Preparing for climate change: does continental Southeast Europe and Central Asia need special attention?

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Climate change threats from a European perspective: the "Green Paper"

In summer 2007 the European Commission has issued a document entitled "Adaptation to climate change in Europe - options for EU action" („Green Paper"), which is a product of the European Climate Change Program (Anon. 2007). The objective of the publication was to open a Europe-wide public debate and consultation on modalities to develop adaptation strategies and to promote common research and the exchange of information with partners around the world. This consultation is still ongoing.

The "Green Paper" is the first common European policy document on adaptation to impacts of climate change, and reflects present priorities and attitudes toward a multiplicity of profoundly intertwined and often contradicting problems. It identifies however problem areas and challenges from a viewpoint which – according to the opinion of the author – does not represent fully the complexity of diverse natural, ecological, economical and societal conditions of Europe, not to speak of adjoining regions.

The approach of the document is primarily urbanite and technocrat. The highlighting of the sectors energy and infrastructure nourishes the impression that the tasks of mitigation and adaptation are first of all of technical/economic character. The treatment of the biotic environment, its resources and of sectors which utilise them is not according to their importance. The ecological problems concerning the *living natural environment* are at least equally serious as those of the technosphere, even if the contribution of biotic resources to the GDP is statistically low, as most of their essential services are not accounted for in monetary terms. Among the vulnerable social groups, the ones utilizing renewable natural resources (agriculture, forestry) should be dealt with similar attention: their activities significantly influence many components of climate forcing.

Ecoregions of Europe are also not equally treated. The impacts of the increase of drought frequency and severity in continental Southeast Europe should be stressed much more as the effect on conditions and quality of human life and on the functioning ("services") of ecosystems will be profound. The fact that the continental plains of Southeast Europe have their natural continuation eastward into the Turan Basin, i.e. Central Asia, is also frequently escaping the attention.

It may be concluded that due to different reasons (mainly because of weak representation of interests of this region in the European Union) the awareness regarding the specific problems and real importance of forests and forestry in the Southeast of the continent is limited and this is reflected in high-level European policy documents.

It was therefore a well-timed and proper decision by FAO to organise a special workshop to identify specific problem areas and the potential for collaboration between countries of the region. The SEC/SEU Joint Forestry Initiative on *"Climate Change Impacts on Forest Management in Eastern Europe and Central Asia"* provided a platform for exchanging information on climate change impacts on forest management, to analyse the current status of knowledge and to identify needs for potential technical assistance. The published reports in this volume confirm the necessity of this step. (The conclusions and recommendations of the workshop are evaluated in a separate section).

In this paper we propose for consideration some aspects why continental Southeast Europe and Central Asia should get more attention in international cooperation, research and in the development of national and transnational strategies of adaptation to climate change. We will concentrate on specific aspects of ecological conditions in the forest/steppe ecotone (transitory) zone, which is strongly represented across Southeast Europe and Central Asia. It should be noted that in addition to the climatic/ecological problems discussed here, the rapid social and economic transition and restructuring in the region has also a significant effect on land use –another important component of climatic forcing.

Climatic and biogeographic conditions of the region: is there anything in common?

The climatic and bio-geographic conditions of Southeastern Europe and Central Asia are very diverse, and this is similarly true for their socio-economical status. Accordingly, the problems raised by predicted climatic changes are also manifold, from land use change, forest degradation and desertification to the melting of glaciers.

What makes this region specific is the *presence of the so-called xeric limit* of forests and forest tree species. Xeric (or rear, trailing) limits at the low latitude and low altitude end of distribution ranges are determined by climatic aridity (Mátyás et al. 2009). Xeric limits are apparent along the arid foothills of Mediterranean mountain ranges, but they appear most extensively on temperate, continental plains. On flat terrain these limits are, however, difficult to trace as humidity conditions change due to small-scale site variation and because of strong human interference.

At the xeric limit the closed forest belt forms a transition zone (ecotone) toward the woodland or forest steppe type vegetation, which dissolves southward into the true steppe of East Europe and the Turan. The ecotone is dependent on a volatile minimum of rainfall and is therefore sensitive to prolonged droughts. Predicted changes may easily trigger the loss of already sparse forest cover, which may lead to the disruption of vital ecological services forests are providing.

The biotic-ecological factors of the xeric (rear) limits are shaping the physiognomy of natural vegetation and influencing land use of Southeast Europe and Central Asia. In Southeast Europe, the ecotone is a densely populated and agriculturally important zone which has been under human influence for millennia. This belt reaches from East-Central Europe across the plains of Southeast Europe (Romania, the Ukraine and South Russia) and of Northeast Kazakhstan far into Southern Siberia and North China (Manchuria). A narrower and fragmentary transition zone follows the southern and eastern mountainous rim of the Central Asian plain. The transition zone appears in temperate climate also on other continents, first of all in the Midwest of the US and north into Alberta at the edge of the Prairies.

What makes the transition zone in flat lands especially vulnerable is the magnitude of the *latitudinal lapse rate*. It is generally known that the altitudinal lapse rate for temperature (i.e. the rate of change with increasing elevation) amounts to 5.0 - 6.5 ºC/1000 m. At the same time, the latitudinal lapse rate is less recognized: in the temperate zone its mean value is around *6.9 ºC/1000 km* - a difference of three magnitudes! A consequence is that obviously even minor changes of temperature *affect disproportionately larger tracts of plains* as compared to mountainous regions. One degree of temperature increase causes a shift upwards along a mountain slope of approximately 170 m: the same change triggers on a plain a shift of close to 150 km northward. Presuming a spontaneous migration speed of approx. 50 km/100 years, an increase of temperature of just 1 ºC would imply for a tree species a migration time of 300 years (Jump et al. 2009). This fact explains the much larger vulnerability of plains in Southeast Europe and Central Asia, as compared to the generally mountainous coasts of the Mediterranean.

The hidden threat at the xeric limits: increasing drought

Contrary to general belief, the trend of raising temperatures and declining summer rainfall will not result in a "mediterranisation" in continental Southeast Europe because the regulating effect of the distant sea is weak and the predicted climate anomalies will be different from general trends. According to calculations of IPCC (2007) predicted temperature changes of the critical summer climate at the end of the century are more drastic as in the boreal zone of North Asia or North Europe (Figure 1a). Models show also a decrease of precipitation, especially for Southern Europe. (It should be mentioned that the changes for Southern Europe alone might be somewhat milder, as the prediction of IPCC was made coupled with the whole Mediterranean Basin, including North Africa.) Predicted summer precipitation change is of special significance at the xeric limits which are extremely sensitive to relatively minor humidity variations. Drought events will happen in line with predicted climatic changes but their frequency and severity may change at a rate different from trends in Northern Eurasia (Figure 1c). The shifts in drought frequency may cause drastic changes in lowland forest regions of South-eastern Europe and Central Asia. Even a relatively minor shift of temperature and precipitation parameters will affect profoundly the available climatic niche of dominant forest species. Mass mortality may appear at the rear edges, especially on sites with unfavourable water regime.

A case study: Hungary

Frequency changes of drought events have been analysed for the territory of Hungary. The predicted frequency of drought summers (precipitation decline exceeding 15% of the seasonal mean) are shown in Table 1. It is highly remarkable in Table 1 that from 2050 onward, the model defines every second summer as drought event: 24 summers out of 50 years will be drought summers, with growing anomalies (Gálos et al. 2008).

Table 1. Frequency of recent and predicted drought events for Hungary, according to scenario A2, calculated with MPI's REMO climate model. Reference period: 1951-2000 (Gálos in: Mátyás 2009)

Period	**Drought summers**		
	number of years (out of 50 years)	mean of precipitation anomalies (%)	mean of temperature anomalies (°C)
1951–2000	15	–28.02	+0.95
2001–2050	9	–29.21	+2.00
2051–2100	24	–34.98	+2.86

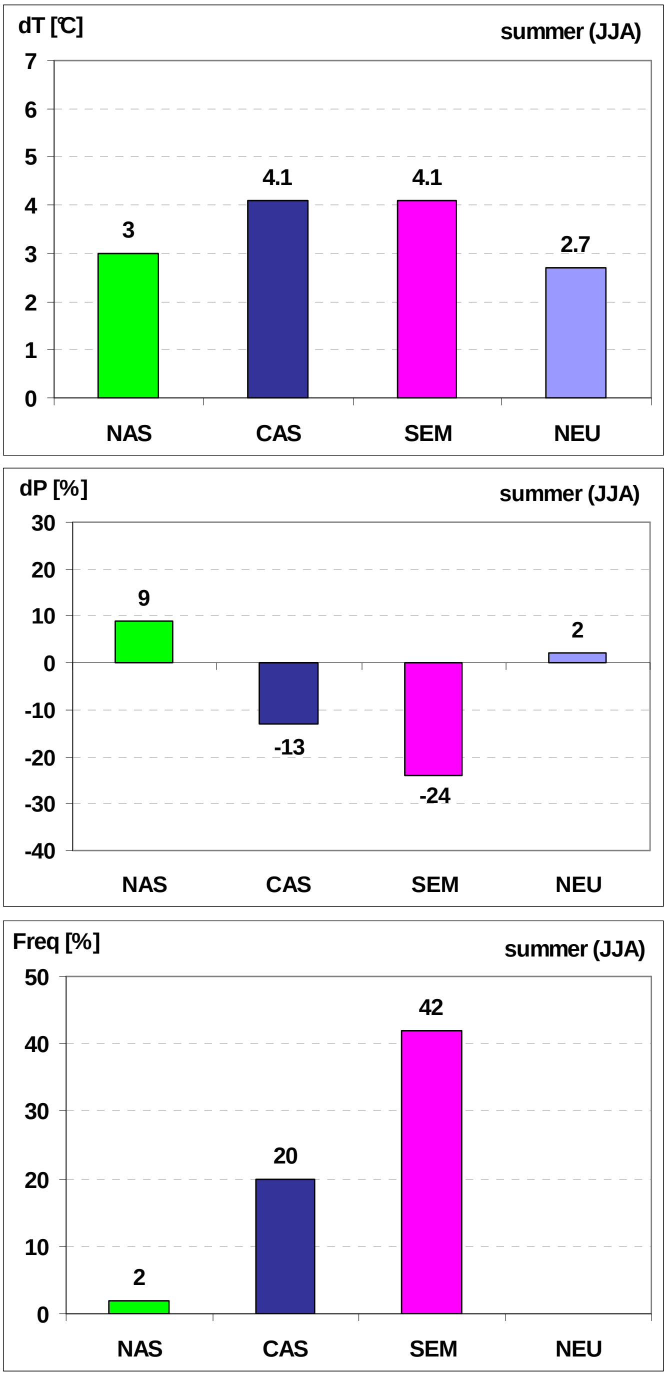

Figure 1. Predicted summer climate changes for the period 2080-2099 vs. the reference period of 1980-1999, according to the A1B scenario.
a) Change of mean summer temperature, dT (°C)
b) Change of mean summer precipitation, dP (%)
c) Change of the frequency of dry summers, Freq (%)
The four columns represent predicted averages for the regions of boreal, Northern Asia (NAS); Central Asia (CES), Central-Southern Europe with the Mediterranean (SEM) and North Europe (NEU).

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

Climate forcing and forests: specific conditions at the xeric limits

Climate model simulations prove that land cover, i.e. vegetation has an important role in climate regulation. Forests dominate the terrestrial carbon sequestration process, modify the hydrological cycle, albedo and turbulent fluxes above the land surface. Thus, forests have both a direct and indirect effect on the majority of factors contributing to anthropogenic climate forcing, such as atmospheric CO_2 content, surface albedo and land use change (forest destruction or afforestation), soot of biomass burning, as well as sedimentation of aerosol and dust particles. In addition to forest clearing and forest fires, also harvesting and industrial use of timber have an important indirect effect through the creation of additional carbon sinks. Land use changes of half a century are enough to cause changes in the course hourly temperatures (Drüszler et al. 2010, Figure 2).

The climate forcing effect of forests, covering more than one quarter of the land surface of the Earth, is therefore crucial. Surprisingly, current views on the role of forests are contradicting and fragmentary: some opinions even state that temperate forests have little to no benefits to climate (Bonan 2008). In the transition zone of closed forests toward the woodland/steppe region, surface albedo, evapotranspiration, carbon emission and sequestration are affected by land use change, afforestation programs and changes in forest policy (tree species preference change). At the xeric limits where summer temperatures tend to increase, surface albedo and evapotranspiration have ambivalent effects. Both deciduous and conifer forests have a lower

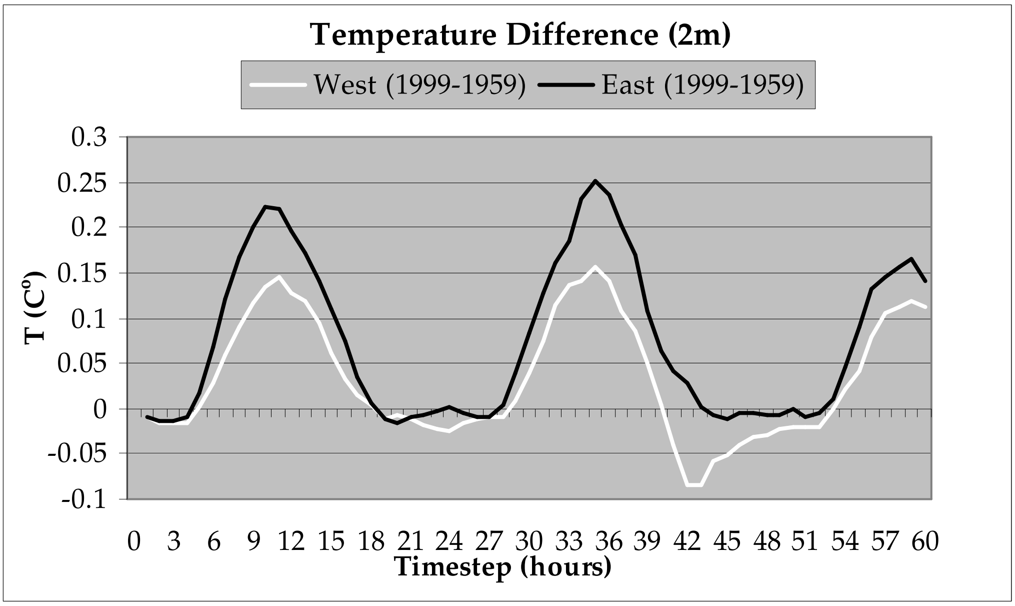

Figure 2. Regional climatic effects of land use change in the western and eastern half of Hungary between 1959 and 1999. The graph shows temperature differences between the two land use situations during the vegetation period, based on the MM5 meso-scale weather forecasting model. The model was integrated for 13 pre-defined macro-synoptic situations, each for 60 hours (the 12th, 36th, and 60th hour correspond to 2 p.m. local time). The results were weighted with the relative frequency of each macro-synoptic type and averaged (Drüszler et al. 2010).

albedo as other forms of land use, which is augmented by the fact that forest canopy masks highly reflective winter snow cover. So, from point of view of albedo, forest cover should cause higher summer and winter temperatures, thus worsening drought situations. Model simulations indicate the opposite (Kleidon et al. 2000) which fact is supported by field observations. Investigations at the Canadian prairie-woodland border prove that forest cover at the xeric limit has a clearly positive effect: summer temperatures are significantly lower where woodland/forest cover remained. Hogg and Price (2000) found that deciduous forest causes anomalies first of all in summer: temperatures are cooler, mean precipitation is higher and length of growing season increases. The cooling and humidifying effect of intensive evapotranspiration of forests seem to prevail in spite of the forcing effect of additional water vapour and lower albedo. The input of agricultural surfaces to climate control is less, due to lower water consumption and shorter active vegetation period.

Persistence of forests to drought as compared to grass or crop vegetation is the result of deep rooting of trees, utilizing deeper soil water resources. Surface roughness of the crown layer leads to different aerodynamic conductance, which alters cloudiness and causing additional atmospheric feedback.

Photosynthetic activity – i.e. carbon sequestration, growth and contribution to carbon sinks – depends on available water resources and temperature conditions. At the xeric limits, effect of summer temperature rise and falling precipitation amounts are confounded with increasing CO_2 levels and the fertilizing effect of nitrogen deposition (the latter is enhanced in the ecotone zone by usually dominant, intensive agriculture). Higher CO_2 causes photosynthetic

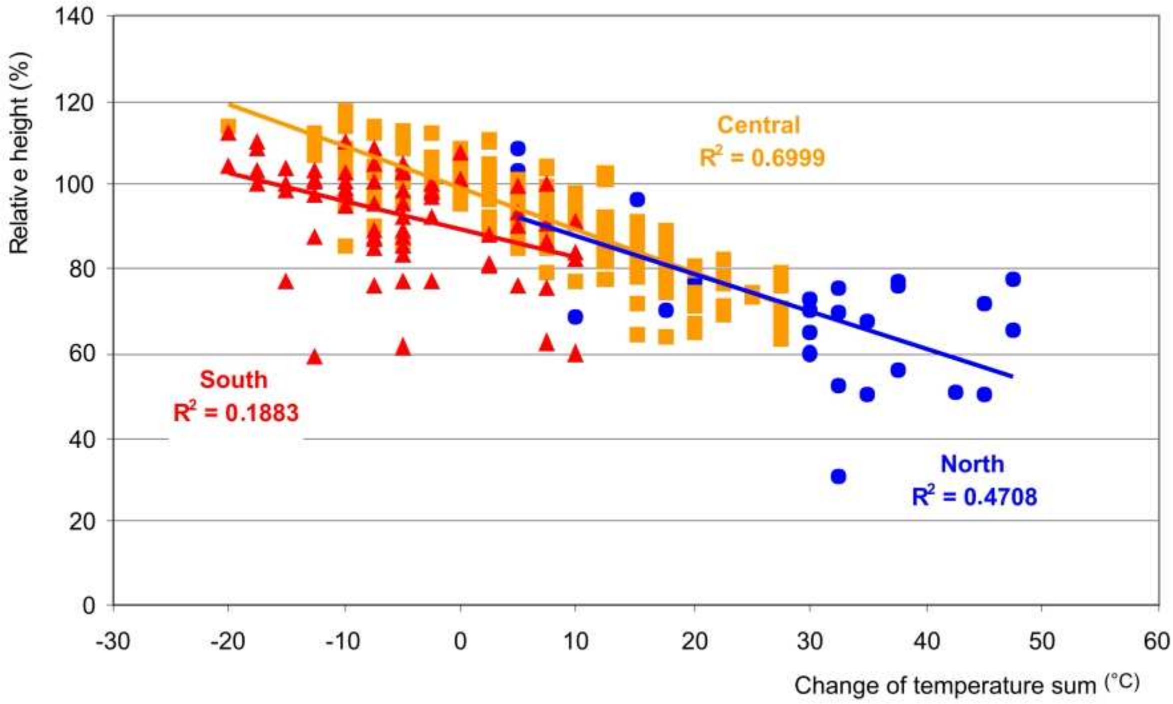

Figure 3. Declining relative height growth (age 16, in percents) of Scots pine (Pinus silvestris) populations, tested in 6 common garden (provenance) tests in European Russia. Irrespective of origin (northern, central and southern), all populations responded to increase of temperature sum with significant slowing down of growth (analysis: Mátyás and Nagy, in: Strelcova et al. 2008)

enhancement, more efficient water use capacity and increased primary production: this has a negative feedback effect on climate change.
Numerous studies and also IPCC's 2007 report forecast a decline in growth and production of forest stands for East Europe: however, up to now this tendency is not measurable yet as a general trend (e.g. Somogyi 2008). It should be noted, however, that the reason for the missing evidence for gradually worsening ecological conditions in Southeast Europe has to be sought probably in the improper selection of datasets. Analyses are usually based on large-scale forest inventory data which are not detailed and precise enough to trace complex effects of opposing trends of negative and positive environmental effects acting simultaneously across climatic gradients. Specific experiments on growth and yield confirm the negative effects of changing site conditions (Mátyás and Nagy, Figure 3).

Role of forest management

A recurrent drawback of models describing impacts of climate change, constructed by ecologists and earth scientists, is the lack of consideration of effects of forest management. All over temperate Europe and across large tracts of forests of Central Asia, planned and sustainable forest management has been introduced, except for inaccessible alpine areas. Planned forestry means that the structure, species composition and demography conditions of forests are determined by current management concepts, strategies and laws. Spontaneous processes are suppressed or tolerated only as far as they fit into the accepted strategies. Planned, sustained harvesting methods decide on the applicable techniques for regeneration of forest stands.
Forest management according to operational plans implies therefore that spontaneous forest cover changes determined by climatic shifts may be balanced by human action, if principles of forest policy are oriented towards adaptation to effects of change. Artificial regeneration together with forest protection measures may effectively buffer the spontaneous effects of climatic shifts – needless to say, only until the physiological and genetical limits of the species. Consequently, goal-oriented forest policy and management should be seen as effective measures to serve climate adaptation.
All this has an input also on the carbon sink function of the forest vegetation. Fully protected (or primeval) forests may be regarded as carbon neutral. The extraction of timber for industrial purposes creates new carbon sinks in the human infrastructure which might last sometimes for centuries. Life cycle analysis (LCA) techniques will help to elucidate its importance for the carbon cycle.
The forest/steppe transition zone across Southeast Europe and Central Asia offers much better opportunities for the described human intervention as in boreal regions, due to high population density, available manpower and regulated management.

Summary

Although issues of global change are in the focus of international research and politics, mainstream research as well as European mitigation policy regards the specific problems of continental Southeast Europe and Central Asia as marginal issues. It should be however taken into account that:

- climatic forecasts for Southeast Europe and Central Asia show high uncertainties and trends different or even opposite to forecasts for West and North Europe or boreal Asia,

- there are extensive plains in the region which are situated in a broad climatic and ecological transition zone (ecotone) towards steppes and arid lands. The vulnerability of this zone to climatic changes is high,
- the decline of vitality and stability of forests may generate in this region ecologically harmful processes (degradation, aridification, oxidation of organic carbon stored in the soil of forest ecosystems etc.),
- the forest/steppe transition zone is densely populated, and plays an important role in food production and industry. The economical and social restructuring following the political transitions has not reached a stabilization phase yet. These facts may enhance expected ecological consequences of changes considerably,
- most of the region has been under extensive land use for long historic periods, which renders potentially beneficial, spontaneous processes of adaptation (e.g. migration) dysfunctional. At the same time, this fact offers the possibility of applying planned measures to support natural processes by human interference.

The above problems are common all over continental Southeast Europe and the forest/steppe transition zone of Central Asia. The communication and cooperation of the numerous, mostly small nations of the region is yet underdeveloped. Initiatives to promote collaboration in adaptation to climate change would therefore benefit the whole region and may have a global effect as well.

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