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PREDICTION OF SOUND PROPAGATION ARISING FROM THE ECONOMIC ACTIVITIES CARRIED OUT IN THE RODNA MOUNTAINS OF NATIONAL PARK

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Abstract: *The paper presents a study of the sound pollution caused by economic activities in the immediate vicinity of the National Park Reserve Natural of Rodna Mountains. The work, according to the study conducted, acting unfavorably on the fauna and flora Habitat. From the reserved area it was found that the animals and the birds have migrated to zones of silence, on an area of 40-45% of its original area. The study was limited to measurements in the vicinity of the protected area, but the effects are felt over it.*
Key words: *Noise pollution, Rodna Mountains, economics activities, protected areas.*

1. INTRODUCTION

In the external environment, the propagation of sound from their spherical shape, intensity decreases constantly due to natural phenomena: air intake, ununiformity propagation environment influenced by meteorological conditions, interaction with soil and solid obstacles.

For sound propagation prediction in wooded areas, there are a number of programs for modeling the temporal and spatial noise. Most instruments have been developed for modeling the propagation of noise in human-dominated ecosystems CadnaA, LIMA, NoiseMap and SoundPLAN [1].

The System for the Prediction of Acoustic Detectability (SPreAD-GIS) developed by the United States Forest Service (USFS) and the environmental protection agency in United States of Environmental Protection Agency (US-EPA), was specifically designed for modeling the propagation of noise in forested ecosystems. Analyzing the activity report for the year 2013 the Rodna Mountains National Park Administration, you can outline a few anthropogenic pressures exerted on this, who are directly related to the level of noise in the Park [3]:

-illegal cuts and extraction out of timber;

-failure of the technological process in the work of the wood;

-practicing illegal means tourism: offroad, enduro, atv etc.

The density of forest roads in the Valley of the Anieș River is closely connected with the economic activity carried out in this area. Noise from the vehicles transporting timber or stone, equipment and work equipment for cutting wood in the Park spreads over large distances, due to the terrain and wooded areas.

2. MATHEMATICAL MODEL

2.1 The basic notions

Mathematical model for calculating named the SPreAD includes most of the factors affecting the propagation of sound: wind, atmospheric effects, soil and vegetation. The program depends as well as the characteristics of the sound source.

The process for calculating in the SPreAD-GIS comprises six stages, each of them includes an additional factor, that influences the manner in which any frequency band propagates through space [1]:

- **Spherical spreading loss** - Mitigation of noise due to geometrical divergence *Adiv* (decrease with the increase of noise propagation distance) is calculated on the basis of spherical propagation from a source point in free field (expressed in dB). Attenuation due to geometrical *Adiv* differences can be expressed by the relationship [ISO 9613-2]:

$$A_{div} = \left[20\log\left(\frac{d}{d_0}\right) + 11\right] dB \qquad (1)$$

where:
d - is the distance from source to receptor [m];
d_0 - reference distance =1m.

Sound power level can be calculated thus [6]:

$$L_p = L_w - 10\log\frac{S}{S_{ref}} \qquad (2)$$

where:
S - area [m^2];
S_{ref} - reference area =1m^2;
L_w - acoustic level sound pressure [dB];
d - is the distance from source to receptor [m].

Expressed the area the (2) becomes:

$$L_p = L_w - \left(10\log(4\pi d^2) - 10\log(S_{ref})\right) \qquad (3)$$

- **Loss due to air intake** is calculated for sound level reduction due to atmospheric absorption, being dependent on the frequency as a function of temperature, relative humidity, and altitude. Sound power level can be calculated using the formula:

$$L_p = L_w \quad 10\log\frac{S}{S_{ref}} \quad \alpha r \qquad (4)$$

in which:
α - absorption air coefficient [dB/m];
r - is the distance from source to receptor [m];
S - studied surface [m^2];
S_{ref} - reference surface =1m^2.

Attenuation coefficient α depends on the frequency of the air intake, air humidity, temperature and atmospheric pressure, expressed in dB/m atm, being given by the relation (4) developed in [4], having the explanations in the followings:
f - frequency [Hz];
T - atmosphere absolute temperature [^{o}K];
T_0 - 293,15K –the given temperature for 20^{o}C;
p_s - local atmospheric pressure [atm];
p_0 - reference atmospheric pressure, 1 atm;
H - absolute humidity;
$f_{r,N}$ and $f_{r,O}$ - relaxation frequencies are associated with nitrogen and oxygen molecules vibration.

$$\alpha = f^2\left[\left(\frac{1{,}84\cdot10^{-11}}{\left(\frac{T_0}{T}\right)^{\frac{1}{2}}\frac{p_s}{p_0}}\right) + \left(\frac{T_0}{T}\right)^{2{,}5}\cdot\left(\frac{0{,}10680e^{\frac{-3352}{T}}f_{r,N}}{f^2+f_{r,N}^2} + \frac{0{,}01278e^{\frac{-2239{,}1}{T}}f_{r,O}}{f^2+f_{r,O}^2}\right)\right] \qquad (4)$$

- **Noise Attenuation due to foliage**, who calculats the diminuated the sound level for to absorption and scattering by vegetation. The loss acoustic energy depinds of density of leaves and foil cover, as well as the distance from the source. In wooded areas, the excess attenuation can be expressed using the following relationship as determined by several measurements:

$$A_{fol} = 0{,}01 r_f f^{1/3} \qquad (5)$$

in which:
f - the sound propagation frequency [Hz];
r_f - distance from the edge of the forest to the application point of measurement [m].

The distance r_f can be expressed by:

$$r_f = r_1 + r_2 \qquad (6)$$

and r_1 , r_2 are the radii as in figure 1 [5]:

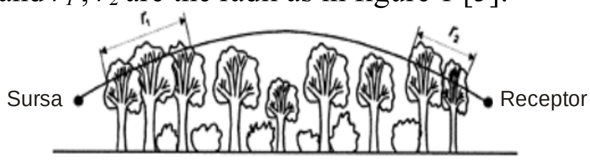

Fig. 1. The foliage distances [5]

- **Wind speed Gradient** with blowing, lowers the level of sound through the scrolling distance.

- **Noise Attenuation due to ground effect** is given by the topography of the land. Attenuation of noise due to ground effect A_{gr} is caused by the interference of the reflected noise and noise that propagates directly from the source to the receiver. If the sound propagation takes place on a porous or mixed, the attenuation due to ground effect can be calculated with relation [ISO 9613-2]:

$$A_{gr} = 4.8 - \left(\frac{2h_m}{d}\right)\left[17 + \left(\frac{300}{d}\right)\right] \geq 0 \ [dB] \quad (7)$$

having:

h_m - the average height of the propagation path above the ground [m];

d - is the distance from source to receptor [m].

The negative values of A_{gr} will be made zero inside them.

2.2 Making noise propagation measurements and prediction

The measurements were carried out in the vicinity of the National Park named the Rodna Mountains (Figure 2), on Unieș Valley, with "intense" economic activity zone, where there is vast timber sawmills, a crushing station and a pumping station on the capture and water for boilers.

Effect of reverberation and the thermal and geometrical divergence or presenting refraction of the land, the noise arising from the economic activities in the area adjacent to the National Park, is propagated through the forest over large distances. Input variables shall take into account the source and receiver geometry, dimensions of the forest, weather conditions, time of reverberation and the sound power level.

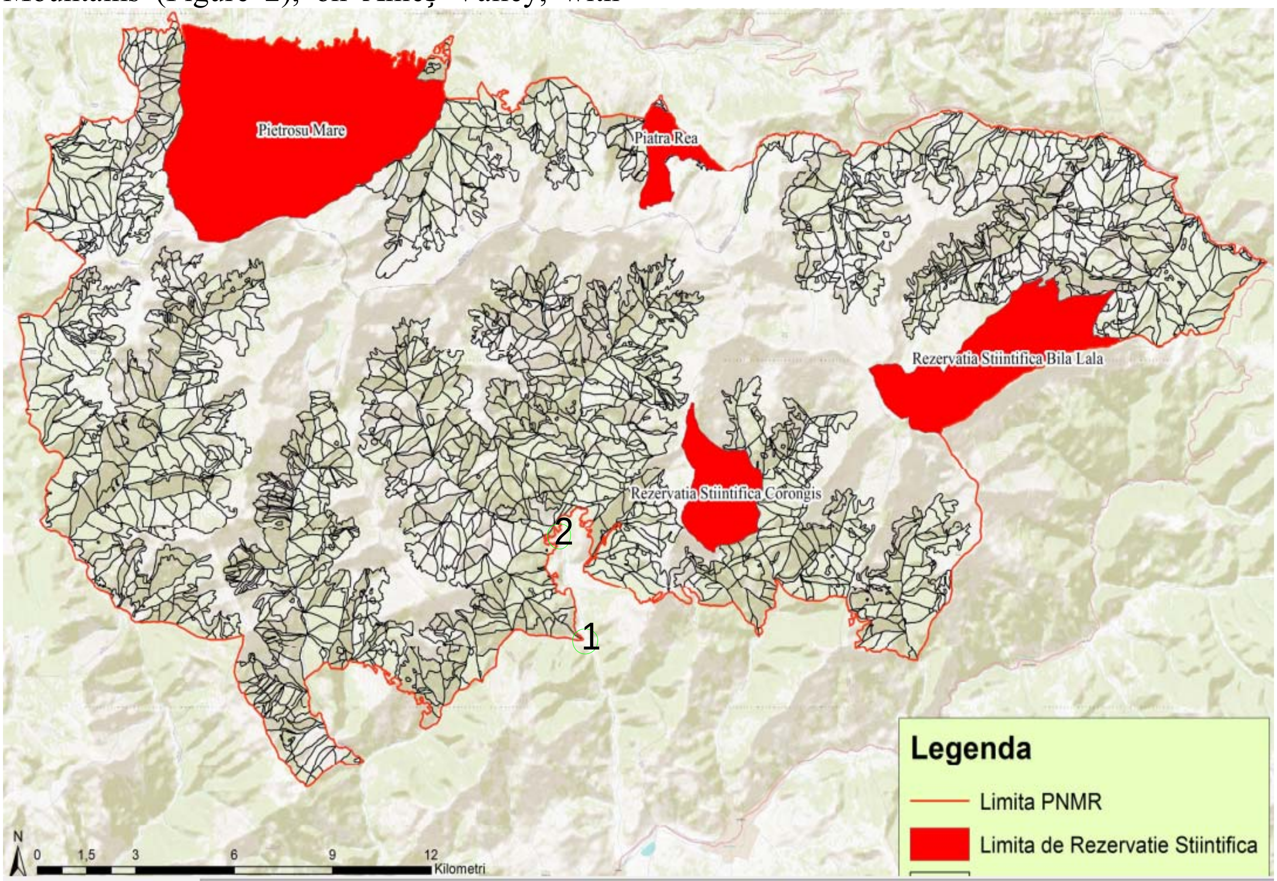

Fig. 2. Rodna Mountains National Park Map - the location of measuring points [7]

The measurements were made with the help of sound-level meter type NL-32. The sound level meter has been set to determine a weighted sound pressure level "*A*" continuously for 5-minute intervals. Registration values was subtracted from the card for which have been drawn up and was carried out with the help of graphics program NL-22PB1.

As a result of the measurements carried out in the vicinity of the three points that are considered as sources of noise pollution, the distance between source and receiver is approximately 50 m and 200 m, and obtained the values have presented in table 1.

Table 1

The measurement obtained values

Position	Distance	L_{Aeq}	L_{AE}	L_{Amax}	L_{Amin}	L_{A05}	L_{A10}	L_{A50}	L_{A90}	L_{A95}	L_{Cpeak}
Sawmill 2	50 m	65.60	77.47	69.87	63.70	67.33	66.23	65.10	64.30	63.90	96.00
	200 m	51.69	61.69	53.53	49.93	53.08	52.77	51.35	50.38	50.24	72.77
Crushers and Sawmill 1	50 m	64.07	73.95	69.85	56.98	68.97	67.83	62.49	58.49	57.83	88.28
	200 m	63.18	73.18	64.96	54.40	64.59	64.28	62.92	61.87	61.62	87.96

The measuring points located at approximately 200 m in Rodna Mountains National Park boundary, in the skirts of the forest.

The time of the measurements was 10 minutes at 14°C air temperature and relative humidity of the atmosphere 23%.

Data obtained from measurements carried out in the vicinity of the station of crushing and sawmill 1, are shown in Figure 3.

With the help of the software the SPreAD of GIS model for the propagation of the noise measured at a distance of 50 m from the crushing station and sawmill 2. The map used in this model is shown in Figure 4.

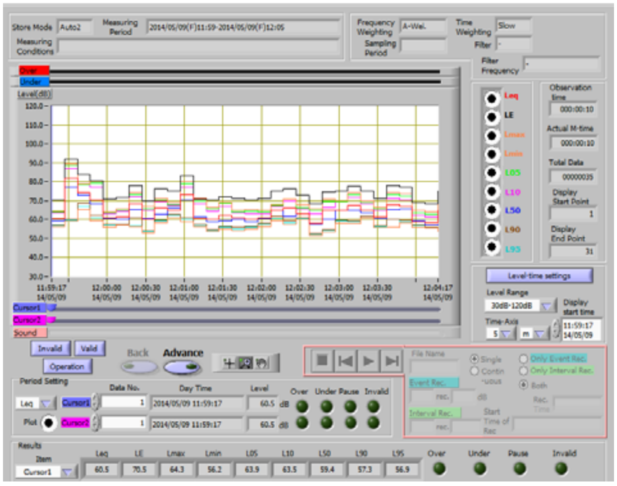

Fig. 3. Representation of data obtained from measurements in item 1

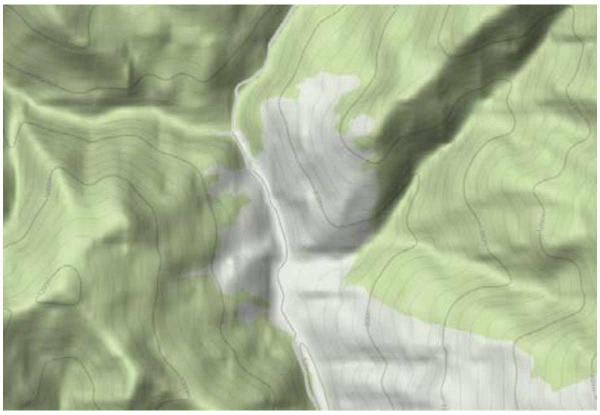

Fig. 4. Studied Area Map [2]

For noise propagation prediction originated from crushing station, we used the following data entry, as shown in figures 5-7.

a) *Create ambient sound conditions dataset*

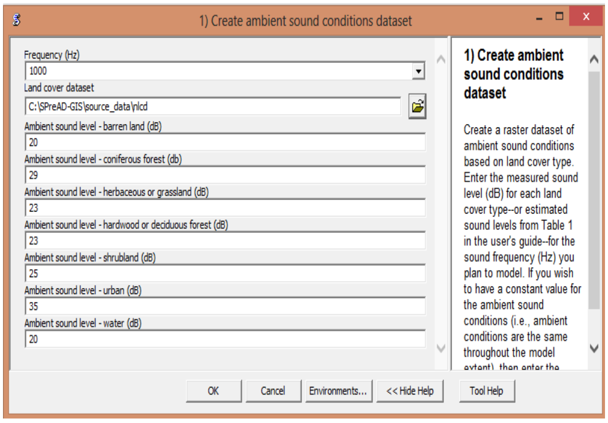

Fig. 5. Ambient Sound Conditions

b) *Calculate noise propagation for one point*

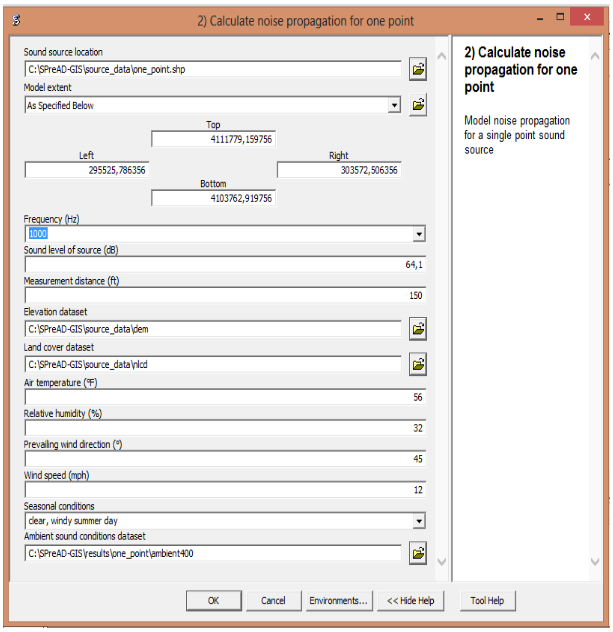

Fig. 6. Calculate noise propagation for one point

c) *Calculate noise propagation for multiple frequencies*

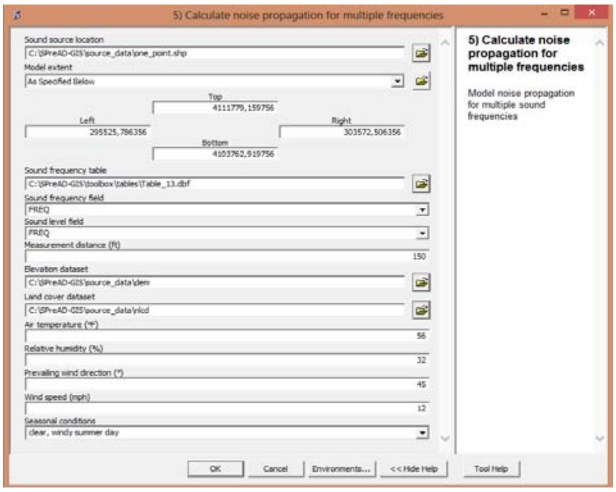

Fig. 7. Calculate noise propagation for multiple frequencies

The model obtained for the propagation of sound in the Woods, is shown in Figure 8.

3. CONCLUSIONS

Based on the measurements of the sound pressure level close to sources of pollution-generating audible, he developed a mathematical model for prediction of sound propagation in Rodna Mountains National Park. This mathematical model validation through measurement and its application in other places regarded as sources of noise pollution, will help to determine areas of risk relating to changes in the behavior of animals, especially large carnivores.

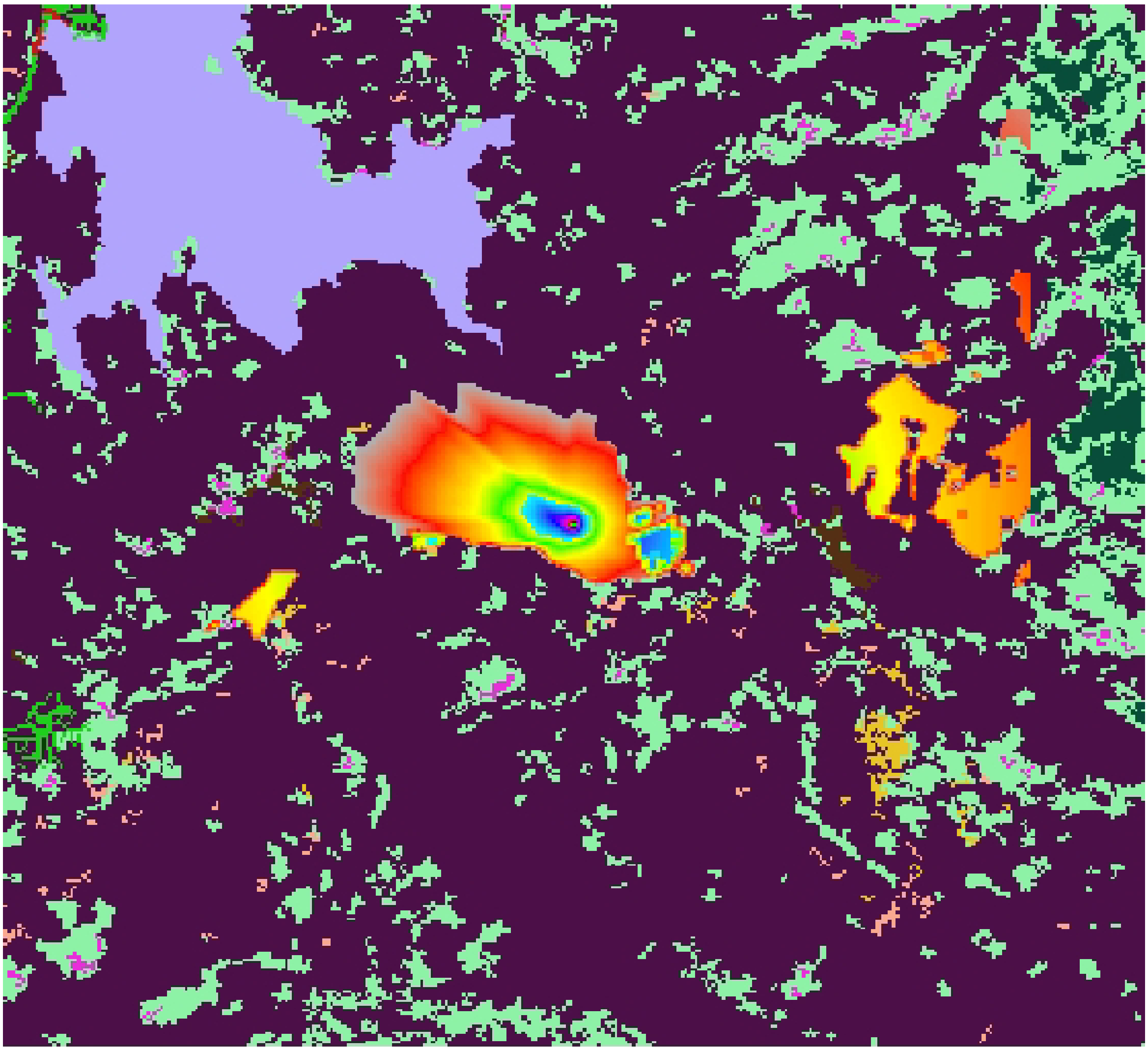

Fig. 8. Model obtained for the propagation of sound in the Woods

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Predicţia propagării sunetului provenit din activităţile economice desfăşurate în apropierea Parcului Naţional Munţii Rodnei

Rezumat: Lucrarea prezintă un studiu asupra poluării sonoră produsă de activitățile economice din imediata apropiera a Rezervației Naturale din Parcul Național Munții Rodnei. Activitatea, conform studiului efectuat, acţionează nefavorabil asupra habitatului faunei și florei. Din zona rezervată s-a constatat că animalele și păsările au migrat către zonele de liniște, pe o suprafață de 40-45% din suprafața inițială. Studiul s-a limitat la efectuarea măsurătorilor în vecinătatea zonei protejate, dar efectele se resimt asupra acesteia.

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