Calculus and evaluation methods for forest roads execution impact upon the environment

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***Abstract*—**The paper presents the impact influence upon the environment determined in the execution process of forest roads and their exploitation. The quantification methodology of the impact intensity upon the main environment factors, respectively air, water, soil and biodiversity is also mentioned.

***Keywords*—**assessment, biodiversity pollution, environment, forest road

I. Introduction

Forest roads construction leads to a series of implications regarding waters, soil, vegetation, wildlife habitats, generally the natural environment. Considering that the provoked implications could present unfavorable consequences, there is necessary that in the forest roads construction activity, to be followed on the one hand a series of rules and recommendations which to assure the environment protection, and on the other hand, to know the main impact manifestations and the measures regarding its prevention or reduction.

The main recommendations regarding the environment protection are:

- The identification, yet from design phase, of the destructive hazards, in order to maintain the execution impact to a low level;
- The roads deployment will be done in order to avoid the hazard of some irreversible destructions;
- Biodiversity conservation;
- Protected areas conservation;
- The avoiding of some scientific and cultural areas deterioration (natural monuments, wildlife reservations, archeological sites, experimental surfaces);
- Integral timber capitalization from the road corridor;
- Judicious deployment for fillings depots outside the road territory, in stability conditions, with their coverage with vegetation, similar to filling embankments;
- The execution of rock cutting works only with normally charged blowholes;
- Keeping of the standing trees in front of the rock cutting works advancement as a protective strip with a width of 10 to 12 m;
- The avoiding of rock pushing with bulldozer, in order to avoid rock rollovers on the valley side, eventually wood-made parapets construction on the valley side in exceptional cases;
- The zone ecological equilibrium remaking, through reinforcement and protection works for embankments;
- Filling embankments protection, preferably with vegetation (forest vegetation with production role), and for cutting embankments with shrub vegetation (protection role);
- Reduction of collected waters in road zone upon the existent hydrographic network;
- Connection of new realized roads to the existent network without constructive elements deterioration for the existent network;
- Execution works management regarding the environment protection normative.

The manifestation forms of forest roads execution impact upon the environment, as well as the prevention and reduction measures are presented in table no. 1.

The impact quantification is made in accord with National Environment Protection Agency normative. As a result, field deployment of a road project, can be done only after **the environment accord** obtaining, on the basis of a special documentation, which must include an impact evaluation of the road upon the environment.

Table I – Forest roads execution works impact upon the environment

Impact manifestation forms	***Damages***	***Impact prevention or reduction measures***
1.Forest integrity interruption through road corridor execution	Productive surface losses; qualitative damages exposing of the stands (fungi and insects attacks, insolation); wind felling hazard increment;	Adequate roads deployment; choosing of a minimum road territory width; cutting and filling volumes equilibration; embankment surfaces recovery;
2.Equilibrium conditions modification	Erosion; earth flow;	Surface waters collection and evacuation; drainages; embankments protection; reinforcement works;
3.Natural landscape deterioration	Nude surfaces apparition (cutting and filling embankments); rock denuding as a consequence of local quarries realization;	Embankments coverage with vegetation; local quarries masking with vegetation; protection shields realization (trees and shrub for road sectors deployed outside the forest – link roads);

Table I – Forest roads execution works impact upon the environment (continuation)

Impact manifestation forms	***Damages***	***Impact prevention or reduction measures***
4.Forest vegetation damaging	Tree damaging (top breakage, cutted stems, barking, etc.), as consequences of explosives deployments, and rock pushing over the valley sides;	The avoiding of explosions with throwing effect; retaining parapets execution on the valley side;
5.Environment pollution	Atmosphere pollution with dust and discharge gasses; surface and deep water pollution; phonic pollution of the zone as result of execution and transport machines deployment;	Ecological fuels and low-pollution machines utilization; interdiction of salt and chemical substances usage in winter conditions; water quality management; adopting in execution of some silent machines and limitation of noisy machines usage;
6.Wildlife habitat perturbation	Wildlife migration; hunting and fishing effectives reduction; productivity reduction for hunting and fishing funds; overall vegetation contamination both, for hunting effectives alimentation and for general alimentation;	Phonic pollution reduction; conservation of the protected areas; biodiversity conservation; water pollution prevention; protection shields (trees and shrub) for roads outside the forest;
7.Soil wildlife habitat destruction	Ecological equilibrium deterioration;	Interdiction in usage for tracked machines; adequate roads deployment;

II. Impact Assessment

The impact of the road upon the environment is made through **the quantitative type analytical method** which considers reliability grades (Nb), or the graph - analytical method, which determines the global pollution index (I.P.G.).

A. *The Analytical Method*

The analytical method considers a reliability scale, expressed through grades between 1 and 10, which highlights the pollutants effect upon the environment. The general reliability scale (table 2) accords grade 10 to the unaffected natural state and grade 1 to the maximum pollution state.

The environment factor or element reliability is categorized on the reliability scale in rapport with admissible limits prescribed by the current normative.

In the impact quantification are considered only the main factors. These can be four, respectively: **water, air, soil and biodiversity**, characteristic for square variant, or six, in which case, are considered another two factors, respectively: forest stands interruption and natural landscape degradation, characteristic to the hexagon variant.

Table II – General reliability scale

Reliability grade	***Effects upon the man and environment***
10	-environment factors quality: natural, equilibrium; -man health state: natural;
9	-without effects;
8	-without casualty detectable effects; -the environment is affected in admissible limits – level 1;
7	-the effects are not harmful; -the environment is affected in admissible limits – level 2;
6	-the effects are accentuated; -the environment is affected in admissible limits – level 1;
5	-the effects are harmful; -the environment is affected over the admissible limits – level 2;
4	-the effects are harmful and accentuated; -the environment is affected over the admissible limits – level 3;
3	-the effects are lethal on medium exposure durations; -the environment is degraded – level 1;
2	-the effects are lethal on short exposure durations; -the environment is degraded – level 2;
1	-the environment is improper to life forms;

The environment factor or element reliability is categorized on the reliability scale in rapport with admissible limits prescribed by the current normative.

In the impact quantification are considered only the main factors. These can be four, respectively: **water, air, soil and biodiversity**, characteristic for square variant, or six, in which case, are considered another two factors, respectively: forest stands interruption and natural landscape degradation, characteristic to the hexagon variant.

No matter what variant is considered, the impact quantification involves a conversion system establishment for considered technical factors dimensions in conventional dimensions, respectively in reliability grades. In this order, there is imposed, on the one hand, the choosing of the most adequate technical dimensional element for the considered factor with his variation limits highlighting, and, on the other hand, normative obeying, where they exist.

In the following, is presented the square variant, which takes in consideration the factors water, air, soil and biodiversity, characterized by the following technical dimension able elements:

- For water and air, the concentrations of diverse pollutants (C), are compared with maximum admissible concentrations (CMA), prescribed through STAS 12574/87 and MAPPM Order 462/93 (for air) and NTPA 001/2002 (for water).

The environment pollution index (Ip) results from the two elements rapport:

$$Ip = \frac{C}{CMA} \quad . \qquad (1)$$

The maximum admissible concentrations, prescribed through the mentioned standards, are presented in table 3, and the real values of the concentrations (C), are determined by laboratory analyses. The environment pollution index (Ip) is determined for each pollutant, and in final are obtained through conversion, different reliability grades. The reliability grade for a factor is obtained as average grade.

Table III – Maximum allowable concentrations for pollutants

Crt. No.	***Pollutants denomination***	***M.U.***	***Maximum admissible concentrations***
	A. Air		
1.	CO	mg/m^3	2,0 (daily)
2.		mg/m^3	2,0 (daily)
	B. Water		
1.	pH	-	6.5…8.5
2.	Suspensions	mg/l	30
3.	CBO_5	mg/l	12
4.	CCO-Cr	mg/l	30
5.	Total Nitrate	mg/l	5
6.	Total Phosphor	mg/l	0.5
7.	Phenols	mg/l	0.2

Technical dimensions conversion (through which pollution index (Ip) is expressed), in reliability grades (Nb) is presented in table 4.

Table IV – The pollution indexes conversion for air and water in reliability notes

I_p value $I_p = \frac{C}{CMA}$	***Reliability grade N_b***
0	10
0,0-0.25	9
0.26-0.50	8
0.51-1.00	7
1.10-2.00	6
2.01-4.00	5
4.01-8.00	4
8.01-12.00	3
12.01-20.00	2
>20.00	1

For soil there are appreciated as being satisfactory the values for two pollutants: the volume of cuttings effectuated on the corridor length expressed in m^3/hm and the timber exploitation residuals resulted from corridor timber exploitation, expressed in mst/ha.

For conversion scale elaboration for cutting volumes (m^3/hm) in conventional units (Nb), there were calculated the afferent cutting volumes for a road with a single lane (with an average width roadway), for different terrain conditions (transversal slope of terrain).

The obtained characteristic transversal profiles were grouped in three categories, respectively, for the following calculus hypotheses:

- Earth zones, in which the road platform does not need retaining walls (transversal slopes between 0 and 50% - hypothesis 1);
- Earth zones, in which the road platform needs retaining walls (transversal slopes between 60 and 70% - hypothesis 2);
- Rock zones (transversal slopes between 80 and 100%% - hypothesis 3).

A synthetic situation of calculations regarding the embankment works for the three hypotheses is presented in table 5.

Table V – Embankment works volumes for different transversal slope conditions

Section No.	***Surface (m^2/hm-road)***				***Road territory***		***Transv. slope***
	Fill	Cut	R.W.	Rock	Width	Surface	%
1	2.5	-	-	-	5.5	550	10
2	2.3	-	-	-	5.9	590	20
3	3.9	1.4	-	-	9.0	900	30
4	2.1	5.6	-	-	10.3	1030	40
5	3.6	7.2	-	-	12.3	1230	50
6	1.5	8.9	5.2	-	9.0	900	60
7	-	10.7	6.44	-	7.9	790	70
8	-	-	-	11.2	7.3	730	80
9	-	-	-	10.8	6.9	690	90
10	-	-	-	14.0	8.5	850	100
1	250	-	-	-	5.5	550	10
2	230	-	-	-	5.9	590	20
3	390	140	-	-	9.0	900	30
4	210	560	-	-	10.3	1030	40
5	360	720	-	-	12.3	1230	50
6	150	890	520	-	9.0	900	60
7	-	1070	644	-	7.9	790	70
8	-	-	-	1120	7.3	730	80
9	-	-	-	1080	6.9	690	90
10	-	-	-	1400	8.5	850	100

As seen in table 5, the cutting volumes in the case of earth deployed road territory (without retaining walls), vary between 140..720 m^3/hm – road; in the case of retaining walls usage, the cutting volumes, including the retaining walls volumes, vary between 1410…1714 m^3/hm – road.

For the impact assessment upon the soil there is proposed the consideration of both, the earth cuttings for road territory and retaining walls realization. Rock cuttings will be considered in the case of environment factor ,,landscape deterioration”.

The first two calculus hypotheses are using the conversion from table 6, and the third one, the conversion from table 7. In the case of some non homogeneous conditions, the pollution index is established for each situation apart, then it is converted in reliability grades and an average value can be provided.

By considering the tables 6 and 7, there can be obtained a first reliability grade for the soil factor (Nb_{1soil}).

Table VI – Cutting volumes conversion in reliability grades - Nb_{1soil} (1 and 2 hypotheses)

Cut volume ***m^3/hm-road***	***Reliability grade Nb_{1soil}***
Under 140	10
141-250	9
251-360	8
361-470	7
471-580	6
581-690	5
691-810	4
811-920	3
921-1030	2
Over 1030	1

Table VII – Earth volumes conversion in reliability grades - Nb_{1soil} (hypothesis 3)

Cut volume ***m^3/hm-road***	***Reliability grade Nb_{1soil}***
Under 140	10
1401-1450	9
1451-1500	8
1501-1550	7
1551-1600	6
1601-1650	5
1651-1700	4
1701-1750	3
1751-1800	2
Over 1800	1

To the soil pollution contribute as shown the timber exploitation residuals, resulted from corridor realization, and which, by clearing the corridor pollute the adjacent terrain. According to the specialty literature, the timber exploitation residuals vary between 0.5 and 10 mst/ha. As a result, the residuals volume conversion in reliability grades Nb_{2soil} can be made by using the values from table 8.

Having the two reliability grades for the soil factor, Nb_{1soil} and Nb_{2soil}, the reliability grade for soil factor is obtained as a weighted average of the first two, and can be expressed with the following relation:

$$Nbsoil = \frac{7Nb1soil + 3Nb2soil}{10}. \qquad (2)$$

The methodology regarding the impact assessment for soil factor is a proposal, which, obviously can be improved from conversion scales point of view.

For biodiversity, the road construction impact must be assessed by considering the field collected data regarding the following aspects:

- The encountered biotypes on the road corridor (forests, swamps, wetlands, sands, etc.);
- Local flora;
- Animal and vegetal habitats in the crossed zone, etc.

There can be appreciated, more or less theoretically, the percent in which the biodiversity is affected (P%), and the pollution index Ip results from the following relation:

$$Ip = P\%/100. \qquad (3)$$

Table VIII – Exploitation residuals conversion in reliability grades - Nb_{2soil} - proposal

Exploitation residuals [mst/ha]	***Reliability grade $N_{brest.ex}$***
Under 0,5	10
0,6-1,5	9
1,6-3,0	8
3,1-4,0	7
4,1-5,0	6
5,1-6,0	5
6,1-7,0	4
7,1-8,0	3
8,1-9,0	2
Over 9	1

With the obtained value the reliability grade can be extracted from table 9.

Table IX – Biodiversity pollution in reliability grades Nb

Biodiversity pollution index I_p	***Reliability grades, Nb***
Under 0,10	10
0,11-0,20	9
0,21-0,30	8
0,31-0,40	7
0,41-0,50	6
0,51-0,60	5
0,61-0,70	4
0,71-0,80	3
0,81-0,90	2
Over 0,90	1

B. Graph Analytical Method

After the reliability grades determination for the mentioned factors (water, soil, air and biodiversity) there can be made the global assessment of the impact upon the environment by using the global pollution index I.P.G. and the environment quality scale (table 10).

Table X – Environment quality scale

Value	***Environment quality***
1=IPG	Natural environment, unaffected by human activity
$1 < IPG \leq 2$	Environment affected by human activity in admissible limits
$2 < IPG \leq 3$	Environment affected by human activity, with discomfort for life forms
$3 < IPG \leq 4$	Environment affected by human activity, with disturbances for life forms
$4 < IPG \leq 6$	Very affected environment by human activity, dangerous for life forms

6<IPG	Degraded environment, improper for life forms

According to the table, when I.P.G.=1, the environment is not polluted and when I.P.G.>1 there appear quality modifications which are increasing up to total degradation of environment for values greater than 6.

The global pollution index value is determined through graph analytical method, using the diagram presented in fig. 1 and the following relation:

$$IPG = \frac{S_i}{S_r} . \quad (4)$$

Where Si represents the ideal state, expressed by square surface and Sr represents the real state expressed by the black polygon.

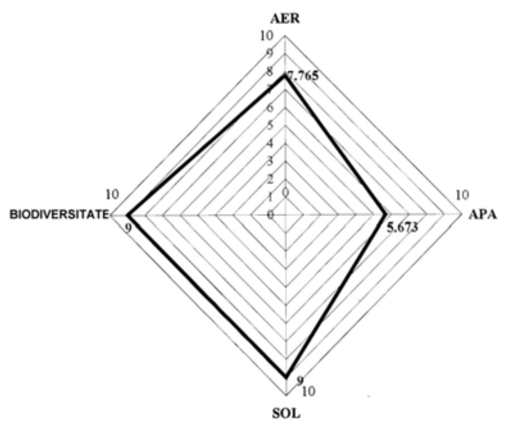

Fig. 1 – Graphical representation for IPG determination

The square presented in the mentioned figure has in each corner inscribed one of the main considered environment factors (air, water, soil, biodiversity), and each semi diagonal afferent to a certain factor is composed from ten conventional units, according to the reliability scale, the gradations beginning from the diagonals intersection and ending to each corner of the square. Using the conventional gradations, Si results as being 200, and Sr is graphically determined. By marking on each semi diagonal the value for reliability grade and joining the resulted points a new polygon is created. The new polygon area represents the real state of the considered zone after the environment elements pollution.

In this way, the global pollution index IPG expresses in a quantified form the road construction impact upon the environment. Thus, in the certain case presented in fig. 1, the pollution index for „air" factor is of 7.765, 5.673 for „water", 9 for „soil" and 9 for „biodiversity". Results a polygon with conventional area of 122,997. By applying the relation no. 4, there results an global pollution index IPG of 1,63. According to the environment quality scale (table 10), results that in this case the environment is affected in admissible limits.

III. MONITORING OF FOREST ROAD CONSTRUCTION IMPACT

An important side regarding the forest roads impact monitoring refers to technological process monitoring. Practically, the technological process monitoring in the case of the embankment works executions has to be understood as being the action of step by step supervision of the entire process, through verifying activities, specific technical sampling, and results comparing to some referential systems predictions.

The main purpose of process monitoring is to eliminate some immediate causes which could lead to nonconforming with different execution stages of the embankment works execution. This, also leads to economical process improving. The specific verification and sampling activities (in situ) are presented in the following:

A. Execution of topographic works

Execution of topographic works involves the pickets verification, concordance between design and terrain verification, work marking verification, slope models verification and marking details (outside the working zone) verification.

The pickets' verification takes place before the work start and implies the materialization and conservation mode inspections. A special attention will be granted to reference cote pickets.

The concordance between design and terrain verification is made after design layouts receiving (situation plan, profile, sections), the mentioned layouts being verified and approved by the project engineer. In the case of major differences, in a term of maximum 15 business days, these can be official presented to the design engineers, which must realize the necessary corrections for the all project details (execution and economic design).

The work marking verification involves the inspection of axes and road territory widths, both in cut and fill zones. With this occasion is also verified pickets' materialization, especially for those which mark road territories.

The slope models verification implies the models location and their protection during the execution activity. This stage is realized before the work starting, as well as during the work execution, by team supervisor and work point supervisor.

Marking details outside the working zone verification involves the identification and inspection through measurements of the marking details for the main points (angle, tangents, bisectors, curves, transversal changes of slope, crossing works points, etc).

B. Execution of preparing works

The quality control in the preparing works execution stage implies activities as: verification of legal forms for deforestation and terrain movement from forestry circuit, deforestation mode verification, vegetal layer cleaning mode verification, working zone drainage verification.

The legal forms verification is realized by site supervisor. The legal forms concern the embankment works client. This activity is realized before the preparation works, being the responsibility of embankment works site supervisor.

Deforestation (fig.2) mode verification involves activities such as tree felling, roots removing, holes filling, vegetal residuals cleaning. This activity is realized on different sectors, by working point supervisor.

The vegetal layer cleaning mode verification (Fig.3) considers the thickness of vegetal layer which is removed, as well as its depositing outside the road territory. This activity is applied only to support layers for filling and is realized by the working point supervisor, on before established sectors.

The drainage mode verification refers to ditches positioning, their slopes and platforms slopes. This activity is realized by the working point supervisor.

Fig. 2 – Deforestation in the site area

Fig. 3 – Vegetal layer cleaning

C. Establishment of borrows locations

The quality control in the borrowings locations establishment stage imposes the following verifying and sampling activities: verification of physic and mechanical qualities of the earth from borrowings and legal forms verification regarding the circuit changing for borrowings locations.

The first activity involves samples logging from different locations and depths in the borrowing location and their sending to a specialty laboratory. Here is determined the earth type and specific characteristics (plasticity index, aggregate grading, maximum compaction grade, etc.)

The second activity is realized by site supervisor before the exploitation works beginning.

D. Experimental sector execution

The quality control in the experimental sector execution stage (regarding the establishment of embankments compaction elements: layer thickness, number of passes for the compaction machine) imposes the following verification and sampling activities: geometrical dimensions verification for the experimental sector (widths, heights, lengths), technical characteristics of the compaction machine verification (weight, average moving velocity), the determination of compaction grade for each layer after some before established passes, earth layers thickness verification after the realization of the maximum compaction grade.

First activity is realized by working point supervisor during and after sector configuration, second activity is realized before the compaction activity beginning; third activity is maintained until the maximum compaction grade is achieved for each layer form sector (is realized in the site laboratory). The maximum compaction grade (Proctor methodology) for earth used for experimental sector is realized by an authorized superior rank specialty laboratory.

The last activity is realized by working point supervisor and as a result of this the mentioned activities an analysis form is elaborated in which are specified the obtained results.

E. Cut works execution

The control activity is deployed in the cutting areas, vegetal residuals removing areas and borrowing areas. In this sense there are necessary the following activities: thickness verification of the removed vegetal earth layer, embankment slopes verification, slopes and cotes verification for platforms (Fig.4), longitudinal profile and sections, main finishing realization verification, watersheds mode from the cutting areas.

Fig. 4 – Cutting works

First activity is realized on embankment sectors as well as on borrowings areas, where is removed only the vegetal soil by the working point supervisor, second activity is realized in the same time with the cutting works, filling works, borrowings. In this order there are used slope markers and the verifications are made by using as reference systems of execution layouts. The third activity is realized for cutting and filling portions, especially when there the final cotes are achieved, but also for borrowings. The fourth activity is realized after the embankment works, and the last activity is taking place in the same time with the execution, but especially when the final cutting cote is achieved.

F. Earth transport, unload and bedding

This stage is specific to the filling areas, when the quality control is made through the following activities: permanent roads' technical state verification, daily checking of the transport machines, earth unload and bedding verification, uniformity and thickness verification for the deployed earth layer, platform lateral and longitudinal slopes' verification, and earth moisture for the anterior executed layers verification.

Fig. 5 – Embankment realization with bulldozer

The first and the second activity is realized both by working point supervisor and drivers, the third and fourth ones is realized in the same time with filling works, permanently by the responsible person and periodically by the working point supervisor, on the basis of the technical working procedure. The fifth activity is realized on each sector, immediately after bedding by embankments team supervisor. The last activity is realized by site laboratory in the drainage period of the filling support layer.

G.Compaction works execution

This quality control stage is executed in cutting and filling areas as well as in the zones where the vegetal soil is removed. This stage involves the following activities: embankment earth moisture verification realized by the site laboratory before the compaction work beginning, compaction technology verification which is permanently realized for each sector by team supervisor on the execution time and at the beginning of each day by the working point supervisor, transversal and longitudinal slopes verification for each sector is made by the working point supervisor after the compaction work realization having as reference systems the sections from the execution layout, compaction grade verification realized for each filling layer, filling support by site laboratory in minimum three unfavorable points at 2000 square meters. In the case of filling supports, the verification points are distanced at maximum 250 ml each other. The verifications are made with the Proctor analysis specifications.

Fig. 6 – Compaction machine

H.Finishing works execution

The quality control in the stage of embankment works finishing involves the following activities:
-verification of the earth fractions detachment mode from the embankments;
-verification of the final embankments slopes;
-verification of compaction state of embankments;

Fig. 7 – Finishing works with grader

These activities are realized by team supervisor and working point supervisor, in the same time and after the finishing of each sector, having as reference system the task books specifications.

Fig. 8 – Finished platform and ditches

I. Embankment protection works execution

The quality control in the protection works execution follows the directives described below:
-width and depth verification for the stepped cutting embankments realized by the working point supervisor for each sector before the vegetal earth bedding;
-vegetal earth verification (vegetal earth settled on the embankments): compaction, spreading, herbal seeds, raking; this activity is made by the working point supervisor on each sector in the same time and after the work realization;
-verification of the anchorage and fixation of the concrete squares in the case of protection with these;
-verification of the distance between the seedling plants in the case of reforestation protection;
-verification of the sand layer, compaction and support foundation in the case of rock ripraps protection;
-verification of the plastic or metallic meshes as well as their anchorage when this protection solution is adopted;
-geometrical dimensions verification of the ditches and side ditches as well as the sand layer thickness under them.

IV. CONCLUSIONS

There can be extracted the following conclusions regarding the presented paper:

1. The impact study constitutes a mandatory piece in the forest road design which is necessary in order to obtain all the approvals for forest road execution;
2. Through the impact study, the impact is quantified in accordance with Environment Protection Agency directives;
3. Impact assessment contributes to a better landscape solution through the extension of the wood as a construction material and the realization of bridges and retaining walls based on wood;
4. The national natural parks protection is assured through the respecting of the integral protection zones, the road tracks being lead only to the touristic and administrative boundaries.

REFERENCES

[1] Alexndru, V., Ciobanu, V., *Environmental Impact and Assessment of Forest Roads Construction,* Pro-Active Partnership in Creativity for the Next Generation, Presses Internationale Polytechnique, 2007, pp. 671-673.

[2] Bereziuc, R., Ciobanu, V., Ignea, Gh., *Founding Elements for Forest Roads Design Normative,* Transilvania University Publishing House, Braşov, 2008.

[3] Bereziuc, R., Alexandru, V., Ciobanu, V., Ignea, G., Abrudan, I., Derczeni, R., *Guide for Forest Roads Design, Construction and Mantining*, Transilvania University Publishing House, Brasov, 2006.

[4] Bereziuc, R., Alexandru, V., Ciobanu, V., Ignea, G., Abrudan, I., Derczeni, R., *Best practice guide in forest road construction*, Transilvania University Publishing House, Brasov, 2006

[5] Zarojanu, H., Transport Instalations, Ştefan cel Mare University Publishing House, Suceava, 2006.

[6] Zarojanu, D., *Roads. Superstructure*, Polytechnic Institute, Iaşi, 1974.

[7] xxx, *Forest Constructions in Forest Sustainable Development Context*, Forest Constructors Association, Lux Libris Publishing House, Braşov, 2006.

[8] xxx, *Procedure for Environment Impact Assessment and Environmental Approval Emission*, O.M. of M.A.P.M., no. 860, 2002.

[9] xxx, State Standard Collection.