

## AMPLITUDE OF THE DEER DAMAGE IN THE NORWAY SPRUCE FOREST OF THE EASTERN CARPATHIAN MOUNTAINS

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**Abstract:** The goal of the research was to establish the amplitude of the deer damage corresponding to the Norway spruce forest from the Eastern Carpathian Mountains. A database was created, containing all Norway spruce stands damage by deer, differentiated by working sections, forest districts and forest department. Then, assisted by a computer program it was possible to calculate the area affected by deer, by age class. Afterwards, it was possible to determine the distribution of stand area affected by deer, by damage categories, in relation with stand age, site type, forest type, land slope, stand exposure, land altitude and site class for each working section and forest district as well as for the entire Suceava Forest Department, the most affected region from the study area. A first conclusion relating to the amplitude of the damage produced by deer is the fact that significant damage from point of view of area affected by deer is recorded in forest district located in the Northern Carpathians. In Suceava Forest Department stands affected area is about 84266.2 ha (21.3% from forest area). The data analyzed indicates that the most significantly are affected the Norway spruce stands about 21 and 80 years old, integrated in the „Mountain mix *Ps*, brown high edaphic, with *Asperula-Dentaria*” site type and in the „Norway spruce - European beech mixed stand” forest type, which grow on lands having a slope between 11° and 30°, at altitudes between 600 m and 1200 m, in superior site class (site class 1 and 2).

**Keywords:** Norway spruce, deer damage, Eastern Carpathian, cervid, bark stripping

### 1. INTRODUCTION

The perturbation of forest biocenoses in certain areas, organized according to the laws of natural ecosystems in report with management strategy, was possible by replacing the former natural stands having polyvalent functional structures capable of meeting multiple requirements, with artificial single-crop systems (Ichim, 1988; Giurgiu, 1995; deCalesta, 1994; Bachmann, 1998; Siipiletho & Heikkilä, 2005).

Artificial forest crops, very far from the natural forest pattern, are unstable and cannot survive without permanent and extra energy consuming human interventions, meant to replace the self-adjustment functions of the natural ecosystems. Hence the multiple damage registered in these artificial forest crops, a large-scale consequence of the ecological disorder being the damage caused by deer to the Norway spruce artificial stands established in place of former

natural forests having natural stable structures, in the stage where coniferous trees are mixed with European beech (Alverson, et al., 1988; Ichim, 1990; Bachmann, 1990, 1998; Anderson & Katz, 1993; Heikkilä & Härcönen, 1996; Putman & Moore, 1998; Heikkilä, et al., 2003; Vlad et al., 2007; Takatsuki, 2009).

The problems of the deer damage in some forest from Romania are caused by the breaking of the ecological balance of these forest ecosystems (Ichim, 1988, 1989, 1990; Giurgiu, 1995).

The damage caused by deer to the forest plantation became a problem for Romanian forestry around the year 1960 in forest area with a high deer population (Ichim, 1988).

The problem of the deer damage in Northern Carpathians was pointed out in 1964 based on the observations carried out in Iacobeni forest district (Ichim, 1990).

At the level of the year 1972, the damage caused by deer to spruce and fir trees through bark

stripping was considerable. The areas with plantation damaged and the damage produced to natural regeneration with European silver fir could be added (Ichim, 1990).

Recuperation of the ecological balance in the Norway spruce artificial stands, has in view, first of all, increasing the stability of these against snow and wind, outlining the directions for a durable, medium and long term management (Vlad, 2007, 2009).

The durable management of deer-damaged artificial forest ecosystems should start from the economic target determined by the destination assigned, by the functional efficiency of the forest for the entire time span of its development (Ichim, 1990; Bachmann, 1990, 1998; Kay, 1993; deCalesta, 1997; Putman & Moore, 1998; Stout, 1998; Ballon, et al., 1999, 2005; Motta, 2003; Renaud, et. al, 2003; Rooney & Waller, 2003; Tremblay et al., 2004; Siipilehto & Heikkilä, 2005; Vlad, 2007; Ward & Mervosh, 2008; Miller et. al, 2009; Vlad & Cuciurean, 2009).

The measures taken for the ecological management of the spruce stands affected by deer should start by determining the intensity of this phenomenon on large forest lands (Tilghman, 1989; Spitz, 1998; Stout, 1998; Yokoyama et al., 2001; Akashi & Terazawa, 2005; Vlad et al., 2007; Vlad & Cuciurean, 2009).

Afterwards, the forestry work to be carried out should be included in the forestry tending systems for the Norway spruce stand ecosystems in the areas exposed to the unfavorable action of biotic and non biotic disturbance factors, in order to solve the major problems of the spruce stands, meaning their stability and their productivity (Ichim, 1990; Giurgiu, 1995; Bergquist & Örlander, 1998; Tremblay et al., 2004; Vlad, 2009).

The objective of the research was to determine the amplitude of the deer damage on large forest area, by studying the distribution of the stand area damaged by deer through bark stripping, on damage categories in relation with stand age, site type, forest type, land slope, stand exposure, altitude and site class.

## 2. STUDY AREA

In accordance with the objectives of this work, the research made to meet in evidence the damage caused by cervid on large forest areas, were conducted in representative surfaces, in terms of economic and environmental impacts resulting from damage caused by deer in Norway spruce stands.

As a result, the studied area is placed in the working section, forest district and forest department

of the Eastern Carpathian Mountains and especially in Suceava Forest Department where the most damaged Norway spruce forest are (Fig. 1).

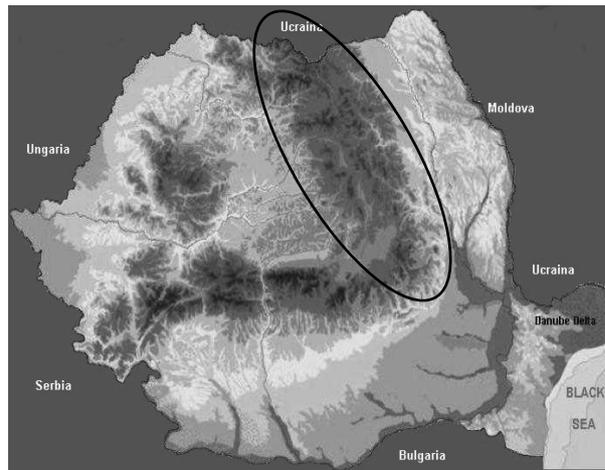


Figure 1. Study area.

## 3. MATERIALS AND METHODS

In order to characterize the intensity of the damage caused by deer, it is important to analyze the specific distribution of the damage categories. These aspects give a first image of the amplitude of the phenomenon on large forest areas, in relation with characteristics specific to spruce stands.

The categories of damage, expressed in the percentage value of the damage by number of trees are listed below: low damage (1% to 10%); moderate damage (11% to 25%); strong damage (26% to 50%) and very strong damage (> 50%).

For a better knowledge of the phenomenon on large forest areas was made up a database containing all management units (Norway spruce stands) by working sections and forest districts from Eastern Carpathian Mountains differentiated function of the damage frequency produced by deer.

Assist by a computer program was possible to calculate the area affected by deer by age class differentiated by working sections and forest districts. Data from a number of 2652 management units were processed. Afterward was established the distribution of the stand area damaged by deer on damage categories in relation with stand age, site type, forest type, land slope, stand exposure, altitude and site class for each forest district, working section researched and for Suceava Forest Department.

Spatial variation analysis of the damage frequency caused by deer on large forest areas (in the Suceava Forest Department) was done based on the GIS technique.

#### 4. RESULTS AND DISCUSSION

According to the research conducted so far significant harm in terms of the area affected by deer are recorded in the forest departments of the Northern Carpathians. By far the most damage in terms of the considered indicator is recorded in the Suceava Forest Department.

Table 1 presents the area affected by deer through bark stripping, in relation with the age classes, within forest departments of the Eastern Carpathians forest.

Surface damaged by deer corresponding to the Eastern Carpathian forest are about 122657.7 ha from a total of 2219387.4 ha. It can be seen that in terms of area most affected are Suceava Forest Department (84266.2 ha), Neamț (11284.5 ha), Mureș (8885.8 ha), Bistrița (5550.7 ha), Maramureș (4227.7 ha), Bacău (1377.9 ha) and Buzău (1374.9 ha).

Reporting the surface affected by deer to the surface corresponding to the age classes it is found that the Norway spruce stands within age of 21 and 80 years are the most affected.

Table 1. Area affected by deer through bark stripping in the forest departments of the Eastern Carpathians

Forest department	Age classes (year) / Surface (ha)						Total (ha)
	1-20	21-40	41-60	61-80	81-100	>101	
Bacău – forest surface	27242.2	51651.1	34989.8	37528.9	36094.2	52526.2	240230.4
Surface affected by deer	437.6	499.2	107.3	16.6	33.5	85.7	1179.9
% from age class surface	1.6	1.0	0.3	0.0	0.1	0.2	0.6
Buzău – forest surface	8340.3	20905.8	19144.9	16548.9	11179.1	19201.8	95518.8
Surface affected by deer	110.5	721.4	543				1374.9
% from age class surface	1.3	3.4	2.8				1.4
Neamț – forest surface	18641.3	44946.7	24573.5	27040.8	33894.3	84877.6	234173.2
Surface affected by deer	1241.9	4788.1	2273.8	1544.1	687.5	749.1	11284.5
% from age class surface	6.7	10.7	9.3	5.7	2.0	0.9	4.8
Vrancea – forest surface	21615.8	32010.3	26390.7	30213.5	14770.1	30357.9	155556.3
Surface affected by deer	10.7		545				555.7
% from age class surface	0.05		2.07				0.4
Bistrița – forest surface	27246.6	32527.4	32053.2	21540.6	19019.9	27232.1	159619.8
Surface affected by deer	953	1638.6	1358.4	736.6	585.4	278.7	5550.7
% from age class surface	3.5	5.0	4.2	3.4	3.1	1.0	3.5
Brașov – forest surface	10907.4	13487	15434.8	16544.9	21524.6	27049.4	104948.1
Surface affected by deer	112.8	144.6	24.8	5.8	40.4	24.9	703.4
% from age class surface	1.0	1.1	0.2	0.1	0.2	0.1	0.7
Covasna – forest surface	18181.8	31209.6	21387.7	26857.9	21443.5	25772.3	144853
Surface affected by deer	6.2	10.9	25.7				43
% from age class surface	0.03	0.03	0.12				0.03
Harghita – forest surface	14928	21822.7	22203.7	26223.3	21283.6	16681.9	123143.2
Surface affected by deer	283.2	1053.8	1017.9	120.5	340	165.3	2980.7
% from age class surface	1.9	4.8	4.6	0.5	1.6	1.0	2.4
Maramureș – forest surface	39407.8	50644.6	37064.2	37020.9	36024.4	57973.5	258135.4
Surface affected by deer	867	1600	1033.4	128.3	191.3	407.7	4227.7
% from age class surface	2.2	3.2	2.8	0.3	0.5	0.7	1.6
Mureș – forest surface	21694.7	37667.8	38999.5	27388.8	25127.1	28835.6	179713.5
Surface affected by deer	828.7	3027.7	2779.7	821	844.9	583.8	8885.8
% from age class surface	3.8	8.0	7.1	3.0	3.4	2.0	4.9
Prahova – forest surface	9280.4	23567.5	23795.4	27686	12999.7	30703.6	128230.6
Surface affected by deer	46.8	108.2	67.2	155	155	1073.0	1605.2
% from age class surface	0.5	0.5	0.3	0.6	1.2	3.5	1.2
Suceava – forest surface	35434.4	83563.2	69904.9	67842.4	71754.3	66765.9	395265.1
Surface affected by deer	5011.8	27474.3	22309.0	17651.6	7842.9	3976.6	84266.2
% from age class surface	14.1	32.9	31.9	26.0	10.9	6.0	21.3

The areas affected by deer, differentially by forest district in the Suceava Forest Department, are presented in figure 2.

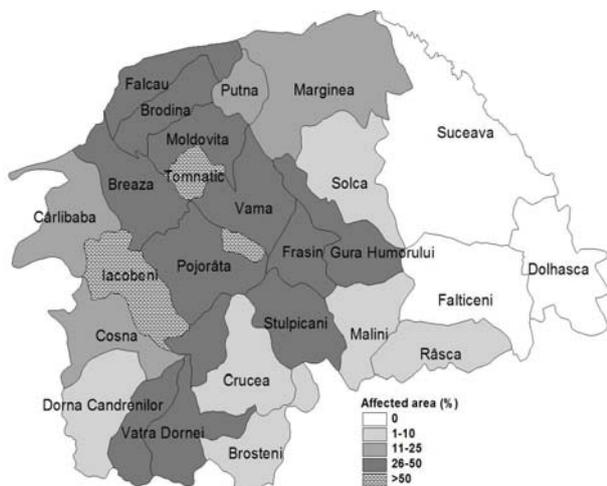


Figure 2. Area affected by deer in forest district form Suceava Forest Department.

According to figure 2 the most affected forest districts (with an average value of area affected by deer more than 25% from total of forest district) are: Tomnatic forest district - 65.8%, Iacobeni forest district - 50.9%, Pojorâta forest district - 42.5%, Moldovița forest district - 39.9%, Brodina forest district - 35.2%, Vama forest district - 35.1%, Frasin forest district - 30.5%, Gura Humorului forest district - 30.0%, Falcău forest district - 29.2%, Breaza forest district - 29.2%, Stulpicani forest district - 29.1%, Vatra Dornei forest district - 28.8%.

Research carried on in the Norway spruce stands, made it possible to draw some conclusions about the laws that governing the manifestation of this phenomenon, the age of the stand being one of the factors which influence the intensity and the extend of the damage on large forest areas.

Figure 3 shows the distribution of the area affected by deer in relation with the age class area in the Suceava Forest Department.

Referring the area affected by deer to the total area corresponding to age classes it is found that: in age class two (stands with age between 21 and 40 years) we discovered 32.9% surface affected by deer, in age class three 31.9% (stands with age between 41 and 60 years) and in age class four 26.0% (stands with age between 61 and 80 years).

Stands affected by deer from age class one (age between 1 and 20 years) occupy 14.1% from area corresponding to age class, ones from age class five 10.9% (age between 81 and 100 years) and stands older than 101 years occupy 6.0%.

Reporting the data to the total of affected area by this disturbance factor, it results that stands from

age class one hold 5.9%, stands from age class two - 32.6%, stands from age class three - 26.5%, stands from age class four - 20.9%, stands from age class five - 9.3% and stands older than 101 years hold 4.7%.

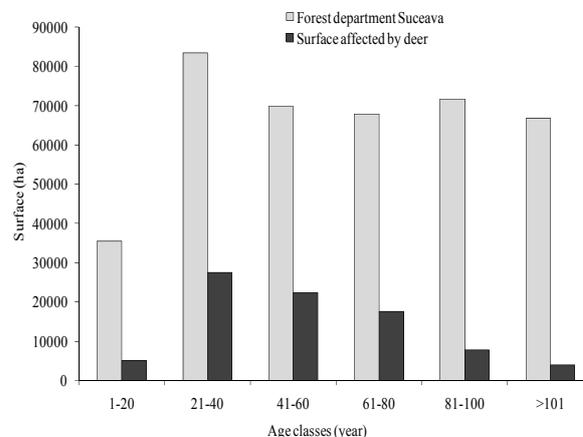


Figure 3. Repartition of the area affected by deer in relation with the age class area in Suceava Forest Department.

To summarize the above mentioned, it can be clearly stated, that both in terms of average percentage of the damage by number of trees and the frequency of damage categories, stands of age class two, three and four are the most affected. The least affected, in terms of the considered indicators, are the stands more than 80 years old.

Regarding the distribution of the area affected by deer by damage categories, in the Suceava Forest Department, stands with low damage hold 54.1% from the total of affected area, stand with moderate damage hold 32.6%, stand with strong damage hold 10.2%, and stands with very strong damage hold 2.7%. The distribution of the area affected by deer on damage categories is presented in figure 4.

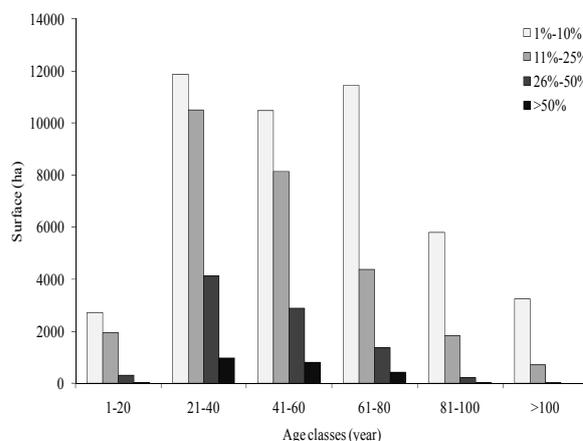


Figure 4. Distribution of the area affected by deer by damage categories in relation with age classes.

The most unfavorable situation expressed by stands area where the damage frequency is between 26% and 50% are in the following forest districts: Iacobeni (4099.5 ha), Pojorâta (1991.5 ha), Tomnatic (1200.9 ha), Moldovița (1179.3 ha), Breaza (664.2 ha), Frasin (527.2 ha), Vama (224.6 ha), Râșca (203.1 ha), Cârlibaba (197.1 ha), Stulpicani (183.2 ha), Coșna (131.8 ha). The forest district with stands areas where fervency of the deer damage is more than 50% are listed below: Iacobeni (1722.5 ha), Pojorâta (243.3 ha), Râșca (127.6 ha), Tomnatic (58.6 ha), Moldovița (49.5 ha), Frasin (15.4 ha), Vama (13.5 ha), Breaza (12.9 ha).

Figure 5 presented the most affected site types (which are extending more than 5% from affected area). There are those with the indicative 3333 - „Mountain mix *Ps*, brown high edaphic, with *Asperula-Dentaria*” (53.7% of affected area), 2333 - „Mountain spruce stands *Ps*, brown acid and andosol, edaphic large and medium with *Oxalis-Dentaria* ± acidophilus” (16.5% of affected area), 2332 - „Mountain spruce stands *Pm*, medium brown edaphic, with *Oxalis-Dentaria* ± acidophilus” (13.2% of affected area), respective 2312 - „Mountain spruce stands *Pm*, podzolised medium edaphic, with *Hylocomium*” (5.6% of affected area).

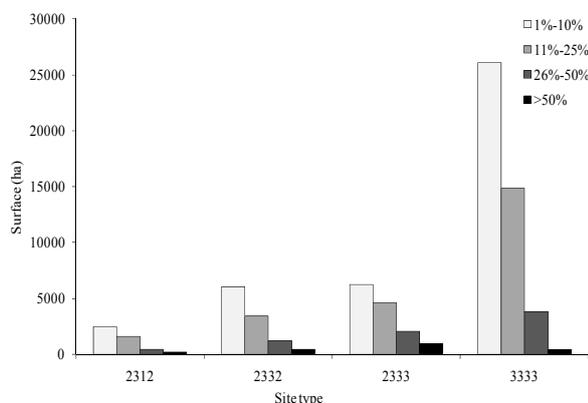


Figure 5. Distribution of the area affected by deer by damage categories in relation with site type.

The most affected forest types (which are extending more than 5% of affected area) are those with the indicative 1311 - „Norway spruce - European beech mixed stand” (26.8% of affected area), 1111 - „Norway spruce stand with *Oxalis acetosella*” (19.4% of affected area), 1114 - „Norway spruce stand with *Oxalis acetosella* on skeletal soil” (11.4% of affected area) and 1211 - „Norway spruce - silver fir mixed stand with mull flora” (10.8% of affected area) (Fig. 6).

The explanation is that, although most forest type stands in the research area are characteristic of mixtures of resinous and beech, pure Norway spruce

stands are artificially installed in the place of the old natural mixture forest which have vegetated in this area.

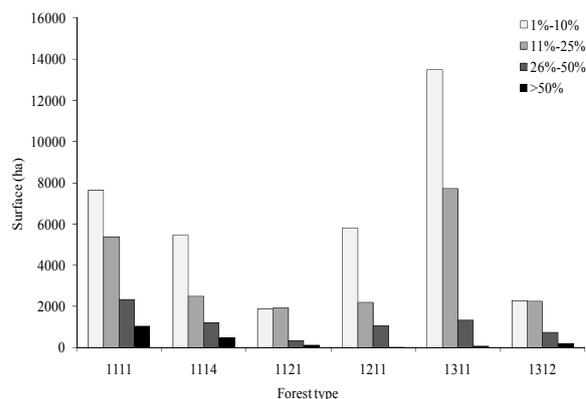


Figure 6. Distribution of the area affected by deer by damage categories in relation with forest type.

From the viewpoint of distribution by slope category, the best represented are the damaged stands which grow on land slope between 21° and 30° (57.0% of affected area) and the damaged stands which grow on land slope between 11° and 20° (28.5% of affected area). The remainder stands damaged by deer are distributed by category as it follows: 1.83% on land slope between 0° and 10°, 12.3% on land slope between 31° and 40°, respective 0.33% on land slope > 40° (Fig. 7).

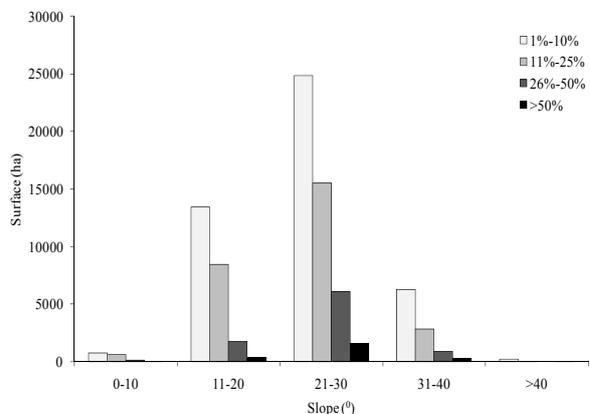


Figure 7. Distribution of the area affected by deer by damage categories in relation with slope.

Analyzing the distribution by the exposure categories it is found that the most damaged stands are on shaded exposure (NV, N, NE) - 45.1%, followed by stand which grow on sunny exposure (SV, S, SE) - 33.3%. The stands which grow on partial sunny exposure (E, V) occupy 20.0%, and the stands which grow on plat land 1.6% (Fig. 8).

The distribution of the deer damaged stands in the Suceava Forest Department by altitude categories are as follows: 2.6% of the area with

altitude between 201 m and 400 m, 3.5% of the area with altitude between 401 m and 600 m, 13.8% of the area with altitude between 601 m and 800 m, 32.3% of the area with altitude between 801 m and 1000 m, 32.3% of the area with altitude between 1001 m and 1200 m, 14.7% of the area with altitude between 1201 m and 1400 m, respectively 1.9% of the area more than 1400 m (Fig. 9).

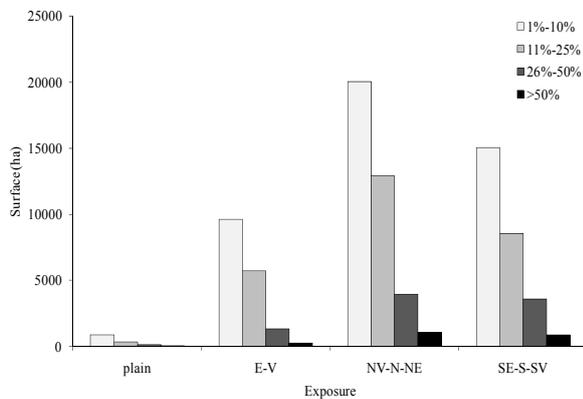


Figure 8. Distribution of the area affected by deer by damage categories in relation with exposure.

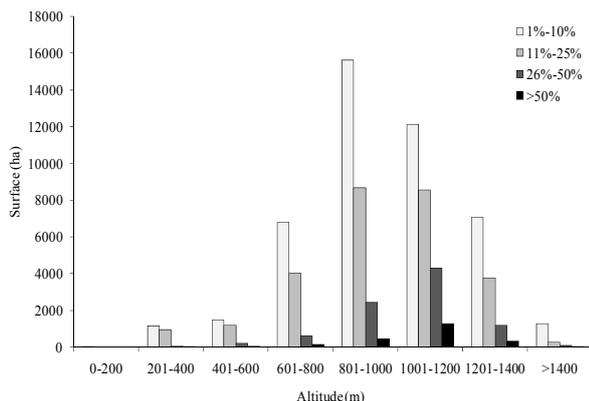


Figure 9. Distribution of the area affected by deer by damage categories in relation with altitude.

Based on the results from deer damage mapping in relation with land altitude, it can be stated that altitude is a limiting factor, in terms of the damage frequency in Norway spruce stands from the areas exposed to the risks of the action of this perturbing factor.

The areas of the researched stands are in relation with site class as follows: site class 1 contains 9.1% from affected area by deer, site class 2 - 63.7%, site class 3 - 25.4%, site class 4 - 1.6% and site class 5 - 0.1% (Fig. 10).

As noted from the above, the damage caused by deer on large forest areas is influenced both by some characteristics of forest stands and by some station factors. It is important to know the weight

with each influencing the manifestation of this phenomenon.

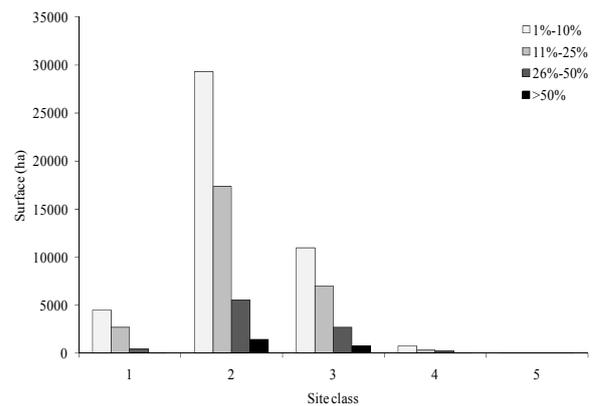


Figure 10. Distribution of the area affected by deer by damage categories in relation with site class.

## 5. CONCLUSIONS

A first finding relating to the amplitude of the damage caused by deer in the Suceava Forest Department refers to area of the affected Norway spruce stands which amounts to 84266.2 ha (21.3% of the forest area). This represents an important percentage for the future mid-term and long term wood harvest planning if it takes into account the distribution of the affected stands by age class.

The result of the data analyzed was that the stands about 21 and 80 years old are significantly damaged. The results obtained are conclusive enough to realize the severity of the phenomenon and the condition of one of the most beautiful and the valuable Norway spruce stands.

The result for the Suceava Forest Department was a total of 11202.4 ha what means stands where the damage frequency exceeds 50%. Out of this total amount 2253.1 ha are stands with a damage frequency higher than 70%, where ecological reconstruction works are needed. The durable management of deer-damaged artificial forest ecosystems should start from the economic target determined by the destination assigned, by the functional efficiency of the forest for the entire time span of its development.

From the point of view of distribution by age classes, 10618.1 ha contain 21 and 80 years old stands with a damage frequency higher than 50%. Out of this total (age class two to four) on 2218.1 ha there are stands with a damage frequency higher than 70%.

A comparative analysis of the years 2004 with the years 1975, leads to the conclusion that affected area by this biotic disturbance factor increased by 32831.2 ha.

From the point of view of the distribution by age class of the stands affected by deer it is found that the deer damaged area corresponding to the age class one has been decreased about 7559,2 ha. Also, on the area of the damaged stands there is a shift towards the age classes two, four and five and toward stands older than 101 years, even if the affected area has increased. This is a process deriving from the passing of the stand registered in 1975 into another age class.

It can be said that the distribution of the deer damaged stands depends on their structure (age, composition), by the localization of the clear felling on large area in relation with cervids development and some site condition.

So, most exposed to damages produced by deer through bark stripping are the artificial spruce stands about 21 and 80 years old, integrated in the site type with the indicative 3333 - „Mountain mix Ps, brown high edaphic, with *Asperula-Dentaria*” and in the forest type with indicative 1311 - „Norway spruce - European beech mixed stand”, which grow on land with slopes between 11<sup>0</sup> and 30<sup>0</sup>, with altitudes between 600 m and 1200 m, situated in superior site class (site class 1 and 2).

When choosing the bases for forest planning (regime, treatment, composition, exploitability) by which one can define the optimum structures towards which the stands and the forest should be led in order for them to carry out adequately the functions assigned, more and more special attention shall be paid to the preservation of biodiversity, to providing the stability of the stands and of the forest which is to be planned as a whole.

According to the ecological criterion, the areas with deer action risk, compositions with natural potential will be promoted which are as close as possible to the ones of the natural ecosystems which have vegetated in the area, thus providing, ever since the crops have been established, the conditions necessary for the stability of the forest ecosystems, with high functional efficiency.

#### ACKNOWLEDGEMENTS

This work was supported by CNCSIS - UEFISCSU, project number PNII - IDEI 50/2008.

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Received at: 20. 04. 2010

Revised at: 17. 11. 2010

Accepted for publication at: 22. 11. 2010

Published online: 24. 11. 2010