BIODIVERSITY EVALUATION IN THE FRAMEWORK OF FOREST MANAGEMENT PLANS

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ABSTRACT - Biodiversity values are not always considered correctly in the forest management plans. This study aims at elaborating a methodological concept on the measurement and assessment of "biodiversity" as a non productive forest functions" and including them in the decision making process of management. The proposed approach constitutes the theoretical background on which an analytical and practical inventory and evaluation procedure for the non-timber forest functions is built. Biodiversity assessment is done considering species diversity and ecological diversity of plant communities. The three target systems provide for derivation of appropriate variables to be inventoried for the selected function (biodiversity preservation). Evaluation of external factors leads to a division of the forest area into homogenous zones of similar function potentials and provides for appropriate land use planning measures at landscape level. Evaluation of the internal factors results in a grouping of the forest stands into groups with similar characteristics and provides for appropriate sylvicultural measures to improve stand performance with respect to the function (biodiversity preservation). Evaluation of biodiversity identifies those stands having particularly high biodiversity values that need to be preserved and therefore, carefully treated during forest management activities.

KEYWORDS - forest management, non-productive forest functions, multi-criteria analysis, biodiversity assessment, plant associations.

INTRODUCTION

Forest management can be defined as "deciding what one wishes to do with a forest, taking into account what one can do with it and deducing what one should do with it" (FAO). In the framework of sustainable and multifunctional forest management, the classic principle of production continuity is enlarged, including other ecological and social functions of the forest. It is still difficult to include ecological and social functions of the forest in the forest management. The qualitative nature of these functions makes difficult their quantitative measurement.

The main objective is to elaborate a methodological concept on the measurement and assessment of "non productive forest functions" and including them in the decision making process of management.

The study will show how a mathematic analyzing model can help forest management decision-making process. The study will analyze the potential and suitability of forest stands to preserve biodiversity as well as will asses the existing biodiversity values that need protection.

The study will also show the use of the huge amount of data collected during field works for forest management plans. The study proposes also the use of new indices of biodiversity assessment.

In order to concretely apply the methodological concept we use the forest economy "Mbasdejë-Zall Gjoçaj", overall area of 4106 ha, located northeast Mati district. This forest economy has been recently managed according to the new forest management guidelines. It is part of the Mati river watershed, including the rivers of Zall Gjoçaj and Mbasdeja (Shelca). It is under the administration of DFO Mat, within the natural borders of Derjan and Macukull communes.

MATHERIAL AND METHODS

Forest management is defined as "the technical action that helps to lead forest governance to achieve predefined objectives". Sustainable forest management consider a *"variety of values"* to achieve, at best possible level a *"variety of goals"*. For any forest elementary unit (forest type, association) it is possible to apply two or more management alternatives.

The analysis of the natural phenomena that take place in the manifestation of a function can lead to the determination of important factors that influence a function (Gatzojannis *et al*, 2001). The great amount and different nature of these factors denote that a complex of variables should be included in the inventory system. Moreover, overlapping and interrelations of factors make the assessment of the contribution of each factor difficult. To overcome these problems a systematic classification of factors is needed. Classification reveals the interrelations among factors and the structure through which factors affect each non-timber function. A classification of these factors according to the system analyses technique has revealed three target systems:

- External factors include all factors that formulate the surrounding environment of the forests. External factors determine "the potential" (see FIGURE 1);
- Internal factors are related to the forest stands and subject to major changes due to stand development, species succession and management practices. Internal factor determine the "suitability" (see FIGURE 2);
- Special values influencing a certain factor (biodiversity indices) (see FIGURE 3).

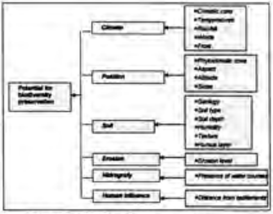

FIGURE 1 - External factors influencing biodiversity conservation.

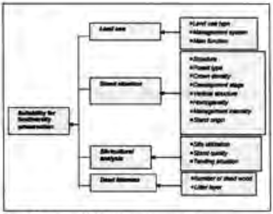

FIGURE 2 - Internal factors influencing biodiversity conservation.

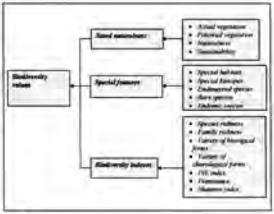

FIGURE 3 - Biodiversity values.

The basic characteristics of the systems for the evaluation of non-timber functions include:

- Direct relationships among factors (classification relationships) which classify factors into groups of homogenous information (climate, soils, landscape, etc).
- Complementary "means-to-objective" relationships from right to the left of the system;
- Interdependencies among factors. They express the degree at which one factor affects positively or negatively another factor;
- Hierarchical evaluation starting from the more detailed to the less detailed, and eventual evaluation of the whole function;
- Open-ended structure, since irrelevant to a function factors can be omitted or additional factors can be added as needed.

Irrespective of the system it belongs, each factor is determined by two features: its quality and its importance (relative weight). There are three basic characteristics of the factors that determine the methodological framework:

- Factors of different nature have different units of measurement;
- A number of factors can be assessed only qualitatively;
- Factors have a different meaning with respect to different functions.

The synthesis of the evaluation results along the levels of the hierarchy can only be achieved at a common scale in which all factors could be expressed. Interval scales are valuable tools to overcome this problem (see FIGURE 4).

Assessment of qualitative factors (e.g. vegetation zone, species composition) by an interval scale can be done using the rating scale. Assessment of quantitative factors (e.g. forest cover percentage or slope) requires transformation of the physical values to vales of the interval scale.

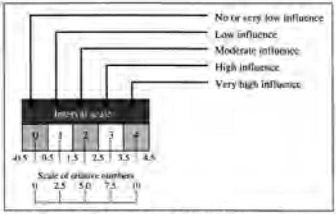

FIGURE 4 - Example of calculation of the stand suitability for biodiversity protection.

Based on the quality (q_i) and the relative weight (g_i) of the lower level factor, the quality of an upper level factor can be estimated by the function $N=\Sigma(q_i*g_i)$. Successive evaluations along the hierarchy result to the evaluation of a non timber function. The above synthesis can also be expressed by the following equation:

$$y = b_1*X_1 + b_2*X_2 +\ldots+ b_n*X_n$$

- y - the quality of a function;
- X1, X2, ..., Xn - the quality of last level factors expressed in degrees of the common interval scale;
- b1, b2, ..., bn - equation parameters expressing the weight of each factor on the formulation of a function.

The long-term interactions of natural forces (external factors) in relation to human activities create a certain situation of dynamic equilibrium in the area. In the frame of this equilibrium, specific natural processes take place and formulate a given status for each non-timber function.

The spatial distribution of non-timber factors implies that non-timber functions cannot be inventoried and evaluated point by point but only on the base of an area unit. The size of the area unit for this study is set to the forest stand size as the smallest management unit detailed data are collected for. The evaluation of external and internal factors is done using data from the fieldwork of management plan. Some data (hydrography, distances, etc) results from the use of GIS applications.

Because of the variety of elements of biodiversity, and of differences between them, there is no single all-embracing measure of biodiversity-nor there ever be one. This means that it is impossible to state categorically what the biodiversity of

Criteria	*value*	q_i	g_i	q_i*g_i	Q_i	G_i	Q_i*G_i
[1] LANDUSE AND FUNCTIONS		*sum*	**100**	**367.5**	**3.68**	**16.25**	**59.72**
[1.1] Land use form	*Forest*	**4**	**33.75**	**135.00**			
[1.2] Management system	*High forest*	**4**	**33.75**	**135.00**			
[1.3] Main function	*Production*	**3**	**32.5**	**97.50**			
[2] STAND SITUATION		*sum*	**100**	**286.25**	**2.86**	**38.75**	**110.92**
[2.1] Stand structure	*Evenaged*	**1**	**6.25**	**6.25**			
[2.2] Forest type	*Broaleaves*	**4**	**21.25**	**85.00**			
[2.3] Crown density	*0.8-1.0*	**3**	**21.25**	**63.75**			
[2.4] Development stage	*Pole wood*	**2**	**18.75**	**37.50**			
[2.5] Vertical structure	*Single store*	**1**	**6.25**	**6.25**			
[2.6] Homogeneity	*Uniform*	**2**	**8.75**	**17.50**			
[2.7] Management intensity	*Low*	**4**	**8.75**	**35.00**			
[2.8] Stand origin	*Seeds*	**4**	**8.75**	**35.00**			
[3] SYLVICULTURAL ANALYSIS		*sum*	**100**	**227.5**	**2.28**	**21.25**	**48.34**
[3.1] Site capacity use	*High*	**2**	**38.75**	**77.5**			
[3.2] Stand quality	*Medium*	**2**	**33.75**	**67.5**			
[3.3] Tending status	*Low*	**3**	**27.5**	**82.5**			
[4] DEAD BIOMASS		*sum*	**100**	**187.5**	**1.88**	**23.75**	**44.53**
[4.1] Dead woods number	*High*	**3**	**43.75**	**131.25**			
[4.2] Liter layer	*Missing*	**1**	**56.25**	**56.25**			
					sum	***100.00***	***263.52***
SUITABILITY FOR BIODIVERSITY PROTECTION: $Q=\sum Q_i \cdot G_i/100$ $Q=2.64=3$							

FIGURE 5 - Interval scale for assessment of the factors influencing non-timber functions (adopted from Gatzojannis 1984, 2001).

an area is. Instead, only measures of certain components can be obtained, and even then, such measures are only appropriate for restricted purposes. Whilst one may feel uncomfortable with notion, it is important to realize that it also applies, though perhaps not so obviously, in making many other concepts operational. For example, the topic of complex system is attracting wide interest across a spectrum of fields of research, but there is no single measure of complexity (or simplicity for that matter). Instead, there are many measures, none necessarily any more correct than the other is, and which quantify rather different things.

For the purpose of this study, we have considered species biodiversity (β diversity) and ecological diversity (γ diversity) by measuring and evaluating species diversity in terms of special habitats, special biotopes, rare species, endangered species, endemic species; Ecological diversity, in terms of actual vegetation types, potential vegetation types, naturalness, and sustainability; as well as biodiversity indices. Following is a list of useful diversity indices:

- **Species richness**. Species number is the most natural indicator of species richness in an assemblage. We calculate species richness by tabulating the number of non-zero rows in the input vector and in the rarefied samples;
- **Family richness**. The number of families encountered in an assemblage;
- **Variety of biological forms** encountered in an assemblage;
- **Variety of chorological forms** encountered in an assemblage;
- **PIE**. Hurlbert's (1971) index calculates the probability of an inter-specific encounter (PIE). In other words, this index gives the probability that two randomly sampled individuals from the assemblage represent two different species. Let N equal the total number of species in the assemblage, and let p(i) represent the proportion of the entire represented by species i. PIE is calculated as:

$$PIE = \left\{\frac{N}{N-1}\right\}\left\{1-\sum_{i=1}^{s} p_i^2\right\}$$

There are several advantages of using PIE as a simple index of evenness: First, the index is easily interpreted as a probability. Second, this index is one of the few that is unbiased by sample size, although the variance increases at small N.

- **Dominance**. Dominance is simply the fraction of the collection that is represented by the most common species. Dominance can be a useful index of resources monopolization by a superior competitor, particularly in communities that have been invaded by exotic species. Like species richness, dominance is sensitive to sample size. In the extreme case of a collection of only 1 individual, dominance would always equal 1.0;
- **Shannon diversity index**. The Shannon-Weiner diversity index is calculated as:

$$H' = -\sum_{i=1}^{s} p_i \ln(p_i)$$

Where p(i) is the proportion the sample represented by species i, and ln is the natural logarithm.

The problem with H' (and with most diversity indices) is that it confounds species richness and evenness in a single number that cannot be interpreted biologically or statistically. If two communities differ in H', we cannot be sure whether this reflects differences in species richness, species evenness, or simply sampling differences.

RESULTS

The analysis of floristic inventory has shown the presence of 94 plant species grouped in 27 families. The biological spectrum is rich on Hemicriptophytae, and fits with the climate conditions of this area, located in the cold mountainous Mediterranean climatic zone. The chorological spectrum is rich on European and Euro-Mediterranean species that is normal for the geographical position of this forest economy, located in a mountainous area at the border between Mediterranean and continental European vegetation zones. The low presence of Steno-Mediterranean species indicates the low influence of human activities in the vegetation of this forest economy. Studying the inventory of plant species, we have identified 11 medicinal plants, 4 aromatic plants and 8 valuable food plants, as well as 10 endangered plant species. In order to help forest managers to better understand vegetation values we have prepared a list of indicatory forest plants.

The analysis of the floristic inventory (based on principles of Braun-Blanquet) of the selected forest economy using a computerized program (SYNTAX IV) helped us to identify the actual vegetation types (plant associations) occurring in the forest economy "Mbasdejë-Zall Gjoçaj". A detailed distribution of these associations is shown in Annex 6 "map of vegetation types" and the occurring associations are Fageto-Pinetum leucodermis; Daphno-Fagetum; Erico-Pinetum mixtum;

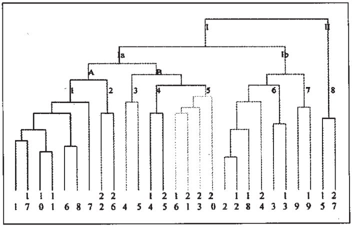

FIGURE 6 - Dendrogram of releves inventoried in the Forest economy "Mbasdejë-Zall Gjoçaj"

Querco-Frainettum cerris; Erico-Pinetum; Festucopso-Pinetum leucodermis; Genisto-Pinetum leucodermis; Quercetum trojanae; Asperulo - Fagetum.

Based on the general phyto-sociological classification of Albanian vegetation, the associations encountered in the forest economy of "Mbasdejë-Zall Gjoçaj" must belong to the Classes *Querco-Fagetea* and *Erico-Pinetea*. Main potential vegetation types are Fagetum sylvaticae; Pinetum nigrae; Quercetum sp., Abietum albae; Pinetum leucodermis; Pinetum peuceae; Riverine forests.

Analyzing the level of naturalness of forest stands, we found that the majority of them are natural forest stands and semi natural stands where harvesting is done, but the natural regeneration keeps its natural structure and composition. Only few stands, especially those close to settlements, are moderately altered (extensively managed stands with few elements of the natural structure that has been drastically changed by harvesting and grazing) or altered (extensively used forest, no natural elements).

Regarding special biotopes in this area we found a huge amount of natural or semi natural forests. Some other special biotopes include residuals of ex natural forests (associations of Genisto-Pinetum leucodermis and Festucopso-Pinetum leucodermis), wet biotopes and dry biotopes (at mountains peaks) of *Festucopsis serpentini* and *Pinus leucodermis*).

The following graph shows the values of main biodiversity indices for all the releves inventoried in this forest economy (please note that some of the values are transformed for comparison purpose).

The proposed approach constitutes the theoretical background on which an analytical and practical inventory and evaluation procedure for the non-timber forest functions is built. The three target systems provide for derivation of appropriate variables to be inventoried for the selected function (biodiversity preservation).

Evaluation of **external factors** leads to a division of the forest area into homogenous zones of similar function potentials and provides for appropriate land use planning measures at landscape level. Analyzing the results of external factors evaluation, we found that the selected forest economy shows a high ecological potential for the preservation of biodiversity. The fact that more than 90% of the stands number (95% of the area) are classified as medium (58% of the stands, 51% of the area) and high potential (35% of stands, 46% of the area), shows it clearly. We must con-

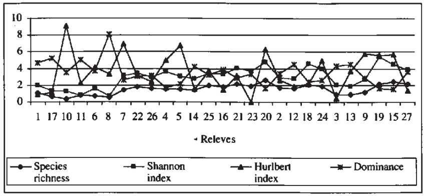

FIGURE 7 - Comparison of values of biodiversity indices.

sider here that the classification of some stands as low potential is because during data collection process, some of the variables are not evaluated for those stands.

Evaluation of the **internal factors** results in a grouping of the forest stands into groups with similar characteristics and provides for appropriate sylvicultural measures to improve stand performance with respect to the function (biodiversity preservation). It must be emphasized that at this point, forest stands are clearly distinguished by non-forest stands, whose internal factor value is zero. At the other hand, there is no stand classified as value 4, what shows the extent and complexity of variables considered that makes it impossible to have an optimum value for all of them in a single stand.

The analysis of the internal factors evaluation shows a good situation of forest stands, able to preserve biodiversity, as the majority of them (45% of the stands, 74% of forest stands, or 55% of the area, 75% of the forest area) are classified as value 3.

Evaluation of **biodiversity** identifies those stands having particularly high biodiversity values that need to be preserved and therefore, carefully treated during forest management activities. Generally, there is a uniform distribution of stands in three categories, respectively 32% of stands (24% of the area) with value 1, 34% of stands (42% of the area) with value 2, and 28% of the stands (31% of the area) with value 3. As we had already mentioned, there is no stand with maximum biodiversity values as result of the vastness and complexity of the variables considered. A more detailed analysis shows that only 19 stands have a biodiversity value more than 280, while only 4 of them reach a biodiversity value equal or above 300.

Overall evaluation help the forest manager to easily identify those stands that optimally fulfill the selected function (biodiversity preservation) and define the appropriate management alternative (treatment) for those stands that will be dedicate to biodiversity preservation. The analysis of overall results shows an almost equal distribution of stands in three categories (38%, 34% and 28%), although, the majority of the area falls in the category 2 (27%, 42% and 31%).

A production-oriented manager must be satisfied with the evaluation results, while a protection oriented manager with the desire to preserve some biodiversity values must thoroughly evaluate the results to find the necessary arguments for treating some stands for biodiversity preservation. This because there are no value 4 stands that will be automatically set under protection as "protected forest area" for the high biodiversity values it contains. If biodiversity preservation will be considered important, than it will be worthy to put under protection the 14 stands having the highest results.

However, the planning of sylvicultural measures for all the stands classified at value 3 must consider that these stands have high biodiversity values and the potential and ability to preserve those values thus the manager should foresee non-intensive interventions. In case these interventions are necessary, they must be followed by an accurate environmental impact assessment in order to avoid biodiversity deterioration and degradation.

The planning of sylvicultural intervention for stands classified at value 2 does not interfere to much to their ability to preserve biodiversity. So, these stands can be used for timber production or other intensive purposes without causing no damage to the biodiversity values of the forest economy. In any case, the harvesting or any other intervention must be environmentally sound in order to avoid any damage or degradation of the area.

Discussion

The studied forest economy is located on sites of relatively high species richness and ecological **potential**. The majority of forest stands are on good conditions and **suitable** for preserving and enhancing biodiversity values, including wildlife.

The presence of endemic species *Festucopsis serpentini* and *Genista hasertiana*, as well as the high naturalness level of some stands, considerably influence the quality of biodiversity values. In some cases, cautious human interventions enable the establishment of new biodiversity values (association 5 and 8).

The approach is based on a hierarchical system of evaluation that can be used for any specific forest function. The approach enables a rational use of the actual forest database, making them functional for any future study. The approach enables the use of complex evaluation ratings of different factors by transforming them to a single unit (interval scale).

The approach enables the establishment of a digitized monitoring system to evaluate dynamic developments of forest vegetation by numerical comparison of qualitative and quantitative aspects of a function formulation.

The approach enable numerical based decision making on priorities and management alternatives for each elementary unit, at different levels. This approach constitutes a useful decision-making tool for land use planning and forest management.

The variables selected as well as the codification of their values involve a high degree of subjectivity. Appropriately planned experimentation process is necessary to reduce the bias level and improve the reliability of this evaluation approach.

The appropriate implementation of operation research techniques, particularly in subjects related to qualitative variables of the systems, and the use of GIS in spatial analysis, provide the necessary tools and create promising prospects for a rational confrontation of the inventory techniques and evaluation of non-timber functions of forests.

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Riassunto

Questo lavoro intende ad elaborare un concetto metodologico per la valutazione dellla biodiversitta della vegetazione nei piani di assetamento forestale. Il metodo proposto constituisce la base teorica sulla quale si construisce l'intero proceso dell inebtario e valutacione pratico e analitico dei funzioni non produtivi dell bosco quale la preservazione della biodiversita. Per la valutazione della bio-

diversita della vegetazione a preso in consideracione sia la diversita e richezza delle singole specie anche la diversita delle associazioni. I tre sistemi hierarchici identificati per la valutazione della funzione "preservazione della biodiversita" provedono per una definizione e valutazione piu appropriata delle variabili che devono essere missurate e considerate nell processo valutativo. La valutazione dei fatori esterni permette la divisione del'area in zone omogenee riguardo al potenziale di sercitare la funzione. Ciò permete una pianificazione piu appriopriatta del uso del territori al livelo paesagistico. La valutazione dei fattori interni risulta in un ragrupamento dei soprasuoli in grupi con carateristiche simili, permetendo l'identificazione piu appropriata degli interventi silvicolturali che posono migliiorare l'esercizio della funzione prescelta (preservazione della biodiversita). La valutazione dei valori speciali della biodiversita serve a identificare quei suprasuoli che porano dei valori particolari da protegere, e per coi devone essere tratte con cautella nel proceso del assestamento forestale.

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Annex 1: Example of the calculation of the potential and suitability l of a stand for biodiversity preservation as well as special biodiversity values.

External Factors evaluated and quality classes (qi) and respective weights (gi).

Criteria	*Quality classes (q_i)*			
[1] CLIMATE (G_i = 12.5)				
[1.1] Climate zone (g_i = 32.5)	**4**	**3**	**2**	**1**
Mediterranean mountainous zone (east)	+			
[1.2] Average annual temperature (g_i = 21.25)	**4**	**3**	**2**	**1**
7-10 ∫C			+	
[1.3] Rainfall (g_i = 18.75)	**4**	**3**	**2**	**1**
1300-1800 mm/year		+		
[1.4] Winds (g_i = 13.75)	**4**	**3**	**2**	**1**
Wet marine winds				+
[1.5] Forst days (g_i = 13.75)	**4**	**3**	**2**	**1**
120 frost days per year				+
[2] POSITIONS (G_i = 16.25)				
[2.1] Phytoclimatic zone (g_i = 31.25)	**4**	**3**	**2**	**1**
Castanetum	+			
Fagetum		+		
Pinetum			+	
Alpine meadows				+
[2.2] Altitude (g_i = 23.75)	**4**	**3**	**2**	**1**
0-800 m	+			
801-1200 m		+		
1201-1600 m			+	
1601-2000 m				+
> 2000 m				+
[2.3] Aspect (g_i = 22.50)	**4**	**3**	**2**	**1**
N-NE				+
E			+	
SE		+		
S-SW	+			
W		+		
NW			+	
[2.4] Slope (g_i = 22.50)	**4**	**3**	**2**	**1**
0-10 %		+		
11-40 %	+			
41-70 %			+	
> 70 %				+
[3] SOIL (G_i = 23.75)				
[3.1] Geology (g_i = 11.25)	**4**	**3**	**2**	**1**
Limestone	+			
Ultra basic		+		
Flish			+	

Clay				+
[3.2] Soil type (g_i = 23.75)	**4**	**3**	**2**	**1**
Humic cambisoils			+	
Eutric vertisoils		+		
[3.3] Soil depth (g_i = 13.75)	**4**	**3**	**2**	**1**
Very shallow (<15 cm)				+
Shallow (16 ñ 30 cm)			+	
Medium (31-60 cm)		+		
Deep (> 60 cm)	+			
[3.4] Humidity (g_i = 18.75)	**4**	**3**	**2**	**1**
Dry			+	
Fresh	+			
Wet		+		
Very wet			+	
[3.5] Texture (g_i = 11.25)	**4**	**3**	**2**	**1**
Sandy (R)			+	
Sub-sandy (SR)		+		
Sub-clay light (SAL)		+		
Sub-clay medium (SAM)	+			
Sub-clay heavy (SAR)			+	
Clay (A)				+
[3.6] Humus layer (g_i = 11.25)	**4**	**3**	**2**	**1**
No humus layer				+
Thin (1ñ2cm)			+	
Medium (3ñ5cm)		+		
Thick (>5cm)	+			
[3.7] pH (g_i = 10.0)	**4**	**3**	**2**	**1**
Acid			+	
Neutral		+		
Basic	+			
[4] Erosion (G_i = 16.25)				
[4.1] Erosion level (g_i = 100)	**4**	**3**	**2**	**1**
No erosion	+			
Superficial erosion		+		
Deep erosion			+	
Land slide				+
[5] Presence of water courses (G_i = 12.5)				
[5.1] Presence of water courses (g_i = 100)	**4**	**3**	**2**	**1**
No				+
Few			+	
Medium		+		
Many	+			
[6] Human influence (G_i = 18.75)				
[6.1] Distance from settlements (g_i = 100)	**4**	**3**	**2**	**1**
0-1 km				+
1-2 km			+	
2-4 km		+		
> 4 km	+			

Example of calculation of potential for biodiversity preservation of a selected stand.

		c_i	p_i	c_i*p_i	C_i	P_i	C_i*P_i
[1] CLIMATE		*sum*	**100**	**256.25**	**2.56**	**12.5**	**32.03**
[1.1] Climatic zone		**4**	**32.50**	**130.00**			
[1.2] Temperature		**2**	**21.25**	**42.50**			
[1.3] Rainfall		**3**	**18.75**	**56.25**			
[1.4] Winds		**1**	**13.75**	**13.75**			
[1.5] Frost days		**1**	**13.75**	**13.75**			
[2] POZITION		*sum*	**100**	**231.25**	**2.31**	**16.25**	**37.58**
[2.1] Phytoclimatic zone	*Fagetum*	**3**	**31.25**	**93.75**			
[2.2] Altitude	*1430*	**2**	**23.75**	**47.50**			
[2.3] Aspect	*East*	**2**	**22.50**	**45.00**			
[2.4] Slope	*55%*	**2**	**22.50**	**45.00**			
[3] SOIL		*sum*	**100**	**306.25**	**3.06**	**23.75**	**72.73**
[3.1] Geology	*Ultra basic*	**3**	**11.25**	**33.75**			
[3.2] Soil type	*Humic cambisoils*	**2**	**23.75**	**47.50**			
[3.3] Soil depth	*Medium*	**3**	**13.75**	**41.25**			
[3.4] Soil humidity	*Fresh*	**4**	**18.75**	**75.00**			
[3.5] Soil texture	*Sub clay light*	**3**	**11.25**	**33.75**			
[3.6] Humus layer	*Thick*	**4**	**11.25**	**45.00**			
[3.7] pH	*Neutral*	**3**	**10.00**	**30.00**			
[4] EROSIONI		***No erosion***			**4.00**	**16.25**	**65.00**
[5] WATER COURSES		***few***			**3.00**	**12.50**	**37.50**
[6] HUMAN INFLUENCE		***0-1 km***			**1.00**	**18.75**	**18.75**
					sum	***100.00***	***226.02***
STAND POTENTIAL FOR BIODIVERSITY PRESERVATION: $Q=\sum Q_i \ G_i/100$							
Q = 2.26=2							

Internal Factors evaluated and quality classes (qi) and respective weights (gi).

Criteria	*Quality classes*			
[1] LAND USE (G_i = 16.25)				
[1.1] Land use categories (g_i = 33.75)	**4**	**3**	**2**	**1**
Forest	+			
Agriculture				+
Pasture/meadow		+		
Bare land			+	
Urban and infrastructure				+
Water bodies			+	
[1.2] Management systems (g_i = 33.75)	**4**	**3**	**2**	**1**
High forest	+			
Coppice			+	
Shrubs			+	
Pasture/meadows				+
[1.3] Main functions (g_i = 32.5)	**4**	**3**	**2**	**1**
Prodiction		+		
Protection			+	
Conservation	+			
Recreation				+
[2] DENDROMETRIC DATA (G_i = 38.75)				
[2.1] Stand structure (g_i = 6.25)	**4**	**3**	**2**	**1**
Evenaged				+
Unevenaged		+		
Close to nature	+			
[2.2] Stand type (main species) (g_i = 21.25)	**4**	**3**	**2**	**1**
Conifers				+
Broadleaves	+			
Conifers mixed with broadleaved			+	
Broadleaved mixed with conifers		+		
[2.3] Crowndensity (g_i = 21.75)	**4**	**3**	**2**	**1**
0-0.3				+
0.3-0.5			+	
0.5-0.7	+			
0.8-1.0		+		
[2.4] Development stage (g_i = 18.75)	**4**	**3**	**2**	**1**
Springs/seedlings				+
Young stand			+	
Mature stand		+		
Overmature stands	+			
[2.5] Vertical structure (g_i = 6.25)	**4**	**3**	**2**	**1**
Single storey				+
Two storey			+	
Multiple storey	+			
[2.6] Homogeneity (g_i = 8.75)	**4**	**3**	**2**	**1**

Homogenous			+	
Non homogenous	+			
[2.7] Management intensity (g_i = 8.75)	**4**	**3**	**2**	**1**
Low	+			
Medium		+		
High			+	
[2.8] Stand origin (g_i = 8.75)	**4**	**3**	**2**	**1**
Seed	+			
Sprouts			+	
Mixed		+		
[3] SYLVICULTURAL FEATURES (G_i = 21.25)				
[3.1] Site use intensity (g_i = 38.75)	**4**	**3**	**2**	**1**
Low	+			
Medium		+		
High			+	
[3.2] Stand quality (g_i = 33.75)	**4**	**3**	**2**	**1**
Low				+
Medium			+	
High		+		
[3.3] Tending situation (g_i = 27.5)	**4**	**3**	**2**	**1**
Low		+		
Medium			+	
High				+
[4] DEAD BIOMASS (G_i = 23.75)				
[4.1] Number of dead trees (g_i = 43.75)	**4**	**3**	**2**	**1**
Low				+
Medium			+	
High		+		
Very high	+			
[4.2] Litter layer (g_i = 56.25)	**4**	**3**	**2**	**1**
No litter layer				+
Thin			+	
Medium		+		
Thick	+			

Example of calculation of suitability for biodiversity preservation of a selected stand.

Criteria	*value*	q_i	g_i	q_i*g_i	Q_i	G_i	Q_i*G_i
[1] LANDUSE AND FUNCTIONS		*sum*	**100**	**367.5**	**3.68**	**16.25**	**59.72**
[1.1] Land use form	*Forest*	**4**	**33.75**	**135.00**			
[1.2] Management system	*High forest*	**4**	**33.75**	**135.00**			
[1.3] Main function	*Production*	**3**	**32.5**	**97.50**			
[2] STAND SITUATION		*sum*	**100**	**286.25**	**2.86**	**38.75**	**110.92**
[2.1] Stand structure	*Evenaged*	**1**	**6.25**	**6.25**			
[2.2] Forest type	*Broaleaves*	**4**	**21.25**	**85.00**			
[2.3] Crown density	*0.8-1.0*	**3**	**21.25**	**63.75**			
[2.4] Development stage	*Pole wood*	**2**	**18.75**	**37.50**			
[2.5] Vertical structure	*Single store*	**1**	**6.25**	**6.25**			
[2.6] Homogeneity	*Uniform*	**2**	**8.75**	**17.50**			
[2.7] Management intensity	*Low*	**4**	**8.75**	**35.00**			
[2.8] Stand origin	*Seeds*	**4**	**8.75**	**35.00**			
[3] SYLVICULTURAL ANALYSIS		*sum*	**100**	**227.5**	**2.28**	**21.25**	**48.34**
[3.1] Site capacity use	*High*	**2**	**38.75**	**77.5**			
[3.2] Stand quality	*Medium*	**2**	**33.75**	**67.5**			
[3.3] Tending status	*Low*	**3**	**27.5**	**82.5**			
[4] DEAD BIOMASS		*sum*	**100**	**187.5**	**1.88**	**23.75**	**44.53**
[4.1] Dead woods number	*High*	**3**	**43.75**	**131.25**			
[4.2] Liter layer	*Missing*	**1**	**56.25**	**56.25**			
					sum	***100.00***	***263.52***
SUITABILITY FOR BIODIVERSITY PROTECTION: $Q = \sum Q_i \cdot G_i / 100$ ***Q = 2.64=3***							

Biodiversity values evaluated and quality classes (qi) and respective weights (gi).

Criteria	Quality classes			
[1] STAND NATURALNESS (G_I = 33.75)				
[1.1] Actual vegetation type (g_i = 31.25)	**4**	**3**	**2**	**1**
Fageto - Pinetum leucodermis Horv 50			+	
Daphno - Fagetum		+		
Erico - Pinetum mixtum St 62		+		
Querco - Frainettum cerris Ht 58.		+		
Erico - Pinetum Horv.44			+	
Festucopso - Pinetum leucodermis			+	
Genisto - Pinetum leucodermis		+		
Quercetum trojanae St. 62	+			
Asperulo - Fagetum Mayer 64				+
[1.2] Potential vegetation type (g_i = 23.75)				
Fagetum sylvaticae				+
Pinetum nigrae			+	
Quercetum sp.		+		
Abietum albae			+	
Pinetum leucodermis	+			
Pinetum peuceae	+			
Riverine vegetation		+		
[1.3] Naturalness (g_i = 23.75)				
Artificial				+
Altered			+	
Moderately altered			+	
Semi-natural		+		
Natural	+			
[1.4] Sustainability (g_i = 21.25)	**4**	**3**	**2**	**1**
Climax	+			
Sub-Climax		+		
Degraded				+
Pioneer			+	
[2] SPECIAL FEATURES (G_I = 27.5)				
[2.1] Presence of special biotopes (g_i = 17.5)	**4**	**3**	**2**	**1**
Low	+			
Medium		+		
High			+	
Very high				+
[2.2] Presence of special habitats (g_i = 18.75)	**4**	**3**	**2**	**1**
Low				+
Medium		+		
High	+			
[2.3] Presence of endangered species (g_i = 23.75)	**4**	**3**	**2**	**1**
Low				+
Medium			+	

High		+		
Very high	+			
[2.4] Presence of rare species (g_i = 21.25)	**4**	**3**	**2**	**1**
Low				+
Medium			+	
High		+		
Very high	+			
[2.5] Presence of endemic species (g_i = 18.75)	**4**	**3**	**2**	**1**
Low				+
Medium			+	
High		+		
Very high	+			
[3] BIODIVERSITY INDEXES (G_i = 38.75)				
[3.1] Number of species (g_i = 16.25)	**4**	**3**	**2**	**1**
Low				+
Medium			+	
High		+		
Very high	+			
[3.2] Number of families (g_i = 10)	**4**	**3**	**2**	**1**
Low				+
Medium			+	
High		+		
Very high	+			
[3.3] Number of biological forms (g_i = 11.25)	**4**	**3**	**2**	**1**
Low				+
Medium			+	
High		+		
Very high	+			
[3.4] Number of chorological forms (g_i = 11.25)	**4**	**3**	**2**	**1**
Low				+
Medium			+	
High		+		
Very high	+			
[3.5] PIE index (Hurlbert's) (g_i = 16.25)	**4**	**3**	**2**	**1**
Low				+
Medium			+	
High		+		
Very high	+			
[3.6] Dominance (g_i = 16.25)	**4**	**3**	**2**	**1**
Low	+			
Medium		+		
High			+	
Very high				+
[3.7] Shannon index (g_i = 18.75)	**4**	**3**	**2**	**1**
Low				+
Medium			+	
High		+		
Very high	+			

Example of calculation of special biodiversity values of a selected stand.

Criteria	*Value*	q_i	g_i	q_i*g_i	Q_i	G_i	$Q_i \cdot G_i$
[1] STAND NATURALNESS		*sum*	***100***	***211.25***	**2.11**	**33.75**	**71.30**
[1.1] Actual vegetation	*Asperulo Fagetum*	1	31.25	31.25			
[1.2] Potential vegetation	*Fagetum sylvaticae*	1	23.75	23.75			
[1.3] Naturalness	*Semi natural*	3	23.75	71.25			
[1.4] Sustainability	*Climax*	4	21.25	85			
[2] SPECIAL FEATURES		*sum*	***100***	***98.75***	**0.99**	**27.5**	**27.16**
[2.1] Special biotopes	*Medium*	2	17.5	35			
[2.2] Special habitats	*Low*	1	18.75	18.75			
[2.3] Endangered species	*Low*	1	23.75	23.75			
[2.4] Rare species	*Low*	1	21.25	21.25			
[2.5] Endemic species	*Low*	1	18.75	18.75			
[3] BIODIVERSITY INDEXES		*sum*	***100***	**48.75**	**0.49**	**38.75**	**18.89**
[3.1] Number of species	*Low*	1	16.25	16.25			
[3.2] Number of families	*Low*	1	10	10.00			
[3.3] Biological forms	*Low*	1	11.25	11.25			
[3.4] Chorological forms	*Low*	1	11.25	11.25			
[3.5] E index	*Low*	1	16.25	16.25			
[3.6] Dominance	*Low*	1	16.25	16.25			
[3.7] Shannon index	*Low*	1	18.75	18.75			
				sum		**100**	**117.34**
BIODIVERSITY VALUE: $Q = \sum Q_i \ G_i / 100$ ***Q = 1.17=1***							