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Structure of Sequestered Carbon in the Biomass of Forest Stands in the Garden Art Park-Monument of National Significance "Feofania"

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Abstract. The state of forest ecosystems and processes of carbon sequestration have both global and local significance upon investigating the influence of natural and anthropogenic factors on biogeochemical cycles. The study of the consequences of their impact on forest stands is initiated by international and state environmental programs aimed at solving the problems of climate change. Sequestration of carbon in the biomass of forest stands depends on the productivity of stands, the formation of tree mortality and the conduct of economic activities. The purpose of the study was to establish the regularities of changes in the reservoir of sequestered carbon in the biomass components of the stands in the garden art park-monument "Feofania". The processes of transformation of forest ecosystems were investigated on permanent experimental plots of the "Feofania" Park territory using the methods of forest inventory. The observations results confirmed the general increase in the reservoir of sequestered carbon in the biomass of tree stands and the multi-vector dynamics of the sequestered carbon structure in the live biomassand mortmass of tree stands. Evidence of decrease in the carbon-sequestering potential of stands under intense mortality and lesser increase in the live biomass of stands was obtained. From an ecological standpoint, a positive trend towards an increase in the share of coarse woody debris (mortmass) in the biomass structure of permanent plots was established. The main carbon structure of biomass, according to the species composition, is represented by common oak, common hornbeam, and Norway maple. Nature protection decisions and measures implemented in the territories of the natural reserve fund should increase the intensity of carbon sequestration in biomass and the resistance of forest ecosystems to the influence of environmental factors. Given the priority of carbon sequestration in the biomass of tree stands as an ecological function, it is necessary to practice measures to promote current increment in carbon sequestered in the biomass and increase the resistance of trees to natural and anthropogenic disturbance

Keywords: live biomass, mortmass, woody debris, mortality, snagss, logs

Introduction

Over the past three decades, the world community has been actively looking for ways to reduce the risk of rapid climate change on the planet and is joining efforts to reduce anthropogenic impact on the environment. One of the main tasks for scientists and governments of all countries worldwide at the turn of the second and third millennia was to counteract the acceleration of climate warming. This initiative was clearly formulated within the framework of global events and conferences, starting with the United Nations Conference on Environment and Development in Rio de Janeiro and the adoption of the United Nations Framework Convention on Climate Change [1]. The adoption and ratification of the Kyoto Protocol [2] and the Paris Agreement [3] had a key role on the way to solving climate change problems, which declare the importance of preserving and strengthening absorbers and accumulators of greenhouse gases. In 2016, Ukraine signed and ratified Paris Agreement, which recommends actions to support strategic approaches and positive incentives to reduce emissions from deforestation and forest degradation, develop sustainable forest management and increase carbon sequestration in forests [4]. United nations framework convention on climate change United nations framework convention on climate change.

The purpose of this study is to figure out the specific features of the dynamics and structure of the sequestered carbon in the components of the biomass of the tree stands in "Feofania", a garden art park-monument of national

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significance. The originality of this study lies in the comprehensive investigation of the formation of the reservoir of sequestered carbon in forests with conservation status within urban ecosystems, as opposed to the investigation of this issue in stands of other forest categories, namely commercial ones.

Forest ecosystems are one of the key absorbers of carbon dioxide and carbon accumulators. Therewith, studies [5] on the impact of disturbances on the carbon cycle in the forest ecosystems of Ukrainian Polissia indicate a volatile balance of carbon absorption and emission, which substantially depends on the heterotrophic respiration of soils and the loss of biomass of stands as a result of biotic, abiotic, and anthropogenic disturbances. The occurrence of disturbances in forest ecosystems has substantially increased over the past decades, and the adverse impact of large-scale disturbances is becoming increasingly significant for the achievement of forestry goals. Thus, to fulfil the role of a carbon accumulator, forest ecosystems need sustainable management, which over time will make it impossible to exceed the emission of carbon compared to its sequestration.

If it is practically impossible to influence the heterotrophic respiration of forest soils (except for some solutions, such as minimising erosion and soil damage caused by economic activities), then increasing biomass growth and the resistance of stands to agents of large-scale disturbances are the main tasks of conventional forestry.

Compared to commercial forests, conservation stands in Ukraine are minimally affected by economic activities, namely felling, formation, and sanitation. That is why the investigation of the growth and development of stands and the formation of mortality, specifically in urban forests [6], allows estimating the role of stands as carbon reservoirs [7; 8].

The conclusion and ratification of Kyoto Protocol [2] and Paris Agreement [3] led to the rapid development of research on forests as the main absorbers of carbon dioxide, capable of naturally reducing its concentration in the atmosphere [9-11]. Studies of organic carbon stocks in forest live biomass are characterised by a variety of methodological approaches and experimental plots [12-14].

Studies of the regularities of the carbon cycle of forest ecosystems [15; 16] are currently becoming even more relevant to achieve the goals of low-carbon development [17]. The study of patterns of carbon sequestration in the components of forest ecosystems reflects the accumulative potential of forest biomass [18-20] in conditions of anthropogenic transformation of the environment [21]. Based on the scale of production and, especially, the duration of carbon sequestration in woody plants, forests are recognised as a relatively stable system for preventing the greenhouse effect [22-24].

At the same time, according to the "Global assessment of forest resources 2020" report, global processes related to the condition of forest ecosystems indicate a decrease in forest cover globally [25]. The rate of forest mortality has slowed over the past two decades, with the rate of net forest mortality dropping from 7.8 million ha per year in 1990-2000 to 5.2 million ha in 2000-2010 and 4.7 million ha per year in 2010-2020 [4]. The greatest rates of decline in net mortality of forest stands were observed during the last decade. The total stock of wood in the world decreased slightly from 560 billion m^3 in 1990 to 557 billion m^3 in 2020, while carbon stocks in forests decreased from 668 Pg in 1990 to 662 Pg in 2020 [4].

Forest ecosystems in conditions of anthropogenic impact, performing conservation functions and improving the quality of the natural environment, are affected by external and internal factors, because of which they may partially or completely lose their useful properties [26]. One of the important ecological functions of forest stands is carbon sequestration. The dynamics of tree stock is closely related to changes in carbon sequestration and the production of other ecosystem services. Forest stands affected by anthropogenic factors may lose these basic functions.

The main share of absorbed carbon accumulates in the live biomass components of forest stands. However, the accumulation of mortmass of forests also plays a significant role in long-term carbon sequestration. Earlier analytical studies [27] proved that the carbon reservoir of the forest biomass of the garden art park-monument "Feofania" can comprise 92-93% of the live biomass carbon and 7-8% of the mortmass carbon. The total amount of sequestered carbon in the biomass of the forest ecosystems of the "Feofania" park as of 2013 was about 11 GgS, and the carbon density decreased from 15.1 $kgS{\cdot}m^{-2}$ in 1979 to 10.7 $kgS{\cdot}m^{-2}$ in 2013. It is the decrease in the density of accumulated carbon in the biomass of the stands in the "Feofania" park that raises an important question about the productivity of carbon sequestration by urban forest stands under conditions of minimal economic intervention.

Materials and Methods

The study was performed on four permanent experimental plots (EP), which in 2016-2017 were laid out on the territory of the garden art park-monument of national significance "Feofania" (the "Feofania" Park) and considered in the international database data of the Forest Observation System (FOS). The total area of the object under study is 107 hectares, which is in the southern part of Kyiv [28].

During the field work, four permanent experimental plots (EP No. 1-4) were set up considering the age-class composition of forest stands. EP No. 1 and 4 are ~80 years old, while EP No. 2 and 3 are 180 years old (Table 1). According to the general geomorphological and bioclimatic characteristics, the park belongs to the Forest-Steppe zone of Ukraine. The territory of the "Feofania" Park is located at an altitude of 75-189 m above sea level. The landform is represented by a valley-ravine relief with steep slopes. The climate of the area under study is humid continental, the average monthly temperature ranges from -5.6°C (January) to 19.3°C (July), the average annual temperature is 7.7°C. Average monthly precipitation ranges from 35 mm (October) to 88 mm (July), while the average total annual precipitation is 650 mm [29].

The species composition of the object under study is represented by common hornbeam (*Carpinus betulus* L.), Norway maple (*Acer platanoides* L.), common oak (*Quercus robur* L.), small-leaved linden (*Tilia cordata* Mill.), European white elm (*Ulmus laevis* Pall.), black locust (*Robinia pseudoacacia* L.), common ash (*Fraxinus excelsior* L.).

As a result, it was found that in terms of species composition (by the number of trees) in the research stands of the "Feofania" Park on permanent trial plots, common hornbeam (EP No. 2 and 3) and Norway maple (EP No. 1 and 4) prevail. The number of trees of common oak, small-leaved linden, European white elm, black locust, and common ash in the experimental plots is lesser. According to the dynamics of the formation of snagss during 2016-2021, the predominant amount falls on dead common oak and common hornbeam trees, and according to permanent trial areas it was: EP No. 1 – 40, EP No. 2 – 20, EP No. 3 – 22, EP No. 4 – 19 units (Table 1-2).

Table 1. Characteristics of the investigated EP No. 1-4 by species composition and dynamics of formation of snagss (pcs.), 2016 (2017)

Type	EP No.							
	1 (2016)		2 (2016)		3 (2017)		4 (2017)	
	0*	1	0	1	0	1	0	1
Common oak	98	6	33	5	7	–	63	8
Common hornbeam	–	–	215	2	181	1	57	8
Common ash	–	–	–	–	–	–	1	–
Norway maple	142	6	36	–	8	–	73	2
Black locust	5	–	–	–	1	–	–	–
Small-leaved linden	1	–	23	–	6	–	9	4
European white elm	2	–	–	–	10	–	1	–
Total	**260**		**314**		**214**		**226**	

Note: 0 – living tree; 1 – snagss

Table 2. Characteristics of the investigated EP No 1-4 by species composition and dynamics of formation of snagss (pcs.), 2021

Type	EP No.							
	1		2		3		4	
	0*	1	0	1	0	1	0	1
Common oak	73	31	31	7	7	–	57	14
Common hornbeam	–	–	204	13	162	20	50	15
Common ash	–	–	–	–	–	–	1	–
Norway maple	138	10	35	1	7	1	68	7
Black locust	5	–	–	–	1	–	–	–
Small-leaved linden	1	–	23	–	5	1	5	8
European white elm	2	–	–	–	10	–	1	–
Total	**260**		**314**		**214**		**226**	

Note: 0 – living tree; 1 – snagss

On experimental plots such tasks as geodetic survey, determination the GPS coordinates of each tree using Garmim Dakota10, measuring the diameter at breast height (1.3 m) using a Codimex caliper with an accuracy of 0.1 m and tree height using Halgöf EC-II-D electronic clinometer were performed. The list of trees by species composition and assessment of their life status was composed according to the method of taxation. The sequestered carbon stock of live biomass components was estimated using classical formulas for calculating the volume of growing tree trunks and the use of forest inventory reference books and standards [30; 31] for estimating the above-ground live biomass components of trees of the main forest-forming species of Ukraine.

Results and Discussion

The results of the study showed that the live biomass of common oak trees accounted for the largest share in the live biomass structure of the stands under study (Figs. 1-4). In EP No. 1 (Fig. 1), the stock of sequestered carbon in 2016 was 88.5 Mg C·ha^{-1}. 72.6% accounted for common oak, 20.8% – Norway maple, 6.3% – black locust, and a small share accounted for European white elm (0.2%) and small-leaved linden (0.1%). As of 2021, the stock of carbon sequestered by the live biomass of the forest stand was partially transformed into the mortmass carbon and decreased to 81.9 Mg C·ha^{-1}, including 68.4% of the carbon sequestered by the live biomass of common oak, 24.1% – by Norway maple, 7.1% – by black locust, 0.3% – by European white elm, and 0.1% – by small-leaved linden (Fig. 1). Thus, the share of common oak live biomass carbon decreased, and the share of Norway maple and black locust increased in 2021, compared to the 2016 data. This is explained by the natural mortality of mature common oak trees and more intensive growth of younger Norway maple and black locust trees.

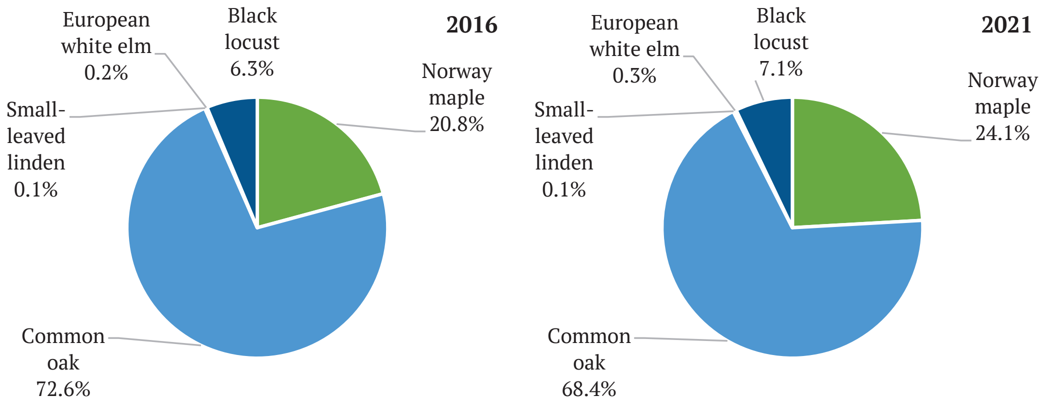

Figure 1. Structure of carbon stock sequestered by living trees, depending on the species composition of the stand on EP No. 1, 2016-2021

The largest stock of carbon sequestered by the live biomass among all permanent plots was on EP No. 2, which in 2016 amounted to 190.3 Mg C·ha^{-1}, of which 58.3% of carbon was sequestered by the live biomass of common oak, 22.0% – by common hornbeam live biomass, 14.2% – by Norway maple live biomass, 5.5% – by small-leaved linden live biomass. As of 2021, the stock of carbon sequestered by the live biomass increased to 194.1 Mg C·ha^{-1} and a slight redistribution in the carbon structure took place: 58.0% of carbon was sequestered by common oak, 22.5% – by common hornbeam, 13.7% – by Norway maple, and 5.8% – by small-leaved linden (Fig. 2).

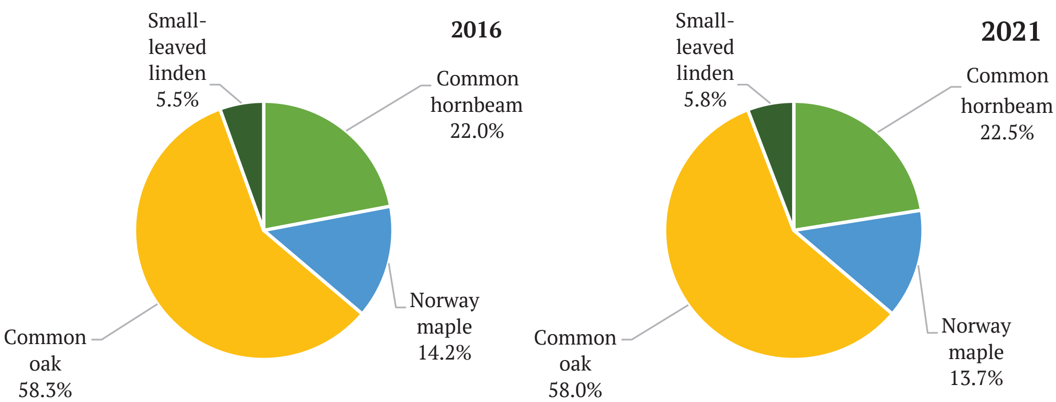

Figure 2. Structure of carbon stock sequestered by living trees, depending on the species composition of the stand on EP No. 2, 2016-2021

74.0 Mg C·ha^{-1} was estimated on EP No. 3, of which 49.0% fell upon common hornbeam, 45.4% – on common oak, 2.5% – on European white elm, 1.7% – on small-leaved linden, as well as an insignificant share characterised by black locust (0.8%) and Norway maple (0.6%). Already in 2021, the carbon sequestered by the live biomass of the permanent plot amounted to 79.4 Mg C·ha^{-1}, the main shares of the carbon stock belonged to common hornbeam (47.8%) and common oak (45.8%), the share of European white elm increased to 3.3%, and the shares of small-leaved linden, black locust, and Norway maple stayed unchanged compared to 2017 (Fig. 3).

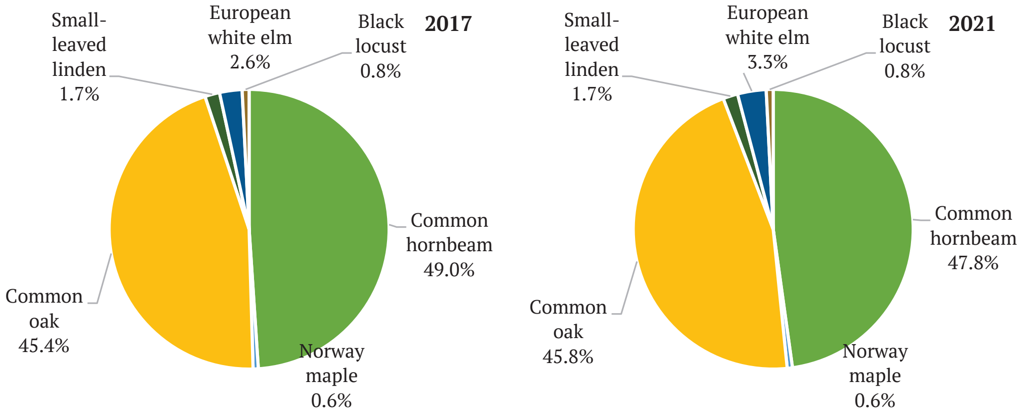

Figure 3. Structure of carbon stock sequestered by living trees, depending on the species composition of the stand on EP No. 3, 2017-2021

Among the permanent plots, the lowest carbon stock (44.6 Mg C·ha^{-1}) in 2017 was found on EP No. 4, where the main share fell upon common oak (80.3%), Norway maple accounted for 11.8%, common hornbeam – 3.7%, common ash – 3.3%, small-leaved linden – 0.8%, and European white elm – 0.1% (Fig. 4).

Over four years, the carbon stock increased only by 0.2 Mg C·ha^{-1} and in 2021 amounted to 44.8 Mg C·ha^{-1}. In the structure of sequestered carbon, compared to 2017, the share of common oak decreased slightly and amounted to 77.7%. The share of Norway maple increased to 14.2%. The share of common hornbeam (3.7%) and European white elm (0.1%) stayed unchanged, the share of common ash slightly increased (3.7%), and small-leaved linden decreased to 0.6%.

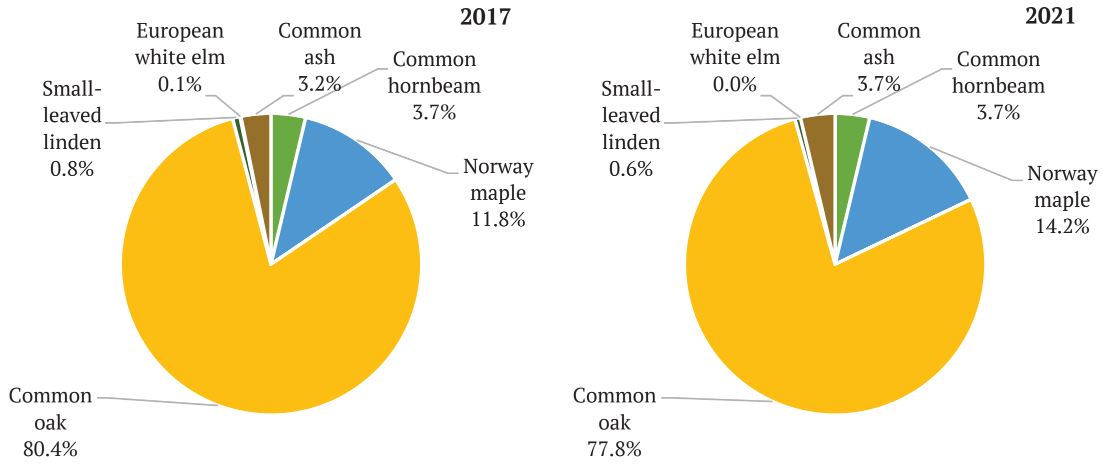

Figure 4. Structure of carbon stock sequestered by living trees, depending on the species composition of the stand on EP No. 4, 2017-2021

Much smaller in volume, but no less valuable carbon reservoir of forests is woody debris or mortmass of forest ecosystems (Figs. 5-8). The results of inventory of carbon sequestered by mortmass components of snagss and logs on EP No. 1 established the amount of 1.92 Mg C·ha^{-1}, which is mainly represented by carbon of the debris from common oak (86.5%) and Norway maple (13.5%).

During 2016-2021, a relatively intensive mortality took place on EP No. 1, which led to an increase in the stock of carbon sequestered by snagss and logs in 2021 to 13.43 Mg C·ha^{-1}. Specifically, 12.6 Mg C·ha^{-1} of common oak (93.9%) and 0.83 Mg C·ha^{-1} of Norway maple (6.1%). The share of carbon from the mortmass of snagss and logs in the structure of the total biomass in EP No. 1 increased from 2.2% to 16.4%. Notably, during the experimental 5-year period, the sequestered biomass carbon increased by 5.4% compared to 2016.

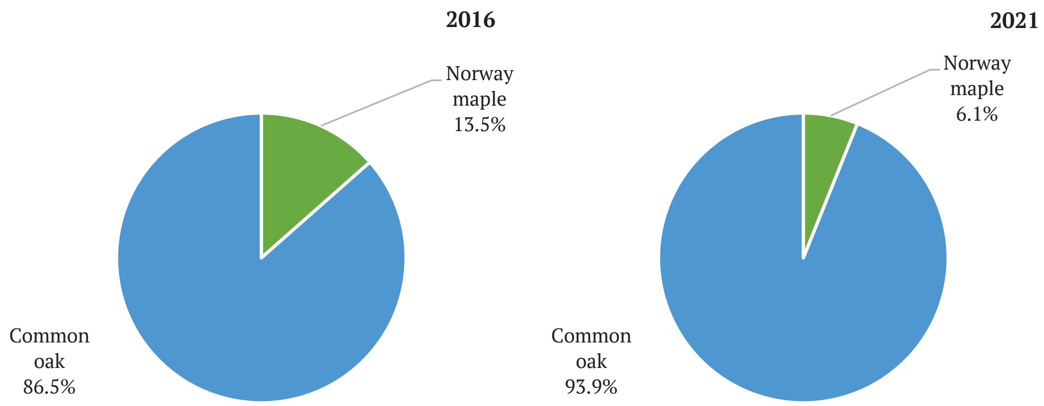

Figure 5. Structure of carbon stock sequestered by mortmass of snagss and logs by the species composition of the stand on EP No. 1, 2016-2021

As of 2016, estimation of carbon sequestered by the mortmass of snagss and logs on EP No. 2 showed a reserve of 7.00 Mg C·ha^{-1}. The carbon sequestered by common oak was 6.89 Mg C·ha^{-1} (98.4%) and common hornbeam – 0.11 Mg C·ha^{-1} (1.6%). In 2021, the stock of carbon sequestered by snagss and logs increased to 15.54 Mg C·ha^{-1}.12.63 Mg C·ha^{-1} accounted for the carbon from coarse woody debris of common oak (81.3%), 1.63 Mg C·ha^{-1} – Norway maple (10.5%) and 1.28 Mg C·ha^{-1} – common hornbeam (8.2%). Thus, the share of carbon sequestered by mortmass of snagss and logs in the total carbon of biomass increased to 8% in 2021, compared to 3.7% in 2016.

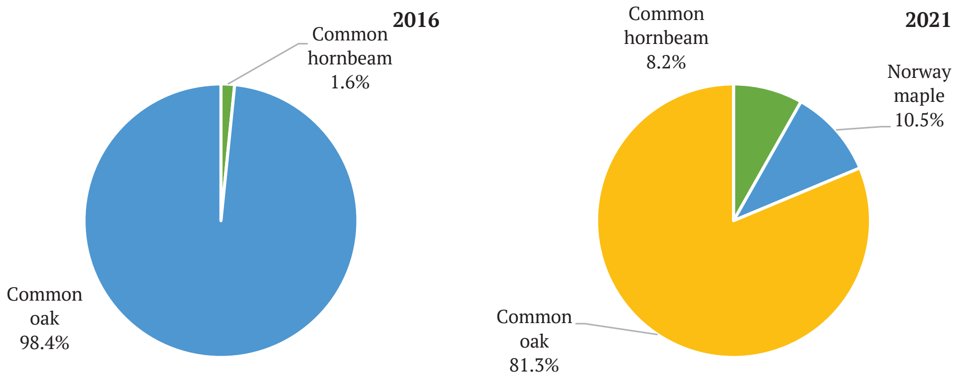

Figure 6. Structure of carbon stock sequestered by the mortmass of snagss and logs by the species composition of the stand on EP No. 2, 2016-2021

In terms of species composition, common hornbeam and Norway maple prevailed on EP No. 3, and the mortality on this plot was less intense. At the beginning of the study in 2017, the stock of carbon sequestered by the mortmass was 0.04 MgS·ha^{-1}, which was completely represented by the woody debris of common hornbeam (100%). In 2021, 1.42 Mg C·ha^{-1} was sequestered by the mortmass of common hornbeam (98.8%) and 0.02 Mg C·ha^{-1} of Norway maple (1.2%). Consequently, the share of carbon sequestered by the mortmass from snagss and logs in the total carbon of biomass increased to 1.8% in 2021, compared to 0% in 2017.

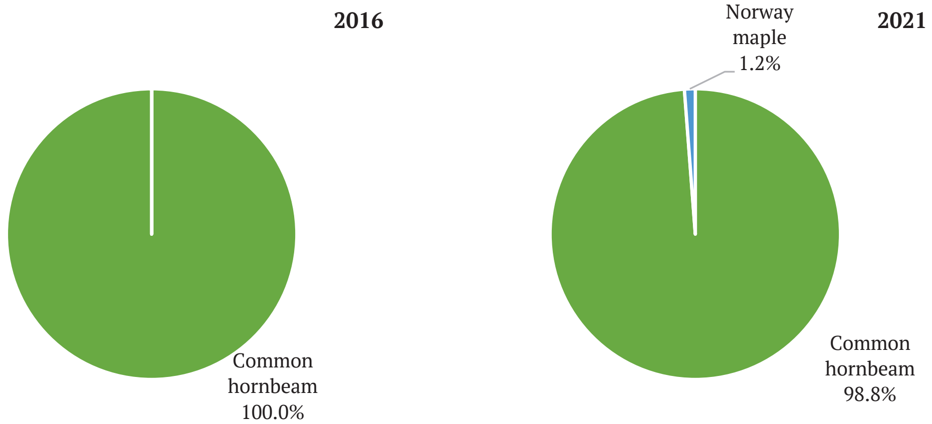

Figure 7. Structure of carbon stock sequestered by mortmass from snagss and logs by the species composition of the stand on EP No. 3, 2017-2021

In 2017, in the permanent plot on EP No. 4, 2.91 Mg C·ha^{-1} was sequestered by mortmass of snagss and logs of four tree species: 2.52 Mg C·ha^{-1} was sequestered by mortmass of common oak (86.7%), 0.27 Mg C·ha^{-1} – common hornbeam (9.2%), 0.09 Mg C·ha^{-1} – small-leaved linden (3.0%), 0.03 Mg C·ha^{-1} – Norway maple (1.1%). In 2021, on the same EP No. 4, 5.43 Mg C·ha^{-1} was sequestered, of which 4.79 Mg C·ha^{-1} – by common oak (84.0%), 0.18 Mg C·ha^{-1} – by common hornbeam (8.1%), 0.28 Mg C·ha^{-1} – by small-leaved linden (4.8%) and 0.18 Mg C·ha^{-1} – by Norway maple (3.1%). Overall, from 2017 to 2021, the stock of carbon sequestered by the mortmass of snagss and logs increased by 86.6%, which led to an increase in the share of carbon sequestered by mortmass from 6.1% in 2017 to 10.8% in 2021 in the total carbon structure of aboveground biomass.

Admittedly, the difference in the structural dynamics of carbon sequestered in different experimental plots is explained by the specific features of productivity, species and age-class composition of trees in forest stands. Tellingly, during the period under study, the proportion of carbon sequestered by mortmass of Norway maple increased on EP No. 2-4.

The estimation data of the dynamics of the sequestered biomass carbon indicate a natural tendency to increase the carbon reservoir over the years in each of the permanent plots. On EP No. 1, 2, 4, the main share of sequestered carbon falls upon common oak trees and, respectively, amounts to 12.6, 12.6, and 4.8 Mg C·ha^{-1} in 2021. At the same time, on EP No. 3, the amount of carbon was 1.4 Mg C·ha^{-1}, sequestered by common hornbeam trees.

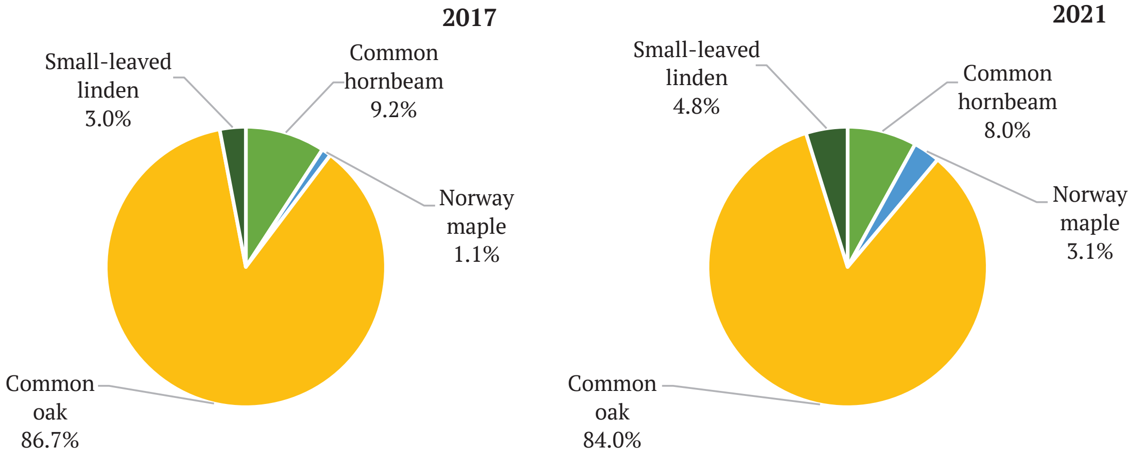

Figure 8. Structure of carbon stock sequestered by mortmass from snagss and logs by the species composition of the stand on EP No. 4, 2017-2021

The total volume of the biomass carbon reservoir of permanent plots forms the total volume of carbon sequestered by live biomass and mortmass in the respective years (Table 3, 4) as follows: on EP No. 1 in 2016, it was estimated at 90.4 Mg C·ha^{-1} and in 2021 – 95.3 Mg C·ha^{-1}; on EP No. 2 in 2016 – 197.3 Mg C·ha^{-1} and in 2021 – 209.6 Mg C·ha^{-1}; on EP No. 3 in 2017 – 74.1 Mg C·ha^{-1} and in 2021 – 80.9 Mg C·ha^{-1}; on EP No. 4 in 2017 – 47.5 Mg C·ha^{-1} and in 2021 – 50.5 Mg C·ha^{-1}.

Table 3. Carbon sequestered by permanent plots in the "Feofania" Park, 2016-2021

EP No.	2016 (2017)		2021		2016 (2017)	2021
	Live biomass carbon, Mg C·ha^{-1}	Mortmass carbon, Mg C·ha^{-1}	Live biomass carbon, Mg C·ha^{-1}	Mortmass carbon, Mg C·ha^{-1}	Biomass carbon, Mg C·ha^{-1}	Biomass carbon, Mg C·ha^{-1}
1	88.5	1.9	81.9	13.4	90.4	95.3
2	190.3	7.0	194.1	15.5	197.3	209.6
3	74.0	0.0	79.4	1.4	74.1	80.9
4	44.6	2.9	44.8	5.7	47.5	50.5

Table 4. Dynamics of the carbon structure sequestered by aboveground biomass components of permanent plots, %

EP No.	2016 (2017)		2021		Change in share of mortmass carbon
	Share of live biomass carbon	Share of mortmass carbon	Share of live biomass carbon	Share of mortmass carbon	
1	97.9	2.1	85.9	14.1	+12.0
2	96.5	3.5	92.6	7.4	+3.9
3	100	0	98.2	1.8	+1.8
4	93.8	6.2	88.7	11.3	+5.1

Therewith, the largest share of biomass carbon in the experimental plots fell upon: on EP No. 1 in 2016 – common oak (73.0%), Norway maple (20.8%) and in 2021 – common oak (68.4%), Norway maple (24.1%); on EP No. 2 in 2016 – common oak (58.3%), common hornbeam (22.0%) and in 2021 – common oak (58.0%), common hornbeam (22.5%); on EP No. 3 in 2017 – common hornbeam (47.7%), common oak (45.9%) and in 2021 – common hornbeam (47.8%), common oak (45.8%); in EP No. 4 in 2017 – common oak (80.3%), Norway maple (11.8%) and in 2021 – common oak (77.7%) and Norway maple (14.2%). For all surveyed experimental plots, the main share of biomass carbon, by species composition, is sequestered by common oak, common hornbeam, and Norway maple.

Accumulation of sequestered carbon in biomass components is noted according to cumulative changes in life status and inventory parameters of trees in all experimental plots. First of all, this is due to more intensive carbon sequestration by younger trees, even in stands where the storey of old common oaks has reached natural maturity, as well as carbon sequestration by mortmass, which is conditioned upon mortality and the formation of snagss and logs. Naturally, mortality and its intensity depend not only on the age and productivity of trees, but also on natural and anthropogenic disturbances affecting the biogeochemical cycle in forest ecosystems.

Comparing the obtained data with the results of earlier studies [32], it is worth noting that carbon sequestration largely depends on formation and accumulation of snagss and logs. Therewith, the different-aged and mixed composition of the permanent plots, which contain old and young trees, ensures an increase in live biomass and positive dynamics of sequestered carbon.

In all four permanent experimental plots in the forest stands of the "Feofania" Park, during the period under study, an increase in the reservoir of sequestered carbon in the biomass of the stands was found. Therewith, a decrease in the carbon sequestered by live biomass on EP No. 1 and a slight increase in live biomass carbon by 0.2 Mg C·ha^{-1} on EP No. 4 were found, which indicates a decrease in the carbon-sequestering potential of stands under more intense mortality and lesser current increment of live biomass of tree stands.

Estimation of ecosystem services and functions of forest stands should include the analysis not only of the regularity of live biomass growth, but also the specific features of the formation of mortality and the destruction of mortmass of stands of the main forest-forming species of Ukraine. This will open opportunities for a more comprehensive understanding of carbon cycle patterns and will serve as the basis for international reporting on forest resources and the implementation of effective forest surveying measures for forest management in the context of fulfilling the tasks and provisions of Paris Agreement.

Conclusions

In the territories of the Nature Reserve Fund of Ukraine, an essential indicator of the effectiveness of forest management lies in carbon sequestration processes, which determine the productivity of stands and the formation of net primary products and affect the mortality under small and large-scale disturbances of natural and anthropogenic origin.

Observations on permanent test areas within the "Feofania" Park indicate the transformed state of forest ecosystems under anthropogenic activity and natural processes, which determine the multi-vector redistribution of carbon stock in the biomass components of forest stands.

Given the prioritisation of carbon sequestration in the biomass of stands as an ecological function, it is necessary to practice measures to raise the current increment of sequestered carbon in the biomass and increase the resistance of trees to natural and anthropogenic disturbances.

Considering the nature conservation status and the formidable ecological importance of the garden art park-monument "Feofania", it is worth noting a positive trend towards an increase in the share of coarse woody debris (mortmass) in the biomass structure of permanent plots.

Promoting the formation of mixed and different-age stands ensures a more sustainable sequestration of carbon by the biomass of stands and reduces the risks of a negative balance of the carbon cycle in forest ecosystems. Further long-term observation of carbon dynamics on permanent experimental plots allows substantiating the impact of climate changes and anthropogenic factors on the development of forest stands and their carbon-sequestering function.

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Структура депонованого вуглецю в біомасі лісових деревостанів парку-пам'ятки садово-паркового мистецтва загальнодержавного значення «Феофанія»

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Анотація. Стан лісових екосистем, процеси накопичення вуглецю мають як глобальне, так і локальне значення при вивченні впливу природних і антропогенних факторів на біогеохімічні цикли. Вивчення наслідків їхнього впливу на лісові насадження ініційовано міжнародними і державними екологічними програмами, спрямованими на вирішення проблем змін клімату. Депонування вуглецю у біомасі лісових насаджень залежить від продуктивності деревостанів, формування відпаду дерев та проведення господарських заходів. Метою досліджень було встановлення закономірностей зміни резервуару депонованого вуглецю в компонентах біомаси деревостанів парку-пам'ятки садово-паркового мистецтва загальнодержавного значення «Феофанія». Процеси трансформації лісових екосистем досліджено на постійних пробних площах території парку-пам'ятки «Феофанія» за допомогою методів таксації дерев, що ростуть. Результатами спостережень підтверджено загальне збільшення резервуару депонованого вуглецю в біомасі деревостанів і різновекторну динаміку структури депонованого вуглецю у фітомасі та мортмасі деревостанів. Отримано свідчення про зменшення вуглецедепонуючого потенціалу насаджень за умов інтенсивнішого відпаду і меншого поточного приросту фітомаси деревостанів. Встановлено позитивну, з екологічної точки зору, тенденцію до збільшення частки грубого деревного детриту (мортмаси) у структурі біомаси дослідних насаджень. Основну структуру вуглецю біомаси, за видовим складом порід, представлено дубом, грабом і кленом. Природоохоронні рішення і заходи, впроваджені на територіях природо-заповідного фонду мають підвищувати інтенсивність депонування вуглецю в біомасі та стійкість лісових екосистем до впливу чинників довкілля. За умови пріоритетності депонування вуглецю в біомаси деревостанів, як екологічної функції, необхідно практикувати заходи для збільшення поточного приросту депонованого вуглецю в біомасі та підвищення стійкості дерев до природних та антропогенних порушень

Ключові слова: фітомаса, мортмаса, деревний детрит, відпад дерев, сухостій, деревна ламань