Received: 20.10.2025; Revised: 16.01.2026; Accepted: 26.02.2026; Published: 31.03.2026

UKRAINIAN JOURNAL OF FOREST AND WOOD SCIENCE

Journal homepage: https://forestscience.com.ua/en
Ukrainian Journal of Forest and Wood Science, 17(1)

UDC 581.9
DOI: 10.31548/forest/1.2026.08

ISSN 2664-4452
e-ISSN 2664-4460

Rare plant species of the natural forest stands in the Feofania tract and their phytocoenotic association (Kyiv, Ukraine)

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Abstract. Clarifying the current state of distribution of plant species included in the Red Data Book of Ukraine, in particular in the territory of the Feofania tract, is becoming especially relevant, since they are sensitive markers of the level of anthropogenic impact and changes occurring in ecosystems. The aim of the study was to identify new habitats of rare plant species in natural forest stands of the Feofania tract (Kyiv, Ukraine) and to clarify their phytocenotic localisation. Monitoring and geobotanical studies were conducted within the tract during the growing seasons of 2009-2012 and 2021-2024. The structure and condition of the forest stands were also assessed as part of the study. A decline in mature *Quercus robur* and *Carpinus betulus*

Suggested Citation:

Kozyr, M., Tertyshnyi, A., & Vasylyshyn, R. (2026). Rare plant species of the natural forest stands in the Feofania tract and their phytocoenotic association (Kyiv, Ukraine). *Ukrainian Journal of Forest and Wood Science*, 17(1), 8-23. doi: 10.31548/forest/1.2026.08.

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trees was observed, reflecting ongoing ecological changes within the forest ecosystem. As a result, new localities of *Lilium martagon*, *Neottia nidus-avis* were established, and *Epipactis helleborine* was also found for the first time. It is mentioned that *Cephalanthera longifolia*, found on the territory of the Feofania tract in the 80s of the 20th century, apparently disappeared from the studied area. It has been noted that anthropogenic impact on the location of rare species is increasing. This is confirmed by the penetration of invasive species, in particular Impatiens parviflora, into the phytocoenoses where they occur. Here in the first decade of the 21st century such species from the Red Data Book of Ukraine as *Allium ursinum*, *Crocus heuffelianus*, *Erythronium dens-canis*, *Galanthus plicatus*, G. nivalis, Gymnospermium odessanum were successfully introduced. Phytocoenoses with the participation of Neottia nidus-avis were detected in the territory of the second compartment (the 6th subcompartment) of the Feofania Monument Park with a stock of wood of the first and second tiers of about 380 m^3/ha and the third compartment (the 6th subcompartment) with a stock of wood of two tiers of about 330 m^3/ha. Regionally rare species Convallaria majalis and Corydalis cava also occur on the territory of the tract. The information obtained will be useful for biomonitoring, distribution and dynamics of these species and phytocoenoses in which they occur

Keywords: rare species; *Epipactis helleborine*; *Lilium martagon*; *Neottia nidus-avis*; protection; anthropogenic impact

Introduction

Parks, squares, gardens and other objects of the green zone play an important role in megalopolises and cities being their integral component. Artificial green spaces, natural forests, floodplain and dry meadows, swamps and other plant complexes not only surround cities, but also are the part of their urban landscapes. They directly influence on the microclimate, purify the air from dust and gases and saturate it with oxygen, delay winds and precipitation, reduce surface runoff, prevent excessive evaporation of moisture and formation of dust storms. In addition, they are of strategic importance, as they are stocks of wood, medicinal, edible and fodder plants, as well as a natural obstacle for enemies. For city dwellers, the green zone is a place of rest and interaction with nature in order to learn about it and obtain aesthetic and intellectual satisfaction. However, large cities are characterised by a high level of anthropogenic load on the flora, which negatively affects the floristic diversity of woodlands, parks and other green areas. In such conditions rare species are sensitive indicators of the state of the environment, including the natural forest stands in which they occur. Therefore, detecting their presence or disappearance is extremely relevant for understanding the state of forest ecosystems.

The study by S. Koniakin & L. Gubar (2022) focused on the spontaneous flora of the Feofania tract (Kyiv, Ukraine). The authors carried out an inventory of vascular plants, determined the floral structure by life forms and ecological groups, and assessed the degree of anthropogenic transformation of the vegetation cover. The paper identified species listed in the Red Data Book of Ukraine and outlined changes in the flora under urbanisation pressure. The results provide a basis for further

monitoring of rare species and assessment of the ecological condition of Feofania habitats. P. Marinov & M. Mihailova (2024) drew attention to the importance of preserving and creating forest areas in modern cities, as they are an important and effective tool for solving problems related to urbanisation and climate change. J.P. Schmit *et al*. (2025) investigated the impact of urban development and human economic activity on forest tree composition, diversity, and structure and pointed to the impoverishment of the age structure and species diversity of forest ecosystems surrounded by urbanised and agricultural areas. In their research M. Baker *et al*. (2025) noted that Urban woodlands require rapid, iterative assessment of their composition, structure, and condition at the local government level.

In their study, N.F. Sonti *et al*. (2024) pointed out the importance of continuous monitoring and protection of forest natural areas given their unique contribution to ecosystem services and taking into account the increasing anthropogenic impact and climate change. O.I. Shynder *et al*. (2024) did floristic research in the territory of Kyiv City and its environs (in the adjacent territories of Kyiv Region). The authors found five new taxa for the flora of Ukraine. Among all discovered taxa there were rare aboriginal and expansive alien. The results confirm the high level of the richness of the studied flora and its rapidly changing character. N.A. Pashkevych (2020) studied the biotopes of the Feofania Gardens. The author pointed out the main aspects of recreational impact on the natural vegetation of Feofania. The impact was regular and unlimited. The study gave an example of the interpretation of park and semi-natural forest vegetation due to the habitat concept.

However, these studies did not mention rare species and their confinement to a specific biotope. Thus, previous studies did not allow to establish the phytocenotic confinement of natural rare plant species, their belonging to a specific habitat, as well as to use these materials for further monitoring. Thus, the purpose of the study was to supplement existing biodiversity databases, which allows to clarify the current state and development trends of forest ecosystems in Feofania Park, and to promote effective biomonitoring of rare species and their habitats in the future.

Materials and Methods

Geobotanical studies of the vegetation cover of the Feofania tract (Kyiv, Ukraine) were conducted using the floristic classification approach of J. Braun-Blanquet in combination with general floristic surveys (Fig. 1). Field investigations were carried out during the vegetation periods from late April to August in two stages: 2009-2012 and 2021-2024. During the first stage, more than 120 geobotanical relevés were made, while additional 84 – during the second one. Alongside the geobotanical surveys, regular monitoring of previously documented habitats of rare plant species was undertaken, and systematic field inspections were conducted to identify additional localities. Data were collected on species composition, the vertical structure of forest stands, and the distribution of rare plant species within different forest communities. During the second study period, repeated surveys of forest stands were performed to document changes in species composition and stand structure under conditions of increasing anthropogenic pressure, climatic variability, the spread of tree diseases and pests, and the decline of old-growth trees. Particular attention was paid to the phytocoenotic affiliation of rare species, allowing their occurrence to be assessed within the context of forest community structure.

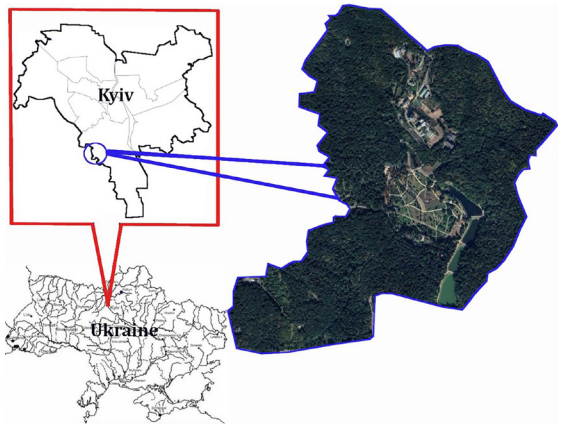

Figure 1. Location of the Feofania tract
Source: developed by the authors with using Google Earth Pro and GNU Gimp 2.10.18

The research was conducted in compliance with ethical standards (Convention on Biological Diversity, 1992). Latin names of species followed the nomenclature of S. Mosyakin & M. Fedoronchuk (1999). The names of syntaxa followed the nomenclature of D. Dubyna *et al.* (2019). Photographs of rare species included in national red lists (Red Data Book of Ukraine, 2009; Order of the Ministry..., 2021), together with their geographic coordinates, were uploaded to the iNaturalist platform (Kozyr, 2024). This allowed the integration of new records into species-specific databases and the supplementation of existing data on distribution and abundance, which may be used in further monitoring and analyses of distribution patterns. In addition, the uploaded georeferenced photographs enabled verification of taxonomic identification. Links to species records on the iNaturalist (n.d.) platform are provided in the text as of early 2025. Devices equipped with integrated GPS modules were used for coordinate recording. Positioning accuracy, according to navigation software (Android Speedometer, GPS Test), ranged from 1 to 7 m. Coordinates were recorded in decimal degrees. At locations where rare species occurred, test plots measuring 25 × 25 m were established to clarify the phytocoenotic affiliation of these sites.

Results and Discussion

The Feofania tract is one of the well-preserved unique objects of the green zone of the Holosiiv district in Kyiv. In the past the tract was the only large forest massif along with Lysa Gora and Holosiivsky forest (Goncharenko *et al.*, 2013). Its area is 150 hectares, of which about 130 hectares are natural massifs mainly formed by oak-hornbeam-maple, oak-hornbeam, hornbeam and other phytocoenoses of forest vegetation, which occur less often than the previous ones. Because of the active urban development of the metropolis, the number of visitors has increased significantly (in general, recreational load has been increasing every year since the 1980s (Goncharenko *et al.*, 2013). Various impacts on vegetation and animal life have accordingly increased. Because of construction close to the park, trampling, walking of domestic animals, laying of paths and roads, and natural changes in phytocoenoses, alien species displace gradually natural ones. Rare species of

plants suffer the most from this, since the localities of their population in the studied territory are already insignificant. Therefore, the updating of information on rare species of flora will make it possible to provide measures for the protection and monitoring of the population of rare species and the phytocoenosis in which they grow and, thus, to preserve the floristic and phytocoenotic wealth of the tract.

According to a study by Yu. Kleopov (1990), herbaceous plants are an important component of forests. Some of these plants are indicators of forest vegetation conditions (Pogrebnyak, 1955). Rare and endangered herbal species of such phytocoenoses, particularly of the Feofania tract, are sensitive indicators of the ecological balance of forest ecosystems. The disappearance of their localities indicates risks and disturbances that can lead to irreversible changes in the biodiversity of the forest ecosystem and, as a result, the impoverishment of its gene pool.

During studies of the Feofania tract, new habitats of natural species included in the Red Data Book of Ukraine were found: *Lilium martagon*, *Neottia nidus-avis*, *Epipactis helleborine* (this species was found for the first time in the park and had not been mentioned here before). Since significant attention is being paid to the protection of habitats where species exist, as one of the ways to protect rare species in particular and biodiversity in general, the main idea of the research was to establish the phytocoenotic localisation of the found rare species. This is because the habitats are based on phytocoenoses in one way or another, and therefore, the establishment of communities in which rare species grow will allow for the establishment of habitats, more effective protection of biodiversity in general. So, in total 15 habitats of rare species were found where it was made geobotanical relevés. Of these, 9 involved *Lilium martagon*, *Neottia nidus-avis* was present in 5 relevés, and *Epipactis helleborine* was noted in only one (Table 1).

Table 1. Locations of rare plant species recorded during the 2021-2024 monitoring period

Species name	Coordinates of location	Conservation status/degree of vulnerability	Phytocoenosis name	Degree and type of anthropogenic impact	Presence of individuals
Epipactis helleborine	50.347275°N, 30.493608°E	RDBU CITES	*Aceri platanoidis-Fraxinetum excelsioris*	R	+
Lilium martagon	50.336967°N, 30.485952°E	RDBU	*Aceri platanoidis-Fraxinetum excelsioris*	R	–
	50.343257°N, 30.496245°E	–//–	–//–	R	–
	50.342685°N, 30.484599°E	–//–	–//–	R	+
	50.344381°N, 30.483819°E	–//–	–//–	R	+
	50.342945°N, 30.485174°E	–//–	–//–	R	+
	50.344555°N, 30.480988°E	–//–	–//–	R	+
	50.345112°N, 30.482742°E	–//–	–//–	R	+
	50.343193°N, 30.482908°E	–//–	–//–	R	+
	50.343403°N, 30.495335°E	–//–	–//–	R	+

Table 1, Continued

Species name	Coordinates of location	Conservation status/degree of vulnerability	Phytocoenosis name	Degree and type of anthropogenic impact	Presence of individuals
Neottia nidus-avis	50.344028°N, 30.485397°E	RDBU, CITES	*Aceri platanoidis-Fraxinetum excelsioris*	R	+
	50.336578°N, 30.489725°E	–//–	*Galeobdolo lutei- Carpinetum*	R	+
	50.336417°N, 30.491606°E	–//–	–//–	R	+
	50.344261°N, 30.492887°E	–//–	–//–	R	+
	50.343399°N, 30.493150°E	–//–	–//–	R	+

Note: R – recreation, CITES – Convention on International Trade in Endangered Species of Wild Fauna and Flora, RDBU – Red Book of Ukraine
Source: developed by the authors

Based on an analysis of published sources and original data, four natural rare species included in the Red Data Book of Ukraine (Didukh, 2009) were documented within the Feofania tract during the study period: *Epipactis helleborine, Neottia nidus-avis, Lilium martagon, Cephalanthera longifolia*. Two of them are listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (1983): *E. helleborine* and N. nidus-avis. V. Lyubchenko (1983) and Y. Shelyag-Sosonko *et al.* (2009) mentioned the occurrence of *Cephalanthera longifolia*, but no locations of this species have been recorded since 1983. Rare introduced plant species are also found here: *Allium ursinum, Crocus heuffelianus, Erythronium dens-canis, Galanthus nivalis, Galanthus plicatus, Gymnospermium odessanum*. In addition to those already listed, regionally rare species for the city of Kyiv – *Convallaria majalis, Corydalis cava* – occur in abundance on the territory of Feofania (Andrienko & Peregrym, 2012).

Epipactis helleborine (Orchidaceae) is a polymorphic species with a wide ecological and cenotic amplitude, a hemicryptophyte, its conservation status is unvalued (Order of the Ministry..., 2021). The species is native to the Palearctic. It has also been naturalised in North America. In Ukraine, it occurs in forest, forest-steppe, steppe zones, the Carpathians, and the Mountainous Crimea. It is known in all administrative regions of Ukraine. For the first time the only location of *Epipactis helleborine* was discovered by on the territory of the tract at the end of May 2024 on a small slope of western exposure in a hornbeam-oak forest near the road (Kozyr, 2024). In Information on the habitat of this and other rare species currently noted for convenience was summarised in Table 1.

The coenosis has a four-tier structure with 26 identified species of higher vascular plants. The first tier formed by *Quercus robur* and *Acer platanoides* is up to 25 m high with a crown density (c. d.) of 0.2 and 0.15, respectively. The second tier formed by *Carpinus betulus* (crown density 0.45) is up to 18 m high. The undergrowth represented by *Euonymus europaeus*, *E. verrucosus* is weak, up to 1 m tall, and has a projective coverage of 3-5%. The fourth, grassy tier has a projective coverage of 80% and is up to 30 cm tall. In terms of species composition, it is typical of oak-hornbeam forests, but due to significant anthropogenic impact, 3/4 of the projective coverage at the end of spring – the beginning of summer is occupied

by *Impatiens parviflora*. The number of *I. parviflora* per 1 m^2 is over 30, although every year at the beginning of spring there is an early spring synusia here, consisting of species common to similar plant communities. The phytocoenosis belongs to the association *Aceri platanoidis-Fraxinetum excelsioris* Onyshchenko 1998 (Dubyna *et al*., 2019). In general, *Epipactis helleborine* is typical for forest phytocoenoses in Kyiv. Researchers noted it in the forest areas of the Holosiivskyi Forest, located a few kilometers north of the Feofania tract (Parnikoza & Shevchenko, 2007; Parnikoza *et al*., 2008; Gubar & Koniakin, 2021). According to the assumption, the species spread from the territory of the National Natural Park "Holosiivskyi".

According to Order of the Ministry of Environmental Protection and Natural Resources of Ukraine No. 111 (2021) *Lilium martagon* (Liliaceae) is a geophyte with a disjunctive range. Its conservation status is unvalued. The species' range is European-Siberian. In Ukraine, it is known in Polissya, the Forest-Steppe, the Carpathians, Transcarpathia, Ciskarpattia, Opilla, and Roztochchy. Administratively, the species is present everywhere except Crimea, Luhansk, Donetsk, Zaporizhzhia, Kherson, Mykolaiv and Dnipropetrovsk regions (Didukh, 2009). On the territory of the tract, the species were noted in 9 localities, however, in two of them it has not been recorded for several years (50.336967°N, 30.485952°E; 50.343257°N, 30.496245°E). Coordinates of the points where the species is present as of 2024 are the following (Fig. 1): 1) 50.342685°N, 30.484599°E; 2) 50.344381°N, 30.483819°E; 3) 50.342945°N, 30.485174°E; 4) 50.344555°N, 30.480988°E; 5) 50.345112°N, 30.482742°E; 6) 50.343193°N, 30.482908°E; 7) 50.343403°N, 30.495335°E (Kozyr, 2024). Phytocoenoses in which *L. martagon* grows usually have 2-3 woody tiers, an understory tier, and a grass tier. The first tier, up to 23-27 m tall, is formed by *Quercus robur* (c. d. 0.15-0.35) with an admixture of *Tilia cordata* (c. d. up to 0.3), *Acer platanoides* (c. d. 0.1-0.2), and *Carpinus betulus* (c. d. up to 0.75). The second tier, up to 20 m tall, is represented by *A. platanoides* (c. d. 0.1-0.2), *C. betulus* (c. d. 0.1-0.45), sometimes with an admixture of *T. cordata* (c. d. 0.05). The third tier, 15 m tall, is less pronounced and is formed by *A. platanoides* (c. d. up to 0.1), *C. betulus* (c. d. up to 0.23). The undergrowth, up to 1-2.5 m tall and with a projective coverage of up to 20%, is formed by *Sambucus nigra*, *Euonymus europaea*, and *E. verrucosa*. Typical representatives of oak-hornbeam forests form a grass tier up to 30-40 cm tall and with a projective coverage of 6-88%. It is important to note that *Impatiens parviflora* is present in most communities (sometimes it has a projective coverage of up to 45%, the number of individuals per 1 m^2 can be more than 20-30), which clearly indicates excessive anthropogenic impact. Phytocoenoses with the participation of *L. martagon* in the territory of the tract usually occur in groups of the association *Aceri platanoidis-Fraxinetum excelsioris* Onyshchenko 1998. It is necessary to recall the statement of V.M. Lubchenko (1983) that *L. martagon* is a typical species and often occurs in groups of oak-hornbeam forests of the Middle Dnieper region. In 2007, the species was noted in the forests of the Feofania tract in only two localities. Thus, the frequency of occurrence of the species is unstable and fluctuates from year to year, or since 2007, conditions for the growth and spread of the species have improved. The forest biota is closely associated with rare plant species. In Svyatoshynskyi Forest Park near *Formica rufa* anthills the population of *L. martagon* occurs.

According to Order of the Ministry of Environmental Protection and Natural Resources of Ukraine No. 111 (2021), *Neottia nidus-avis* (Orchidaceae) is a sciophyte with an unvalued conservation status. A saprophytic (symbiomycotrophic) type of nutrition and a

complex developmental biology characterizes the plant. The range is Western Eurasian. In Ukraine, it is known in Polissya, in the Forest-Steppe, in the northern part of the Steppe, in the Carpathians, and in the Mountainous Crimea (Didukh, 2009). It has been recorded the species in five locations on the territory of the tract: 1) 50.344028°N, 30.485397°E; 2) 50.336578°N, 30.489725°E; 3) 50.336417°N, 30.491606°E; 4) 50.344261°N, 30.492887°E; 5) 50.343399°N, 30.493150°E (Kozyr, 2012). It is worth noting that locations 1 and 2 are given for the first time. The literature only cites point 3 and the approximate area where it was noted location 4 (Padun, 1985; Shelyag-Sosonko *et al.*, 2009; Radchenko *et al.*, 2019). In the same area, A. Kuzemko (2021; 2024) noted two more locations of this rare species. In the first location, 1 blooming individual was noted, in the second – 4 blooming and 5 dry, in the third – 5 dry, in the fourth – about 30 individuals (dry and blooming), in the fifth – 1 blooming.

Phytocoenoses in which *Neottia nidus-avis* occurs usually have 1-3 tree tiers, an understory layer, and a grass tier. The first tier, up to 23-27 m tall, is mainly formed by *Quercus robur* (c. d. 0.05-0.5), *Tilia cordata* (c. d. up to 0.05), *Acer platanoides* (c. d. 0.1), *Carpinus betulus* (c. d. 0.55-0.7). The second tier, up to 20-22 m tall, is represented mainly by *C. betulus* (c. d. 0.1-0.55), *T. cordata* (c. d. 0.05). The third tier is 15-18 m tall. It is less pronounced and formed by *C. betulus* (c. d. 0.1). The undergrowth is up to 1.5-2.5 m tall with a projective coverage of up to 23%. It is formed by *Sambucus nigra*, *Euonymus europaea*, *E. verrucosa*, and *Acer campestre*. A grass tier is up to 30-40 cm tall with a projective coverage of 8-87%. Typical representatives of oak-hornbeam forests form it. *Impatiens parviflora* is gradually beginning to penetrate some phytocoenoses, and the number of individuals per 1 m^2 can be more than 30. Phytocoenoses with the participation of Neottia nidus-avis on the territory of the tract usually occur in groups of two associations *Aceri platanoidis-Fraxinetum excelsioris* Onyshchenko 1998, *Galeobdolo lutei-Carpinetum* Shevchik, Bakalina et Solomakha 1996. The associations *Aceri platanoidis-Fraxinetum excelsioris* and *Galeobdolo lutei-Carpinetum* were discovered in the second compartment of the Feofania Monument Park (the 6^{th} subcompartment, area 9.7 ha). In general, the first tier stand is formed by *Quercus robur* (predominant) and *Carpinus betulus* (vegetative origin), the second tier is formed by *Acer platanoides* and *Carpinus betulus* (predominant), the underwood is *Sambucus nigra*. The slope is southern exposure, about 10 degrees. The total litter is about 29 m^3 per subcompartment. The incidence of *Fomes fomentarius* is about 10% with a low degree of damage. In the first tier, the average age of *Quercus robur* is 197 years, 29 m high, trunk diameter is 88 cm, the tree wood of the first tier is about 200 m^3/ha. The percentage of the *Quercus robur* lumber is 20%. In the second tier, the age of *Acer platanoides* and *Carpinus betulus* is 62 years. On average, *Acer platanoides* is 25 m tall, and *Carpinus betulus* is 24 m. The diameter of the trunk of *Carpinus betulus* is on average 32 cm, and of the *Acer platanoides* is 34 cm. The tree wood of the second tier is about 180 m^3/ha. The percentage of *Carpinus betulus* lumber is 20%, of the *Acer platanoides* is 40%. An economic measure is proposed – clearing of litter. The grass layer contains *Aegopodium podagraria, Anemone ranunculoides, Asarum europaeum, Chelidonium majus, Convallaria majalis, Corydalis cava, C. solida, Ficaria verna, Gagea lutea, Galium aparine, G. odoratum, Geranium robertianum, Geum urbanum, Lamium galeobdolon, L. maculatum, Mercurialis perennis, Polygonatum latifolium, Polygonatum multiflorum, Pulmonaria obscura, Rabelera holostea, Urtica dioica*.

The *Galeobdolo lutei-Carpinetum* association was discovered in the third compartment of

the Feofania Monument Park (the 6th subcompartment, area 1.4 ha). In general, the first-tier stand is formed by *Quercus robur*, *Tilia cordata*, *Carpinus betulus*, the second – *Carpinus betulus*, *Acer platanoides*, *Tilia cordata*. The underwood consists of *Corylus avellana* and *Sambucus nigra*. The slope is eastern exposure, 10 degrees. The total litter is 37 m^3 per subcompartment. The incidence of *Fomes fomentarius* is about 10% with a low degree of damage. In the first tier, the age of *Quercus robur* is 187 years, *Carpinus betulus* and *Tilia cordata* is 97 years. The height of *Quercus robur* is 30 m, *Tilia cordata* is 28 m, *Carpinus betulus* is 26 m, on average, the diameter of the trunk of *Quercus robur* is 78 cm, *Tilia cordata* is 50 cm, *Carpinus betulus* is 42 cm. On the average the first-tier tree wood is 210 m^3/ha, on a subcompartment – 3.67 thousand m^3. The first-tier timber of *Quercus robur* is 40%, of *Tilia cordata* – 30%, and of *Carpinus betulus* – 10%. In the second-tier, the age of *Carpinus betulus*, *Acer platanoides* and *Tilia cordata* is 55 years. The height of *Acer platanoides* is 25 m, *Tilia cordata* is 24 m, and *Carpinus betulus* is 22 m. On average, the diameter of the trunk of *Carpinus betulus* is 32 cm, *Acer platanoides* is 36 cm, and the *Tilia cordata* is 34 cm. On average, the second tier tree wood is 120 m^3/ha, the subcompartment tree wood is 2.08 thousand m^3. The second-tier timber is 40% of *Carpinus betulus*, 50% of *Acer platanoides*, and 40% of *Tilia cordata*. The proposed management measures are clearing of litter and care for the underwood. The grass layer contains *Aegopodium podagraria, Anemone ranunculoides, Asarum europaeum, Corydalis solida, Ficaria verna, Lamium galeobdolon, Polygonatum multiflorum, Pulmonaria obscura, Rabelera holostea.*

A number of rare species were also introduced into the area, namely: *Allium ursinum, Crocus heuffelianus, Erythronium dens-canis, Galanthus plicatus, G. nivalis, Gymnospermium odessanum* (Bayrak & Hrytsay, 2009; Koniakin & Gubar, 2022). It should be noted that all of the above species have taken root well, and the number of individuals in their populations is increasing. This is especially true for *Allium ursinum*, which was planted in 2000 by Y.V. Dubrovsky (Radchenko *et al*., 2019) in two areas of hornbeam forest (one with planting material from Cherkasy region, and the other from Kyiv region). During the study period this species has spread throughout Feofania Park and is already recorded in five localities (Fig. 1). Therefore, D.A. Davydov's assumption about the naturalisation of this species is correct (Shynder *et al*., 2024).

Figure 2. Distribution of rare species in the Feofania tract included in the Red Data Book of Ukraine
Source: developed by the authors with using Google Earth Pro and GNU Gimp 2.10.18

It should be noted separately that in the last few years, the phytocoenoses of the Feofania tract have been undergoing changes due to the significant extinction and decline of old *Quercus robur* specimens, and the few large specimens of *Pinus sylvestris* here. There have also been more cases of *Carpinus betulus* trees falling. This is due not only to a change in climate to a more arid one, but also to the massive spread of tree pests. It is because of the almost complete disappearance of red forest ants *Formica rufa* from the forest territory of the studied object. In 2014 there were 89 nests here, which were divided into 3 large complexes (colonies), and in 2023 – only 3 single anthills. The results of the present study confirm the ongoing transformation processes within the forest ecosystems of the Feofania tract, which are reflected not only in the floristic composition and structure of the phytocoenoses but also in the condition of associated faunal complexes. Similar tendencies were documented by S. Stukalyuk *et al.* (2016), who monitored the nest complexes of *Formica rufa* within the Feofania Natural Park. Their research indicated that in 2014 there were 89 anthills grouped into three large colonies, demonstrating the previously stable state of the red wood ant populations, which play an important role in maintaining the ecological balance of the forest ecosystem. However, more recent findings by S. Stukalyuk *et al.* (2023) revealed a drastic decline in the number and structural integrity of nest complexes of *Formica rufa* and *F. polyctena* in urban forests of Kyiv, including Feofania. The authors attributed this decline to increasing anthropogenic pressure, habitat fragmentation, and the degradation of mature oak–hornbeam stands. These conclusions are consistent with the observations obtained during the 2021-2024 monitoring period in the present study, where the loss of dominant tree species (*Quercus robur*, *Carpinus betulus*) and a reduction in understory vitality were accompanied by a visible decrease in ant activity and the near disappearance of red wood ant colonies.

Ant species of the genus *Formica* have been documented as key ecological components of forest ecosystems in Ukraine, with a well-established role in trophic interactions and soil processes. According to A.G. Radchenko (2016), ants of the *Formica rufa* group not only regulate populations of forest pests but also actively engage in seed dispersal and soil modification, thereby influencing understory vegetation dynamics. In the present study, a marked decline in *Formica rufa* and *F. polyctena* was observed within the Feofania tract, which corresponded with reduced occurrences of myrmecochorous plant species such as *Lilium martagon*. This concordance suggests that the loss of functionally important ant assemblages could be linked to altered seed dispersal and community structure in urban forest patches. However, whereas A.G. Radchenko (2016) provided a comprehensive faunistic and ecological overview of ant distribution across Ukraine, the current findings extend this understanding by demonstrating how the absence of these ants in a specific urban protected area may correlate with changes in rare plant populations and phytocoenotic conditions.

The loss of the dominants of the first tier leads to the formation of large areas of several hundred square meters, which will contribute to changes in the vegetation cover in the places of their formation. Therefore, this may lead to the transformation of existing phytocoenoses into others that are not typical of this area, and a gradual complete or partial replacement of the species composition of phytocoenoses. The loss of dominant tree species in the first tier, particularly *Quercus robur* and *Carpinus betulus*, leads to the formation of open areas covering several hundred square meters. Such canopy gaps promote changes in

the vegetation cover within their boundaries. These processes can cause the transformation of existing phytocoenoses into new ones that are not typical for the given locality, resulting in the gradual partial or complete replacement of their species composition. During the 2021-2024 monitoring period, signs of this transformation were recorded in the Feofania tract. The decline of mature oak and hornbeam stands has initiated successional shifts towards mesophilous and nitrophilous communities dominated by *Acer platanoides* and *Tilia cordata*. These structural changes appear to reflect both natural successional dynamics and the influence of anthropogenic factors and pest outbreaks.

The growing number of visitors who often come here for leisure activities leads to disturbance of the herbaceous layer due to trampling, digging, uprooting or damaging plants, making bonfires, etc. The same applies to rare species that grow here. It has been repeatedly observed trampled, broken or torn out specimens of *Allium ursinum*, *Convallaria majalis*, *Corydalis cava, Lilium martagon, Neottia nidus-avis*. In this regard, it is recommendable the need to implement measures aimed at reducing the impacts of anthropogenic origin on the habitats of rare species. As such, it is recommended to carry out zoning of the territory and take measures aimed at reducing visits to the habitats of rare species. In addition, to track the status of the populations of these species, it is necessary to monitor them throughout the entire tract and directly in the noted places in accordance with Ukraine's international obligations (Association Agreement..., 2014; European Commission, 2020; Convention on Biological Diversity, 2022). In the future, it is advisable to conduct research into the possibilities of artificial propagation of these plants using all available biotechnological methods. For associations with rare species, it is worth using various silvicultural measures according to the specific situation, including landscape felling of maintenance, selective sanitary felling, elimination of littering, care for underwood, pruning of hanging dry branches from trees, felling of emergency trees along roads and trails, clearing of cross rides (Resolution..., 1995, 2007).

The study of rare plant species in the Feofania tract highlights their critical role as indicators of ecological balance and anthropogenic impact within urban forest ecosystems. The identification of new habitats for species such as *Epipactis helleborine*, *Lilium martagon*, and *Neottia nidus-avis*, alongside the observed decline of mature trees and the spread of invasive species like *Impatiens parviflora*, underscores the ongoing environmental changes in the region. The successful introduction of RDBU species, such as *Allium ursinum* and *Galanthus nivalis*, demonstrates the potential for conservation efforts to bolster biodiversity. These findings provide a foundation for enhanced biomonitoring and targeted conservation strategies to protect the tract's floristic diversity. In conclusion, the research emphasises the need for continued monitoring and management to mitigate anthropogenic pressures and preserve the ecological integrity of the Feofania tract.

Conclusions

For the first time in the territory of the Feofania tract, the *Epipactis heleborine* habitat was discovered. Presumably, the seeds of the plant were brought from the Holosiivskyi Forest National Park, the distance to which is less than 1 km. The obtained geobotanical data showed that *E. heleborine* is confined to the *Aceri platanoidis-Fraxinetum excelsioris* Onyshchenko 1998 association. Other rare species occured on the territory of the tract: *Lilium martagon* and *Neottia nidus-avis*, but quite rarely, and in some known habitats, individuals have disappeared and not recorded for several years in a row. This is due to a number of factors: climate

change, loss of dominants of the woody layer, phytocenotic changes, increased anthropogenic load, penetration of transformant species into phytocoenoses, as well as the mass disappearance of *Formica rufa and F. polyctena ants*. In particular, climate change adversely affects both individual plants and phytocoenoses, as reduced precipitation throughout the year, significant warming in winter, and frosts in spring negatively affect plant life, inhibit their development, allow more pests to survive, and contribute to the spread of plant and animal diseases. The loss of dominants of the woody layer contributes to increased evaporation of moisture from the soil and the rapid appearance of other species and new phytocenosis in these places.

Such changes in forest structure will cause a change in the microclimate and species composition, which will negatively affect rare species due to allelopathic effects. Anthropogenic pressure, which manifests itself in trampling and breaking plants, paving roads, compacting substrates, and picking flowers, also leads to a decrease in populations of rare species. The penetration of alien transformative species (for example, *Impatiens parviflora*) into phytocoenoses will lead to severe shading of rare species, as well as their allelopathic effect. Another negative factor in the number decreasing of rare species is the disappearance of *Formica rufa* and *F. polyctena* ants from the park. These insects not only fought pests but also contributed to the spread of seeds of rare species (for example, *L. martagon* seeds have an edible appendage that ants eat when transporting the seeds along the way to the anthill).

Regarding phytocenotic localisation, *L. martagon* occured in the *Aceri platanoidis-Fraxinetum excelsioris* Onyshchenko 1998 association. While *N. nidus-aves occurs* in the coenoses of two associations: *Aceri platanoidis-Fraxinetum excelsioris* Onyshchenko 1998 and *Galeobdolo lutei-Carpinetum* Shevchik, Bakalina et Solomakha 1996. It had not previously noted the rare species *Cephalantera longifolia* from the Central Ukraine Reserve, which is presented here. It has completely disappeared from the studied area. In the first decade of the 21st century, a number of rare plants were introduced into the Feofania tract, including 6 species listed in the Central Ukrainian Plant Conservation Register: *Allium ursinum, Crocus heuffelianus, Erythronium dens-canis, Galanthus plicatus, G. nivalis, Gymnospermium odessanum*. These species have taken root well and actively spread throughout the area. This is especially true for *A. ursinum*, which has been recorded in several localities at a considerable distance from the place of their planting.

Therefore, the received materials gave possibility to conduct ecomonitoring in the future and track changes that will occur in the populations of the species described above and the phytocoenoses in which they grow.

Acknowledgements

None.

Funding

None.

Conflict of Interest

None.

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Раритетні види рослин природних лісових насаджень урочища Феофанія та їхня фітоценотична приуроченість (Київ, Україна)

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Анотація. З'ясування сучасного стану поширення видів рослин, які включені в Червону книгу України, зокрема на території урочища Феофанія, набувають особливої актуальності, оскільки вони є чутливими маркерами рівня антропогенного навантаження та змін, що відбуваються в екосистемах. Метою дослідження було виявлення нових місцезростань рідкісних видів рослин природних лісових насаджень урочища Феофанія (Київ, Україна) та з'ясування їхньої фітоценотичної приуроченості. У межах урочища проводились моніторингові та геоботанічні дослідження упродовж вегетаційних сезонів 2009-2012 рр. та 2021-2024 рр. Також у межах дослідження було оцінено структуру та стан лісових насаджень. Виявлено зниження життєздатності старих дерев *Quercus robur* і *Carpinus betulus*, що відображає триваючі екологічні зміни в межах лісової екосистеми. У результаті встановлено нові локалітети *Lilium martagon*, *Neottia nidus-avis*, а також вперше знайдено *Epipactis helleborine*. Згадується, що *Cephalanthera longifolia* знайдений на території урочища Феофанія у 80-ті рр. XX ст. очевидно зник із дослідженої території. Відмічено, що на місцезнаходження рідкісних видів зростає антропогенний тиск. Це підтверджується проникненням у фітоценози, де вони трапляються, інвазійних видів, зокрема *Impatiens parviflora*. Тут у першому десятиріччі XXI ст. було успішно інтродуковано ще такі види

із Червоної книги України як *Allium ursinum*, *Crocus heuffelianus*, *Erythronium dens-canis*, *Galanthus plicatus*, G. *nivalis*, *Gymnospermium odessanum*. Фітоценози з участю Neottia nidus-avis виявлено на території другого кварталу (виділ 6) парку-пам'ятки «Феофанія» із запасом деревини першого та другого ярусів близько 380 м^3 / га та третього кварталу (виділ 6) із запасом деревини двох ярусів близько 330 м^3 / га. На території урочища також трапляються регіонально рідкісні види *Convallaria majalis* та Corydalis cava. Отримані відомості будуть корисними для біомоніторингу, поширення та динаміки цих видів і фітоценозів, у яких вони трапляються

Ключові слова: раритетні види; *Epipactis helleborine*; *Lilium martagon*; *Neottia nidus-avis*; охорона; антропічне навантаження