Délkelet-Európai
Klímahatás Kutató Központ
NEESPI
Regional Focus Research Center
for Non-boreal Eastern Europe

Climate- land cover interactions and impacts in South Central Europe

(Vulnerability of land cover and land use due to rapid progress of clamtic changes in lower elevation Central Europe

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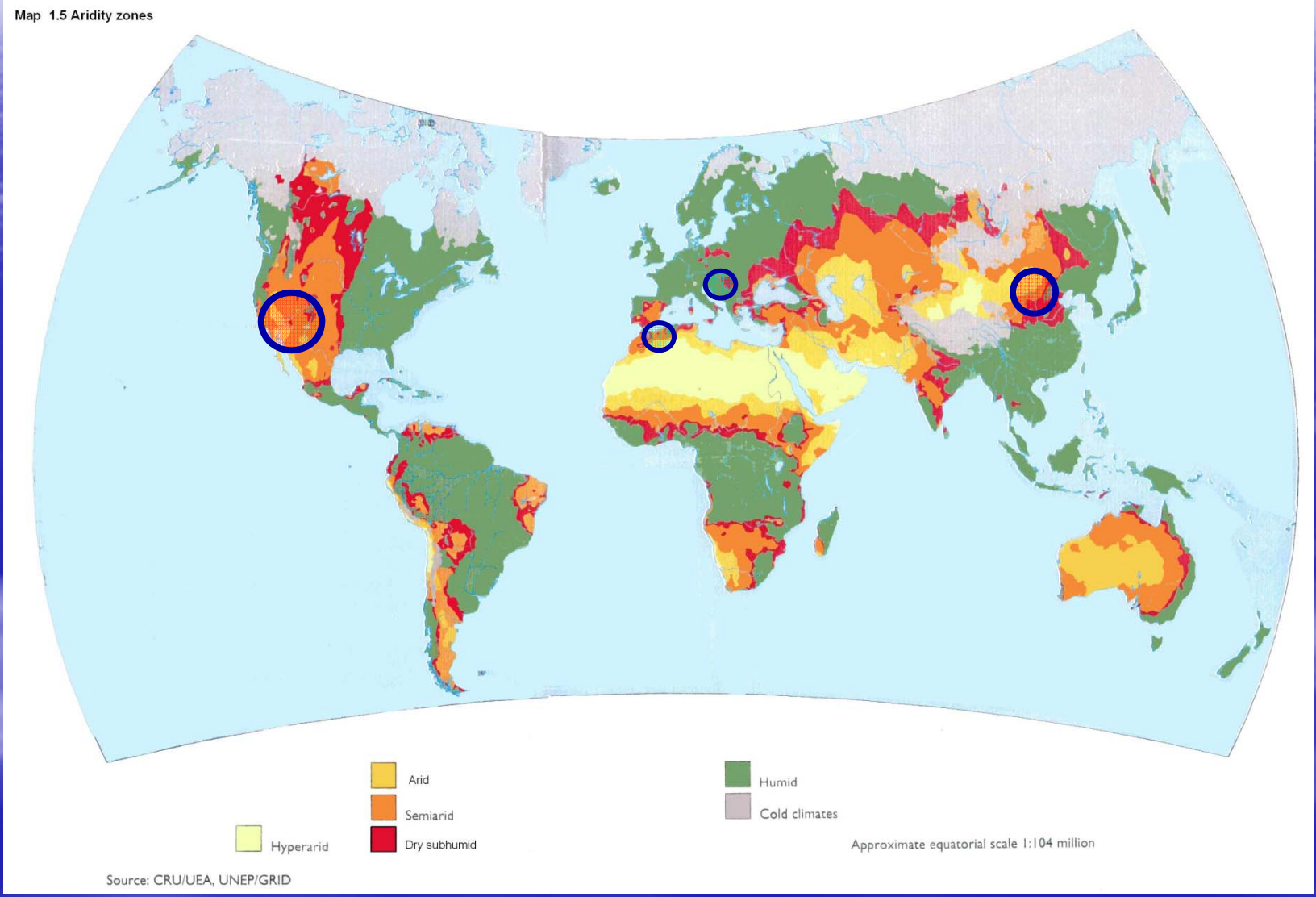
Institute of Environmental and Earth Sciences

NEESPI Focus Research Center for Nonboreal Eastern Europe

Climate change and SE Europe

- Temperate-continental environment:
  at the xeric limit: extremes!
- Extensive plains = fast progress of changes
- Dominant species at their limits + strong human transformation of environment:
  → adaptation constrained
- Limited sources for alternative species:
  →human support
- Fragile landcover, sustainability at stake

A global issue: temperate xeric limits



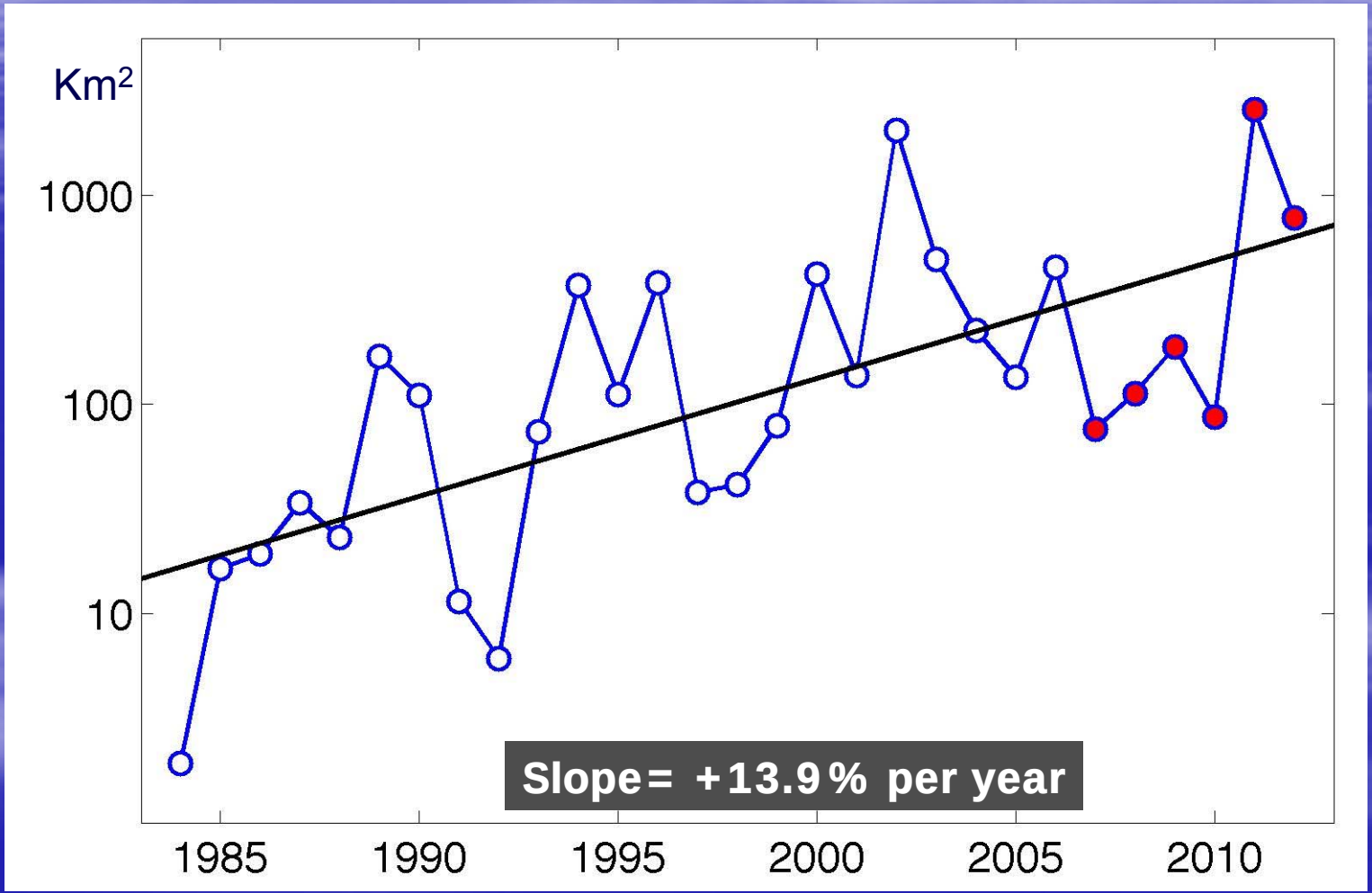
Source: UNEP

Cedar grove, Azrou, Moyen Atlas, Morocco, 2002 (Photo Mátyás)

At the limit: Moyen Atlas, Morocco, 2002 (Photo Mátyás)

The desert progressing: Moyen Atlas, Morocco, 2002 (Photo Mátyás)

Risks at the xeric limit: forest fires
Annual Burned Area, Southwest US



Allen, ex Williams et al. 2010, *PNAS*, updated

Las Conchas fire (N.Mex), 2011
17,320 hectares in first 14 *hours* …> 60,000 ha total

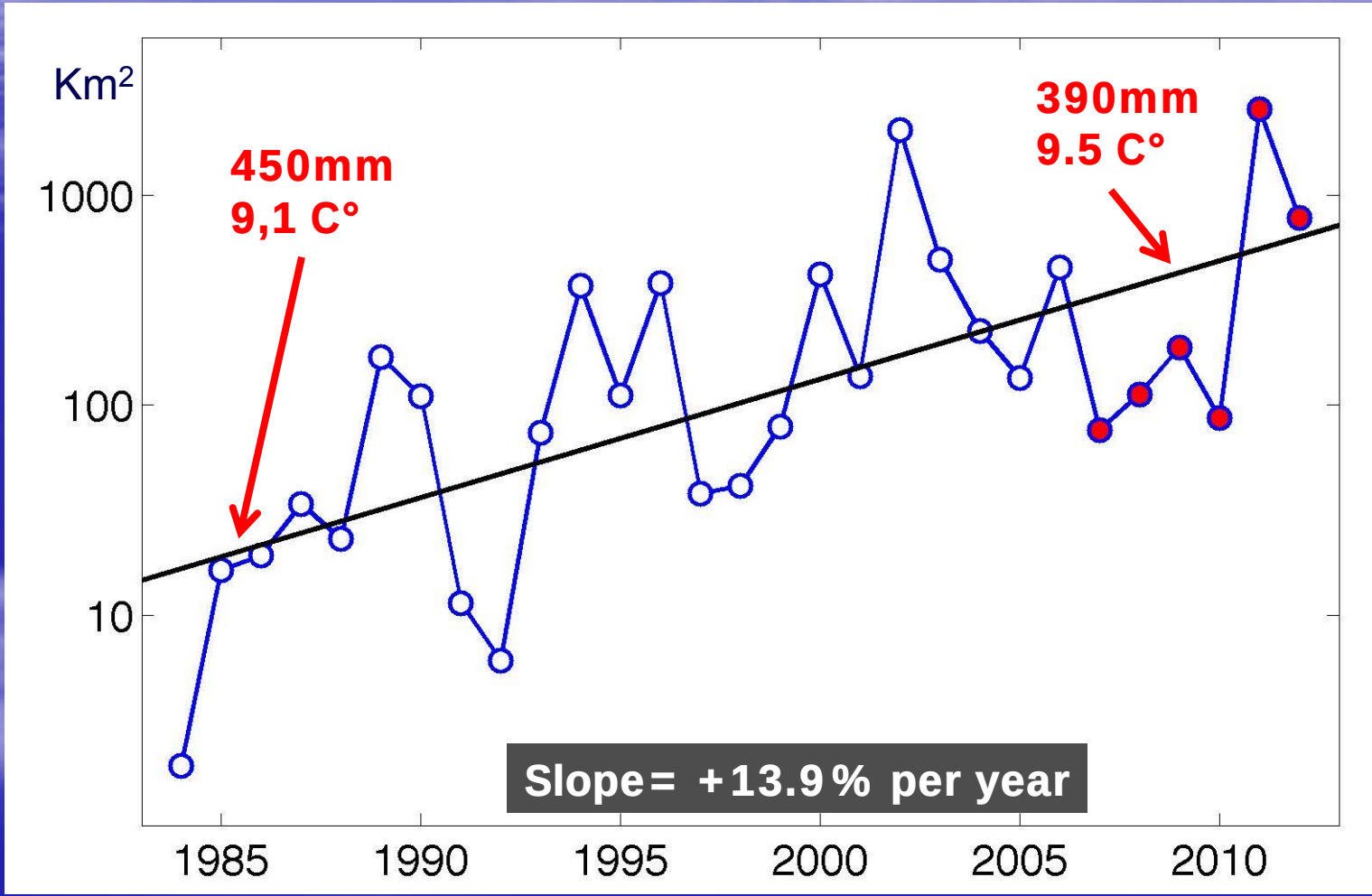
Photo Craig Allen

Rodeo-Chediski Fire (N. Mex), 2002
Photo C Allen

Photo C Allen

Annual Burned Area, Southwest US

1984–2012: T increase:0.4 C° , P decrease: 60mm



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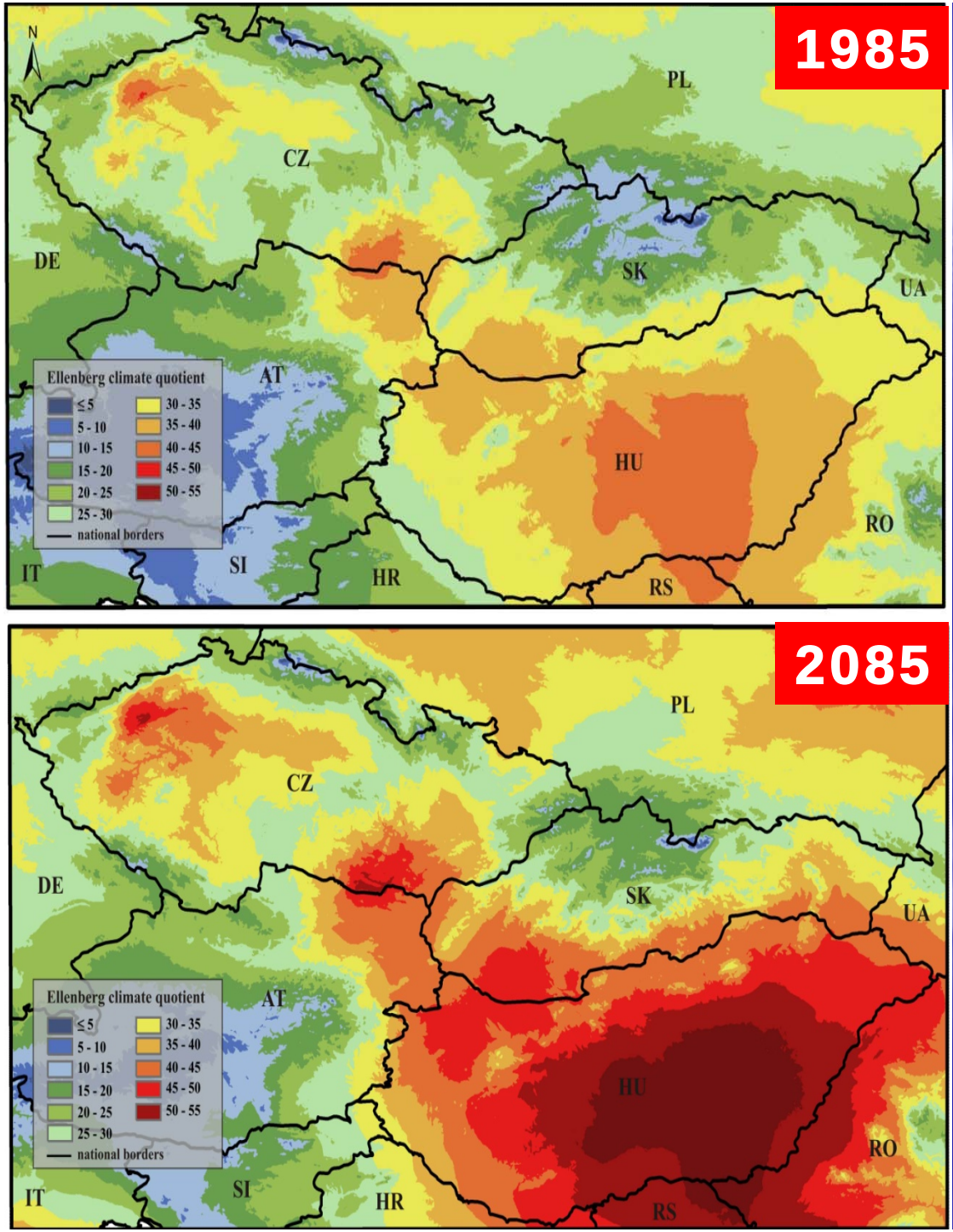
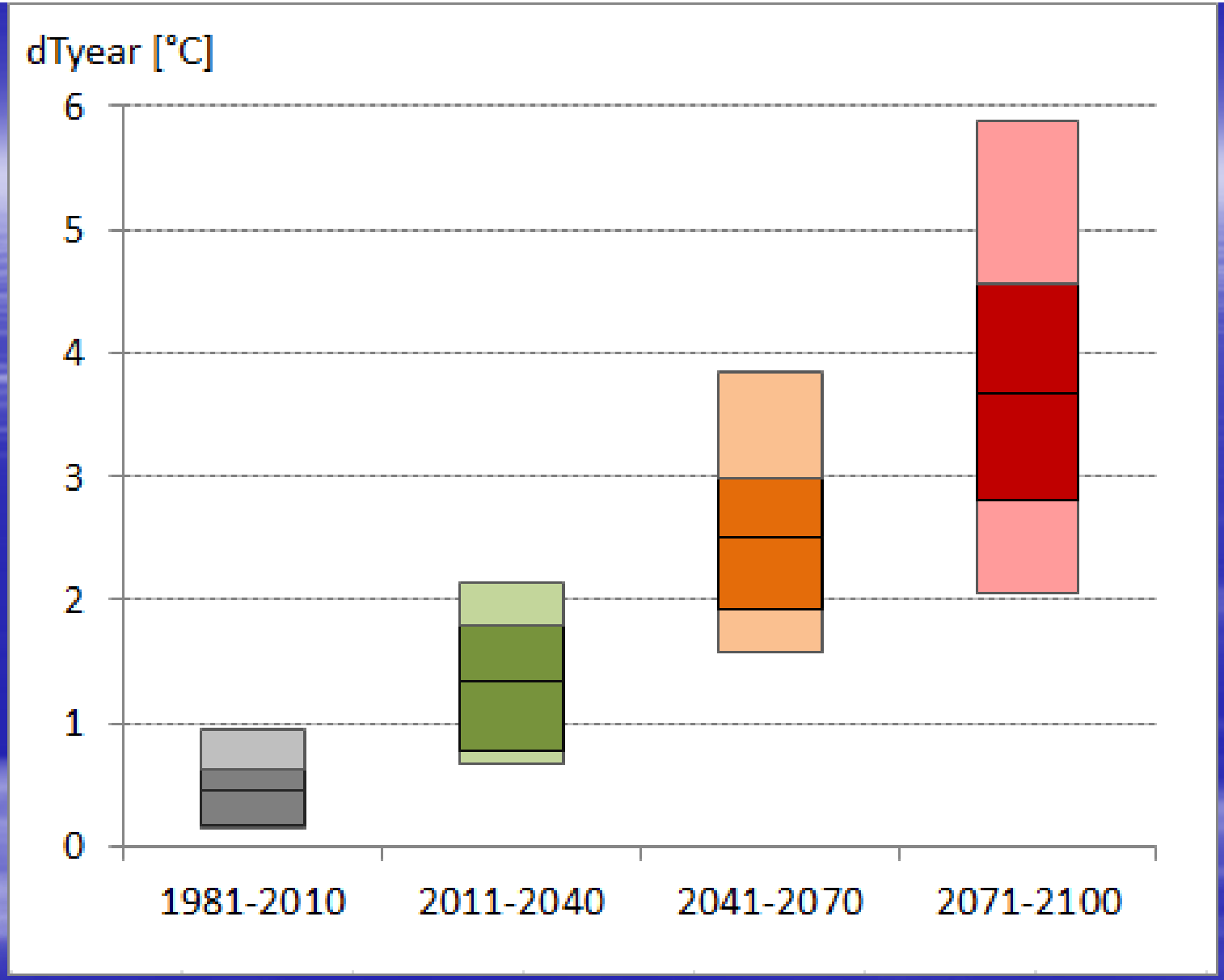


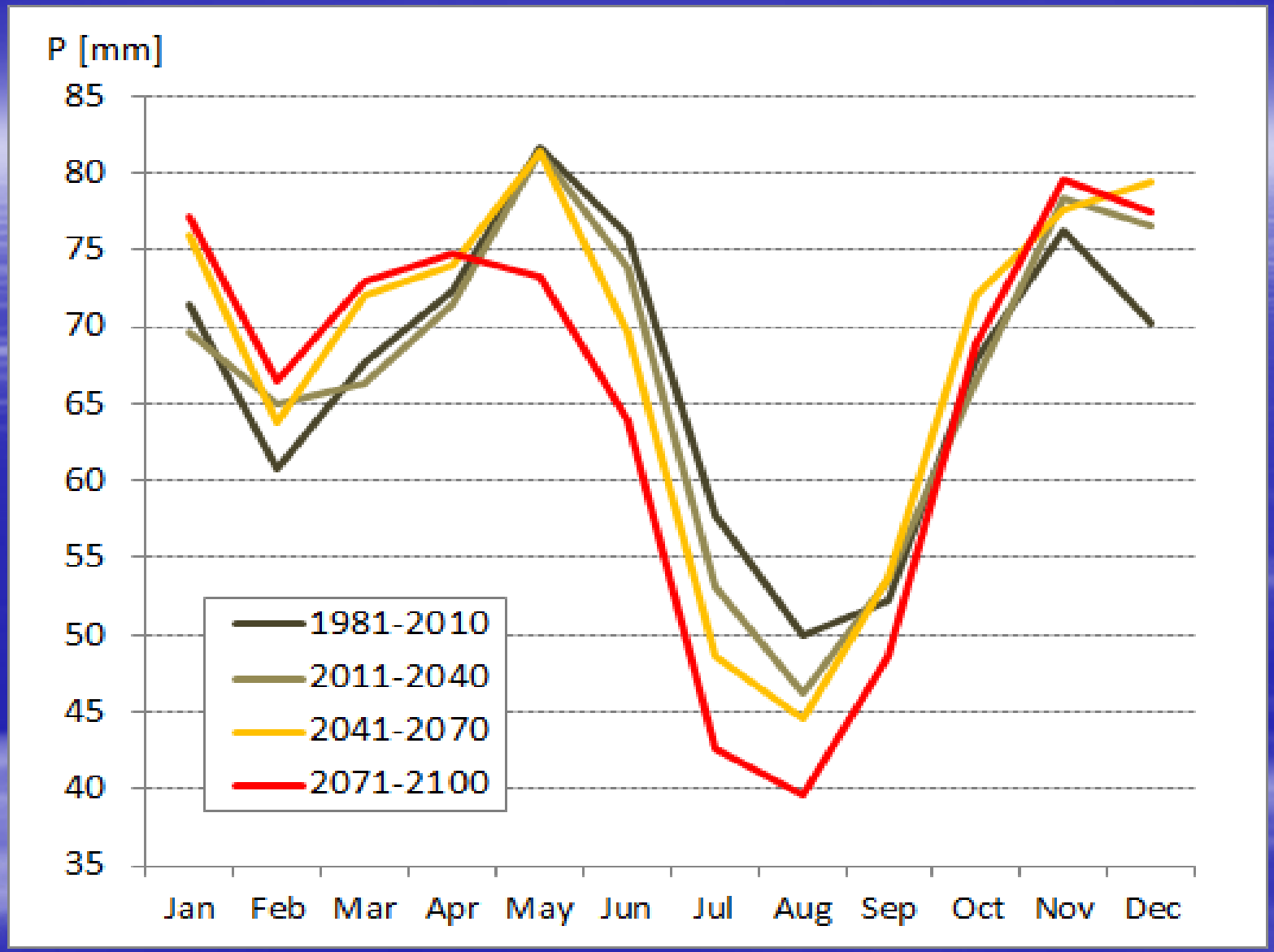
Drought index change In 100 years, Cental Europe 1985 – 2085

CarpatClim database, 1x1 km

T. Hlásny, C. Matyas et al., L.C. Forestry Journal, Prague, 2014.



Projected change of mean annual temperature in the Carpathian Basin average and variability of 12 climate model projections (*Gálos B, 2013)*



Trend change in interannual distribution of precipitation
Carpathian Basin, mean of 12 climate models *(Gálos B, 2013)*

Hidden threat: progressing drought

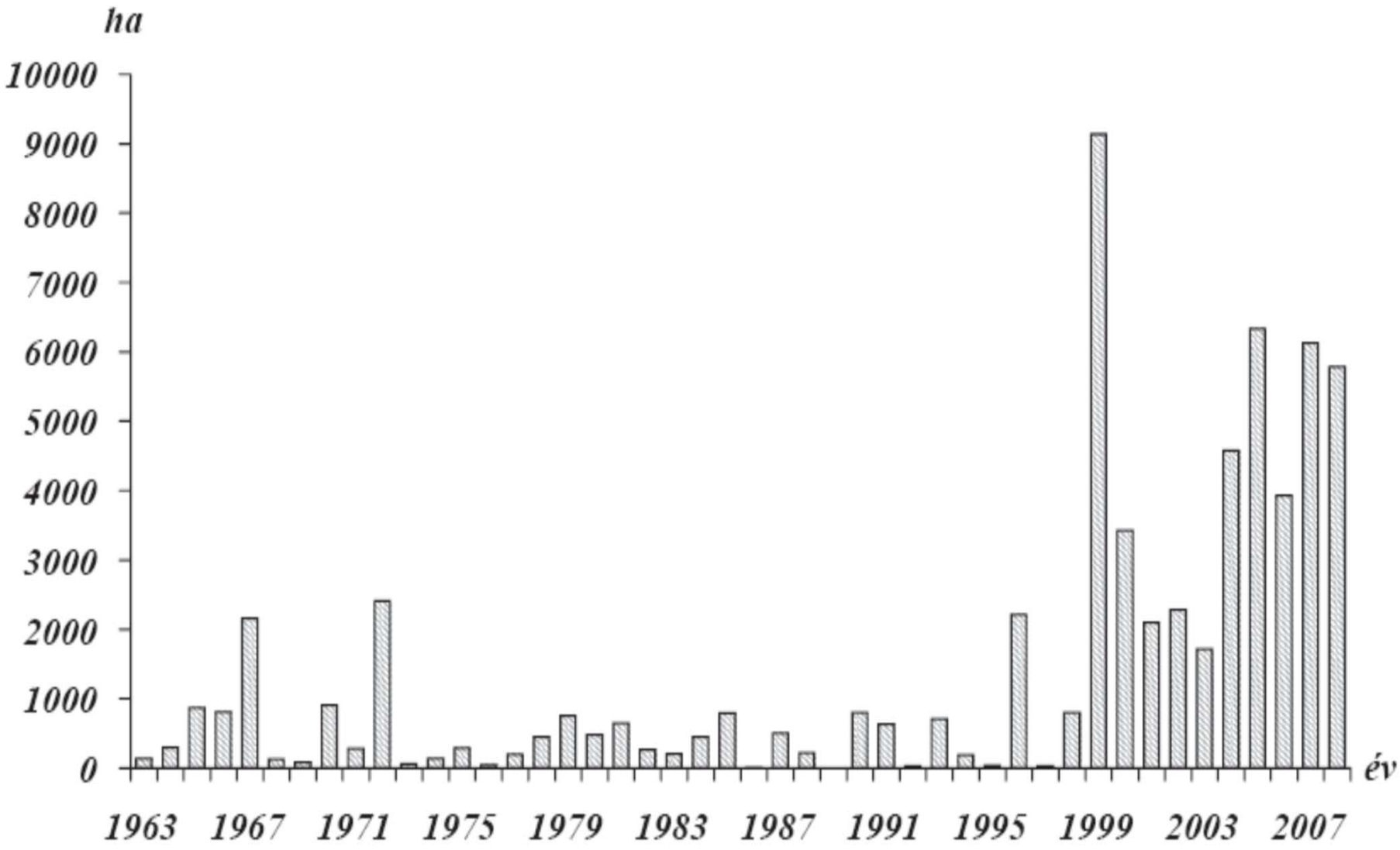
Since 1950: increasing temperatures

- **Hungary**: increase 0,14- 0,21°C/decade
- **North China**: droughts (Mongolia +2°C since 1940)
- **SW USA**: hotter since1950 than anytime in the last 600 years

The planet just had its warmest September on record

Impacts on landcover

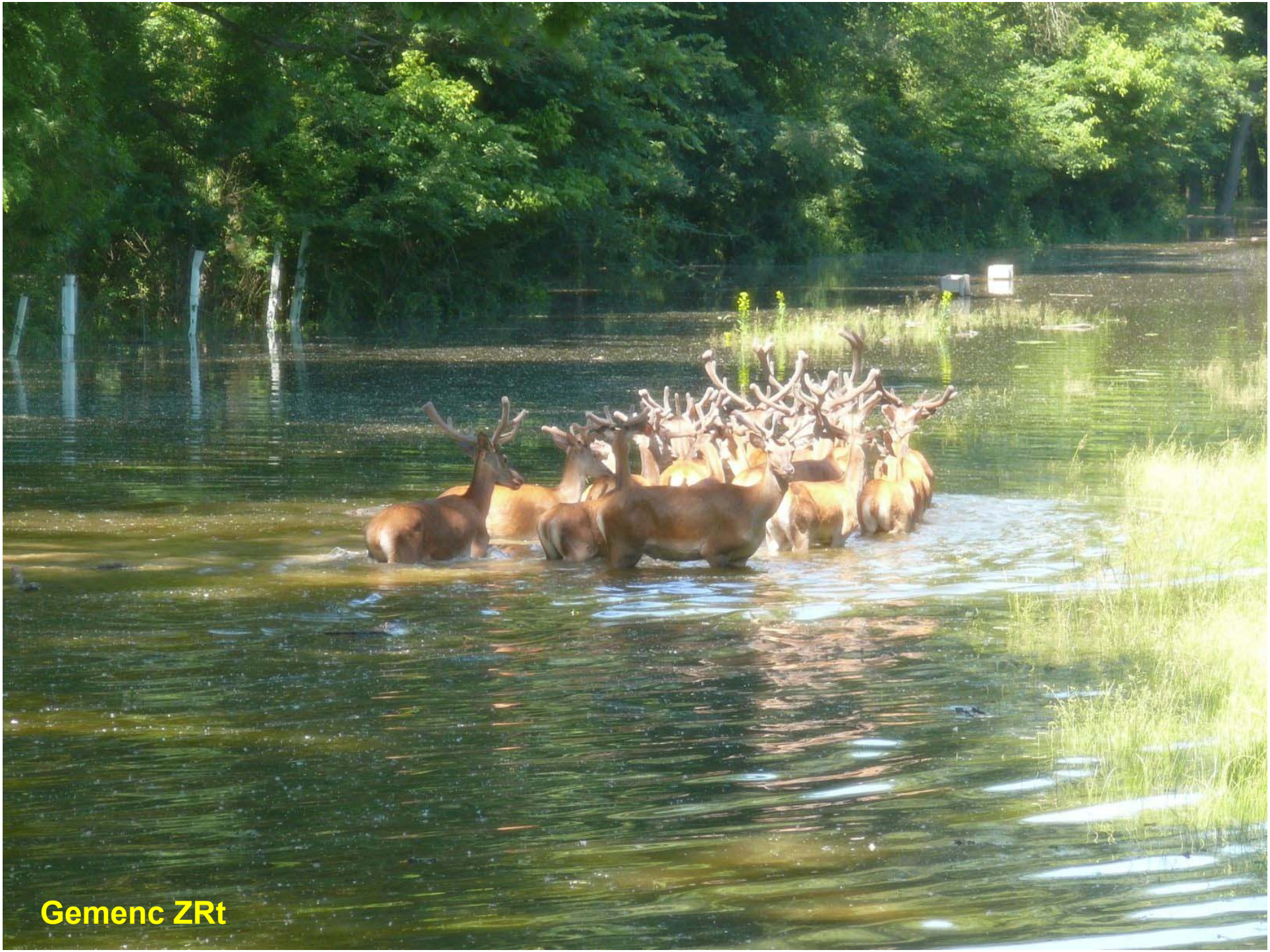
- Abiotic extremes
- Groundwater supply
- Insect damage
- Degradation
- Growth and increment change
- Mortality

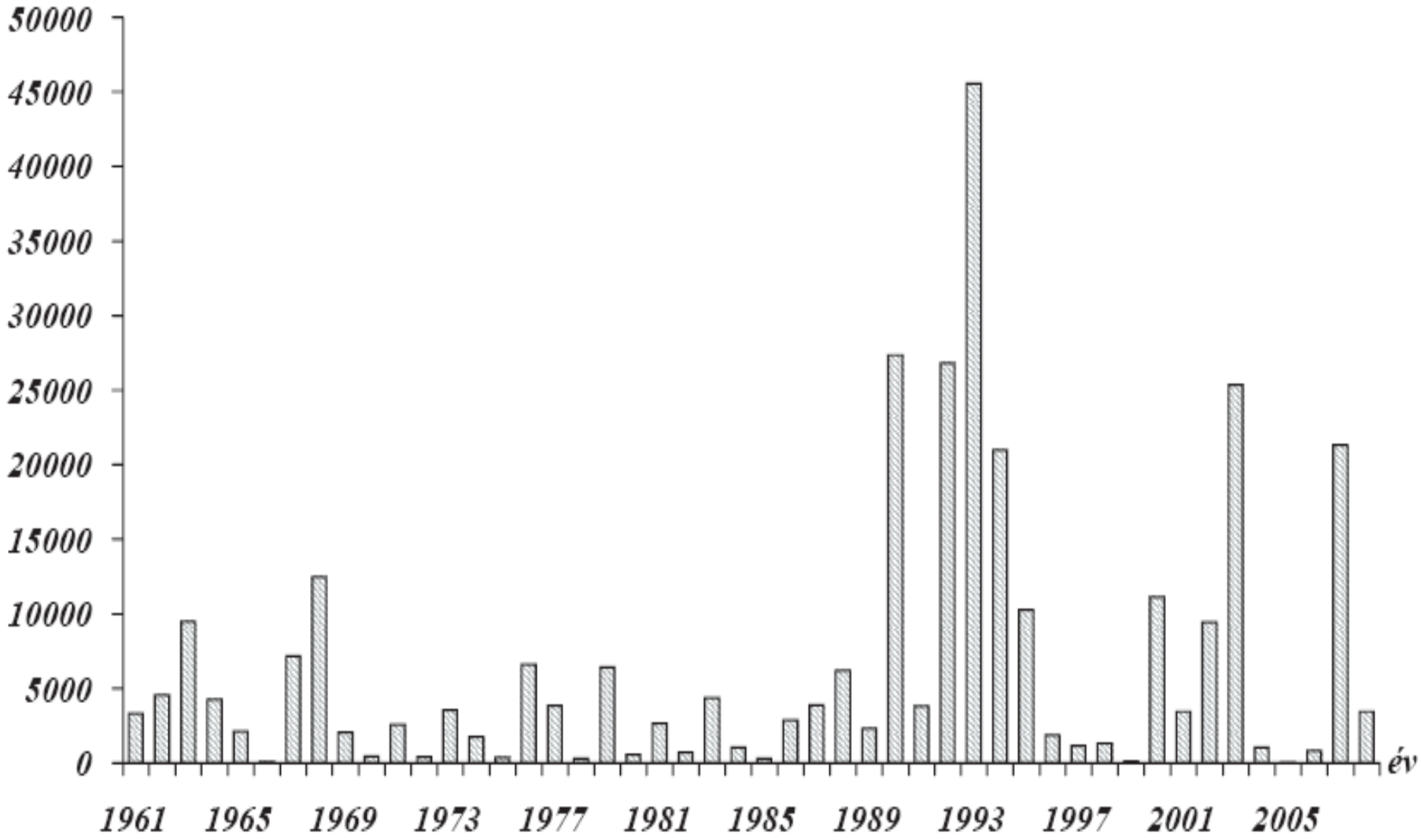


Reported damage (in hectares) caused by windthrow in Hungary between 1963 and 2008

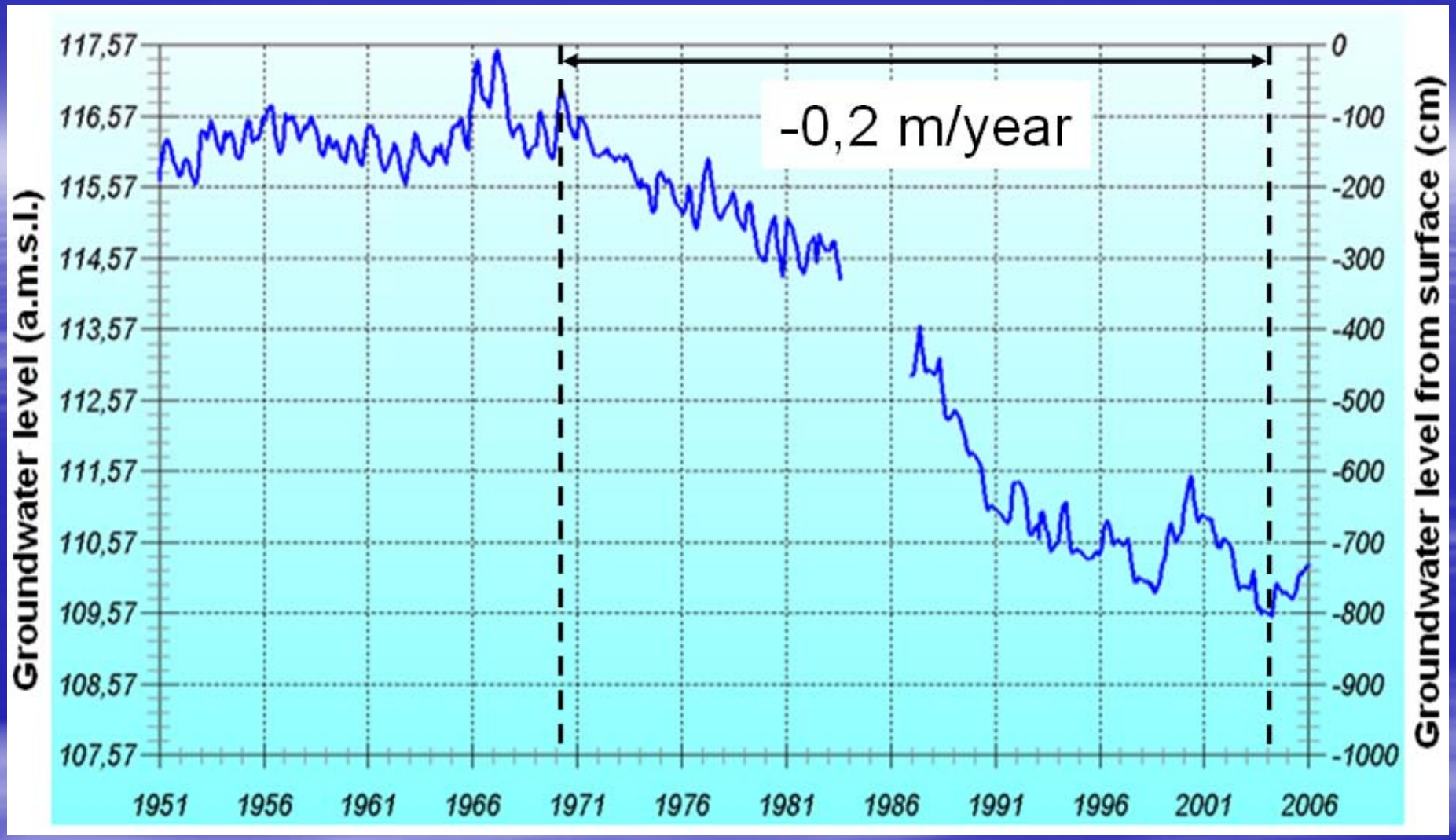
Északerdő ZRt.

Pilisi Parkerdő ZRt.

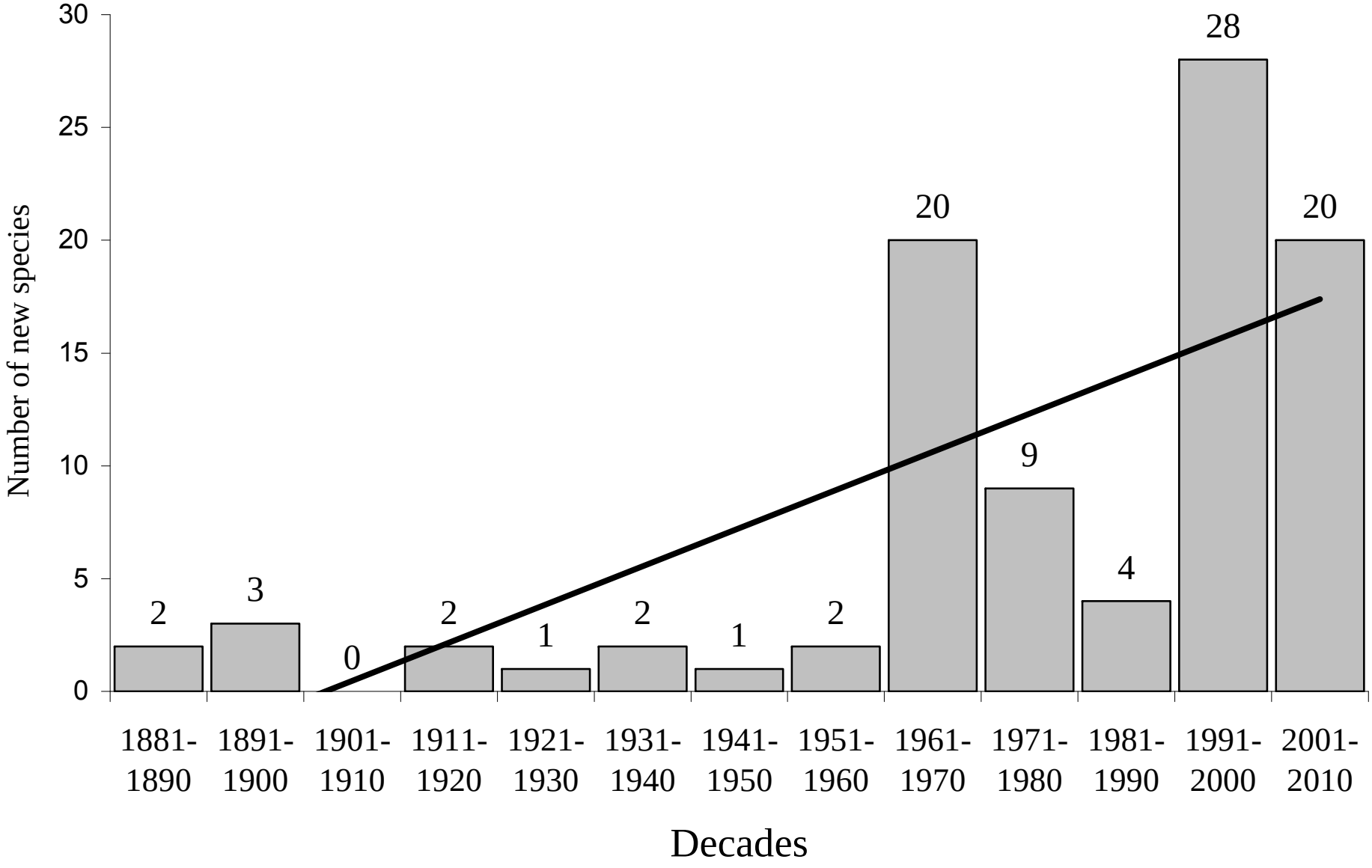

Gemenc ZRt



Reported drought damage (in hectares) in Hungary between 1961 and 2008



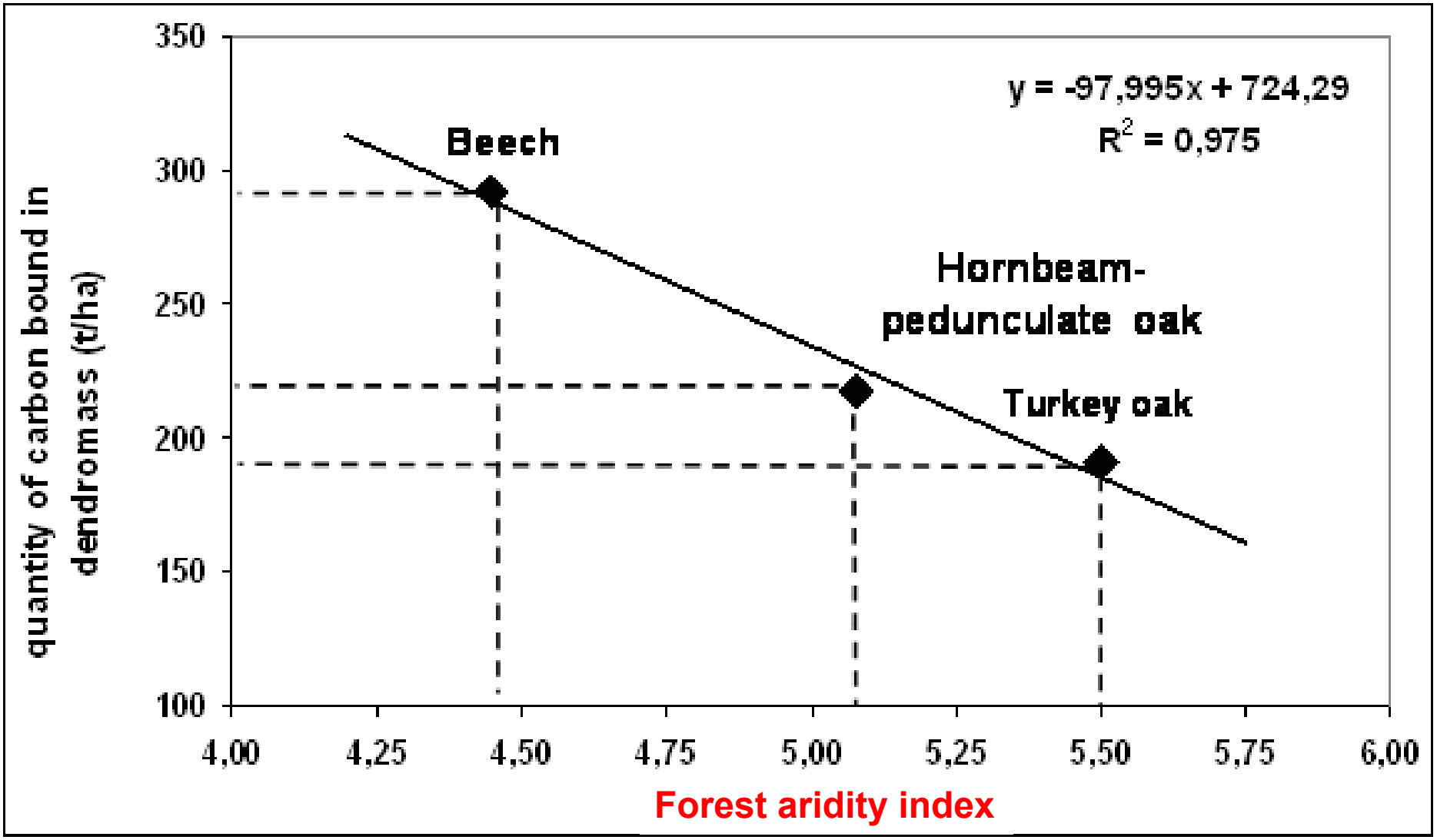
Groundwater level depletion in the central Great Plains from 1951 to 2006



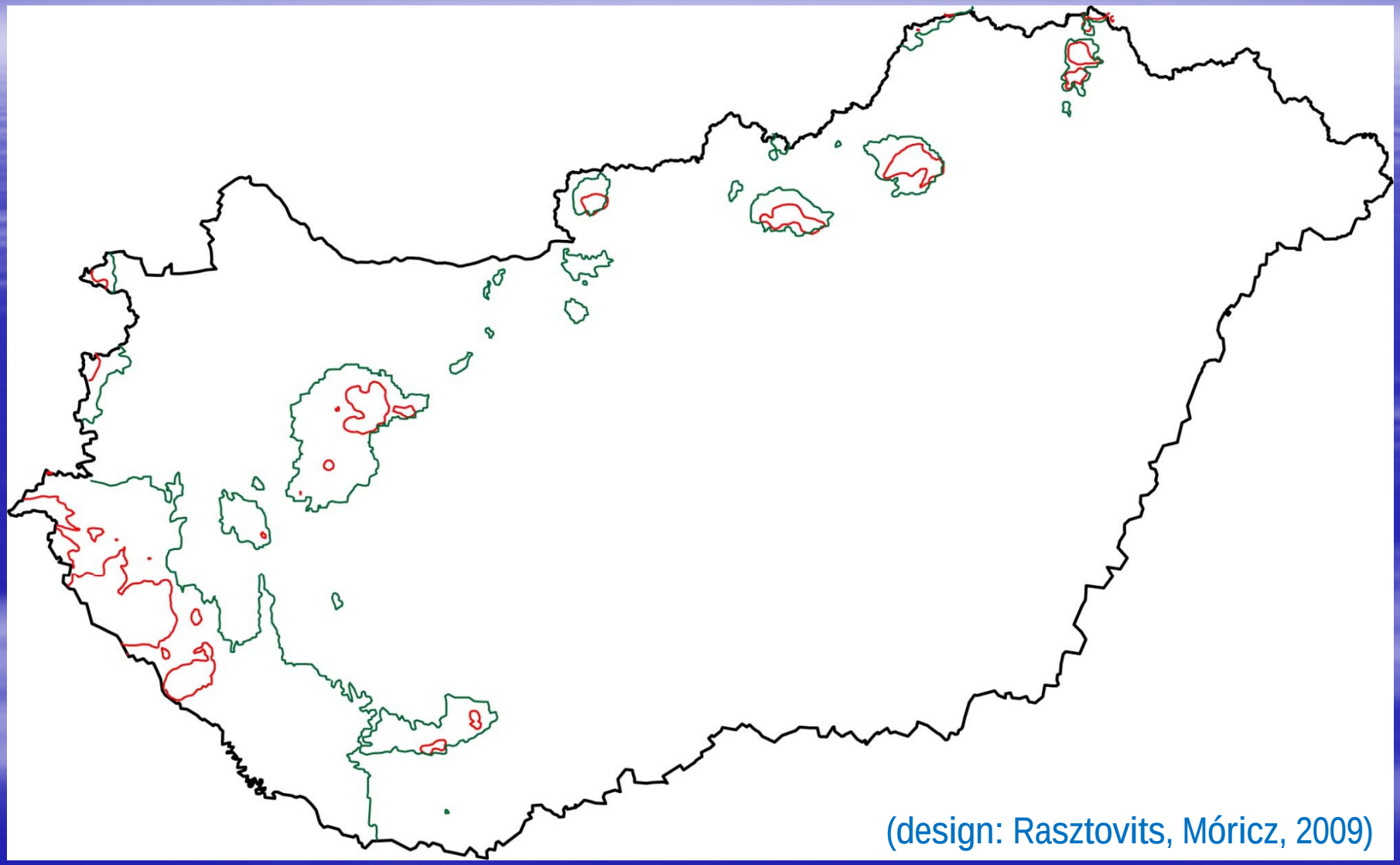
Alien forest insects by decades of their first appearance in Hungary
Since 1991: more species than in the previous century!!

Ugly face of trailing limit: spruce in West Hungary

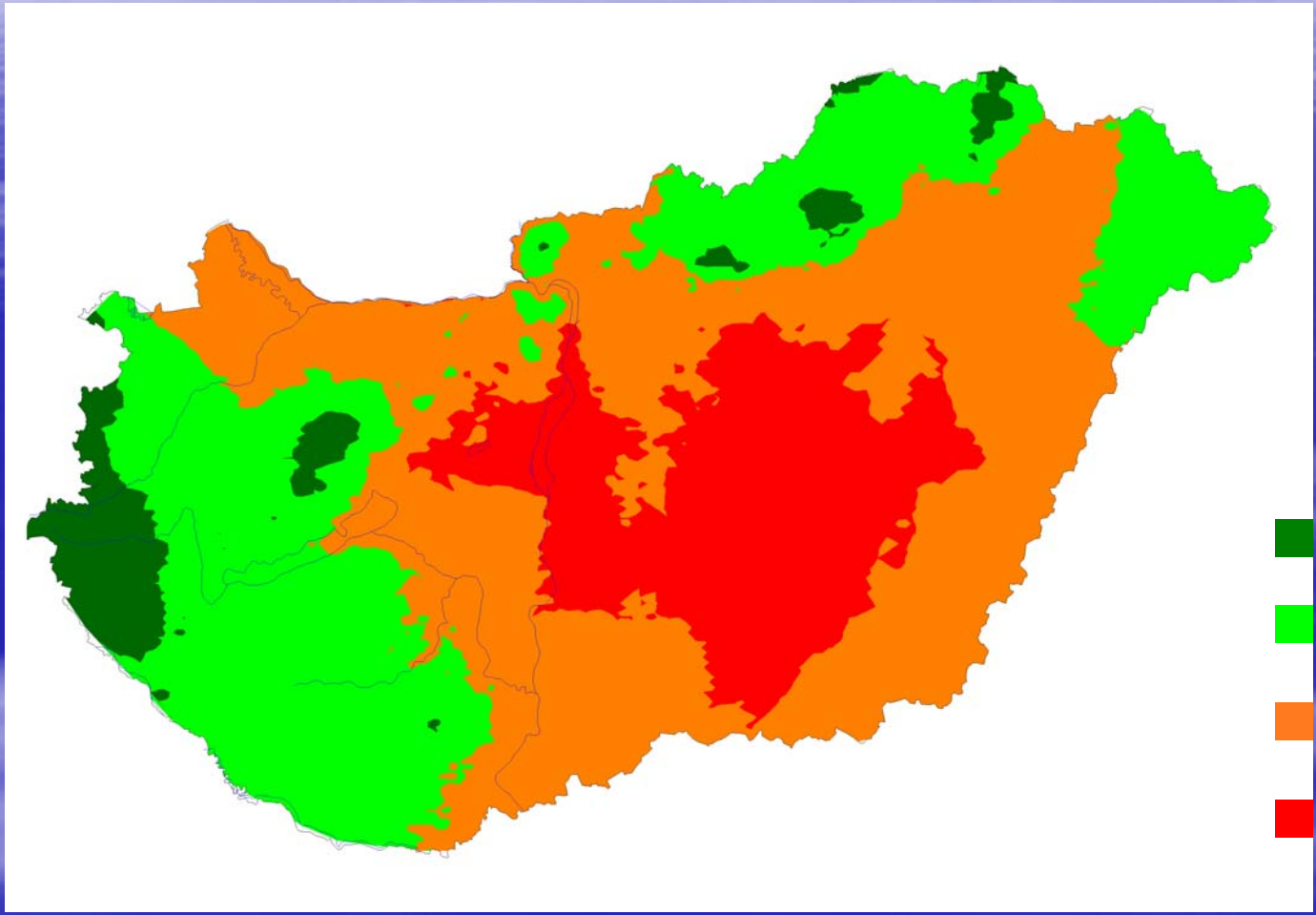
Growth and carbon sequestration of forest types and climate change



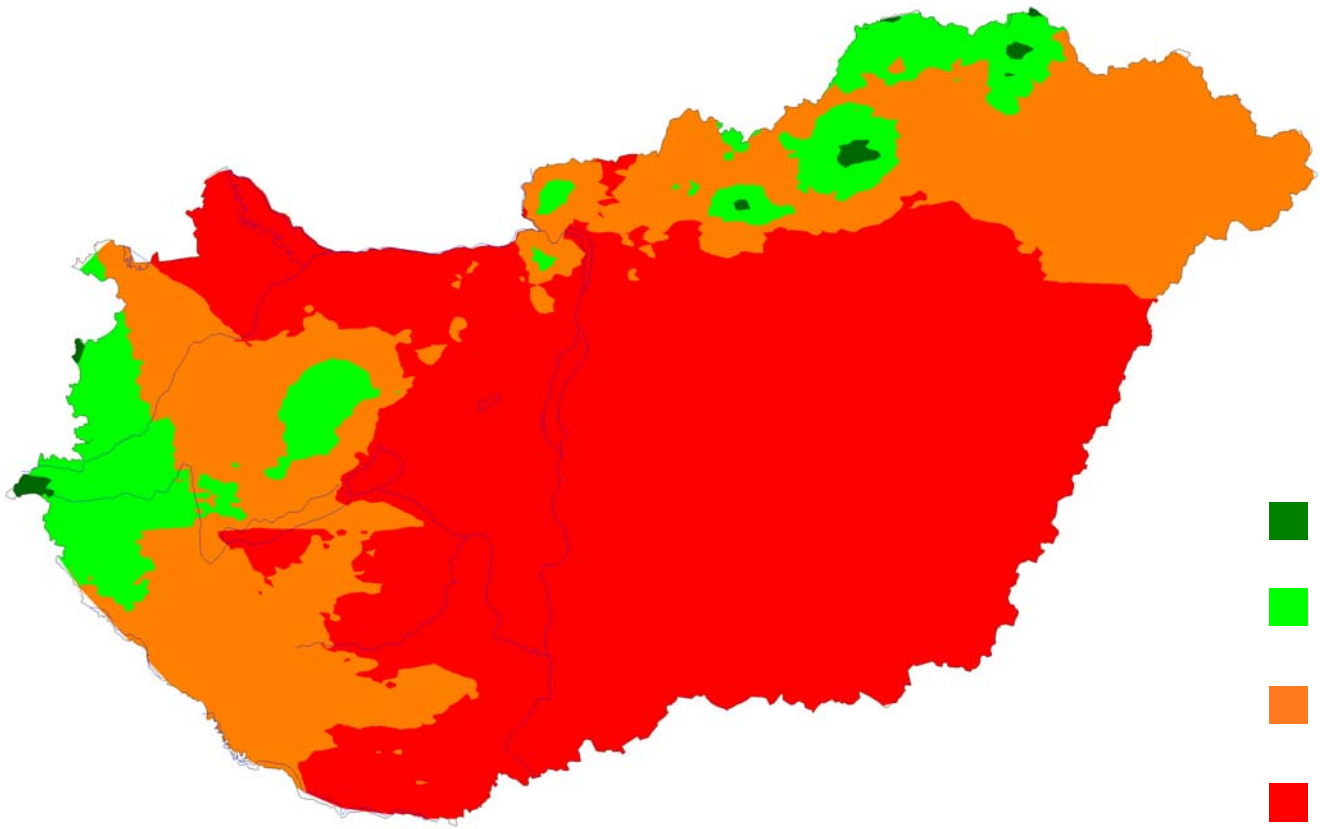
Shrinking of beech climate in course of a century



EQ index contour line 24 : 1901-1930 (green) vs 1975-2004 (red)



Present vegetation (climatic) zones, Hungary

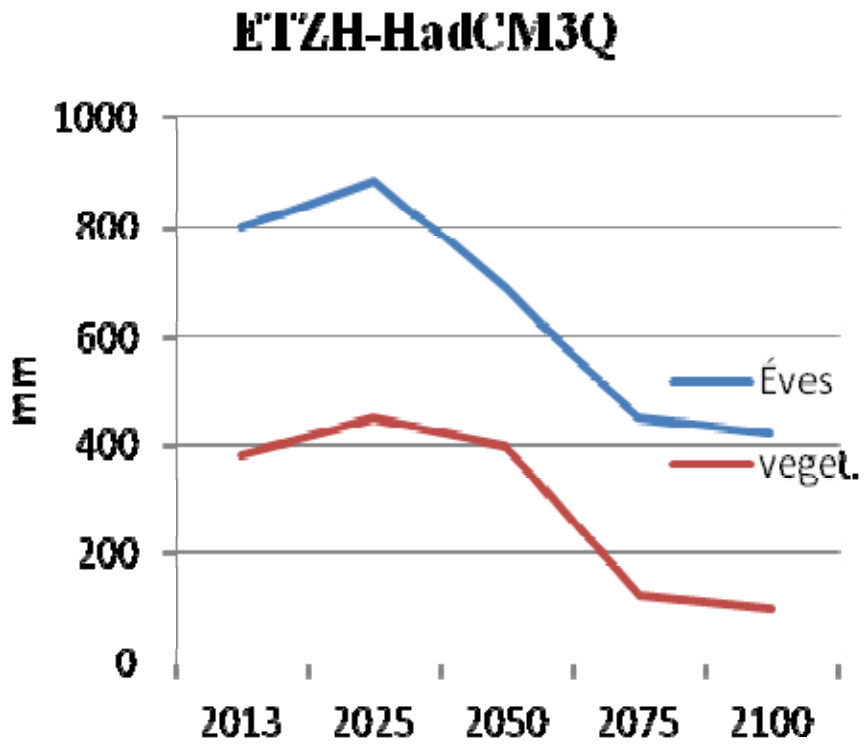


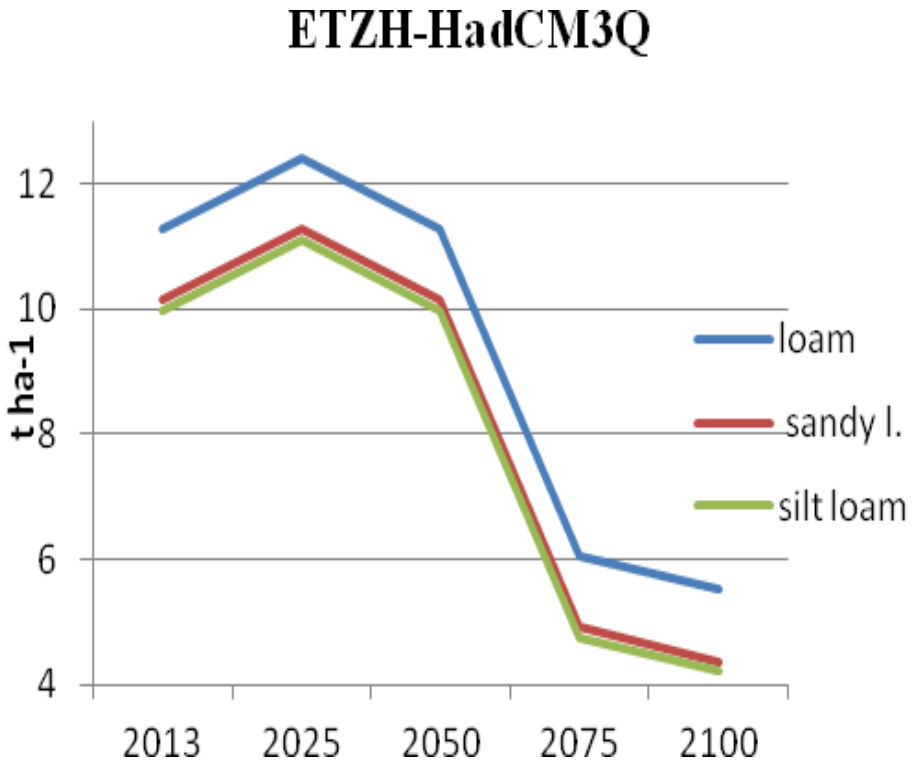
- bükkös klíma
- gyertyános-tölgyes klíma
- kocsánytalan tölgyes ill. cseres klíma
- erdőssztyepp klíma

REMO regional climate model, 2070 , scenario A1B

Yield of maize (t/ha) projected with DSSAT

climate model: ETH Zürich, data: M. Neményi

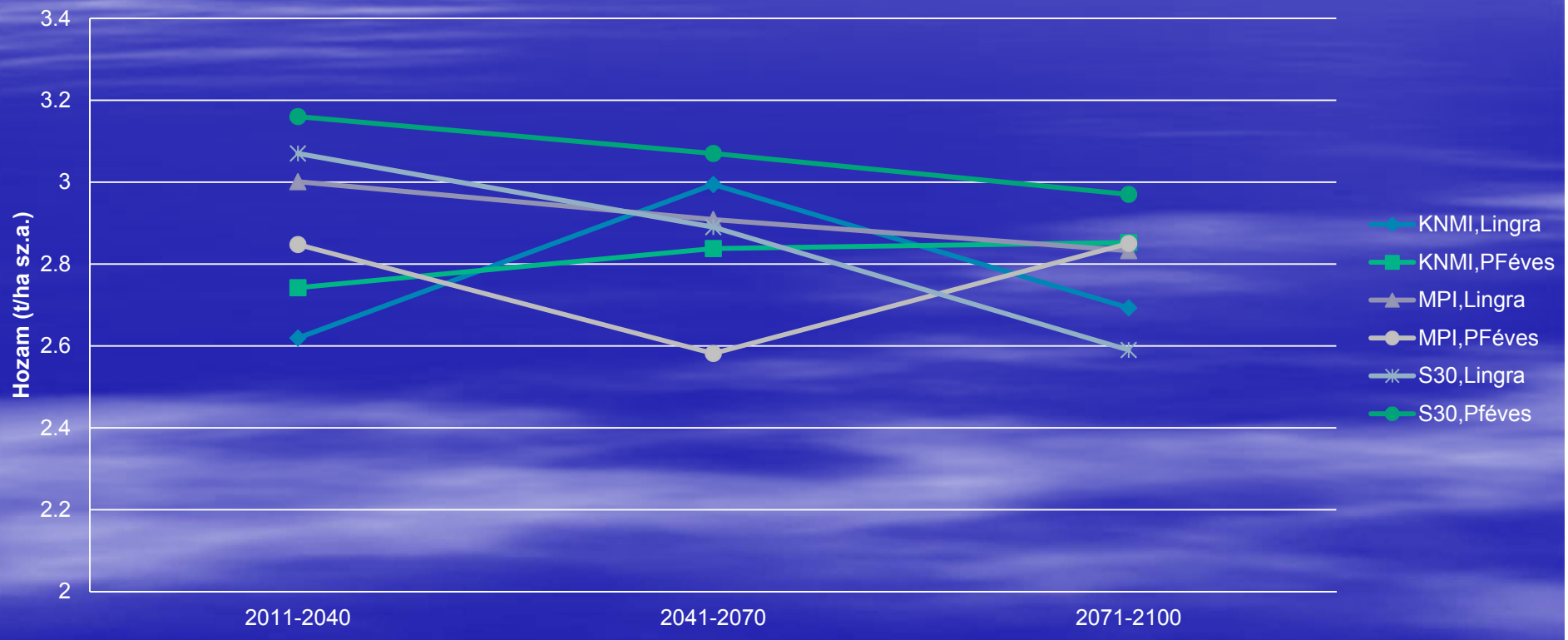




annual (blue) and veget.period precipitation (mm)

projected yield (t/ha)

Dry matter yield of grass cultivars (t/ha) (Szabó 2014)



Rangeland (pasture) hay yield by reference periods 2011-2100

Intuitive ecological services of forest cover

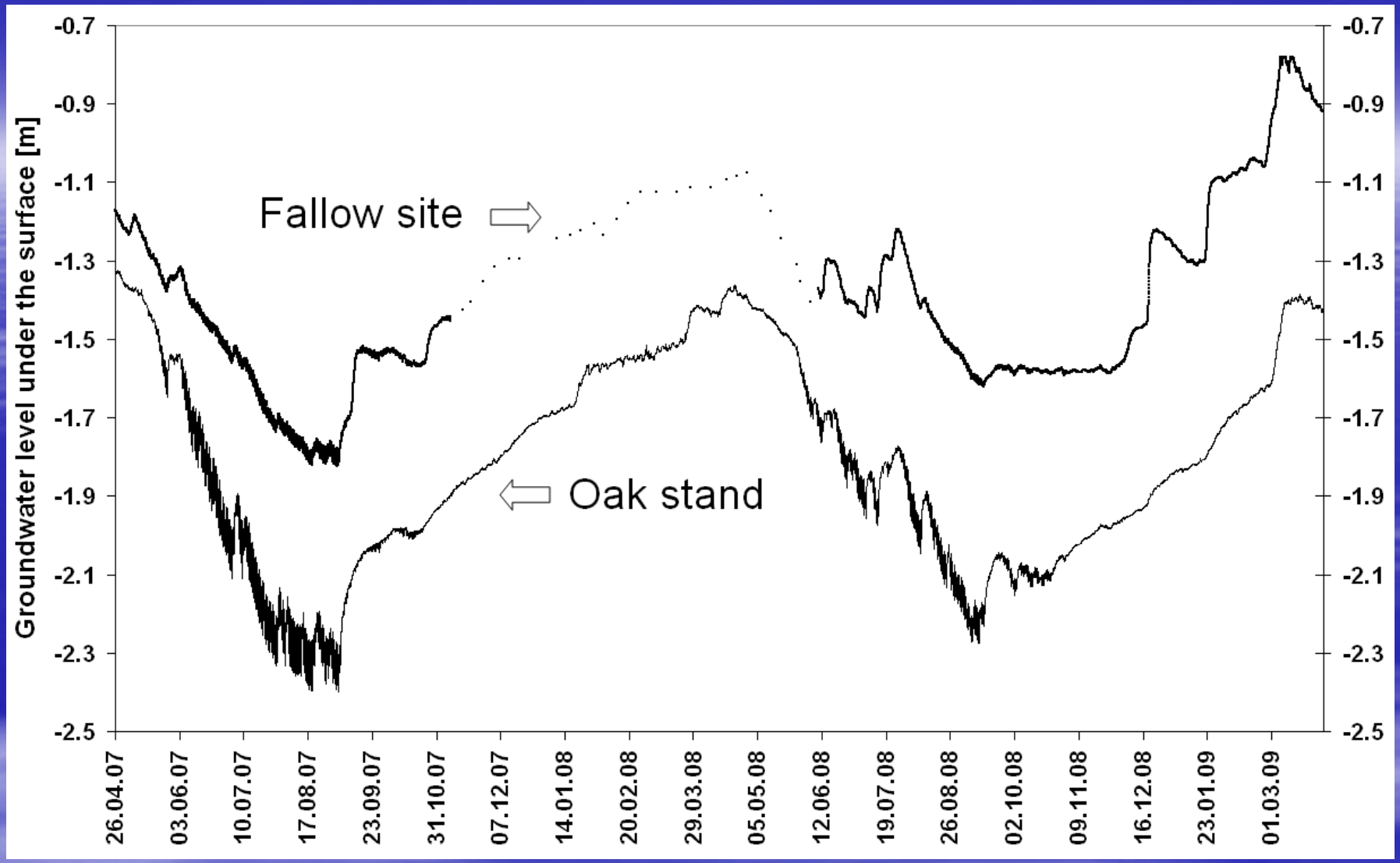
- Conservation of groundwater resources
- Stabilization of surface water flow
- Favorable effect on regional climate
- Carbon sequestration

Do afforestations provide ecological advantages at the xeric (steppe) limit?

A) Hidrology: forests are transpiring more water than grassland:

- Higher biomass
- Deeper rooting
- Higher leaf area (LAI)
- Forest evapotranspiration higher
- Forest groundwater use higher

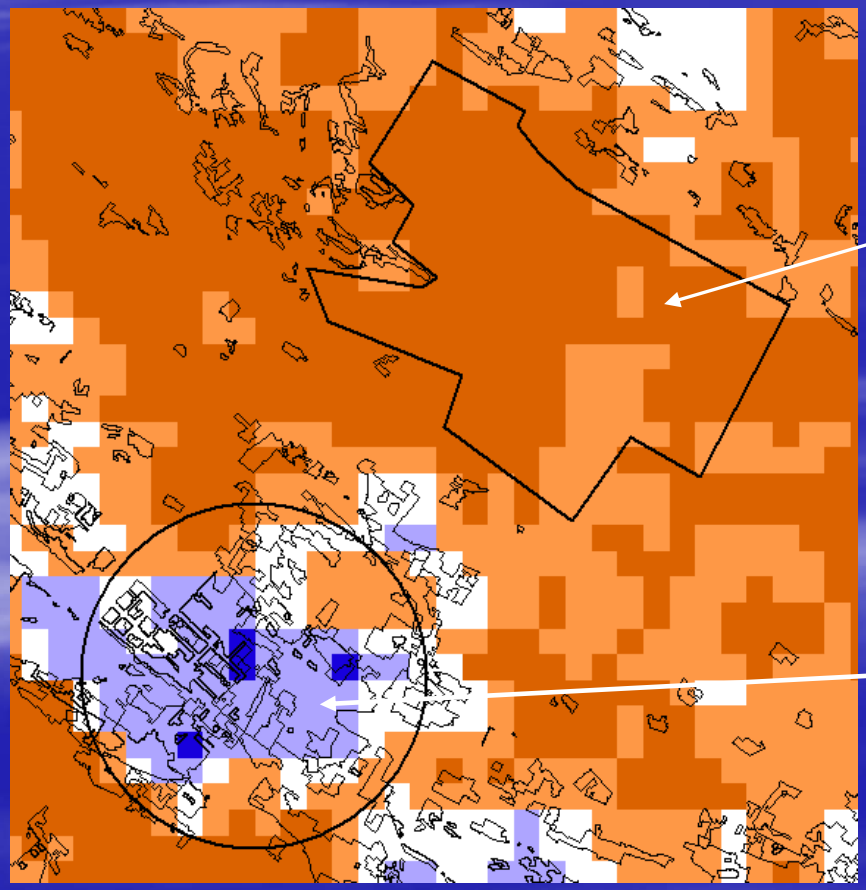
Covered by climate prediction models?



Forest vs grassland: use of groundwater resources, 2 years cycle (Móricz N., in: Mátyás, Sun and Zhang 2013)

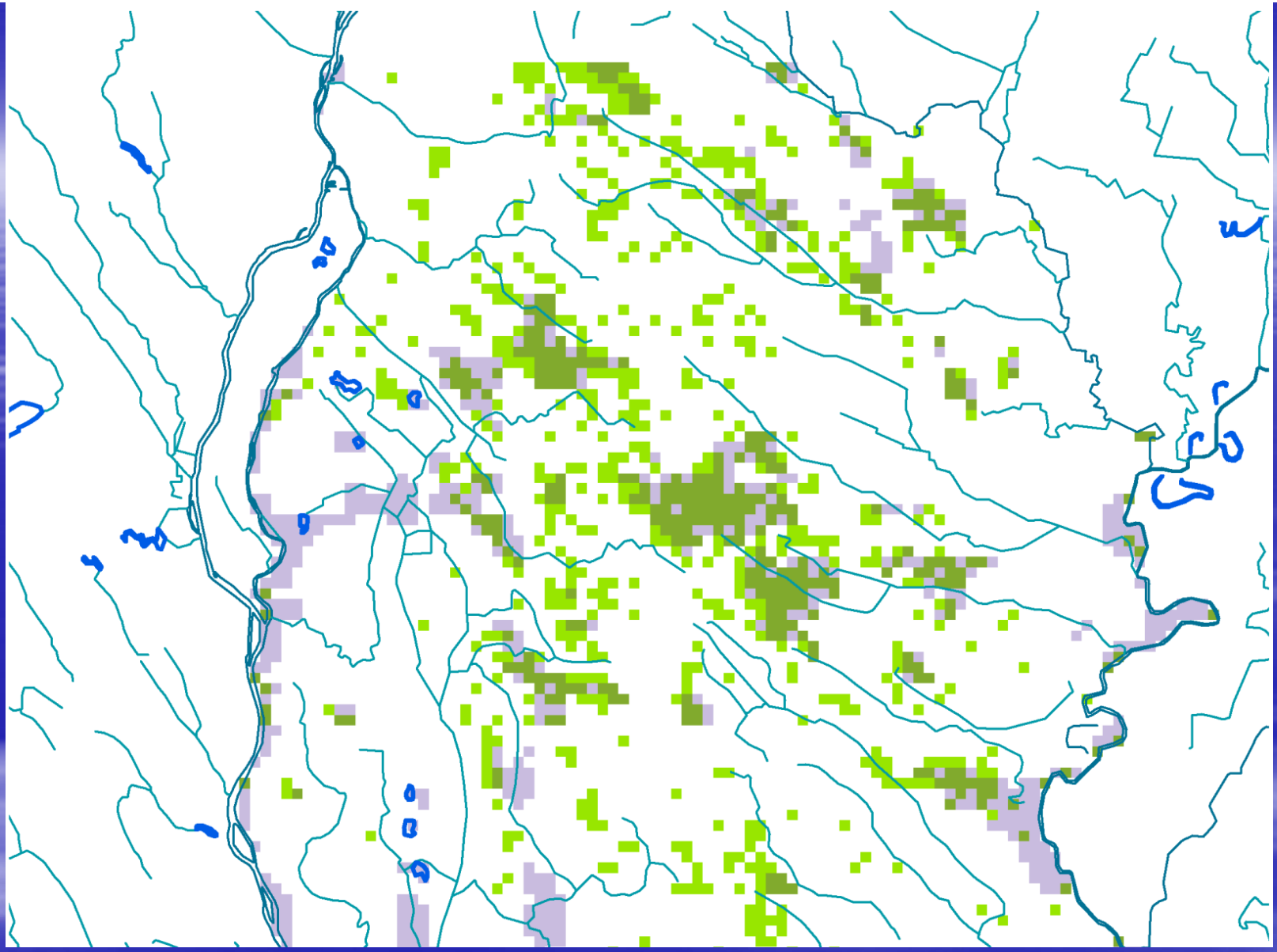
Effect of rainfed forests on evapotranspiration in the forest-steppe lowlands (MODIS based estimation)

Forest:~ +20% more ET/year



Agricultural area:
400-480 mm/year

Forested area:
500-600 mm/year



Forests on the Great Plain and areas with negatively recharged groundwater (Szilágyi et al. 2012)

B) Climatic feedback of forest cover:

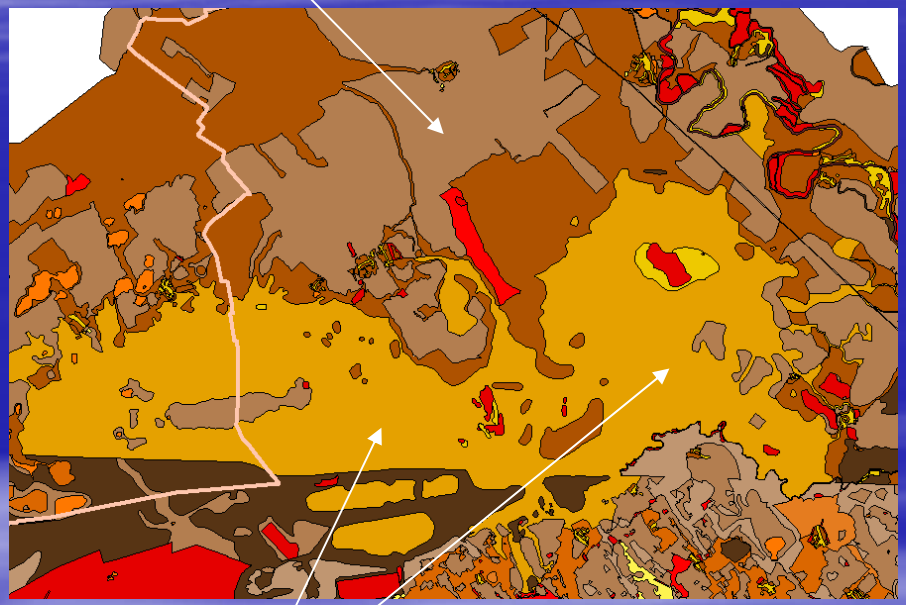
Contradicting picture: balance of low albedo and high evapotranspiration

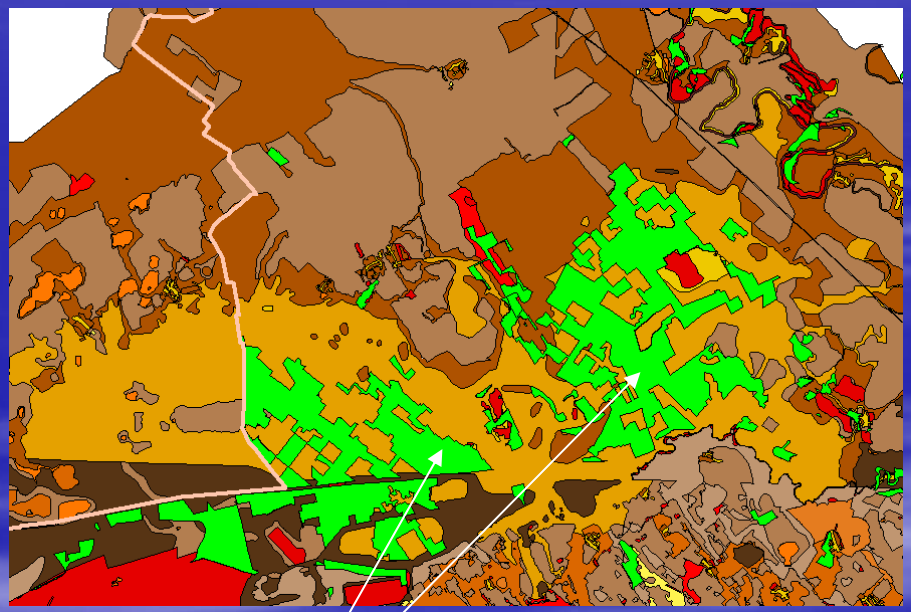
„in the temperate zone the effect of forests on climate is negligible or negative"
(Bonan, 2008: Bala et al. 2007)

Forest cover change in NW Hungary in a century

1900 **2000**

Agricultural use





10 km

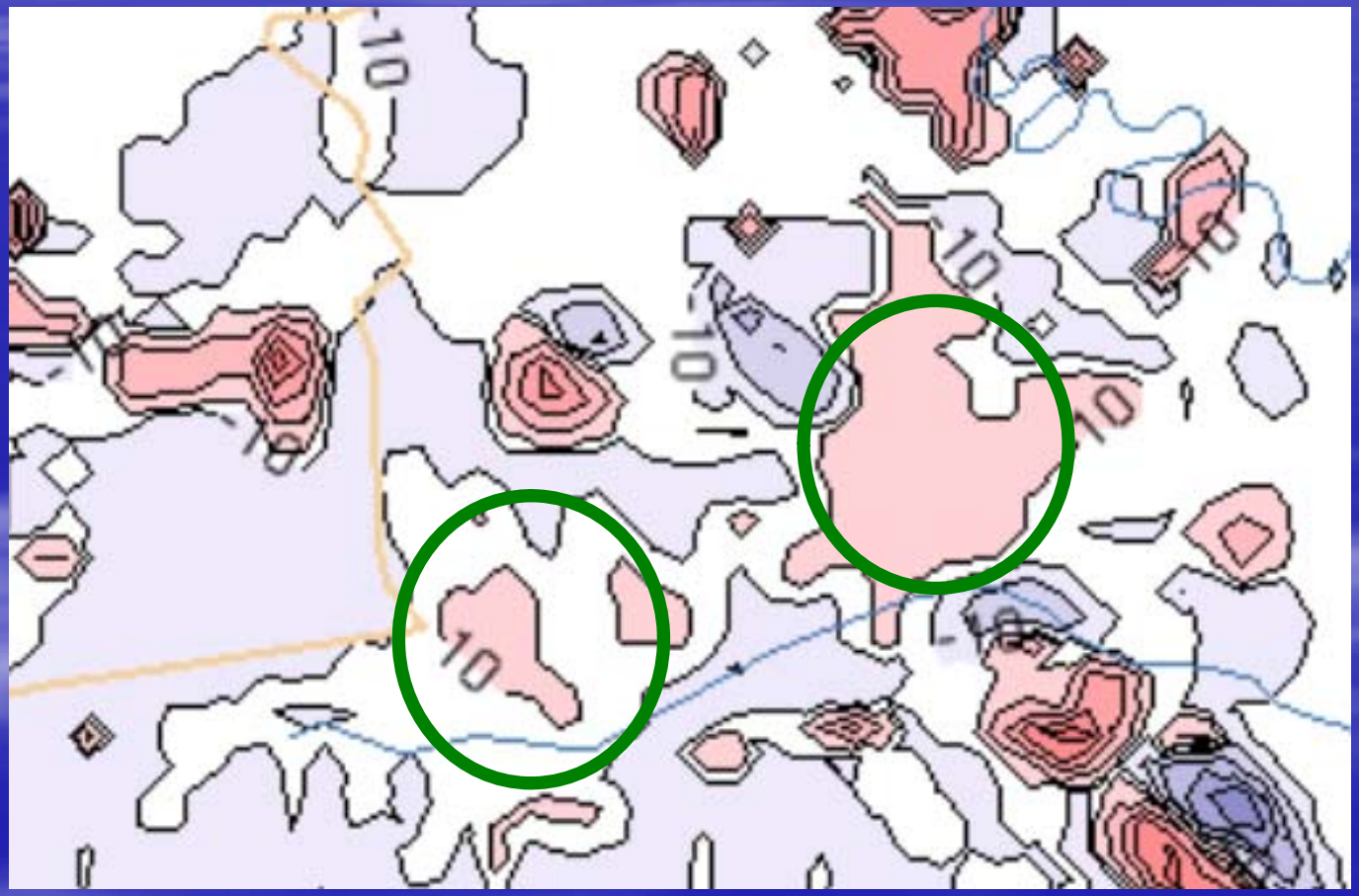
Grassland

Afforested area

Drüszler, 2012

Change of forecasted energy balance (MM5 model) due to land use change of 100 years

+10 W/m^2 in sensible heat due to albedo change



Drüszler, 2012

Change of forecasted daily average air temperature due to land use change of 100 years (MM5 model)

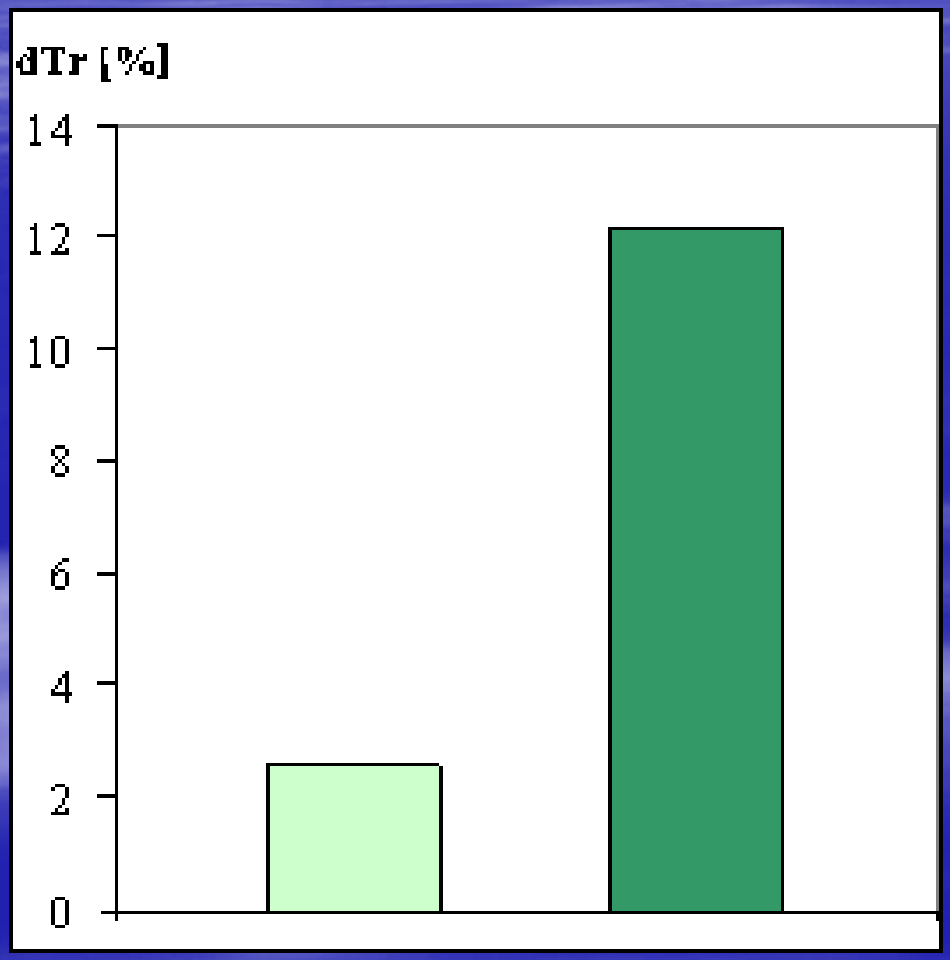
Afforestation: rise in air temperature (forest: +0.1°C, total rise: +0.6°C)

Drüszler, 2012

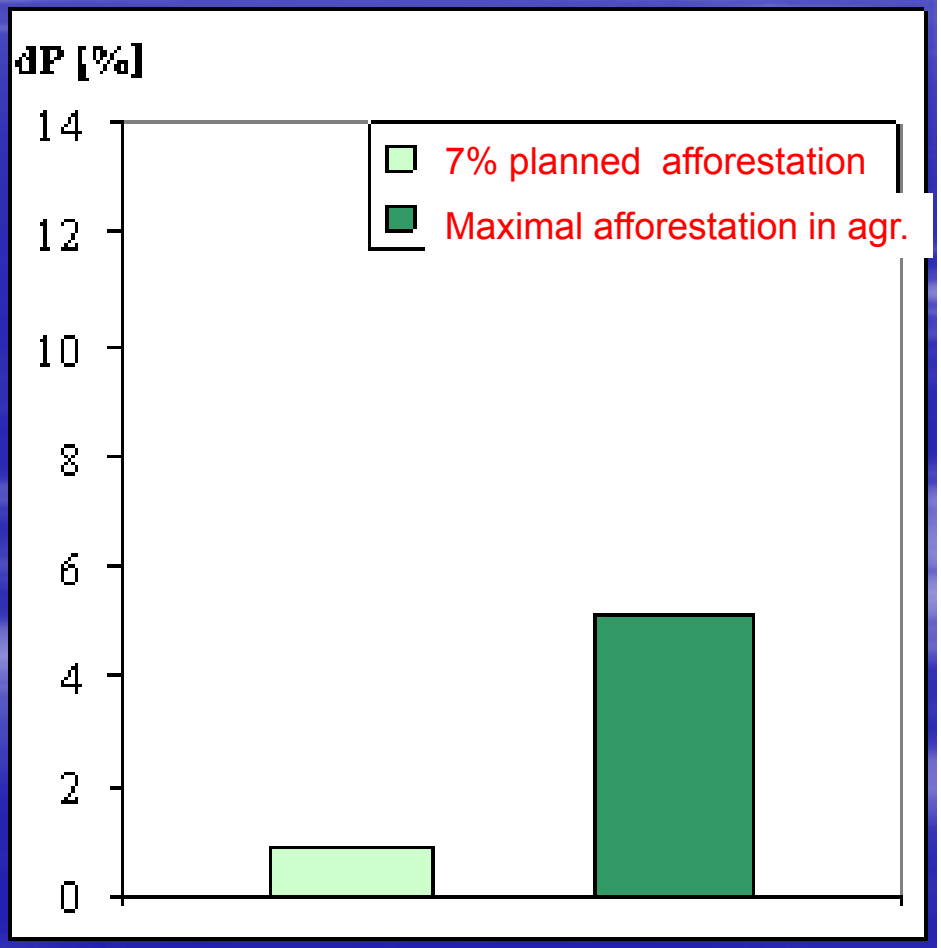
Feedback of forest cover increase on climate

(prec. decline in summer, 2071-2100: 24%)

Even max. afforestation might balance only a quarter of summer precipitation loss (Gálos et al., 2011)



Transpiration difference



Precipitation difference

C) Runoff, water yield and afforestation:

At xeric limits acute problem:

North China, SW US, Hungary?

China: „Great Green Wall Program",

23,7 mill ha afforested 1978-2010

1998-2006 costs: 22 billion USD

Loess Plateau: (aver. ann. prec: 463 mm)

Forested catchments: 16 mm/ann. ~ 3%

Non-forest catchments : 39 mm/ann. ~ 8%

Consequence: since 2000: 40% planted with shrubs

Strategy and concept changes ahead

Landcover and land use changes imminent

Water availability dictates land cover/use options

Afforestation to be limited?

Nature close vs proactive management: human support needed, e.g. species migration

Life quality of rural population strongly affected

Restrictions between LU options to be lifted

Decision Support Systems needed!

„AGRÁRKLÍMA” project:
adaptation in forestry and agriculture

Joint EU - national rural development project, 2012 – 2014
budget: 830 mill. HUF (2.75 mill euros) cont’d -2018!

AGRÁRKLIMA: Impact assessment of the projected climate change and the possibilities of adaptation in forestry and agriculture

Developing a Decision Support System
Coordination: Prof. C. Mátyás

Consortium partners:

- **University of West Hungary,**
- **Forest Research Institute,**
- **State administration bureau of county Zala (pilot region)**

Reg. Nr.: TÁMOP-4.2.2.A-11/1/KONV-2012-0013

Novelty of the project

Covering the whole climate-dependent agrarian sector:

rainfed agriculture, pasturage, forestry

Direct, site-bound information for the land user - yield and technology in geoinformatic framework

Long-range time horizon (until 2100)

Land use options considered as alternatives

Integration of natural capital (ecological services, biodiversity, carbon, water resource balances)

Social, economic, land use change and rural development aspects included

Structure of the Agrárklíma project

- **A) Development of the Decision Support System**

  Dr. A. Borovics, director, Forest Research Inst.
- **B) Conservation of the natural capital**

  Prof. Dr. F. Lakatos, dean, WHU Forestry Faculty
- **C) Impact analysis, adaptive management of forest stands**

  Dr. A. Bidló, WHU Forestry Faculty
- **D) Economic impacts and risks**

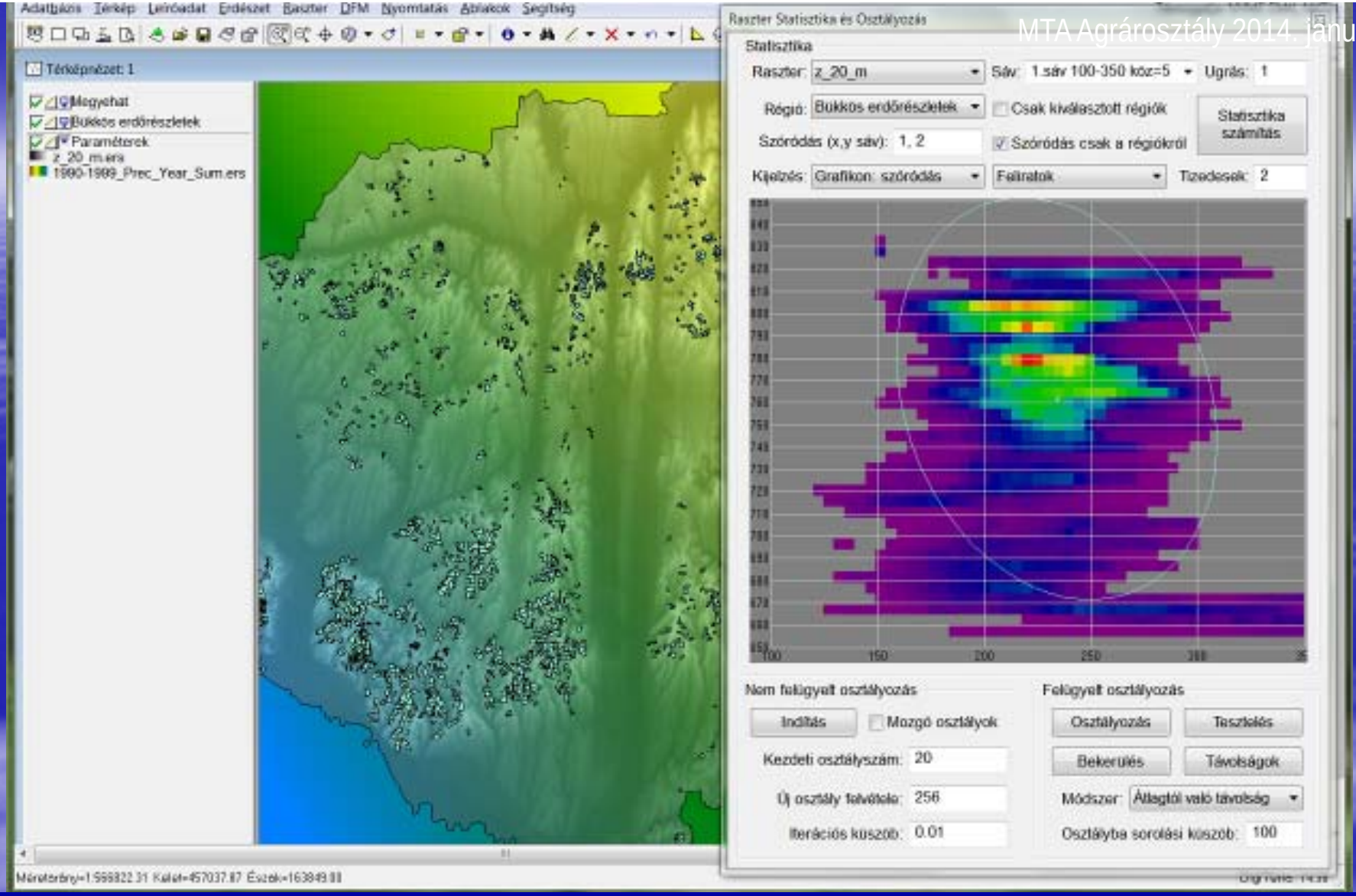
  Dr. E. Schiberna, Forest Research Inst.
- **N) Agricultural yields, changes in land use, socioeconomy, sustainability and environmental risk assessment**

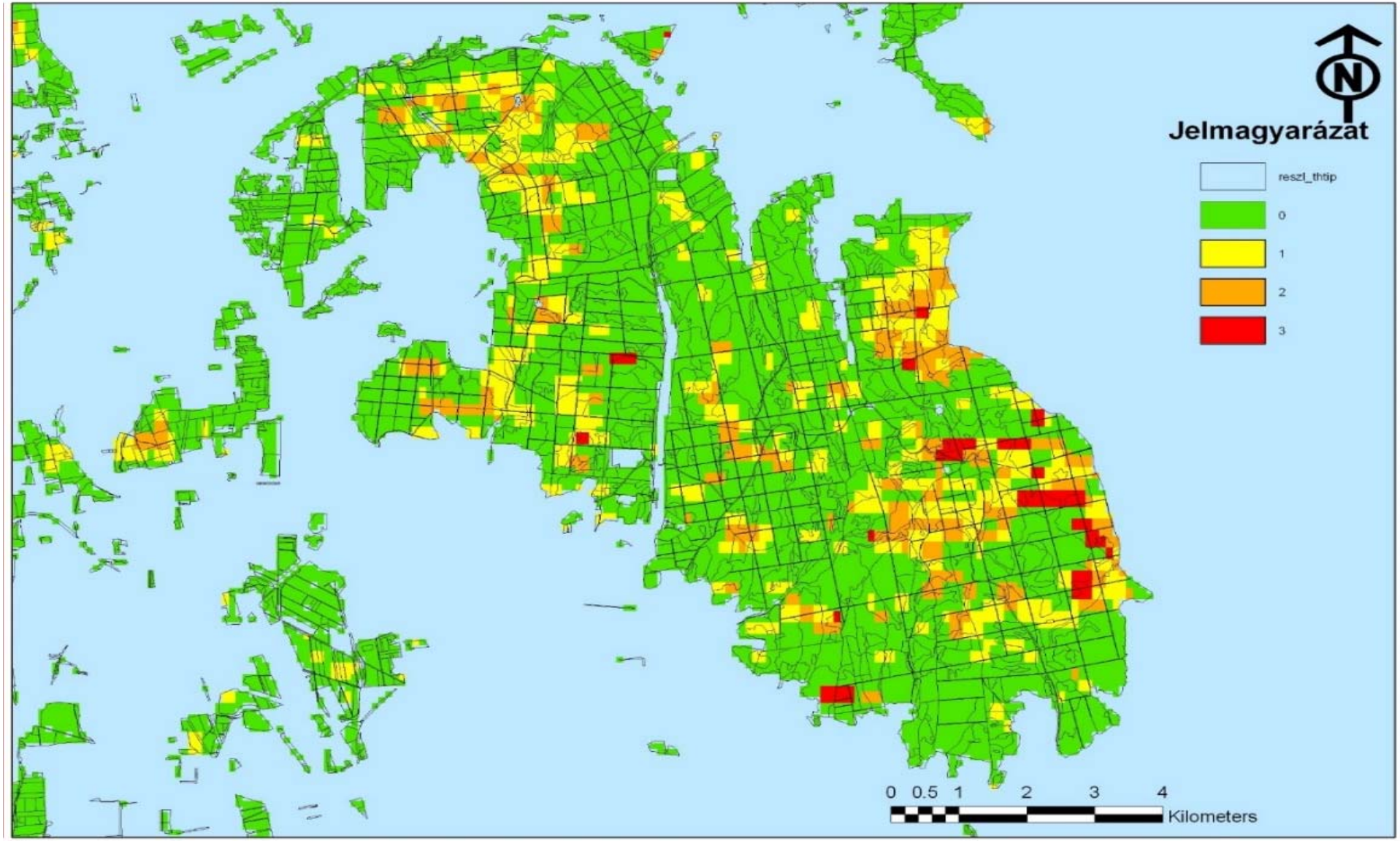
  Prof. dr. M. Neményi, WHU Faculty of Agronomy

Geoinformatic services of the DSS:

Reachable by web browser, ArcGIS, DigiTerra

- **Climate and weather data** (daily/monthly)
  - **past: 1960 - 2010**
  - **projected: 1960 – 2100** (ensemble of 12 models)
- **Integrated site database: surface, soil, geology, hydrology conditions**
- **Potential yield data for agrarians, foresters**
- **Real-time vegetation satellite monitoring: MODIS data**
- **Technological information, energy balance etc**
- **Sensitivity-vulnerability changes**
- **Land use options and economy**
- **Available also for regional, strategic planning**



Application examples: probability of beech presence altitude vs. aver. precipitation (1990-2000)

Forest compartments with vitality decline (MODIS data analysis)