Multi-scale interactions between disturbances and ecological and socio-economical changes in the Kiskunság Sand Ridge region (KISKUN LTER Platform)

Miklós Kertész[1], Edit Kovács-Láng[1], György Kröel-Dulay[1], Eszter Kelemen[2], Mariann Bíró[1]

[1]Institute of Ecology and Botany, Hungarian Academy of Sciences, Vácrátót, Hungary
[2]Department of Environmental Economics, Szent István University, Godollő, Hungary

Introduction

The Kiskunság Sand Ridge region in the Danube-Tisza Interfluve represents a biome transitional zone (ecotone) between temperate deciduous forests and continental steppes in Eurasia. The characteristic feature of the region is the hierarchic mosaic of ecosystems. The hierarchical mosaic pattern of the landscape can be principally related to to geomorphology and geological structure, the water-flow systems (precipitation recharge at higher elevations, gravitational flow, discharge to lower elevations) and the history of human land use. The Kiskunság Sand Ridge region is a fine mosaic of fragmented semi-natural habitats (fens, alkali lakes and marshes, semi arid sand dunes and some woodlands) and cultivated areas (arable fields, vineyards plantations, gardens, old-fields).

The region is semiarid, i.e. regularly suffers of drought. The parent material, the coarse sand, has extreme moisture regime, which contributes to the drought sensitivity of the region. The driest vegetation type, the open perennial sand grasslands is the richest in endemic plant species among the plant communities in the Carpathian Basin.

The KISKUN LTER program, launched in 1995, originally focused on the most natural and diverse communities, their disturbance regime, natural succession, and restoration. Since then, the scope of the KISKUN LTER has expanded to cover all the Sand Ridge region, and to treat also the socio-economic relations.

History

Until the end of the 18th century, in the sparsely inhabited Kiskunság region extensive gray cattle raising sustained the sand surface open, causing catastrophic sand storms. As a protective measure of the local society intensive afforestation of large areas started reducing the area of the semi natural grasslands to their 6% only.

A special small-farm system, adapted to the natural conditions developed and flourished in the region at the turn of the 19th and 20th centuries. Disintegration of this land use system was accelerated in the 1980´s, mainly as a consequence of changes in political and economical environment. Giving up of farms resulted in mass abandonment of cultivated lands which gave broad way to spread of invasive species.

The parallel sinking of ground-water table in the region (caused by drought, forced drainage, increased water extraction) resulted in drastic decrease of species and habitat diversity. As a result the semi arid character of the landscape increased the emigration of human population and also socio-economic rearrangements at landscape and regional levels have been started.

Scales
The three embedded scales considered are on Figure 1. At the finest scale, or site level, we focus on the most diverse communities of the region. At the intermediate scale, or landscape level, we treat the landscape which contains most the natural or semi natural plant communities, including that of the site level. At the coarsest scale, or regional level we deal with the whole region of 7000 km^2.

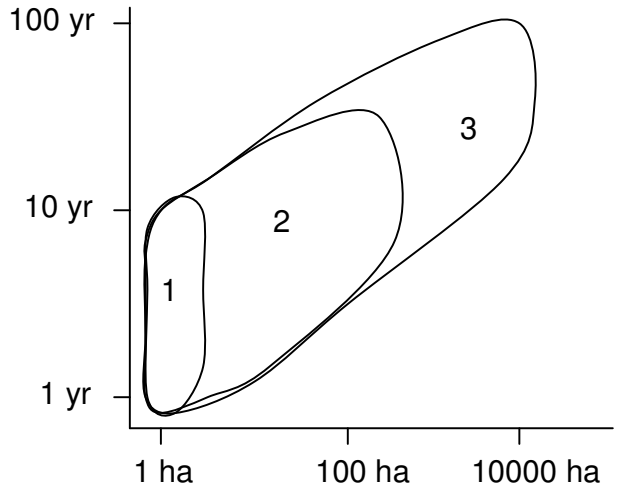

Figure 1: Spatial and temporal scales studied
1: Site level. Complex of juniper-poplar woodland and sand grasslands; Corresponds to intensive plots of KISKUN LTER.
2: Landscape level. Sand dune systems with associated depressions. Corresponds to larger study sites of KISKUN LTER.
3. Regional level. Kiskunság Sand Ridge region. Corresponds to the area of KISKUN LTER Platform.

Narrative: Site level socio-ecological system

The core areas of the KISKUN LTER site are large stands of sand forest-steppe mosaic composed of Juniper-Poplar thickets and open sand grasslands. The actual pattern of the vegetation mosaic at this level is affected by the geomorphology of sand dunes and the availability of water.
This unic type of ecosystem still preserves high biodiversity and many endemics. Increasing frequency of extreme droughts with regional climate change and decreasing grazing pressure could strongly influence the dynamics of this ecosystem causing phytomass and litter accumulation, therefore increasing fire risk on the area. Fires could change species composition and dominance in the woody patches reducing the proportion of Juniper increasing the importance of white poplar, and combined with droughts the process of desertification can be expected. Extreme drought events can alter biotic structure of the ecosystem suppressing perennial grasses in favour of annuals.

The consequences for ecosystem services could be: changes of biodiversity, changes in primary production, C and nutrient turnover, reduced fire regulation, changes in the attractiveness for ecotourism.
Changes in ecosystem services would have impact on the local human population,s behaviour, the researcher and conservationist communities. Regional, national and EU policy can influence the local measures to be taken for mitigation and/or ecological adaptation.

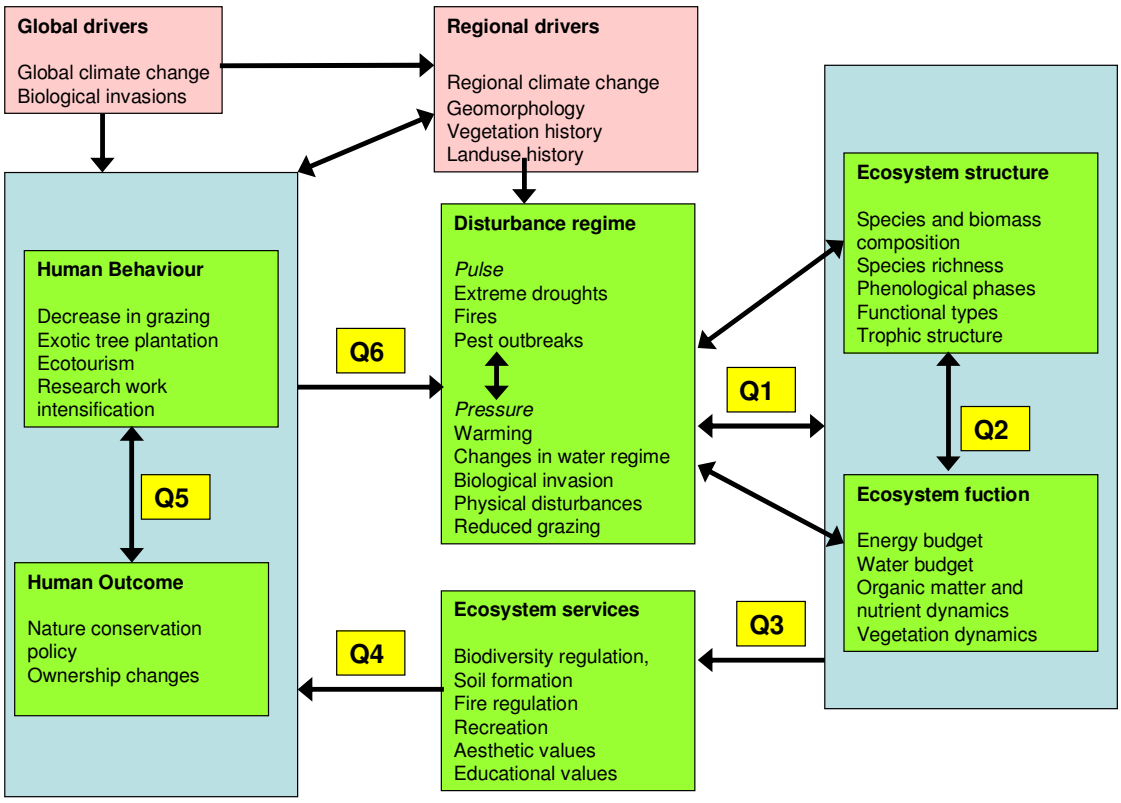

Figure 2. Site level socio-ecological system

Site level research questions (Fig. 2.):

Q1. How can long-term changes in water regime and grazing pressure interact with extreme droughts and fires to influence ecosystem structure and function?
   1. How could decreasing grazing pressure combined with droughts influence biomass composition and trophic structure of the ecosystem?
   2. What is the role of frequent fires in the changes of species composition and vegetation dynamics?

Q2. How are the feed-backs between vegetation pattern and functioning (organic matter dynamics, vegetation dynamics) affected by changes in water regime reduced grazing pressure and increased fire frequency?

1. How do changes in species and biomass composition influence organic matter and nutrient dynamics?
2. How do changes in vegetation dynamics affect the structure and spatial pattern of the community?

Q3. How do altered ecosystem dynamics affect ecosystem services such as biodiversity regulation, fire regulation, soil formation and recreation?

Q4. What values and attitudes do local community members link to nature protection areas, and how do these values and attitudes affect human activities on the site?

Q5. What are the possibilities to shape and focus the attitude of of the local community (human actions) for taking mitigation and/or adaptation measures?

Q6. Are there differences among human activities in terms of contributing to pulses and presses?

Narrative: Landscape level socio-ecological system

The sand dune systems and associated wetlands had been used as pastures, meadows, and for hunting. From the end of the 19th century, more and more people moved to the sand, and began to cultivate vinegrape, fruits, vegetables, alfalfa, and cereals, mostly rye. Since the 1950s extensive afforestation campaign has been carried on resulting in large exotic tree plantations.

The economic activity on the sand peaked at the end of the 1970s, and since then, most of the culticated fields have been abandoned in the sand dune areas, which have gradually lost their human populations.

From the point of view of the nature conservation, the field abandonment gives opportunity to the restoration of the original communities taken for cultication. On the other hand, the abandonment provide habitat for weeds and invasive species. Most of the abandoned fields are covered by invasive species, and provide propagules for their establishment on non-abandoned natural or seminatural vegetation types.

The regional drop of groundwater level resulted in homogenization of the landscape, transforming most of the saline lakes and reedbeds to species poor secondary meadows.

Although the cultivated area decreased in the last decades, the communities of the sand dune systems are more threatened by the invasions, regional groundwater level dercrease, and afforestation. As the agricultural activity decreases, the nature conservation may play decisive role in landscape management.

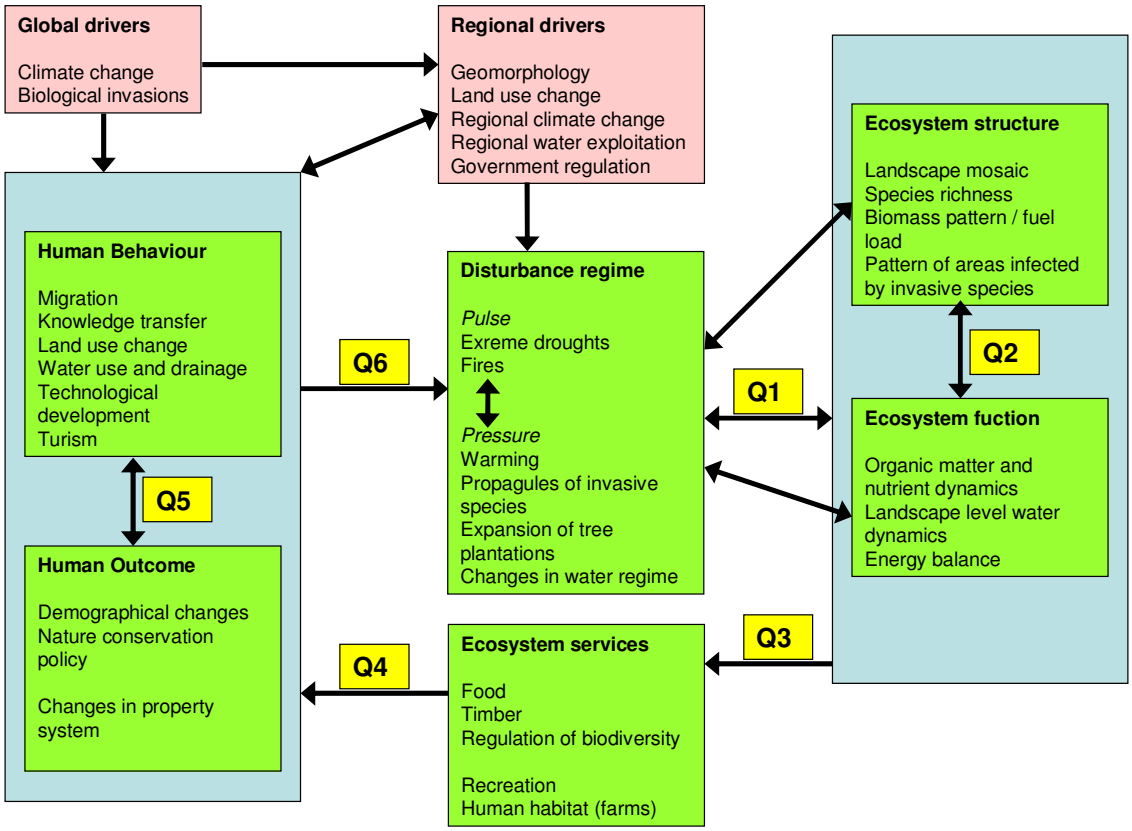

Figure 3. Landscape level socio-ecological system

Landscape level research questions (Fig. 3.)

Q1. What is the effect of land use change on the landscape mosaic?
   1. What is the effect of invasive species pressure on the landscape level biodiversity?
   2. What are the factors of spreading of invasive plants from abandoned fields and tree plantations to natural-seminatural communities?

Q2. How do the invasive plants change the organic matter, nutrient, and water dynamics of different vegetation and land use types?

Q3. What is the impact of the land abandonment on biodiversity regulation, food and timber provisions and the recreation value of the landscape?

Q4. How do invasive species affect the well-being of different social groups (inhabitants, tourists, conservationists etc.) benefitting from the natural environment?

Q5. What is the relation between land abandonment and demographical changes?

Q6. What is the contribution of the land use change to the disturbance regime?
   1. What is role of land abandonment and reduced grazing in the increase of invasive species pressure

Narrative: Regional level socio-ecological system

At the regional scale, climate, soil water availability and current and past land-use combine and lead to a high diversity of ecosytems. Changes in drought frequency, and temperature induced by climate hange, decline in ground water table induced by changes in climate, land-use and water use lead to significant changes in the proportion of land cover types, land cover type pattern, and water budget at the regional scale (Q1).

The shrinking of arable lands, and the expansion of tree plantations and abandoned land may considerably change regional-scale water budget (Q2). Changes in the extent of differrent land cover types and the overall changes in water budget lead to changes in ecosytem services with a decline in food and increase in timber production, a decline in fresh water availaiblity and associated changes in biodiversity regulation (Q3).

Changes in water avaiability coupled with agricultural policy induce further changes in land-use and economic structure by generating furher land abandonment and afforestation (Q4). Conservation policy struggles with the conservation of wet ecosystems whereas regional development plans are considering a large-scale water supply from outside, from the river Danube (Q4).

Changes in economic sructure coupled with inappropriate development policy may lead to a migration from the rural areas to urban centres, while appropriate regulations may result in a better water management and save water (Q5). The region, given its special environmantal and socio-economic conditions, would need region-specific regulation and development plans but local authorities? may not be strong enough to lobby for this (Q5).

Further changes in land-use, water use, and rural population density will further affect the level of ground water table and the expansion of tree plantations and abandoned lands in the region (Q6).

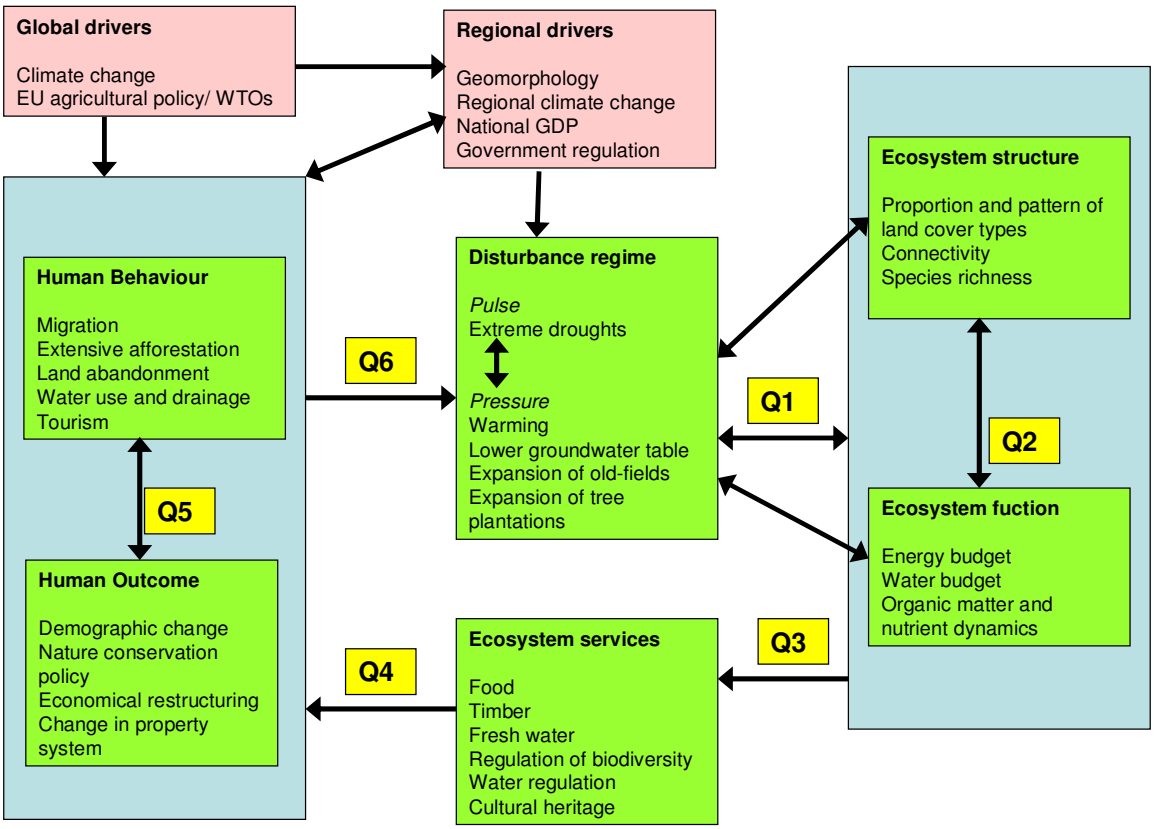

Figure 4. Regional level socio-ecological system

Regional level research questions (Fig. 4.):

Q1.How do changes in extreme drought frequency, water table depth and the extent of old fields and tree plantations affect the proportion of land cover types and the water budget?

1. How do warming, decreasing water table, an changing land-use affect regional-scale water budget?
2. How do increasing drought frequency and severeity, warming and decreasing water table affect the proportion of land cover types?

Q2. How do changes in the proportion and configuration of land cover types affect water budget and organic matter (C) dynamics.

1. How do the changes in the proportion of land cover types affect water budget?

Q3. How do changes in the proportion of land cover types, water budget, and organic matter dynamics affect ecosystem services such as food, timber, fresh water, water regulation, and C-storage:

1. How do changes in water budget affect fresh water availabilty?
2. How do changes in proportion of land cover types affect food and timber production?

Q4. How do water use, land-use, conservation policy, the structure of economy, ownership pattern change as a response to changes in water availability?

1. How do conservation and development policies respond to changes in water availability and biodiversity regulation?
2. How do changes in fresh water availability affect land-use?

Q5. How would changes in conservation policy and economic structure affect human migration, land-use and water use?

1. How could development and conservation policies influence human activities concerning water use in the region?
2. How do changes in human behaviour resulting from altered water availability induce regulations and development plans specific for the region?

Q6. How do changes in water use, land-use, economic structure and conservation policy affect disturbances such as water table decline and the expansion of old-fields and tree plantations.

1. How do existing water use patterns contribute to water table sinking?
2. How do changes in land-use affect the expansion of old-fields and tree plantations?

Regime shift and interactions

We summarized the most important regime shifts by scales and by domains. Inside the blocks, the arrows stand for the present time changes. The arrows between the blocks can be considered research questions: a few of them have been investigated, while most of them are worth to investigate.

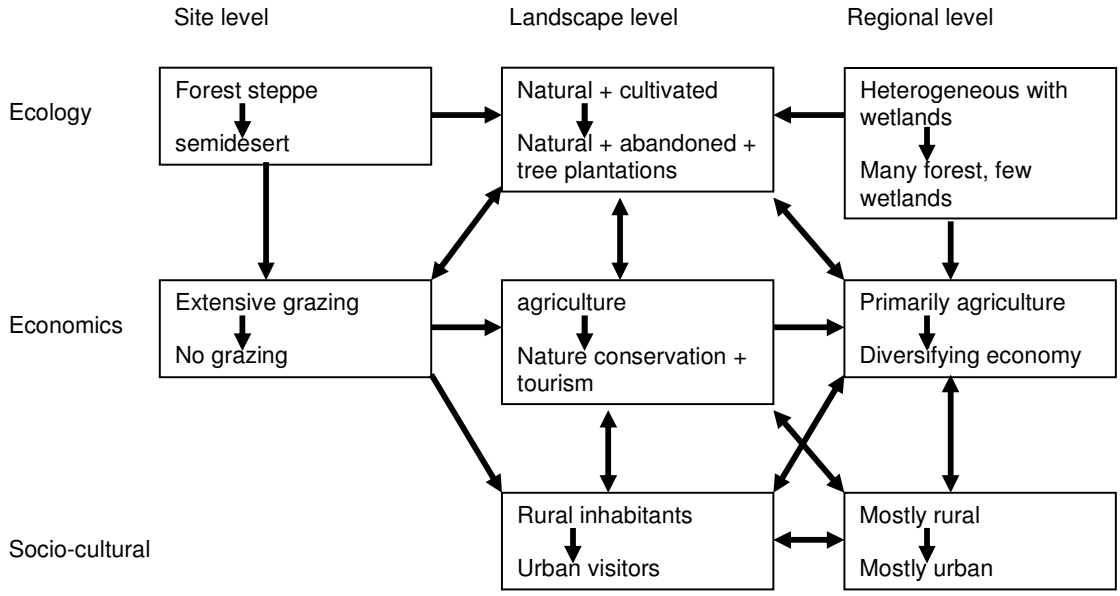

Figure 5. Interactions between regime shifts in the KISKUN LTER Platform