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RELATIONS OF CONSERVATION OF PLANT DIVERSITY AND FOREST PRODUCTIVITY IN THE COLCHIC FLORISTICAL REFUGIUM

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The unique characteristics and the regional and global significance of the woody vegetation of the Colchic natural relict complexes are discussed with recommendations for their successful preservation and increased biological (including timber) productivity of the region.

Key words: Caucasus forests, Colchis, forest vegetation, monoculture, productivity, relicts

INTRODUCTION

Habitat conservation, and optimisation of the interaction between human populations and natural resources on global, regional and local level are among the most pressing problems that we all have to face. This is particularly relevant in the countries of Eastern Europe and the former USSR where new dimensions of social and economic changes and those of human rights are developing, and the importance of the rational exploitation of natural resources, the need for broader understanding of biological diversity and the importance of the optimal functioning of natural systems is clearer than ever. A special responsibility rests on all the authorities involved and the populations, especially in regions where unique natural complexes are concentrated. Colchis is one of those special regions, covering the whole mountain amphitheatre from Tuapse (Russia) to Trabzon (Turkey) adjacent to the eastern part of the Black Sea.

Its main peculiarities are the impressive high mountains and humid, warm-temperate coastal climate, which create excellent conditions for a rich flora and vegetation as part of a peculiar system of natural complexes

found nowhere else in the world. One of the most important components of these complexes is the extensive woody vegetation. These forests are a highly important source of information reflecting the dynamics of natural processes, and the interactions between people and nature.

Here the forest vegetation has a well defined vertical zonation from the coastal level up to the timberline at approximately 2,200 m, all belts containing important elements concerning nature conservation. As everywhere else, the forests of Colchis are reservoirs of diversity of the living world, with many relict and endemic species including a number of woody plants like *Abies nordmanniana* (Stev.) Spach, *Pinus pityusa* Stev., *P.* (*sylvestris* subsp./var.) *kochiana* Klotzsch ex C. Koch, *Buxus colchica* Pojark., *Castanea sativa* Mill., *Fagus orientalis* Lipsky, *Pterocarya pterocarpa* (Michx.) Kunth ex Iljinsk., *Quercus iberica* M. Bieb., *Q. imeretina* Steven ex Woronow.

The flora of Colchis is of Tertiary origin having 3,569 species of vascular plants (CHITANAWA 2004) including 20 endemic and 450 relict-endemic species (KOLAKOVSKY 1980). Of the woody flora of the Caucasian fir forests, the relicts in these stands amount to 70%, Colchic endemics to 36% and the Caucasian ones to 23%. The beech-fir stands of Colchis are considered to have the highest productivity in Europe. With optimum development these have a timber-reserve of 1,500 to 2,000 m^3/ha (BEBYA 2002). The virgin relict forests of Colchis are unique not only regionally but also globally, which makes their preservation and rational exploitation essential.

The alarming rate of the depletion of the worlds' forests has driven many relict species into regression. Already in 1972 in Ljubljana (Slovenia) at the session of the International Union of Forest Research Organizations a special appeal was made to all countries of Europe to urge measures to preserve the remaining old-growth forests. The Colchic virgin forests are among the most valuable of such remnant temperate-warm-temperate forests.

MATERIAL AND METHODS

The conditions of flora and vegetation and the integrity of natural ecosystems of the presently protected areas have been studied in various ways including extensive field work, analyses of background materials of the flora and vegetation as well as with the relevant botanical and silvicultural literature.

Studying the conditions of previously cut forests has been continued for more than 30 years in the field with series of biometric documentation, and recording estimates and various ways of measurement. Temporary and permanent experimental areas of 0.25–1.0 ha have been set up in formerly commercially exploited areas of different ages. In these experimental areas phytosociological and forestry descriptions and processes of natural regeneration have been registered (BEBYA 2002). The results of this documentation in formerly exploited fir-dominated areas served as basis for the evaluation of the effectiveness of the method described below and for silvicultural proposals for future forestry planning and operations. Data obtained from continual counting/measuring trees grown in monoculture stands have also served as background material for productivity research of introduced woody species, with subsequent determination of the estimation indexes using procedures generally practiced in forestry research. All results have been verified against literature references.

DISCUSSION

It is impossible to preserve the rare and vanishing species of flora and the relict plant communities without the conservation of their habitat – the complete associations in which they thrive.

It is equally important that all habitats of the archaic Colchic woody plants, which may be traced back to the age of the dinosaurs, must be incorporated in the protected areas. Presently, in the countries belonging to the floristical region of Colchis – Russia, Abkhazia, Georgia and Turkey – the full amount of protected Colchic forest areas amounts to only 140(!) ha. For comparison, one biosphere reserve in the Caucasus Mountains takes up 263 thousand ha (MAB – Kavkazskiy Reserve)! The extraordinarily minute Colchic protected areas are absolutely insufficient for the preservation of its rich and unique diversity. Furthermore, these small fragments of protected "plots" are separated by man-made and problematic (state) boundaries. Thus they are isolated from each other and differ in their extent. Their maintenance is often poor and depends, in many respects, on the political and economic situation of the respective countries. Even under such circumstances, these small lands of conservation include a wide spectrum of primary natural complexes of essential woody plants, including certain endemisms and unique members of the Tertiary flora (ADZINBA and BEBYA 2002).

Generally, the most destructive factor of habitat depletion in the Colchis region is the anthropogenic pressure. For example, the Pitsunda–Mysser

reserve lies gripped in a vice of recreation-economic surroundings. From all sides its territory is surrounded by a growing array of health resorts. Almost the same conditions exist in the Ritsa National Park established in 1996 on the basis of the Ritsa-Awadhara reserve. Here, uncontrolled "wild" adventure tourism (tourist entertainment) is going on, besides grazing on its alpine meadows; as well as permanent timber cutting has been allowed on certain parts of its territory. All these factors have a negative influence on the preservation of valuable species of flora, fauna, and the natural dynamics of plant communities.

The situation of other Colchic reserves is even more difficult: neither of them can really fulfil its protective functions. Thus it is safe to state that the Colchic refugium is in danger; it's high time to take definite measures for saving it. At present, the situation of the forests, the decrease of their productivity and protecting function, disappearance and regression of the natural habitat of many species that compose them, and the impoverishment of their genetic foundation, are all results of unreasonable human activity, first of all, uncontrolled timber cutting.

In more than 80% of the commercially used forests, timber harvest takes place by industrially chosen methods and so this activity is in a state of disorder, which is harmful for the natural regeneration and ecologically destructive. To illustrate the merits of these forests, it needs to be said that of the 62 tree and shrub species growing in the fir forests of Colchis, 10% fall in the category of rare and vanishing species and are included in the Red book of the USSR. These are: *Betula megrelica* Sosn., *Buxus colchica* Pojark., *Quercus pontica* K. Koch, *Staphylea colchica* Steven, and *Taxus baccata* L. However, as to our research and seeing the present situation of the Colchic forests, at least another 12 species need to be added into the regional Red Book. These are as follows: *Blechnum spicant* (L.) Roth, *Castanea sativa* Mill., *Colchicum speciosum* Steven, *Corydalis caucasica* DC., *Corylus colchica* Albov, *Daphne caucasica* Pall., *D. pseudosericea* Pobed., *Pachyphragma macrophyllum* Busch, *Polystichum woronowii* Fomin, *Rhododendron ungernii* Trautv., *Sorbus migarica* Zinserl., and *Ulmus glabra* Huds.

It is clear: if nothing is done to save the remaining virgin forests of Colchis, their fate will be the same as those in Europe, as discussed in many research reports (MAYER 1969, VYSCOT 1978, LEIBUNDGUT 1982).

No doubt, the disordered forests of Colchis must be restored. We worked out a method of natural renewal that may assure the revival of the fir forests in 20–30 years (BEBYA 2002).

Classical methods of setting up fir and beech plantations on clearings – as practiced in the northern Caucasus – have had unsatisfactory results (MALCEV 1979), and they are also a costly way of regeneration. The fir and beech plantations established within the forest suffer from damage by wild animals, from quickly growing high grasses, and year by year they require labour-demanding agrotechnical nursing.

On the forest edge and under the canopy of the Caucasian fir forests there are plenty of seedlings of various ages and vitality representing of all the species that compose the forest. This kind of natural "forest nursery" can be easily used for regeneration and so there is no need for expensive plantations. These naturally appearing seedlings and saplings can be used for restoring openings in the forests. (And, they can add biodiversity to the forest in a manner monoculture plantation trees cannot provide.) Between 1967 and 1970, experimental parcels were established under various forests at different elevations above sea level. Small Caucasian fir saplings of 5–10 years old and 0.2–0.4 m high were dug out with the necessary soil balls. These were transplanted within thinned stands, into small clearings of 2.5 × 2.5 m. Survival rate in these transplanting operations reached 80–96%. Further nursing meant making the soil friable in the next 3 years and clearing the underbrush between the rows every 5 years. At the age of 25–27 years these fir seedlings reached an average of 10–11.4 m height, and trunk diameters of 14–17 cm, and the current growth is 54–78 cm per year. Height differentiation of the fir trees is increasing.

Our many years' observation of fir and beech seedlings for renewal of virgin stands in experimental plantings has demonstrated the effectiveness of this method. However, the main forest component trees here – the fir and beech – will take 120–160 years to be technically ripe (for harvest). This has to do with the harvest cycle and the shortage (and need) of timber in the overall area. This problem can be solved by making plantations with introduced quick-growing, valuable timber species.

The Abkhazian Scientific Research Forest Experimental Station (in Ochamchira) conducts experimental research since 1961 with more than 300 introduced woody plant species. Experimental forest plots (monocultures) have been set up at various elevations in the following forest belts:

– at *ca* 20 m above sea level, in the zone of mixed subtropical forests;
– at *ca* 500 m above sea level, in the belt of chestnut forests in a warm temperate climate;
– at *ca* 900 m above sea level, in the belt of dark coniferous forests in a temperate climate;
– at *ca* 1, 650 m above sea level, in the belt of dark coniferous-subalpine forests in a cold temperate climate.

Table 1. Timber yield and other parameters in monocultures established in Abkhazia: results of a 30-year investigation

Tree species	Age, years	Average tree diameter, cm	Average tree height, m	Timber volume, m^3/ha	Mean annual increment, m^3/ha	Timber volume in 50 years, m^3/ha	Recommended growing elevation, m
Cedrus deodara	33	25	23	479	14.5	725	0–700
Cryptomeria japonica	35	22	23	371	10.6	530	0–700
Cupressus lusitanica	25	31	18	576	18.6	1,152	0–500
Metasequoia glyptostroboides	46	32	28	1,360	29.6	1,478	0–600
Pinus wallichiana	29	29	17	476	16.4	821	0–700
Taxodium distichum	33	30	22	660	20.0	1,000	0–700
Sequoia sempervirens	46	43	28	1,646	35.8	1,789	0–600
Liquidambar styraciflua	46	26	17	444	9.7	483	0–700
Liriodendron tulipifera	46	28	21	784	17.0	852	0–600
Quercus castaneifolia	32	23	21	370	11.6	578	0–700
Abies nordmanniana	–	–	–	–	7.0	353	700–1,800
Fagus orientalis	–	–	–	–	5.0	250	500–1,500

The quantity of trees in such monocultures amounts to 100 specimens per 625 m^2. Our investigations over the past *ca* 30 years show that the best producing introduced woody plant species are as follows: *Sequoia sempervirens* Endl., *Cryptomeria japonica* D. Don, *Metasequoia glyptostroboides* Hu et Cheng, *Cedrus deodara* (Roxb. ex D. Don) G. Don, *Cupressus sempervirens* L., *C. lusitanica* Mill., *Pinus pinaster* Ait., *P. taeda* L., *P. wallichiana* A. B. Jacks., *Taxodium distichum* (L.) Rich., *Liquidambar styraciflua* L., *Liriodendron tulipifera* L., *Quercus rubra* L., *Eucalyptus viminalis* Labill. (MLOKOSEVICH 1982, BEBYA 1987, MLOKOSEVICH and LEIBA 1988).

Based on our research the average annual yield of the above species in monocultures has reached from 9.7 m^3/ha (*Liquidambar styraciflua*) to 35.8 m^3/ha (*Sequoia sempervirens*) in the belt of the mixed subtropical forests (Table 1). This is higher than that of the endemic tree species of *Abies nordmanniana* and *Fagus orientalis* which at their maturity (of 120–160 years) show 7.5 m^3/ha. Whereas the quick-growing introduced species are ripe for exploitation at the age of 50–60 years. After 50 years they provide a full amount of 483–1,789 m^3/ha timber. At the same time the Caucasian fir (at 50 years of age) has 353 m^3/ha and the beech has 250 m^3/ha (Table 1).

Building on the productivity of the plantation (production) forests the region's timber production can increase 1.9–7.2-fold and the native forest can be preserved for their protective functions and maintaining the biodiversity of the Colchic flora.

CONCLUSIONS AND RECOMMENDATIONS

The Colchic floristical area is a major refugium of many plant species of Tertiary origin; this relict flora and the region's vegetation, first of all its unique forests, fulfil an important protective function. The genetic foundations that maintain the region's biodiversity are unique at both the regional and global level. Presently, the forest stands are exploited in the most inappropriate way and cannot be regenerated properly. We have worked out an effective method for renewal of these harvested areas by using transplanted saplings of the main forest components, first of all *Abies nordmanniana* and *Fagus orientalis* dug out from under well-kept stands, near the clear-cut areas. These saplings become easily acclimatised. In 25–30 years these plantings form a closed stand of young trees. This method of renewal is much less expensive than making forest plantations in distant nurseries.

On the other hand, to increase the timber productivity of forests in short time we suggest establishing plantations of introduced species in areas from near sea level to up 500–700 m. Using this method, the overall timber production of the region can be increased by 1.9–7.2 fold. The period of obtaining mature stands can be significantly shortened and the cutting rotation increased 2–3 fold. At the age of 50–60 years a full yield of 233–1,539 m^3 can produce more valuable timber than plantations of native species, especially Oriental beech.

Renewing native forests and increasing timber productivity by applying introduced species can assure the protection of the unique natural complexes and biodiversity of the Colchic flora and vegetation.

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REFERENCES

ADZINBA, Z. I. and BEBYA, S. M. (2002): *Dostoinuiu ohranu Kolhidskomu floristicheskomu refugiumu*. Tr. 9-oi Mejdunarodnoi konferencii "Krym 2002". [Appropriate protection required for the Colchis Floristical Refugium]. Proceedings of the International Conference "Krym 2002", Moscow, Tom. 1, pp. 480–482.

BEBYA, S. M. (1987): Nekotorye bioekologicheskie i lesovodstvennye osobennosti liriodendrona tulpannogo v usloviah Abkhazii. [Ecological and silvicultural characteristics of Liriodendron tulipifera in Abkhazia]. – *Trudy Sukhumskogo bot. sada*, Sukhum **31**: 45–47.

BEBYA, S. M. (2002): *Pihtovye lesa Kavkaza*. [The fir forests of the Caucasus]. – Russian Acad. Sci., Moscow, 270 pp.

CHITANAVA, S. M. (2004): *Flora Kolhidy*. [The Flora of Colchis]. – Sukhum, 239 pp.

KOLAKOVSKY, A. A. (1980): *Flora Abkhazii*. – Tbilisi, Vol. 1, 245 pp.

LEIBUNDGUT, H. (1982): *Europäische Urwälder der Bergstufe*. – Verlag Paul Haupt, Bern, Stuttgart, 308 pp.

MALCEV, M. D. (1979): O nekotoryh lesovodstvennyh osobennostiah pihty kavkazskoi v molodyh kulturah na vyrubkah. [Silvics of post-harvest young stands of Caucasian Fir]. – *Cb. nauchnyh trudov VNIILM, Moscow* **14**: 11–20.

MAYER, H. (1969): *Tannenreiche Wälder am Südabfall der Mittleren Ostalpen*. – BLV Verlagsgesellschaft, München, Basel, Wien, 259 pp.

MLOKOSEVICH, B. V. (1982): *Introdukcia drevesnyh porod v Abnilos*. [Woody plant introductions in Abnilos]. – Tezisy dokladov XVIII sessii Soveta botanicheskih sadov Zakavkazia, Tbilisi, pp. 50–53.

MLOKOSEVICH, B. V. and LEIBA, V. D. (1988): *Opyt introdukcii cennyh drevesnyh porod dlia obogashchenia lesov Abkhazii*. [Introduction of valuable alien tree species, as experienced for the enrichment of the forests of Abkhazia]. – Tezisy dokladov nauchno-prakticheskoi konferencii po voprosam sohranenia, povyshenia produktivnosti i racionalnogo ispolzovania lesov Abkhazii, Sukhum, pp. 16–19.

VYSKOT, M. (1978): Tschechoslowakische Urwaldreservate als Lehrobjekte. – *Allgem. Forst Zeitschr.* **24**: 696–697.

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