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SILVICULTURAL SYSTEMS SELECTION BY DISCRIMINANT ANALYSIS

VOLBA HOSPODARSKEHO ZPUSOBU POMOC! DISKRIMINACNI ANALYZY

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ABSTRACT: The study evaluates the possibilities of selecting a certain silvicultural system by means of a statistical tool that could be implemented in the information system of forest management planning as a subprogram for field data validation. Performing the sensitivity analysis of discriminating functions it is also possible to assess the necessary hauling distance to be achieved if protective functions require a more intensive silvicultural treatment for each particular stand.

forest management; silvicultural system; decision-making process; discriminant analysis; information system

ABSTRAKT: Studie hodnoti moznosti vyberu urciteho hospodarskeho zpusobu pomoci diskriminaCni analyzy (DA), jednoho z uCinnych prostfedku statistiky. Zkouma se moznost zahrnout program DA do souboru programu, urCeneho ke zpracovani a hodnoceni dat z terenu, ktery se v Rumunsku pouzi'va pro upravu lesu. Pozornost je vSnovana faktorum, ktere ovlivnuji volbu hospodarskeho zpusobu v£etne zajiStCni ochrany naslednych porostu, a udajum, popisujicim pnrodni, porostni a hospodafske podminky konkretniho porostu a vstupujicim do procesu DA. DA se pouziva k rozhoanuti, do ktere ze dvou nebo vice navzajem odliSnych skupin se objekt na zakladC konkretnich udaju zafadi a jake udaje jsou pro zarazeni rozhodujici. Nastrojem DA je diskriminaCni funkce. Jejf diskriminaCni schopnost je vyjadrena hodnotou *X.* Ve studii je pouiito dvou modelu DA: model binarni a model jedineho shl.uku. Vysledky ukazuji, ze v binarnim modelu dochazi k zeslabovani diskriminaCni schopnosti funkce podle zpusobu pfirazovani promgnnych. VyhodnejSi je model jedineho shluku. Prokazalo se, ze DA lze pouiit k odliSeni hospodarskeho zpusobu na zakladS zavedenych podminek. Bude nutne zdokonalit vyb6r popisujicich promfinnych a zahrnout dalSi faktory, ktere ovlivftuji rozhodnuti upravy lesa.

uprava lesa; hospodarsky zpusob; rozhodovaci proces; diskriminaCni analyza; informaCni system

INTRODUCTION

The choice of a system for adoption in any particular case of exploitable stands could be a difficult task when the protective function prevails. Among the critical factors affecting this decision (Troup, 1928; Matthews, 1991), for Romanian forestry the following ones are most important:

- conditions of regeneration which depend both on the stand structure and site conditions;
- growth conditions such as: light requirement, rate of growth that influences the option system in relation to individual species or mixture;
- nature of terrain and soil related to the protective function of the stand;
- protection against external dangers (such as wind throw);
- nature of wood produce required in special circumstances (resonant or veneer round wood);
- personnel and labor - the more experienced field personnel, the more intensive system could be adopted;
- economic consideration related to felling costs, transport and artificial regeneration costs.

The only systems widely applied are: clear cuttings on areas smaller than 3 hectares; uniform (or selective) system, group system, irregular shelterwood system, selection system, coppice and, to some extent, mixed systems (strip and group shelterwood and strip cuttings).

The forest management planning is based on an information system which contains a subprogram for field data validation, accepting the proposed treatment for each stand to be harvested in the next 20 year period.

The aim of this study is to assess the possibilities of determination this option by means of a statistical tool, implemented in the alluded data validation subprogram. In some previous papers different authors treated this matter in various ways.

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One of the first computational method designed for silvicultural system selection was worked out by Henne (1977) in a very accurate Utility Analysis (UA) application. In this issue it is emphasized that conflicting objectives occur when two or more management alternatives are considered. To overcome these difficulties and find the best compromise the first step is to select the most important goals as a hierarchically arranged chain of objectives. At the end of this chain the target criteria will be found, and will serve as a basis of alternatives evaluation.

Koval et al. (1990) used a simulation model in order to set up the most appropriate system for a beech stand and the logging methods as well. As simulation models should be based on regression functions, the question that arises is whether it is worth measuring so many variables and such a great amount of field data to obtain reliable regression functions, when the economic impact of a failure to choose the system for a particular stand is lower than the expenditure required by using this analytical tool.

Tecle et al. (1988) applied a multi-criterion decision method for system selection. Over 10 criteria were considered according to all kinds of protective and economic functions of forests (watershed protection, revenues from livestock, scenic value and so on) and weighted in a 10 point range for each potential system to be applied. Ranking the resulted function values of decision matrix processing, the most appropriate system can be selected from a set of feasible ones. The chief disadvantage of such an approach consists in a very difficult and finally risky assessment of each criterion value per hectare besides the subjective weights.

In a previous approach (Dissescu, Dragoi, 1991) a grid was carried out in order to select the most appropriate system for a stand that is described by means of 16 criteria which are not quantitative ones but interval scales (1 to 3). Each of them is multiplied by a weight note (1 to 10) according to the main protective function and summing up all these figures the „total score" for any particular stand is obtained. Since each system has its own interval of the total utility value, it becomes very easy to find out which one is the optimum to be applied.

An exclusive economic approach to the matter was performed by Crockford et al. (1987) who tabulated the present value for different combinations of species compositions, silvicultural system, cut ages and present values per hectare. As a management tool, the whole information system supplied is very useful in forest assessment. Properly speaking, that was the main aim of the study and not finding out the adequate treatment for a given stand.

A decision support information system (DSS) to choose the proper treatment for stand shape might be indirectly useful in figuring the hauling distance to be achieved by road network development, proper to a more intensive treatment, from a protective and amenity view point. Obviously, this question makes sense only for uniform and group systems, i.e. the transition from uniform to group treatment or from group to irregular shelterwood system and such a problem is mostly faced in the Romanian forest management; other cases are not so important, since clear cuttings followed by artificial regeneration are appropriate for spruce productive forests. Thus the link between long-term objective, namely more stable structure for the next canopy and current investment decision related to road building is straightened and if connected to the previous exclusively economic approach (Dragoi, 1995) the following problems can be solved:

- finding the investment fund necessary to ensure conditions to apply more intensive treatments from protective and amenity standpoint, by means of shorter off-road distances;
- estimating a kind of inoptimality losses (Jacobsson, 1986; Thuresson, 1995) as the difference between the total investment which ensures to best ratio of present worth increment and related investment outlay and the same figure, but determined for the investment fund required to reach the proper hauling distances for all stands to be regenerated by means of a more intensive treatment. Parallelling the two costs, one may get the image of economic efficiency loss when ecological goals of forest management are straightened, because a smaller capital to be invested could be more efficient in short run than a greater one, focused on achieving the proper hauling distance for all decade exploitable stands.

MATERIAL AND METHOD

Considering the stands described in Tab. I as a sample of models of adopting the right decision concerning the system to be applied, a discriminant analysis was performed to get the proper functions to be implemented in the alluded DSS.

An open slope signifies a side-hill which is adjacent to a lower level region and a closed slope stands for side-hill which is included in larger territory with the same relief.

Discriminant function analysis (DA) is used to determine which variables discriminate between two or more naturally occurring groups, e.g. clusters of system, linked by a global feature, like the kind of shelter for seedlings, the length of regeneration period or systems themselves.

On the other hand, it allows to set up which one is the proper group of any new item that is described by the same variables. The algorithm is the following: having the data which describes that new item, the discriminant values corresponding to each group are calculated, in the same manner as a regressand is assessed by means of two or more regressors. Having these results, the new item will belong to that group corresponding to the highest value of the discriminant values set.

I. A sample of data processed by discriminant analysis of silvicultural treatments widely applied in Romanian forestry

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
49d	0.300	50	1	1.5	840	10.5	2	1	0.875	0	420	15
75d	0.800	120	1	3.8	600	10.0	3	5	2.500	0	700	20
75f	0.800	120	1	3.8	600	10.0	3	5	2.500	0	700	20
109b	1.270	100	1	3.4	800	6.0	10	2	1.100	0	500	15
86a	0.200	30	1	4.5	750	10.0	2	1	0.750	1	350	10
44c	0.500	60	1	3.5	750	10.0	4	2	1.000	0	560	20
lie,	1.000	30	1	3.5	650	10.0	2	1	0.750	1	350	14
74b	0.300	100	2	16.3	800	9.0	3	2	1.250	0	550	10
26d	0.400	110	2	15.4	750	8.0	3	3	1.040	0	630	9
28	0.300	60	2	15.4	750	7.0	1	3	1.040	0	630	9
39a	1.100	110	2	14.5	850	7.0	3	3	0.865	1	650	10
130a	1.200	130	5	19.4	850	10.0	10	1	1.280	1	700	2

(1) - stand label (compartment number and sub-compartment symbol)
(2) - overall corrective coefficient of soil water (nondimensional) that includes the following criteria: position on the hill-side, clay content, depth of the soil, exposition and the side-hill type (close or open) - WREG (see Appendix 1)
(3) - stand age (AGE)
(4) - the system already applied or to be applied:
1 - clear cuttings,
2 - strip clear cuttings,
3 - uniform system,
4 - group system,
5 - irregular shelterwood system or conversion to selection system
(5) - area (AREA) in hectares
(6) - average annual rainfall (RAINFALL) (mm)
(7) - average temperature (TEMPERATURE) (°C)
(8) - shade resistance of the main species seedlings (SHADE RESIST) in years
(9) - mast year frequency of the main species (MAST YEAR FRQ) (years)
(10) - weighted average conventional value coefficient of tree species considered in the stand composition (RELATIVE VALUE) - a nondimensional feature - see Appendix 2
(11) - functional type of stand (STAND TYPE) is a „dummy" variable which stands for the importance of protective functions: 1 denotes a highly protective function and 0 a low importance from this point of view
(12) - volume per hectare (VOL.HA^{-1}) (cm^3.ha"')
(13) - hauling distance (HAULING DIST) (hundred of meters)

The most common application of DA is to include many measures in the study in order to determine those that differentiate between the groups. Obviously, it depends to a certain extent on how the discriminant problem is imagined: like a binary tree (Fig. 1) or like a single cluster that links directly all groups or items to a single root (Fig. 2).

In accordance with the statistic patterns of DA, each function has its own discriminative power, denoted by the Wilk's A, value. A zero value denotes a high discriminant power and a one value stands for a no discriminant power, irrespective of statistical relevance of coefficients themselves.

If a binary tree is the subject of discriminant problem, the question is how many variables are involved at each differentiated level. All available variables could be included but even the global feature represented by a particular level might not allow this: it does not matter how old the canopy is since we are talking about the growth condition and light requirements of the seedlings, that is the adequate shelter type for a given composition. On the contrary, the length of regeneration period: if it is to be extended to obtain an uneven age structure of the following canopy one has to have an area large enough to afford this option; so, this variable should be taken into account when per-

1. A three-level branched tree

2. A single cluster branched tree

forming the final branching. In fact, that is the main problem of irregular shelterwood system, which seems to be a very appropriate treatment for protective forests but not suitable for stands of only a few hectares scattered among even aged young stands.

DATA PROCESSING

In the present discriminant models all quantitative variables and even a qualitative one (which can be appraised within a reasonable precision in forest management planning) have been included. The stand composition is transformed in a quantitative criterion by means of the so-called conventional value coefficient, still used to assess the wood-by-stem price, as a function of the ecological value of a given species and its rarity too.

A more difficult step of data preparation is related to quantifying site parameters. In practice the soil mapping reveals only a few quantitative variables such as: clay content, width of active strata, humus content and exchange capacity. In a previous work, Stanciu (1973) found out a very useful indicator of site conditions for Romanian forests, related to the depth of the soil, the clay content, the position on the side-hill, the side-hill type - open or closed - and the exposition as well. This indicator is called „overall corrective coefficient of water regime" and it is used to assess the moisture regime of the soil. As the annual rainfall and the average annual temperature are taken into account, the „overal corrective coefficient" (tabulated in appendix) was considered to be a satisfactory global indicator for soil conditions.

The data processing was twofold: the first for the binary-tree decision model that simulates the scholastic" approach to silvicultural treatments problem, and the second for the single cluster decision model which includes all the variables at the same time. In both cases, the stepwise analysis was peformed in order to keep further only those variables that differentiate to the greatest extent different systems or groups of silvicultural treatments.

RESULTS

The main findings of DA are shown in Tabs. II to VII, containing the discriminant functions obtained both by standard analysis and stepwise approach of DA. The latter set of coefficients is in brackets. Both alternatives of DA were considered, namely multi-level branched tree (Tabs. II to V) and a single cluster one (Tabs. VI and VII).

For sake of the statistical relevance, all variables described above were used both in standard and stepwise DA, aiming at finding the most reliable data from a statistic standpoint. .,

The interception coefficients stand for all factors riot taken into account and Tabs. VI and VII exhibit an increasing trend of these values, according to how many factors were taken away. Certainly, more important protective functions imply more data to be analyzed and some of these are not as important as to be expressed in figures or simply cannot be quantified at all.

At this stage of discriminant analysis, the most important one since all debates in Romanian forestry are focused on, the Wilk's A, coefficient has the greatest value, so the discriminating power is low. It could be noticed that stepwise analysis kept only the off-road transportation distance and average temperature; the latter is not so relevant from a silvicultural point of view. The functional type had been purposefully omitted because of zero values of covariance matrix, occurred when a variable took only one value for all individuals belonging to a certain group: this is the case of irregular shelterwood system associated only to the third factional type.

The first conclusion drawn when analysing the chain of functions which reconstitute the traditional pattern of

II. Discriminant function between the clear cuttings system and treatments based on natural regeneration found by standard DA (A. = 0.279482) and by stepwise DA (X = 0.2847083)

Variable	Clear cuttings followed by reforestation		Systems based on natural regeneration	
VREG	(2.8040)	33.116	(-2.7144)	28.209
AGE	(0.0118)	-0.546	(0.1332)	-0.419
AREA	(0.0460)	1.076	(0.2955)	1.344
RAINFALL		0.379		0.381
TEMPERATURE		5.856		5.938
SHADE RESIST		-0.829		-0.910
MAST YEAR FRQ	(-0.1805)	2.937	(0.6103)	3.721
RELATIVE VALUE	(3.6374)	44.197	(-0.1000)	40.423
STAND TYPE		26.786		28.066
VOL.HA-[1]	(0.0415)	0.052	(0.0532)	0.063
HAULING DIST	(0.3086)	-0.402	(-0.1936)	-0.964
Intercept	(-18.1148)	-246.836	(-25.0381)	-260.054

III. Discriminant function between the strip clear cuttings system and the other treatments based on natural regeneration found by standard DA (X = 0.2393733) and by stepwise DA (X = 0.2726736)

Variable	Strip clear cuttings followed by natural regeneration		Systems which ensure lateral or upward protection for the new crop	
WREG		36.158		40.888
AGE	(-0.037)	-0.502	(0.127)	-0.381
AREA		1.821		1.866
RAINFALL	(0.346)	0.531	(0.303)	0.497
TEMPERATURE		3.382		3.901
SHADE RESIST	(-1.920)	-2.047	(-1.322)	-1.390
MAST YEAR FRQ	(2.199)	6.915	(3.008)	7.738
RELATIVE VALUE		76.241		81.153
STAND TYPE	(40.208)	68.318	(33.991)	62.603
VOL.HA"'		0.262		0.265
HAULING DIST		-2.459		-2.443
Intercept	(-212.482)	-462.170	(-180.376)	-449.982

IV. Discriminant function between uniform system and treatments which ensure lateral shelterwood for the new generations found by standard DA (X = 0.338822) and by stepwise DA (X = 0.3475828)

Variable	Uniform system		Group and irregular shelterwood system	
WREG		30.425		29.060
AGE	(0.840)	0.123	(1.095)	0.391
AREA		1.006		0.992
RAINFALL	(0.079)	0.181	(0.060)	0.160
TEMPERATURE		3.133		2.798
SHADE RESIST	(-0.326)	0.509	(-0.741)	0.079
MAST YEAR FRQ	(4.741)	5.498	(5.698)	6.503
RELATIVE VALUE		45.656		44.541
VOL.HA-[1]	(0.109)	0.136	(0.132)	0.159
HAULING DIST	(-1.008)	-0.562	(-1.711)	-1.274
Intercept	(-109.950)	-186.763	(-129.622)	-200.617

V. Discriminant function between the group system and irregular shelterwood system (or conversion to selection system) found by standard DA (X = 0.1405697) and by stepwise DA (X = 0.5084766)

Variable	Group system		Irrelugar shelterwood system	
WREG		31.741		33.859
AGE		-5.038		-5.753
AREA		7.580		8.633
RAINFALL		1.366		1.530
TEMPERATURE	(3.6732)	-12.670	(2.9572)	-15.556
SHADE RESIST		-9.635		-10.815
MAST YEAR FRQ		6.003		6.793
RELATIVE VALUE		158.256		176.503
STAND TYPE		231.602		259.119
VOL.HA^{-1}		0.468		0.520
HAULING DIST	(0.5638)	-9.388	(0.2331)	-10.847
i Intercept	(-20.8766)	-768.026	(-13.1775)	-931.140

defining each treatment is the decreasing of discrimination power according to how the decision tree is rolling forward. When implementing the model into a decision support system, the only way to avoid a wrong option is to interrogate the user at each branching whether or not he agrees with the partial solution offered by the program. But this is the worst solution as it makes no sense to implement a computer program decision support system which is assisted by the user.

Having the above considerations, the only advisable solution is to implement the second group of functions which are obtained by single-cluster forward stepwise DA. Parallelling the two sets of functions - obtained by standard DA (Tab. VI) and by stepwise DA (Tab. VII) - it is worth noticing that discriminative power is high and only two variables were statistically omitted. As it was explained above the functional type was omitted from the very beginning of data processing.

As it was stated in the introduction, a very interesting use of the discriminant functions is derived from the sensitivity analysis. As the only variable subject to managerial control is the hauling distance, for the forest management it could be useful to assess the necessary hauling distance to be achieved in order to allow a more intensive system to be applied, for any given stand.

Briefly, for any given stand supposed to be regenerated by uniform or group system in accordance with the DA results, the following problem might be solved: what is the required off-road transportation distance to apply the group system instead of uniform system or the irregular shelterwood system or conversion to selection system instead of group system.

A decision support program focused on the whole problem of silvicultural system option is based on the flowchart shown in Fig. 3. A sample of results supplied by the program is shown in Tab. VIII.

DISCUSSION AND CONCLUSIONS

As it is shown in Tabs. II-V, the *X* values increase according to how many branches had been passed and that is the main disadvantage of such an approach.

Parallelling DA results with those obtained by Utility Analysis (UA) some final remarks may be summarized as follows.

VI. The discriminant functions between the five main silvicultural systems widely applied in Romanian forestry, found by standard DA (K = 0.0488785)

Variable	Clear cuttings	Strip clear cuttings	Uniform system	Group system	Irregular shelterwood system
WREG	23.414	16.318	21.334	18.331	19.448
AGE	-0.476	-0.361	-0.377	-0.326	-0.356
AREA	0.744	1.039	0.986	1.045	1.167
RAINFALL	0.297	0.303	0.298	0.295	0.308
TEMPERATURE	5.403	4.723	5.765	5.426	4.711
SHADE RESIST	0.095	-0.331	0.420	-0.072	-0.076
MAST YEAR FRQ	1.661	2.512	2.321	2.908	3.243
RELATIVE VALUE	37.447	33.225	35.358	34.518	36.188
VOL.HA"[1]	0.047	0.070	0.051	0.058	0.068
HAULING DIST	0.846	-0.028	0.479	0.027	-0.525
Intercept	-169.804	-174.855	-184.195	-177.194	-186.845

VII. The discriminant functions between the five main silvicultural systems widely applied in Romanian forestry, found by forward stepwise DA (K = 0.058966)

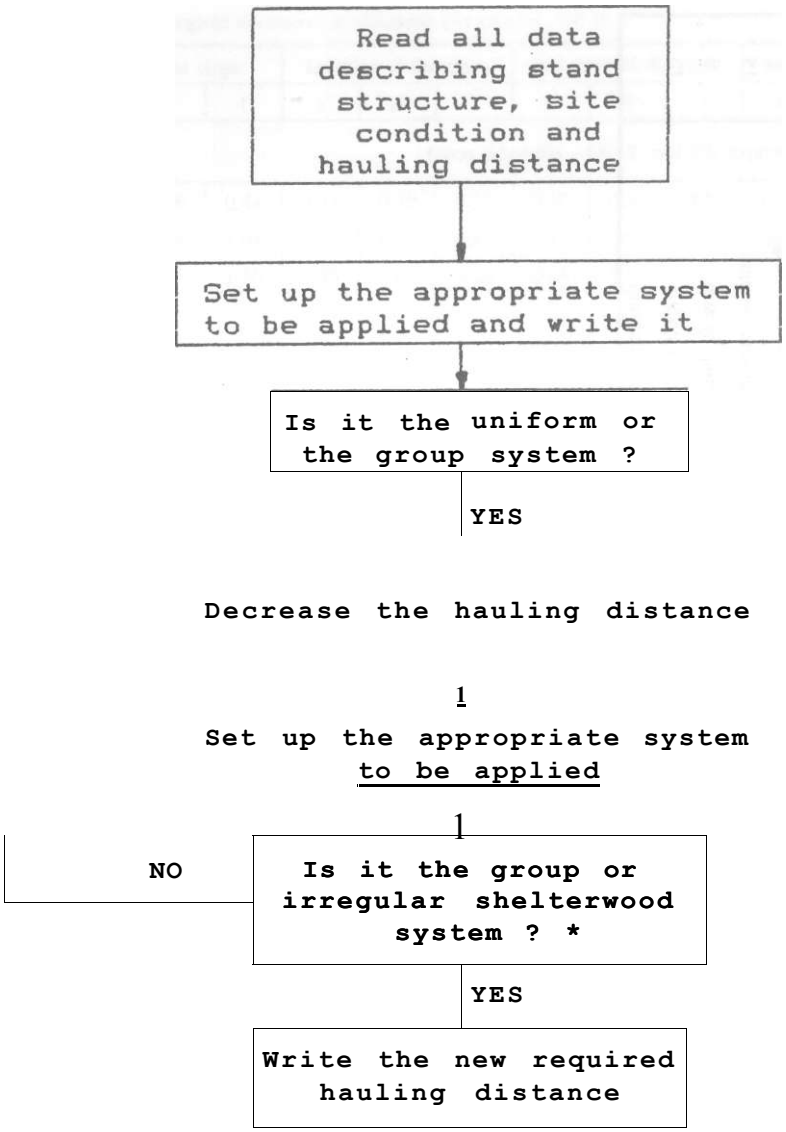
Variable	Clear cuttings	Strip clear cuttings	Uniform system	Group system	Irregular shelterwood system
HAULING DIST	0.4908	-0.3766	0.1158	-0.3262	-0.8777
AGE	0.0086	0.1433	0.1044	0.1542	0.1572
SHADE RESIST	0.1215	-0.3034	0.4463	-0.0459	-0.0482
AREA	0.0297	0.3103	0.2694	0.3373	0.4266
MAST YEAR FRQ	-0.1800	0.5099	0.5288	1.0923	1.1949
WREG	3.5475	-3.1170	1.0430	-1.4415	-0.2087
VOL.HA-[1]	0.0321	0.0537	0.0374	0.0433	0.0515
RELATIVE VALUE	3.9899	-1.0434	1.8620	1.3508	1.3458
Intercept	-17.7565	23.8356	-27.7674	-27.0168	-31.6244

VIII. Numerical examples of choosing the silvicultural system by means of discriminant functions and the required hauling distance to apply a more intensive treatment whether protective functions prevail (only for uniform system and group system)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
10 BE	d si	M	E	C	18	100	3	23.8	6	0.300	500	1.2	group system	5
5 BE 5 OK	d si	M	N	c	15	130	7	23.9	8	0.300	500	1.9	group system	5
5 BE 5 SP .	t s	B	N	c	10	110	5	23.0	8	0.700	700	1.1	group system	9
6 AS 4 SP	t s	B	E	C	18	130	15	12.9	4	0.900	600	1.0	uniform system	8
6 BE 4 OK	d si	M	S	C	14	130	5	22.8	6	0.400	700	1.7	group system	8
10 SP	m si	U	N	C	4	100	3	10.8	5	0.900	600	1.0	irregular shelterwood system	
6 BE 4 SP	t s	M	N	0	5	110	7	23.9	6	1.100	700	1.1	irregular shelterwood system	
10 BE	t s	B	E	C	20	130	10	23.4	5	0.900	600	1.2	uniform system	16
8 BE 2 SP	t s	M	E	C	23	130	5	12.9	5	1.100	600	1.2	uniform system	19
10 SP	t s	U	S	0	13	90	1	30.8	4	1.020	600	1.0	strip clear cuttings	
5 AS 5 SP	d si	M	N	C	20	150	15	23.9	4	0.300	550	1.0	uniform system	15
6 BE 4 AS	d1	I	N	C	16	120	4	23.9	5	0.200	600	1.1	group system	6
5 BE 3 SP 2 AS	m si	M	E	C	20	140	10	34.9	6	0.900	600	1.1	group system	10
10 HO	m si	B	N	C	12	60	4	12.8	1	0.600	400	1.0	clear cuttings	

Explanations:

(1) stand composition: BE - beech, Fr - fir, SP - Norway spruce, HO - hornbeam, OK - oak, AS - aspen
(2) depth and texture of the soil: d - deep, t - shallow, m - medium, s - sandy, si - sandy to loamy, 1 - loamy
(3) stand position on the slope (M - middle, B - step of the slope, U - upper third of the slope)
(4) exposition
(5) slope type (C - closed, O - opened)
(6) the existing hauling distance
(7) age
(8) shade resistance of the main species seedlings
(9) area
(10) mast years frequency
(11) water regime corrective coefficient (see Appendix 1)
(12) volume per hectare
(13) relative value coefficient of the stand (see Appendix 2)
(14) the proper system according to the existing hauling distance
(15) the hauling distance required by the next more intensive treatment (group system or irregular shelterwood system)



3. The flowchart of a decision support system for silvicultural system choice

* In order to avoid the exit from the loop after the first decrement, the system previously established is stored and is taken into account in a more complex logical condition which seems like the following one: *„If the system established in the first step is the uniform one and the new treatment is group system and the reduce hauling distance is still positive then... otherwise if the system established in the first step is group system and the new one is the irregular shelterwood one and the reduced hauling distance is still positive then..."*

- The DA model is as perfectible as UA one but the former is more reliable, because any idealistic assumption is neglected; results depend only on the successful experience of each system in a given set of natural and technological conditions.
- The technological and economic features related to the harvesting process are not stressed and detailed as in the UA model and that could be a lack of the present approach, explicable through the miscellaneous sources of such information not available for those who gather field data for forest management planning.
- All information with respect to amenity and ecological value are condensed in the functional type criteria, which is actually a „dummy" variable: zero value denotes a high protective function and one value shows a low protective importance of each stand. A further version of such an analysis could take into account the economic value of the protective/amenity function.

* - According to a common sense expectation, some relevant variables were kept by stepwise DA, but others were not taken into account, in spite of their practical relevance, e.g. stand area when discriminating between the group and irregular shelterwood systems (Tab. V) or climatic features as annual temperature and rainfall (Tab. VII).

The chief advantage of an integrated information system of forest fund management (including harvest planning) consists in the opportunity to extend more intensive systems according to how silvicultural and harvesting conditions allow such an option. For the time being, personnel and labor conditions were not taken into consideration as well as dangers as wind throw and insect attacks. These are two directions the model could be improved, adding the third one that is taking into account the protective or amenity value of each stand existence.

Acknowledgements

This paper is a part of a systems analysis of cutting budget and silvicultural treatments decisions and its

Appendix 1 - Moisture regime corrective coefficients (Stanciu, 1973)

Text.	Step of the slope			1st third of the slope			2nd third of the slope			3rd third of the slope			Plateau		
	s	si	1	s	si	1	s	si	1	s	si	1	s	si	1
Soil depth	Open side-hills - SE, S, and SW expositions														
t	0.30	0.36	0.44	0.25	0.30	0.37	0.20	0.24	0.30	0.15	0.18	0.22	0.12	0.15	0.18
m	0.71	0.84	1.04	0.59	0.70	0.87	0.47	0.56	0.70	0.35	0.42	0.52	0.29	0.35	0.43
d	1.02	1.20	1.50	0.85	1.00	1.25	0.68	0.80	1.00	0.51	0.60	0.75	0.42	0.50	0.62
	Closed side-hills - SE, S, and SW expositions														
t	0.37	0.45	0.55	0.32	0.39	0.48	0.25	0.30	0.37	0.20	0.24	0.30	0.12	0.15	0.18
m	0.88	1.05	1.30	0.77	0.91	1.13	0.59	0.70	0.87	0.47	0.56	0.70	0.29	0.35	0.43
d	1.27	1.05	1.87	1.10	1.30	1.62	0.85	1.00	1.25	0.67	0.80	1.00	0.42	0.50	0.62 1
	Open side-hills - NE, N, and NW expositions														
t	0.35	0.42	0.52	0.30	0.36	0.44	0.22	0.27	0.33	0.17	0.21	0.26	0.12	0.15	0.18
1 m	0.83	0.98	1.22	0.71	0.84	1.04	0.53	0.63	0.78	0.41	0.49	0.61	0.29	0.35	0.43
d	1.19	1.40	1.75	1.02	1.20	1.50	0.72	0.90	1.12	0.59	0.70	0.78	0.42	0.50	0.62
	Closed side-hills - VE, N, and NW expositions														
t	0.37	0.45	0.55	0.35	0.42	0.52	0.27	0.33	0.41	0.22	0.27	0.33	0.12	0.15	0.18
m	0.88	1.05	1.30	0.83	0.98	1.22	0.65	0.77	0.96	0.53	0.63	0.78	0.29	0.35	0.43
d	1.27	1.50	1.87	1.19	1.40	1.75	0.93	1.10	1.37	0.72	0.90	1.12	0.42	050	0.62
	Open side-hills - E and W expositions														
1	0.32	0.39	0.48	0.27	0.33	0.41	0.22	0.27	0.33	0.17	0.21	0.26	0.12	0.15	0.18
m	0.77	0.91	1.13	0.65	0.77	0.96	0.53	0.63	0.78	0.41	0.49	0.61	0.29	0.35	0.43 1
d	1.10	1.30	1.62	0.93	1.10	1.37	0.72	0.90	1.12	0.59	0.70	0.87	0.42	0.50	0.62
	Closed side-hills - E and W expositions														
t	0.35	0.42	0.52	0.32	0.39	0.48	0.27	0.33	0.41	0.20	0.24	0.30	0.12	0.15	0.18
m	0.83	0.98	1.22	0.77	0.91	1.13	0.65	0.77	0.96	0.47	0.56	0.70	0.29	0.35	0.43
d	1.19	1.40	1.75	1.10	1.30	1.62	0.93	1.10	1.37	0.67	0.80	1.00	0.42	0.50	0.62

soil depth: t - shallow; m - medium; d - deep
soil texture: s - sandy; si - sandy to loamy; 1 - loamy

Appendix 2 - Relative value coefficients used by the stumpage pricing system (only values for round wood have been considered)

Species and groups of species	SP, FR, LA	PI	BE	OKS	QC	MA, AS, CE	HB, HQ	LM, AD	LQ
Value coefficient	1.00	0.85	1.20	2.50	1.80	2.60	1.00	0.75	0.70

Explanations:
SP - Norway spruce; FR - fir; LA - larch; PI - pine species; BE - beech; OKS - oak species; QC - *Quercus cerris;* MA - maple tree; AS - ash tree; CE - cherry tree; HB - hornbeam; HQ - various high quality hardwood species; LM - lime; AD - alder; LQ - various low quality hardwood species

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YOLBA HOSPODAftSKfiHO ZPUSOBU POMOCI DISKRIMINACNI ANALYZY

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Clanek se zabyva moznosti vyberu urciteho hospodarskeho zpusobu pomoci diskriminacni analyzy, jednoho z ucinnych prostredku statistiky, v podminkach rumunskeho lesniho hospodarstvi. Nejdulezitejsi faktory ovlivnujici volbu hospodarskeho zpusobu pro rumunske lesnictvi jsou: podminky regenerace, rustove podmi'nky, charakter terenu a pudy, vnejsi faktory, pozadovane sortimenty a kvalifikace pracovnich sil. Z hospodarskych zpusobu se pouzivaji: holosec s rozlohou menSi nez 3 ha, clonna sec, skupinovy obnovny system, badenska clonna sec, vyberny hospodarsky zpusob, vymladkove hospodarstvi a do jiste miry smisene systemy (prvkova a skupinova clona a pruhove sece).

Lesni planovani je zalozeno na informacnim systemu, jehoz soucasti je program na hodnocem terennich dat. Ruznym zpusobem se pristupovalo a pristupuje k otazce vyuziti statistickych prostredku v programu a jeho pouziti k vyberu hospodarskeho zpusobu (Henne, 1977; Koval, 1990; Tecle, 1988; Dissescu, Dragoi, 1994; Crockford, 1987; Dragoi, 1995; Jacobsson, 1986; Thuresson, 1995, aj.).

Porosty popsane v tab. I jsou uvazovany jako vzorek modelu, na kterych byla provedena diskriminacni analyza k nalezeni spravnych funkci, ktere mohou byt realizovany v podpurnem systemu pro spravnou volbu pouziteho zpusobu. V procesu DA se pouzily bezne udaje vyuzivane v rumunskem lesnictvi: 1. oznaceni porostu, 2. celkovy korektivni koeficient pudni vody, 3. start porostu, 4. pouzity zpusob nebo uvazovany k pouziti, 5. vymera porostu (ha), 6. prumerne rocni srazky (mm), 7. prumerna teplota (°C), 8. stinova rezistence semenacku hlavnich drevin, 9. cetnost semen hlavnich druhu (roky), 10. koeficient prumerne vekove hodnoty drevin porostu, 11. typ porostu vzhledem k dulezitosti ochrannych funkci, 12. zasoba (m^3.ha~'), 13. odvozni vzdalenost (stovky m).

Diskriminacni analyzy se pouziva k rozhodnuti, do ktere ze dvou nebo vice skupin se objekt na zaklade konkretnich udaju zaradi a ktere promenne jsou pro toto zarazeni rozhodujlcf, tj. ktere rozlisuji skupiny. Na druhe strane umoznuje stanovit, do ktere skupiny je spravne zaradit objekt popsany stejnymi promennymi. Nejbeznejsi zpusob pri aplikaci DA je zahrnout mnoho mer k urceni tech, ktere rozlisuji skupiny. Zalezi vsak na pouzitem modelu DA. V prispevku je pouzito dvou modelu; je to model binarniho stromu a model jednoducheho shluku. Nastrojem DA je diskriminacni funkce. Jeji diskriminacni schopnost je vyjadrena hodnotou Wilkova A, Nulova hodnota znaci vysokou diskriminacni schopnost, hodnota 1 zadnou diskriminacni schopnost.

V praci se prislusne diskriminacni funkce ziskavaji jednak standardnim postupem, jednak postupnou analyzou, aby se v procesu zachovaly pouze rozhodujici promenne.

V tab. II az V jsou uvedeny koeficienty diskriminacnich funkci vzdy mezi dvema uvazovanymi hospodarskymi zpusoby s prislusnymi hodnotami standardniho vypoctu a postupne analyzy (v zavorce). Ukazalo se, ze diskriminacni sila funkce pouzitych promennych je nizka. Postupna analyza dokonce zachovava pouze promenne teplota a odvozni vzdalenost. Prokazalo se, ze dochazi k poklesu diskriminacni sily v zavislosti na zpusobu postupu vetveni binarniho stromu a zvysuje se moznost nespravne volby, kterou lze snizit asistenci uzivatele; ten by odsouhlasil castecne reseni. Tento postup je pri pouziti pocitacoveho programu v systemu na podporu rozhodnuti nevhodny.

Metoda jednoducheho shluku se ukazuje jako vhodnejsi (tab. VI a VII). Diskriminacni sila diskriminacnich funkci je vysoka a pouze dve promenne byly statisticky vylouceny. Z konkretni analyzy vyplyva, ze rozhodujici