ECONOMIC EVALUATION OF THE PRODUCTIVITY OF AGROSILVOPASTORAL SYSTEMS WITH EUROPEAN BEECH (*FAGUS SYLVATICA* L.) FROM THE GURGHIULU MOUNTAINS

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Abstract. *Agrosilvopastoral systems (ASPs) represent one of the main approaches for mitigating the negative effects of global warming on livestock production during the grazing season. The study was carried out in the Gurghiu Mountains, the Eastern Carpathians, within the localities of Ibăneşti and Eremitu in Mureş County, Romania. The pasture, located at an elevation of 900–1,150 m a.s.l., covers an area of 700 hectares and contains an average of 14 well-developed Fagus sylvatica trees per hectare, with a mean crown cover canopy of 2,900 m^2 h^{-1}. The average green fodder (GF) production under the tree canopy was estimated at 9.65 t ha^{-1}, with a pastoral value index (PV) of 57.3, resulting in a milk production of 1,462 L ha^{-1} during a 135-day grazing season. In the open pastures without trees, the GF production was estimated at 5.96 t ha^{-1}, with a PV of 38.2, and a potential milk production of 621 L ha^{-1}. The production of timber was 91.22 m^3 ha^{-1} and 41.61 m^3 h^{-1} of firewood. The annual production of beech mast was estimated at 125 kg ha^{-1}. The total economic value of products derived from ASP amounted to €1,013 ha^{-1} $year^{-1}$, which was nearly 3.3 times higher than the value of the milk produced on treeless pastures without shade for animals.*

Keywords: Agrosilvopastoral system with Fagus sylvatica; milk production; timber production; economic value

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1. Introduction

Agrosilvopastoral systems (APSs) represent one of the most effective means of protecting livestock during the grazing season against the negative effects of global climate warming [5,6,10,16,17].

In our country, former communal pastures were traditionally populated with various tree species providing shade for grazing animals, which are currently more or less neglected [5, 14].

For these reasons, several studies have been initiated and continued on the ASP systems that have survived to the present day, focusing on their economic value assessment.

The present paper is a continuation of the studies regarding the economic value of an ASPs with beech (*Fagus sylvatica* L.) located in the mountainous area of the Eastern Carpathians.

2. Materials and Methods

Studies on the economic value of the ASPs with beech were conducted in the Gurghiu Mountains, on a pasture belonging to the localities of Ibănești and eremite, situated at an altitude of 900-1,150 m a.s.l., covering approximately 700 ha and surrounded by forest.

In the first phase, the floristic composition of the grasslands under the beech canopy and in open areas was studied, based on which green fodder (GF), pastoral value index (PV), and livestock stocking rate per hectare were evaluated [6,8,9,11].

On this occasion, soil and forage samples were collected for analyses (Table 1).

Table 2. General characteristics of the agrosilvopastoral system (ASPs) with beech at Ibănești-Eremitu

Pasture condition		Soil		Dominant species	Forage		
		pH	Humus (%)		CP	CF	OMD
Open field		4.7	12.12	*Nardus stricta* *Festuca rubra* *Agrostis capillaris*	11.1	37.6	45.0
Under tree canopy		4.8	12.18	*Festuca rubra* *Poa pratensis* *Agrostis capillaris*	11.9	37.1	47.3
Difference	+, -	+ 0.1	+ 0.06	-	+ 0.8	- 0.5	+ 2.3
	%	102	101	-	108	99	105

CP = crude protein (N x 6.25); CF = crude fiber; OMD = organic matter digestibility

The herbaceous cover in open pastures was dominated by *Nardus stricta* and *Festuca rubra*, whereas under the beech canopy a more favorable floristic composition was observed, characterized by the dominance of *Festuca rubra* and *Poa pratensis* ensured a higher crude protein and improved forage digestibility on the pasture [2, 7].

Particular importance is attributed to the conversion coefficients of green fodder production into animal production, which are based on forage consumption indices required to produce one liter of milk or one kilogram of live weight gain in cattle [12,13].

The green fodder consumption index per 1 liter (L) of milk was calculated using the following equation:

$$\text{GF consumption (kg) for 1 L milk} = 9.5 - 0.05 \times PV \quad (1)$$

The cow milk production per hectare was calculated using the following equation:

$$\text{Milk production (L ha}^{-1}\text{)} = \text{GF (kg ha}^{-1}\text{)} / \text{GF consumption (kg) for 1 L milk} \quad (2)$$

The green fodder consumption index per 1 kg live weight gain in young cattle was calculated using the following equation:

$$\text{GF consumption (kg) for 1 kg of gain} = 100 - 0.5 \times PV \quad (3)$$

Similarly, the green fodder consumption for 1 kg of live weight gain varies from 50 kg of GF for the maximum PV index of 100 to 100 kg of GF for the lowest PV index.

The live weight gain (meat production) per hectare in young cattle was calculated using the following equation:

$$\text{Weight gain production (kg ha}^{-1}\text{)} = \text{GF (kg ha}^{-1}\text{)} / \text{GF consumption (kg) for 1 kg of gain} \quad (4)$$

According to EU average market prices, cow's milk was priced at €0.5 L^{-1}, whereas live cattle were priced at €3.2 L^{-1} live weight [MADR, 2026].

Subsequently, studies were conducted on the isolated beech on the pasture to evaluate the economic value of timber and fruits (beech mast).

The forest vegetation on the Ibănești-Eremitu pasture was analyzed by establishing four experimental plots of 1 ha each, which were representative in terms of tree density and vegetation condition (Figure 1).

Within each experimental plot, all trees were inventoried by measuring and estimating their main dendrometric characteristics, namely diameter at breast height, total tree height, stem height, and four radii along the N, S, E and W directions in order to determine crown projection area.

A total of 55 beech trees were identified, scattered throughout the pasture. Only one experimental plot contained a higher number of trees (21), while the others contained 10 to 12 trees each, corresponding to an average density of 14 trees ha^{-1}.

Shrub vegetation was present in only one of the four experimental plots and consisted of three individuals of hawthorn (*Crataegus monogyna* Jack.).

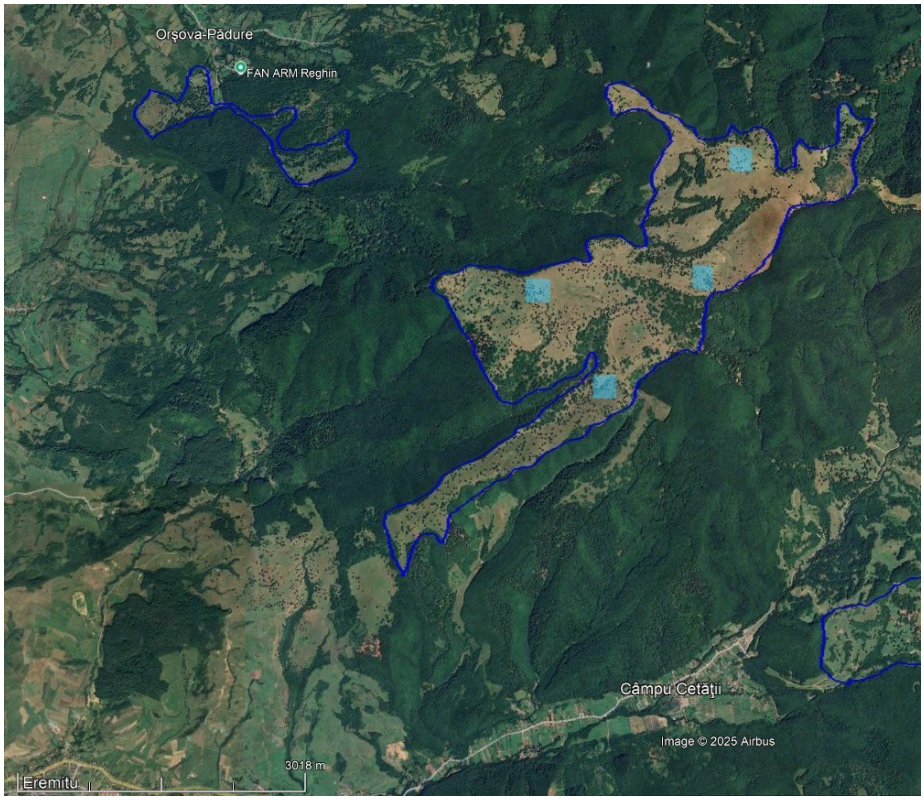

Fig. 4. Eremitu pasture and the location of the experimental plots

2.1. Economic evaluation of the Agrosilvopastoral systems (APSs)

The presence of trees in pastures provided ecological, economic, and social benefits; therefore, the services provided by these pastures with trees include both quantifiable and non-quantifiable values.

The microclimatic conditions created by trees within pastures constitute a significant ecological benefit, although it is difficult to quantify.

In contrast, the wood and non-wood products derived from trees on pastures are quantifiable, and their economic evaluation is important for promoting the conservation and management of existing pastures, as well as the establishment of new ones.

Beech mast, the fruit of beech trees, constitutes an important feed resource for pigs, sheep, and, to a lesser extent, cattle. Moreover, during specific periods when forage resources are scarce, tree leaves can also contribute to supplementing animal nutrition.

Economic returns may also be derived from timber harvested through the selective cuts of pastures trees, provided that these interventions do not adversely affect the ecological stability and equilibrium of the systems.

To quantify the income that can be generated from timber harvested in pastures, it is necessary to determine the volume of the trees.

Tree volume can be estimated using equations that take into account the diameter at breast height and tree height. The most commonly used general equation for estimating tree volume is:

$$V = BA \times h \times f = 0.7854 \times DBH^2 \times h \times f \quad (5)$$

where:

- V = tree volume (m^3)
- BA = basal area (m^2)
- DBH = diameter at breast height (cm)
- h = total tree height (m)
- f = form factor, accounting for trunk shape (typically ranging from 0.4 to 0.7 for forest trees).[3]

3. Results and Discussions

The main productivity indicators of the beech-based ASPs highlighted the superiority of the herbaceous cover under the tree canopy compared with that in open pasture areas (Table 2).

Under the beech canopy, GF yield reached 9.65 t ha^{-1}, which was 62% higher than in the open pasture, while PV reached 57.3, representing a 50% increase compared with the treeless pasture.

Under these conditions of GF yield and PV, the GF consumption for 1 L milk was 6.6. kg under the canopy and 9.6 kg in the open pasture, resulting in a milk production of 1,462 L ha^{-1} under the trees, which was 2.4 times higher than that recorded in the open pasture.

Table 3. Evaluation of the main productivity indicators of pastures within the ASPs with beech during a 135-day grazing season

Parameter	Unit	Open pasture	Under tree canopy	Difference	
				+, -	%
Green fodder (GF) yield	t ha^{-1}	5.96	9.65	+ 3.69	162
Optimal stocking rate	LU ha^{-1}	0.68	1.10	+ 0.42	162
Pastoral value index (PV)	Index	38.2	57.3	+ 19.1	150
GF consumption for 1 L milk	kg L^{-1}	9.6	6.6	- 3.0	69
Cow milk production	L ha^{-1}	621	1,462	+ 841	235

Regarding the dendrometric parameters, diameter at breast height ranged from 45 to 193 cm, while tree height varied between 7.4 and 30.4 m. A higher variation was recorded for the crown projection area, which ranged from 64 to 386 m^2 (Table 3).

Excluding the shrubs occurring on the pasture, the ground cover provided by forest vegetation, expressed by the canopy cover index, reached a value of 0.29 in the analysed plots, corresponding to a canopy closure of 0.3. This value indicates a favourable tree cover level for silvopastoral systems.

The crown ratio, expressed as the proportion of crown height to total tree height, ranged from 73% to 94%, reflecting the significant development of the beech trees growing on the pasture and highlighting their importance in terms of accumulated foliar biomass. Given that the coefficient of variation (CV) for this parameter was only 5%, it can be concluded that the most possessed well-developed and dense crowns.

The value of the coefficient of variation for the mean crown projection area is 36%, indicating a relatively high variability in crown shape, this suggests that is not uniform and symmetrical in all cases.

Regarding tree health status, approximately 42% of the trees showed signs of decline or dieback, such as dry and/or broken tops and branches, wounds, basal scars, lichens, and tree cavities.

Seed production was abundant in two of the four inventoried plots, normal in one, and poor in the fourth plot. Although the pasture is grazed, though not continuously; therefore, it is necessary to identify methods to protect the natural regeneration of beech.

Given their very large DBH (mean is 104 cm), it can be concluded that the trees on the Eremitu pasture are of an advanced age.

Under conditions of low stand density, these trees have developed large crowns, with crown rations ranging from 73% to 94% of total tree height (Table 3), together with thick and relatively short stems compared to trees growing within closed forest stands.

Table 4. Main dendrometric parameters of beech trees on the Eremitu pasture

Dendrometric parameters	**N/ 4ha**	**Mean**	**Minimum**	**Maximum**	**Coefficient of variation (%)**
Diameter at breast height (DBH, cm)	55	104	45	193	24
Tree height (H, m)	55	20.8	7.4	30.4	18
Crown height (m)	55	18.2	5.4	28.6	21
Crown ratio (% of total height)	55	87	73	94	5
Mean canopy projection area (m^2)	55	223	64	386	36
Total canopy projection area per hectare (m^2 ha^{-1})	14	2,903			
N – number of inventoried trees.					

Given the isolated growth conditions of the trees on the Eremitu pasture and the relatively small proportion of stem length relative to total tree height (ranging from 6% to 27%), together with their expansive crowns and thick branches, the form factor was estimated at relatively low values (0.35).

Consequently, volume estimates may be associated with a certain margin of error in the absence of precise field data on the volume of scattered pasture trees.

It should also be noted that the volume calculated using this formula does not include the volume of branches, but only the stem volume, measured from the base to the tip of the main stem. To account for branch volume, an additional

correction coefficient is applied, which for beech is estimated at 0.50 % of the stem volume.

The choice of a branch volume correction coefficient of 0.50 is directly supported by biometric field data collected.

The structural analysis of the sampled trees revealed that the crown ratio ranged from 73% to 94% of the total tree height. This parameter indicates a strong crown development at the expense of cleat bole length, which in some cases represents only 6% of the total height.

Considering that the biomass of the main branches in these trees compensates the low proportions of stem volume, the use of the 0.50 factor ensures an accurate and conservative estimation of the total volume, fully consistent with allometric models developed for scattered trees in European agroforestry systems.

For the experimental plots established on the Eremitu pasture, stem volume was calculated using the formula presented above, with a form factor value of 0.35.

It should be noted that this form factor value incorporates a crown reduction coefficient, given that the canopy occupies slightly over 70% of the total height for the trees on Eremitu pasture.

Thus, the total stem volume of beech trees across the four inventoried plots amounted to 364.89 m^3, corresponding to a mean volume of 91.22 m^3 ha^{-1}. This volume refers exclusively to stem volume, measured from the base to the tip of the main stem.

Structurally distinct from oak, beechwood is a hard, dense and versatile material, widely used in the furniture industry (particularly for bent components and load-bearing structures), interior design, for the manufacture of kitchen utensils and toys, as well as a premium energy source in the form of firewood and smoking wood.

Due to its poor quality as timber, the beechwood from the pasture is almost entirely downgraded to the firewood category; its market value ranges between €50 and €120 m^3, depending on the point of sale (either directly at the logging site or from specialized timber depots).

Grown in open space with light available from all directions, beech trees on the pasture develops thick branches very close to the ground. The stem remains short, knotty, and often crooked, making it unsuitable for high-quality sawn timber or veneer production. Being exposed directly to winds from all directions, the wood develops spiral grain, which causes it to crack and warp severely during the drying process.

Old pasture trees frequently exhibit knots, sweep, and large wounds caused by branch breakage or animal damage, which facilitate fungal infection, ultimately leading to the development of extensive red heartwood or central rot.

To the firewood volume calculated solely for the stem, the volume of large limbs and secondary branches – also referred to as mixed firewood – is added, the total tree volume (main stem and branches) is calculated as follows: $V_{total} = V_{stem} + V_{stem} \times 0.50$.

The volume of branches amounted to 182.45 m^3 across the four experimental pots, corresponding to 45.61 m^3 ha^{-1}. The market value of this of this category if firewood may be estimated at €75 m^3. The total price of beech firewood, including stem wood, branches, and the total volume, is presented in Table 4.

Given the important ecological and landscape functions provided by trees, timber harvesting is not considered a management objective. Nevertheless, the economic evaluation of silvopastoral systems highlights the economic potential of these pastures in addition to their ecological benefits.

Only dead trees or individuals exhibiting a high degree of crown dieback should be considered for removal from the pasture.

Table 5. Volume and market value of beech wood from the Eremitu pasture

Species	V_{stem} (m^3 ha^{-1})	Average price of V_{stem} (€ m^3)	Total value of V_{stem} (€)	$V_{branches}$ (m^3 ha^{-1})	Average price of $V_{branches}$ (€ m^3)	Total value of $V_{branches}$ (€)	Total value of V_{total} (€)
Beech	91.2	120.0	10,946.4	45.6	70.0	3,192.7	14,139.2

On a pasture, the true value of beech trees does not lie in their timber volume, but rather in the ecosystem services provided: i) providing shelter for livestock from heat stress during hot summer days, thereby helping to maintain milk production and animal body weight; ii) preventing soil erosion on sloping pastures through their root system, while the canopy reduces soil water evaporation beneath the crown projection to maintain a more humid microclimate; and iii) functioning as authentic "biodiversity islands" that provide nesting sites for birds of prey (which control pasture rodent populations) and habitats for beneficial insects.

In addition to the benefits outlined above, beech trees produce fruits (beech mast), which constitute a valuable source of nutrients, including proteins, lipids, carbohydrates, minerals, and vitamins [1, 15].

Beech mast is an excellent feed resource for pigs. The meat and lard of animals fed on beech mast acquire a distinctive texture and flavor, a phenomenon

comparable to that observed in Spain, where free-range pigs are finished on acorns.

Although less well known in local gastronomy, beech nut oil regarded as a delicacy in certain European regions, particularly in France, owing to its high resistance to rancidity and its mildly sweet flavor, reminiscent of walnuts pr almonds.

On pastures, where beech trees benefit from greater light availability and reduced competition for space, fructification occurs more frequently. Seed production typically begins at 40 to 50 years of age, with a periodicity of 5 to 6 years, though partial masting may also occur between full mast years [3].

The occurrence and intensity of mast production are influenced by climatic conditions (temperature and drought), soil characteristics, and tree stress factors, such as water deficit, harvesting interventions, or disease. While specific measurements of beech mast production were not conducted within the analyzed pasture plots, but in beech stands trees may produce between 400 and 800 kg ha^{-1}, depending on the fructification year [15].

The labor cost for harvesting one kilogram of beech mast varies from €8 to €16, with a higher value corresponding to years of low fruit production.

These values were calculated based on the Unified Time and Production Norms for Forestry Operations [4] under average masting conditions.

Labor costs are further increased by the commercial margin applied during subsequent marketing of the product, resulting in a final market price ranging from €24 to €36 per kilogram. However, because the beech mast is consumed on-site as forage by both wild and domestic animals, its baseline economic value was estimate at €3 per kilogram.

The final economic value of milk, timber, and beech mast production within the ASPs is presented in Table 5.

Table 6. Comparative economic evaluation of the agrosilvopastoral system (ASPs) and treeless pasture (TlP)

Item	Pasture systems			Diferențe ASP-FA	
	ASPs	%	TlP	+, -	%
Milk production (L ha^{-1} yr^{-1})	865		621	+ 244	139
Value x 0.5 € (L ha^{-1} yr^{-1})	433	43	311	+ 122	139
Timber volume (m^3 ha^{-1} at 120 years)	91.22		-	-	-
Annual timber yield (m^3 ha^{-1} yr^{-1})	0.76		-	-	-
Value × 120 € (m^3 ha^{-1} yr^{-1})	91	9	-	-	-
Firewood volume from	45.61		-	-	-

branches (m^3 ha^{-1} at 120 years)					
Annual firewood yield (m^3 ha^{-1} yr^{-1})	0.38		-	-	-
Value × 70 € (m^3 ha^{-1} yr^{-1})	27	3	-	-	-
Beech mast production (kg ha^{-1} yr^{-1})	125		-	-	-
Value × 3 € (kg ha^{-1} yr^{-1})	375	37	-	-	-
Additional milk production (20%) (L ha^{-1} yr^{-1})	173		-	-	-
Value × 0.5 € (L ha^{-1} yr^{-1})	87	8	-	-	-
Total annual value (€)	1,013	100	311	+702	326

For milk production within the ASP system, a weighted average was calculated between the under-canopy yield of 1,462 L ha^{-1} over a total crown projection area of 2,900 m^2 and the open-pasture yield of 621 L ha^{-1} obtained across the remaining 7,100 m^2, resulting in a final average of 865 L ha^{-1}.

The stem timber volume intended for industrial processing from the 14 beech trees was evaluated at 99.22 m^3 ha^{-1} over a 120-year cycle, corresponding to an annual increment of 0.76 m^3 ha^{-1} yr^{-1}.

Firewood volume accounted for 45.61 m^3 ha^{-1} at 120 years, equivalent to an annual yield of 0.38 m^3 ha^{-1} yr^{-1}.

Average beech mast production was estimated at 125 kg ha^{-1} yr^{-1}.

The beneficial effect of tree shade on cattle performance was estimated to increase milk production by 20%, resulting in an additional 173 L ha^{-1} yr^{-1}.

Based on current market prices for livestock and forestry products, the total economic value of the ASPs reached €1,013 ha^{-1} yr^{-1}, a value 3.3 times higher than that of the pasture without trees.

The proportional distribution of the economic value within the ASP system consisted of 51% from milk production, 37% from beech mast yield, 9% from trunk timber and 3% from firewood.

Conclusions

(1). Pastures containing a mean of 14 beech trees per hectare, with a total crown projection area of 2,900 m^2 provide effective protection for both pasture vegetation and grazing animals and may therefore be considered highly economically efficient agrosilvopastoral systems (ASPs).

(2). The green fodder yield and the pastoral value index beneath the beech canopy are 50% to 62% higher compared to those of the treeless pasture.

(3). Tree volume by wood assortments amounted to 91.22 m^3 ha^{-1} of timber and 45.61 m^3 ha^{-1} of firewood over a 120-year period, representing an annual equivalent of 0.76 m^3 yr^{-1} and 0.38 m^3 yr^{-1}, respectively, supplemented by an annual beech mast production of 125 kg ha^{-1} yr^{-1}.

(4). The total economic value of the ASPs was €1,013 ha^{-1} yr^{-1}, with cow milk production contributing 51%, beech mast yield 37%, timber 9% and firewood 3% to the overall financial value.

(5) The beech-based ASPs is approximately 3.3 times more economically valuable than the treeless pasture.

R E F E R E N C E S

[1] Corlățeanu, S., Produsele accesorii ale pădurii, Editura Ceres, București (Forest by-products, Ceres Publishing House, Bucharest) (1984)

[2] Giurgiu, V., Dendrometrie și auxologie forestieră, Editura Ceres, București (Forest dendometry and auxology, Ceres Publishing House, Bucharest) (1979)

[3] Haralamb, A. Cultura speciilor forestiere. Editura agro-silvică București. (Forest species culture. Agro-Silvica Publishing House, Bucharest) (1967).

[4] MAPPM_RNP, Norme de timp si producție unificate pentru lucrări din silvicultură (Unified time and production standards for forestry work). (1997).

[5] Maruşca, T., Sistemul agrosilvopastoral durabil, în contextul încălzirii globale a climei.

Revista de Silvicultură și Cinegetică, Anul XVII, nr. 30, Editat de Societatea Progresul Silvic, Braşov. Sustainable agrosilvopartoral system in the context of the global climate change, Year XVII no. 30, Published by Progresul Silvic Society, Brasov) (2012)

[6] Maruşca, T., Contributions to the evaluation of pasture productivity using the floristic releve, Romanian Journal of Grassland and Forage Crops BDI Nr. 19, Cluj – Napoca, pp. 33- 47, (2019)

[7] Maruşca, T., Zevedei, M.P., Taulescu, E., Andreoiu, A.C., Studii privind sistemul agrosilvopastoral cu fagi din Carpații Orientali (Studies concerning the agrosilvopastoral system with beech from the Oriental Carpathians, Jurnalul de Montanologie, no. 12, pp.7-11 (2020).

[8] Maruşca, T., Taulescu, E., Memedemin, D., Preliminary study of agrosilvopastoral systems from Romania, Romanian Journal of Grassland and Forage Crops No.. 22, Iași, pp. 25-32, (2020).

[9] Maruşca, T., Taulescu, E., Zevedei, P. M., Andreoiu, A.C., Comșia, C. C., Study on the agroforestry system with oak trees (Quercus robur l.) in the context of changing climate, Annals of the Academy of Romanian Scientists Series Agriculture, Silviculture and Veterinary Medicine Sciences, Volume 9, Number 2/2020, pp. 44-54. (2020).

[10] Maruşca, T. Praticultură și pastoralism în cercetarea științifică, Editura Universității Transilvania din Brașov, 311 pagini (Praticulture and pastoralism in the scientific research. Transilvania Univresity Publishing House (2022).

[11] Marușca, T., Mihăilă, E., Taulescu, E., Zevedei, M. P., Tudora, A., Contributions to the economic evaluation of the productivity of agrosilvopastoral systems with wild pear (Pyrus pyraster) in Transylvania, Annals of the Academy of Romanian Scientists Series Agriculture, Silviculture and Veterinary Medicine Sciences, Volume 14 (1) (2025).

[12] Marușca, T., Evaluation based on floristic survey of milk production and live weight growth in cattle during the grazing season of meadowlands, Oferta cercetării științifice pentru transfer tehnologic în agricultură, industria alimentară și silvicultură, vol. XXVIII, ASAS București (sub tipar) (2025).

[13] Marușca T., Indici zoopastorali de evaluare şi conversie a producţiei vegetale în producţie animală la taurine în sezonul de păşunat, Academia Oamenilor de Știință din România Secția de Agricultură, Silvicultură și Medicină Veterinară, vol.15, nr. 1 (sub tipar) (Zoopastoral indices for evaluation and conversion of vegetal production into animal production in cattle during the grazing season, Annals of Academy of Romanian Scientists, Series Agriculture, Silviculture and Veterinary Medicine Vol.15, No.1- In Print (2026).

[14] Mihăilă, E., Costăchescu, C., Dănescu, F., Drăgoi, S., Sisteme agrosilvice, Editura Silvică, București. (Agroforestry systems. Silvica Publishing House, Bucharest) (2010).

[15] Nesterov, V., Negruțiu, A., Ionescu, O., Gărgărea, P., Adămoaia, I., Furaje și ogoare pentru vânat. Editura Orion. (Fodder and fields for hunting. Orion Publishing House) (2006).

[16] Olea, L., San Miguel-Ayanz, A., The Spanish dehesa. A traditional Mediterranean silvopastoral system linking production and natural conservation, 21st. General Meeting of EGF, pp. 3-13, Badajoz, Spain (2006).

[17] Sharrow, S.H., Flechter, R.A., Trees and Pastures: 40 years of agrosilvopastoral experience in Western Oregon, USA, Agroforesty Symposium, National Agroforesty Center (1994).