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SILVICULTURE: FOREST PROTECTION

The multiple services provided by forests (conservation of: biodiversity, soil and water resources, mitigation of climate change, cleaning of air and water, timber production, landscape and recreation) are strongly dependent on forest health. In this paper we synthesize the main outcomes of the session on 'Silviculture, Forest Protection' held within the III Italian National Congress of Silviculture, Taormina, 16-19 October 2008.

Key words: insects; fungi; pollution; climate change.

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1. PLANT PATHOLOGY

The phytosanitary situation of the Italian forests, often tied up to irrational silvicultural practices, is conditioned to be threaten by pathogens of new introduction, by the recrudescence of endemic infective entities and by the increase of the stress induced from changes of the environmental conditions. A typical example is provided by *Discosporium*, a poplar pathogen, known to be harmful in the south of the country, but now

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common also in the north. The geographical position of Italy has always offered good opportunities to pathogens to entry from other countries and continents, which has favoured epidemics such as: *Cryphonectria parasitica* on chestnut tree, *Marssonina brunnea* on cultivated poplars, *Ophiostoma* spp. on elm, *Seiridium cardinale* on cypress, *Ceratocystis platani* on plane tree. The introduction of invasive species is facilitated by the climatic change, that induces pathogens (Chromista, Fungi, Bacteria, Virus) to modify their range. The most significant cases concern however insects, because pathogens are generally slower to respond. In the last years the European Union has introduced specific norms about quarantine organisms (e.g. the Directive 2000/29), also through international organisations such as the European and Mediterranean Plant Protection Organisation (EPPO), listing organisms not yet present on the continent (A1), those already reported locally in Europe (A2), as well as a list of alarm for the species of potential introduction. A lot of attention has also been paid to the introduction of the plant passport and the phytosanitary certification for the commercial transport. Among the pathogens whose introduction is feared in our country, the agents of tracheomycosis by *Ceratocystis fagacearum* on oak and chestnut tree, the pathogens of the pines such as the rust from *Cronartium fusiforme* and *C. quercuum* and the tracheomycosis by *Ophiostoma wagnerii* are listed.

The strong conditions of stress associated with the increase of atmospheric pollutants, the most frequent droughts, the increase of the mean temperature and the reduction of the annual precipitation, have altered the microbiological equilibrium of the soil and the state of mycorrhiza, starting tree decline with to rise of pathogens of weakness, agents of root rot and agents of cortical necrosis. The gravity of the attacks imposes timely interventions, the nature and the form of which must be framed in a multidisciplinary context, as basic knowledge of ecology, economy, epidemiology of the harmful species, as well as their interactions, is required. The control strategies are bound to the characteristics of the forests. In the new plantations, the genetic improvement results to be the best way of control. The certification and the control of the material coming from the nurseries, the measures of quarantine and the green passport for the material of importation, represent important tools of prevention. To avoid to introduce plants or parts of them defective for conformation and/or carriers of pathogens (for the most part fungi, but also chromista and bacteria), it is possible to use chemical products in nurseries, keeping in mind however that those authorized are a few and they do not offer protection against all the main pathogens. In nurseries it is in general recommended to apply integrated control methods, in particular the induction of the ectomycorrhiza symbiosis. In forests, important results have been achieved in the biological control of *Castanea-Cryphonectria* and *Castanea-Phytophthora cambivora*

pathosystems. In the first case, the spread of the hypovirulence strain has definitely avoided the disappearance of the chestnut tree in Italy and in Europe; some biological glues for the protection of the grafts and the wounds has also been developed. In the second case, treatments with biological preparations have reduced the attacks and allowed the recovery of the most infected plantations.

The situations described above and many others require the adoption of suitable strategies of control through the activation and the maintenance of monitoring systems, both to identifying declining forests and the outbreak risk, and to build predictive models of pathogen attacks and the necessary measures of prevention and therapy.

2. ENTOMOLOGY

The climate change is affecting the functioning of the forest ecosystems also through the expansion and the performance of forest pests, as shown for the pine processionary moth and the spruce bark beetle, asking for measures of preventive silviculture. As poikilothermic organisms, insects are responding quickly to climate both directly and indirectly, such as through changes in phenology and quality of the food plant. The interactions between insect herbivores and their competitors and natural enemies (parasitoids, predators, pathogens) are also affected. The pine processionary moth (*Traumatocampa pityocampa*) has already colonized pine stands at high elevation thanks to a higher number of hours available to female moths for spreading and to suitable temperature for larval survival under new conditions. It appears that the pest is also promoted by some silvicultural practices, such as the species chosen for the plantation and the type of planting. The spruce bark beetle (*Ips typographus*) is a well-known pest of spruce forests, associated with stand damage by windfelling or drought in the previous year. Its aggressiveness in the Italian Alps is increased by the possibility to carry out two or three generations per year under warmer conditions, while in colder sites of northern Europe mainly one generation is known to occur. This species may cause an important economic loss, although the ecosystem damage may results even more important, as the landscape can be severely affected. The silvicultural practice may offer in this case the possibility to interact significantly with the risk of outbreaks, by modifying the stand density and age, and by the introduction of broadleaved trees. In addition, the quick removal of infested tree parts is still essential to limit population growth and damage to standing trees.

Climate change is also associated with the increase of threats by alien species. Most important examples are the pine bast scales *Matsucoccus*

feytaudi on maritime pine and *Marchallina hellenica* on Mediterranean pines, the chestnut cynipid *Dryocosmus kuriphilus*, the bugs *Corythucha ciliata* on plane and *C. arcuata* on oak, the palm weevil *Rhynchophorus ferrugineus*, the Asian longhorn beetle *Anoplophora chinensis* and *A. glabripennis*, the broadleaved platypodid *Megaplatypus mutatus*, the conifer seed bug *Leptoglossus occidentalis* and the eucalypt gall wasp *Ophelimus maskelli*. Programmes of classical biological control with the introduction of natural enemies have been successfully adopted in a few cases. Species at risk of introduction are some moths (*Dendrolimus sibiricus*, *Malacosoma disstria*, *M. americanum*, *Orgyia pseudotsugata*), bark beetles (*Pseudopityophthorus*, *Ips*, *Dendroctonus*), and buprestid beetles (*Agrilus planipennis*).

As insect herbivores affect the primary productivity and thus the carbon cycle, their action could be considered in the post-Kyoto discussion on carbon budget. This can be addressed as standard consumption under non-outbreak conditions as well as pulses of carbon at outbreak events.

The physiological responses of trees to an herbivore attack are now better known and they may offer the possibility to explore systemic resistance as a way to increase protection. Mechanisms can work at the tree individual level and also at community level, through the interaction with natural enemies of the herbivores, that may respond directly to tree signals. Stand biodiversity is also important in this perspective. Mechanism of direct and indirect resistance of trees to insect pests have been shown in a number of cases, and some of them are being explored for application, such as in the case of the pine bast scale.

Pest monitoring has increased of importance in the last decades, thanks to the enormous improvement in techniques for spatial data analysis. This is leading to much better predictive models, that may be associated with specific preventive silvicultural practices.

3. AIR POLLUTION AND CLIMATE CHANGE

Because of global change, forests are facing many interlinked stress factors. Many traditional pollutants and “new” greenhouse gases are emitted from the same sources, contribute to the Earth’s radiative balance, interact in the atmosphere, and jointly affect ecosystems. Air pollution and climate change are thus sides of the same story. Many effects are now irreversible. Studying the adaptation of forests is thus a priority and also a challenge, because of the complex interactions among the many factors involved. Ozone pollution and climate change are the global change factors of major interest for Mediterranean forests, even because they interact with each other. Experiments under controlled conditions have suggested that ozone is the phytotoxic pollutant of major concern for forests. Validating ozone effects on

the real-world forests, however, is challenging because: ozone effects are aspecific; ozone does not accumulate in plant tissues; ozone effects vary with variable environmental conditions and plant genotype. Climate change is increasing the risk of both heavy rains, with consequent flooding and erosion, and drought. Ozone exposure reduces long-term stomatal conductance. Recent findings suggest that ozone-exposed stomata are slower in response to environmental stimuli, e.g. water deficit, so that short-term transpiration increases with increasing ozone pulses. An altered stomatal control as well as an ozone-induced reduction of carbon allocation to roots increase plant predisposition to drought injury. A higher shoot/root ratio increases the susceptibility of ozone-exposed trees to wind damage too. An imperfect stomatal control also increases tree susceptibility to fire. Under controlled conditions, ozone has been also demonstrated to increase tree susceptibility to frost, pests and pathogens, although the mechanisms are still unclear.

In Italy, the effects of environmental stress factors (pollution and climate) on crown conditions are monitored by the CON.ECO.FOR. project, that started in 1996. Ten years are still not enough for extrapolating long-term trends. The present results, however, show that acidity and sulphur deposition are no longer an issue in Italian forests. Nitrogen deposition appears to modify the underground biodiversity in beech forests. Ozone concentrations are elevated and still rising over time, in particular in central-southern Italy. Ozone visible injury occurs in the pre-Alpine area, where a good water availability stimulates stomatal opening and thus ozone uptake. Ozone exposure increases crown transparency and reduces radial growth of Italian trees. Monitoring ozone levels, trends and effects at local level provides policy makers with the appropriate knowledge for planning a scientifically-sound and ecologically-sustainable environmental management.

The most severe event in the 10 years of CON.ECO.FOR. monitoring was the dry and hot summer 2003, when basal area growth was seriously injured. More frequent climate extremes are affecting Italian forest ecosystems. An unusual snow storm in December 2007 damaged Sardinian cork oak forests and increased fire risks because of pathogen attacks after branch wounding and higher necromass.

Nitrogen deposition exceeds the critical load in 45% of European forests, including Italy. Nitrogen fertilization increases above-ground biomass and necromass and the nitrogen content of leaves and litter. Trees are thus more susceptible to drought, fire, frost, pests and pathogens. Growth and decomposition processes as well as carbon fluxes are altered. Italian forests, however, show on intermediate level of nitrogen saturation.

On the overall, these results suggest that the long-term monitoring of Italian forests must be maintained, extended to the most delicate forests e.g. at the treeline, and integrated with the most updated scientific results.

4. PERSPECTIVES

During several decades the silvicultural approach to the management of abiotic and biotic stress has been based on the assumption that vigorous trees are more resistant to pests and diseases. The mechanism of induced systemic resistance, however, is suggesting that the success of the tree defence can be based on an appropriate repartition of resources between growth and defence. Although, more research is required before any practical conclusion can be taken.

The need to quantify and define the forest area with biotic damage has promoted the implementation of monitoring networks, able to inform about the risk of outbreak and the possible countermeasures. Together with the network, a considerable number of forest service staff has been trained to identify and quantify biotic factors affecting forests. As most of the networks are local and do not cover the whole of Italy, a coordination at national level appears to be very important, also because it may address similar problems with the same approach. A strict link between monitoring and research is also required, especially in this field where expertises from different sectors of forest sciences are necessary.

Outbreak modelling has not been considered thoroughly in this paper, although it will be an important challenge for the future. Especially the variation of the range of forest tree species, associated with climate change, should be taken into account. In this concern, the possibility to use non-native tree species should be discussed with particular emphasis on the risks associated with biotic factors. The quantification of the impact of pests and pollutants on carbon sink is an important step to tackle in the framework of post-Kyoto protocols and in the mitigation measures.

As a general conclusion from this session, the participants are aware that climate change is the major challenge for forest protection, and it should be taken into more consideration in the future work, together with the threats from alien species and the recrudescence of native ones. As more diverse forest ecosystems appear to be more resilient to disturbances, the silviculture could consider the possibility to address measures in order to optimize the forest protection, especially with prevention.

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