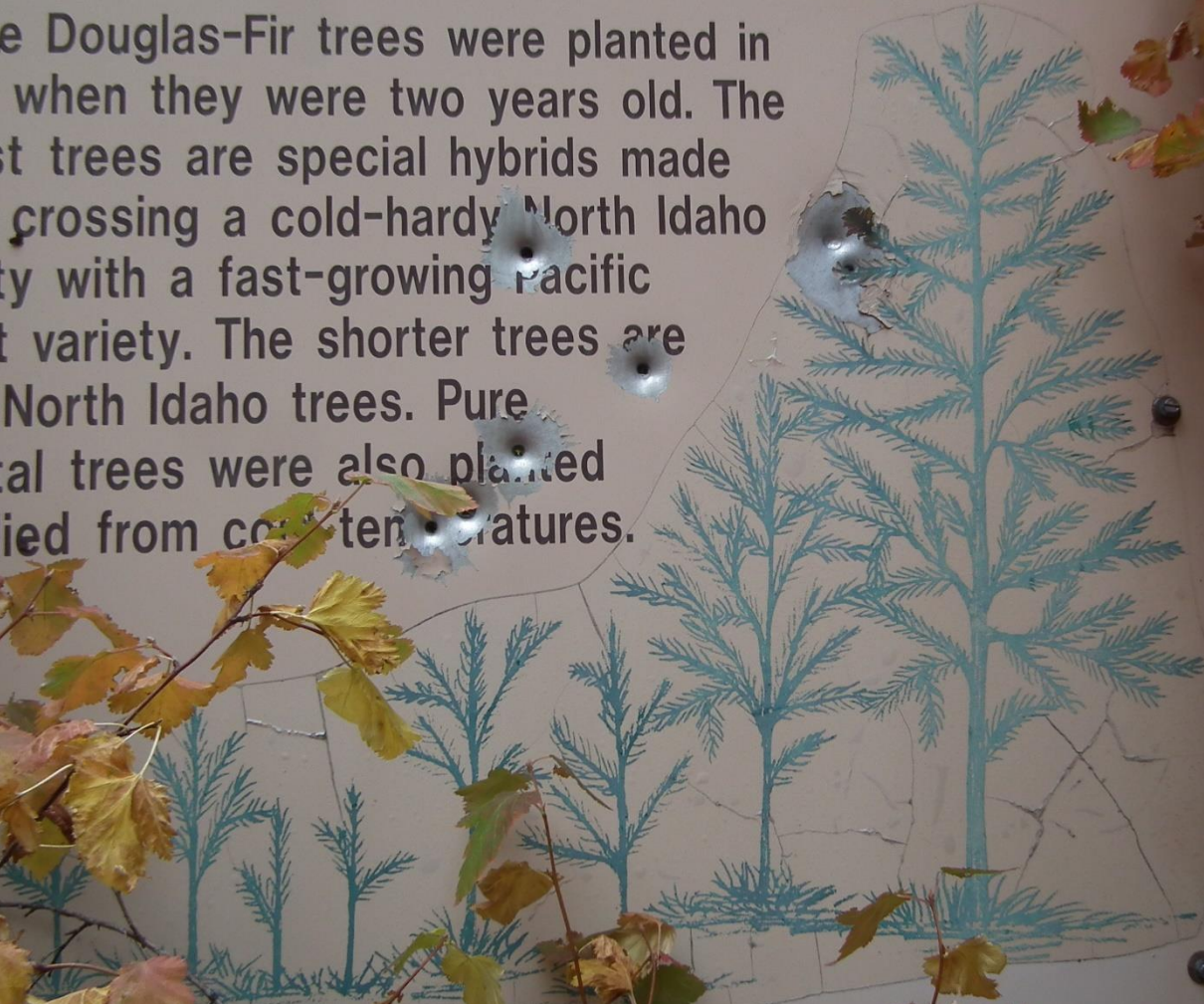
Fig. 7. – Progeny test of Douglas fir hybrids. Height growth at age 16 after planting.

Hybrid forward
selection(s) in the BC
Ministry breeding
orchard at Kalamalka.



GROWING A BETTER DOUGLAS-FIR

These Douglas-Fir trees were planted in 1975 when they were two years old. The tallest trees are special hybrids made from crossing a cold-hardy North Idaho variety with a fast-growing Pacific coast variety. The shorter trees are pure North Idaho trees. Pure coastal trees were also planted but died from cold temperatures.





Green Creek Field Test 44 years after planting

Excellent growth and survival of
the Hybrid families was obvious.

“Realization of the tremendous potential of hybridization for improvement of the interior variety will require at least one backcross generation or additional crosses utilizing introgressed populations.” – Rehfeldt, 1977

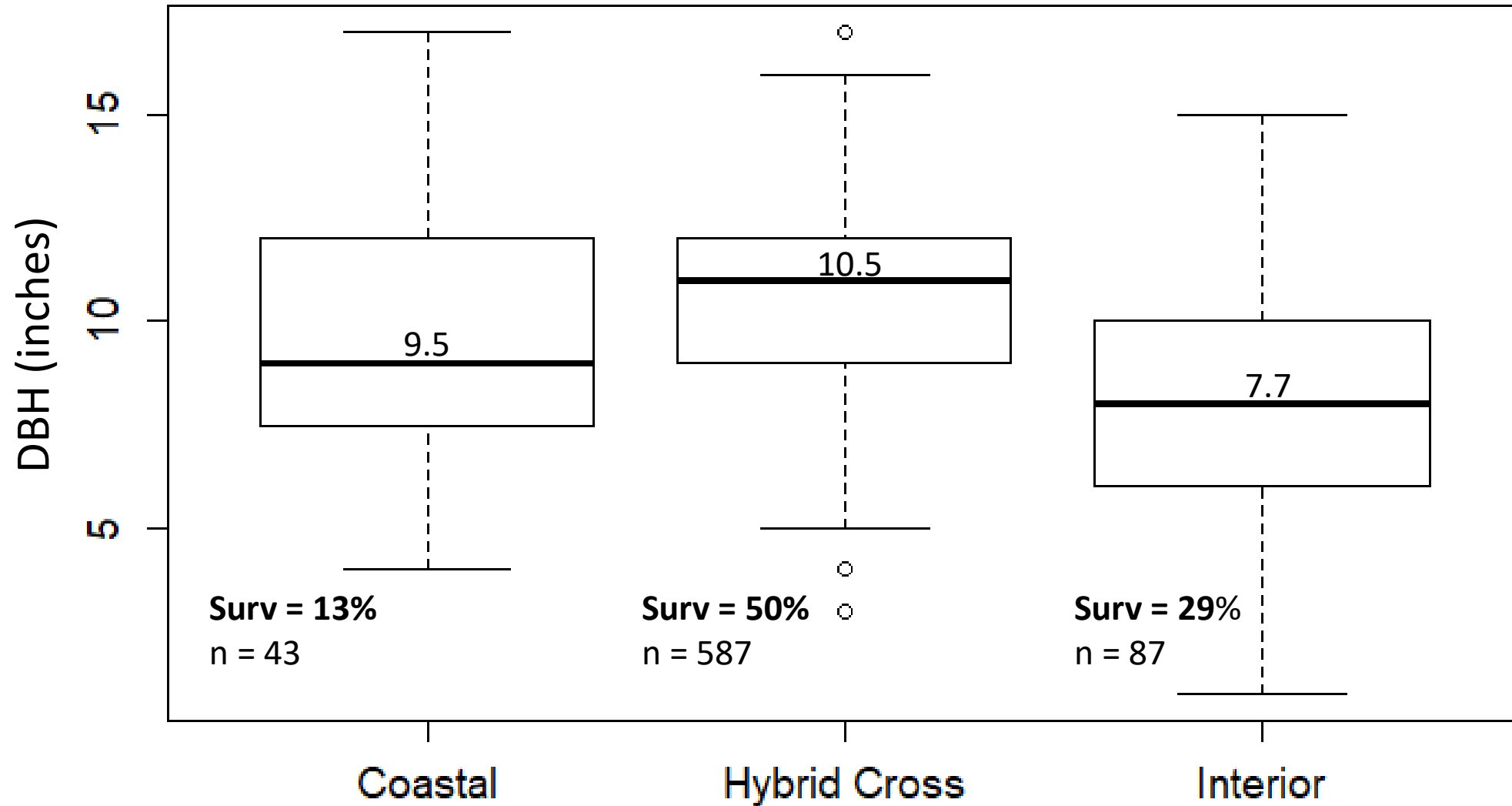


Green Creek Field Test 44 years after planting

- Remonument
- DBH
- Survival
- Growth Increment
- Spatial Data



Green Creek, Idaho Douglas-fir Test



Preliminary results based on 3/4 of test measured, does not consider density dependent competition





Photo by: Florian Deisenhofer



Hybrid Douglas-fir

Moscow Forest Sciences Laboratory

Moscow, Idaho

Planted: ~ 1975



Hybrid Douglas-fir

Moscow Forest Sciences Laboratory

Moscow, Idaho

Planted: ~ 1975

DBH: 23.1 inches

PREF Clonal Orchard

- Planted in 1996 using best performing crosses and parent clones at Green Creek
- Assess Trait Segregation
- Assessing Backcross Performance
- Hybrid Breakdown



IETIC working with NWTIC (Northwest Tree Improvement Coop) to cross top performers from the inland and the coast

- Medford OR orchard will be used to create hybrid crosses this spring.

Potential Production Approaches:

- Top Grafting ?
- Controlled Mass Pollination ?
- Micropropagation via somatic embryogenesis ?



Photo by: Nathan Hanzelka



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Key Management Point:

- Hybrid Douglas-fir is outperforming interior and coastal parent sources in Northern Idaho.

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