

Rapid shift of climate stress factors: a prime effect supporting invasive species

Prof. Csaba Mátyás

University of West Hungary, Faculty of Forestry

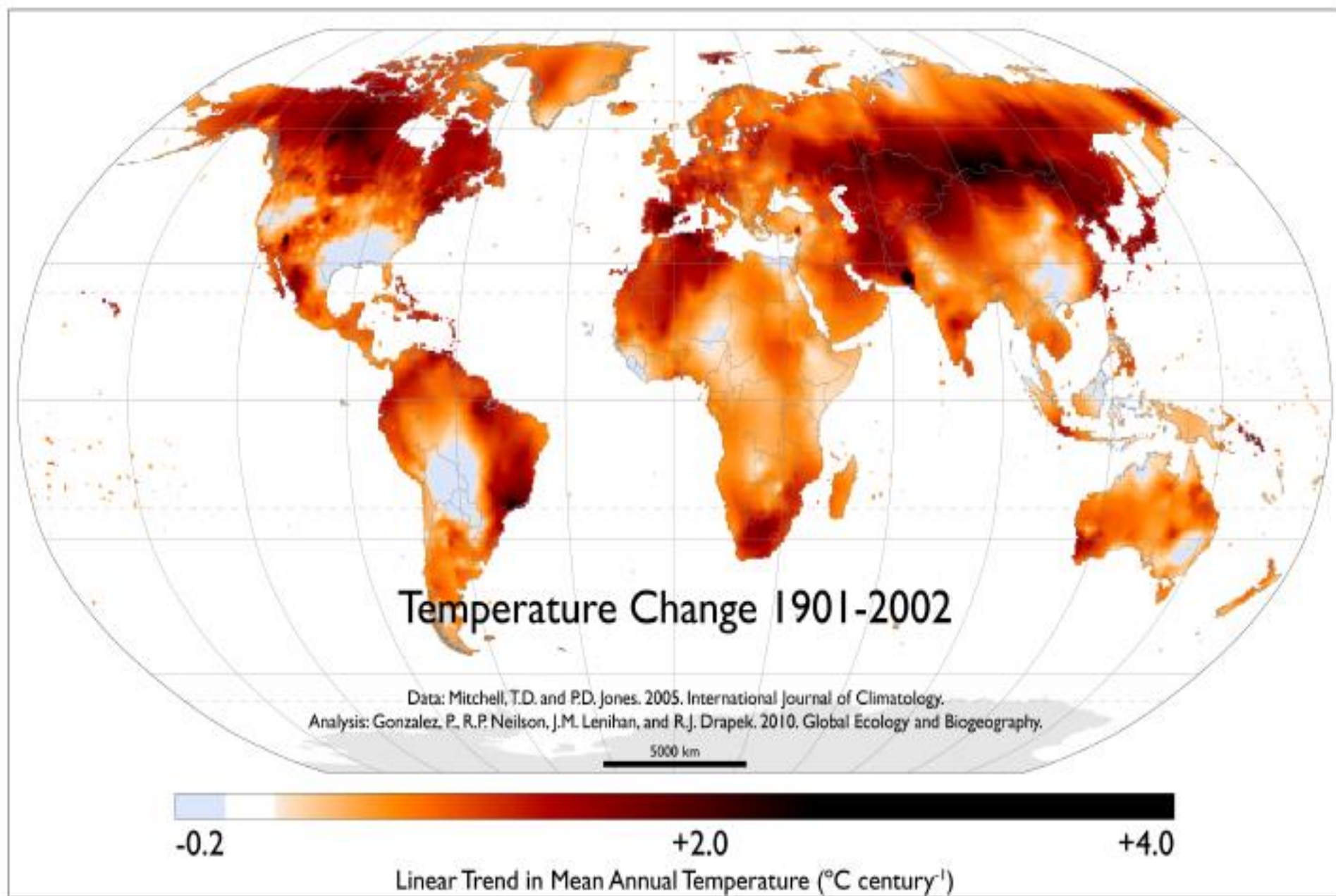
Institute of Environmental and Earth Sciences

NEESPI Focus Research Center for Nonboreal Eastern Europe

Sopron, Hungary

Climate stress impacts in forestry - a genetic perspective

- A global issue - how serious?
- Regional impacts and predictions
- Why are plains more threatened?
- Why introducing the role of genetics?
- Predicting vitality loss in common gardens
- Greatest challenge to sustainable forestry for 300 years



PAST: global warming in a century



1 million hectares of aspen mortality in western Canada

Allen ex Michaelian 2010



Progressing drought damage in Morocco Photo Matyas



**Abrupt drought-induced death in Jarrah forest
(*Eucalyptus marginata*) SW Australia -- July, 2011**

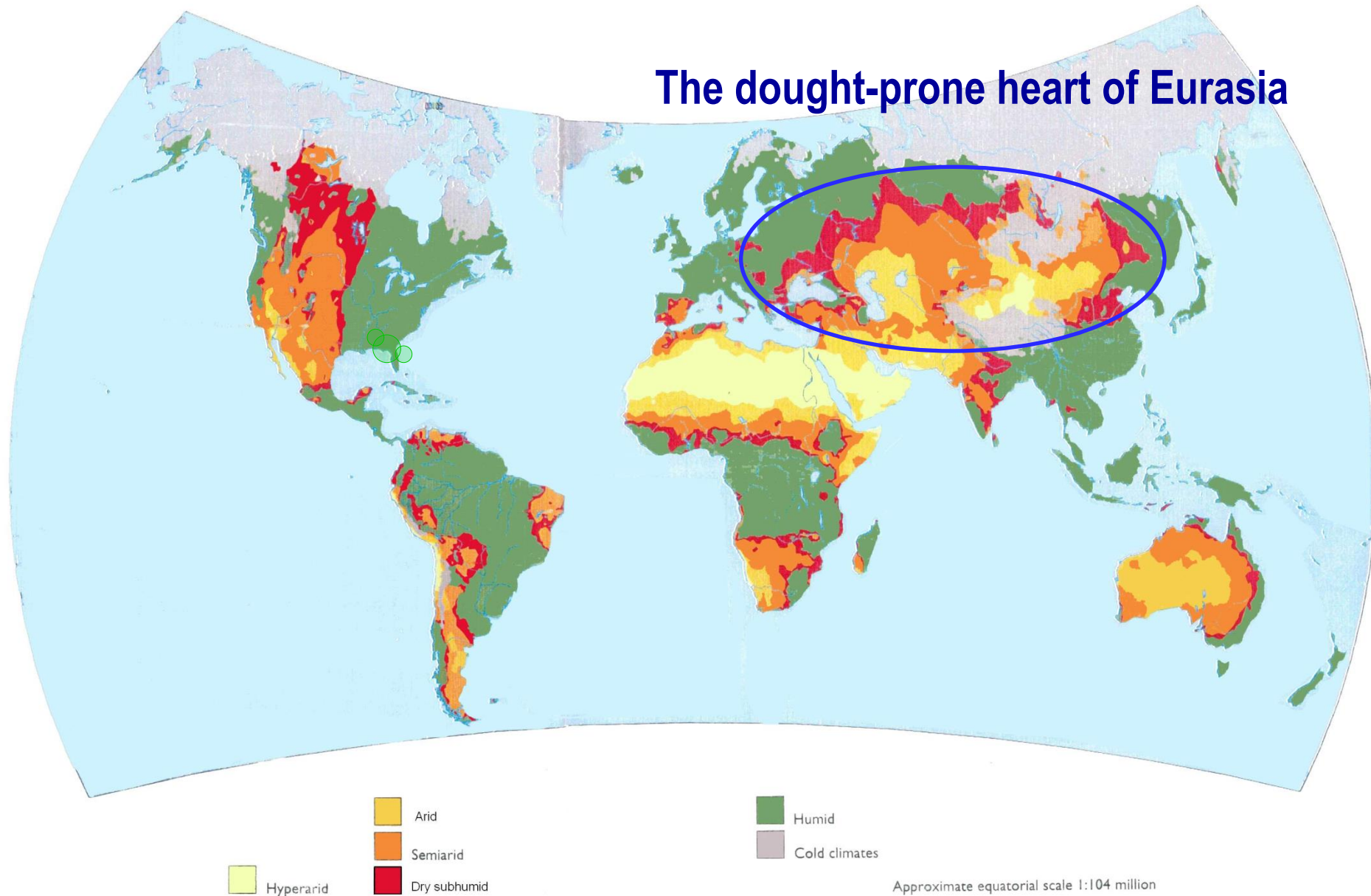
How serious are projected changes compared to postglacial changes?

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

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

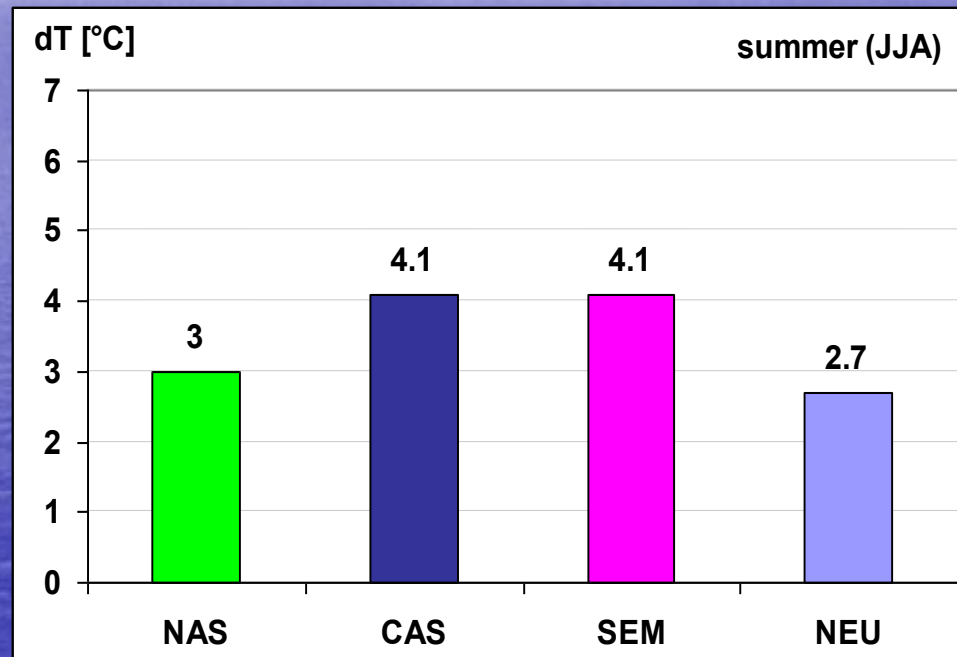
Climate change and aridity zones

Map 1.5 Aridity zones



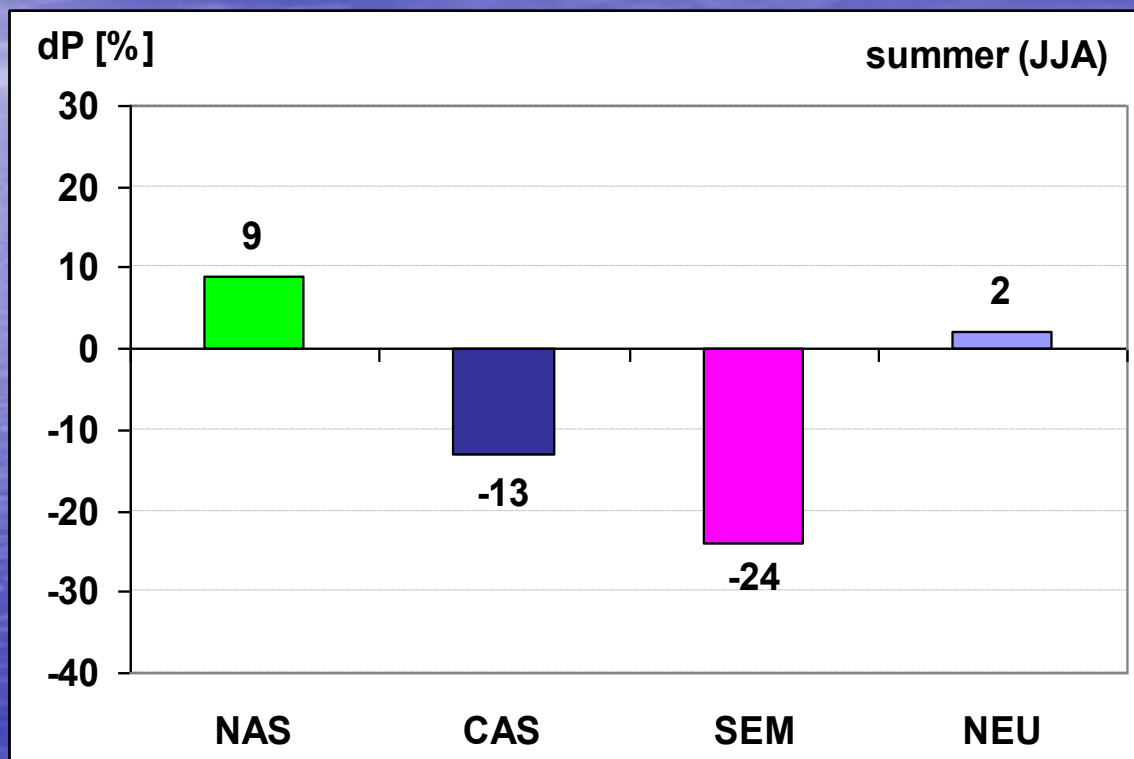
Predicted summer climate changes in temperate Eurasia A1B scenario for the period 2080-2099 vs. the reference period 1980-1999,

Change of mean summer temperature (°C)



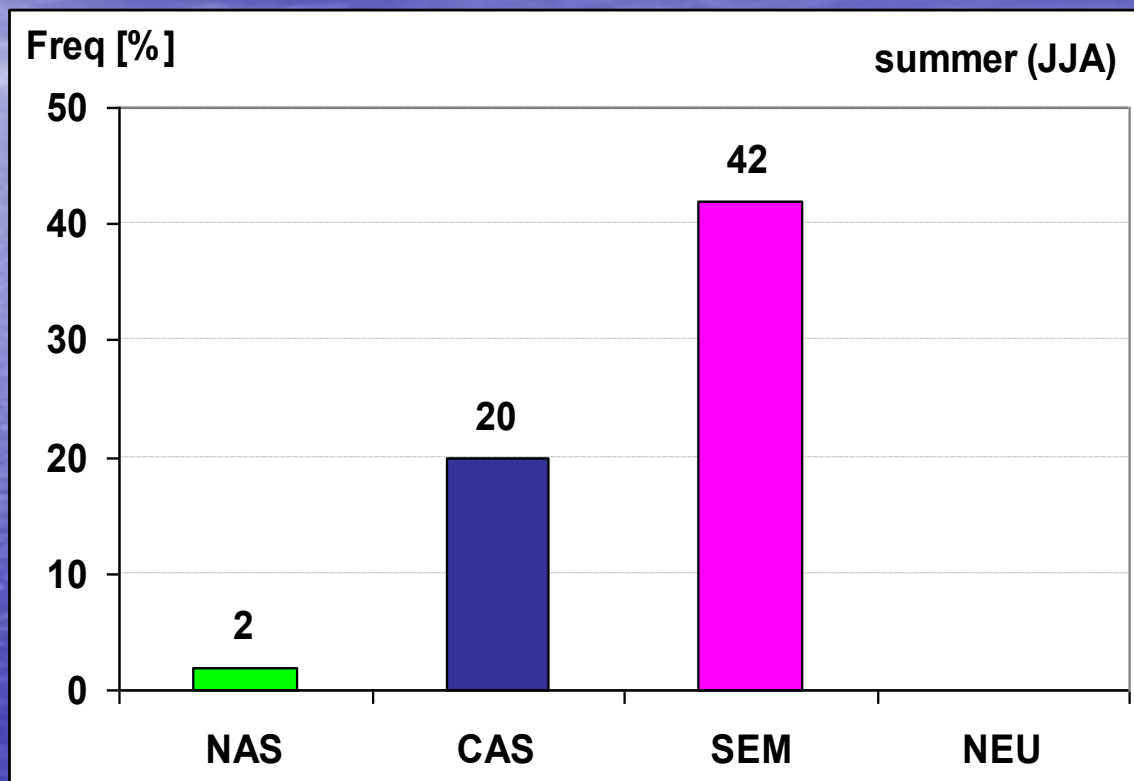
averages for the regions Northern Asia (**NAS**); Central Asia (**CAS**), Central-Southern Europe with the Mediterranean (**SEM**) and North Europe (**NEU**). *Source: data of IPCC 2007, design: B. Gálos*

Change of mean summer precipitation (%)



averages for the regions Northern Asia (**NAS**); Central Asia (**CAS**), Central-Southern Europe with the Mediterranean (**SEM**) and North Europe (**NEU**). *Source: data of IPCC 2007, design: B. Gálos*

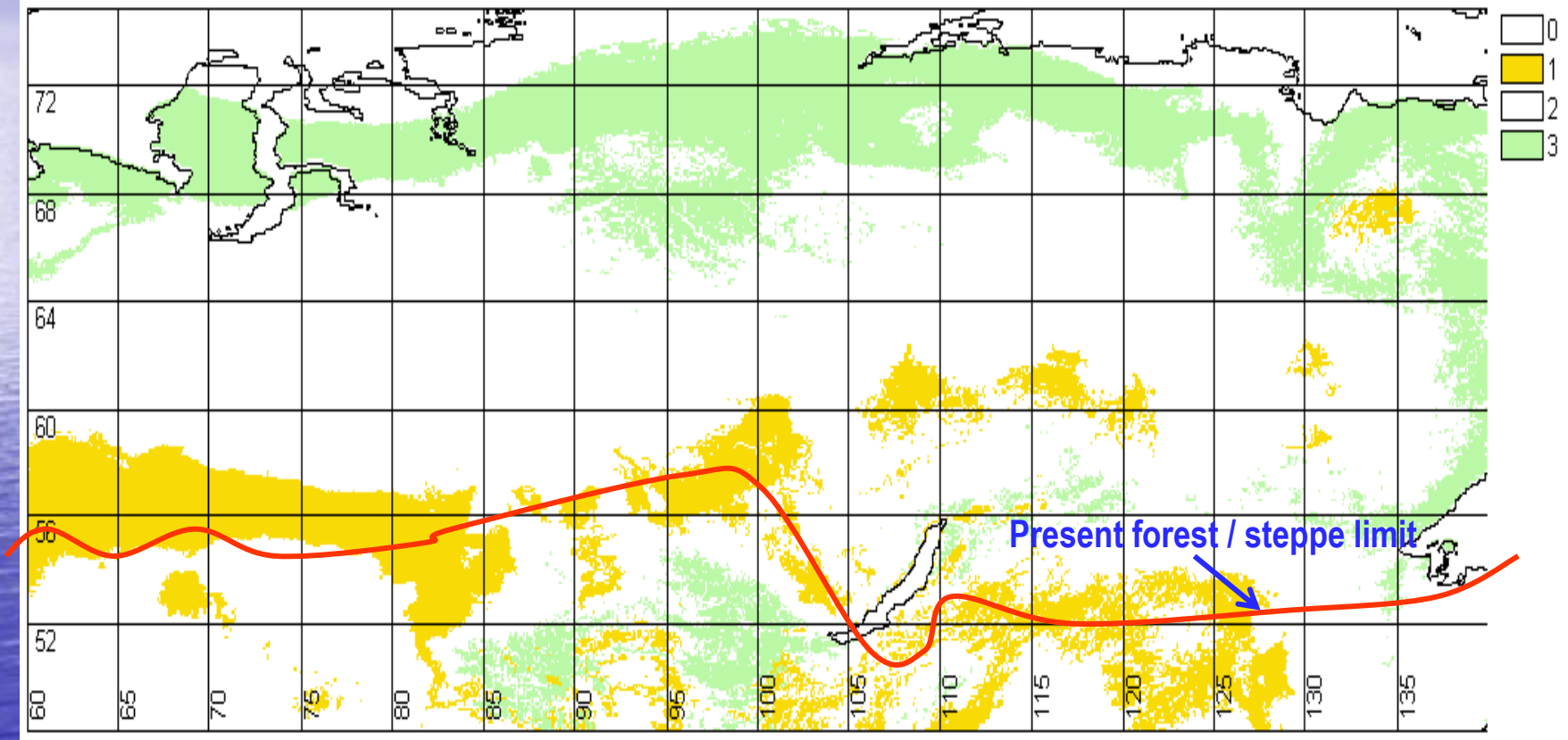
Change of frequency of dry summers (%)



averages for the regions Northern Asia (**NAS**); Central Asia (**CAS**), Central-Southern Europe with the Mediterranean (**SEM**) and North Europe (**NEU**). *Source: data of IPCC 2007, design: B. Gálos*

Theoretical biome shifts in Siberia by 2080

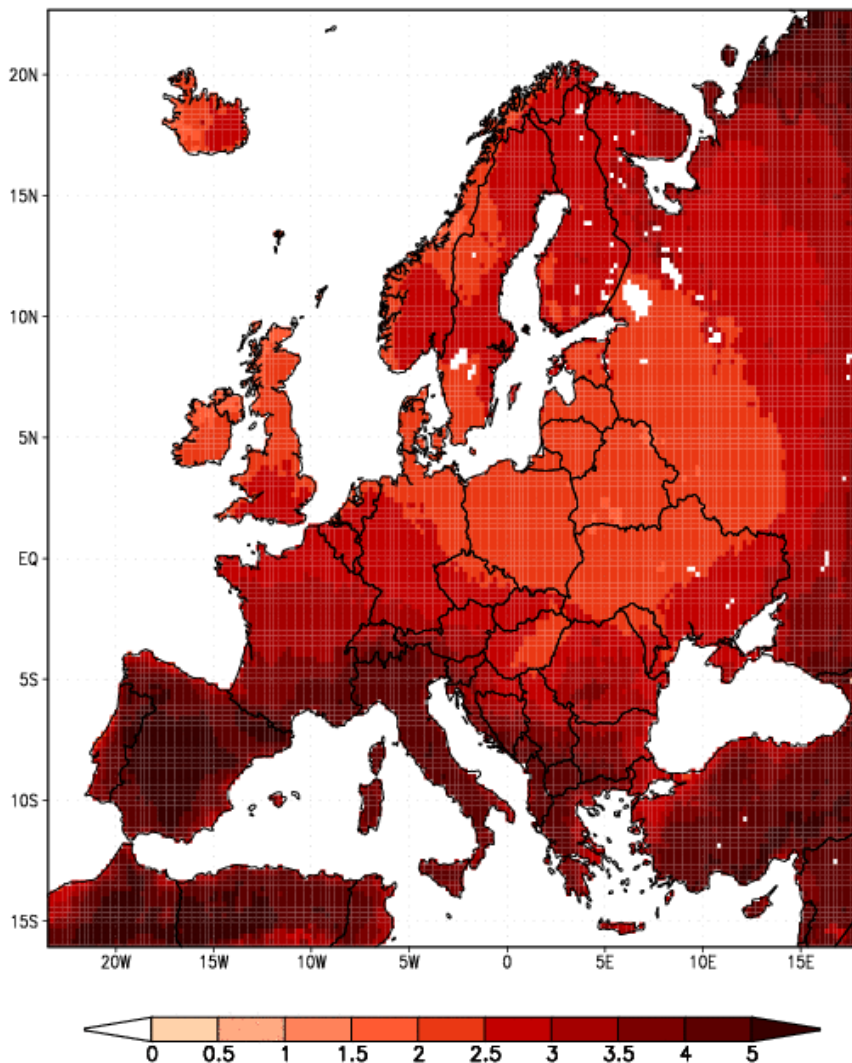
HadCM3 B1 projection (*Tchebakova and Parfenova, EGU 2011*)



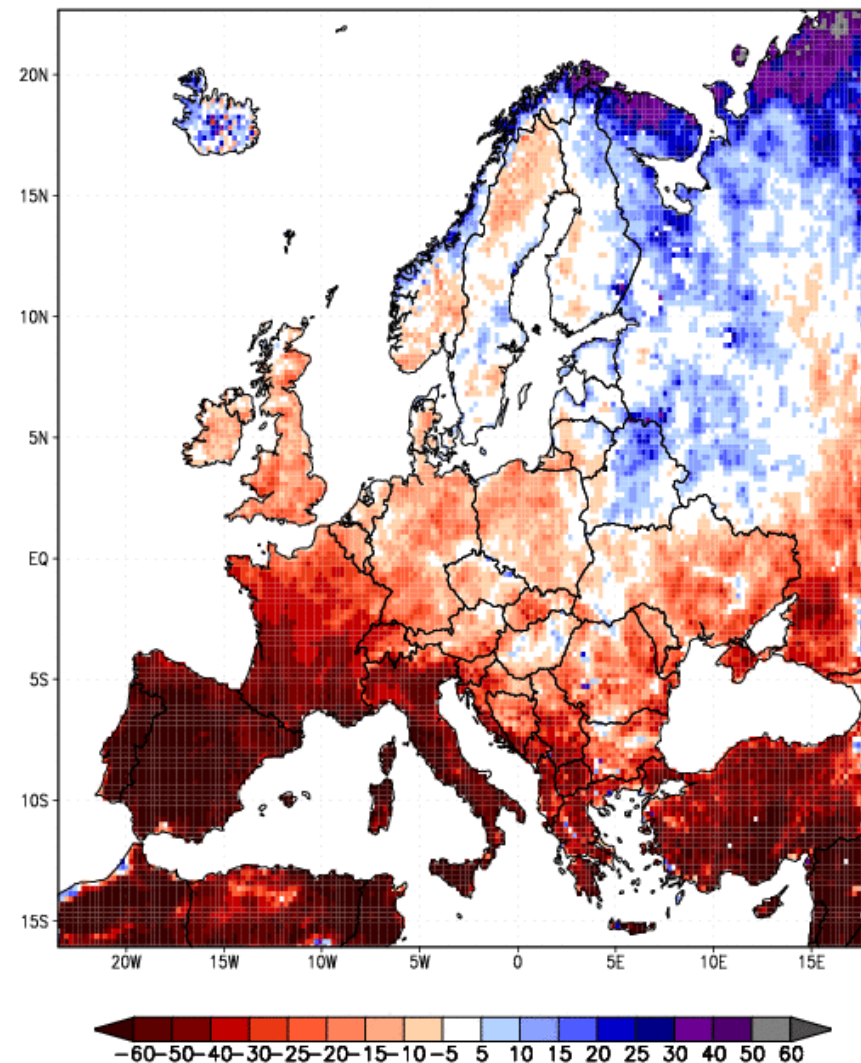
green – new forest habitats; yellow – new steppe habitats; white – no change

By 2080 40% of the Siberian boreal forest may be occupied by steppe and forest steppe

diff temp [°C] 2071–2090 vs. 1971–1990 JJA



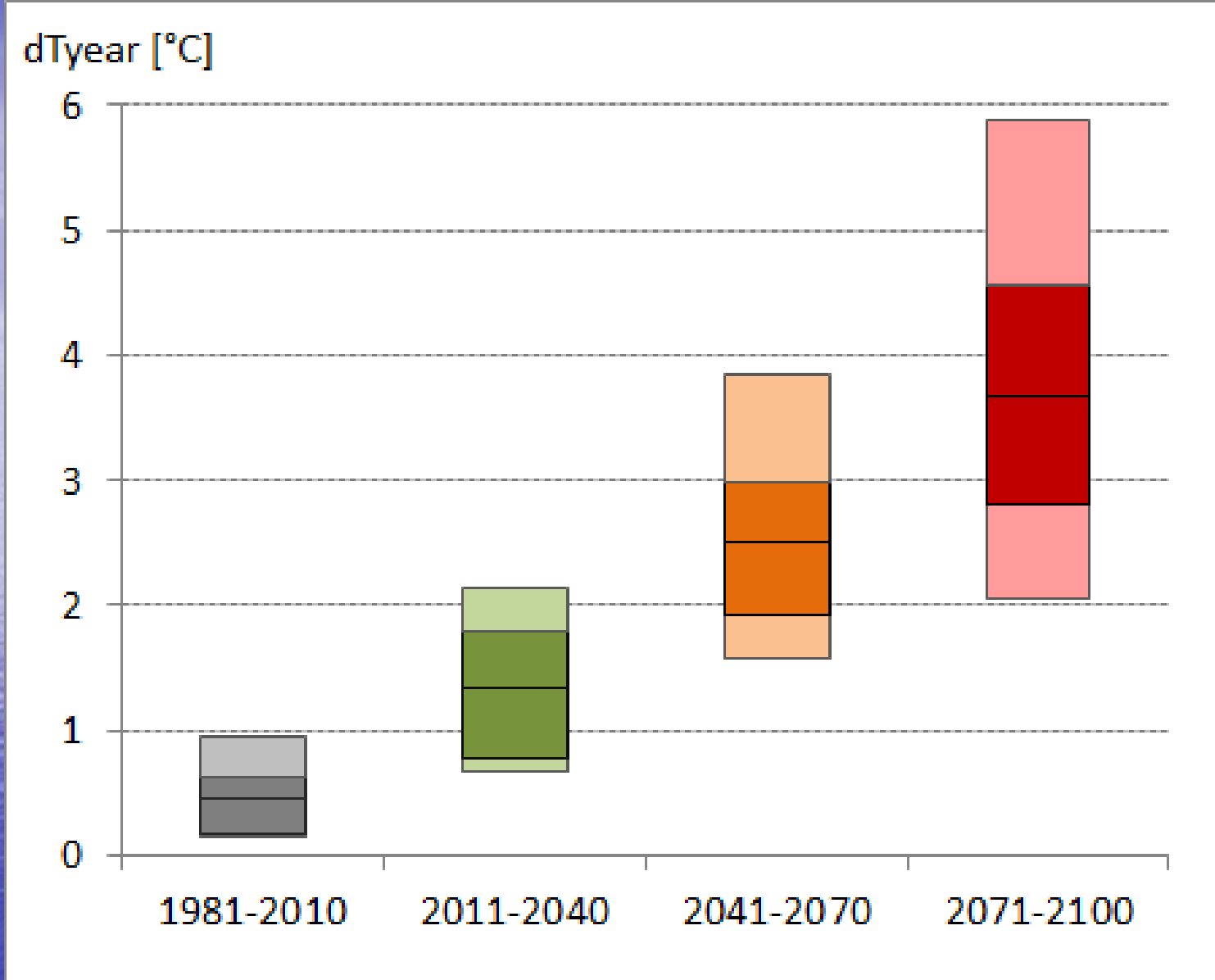
diff prec [%] 2071–2090 vs. 1971–1990 JJA



Future in Europe: 1980 vs. 2080

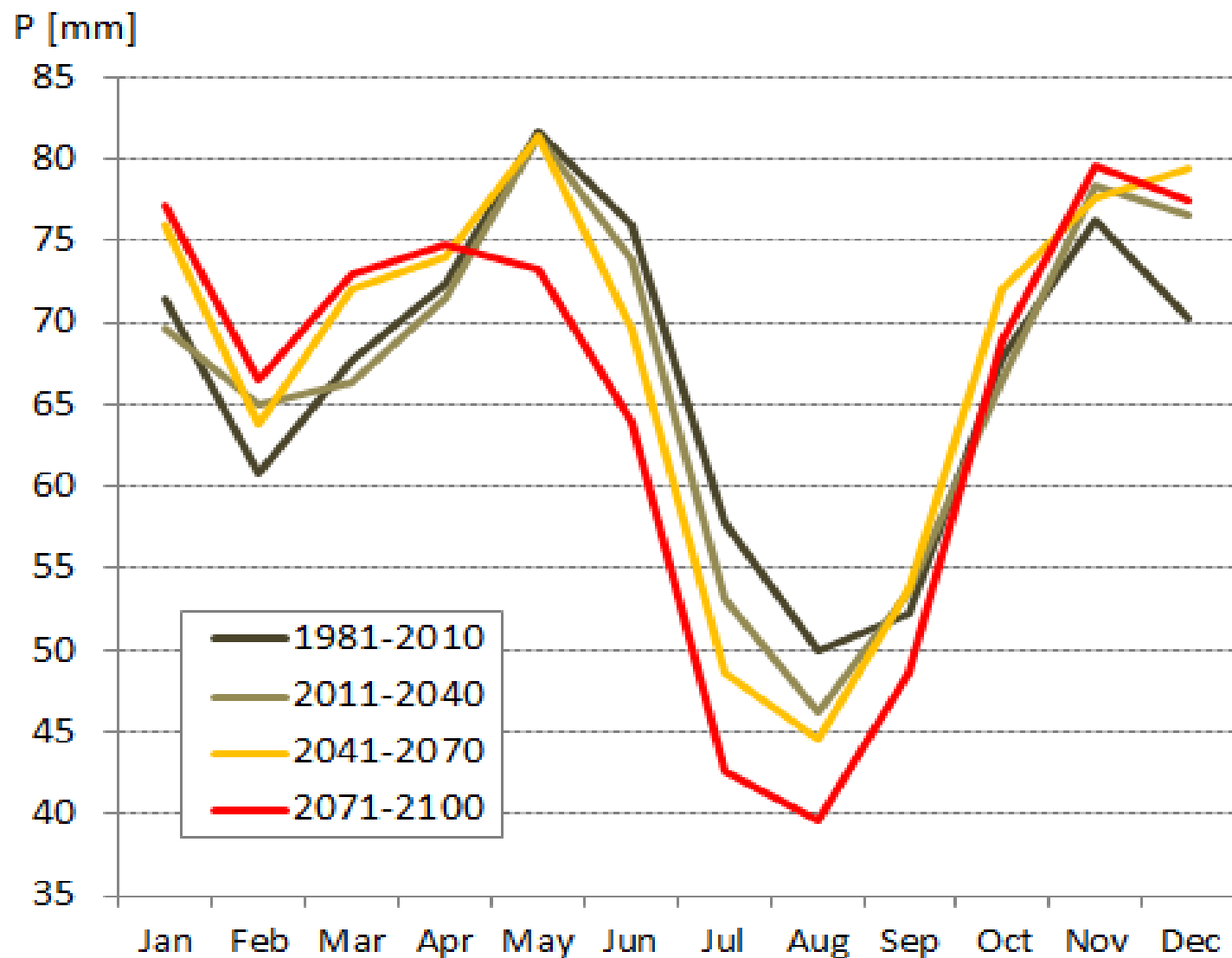
Summer temperature and precipitation increase

ENSEMBLES Model, 25x25 km raster (Gálos et al. 2010)



**Projected change of mean annual temperature in the Carpathian Basin
average and variability of 12 climate models**

Gálos B, 2013



Trend change in interannual distribution of precipitation
Carpathian Basin, mean of 12 climate models

Gálos B, 2013

Why are plains more threatened?

- **Altitudinal thermal gradient:**

5-6.5°C/ 1000 m

Change of 1°C: **167 m** altitude
(may be overcome)

- **Latitudinal (S - N) isotherm gradient:**

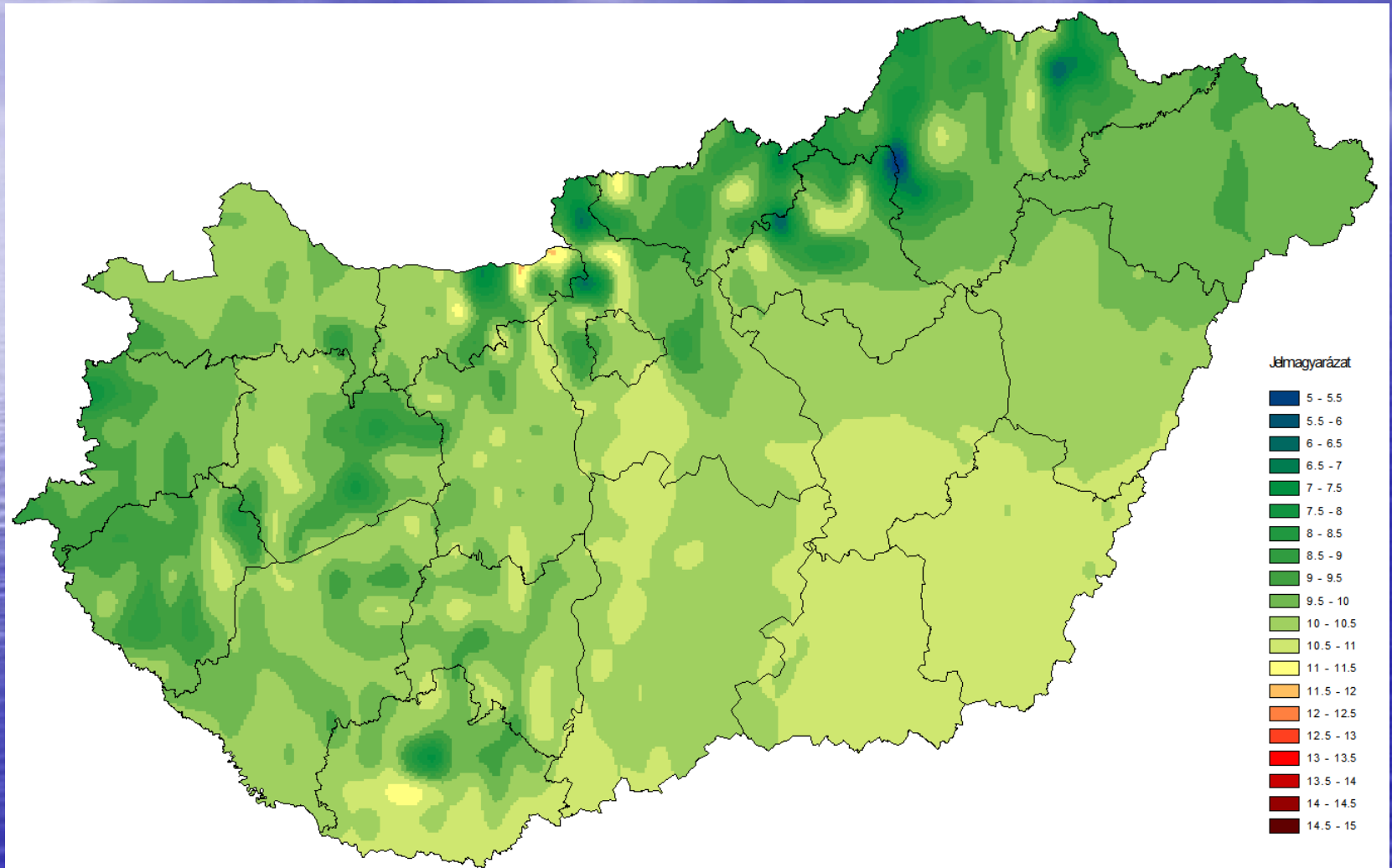
6.9 °C/ 1000 km

Change of 1°C: **= 145 km!**

Difference of three magnitudes!

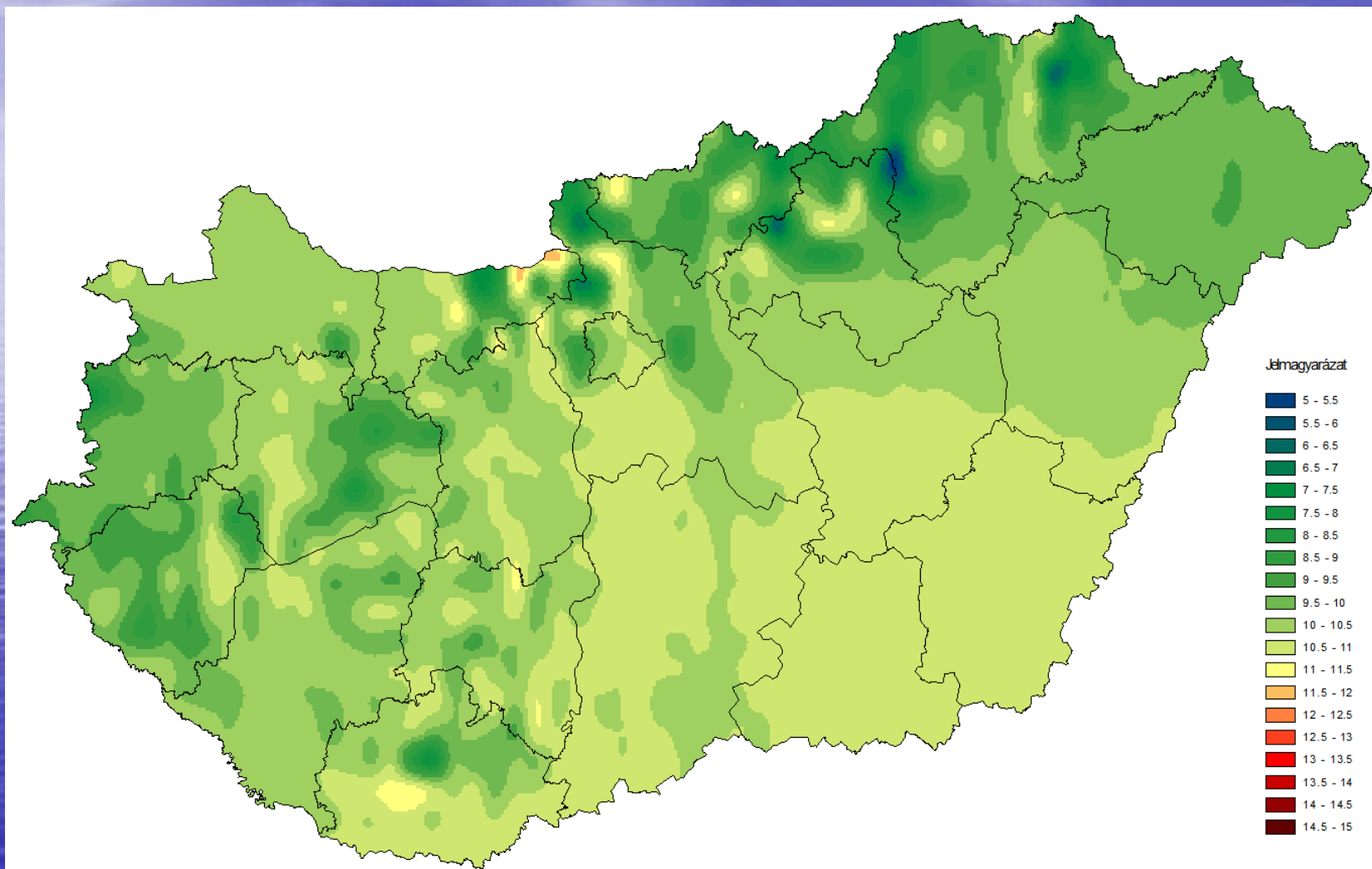
Jump A, Cs Mátyás, J Penuelas 2009 : The altitude-for-latitude disparity in the range retractions of woody species. TRENDS IN ECOL. & EVOL. 24:(12) pp. 694-701. (2009)

10éves átlaghőmérséklet - Avg. decadal temperature 1961-1970



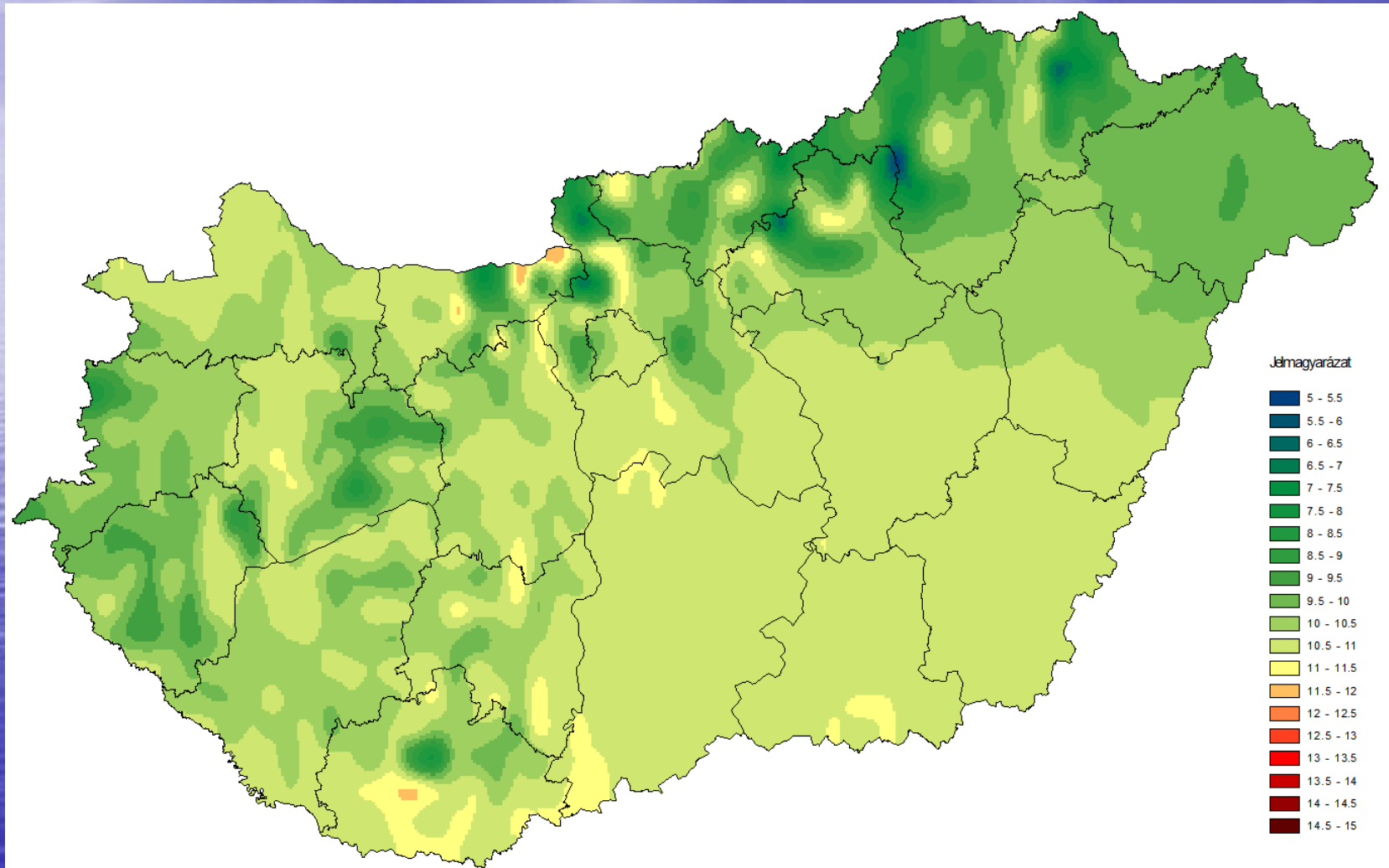
Térkép: DIGITERRA, Czímber Kornél 2016

Avg. decadal temperature 1971-1980



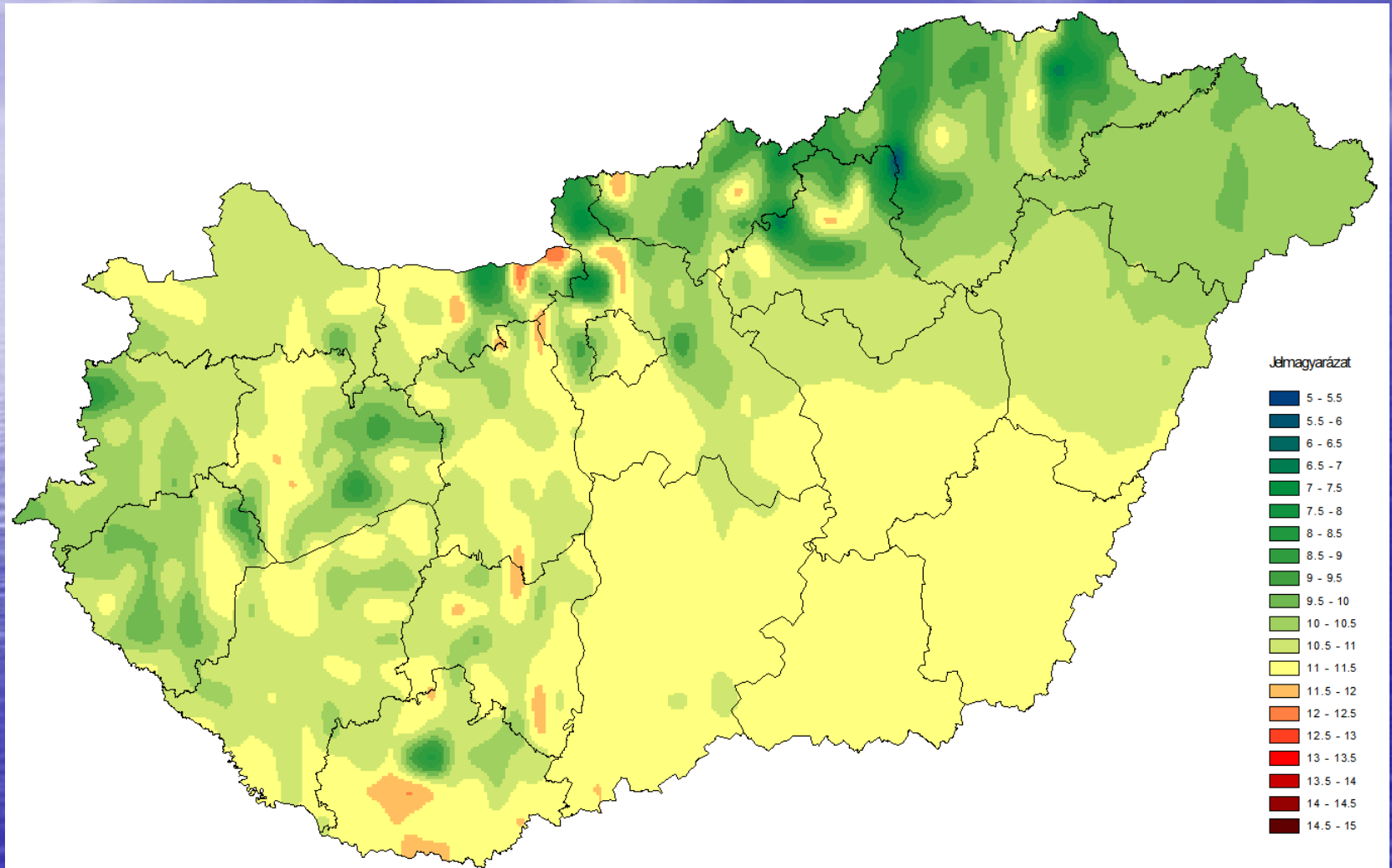
Térkép: DIGITERRA, Czímber Kornél 2016

Avg. decadal temperature **1981-1990**



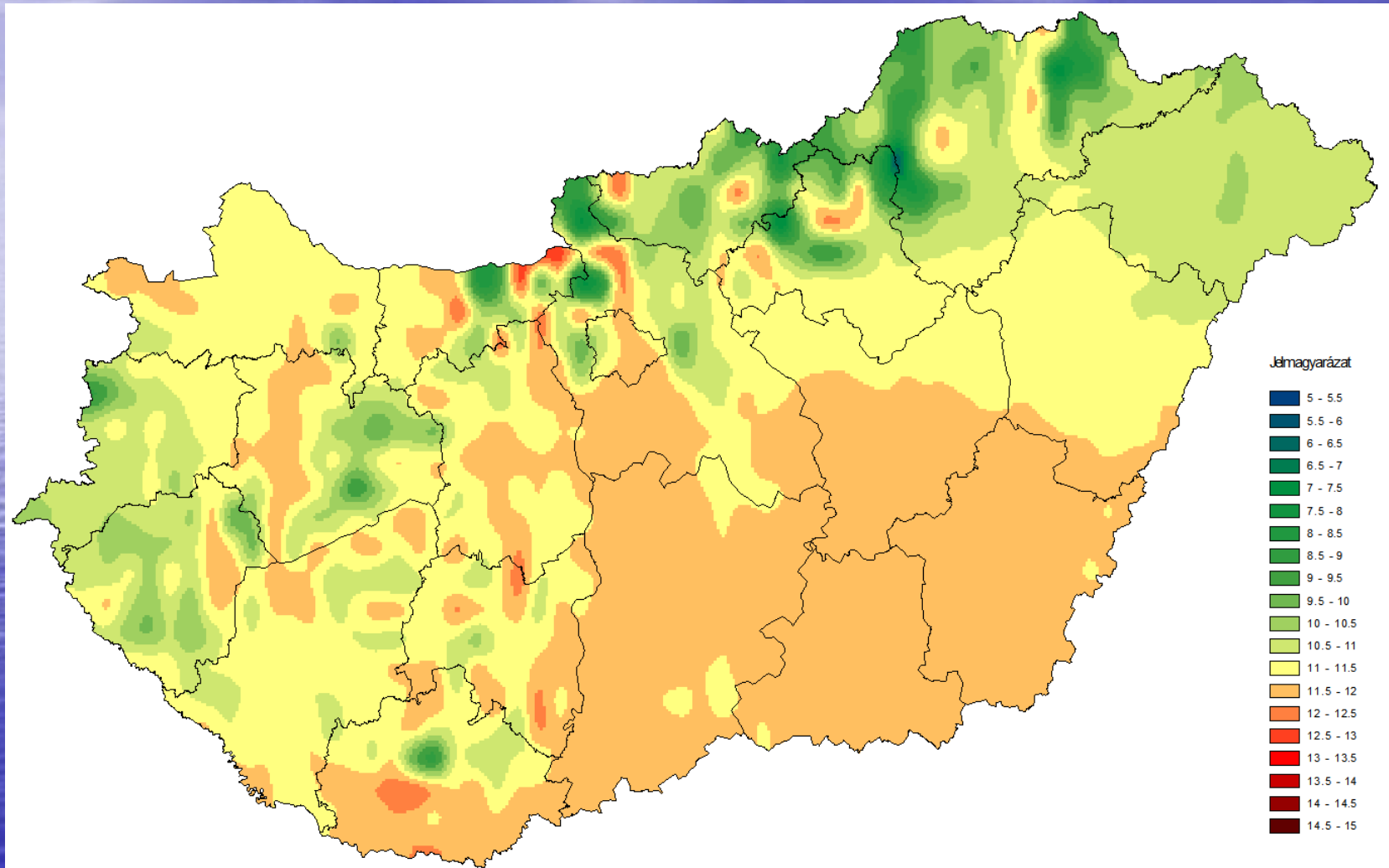
Térkép: DIGITERRA, Czímber Kornél 2016

Avg. decadal temperature **1991-2000**

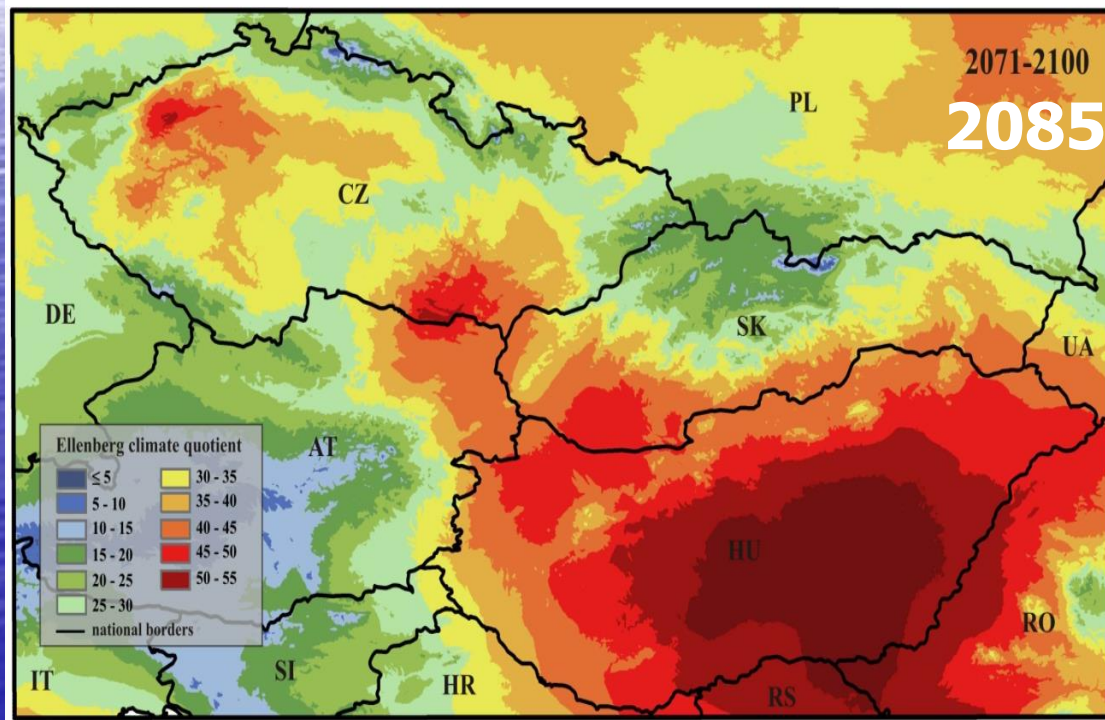
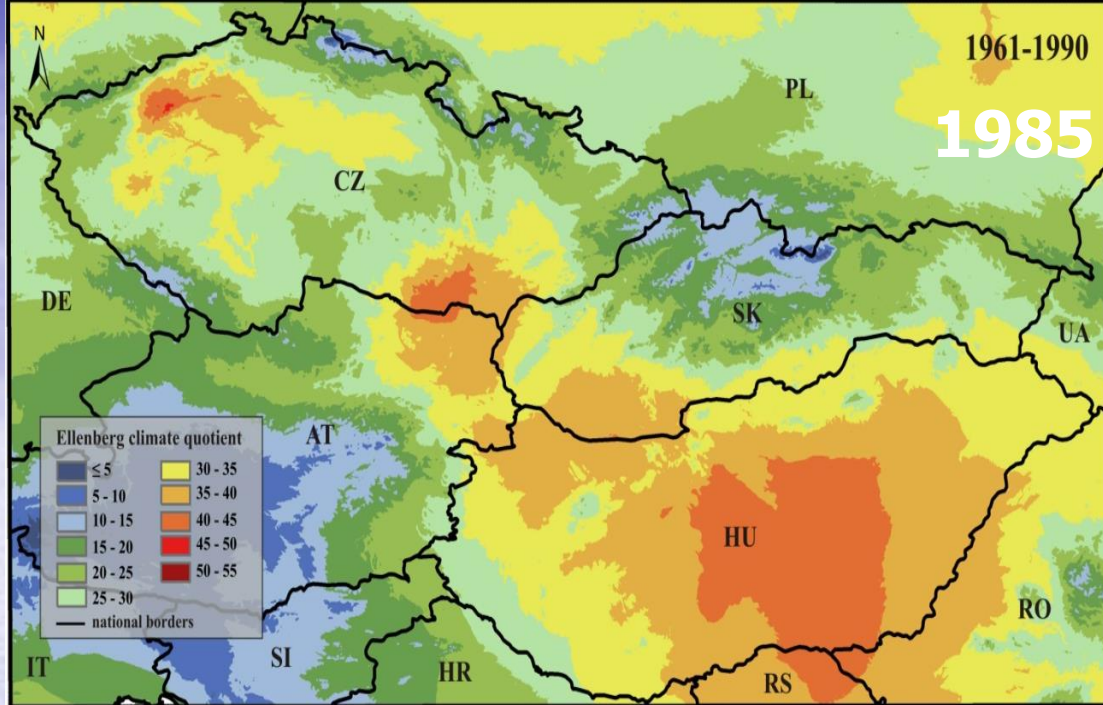


Térkép: DIGITERRA, Czímber Kornél 2016

Avg. decadal temperature **2001-2009**



Map: DIGITERRA, Czímber K. 2016

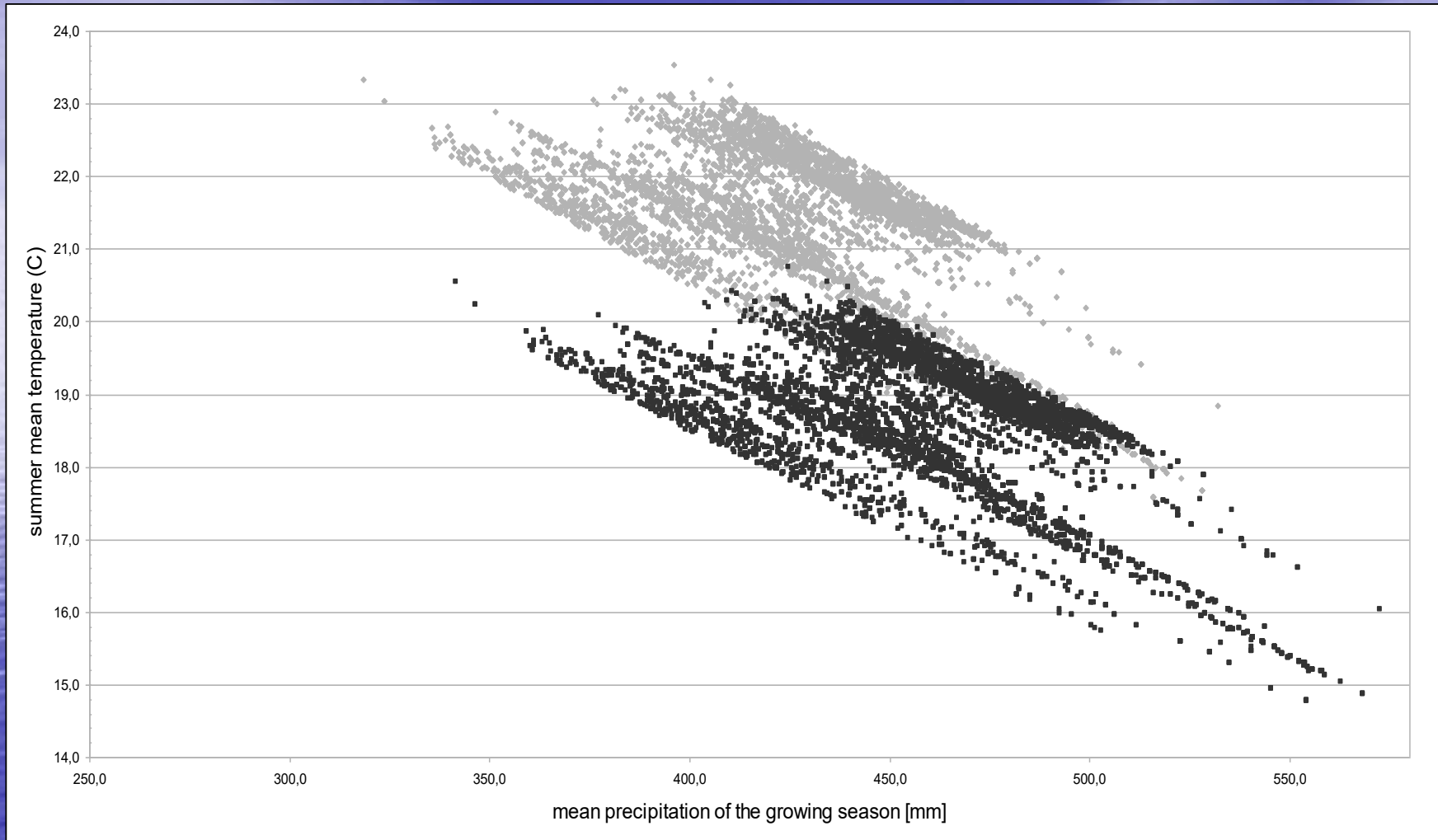


**Drought index change
in Central Europe
1985 – 2085**

**Intensification of
drought in
100 years**

**CarpatClim database,
1x1 km
T. Hlásny et al. 2014.**

Climate niche of beech in Hungary 2000-2050



Prediction: Prudence project (data: E. Rasztoivits)

(in: Führer, Mátyás, Csóka, Lakatos, Bordács, Nagy, Rasztoivits, 2010 Current status of European beech genetic resources in Hungary. Comm. Inst. For. Boh, Praha, 2012)

Impacts on forests

- Abiotic extremes
- Groundwater decline
- Insect, disease damage
- Invasive species, non-analog associations
- Degradation: loss of diversity
- Growth and increment decline
- Mortality



Mortality in a sessile oak forest, NE Hungary Photo: G. Csóka



Climate driven succession: NE Hungary (2013)
Quercus petraea vs. *Qu. cerris* Photo C Mátyás

A photograph of a forest clearing with many tree stumps and a dense forest in the background. The ground is covered with reddish-brown soil and some green vegetation. In the foreground, there are several tree stumps. In the middle ground, there are two small black signs on wooden posts. The background is a dense forest of tall, thin trees.

Limits to adaptability is genetic-driven!
Species comparison expt, Budafa, SW Hungary

, Photo: K. Kovács 2013

Ugly face of trailing limit: spruce in West Hungary



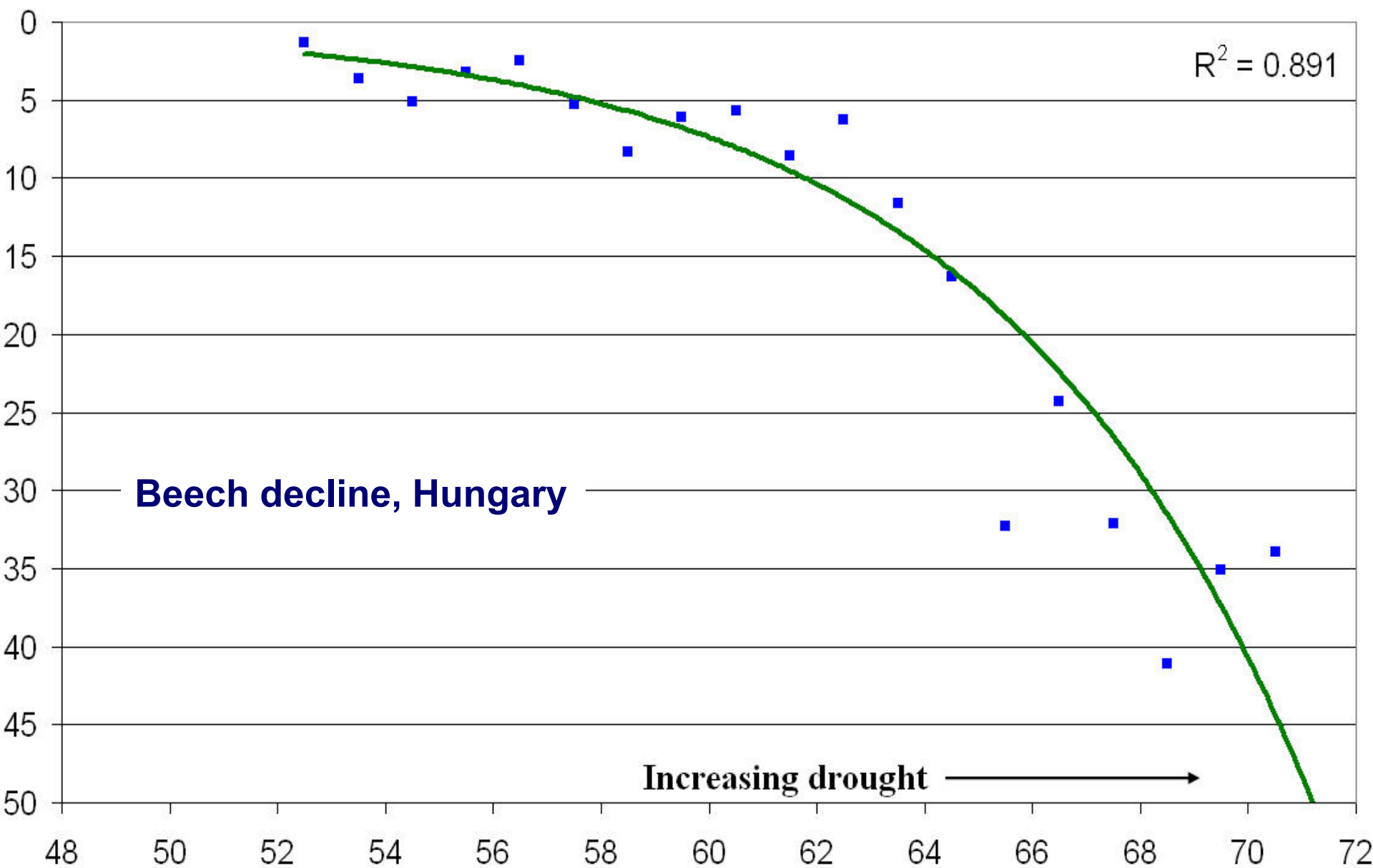
Field monitoring of vitality decline
and insect damage

Photo
T. Szép

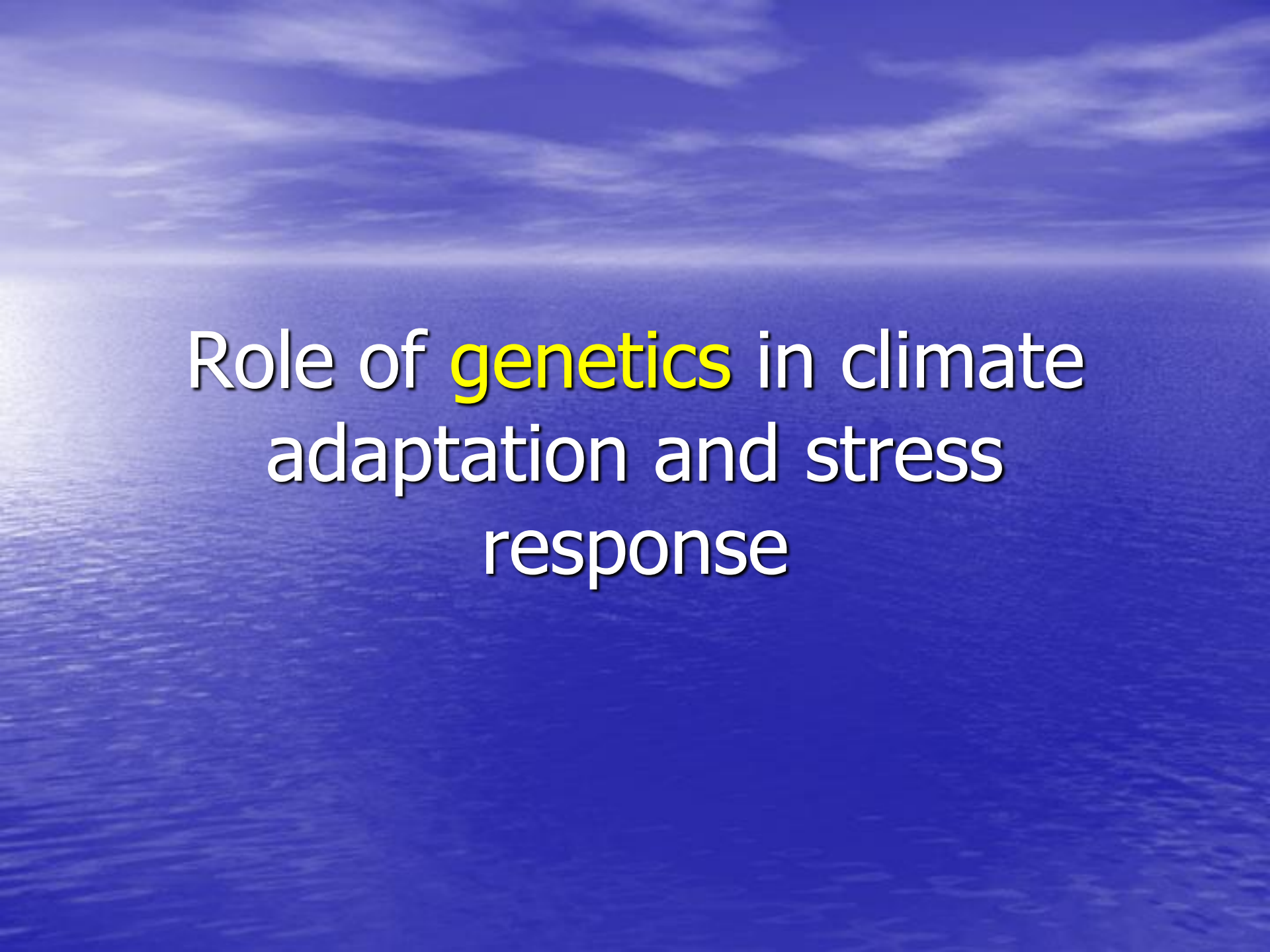


Fenyőfő, „ősfenyves” 2014, fotó: Bidló A.





**Mortality increase in beech (Y axis: mortality rate %)
with growing drought (X axis: Ellenberg drought index)**



Role of **genetics** in climate adaptation and stress response

Drought stress mortality, W Hungary 2011

N.simonyi 1C

N.sim. 1A

If less tolerant individuals die →
genetic composition changes

Difference in climatic selection: continental vs maritime provenances



Flushing (H): 92%

Egregy (H) H: 3,13 m



Flushing (H): 29%

Soignes (B) H: 2,62 m



Survival of beech in common garden at Kutina HR 2008

/ front: Bretagne, back: Delnice HR

Extreme selection: snowbrake in beech



**Straza, Slovenia, 2013 - mass mortality of
maritime French provenance Plateaux** photo Bozic

Torup, Sweden



**Swedish and German beech
in Hungarian trial**

Farchau, Germany





53
АЯНСК
12

Ayan (Pacific coast!) in Middle Siberia (Boguchany) Photo Matyas 2012

and in Hungary ...

Hungary (local)

Ayan, RU

Turkey

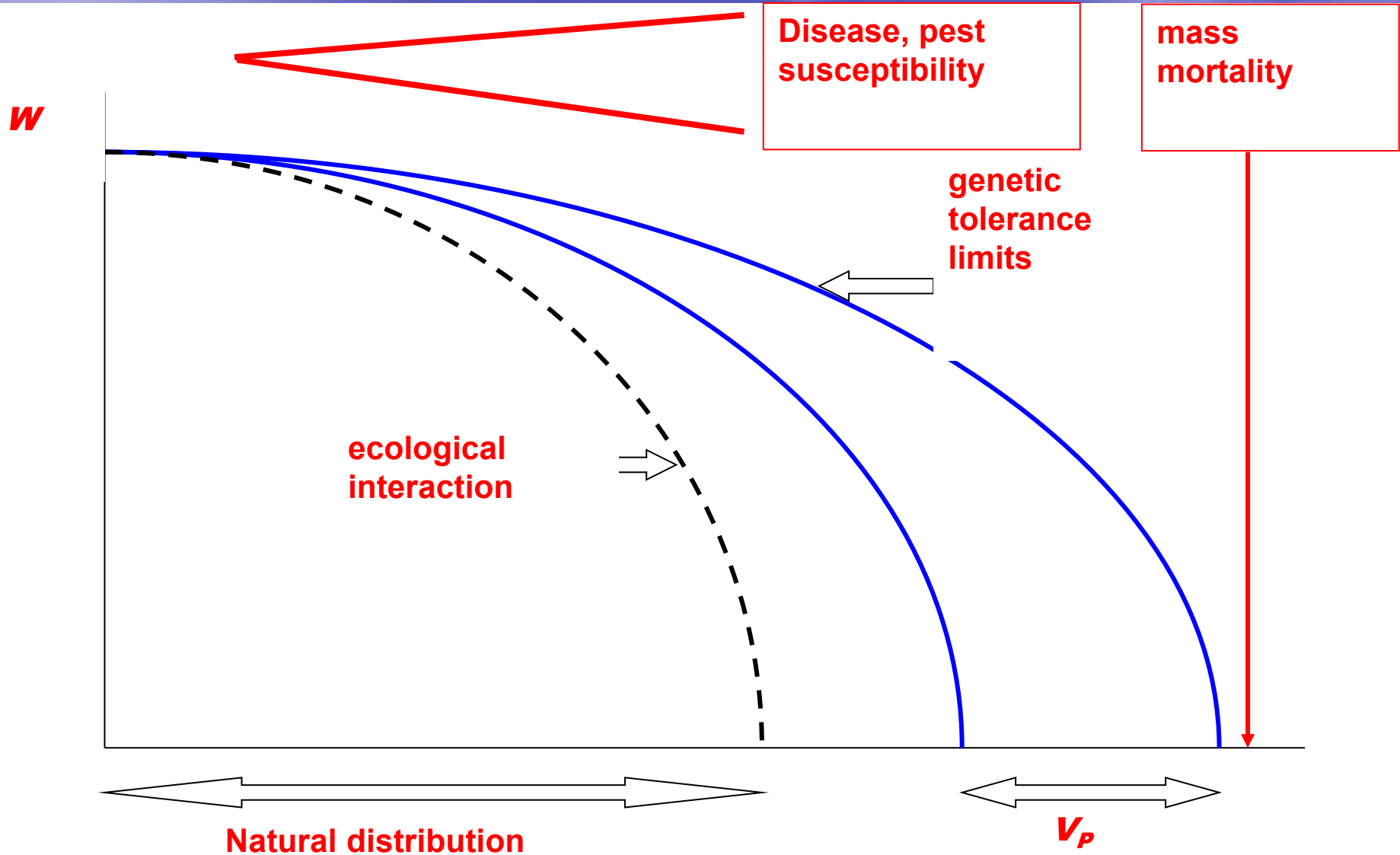
Mass mortality, beyond the limits of tolerance

Test site: Kamon (Hungary) nr. ffd: 180, ann. prec.: 700 mm

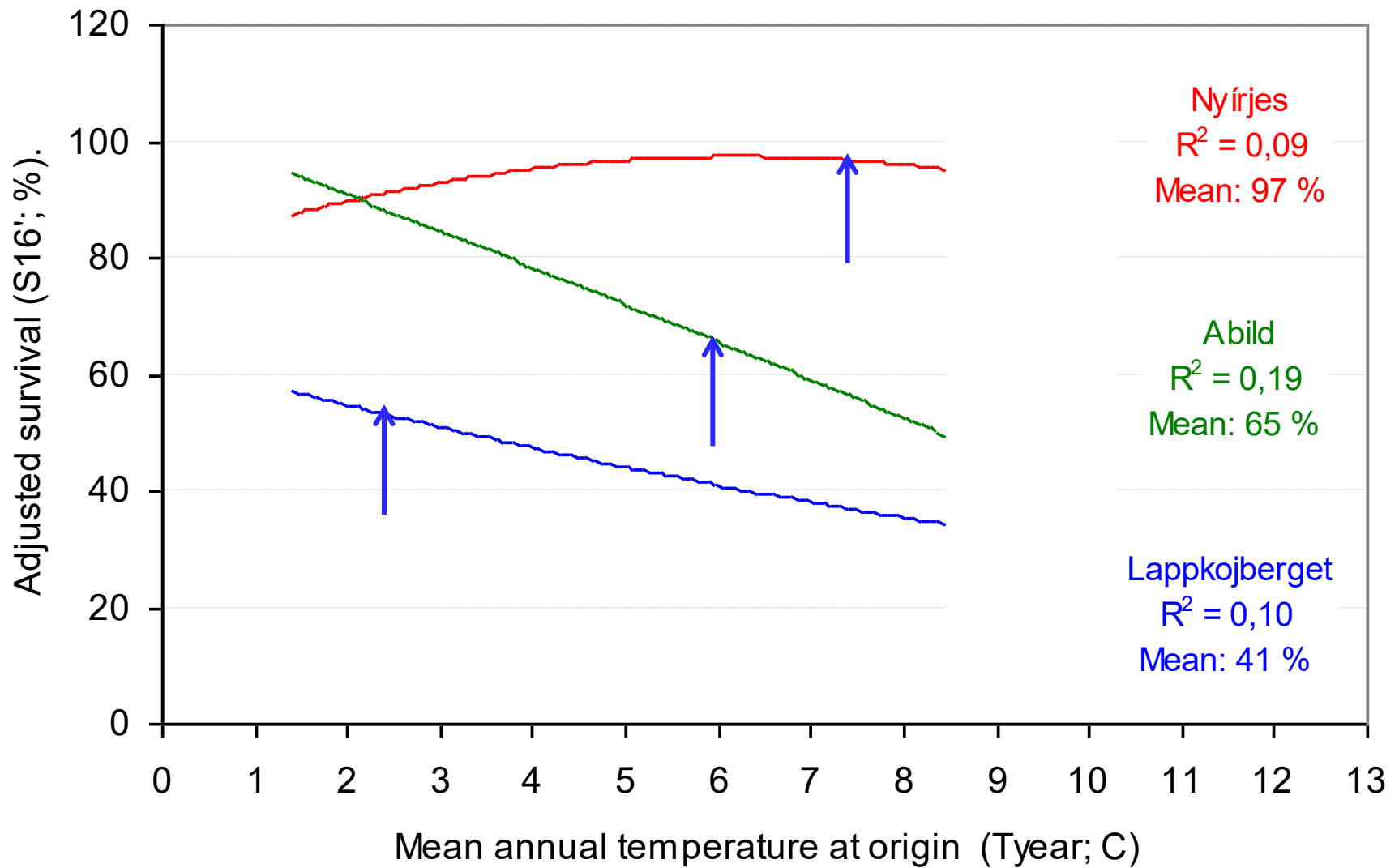
Provenance: Ayan, Yakutia (Russia)

Number of frostfree days: 107, annual precipitation: 890 mm

Stress selection



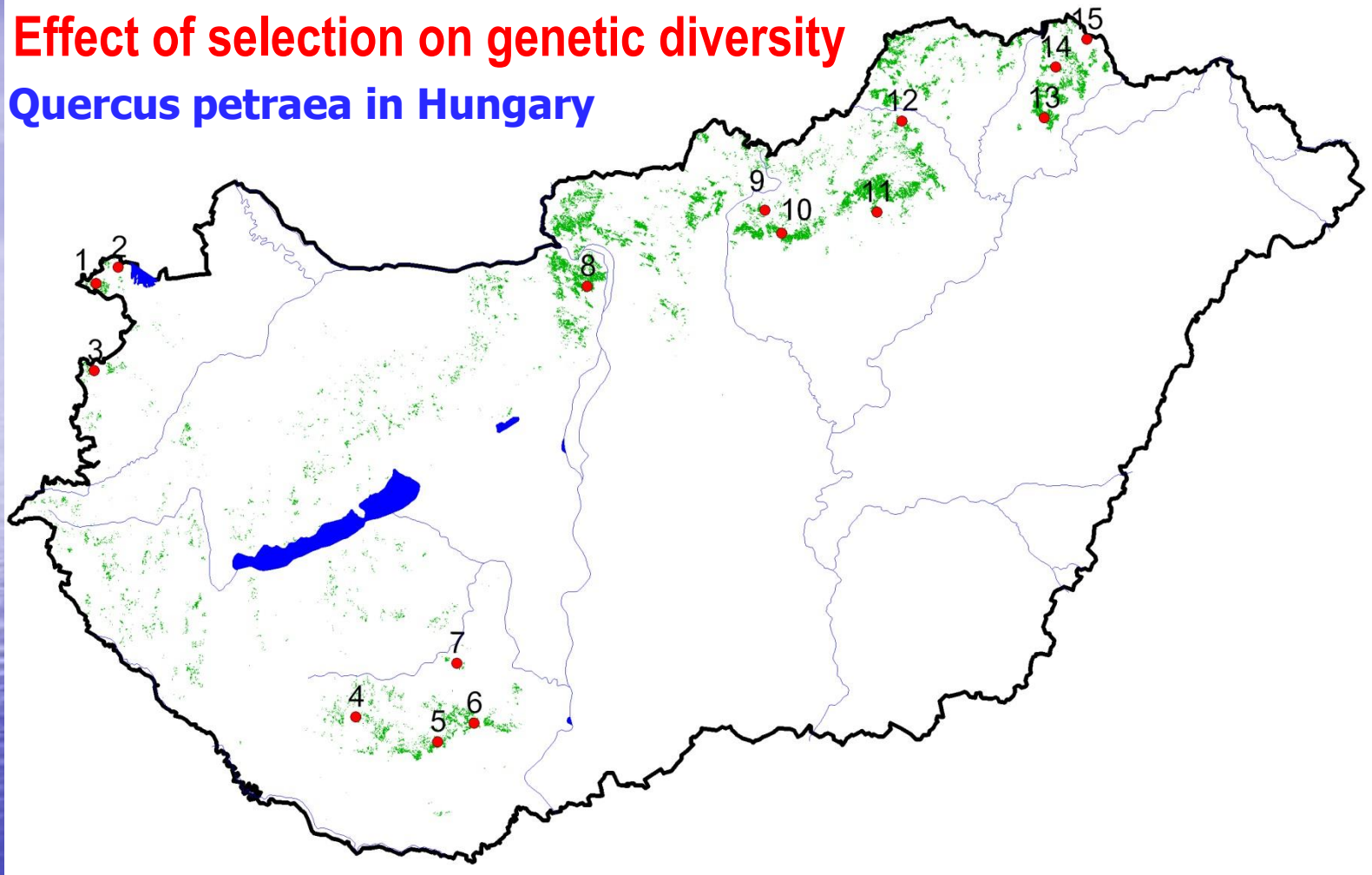
Increasing environmental stress>>>>>



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

Effect of selection on genetic diversity

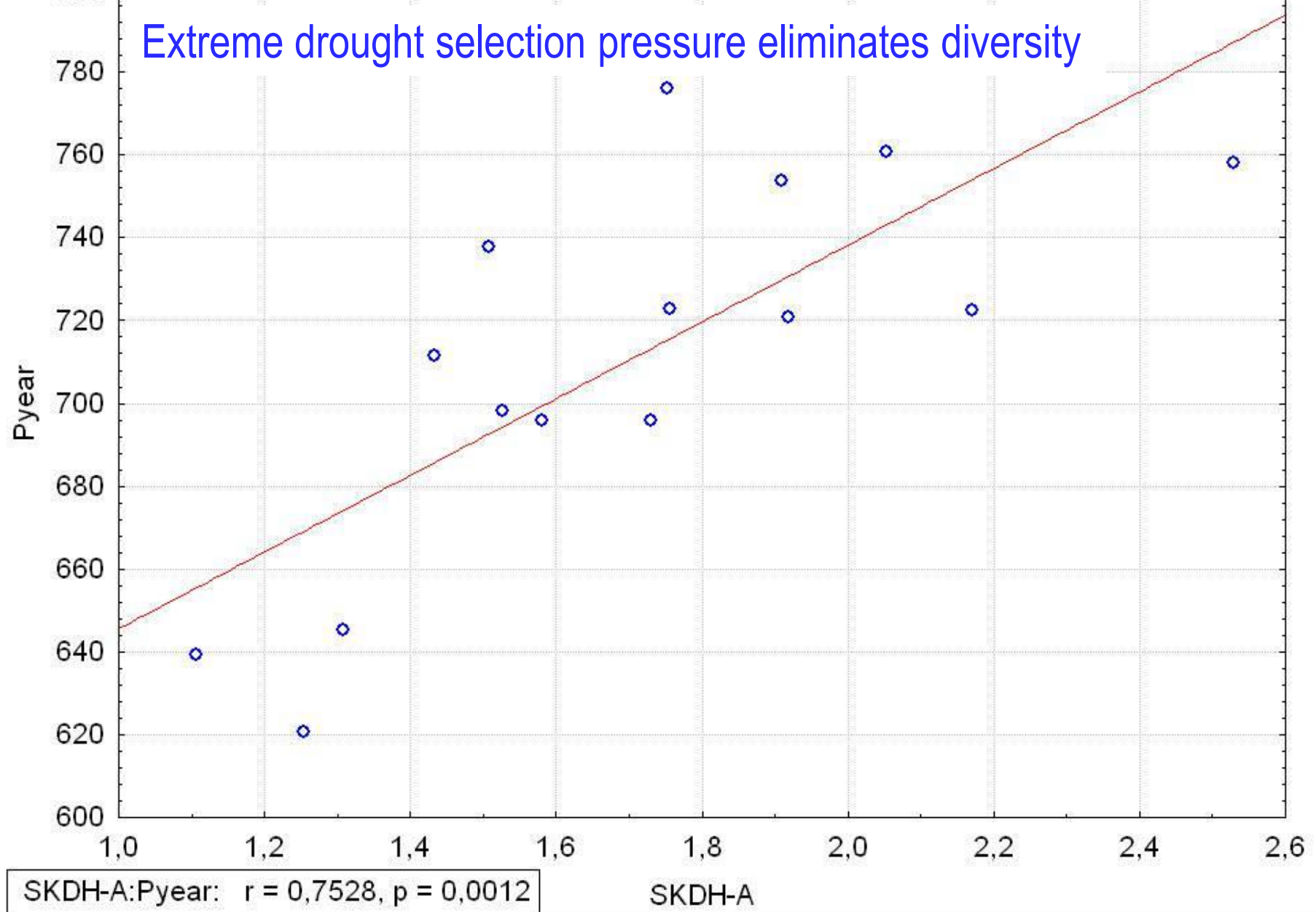
Quercus petraea in Hungary



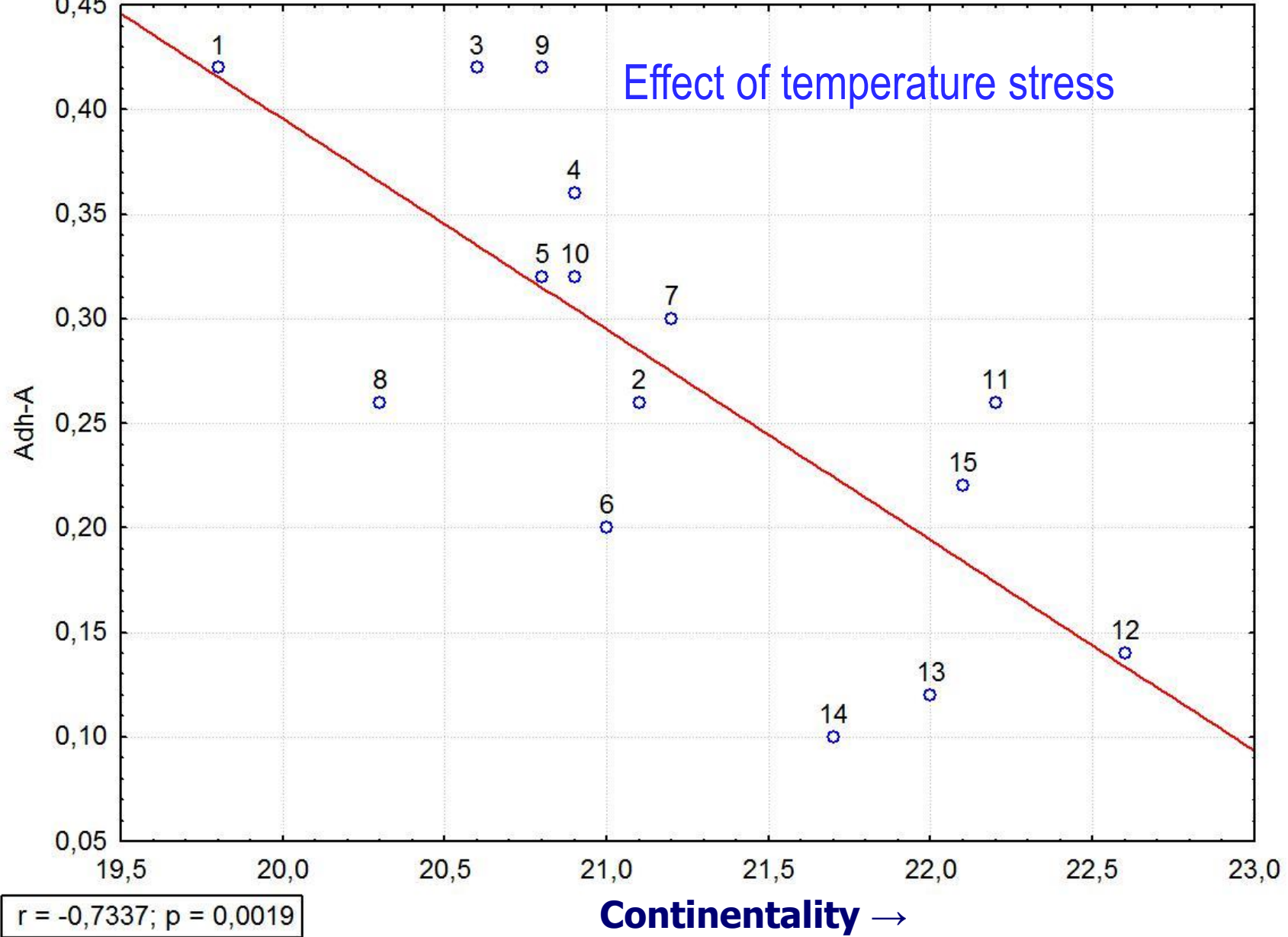
Sampled: 15 stands exposed to drought selection

(Borovics A, Mátyás C. 2013: Decline of genetic diversity of sessile oak at the retracting (xeric) limits. ANN. FOR. SCI. 70:(8) pp. 835-844. (2013))

Extreme drought selection pressure eliminates diversity



Number of gene variants (genetic diversity)
Allels at the SKDH gene locus, vs. ann. precipitation (Y axis)



Frequency of a temperature sensitive gene variant allele A at the ADH gene locus vs. temperature continentiality

Photo: A. Woods

Insect and disease invasions and climate change

Canada, NW US: >23 Mha insect & disease calamity

Dedroctonus micans: 11 Mha (1990-)

Dendroctonus calamity in *P. contorta*
Lake Bonaparte, British Columbia

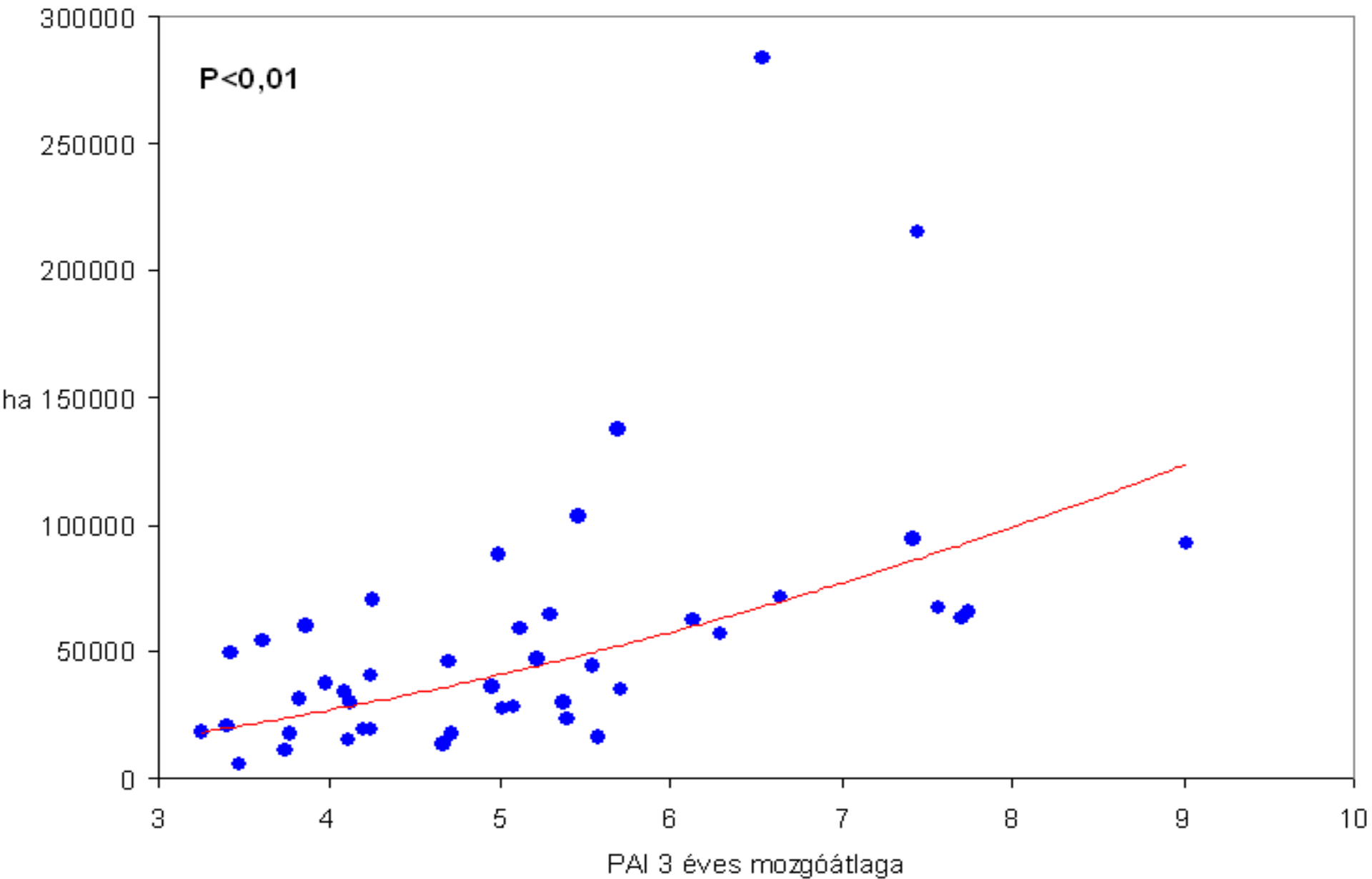




S U - 125

Алтайский
лесхоз

Kazakh population: sensitive to needlecast



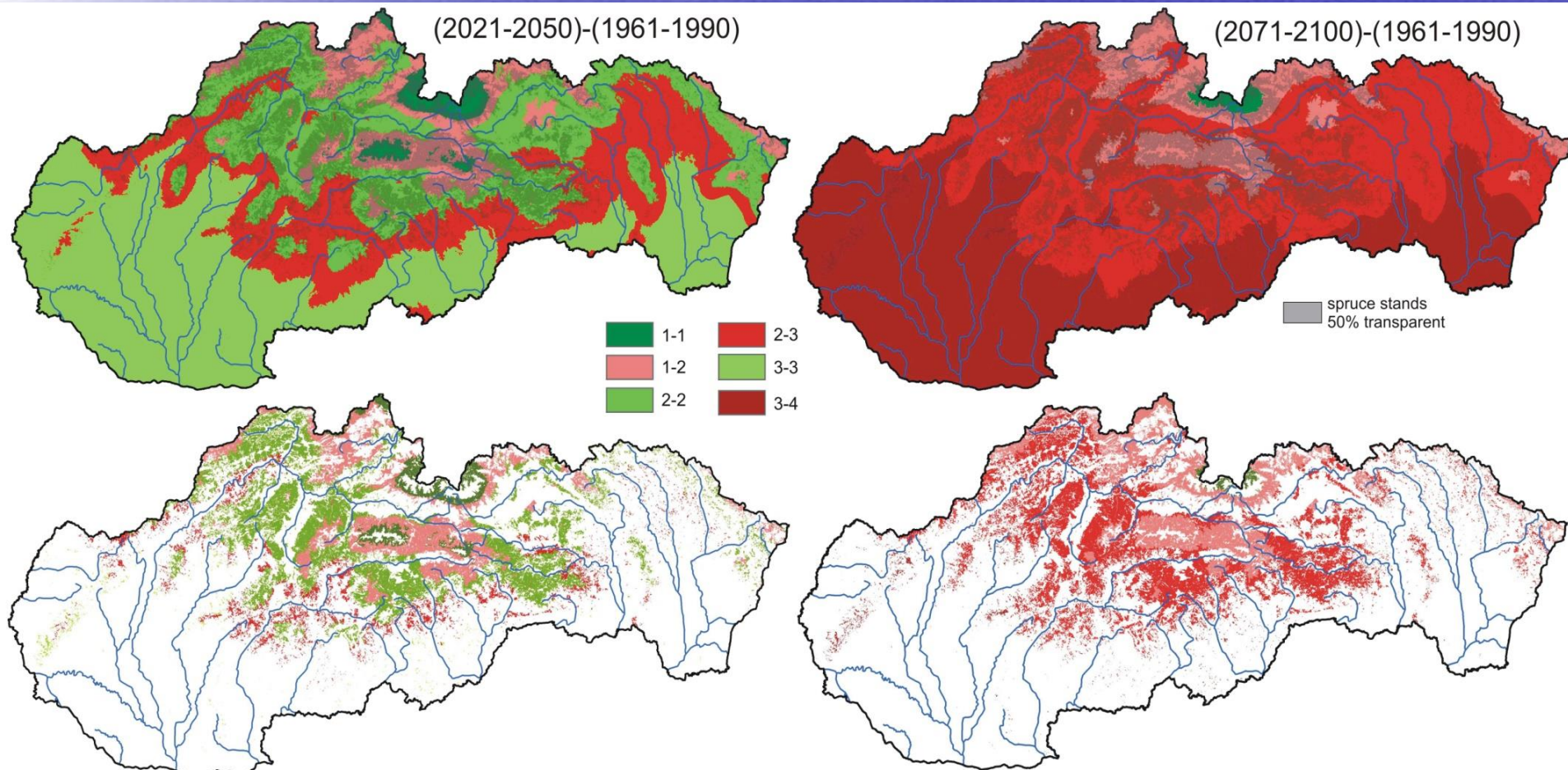
**Annual total insect damage (hectars) in Hungary
versus Pálfi's drought index (PAI)**

Number of generations of spruce bark beetle (*Ips typographus*) (Tomás Hlásny, Zvolen 2014)

Forecasts for the near and far future

Upper line: number of generations on the whole territory of Slovakia

Lower line: number of generations in the actual range of spruce in Slovakia



The largest challenge in forestry since the 17th century

Disorder in sustained use:

- Disorder in yield and income planning
- Disorder in market relations

Social problems: dwindling rural income

Approach: conservative vs. future-oriented?

Tensions with nature conservation and greens

Discrepancy with centrally regulated mitigation measures

Rethinking of the concept of sustainability?



Mit Gott!
SYLVICVLTVRA OECONOMICA,
Oder
Hauswirthliche Nachricht und Naturmäßige
Anweisung
Zur
Wilden Baum-Zucht,

Nebst
Gründlicher Darstellung/
Wie zu förderst durch Göttliches Benedeyen dem allenthalben und insgemein einreißenden
Grossen Holz-Mangel/

Bermittelst Sae-Pflanz- und Verfezung vielerhand Bäume zu prospiciren/
nach also durch Anflug und Wiederwachs des so wohl guten und schleunig anwachsend, als andern geröschlig/
und nützlichen Holzes, ganz öde und abgetriebene Holz-Ländereyen, Plätze und Orte widerum Holzreich, nützlich und brauchbar zu
machen: Gewerab von Saam-Schumen und wie der wilde Baum-Saamen zu sammeln, der Grund und Boden zum Sien zu
richten, solche Saat zu bewerkstelligen, auch der junge Anflug und Wiederwachs zu beobachten. Daneben das sogenannte lebendige,
oder Schlag- und Ober- und Unter-Holz aufzubringen und zu vermehren, welchen beigefügt die Arten des Fangel- und Laub Holzes,
welchs deren Eigenschaften und was befagtes Holz für Saamen trage, auch wie man mit fremdden Baum-Gewächsen sich zu
verhalten, ferner wie das Holz zu fällen, zu verholzen, zu lischern und sonst zu nützen.

Wes zu nothdürftiger Versorgung des Haus-, Bau-, Brau-, Berg- und Schmeltz-Wesens/
und wie eine immerwährende Holz-Nutzung Land und Leuten/ auch jedem Haus-Wirthe zum schätzbaren großen
Aufnehmen/ pfleglich und nützlich zu erziehen und einzuführen.

Worbey zugleich eine gründliche Nachricht von den in Churfst. Sächss. Landen
Gefundenen Turff

Dessen Natürliche Beschaffenheit/ grossen Nutzen/ Gebrauch und nützlichen Verkohlung.
Aus Liebe zu Beförderung des allgemeinen Bestens beschrieben

Von
Hanns Carl von Carlowitz/
Königl. Pohl. und Churfst. Sächss. Cammer-Rath und Ober-Berg-Hauptmann.



Mit Königl. Pohl. und Churfst. Sächss. allergnädigsten PRIVILEGIO.

LEZP336/
verlegt Johann Friedrich Braun 1713.

Other (non-genetic) measures

- thinning with medium intensity
- keep closed canopy
- keep low stem numbers
- monitoring is essential!
- collect information from exposed (southern) regions, also from abroad
- keep rotation age lower
- **Develop decision support system**

Untimely admonitions

- A decisive reason for global economic problems is the depletion of natural and social capital
- The „must“ of **economic growth** limits the necessary regeneration of environmental and societal resources
- **Economy is a subsystem of the human society, and can function only within the frame of the natural system**
- The solution needs a general overhaul of society and economy

The building of a sustainable society is a *cultural* issue

Managing for more resilient forests

Intuitive concepts might not hold

Do less modeling, more field observation, monitoring

act with long-term vision,

work collaboratively,

continue to learn,

and expect surprises!

Adapted: Craig Allen, Los Alamos, USGS