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THE FIR FORESTS OF THE CAUCASUS MOUNTAINS AND CONSIDERATIONS ON THEIR PRESERVATION

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Multi-year studies of the forest formation processes in the virgin *Abies nordmanniana* forests reveal new facts on the origins and recent distribution of the fir forest communities in the Caucasus mountains. Characteristics of the biological background, seed-bearing, natural renewal, and "life strategy" of this species, the structure and dynamics of the *Abies* forests as well as ways of their rational use and protection are discussed.

Key words: *Abies nordmanniana*, age dynamics, Caucasus, conservation, forest types, formation, relict, renewal, seed-bearing, strategy, virgin forests

INTRODUCTION

The study of the virgin forests of the Caucasus Mountains, with attention to the stands of the native fir species, *Abies nordmanniana* (Stev.) Spach, has special significance in the practice of botanical and forestry investigations in Abkhazia, as well as in other areas of the region. The knowledge accumulated so far provides enormous material for comprehending the basic dynamics of the plant cover of the whole mountain range. The author's main focus of the work has been devoted to understanding and explaining the origins, development, and forest formation processes of the *Abies* forests.

The ancient stands of *Abies nordmanniana* (Stev.) Spach, that grow in considerably large areas (about 3,200 km^2) on the upper mountain zone of the western Caucasus, reveal a great deal of originality and peculiarity. They are one of the most productive and richest forest communities in easternmost Europe. They have a great role in soil and water conservation, and have climate regulating functions that effect the whole region. They also provide habitat for rare natural complexes and support a good number of endemic plants and other wildlife. They are perhaps the most characteristic and most important component in the montane landscapes of the Caucasus.

However, commercial exploitation of these *Abies* forests has reached an alarming rate, which has led to significant disturbance, even disorder, and decreasing productivity in them. Furthermore, this threatens the future existence of these once untouched *Abies* stands. In addition, logging and clearcutting in these forests

have been causing severe problems to many relicts and endemics that are important part of their phytocenological composition.

Thus the investigation, preservation, assisted regeneration and rational use of the *Abies* forests in this region has become one of the most urgent actual tasks in botany and in the present science of forestry practices.

The author took part in a comprehensive set of tasks dealing with issues of paleogeography, floristics, geobotany and several fields of forest science related to the species in concern. It has been a challenge to assess all aspects of the formation processes of the Caucasian *Abies* forests on the level of treating them as a whole unit and explore the scientific grounds of the interactions of these forests and the local population's economic activity. For the first time, the results of the studies of the *Abies* forests are shown in a way that starts from the plant species, while the scope of the investigation grows into the level of the entire formation (BEBYA 2002). In this work the origin, history of formation and the modern spread of the fir forests are also discussed. A new, updated sketch map of the *Abies nordmanniana* forests, divided into certain districts was also compiled. Furthermore, morpho-biological, ecological, phytocenological phenomena have been studied based on experimental observations. Peculiarities of cone- and seed production and natural regeneration of the fir species in the natural forests were discussed. The main regularities of the age structure, composition and stand dynamics in general, the characteristics of differentiation and evaluation of individual trees in the forests were ascertained, too.

MATERIAL AND METHODS

The main purposes of the work were identified as follows:

- reach a better understanding of the "life strategy" of *Abies nordmanniana* (Stev.) Spach in its natural range;
- provide a modern classification of forest types in relation with the habitat conditions of the species;
- develop a system of tree measurement, forest productivity, and practical forest typology for optimal usage with the objective of better protection of these forests.

The investigation was based on traditional methods of floristical exploration and documentation, including several field surveys with specimen collecting, vegetation mapping, identifying plant distribution, and consulting herbarium specimens in the local herbarium of the Botanical Institute of the Abkhazian Academy of Sciences, Sukhum (SUCH). Also, corresponding materials in the herbaria located in Batumi (BATU), Kiew (KW), St Petersburg (LE) and Moscow (MW) were studied. The author had several opportunities to consult Hungarian dendrologists Drs Zsolt Debreczy and István Rácz during their Dendrological Atlas Project expeditions (on two occasions, in Japan and in Taiwan the author was part of the research team), as well as collections of Caucasian, mainly woody, plants in the herbarium of the Botanical Department, Hungarian Natural History Museum, Budapest

(BP). All relevant literature on the flora and vegetation available to the author was studied and used throughout the investigation.

DISCUSSION

All facts available are proving the autochthonous mountain origin of the *Abies* forests of the Caucasus mountains. According to paleontologial data, extensive *Abies nordmanniana* forests grew in the middle and upper mountain belt of the mountain range, at the end of the Pliocene. The species was found in association with *Fagus orientalis, Picea orientalis* and other companions that are still present in the extant *Abies* forests (KOLAKOWSKIJ 1956, BEBYA 1994).

Floristical characteristics

The relative floristical richness of their associations (207 species) is regarded as one of the distinguishing characters of the modern *Abies* forests of the Caucasus. Of these 207 species, 82% are elements of the Mediterranean-montane* floristical region, i.e. immigrants of high altitude flora. 38% of the species are relicts, of which 56% are woody species. With regard to species composition, in the old-growth indigenous forests 85% of these relicts are constantly present. Their presence amounts to 17–100%, and their phytocenotical index is over 34. Every one of the relict species is characteristic and constant in at least two forest types. Only 15% of the relicts are "optional", but even these show permanent connection with the associations of the old-growth forest types. Every one of these is typical for at least one of the forest types (BEBYA 1994).

The high degree of continuity of the plant composition of the Pliocene fir forests, and those of the modern *Abies* stands, respectively, the sufficiently stable position of the relict species in the composition of the modern *Abies* forests, their comparatively high content in their Colchidean (36%) and common Caucasian (23%) endemic elements prove not only the ancient autochthonous character of this floristical centre, but also prove that the virgin *Abies* forests have preserved their relict characteristics.

The account of morphological characters and the ecological background of the species support the supposition that *Abies nordmanniana* as a fir species represents an ancient evolutionary branch within the genus. Its morphological and ecological peculiarities may be viewed as the manifestations of common biological

* A new "Mediterranean-montane region" was assigned for the first time by Prof. Alfred Kolakowskij in 1956. It includes only mountain regions of the Earth.

regularities which led to the evolutionary specialisation of the species and to its present distribution, centred on the Colchidean refugium, considerably isolated from other *Abies* species.

The "strategy" of *Abies nordmanniana* is sufficiently stable within its natural habitats, even on the natural boundary of its distribution. It is a dominating "character tree" of plant communities, and it shows no sign of being influenced by interspecific competition in its communities. This is proven first of all by its high indices of presence in all forest types (100%) and by the phytocenotical index (5400). In all types of forests the renewal continues from *Abies* to *Abies*, and we could not detect any changes with accompanying species (BEBYA 1994).

Habitat conditions

A long process of geological, historical, climatic – first of all hydrothermic – conditions, combined with the ecological peculiarities of *Abies nordmanniana*, as well as anthropogenic influences have resulted in the recent distribution of the *Abies* forests in the western Caucasus. Specific features of the distribution of the species is determined by the complex influence of these factors (GULISASHVILI 1964).

With regard to soils, mainly brown acidic forest soils and brown pseudo-podzol forest soils develop under the *Abies* forests. Differentiation by genetic horizons profile is so subtle that this should be considered one of the distinctive peculiarities of these *Abies* forests. Both types of soil are fertile enough to support highly productive (up to 2000 m^3/hectares) *Abies nordmanniana* and *Abies-Fagus* stands (ZONN 1950, ORLOV 1951, BEBYA 1999).

Regeneration

The seed yield of *Abies nordmanniana* is as usual in the genus: good crop years are followed by 1 or 2 years with very little or no coning. With regard to coning and seed production, the natural fir forests may be grouped into three categories.

I) in forests dominated by old trees (over 180 years), 91–94% of the trees are cone producers;

II) in forests dominated by middle-aged (121–180 years old) trees, 33–36% of the trees are coning, and

III) in those of young trees (age up to 120 years) this value is up to 1% (GIGAURI 1974, BEBYA 2002).

Setting cones of young trees is occasional. Spontaneous *Abies* stands of different age provide abundant seed crops both in quantity and quality for a continuous renewal. On 1 hectare the seed yield of *Abies nordmanniana* reaches 149 kg and 1,062 thousand pieces of good quality. Thus, harvesting and reforestation in these forests may be based mainly on natural revival of the species, without going into artificial ways of regeneration (BEBYA 1973).

The best natural renewal is observed in the so-called "mixtaherbosum" *Abies* forests, where the undergrowth is dominated by *Vaccinium* and *Festuca*. Regeneration is satisfactory in the *Abies* forests with an undergrowth of *Ilex aquifolium*. However, renewal is weak in the *Abies* stands characterised as "luzulosum" and "filicosum" with an undergrowth of *Prunus/Laurocerasus* and *Rhododendron*. Within these groups of forest types renewal shows better values at 0.6 stand cover (60%) in the groups of "festucosum" and "luzulosum" types with an undergrowth of *Vaccinium* and *Ilex aquifolium*, and at 0.5–0.6 stand cover in the case of the "mixtaherbosum" ones. In the "filicosum" group better renewal can be expected at 0.6 stand cover. These indices must be taken into consideration when planning tree felling in the *Abies* forests.

In natural openings, *Abies* regenerates well in the forest floor. Within the group of forest types the process of renewal depends mainly on the size and form of openings, and on the steepness and exposure of the slope. In case of the "festucosum" and "mixtaherbosum" *Abies* forests windows of middle size, with a diameter from 18 to 24 metres, regenerate the best.

The study of the virgin *Abies* forests in the Caucasus has conclusively shown that age unevenness and a well structured and complex composition of vertical layers is a basic characteristic of the stands of all forest types. The forests reveal a great variation of tree age (up to 450–500 years), tree height (up to 60 m) and trunk diameter (up to 2 m).

Age dynamics

The distinguishing peculiarity of the *Abies nordmanniana* old-growth forests is the continuous character of age dynamics. This is a continuous process in which old, dying trees or groups of mature trees are continually being replaced by young(er) ones. In these forests, in general, all stand age groups and saplings are always present, which contributes greatly to the stability of the stands. This observation also refutes the misconclusion of a certain fir forest development theory, according to which the virgin (mature) forests of *Abies nordmanniana* of different age are replaced by younger stands and again these grow into old-growth forests to be replaced by younger ones. The continuous process of natural renewal, the com-

plex age structure of stands and the level of continuity in their development are the most important factors to assure the flourishing *Abies* forests of the Caucasus.

For forest surveying works and for purposes of forestry it seems to be most appropriate to divide the complex stands of different age into three tiers, excluding saplings. The first, upper tier consists of the old-aged and mature stands. The second, middle tier consists of the middle-aged and developing stands. The third one is characterised by young trees. When surveying forests, the estimation indices must be stated separately for each tier. This method of forest surveying is very important for projecting economic measures and organising the rational use of the forests.

In the *Abies* forests of the Caucasus mountains, the most important and actual tasks of modern forestry operations should be based on forest typology. The author, in cooperation with local experts, offers a complete classification of the *Abies* forest types of the Caucasus mountains for the first time. Using accepted ecological and genetical principles, this system of classification is based on the analysis of a large quantity of documentation and personal investigations, i.e. those conducted on typological test sites (BEBYA 2002). Taking into account the spatial and time factors of the development of forest associations, phases of association development have been drawn up beginning from common to particular (from an indigenous type of forest to a derived one) and from simple to complex (reforestation into initial type of forest). Phases of development define genetically related biogeocenotics (associations, fullness of stands). When these are taken together with the indigenous stands, they form a united biogeocenotic system. We recommend to unite the currently (locally) used forest types into natural groups of forest types.

CONCLUSIONS AND RECOMMENDATIONS

The multi-year investigation and the above outlined observations made it possible to work out a new classification of forest types for the *Abies* forests of the Caucasus. We distinguish the following *Abies nordmanniana* forest types:

- festucosum;
- luzulosum;
- mixtaherbosum;
- filicosum;
- fir forests with evergreen Colchidean undergrowth;
- fir forests with deciduous Colchidean undergrowth;
- subalpine fir forests; and
- rock forest complexes.

Based on our investigation, we compiled a list of 13 plant species that require urgent protection and need to be brought into the regional Red Book. These are: *Acer sosnowskyi, Blechnum spicant, Castanea sativa, Colchicum speciosum, Corydalis caucasica, Corylus colchica, Daphne caucasica, D. pseudosericea, Pachyphragma macrophyllum, Polystichum woronowii, Rhododendron ungernii, Sorbus migarica, Ulmus glabra.*

For the purposes of practical forestry and the commercial use of the fir forests a simplified grouping of the *Abies nordmanniana* forests was outlined (BEBYA 2002). For each of these a system of measures is also offered, which will hopefully result in the rational use of the given category, will help to improve commercial productivity, and will bring more protection from improper exploitation. Experience based on this approach will hopefully take practical measures on a larger scale also.

The practical grouping of the *Abies* forests is as follows:

- festucosum;
- luzulosum;
- mixtaherbosum;
- those with undergrowth of Colchidean elements;
- subalpine.

The ecological characteristics of the species and the *Abies nordmanniana* forests, their ways of natural renewal and the composition and age structure of the stands, require special attention to their means of exploitation (ORLOV 1951, GULISASHVILI 1972, BEBYA 1972). The "voluntary selective felling" and the "group-selective felling" best suit the nature of these forests and these have proven more effective than the "industry-selective" and "gradual" felling practiced nowadays. Both the economic effectiveness and the protective functions of forestry operations should be brought into harmony with the complex aims of habitat preservation and securing the best renewal of the fir species without additional expenses.

This is possible by the even and continuous use of the forests, with increasing its general productivity by 11–14%, compared with the current, haphazard methods of logging practiced by the industry, including selective logging.

The concerns and tasks discussed in the work aim at the preservation not only the highest possible species diversity of these *Abies* forests (along with the protection of endemic, rare and vanishing plant species) but also the protection of the standard and unique plant associations. In the plant record of the *Abies* forests of the Caucasus, 6 species of woody plants (10% of the total 62) are listed in the Red Book of the USSR. More emphasis should be put on the preservation of these.

If cutting the *Abies nordmanniana* (and *Fagus*) forests continues at the present rate, these majestic stands may disappear from the slopes of the Caucasus for-

ever. In a very short time, it will be possible only to observe and study the remains of the old-growth *Abies* forests in a few national parks and small special reserves. We urge continued study and a better preservation of the ancient forests in the Caucasus and everywhere else they still exist.

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