

## THE ECOLOGICAL RESTORATION OF MOUNTAIN HABITATS BY ARTIFICIAL REGENERATION

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**Abstract:** The monitoring of alpine habitats showed that they are some of the most threatened habitats in Romania. In order to restore and maintain the mountain pine shrubs of this area to a favourable conservation status, fully in line with the existing EU and national legislation and environmental requirements, some management measures are proposed. To achieve the protection and preservation of the habitats from the Retezat National Park, certain general management measures are required to maintain the habitats at an optimal level. In the paper, the assessment of the alpine habitats found in Retezat National Park, located in Meridional Carpathians (Romanian Southern Carpathians), and the conservation management activities used to halt the alpine habitats destruction in the Retezat Mountains are presented. The current state of mountain pines in the Retezat National Park, under the action of subalpine and alpine grazing degradation, is also explained. Additionally, the study offers details concerning methods for restoration of degraded habitats, using the mountain grassland regeneration technique. Developing grazing regulations for maintaining livestock according to the current conditions of the grasslands, as well as promoting the natural regeneration of forest habitats, are both important measures in this regard.

### Introduction

In recent years, there has been much discussion concerning the loss of biological diversity and the danger caused by the widespread increase of habitat loss. In this regard, the natural environment of Europe is particularly rich, housing a large number of ecosystems and habitats. The protected areas of the continent, due to the natural value and low human impact, are the best examples and models for natural and seminatural ecosystems. European national parks, established to protect the ecological integrity of one or more ecosystems, are well-defined areas that aim to protect and preserve representative samples. These areas are protected because they contain natural elements with special value. The parks generally extend over large areas of land allowing only traditional activities to be carried out by the communities neighbouring such national park areas (RADU 2004; REPORT 2013).

Monitoring is one of the most feasible ways to audit the management of protected areas (DONIȚĂ et al. 2005; HODOR 2008; PROGRAMME 2008, UNTARU et al. 2013). However, monitoring of habitats that spread over large areas, especially if created by slow-growing woody plants, as in the case of mountain pine hedges, is very difficult with initial results first appearing after many years of research. Nevertheless, protocols for biodiversity monitoring are simple and their application does not necessarily require special training, allowing them to potentially be implemented by volunteers (but they still require deep knowledge on species recognition). Natural ecological systems face many threats to biodiversity often resulting in irreversible degradation of the natural environment. The protected areas act as advocates of the ecosystems, and can be assessed and monitored, expressing to a certain extent, the ecosystem status at a given moment. Alternatively,

one negative aspect affecting the protected areas is the lack of management plans. This also hinders the proper exercise of inspections because the areas where sustainable management is allowed cannot be clearly delineated from those that benefit from a strict protection regime.

These protected natural areas are an important economic and productive asset, providing an intense flow of products and services, which are economically valuable by applying a sustainable management system that can generate significant resources for economic development. On the other hand, the lack of management plans will result in an irremediable decline of biological diversity and loss of important economic benefits (REPORT 2008; REPORT 2009; REPORT 2012; REPORT 2013).

### **Materials and methods**

Romanian protected areas, national parks and reservations cover about 8% of its territory (Figure 1). The protection and preservation of nature in Romania is achieved mainly through the declaration and establishment, at the national level, of a network of protected areas of various categories. There are 1377 natural areas protected in Romania, their list includes certain sites recognized worldwide as true monuments of nature. The network of protected areas in the Romanian Carpathians includes 22 major protected areas (12 national parks and 10 natural parks). In terms of size, connectivity and management, this network is insufficient to prevent the irreversible loss of biodiversity in the Carpathian eco-region. The largest protected area, Retezat National Park, is intended to preserve the beauty of these mountains as well as the endemic flora and fauna. Placed in the Meridional Carpathians, of Hunedoara County, Retezat National Park has an area of 54400 ha and an altitude of 800–2509 m. The area shelters one of Europe's last remaining intact old-growth forests and the continent's largest single area of pristine mixed forest. It was established in 1935, and since 1979 is known as a Biosphere Reserve.

Today, people increasingly focus on actions for preventing ecological disasters. Therefore the preservation of biodiversity is currently one of the most notable international issues. Experience has thus far shown that it is very hard to restore a damaged ecosystem, due to the dependence on many factors besides the natural ones, and the process may not always lead to the complete restoration of the original ecological balance. In any ecological restoration project the causes of degradation must be identified and further intervention control measures must be applied (REPORT, 2008; REPORT, 2012; REPORT, 2013). Ecological reconstruction seeks the resumption of the natural functions of an ecosystem, along with the restoration of its natural evolutionary conditions in order to regenerate the habitats and the entire original biodiversity of that ecosystem.

Each Biosphere Reserve must fulfil three basic functions, which have a complementary and mutually reinforcing relationship:

- The preservation function—i.e. to contribute to the preservation of landscapes, ecosystems, species and genetic variation;
- The development function—i.e. to support the sustainable economic and human development from socio-cultural and ecological points of view;

- The logistic function—i.e. to provide local, national and global support for research, monitoring, education and information exchange related to preservation and development.

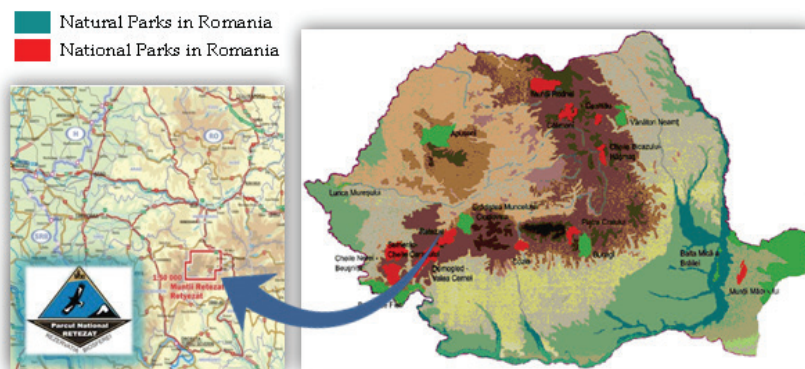


Figure 1. The largest protected area in Romania – the Retezat National Park  
 1. ábra Románia legnagyobb védett természeti területe: a Retezat Nemzeti Park

The biosphere reservations are protected areas that combine the preservation and the representation of the world's major ecosystems as well as sustainable development, serving as a development model for particular environments. In this regard, the Retezat Mountains are representative for well preserved mountain habitats. We can find here some areas that were well protected for a long period of time, and where the human impact is insignificant, being considered true natural habitat models. Therefore, the maintenance and proper management of this Romanian national park is a real priority, in which the monitoring and assessment of the ecological systems status can be achieved in pilot areas, e.g. in protected areas.

The assessment of alpine habitat status was an intensive study that consisted of 10 areas, covering, to a large extent, the conditions found throughout Retezat. Identified as a key habitat within the studied habitats, efforts were directed toward this priority habitat – containing creeping mountain pine hedges (*Pinus mugo*), which is the only shrub living in the coniferous forests of the Carpathians' mountain and sub-mountain regions. The mountain pine hedges represent a habitat threatened by human impact (tourism, logging, grazing, burning, etc.), and suffer changes of boundaries, extending its upper limit toward the alpine zone and losing areas in the vicinity of spruce forests, in favour of the latter. According to a new study, ambient ozone levels are high enough to cause visible injury in native species. In Europe, cone and seed production can also be reduced by ozone stress in pine-areas (RAJKOVIC et al., 2012). This habitat is particularly important for stabilizing the slopes, especially those covered with debris.

Grazing is the primary factor in damaging the biodiversity of this area because of its negative effects: vegetation degradation, massive flora destruction and land degradation from soil compaction of hooves. The grazing itself harms the biodiversity, but there is still a level of capacity of the alpine meadows, which should be accepted and respected. The idea of a national park requires a lower level, or even the complete ban of grazing. However, in Retezat National Park the animals are grazing intensively beyond the capacity

of the land. While the protective measures, such as rules and regulations concerning activities in the park shall remain enforced, the emphasis of protected area management should maximize positive interaction.

In the study of alpine habitat status assessment, some recommendations for the management and monitoring of management effectiveness have been developed in order to maintain these habitats in a favourable preservation status. In developing the study, information was analysed and synthesised from the field, and then these data were enriched with new information from literature.

## Results

Among the plant species most affected is the mountain pine. Since 1952, the *Pinus mugo* species has been, protected by law in Romania due to its jeopardized condition. However, the reduction of habitat areas has continued, due to the deforestation actions favouring the extension of grasslands—in which mountain pine is used as firewood by shepherds, tourists and chalet workers, the collection of young shoots for medicinal purposes, and intense adjacent grazing. The importance of this habitat is to stabilize the slopes, especially those covered with debris, that act as shelter for the fauna inhabiting these high altitudes during spring and summer, particularly for some species of wild birds.

The mountain pines (*Pinus mugo*) are very dense non-forestry woody formations, spread over relatively small areas, which have a major role in preventing soil erosion and land consolidation in subalpine zones. These bushy shrubs have a special ecological role in fixing screens and protecting the adjacent herbaceous layer – especially against grazing, and give life to the barren rocky slopes. In winter, the mountain pine blocks the snow drifts, reducing – to a large extent – the avalanche risk. Thanks to mountain pines, the Carpathian avalanches are much less extensive than those in the Alps – where mountain pine is not present.

Due to the intensity of destructive actions, many upland habitats, including mountain pines, have been destroyed. In the life of habitats and their components (in this case, mountain pines and their cohabiting species), various kinds of threats have already occurred and continue to occur, jeopardizing the existence of one or more habitats, as well as the existence of some single components of them. The main threat for the rare and endangered alpine or subalpine plants protected by law is caused by the destructive grazing of domestic animals (sheep, cattle, horses) and wildlife (deer, chamois). The destruction is not only made by grazing but also the trampling of plants — corresponding to the extinction of some single species within the habitat — the reduction of plant population size, soil degradation — resulting in erosion — and also the destruction of the mountain pine seedlings occurring from natural regeneration.

The destruction of subalpine and alpine grazing has led to the sacrifice of major ecosystems, predominantly including mountain pines. However, more specifically this destruction is seen on steep slopes and in particular in the area of torrent supply basins, in which mountain pines deforestation can have serious adverse consequences.

Due to abusive overgrazing, the natural grasslands in the highlands were rapidly, both quantitatively and qualitatively, degraded. As a result of this degradation, the irrational

practice of extending secondary grasslands through uncontrolled deforestation of adjacent forest glades and especially of mountain pines has emerged, and whose reserves found in Carpathians seemed to be inexhaustible.

The action of extending the grasslands by uncontrolled destruction of the mountain pines has excessively increased over the extent of the Carpathians. It can be stated, based on arguments, that the current state of mountain pines in the Carpathians — including the Retezat Reservation — is critical. In the other mountains, this species has been reduced to small groups or isolated trees, deprived of its reproductive ability, accelerating the possibility of extinction.

The result of mountain pine destruction within the entire sub-alpine zone is grim and damaging, and may be described as:

- leading to a decrease of the upper limit of mountain pines, by an average of about 200 m, which means tens of thousands of hectares exposed to erosion;
- causing chain disturbances resulting in other species in the subalpine zone having similar fates;
- leading to the destruction of herbaceous flora, including some rare species protected by law;
- promoting the exile of birds and mammals from the subalpine zone;
- increasing the intensification of soil erosion across the entire subalpine zone;
- and causing downstream flooding, and increased frequency of avalanches, with their destructive effects.

The question left is what needs to be repaired and how much is still possible? The current conditions of the degraded lands require the execution of land consolidation, preparation for planting and the use of specific procedures for afforestation.

In order to restore and maintain the mountain pine shrubs in a favourable conservation status that is fully in line with the existing EU and national legislation with similar results of other projects that have consisted of this type of habitat study, as well as with their environmental requirements, the following management measures are proposed:

- continuous monitoring of the alpine habitats in Retezat Mountains;
- promotion of ecological restoration and natural regenerations in the forest habitats by restoring the mountain habitats with mountain pine shrubs—in which seedlings of two years originating from natural populations are to be planted in soil beds;
- prohibition of the cutting of any trees, shrubs or bushes in the forest habitats;
- prohibition (or, where appropriate, regulation) of grazing and prevention of animal access (domestic or wild);
- promotion of conservation management by applying natural regeneration;
- protection and conservation of ecosystems and preservation of genetic resources and biological diversity.

The destroyed mountain habitat can be restored only partially and will never be identical to the original one. In general, woody species populations can be restored, but it is much more difficult, or sometimes impossible, to restore entire extinct herbaceous species as well as previous large or small bird and mammal populations.

### *Methods for restoration of degraded habitats*

The potentially destructive factors of mountain pine loss act either alone or in combination. The Environmental Management Plan, applied to these upland habitats, should take into account the elimination of causes and, secondarily, the avoidance of effects, as they cannot be controlled until the causes are removed. Therefore, the protective actions of the sustainable management, as a method of preventing damages, should be primarily directed towards the most aggressive factors (humans, animals, etc.), which produce the degrading effects. This strategy to prevent the destructive effects applies more easily and with much less physical and material efforts than if damages must be repaired.

Two recovery methods are applicable in subalpine conditions, namely: natural regeneration and artificial regeneration. Since the natural regeneration of mountain pine is slow and difficult, artificial regeneration by planting appears as the only method to be successfully applicable within a reasonable period of time, although also respectfully slow. The artificial regeneration of the cleared mountain pine trees requires compliance with certain genetics and environmental principles, and needs some compulsory work steps.

Besides the mountain pine regeneration, it is required to restore the populations of the other cohabiting wood species that have been cut, burned or degraded. Some of these species cannot regenerate by themselves, thus requiring artificial regeneration activities, while other species have the biological possibility to regenerate naturally. Forests may reproduce more successfully when special efforts are made to encourage regeneration. Either artificial regeneration that involves planting seeds or seedlings, or natural regeneration that relies on existing seedlings or seed may be used. Site preparation is carried out to create a favorable environment for the successful establishment and growth of seeds and seedlings.

Proper species selection and careful handling and care of seedlings are vitally important in the success of their reforestation. Planting is done in the last weeks of August and can be extended up until snowfall. For planting, the holes dug in June are made larger than the pots and bags housing the root bally of the seedlings. Before placing the seedlings in the planting holes, the bags shall be broken gently to avoid damaging the root balls, after which the seedlings are planted normally. Spring planting is not advisable, as the risks are greater than those planted late summer.

### **Conclusions and remarks**

Using an effective management process is the best solution for keeping a balance between the economic activities and nature preservation (APPLETON 2002; RADU 2004). A proper conservation management plan must demand a complete ban on logging and harvesting, establish alternative tourism routes (prohibiting camping within the areas adjacent to the habitat), and establish an enforcable system of significant fines in case of offenses. The management goal is to preserve the protected areas as a place where nature takes its natural course, whose values are acknowledged by the general public, locals and scientists, where responsible tourists are welcomed, and the sustainable use of natural resources is regulated by law.

The maintenance of the habitats located in areas with strict and full protection, in their

natural status—or as close as possible—as well as the reduction of human impact in other areas of the park to a level to which cannot change the natural processes, are considered priority goals. Thus, the management should be effective and adaptable by providing an integrated management system. However to do so, first, certain policies are required to encourage the growth of the local economy in a sustainable way, based on the existence of protected areas. Second, other policies are required to involve the local people in planning and management of these protected areas. Finally, only the culmination of these policies will lead to a joint management.

To achieve the protection and preservation of the habitats of the community of interest, certain general management measures are required to maintain the habitats at optimal levels. The careful monitoring of alpine habitats showed that these are some of the most threatened habitats in Romania. Their intensive and extensive exploitation in the past century had dramatically transformed their natural values and ability to support the fragile biodiversity found here. Developing grazing regulations for maintaining livestock according to the specific conditions of the grasslands, as well as promoting the natural regeneration in the forest habitats, are both important measures in this regard. Due to the unique habitat in the Retezat Reservation, considered fragile and easily threatened by grazing, there are specific required management measures aimed to limit the grazing in these areas and the passage of herd animals.

The afforestation of degraded lands, associated with the installation of windbreaks, is one of the most effective measures for environmental protection and climate change mitigation, due to the vital functions exerted by forests, while ensuring renewable material resources. However, we have to face the challenge that the forestry sector will be more sensitive to climate change than manufacturing and retailing and the effects will be more negative in marginal regions aggravating current economic and social problems (MARACCHI et al. 2005). It is still controversial if species migration is able to keep pace with climatic changes (GARAMVÖLGYI and HUFNAGEL 2013). The urgent need for assessing soil quality changes (PODMANICZKY et al. 2011) and adaptation management in protected areas (MALATINSZKY et al. 2013) should be supported by research on shifting distribution of certain plant species due to climatic changes. For example, BEDE-FAZEKAS et al. (2014) give a suitable methodology for that.

Using the mountain grassland regeneration technique developed by specialized institutions, the artificial restoration of the herbaceous carpet consisting of species, whose populations are abundant in the vicinity of the habitat to be restored, becomes possible. With the ecological reconstruction of mountain pines, it is also necessary to restore the herbaceous flora of special interest. Its regeneration is possible both naturally and artificially.

The biological anti-erosion methods applied should be based on comprehensive studies, which should be determined by the characteristics of the land, the assortment of species, and the appropriate afforestation technologies. Given the large scale of this action, it is necessary to develop afforestation programs broken down into stages and geographical areas, which establish the necessary number of seedlings, starting from the assessment of the required forested area and the urgency of intervention.

We recommend further research on the current status, evolution and monitoring of the protective forests, for various categories of degraded lands, aimed to find and apply the best regeneration methods.

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## HEGYVIDÉKI ÉLŐHELYEK ÖKOLOGIAI RESTAURÁCIÓJA MESTERSÉGES REGENERÁCIÓVAL

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Az alpesi élőhelyek monitorozása rámutatott arra, hogy ezek az élőhelyek a leginkább veszélyeztetettek közé tartoznak Romániában. A területen megtalálható törpefenyő állományok kedvező természetvédelmi helyzetének helyreállítása és megőrzése érdekében gazdálkodási javaslatokat teszünk a vonatkozó Európai Unió előírások fényében. Annak érdekében, hogy optimális állapotban megővjük a Retyezát Nemzeti Park élőhelyeit, konkrét gazdálkodási módszerekre van szükség. Cikkünkben a Retyezát Nemzeti Parkban (romániai Déli-Kárpátok) alpesi élőhelyeit és a megőrzésük érdekében kifejtett természetvédelmi beavatkozási módszereket értékeljük. Bemutatjuk a törpefenyő állományok jelenlegi helyzetét a szubalpin és alpesi legeltetés következtében. Emellett kitérünk a degradált élőhelyek helyreállításának módszereire a hegyvidéki gyepek regenerációjának technikáját alkalmazva. Ebből a szempontból fontos módszerek a legelő állatállomány gyepállapothoz igazítása érdekében tett gazdálkodási előírások, valamint az erdei élőhelytípusok regenerációjának támogatása.

