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Conservation of Macedonian pine (*Pinus peuce* Griseb.) genetic resources in Pelister National Park

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Abstract

The principal objective of national parks as protected areas is to preserve forest ecosystems, but at the same time they may serve genetic conservation. The Macedonian pine (*Pinus peuce* Griseb.) is a five-needle pine native to the Balkan peninsula, occupying an area of 2 500 hectares at Pelister National Park (NP).
The native populations of Macedonian pine in Pelister NP represent an especially valuable genetic resource for conservation. *In situ* and *ex situ* methods were implemented for the conservation of Macedonian pine genetic resources in Pelister NP. *In situ* conservation has aimed at preserving an existing, native population of Macedonian pine within the community of which it forms a part and in the environment to which it is adapted. An *ex situ* conservation of Macedonian pine in Pelister NP was also considered and carried out, but only to the extent that it enhanced the goals of the previous in situ genetic conservation activities. The overall conservation approach applied involves preserving not only associated flora, fauna, and ecosystem processes, but maintaining the Macedonian pine populations in Pelister NP within a dynamic environment in which the genetic variation can continue to respond to natural influences.

Profile

Protected Area

Pelister National Park

Mountain range

Baba

Country

Macedonia

Introduction

Genetic diversity ensures the success of species in environments that are highly variable and subject to change. It is therefore vital that genetic resources be conserved, maintained and used in a sustainable manner to ensure the preservation of genetic diversity for future needs. Indeed, man, as steward of the earth, has an ethical responsibility to preserve species and safeguard genetic diversity for future generations. The need to conserve forest genetic resources better has been widely recognized in recent times because of the risks associated with global changes in the environment, including climate change.
Conservation and sustainable management of forest genetic resources aim to secure the ability of forest tree species to adapt to environmental changes and to maintain the basis for improving production and other benefits of growing trees (Graudal et al. 1997). This might be even more important if global change models become reality.
Conservation and sustainable use of forest genetic resources are major issues in national and international policies (Young et al. 2000). New Forest Management is no longer focused on maximizing profits from timber and non-wood forest products but is also concerned about sustaining the integrity of forest ecosystems.
There are two basic strategies for genetic conservation, *in situ* (FAO et al. 2001) and *ex situ* conservation (Namkoong et al. 2002). These two strategies complementary to each other.

Figure 1 – Infructescence of Pinus peuce *Griseb. © Pelister National Park (NP)*

Protected areas are "areas especially dedicated to the protection and maintenance of biological diversity and associated cultural resources, and managed through legal or other effective means" (IUCN 1994). The contribution of protected areas to the preservation of biological and genetic resources depends very much on the following aspects (MacKinnon et al. 1986; Boyle & Sawyer 1995):

- Optimal distribution across the landscape, with protected areas linked by vegetation corridors and connected with other conservation elements in the landscape, such as managed forests.
- Area size, which should be as large as possible, with good design of shape, infrastructure, zoning, boundary features, edge effects and buffer zones.

Figure 2 – In situ *conservation of Macedonian pine at Pelister NP (selected seed stand). © Authors*

- Integrity including levels of protection and the extent to which they are respected by local people.

The management regimes of existing protected areas are typically designed for the conservation of forest ecosystems, which is often compatible with conservation of genetic resources *in situ*. Nevertheless, current protected areas provide important conservation of many species. Effectively conserved forest ecosystems can maintain a reservoir of continually evolving tree species and populations, including species whose economic and other values have yet to be recognized (Mc Neely & Vorhies 2000).

In order to enhance biodiversity conservation, Blochus et al. (1992) recommend that protected area systems be established that cover:

- representative areas of all types;
- examples of forests with high species diversity and / or high levels of endemism;
- forest habitats of rare and endangered species or species associations.

Article 8 of the 1993 Convention on Biological Diversity (CBD), which deals with *in situ* conservation, calls on each contracting party to establish a system of protected areas or areas in which special measures are undertaken to conserve biological diversity. It is also highly desirable that new protected areas be located in areas that will enhance their contribution to preserving forest genetic resources.

The advantages of the conservation of forest genetic resources in protected areas include:

- extra value added to protected areas;
- conservation of species associated with forest trees;
- several species may be conserved within one area;
- spreads the concept of gene conservation;
- resource efficient.

The principal objective of national parks as protected areas is to preserve the forest ecosystem but at the same time they may serve genetic conservation. Furthermore, due to their size and land cover, geographic locations and the management practices that promote natural regeneration, national parks have advantages over other protected areas with regard to the conservation of forest genetic resources.

A case in point

Pelister NP is located in the south-western part of the Republic of Macedonia, covering an area of 10 870 ha on the northern side of the Baba mountain range at altitudes between 900 and 2 601 m. It was established in 1948 as the first NP in former Yugoslavia.

Because of the geological composition, specific terrain and the local mountain climate, various habitat types have formed in the park that support a rich and important biological diversity. Of these, the most prominent are the extensive forests of Macedonian pine – one of the most valuable conifer species in the Balkan peninsula – the glacial lakes and the alpine grasslands. In addition to the nine local endemics – species that can only be found in this NP – there are also several dozens of rare and threatened species.

The forests in Pelister NP cover approximately 5 672 ha, that is more than half the total area of the NP. In the NP there are nine types of forest communities, two of which are formed by the Macedonian pine (*Pinus peuce*), four by beech (*Fagus moesiaca*) and three by oak (*Quercus spp*).

The Macedonian pine forests in Pelister NP are divided into two associations and the following subassociations:

1. ass. *Myrtillo-pinetum peucis* (with blueberry)
1.1. subass. *montanum*
1.2. subass. *montanum abietetosum*
1.3. subass. *subalpinum*
2. ass. *Pteridio - pinetum peucis* (with fern)
2.1. subass. *abietetosum*

The Macedonian pine is also dispersed as mixture in associations of other forest species, such as:

- ass. *Fagetum moesiacae montanum pinosum peucis*
- ass. *Fagetum moesiacae subalpinum pinosum peucis*

The Macedonian pine is a relict from the Tertiary and an endemic species of the Balkan peninsula. Austrian botanist A. Grisebach discovered it in 1839 at Pelister in Macedonia and described it in 1844 as *Pinus peuce.* This pine is the only one from the subgenus *Strobus* native to the Balkan peninsula. It occurs in some of the high mountains between northern latitudes of 41° and 43°. It covers a total area of 30 000 ha and has a wide altitudinal range, from the lower border of the submontane belt to the upper border of the subalpine forest belt. This indicates the high ecological adaptability of the species. Macedonian pine thrives in the upper mountane belt and produces high yields of timber. Of all Macedonian pine forests, those in Pelister are particularly large and ideal-typical. The Macedonian pine forests in Pelister cover an area of 2 500 ha and in some parts are older than 200 years, although the vast majority of the current area is the result of the processes of natural succession, particularly during the period after the designation of Pelister

NP. Although there are still uncertainties concerning the development of natural processes in these forests, long-term observations indicate that the Macedonian pine is vital and can rapidly spread in open spaces in the park but also more often outside the NP boundaries. At the same time, counter processes are taking place. For instance, while the Macedonian pine is fast in conquering the block streams, the former pastures, areas of degraded forests of other types or abandoned agricultural land, the fir (*Abies borisii-regis*) is gradually outcompeting the Macedonian pine in the old forest stands. In addition, the mature Macedonian pine trees growing on the block streams are facing a shortage of nutrients and often wither prematurely. In addition, occasional avalanches can destroy large areas of the Macedonian pine forest. Human activity in the NP may also threaten these forests: near Hotel Molika, for instance, the molika forests are withering where the effluent from the wastewater treatment plant is discharged. Except for this last example, these instances are considered to be part of the natural dynamics of the molika forest and therefore should not be acted upon by humans. However, there are also indications that not all of the natural processes are occuring on a full scale. For instance, due to the small population of some of the birds, the control of pests (insects) is insufficient and there is a potential danger of outbreaks on large areas.

The destruction of the Macedonian pine forest in large areas through natural succession (including the outbreak of pests and diseases) or as a result of pollution and fires would decrease the aesthetic value of the landscape. On the other hand, the beauty of the landscape, which is attributed to a large extent to the Macedonian pine forest, is one of the main reasons for the large number of visitors to the NP.

Conservation methods (*in situ* and *ex situ*)

As the Macedonian pine is an endemic species, the first step in the conservation and tree improvement must be the preservation of existing genetic stock. This is crucial for understanding this species better as well as for its genetic improvement. The genetic variability of the natural Macedonian pine forests is best preserved within the protected areas (national parks and nature reserves).

Figure 3 – Expansion of Macedonian pine on open spaces. © Authors

To preserve the broadest genetic diversity, not only the most representative tree populations or important single trees should be subject to gene conservation. Populations from marginal localities also need to be conserved despite their lower economic importance as such populations and trees may carry genes of importance for breeding (adaptability, resistance).

The range of genetic conservation activities of Macedonian pine in Pelister NP was divided into two basic approaches: *in situ* and *ex situ* methods. Both approaches are taking into account the whole range of the geographic distribution of the Macedonian pine as well as the species' metapopulation structure at Pelister NP.

In situ conservation has aimed at continuing maintenance of an existing, native population of Macedonian pine within the community of which it forms a part and in the environment to which it is adapted. In this regard, two Macedonian pine seed stands of

Table 1 – Factors and conditions for in situ genetic conservation of Macedonian pine in Pelister NP

Factor	Condition
Regeneration conditions	Near-natural or managed environment to enable continued regeneration of Macedonian pine.
Potential for hybridization	Common or abundant tree species with effective mechanisms to minimize interspecific hybridization.
Degree of interdependence of other ecosystem components in reproduction and dispersal	Area of sufficient size and diversity to support specialized pollinators and animal seed dispersers.
Status of remaining populations of Macedonian pine	Viable populations of Macedonian pine, representing the range of genetic variation in the species, still existing and amenable to management.
Type and level of threats	Threats to survival of populations can be identified and minimized through planning and management.
Economic value and utilization	Tree species is sustainably or non-destructively utilized and is locally valued as an economic or other resource.
Land use and human population pressures	Macedonian pine populations or ecosystem occur in areas with limited human activities.
Land tenure	Secure, well-defined land tenure.
Capacity of relevant authorities to manage and protect designated stands	Pelister NP authorities are competent and well resourced and able to manage and protect forested areas under their control effectively.

*Figure 4 – Macedonian pine (*Pinus peuce *Grisb.) at Pelister National Park (NP). © Pelister NP*

5 ha in total were selected in Pelister NP. In addition, the 20 candidate-elite Macedonian pine trees showing phenotypically superior growth, form and resistance (trees showing no damage from insects and diseases) were selected.

Table 1 shows factors and conditions that were taken when *in situ* measures were applied on the Macedonian pine at Pelister NP.

The *ex situ* conservation of Macedonian pine in Pelister NP was also considered and performed but only to the extent that it enhanced the aims of the previous *in situ* genetic conservation activities. Within this activity, the gene conservation stand / seedling seed orchard was established on an area of 1.1 ha. It includes 20 different clones from the selected candidate and elite Macedonian pine trees from Pelister NP. This gene conservation stand / seedling seed orchard represents an important parallel conservation activity to the conservation of natural populations of Macedonian pine *in situ* in Pelister NP. It plays a variety of roles including conservation support, research, education and commercial applications. A natural resistance of the Macedonian pine to various diseases, especially to *Cronartium ribicola*, makes the species important for hybridization with other five-needle pines.

Conclusion

A critical feature of the *in situ* approach is the conservation of those associated populations and species, natural disturbances and underlying processes that work to maintain a genetic structure and diversity within a normal range of variation of Macedonian pine in Pelister NP. Not only is an understanding of these co-evolved organisms and processes important for an effective genetic conservation of the target species, but, by securing the opportunity to understand the web of ecological interactions similar to those under which the Macedonian pine evolved, there may be some valuable insights for silvicultural, breeding and tree improvement efforts of the Macedonian pine.

Because natural ecosystems are not static but dynamic, genetic conservation of Macedonian pine in Pelister NP should not be restricted to maintaining a given state (i.e. static conservation) forever but be directed at ensuring the adaptability of the ecosystem and at enhancing the genetic diversity presently available to meet future requirements (i.e. dynamic conservation or evolutionary conservation).

Without concurrent conservation of the Macedonian pine forest ecological community, adult plants may be maintained for some time but genetic diversity in future generations may be compromised.

The conservation approach applied here preserves not only associated flora, fauna, and ecosystem processes but maintains the Macedonian pine populations in Pelister NP within a dynamic environment in which the genetic variation can continue to respond to natural influences.

Individual selection of Macedonian pine is aimed at preserving the phenotypically best material and simultaneously using it for tree improvement and seed production for practical purposes.

Thus *in situ* conservation in Pelister NP provides a basis of information and material for future genetic investigations, breeding improvement and greater utilization of Macedonian pine for reforestation and afforestation.

The Macedonian pine at Pelister NP has a high ecological adaptability. It thrives in the upper montane belt and produces high yields of timber. So it can be widely used in other sites for the improvement of low yielding stands of other species and for artificially expanding the upper tree line, lowered by excessive cuttings.

The exceptional adaptation of Macedonian pine to the severe mountain climate conditions makes it a valuable species for afforestation on high terrain for protection against erosion.

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