Scientific Papers. Series A. Agronomy, Vol. LXVIII, No. 1, 2025
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

PARTICULARITIES REGARDING THE TENDING OPERATIONS IN FOREST SHELTERBELTS

Elena MIHĂILĂ, Mihăiță BÎTCĂ, Adrian TUDORA, Dorina DRĂGAN, Elena ACHIM, Any Mary PETRIȚAN

National Institute for Research and Development in Forestry "Marin Dracea", 128 Eroilor Blvd, Voluntari, Ilfov, Romania

Corresponding author email: lilianmihaila@gmail.com

Abstract

In order to optimize the ecological and economic functions that forest shelterbelts perform, it is necessary to carry out appropriate maintenance work, through which certain trees are extracted and their density is reduced. In this regard, tending operations were carried out in forest shelterbelts with different compositions and ages to ensure sufficient and as uniform space as possible for the growth of the remaining trees. This spacing of the trees has an influence on the growth and quality of the trees but also on the resistance to disruptive climatic factors and implicitly on the protective functions they perform. The gradual and periodic reduction of the number of trees corresponding to the age and stage of development of the shelterbelts is carried out according to the principles adopted in forestry, mainly applying negative selective thinning, namely the extraction of small, poorly formed, injured, diseased, and dry trees. However, unlike stands, care will be taken to ensure that the extractions carried out do not affect the semi-penetrability of the forest shelterbelts, which must perform specific functions. By experimenting with different degrees of thinning, the aim is to establish an optimal density, through which the forest shelterbelts can exercise their protective functions, and the equilibrium state of this agroforestry system is not affected.

Key words: *forest shelterbelts, tending operations, cleaning, thinning, agroforestry system.*

INTRODUCTION

Since forest shelterbelts are the most representative agroforestry systems in our country in terms of importance and occupied area, in the last three decades there have been constant concerns for their establishment in as large areas as possible (Adam et al., 2012; Constandache et al., 2013; Dănescu et al., 2007; Dănescu et al., 2007; Dănescu et al., 2017). During this period, forest shelterbelts for the protection of fields and roads were established by farmers and/or authorities in different areas of the Romanian Plain, to protect agricultural crops and roads from the effects of disruptive climatic factors such as: droughts, strong winds and heavy snowfalls (Dolocan et al., 2022; Nițescu, 2023). Although they occupy small areas compared to what needs to be protected in the Romanian Plain (Costăchescu, 2010, Mihăilă et al., 2022), which is vulnerable from a climatic point of view (Prăvălie et al., 2017), they have a proven favourable effect in terms of improving the local microclimate and implicitly increasing agricultural production and the quality of agricultural production (Vasilescu, 2015). Climatic factors, soil type, species composition and forest shelterbelts management significantly influence the efficiency of these forest formations. Since climatic factors cannot be influenced by humans, and the species composition is established according to the soil type when forest shelterbelts are established, it is important that their management to be done constantly and systematically, from establishment to harvesting and not just until the trees are completely closed. Therefore, maintaining and consolidating the protective and productive role of forest vegetation in forest shelterbelts is achieved by carrying out all silvicultural works. In the context of climate change, these tending operations must be adapted to ensure the resilience of forest stands and to maintain their long-term protective role. Only in this way, forest shelterbelts can fulfill as many ecosystem services as possible, from improving the microclimate, improving soil fertility and conservation conditions, preserving and increasing agricultural production, to increasing biodiversity, storing carbon and improving the quality of air, water and landscape (Costăchescu et al., 2010; Lupe, 1952; Neșu, 2012). The works will be carried out depending on the condition and stage of development of the forest vegetation in the shelterbelts. Their timely and appropriate implementation influences both the increase in the value and resistance of the forest vegetation to disturbing factors and the full use of the production capacity of the site. Just as the tending operations of stands, correctly conceived and applied, represent an indispensable and efficient means for the sustainable management of cultivated forests (Petrescu, 1971), the same concern must exist for the forest vegetation in the forest shelterbelts. Therefore, the following tending operations will also be carried out here: cleaning, thinning, and hygienic cutting. These works are essential for ensuring an optimal structure and implicitly fulfilling the functions for which the protective forest shelterbelts were created.

The influence that forest vegetation has on crops, as well as the interactions between them, is reflected in the benefits that the newly created system brings, namely ecological, economic and social benefits, some of which predominate depending on the type of forest cover existing in a given area (Costăchescu et al., 2010).

To date, no research has been conducted in our country to substantiate the method of carrying out tending operations in forest shelterbelts and other agroforestry systems, so it was considered necessary and appropriate to introduce these aspects into the research theme of the FORCLIMSOC Nucleu Program (Tudose et al., 2023-2026). "Technical forestry guidelines for the establishment and tending operations of forest vegetation in protective forest shelterbelts" have been developed (Annex to Ord. MAAP No. 636 of 23.12.2002), but they are based only on the experience gained in the tending operations of stands.

In addition, for field protection forest shelterbelts these norms are not mandatory. Due to the costs of these works and the lack of technical personnel to apply them and verify the correctness of their implementation, these guidelines have not been applied. Sporadically, some shelterbelts have been carried out in hygiene works and firewood extraction works.

The present paper aims to analyse the particularities regarding the implementation of tending operations in protective forest shelterbelts, of different ages and compositions, highlighting the thinning methods and the effect of these interventions on forest vegetation, thus contributing to the optimization of management strategies of these essential agroforestry systems in the plain area of our country. Also, practical aspects related to the management of these forest formations under different pedoclimatic conditions and in the context of current climate change are addressed.

MATERIALS AND METHODS

In 2023, three experimental setups were installed in three different forest shelterbelts. Each experimental setup consists of three experimental blocks, each block having four variants. The four variants correspond to a control variant and the three thinning intensities applied, namely: strong, moderate and weak, through which a larger number of exemplars were extracted, corresponding to the strong variant, to minimal tree extractions corresponding to the weak variant. In the selected forest shelterbelts, two tending operations types were carried out, namely: cleaning and first thinning.

In order to establish the most appropriate tending operations for the selected shelterbelts, an analysis of the structural characteristics of the forest vegetation was previously carried out, in the horizontal plane: composition, consistency, density, average diameter and basal area, and in the vertical plane, average height, by species and for the forest shelterbelts as a whole (Mihăilă et al., 2024).

Cleaning works were carried out in two experimental setups: i) the forest shelterbelts formed by Siberian elm (*Ulmus pumila* L.) and honey locust (*Gleditsia triacanthos* L.), established in the spring of 2020 at the Perișoru Farm, Călărași County, which is 5 years old; and ii) the protective forest shelterbelts formed by greyish oak (*Quercus pedunculiflora* K. Koch), flowering ash (*Fraxinus ornus* L.) and wild pear (*Pyrus pyraster*) established in the fall of 2017 at the Grădiștea Farm, Călărași County, 7 years old.

The first thinning was carried out in one experimental setup, the forest shelterbelts formed by Siberian elm and honey locust, established in the spring of 2018 at the Grădiștea Farm, Călărași County, 7 years old.

The size of the test areas is 140 m^2 (10 x 14 m), at the Perișoru Shelterbelt and in the Grădiștea Shelterbelt, with Siberian elm in the composition and 100 m^2 (10 x 10 m) in the Grădiștea Shelterbelt, with greyish oak and flowering ash in the composition.

To determine the intensity of thinning work in the forest shelterbelts, all the trees in the sample areas were inventoried, both those remaining in the shelterbelts following the tending operations and those extracted, measuring their circumference at 1.30 m from the height of the tree and their total height (H). Based on the recording of the circumference of the trees, the diameter at breast height (Dbh) of the trees was determined, in centimetres, which was the basis for determining the basal area. The basal area, BA, which represents the area corresponding to the diameter of the base of a tree, was determined with the formula: $BA = \pi \cdot Dbh^2/4$.

The basal area for each sample area was determined by aggregating the basal area of all trees in the area.

Recording the number of trees, as well as determining the basal area, before and after the thinning work, were the basis for determining the thinning intensities. The thinning intensity by the number of trees is more expeditious, but because the trees were not relatively evenly distributed, it was chosen to establish the intensity of the extraction works by the basal area, which presents greater accuracy in the specific conditions of the analysed forest shelterbelts.

The intensity of the basal area (i_{BA}), expressed as a percentage, was determined as the ratio between the basal area of the extracted trees and the cumulative basal area of the trees in the sample area before the thinning work, according to the formula:

$i_{BA} = BA_e/BA_i \cdot 100$

The recording of tree diameters and heights was also done one year after the tending operations were carried out, to analyse the reaction of the remaining trees as a result of the reduction in the number of trees. In particular, the recording of height is important in forest shelterbelts, because the protected agricultural area depends on the size of this parameter. The data collected have been statistically processed and interpreted, using Microsoft Excel and Statistica 7.1.

RESULTS AND DISCUSSIONS

By carrying out the tending operations, the development of forest shelterbelts is supported and directed to fulfill the protection and production functions in the best conditions and with maximum efficiency. Failure to carry out these works or their omission significantly reduces the beneficial effect of the forest component within these agroforestry systems, leading to the degradation or premature aging of the forest vegetation (Figure 1).

Figure 1. Degraded forest shelterbelts where the tending operations were not carried out

Since only two to three species were used in the afforestation works to create the studied forest shelterbelts, a small number of rows (5 and 7), specific to forest shelterbelts for crop protection, and a planting scheme of 2 x 1 m, after the trees reach crown closure, there was no danger of some specimens being overwhelmed by others, as happens in naturally regenerated stands. For this reason, the maintenance works in these shelterbelts do not include early cleaning works, but only cleaning and thinning works, depending on the age of the forest shelterbelts and the development of the trees within them. These works are necessary to conveniently direct the development of the trees and accelerate their growth.

Four years after planting, when the structure of the forest vegetation was assessed, in the forest shelterbelts with Siberian elm and honey locust from Perișoru, the total number of trees per hectare was 37% lower than at planting, Siberian elm by 39% and honey locust by 35% (Mihăilă et al., 2024). Although the number of trees decreased, maintenance work was still necessary because many specimens, especially Siberian elm, had 2-4 shoots, which competed with each other. There were also areas where the specimens were very dense and, under conditions of competition, their development was not achieved in optimal parameters.

The average diameter in the sample areas varies from 4.2 to 6.1 cm and the height from 4.8 to 5.4 m (Mihaila et al., 2024) so the silvicultural work indicated and necessary in this shelterbelt is clearing. The purpose of these works is to obtain a well-proportioned and spaced mixture so that the remaining trees accelerate their height growth and develop their crown as well as possible (Figure 2).

Six years after planting, when the forest vegetation structure was evaluated, in the Siberian elm forest shelterbelt in Gradiștea, the number of trees per hectare decreased by 26% compared to that at planting, a lower percentage than in the Perișoru forest shelterbelt (Mihăilă et al., 2024). This may have several explanations: i) at Grădiștea, the forest shelterbelt was installed only with Siberian elm, therefore, there was no competition between species as in the Perișoru forest shelterbelt; ii) the seedlings adapted better to the seasonal conditions; and iii) the seedlings benefited from the groundwater supply during times of active growth, the Grădiștea shelterbelt being located near the Danube, at approximately 500-700 m. Because there were portions in the shelterbelt with a large number of trees, most of them with 2-5 shoots, maintenance work was necessary to direct the competition process between specimens and create space for the remaining specimens to grow.

Regarding the biometric characteristics 6 years after planting, the average diameter in the sample areas varies from 5.2 to 6.5 cm, and the average height from 4.8 to 6.4 m. Since the trees were very well developed, with the dominant height being over 8.5 m, the silvicultural work required in this shelterbelt can be considered the first thinning, even if no other care work was carried out up to this age. The purpose of this work is to create an optimal development space for the remaining trees and accelerate their height growth.

a.

b.

Figure 2. Forest shelterbelt with Siberian elm and honey locust in which no maintenance work was done (a) and after clearing work (b)

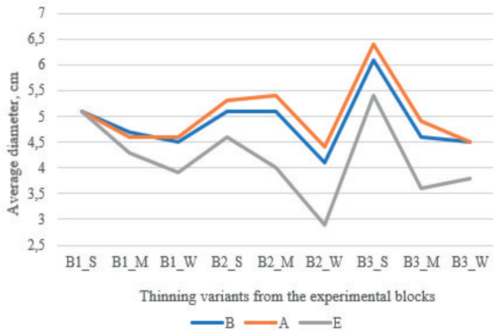
The oak and flowering ash forest shelterbelt from Grădiștea consists of five rows of trees arranged according to the scheme: STB • MJ STB • MJ (PĂ) • STB (STB - greyish oak, MJ - flowering ash, PĂ - wild pear). Unlike the other areas analysed, in the greyish oak and flowering ash shelterbelt, many specimens were missing in the rows with the flowering ash, in some cases, these species were completely missing, the cause being very likely the poor quality of the seedlings used for planting. The distance between rows of 2 m and between seedlings in a row of 1 m led to the development of greyish oak, which did not have to endure the competition of flowering ash. At the time of the inventory, 6 years after planting, the total number of trees per hectare decreased by 45% compared to the planting date, the greyish oak by 30%, and the flowering ash by 37% (Mihăilă et al., 2024). The cleaning works carried out practically reduced the density in the greyish oak and flowering ash rows by extracting shoots and trees with negative characteristics and, thus, creating a larger space for the remaining trees to develop (Figure 3).

a.

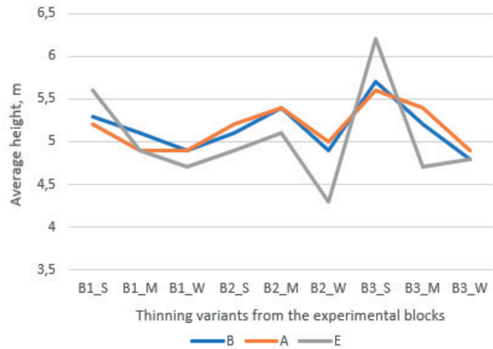
b.

Figure 3. Forest shelterbelt with greyish oak and flowering ash from Grădiștea, without tending operations (a) and after cleaning (b)

In all three forest shelterbelts, multiple shoots from a specimen were first extracted, with smaller dimensions than the remaining tree, small trees (both diameters and heights) that do not have the chance to develop very much, with wounds from maintenance work, injured by game species with sinuous trunks, bent, generically speaking, trees of inappropriate size and quality, which hamper the harmonious development of specimens with positive characteristics (straight, with symmetrical, developed crown) (Figure 4).



a.



b.

Figure 4. Variation of average diameter (a.) and average height (b.) in experimental blocks (B1, B2 and B3) before (B) and after cleaning works (A) and for extracted trees (E) (thinning variants are: S - strong, M - moderate, S - weak) in experimental setup installed in the Siberian elm and honey locust forest shelterbelt Perișoru

It was taken into account that the extractions carried out did not reduce the consistency below 0.8-0.7, which means not to strip the soil too much.

Regarding the intensity of tending operation after the basal area (i_{BA}), this naturally differed from one area to another, depending on the density, the number of specimens and the condition of the specimens in the analysed sample area. Starting from the scale for assessing the intensity of tending operation (MMAP, 2022), a similar scale for assessing the intensity of present interventions is proposed, but with different ranges: one for the shelterbelt composed of Siberian elm and honey locust and the other for the shelterbelt with greyish oak and flowering ash (Table 1).

In the first case, the extraction of trees from the sample areas determined the division of the cleaning and thinning into weak (i_{BA} < 10%), moderate (i_{BA} = 10-18%) and strong (i_{BA} > 18%). In the second case, the cleanings were of weak intensity, with i_{BA} < 5%, moderate, with i_{BA} = 5-8% and strong, with i_{BA} > 8%. It is mentioned that the establishment of these degrees is based only on the experiments in the three forest shelterbelts analysed and is not definitive.

Table 1. Intensity of tending operations and the ranges of variation of the three degrees of intensity (weak, moderate, strong)

Forest shelterbelt	Intensity of tending operations		
	Week	Moderate	Strong
	i_{Ba} < 10 %	**i_{Ba} = 10-18 %**	**i_{Ba} > 18 %**
Perișoru (Siberian elm, honey locust)	4.4; 8.7	11.8; 13.3; 13.6; 16.9	18.3; 18.5; 23,0.
Grădiștea (Siberian elm, honey locust)	5.0; 8.5; 9.5	12.1; 15.4; 18.1	18.8; 22.0; 26.6
	i_{Ba} < 5 %	**i_{Ba} = 5-8 %**	**i_{Ba} > 8 %**
Grădiștea (greyish oak, flowering ash)	3.0; 4.1	5.3; 5.6; 5.6; 7.3	8.5; 14.3

The maintenance works carried out, including cleaning and thinning, were performed during the growing season after the period of maximum accumulation specific to the beginning of the trees' vegetative phase, using lightweight mechanical saws and/or axes, by cutting the trees at ground level, which were then removed to the edge of the shelterbelt for utilization.

Regarding the effect of the maintenance works on the forest vegetation, it will be analysed after at least two - three growing seasons, the only year since the interventions did not show a significant response in terms of increases in height and diameter at 1.30 m.

For example, the analysis of relative height growth in the control and the three thinning variants at the Perișoru forest shelterbelt shows that the cuttings did not influence height growth. In the control variant, the height growth of the Siberian elm is higher, even significantly, compared to the moderate and strong thinning variants (Figure 5). In honey locust, the greatest height growth is recorded in the strong variant, although there are no significant differences between the four variants. This can be explained by the fact that height growth is greater under competition conditions between individuals.

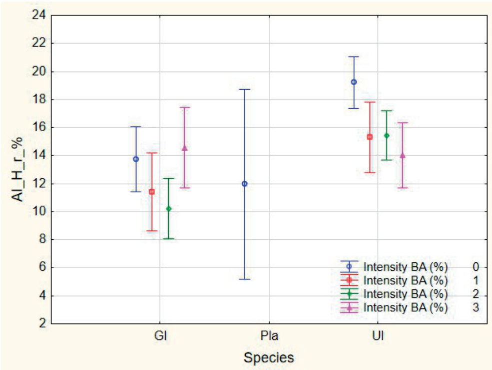


Figure 5. Relative height (H) growth of species in the Perisoru forest shelterbelt in the control variant (0) and the three thinning variants (1 - weak, 2 - moderate, 3 - strong) (Ul - elm, Gl - honey locust)

There are significant differences in diameter growth between the control variant and the three thinning variants, but only for the elm (Figure 6). This can be explained by the growth characteristics of the elm and the reduction in stand density, which led to increased growth primarily in diameter.

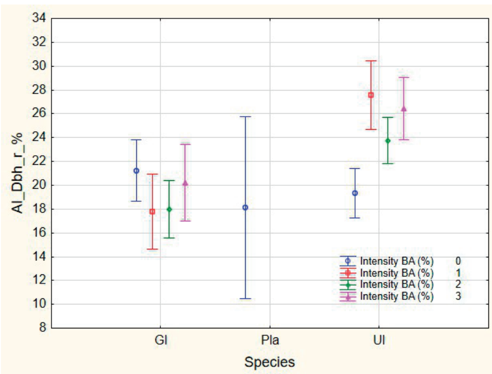


Figure 6. Relative diameter (Dbh) growth of species in the Perisoru forest shelterbelt in the control variant (0) and the three thinning variants (1 - weak, 2 - moderate, 3 - strong) (Ul - elm, Gl - honey locust)

At the Grădiștea forest shelterbelt, there are no significant differences between the control variant and the three thinning variants, neither for greyish oak nor for flowering ash (Figure 7).

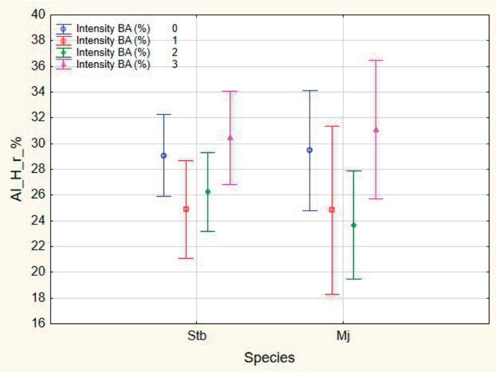


Figure 7. Relative height (H) growth of species in the Gradiștea forest shelterbelt in the control variant (0) and the three thinning variants (1 - weak, 2 - moderate, 3 - strong) (Stb - greyish oak, Mj - flowering ash)

Relative growth in diameter and height was analysed because, unlike absolute growth, it can better reflect differences in growth between species, considering that the shelterbelts consist of two to three different species. Additionally, growth differences also arise from the fact that after planting, supplementary plantings were carried out with seedlings that were generally smaller than those initially planted, leading to differences in tree sizes. Under these conditions, relative growth provides a clearer perspective on growth efficiency concerning the initial size of the trees.

CONCLUSIONS

Since, in the forest shelterbelts for crop protection, tending operations are not systematically performed, cleaning and thinning works were carried out, with different degrees of tree extractions, in three experimental setups installed in forest shelterbelts of different ages and compositions. In each experimental setup, three experimental blocks were placed, each block comprising four variants, one control and three variants with tree cutting/extractions of different intensities: strong, moderate and weak. The intensities of cleaning and thinning varied according to the condition of the forest shelterbelts (density and health of the trees).

The tending operations were carried out to create an optimal space for the development of the trees so that they develop their crown and grow in height, to protect the agricultural land to the greatest extent possible. The interventions had different intensities precisely to observe the best reaction of the trees to the tending operations while maintaining an adequate degree of semi-penetrability (40-60%) of the forest shelterbelts for field protection.

ACKNOWLEDGEMENTS

This research work was carried out with the support of Ministry of Education and Research (former Ministry of Research, Innovation and Digitalisation) through the national project PN23090203: New scientific contributions for sustainable management of watersheds, degraded lands, forest shelterbelts and other agroforestry systems in the context of climate change.

REFERENCES

Adam, I., Cadar, N., Merce, O., Cântar, I. (2012). Fundamente științifice pentru crearea perdelelor forestiere de protecția câmpului în Câmpia Banatului. *Revista de Silvicultură și Cinegetică*, nr. 42, pp. 16–22.

Constandache, C., Nistor, S., Untaru, E. (2013). Public road shelterbelts – an efficient solution for preventing damage caused by blizzards. In Quality-Access to Success 14, S1: 357–364.

Costăchescu, C., Dănescu, F., Mihăilă, E. (2010). *Perdele forestiere de protecţie* (*Forest shelterbelts*). Editura Silvică, Bucureşti (in romanian).

Danescu, F., Costachescu, C. (2014). Crearea reţelei naţionale de perdele forestiere de protecţie, premisă importantă pentru ameliorarea condiţiilor de mediu, între necesitate şi posibilitate de realizare (Establishing a national network of forest shelterbelts, an important premise for improving environmental conditions, between necessity and feasibility). *Revista de Silvicultură şi Cinegetică*, 35, 63–70 (summary in English).

Dănescu, F., Costăchescu, C., Petrila, M. (2007). Study for the installation of forested field protection belts in Constanta County. *Anals of Forest Research, vol. 50*. Editura Silvică, Bucureşti, pp. 299–313.

Dolocan, C., Mușat, M., Ciceoi, R., Argatu, G., Mușat, I.B., Petcu, M. (2022). Aspects regarding the shelterbelts establishment in Baragan Plain. *Scientific Papers. Series A. Agronomy, LXV*(2), 54–60.

Ministerul Mediului, Apelor și Pădurilor, 2022. NORME TEHNICE privind îngrijirea și conducerea arboretelor. https://www.mmediu.ro/app/webroot/uploads/files/Anexa%20Ordinului%20nr.%202534%20din%202022%20%28NG%202%29.pdf

Lupe, I. (1952). *Perdele forestiere de protecţie şi cultura lor în câmpiile Republicii Populare Române*, Editura Acad. R.P.R., Bucureşti.

Ministerul Agriculturii Alimentației și Pădurilor (2002). ORDIN nr. 636 din 23 decembrie 2002 privind aprobarea Îndrumărilor tehnice silvice pentru înfiinţarea, îngrijirea şi conducerea vegetaţiei forestiere din perdelele forestiere de protecţie.https://www.primaimpadurire.ro/wp-content/uploads/2023/01/OM-636-din-2002-Indrumari-perdele-for.pdf

Mihăilă, E., Drăgan, D., Marcu, C., Costăchescu, C., Dănescu, F., Cojoacă, F.D. (2022). Elaboration the substantiating studies for the necessity of forest shelterbelts to protect the field, premise for obtaining funds for their realization. *Scientific papers, Series E, XI*, Bucharest, 240–246.

Mihăilă, E., Tudora, A., Bîtcă, M., Drăgan, D., Achim, E. (2024). Evaluarea structurii vegetației forestiere din perdele forestiere în vederea realizării lucrărilor de îngrijire și conducere. *Revista pădurilor, 4*: 3–34.

Neşu, I. (2012). Perdele forestiere de protecţie a culturilor agricole - o necesitate. *Revista de Silvicultură și Cinegetică, nr. 30*, 56–58 (abstract in English).

Nițescu, E.O. (2023). Perdele forestiere: de la deziderat la realizări pe autostrada A2. Conferința Sistemele agrosilvice: prezent și perspective. https://padureademaine.ro/2023/10/19/conferinta-sistemele-agrosilvice-prezent-si-perspective-18-octombrie-2023/

Petrescu, L. (1971). *Îndrumător pentru lucrările de îngrijire a arboretelo*r. Editura Ceres București.

Popov, E., Hinkov, G., Kachova, V., Constandache, C., Dincă, L. (2017). A brief review of forest shelter belt establishments in Bulgaria and Romania. *Revista de Silvicultură și Cinegetică, nr. 41*, 16–23 (abstract in English).

Prăvălie, R., Patriche, C., Bandoc, G. (2017). Quantification of land degradation sensitivity areas in Southern and Central Southeastern Europe. New results based on improving DISMED methodology with new climate data. *Catena 158*, pg. 309–320. https://doi.org/10.1016/j.catena.2017.07.006

Tudose, N.C. (2023-2026), coordinator of the project "Contribuții științifice noi pentru un management sustenabil al bazinelor hidrografice torențiale, terenurilor degradate, perdelelor forestiere și al altor sisteme agrosilvice în contextul schimbărilor climatice" (Manuscript INCDS).

Vasilescu, M.M. (2015). *Perdelele forestiere de protecţie în contextul organizării teritoriului*. Editura Lux Libris, Brașov.