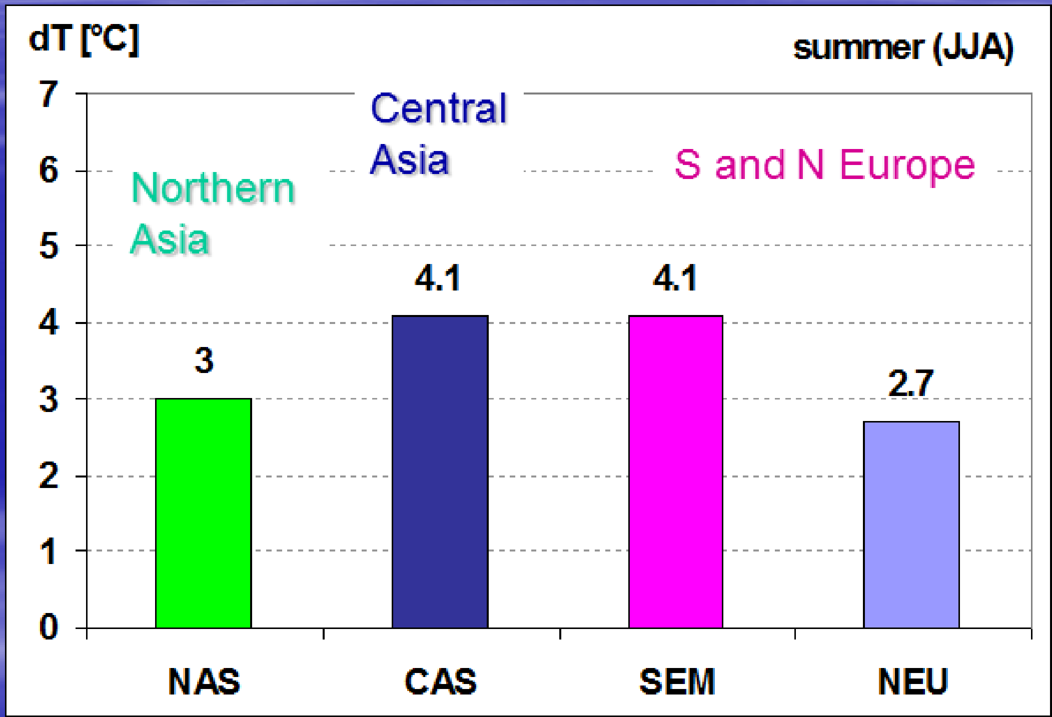
Predicted summer climate changes in temperate Eurasia

A1B scenario for the period 2080-2099 vs. the reference period 1980-1999,

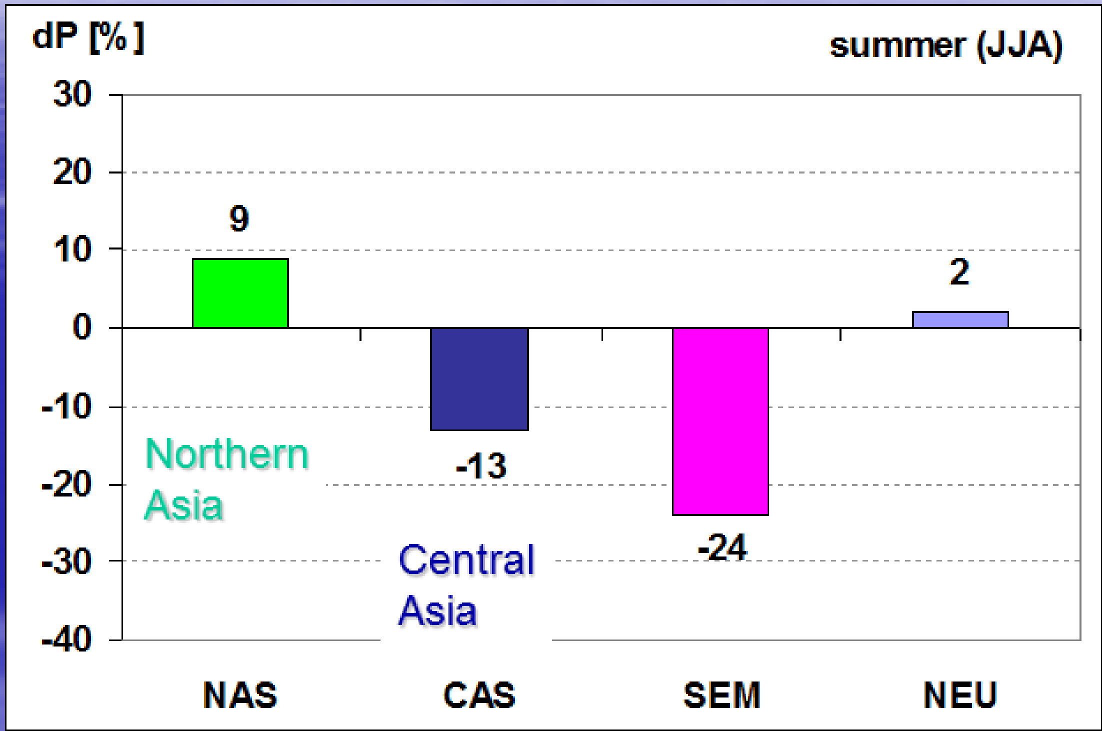
Change of mean summer temperature (°C)



averages for the regions Northern Asia (**NAS**); Central Asia (**CAS**), Central-Southern Europe with the Mediterranean (**SEM**) and North Europe (**NEU**).

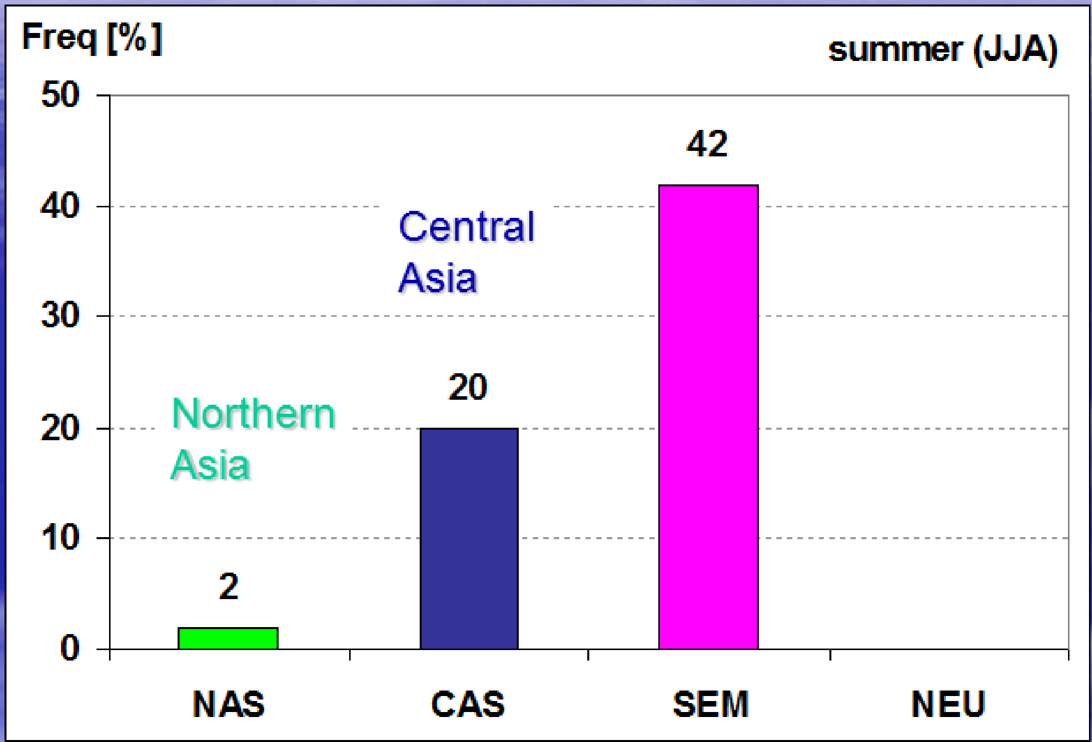
Source: data of IPCC 2007, design: B. Gálos

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*

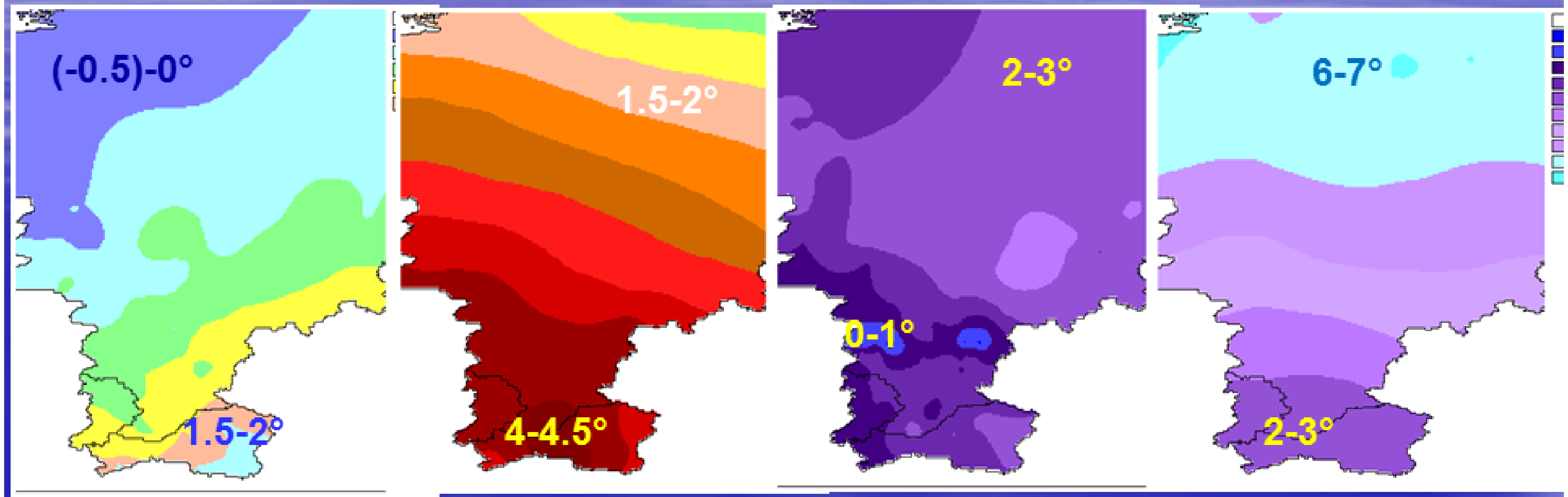
Change of the frequency of dry summers (%)



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*

Climate change in central Siberia from 1960-1990 to present (1991-2010) and from present to 2080 (HadCM B1)

past 3 decades | until 2080 | past 3 decades | until 2080



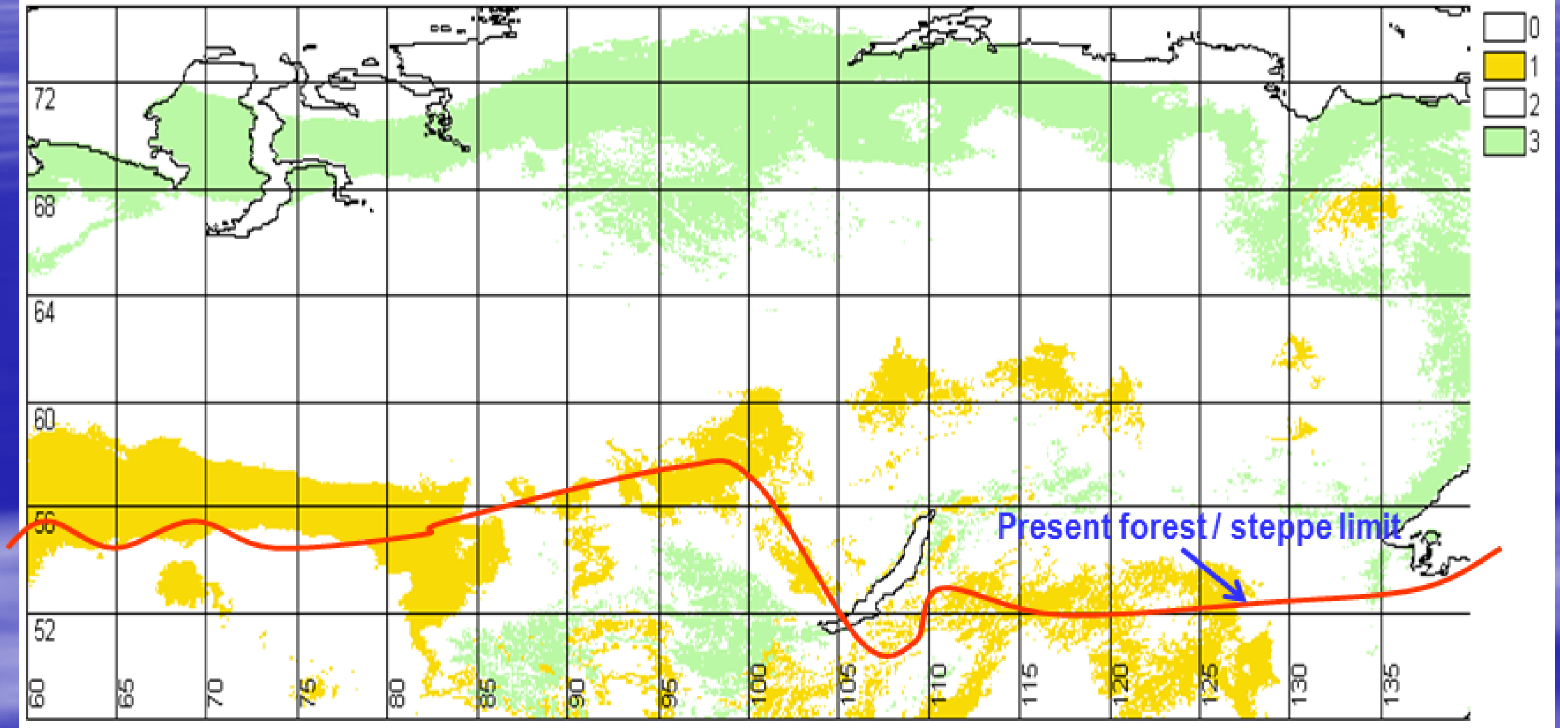
July temperature | **January temperature**

Precipitation change: moderate, +10-20%

(*Tchebakova* and *Parfenova, EGU 2011)*

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

How will trees respond *within a generation!*

- Is available adaptive capacity (= genetic resources) sufficient?
- Do natural processes function? (migration, evolution)
- **How much climatic (site) change is tolerated?**

In forestry/conservation practice:

- Which populations to plant, where?
- How to conserve, what?

Is (evolutionary) adaptation possible?

Optimistic answer: evolution of ecosystems is adapted to changes which happened continuously during Earth history – present changes are not unusual!

- Unique genetic system and diversity of trees cope with changes,
- Plasticity of trees is high,
- Gene flow helps to exchange favorable genes across large distances
- Migration secures continuous forest cover

How serious are predicted changes compared to postglacial changes?

Past climatic fluctuations in the Holocene:

Global mean temperature fluctuation
in the last 100 tsd. years: **-8 ~ +2°C**

Estimated fluctuation of mean temperature
in the last thousand years : **- 0,6 ~ + 0,5°C**

Estimated summer temperature increase in South-Central Siberia until 2100:

+3,5 ~ +5,0 °C = very serious!

Is spontaneous migration a realistic expectation?

(Jump, Mátyás, Penuelas 2009, Mátyás, 2002)

- Postglacial migration
  - of beech: 20 – 30 km/century
  - of oaks: 7,5 – 50 km/century
  - of spruce: 8-50 km/century

If + 1.8 °C - + 3.3 °C temp. increase:

- Altitudinal shift of isotherms: 250-500m
- Northward shift on flat terrain:

  260 - 480 km/century! = 1000 years!!!

  →**Rapid regression in flat lands, especially threatened: forest - steppe limit!**

EVOLTREE Workshop

Forests at the limit –

selective environment at the receding (xeric) edge of distribution and consequences

May 11-14, 2009

Sopron, Hungary

Örefajökull – Skaftafjell, Island 2006

Örefajökull – Skaftafjell, Island 2006

Plant cover and climate shifts

Climatic shifts: vegetation as marker and indicator

- **Migration: „front" limits > over-represented**
- **Extinction: „trailing/retracting" limits > under-represented**

Past: paleo-biogeography

Present: modelled: niche or process-based

Future: predicted from present models

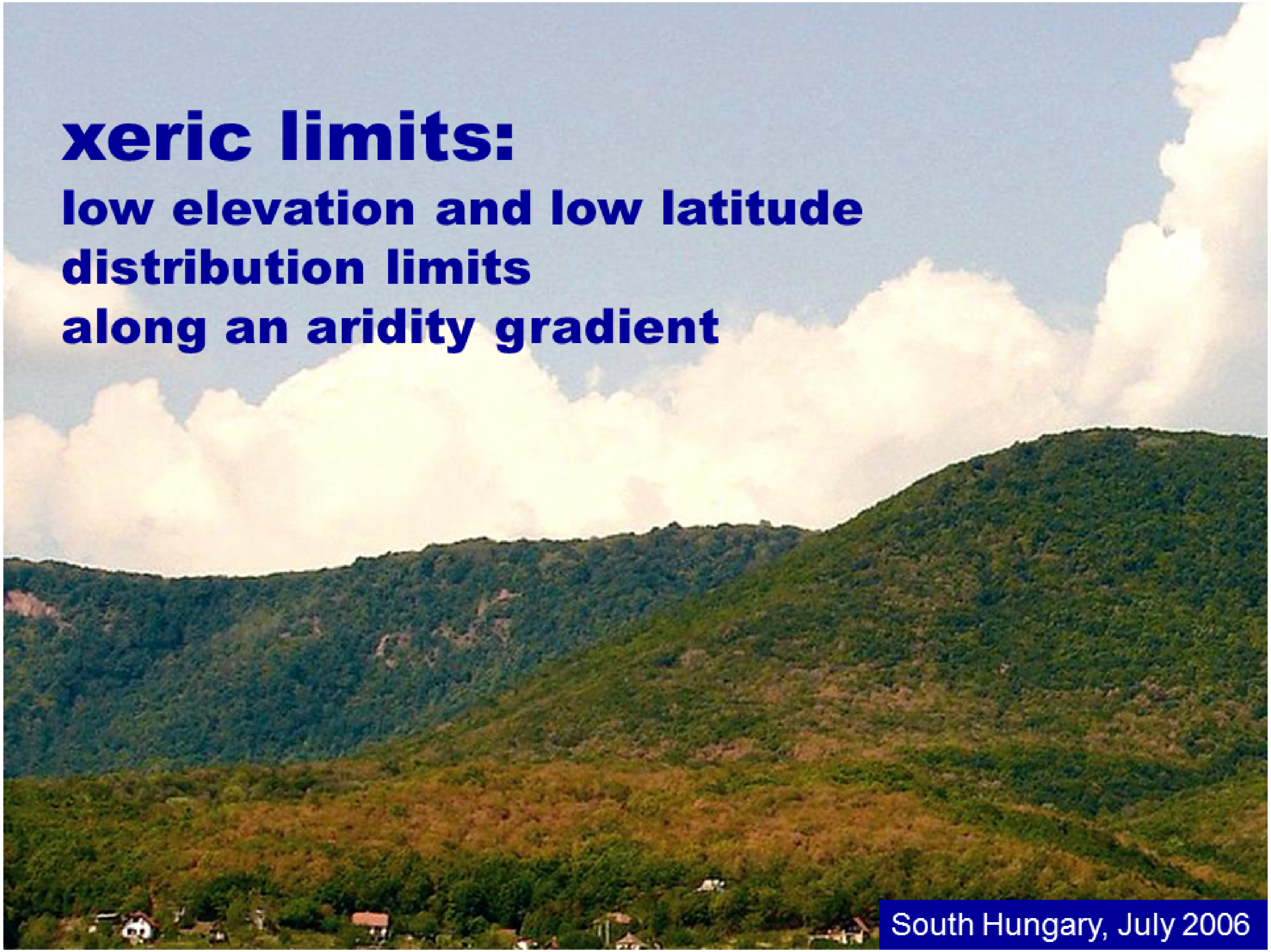
Reasons for overrepresentation of the „forward limit”:

- temperature driven
  - Thermic data well measurable
  - Sensitive to changes
  - Progress illustrative
  - Close to research centres
  - Happening in +/- natural settings
  - Emotional content: positive (production)


T: -2º P: 450 mm

Temperature increase
20th century: +1ºC
Expected 160 m alt.
Observed: 60 m alt.

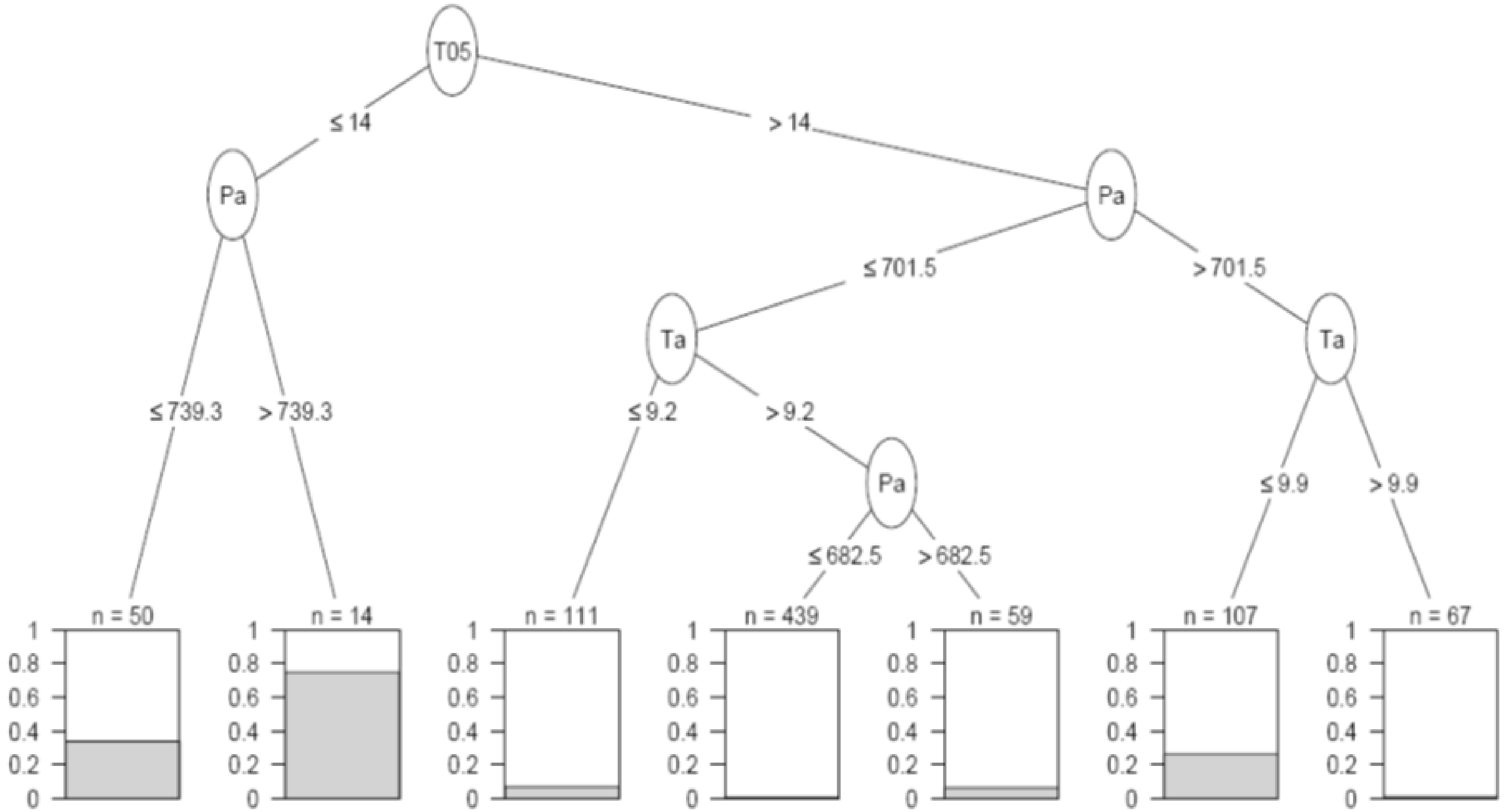
Temperature increase
20th century: +1ºC
Expected 160 m alt.
Observed: 60 m alt.


xeric limits:
low elevation and low latitude
distribution limits
along an aridity gradient
South Hungary, July 2006

Reasons for underrepresentation of the „xeric" / rear limit

- drought driven
  - Changes camuflaged by persistence
  - Moisture conditions difficult to measure
  - Progress fuzzy, disperse
  - Happening in anthropogenic settings
  - Away from research hubs
  - Emotional content: negative (retreat)

The ugly face of „migration”: perishment of the trailing limit



Decision tree-based bioclimatic model for xeric limits of beech

Bar diagrams: probability of being above the aridity limit

(Czucz-Galhidy-Mátyás Ann. For. Sci. 2008)

PREDICTING ADAPTIVE RESPONSES OF FOREST TREES

FROM THE PERSPECTIVE OF EVOLUTIONARY ECOLOGY

Csaba Mátyás - Attila Borovics

Institute of Environmental and Earth Sciences, University of West Hungary, Sopron, Hungary, and Forest Research Institute, Sárvár, Hungary

How will trees respond *within a generation?*

- Are available genetic resources sufficient?
- Speed of adaptation/evolution?
- Limits to genetic adjustment?
- Acting of natural (spontaneous) evolution?

In forestry/conservation practice:

- **Which populations to plant, where?**
- **How to conserve, what?**

Evolutionary ecology

Analysis of historical / contemporary patterns of variation in natural systems and their function

Evolutionary biology	Ecology
+/- historic, phylogeny, genetic models	+/- contemporary, effects of abiotic/biotic environment

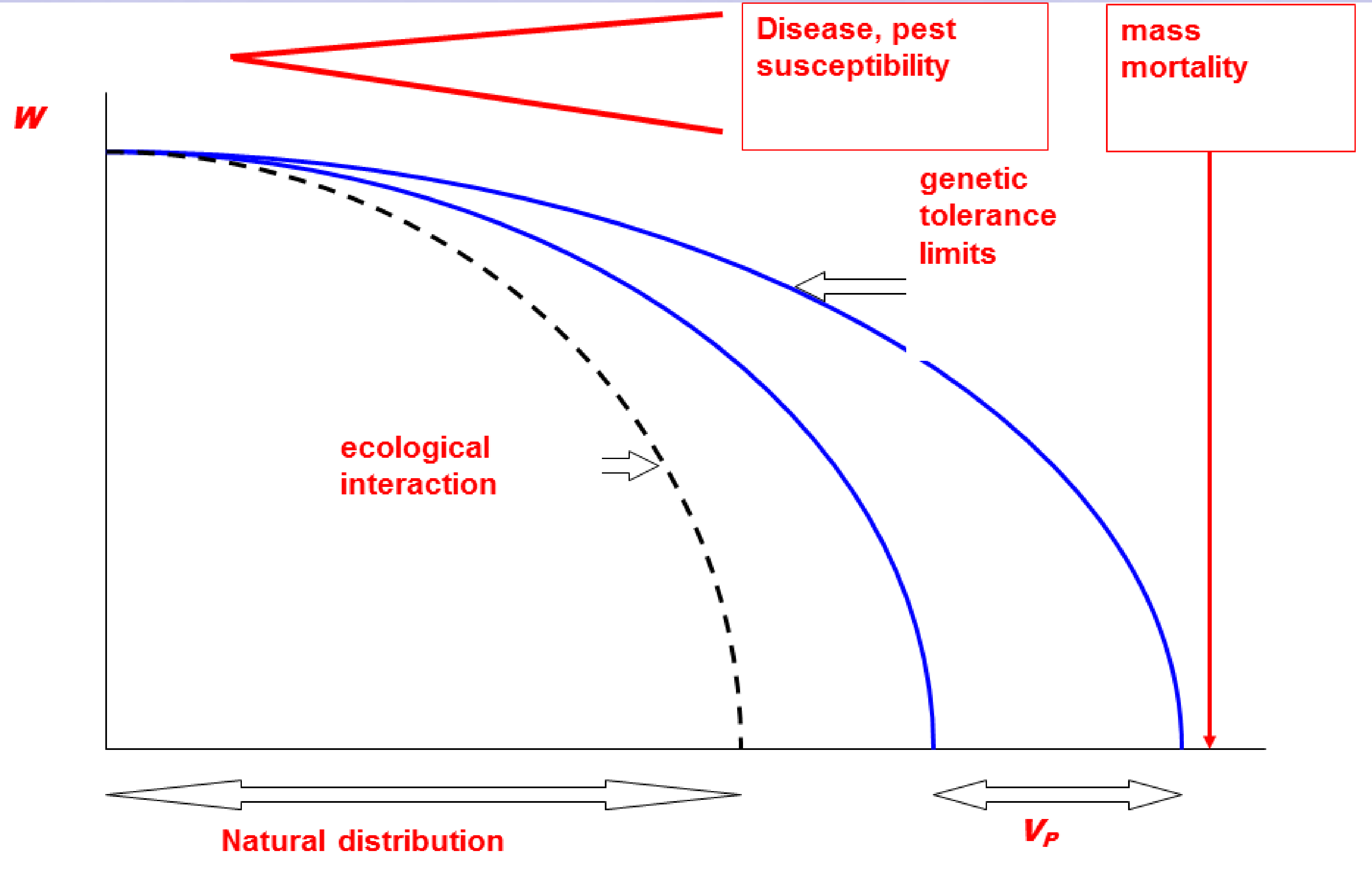
Study of variation on all levels

Genetically (lineage-) dependent processes and their constraints

Tested hypotheses:

- adaptive significance of traits
- selective factors shaping patterns and resources
- „evolvability" of traits and
- its constraints (tolerance limitations)

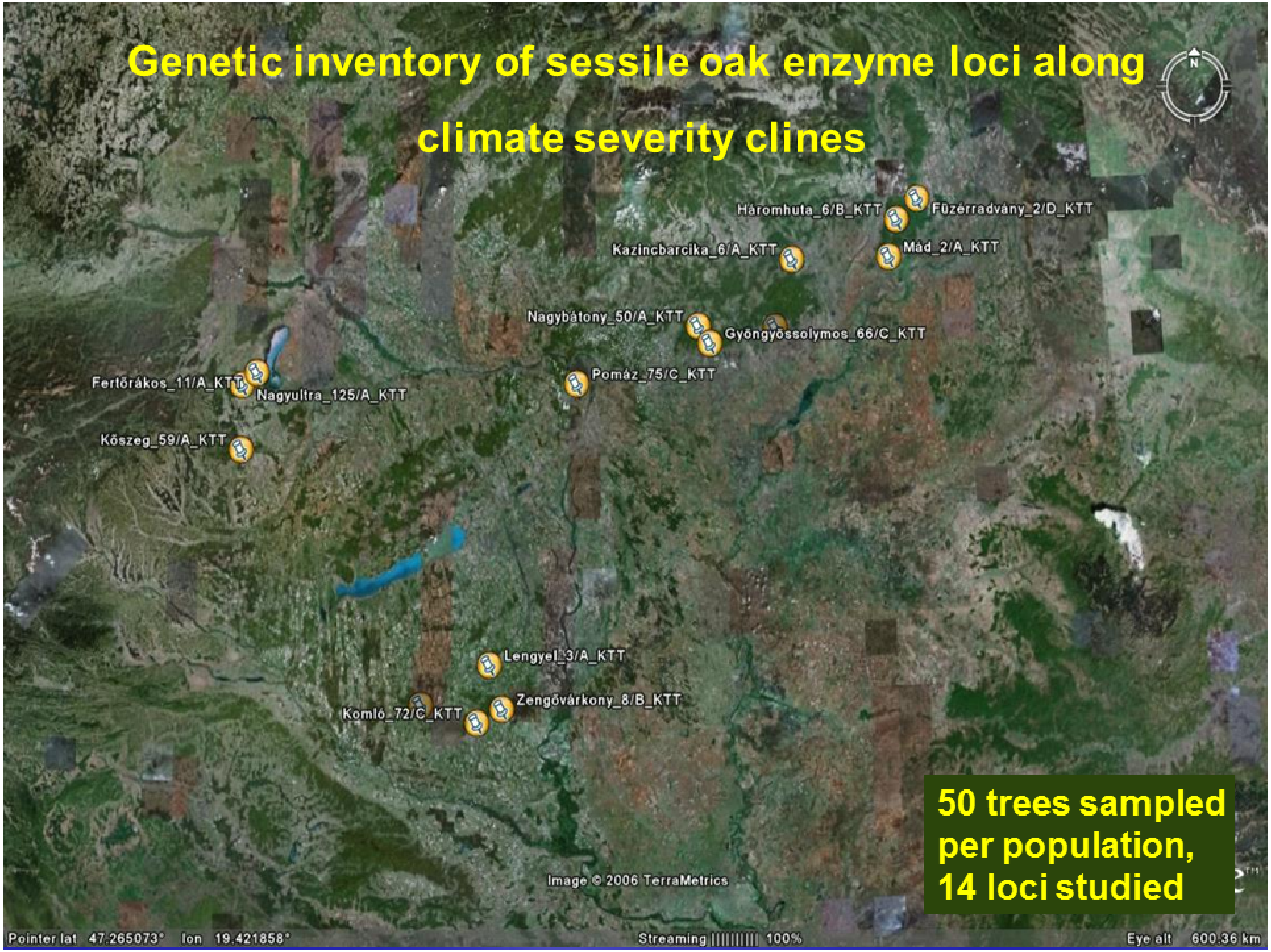
Ecological-genetic hypothesis of population tolerance and stability (to the right: increasing environmental stress)



Dothistroma needle blight, lodgepole pine, Canada,B. C.(photo: A. Woods)


Beech in West Hungary (photo C. Matyas)

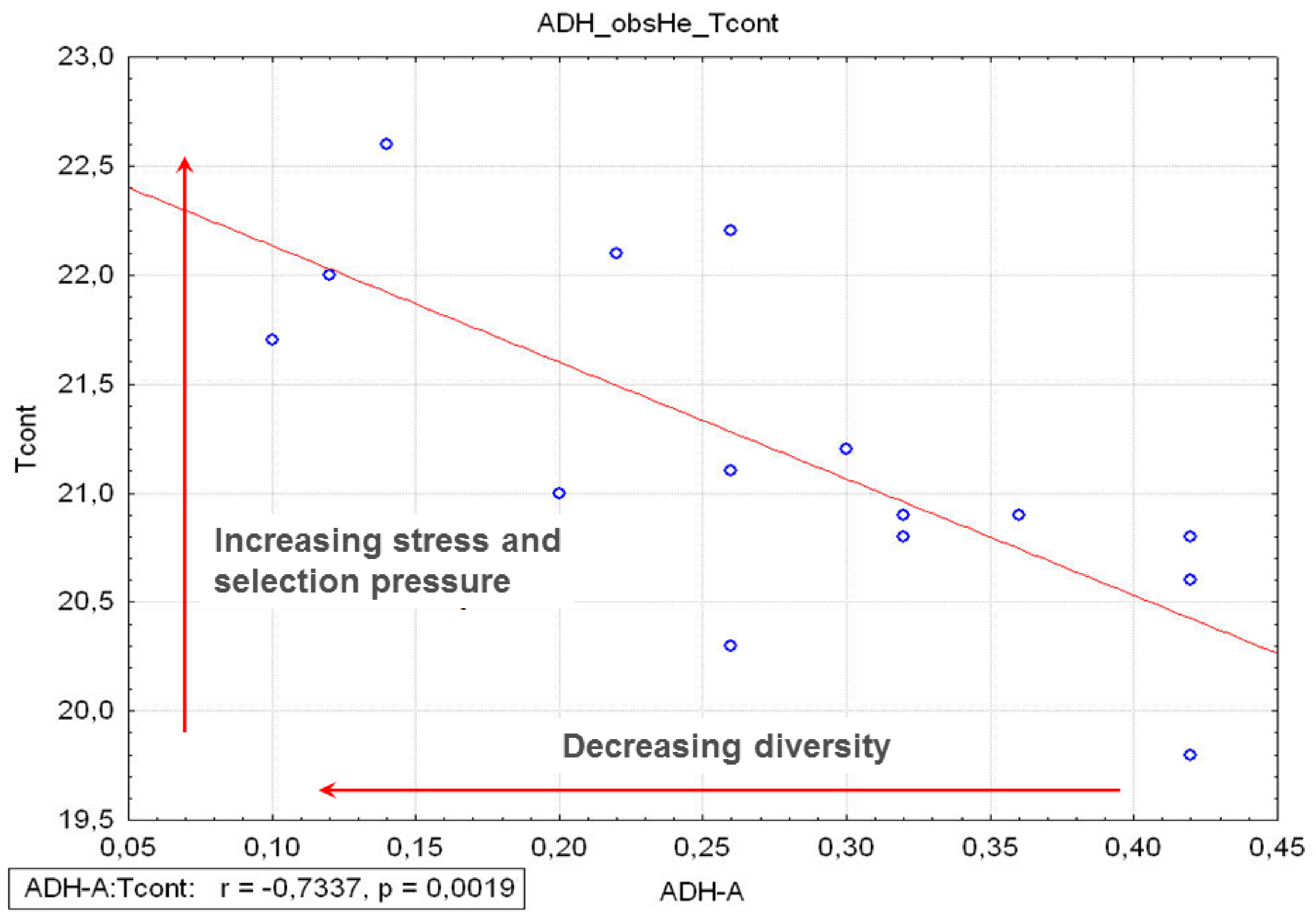
Atlas cedar, Morocco (photo C. Matyas)


Genetic inventory of sessile oak enzyme loci along
climate severity clines
N
Háromhuta_6/B_KTT
Füzérradvány_2/D_KTT
Kazincbarcika_6/A_KTT
Mád_2/A_KTT
Nagybátony_50/A_KTT
Gyöngyössolymos_66/C_KTT
Pomáz_75/C_KTT
Fertőrákos_11/A_KTT
Nagyultra_125/A_KTT
Kőszeg_59/A_KTT
Lengyel_3/A_KTT
Zengővárkony_8/B_KTT
Komló_72/C_KTT
50 trees sampled
per population,
14 loci studied
Image © 2006 TerraMetrics
Pointer lat 47.265073° lon 19.421858°
Streaming |||||||||| 100%
Eye alt 600.36 km

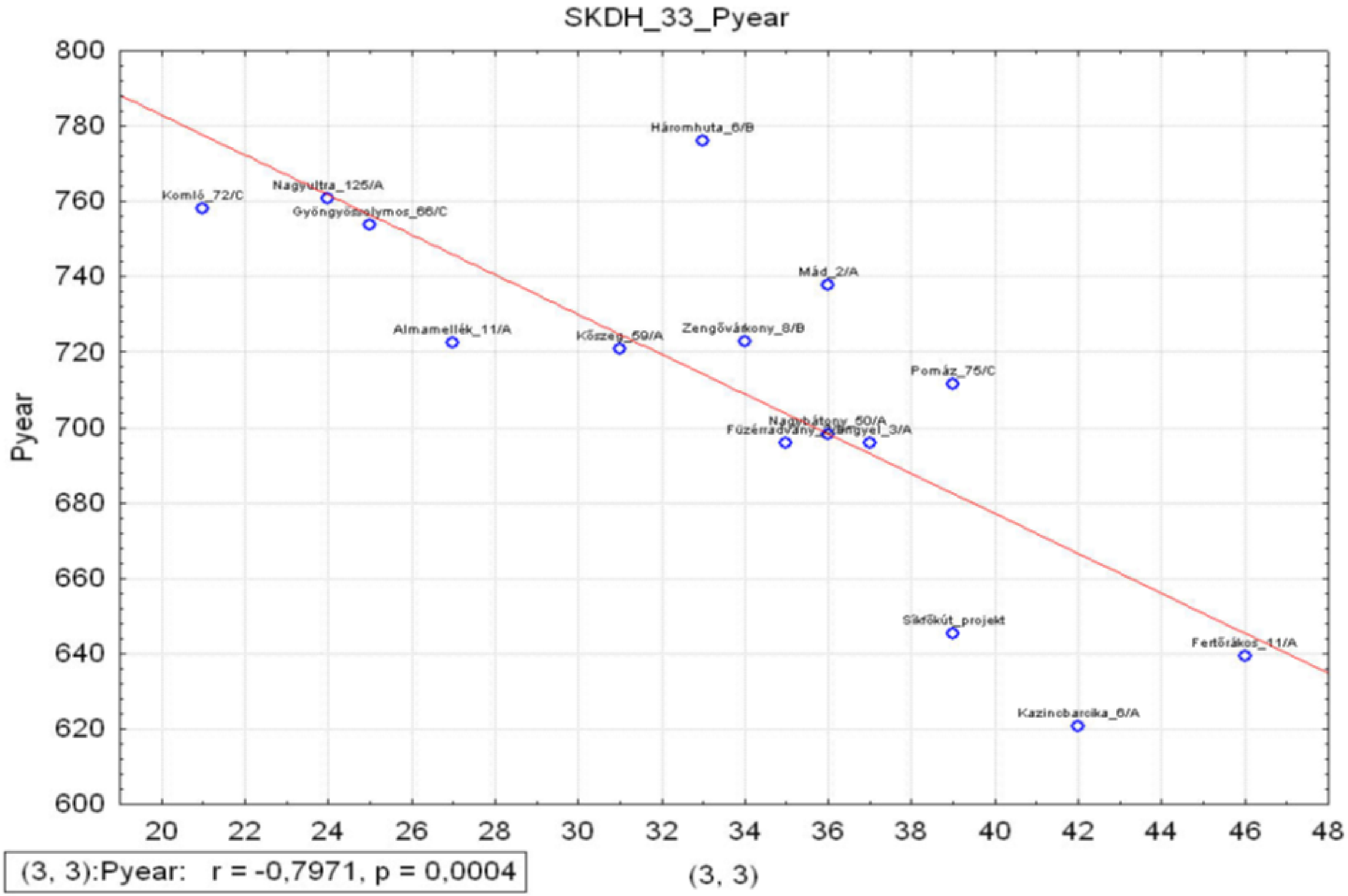
Climate selection effect on allelic diversity: Spring precipitation vs allelic frequency of ADH-A alleles

(unpubl. data for sessile oak by A. Borovics)

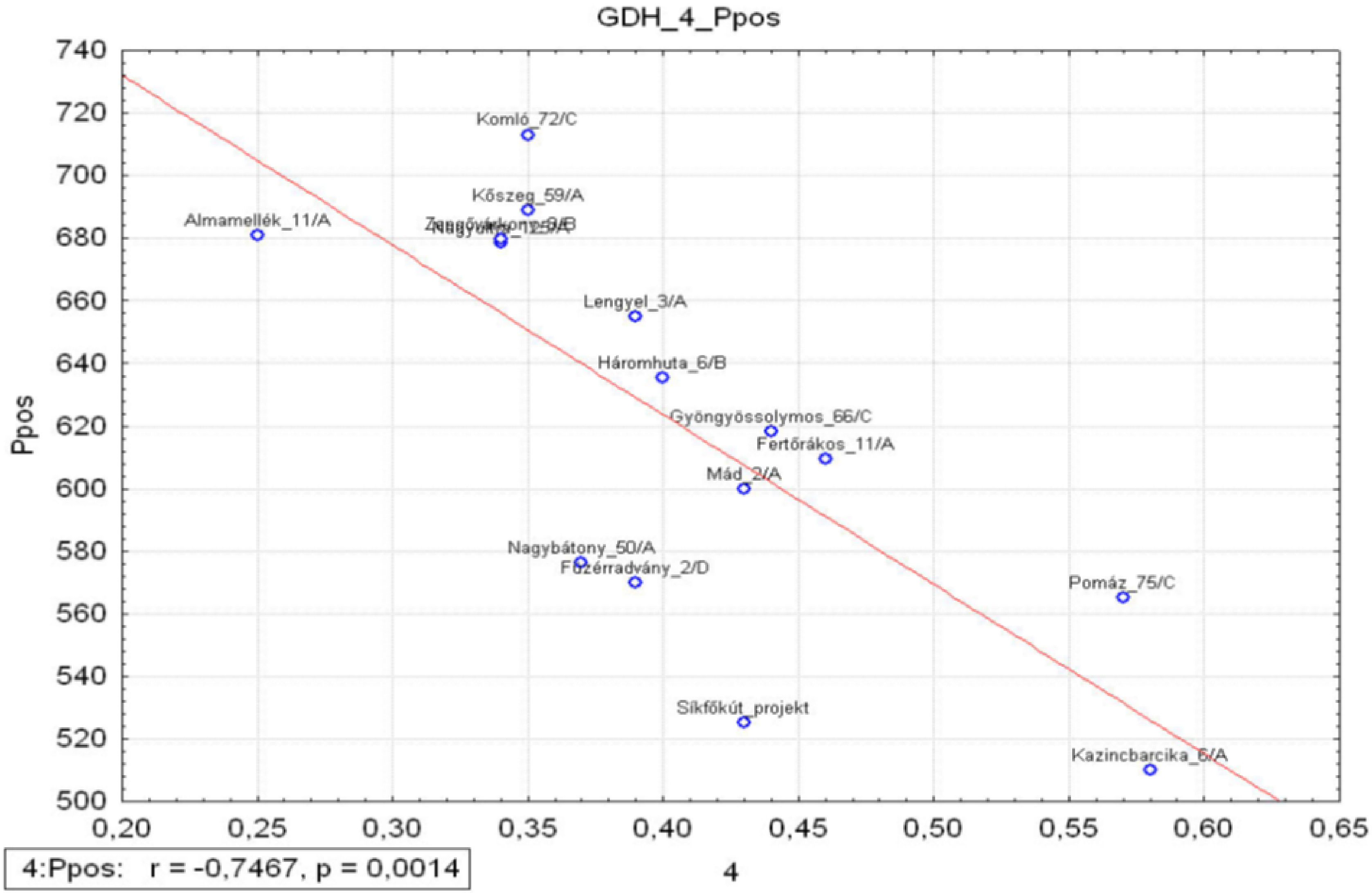
Allele type	Correlation with spring precipitation
ADH-3	+ 0,67 *
ADH-4	non sign.
ADH-5	- 0,73 **
ADH-6	- 0,65 *



Observed heterozigosity at locus ADH-A vs. continentality (Tmax-Tmin)



Frequency of genotype *SKDH-A 33* homozygote vs. annual precipitation



Frequency of allele GDH-A 4 „drought resistant” vs. precipitation of months with positive means above 0º C

Climatic selection linked to ecological status

Climatic selection is effective in spite of gene flow, human interventions

- Clear correlation with selection pressure at many loci (genotype, allele frequency, heterozygosity)
- Genetic similarity among geographically distant, ecologically similar sites
- Novel adaptations not found

(Micro-)evolutionary effect of selection

- there is no "optimum" diversity
- adaptation may degrade allelic diversity
- effect of diversity loss unpredictable

→unreliable indicator of adaptability or adaptedness

- effect on plasticity: regulatory changes

Forecasting response of biological systems:

(reasons for low reliability)

- **Delays in response:** lags conceal causal relations
- **Caotic** behaviour: realistic forecasting depends on proper identification of initial conditions
- **Non-linearity**: responses evade human thinking
- **Non-optimality** of functioning leads to non-equilibrium

Non-equilibrium conditions!

- Evolutionary-ecological optimization and equilibrium state are still implicit premises of modelling
- Inequilibrium: interpretation principle of modern ecology (striking analogies also in population genetics!)
- **What are the resources and limitations of adaptation in a non-equilibrium system?**