

Using genome scans and landscape genetics on regional and continental scales to detect temperature-related natural selection in a wind-pollinated tree

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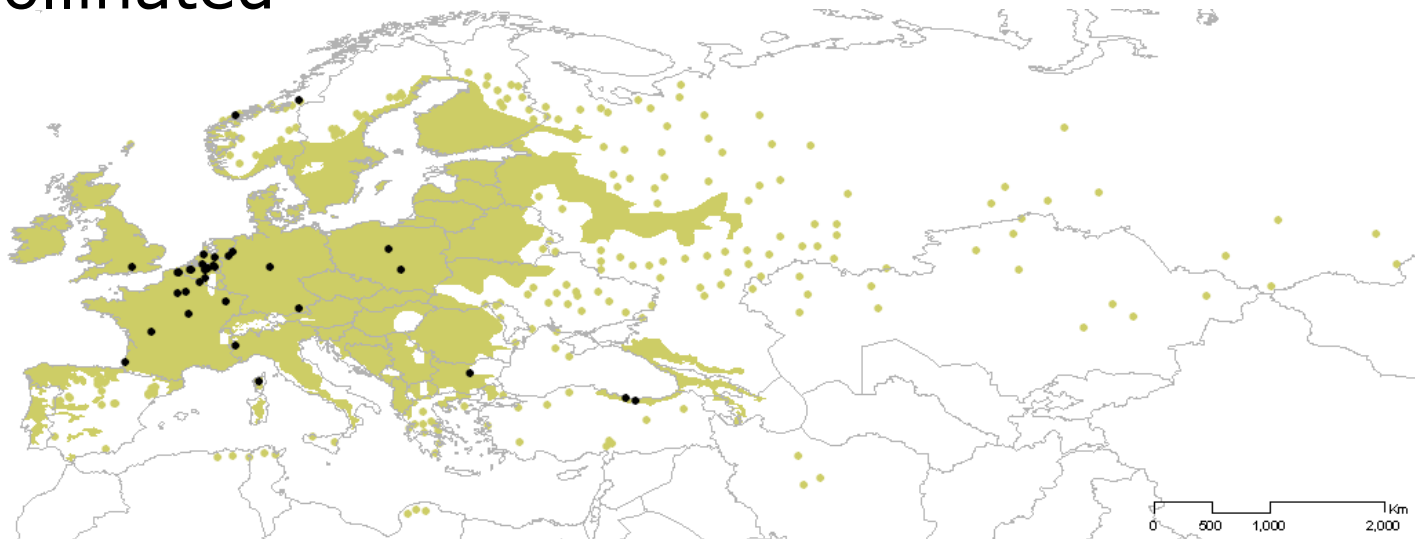
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Regions of provenance

- Delineation of regions of provenance and seed zones: tradition in forestry; becoming relevant for herbaceous species
- Local adaptation: how local is local?
- *Alnus glutinosa* (Black alder): outcrossing, wind-pollinated



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- Landscape genetics (2 different approaches)
- Genome scan
- On a regional (Flanders, northern Belgium) and European scale

Expectations

- Low genetic differentiation
- High levels of genetic diversity
- Clear signs of selection > European scale
- Relation with certain climate variables

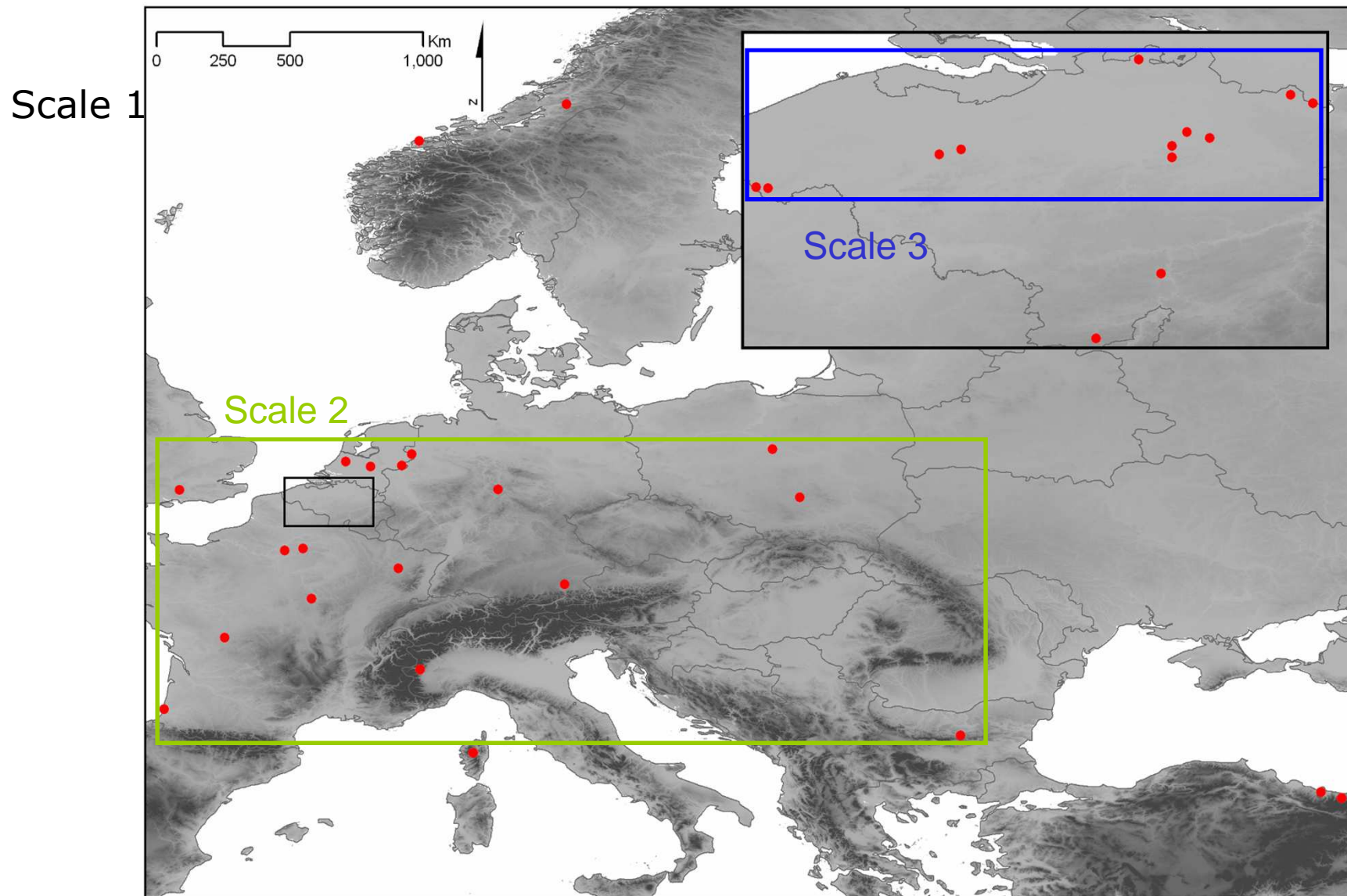


Samples and AFLP

- 550 seedlings
 - Seed from 11 Flemish populations (northern Belgium)
 - Seed from 14 European populations
- AFLP: 6 primer combinations, 163 markers



Location and scales



Genetic diversity

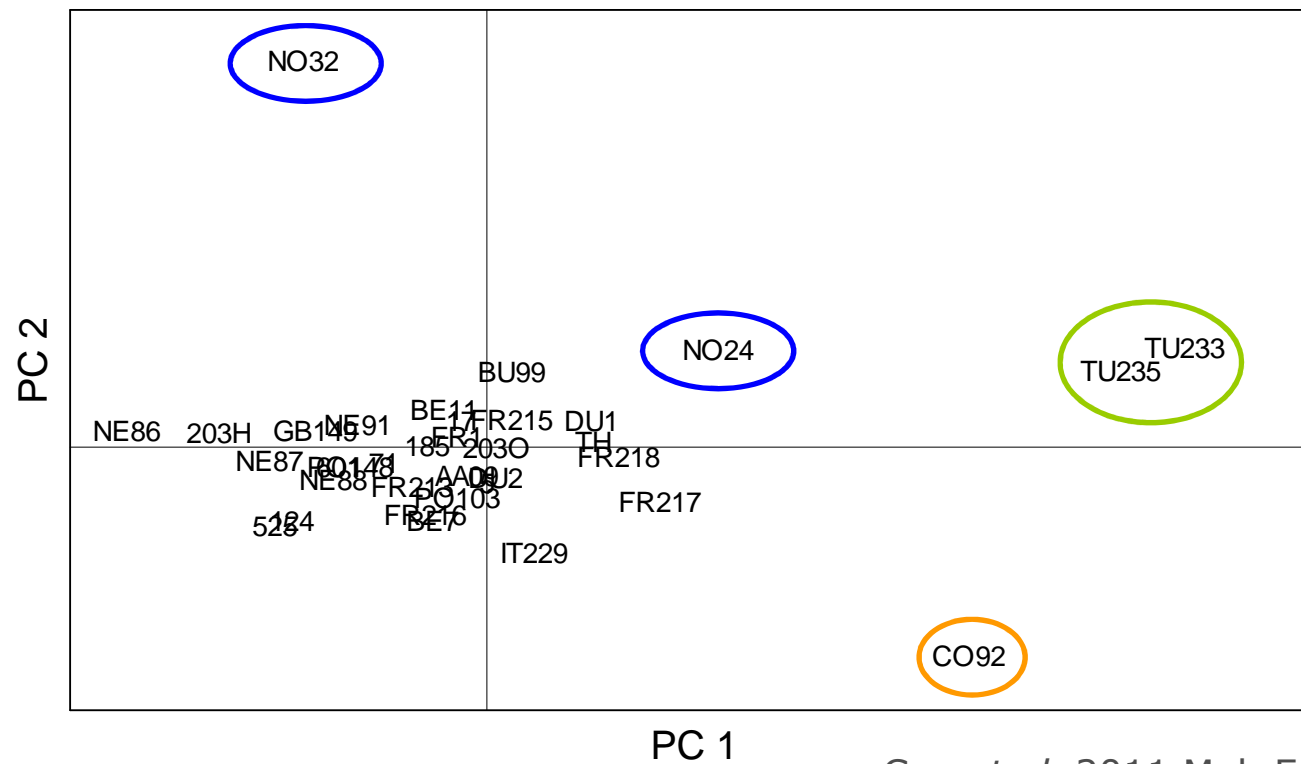
- Moderate to high levels of genetic diversity
- For H_j ($\approx H_e$): 0.2056 (Corsica) to 0.2871; an average of 0,2491
- PPL: 58.3% (Corsica) to 79.8%; mean of 70.7%

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- PPL: 58.3% (Corsica) to 79.8%; mean of 70.7%
- $H_j \nearrow$ when latitude \nearrow
- PPL \searrow when longitude \nearrow
- Genetic diversity vs. distance to refuge: NS

Genetic structure

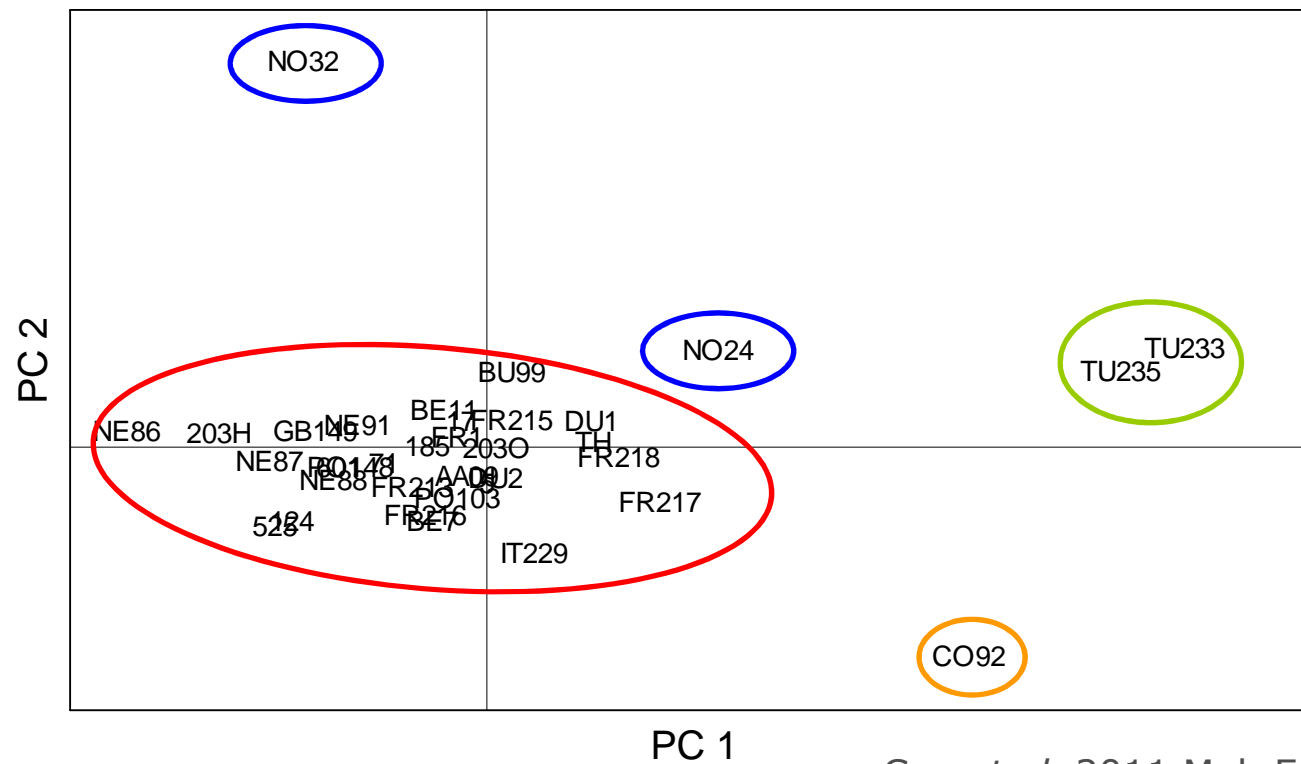
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Cox *et al.* 2011 Mol. Ecol.

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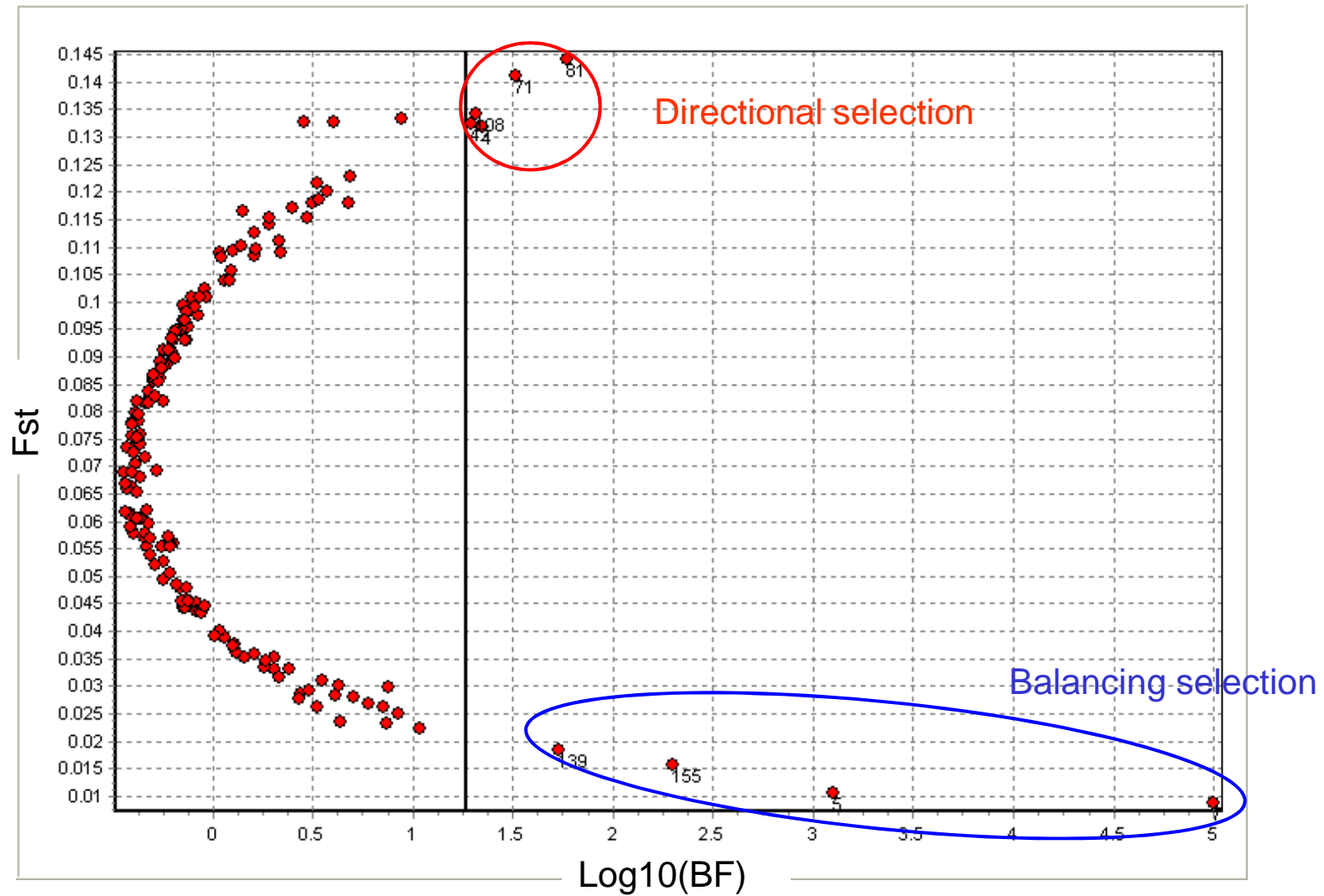
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- Scale 2 = one gene pool
- Significant isolation-by-distance but not on the Flemish scale
- Significant correlation between population-specific F_{ST} and H_j/PPL : no migration-drift equilibrium

Selective loci

Genome scan:

- BAYESCAN (Foll and Gaggiotti 2008); outlier loci based on locus- and population-specific F_{ST} values $>$ signals of natural selection on (genes close to) loci
- Nature of selection: directional or balancing
- Necessary to implement genetic structure; otherwise a risk of obtaining false positives.

Selective loci



Correlation with climate

- SAM (Joost *et al.* 2008): logistic regressions between binary data of each locus and climate variables (88 mainly monthly variables, altitude, latitude and longitude)

[Nested data and collinearity](#)

- First: selection of independent climate variables through VIF (mean yearly variables)
- Second: GLMM with population as random intercept
- Spatial effect



Selectieve loci: summary

| Scale | BAYESCAN | SAM | GLMM |
|-------|---|--|--|
| 1 | Directional: 4, 42, 71, 81, 89, 108 Balancing: 5, 7, 139, 155 | ***: 4, 37, 108, 158, 163 ** : 31, 32, 34, 53, 123, 162 * : 146 | * : 28, 48, 69, 98, 107, 122 * < P < 0.1: 13, 15, 18, 51, 54, 57, 108 , 144, 148 |
| 2 | Directional: 4, 42, 71, 108 Balancing: 5, 7, 55, 100, 101, 137, 155 | ***: 4, 108 * : 32, 34, 74, 116, 123, 142, 162, 163 | ** : 118 * : 13, 18, 69, 72, 74, 86, 122 * < P < 0.1: 15, 26, 98 |
| 3 | Directional: 71, 89, 108 , 133, 161 | ***: 108 ** : 38, 81 * : 89 | ***: 81 ** : 89 * : 12, 80, 106, 124, 152 * < P < 0.1: 33, 35, 76, 129, 134, 156 |

Loci in bold are detected by BAYESCAN and the SAM and/or the GLMM approach.

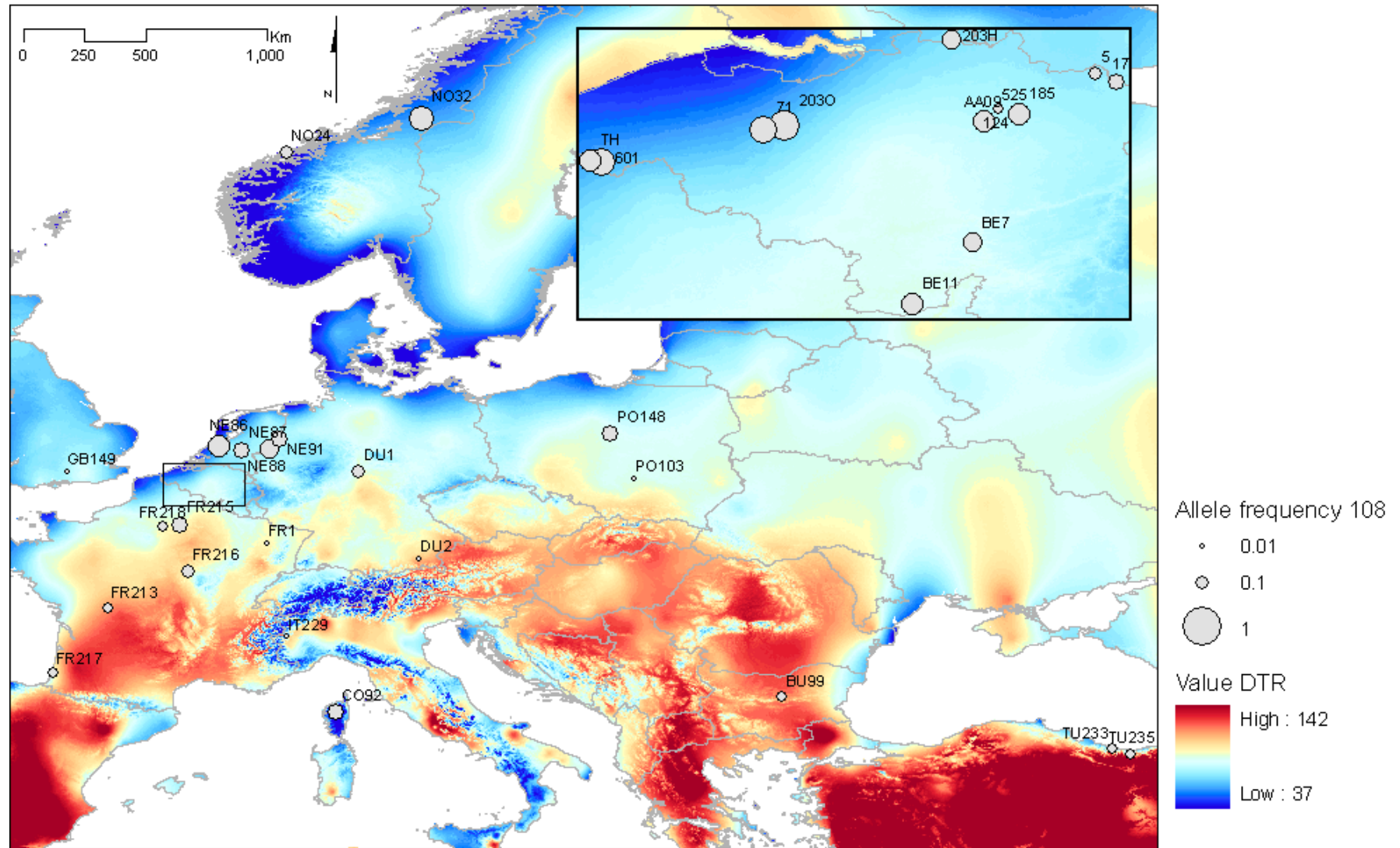
*** P < 0.001; ** P < 0.01; * P < 0.05.

Selective loci: summary

- Locus 108: DTR and several monthly T (scale dependent)
- Locus 4: monthly min. T  Only at European scale
- Locus 81: DTR, 1 to 2 monthly values of max. T, precipitation and sunshine fraction
- Locus 89: precipitation 
- **Mainly in relation with temperature-related variables**

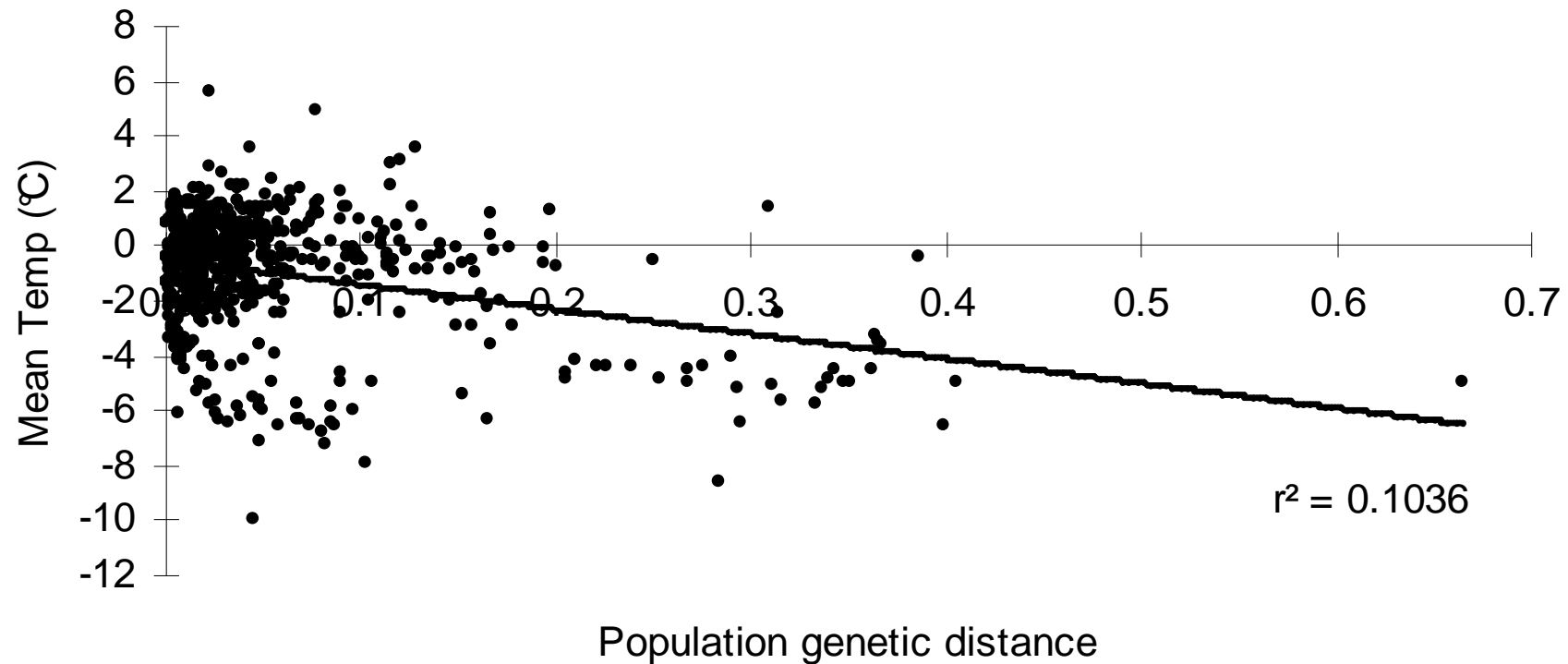
Only at regional scale 

Locus 108 vs. DTR



(DTR grid: Hijmans *et al.* 2005; <http://www.worldclim.org>)

Isolation-by-temperature



Maximum T ($r^2 = 0,1012$, $P = 0,035$)

No relation with neutral loci

Cox *et al.* 2011 Mol. Ecol.

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 - Selective loci found **on the European and on the regional scale**
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 - **Genome scan + population genetics** approach = **more confident results**
 - Selective loci found **on the European and on the regional scale**
- ✓ Relation with certain climate variables
 - Selective loci: under **directional selection**, in relation with **temperature**



Thank you!

Thomé 1885