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General aspects of the Forest Fund Managed by the Sasca Montană Forest District

Maria Mihaela MOATĂR[1], Vlad FLORESCU[1], Marinela BORA[2], Petre Alexandru PANICI[1], Daniela Nicoleta SCEDEI[3], Petru Ioan DRAGOMIR[1]*

[1]University of Life Sciences "King Mihai I" from Timisoara, Faculty of Engineering and Applied Technologies, Department of Forestry, e-mail: mihaela.moatar@usvt.ro, vlad.florescu.fita@usvt.ro, alexandrupanici@usvt.ro, petruioandragomir@usvt.ro
[2]University of Life Sciences "King Mihai I" from Timisoara, Faculty of Engineering and Applied Technologies, Department of Genetic Engineering, e-mail: marinela.bora.fbira@usvt.ro
[3]University of Life Sciences "King Mihai I" from Timisoara, Faculty of Engineering and Applied Technologies, Department of Horticulture, e-mail: daniela.scedei@usvt.ro

* Corresponding author: alexandrupanici@usvt.ro, petruioandragomir@usvt.ro

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Abstract
This study examines the forest fund managed by the Sasca Montană Forest District, integrating ecological, pedological, geomorphological, and climatic characteristics relevant to the foundation of sustainable forest management. Field investigations included medium-scale site mapping, detailed soil profile descriptions, physico-chemical analyses, and assessments of stand structure. The analysis of lithological substrate and landforms highlights their influence on soil formation and the productive potential of forest ecosystems. The climatic and hydrological regime, marked by balance and diversity, contributes to vegetation stability and the ecological functionality of forested areas. The data collected were codified and processed automatically, facilitating the development of management plans, functional zoning, and the identification of conservation measures. This work provides a robust scientific basis for the integrated management of forest resources in the context of current ecological challenges. The effectiveness of silvicultural measures will be evaluated at the end of the management cycle by comparing the current structure with the optimal model. Based on the results obtained, effective solutions will be continued, and new measures will be adapted to the ecological and economic realities of the forest fund.

Keywords: forest, sites, characteristics, management, vegetation

Introduction

The Sasca Montană Forest District, encompassing a total area of 19,129.93 hectares, is administered by the Caraș-Severin Forestry Directorate and represents a forested territory of remarkable ecological complexity. Located within the Semenic–Almăj, Aninei, Locvei, and Ravenscă Mountains, as well as the Cărbunari Plateau and the Oravița Hills, this area is distinguished by its geomorphological and phytoclimatic diversity, offering favorable conditions for a wide range of forest ecosystems [1, 2, 24].

From a phytoclimatic perspective, the district's forests are distributed across two vegetation zones: the hilly zone of sessile oak, beech, and mixed oak-beech stands (F.D.3), covering 62% of the area, and the hilly zone of thermophilous oak and hill forest-steppe stands (F.D.2), accounting for 38%. This distribution reflects the adaptability of forest species to local relief, soil, and climatic conditions, contributing to the ecological stability of the region [26].

The forest district lies entirely within Caraș-Severin County. The allocation of forest resources across administrative-territorial units and production units reveals a complex structure, with direct involvement of local communities in forest resource management. Territorial access is provided via county roads DJ 571 and DJ 571B, and the administrative headquarters is located in Sasca Montană [1, 20, 21].

The ecological significance of the Sasca Montană Forest District is enhanced by its partial overlap with Natura 2000 sites of community interest (ROSCI0031 Cheile Nerei–Beușnița, ROSCI0206 Porțile de Fier) and special avifaunal protection areas (ROSPA0020 Cheile Nerei–Beușnița, ROSPA0080 Munții Almăjului–Locvei). This interconnection underscores the strategic role of the district in biodiversity conservation and in maintaining regional ecological balance.

The territorial boundaries of the district are clearly defined by both natural elements (ridges, valleys, rivers) and artificial landmarks (roads, border strips), and are physically marked on site through boundary stones and forest management signage. Its proximity to other forest districts and the national border with Serbia confers a distinctive geographical position with implications for transboundary natural resource management [16, 30].

Forest fund administration is conducted in accordance with forestry regulations and environmental protection standards, divided between public state ownership (19,129.93 ha) and public ownership of administrative-territorial units (134.20 ha). In this context, the responsibility for sustainable management lies with both the National Forest Administration – RNP Romsilva and local authorities, either individually or in association, in compliance with current forestry legislation [25, 27, 28, 29].

This study aims to provide an integrated characterization of the forest fund managed by the Sasca Montană Forest District, emphasizing the relationship between vegetation structure, physical-geographical conditions, and management regime, as a foundation for conservation and sustainable valorization measures.

Within the district's territory, there is also a forested area of 207.30 ha under private ownership, of which 202.20 ha result from property restitution under Law no. 18/1991, and 5.10 ha were allocated under Law no. 1/2000. The management of these forests is the exclusive responsibility of the owners, either individually or through associative forms, in compliance with forestry regulations and environmental protection norms. This responsibility entails the application of sustainable management principles aligned with the ecological, economic, and social functions of the forest.

In addition to the officially registered forest fund, the district also includes 1,393.60 ha of land covered by forest vegetation located outside the national forest fund. Although not formally recorded, these forests contribute significantly to local and regional ecological balance. Their management is carried out by the respective owners, in accordance with their designated purpose, and in compliance with the Technical Forestry Norms concerning forest vegetation on lands outside the forest fund and general environmental protection rules [13,19, 21].

Geologically, the territory of the Sasca Montană Forest District reflects structural diversity closely correlated with the succession of major relief units—mountains, hills, and depressions—belonging to the Semenic and Locvei mountain groups. In the northern area of the Nera River and along its narrow-left bank, extensive limestone formations have generated typical karst relief, with dolines and spectacular gorges such as those at Cărbunari and Cheile Nerei. The lithological succession includes Lower Triassic conglomerates and sandstones, Upper Jurassic dolomitic limestones and marls (Oxfordian and Barrenian), and Lower Cretaceous formations (Neovonian and Apasian).

In the Micoș Valley area, on the lower left slope, crystalline schists with sedimentary dominance over basic tuffaceous material are present. These substrates have given rise to rendzinas and eutric cambisols—medium to deep soils favorable for pure beech stands or mixed compositions, under more restrictive conditions, lithic subtypes emerge, supporting lower productivity stands.

The Locvei area is characterized by metamorphic and magmatic rocks, such as chlorite schists with albite porphyroblasts, amphibolite schists, orthoamphibolites, and sericitic quartzites, which have generated preluvosols and luvisols—fertile soils supporting sessile oak, Turkey oak, and mixed *Quercus* stands. In areas with lithic substrates, vegetation is less vigorous, reflecting reduced forest productivity.

Overall, strict delineation between rock categories is challenging, as the alteration of compact rocks and the presence of unconsolidated materials (deluvium, colluvium, alluvium) generate a varied lithological complex. The parent material often consists of mixtures of course and fine fragments, and the influence of climatic factors, combined with inappropriate anthropogenic interventions, may trigger forest ecosystem degradation processes [5, 9, 12]. This reality calls for a cautious approach tailored to the local geological context to preserve the ecological functions of the forest [15].

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The Sasca Montană Forest District is situated in the southwestern part of Caraș-Severin County, covering an extensive forested territory that overlaps diverse geomorphological units: the Semenic–Almăj, Aninei, Locvei, and Ravenscă Mountains, the Cărbunari Plateau, and the Oravița Hills. From the mountainous Semenic area, the relief descends in steps, forming low mountains and karstic hills with fragmented plateaus and strongly undulating slopes. The forested area is distributed across two major zones: high hills (62% of the territory), with varied slopes and beech–oak forests, and medium hills (38%), dominated by beech–*Quercus* mixtures. Additionally, there are patches of elevated floodplains where black alder thrives.

The predominant landform within the Sasca Montană Forest District is the slope relief, characterized by a fragmented configuration. In valley areas, spectacular gorges emerge, such as those in Valea Rea and Cheile Nerei. In limestone regions, specific karst formations—dolines, ravines, subterranean streams, and karst lakes—develop, significantly influencing site conditions. On steep slopes, litter formation and humus accumulation are limited, leading to the presence of lithic, excessively skeletal soils that support low-productivity forest vegetation [3, 8, 11]. Conversely, on gentler slopes, pedogenetic processes occur normally, favoring the development of medium to deep soils enriched with nutrients, which host forest stands of medium to high productivity.

Geomorphological diversity induces a wide range of slope gradients, from 0–5° in floodplains and plateaus to over 40° in hilly areas, with a frequent average slope of 25°. Forest area distribution by slope class reveals a predominance of terrains with slopes between 16–30° (54%), followed by very steep slopes (31–40° – 23%) and abrupt slopes (>40° – 12%). Altitudes range from 120 m to 1150 m, with a major concentration between 400–600 m (45%) and 200–400 m (35%).

General aspect is influenced by the flow direction of the Nera River, with southwest-facing slopes in the Aninei Mountains and north-facing slopes in the Locvei and Ravenscă Mountains. Detailed exposures, shaped by valley and stream orientation, generate a mosaic vegetation landscape. On sunlit slopes, where soil moisture is reduced during the growing season, beech is replaced by thermophilous species such as sessile oak and Turkey oak. On shaded slopes and along valleys, beech regenerates naturally under optimal conditions. Forest area distribution by aspect confirms the predominance of partially sunlit slopes (52%), followed by shaded (22%) and sunlit (26%) slopes. Aspect acts as a limiting or compensatory factor for forest vegetation, influencing the distribution of light-demanding species (sessile oak, Turkey oak, manna ash) and shade-tolerant species (beech, hornbeam). Except for a few introduced conifers (Norway spruce, Douglas fir, Scots pine, black pine, eastern white pine), the forest species encountered develop within their natural vegetation range.

Hydrologically, the district lies within the Nera River basin, which flows east to west and discharges into the Danube on Serbian territory. Between the district's entrance and Sasca Montană village, the Nera traverses spectacular gorges included in the protected area of the Cheile Nerei–Beușnița National Park. The hydrographic network is well represented, with major tributaries on both slopes: Valea Bei and Valea Rea on the right, Valea Runcea and Valea Micoș on the left, along with numerous secondary streams and gullies. The Șușara and Beușnița streams are notable for their waterfalls and scenic gorges, and a national seismological station operates in the Șușara Valley.

The flow of these waters supports a relatively stable hydrological regime, with limited seasonal variation, sustained by abundant precipitation (700–1000 mm/year). These conditions favour forest vegetation development and ecosystem stability. However, in areas with steep slopes (12% of the territory with slopes over 40°), torrential rains may cause severe erosion, prompting functional zoning of the terrain. In karst regions, surface waters often disappear underground, as in the case of Beiul Sec.

To maintain hydrological balance and enhance the ecological functions of the forest, prudent conservation and management measures are required: avoiding main harvests on erodible soils, maintaining forest roads, clearing valleys of logging debris, reinforcing torrent control structures, and using appropriate timber extraction technologies (including cable systems). Natural regeneration should be complemented by afforestation with species adapted to the native forest type, contributing to both productivity and the hydrological role of forest ecosystems.

Climatological characterization of the Sasca Montană Forest District was based on data from local meteorological stations, supplemented by information from the Climatological Atlas for intermediate altitudes. The local climate results from a complex interaction between solar radiation, atmospheric

circulation, and relief features, which—through altitude, slope orientation and inclination, and landform configuration—generate pronounced climatic stratification and diverse topoclimates.

The thermal regime reflects this complexity, with annual average temperatures ranging between 8°C and 11°C. July is the warmest month (20–21°C), and January the coldest (–2°C to –3°C). The absolute maximum was recorded in July (39°C), and the absolute minimum in January (–40°C), confirming the temperate continental character of the climate, favourable to the development of characteristic forest species.

Seasonal average temperatures range from –1°C in winter to 18–20°C in summer, with a growing season average of 15–17°C. Monthly daily maximum and minimum averages indicate significant thermal amplitude, with summer highs up to 39°C and winter lows down to –25°C. The first day with temperatures above 0°C typically occurs between March 1–21, and the last day with temperatures above 15°C around October, with an estimated annual sum of average temperatures between 3200 and 3600°C.

Thermal distribution is influenced by relief, especially in the cold season, when cold air accumulates in valleys and depressions, while warmer air masses persist on slopes and elevated areas. In summer, temperature decreases with altitude exceed 0.7°C per 100 m, accentuating microclimatic differences. These variations contribute to the diversification of site conditions and the adaptability of forest species, which are distributed according to altitude, aspect, and local thermal regime [4, 6, 7].

The pluviometric regime reflects the combined influence of atmospheric circulation, solar radiation, and varied relief, which—through altitude, aspect, and configuration—generate differentiated precipitation patterns and diverse microclimates. Annual average precipitation ranges between 700 mm and 1000 mm, with a peak in June (90–120 mm) and a minimum in February (50–60 mm). Over 55% of the annual total accumulates during the growing season (430–570 mm), ensuring favourable conditions for forest vegetation development.

Seasonal precipitation averages indicate balanced distribution, with higher values in the warm season (240–310 mm in summer) and lower in winter (160–210 mm). The absolute maximum recorded within 24 hours reached 76.5 mm, with no frequent occurrence of severe or prolonged droughts. Snowfall plays an important ecological role, with the persistent snow layer providing thermal insulation and protection for soil and forest regeneration. The average number of snowfall days is 30–40 per year, and snow cover duration ranges from 60 to 80 days.

Relative air humidity remains high during cold and transitional months, with peak values in January and April (up to 88%), and decreases in summer, reaching lows of 65% in July. On slopes, relative humidity increases during the warm season compared to valley areas, favouring cloud formation and intensified precipitation. Monthly average cloudiness ranges between 50% and 75%, with the highest values in autumn and winter. The estimated average number of clear days per year is 80–100, with higher frequency in summer and early autumn (12–14 days/month).

These climatic characteristics contribute to the stability of the hydrological regime and the ecological balance of forest ecosystems, providing favourable premises for implementing sustainable forest management measures tailored to site-specific conditions [10, 14, 20].

The analysis of climatic factors and determinants reveals ecologically favourable conditions for the development of the main forest species within the Sasca Montană Forest District. Recorded climatic parameters—annual average temperature, precipitation regime, sum of effective temperatures, growing season duration, and atmospheric humidity—fall within optimal or highly favourable ranges for dominant species: beech (*Fagus sylvatica*), sessile oak (*Quercus petraea*), and Turkey oak (*Quercus cerris*).

For beech, the annual average temperature of 8–11°C, annual precipitation between 700–1000 mm, and a growing season of approximately six months meet the species' high ecological requirements. Relative humidity in July is around 65%, close to the optimal threshold (70–80%), allowing balanced development, especially on shaded slopes and along valleys.

Sessile oak benefits from a wider thermal amplitude, with optimal requirements between 8.7–10.6°C and increased tolerance to higher temperatures. Precipitation exceeding 600 mm/year and a ≥0°C temperature sum of 3200–3600 confirm high climatic favourability, while a growing season of approximately seven months supports good forest productivity. Relative humidity of 65% in July is at the lower limit of its requirements but does not constitute a major limiting factor.

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Turkey oak (*Quercus cerris*), a thermophiles species, thrives under conditions of annual mean temperatures between 9.5–10.6°C and minimum annual precipitation of 550 mm. The values recorded in the studied area—temperatures ranging from 8.1 to 11°C and precipitation around 700 mm—fall within the favourable range, while the growing season duration of approximately seven months aligns with the species' ecological requirements. A relative air humidity of 70% in July is adequate, supporting the development of Turkey oak on sunlit slopes and in well-drained soils.

Materials and Method

The structural characterization of the forest fund managed by the Sasca Montană Forest District was based on a detailed analysis of data concerning the distribution of areas by species groups, age classes, production classes, composition, density, average age, current increment, average and total volume, as well as functional groups. These data reflect not only the current state of forest ecosystems but also their production potential and regeneration capacity, depending on site conditions and the history of silvicultural interventions.

The total analysed area amounts to 18,695.51 hectares, distributed across four production subunits (A, E, K, M), each with distinct structural and functional characteristics. Subunits A and E concentrate over 80% of the total area, featuring mature structures and high species diversity. Subunit K is marginal, with only 60.23 ha, while subunit M, although smaller (3,649.67 ha), presents a balanced structure and significant productive potential.

From a floristic composition perspective, beech stands (FA) clearly dominate the forest landscape, occupying 56% of the area, followed by Turkey oak (CE), sessile oak (GO), hornbeam (CA), lime (TE), manna ash (MJ), and other broadleaved species. Conifers (DR) are poorly represented, accounting for only 4% of the total, mostly found in plantations or isolated mixtures. Thermophilus (DT) and mesophiles (DM) species together cover approximately 32% of the forest fund, reflecting vegetation adaptation to local climatic and edaphic conditions.

Age class analysis reveals a mature stand structure: 20% of the area falls within age class IV (81–100 years), 16% in class V (101–120 years), and 41% in class VI and above (over 120 years). Young classes (I–III) account for only 23%, indicating a trend of forest aging, with direct implications for regeneration and conservation planning. This distribution varies across production units: for example, in U.P. I, over 48% of the area is occupied by stands in class VI, while in U.P. III, middle-aged classes (III–IV) predominate, suggesting a more dynamic structural evolution.

Distribution by production class confirms a medium to high productive potential: 54% of the area falls within class III, 26% in class IV, and 17% in class V. Classes I and II are poorly represented (under 4%), mainly associated with stands on fertile soils or recent silvicultural interventions. This structure indicates good biomass accumulation capacity and high efficiency in utilizing site resources, especially in beech and sessile oak stands.

Functionally, the forest fund is structured into two major groups: production forests (Group I) and forests with special protection functions (Group II). Production forests cover 15,418.23 ha (82%), evenly distributed across all production units, while protection forests total 3,277.28 ha (18%), concentrated in areas with steep slopes, erodible soils, or near watercourses. This distribution reflects a balanced approach between timber resource utilization and ecological function conservation.

Species structure within functional groups confirms the dominance of beech stands in both categories, followed by sessile oak, Turkey oak, and mixed *Quercus* stands. In protection forests, there is a higher proportion of thermophiles species and those adapted to restrictive site conditions, such as manna ash, hornbeam, and Turkey oak. This functional diversity is essential for maintaining ecosystem stability and adapting to climate change.

Dendrometric indicators support this assessment: the average stand age is 91 years, with higher values in beech (96 years) and sessile oak (97 years), and lower values in manna ash (45 years) and alder (40 years) stands. The average current increment is 4.4 m³/ha/year, with maximum values in beech (4.8 m³/ha/year) and conifer plantations (8.7–11.4 m³/ha/year), and minimum values in Turkey oak and manna ash stands (under 2.5 m³/ha/year). The average volume per hectare is 240 m³, and the total estimated volume for the entire forest fund is 4,495,475 m³, of which over 2.8 million m³ are concentrated in beech stands.

This complex structure, resulting from the interaction between natural conditions and silvicultural interventions, provides a solid foundation for sustainable forest management planning. The balanced distribution by age and production class, compositional and functional diversity, and high productive potential of the stands support the implementation of differentiated strategies for conservation, regeneration, and valorisation, tailored to the specific characteristics of each production unit.

Results and Discussion

The analysis of the forest fund within the Sasca Montană Forest District revealed a complex ecological and functional structure, with remarkable diversity in forest types, formations, and site conditions. The results obtained from fieldwork, site mapping, and the processing of pedological and dendrometric data allow for an integrated interpretation of the current state of forest ecosystems and their potential for sustainable valorisation.

In terms of natural forest types, hill beech forests on shallow soils with limestone substrate (type 421.3) predominate, occupying 24% of the total area, followed by medium-productivity mull-flora beech forests (421.4 – 21%) and beech forests on skeletal soils (421.2 – 15%). These types reflect vegetation adaptation to local edaphic and geomorphological conditions, especially in karst areas and on steep slopes. Distribution by natural productivity categories indicates a dominance of the medium class (58%), followed by the lower class (40%), with only 2% of the area falling into the superior category, highlighting the need for differentiated silvicultural interventions.

Forest formations are dominated by pure hill beech stands (69%) and mixed beech stands (14%), with a significant presence of sessile oak stands, mixed oak-beech stands, and *Quercus* mixtures. Regarding the current character of the forests, 89% are classified as fundamental natural formations, indicating a high degree of conservation and favourable ecological continuity. Partially derived, fully derived, and artificial formations together account for only 11%, reflecting low anthropogenic pressure and good natural regeneration capacity.

The age class structure shows a predominance of mature and overmature stands: 41% of the area falls into class VI and above, while classes IV and V account for 36%. Young classes (I–III) are underrepresented, at only 23%, suggesting a trend of forest aging and the need to intensify regeneration efforts. Distribution by production class confirms a medium to high productive potential, with 54% of the area in class III, 26% in class IV, and 17% in class V.

Species composition is dominated by beech (56%), followed by hornbeam (10%), sessile oak (8%), lime (7%), Turkey oak (3%), manna ash (3%), and other broadleaved species. Conifers are poorly represented (4%), mainly present in plantations or areas with special functions. The average stand age is 91 years, with higher values in beech and sessile oak stands (over 95 years), and lower values in manna ash and alder stands (under 50 years). The average current increment is 4.4 m³/ha/year, and the average volume per hectare is 240 m³, with a total estimated volume of 4,495,475 m³.

Functionally, production forests occupy 82% of the area, while protection forests account for 18%, strategically located in areas with steep slopes, erodible soils, or near watercourses. Species distribution within these groups confirms the dominance of beech and sessile oak stands, with structural diversity adapted to site conditions.

The interpretation of these results highlights the generally good condition of the forest fund, with high ecological capacity and valuable productive potential. At the same time, the need for differentiated conservation and regeneration measures becomes evident, depending on forest type, age class, productivity, and assigned function. In areas with lithic soils, steep slopes, and sunlit exposures, maintaining existing vegetation and avoiding main harvests is recommended, while in stands with high potential, regeneration and ecological reconstruction works may be applied.

To determine the qualitative structure of the analysed forest fund, a species composition analysis was conducted. The data obtained allowed for a synthetic representation of the percentage share of each species or species group within the total forest fund. As shown in Figure 1, the compositional structure is characterized by an uneven distribution and a clear dominance of a single species.

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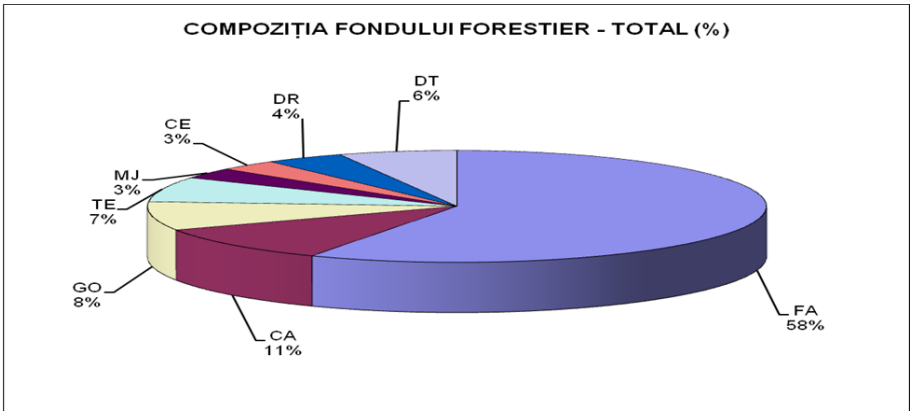

Figure 1. Composition of the forest fund

The figure illustrates the percentage distribution of tree species composing the forest fund. It highlights the absolute dominance of Beech (FA), which accounts for 56% of the total. Notable secondary percentages are recorded for Hornbeam (CA, 11%) and Sessile Oak (GO, 8%), indicating a composition predominantly based on broadleaved species, with a strong concentration around the dominant species.

Conclusions

The analysis of the forest fund within the Sasca Montană Forest District reveals a complex ecological and functional structure, characterized by the predominance of natural formations and a high capacity for adaptation to local climatic and edaphic conditions. The balanced distribution of forest types, compositional diversity, and the presence of mature and overmature stands provide a solid foundation for the implementation of sustainable forest management strategies.

Changes in forest area, as well as terrain movements, have influenced the regulation of the production process, leading to deviations from the structure considered optimal. Although management databases have been periodically updated, the uneven application of silvicultural provisions has resulted in the persistence of structural imbalances. The current organization of forests—regarding species composition, diameter distribution, and spatial arrangement—differs significantly from the optimal model, necessitating corrective silvicultural interventions.

To normalize the structure and size of the forest fund, the following measures are recommended:

- Maintaining the integrity of the forest fund and preventing its fragmentation;
- Timely and appropriate application of tending and stand management operations;
- Compliance with regulations on timber harvesting, with priority given to conservation works in stands with special functions;
- Intensification of natural regeneration and its supplementation through afforestation with native species adapted to the fundamental natural forest type;
- Reintroduction into the forestry circuit of temporarily unproductive lands and restoration of low-productivity stands through ecological reconstruction.

The effectiveness of silvicultural measures will be evaluated at the end of the management cycle by comparing the current structure with the optimal model. Based on the results obtained, effective solutions will be continued, and new measures will be adapted to the ecological and economic realities of the forest fund.

In conclusion, the climatic conditions within the Sasca Montană Forest District are favourable to highly favourable for the dominant forest species, allowing for balanced distribution and efficient natural regeneration according to site-specific characteristics. This compatibility between the ecological requirements of species and local climatic parameters provides a strong argument for the preservation and sustainable valorisation of the existing forest fund.

The forest fund of the Sasca Montană Forest District is defined by a balanced structural and functional diversity, with a predominance of natural formations and good adaptability to local climatic and edaphic conditions. These findings offer a solid basis for the development of forest management plans and the implementation of sustainable management strategies aligned with the ecological, economic, and social functions of the forest.

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