Management and Impacts and Climate Change
Programme GICC
CRP 2001

9/01 – Global changes and biodiversity: Relative performances of introduced and indigenous species and simulation of distributional changes

Summary of Final Report

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The objective of this project was to analyse the effects of the increase in temperature and of changes in the precipitation regime foreseen in Europe on the phenology, growth and reproduction of woody and herbaceous plant species, and to assess the consequences regarding their geographical distribution. This project was approached from two angles:

1/ The experimental evaluation of the effects of a rise in temperature and of a drop in precipitation on the phenology, growth and fertility of several plant species reflecting the major functional types: C3/C4 photosynthetic pathway, Monocotyledon/Dicotyledon, annual/perennial, herbaceous/woody;
2/ The development of mechanistic models of the geographical distribution of the studied species, in order to be able to predict potential changes in this distribution.

An experimental installation was set up *in situ* by the participating research team during the winter and spring of 2002 at the experimental field station of CEFE. This installation is used to apply *in situ* an increase in temperature (+1.5℃ and + 3℃) combined or not with a 30 % reduction in preci pitation. The selected levels of temperature and precipitation are those predicted by climatic models for the south of Europe in 2100.

Due to the late constitution of the plant communities in the spring of 2002 in comparison with the normal vegetative cycle, the first six months of the experiment gave no results, with a few exceptions. However, the measurements carried out from the autumn of 2002 to the autumn of 2003 highlighted important phenological discrepancies as a result of the increased temperature, with marked repercussions on growth and fertility. The impact of temperature on phenology tends to bring forward the date of the different development stages in all species,

but more or less so depending on the species (from -1.5 day/℃ to –35.2 days/℃). The more reactive species are the C4 Gram ineae (*Setaria*) and the least reactive the C3 Graminae (*Lolium*). Meta-analyses carried out on phenological changes over the 20th century showed that, worldwide, the different phenological stages, in particular the spring stages, took place 2.3 days/decade earlier on average. Temperature having risen by 0.6℃ since 1950, we can infer that phenology responds to climate warming by 19.2 days/℃. Our experimental results are therefore in agreement with historical data, with the added information that the response may be highly variable depending on the species.

Higher temperatures also induce either a shortening of the vegetative cycle in annual species (such as *Lolium rigidum*), or a lengthening of the vegetative cycle in perennial species (such as Oaks). It appears that phenology is capable of adapting to temperature rises of +12℃ for the nort hernmost populations, which is considerable. There already exists a large difference between the temperature of the experimental site (Montpellier) and that of the sites from which the various populations originate (-9.2 ℃ in Estonia, -6.5℃ i n Bohemia, -5.2℃ in Lille, -3.9℃ in Orleans and 1.7℃ in Vendée).

However, the effects of these phenological changes on growth and fertility vary widely from one species to the next. Only one species (*Setaria parviflora*, a perennial C4 Gramineae) was very significantly advantaged by the increasing temperatures as to both growth and fertility, and very little affected by the decreasing precipitation. In contrast, C3 species, whether Monocotyledons (*Lolium*) or Dicotyledons (*Artemisia*) are all affected by the temperature rise, more or less depending on the geographical origin of the populations; overall, their biomass and fertility tend to decrease (although not significantly) with the increase in temperature. These findings are awaiting the 2004 data for confirmation.

Precipitation changes have had very little significant effects - but then 2003 was an atypical year regarding its precipitation pattern.

The variability of the responses to temperature according to species and populations remains very high in all measured traits, a fact that reveals that the sampling of the genetic diversity within the geographical range of the species was appropriate.

The PHENOFIT model, which makes it possible to model the geographical distributions of species on the basis of such experimental results, was improved to better take into account some aspects of the species' biology. It is currently being adapted to European woody and herbaceous species on the basis of the experimental results. The sensitivity to characteristics of the climate data entered in the model was analysed. Results underlined the importance of using daily temperature data and the bias introduced by the spatial and temporal data disaggregation techniques, thus stressing the importance of using the scenarios'

daily climatic data. Simulations of distributional changes in two tree species using climatic data from HadCm3 according to two different scenarios (A2 and B2) showed that the ranges of species of the temperate zone will be massively reduced in their southern part, while only slightly expanding northwards into new regions. More boreal species, in contrast, will not be severely affected by the climate change as they will see their distribution expand northwards, especially in the B2 scenario (+2.5℃) and somewhat less so in th e A2 scenario (+5-6℃).