The effects of thinning on a spruce stand, over a period of 40 years of monitoring

Michaiel A. Piticar

Faculty of Forestry, "Ştefan cel Mare" University, Suceava, Romania. Corresponding author: M. A. Piticar, michaiel_piticar@yahoo.com

Abstract. This survey is based on an experiment conducted by the National Institute for Research and Development in Forestry (ICAS) Câmpulung Moldovenesc in the period of 1974-2004. The experiment consisted of 8 experimental areas, where thinnings of different intensities were performed (years 1974, 1979, 1984, 1989, and 2004). The personal contribution consisted in the inventory from 2010, the analysis and interpretation of personal data and of data taken from other sources. The aim of this paper is to outline the influence of thinning intensity and the evolution of the spruce stand in time, in terms of structure, productivity and stability. Therefore, it appeared that the heavy thinning has significantly influenced the spruce stand. The stand average diameter has registered a higher growth in the areas with moderate and heavy areas, due to higher extraction intensity, that reduces the competition for sunlight, highlighting the diameter growth. The heavy thinnings have influenced the average height, as it has indicated lower figures, due to the competition for sunlight and the higher increment. The improper values of the number of trees, the spacing factor, the density factor, the total production, indicate the destructuring of the stand for 2010 in the heavy thinning areas. The implementation of thinnings had a negative effect on the stand, especially in the heavy thinning areas, leading to its destablishing.It can be concluded, that for the studied stand after the age of 30, light thinnings were recommended. These aspects are outlined by means of the productivity analysis and of the current structural parameters from the control area, where this type of thinning intensity was implemented.
Key Words: stand density, thinnings intensity, biometric features, stability, stand production.

Rezumat. Studiul se bazează pe un experiment al Institutului de Cercetări şi Amenajări Silvice (ICAS) Câmpulung Moldovenesc efectuat în perioada 1974-2004. Experimentul a constat în formarea a 8 suprafeţe exeperimentale în care s-au practicat rărituri de intensitate diferită în anii 1974, 1979, 1984, 1989, 2004. Contribuţia personală constă în efectuarea inventarierii din anul 2010, analiza şi interpretarea datelor personale şi a celor preluate. Scopul acestei lucrări este de a evidenţia influenţa intensităţii răriturilor şi evoluţia arboretului de molid în timp, din punct de vedere al structurii, productivităţii şi a stabilităţii. Astfel a rezultat că răritura de intensitate forte a influenţat semnificativ arboretul de molid. Diametrul mediu al arboretului a înregistrat o creştere mai mare în variantele moderat şi forte, datorită intensităţii mai mari a extragerilor, care reduc concurenţa pentru lumină, accentuând creşterea în diametru. Răriturile de intensitate forte au influenţat înălţimea medie, aceasta având valori mai mici, aspect datorat reducerii concurenţei pentru lumină şi accentuării creşterii în grosime. Valorile necorespunzătoare ale numărului de arbori, factorului de spaţiere, indicelui de densitate, producţiei totale, indică destructurarea arboretului la nivelul anului 2010 în suprafeţele pe care s-au realizat rărituri de intensitate forte. Practicarea răriturilor a avut o influenţă negativă asupra arboretului, mai ales în variantele cu intensitate forte, ducând la destabilizarea acestuia. Se poate concluziona că pentru arboretul studiat după vârsta de 30 de ani se recomandau răriturile de intensitate slabă. Aceste aspect sunt evidenţiate prin analiza productivităţii şi a parametrilor structurali actuali din suprafaţa martor, parcursă cu acest tip de intensitate a răriturii.
Cuvinte cheie: arboret de molid, intensitatea răriturilor, caracteristici biometrice, stabilitate, producţia arboretului.

Introduction. Thinnings create favorable conditions for the development of stands, by means of optimizing the composition and strength, given the judicious combination of silvicultural, ecological and social considerations with the economical ones (Gheorghe 2004). These aim the control of forest growth and development, with the purpose of performing or promoting optimal structures of forest stands from an ecological and genetic point of view, in conformity with the forest ecosystems structuring and functioning laws. At the same time, one aims the increase of multiple functional effectiveness of forests, both with regard to protection factors and the wood production (Petrescu & Haring 1977).

Thinnings involve the improvement of protection and production functions of forest stands, their plant health improves and conserves itself and the biodiversity of the forest ecosystem is improved, with the purpose of increasing the degree of stability and strength of forest stands to the action of disturbances (wind, snow, diseases, pests, pollution etc.) (Negulescu 1973).

Resinous forests and particularly spruce forests, which are usually cultivated uniform stands, are of great economic importance and play a special role in the protection of the environment. However, these forests are damaged by large-scale fellings and wind breakages, not to mention the serious disruptions in the past decades. The fellings are largely based on extreme natural phenomena, which affect these forest stands, but also on the improper application of the tending and handling works within the cultivated forest.

The purpose of this research is to control out the influence of thinnings and the evolution of spruce stands from a structure, stability and growth perspective, that is induced by thinnings with different intensity variants. In order to achieve the researchers' purpose, the structural features of the stand (over a period of 40 years of works) were studied by reference to the main biometric features (diameter, height), the number of trees on unit, the stand's base area and its volume, the growth, the stability (slenderness coefficient).

Material and Method. The survey was conducted in the range of the Forest Division Frasin, on experimental areas of I.C.A.S. Campulung Moldovenesc, Romania (Figure 1).

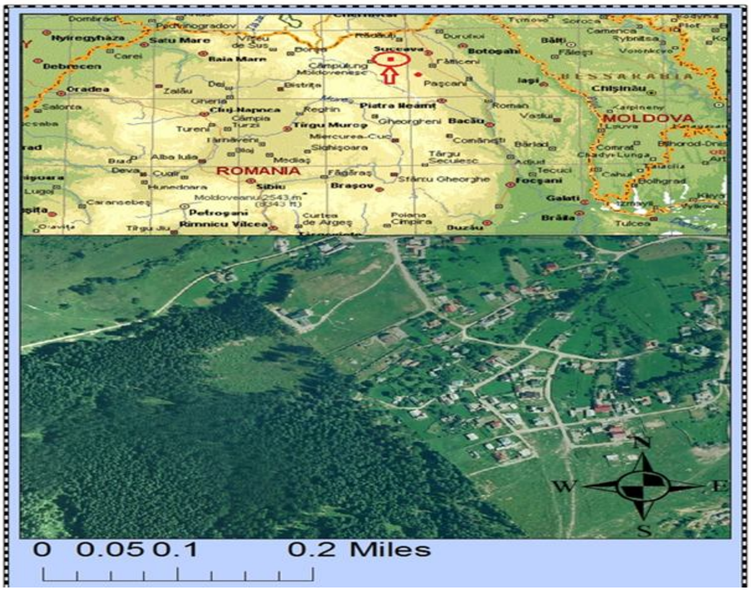

Figure 1. Study area.

Geographically, the Forest Division Frasin is situated in the county of Suceava, comprising a part of the forest regions from the middle basin of the river Moldova upstream to the city of Gura Humorului. From an administrative point of view, the Forest Division is subordinated to the Forestry Department Suceava, the entire surface being managed by the National Forests Administration Romsilva.

The Bahna experimental block comprises 8 experimental areas, located in UP II Sălătruc, lot 2A, where thinnings of three different intensities were performed. Three of those areas were affected by fellings (V4, V5, V7) being totally damaged; there are currently five areas left.

Table 1

Experimental areas

Experimental plot	*V1*	*V2*	*V3*	*V4*	*V5*	*V6*	*V7*	*V8*
Thinning intensity	Moderate	Moderate	Moderate	Heavy	Heavy	Heavy	Control plot	Control plot

In our country, according to their intensity, thinnings are classified as: light (<6%); moderate (6-15%); heavy (16-25%); very heavy (>25%), (*** 2000). Thinning intensity varies in relation to stands, species, age and structure. In the V8 area, used as control, one has performed light thinnings.

Lot 2A covers 27.8 ha, the type of site is the mountain mixed forest site, of superior site quality. Hence, it is Norway spruce stand with mull flora, situated on an waved slope, north-easterly direction, inclination of 15°, altitude 530-660 m, of the age of 70 years and a current mixture of 8Mo 2Br (*** 2009).

The areas were monitored by I.C.A.S. since 1974. Four stages of thinnings were performed between 1974-1989, which followed every 5 years. After every stage, one has conducted the inventory of all trees from the experimental areas and also the processing of data. The most recent inventory and all the necessary estimations for highlighting the influence of thinning and the stands structural evolution were performed in this paper. The diameters of all trees (178 trees) and also 54 heights were measured on site, in order to lay out the curves of heights.

The volume of trees was determined with the help of the following formula (Giurgiu et al 2004):

$$V = G \times H \times f$$

Where: G = base area of the stand
H = medium height
f = form factor (spruce „f = 0.544”).

The thinning intensity will be established as a percentage ratio between the number, or the base area, or the volume of the trees to be extracted and the number, the base area, or the volume of all the trees from the stand, before extraction. Percentage indices result: I_N – for the number of trees; I_G – for the base area; I_V – for the volume.

$$I_N = \frac{N_e}{N_i} \times 100$$

Where: I_N = density index
N_e = number of extracted trees
N_i = initial number of trees

The Hart-Becking spacing factor is expressed in percents by the average distance between trees from their dominant height. The procedure is based on the idea, that the intensity on the number of trees of the cultural operations, can be expressed by means of the optimal necessary vital space of each tree, in order to develop normally (Negulescu 1973).

$$S = \frac{a}{H_{dom}} \times 100$$

Where: S% = Hart-Becking spacing factor
a = average distance between trees in meters
H_{dom} = dominant height (superior) of the stand.

The slenderness coefficient was used as stability indicator of the stand. This coefficient is to express the distribution of the bole biomass in space (Grudnicki 2004) and is to be determined as a ratio between the bole height and the tree's base diameter.

$$\lambda_d = \frac{h}{d} \text{ m x cm}^{-1}$$

Where: λ_d = dendometric slenderness coefficient
d = tree base diameter (cm)
h = bole height (m)

The average slenderness coefficients were calculated in this paper for every experimental area.

The calculations, charts and the determination of statistical parameters were elaborated with the help of analytical calculation programs.

Results and Discussion

Study of thinnings character in relation to stand density

Thinning intensity. As can be seen from Figure 2, the different thinning intensity depending on the selected option in the experimental areas. One can observe the stronger intervention in the first thinning stages, because heavy thinnings are recommended in case of the spruce, in the initial development stages (Wallentin 2007).

Heavy, moderate and light thinnings were performed in the first thinning stages, after which the intensity decreased and light interventions (<6%) were performed for the last thinning from all experimental areas, except the control area, where a moderate thinning (6-15%) was performed.

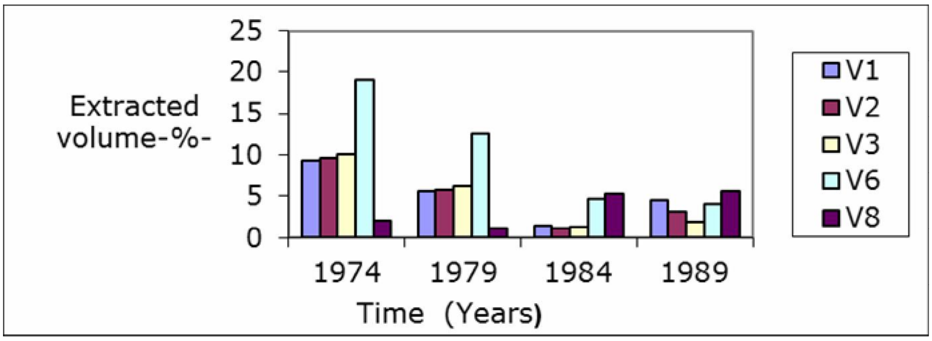

Figure 2. Thinning intensity.

The number tree number dynamics. The number of trees has decreased differently in every area, due to the variation of extractions in the period of 1974–1989 depending on the selected intensity for every experimental area but also because of the effect of destabilising factors (wind, snow), that have affected the stand (Figure 2).

The drastic reduction of the number of trees (destructuring) in the area where heavy thinnings were performed. None of the areas with moderate thinning (V2) has developed well, the latter having a very small number of the trees for their development stage. The best values are registered for the moderate thinning variants but also for the control variant (Figure 3).

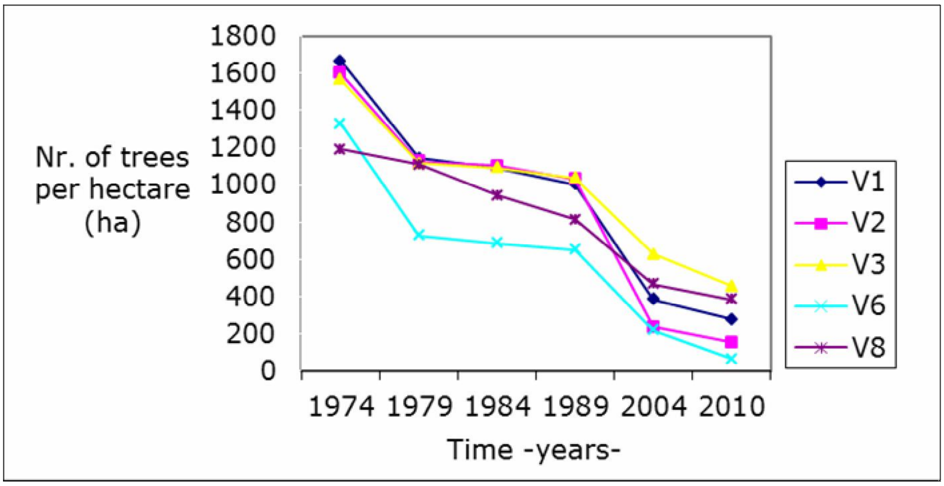

Figure 3. The number of trees evolution.

In 1989, the density index showed values of: 0.9 – in all 3 moderate variants; 0.6 - heavy variant; 0.8 - control variant. The technical norms recommend for the Romanian stands, the decrease of density by means of thinnings up to a value of 0.8 (*** 2000). In this case, the value of the density index is under limit for the heavy variant, which led to the stand increase of instability and its destructuring in time.

Evolution of the Hart-Becking spacing factor. As it can be observed from the first thinning, the stand is dense, instable because the Hart-Becking index value is between 10-15%; light and moderate thinnings are recommended for the stand and heavy interventions are prohibited (Figure 4).

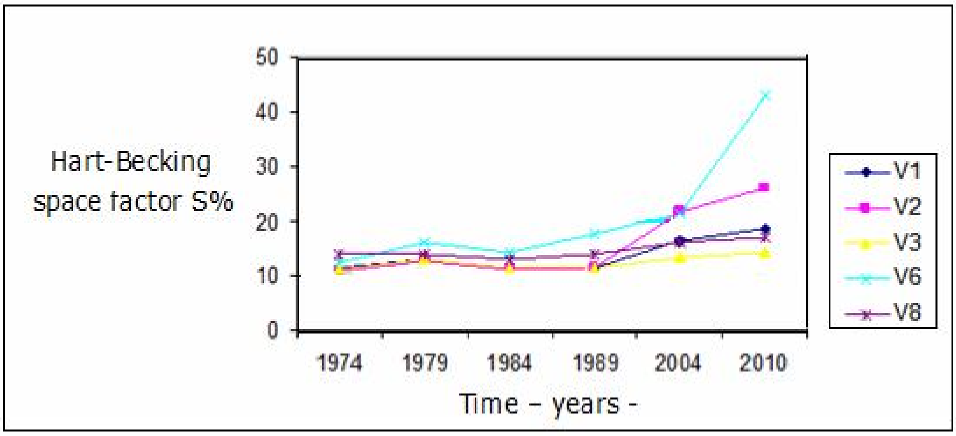

Figure 4. Evolution of Hart-Becking space factor.

The optimal value of the spacing coefficient is between 16-20% in case of spruce (Negulescu 1973). At the inventory from 1989 it was established, that the optimal value was reached only for the heavy variant (V6), however, during the inventory the present paper is based (2010), it is noted that the thinning intensity has affected the structural stability of this experimental area. The optimal value was reached moderately in the areas V1 and V8, where the moderate and the light thinning was performed.

The influence of thinnings on the biometric features of the stand

The influence of thinning on the average diameter. Thinnings have a great influence on the biometric features of the stand. They have a significant influence on the diameter, according to published literature. The diameter increase is more obvious for the areas, where interventions are performed (Petrescu & Haring 1977).

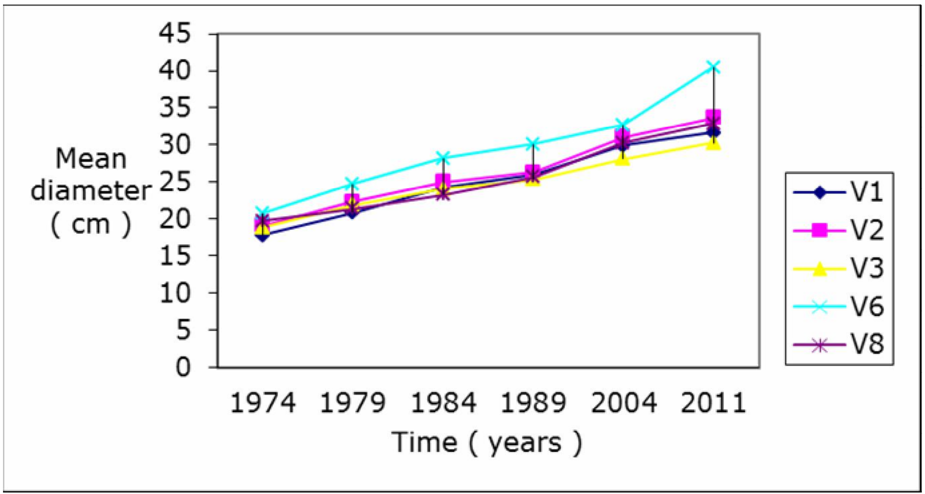

Figure 5. Average diameter evolution in relation to time and thinnings intensity.

It has a faster growing in case of the stand with heay thinnings compared to the stands with moderate or light thinnings. According to the figure e.g. the control variant, with light thinnings, has the slowest development.

Dynamics of diameters of trees, remained within the stand from the beginning until the end of experiment (1974-2016).

It is noted from the Figure 6, that the growth was higher in the period of interventions. One of the causes could be the induced growth of the diameters from the thinning. The moment the trees with diameters under the average diameters are extracted, the average diameter grows artificially. With regard to the biometric features, a favorable evolution in the areas with heavy intensity was noted, as these responded well.

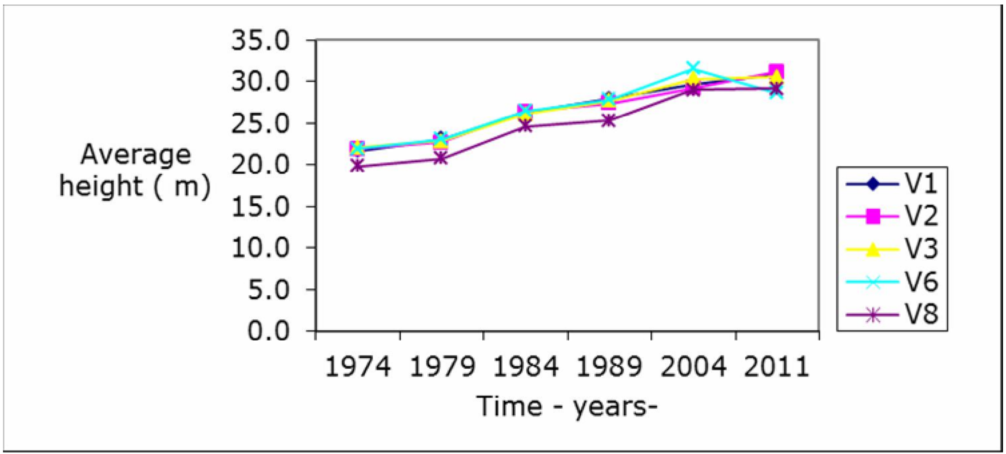

Figure 6. Average height evolution in relation to age and thinnings intensity.

According to Figure 6, the evolution of the average height indicates small differences in all 5 experimental areas; practically the stand has a parallel evolution of the growing curves, as the height is less affected by the thinning intensity than the diameter. In the heavy thinning area, it is noted a decrease of the average height after 2004, which indicates the stands destructuring, because there were fewer trees left for the height measurement and they were not representative.

The improvement of ecologic conditions of the trees left after performing cultural operations materializes, first of all, by means of increase in thickness. The height growth, in case of normal thinning is conversely, weak influenced and remains usually stationary. The reason for this is that from the total quantity of organic substances, elaborated as an effect of strenghtening the assimilation process, the greatest part is being used for the regeneration and development of the foliar system and of the root-system and only a small part is used for the activation of height growth, which is conditional upon the site quality and less upon the performance of tending and control works. Therefore, it is rather low, in order to be widely influenced by applying cultural operations. According to Figure 7, the almost parallel evolution of the height curves can be noted. The curve from the heavy thinning area has shifted due to the stands destructuring. However, the heavy thinning has influenced the average height from the area with low figures compared to the other areas, the reason for this being the competition for sunlight within the stand. Therefore, the diameter growth of trees from the heavy thinning area was obvious after the thinning.

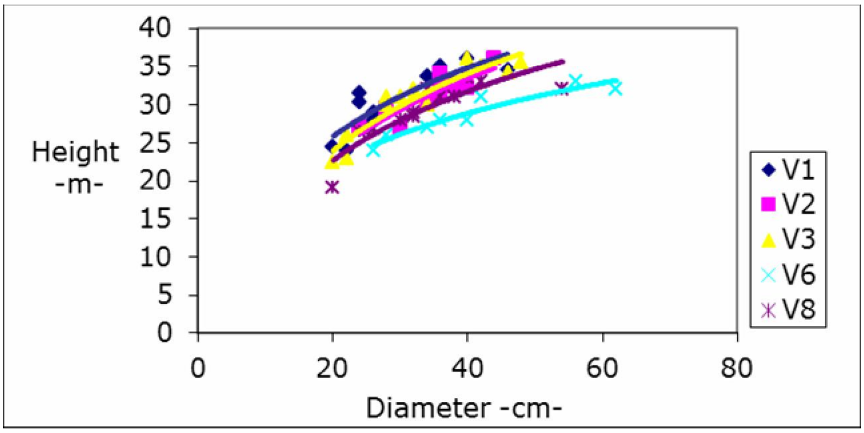

Figure 7. Height variation between plots (2010).

Thinning influence on stand production. One of the effects aimed by performing thinnings is to increase growth and the total wood mass production of stands. For this purpose, between 1880 and 1925, in different European countries, one has installed experimental blocks of two or more intensity variants.

The results obtained with regard to thinning influence on the wood production were surprising. It was noted that, if the dense stand is not interrupted too long during those works, their intensity can variate between certain limits, so that the growth and the wood production are not significantly changed. A higher growth within the stands with thinnings was noted as compared with those, where no interventions were conducted (Wallentin 2007), (Pretzsch 2004). In 1960, in Northern Europe, an idea has arisen, that was also adopted in Romania. This supports the heavy thinning in young spruce stands, followed by a decrease in intensity up to moderate to light in the second part of the rotation (Wallentin 2007; Vlad & Petrescu 1977). Taking into account all these conclusions, nowadays, it is assessed, that the effect of thinnings on wood mass accumulation is not yet solved in a safe and constant way.

<u>Average tree volume</u>. Figure 8 indicates that in the areas with heavy and moderate thinnings, the average tree volume is higher as compared to the control area; the greater value was registered within the area with heavy thinnings. The average tree volume is influenced by the thinning, according to the published literature, which states, that following the research on spruce, the heavy thinning accelerates with ca. 20 years the stands production until the age of 50, after which it tends to equalize the production from the areas with moderate and light thinnings (Negulescu 1973).

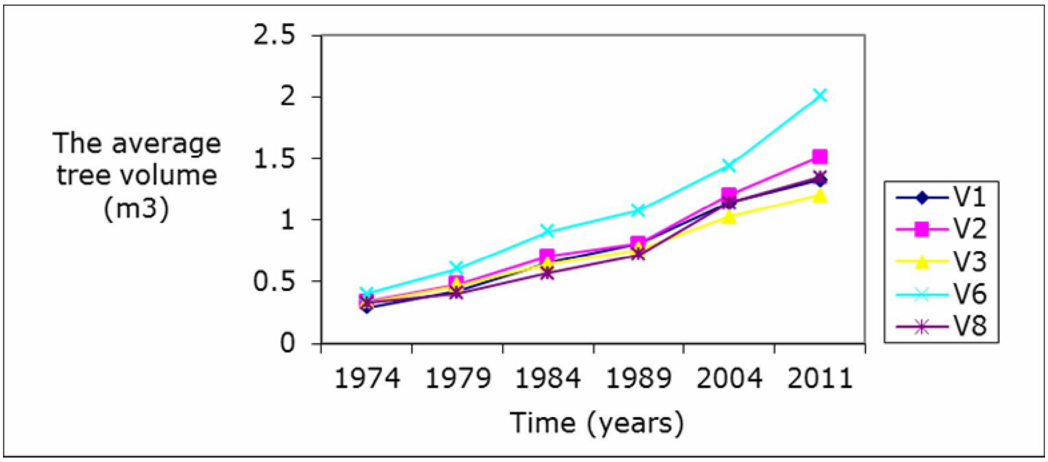

Figure 8. Evolution of average tree volume.

According to Table 2, the greatest growths were registered in the area with heavy thinning, with an increase of 52% as compared to the control area. Lower growths were registered within the variants V1 and V3 as compared to the control variant. Even if the control variant has registered lower growths of the average tree volume at the beginning, due to weak intensity extractions, this situation has been adjusted after performing cultural operations.

Table 2

The average tree volume at the beginning and end of the study on variants of thinnings intensity

Experimental area	*1974*	*2010*	*Growth (m^3)*	*Growth % compared to control plot*
V1	0.296	1.328	1.032284	-2
V2	0.342	1.513	1.1707006	12
V3	0.335	1.200	0.8647872	-18
V6	0.405	2.005	1.5997027	52
V8	0.295	1.349	1.0539402	-

Stand volume. The total production of a stand represents the summing of the main stand volume with the volume of the extracted trees, after tending and control works. Figure 9 indicates a normal evolution of the stands total production by 1989; the lowest volume value was registered within the area with heavy thinnings, also due to the more intense extractions. After 1989, it is noted a sudden decrease in volume, due to the action of destabilizing factors, which have affected this stand below the average values.

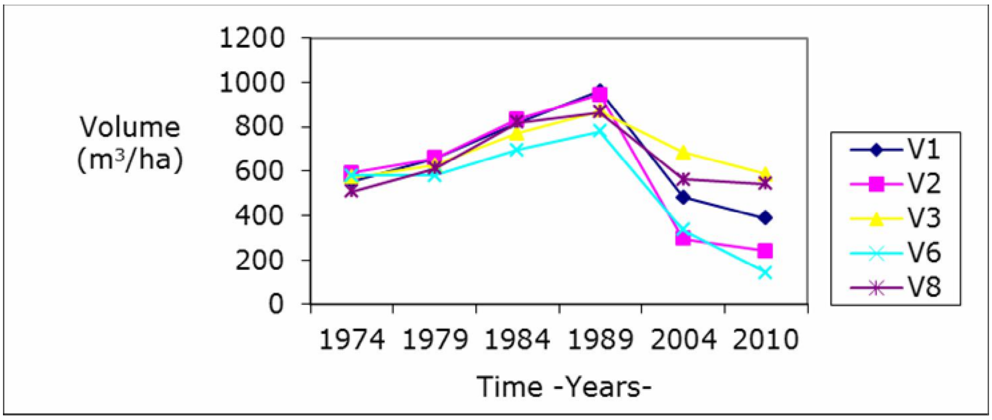

Figure 9. Stand volume dynamics.

Thinning influence on the slenderness coefficient. There is a strong correlation between the values of the slenderness coefficient with the damages caused by wind and snow (Nicolescu et al 2003), therefore this is used in determining the stability of the stands and of the individual trees. It is considered, that the stands with average slenderness coefficients of 0.8-0.9, fall within the area of stable stands, 0.9-1.0 relatively stable stands, >1.0 unstable stands.

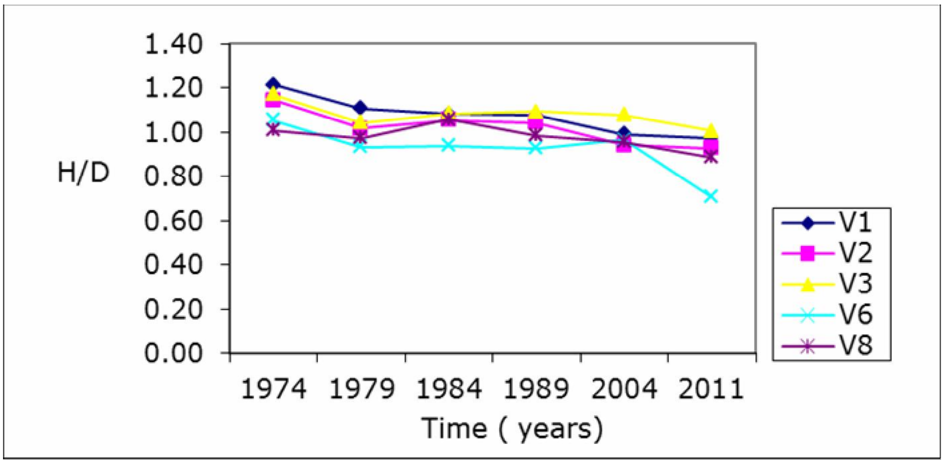

Figure 10. Stand stability dynamics.

According to Figure 10, at the beginning of the experiment, the slenderness coefficient was >1, and was qualified as unstable in all areas. During the implementation of cultural operations, it fell below the value 1 only in the control areas and heavy thinning areas, these being considered relatively stable stands at the end of thinnings. However, the value of the slenderness coefficient, which indicates a relative stability in heavy thinning areas, is called into question by the stands evolution in time. According to (Barbu 2004), the heavy thinnings in young trees and more reduced after the age of 30-35, contributes significantly to the increase of stands growth and stability. In this case, one can note the veracity of the assertion, because heavy thinnings were performed around and after the age of 30, which led to the instability of the stands evolution. It seems that in the case of the studied stand, the light thinning is the recommended one.

Conclusions. Following the conducted survey, a favorable evolution of the stand by 1989, was noted as the structural parameters had a good evolution, within normal limits.

After the implementation of the last operation, the stand has evolved in a negative way, being affected by destabilising factors, which acted differently in every area, depending on the thinning intensity.

The improper values of the number of trees, the spacing coefficient, the density index, the total production, indicate the destructuring of the stand for 2010 in the areas with heavy thinnings. Moreover, the destruction of the area V7, where light thinnings were performed, is due to the cut of the stand, as a consequence of the fellings from the heavy thinning areas. Although the current productivity of the average stand is superior in the area with heavy thinnings, one must take into account the stability aspect that made the difference among the current total production values, at the level of the stand.

It can be concluded that in the case of the studied stand after the age of 30, light thinnings were recommended. These aspects are outlined by means of the productivity analysis and of the current structural parameters from the control area, where this type of thinning intensity was implemented.

Future studies should cover more the aspects of stability increase but also of the stands productivity, highlighting the intensity degree that must be implemented in different conditions in which these stands are growing and that can significantly influence their evolution in time.

References

Barbu I., 2004 Gospodărirea culturilor de rășinoase instalate în afara arealului. Analele Universității "Ștefan Cel Mare" Suceava 1:37-70.

Gheorghe G., 2004 Cercetări pentru stabilirea indicilor de recoltare pentru tăieri de îngrijire (curățiri, rărituri), în concordanță cu silvicultura lemnului de calitate în arborete de fag. Analele ICAS 47(1):47-62.

Giurgiu V., Decei I., Drăghiciu D., 2004 Metode și tabele dendrometrice. Editura Ceres, Bucureşti, România.

Grudnicki F., 2004 Coeficientul de zvelteţe și stabilitatea individuală a arborilor de molid. Bucovina Forestieră 12(1-2):75-87.

Negulescu E. G., 1973 Silvicultura: fundamente teoretice și aplicative. Vol. 2, Editura Ceres, Bucureşti, România.

Nicolescu N., Petritan I., Vasilescu M., Ferreira P., Henriques S., 2003 Schemele de împădurire dese şi stabilitatea monoculturilor de molid – este posibilă realizarea unui echilibru de durată? Bucovina Forestieră 11(2):27-35.

Petrescu L., Haring P., 1977 Periodicitatea și intensitatea curățirilor și răriturilor în arborete de molid și pin Silvestru. Studii și cercetări. Silvicultura pp. 159-164.

Pretzsch H., 2004 Density-growth-relationship in forests. A biometrical solution for stands of Norway spruce (*Picea abies*) and European beech (*Fagus sylvatica*). Allgemeine Forst und Jagdzeitung 175:225-34.

Vlad I., Petrescu L., 1977 Cultura molidului în România. Editura Ceres, Bucureşti, România, 359 pp.

Wallentin C., 2007 Thinning of Norway spruce. PhD Thesis, Faculty of Forest Science Southern Swedish Forest Research Centre Alnarp, Swedish University of Agricultural Sciences, 115 pp.

*** 2009 Amenajamentul O.S. Silvic Frasin, Direcția Silvică Suceava, UP III, Sălătruc.

*** 2000 Norme tehnice pentru îngrijirea și conducerea arboretelor. MAPPM, nr. 2, 142pp.

Received: 07 July 2016. Accepted: 11 August 2016. Published online: 16 August 2016.

Author:
Michaiel Alexander Piticar, "Ștefan cel Mare" University, Faculty of Forestry, Romania, Suceava, 7290229, Universității Street 13, e-mail: michaiel_piticar@yahoo.com

How to cite this article:
Piticar M. A., 2016 The effects of thinning on a spruce stand, over a period of 40 years of monitoring. AAB Bioflux 8(2):77-86.