Challenges of conservation:

Assets and constraints of amplifying genetic adaptability in view of climatic change - seen from spruce and pine prov. tests

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Dilemma: Human support vs spontaneity

Great challenge to forestry:

- Preparation for climate change +
- Return to nature-close silviculture

Reliance on spontaneous processes or human intervention?

What is the mission of conservation?

- Which diversity is valuable and contributing to adaptation?
- How to utilize in a nature-close forest management environment?

How serious are projected changes compared to postglacial changes?

Fluctuation of annual average temperatures (deviations from the grand mean, °C)

Last 100 thousand years (global ann. average)	-8 / +2
Last 1000 years (ann. average, Europe)	-0,8 / +0,8
Projected for the 21. century	+2 ~ +4-5...

Is spontaneous (diploid) migration a realistic expectation?

Speed (km/century) of postglacial migration vs. projected S→N isotherm shift

Spruce (Davis-Shaw 2001)	8-50 km/century
Isotherm shift speed, 2.0 °C temp. increase	290 km/century (= 600 years!)
Isotherm shift speed, 4.0 °C temp. increase	580 km/century (= 1150 years!)

(Jump, Mátyás, Penuelas Trends Ecol. Evol. 2009)

Contribution of spontaneous processes to genetic adaptation: from a generation perspective

	Present generation	Next generation	Far future
Diploid migration	-	+/-	++
Gene flow	-	+/-	+/-
Mutation	--	--	-
Natural selection	+	+	+
Plasticity	++	++	++
Epigenetics	??	??	??

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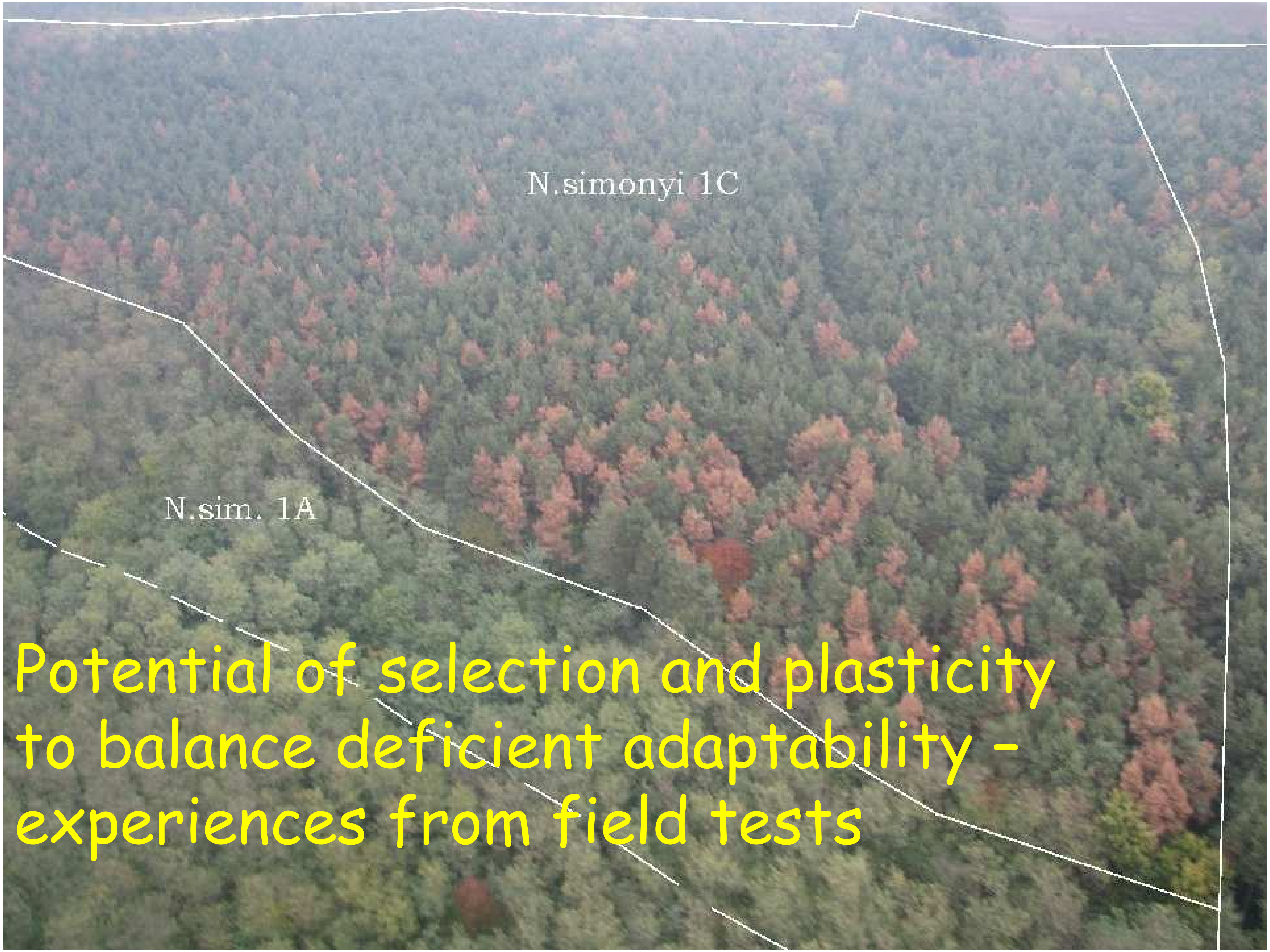
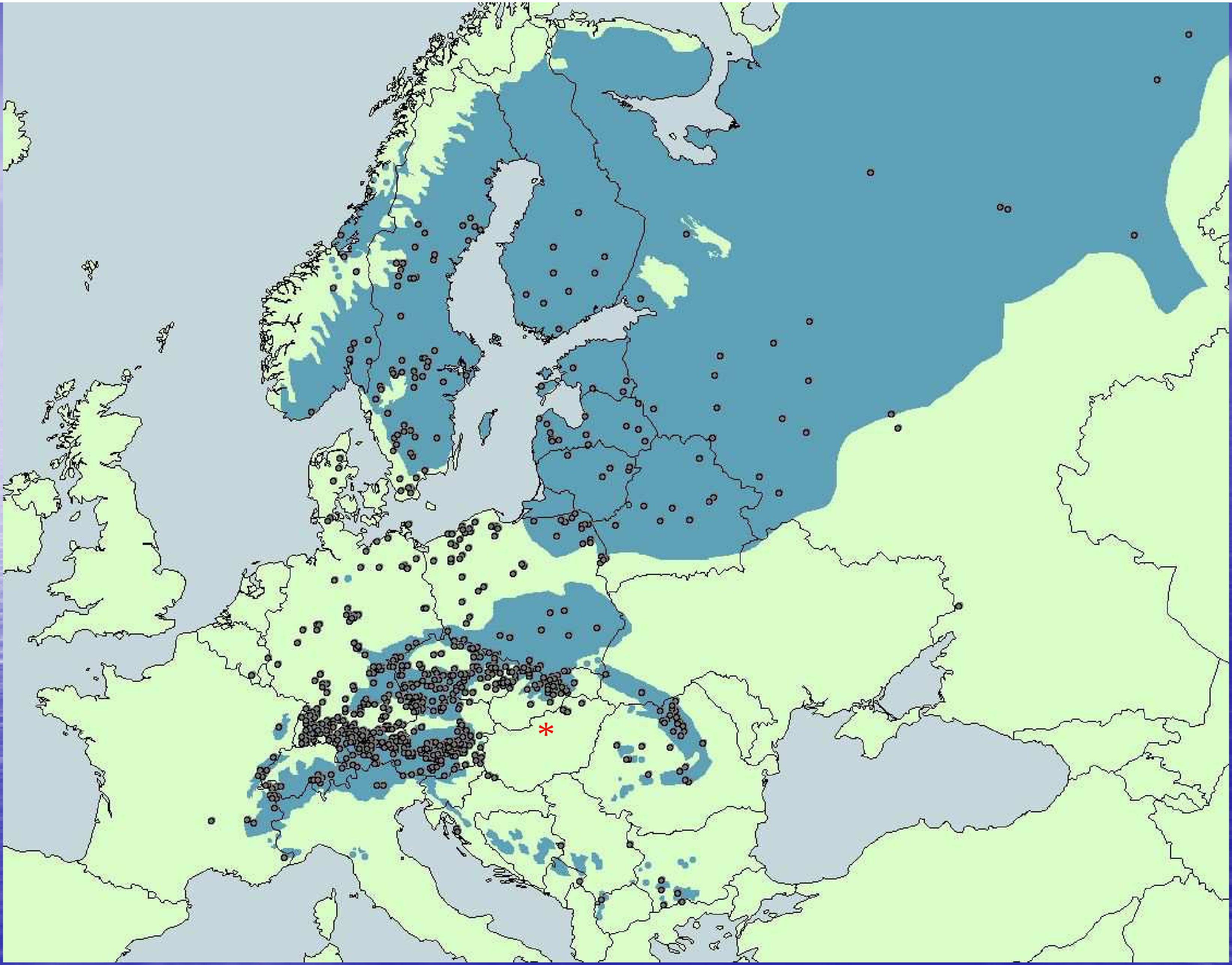
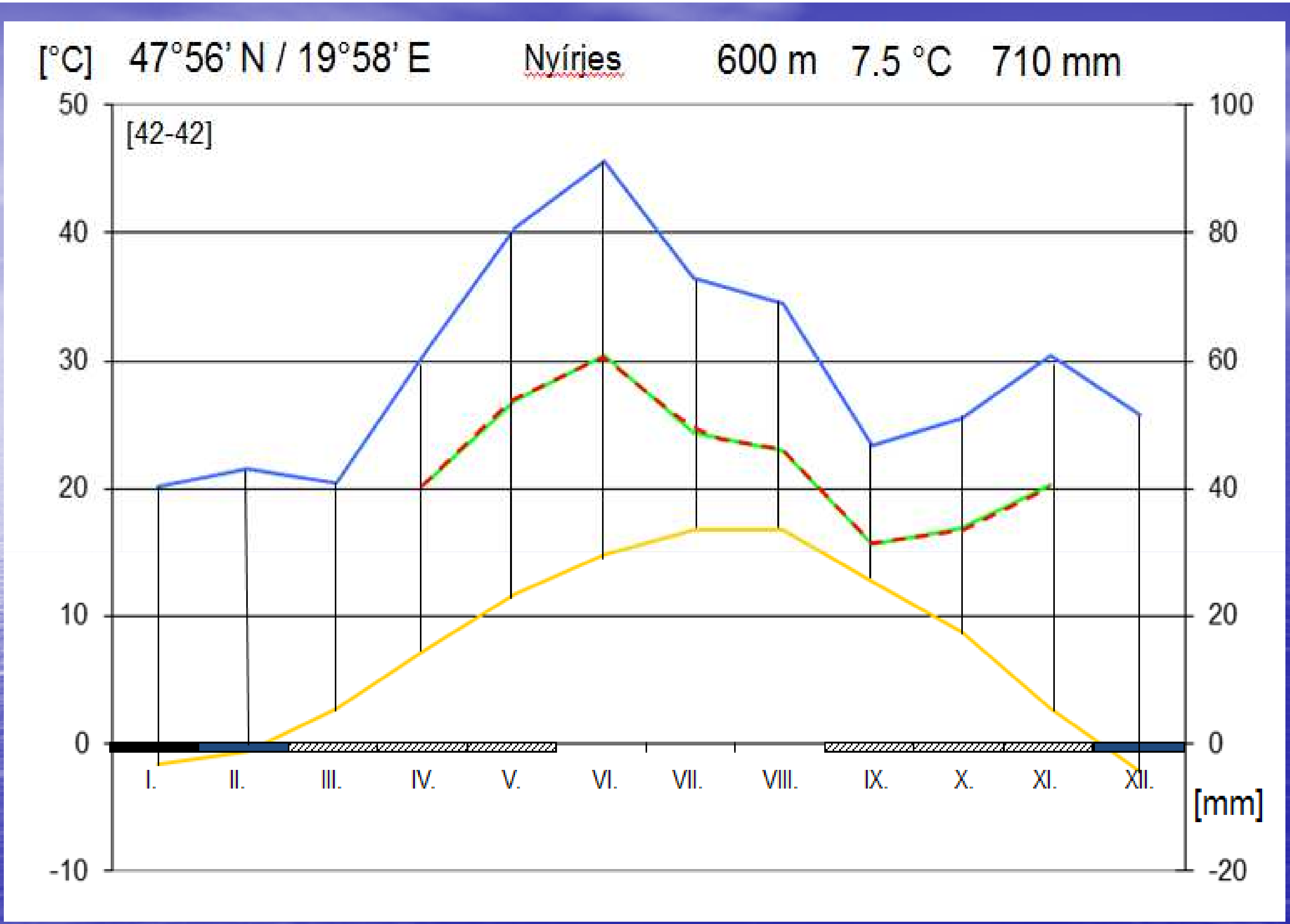
Natural selection	+	+	+
Plasticity	++	++	++
Epigenetics	??	??	??

Potential of selection and plasticity to balance deficient adaptability – experiences from field tests





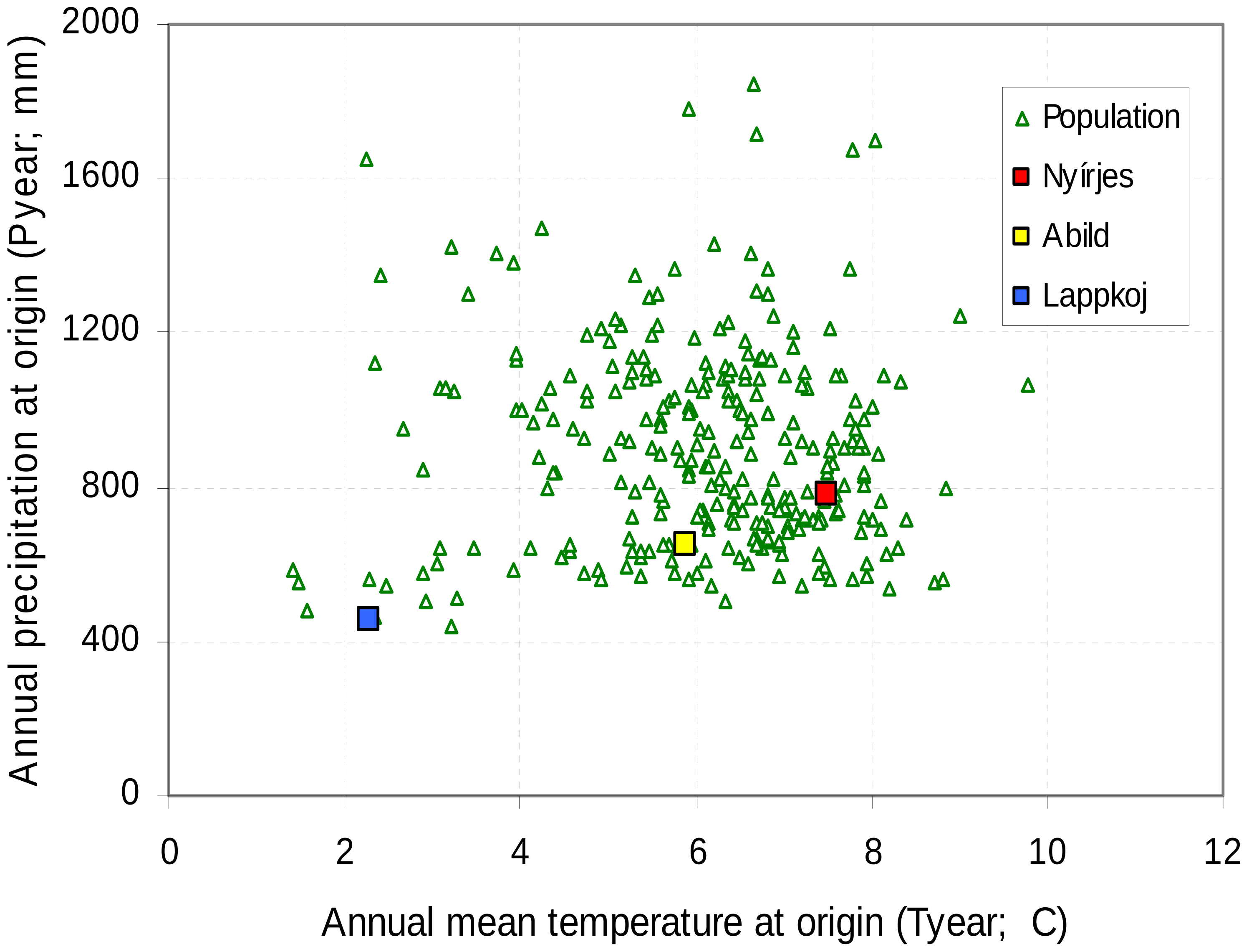
Natural distribution of Norway spruce (EUFORGEN) and location of tested provenances and of IUFRO test site Nyírjes , Hungary



*Climate diagram for 1968-2010: **„beech climate zone”***

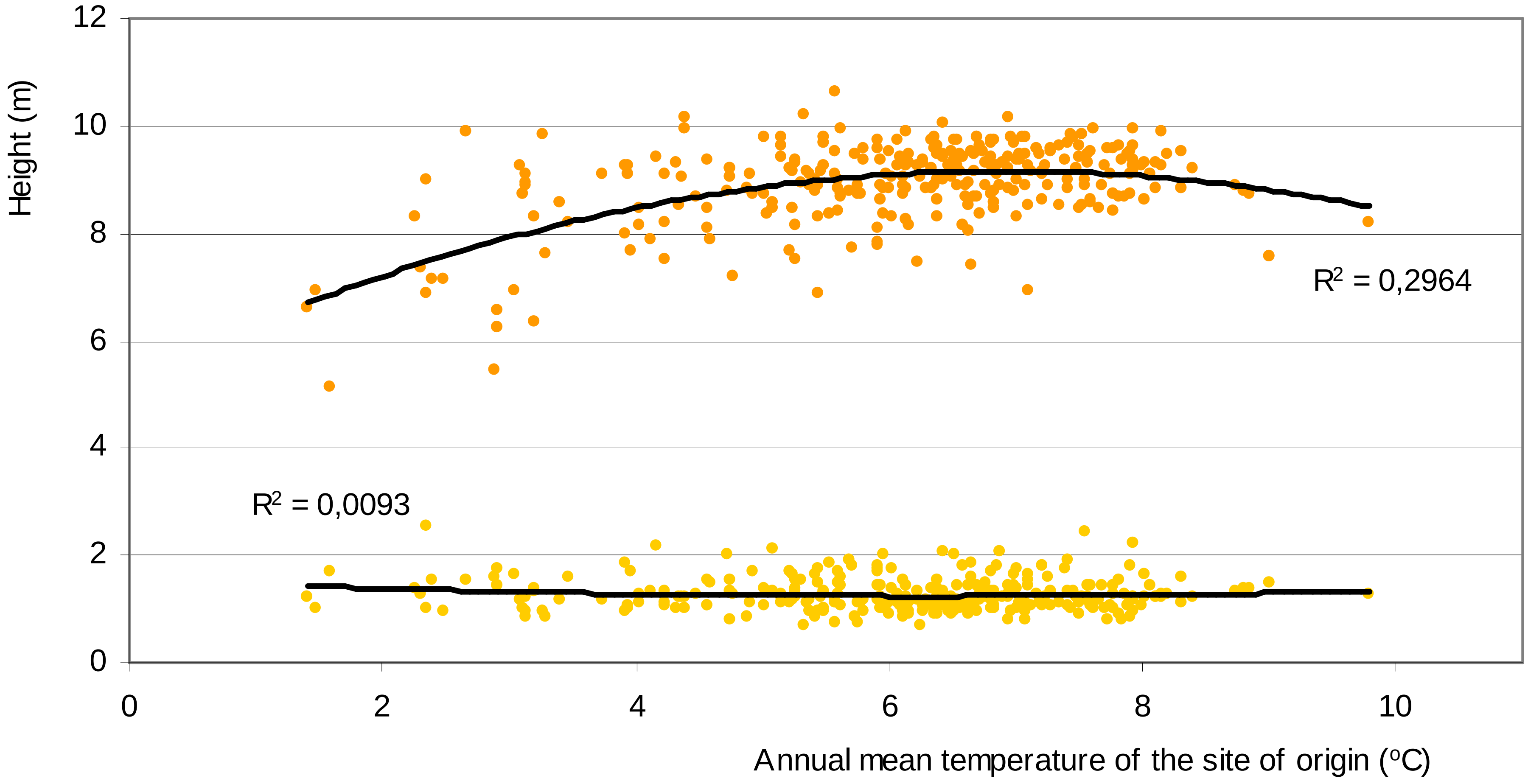
Established 1968, geographical coordinates: 47° 56´ Lat., 19° 58´Long

Net area: 11 ha, 1100 provenances *(Rasztovits – Móricz)*



Outside of range, inside of climate niche: *distribution of the tested 291 provenances (annual temp. vs precipitation), location of sites*

IUFRO NS test, Nyírjes, Hungary

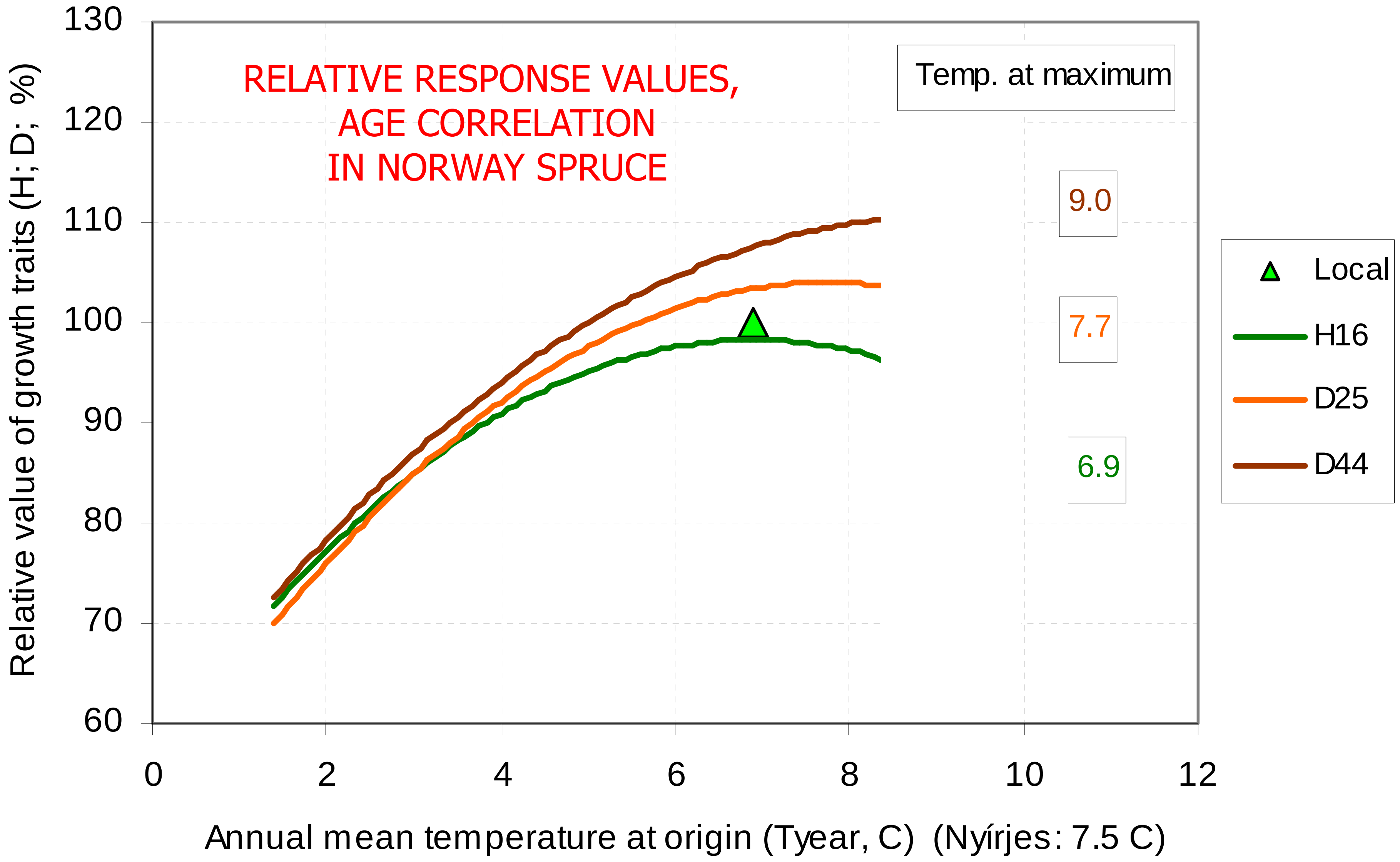


Average tree height (vertical axis) of Norway spruce at age 16

and within-population stdev.of height

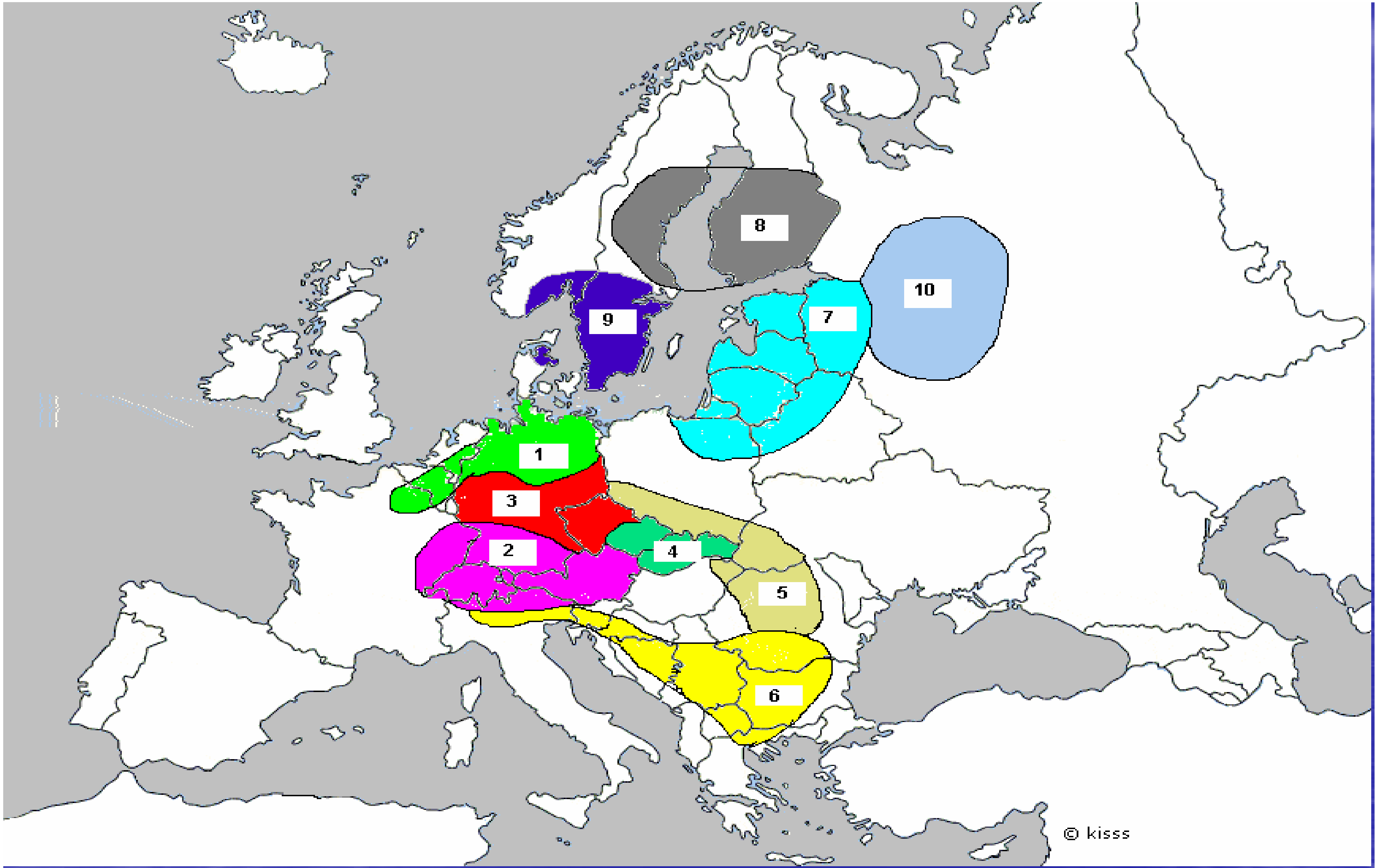
versus annual mean temperature of the location of origin

(É. Ujvári-Jármay, L. Nagy, C . Mátyás 2010)

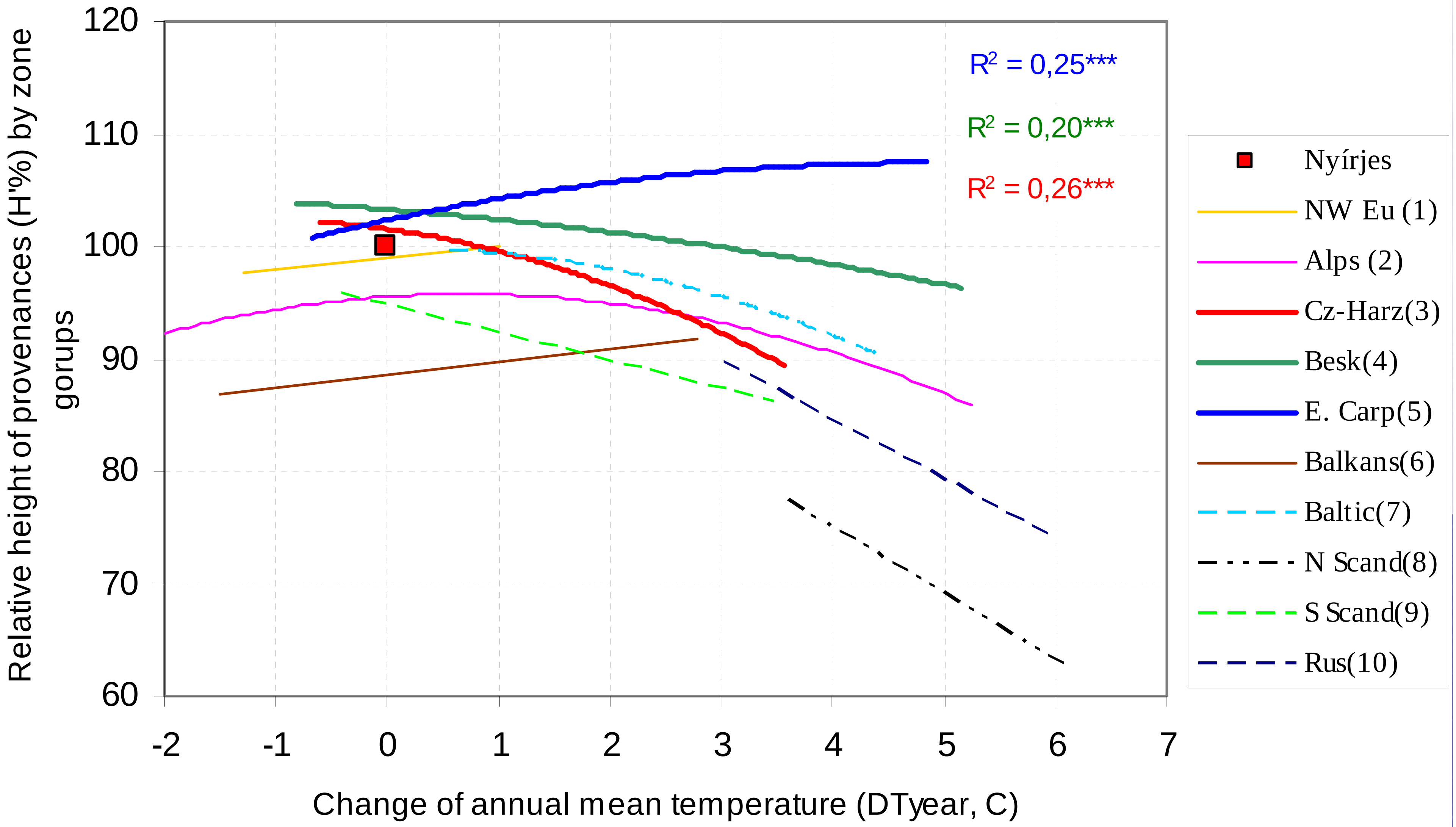


Regression of H16 and 25-, 44-year DBH (%) of identical provenances versus mean annual temperature (°C) at origin (horizontal axis) at Nyírjes

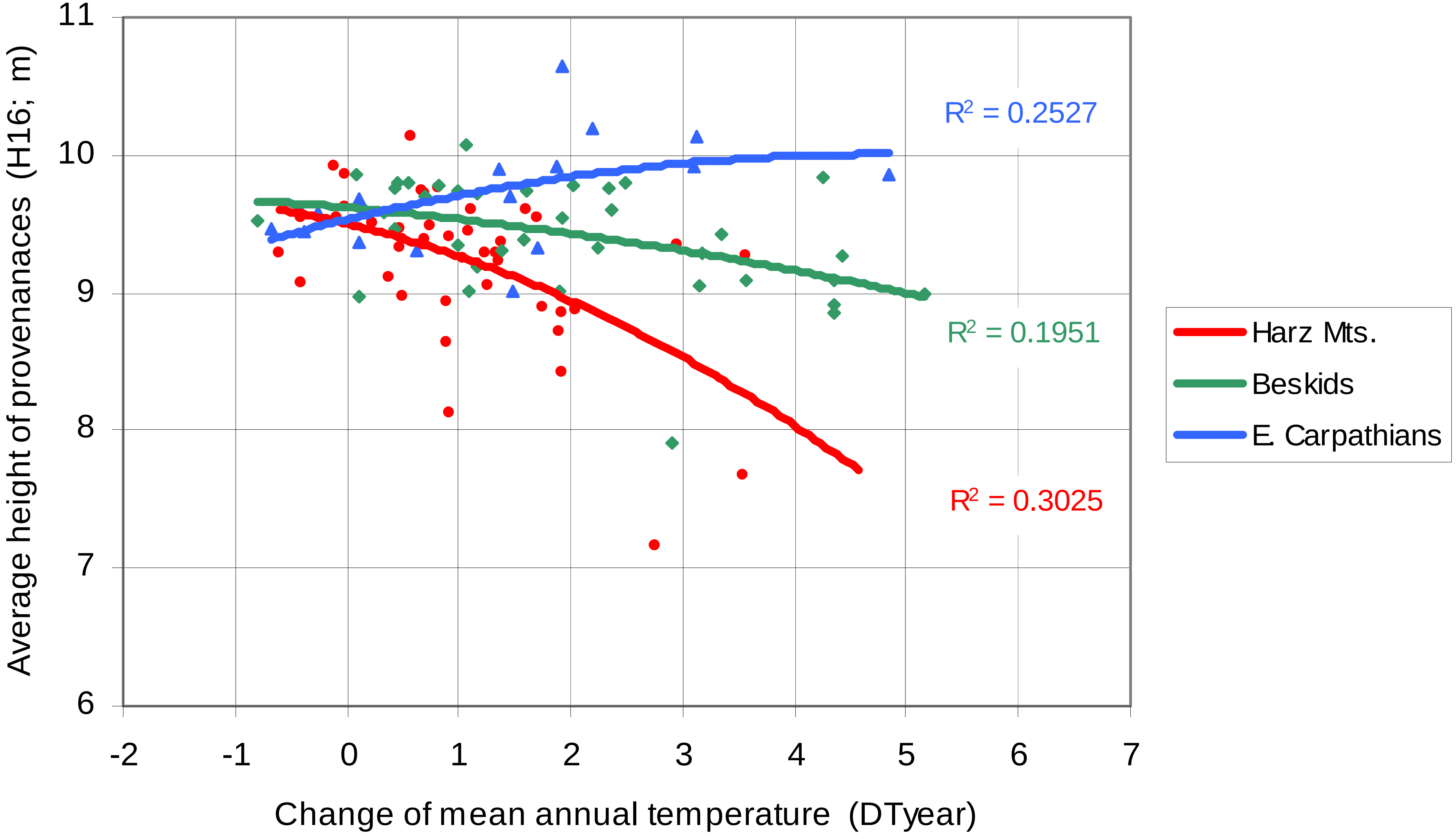
Temperature increase in lifetime of test: 1.3 °C!! (É. Ujvári-Jármay)



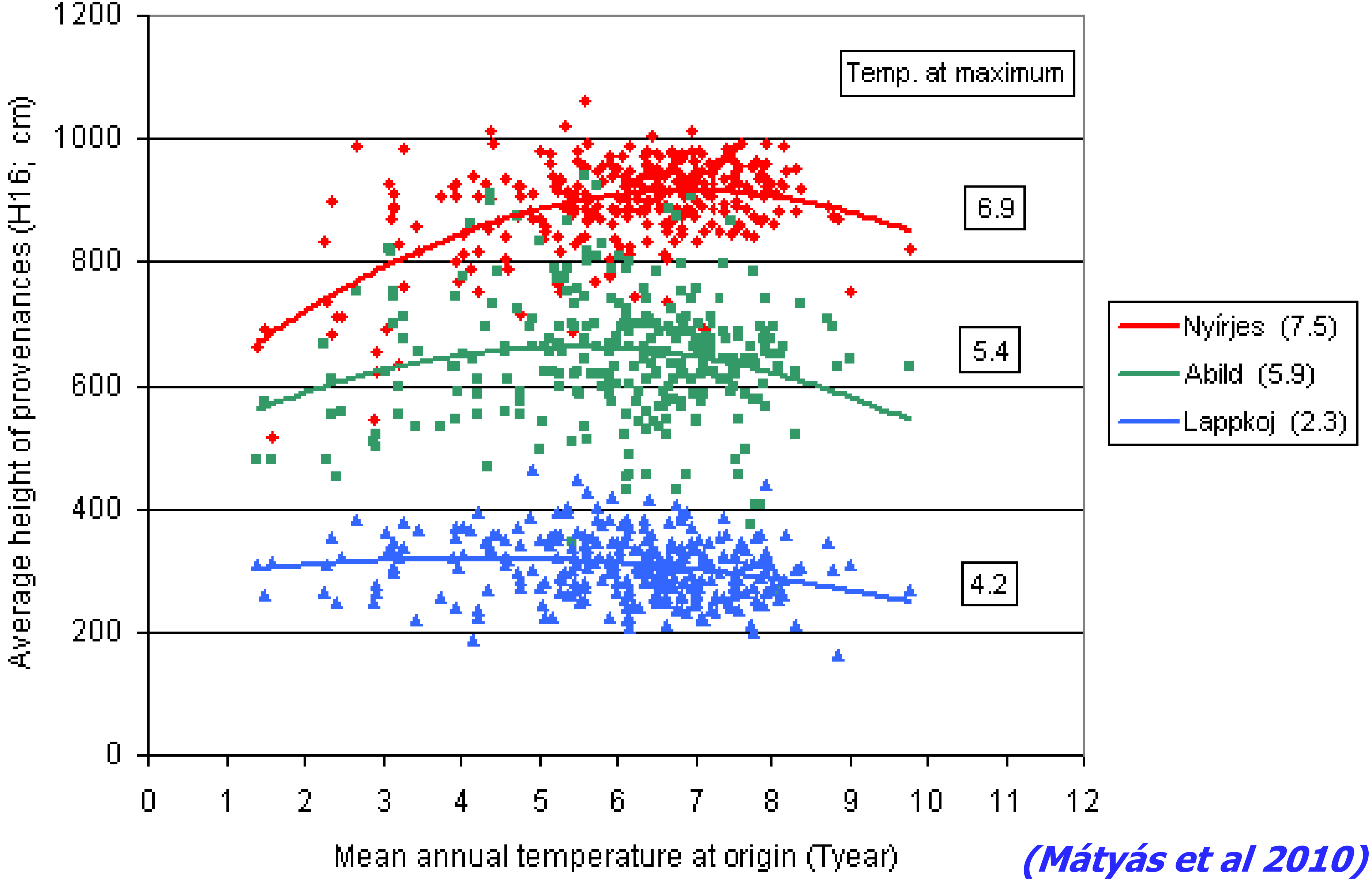
zone grouping of analysed 300 Norway spruce provenances *(Ujvári-Jármay 2006)*



Response regression of zone goups (Nyírjes,Hungary)
Mean annual temperature change (°C) vs 16-year relative height

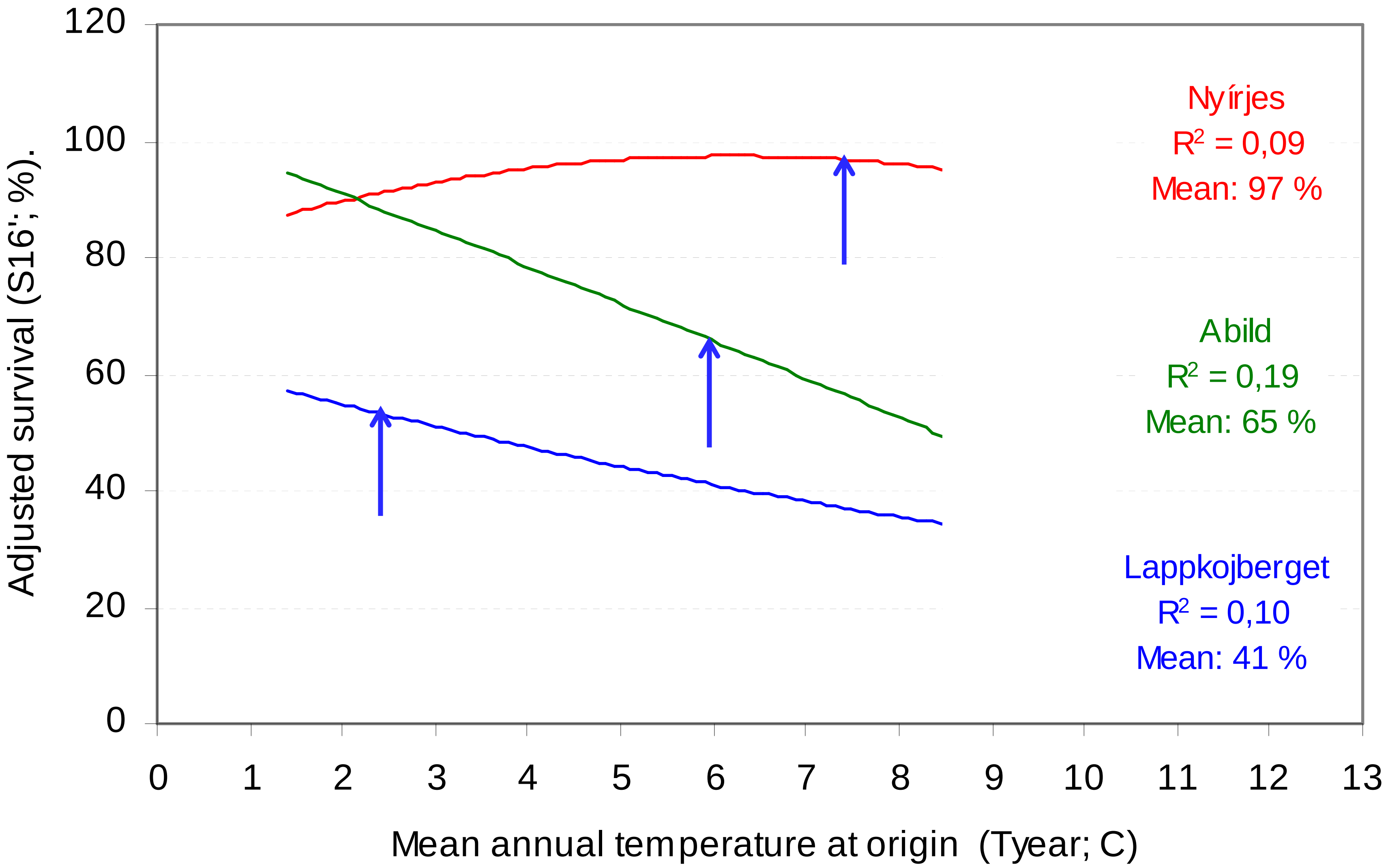


Mean annual temperature change (°C) vs 16-year relative height, 3 provenance groups ***(Mátyás et al 2010)***



(Mátyás et al 2010)

Height 16 of identic Norway spruce provenances vs mean annual temp.



Survival at age 16 (%) of 291 identic provenances at 3 test sites, versus mean temperature at origin. Arrows: temp. at test (É. Ujvári)

Data of three experiments (height 16)

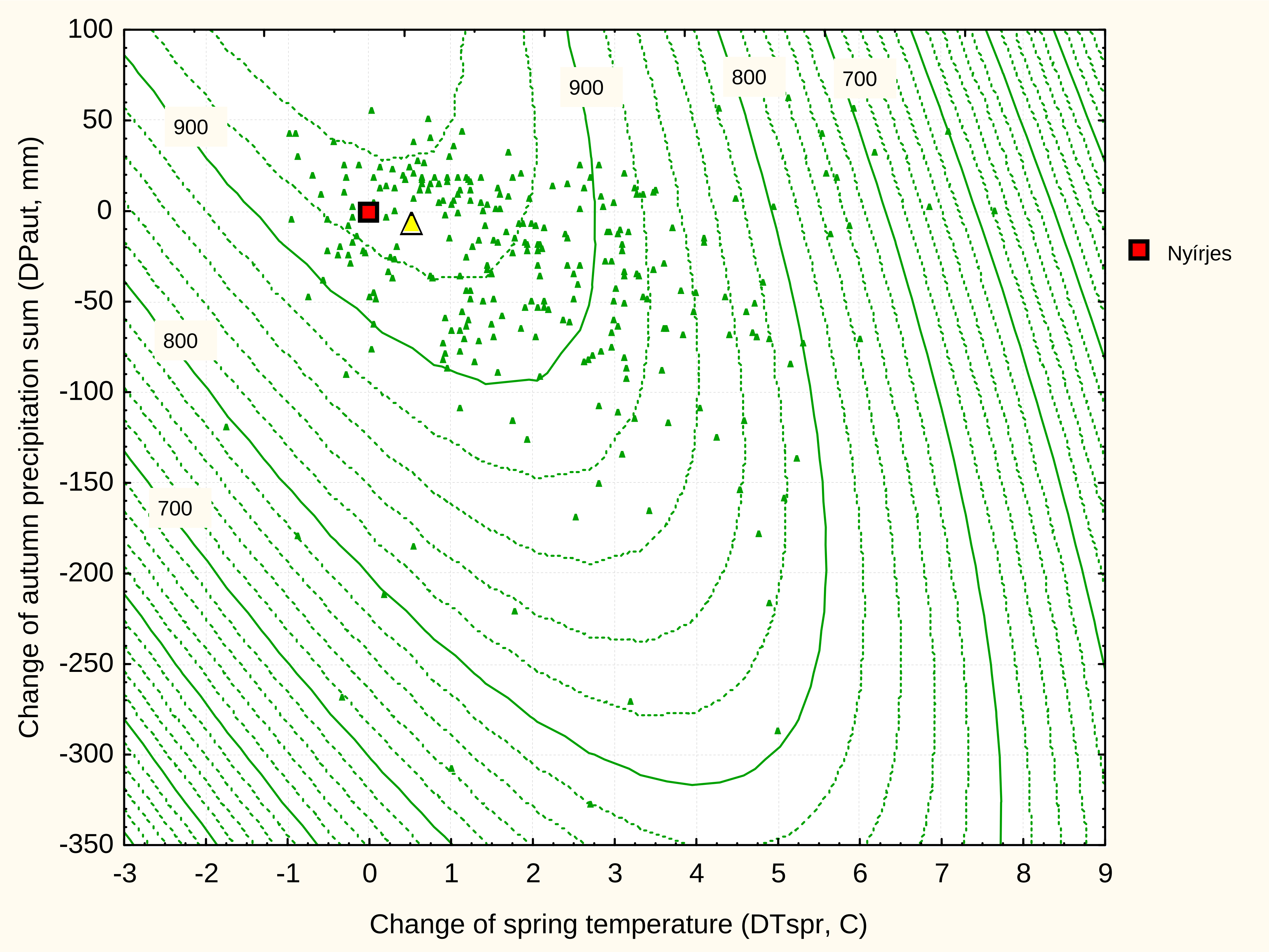
Experimental site data			
Test name	mean height of test (cm)	Mean temp. °C	Mean prec. (mm)
Nyírjes (HU)	892.5	7.5	782
Abild (SE)	643.1	5.9	654
Lappkoj (SE)	305.4	2.3	456

Response function (H16) maximum vs experimental mean (identic populations!)

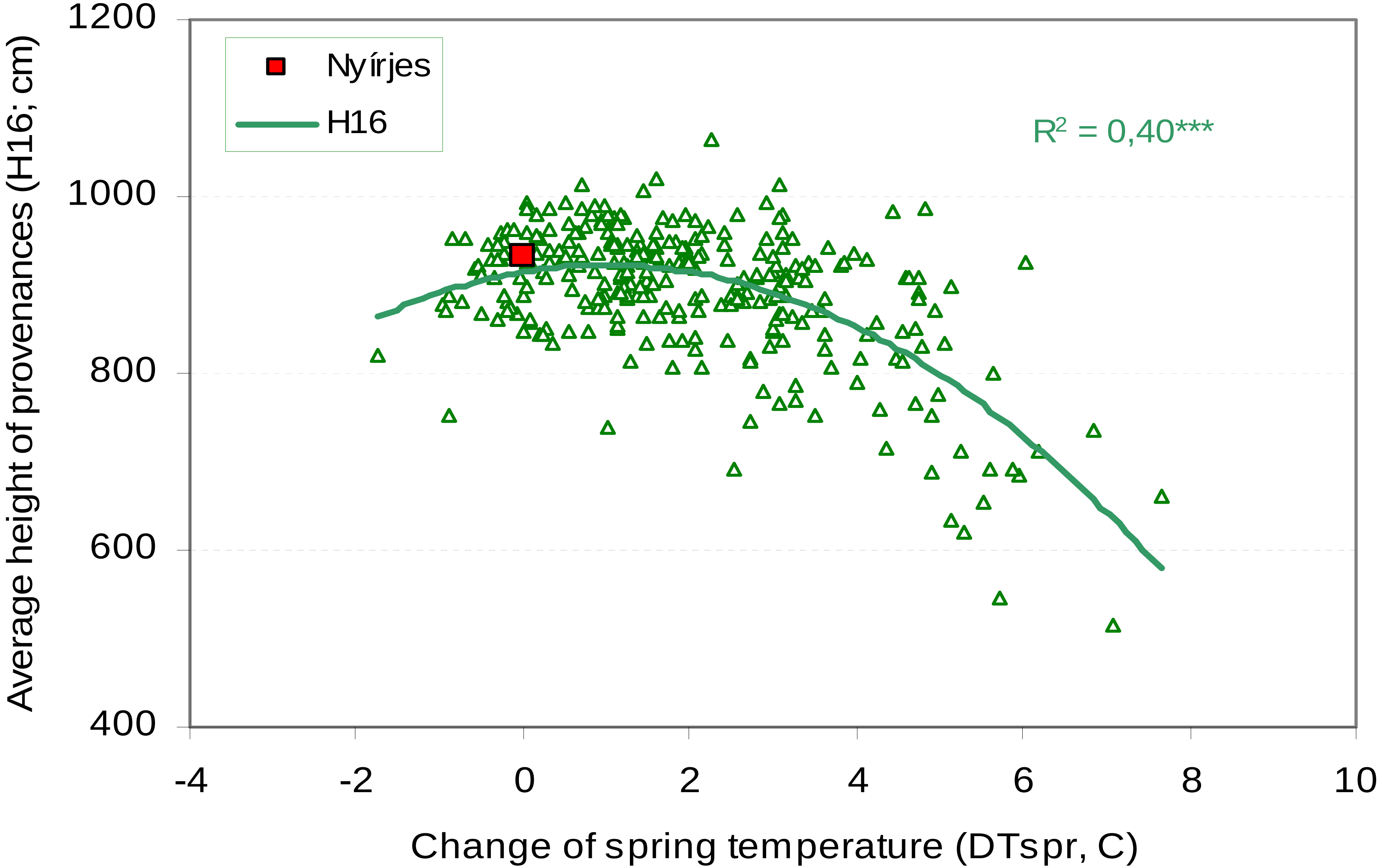
Experimental site data			Response function	
test name	mean temp. (°C)	mean height (cm)	temp. at maximum (T_{max} °C)	**mean height at T_{max} (cm)**
Nyírjes (H)	**7.5**	890.3	**6.9**	**916.1**
Abild (S)	**5.9**	643.1	**5.4**	**661.7**
Lappkoj (S)	**2.3**	305.4	**4.2**	**319.1**

Correlation between adjusted heights (H16) in 1983 and different ecodistance values of transfer to test site Nyírjes

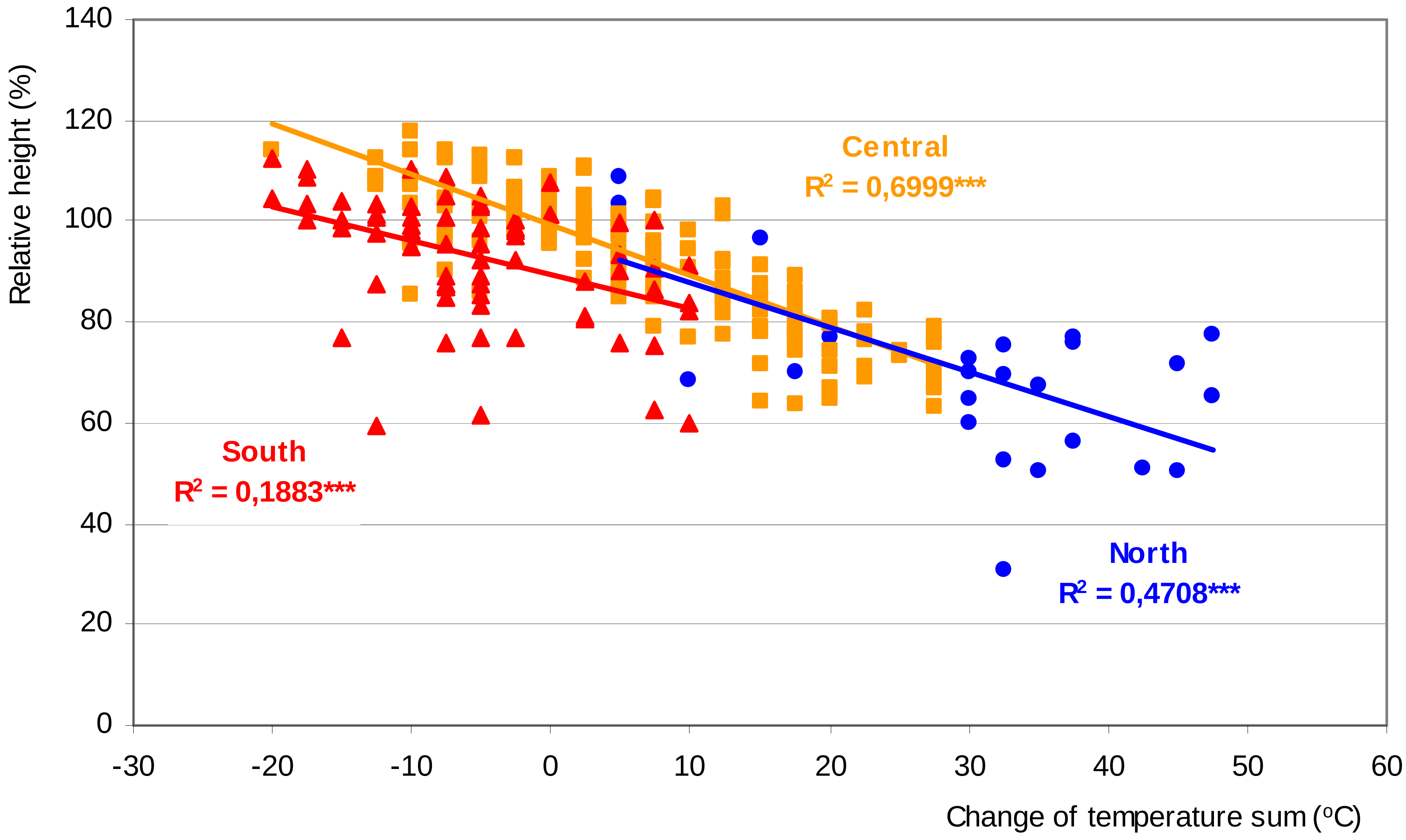
Variables Name of ecodistances	All prov. (n=291)	Southern range (n=236)	Northern range (n=55)
Mean annual temperature, C° (DT_{year})	- 0.44	- 0.11	**- 0.79**
Continentality, T_{max} - $T_{min.}$ (DT_{cont})	0.18	- 0.49	**0.30**
Mean temp. of vegetation period, 04-10 (DT_{veg2})	- 0.41	- 0.26	**- 0.82**
Mean winter temperature, 12, 01, 02 (DT_{win})	- 0.38	0.17	**- 0.61**
Mean spring temp, 03-05 (DT_{spr})	- 0,51	- 0.23	**- 0.81**
Mean summer temp, 06-08 (DT_{sum})	- 0.26	-0.29	**- 0.72**
Mean autumn temp, 09-11 (DT_{aut})	- 0.43	- 0.07	**- 0.75**
Number of months above 5 C° (DT5+)	- 0.49	- 0,22	**- 0.72**
Average precipitation sum per year, mm (DP_{year})	0.09	**0.53**	- 0.11
Av. precip. sum in veget. period, 04-10 (DP_{veg2})	0.06	**0.50**	- 0.14
Av. precip. sum in winter, 12, 01, 02 (DP_{win})	0.14	**0.48**	- 0.07
Av. precip. sum in spring, 03-05 (DP_{spr})	0.01	**0.51**	- 0.27
Av. precip. sum in summer, 06-08 (DP_{sum})	0.00	**0.43**	- 0.11
Av. precipitation in autumn, 09-11 (DP_{aut})	0.25	**0.56**	- 0.03



Change of autumn precipitation sum (DPaut, mm)
Change of spring temperature (DTspr, C)
100
50
0
-50
-100
-150
-200
-250
-300
-350
-3
-2
-1
0
1
2
3
4
5
6
7
8
9
900
900
800
700
800
700
Nyírjes



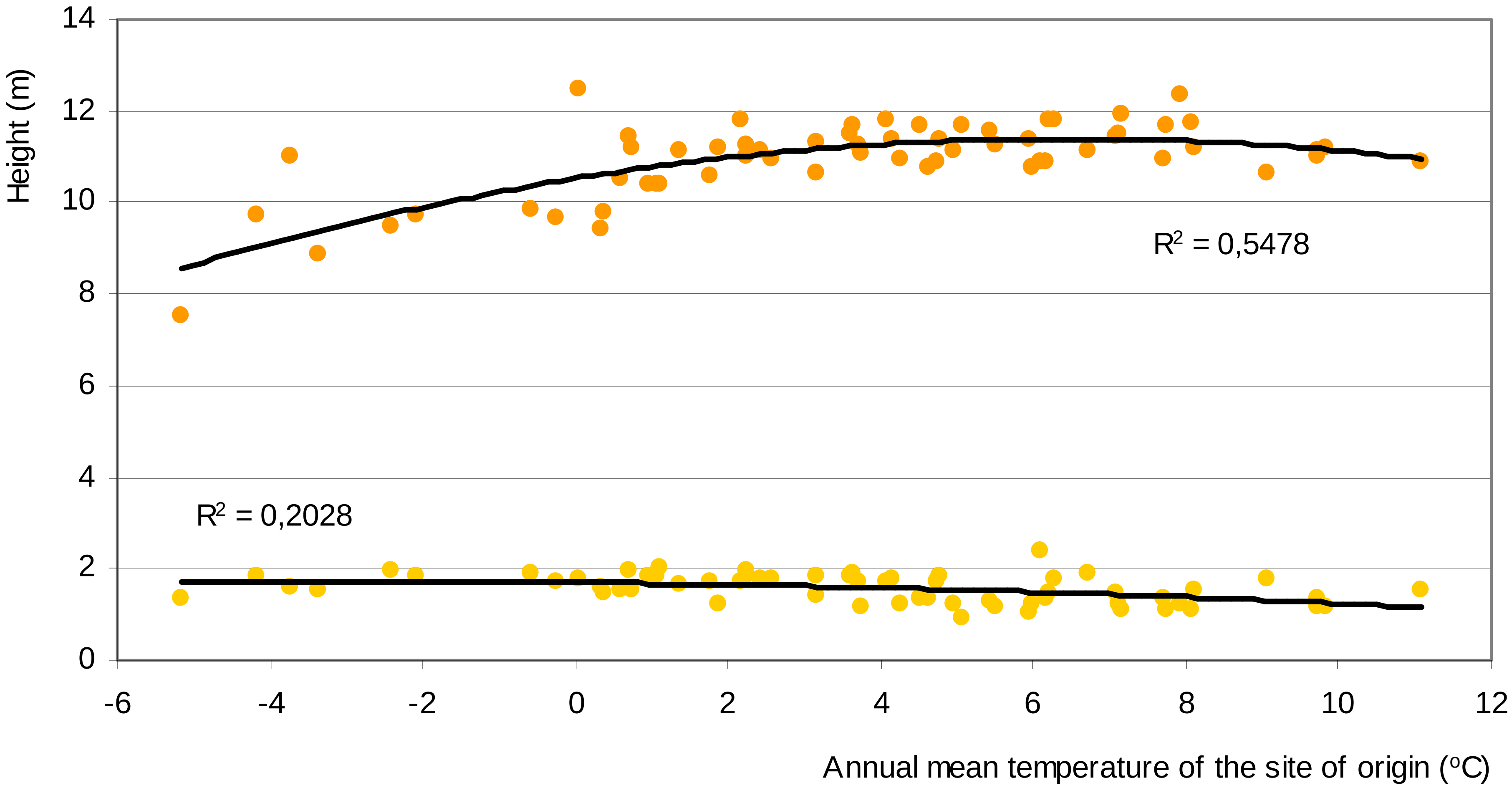
Cross-section of the three-dimensional GRM of H16 versus changing spring temperature (É. Ujvári-Jármay)



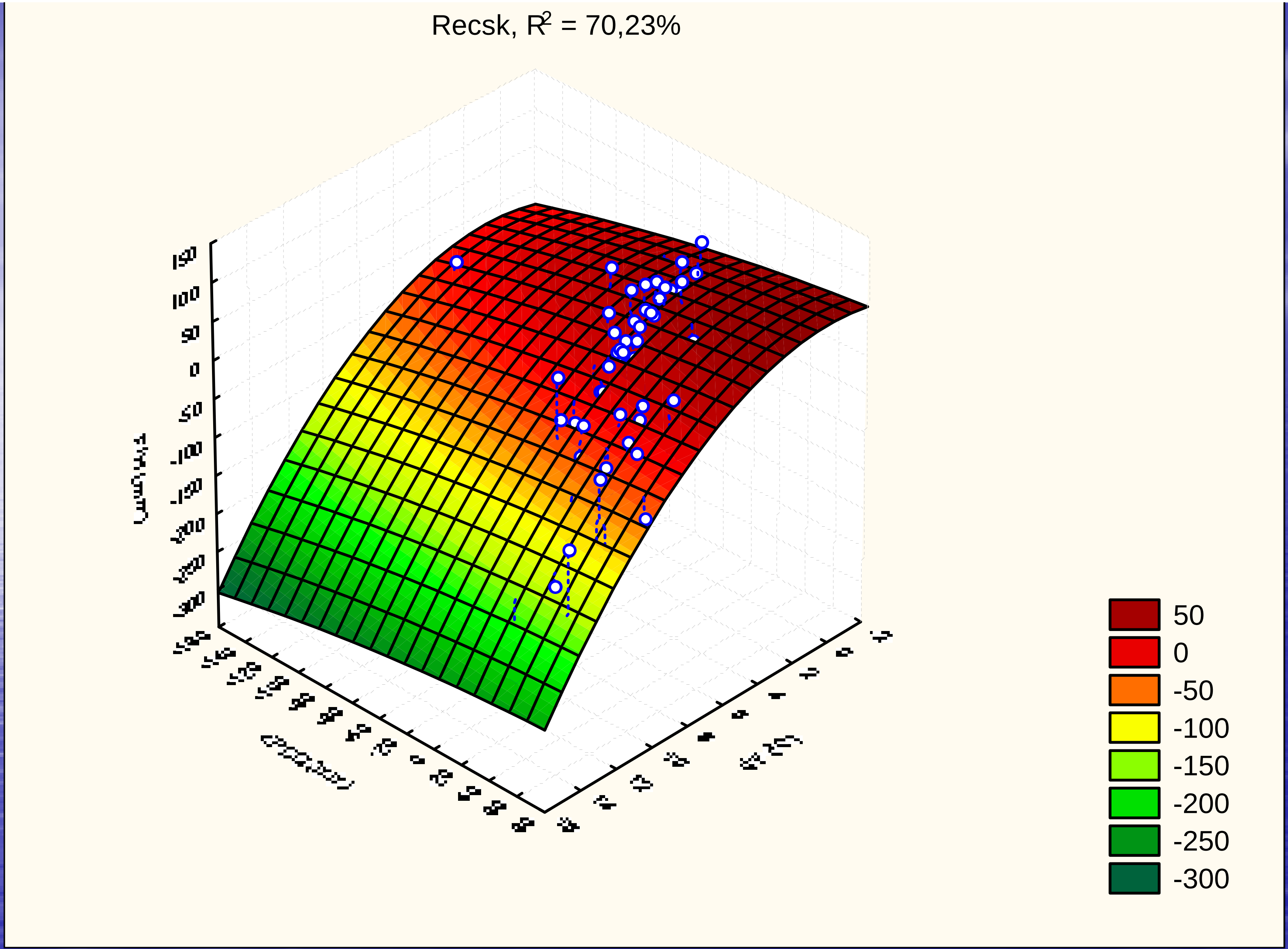
Relative tree height versus change of temperature sum (degreedays in °C) due to transfer

Scots pine in 6 Russian tests (Mátyás and Nagy 2005)

Comparison: Scots pine, VNIILM experiment, Hungary

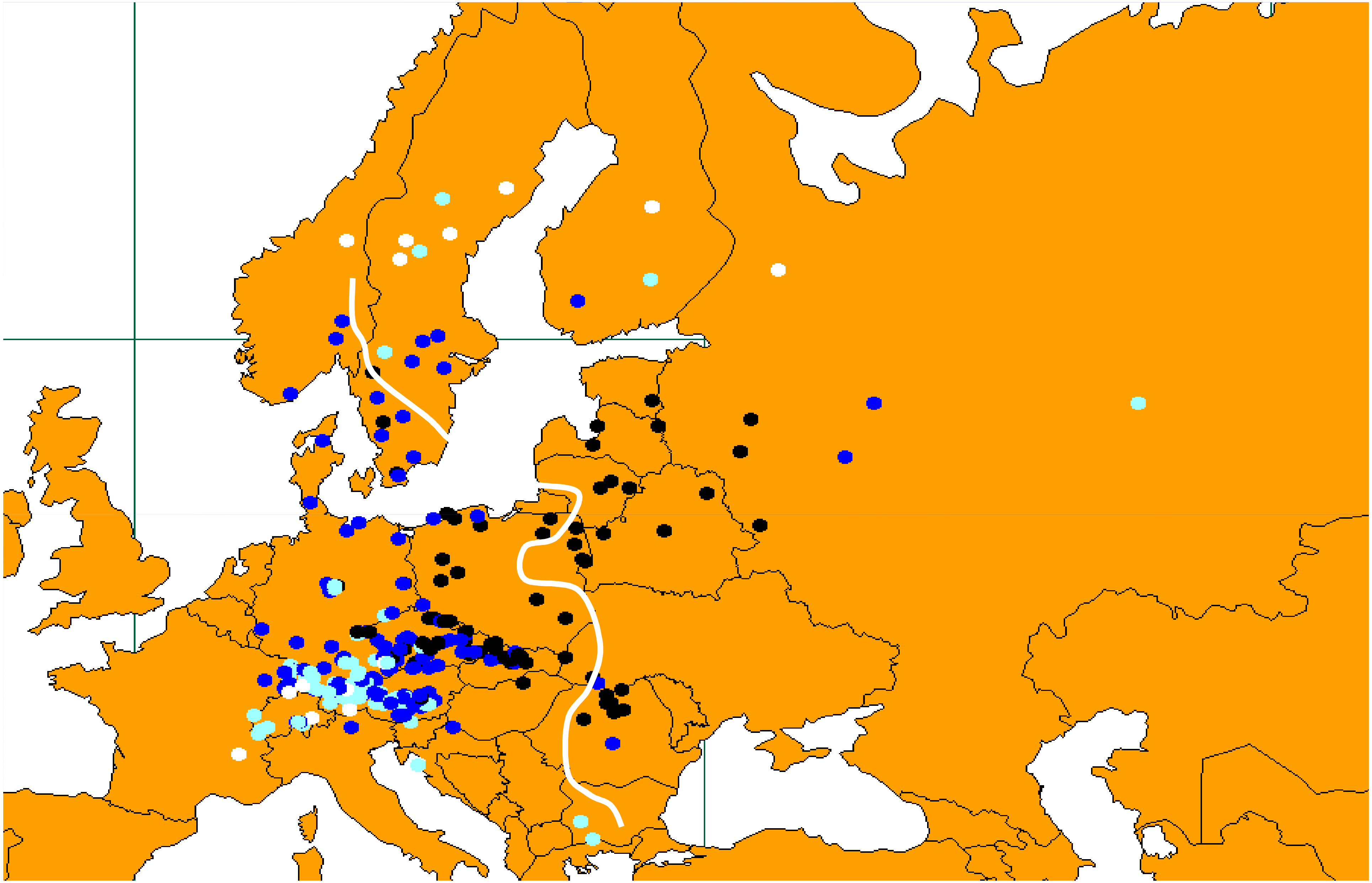


***Average tree height and within-population standard deviation at age 15 of Scots pine populations in the Recsk provenance test, versus annual mean temperature of the location of origin** (L.Nagy)*



Transfer functions of VNIILM Scots pine populations in Recsk, Hungary

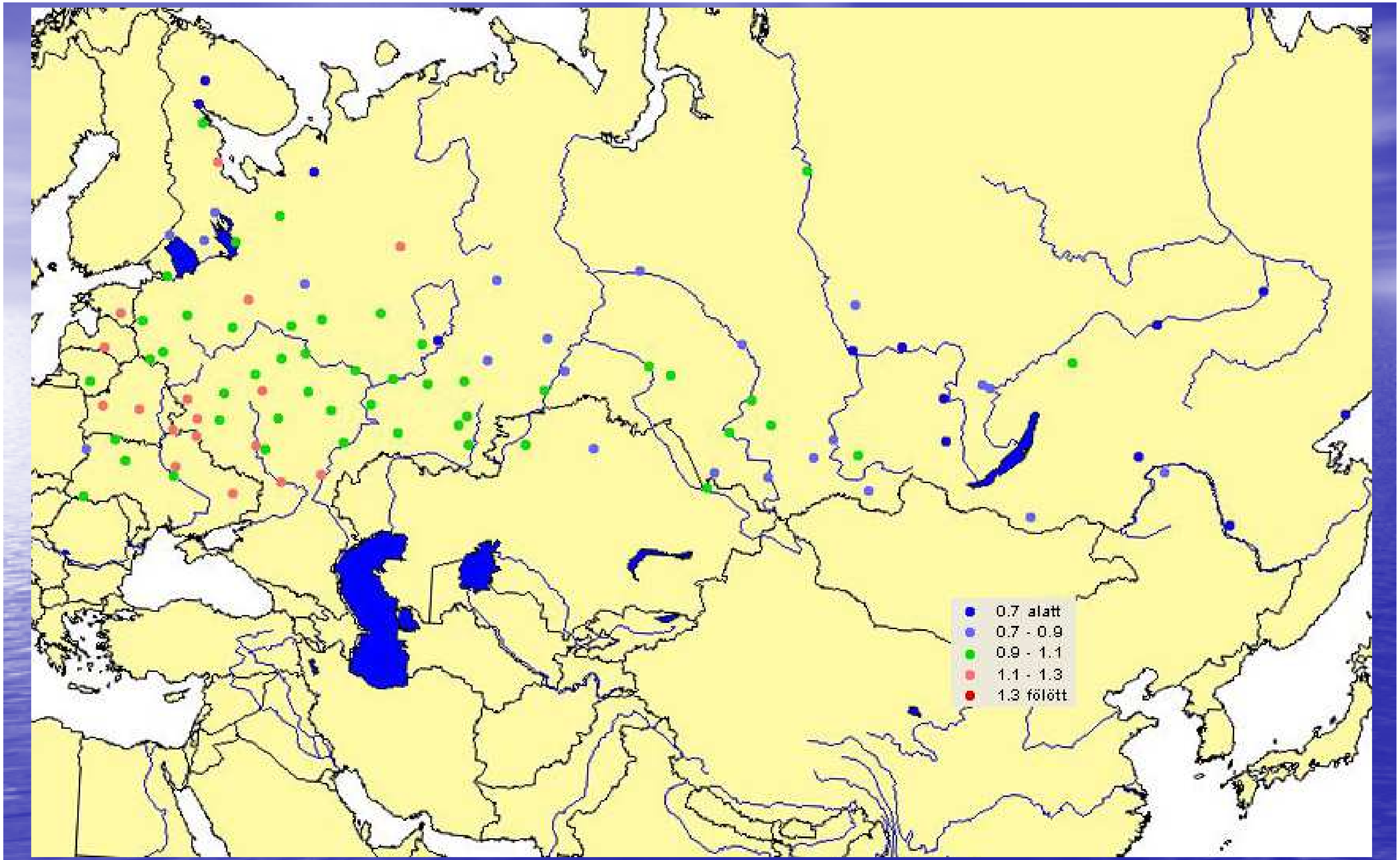
Left axis: dPDQ (precip. driest quarter) Right axis: dT (ann. mean temp)



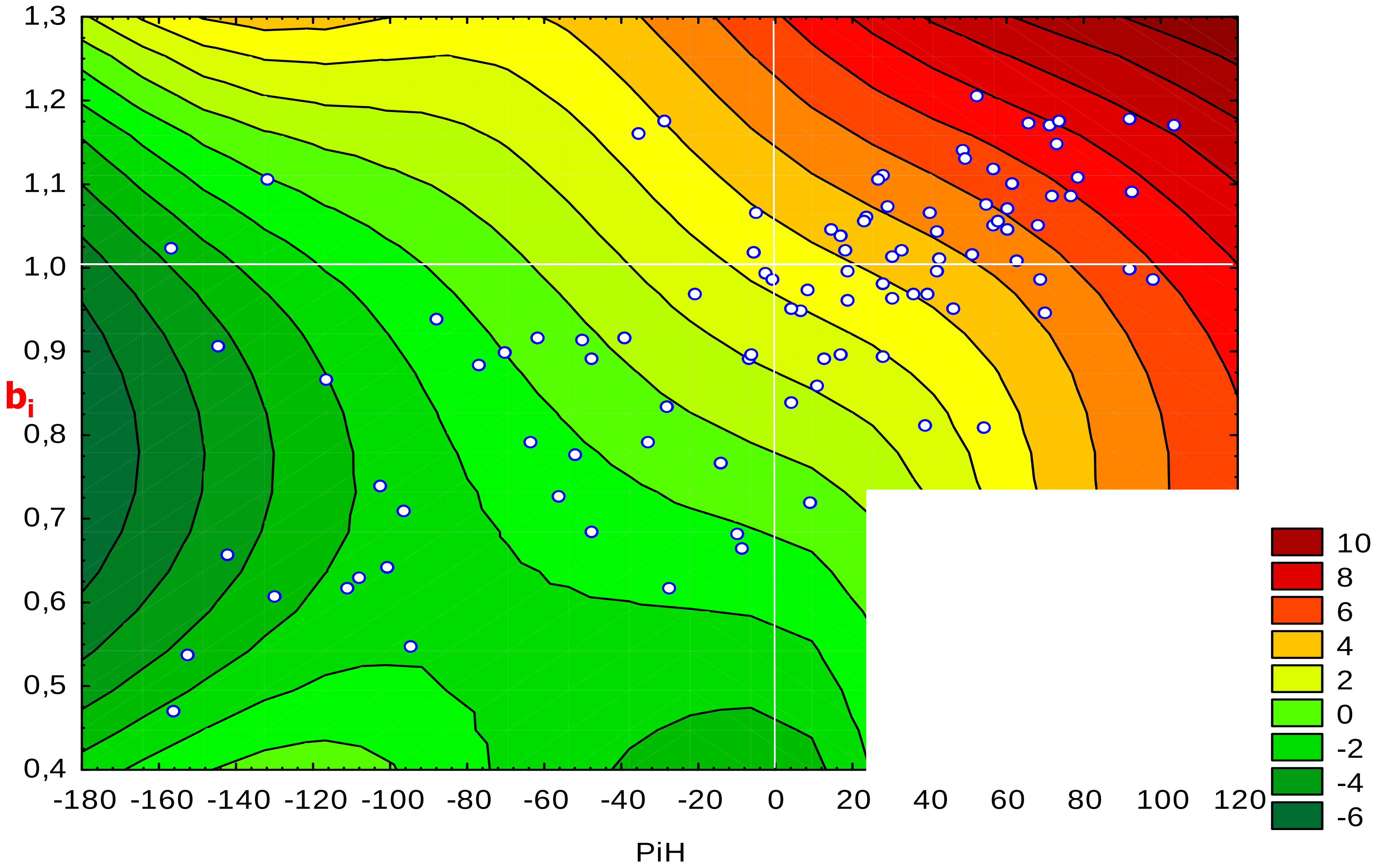
Plasticity of Norway spruce in 5 IUFRO trials

Relative performance: black 100-120%, blue 90-100%, light blue 80-90%, white: 50-80%

(Mátyás, Nagy, Ujvári unpubl.)

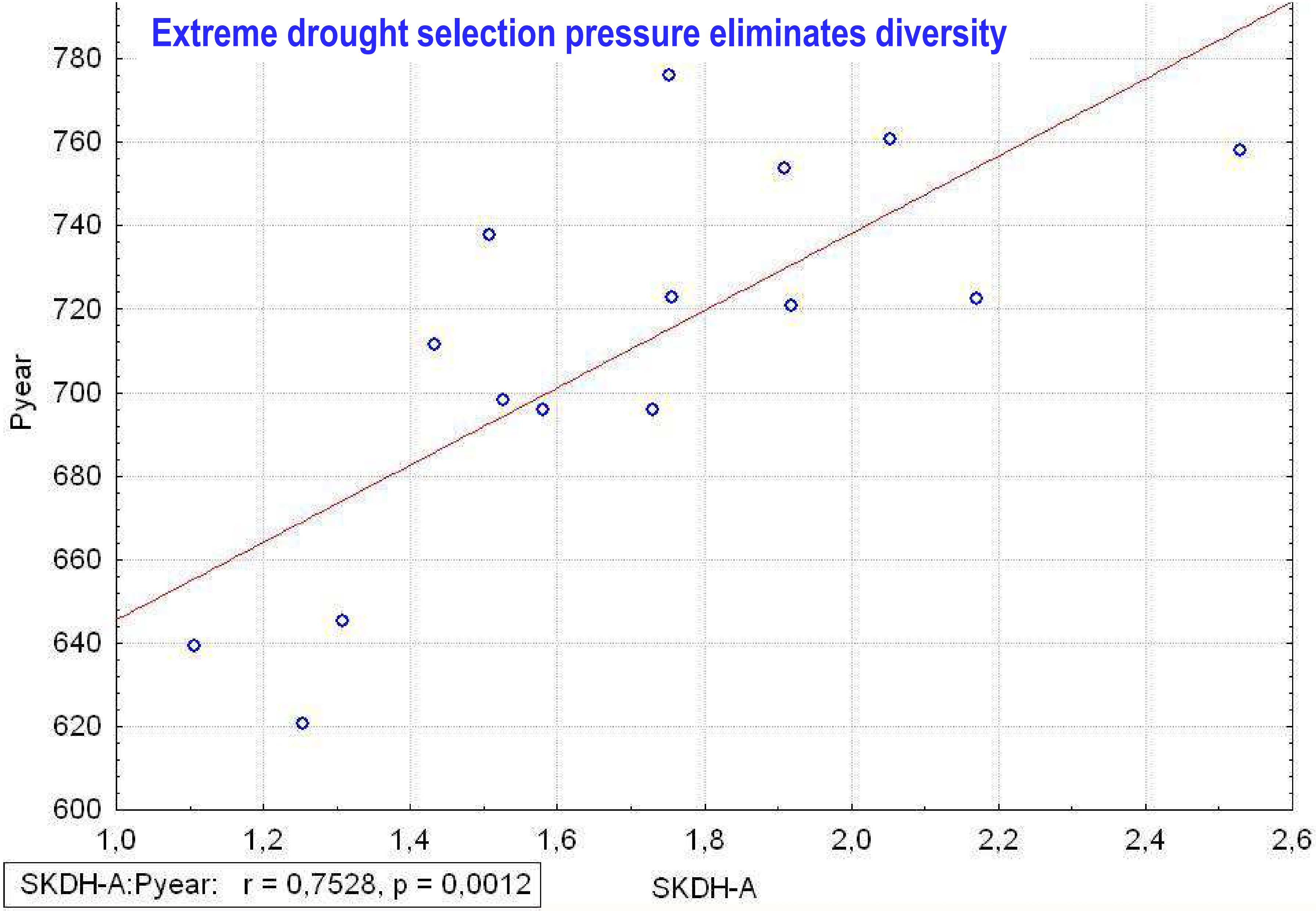


Geographical distribution of Eberhart-Russell's stability index (b_i) for height growth in the VNNILM Scotch pine test *(L.Nagy)*



***Stability (b_i) and height growth performance (PiH) indices vs annual mean temperature - VNNILM Scotch pine test** (L.Nagy)*

Extreme drought selection pressure eliminates diversity



Number of gene variants (genetic diversity) in beech
Allels at the SKDH gene locus, vs. ann. precipitation (Y axis)
(Borovics A., Mátyás C., Ann.For.Sci 2013,70:(8) 835-844

What do field tests of Norway spruce and Scots pine show?

- Lag in adaptation determined by balance between the genetic system, selection pressure, plasticity and gene flow,
- Phenotypic plasticity: regional differentiation,
- Weight of selective factors change with environment,
- Plasticity is low at (upper) limits (selection pressure high),
- Adaptibility/tolerance has constraints, especially vs thermic stress.

Conclusions for conifer breeding and conservation

Local adaptation is less developed than assumed

Between-pop. variation: strong correlation with climatic factors

Within-pop. variation: macroclimatic effect undetected (centre vs. margins)

Response to simulated climate change primarily provoked by heavy thermal stress

High phenotypic plasticity of populations in milder, variable climate?

SP: in Western Russia

NS: East-Centr. Europe

Severe climatic stress may cause limited plasticity → limited adaptability?

Conservation as means of facilitating adaptive processes

Necessity of supporting spontaneous adaptation

- *adaptation has to be mastered within one single generation*
- *unprecedented speed of expected climatic changes*
- *local resource limitations of species and genes*

Conservation should (directly) support FRM production

Gene conservation in a rapidly changing environment

Ecological/climatic criteria instead of geographic ones should gain primary importance

Plasticity might get priority over autochthony

Plastic sources have to be identified, conservation and use promoted

Assessment and valuation of populations at range limits necessary prior to evacuation

Resources for *future FRM demand* have to be identified and conserved (not for the past!)

Sites of in situ gene conservation should be checked for future climate threats

Climate shift: differentiated measures Urgency for conservation depend on the local situation

optimum zone: exigent measures unnecessary

exposed sites: selective conservation urgent

beyond the future tolerance limits of the species:
transfer / evacuation of *valuable* populations

Most probably, I have talked too much.
Thanks for patience.