



Sustainable Management Strategies for the Black Sea Coast Ecosystems

Estrategias de Gestión Sostenible para los Ecosistemas de la Costa del Mar Negro

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ABSTRACT

The paper addresses the geobotanical features of key areas along the Black Sea coast, focusing on the region from Novorossiysk to Kabardinka and from the Betta farm to Inal Bay (Russia). The study assesses the condition of plant populations, evaluates community disturbances caused by various factors, and examines vegetation patterns in relation to elevation. Of significant concern is the impact of both natural conditions and human activities on these coastal ecosystems. The paper underscores the need for effective management strategies to mitigate the detrimental consequences of human intervention and to safeguard the region's biodiversity. The study underscores the importance of sustainable practices and eco-friendly tourism as part of responsible management approaches to maintain the appeal and ecological integrity of the Black Sea coast. In conclusion, the paper's insights into the geobotanical aspects of the Black Sea coast offer valuable guidance for management strategies that can harmonize human activities with the protection and restoration of these vital coastal ecosystems.

Keywords: Black Sea coast, ecosystem, Novorossiysk, Kabardinka, Betta, vegetation cover.

RESUMEN

El documento aborda las características geobotánicas de áreas clave a lo largo de la costa del Mar Negro, centrándose en la región desde Novorossiysk hasta Kabardinka y desde la granja Betta hasta Inal Bay (Rusia). El estudio evalúa la condición de las poblaciones de plantas, evalúa las perturbaciones de la comunidad causadas por varios factores y examina los patrones de vegetación en relación con la elevación. De gran preocupación es el impacto de las condiciones naturales y las actividades humanas en estos ecosistemas costeros. El documento subraya la necesidad de estrategias de manejo efectivas para mitigar las consecuencias perjudiciales de la intervención humana y salvaguardar la biodiversidad de la región. El estudio subraya la importancia de las prácticas sostenibles y el turismo ecológico como parte de los enfoques de gestión responsable para mantener el atractivo y la integridad ecológica de la costa del Mar Negro. En conclusión, los conocimientos del documento sobre los aspectos geobotánicos de la costa del Mar Negro ofrecen una valiosa orientación para las estrategias de gestión que pueden armonizar las actividades humanas con la protección y restauración de estos ecosistemas costeros vitales.

Palabras claves: Costa del Mar Negro, ecosistema, Novorossiysk, Kabardinka, Betta, cubierta vegetal.

1. INTRODUCTION

The presence of a large number of different types of nature management within coastal geosystems, especially on the coasts of the southern seas of Russia, leads to the emergence of certain contradictions, both between the directions of economic use of the territory and in general between the human activity and the natural environment (Gogoberidze, Rumiantceva and Kosyan 2022). Within the territory of the Azov and the Black Sea coast of the Krasnodar Territory, which includes unique coastal landscapes, the anthropogenic load on the components of the natural environment increases, which can eventually lead to irreversible consequences. Disturbances of the biogeochemical cycle as a result of the destruction and oppression of natural ecosystems by humans lead to a weakening of the stability of the life system, many ecosystems, communities, and species of organisms (including humans themselves). Moreover, for humans, the ecological crisis means not only the deterioration of the environment quality but also the deterioration of human health due to the decay of the genome (Asaad et al., 2017; Kachur et al., 2019).

Increasing the scale of production, intensive exploitation of natural resources, and the development of transport increase the degree of risk concerning undesirable impacts, including those leading to irreversible consequences. Environmental problems become especially acute in the conditions of coastal geosystems due to their border position (between the land and the sea) and an increase in the concentration of anthropogenic load due to a large number of different forms of business activities (Yurova and Shirokova, 2020). The importance of environmental problems goes far beyond economics as they have a direct impact on the social, moral, and ethical spheres of life (Delnevo et al., 2021).

Tourism has become an important branch of the economy of many regions of Russia in recent years and is one of the fastest-growing sectors of the global economy. To date, the Black Sea coast of Russia is an attractive well-distinguished tourist area, with all the necessary types of recreational resources, both natural and socio-historical ones.

The unique nature of the Black Sea coast is actively exposed to human influence, resulting in a deterioration of the natural potential, which does not contribute to the attractiveness of the region, and its aesthetic value is lost. The area of the Black Sea coast has been a popular tourist spot for several decades, but the majority of the tourist visits are part of little informative and poorly organized trips and occasional day trips, causing great damage to nature and not bringing significant financial support to the region. There are no economic mechanisms in the region that form the interest in the development of eco-tourism among both entrepreneurs and residents of the region. Besides that, one can note a low level of environmental advertising, propaganda, and agitation (Putkaradze et al 2021).

The conducted study on the assessment of the recreational potential of the area in question and its tourist development demonstrated the causes of the problems of nature management in both theoretical and practical aspects. The most important part of our research includes the study and assessment of natural resources, the features of their location, the nature of use, and the degree of anthropogenic impact.

2. MATERIALS AND METHODS

Geobotanical studies were carried out on key areas of the Black Sea coast: the territory from Novorossiysk to Kabardinka and from the Betta farm to Inal Bay.

Geobotanical studies of vegetation cover included a geobotanical route survey of the vegetation cover of the territory within the boundaries of the zones of a possible influence of the object. Herbarium material was collected to study the ecological and phytocenotic diversity of the territory (Jordon-Thaden et al 2020). Geobotanical studies were carried out in woodlands, communities of rock and scree vegetation, and coastal

phytocenoses. When studying the vegetation cover, we used standard methods of collecting and analyzing the geobotanical, population, and autecological data (Blossey et al 2018; Dean, Muriithi and Culley 2020). Within the framework of field studies, we also assessed the state of plant populations (Van Rossum et al 2022). Determination of the degree of disturbance of the community due to the action of various factors (of natural and anthropogenic origin) was carried out according to the methodological approaches developed by L.G. Ramensky et al. and P.L. Gorchakovskiy.

Trial sites for grassy communities were established, according to V.N. Sukachev and E.M. Lavrenko. Vegetation with smaller phytocenoses or phytocenoses represented by narrow strips was described without establishing trial sites within natural boundaries.

The number of specimens of these species was counted. The text gives descriptions of the main habitats (with photographs) found on the territory of the land acquisition. It indicates the presence of protected taxa with their photos, coordinates, and the number of specimens of a particular taxon.

Plant species included in the Endangered species list of the Russian Federation (2008) or the Endangered species list of the Krasnodar Territory (2017) and the main edificators of vegetation cover in the plots were photographed.

We used the following literature to determine the collected material: the "Determinant of higher plants of the North-Western Caucasus and the Caucasus" by I.S. Kosenko, the "Flora of the North-Western Caucasus" by A.S. Zernov, and the "Plants of the Russian Western Caucasus. A Field Atlas" by A.S. Zernov.

3. RESULTS AND DISCUSSION

According to the physical and geographical zoning, the territory of the Novorossiysk/Kabardinka site belongs to the Crimean-Caucasian mountainous country, the Greater Caucasus region, and the North Caucasus province. The landscape of the region is subtropical northern, Crimean-Caucasian, and sub-Mediterranean.

In general, the territory is represented by natural and cultural landscapes of low structural denudational mountains, composed of chalk flyshes, with thickets of shibliak, steppe meadows, and oak forests on mountain-brown and sod-carbonate soils (Shalnev, 2007).

The lowland and hilly sub-Mediterranean forest and arid, sparsely wooded landscapes on the territory of the reserve are confined to the coastal sea terraces and the foothill and hilly part adjacent to the Greater Caucasus up to a height of almost 100 m. This territory is composed of terrigenous-carbonate flysch; therefore, erosion and denudational relief are characteristic here.

These climatic conditions are characterized by a combination of woody vegetation on the circulating (western) slopes, arid shrubby, and grassy vegetation on the solar (southern) slopes. Woody natural territorial complexes (NTCs) are formed by oak (downy, sessile, Hartwiss oak), as well as pine forests. Shrubby NTCs are mainly represented by thickets of shibliak, and arid woodlands with juniper thickets. Most geobotanists who have studied the vegetation cover of the northwestern tip of the Caucasus (Schiffers, Bush, Maleev, Koval) refer it to the Black Sea province and the Crimean/Novorossiysk subprovince.

On the southern slope of the Markotkh ridge, from Novorossiysk to Kabardinka, there is a juniper forest. It forms here a not quite pronounced belt in the range from 150 to 250-300 m above sea level, towering over the shibliak. Its boundaries change depending on the terrain conditions. Individual juniper plants of the *Juniperus* species and their groups descend far down, reaching the coastal cliffs. Three juniper species grow in the area, namely the Grecian juniper *J. excelsa*, prickly juniper *J. oxycedrus*, and stinking juniper *J.*

foetidissima. In the formation of the juniper forest strip, only the Grecian juniper *J. excelsa* and stinking juniper *J. foetidissima* are significant, while the prickly juniper *J. oxycedrus* is not characteristic for this area and occurs scarcely, mainly in the lower zone. The species forming the juniper strip grow together, but the stinking juniper *J. foetidissima* is more common in the vicinity of Novorossiysk, and the Grecian juniper is more abundant closer to Kabardinka. The stinking juniper rises high into the mountains, some specimens of it are found at an altitude of 400 to 500 m. Permanent companions of the juniper forest are the downy oak *Quercus pubescens*, oriental hornbeam *Carpinus orientalis*, Jerusalem thorn *Paliurus*, and occasionally wild pistachio *Pistacia mutica*.

The herbaceous cover in the juniper forest can be different: in rocky areas, it is represented by astragalus *Astragalus*, Caucasian wormwood *Artemisia caucasica*, flax *Linum lanuginosum*, Komarov's bellflower *Campanula komarovii* and other plants characteristic of rocky slopes; in forest clearings, one can note steppe species like Jacob's rod *Asphodeline taurica*, wheatgrass *Elytrigia*, East Indies bluestem *Bothriochloa ischaemum*, and others. There is a lot of jasmine *Jasminum* in the forest and the clearings.

There is no juniper strip south of Kabardinka, only single bushes grow on the slopes of the beams, mainly of the stinky juniper *Juniperus foetidissima*.

Deciduous forests of mesophilic type are located above the juniper belt. They sometimes descend along deep gullies almost to the sea. These forests have been preserved in their natural state in a few places. The main tree type there is the sessile oak *Quercus petraea*, which together with the hornbeam *Carpinus* and linden *Tilia* forms the first tree tier. The second tier is formed by individual specimens of beech *Fagus*, ash *Fraxinus*, Cappadocian maple *Acer laetum*, mountain ash *Sorbus torminalis*, and cherry *Cerasus avium*. In more favorable humidification conditions, the elm *Ulmus* is also noted along with the aforementioned species. The forest has a very well-developed undergrowth of privet *Ligustrum*, spindle tree *Euonymus*, elder *Sambucus*, wayfarer *Viburnum lantana*, mock orange *Philadelphus* and bladder nut *Staphylea*. In the forest, one can note a lot of greenbrier *Smilax* and occasionally silk vine *Periploca*, vine *Vitis*, and clematis *Clematis*. The following herbs are characteristic of this forest: Crimean peony *Paeonia taurica*, valerian *Valeriana*, cyananche *Cynanchum*, and primrose *Primula*. One can note individual specimens of ash *Dictamnus*, creeping speedwell *Veronica umbrosa*, purple gromwell *Lithospermum purpureo-coeruleum*, *Doronicum orientale*, grey sedge *Carex divulsa*, and such cereals as slender false brome *Brachypodium silvaticum*, etc. In spring, the forget-me-not *Myosotis* blooms profusely in places with enough sunlight.

In the southern part, the oak forest is mixed with the oriental hornbeam *Carpinus orientalis* and smoke-tree *Cotinus*. At the upper border, the blackthorn *Prunus spinosa* forms thickets, behind which mountain-steppe and mountain-meadow vegetation begin.

The low-mountain mixed forests of the northern slope of the ridge are very diverse. They are composed of various forest-forming species, namely, various types of oak, elm, maple, beech, hornbeam, ash, pear, apple, cherry plum, cherry, walnut, and such shrubs as azalea, hazel, and cornelian cherry (Krylenko and Lukinykh 2021; Litvinskaya 2019).

Oak forests usually occupy the warmest and driest habitats; they form a well-defined belt reaching up to 600-700 m above sea level (Stepanov 1952). The dominant position in mixed broad-leaved forests belongs to the sessile oak, accompanied by ash, linden, hornbeam, mountain elm, spindle tree, Cappadocian maple, sycamore maple, common maple, beech, and pear. The undergrowth is formed by *Swida australis*, European spindle tree, hazel, cornelian cherry, and azalea.

Another type of forest dominated by the sessile oak (*Quercus petraea*) is the mixed-grass oak forest. It develops in the foothill zone at an altitude of 500 to 600 m above sea level.

A dry mixed-grass oak forest developing in conditions of scarce moisture looks different. It had thin, low trees with curved trunks. There is no shrubby tier; however, the herbaceous tier is well expressed. It contains field cow-wheat (*Melampyrum arvense*), red clover (*Trifolium pratense*), common oregano (*Origanum vulgare*), greenweed *Genista angustifolia*, slender false brome (*Brachypodium silvaticum*), hawkweed (*Hieracium*), etc.

On the studied coastal territories affected by tourists, downy oak forests (shibliak) are common. Downy oak quite often grows with oriental hornbeam, Jerusalem thorn, smoke tree, prickly juniper, cornelian cherry, and evergreen jasmine. Hornbeam and linden grow along the gullies and crevices. There are many lianas in the forests, such as traveler's joy, woodland grape, smilax sarsaparilla, and common ivy (Caucasian). Among the narrowly Mediterranean littoral species listed in the Endangered species list of the Krasnodar Territory, first of all, one should note the sea poppy (*Glaucium flavum*), sea kale (*Crambe maritima*), Komarov's bellflower (*Campanula komarovii*), *Fibigia eriocarpa*, *Matthiola fragrans*, and *Astracantha arnacantha*.

Territory from the Betta farm to Inal Bay

The studied territory has a sub-Mediterranean type of vegetation belonging to the Crimea/Novorossiysk province. The dominant tree species in the zone of active beach tourism are the Pitsundian pine (*Pinus pityusa*), Crimean pine (*P. pallasiana*), downy oak (*Quercus pubescens*), sessile oak (*Quercus petraea*), oriental hornbeam *Carpinus orientalis*, Jerusalem thorn *Paliurus* and Sicilian sumac (*Rhus coriaria*). Evergreen jasmine (*Jasminum fruticans*) and butcher's broom (*Ruscus ponticus*) are abundant in the undergrowth. Many rare species are growing in pine communities, such as *Pinus pallasiana*, *R. pityusa*, *Campanula komarovii*, all species of the helleborine genus (*Cephalanthera*), Caucasian peony (*Paeonia caucasica*), Orchidaceae (*Umodorum abortivum*, *Orchis punchdata*, *O. simia* Lam., *O. mascula* L., etc.), bladder nut (*Staphylea pinnata* L.) and many others. *Pinus pityusa* is a relict endemic, the most ancient representative of the tertiary flora, growing only on the Black Sea coast. The floral core of the formation is represented by Mediterranean species, among which there are many endemic and rare ones, such as *Orchis simia* Lam., *Orchis punchdata* Steven ex Lindl., *Cephalanthera kurdica* Bomm. ex Kraenzl., *Cephalanthera rubra* (L.) Rich., *Cephalanthera longifolia* (L.) Fritsch, *Anacamptis pyramidalis* (L.) Rich., *Ophrys oestrifera* Bid., *Campanula komarovii*, *Lonicera etrusca*, *Iris pumila*, etc.

The projective coverage of the ground grass and shrub cover equals 40 to 60%. It is based on a *Ruscus aculeatus* (abundance of "sp"), knife grass (abundance of "sp"), creeping gromwell, and one can sporadically note *Physospermum cornubiense*, Eurasian Solomon's seal, and *Laser trilobum*. Of the rare species of herbaceous life forms, the Caucasian peony, monkey orchis, small-dotted orchis, and Balkan anemone have been registered.

Of these herbaceous life forms, the Caucasian peony and the monkey orchis have a high occurrence class (class III).

The grass and shrub tier of the scree coastal slopes is sparse, where the projective coverage does not exceed 20-30%. The basis of the herbage is composed of elements of steppe and petrophytic vegetation. The basis of plant forms is formed by petrophytes (rupicolous species) belonging to the group of Crimean/Novorossiysk endemics, such as *Seseli ponticum*, *Ptilostemon echinocephalus*, Komarov's bellflower, *Salvia ringens*, and *Sideritis taurica*. Most of the species have been included in the Endangered species list of the Russian Federation and the Krasnodar Territory.

The vegetation cover of the North-Western Caucasus is rich and diverse, which is due to the variety of physical and natural conditions: the influence of climate, the proximity of the Black Sea, the difference in the type of climate and soils, and latitude and longitude coordinates. The vegetation cover reflects the history of the formation of the Caucasus as a mountainous country and the fluctuations of the Ice Age (Litvinskaya 2019).

The study of flora is the basis for solving many theoretical and practical issues of taxonomy, botanical geography, and resource studies, as well as for identifying the history of flora and predicting its further changes. The inventory of flora is also important for the implementation of environmental measures (Abalakov, Pankeeva, 2021).

On the southern macro-slope in the northwestern part of the Black Sea coast of the Caucasus, the Mediterranean (Crimean) zone type is pronounced. It is represented by completely different types of vegetation and is fundamentally different from the Colchian type. One can distinguish four belts in it. The lowest belt of littoral vegetation, shrubby thickets of Jerusalem thorn, Sicilian sumac (*Rhus coriaria*), senna (*Colutea cilicica*), and seaside communities of Pitsundian pine. The belt occupies heights up to 100 m. The climate is dry and subtropical (Mediterranean).

5. CONCLUSION

The Black Sea version of the psammophilous complex differs from other versions floristically and cenotically. It should be considered a sub-Mediterranean variant of littoral vegetation. It is expressed on the barrier beaches, namely, the Vityazevskaya, Blagoveshchenskaya, Bugaevskaya, and the Gilyak bank. Of the specific Mediterranean littoral species that grow here, one can name the sea poppy, *Scabiosa sosnowskyi*, *Linaria sabulosa*, sea spurge, and sea holly. The most common communities in the littoral zone are cenoses dominated by lyme grass, common licorice, sea holly, and sea kale.

The vegetation of the seaside cliffs stands somewhat apart. The abrasive cliff is affected by the Black Sea. The cliffs host a specific calcifilic flora rich in endemics. Sometimes they are covered with solid undergrowth of smoke-tree, oriental hornbeam, wild pistachio, and sumac, which acquire a form of dwarf plants. Of the herbaceous and semi-shrubby species, Mediterranean hemixerophilic elements are found, such as *Veronica filifolia*, *Crámbe koktebélica*, *Astracantha arnacanthoides*, *Ptilostemon*, *Agropyron pinifolium*, *Onosma polyphylla*, and *Scabiosa olgae* (south of Tuapse).

Further one can observe the lower mountain belt of hemixerophilic forests and xerophytic woodlands. It is characterized by the dominance of downy oak forests, juniper stands, wild pistachio stands, forests of Pitsundian pine and Crimean pine, and upland xerophytic groupings. It occupies the near-sea ridges up to a height of 500 m above sea level. The climate is dry subtropical, characterized by high summer temperatures (34-40°C), mild winters (the average temperature in January is 3.5 to 4.8°C, the average temperature of the year is about 12°C, and the average annual precipitation ranges from 420 to 760 mm). The soils are sod-carbonate, brown, and heavily eroded.

The mid-mountain belt is represented by sessile oak forests within the heights of 400-700 m above sea level in a complex with downy oak forests and oriental hornbeam thickets. Soils are sod-carbonate, brown forest ones. Post-forest meadows are common in watersheds.

The Mediterranean type of belt ends with a belt of mountain steppes (600-900 m above sea level from needlegrass and grass communities with hemixerophilic Mediterranean elements, such as *Thymus markhotensis*, *Salvia ringens*, Crimean and common Jacob's rod (*Asphodeline taurica*, *A. lutea*), *Sideritis euxina*, and wall germander (*Teucrium chamaedrys*)).

The observed patterns in the change of vegetation with height have only the most general character. The zoning is quite often irregular, which is due not only to natural causes (microclimatic and soil conditions, complex orography, the influence of exposure, and the steepness of the slopes) but also to human activity.

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