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Ecology and management of Mediterranean pine forests – conclusion of the international MEDPINE workshop

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Introduction

Forest clearing, logging and firewood harvesting along with heavy grazing caused the destruction of all forests and maquis in Israel up to the end of the 19th century. Today, as a result of large afforestation effort and nature conservation there are about 80,000 ha of plantations and 30,000 ha of natural maquis. The trend towards an increase in forested areas on account of traditional agricultural lands is typical of all the Mediterranean countries. Of the local pines, Aleppo (*Pinus halepensis* Mill.) and brutia (*P. brutia* Ten.) pines are most important in natural forests as well as in afforestation. Recently, many researches have preformed studies and a lot of knowledge has accumulated on genetics and systematics, physiology and ecology, afforestation and management of Mediterranean pines. This was the scientific basis of MEDPINE that took place during 8-11 February 1999 at Beit Oren, Mount Carmel, Israel. Participants from California, South Africa, Spain, France, Italy, Greece and Israel presented 38 lectures and 12 posters. Dr. Gidi Ne'eman set the foundation for the workshop with a presentation on the state of the art in the various topics related to Mediterranean pine forests. An important emphasis was to focus attention on bridging the gap between theoretical and applied ecological sciences. Naveh (1999) opened the workshop by presenting the dangers of air pollution, pests and diseases, global changes and wild fires to the existence of Mediterranean forests. These dangers call for a long-term mutual effort of researchers and managers, however its success depends on the adoption of a policy of sustainable development.

Biogeography, genetics and ecology

The genus *Pinus* has radiated into habitats of limited biotic stresses imposed by resource competition. In pines much of the life history variation is explained by a model combining site productivity and disturbance frequency, in particular fire return interval (Keeley, 1999). Seven out of the ten species that occur naturally in the Mediterranean basin are invasive in the Southern Hemisphere. These pines have invaded many vegetation types in Australia, Chile, New Zealand, South Africa and Uruguay. The history of these invasions and the studies of invasive alien pines from the Mediterranean basin have contributed to our knowledge of pine ecology and invasion ecology (Richardson, 1999).

The populations of *P. halepensis* and *P. brutia* can be divided into distinct genetic groups according to their geographical distribution. The natural pine populations in Israel exhibit a distinct genetic group and thus were not the result of historic human import to the Middle East. However, the pines used for afforestation were of various foreign origins (Schiller, 1999). The study of three highly informative chloroplast microsatellite markers detected introgression of *P. halepensis* into *P. brutia* (but not *vice versa*) in a sympatric population. The overall hybridization rate was estimated to be 12% (Vendramin, 1999). Some natural vigorous hybrids of *P. halepensis* and *P. brutia* were detected in plantations in Israel. An experimental study of both types of hybrids revealed low germinability of the hybrid seeds, only partial hybrid vigor and hypersensitivity to the bast scale *Matsucoccus josephi*. Therefore, these hybrids are not suitable for afforestation in Israel (Madmoni & Riov, 1999).

Paleonotological and archeological studies strongly suggest that *P. halepensis* was a component of the natural vegetation throughout the Pleistocene, but never a major species. During that period, rises in the proportion of pine pollen were usually observed concomitantly with decreases in oak pollen, interpreted as indicative of drier and warmer periods. During the last ca. 7,000 years,

human activities were the major factor affecting the distribution of *P. halepensis*. Abandoned agricultural lands, at the end of heavily populated eras, were suitable for pine colonization (Weinstein-Evron & Lev-Yadun, 1999).

Dendrochronological studies revealed that the highest age of *P. halepensis* trees was 250 years (Lev-Yadun, 1999), and it is not capable of vegetative growth after logging or a fire. Therefore, the future of Aleppo and brutia pine populations depend solely upon seed dispersal and seedling recruitment. The germination of the seeds is well adapted to the Mediterranean climate as well as for post-fire conditions (Thanos, 1999). *P. halepensis* behaves as a drought avoiding species, as evidenced by the lack of change in its stem water potential and by a marked stomatal closure at midday. The higher resistance to CO_2 influx in the needles does not cause an increase in non-radiative dissipation of excess energy nor in a photoinactivation of photosystem II (Balaguer, 1999). It was calculated that the total annual water transpiration of a pine stand on Mt. Carmel, Israel was 335 mm, about 80% of the effective rainfall. The drop in transpiration and in stem water potential a month after the end of the rainy season indicates that by that time most of the available water in the main root zone was extracted (Schiller & Cohen, 1999). In spite of its thermophilic nature, two year old Aleppo pine seedlings demonstrated frost hardening and were capable of tolerating winter temperatures as low as -12°C (Calamassi, 1999). The season of cambial activity and the width of annual rings are dependent on water availability and temperatures, and are thus adapted to variable environmental conditions (Lev-Yadun, 1999).

Pine trees are monoecious with separate male and female cones. According to sex allocation theory, young trees are expected to start reproduction as males. However, pine trees usually start their reproduction as females and turn later to be monoecious. This pattern holds also for *P. halepensis*. Moreover, female strobili are located mainly on apical fast growing shoots while males on lateral slow growing ones. Several explanations were proposed, but further study on the effect of various environmental factors on this allocation pattern is needed (Goubitz *et al.*, 1999). The maturation of the female cones in Aleppo pine takes about three years, and thereafter most of the brown mature cones disperse their winged seeds under hot and dry and windy weather conditions (Nathan *et al.*, 1999). This feature contributes to the invasive nature of the species. However, a second type of gray serotinous cones stay closed and will disperse their seeds mainly under extreme heating (Leone *et al.*, 1999; Roitemberg & Ne'eman, 1999; Tapias-Martin *et al.*, 1999). These cones are the major constituents of the canopy stored seed bank that is essential for post-fire recovery of pine forests.

Post-fire regeneration

Fire plays a major role in shaping the Mediterranean landscape. Fire removes all the above ground cover and the bare soil is exposed. However, only in the case of very intensive rain events runoff and sediment yields are high but already after six years there is no difference between a burned site and an unburned pine forest (Inbar *et al.*, 1999). Fire also affects the chemical composition of the soil. High intensity fires cause an increase in soil pH and in the concentrations of phosphate but a decrease in ammonium and nitrates. However, during the first post-fire winter a full recovery in the nitrogen soil content occurs as a result of microbial activity (Kutiel, 1999a).

Aleppo pine trees die after fire (Hermanin & Cottignoli, 1999), but as in all other post-fire seeders, the population is capable of regeneration by seedling recruitment, although most other Mediterranean trees regenerate by post-fire resprouting. The open spaces after fires create invasion opportunities for many herbaceous species, which persist only for a couple of years. The result is a temporal, short term, increase in species richness that is followed by a gradual decline to the original pre-fire value. In France, 10 years after fire there is a full recovery of species composition and vegetation structure but not in tree size. Post-fire recovery in Aleppo pine forests does not follow the classical model of secondary succession because species replacement is limited (Trabaud, 1999). This general pattern holds also for the east Mediterranean. Species richness, composition and cover, vegetation structure and tree size, soil as well as canopy stored seed banks gain full recovery 40 years after fire, and the forest can endure an additional fire cycle (Ne'eman, 1999). Fire frequency, soil type and topography affect species richness (Kutiel, 1999b). The high pine and *Cistus* seedling densities after fire are the

cause of an intense stage of inter- as well as intra-specific competition (Eshel & Katz, 1999). At later stages pine seedlings are exposed to lethal attacks by the bast scale (*Matsucoccus josephi*) (Mendel, *et al.*, 1999), and damages by porcupines (*Hystrix indica*) (Izhaki and Ne'eman, 1999). The big burned pine trees have a prominent effect on soil pH and the hydrophobic layer, on seed germination and soil dwelling microarthropods (Henig-Sever *et al.*, 1999; Saracino & Leone 1999). The final result is that pine trees of the post-fire regeneration have a high probability of occupying the microsites of their pre-fire ancestors (Ne'eman 1999). Lithobiontic algae, fungi and lichens, all of which are eradicated by fire, inhabit barren rocks in the Mediterranean basin. The recolonization process of rock inhabiting cryptogams on burnt limestone in the Carmel Mountain is rather rapid. Holes, pits and ruts observed in the burnt rocks seem to comprise an important means of entrapment of cyanobacteria, algae and spores (Garty, 1999).

Buffer zones, where trees are thinned and shrubs removed, are used to reduce the risk of fires along roadsides and around picnic areas as well as around human settlements and nature reserves. Buffer zones are efficiently created by a drastic manual treatment, followed by heavy goat grazing (Perevolotski, 1999). Prescribed fires are used for reduction of fuel load in wider areas to reduce the risk of fire, minimize its damage and increase the chances for controlling it. During the last decade, experimental prescribed fires were carried out in Israel. A correct choice of stand age, fuel load, season, weather and topography are essential to create a rapid low temperature ground fire. Such a fire was found to have no negative effects on forest growth, understorey vegetation and soil inhabiting arthropods (Eshel *et al.*, 1999.

Pine forest fauna

The decomposition of pine needles is dependent upon pine species, season and activity of animals (Virzo De Santo *et al.*, 1999). Soil dwelling microarthropods are important in the decomposition food web. They comprise species that feed directly on pine needles, species that feed and control populations of saprophytic fungi and predators. This fauna in Israel includes five orders of microarthropods (mainly Collembola and Acari) and 15 orders of small macroarthropods (mainly beetles and spiders) (Broza, 1999). Season, fire intensity and soil pH affect soil dwelling species composition and abundance (Ploiakov *et al.*, 1999). Different patterns of species composition and abundance of oniscid isopods, scorpions and millipedes were found in pine forest as compared to oak forest in the Lower Galilee, Israel (Warburg, 1999).

The natural Range of the Israeli bast scale, *Matsucoccus josephi*, is east Mediterranean and corresponds to that of its principle host *P. brutia*. The scale is most attracted to *P. halepensis* in Israel and causes the death of all pine species of the subsection Halepenses except *P. brutia*. Its natural predator *Elatophylus hebraicus* (Heteroptera) as well as other predators of other related bast scales is lured by its sex pheromones. Two species of predators from USA are now experimentally used to augment the predation of *M. josephi* in Israel (Mendel *et al.*, 1999; Adar *et al.*, 1999).

The study of the recolonization of *Pistacia palaestina*, which grows in the understorey of natural pine forest, by their gall forming aphids after fire on Mount Carmel, showed that this process was very rapid for some species while others did not return during the six years of the study. The differences in recolonization success could be related to the abundance of the species in the surrounding unburned areas and to differences in their life history traits (Inbar & Wool, 1999).

Solitary bees are the major group of pollinators in Israel and the Mediterranean basin. *Bombus terrestris*, which is native to the northern region of Israel invaded massively during the last two decades, into natural habitats on Mt. Carmel, Israel. This invasion is the result of intensive gardening, which supply resources during summer, coupled with escape from greenhouses, where it is used as pollinator, plus the availability of open post-fire habitats. Nine years after fire on Mt. Carmel, the diversity of solitary bees was low and *B. terrestris* performed 90% of the entire bee's visits. Such a situation poses a threat on one of the worlds richest bee faunas – the Mediterranean phrygana (Dafni *et al.*, 1999).

The diversity of small mammal species in pine forests of the east and west Mediterranean countries is very low. Fire erodes the populations of small mammals. Species that live in open and arid habitats are the first to recognize burned areas and they are followed by the typical forest dwellers (Haim, 1999). Pine trees are the nesting and breed-

ing sites as well as food source for whole populations of black rats (*Rattus rattus)*. Pine seeds are very nutritious and pines bear closed cones all year round. Therefore, black rats that can extract seeds from the closed cones are well supplied. However, the extraction of seeds from pine cones was found not to be innate. This behavioral pattern must be transmitted from parents to offspring by learning (Aisner, 1999). The effect of rats on the regeneration ability of pine forests has not yet been studied.

Only 22% of the 343 bird species in the Mediterranean region are forest species. Eight species are endemic, but only two live in pine forests. Bird communities in pine plantations are similar to those of natural forests. The composition of bird communities was explained better by the composition of the understorey than by the size of the pine trees. The rate of recolonization of burned forest is high during the first two years, thereafter the rate of change in bird composition decreases until after about 25 years there is no difference between burned and unburned sites (Izhaki, 1999).

Management and conservation

Since the mid-1920's the forest plantations in Israel have been dense monocultures dominated by *P. halepensis*. The massive decline in these forests as well as public debate has caused a change in the objectives of afforestation. The old objectives were mainly wood production and land ownership, while the future ones will be landscaping, recreation, environmental improvement, arresting desertification and restoration of degraded sites. These objectives as well as ecological and economic considerations are reflected in afforestation management. An integrated approach of planning that takes into account landscape, roads and soil quality was adopted. Planting changed by improved site preparation and seedling quality, weed control and reduced density of planting as well as of mature forests. In contrast to the early monocultures, various conifers are planted in patch mosaic pattern whereas broadleaf native trees are randomly spread throughout the plantings (Boneh, 1999; Sterenberg *et al.*, 1999). Afforestation of drylands may, in conjunction with other local benefits, may be an important component of international efforts to control builtup of atmospheric CO_2 (Gerssel, 1999).

As a result of afforestation, nature conservation, socioeconomic changes, and pine invasions, the forested areas have increased throughout the Mediterranean basin. Faced with this dynamic and constrains imposed by the Common Agricultural Policy, livestock farmers have come up with new projects for forestlands. These sylvopastoral systems propose a renewed model of Mediterranean forest management based on land use sharing between farmers and foresters (Etienne, 1999). Also in some cases in Israel, a multi purpose land use concept was adapted. Grazing was introduced into pine plantations, and it is also now used as a management tool in several nature reserves. In a similar way tourism and recreation are part of afforestation and nature reserves. Moreover, the rehabilitation of degenerated natural maquis has become one of the targets of afforestation while a dilemma exists regarding the treatment of pine invasion into nature reserves (Perevolotski, 1999).

Conclusions

At the end of the MEDPINE workshop, Trabaud drew routs for future research and a general discussion was held on the ecology and management of pine forests and mainly on the relationship among researchers, nature conservationists, grazing managers and foresters. The conflict among these groups seems to exist in most of the countries because of differences in viewpoints and mainly of interests. In spite of the conflict, on the basis of common principles and mutual interests, in California and France such differences were bridged by the agreement on common management of open areas. The threat on the future of open lands, nature reserves, plantations or grazing lands calls for a united campaign for the future of open landscape versus intensive urban development. The understanding that nature conservation requires active management, the recent change in the objectives of afforestation, the increasing effect of recreation and the introduction of grazing into nature reserves as well as into plantations, decreases the gap between the people in charge of the various land use types.

The modern concept of biosphere reserve distinguishes three parts along contrasting gradients of nature conservation and human intervention and development. The core area is devoted to conservation. Research, ecotourism, grazing and

afforestation in the buffer zone and sustainable development in the transition zone. This biosphere reserve concept views the human culture and traditional activity as features to be conserved. Research and long term monitoring are essential parts of that concept, the reserve is the place for ecological research initiated by academic staff, but it is the responsibility of the reserve authorities to see long term monitoring as a tool for serving management. Management plans should be based on the results of ecological research, while long term monitoring should indicate whether or not the goals of a management plan were achieved. An international biosphere reserve has been planned after the big fire of 1989 in the Carmel and was formally declared in 1996. This biosphere reserve by an integrated plan of action should be a model of managing open areas and bridging the gap between development and conservation and among conservation, afforestation, grazing and recreation. In the conclusion of the discussion there was an agreement that the gap between the parties was narrowed, a fact that should also be reflected at the management level.

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