Using climate projection uncertainty to select FRM for future forest sites (B4EST-WP1)

Duncan Ray, Forest Research, Roslin, UK
Marta Benito-Garzon, INRA, Bordeaux, France
Maurizio Marchi, CREA, Arezzo, Italy
Overview

B4EST is an EU-funded H2020 project

Objectives

• Provide new, flexible and resilient tree breeding strategies and tools, using traits of tested genotypes to assess adaptive variation and phenotypic plasticity to the impacts of climate change and pests and diseases currently threatening European forests
• B4EST will match forest genetic resources to the environments where they will perform best, and will provide deployment recommendations for policy makers and forest managers.

Use new science (data and methods)

• New projections that include the variability of extreme climatic conditions into the future
• Linear mixed effect models that combine parameters of both phenotypic plasticity and local adaptation of fitness-related traits from common gardens
Why consider uncertainty?

• By considering a range of uncertain scenarios of the future we will **identify resilient selection, breeding and management pathways**

• **Resilient forest management pathways** will be less affected by abiotic and biotic impacts under climate change

• EC is keen to explore ways that the **European forest industry** can help foster a competitive **bio-based economy**, that will depend upon **resilient selection, breeding, and management pathways** for forests
Climate change uncertainty

**RCP scenarios**

RCP 2.6, 4.5, 6.0, 8.5 (radiative forcing - Wm⁻²)

Only RCP 2.6 keeps below 2.0°C

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**IPCC AR5 WG1 best & worst case**

**global temperature increase projections**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2046-2065</th>
<th>2081-2100</th>
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<tbody>
<tr>
<td></td>
<td>mean</td>
<td>likely range</td>
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<tr>
<td>RCP8.5</td>
<td></td>
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<td>worst case</td>
<td>from 2005</td>
<td>2.0</td>
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<td></td>
<td>from 1850</td>
<td>2.6</td>
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<td>with AR4 A2 carbon feedback &gt;1.0°C by 2100</td>
<td>2.4</td>
<td>2.4 to 3.4</td>
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</tbody>
</table>
RCP 4.5 projections – GCM climate model uncertainty

- Using WorldClim portal
- CMD calculated from 17 GCMs – RCP4.5 2050
- Ensemble mean CMD (left)
- Ensemble standard deviation CMD (centre)
- Threshold of exceedance - CMD 260mm, RCP4.5, 2050 normal period (right)
New European 12km resolution climate projections from UKCP18 RCP8.5 - Examples

January spatial mean temperature

Monthly temperature & annual moving average
1. Droughts eventually occur everywhere
2. Climate warming = hotter droughts
3. Moisture demand increases non-linearly with temperature
4. Mortality occurs rapidly with hot droughts
5. Short droughts more frequent and more lethal with higher temperature
6. Mortality risk following drought continues for several years - a long growth interval needed for forest recovery
7. Abiotic stress causes biotic disturbance to occur
Projected number of years CMD >= 300mm (1981 – 1990) from decadal analysis of UKCP18 RCP8.5
Projected number of years CMD >= 300mm (2010 – 2019) from decadal analysis of UKCP18 RCP8.5.
Projected number of years CMD >= 300mm (2051 – 2060) from decadal analysis of UKCP18 RCP8.5
Projected mean maximum decadal summer temperature (2010 – 2019) from UKCP18 RCP8.5
Projected mean maximum decadal summer temperature (2051 – 2060) from UKCP18 RCP8.5
Climate driven biotic impacts: Scots pine

• Dothistroma needle blight – Ray et al (2019), For Pol Econ, 103:17-27
  • Pine vulnerability based on:
    – Climatic characteristics (temperature, rainfall and potential evaporation)
    – Pine species
    – Forest management system

• Pine-tree lappet moth – Ray et al (2016), Forestry, 89:230-244
  • Pine vulnerability based on:
    – Seljaninov Hydrothermal Coefficient
    – Climatic characteristics (temperature and rainfall)
    – Soil type
    – Forest management system
  – (a) = baseline climate; (e) = 2080 RCP8.5 scenario
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Scots pine susceptibility to DNB
e.g. Reaction norms of native Scots pine populations to DNB severity
(Perry et al 2016, Evolutionary Applications 9)
Trait spatial distribution

Probability of survival of beech

Trait value = $a_0 + b_1 CP + b_2 CS + b_3 CP \times CS + \beta + \delta + \varepsilon$
Summary of use of data uncertainty

- Common garden trial re-analysis with **new scale-free climate data**
- Use climatic variables and indices in **DtraitSDM models**
- Model (DtraitSDM) trait values (e.g. survival) against the climates of origin sites and the climates of common garden test sites to **split the phenotypic trait response of genotypes from local adaptation**, and to quantify phenotypic variation across environments
- Test the **sensitivity of the phenotypic trait responses** of genotypes under climate change uncertainty to select material within climatic uncertainty thresholds, as well as understanding **trade-offs among traits**
- Assess and the **potential benefits, constraints and trade-offs** in deploying phenotypes for forest management under uncertain climate futures at the **landscape scale**
- Within an uncertainty context **develop guidelines** and forest management **recommendations for FRM deployment** in Europe
CONTACT US

duncan.ray@forestreresearch.gov.uk
catherine.bastien@inra.fr

‘B4EST project’ on ResearchGate

info@b4est.eu

b4est.eu (web site)

@B4EST_EU