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Full Length Research Paper

Evaluation of the territorial system of forest recreation by natural indicators: Belgrade forest example

Sinan Destan[1]* and Sultan Bekiro lu[2]

[1]Department of Forest Management, Faculty of Forestry, Istanbul University, 34473 Bahcekoy/ Istanbul/Turkey.
[2]Department of Forestry Economics, Faculty of Forestry, Istanbul University, 34473 Bahcekoy/Istanbul/Turkey.

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The current study presents a method for establishing a complex recreation resource within a territorial system for forest recreation areas within the period of 1960 to 2008, using quantitative forest stand indicators. Use of the methodology for direct assessment of forest stands with recreational functions on the basis of natural indicators. The assessment is tied to performance of pre made "bioclimatical analysis" and requirements of recreational ergonomics of the site. The phases adhered includes I-Classifying the results from the conducted studies on plant succession and forest types. II- Inventory and assessment of stand recreation suitability by category. iii- Type and class of recreation occurring in the forest. iv- Calculation of the average coefficients of recreation suitability under various scenarios. The present study primarily targets an efficient forest management approach, in order to help planners in making the optimal decision for recreation activities in forests.

Key words: Recreation planning, forest recreation, suitability, Belgrade forest.

INTRODUCTION

One of the major problems of planning in the forestry sector is to estimate the specific number values for the set of indicators, which serve as the basis for the functional assessment of a given forest resource. Solving this problem requires digitizing each element or com-ponent influencing the studied forest function. Following this, it is necessary to establish, from a multi-aspectual perspective, the appropriate ecological, technical, social and economical criteria and factors in relation to the planned timber harvests. The next phase involves harmonization of the criteria and factors in question in an orderly system of interrelated natural indicators; and grouping these appropriately, establishes various criteria for assessing a particular forest function. To obtain such an assessment, it is necessary to possess a com-prehensive database for reference and comparison of data and legislative documentation. Unfortunately, such a global database does not exist yet.

Many studies deal with forest management and therefore, among the theoretical studies on functional assessment, those on forest recreation planning are more important for the purposes of this research. The literary sources containing concepts for functional assessment of a forest's recreation potential are usually based on themed maps, showing only the spatial pro-portions of landscape components.

One of the first who have included this component in their studies is Scharrel (1979) who, on the basis of biotope mapping conducted using plant criteria, developed maps showing a region's recreation suitability. Jaczewski (1981) also included forests as an important component of recreation. The studies by Weihs (1982) also focus on forest ecology. Burnett and Conklin (1979) for example, made functional assessments using 43 indicators divided into 5 groups, one of which is the flora. Deja (1981) defines recreation zones on the basis of forest ecology studies and forest stand age.

Bulev (1988) and Pehlivanoglu (1986) made their assessment on the basis of territorial quadrants using a system of indicators with plants being the main indicator. Pipkov and Petrov (1995) presented theoretical studies

*Corresponding author. E-mail: destans@istanbul.edu.tr. Tel: +90212 226 11 00. Fax: +90212 226 11 13.

Table 1. The short descriptions of the RZs are as follows.

Recreation zones	Name	Sub-zones	Total area (ha)	Zones for mass recreation (ha)	Buffer zones (ha)	Distribution of tree	Canopy cover
I	Valide bendi	17	26.62	6.83	19.79	Homogeneously	0.8
II	Ne et suyu	16	54.18	26.74	27.44	Homogeneously	0.9-1.0
III	F.R.Atay	11	27.22	18.32	8.90	Homogeneously	0.9-1.0
IV	Irmak	9	15.31	2.00	13.31	Homogeneously	0.9-1.0
V	. . rsoy	10	21.13	14.14	6.99	Homogeneously	0.9-1.0
VI	Kirazlı bent	8	12.51	2.06	10.45	Homogeneously	0.9-1.0
VII	Pa a kemeri	10	39.75	19.31	20.44	Homogeneously	0.9-1.0
VIII	Ayazma	7	37.47	18.36	19.11	Homogeneously	0.9-1.0
	Total	88	234.19	107.76	126.43		

for assessment of territories on the basis of landscape typology. A specific methodology for direct assessment of the recreation suitability of forest stands on the basis of forest typology was proposed and at the same time, applied by Destan (2001). On the basis of this methodology, the same author (Destan, 2007) defines the theoretical prerequisites for the concept of "age and period of recreation maturity of forest stands". Gale (2003) proposes a methodology for large-scale assessment of recreation of mountainous forest landscapes.

Recreation studies and assessments are based on established structural models, whose components are considered in a predetermined sequence corresponding to their significance (Vodenska, 1992). This means that each quantitative and qualitative indicator of a given recreation resource will be expressed as respective weights in the assessment. Another important part of the assessment is the selection of a limited number of most significant indicators, objectively characterizing the recreation resource. In addition, the opinion of Popova and Tishkov (1989) should be mentioned that these indicators should be balanced in their various aspects, that is they can either positively or negatively impact the assessment. It is obvious that there is a number of concepts and approaches for assessment of forest recreation resources. Discussing them in detail in one paper is impossible.

However, from the point of view of their characteristics and the tasks they solve, these can be grouped into four different categories: social-economic, landscape-architectural, ecological-silvicultural and a forest management category. The specialists for each category develop methodologies for assessment within the scope of competence of their scientific areas. The obtained results for these categories, however, are not sufficiently interrelated, that is, they lack the necessary coherence. This fact does not encourage the systematic planning and organization of the multi-purpose forest management.

The methodology in this study is attached for illustrative purposes only. One of the main purposes is to emphasize the proposed approach, which attempts to establish a system for assessment whose results can be used in forest planning.

Study area

The objects of the present study are the recreational zones of Bentler Forest District. The District has an area of 2622.07 ha and is part of Belgrade forest. The forests in question have the status of protective forests and are managed by Bahcekoy Forest Enterprise in Istanbul. The recreational and water management functions of these forests date back from the Byzantine Period. The natural indicators of 106 stands or parts of stands falling into 8 historically formed recreation zones (RZs) on the territory of the Forest District have been considered. Each RZ consists of two subzones: a zone for mass recreation (ZMR) and a buffer zone (BZ).

For clarity and ease, instead of using their names, the zones will be indicated by Roman numerals (I, II), and the subzones will be shown for each zone Z R, BZ; IIZ R, IIBZ, …, V Z R, V BZ. The ZMR are the areas which are visited by a large number of people and attract more than 90% of the visitors.

The BZs provide a smooth transition when entering the RZs and visually define the natural forest boundaries of the ZMR and separate them from the other areas with different uses. Depending on the category, type and class of recreation occurring in them, the ZMR are divided into groups, series and types of recreation landscapes with forested, semi-forested, semi-open and open areas (Table 1).

Approximately 98% of RZ area in the District is of the forested type of landscape with a canopy cover of 1.0 to 0.8. An exception is only RZ V, which has open areas with sports grounds and facilities for mass events with a total area of 1.29 ha. The stands have homogeneously distributed tree vegetation. Depending on their capacity, the service facilities (roads, car parks, toilets, water-supplying facilities, benches, shelters, etc.) have relatively the same concentration for all of RZ.

METHODS

Invoked methodology for direct assessment of the recreation suitability of forest stands on the basis of methodology is based on the classical concept of assessment of quantitative indicators. But it is synthesized and summarized to serve the forest management planning, forest recreation of the ecosystem basis. The assessment has been made from the point of view of forest recreation ergonomics[1], and deals with three levels (low, moderate and high) of physical activity characterizing recreational activities.

It is based on the bioclimatic characterization of the local weather, obtained through an analysis of the system of criteria and indicators proposed by Tishkov (1983). The results have been compared with the empirical standards for thermal comfort (ISO/DIS 13731, 1996), which has served as the basis for identifying the period for active recreation in a year (21 March to 10 September) Destan (2001). In fact, the traditional types of recreation in these forests have required suitable forested areas with a canopy cover of more than 0.8.

This enables the forest stands to be treated as regular forest ecosystems and be assessed on the basis of the respective reference databases and legislative documentation. It enables comparing the recreation potential of different stands as well as of whole recreation zones. Its validity can be controlled by comparing its results with real data about recreational activities and actual measurements. In order to obtain the necessary data about the studied areas, the research covers the period beginning in 1956, that is the year when the first recreation areas were established in the territory of Bentler Forest District. The assessments have been made as of the years 1960, 1970, 1980, 1998 and 2008.

These years partially coincide with the forest management plan periods (1964 to 1973, 1974 to 1989, 1990 to 1999, 2003 to 2012) which have provided the information about the forest stands' health condition, average diameter, tree species and tree species distribution by diameter, canopy cover, regeneration processes, live groundcover and dead litter etc.

This research has used the results from the forest recreation studies by Pehlivanoglu (1986), Caglayan (1999), Destan (2001) and Ozcan (2009) covering the periods of 1965 to 1985, 1995 to 1997, 1990 to 1999, 2005 to 2009 which have provided specific and accurate information. The rest of the information has been obtained from the forest managing agency: plans for development of the studied recreation zones, management documentation, photos and panoramic images containing valuable visual information about the assessment indicators. After presenting the phases of the used methodology, the study demonstrates a supporting example.

Phases of the method

Studies on the geology and flora, plant succession and forest types

A modern methodology for forest type identification has been proposed; it makes use of the synthesis between the dominant and floristic approaches to plant classification by Pavlov (1998). The approaches arerepresentative of the Ecological and Floristic Schools, respectively, of the plant succession studies. To establish the forest formations and types in Bentler Forest District, this study uses the results of the studies on soil properties and ecology by Kantarci (1980), the botanical studies by Yaltirik (1972), the floristic studies by Yonelli (1986) and the inventory, focused on forest types by Destan (2001).

The final results and the forest type mapping have been obtained by partial gradient analyses (of forest stands alone and of sets of factors characterizing the forest environment). For each forest type, comparative analyses have been conducted by site class and tree species; models of the succession processes in these ecosystems have also been made. Three types of forest formations have been identified (of Oriental beech, oak and chestnut); of these only the oak is represented by two forest types[2] (Destan, 2001).

The results have been analyzed and used to establish a numerical scale for stand ecosystem sustainability/non-sustainability. Each stand has been assessed on the basis of its classification by forest formation and its respective natural forest type. In addition, all factors and stand indicators used for the purposes of this study, on potential productivity, desired composition and ecosystem (species and structure) sustainability have been considered. The values of this scale have been used as base values for the calculation of the total recreation suitability coefficients (C_s^T) of a given stand. It is a 10-point scale under which, using indicators of form and structure, the current ecosystem condition of the stands is graded in comparison with the optimal one. The optimal condition is estimated by established optimal indicators (desired stand composition and structure, optimal productivity etc.) for the forest type to which a stand belongs. For ease of work, 11 groups of stands which have similar plant communities, composition, structure and productivity have been established for the studied zones. Each of them has an average base grade W_i^B) in the range from 5.0 to 10.0. The idea (underlying this approach is supported by the concept that, a natural forest fully corresponding to its site class, showing maximum productivity and sustainability with regard to form, composition and structure is, at the same time, the potentially optimal one as a complex recreation resource.

Inventory and assessment of stand recreation suitability

This phase covers inventory and assessment of stand recreation suitability by category, type and class of recreation occurring in the forest. Although the same Z are used, the inventory is differentiated with regard to the zone in which a stand grows. In the BZs stand is regarded as a whole and is managed under a single silvicultural regime, that is the general-to-specific approach is adopted. In contrast, in the ZMR the inventory, if necessary, is carried out by stand elements (the specific-to-general approach).

The total stand recreation suitability coefficient (C_S^T) is a function of the interrelations between several factors that are, in fact, the basic criteria adopted by the methodology. These are:

$$C_S^T = f\left(B; F; A; Sn; Er; Es\right) \quad (1)$$

where B is site class, F – form, A – average age, Sn – health condition (sanitary), Er – recreation ergonomics, Es – stand aesthetics. In the general case, the calculation of the current (real) stand recreation suitability (W_i^A) is made with its base grade (W_i^B) and its respective total correction coefficient (C_S^T):

$$W_i^A = W_i^B * C_S^T; \quad (2)$$

where C_S^T is a function of the correction coefficients ($C_S^{i(1-6)}$) of

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[1] Physiological level of comfort in a man in a given environment.

[2] The lack of beech and chestnut *archetypes* did not allow the identification of respective forest types.

Table 2. Correction coefficients of stand origin and form (kf).

Stand form	High forest - selection forest	High forest - coppice	Coppice – high forest	Coppice	Disturbed forests
Coefficient of stand origin	1.0	0.8	0.6	0.4	0.2

their respective factors in Equation (1):

$$C_T^S = C_S^B * C_S^F * C_S^{Sn} * C_S^N * C_S^H * C_S^{Er} * C_S^{VE} * C_S \quad (3)$$

where C_S^B, C_S^H, C_S^N and C_S are correction coefficients of inventory indicators; C_S^F is a correction coefficient of stand form; C_S^{Sn} is a correction coefficient of health condition; C_S^r is a correction coefficient of recreation ergonomics; C_S^{VE} is a correction coefficient of visual effect.

Correction coefficients of stand inventory indicators: In the calculation of the weighting of taxonomy, indicators of plantations have used tables for growth and productivity of plantations of oak, hornbeam, chestnut, ash, etc. (Poryazov et al., 2004) eastern beech, (Carus, 1998). The correction coefficients of stand inventory indicators are represented by: volume (C_S^B), average/dominant height (C_S^H), number of trees per hectare (C_S^N) and diameter class (C_S). These are estimated on the basis of established site indices and average diameters by tree species. The values for wood volume include: real stand volume V/ha (m^3), the volume of natural stands of the same tree species and real site class obtained from the yield tables V_T^{RB}/ha (m^3) and volume for first site class V_T^{IB} (m^3) from the same tables. In mixed stands, these volumes may be given only for the dominant tree species or if necessary, by tree species as a proportion of the total volume per hectare. The following ratios are calculated:

$P_1^i = V_i / V$ - tree species volume as a proportion of the total volume (V);

$P_2^i = V_i / (P_1^i * V_T^{RB})$ - tree species volume as a proportion of the volume yield table value (V_T^{RB});

$P_3^i = V_T^{RB} / V_T^I$ - as a proportion of the volume yield table value for first site class.

In turn, the correction coefficient C_S^N is represented by real number of trees per hectare (N/ha) and the ration, number of trees for real site class to number for first site class. The correction coefficient of average height (C_S^H) is calculated on the basis of average (dominant) stand height, the values of the height ratios between a standard stand height (obtained from the yield tables for first site class) and these for the rest of the site indices (height ratio/). The justification of this approach lies in the fact that the average/dominant stand height is adopted as one of the three (V/ha,and N/ha) most important indicators of recreation suitability. These indicators are interrelated but depending on the tree species and stand form, the average heightsshow significant differences. Thus, the average heights for the same volume site class may be different. The indicators in question are directly related to the emotional impact, accessibility and visibility of forest stands which are essential for forest recreation. Differentiated height ratios per tree species (D_{Hi}) are calculated in the same way as the correction coefficient of site class but instead of P_3^i, the height ratios are used with their values obtained from the tables for site indices and age classes by tree species.

The calculation of the correction coefficient of diameter class (C_S) may be made with the diameter classes per tree species or directly by using an average stand diameter. The choice depends on the study aims. In this study, the following coefficients of diameter class are used: <8.0 cm – 0.5; 36.0÷51.9 cm – 0.8-0.9; >52.0 cm –1.0. As far as its impact is concerned, the correction coefficient of diameter class (C_S) has the same balancing effect as the rest of the correction coefficients.

Correction coefficient of stand form: This coefficient is related with stand origin, management practice and timber harvest rotation ( ). According to Bogdanov (2002) "the timber harvest rotation as an important management element also influences the protective and recreational function of forests. The rotation determines the frequency of regeneration cuttings and the rotation period reduction or extension may regulate the protective and recreational function of forests; therefore, it can be adopted as an important corrective of the evaluation of intangible forest assets".

For the correction coefficient calculation, the same author proposes the use of the ratio T/100 where the average rotations are adopted in accordance with the management practices of the respective country. The values calculated in this way will be in the range from 0.5 to 1.5. However, in Turkey, in agreement with the accepted rotation periods (Asan, 1998) the following correction coefficients are calculated (Table 2).For the calculation of the C_S^F of high forest-coppice stands (V> V) and coppice-high forest stands (V> V), volume proportions are used with the aim of a more accurate calculation of their differentiated proportions (D_F^i = V* kf). Correction coefficient of stand health condition: This coefficient represents a general assessment made on the basis of the health condition of the main stand elements: growing stock, live groundcover dead litter and topsoil. The health condition is assessed by inventory of dead and damaged trees in a stand according to indicators such as: growth rate (comparison of the average height with the respective values in the growth tables), density (presence) of leaves with the following grades: 1/5–2/5 - strongly damaged foliage, 3/5 – moderately damaged foliage, 4/5 – slightly damaged foliage, normal foliage, undamaged foliage; leaf colour, condition of roots and stems depending on the presence of mechanical damage, insect or fungal pests, which is graded in the same manner.

The number of dead trees (P_m) is expressed as a ratio to the total number of trees in a stand, which is accepted to be 1.0. To determine the proportion of dying and damaged trees (P_p), the data on stand vigour, obtained from forest protection studies are used (Roloff, 1991; Schüts and Barnola, 1996; Dobbertin and Brang, 2001; Schüts 2001a,b; Balci, 2008). The number of damaged trees (P_p) is reduced by the coefficient of vigour (k_{ds}) whose values depend on the trees' chance to survive and develop fully. For ease of inventory and calculation, k_{ds} has been assigned average values: for severely damaged trees – 0.3, for moderately damaged – 0.5, and for slightly damaged – 0.8. If necessary, these coefficients may be calculated by tree species. Differentiated proportions are considered to be only the remaining healthy trees and the potentially healthy ones of those classified as damaged:

$$D_S^i = 1.00 - P_m + (P_p * k_{ds}) \quad (4)$$

The health condition of live groundcover (D_P^{uc}) and of dead litter (D_{Pltr}) are estimated on the basis of their quantity and quality. The inventory results on groundcover and litter are compared to the results for the forest type, a stand belongs to and if necessary, the degree of damage and degradation is recorded. The area of completely damaged live groundcover and dead litter (P_d) that is part of the total area is subtracted from it. The area of damaged live groundcover and dead litter (P_p^i) is corrected by coefficients of damage (k_p = 0.3; 0.5; or 0.8) and its differentiated proportion is estimated:

$$D_P^{uc} = 1.00 - P_d + (P_p * k_p) \quad (5)$$

$$D_P^{ltr} = 1.00 - P_d + (P_p * k_p) \quad (6)$$

The topsoil condition is graded as non-compacted topsoil (κ_{p1} = 1.0), slightly compacted (κ_{p2} = 0.8), moderately compacted (κ_{p3} = 0.5), heavily compacted (k_{p4} = 0.3), erosive (k_5 = 0.1). Topsoil compaction, that is topsoil consolidation, is estimated with a pocket penetrometer and under a scale of four degrees as follows: 0.5 to 1.5 – weak, 1.6 to 2.5 – medium, 2.6 to 3.5 – strong, >3.5 – borderline. The device is used for areas in which there are visible indications such as lack of live groundcover ordead litter, topsoil loss and erosion, exposed tree roots etc. The results of the samples taken per stand (which are at least 30) are averaged. The coefficient of soil erosion takes into account the area but it does not reflect the erosion type and degree. The differentiated proportions (D_{Sci}) are calculated in a similar way as that of formulas (4), (5) and (6). The end value is the product of the differentiated proportions of the three stand elements:

$$C_S^{Sn} = D_S^i * D_P^{uc} * D_p^{ltr} * D_{Sk}^i \quad (7)$$

Correction coefficient of stand recreation ergonomics: The coefficient is estimated according to the criteria for stand accessibility and visibility. The accessibility criterion reflects the ease of access into the stand for a visitor making certain physical effort[3]. It mainly depends on terrain slope measured within the following ranges: 0° to 4°, 5° to 10°, 11° to 20°, 21° to 30°, > 30ë and on stand density (N/ha) . As with the other indicators, accessibility is assessed using grades which in this case, are: unlimited accessibility, high, medium and poor with the following values: 1.0, 0.8, 0.5, 0.3 and 0.0. The stand parts are assigned an accessibility grade value and their corrected proportions are estimated. Their sum subtracted from 1 is the necessary differentiated proportion of accessibility (see formulas (4), (5) and (6).

Stand visibility is the average distance (m) from which there is a full front view of a human figure. In many cases the factors that impact visibility and accessibility are common: terrain slope, density and average height of understorey and groundcover, stand density, presence of natural physical barriers, poor drainage etc. Although the methodology by Destan (2001) makes it possible to estimate visibility theoretically, it has been estimated empirically. To do this, a laser distance meter has been used. Thus, the distance and understorey/groundcover impact are estimated directly. The 100 m distance is accepted as one (1.0) and the shorter and longer distances are expressed as tenths of it. A 10 m distance step is used in the calculations. The measurements are made from several points in each plot in at least 8 directions; 4 of them are the main ones (east, west, north, south) and the rest are decided upon by the inventory crew member. The calculated values are used as correction coefficients of stand visibility.

After estimating the corrected proportions (P_{Vi}), thedifferentiated proportion (D_{Vi}) is calculated. The requiredcorrection coefficient (C_{SSn}) is the product of the twodifferentiated proportions (D_{Vi} D_S^i). Correction coefficient of visual impact in a Z R: The coefficient represents the attractiveness of plants found in a stand, the plant species and shape diversity, the interesting (for the visitor) plant communities, the seasonal leaf coloration of tree species and of forest floor vegetation, the change of aspects and fluctuations, the visual perception of morpho-sculptural relief formations. The respective forest type with its uniquely characteristic visual environment, serves as the basis for comparison with the real condition of the studied stand, that is assessed as a whole or as parts. The specific stand condition identified as a result of terrain observations is also considered. In this study, the correction coefficients are estimated by a simplified but efficient enough method for its purposes[4].

C_S^{VE}

In the score system used, the of uniquely characteristic visual environment is accepted as one (1.0), and the positive and negative factors correct the coefficient with +0.1 or –0.1. To this

[3] The average physical abilities of a healthy 40-year-old person are accepted as a norm. This is the average age of people participating in mass recreation activities in forests.

[4] The simplified and adjusted score system of Pehlivanoglu (1986).

end, the results of targeted inventory were grouped and evaluated under the above categories. While local and validity on the basis of these estimates, was established suitable for the purpose of the

scoring system. The corrected differentiated proportions (D^i_{Es}) are calculated only for the active recreation period (20 March to 10 September).

Correction coefficient of recreation proportion of stands in a BZ: The methodology used requires estimating the correction coefficient of recreation proportion (K^i_{RP}) of stands in BZs in relation to Zs R. The purpose of this is to estimate the visual and recreation potential which a stand in a buffer zone can have being at the point of access to/exit from a Z R. Besides these stands, defining the boundaries of a ZMR, also contribute to its qualities. The factors on which the coefficient depends are, part of the length of the stand

boundary defining a ZMR l_i (m), area f_i (ha) and panoramic f^i_p (ha) contribution of a BZ stand, stand recreation suitability W_{iA}. Stand panoramic contribution is the area which can be observed from a ZMR and depends on the relief.

In addition to that, the panoramic contribution expressed in hectares is corrected by a number of factors such as, number of vistas (objects in the distance), aesthetic features of silhouettes, contours and mosaic patterns of relief during the active recreation period (ARP) etc. With few exceptions (only one stand), the studied zones did not require this correction and therefore unnecessary details about it are omitted on purpose. The following equation has been used:

$$K_{RP}{}^{i} = \left[\left(f_s{}^{i} / F\right) * \left(l_s^{i} / L\right)\right] * W_i{}^{A} * \left[\left(f_p{}^{i} / f_s{}^{i}\right) + 1\right] \quad (8)$$

where F – is the total area of stands in a buffer zone (ha), L – the length of the common boundary between a BZ and a ZMR (km).

Calculation of coefficients of significance of landscape components

Due to the lack of empirical data about forest recreation, the six criteria above are considered with an equal weight, in the calculation of stand recreation suitability. As it has been explained, the criteria used in the methodology, in accordance with their nature are graded, measured and averaged on the basis of scales and table indices. The approach of this study, to a great extent, has overcome the subjectivity in the assessment of recreation resources in relation to the specific category of recreation.

Summary and generalization of assessments by recreation zone and forest district

First, the summary of assessments has been made by subzone (BZ and ZMR), separately for each RZ. Depending on the zone in which a stand is located, this stand is expressed in the total assessment with its Coefficient of Complex Recreation Suitability (CCRS) and area. Then, the assessments are generalized for the whole Territorial System for Forest Recreation (TSFR) of Bentler Forest District. In turn, each subzone is expressed with its total CCRS and area.

After this necessarily short description of the used methodology, an example of the calculation procedures of part of the representative stands of Z R is presented below.

Example: The studied stand has a normal canopy cover, site class II, average diameter of 24 cm and tree composition: 70% Oriental beech, 20% oak and 10% hornbeam. The volume density (Vstand/Vtabl.) calculated on the basis of the dominant tree species is 0.63. The stand area expressed as part of the total ZMR area is fi/F = 0.188. According to the forest type assessment the base

grade is W_{iB} = 10.0. Oriental beech belongs to site class II and age class V, oak – site class II, age class V and hornbeam – site class III and age class IV. Hornbeam is of coppice origin and therefore the stand is classified as a high forest – coppice stand with a coefficient kf = 0.8 (Table 2); the coefficient of stand origin is:

$$C_{SF} = 1.0 - (V \quad * \text{kf}) = 1.0 - (0.100*0.8) = 0.92$$

With regards to the average diameter of the three species, it is in the range of 23.0 to 26.0 cm (diameter class C). This relatively homogenous distribution of diameters has allowed the calculation to be made using only the coefficient of average weighted diameter

(24.0 m, C_S = 0.731). Differences in average diameters will require the application of the differentiated approach. The site class coefficients of Oriental beech, oak and hornbeam are: volume ratios ($V^{I_{bon}} / V^{i_{bon}}$) – 0.835, 0.813, 0.749, height ratios ($H^{I_{bon}} / H^{i_{bon}}$) – 0.916, 0.846, 0.695, trees per hectare ratios ($N_{I_{bon}} / N_{i_{bon}}$) – 0.887, 0.912, 0.938.

The proportional volumes of the tree species, oriental beech, oak and hornbeam, occurring in the stand are 0.701, 0.199 and 0.100, respectively.

The stand accessibility is 80% due to the 15% inaccessible area with poor drainage and areas (10%) with a slope of 11° to 20°. The average visibility depth is 110 m. On the basis of these values, the differentiated proportions are:

D_{Sci} = 1.00 – 0.15 – (0.10 * 0.5) = 0.80; and D_{Vi} = 1.1, $C^{Er}_S = D^i_{Sc} * D^i_V$ = 0.80*1.1= 0.88

The data on the stand health condition are as follows: in the category of growing stock 5% are dead trees (P_m), 50% - damaged, dying, infected and mechanically damaged trees (P_p) (which are graded as follows: 30% have k_{ds} =0.8, 15% to 0.5, and 5% to 0.3), there is no understorey and shrubs, live groundcover is typical on 40% of the stand area, in 20% of the area it is completely damaged, in 20% - strongly damaged and in 20% - slightly damaged, there is no dead litter on 35% of the area and 15% are strongly damaged, 30% of topsoil are heavily compacted, 10% - moderately compacted, 10% - slightly compacted. Calculated with formulas (4), (5) and (6), the values of D^t_S, D^t_{Sl}, D^{uc}_S and D^{ltr}_P are 0.780, 0.720, 0.560 and 0.695, respectively. Using formula (7) C_S^{Sn} = 0.219. For ease and practical considerations, the first phase of the simplified calculation procedure is presented in Table 3.

The obtained primary total coefficient of recreation suitability (C_S^P) is multiplied by the correction coefficients C_S^{Er} (0.88) and C_S^{Sn} (0.219). The result (0.4549) is only for the studied stand but it does not show the weight of the stand area in proportion to the

Table 3. Calculation procedure for estimating primary total coefficients of stand recreation suitability (C_S^P).

Tree sp.	Site class	P_{i3} (Vi/Vt)	C_S^F	(Vs/Vt)	C_B^S	C_H^S	C_N^S	$P_{i3} * C_B^S$ (3*6)	C_P^S (9*7*8)*4
1	2	3	4	5	6	7	8	9	10
F	II	0.701			0.835	0.916	0.887	0.585	0.4753
Q	III	0.199	0.92	0.63	0.813	0.846	0.912	0.162	0.1250
C	III	0.100			0.749	0.735	0.833	0.075	0.0459
Total		1.000							0.6462

Table 4. Calculation procedure for estimating the total coefficient of recreation suitability of a ZMR (W_i^A) and recreation proportion of stands.

Z R	Stand	Primary coefficient (C_S^P)	Visual assessment (C_{VE}^S)	Basic recreation suitability (C_T^S) (2*3*4)	Base grade W^B ( )	Recreation suitability W^A ($_i$) (5*6)	Stand area proportion (f / F)	Area correction (W_i^A) (6*7)	Recreation proportion in theZMR (w/wi)
Plot	1	2	3	4	5	6	7	8	9
178	8Fr+1Q+1C (d3)	0.5410	1.1	0.5951	10	5.951	0.115	0.6844	0.1500
179	10Q (d3)	0.0392	1.0	0.0392	10	0.392	0.095	0.0372	0.0082
	8F+2C (dc3)	0.0470	1.0	0.0470	10	0.470	0.085	0.3995	0.0875
181	6Q+3Fr+1C (dc3)	0.1620	1.0	0.1620	10	1.620	0.125	0.2025	0.0444
	5Pn+5Pb (cb3)	0.0080	0.7	0.0056	7	0.056	0.085	0.0048	0.0002
206	7F+3C (dc3)	1.3161	1.0	1.3161	10	10.316	0.171	1.7640	0.3867
207	7F+2Q+1C (c3)	0.4549	1.0	0.4549	10	4.549	0.323	1.4693	0.3221
Total		2.5695		Total			1.000	4.5617	1.0000

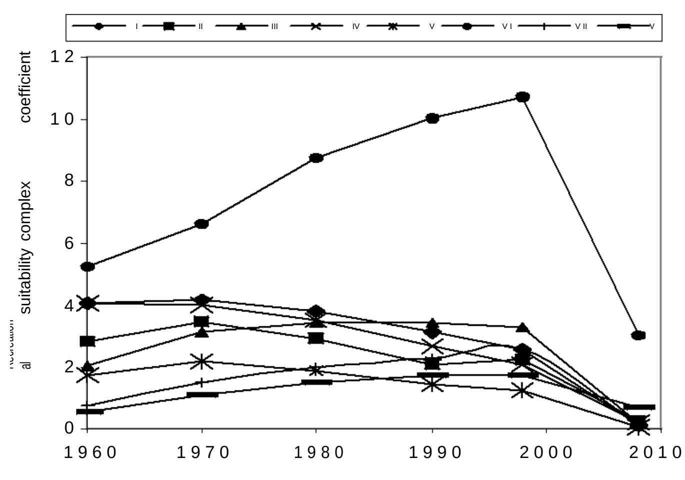

Figure 1. The curves of recreation suitability complex coefficients (RSCC) of the mass recreation zones.

recreation subzone area.

The second phase of the calculation estimates the total assessment of recreation suitability of the whole subzone (W_{ZMR}^A) (Table 4 and Figure 1) . The third phase is the calculation of the assessment of current (real) recreation suitability of the whole territorial system of forest recreation (W_{TSFR}^A) (Figure 2) . The calculations are similar to those in Table 4 (columns 6, 7 and 8) but they also take into account the area proportions of the TSFR and W_{iA} (Table 5). The fourth phase is the calculation of the real-potential (W_i^{RP}), theoretical (W_i^T) and hypothetical (W_i^{Hip}) coefficients of recreation suitability of a ZMR and of the whole TSFR. To do this, depending on the coefficient that is being calculated, different factors are considered.

The calculation procedure for estimating the recreation suitability of buffer zones is the same but instead of the visual assessment (C_{VE}^S), the correction coefficient of recreation proportion (K^t_{RP}) is

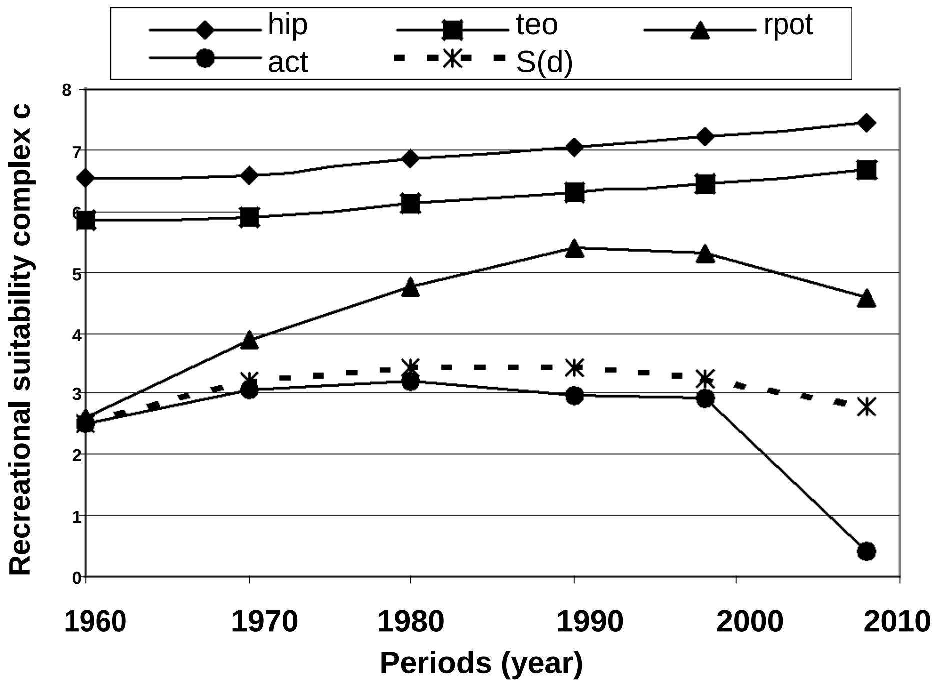

Figure 2. The curves of Rekreasyonel suitability complex coefficients (RSCC) of the mass recreation zone's (ZsMR) system.

Table 5. Calculation procedure for assessment of current recreation suitability of the whole territorial system for forest recreation (W^A_{TSFR}).

Zone for mass recreation (ZMR)	Area proportion (f/F)	Recreation suitability W^A_i	Area correction W^A_i
IZMR	0,140	2,552	0,357
IIZMR	0,146	2,201	0,322
IIIZMR	0,124	3,241	0,403
IVZMR	0,132	2,071	0,273
VZMR	0,096	1,246	0,120
VIZMR	0,076	10,724	0,810
VIIZMR	0,148	2,569	0,380
VIIIZMR	0,138	1,753	0,242
Total	1,000		W^A_{TSFR} = 2,907

used.

RESULTS

In the calculation of the real-potential coefficient of recreation suitability (W_i^{RP}) all factors are expressed with their current (real) values, and C^{Sn}_S and C^r_S - with their maximum values that is, it is accepted that the stands are in good health condition and are high forests. In the calculation of the theoretical coefficient (W_{iTheo}) the base grades are real ($W_{i\,B}$) but all other factors are expressed with their maximum values. In the calculation of the hypothetical coefficient ($W_{i\,Hip}$) all factors are expressed with their maximum values. To analyse the development of the total health condition of all ZsMR and of the tree species only, the curves of C^S_{ZMR} (Figure 4) and S(d)

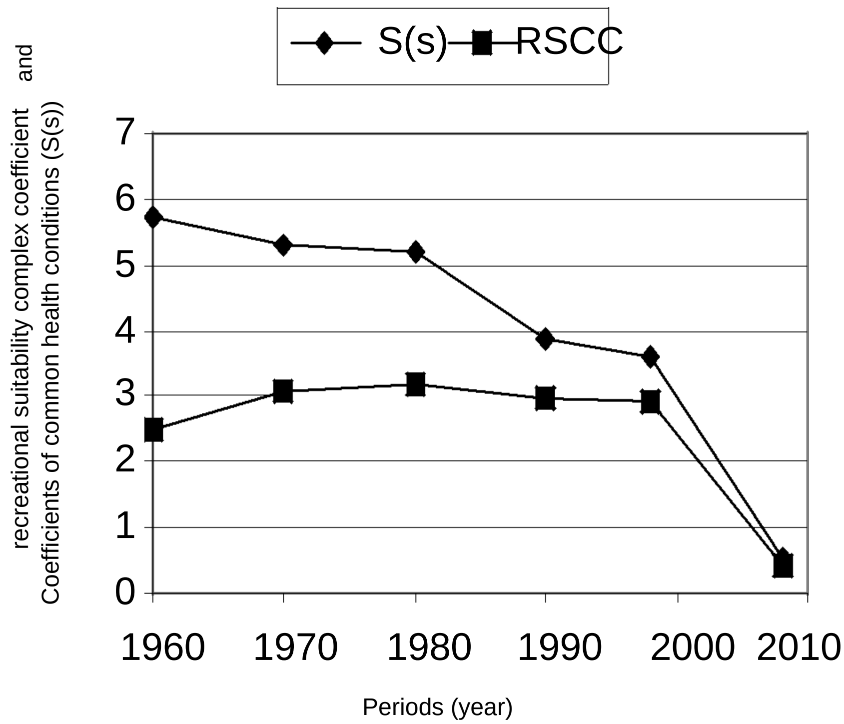

Figure 3. A comparison between the curves of recreational suitability complex coefficients (RSCC) of mass recreation zone's system and the curves of coefficients of common health conditions (S(s)).

(Figure 3) have been calculated. For this purpose, the calculation of S(d) eliminates the health condition of live groundcover and dead litter, understorey and topsoil. The calculation of C_{ZMR}^{S} uses only the factors related to the stand health condition.

Depending on the aims and issues they cover, the results are presented in graphs.

As mentioned, the methodology allows for a detailed analysis of individual components, recreational areas and across territorial system of forest recreation. In view of the universality, the topic is presented as an analysis of all studied system.

The curves of the current coefficient W_{ZMR}^{A} and of the health condition of tree species (S(d)) have almost the same values and trend of development until 1970 (Figure 2). This is due to the fact that, the values for the tree species health condition and all other differentiated estimates (D_{ii},..., D_{ni}) used for the calculation of the C_S^{Sn} are used with their maximum values in the assessment. After 1970 the curve S(d) continues its smooth increase whereas W_{ZMR}^{A} maintains its value around 3.0 due to the reduction effect of the D^{t}_{Sl}, D^{uc}_{S}, D^{ltr}_{P} and on the C^{Sn}_{S}.

After 1998, this effect increases sharply and leads to the descent of the total recreation suitability. In 2008, the coefficient of complex recreation suitability obtained its minimum value and by 2010, the territorial system for forest recreation will obviously lose its suitability completely. In 1990, the curve S(d) continues its smooth decrease and will reach its minimum value 30 years after the total suitability. This fact, along with the enormous difference between the demand and supply in favour of the demand, is the only reason for the ongoing recreation activities in this TSFR. From a practical viewpoint, the recreation stand potential is shown by the curve W_{ZMR}^{RP}.

This is mainly due to the assumption that the C_S^{Sn} has a maximum value and the stands are classified as high forest stands. Obviously, both factors increase their effect with the increase of the average stand age. At the same time, the assumption that functional ZMR stands can always maintain good stand condition is, of course, debatable; however, moderate utilization and efficient protection of the landscapes will make this possible. It is necessary to point out that the curve S(d) would have a higher trajectory in the coordinate system, if the C_{SF} had a maximum value that is all stands were high forest stands.

In addition, high forest stands are significantly more long-lived and more resistant and therefore the real

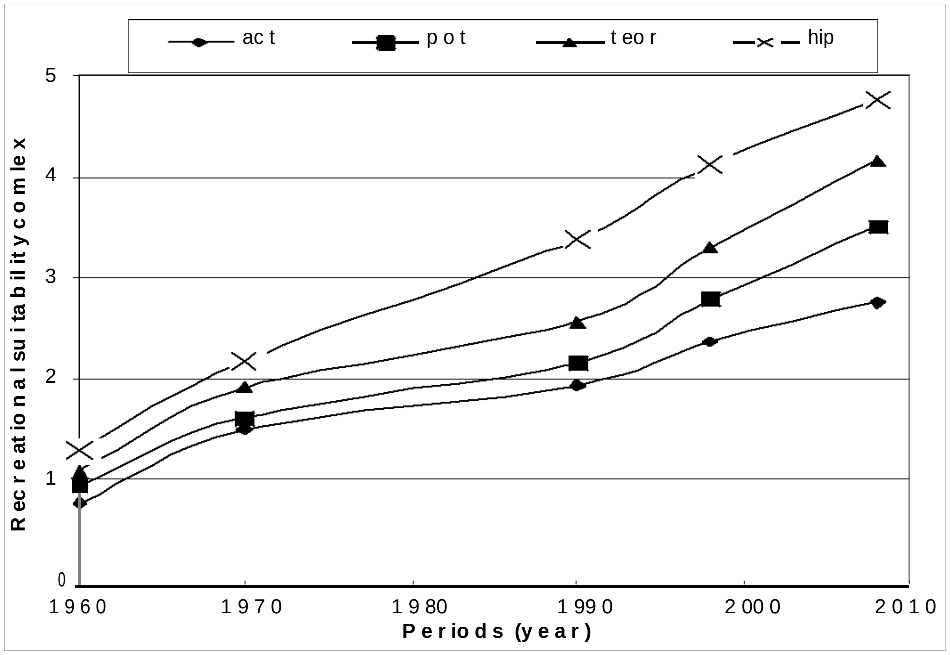

Figure 4. The curves of Rekreasyonel suitability complex coefficients of the buffers recreation zone's system.

trajectory will be even higher than the one calculated with S(d) max.

The course of W_i^{Theo}, shows the development of a completely optimized forest recreation environment in which only the base grade is real. It is a smoothly ascending line because its calculation does not include reduction factors (with the exception of $W_{i\ B}$). It may serve for comparison as a theoretical norm for the design of a TSFR not only in Bentler Forest District. The course of W_{ZMR}^{Hip} shows the ideal condition of a TSFR which can hypothetically be achieved after comprehensive ecosystem analyses, ecological management and special visitor access into this recreation site.

In the buffer zones the course of all functions shows a marked increase. With the exception of W_{BZ}^{Hip}, all curves are S-shaped. These stretching S-shaped curves bear a resemblance to the increase in stand volume. This is normal because these stands do not have health problems caused by recreation activities and therefore the reduction factor C_{SS}, is expressed with its minimum value. The curves W_{TZ}^{RP} and W_i^{Theo} continue, although slightly, to increase their angle while W_{TZ}^{Hip} and W_{TZ}^{A} maintain their course. The angle of W_{TZ}^{A} is smaller than that of W_{TZ}^{Hip} even with a slight hyperbole, due to the recreation activities. All functions show a higher increase although they start from smaller values (between 1.0 and 2.0) than those of the ZsMR. This is due to the fact that the stands occurring in the BZs are (two age classes) younger and therefore demonstrate a faster development of their recreation indicators.

Figure 2 shows the curves of the individual development of each ZMR. While the curves of recreation suitability of IIIZ R, V Z R and V Z R are ascending, the curves of Z R, IIZ R, IVZ R and VZ R are des-cending. It should be pointed out that the curve of V Z R starts from a higher point and is steeper than the rest but with an even steeper decrease after 1998 to 2000. One of the reasons is that, in the zones with descending curves, the recreation activities have started earlier than in the others. V Z R was a zone with a special use which meant a strictly controlled visitor access until 2002; after that it was open to the public. In addition, it has sandy clay topsoil which for a certain period of utilization, has delayed the soil compaction and degradation.

From a theoretical as well as a practical viewpoint, Figure 3 is very important because the curves W_{ZMR}^{A} and C_{SS} (indicated with S(s) in the figure) are graphically compared. In 1960 S(s) had a high value and until 1970, it almost did not obstruct the increase of W_{ZMR}^{A}; after 1980 the curves were parallel. That means that the health condition of the TSFR, has maintained its level and together with the rest of the factors, a period of equilibrium of the CCRS had set in. The decrease of S(s) from 1980 to 1990 is compensated by the relatively rapid increase of the other factors and especially of the accessibility and visibility as a result of thinnings. From 1990 to 1998 the second period of equilibrium sets in and then it is followed by a descent of both curves. In 2008, the curves coincide which proves the completely dominating effect of C_{SS} on $W_{ZMR}{}^{A}$ in this period.

CONCLUSIONS AND RECOMMENDATION

The proposed methodology by the authors of this study for assessing of TSFR is based on the main principles of the environmental approach, forest and landscape inventory. The method is fully applicable and is mainly based on quantitative and partly on the quality indicators for forest and stand types. Due to the lack of studies on forest types, the results of expert evaluations may be used. The methodology content defines its strengths: comparability and relevance of results, desired depth and an option for selection of assessment elements and criteria, analytical assessment that is number values for assessed indicators which allow for mathematical and statistical analyses of results. This accessible and applicable methodology is proposed, to facilitate the practice of forest management in planning forest recreation areas. Because it gives information for evaluating and making decisions on multipurpose individual tree, group of trees, a whole stand, health condition and ergonomical indicators.

Furthermore, it contributes to the establishment of groups and types of series intended for recreational spaces. Weakest link in the methodology applied in the determination of the visual effect of plantations. It is partial because it is only based on the concept of interdependence of the forest type typical for its visual environment and additional factors positive or negative effect. But take into account and studies Pehlivanoglu (1986) and Caglayan (1999) for views of visitors, the results are fully consistent with our approach. They are practical, but must be updated and upgraded, such as studies of Horn et al. (2005) and Tahvanainen et al. (2001). Both studies aimed at testing the preference of visitors for the management of forest recreation uses. Particularly important in shaping the strategy planning of recreation is the practical combination of aesthetic and ecological values in forest management. For example, such is the purpose of Tyrväinen et al. (2003), who studied public opinion against these values in the planning process. In these studies already exists feedback between the home and environment, where the planning process is influenced by preferences and alternatives. But in terms of practical application, are the most important results of research (e.g Silvennoinen et al., 2001) associated with quantitative components of forest stands, which affect the visibility, accessibility and their combinations as weight variables.

Within the results and the analysis in this study, we can make the following practical conclusions: when linking the curves' course with the visitor statistics (recreation rate) in the area, it turned out that in 1975 to 1985, the average number of visitors per year was 2,515 visitors/ha, in 1990 – 3,898 visitors/ha, in 1998 – 7,899 visitors/ha, in 2002 – 9,104 visitors/ha, in 2004 – 9,280 visitors/ha, in 2008 – 11,136 visitors/ha. The difference in the number of visitors between 1990 and 1998 should be noted (over 200% increase); nevertheless, the stand health condition as well as total recreation resource, managed to maintain their horizontal course. However, it is obvious that the increase above this recreation rate has proved critical. According to the norms of recreation, the above figures may mislead the analysts, if the figures are accepted as showing homogeneously distributed visitors for all days of the active recreation period. In reality, the visitors are concentrated at the weekends and to some extent, on national and religious holidays, which means approximately 50 days. This causes peaks of recreation activities whose effect is naturally destructive.

Based on the study findings and accompanying conclusions, the following recommendations have been made:

1. It is necessary to establish new recreation areas and to plan the rotation of these landscapes in the course of time and place. This can only be accomplished by assigning the economic class Forest Recreation to the TSFR and by applying the required forest management practice: management based on forest stand criteria, estimation of the stand age and recreation maturity periods, valuation of the required (recreational-spatial) stand composition, calculation of the optimal total area including alternate areas for rotation etc, for the purposes of the economic class.
2. It is necessary to study the features, peculiarities, significance and impact of all factors on the recreation suitability, to achieve efficient management of a TSFR.
3. It is necessary to investigate the processes of recreation regression by type and class of recreation activities.
4. To allow for timely correction of the recreational function course, it is necessary to adopt continuous forecasting.

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