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METHODOLOGY FOR DETERMINING THE QUALITY OF THE LANDS SITUATED OUTSIDE FOREST RESOURCES IN THE CASE OF THE MAIN TREE SPECIES CULTIVATED IN ROMANIA

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Abstract: *The paper proposes a methodology for assessing the quality of lands situated outside forest resources in the cases in which the latter's use is changed. The methodology used is based on ecological quantification criteria. It also takes into consideration ecological factors and determinants of geo-morphological, climatic and edaphic nature. Out of the 11 evaluation charts established for the taxons most frequently involved in afforestation works in Romania, the paper deals with three case analyses for spruce, beech and sessile oak. Also, the paper makes recommendations concerning completion of these with ecological factors characteristic of various taxons, especially those with a limited action with regard to adaptation.*

Key words: *changing the land use, afforestation, land quality, ecological criteria of evaluation.*

1. Introduction

The change of land use from agricultural use to forest use is being considered by policy makers and the scientific community alike. Out of the reasons supporting such a decision the following should be mentioned:

- the increase of forest areas with a view to reducing the accumulation of carbon dioxide, under the label "carbon sequestration" frequently used for the implementation of the Kyoto Protocol in 1997 [2], [3], [5], [8];
- the founding of a forest plantation for biomass used for bio-energy production [8], [11], [19];
- the interchange between the use of arable and forest lands for the settling of investments related to such situations [9], [20].

Situations when agricultural lands are afforested or when forest lands are forever taken out of forest resources being compensated with lands of similar surface and quality are frequently encountered in Romanian forestry. According to present legislation (Ordinance of the Ministry of Agriculture, Forestry and Rural Development no. 25/2009 concerning the Methodology

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for determining the equivalence of lands and the calculation of financial obligations for a definitive removal of lands from forest resources or for their temporary occupation) [21] in the case of compensation with lands similar in point of surface and quality, a quite frequent situation, the drafting of documents which should contain among other things a pedo-stational study for the lands offered in compensation is necessary. The documents should be drafted by organisms accredited for land improvement works in the field of forestry.

This study must establish: 1 - the type of forest site; 2 - the fundamental natural type of forest; 3 - the main species corresponding to the fundamental natural type of forest; 4 - the level of productivity according to the site quality; 5 - the full afforestation solution based on the main species; 6 - the costs necessary from the forest establishment until the achievement of the close crop phase.

Under these circumstances the main problem to be solved is that of determining the site quality, which presupposes for each case the evaluation according to scientific criteria of geotope, climate and edaphotope, ecological factors and determinants and of their resultant which influences the site quality. As a result the ensuing decision must justify a certain afforestation formula which should focus on one or two main species from the composition of the future tree-stand.

One should also consider the fact that the lands involved in these compensations may be located in various places of great phytoclimatic and edaphic heterogeneity. Likewise, each species has certain adaptive characteristics which manifest themselves by means of a wider or narrower spectrum of reaction to environmental factors. This requires a sound knowledge of ecological and determinant factors with a limiting action.

Therefore, the determination of the level of land quality must be based on accurate and relevant ecological evaluations which should justify a certain technical solution of afforestation.

The present paper proposes a methodology for determining the quality of lands situated outside forest resources and involved in land exchanges by means of using the evaluation method according to ecological criteria.

2. Materials and Methods

Considering the fact that the land exchanges by compensation have in view mostly lands situated near forest resources, especially pastures without forest vegetation or with very little forest vegetation or even agricultural lands, the establishment of the main criteria of classification and analysis (of the forest site and of the fundamental natural forest type) can take place by means of equivalence with situations already existent within the forest resources close to the area under consideration. At the same time, in order to offer technical solutions more frequently encountered ten main species have been considered (spruce, fir-tree, larch, Scots pine, beech-tree, sessile oak, pedunculate oak, Turkey oak, Hungarian oak and locust) along with Euro-American poplar hybrids for which ecological charts of classification according to favourability criteria have been suggested. In order to select the main species according to which the quality is subsequently assessed the following categories of criteria have been suggested:

- geo-morphological conditions (altitude and exposition);
- climatic conditions (temperature and annual average precipitations, length of bioactive period; for the species sensitive to early or late frost these risks should also be considered);
- edaphic conditions circumscribed by analyses of specific physiochemical indices;

The respective data is analysed and turned into points for each species according to 5 favourability criteria (5 represents optimum favourability and 1 represents the minimum level of favourability).

The work stages for determining land quality are the following:

- situating the land in the phyto-climatic layer and the establishment of the fundamental natural forest type;
- analysis of the specific geo-morphological conditions;
- gathering climatic data of interest from the National Meteorological Agency (NMA) for the nearest station; when differences of altitude between the meteorological station and the land in question exceed 1000 meters the data provided by NMA is corrected with the recommended thermal and pluviometric gradients [6]; for the species sensitive to arid conditions the establishment of favourability classes according to the values of the Martonne aridity index is recommended;
- soil profiles are taken from representative areas from which genetic horizons are sampled; the following physiochemical indices are determined in the laboratory: humidity during summer time, *pH*, humus and carbonates content, sum of exchange bases, exchangeable hydrogen, total capacity of cationic exchange, saturation degree in bases, total nitrogen, soluble salts and soil texture;
- the global potential trophicity index is calculated;
- according to the data thus quantified the main species characteristic of the respective forest site is or are established. An ecological chart is drafted for it on the basis of which the quality of the site is calculated and the possible production class of the tree stand is identified.

In conformity with the stipulations of the Ordinance of the Ministry of Agriculture, Forestry and Rural Development no. 25/2009 concerning the Methodology for determining the equivalence of lands and the calculation of financial obligations for a definitive removal of lands from forest resources or for their temporary occupation [21], the production class of the future tree stand is established as follows: production class I and II for forest sites of superior quality, production class III for forest sites of medium quality and production class IV for forest sites of inferior quality.

3. Results and Discussion

The main objective of the present research is the establishment of the evaluation methodology for determining the quality of forest sites and then the presentation of a case analysis for three of the 11 taxons for which evaluation charts have been drafted (spruce, beech and sessile oak - Tables 1, 2 and 3).

Scientific works in the field offer criteria and evaluation methods especially for agricultural lands. Thus, in Romania evaluation criteria for this category of use have been established by Teaci [15] and they involve knowledge of the ecological characteristics of lands and the physiological necessities of lands as opposed to natural conditions, that is of phytocenotic aptitudes [12].

Moreover, the same basic characteristics (ecological characteristics, production potential and phytocenotic aptitudes) are mentioned in the studies concerning forest sites [14]. Vindele and Burgina [17] distinguish three categories of factors according to which land evaluation is done in Latvia: physical (geology, geomorphology, humidity level and vegetation aptitudes), anthropic (ways of using the lands, existent constructions etc.) and aesthetical (visual aspect, prevalence of noise and other pollution sources etc.).

The abbreviations from Tables 1, 2 and 3 are taken from Romanian Soil Taxonomy System and are in accordance with FAO/

UNESCO (1988) and WRB SR (1998) classifications, meaning: AL - Alisols; AN - Andosols; AS - Fluvisols; CP - Spodo-dystric cambisols; CZ - Chernozems; DC - Dystric cambisols; EC - Eutric cambisols; EL - Haplic luvisols; EP - Cambic podzols; ER - Cambisols eroded phase; FZ - Phaeozems; GS - Gleysols; LS - Leptosols; LV - Luvisols; NS - Humic cambisols; PD - Haplic podzols; PE - Vertic subunits; PL - Planosols; RS - Regosols; RZ - Rendzinic leptosols; SG - stagnic luvisols; VS - Vertisols; L - loamy; S - sandy; C - cley.

The conditions which determine the quality and the production capacity of lands are outlined by Kiryuschin [4] according to agro-ecological criteria (climatic, geo-morphological, edaphic, hydrological and biocenotic) and intensity criteria of the anthropic influences (technologies used in land use, the socio-economic status of the area etc). The idea according to which the evaluation of a land must take into account the geographical position in the socio-economic system is also supported by Mejszelis [7]. The present principles of agricultural land evaluation in Romania are based on technical criteria (relief analyses, climate and hydrological and conditions) and on economic criteria (based on the quantity of the potential production to be attained for certain species) [12].

Nevertheless climatic and edaphic factors are of the utmost importance when considering land evaluation. Thus, Wall and Westman [18] emphasize the role of soil properties for the level of forest production in cases of prior agricultural use. Thus, normally agricultural use determines a certain fertility gradient in the soil depth with stronger influences up to depths of 30 to 40 cm, while at a greater depth the original qualities of soils are better reflected and less affected by agricultural use.

It is interesting that when categories and classes established for various uses are analysed, out of the six classes established in Romania for lands of agricultural use [1],

Evaluation chart for spruce (Picea abies (L.) Karst) Table 1

Ecological factor	Favourability (points)				
	5	4	3	2	1
Altitude [m]	1000-1200	900-1000; 1200-1300	800-900; 1300-1450	700-800; 1450-1600	600-700; >1600
Annual average temperature [°C]	5-6	4-5; 6-7	3-4; 7-7,5	2-3; 7,5-8	<2; >8
Annual precipitations [mm]	900-1100	800-900; 1100-1200	700-800; 1200-1300	600-700; 1300-1400	<600; >1400
Length of bioactive period [months]	4.5-6	4-4.5	3.5-4; 6-7	3-3.5; 7-8	2-3
Soil type	DC	EP; PD; NS	RZ; EC; EL;CP;AN	LS;HS; LV;PE;SG	RS; PL; GS
Global Potential trophicity index	>75	50-75	30-50	10-30	<10
Soil *pH*	5.4-5.8	4.8-5.4; 5.8-6.0	4.6-4.8; 6.0-6.6	4.2-4.6; 6.6-6.8	<4.2; >6.8
Saturation degree in bases [%]	55-65	35-55; 65-85	30-35; 85-90	20-30	<20
Total nitrogen in the soil [%]	>0.20	0.15-0.20	0.10-0.15	0.08-0,10	<0.08
Soil texture	L-N	L	N-L; L-A	A-L	N; A
Edaphic volume [m^3/m^2]	>0.70	0.5-0.70	0.30-0.45	0.15-0.30	<0.15
Total score	55-50		49-33	<33	
Quality	superior		medium	inferior	

Evaluation chart for beech (Fagus sylvatica L.) Table 2

Ecological factor	Favourability (points)				
	5	4	3	2	1
Altitude [m]	800-1100	600-800; 1100-1200	500-600; 1200-1300	400-500; 1300-1400	300-400; 1400-1500
Annual average temperature [°C]	7-7.5	6-7; 7.5-8	5-6; 8-8.5	4-5; 8.5-9	3-4; 9-10
Annual precipitations [mm]	900-1000	700-900; 1000-1100	600-700; 1100-1200	550-600; 1200-1300	500-550; 1300-1400
Length of bioactive period [months]	6-7	5-6	4-5; 7-8	3-4	2.5-3
Soil type	EC	AS; EL	RZ; DC; LV; AN	FZ; NS; EP; SG	LS;RS;CP PE;VS;ER
Global Potential trophicity index	>90	50-90	30-50	10-30	<10
Soil *pH*	5.6-6.6	5.2-5.6; 6.6-6.8	4.8-5.2; 6.8-7.0	4.4-4.8; 7.0-7.2	3.4-4.4
Saturation degree in bases [%]	70-90	50-70; 90-100	35-50	25-35	<25
Total nitrogen in the soil [%]	>0.28	0.20-0.28	0.12-0.20	0.08-0.12	<0.08
Soil texture	L-N	L	N-L	L-A; A-L	A; N
Edaphic volume [m^3/m^2]	>0.80	0.60-0.80	0.45-0.60	0.30-0.45	0.15-0.30
Total score	55-50		49-33	<33	
Quality	superior		medium	inferior	

Evaluation chart for sessile oak (Quercus petraea (Mattuschka) Liebl.) Table 3

Ecological factor	Favourability (points)				
	5	4	3	2	1
Altitude [m]	500-600	400-500; 600-700	300-400; 700-900	200-300; 900-1000	1000-1100
Annual average temperature [°C]	8-10	7-8	6-7; 10-11	5.5-6	5-5.5
Annual precipitations [mm]	700-800	600-700	550-600; 800-900	500-550; 900-1000	470-500; 1000-1100
Length of bioactive period [months]	8	7	6	5	4
Soil type	EC; LV; EL	AL; FZ	PL; CZ	RZ; DC; AL; SG	RG; NS; VS; GS
Global Potential trophicity index	>90	50-90	30-50	10-30	<10
Soil *pH*	5.6-6.2	5.2-5.6; 6.2-6.6	4.8-5.2; 6.6-6.8	4.4-4.8; 6.8-7.0	4.2-4.4; 7.0-7.4
Saturation degree in bases [%]	55-75	40-55; 75-95	30-40	20-30	<20
Total nitrogen in the soil [%]	>0.28	0.20-0.28	0.12-0.20	0.08-0.12	<0.08
Soil texture	L-N; L	N-L	L-A	A-L	A; N
Edaphic volume [m^3/m^2]	>0.60	0.45-0.6	0.30-0.45	0.15-0.3	<0.15
Total score	55-50		49-33	<33	
Quality	superior		medium	inferior	

[16] the first five are considered without limitations or significant restrictions on limitations and severe restrictions for agricultural use while only the lands situated in extremely severe conditions for agricultural use are relegated to forest use. While in the case analysed in the present paper the last possible use is not considered according to the phytocenotic aptitude previously discussed, the establishment of equivalence for the situations of exchanging agricultural use with forest use is considered.

The methodology proposed for the evaluation of lands subject to a change of use from agricultural use to forest use is based on the main criteria used in the forest site analysis starting with the establishment of their ecological characteristics.

Thus, the establishment of five favourability classes for the following ecological factors and determinants: geomorphological (altitude and exposition), climatic (temperature and average annual rainfall) and edaphic (humidity level, *pH*, humus content, the sum of exchange bases, exchangeable hydrogen, total capacity of cationic exchange, saturation degree in bases, total nitrogen, soil texture and global potential trophicity) is considered. These might be relevant for any of the main species from the future tree stand.

As a result of the gradiental climatic changes registered on altitude or on latitude, which are very well reflected in the distribution of forest woody species conditioned by their specific adaptations, the quantification in the evaluation charts of the geo-morphological and climatic conditions becomes increasingly important. Also, when establishing the quality level certain ecological characteristics of the main species should be taken into consideration such as:

- in the case of fir-tree and beech tree, which are sensitive to frost and freezing, especially at a young age, the quantification of risks is necessary as well as the establishment of the favourability level according to the occurrence of thermal inversions and of the late freezing;
- in the case of spruce the inferior altitudinal limit of suitable forest sites must take into account the value of the pluviometric factor from the vegetation season (FPV-IX = PV-IX / TV-IX, in which PV-IX and TV-IX represent the average precipitations and the average temperature from the months of May-September); according to Schmidt-Vogt [10] value 24 of the pluviometric factor represents a critical point for spruce;
- in the case of larch the forest sites identified must assure an increased perspiration capacity which should be based on physical characteristics of the soil favourable to the retention of water from precipitations and to allowing this to penetrate the roots with an absorbent role;
- in the case of Scots pine which presents a wide spectrum of reaction and adaptation to various environmental conditions, as a pioneer species and as a result of imperfect stems and of the reduced economic value of wood, one can recommend, though, its use as a main afforestation species for other than oligobasic soils in the extreme oligobasic, ologotrophic soils in the extreme oligotrophic, very acid soils, lands with surface erosion etc.; where the climatic and edaphic conditions are favourable to other species of resinous plants or broad leaves, the determination of land quality according to ecological requirements and the adaptability of Scots pine is not recommended;
- the determination of the land quality for the case in which the main species is represented by pedunculate oak, sessile oak, Turkey oak or Hungarian oak presupposes the consideration of their specificity as opposed to certain ecological factors and determinants such as: 1 - the influence of altitude on the favourability level (sessile oak is suitable for cultures in the hill or pre-mountainous areas while the other three species should not exceed altitudes of 500

up to 600 meters); 2 - sessile oak prefers soils with good drainage while pedunculate oak and especially Turkey oak and Hungarian oak accept soils with late drainage, relatively compact in the case of pedunculate oak and highly compact in the case of Turkey oak and Hungarian oak; 3 - Turkey oak accepts soils with calcium carbonates while Hungarian oak is sensitive to such conditions; 4- according to the soils humidity during summer time the four species could be divided into three categories: the sessile oak is mesophyte, the pedunculate oak is mesophyte - mesohygrophyte while Turkey oak and Hungarian oak are mesoxerophyte species [13]; as a consequence the evaluation charts should mention these adaptive specificities;

- in the case of locust the evaluation chart must mention the tolerable limits characteristic of it: the humidity excess, excessive soil compactness and the high content of carbonates; at the same time its use in afforestation formulae must be cautious in order to eliminate or limit its invasive behaviour;

- forest sites circumscribed to Euro-American poplars are those destined to their culture in river meadows from the plain area; soil salinity and compactness determine a significant reduction of forest sites favourability for the culture of Euro-American poplars.

Starting from the ecological charts drafted for the 11 forest species the quality of forest sites has been established:

Score	Forest site quality
55-50	superior
49-33	medium
<33	inferior

References

1. Blaga, Gh., Filipov, F., et al.: *Pedologie* (*Pedology*). Cluj-Napoca. AcademicPres Publishing House, 2005.
2. Bloomfield, J., Pearson, H.L.: *Land Use, Land-Use Change, Forestry, and Agricultural Activities in the Clean Development Mechanism: Estimate of Greenhouse Gas Offset Potential.* In: Mitigation and Adaptation Strategies for Globale Change **5** (2000) No. 1, p. 9-24.
3. Blujdea, V., Dumitriu, et al.: *3rd National Report on the Implementation of United Nations Convention to Combat Desertification in Romania*. Bucureşti. Silvică Publishing House, 2006.
4. Kiryuschin, V.I.: *Assessment of Land Quality and Soil Fertility for Planning Farming Systems and Agrotechnologies*. In: Eurasian Soil Science **40** (2007) No. 7, p. 789-791.
5. Kubanov, E., Vorobyov, O., et al.: *Carbon Sequstration after Pine Afforestation on Marginal Lands in the Povolgie Region of Russia: A Case Study of the Potential for a Joint Implementation Activity.* In: Scandinavian Journal of Forest Research **22** (2007) No. 6, p. 488-499.
6. Marcu, M.: *Meteorologie şi climatologie forestieră* (*Forest Meteorology and Climatology*). Bucureşti. Ceres Publishing House, 1983.
7. Mejszelis, M.: *Influence of the Bonitation Value and Sold Area on the Single Price of Arable Lands Sold from the Resources of State Agricultural Property*. In: Proceedings of the International Scientific Conference: Economic Science for Rural Development (2008) No. 16, p 100-107.
8. Obersteiner, M., Alexandrov, G., et al: *Global Supplay of Biomass for Energy and Carbon Sequestration from Afforetation/Reforestation*. In: Mitigation and adaptation Strategies for Global Change **11** (2006) No. 5-6, p. 1003-1021.

9. Pratt, A.C.: *Social and Economic Drivers of Land Use Change in the British Space Economy.* Land Use Policy 26S, S109-S114, 2009.
10. Schmidt-Vogt, H.: *Die Fichte-Band I.* Hamburg und Berlin. Verlag Paul Parey, 1977.
11. Scurlock, J.M., et al.: *Utilising Biomass Crops as an Energy Sourse: A European Perspective.* In: Water, Air, and Soil Pollution **70** (1993) No. 1-4, p. 499-518.
12. Spârchez, Gh.: *Cartarea şi bonitarea terenurilor agricole şi silvice* (*Mapping and Bonitation of Agricultural Land and Forest*). Braşov. *Transilvania* University Publishing House 2008.
13. Stănescu, V., et al.: *Flora forestieră lemnoasă a României* (*Woody Forest Flora of Romania*). Bucureşti. Ceres Publishing House, 1997.
14. Târziu, D.: *Pedologie şi staţiuni forestiere* (*Pedology and Forest Sites*). Braşov. Silvodel Publishing House, 2006.
15. Teaci, D.: *Bonitarea terenurilor agricole* (*Agricultural Lands Bonitation*). Bucureşti. Ceres Publishing House, 1980.
16. Ţărău, D., et al.: *The Bonotation Studies and the Technological Characterisation of the Land, Necessary for the Cadastral Organization of the Timiş County.* Available at: http://agricultura.usab-tm/Simpo2008.pdf.
17. Vindele, L., Bugina, V.: *Evaluation Methods of Natural Resources in Latvia.* In: International Scientific Conference: Economic Science for Rural Development, Jelgava (Latvia), 24-25 Apr. 2008. Available at: http://agris.fao.org/agris-search/.
18. Wall, A., Westman, C.J.: *Site Classification on Afforested Arable Land Based on Soil Properties for Forest Production.* In: Canadian Journal of Forest Research **36** (2006) No. 6, p. 1451-1460.
19. Woods, J.: *Bioenergy and Indirect Land Use Change.* In: IPIECA Workshop and Indirect Land Use Change (ILUC), 9th Nov. 2009, Lausanne, Switzerland. Available at: http://cgse.epfl.ch/webdav/site/cgse/shared/Biofuels.
20. Yansiu, L., et al.: *Spatio-Temporal Analysis of Land-Use Conversion in the Eastern Coastal China during 1996-2005.* In: Journal Geogr. Scien. **18** (2008), p. 274-282.
21. *** *Ordinul M.A.P.D.R. Nr. 25/2009 privind Metodologia de stabilire a echivalenţei valorice a terenurilor şi de calcul a obligaţiilor băneşti pentru scoaterea definitivă sau ocuparea temporară a terenurilor din fondul forestier naţional - publicat în Monitorul Oficial al României, Partea I-a, nr. 100 din 19.02.2009* (*Ordinance of the Ministry of Agriculture, Forestry and Rural Development no. 25/2009 Concerning the Methodology for Determining the Equivalence of Lands and the Calculation of Financial Obligations for a Definitive Removal of Lands from Forest Resources Or for Their Temporary Occupation - Published in the Official Gazette, Part I, no. 100 of 02/19/2009*).