European forest reproductive materials recommendations for Douglas fir

Jean-Charles Bastien, Monika Konnert

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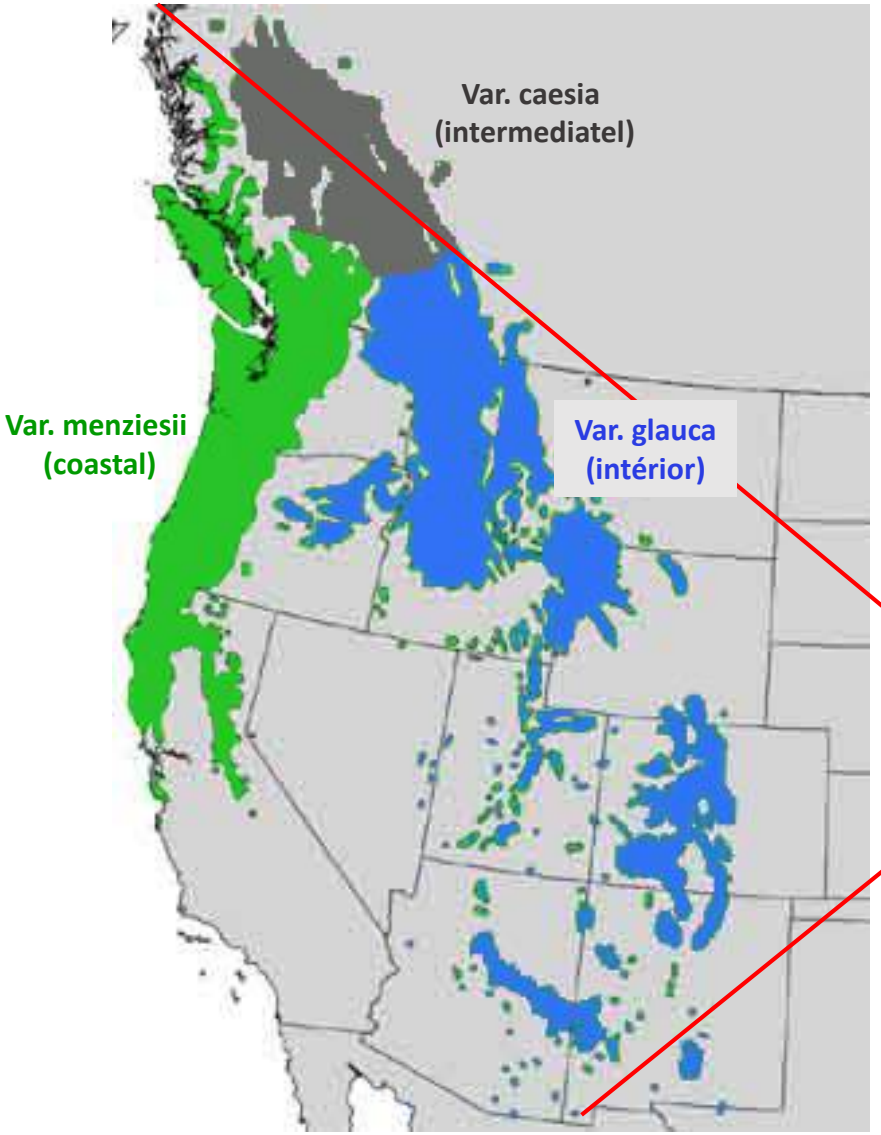
Jean-Charles Bastien & Monika Konnert

Dublin, October 03, 2017

Douglas fir range

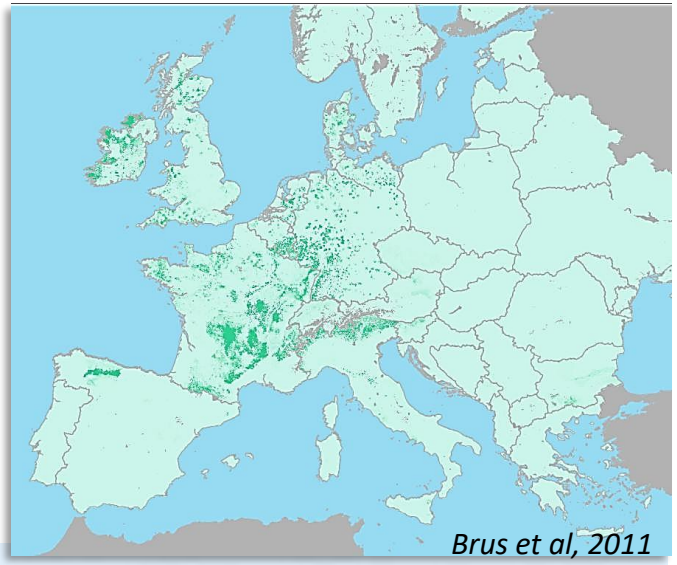
In Northern America



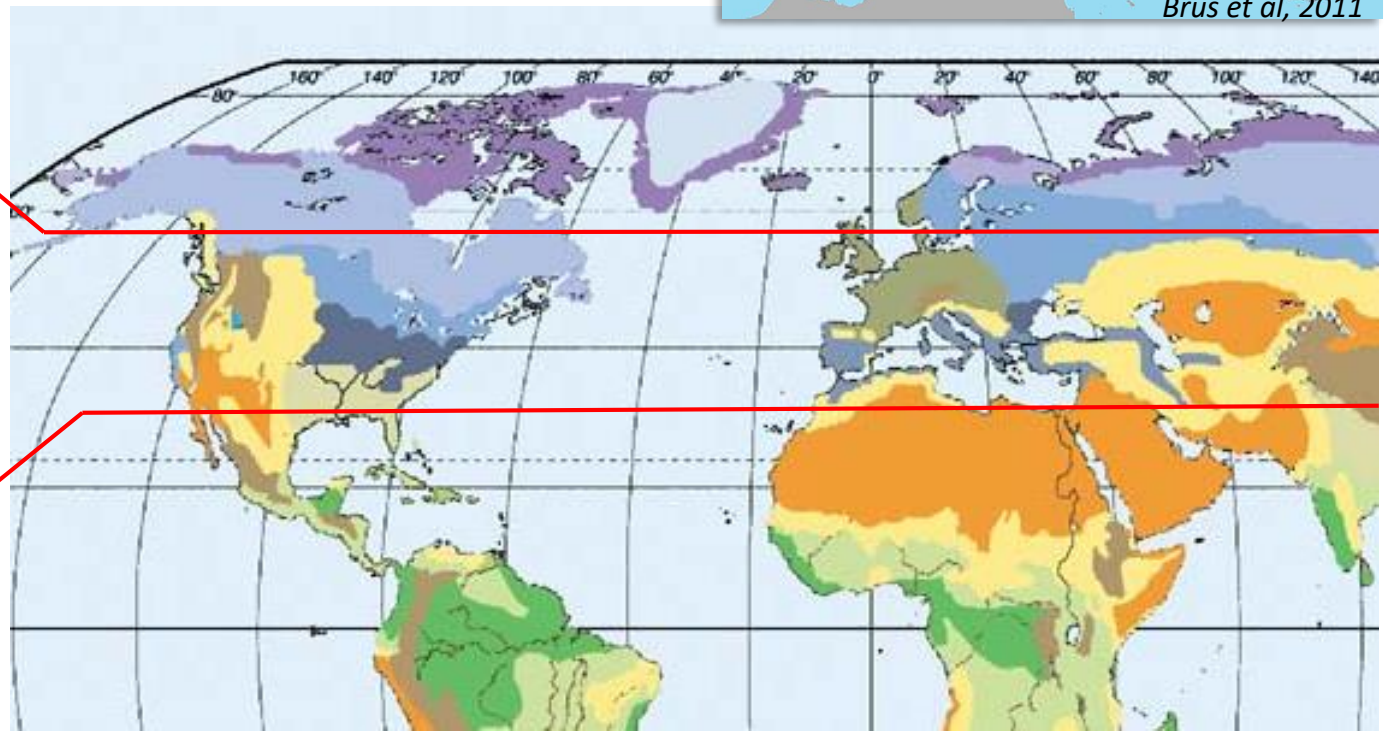
In Europe

± 825, 000 ha (34 countries)

0.41% of the EU forest area



Brus et al, 2011



Examples of mistakes resulting from unsuitable seed sources importations

12 year old provenance test in France (low elevation)

Humptulips
(Wa. coastal)

Santiam
(Or. high elevation)

80 year old stands in Bavaria

Coastal

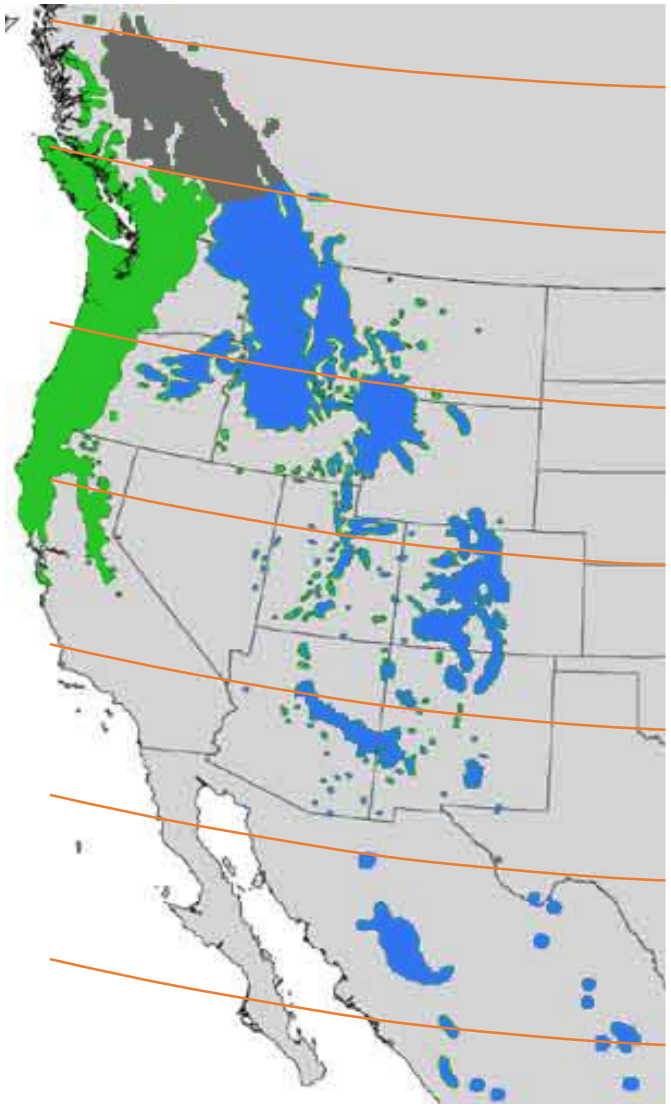
interior

Historical steps of DF provenance introduction in Europe

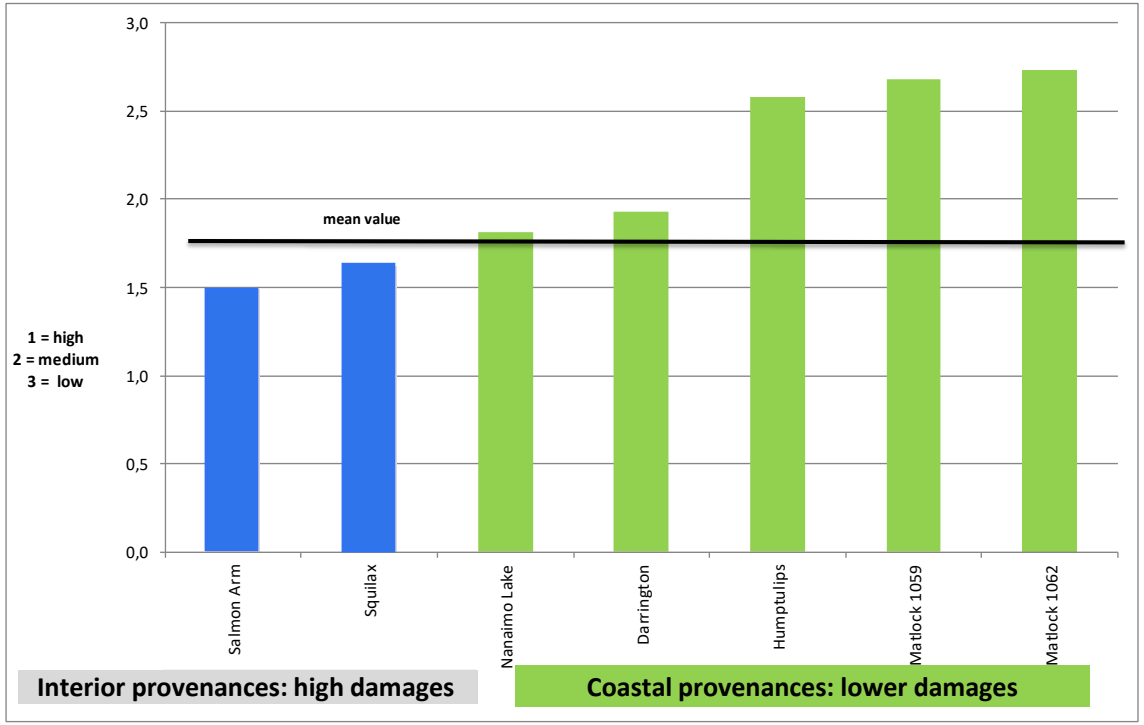
- Early provenance introductions
  - ✓ 1910 : Germany (Schwappach)
  - ✓ 1923 : the Netherlands
- 1932 : Wiedeman collection
- 1954 : Schober collection (commercial sources from BC, Wa. & Or.)
- 1964 : IUFRO collection (176 sources from the whole range)
- 1976 : NFV / INRA collection (115 sources from Washington)
- 1985 : INRA / NFV / SRFGx (1000 o.p. progenies from Wa. & Or.)

Natural variability

High sensitivity of interior sources to late frost

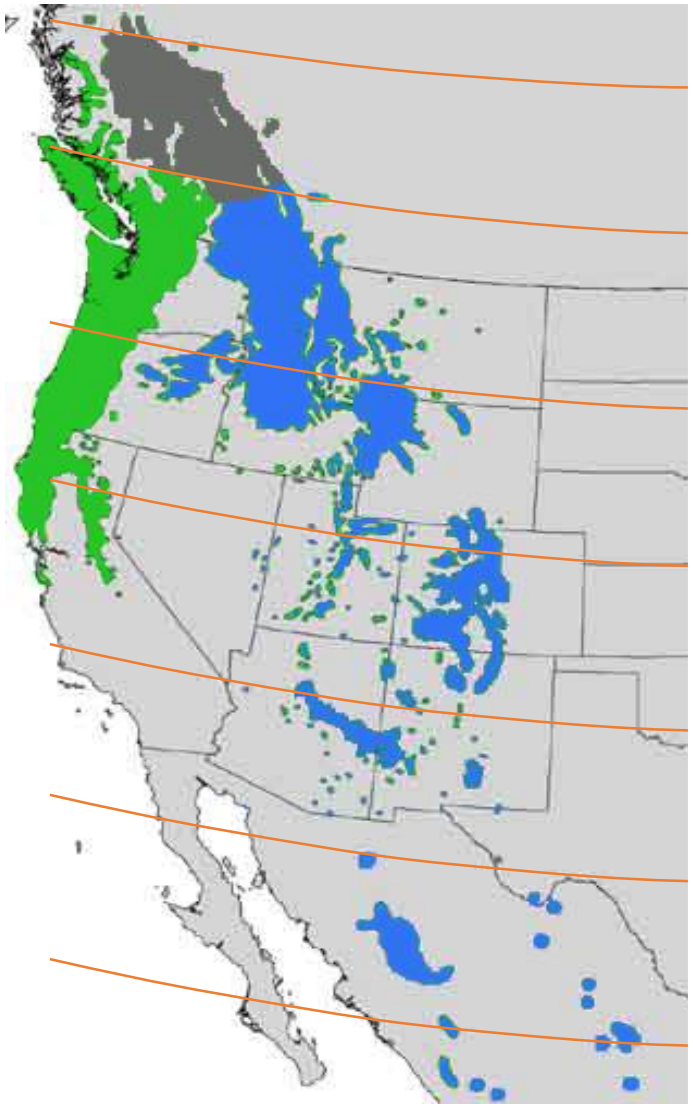


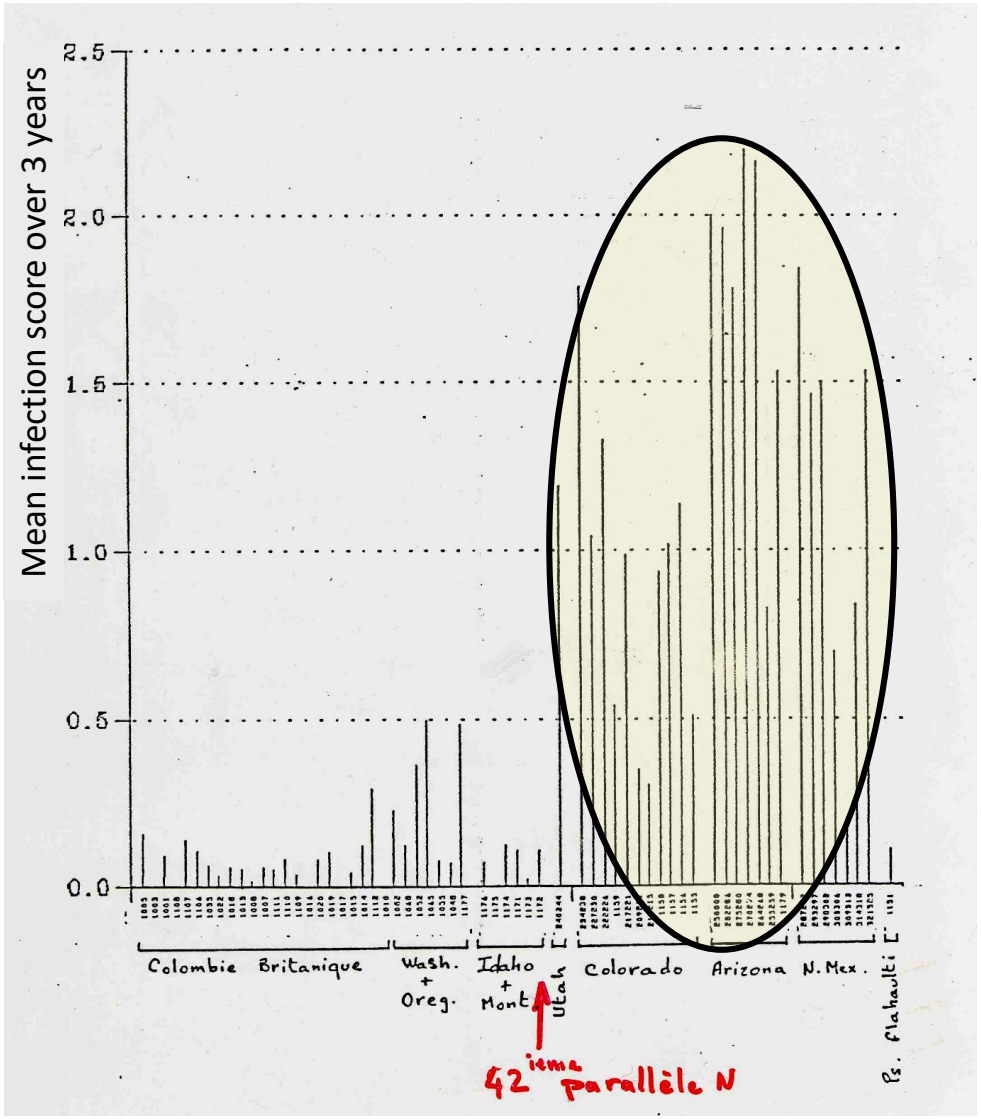
Frost damage scores of interior and coastal DF provenances in Germany



Natural variability

High sensitivity of interior sources to Rhabdocline



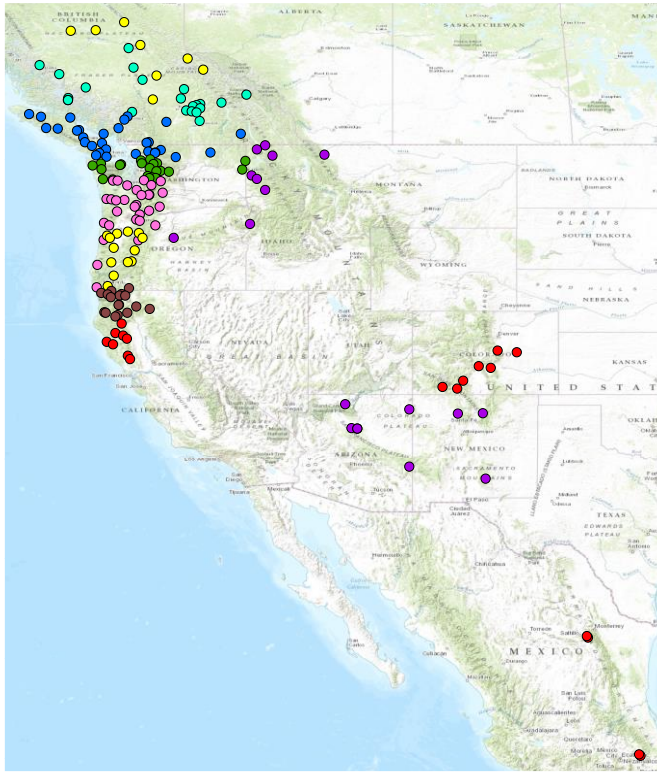


Natural variability

Performances of IUFRO Douglas fir provenances in Europe

J. Boiffin & V. Badeau – 2015

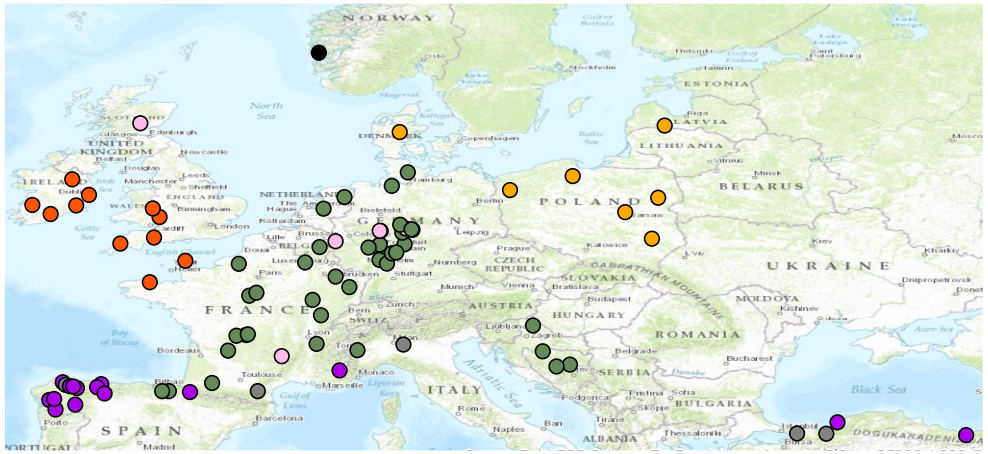
180 provenances



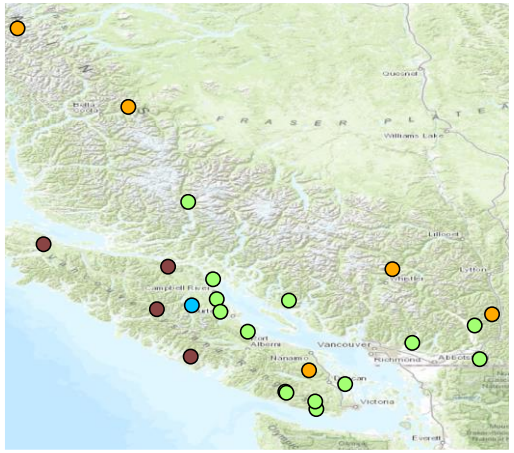
8 bioclimatic groups

108 test sites

Europe



Canada (BC)



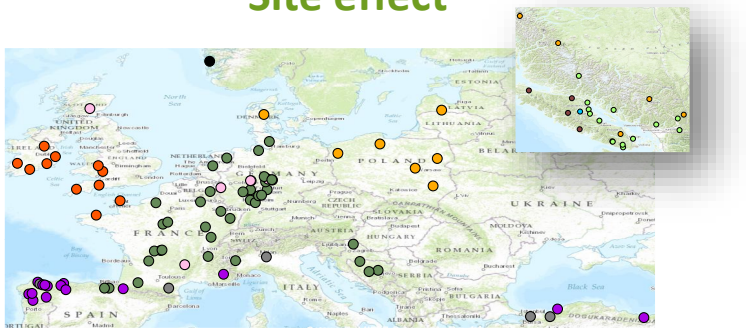
10 bioclimatic groups

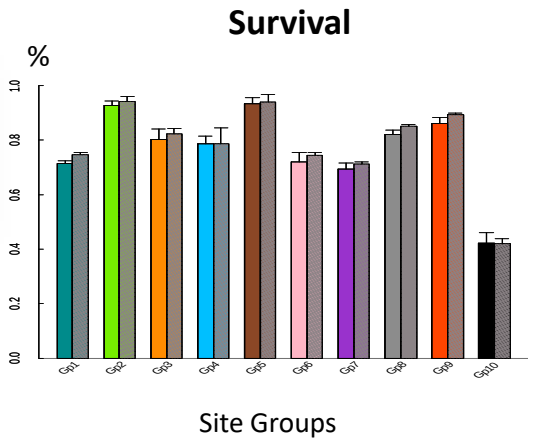
Natural variability

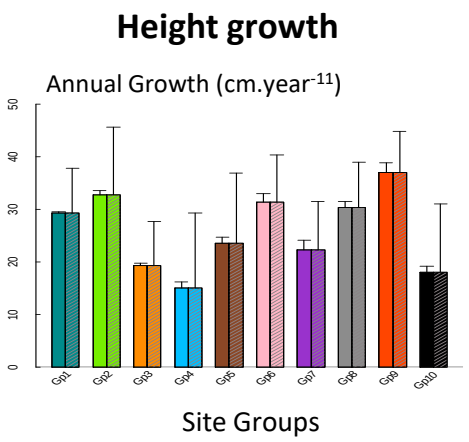
Performances of IUFRO Douglas fir provenances in Europe

J. Boiffin & V. Badeau – 2015

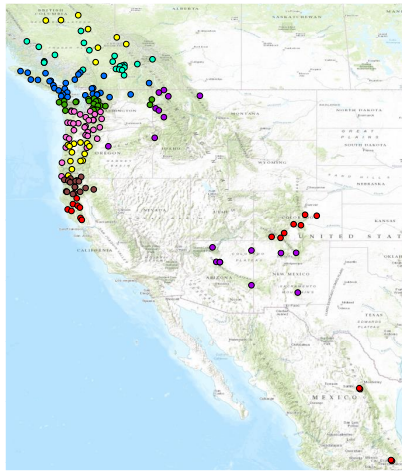
Site effect

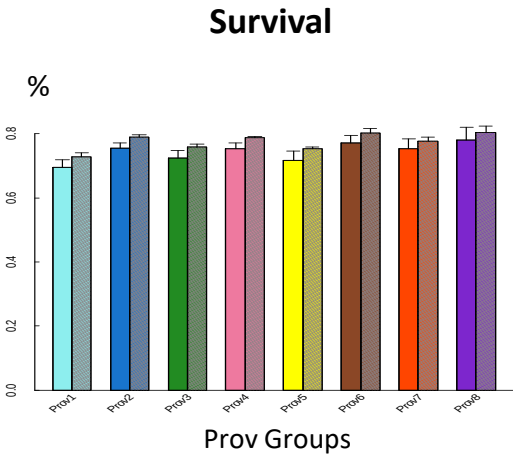


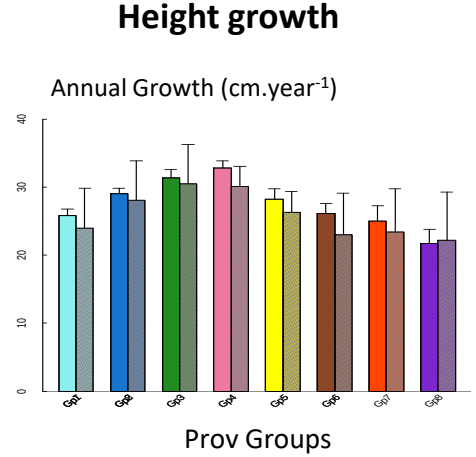




Population effect



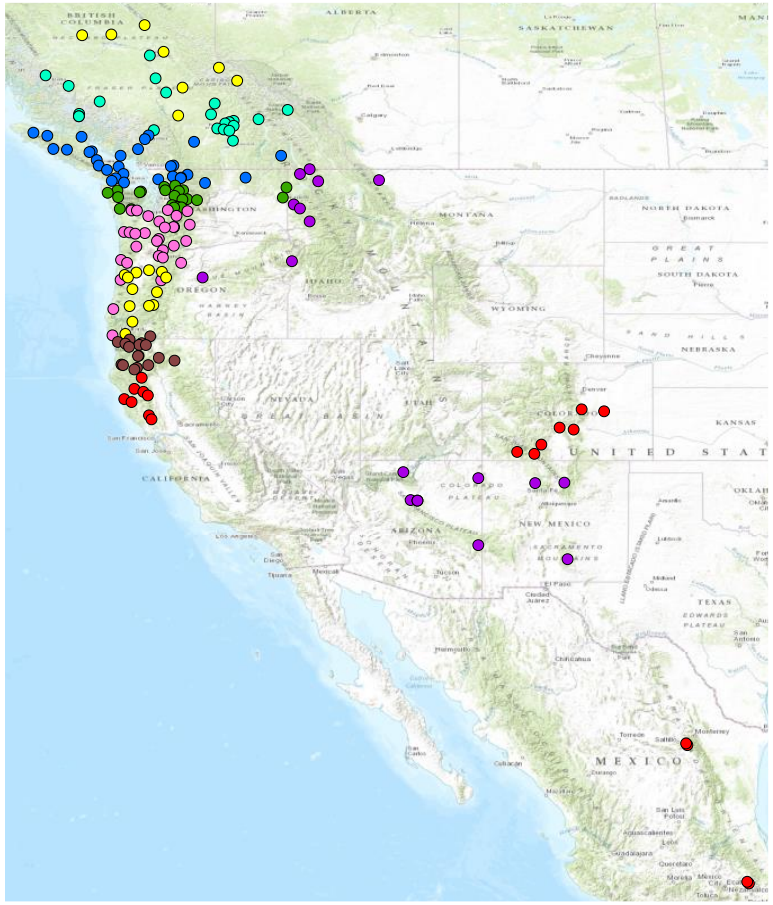




Natural variability

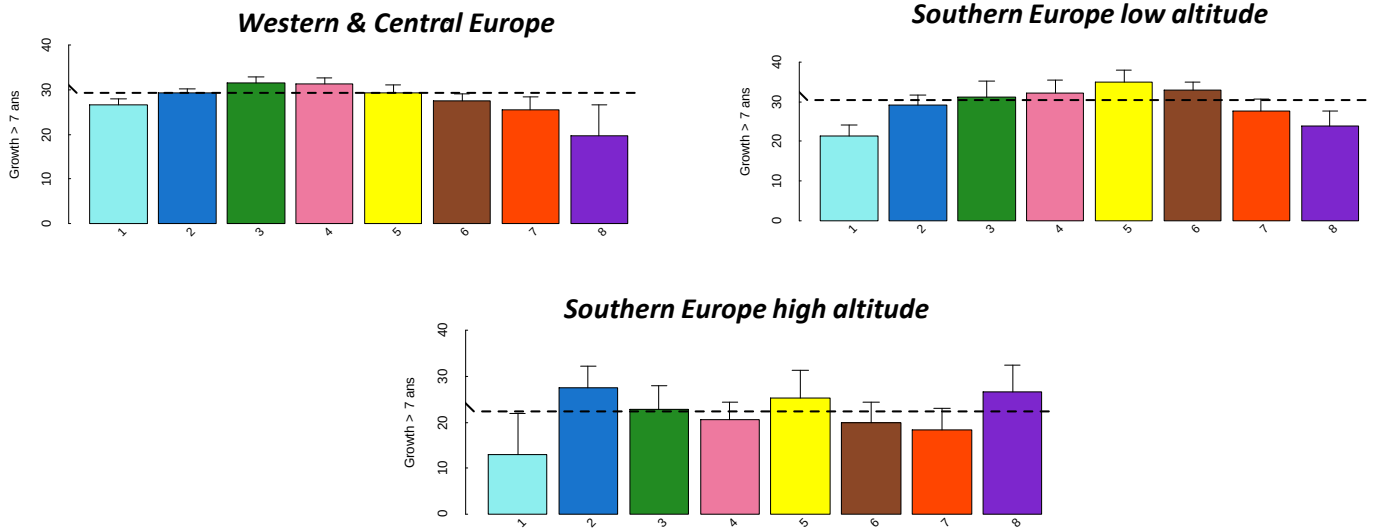
Performances of IUFRO Douglas fir provenances in Europe

J. Boiffin & V. Badeau – 2015



Height growth

Annual growth (cm.year^{-11})



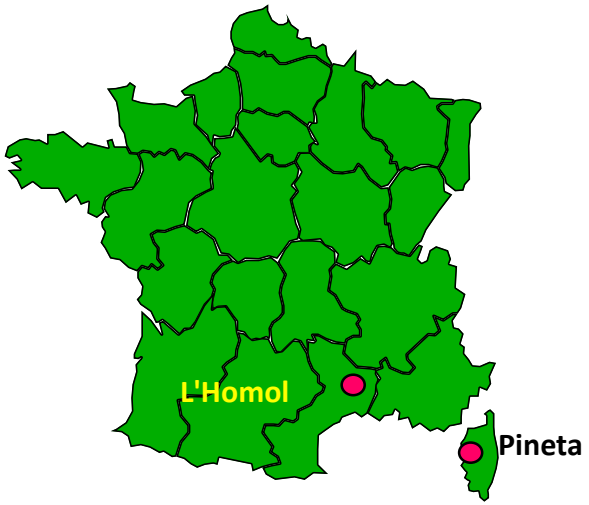
3 regions of provenances are well performing almost everywhere in Europe:

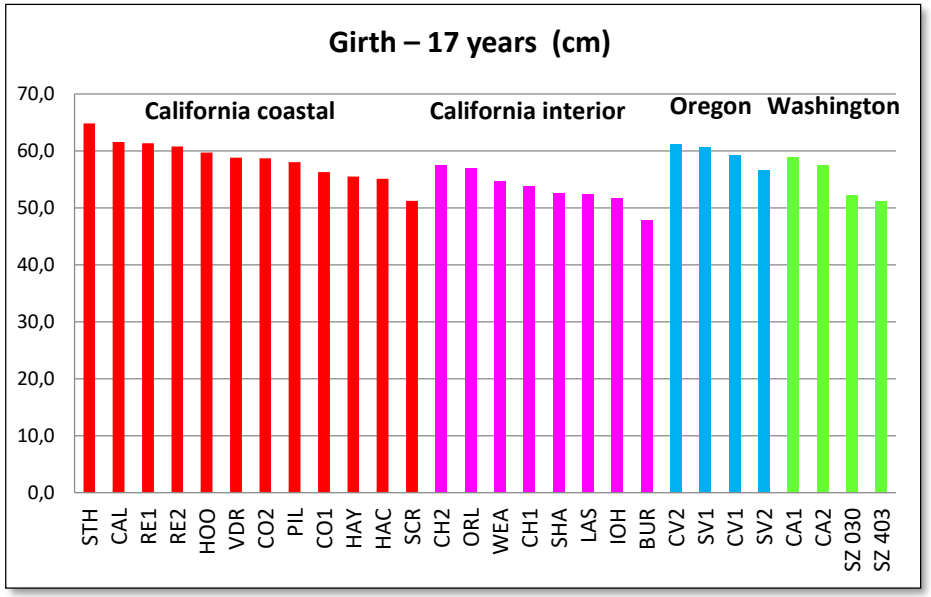
- Vancouver Island
- Coastal range (Wa & NorthOr.)
- Cascade

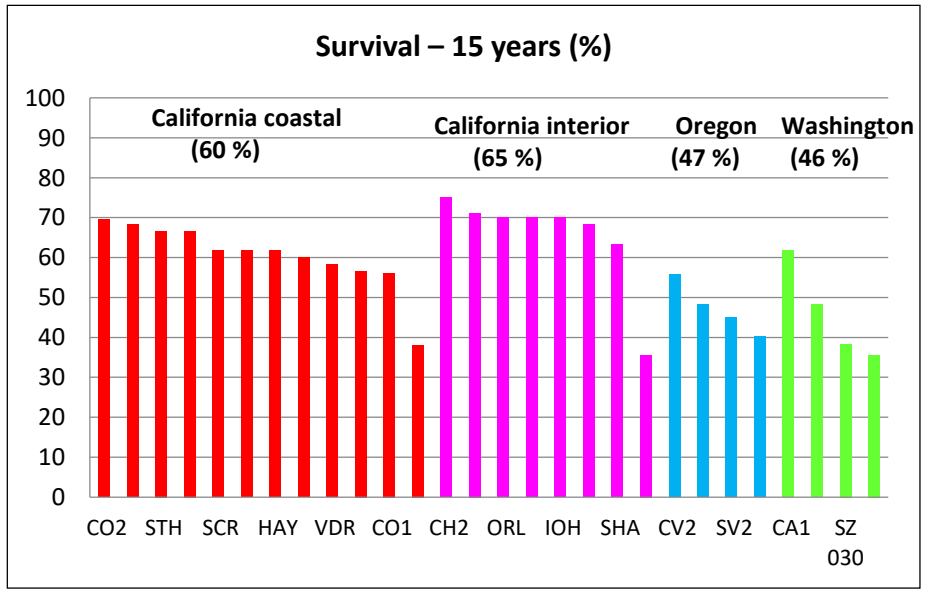
TREES 4 FUTURE

Interest of the Californian origins in Mediterranean area

(Source ONF)



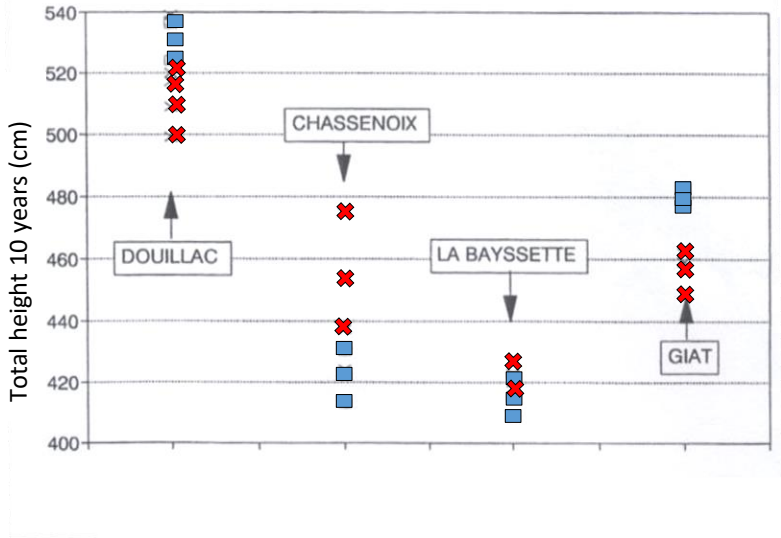




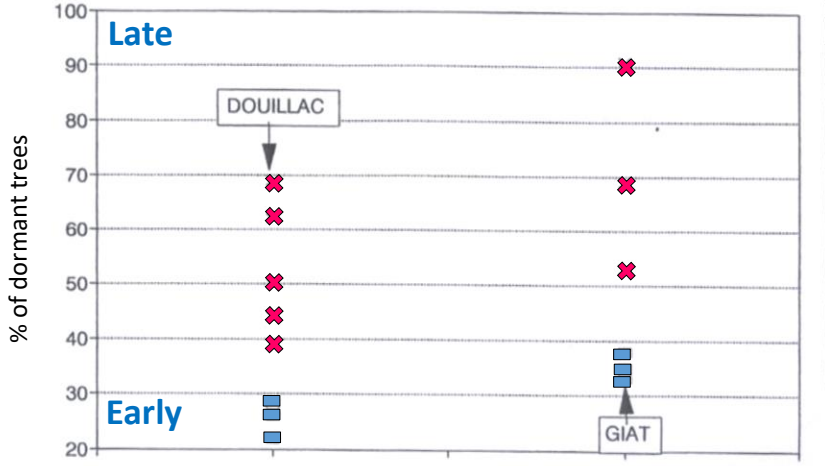
Natural variability

Performances of artificial French populations
Source FCBA

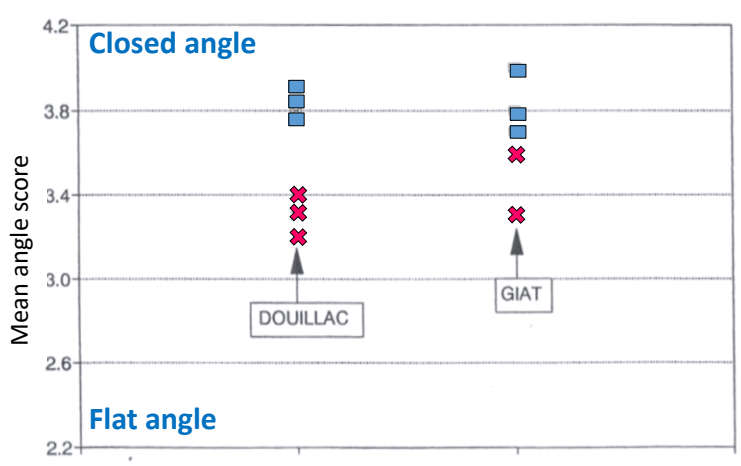
Total height



Vegetative bud flushing



Branch angle



French seed stands US seed stands

FCBA
INSTITUT
TECHNOLOGIQUE

Provenance research – practical recommendations

Good adaptation and growth of the **coastal variety** in Europe was confirmed.

Provenance recommendation according to plantation site:

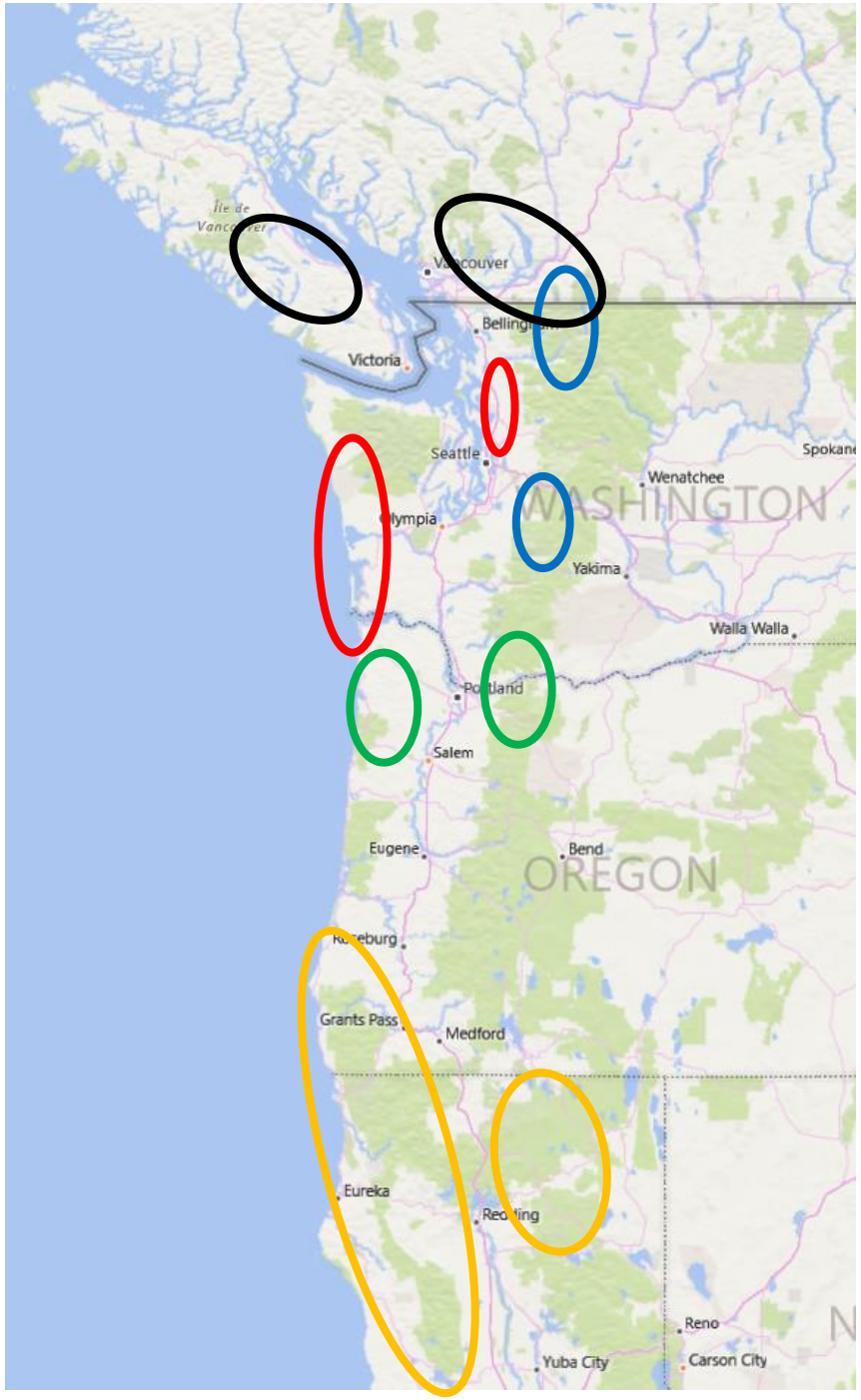
- High elevation – provenances from British Columbia and middle elevation in northern Washington

- Central and eastern Europe - provenances from middle elevation zone of the Cascades in Northern Washington

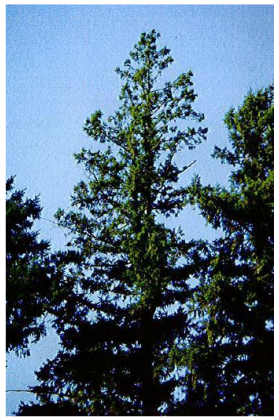
- Oceanic Europe - provenances from low elevation in Washington

- Southern Europe - provenances from Southern Washington and Northern Oregon

- Mediterranean Europe - provenances from Southern Oregon, Northern California

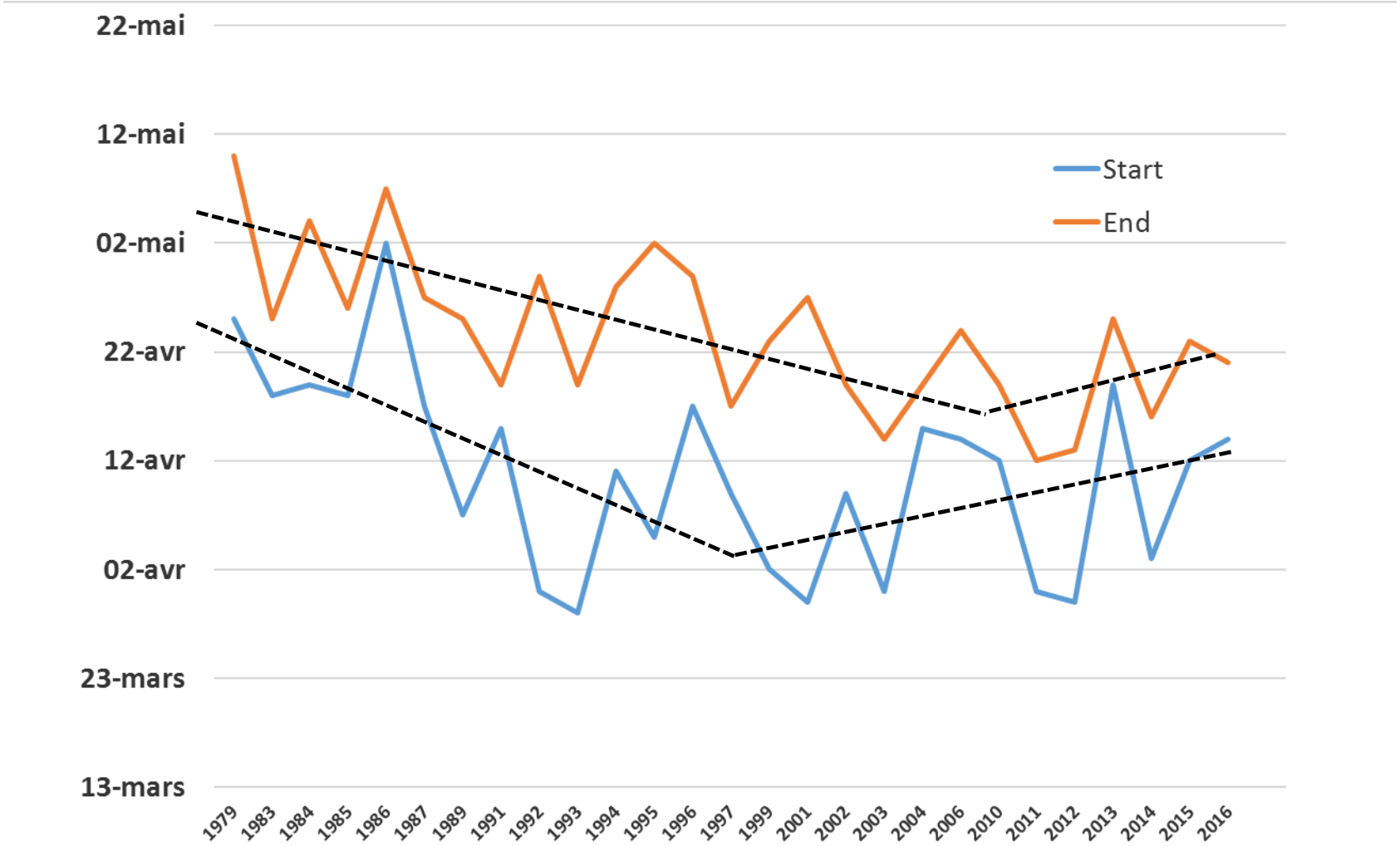


Climate change effect on Douglas fir



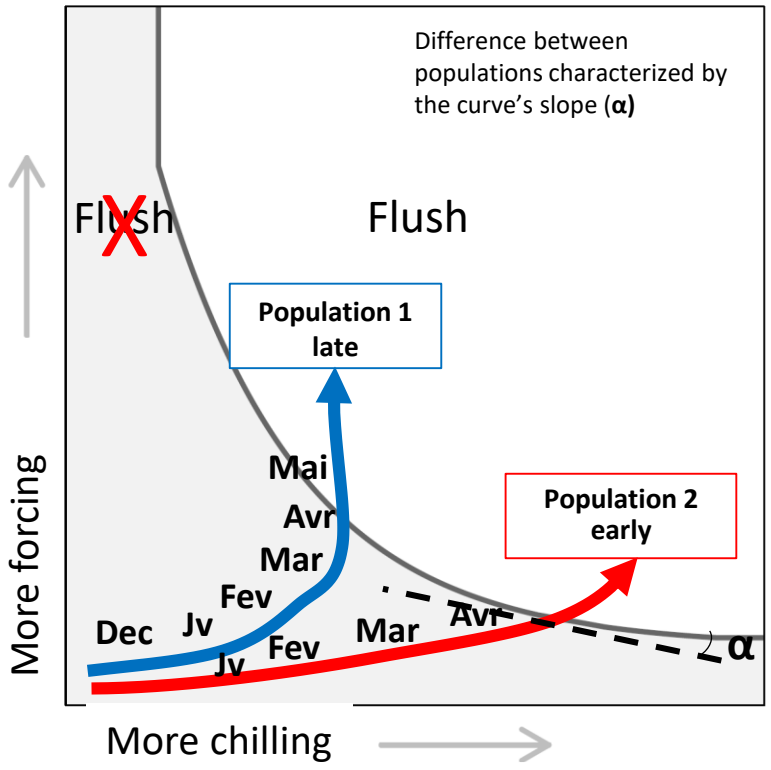
Visible impacts on Douglas fir

Evolution of start and end female flowering dates in Orléans



Flushing modeling under climate change

(Brad St Clair – USFS 2009)



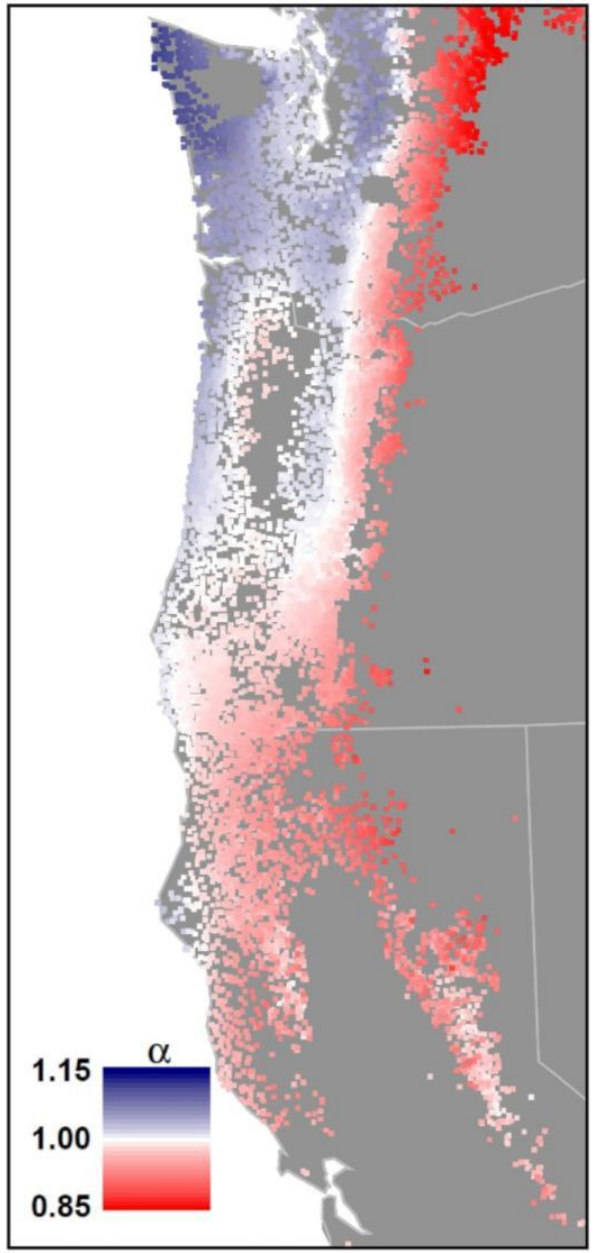
Prédiction du coefficient α des populations

(Brad St. Clair – USFS 2009)

- Coefficient **α** can be predicted by environmental variables

- Best predictors : winter temperatures and summer precipitations

➢ Populations from environments with cold winter and hot/dry summer need less forcing to flush



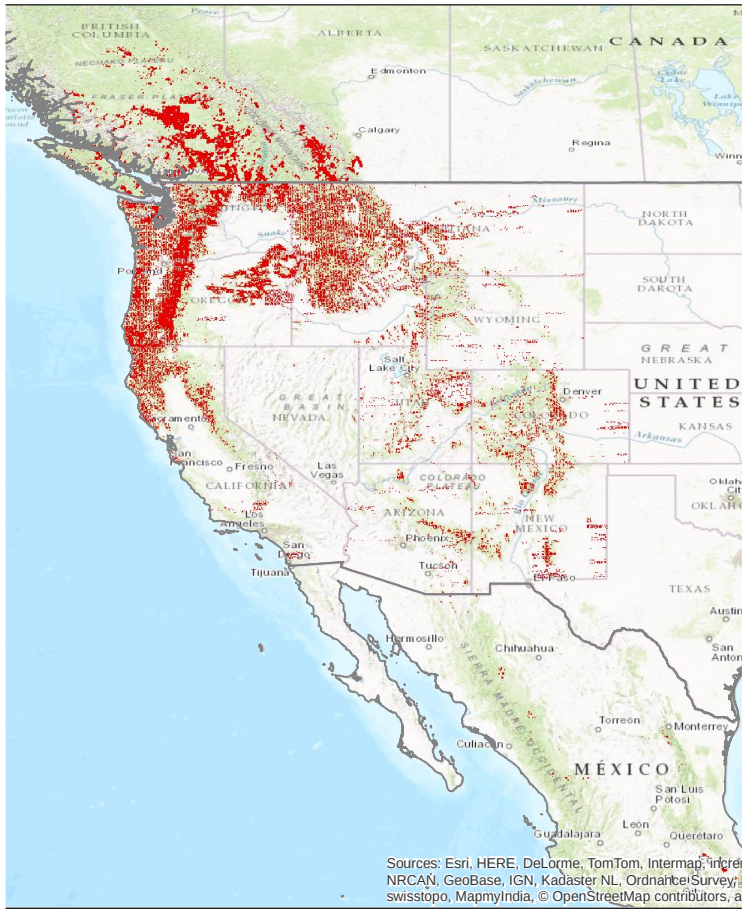
Climate change effect on Douglas fir

Modeling species distribution

J. Boiffin & V. Badeau – 2015

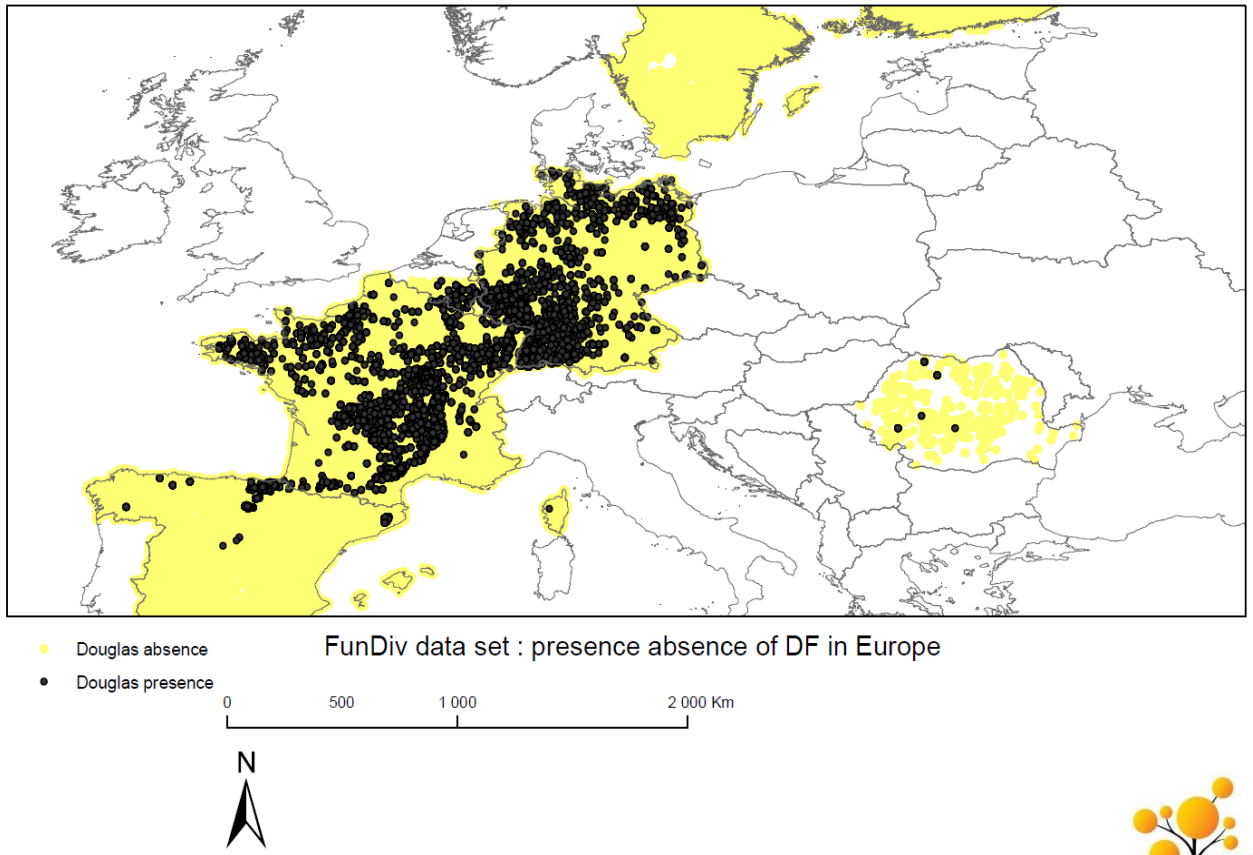
With correlative niche models calibrated in native range (PNW)

Presence/Absence ~ 14 Worldclim climatic descriptors



Projection into introduction range (Europe)

Model evaluation with European presences (FunDIVEurope)



Climate change effect on Douglas fir

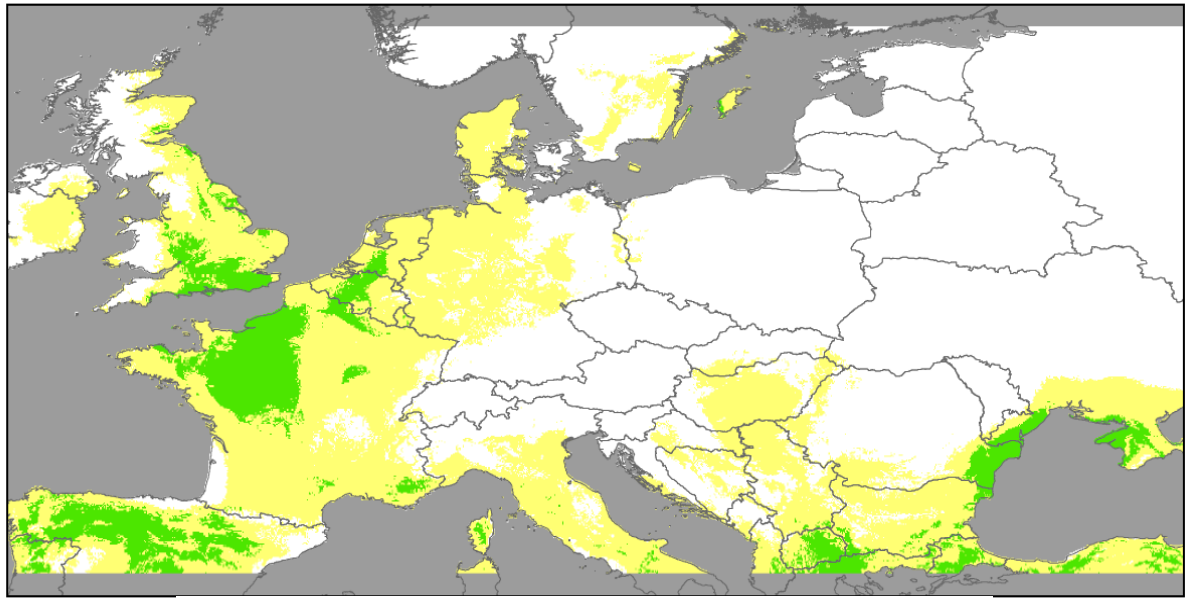
Modeling species distribution

J. Boiffin & V. Badeau – 2015

Douglas fir niche model calibrated in North America

(Random Forest, 20 forests 500 trees each, (Rehfeldt et al. 2014, Worall et al. 2013))

Projection into Europe



Poor predictive power in Europe

Models predict that Douglas fir cannot grow in Europe because climates are too different from that of the native range

Climate change effect on Douglas fir

Modeling species distribution

J. Boiffin & V. Badeau – 2015

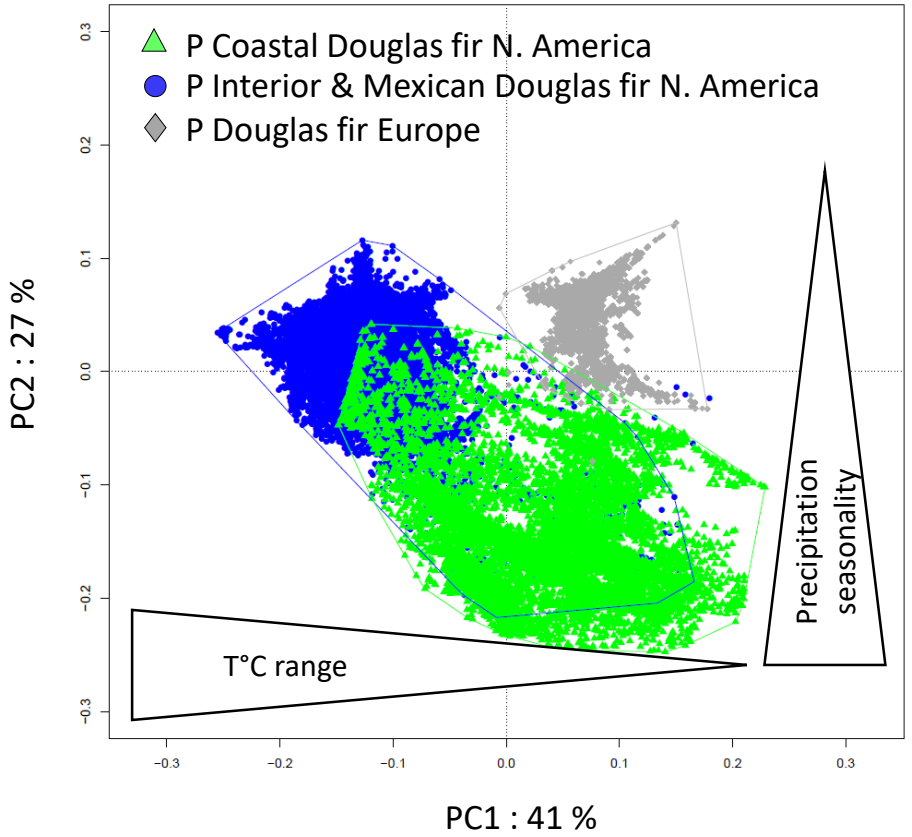
Shift in climatic niche: American range vs. European range

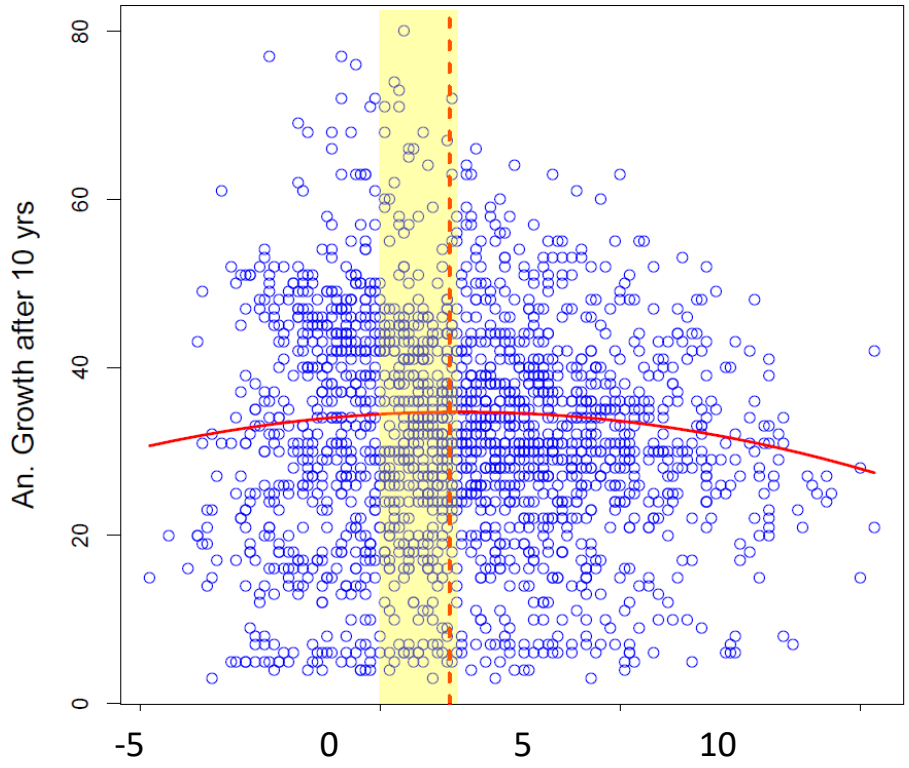
PC1 (41%)

- Temperature Annual Range
- Conrad's continentality index
- Temperature Seasonality (standard deviation *100)
- Min Temperature of Coldest Month

PC2 (27%)

- Precipitation Seasonality (Coefficient of Variation)
- Isothermality
- Precipitation of Coldest Quarter
- Precipitation of Wettest Month



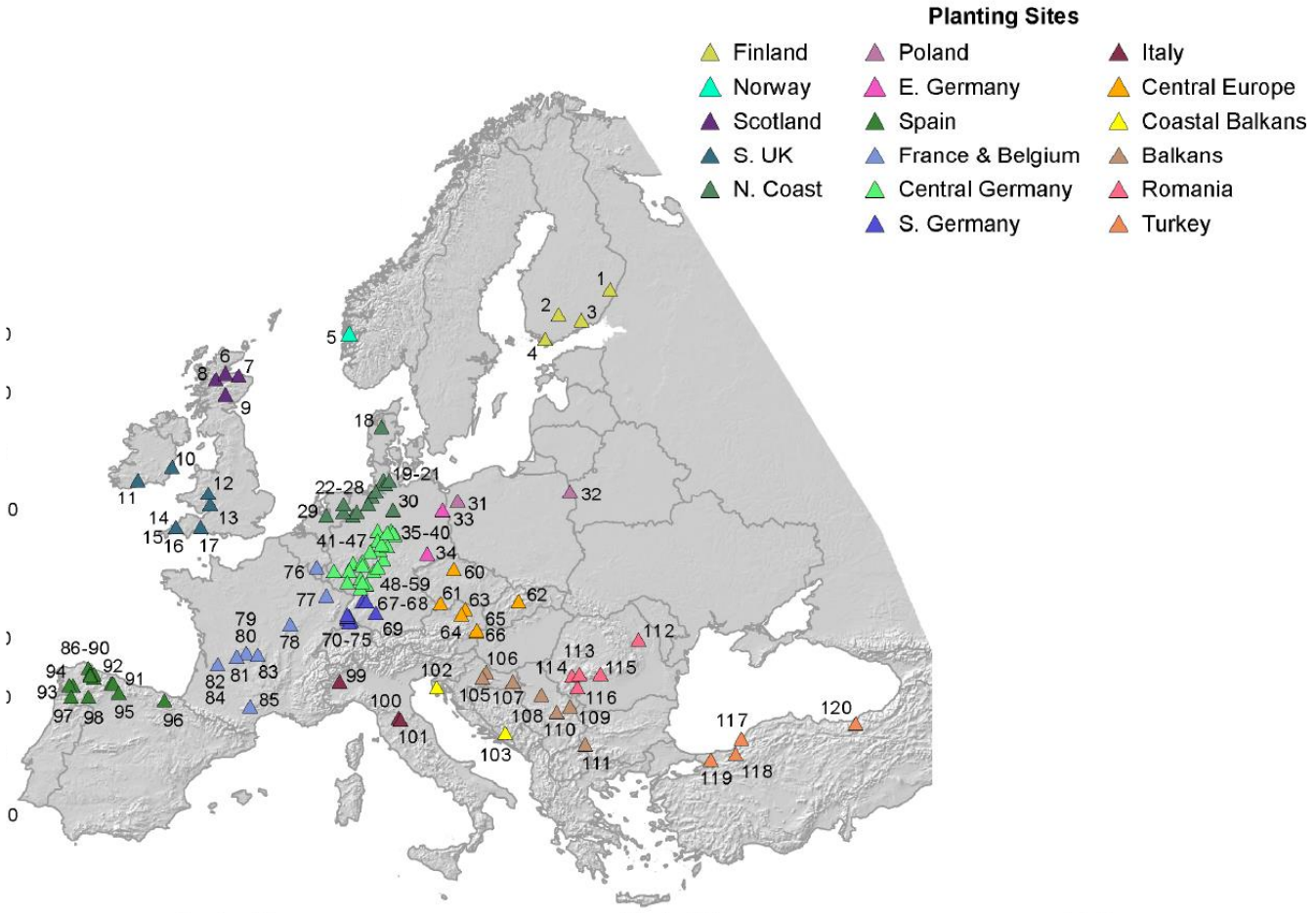


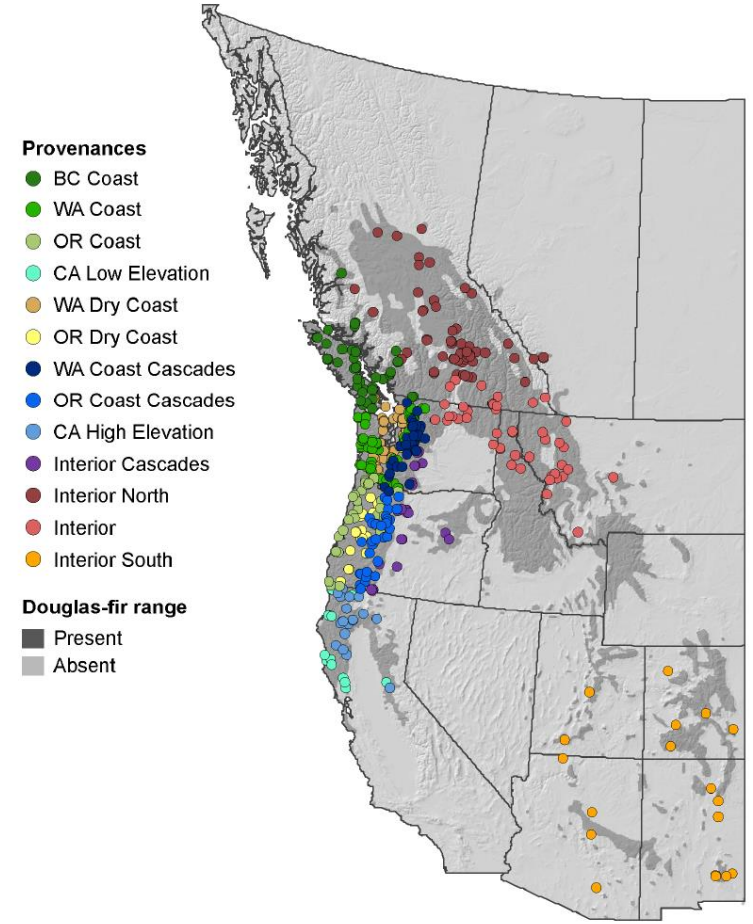
Climate change effect on Douglas fir

Modeling species distribution

M. Isaac-Renton – 2013

2800 provenances 120 European test sites



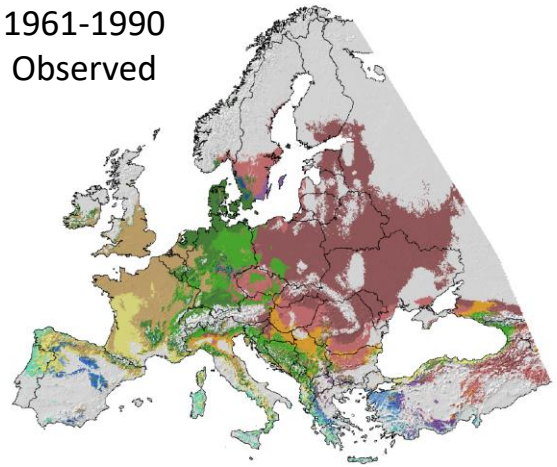


Climate change effect on Douglas fir

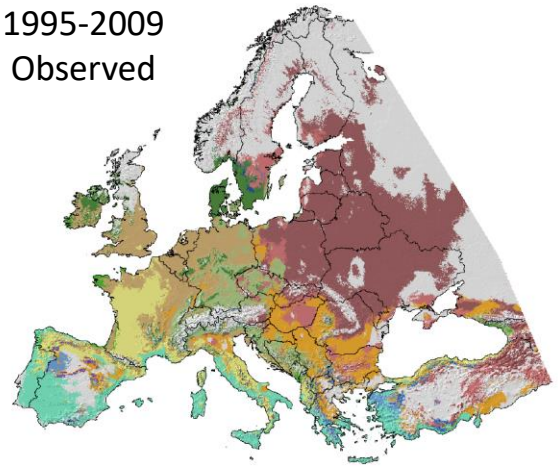
Modeling species distribution

M. Isaac-Renton – 2013

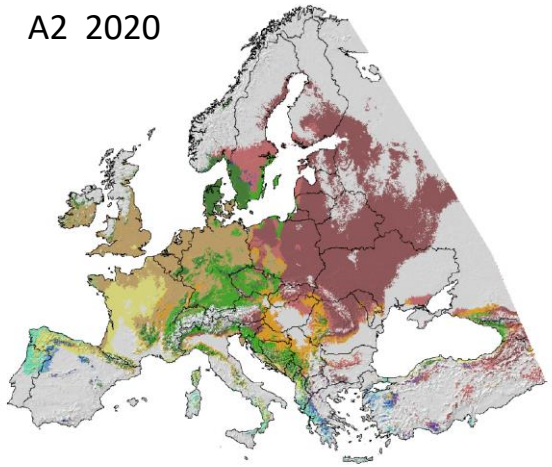
1961-1990
Observed



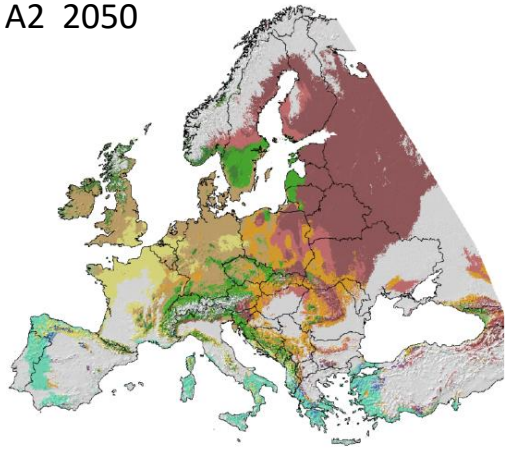
1995-2009
Observed



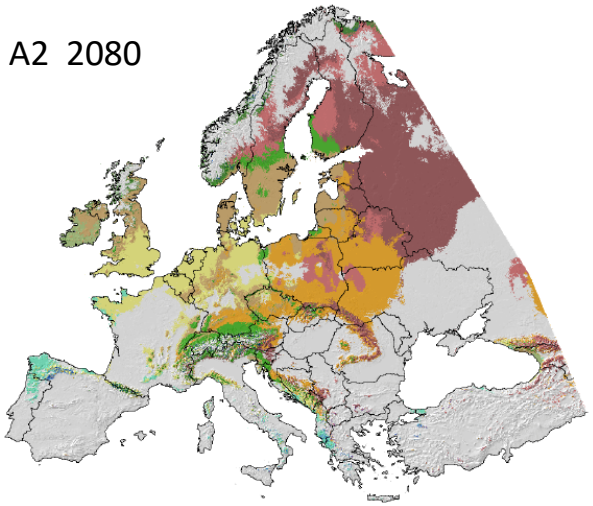
A2 2020



A2 2050



A2 2080



Provenances

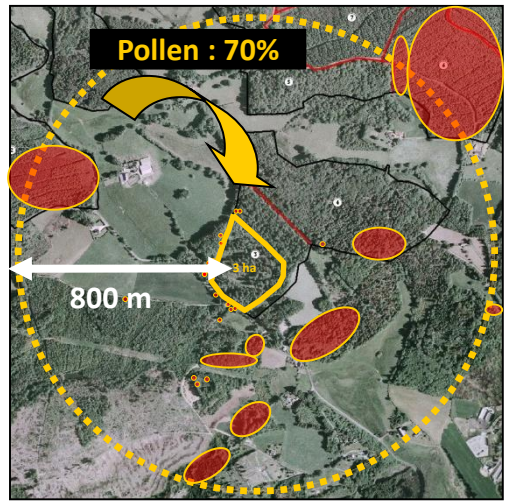
- BC Coast
- WA Coast
- OR Coast
- CA Low Elevation
- WA Dry Coast
- OR Dry Coast
- WA Coast Cascades
- OR Coast Cascades
- CA High Elevation
- Interior Cascades
- Interior North
- Interior
- Interior South

Which DF Forest Reproductive Materials and where?

« Natural » regeneration : possible but not in any way

Points to consider prior natural regeneration:

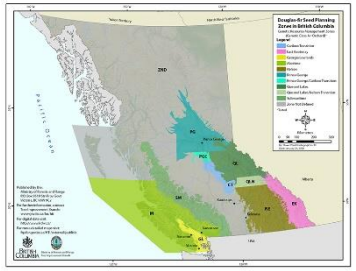
- NR is an option to consider under certain conditions (steep slope, game pressure, public perception)
- Genetic structure of the parent trees is passed to the following generation
- Check phenotypic quality of the trees in the stand and the surrounding stands (important pollen flow from outside – possible introgression between subspecies)
- Take advantage of several of seed years to enhance the genetic diversity

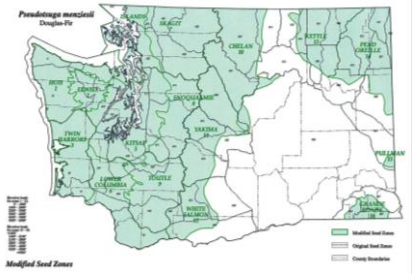


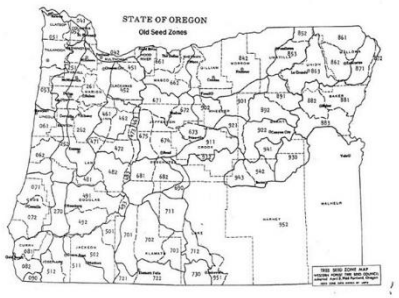
Available Douglas fir FRM in Europe

Identified

(Seed Zones)





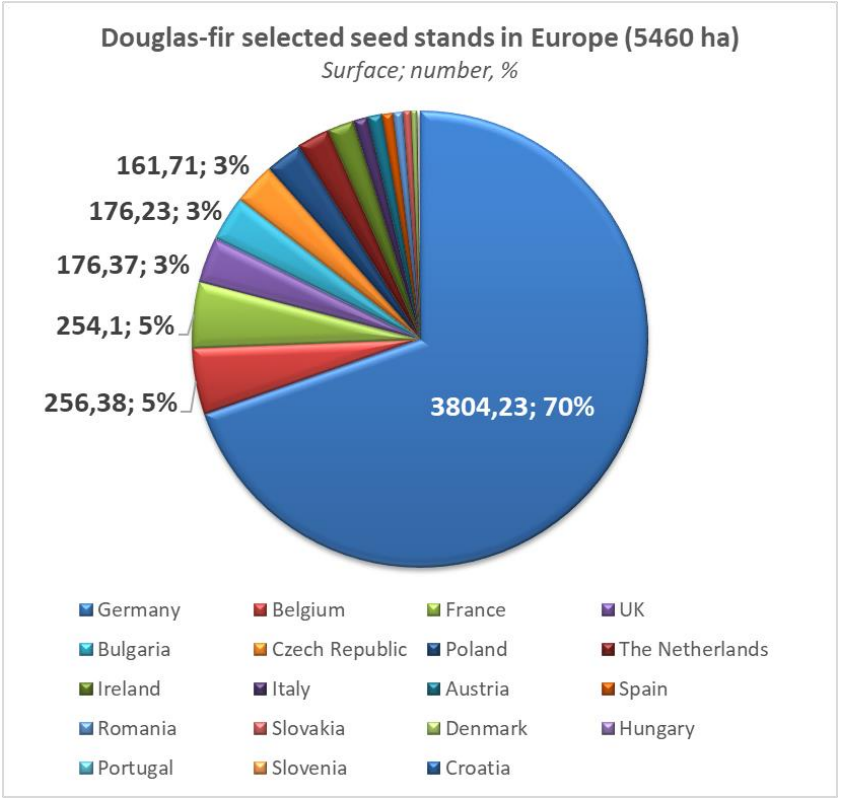


Selected

(Seed stands)

Fort Augustus
(UK)

Grandris
(FR)

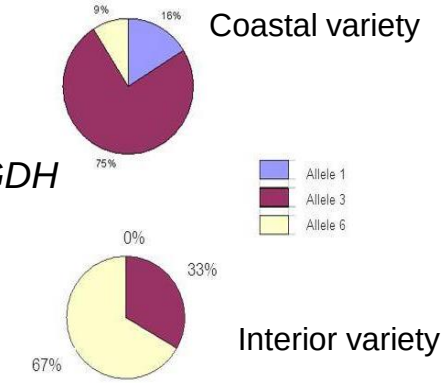


Available Douglas fir FRM in Europe

Genetic quality (variety, diversity) of Douglas fir seed stands in Bavaria

302 stands were investigated

- ➢70 % – pure coastal („green“) variety
- ➢ 3 % – pure interior („grey“) variety
- ➢22 % – mixture of coastal and interior“



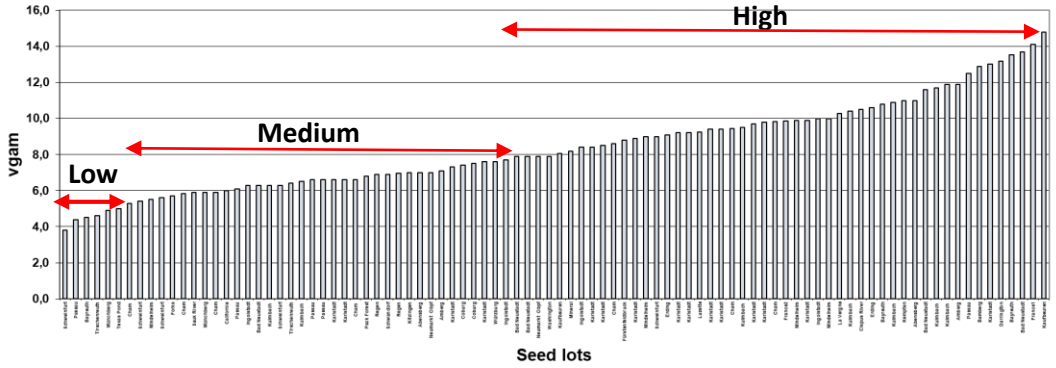
Coastal variety

Distribution of alleles at the locus 6PGDH in the coastal and interior varieties

Interior variety

Large variation in genetic diversity - (v_{gam} = 3 to 20)

- ➢ 10 % with very low diversity (v_{gam} = 2 – 4.5)
- ➢ 60 % with middle diversity values (v_{gam}= 5.0 – 8.0)
- ➢ 30 % with high genetic diversity (v_{gam} > 8.0)



Consequences :

- ➢ For mixed stands and stands with very low genetic diversity, registration as seed stands was revoked
- ➢ New stands are approved only after a genetic check

Available Douglas fir FRM in Europe

Qualified

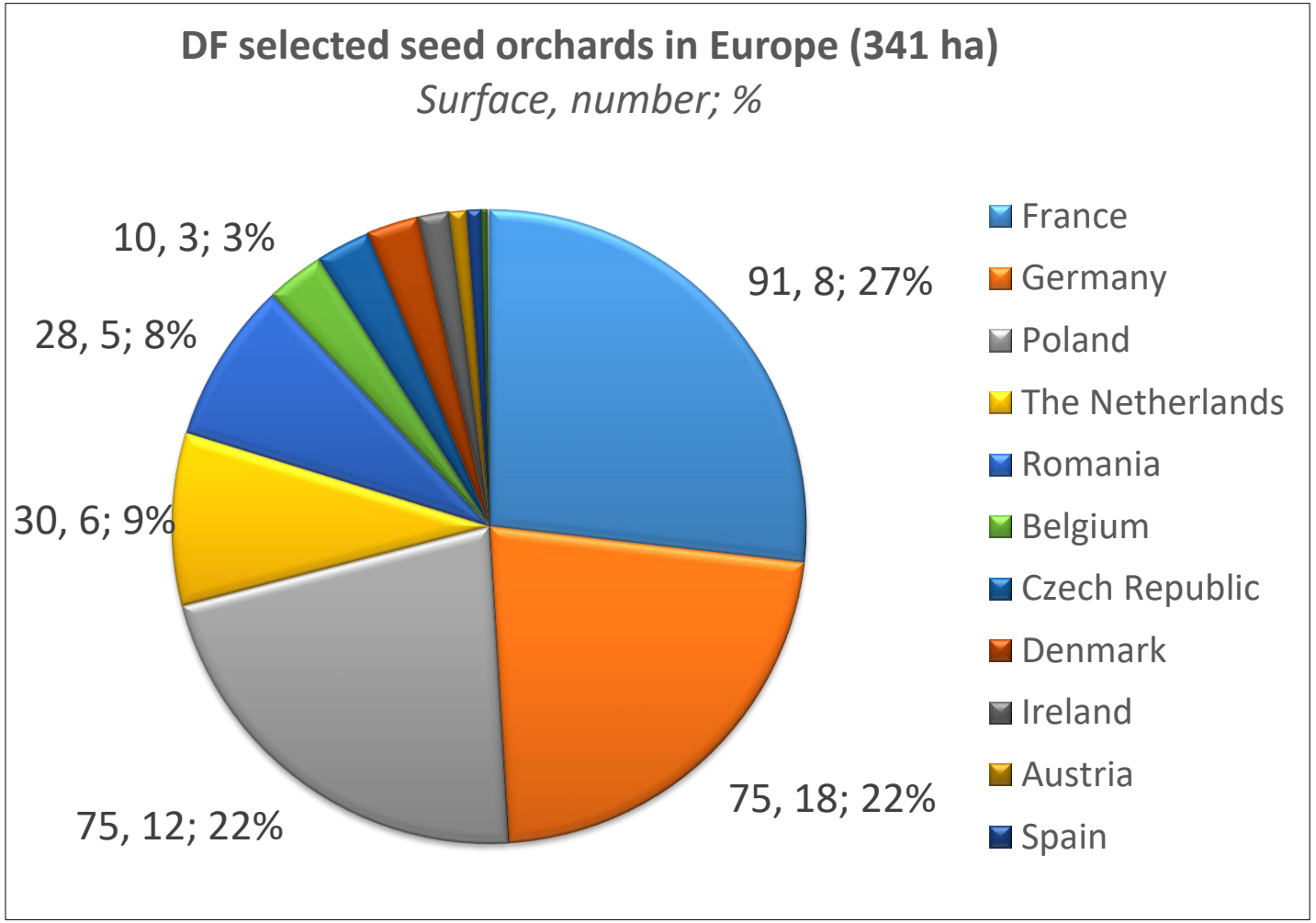
66 Seed Orchards
287 ha

Washington-2
(FR)

Tested

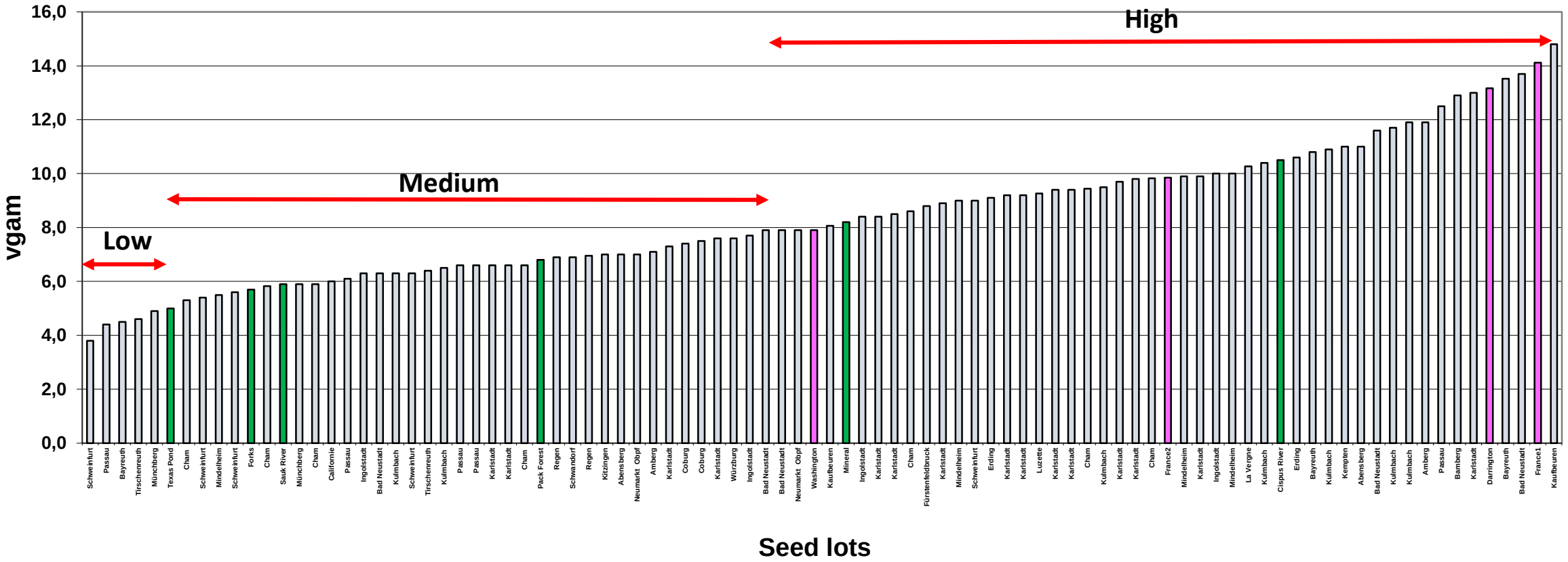
4 Seed Orchards
54 ha

La Luzette
(FR)



Available Douglas fir FRM in Europe

Mulitlocus diversity (Vgam) in seed lots from Washington, Germany and France



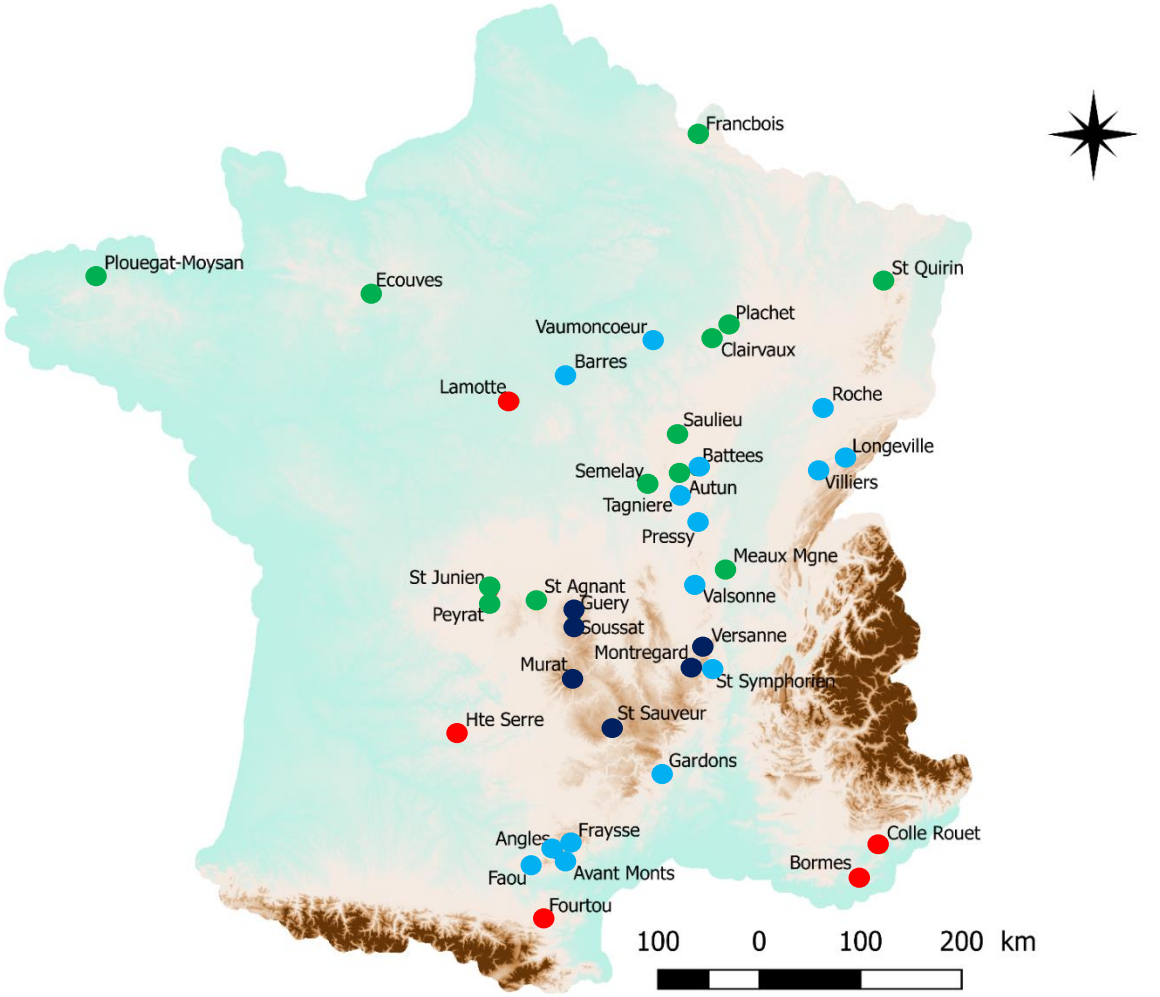
Evaluate the sensitivity of varieties to climate change

French Douglas fir seed orchard evaluation network

Nr of seed orchard : 8
Nr of test sites : 43 *(planted 2009 - 2016)*
Total surface : 33 ha

Test site's environments

- Area's heart (ok/ok)
- Margin 1 (ok/?)
- Margin 2 (no/no)
- Altitude (no/ok)



Evaluate the sensitivity of varieties to climate change

French Douglas fir seed orchard evaluation network

Early results at age 5 in 11 sites

(G. Philippe – 2015)

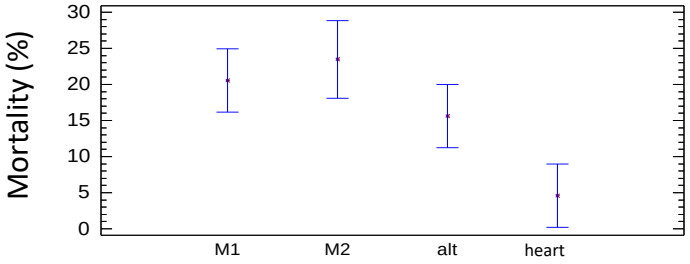
Tested material :

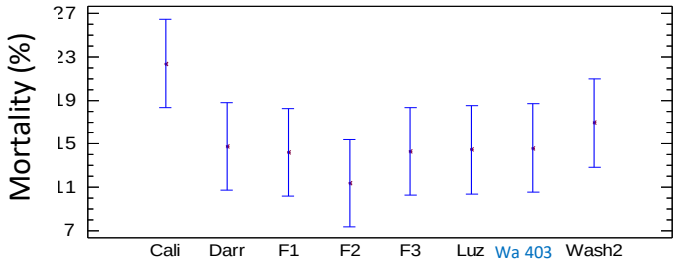
- **7 SO** *(Darrington, Luzette, France 1, 2 & 3, Washington2, California)*
- 1 US prov *(WA403)*

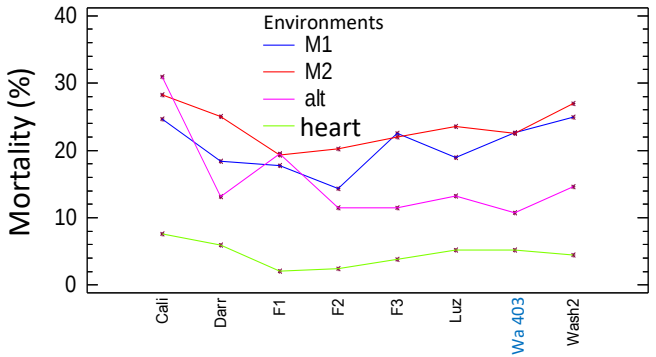
11 sites :

- 3 in area's heart
- 3 in margin 1
- 2 in margin 2
- 3 in altitude

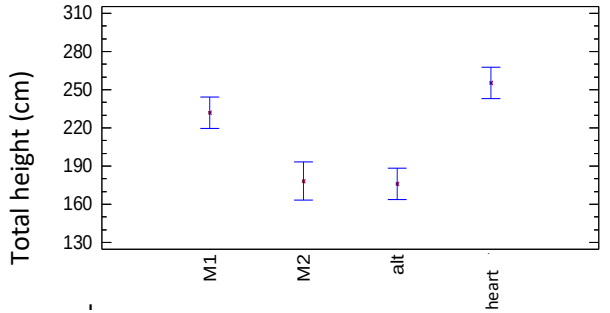
- Mortality

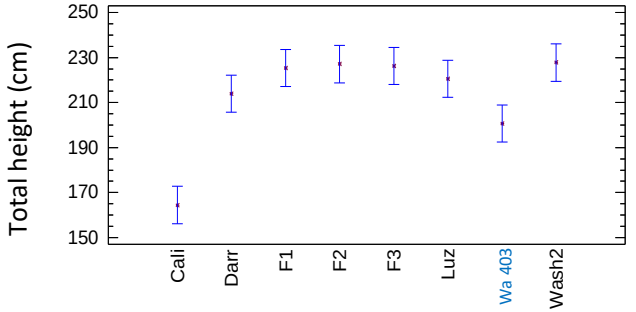


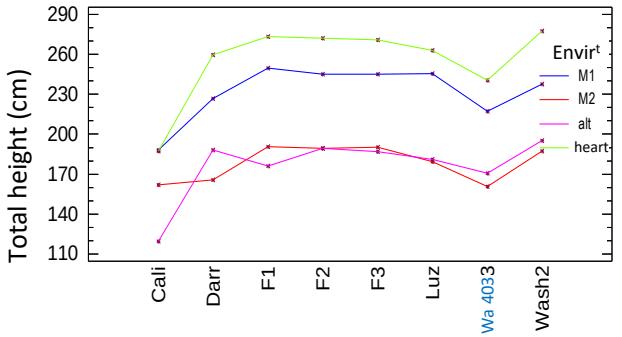




- Height growth

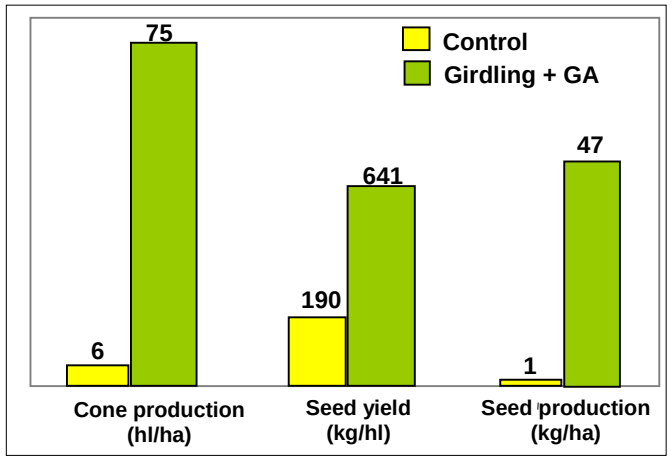


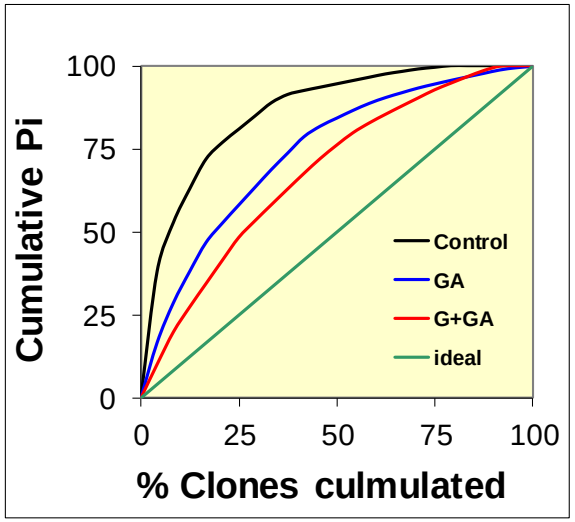




Efficiency of flowering induction treatments on cone production, seed yield and quality in DF seed orchards

(source Irstea)





Fi = (nb female flowers or cones of parent i) . 100 / Total production

Mi = (nb male strobiles of parent i) . 100 / Total production

Pi = (Fi + Mi) / 2

Pi = Gametic contribution of parent i

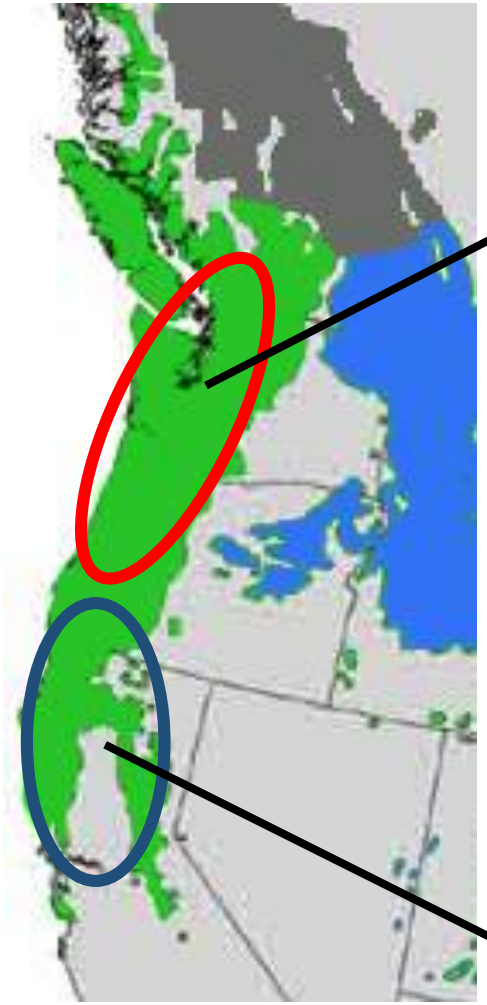
Which DF Forest Reproductive Materials for tomorrow?

Two examples of ongoing DF breeding programs in Europe

- Germany :
  - Short term : evaluation of German land races + EU & US seed orchards
  - Long term : selection & evaluation of 200 German "+" trees or a new generation of seed orchard

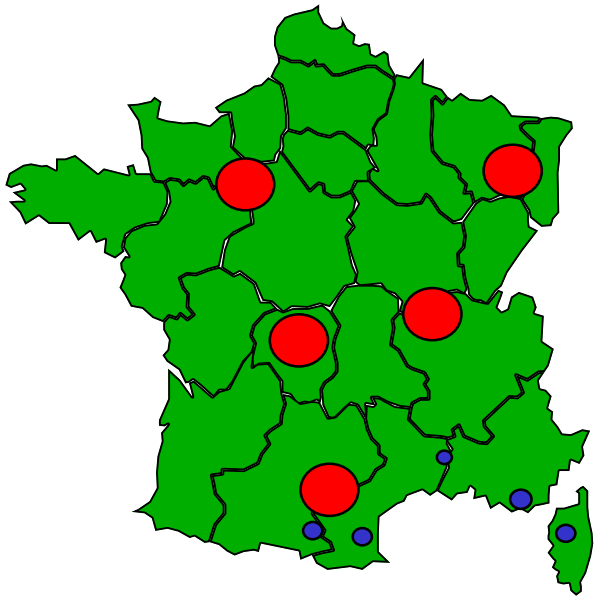
- France: building a new generation of seed orchard by forward selections
  - within Washington and Oregon progenies
  - within Californian provenances tested in Mediterranean area

Towards a new generation of seed orchards in France



Washington & Oregon : 1000 o.p. prog.

19 tests in 5 regions (19-27 years) ➔ 198 ha



Southern Oregon & California: 54 prov.

5 tests (19-31 years) ➔ 15 ha

Breeding population

Forward index selection — **200 clones**

Forward phenotypic selection — **100 clones**

2nd generation seed orchards (100 ha)

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Conclusions

- DF : a forest species of **major importance** for EU in a context of changing climate.
- **Choice of FRM** is crucial for a successful DF stand. Suitable seed origins in the natural range are known, but imports (especially improved material) are still a challenge.
- **Valorize EU land races** (stands) could be good option if quality is controlled.
- **Improved varieties** will perform better than unimproved variety in the next decades.
- DF would justify :
  - Inventory in Europe of authenticated **DF genetic resources** for monitoring & breeding.
  - **Wide range evaluation** of existing EU varieties.
  - EU **coordinated breeding work** in well chosen [representative of] contrasted biogeographic zones.


Thank you for your attention