

SILVICULTURE: CLIMATE CHANGE EFFECTS ON FOREST ECOSYSTEMS

*After a brief introduction on climate change and its interaction with forests, contents of oral contributions are presented. Papers concern: the main results of the National Inventory of the Forests and the Forest reservoirs of Carbon (INFC); the present situation of the Italian network of forest flux stations measuring net carbon exchange; the issue of forest management for adaptation and mitigation; the relationship between climate change, air pollution and forest ecosystem response; the role of the "Register of agro-forest reservoirs of carbon"; the forest situation of the island of Sicily with special reference to the use of forest biomass for bioenergy production; the most recent results of the BIOREFUGIA research project on the potential risks of shift and migration of forest vegetation in Italy; a detailed forest carbon inventory conducted in the Piedmont region; the role of Long Term Ecosystem Research for the monitoring and understanding of the impacts of global change on forest functioning, on long temporal scales; the results of the dendroecological responses of *Abies alba* forests in the last century, in relation to the climatic trend of Central Apennine mountain sites; the role of such key ecological markers and tracers as stable isotopes (C13, O18, H2, N15) for the unravelling of forest ecosystem interactions with carbon, water and other biogeochemical cycles and with climatic factors. In synthesis, it appears necessary to sustain the concrete establishment of the "Register of agro-forest reservoirs of carbon" and the adoption of a kind of National Forest Fund, as recommended in the final statement of this Congress.*

Key words: climate change; Kyoto Protocol; forest ecosystems; adaptation.

The Italian Congress of Forestry and its special Session on Climate Change have coincided with a very significant event, the 50th anniversary of the first measurements of the atmospheric concentration of CO₂. These experiments were conducted in the island of Mauna Loa, Hawaii in 1958, by a scientist recently disappeared, Charles Keeling; he was able to show that carbon dioxide atmospheric concentration had reached 315 ppm, at that time,

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with a growth rate of 0.6 ppm per year, giving therefore the start to the researches on CO₂ worldwide. The atmospheric concentration has constantly increased and has overcome 390 ppm in the last 50 years with a 24% increase, value never reached at least in the past 900,000 years. The present concentration of CO₂ in the atmosphere corresponds to an average increase of carbon in the atmosphere of around 3,3 Gtons a year.

Beyond the quantitative side, the most worrisome aspect is given by the rapidity of the rate of increase of C-emissions in the various countries, especially in those that are experiencing a strong industrial expansion as India, China, Brazil, where the annual increase of 3,5% can cause the doubling of the emissions within the next 25 years. As known, the industrialized countries are bound by the Kyoto Protocol to reduce their collective greenhouse gases (GHG) emissions by 5.2% from the 1990 level, in the period 2008-2012. Nevertheless, according to the projections of the simulation models, the achievement of climatic sustainability corresponds to a CO₂ concentration close to the present one, between 350 and 400 ppm, but it requires to cut by 50% the emissions in comparison to 1990, for the whole planet (MOLOCCHI, 1998).

Forest ecosystems altogether exchange every year with the atmosphere more than 60% of the overall carbon assimilated by all terrestrial ecosystems, despite they cover only 30% of the overall land surface. Therefore, world forests play a fundamental role for the mitigation of the main biogeochemical cycles as carbon, water and in the relationships between biosphere and climate.

When a given country increases the forest surface, by reforestation, afforestation or revegetation, improves the efficiency of forest ecosystems by management or reduces the forest surface devastated by wild fires, that country will be able to discount the quotas of reduction of the gas emissions, as agreed upon by the Kyoto protocol; it will also be possible to exchange the surplus quotas with other countries through a special mechanism, the so called Emission Trade Scheme (EUT) that has been functioning already in the last four years, in the European Union. Eventually, also the United States, that had opposed the Protocol, have recently launched a system of exchange of carbon credits, similar to that implemented by EU, among the industries that produce electric energy.

Currently, the air temperature at the surface of the planet has increased by 0.3-0.6 degrees over the past century and are increasingly evident effects of global warming as the retreat of glaciers in the Alps, the reduction of total mass polar glaciers, hot water heating sub-surface of the seas etc. The effects of these global changes give rise, at the local level, to a particularly intense climatic variability. The information provided by the Intergovernmental Panel on Climatic Change (IPCC) forecasts a persistent global change of the climate

with an increase of the temperature from 1,4 to 5,8 Cs during this century, that can cause sudden changes in the precipitations.

Actually, also in the past geological eras remarkable climatic changes have frequently and cyclically occurred; however, the present rate of climate change could be too rapid for the global biodiversity, and particularly so for the forest species and communities, to adapt and migrate. Under the forecasted climatic conditions these migrations should happen at a rate that has been valued in 1,5-5,5 Km a year in the direction of the poles and 1,5-5,5 m in altitude, almost impossible to match without human intervention.

The consequence is that from the point of view of biodiversity a temporary reduction of species richness could occur in various forest areas of the world, due to degradation or disappearance of the present-day forests. The ensuing critical issues are related to the planning and implementation of a set of options, at the forest and land management level to drive the natural migration of the species as, for example the creation of a complex network of ecological corridors. Conversely, the practical implementation of adaptation measures for forest species is rather costly and requires time and a devoted effort at the scientific, forest management and land organization scales; for sure, this complex endeavour can only be accomplished via an appropriate support plan. To this purpose, specific investments should be adopted, a kind of National Forest Fund should be created, as recommended in the final statement of this Congress.

During this session on climate change interactions with forests, twelve oral presentations were given, covering many different aspects of monitoring, mitigation and adaptation of forest ecosystems under global change.

After an introductory lecture (GIORDANO and SCARASCIA-MUGNOZZA, 2009) on the challenges posed to forest research and management by these critical issues, POMPEI and SCARASCIA MUGNOZZA (2009) presented the main results of the National Inventory of the Forests and the Forest reservoirs of Carbon (INFC), that is being completed with the information on biomass and soil carbon stocks collected from thousands of sample points stratified to represent the wide variation of Italian forest types and ecosystems.

The report by MATTEUCCI (2009) showed the present situation of the Italian network of forest flux stations measuring net carbon exchange, that includes the first of these carbon experimental forests realized in Europe, in the year 1993 in the beech forest of Colledara. The network is presently composed of 13 stations, from the North (Piedmont, Alto Adige) to the South, in Calabria, to sample a wide range of forest environments. Several of these stations are characterized by an approach that allows long-term research to assess the role of trends in climate changes on the ecosystem carbon

balance and the possible impact of extreme events (e.g. the heat waves of 2003 and 2007) or anomalous years (autumn - winter 2006/2007). Moreover, MAGNANI and MATTEUCCI (2009) presented the issue of forest management for adaptation and mitigation. The foresters are called today to recognize and predict forest dynamics, to adapt the cultivation schemes and practices, and where necessary to prevent risks and enhance the possible benefits of change. However, in the Mediterranean environment climate change seems to influence negatively forest productivity, particularly in the southern limit of the natural range of tree species.

The relationship between climate change, air pollution and forest ecosystem response has been addressed by F. Loreto and C. Calfapietra. The increase of CO₂, pollutants and air temperature, combined with the decreased availability of water, could severely impact on the primary and secondary metabolisms of forest trees. Photosynthesis responds positively to the increase in CO₂ but high temperature, acute or chronic exposure to air, water and soil pollutants, and recurring water stress can reduce the trees capacity to sequester carbon, especially in ecologically fragile areas and exposed to desertification, as the entire Mediterranean basin. Climate change and pollutants also affect the secondary metabolism of plants as underlined by the biosynthesis and fate of biogenic volatile organic compounds (BVOC).

VALENTINI and LUMICISI (2009) have investigated the role of the "Register of agro-forest reservoirs of carbon", a carbon-accounting tool within the mechanisms of the Kyoto Protocol, that was recently implemented by the Ministry of Environment to support the compliance of our country to the legal requirements of the KP.

SAPORITO and CANDORE (2009), of the Sicilian Regional Forest Service, presented the forest situation of the island of Sicily with special reference to the use of forest biomass for bioenergy production; PETRICCIONE and PARISI (2009) showed the most recent results of the BIOREFUGIA research project on the potential risks of shift and migration of forest vegetation in Italy as simulated for the end of this century; PETRELLA *et al.* (2009) presented a detailed forest carbon inventory conducted in the Piedmont region, indicating that the C-stock of the soil compartment (first 30 cm of top soil) is almost equivalent to the whole carbon accumulated in the aboveground biomass.

MOTTA and PIUSSI (2009) discussed the role of Long Term Ecosystem Research for the monitoring and understanding of the impacts of global change on forest functioning, on long temporal scales; in fact, the long-term ecological research, initially aimed mainly to the study of ecological succession, found several new developments in research areas such as population dynamics, forest management, ecological planning, sustainable management of natural resources, and above all, the human impact on natural

processes and the impact of global change on ecosystems. Also, the authors presented some of the most relevant LTER sites and studies realized so far in Italy; the Paneveggio forest represents a privileged site for long-term studies on the ecology and silviculture of spruce forests in the Alps and have been the object of careful investigations since the second half of the 19th century. Presently, the Reserve of the Valbona has been included within the Italian LTER network since 2007, as a site belonging to the category of “alpine forests”

D'APRILE *et al.* (2009) provided interesting results on the dendro-ecological responses of *Abies alba* forests in the last century, in relation to the climatic trend of Central Apennine mountain sites; finally, LAUTERI and BRUGNOLI (2009) showed the role of such key ecological markers and tracers as stable isotopes (C13, O18, H2, N15) for the unravelling of forest ecosystem interactions with carbon, water and other biogeochemical cycles and with climatic factors.

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