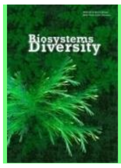

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Demutation of forests on fallow lands of Ukraine: The context of econiche replacement in successions

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Natural afforestation of former agricultural lands is an actual modern problem of forestry, ecology and phytocoenology in Ukraine. The European Commission adopted the European Green Deal with the general aim of making the European continent climate-neutral by 2050. Its main goals, among others, are the return of nature to agricultural lands and the restoration of forests. Manifestations of sylvatization have become widespread in Ukraine as a process of renaturalization of forest ecosystems on fallow lands, which in the past arose on the deforested sites. An analysis of scientific works that highlight the problem was conducted. The aim of the study was a systematic assessment of the process of replacing ecological niche with plant species in the process of demutation of self-seeded forests on fallow lands, as well as an assessment of the state, floristic composition and dynamics of the formation of self-seeded forest communities on fallow lands in the three natural and geographical regions of Ukraine (Ukrainian Polissya, Forest-Steppe and Steppe). During the field work, the main geobotanical research methods were applied: vegetation plot records, route reconnaissance, spatial-temporal dynamical ecological-phytocenotic series. During the cameral stage of research, data systematization and their analysis were performed. The results of the study of sylvatization show significant variability in its causes and manifestations. Afforestation of former agricultural lands occurs depending on the type of land, the intensity of their previous cultivation, the richness and humidity of the soil, the type of forest phytocenoses and the proximity of fallows to the forest. The species composition of trees of self-afforested areas on fallow lands is determined by the species composition of forest stands of nearby forests and forest belts, their biological properties, and ecological conditions for seed germination. The herbage is characterized by a variety of species of different phytocenotic types with a predominance of synanthropic and meadow cenogroups; self-seeded forest communities are characterized by an unformed forest environment. Self-seeded forest areas on fallow lands are currently in an unstable sanitary state due to the lack of appropriate forestry measures. Modern self-afforested areas should be considered in future as formed forest communities with the adaptation of tree species to existing ecological conditions and with the gradual organization of vegetation and floristic complexes. Therefore, it will be necessary to organize research to identify their current ecological state, floristic and syntaxonomic diversity, to establish the patterns of forest environment formation and to develop scientific foundations for optimizing ecologically balanced forest use.

Keywords: fallow lands; self-seeded forest communities; demutation, econiches; successions; plant species composition; natural and geographical regions.

Introduction

The main strategy of the modern paradigm of nature conservation in Europe is to preserve all types of surviving ecosystems and their biodiversity by different ways, as well as to return degraded landscapes to their quasi-natural state. The main and most effective means of its implementation for the stabilization of the environment is the constructing of Pan-European Ecological Network, among the elements of which the natural environment restoration zones occupy a prominent place.

At the end of the 20th century, a large-scale cessation of intensive agricultural use of various categories of land occurred in developed European countries. Usually, post-agricultural restoration processes of vegetation and soils are actively manifested on former agricultural lands (Susyan et al., 2011, Schierhorn et al., 2013, Kalinina et al., 2015). Therefore, in December 2019, the European Commission adopted The European Green Deal (hereafter referred to as the EGD) as a set of political initiatives with the general goal of making European continent climate neutral by 2050. The main aims of this document are to increase the well-being of citizens, to protect biotic diversity and to green the economy. The environmental policy of the European Union is fundamentally aimed at increasing the reserve index, that is increasing the share of nature reserves to 20%, naturalization of agricultural lands, increasing the quantitative and qualitative composition of biodiversity in urban ecosystems, restoring forests, and protecting marine bioresources.

The social and economic crisis in agriculture in the early 1990s in Ukraine initiated the processes of non-use of bioresources on significant areas of former fields, that caused a number of environmental problems. The reasons for the abandonment of fields are different, but in general they come down to the ecological and economic inexpediency of their further use for growing cultivated plants. Many former arable lands, whose use became economically inexpedient, were excluded from intensive agricultural use and turned into fallow lands, especially those located far from settlements. In general, the lack of land use contributed to overgrowing of former agricultural lands with shrubs and low-growing forest communities (Dubyna et al., 2024). In the eastern and southern regions of Ukraine (since 2014), the consequences of Russian military aggression have added to this problem. In this regard, experts estimate a decrease on fallow areas due to their unsuitability for cultivation because of mining, explosion craters, wheeled and tracked damage to the soil surface, etc. About 22% of the area of all agricultural land cultivated in 2021 was occupied (Matviishyn & Havriushyna, 2022).

Taking into account continental trends in environmental policy, EGD should become a guide for Ukraine during its post-agricultural restoration of vegetation cover. Among the recommended flagship initiatives of EGD in this area is maintaining the synergy of agricultural and environmental policies. The goal of the such initiative may be to support Ukraine in its efforts to return degraded agricultural lands and erosion-hazard lands to a quasi-natural state. The implementation of this initiative requires the selection and further removal of plots of land from the arable land category for their afforestation, meadow and wetlands formation, peatland conservation, restoration of wetlands, meadows, steppes and other valuable natural areas. All these categories of land will become biotope resources for the creation of local, regional and national ecological networks. There is no doubt, that this process should be based on legal regulation and improvement of economic instruments to stimulate such transformations.

Most natural landscapes of Ukraine are characterized by a certain degree of anthropogenic transformation. Agricultural activities, especially farming, have destroyed the natural vegetation cover (flora and vegetation), changed the structure of the soil, causing its impoverishment. In recent times, fallow lands have been formed as a new type of post-agricultural ecosystem on the site of dry lands on former old arable fields that have fallen out of agricultural use. Fallow lands include types of agricultural lands (a group of biotopes in the ecological meaning) which were previously arable but for various reasons have fallen out of intensive agricultural use. Unlike plough lands, fallow lands remain uncultivated for a long time, that's why a self-renewal of zonal natural vegetation is observed on them (Dubyna et al., 2024).

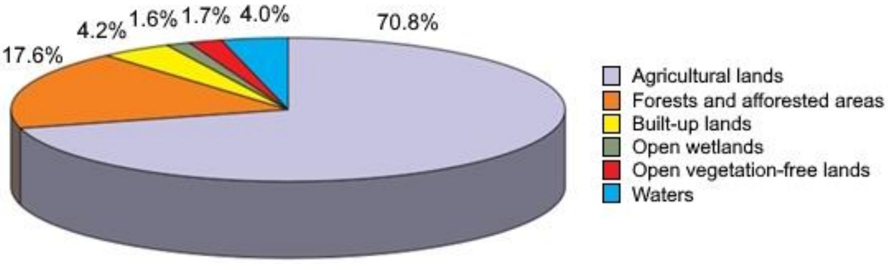

Fig. 1. Structure of the land fund of Ukraine (according to the data of State Land Cadastre of Ukraine)

Thus, one of the important modern ecological, biological and forestry problems in Ukraine is the natural afforestation of former agricultural lands, that have fallen out of agricultural use. The spontaneous development of sylvatization of post-agricultural ecosystems is caused by many factors. Its manifestations are obvious and ubiquitous. On dry lands on old ploughed fields, the processes of renaturalization of forest ecosystems have begun, which indicates the historical determination of the manifestations of sylvatization. The sylvatization of post-agricultural ecosystems is at the same time a scientific and forestry problem. Therefore, scientific research should be deep and diverse. Among the generalizing scientific works that directly or indirectly highlight this problem, we have identified several groups according to the subject-thematic principle.

A number of scientific works are devoted to the peculiarities of the process of sylvatization of former arable lands. In particular, the studies of plant species composition, bonitet assessment of the forest stand and ecological properties of the self-seeded forests were conducted in Ukrainian Polissya (Bilous, 2006; Vedmid et al., 2008; Zakharchuk, 2017). The processes of natural afforestation on former agricultural lands and post-agricultural restoration of vegetation cover and soils on them became especially noticeable in the western regions of Ukraine. First of all, large-scale transformations of fallow lands are typical for Volyn Polissya (Shatsk Lakeland), where in 2003 an in-depth study of the peculiarities of spontaneous afforestation of former arable lands was started (Yashchenko et al., 2003). A number of works based on the results of the research of the course of modern renaturalization and transformational changes in post-agricultural ecosystems of this region have also been published (Yashchenko & Nadoroznyak, 2003; Korus, & Yashchenko, 2009, 2021; Korus, 2020). The results of the research of modern transformational processes in post-agricultural ecosystems of Western Ukrainian Polissya, in particular their spontaneous afforestation and restoration of natural vegetation cover, are well summarized in the monograph "Sylvatization of post-agricultural ecosystems of the Shatsk Lakeland" (Alokhina et al., 2022). This publication examines the theoretical aspects of the regional determinacy of the phenomenon of sylvatization of post-agricultural ecosystems of the Shatsk Lakeland, and characterizes the social, economic, historical, and ecological reasons for its development.

The problem of natural afforestation of post-agricultural lands has also been well assessed in a number of other scientific works. In particular, a group of scientists (Maliuha et al., 2022) conducted a study of the anti-erosion properties of self-seeded forests. On the base of indicators of soil hardness and drainage capacity, the importance of their anti-erosion function has been proven. Also relevant were the methodological aspects of mapping self-seeded forests on agricultural lands and measurement of their areas (Remmel & Perera, 2017; Gorodnycha, 2022). A number of works highlight the organizational and economic principles of rational use of self-seeded forests on agricultural lands (Drebot, 2012; Gorodnycha & Openko, 2023; Openko & Gorodnycha, 2024), and also substantiate the idea of organizational and economic promotion and unified rules that would motivate private owners to the ecologically balanced use and maintenance of self-seeded forests (Lytsur & Tkachiv, 2017; Dorosh & Zastulka, 2022; Gorodnycha, 2024).

Therefore, the outlined research results are relevant and important for understanding the natural processes of forest restoration and determine the factors (soil fertility, water supply, etc.) that influence the success of this process. The features of the formation of self-seeded forests of various tree species and their distribution in areas of reforestation are also highlighted. The research results obtained by the scientists can become a basis for developing effective strategies for conservation, restoration and ecologically balanced management of forest resources in order to stabilize and maintain ecotopic balance and sustainability of post-agricultural ecosystems.

At the same time, the above-mentioned research topics showed, that the floristic component and ecotopic and phytocenotic features of demutation of vegetation cover in post-agricultural ecosystems as a result of sylvatization have mostly not been clarified. Therefore, the results of our research, which are presented below, will contribute to filling this segment of the subject to a certain extent. The purpose of this paper is to highlight the results of a systemic assessment of the process of replacing econiches with plant species in the process of demutation of self-seeded forests on fallow lands of natural and geographical regions of Ukraine.

Materials and methods

General scientific methods were used (observation, comparative assessment, analysis and synthesis, systemic approach). The database of bibliographic sources covers scientific publications and other research materials on the issue of natural afforestation of fallow lands.

The preparation of the manuscript of the article is based on the original materials of field research conducted by the authors during 2020–2024 in different natural and geographical regions of Ukraine. During the field stage of work, the main geobotanical research methods were applied – route reconnaissance, semi-stationary and stationary research. During the field research, vegetation plot records were made and spatial-temporal dynamical ecological-phytocenotic series were constructed (Yakubenko et al., 2017). The bioecological certification of dendroflora species was compiled using the generally accepted terminology and ecomorph system of Belgard (1950) with additions (Baranovsky, 2017). Stationary research were carried out on fallow lands, which in 2018 were included in the territory of the Mykhailivska Tsilyna Nature Reserve (Sumy district, Sumy region), their description is detailed in the text of the paper and illustrated with photographs. During the cameral stage of the research, data systematization and analysis were performed in the fields of floristic, synanthropization and demutational successions. The nomenclature of taxa is given in accordance with the summary by Mosyakin & Fedoronchuk (1999). In the text, the first-mention rule is applied for Latin names of plant species.

Results and discussion

According to the Law of Ukraine No. 2321-IX "On Amendments to Certain Legislative Acts of Ukraine on Forest Conservation", a self-afforested area is interpreted as a land plot of any category of land (except for lands of forestry purpose, objects of Nature Reserve Fund of Ukraine and other nature conservation purpose) with an area of over 0.5 hectares, partially or fully covered with forest vegetation, the afforestation of which occurred naturally. This legislative act is the legal basis for the functioning of self-seeded forests on agricultural lands and on other categories of land that are suitable for increasing the area of self-seeded forests in Ukraine.

From official and bibliographical (Gorodnycha, 2022) sources it is known, that the areas of self-seeded forests in Ukraine are unevenly distributed in the administrative and natural-geographical areas (Table 1).

Table 1
Area of fallow lands with self-seeded forest communities in the administrative regions of Ukraine

Regions		Area,
administrative	physiographical	thou. ha
Volyn region	mixed and broadleaf forest zones	115.71
Zhytomyr region	mixed forest and forest-steppe zones	227.82
Transcarpathian region	Ukrainian Carpathians	182.31
Zaporizhia region	steppe zone	41.96
Kirovohrad region	forest-steppe and steppe zones	61.97
Luhansk region	steppe zone	130.42
Lviv region	broadleaf forest zone and Ukrainian Carpathians	126.22
Mykolaiv region	forest-steppe and steppe zones	55.69
Poltava region	forest-steppe and steppe zones	142.37
Rivne region	mixed and broadleaf forest zones	55.44
Ternopil region	broadleaf forest zone	34.35
Kherson region	steppe zone	17.78
Khmelnytskyi region	broadleaf forest and forest-steppe zones	73.35
Chernivtsi region	broadleaf forest zone and Ukrainian Carpathians	34.74
Chernihiv region	mixed forest and forest-steppe zones	212.85

So, currently, the largest areas of self-seeded forests are recorded in Zhytomyr region and the smallest ones in Kherson region.

Spontaneous reproduction of forest phytocenoses, as one of the forms of the transformation of low-productive arable lands withdrawn from intensive cultivation into forest areas is a long-term process, in most cases, and occurs with the passage of various successional stages towards the restoration of natural zonal vegetation. The natural vegetation cover of fallow lands is restored during autogenic successions, that is, it stays in a state of short-term or long-term demutation changes. In essence, these are post-catastrophic changes in vegetation, which go from pioneer syngenetic to quasi-zonal endoecogenetic stages. A characteristic feature of vegetation demutation is the formation of communities mainly from native plant species and a significant participation of weeds, as well as certain quantity of plant species of former agricultural crops at the first stages of autogenetic successions (Alokhina et al., 2022). The ecological and phytocenotic mechanism of the demutation processes is the sequential formation of stages of successions, at which the ecological niches of populations of plant species with a lower survival strategy are replaced by populations of plant species with a higher potential of survival strategy. The rate of recovery of quasi-zonal forest communities, the sequence of stages of the demutation process and their duration depend on the abiotic and biotic factors of ecotopes and the degree of anthropogenic impact. The ecological factors that determine processes of demutation are the physical and chemical components of soils, climatic features (temperature and water regimes, wind rose, etc.), the duration of agricultural use of the land plot, the method of soil cultivation, the last crop grown on the plot, etc. The methods of using fallow land (grazing, haymaking, no use) are important, as well as the presence of nearby plots of natural vegetation, their distance from the fallow land, and the degree of preservation. All these ecofactors can accelerate individual stages of demutational succession, or slow them down. The classical scheme of this process on fallow lands includes four sequential unidirectional progressive stages: segetal weeds → rhizome grasses → tussock grasses → shrubs and trees. All these stages of demutation can be reversible and last for different periods of time. The classical order of stages of fallow land succession can change due to the influence of the above mentioned ecological factors. Individual stages of succession can disappear or exist for indefinite period of time (Alokhina et al., 2022; Dubyna et al., 2024).

In the mixed forests zone (Ukrainian Polissya), 47% of the total area of shared land was not leased. On most of these agricultural lands, which were neglected in the 1990s due to their limited fertility and significant degree of degradation, self-afforested areas were formed. Most often, Polissya fallows are represented by sod-podzolic, sod-ungleyed, gleyic and gley soils of light granulometric composition. The area of fallow lands with meadow-bog and peat-bog soils and lowland peatlands of varying thickness is a little smaller (Pashkevych & Gavrylov, 2012). The centers of seed distribution are forest areas or forest belts adjacent to the fallows, from where self-seeding of abandoned agricultural lands takes place. The main self-seeding of fallow lands occurs mostly in crop years and is characterized by clump or relatively uniform arrangement of plants on sown areas, their density mainly depends on the distance from the forest and microrelief.

The results of studies of sylvatization processes in the region indicate significant variability in their causes and manifestations. The process of natural afforestation of former agricultural lands depends on the type of land, the intensity of their previous cultivation, the richness and humidity of the soil, the type of forest phytocenoses and the distance of fallow lands to the forest, etc. (Korus, 2020; Alokhina et al., 2022).

In Western Polissya, natural afforestation of fallow lands occurs in accordance with their ecological and biotic specifics. This process can be both long-term, lasting several stages of development of grass vegetation and formation of a tree stand, and rapid. In particular, manifestations of rapid afforestation of fallow lands are observed in areas bordering the forest. In 1990s, as a result of land sharing in this region, the people received additional land plots on dry lands and drained and plowed swamps within the valleys of small and medium rivers. These areas ceased to be used as arable land due to impoverishment of soil and low yields, and eventually they became fallow lands. For Western Polissya, two main types of natural afforestation of fallow lands can be distinguished: the first one on drained peatlands, the second one on dry lands with sod-podzolic soils (Korus, 2020; Alokhina et al., 2022).

In the first stages of fallow land formation on drained peatlands, restorative successions of herbaceous vegetation occur mainly. Fallow lands at this stage are easily accessible for the drift of seeds of shrub and tree species, because they often do not yet have a layer of grass litter or turf and are favorable for seed germination on the soil surface, they also have a sufficient level of moisture supply throughout the year. *Betula pendula* Roth is most active in the first stages of natural afforestation in these wet and damp ecotopes. In the first years of afforestation, it forms pure thickets (low-growing forest communities) with the occasional participation of species of the genus *Salix* L. and *Pinus sylvestris* L., which will begin to predominate over time. The population of dominant *Betula pendula* at the age of 10 years has a crown density of 0.5–0.7 and height of 3–5 m. The distribution of trees over the area is characterized as uniform, very dense in terms of abundance, and reliable in terms of quality and growth potential. A rather dense herbage (projective cover of 80–90%) is formed under the openwork forest canopy, it is variegated according to ecological conditions of growth, phytocenotic location and the ways in which plant species move into the fallow lands of drained bogs. The floristic composition is characterized by the predominance of meadow plant species (*Phalaris arundinacea* L. (50%), *Calamagrostis epigejos* (L.) Roth (20%), *Deschampsia cespitosa* (L.) P. Beauv.) (2%), *Achillea submillefolium* Klok. et Krytzka., *Hypericum perforatum* L., *Phleum pratense* L., *Veronica officinalis* L., *Vicia hirsuta* (L.) Gray, *Holcus lanatus* L.), as well as a significant group of the remaining complex of wetland plant species (*Carex elata* All. (10%), *Juncus effusus* L. (5%), *Epilobium palustre* L. (2%), *Lycopus europaeus* L., *Persicaria maculosa* Gray, *Calamagrostis canescens* (Web.) Roth, *Carex lasiocarpa* Ehrh., *Galium palustre* L., *Lythrum salicaria* L., *Potentilla reptans* L. and others), diaspores of which have been preserved since the pre-drainage period of the bog's existence, as well as species of the remaining weed complex (*Erigeron canadensis* L., *Chenopodium album* L., *Sonchus arvensis* L., *Cirsium arvense* (L.) Scop.). The moss-lichen layer is not formed. At this stage, natural restoration has not reached the stage of intensive growth and differentiation of trees.

At the following stages of demutation, the multiple drift of tree diaspores cause a certain difference in the sizes of their individuals. At the same time, there is also a differentiation of trees of the same age, caused by ecotopic, biotic and phytocenotic reasons.

At the pole stage stand (11–20 years) significant structural and floristic changes are observed in the self-seeded communities of *Betula pendula*. The forest stands with a density of 0.8–1.0 are formed by *B. pendula*, and isolated individuals of *Alnus glutinosa* (L.) Gaerth., *Quercus robur* L., and *Pinus sylvestris* occur. *Betula pendula* trees at the age of 20 are 10–11 m tall with an average trunk diameter of 10–12 cm. In the communities, a sparse (0.1) and low (0.9–1.1 m) undergrowth of single individuals of *Frangula alnus* Mill., *Salix cinerea* L., *Prunus padus* L., *Viburnum opulus* L., and *Rubus nessensis* Hall has formed. A low (0.3–0.5 m) undergrowth of *Quercus robur* and *Pinus sylvestris* is also noted.

Under the dense canopy of the forest stand, a sparse herbage with a projective cover of 25–35% is formed, with a mosaic planar arrangement of plants, a variegated floristic composition, and phytocenotypes already differentiated by econiches. *Calamagrostis canescens* (30%) dominates there usually. This stage of afforestation is characterized by a significant decrease in the participation of the phytocenotic group of meadow plant species (*Danthonia decumbens* (L.) DC., *Hypericum perforatum*, *Plantago lanceolata* L., *Scorzoneroides autumnalis* (L.) Moench, *Agrostis stolonifera* L.) occur constantly, the phytocenotic group of swamp and swamp-forest plant species (*Carex elata*, *Carex rostrata* Stokes, *Carex flava* L., *Juncus effusus*, *Mentha verticillata* L., *Eupatorium cannabinum* L., *Lysimachia vulgaris* (L.) Pohl, *Lycopus europaeus*, *Polygonum hydropiper* (L.) Delabre, *Ranunculus reptans* L.) remains still floristically rich; species of the phytocenotic group of the remaining weed complex (*Fallopia dumetorum* (L.) Holub, *Urtica dioica* L., *Galeopsis ladanum* L., *Potentilla norvegica* L., *Arabidopsis thaliana* L.) are still present. Forest species appear: *Pyrola rotundifolia* (L.) Alef. and *Polytrichum commune* Hedw., which indicates together with the growth of trees and shrubs, the beginning of the formation of a forest environment on the former fallow lands of drained grass wetlands.

The generalized successional sequence of forest demutation on drained peatlands is: wetland forb species (*Carex elata*, *Juncus effusus*, *Lycopus europaeus*) + complex of weed species (*Erigeron canadensis*, *Chenopodium album*) → meadow species (*Phalaris arundinacea*, *Calamagrostis epigejos*, *Hypericum perforatum*) + complex of wetland forb and weed species + *Betula pendula* seedlings → *Betula pendula* – *Phalaris arundinacea* + *Calamagrostis canescens* + wetland and meadow forb species → *Betula pendula* – *Calamagrostis canescens* → *Betula pendula* – *Calamagrostis canescens* + *Polytrichum commune* (Fig. 2).

On dryland fallows with sod-podzolic soils, the beggining of the afforestation stage usually occurs after a short (1–2 years) period of domination of annual or biennial weeds (*Erigeron canadensis*, *Apera spica-venti* (L.) P. Beauv.), a longer period (6–8 years) of development of perennial plants (*Helychrisum arenarium* (L.) Moench, *Rumex acetosella* L., *Pilosella officinarum* Vaill.), as well as communities with domination of grasses (*Elymus repens* (L.) Gould, *Holcus mollis* L., *Corynephorus canescens* (L.) P. Beauv., *Agrostis capillaris* L., *Festuca ovina* L.). Such fallow lands are mostly afforested by *Pinus sylvestris*. The rate of their sylvatization depends on the presence and remoteness of seed sources and edaphic conditions of the fallow land. In dry soil conditions, this process is long-term (up to 10 or more years after several stages of succession of grass communities), while in wet conditions it is short-term. Obviously, the main seeding occurred in the crop years. Natural renewal is characterized by group distribution of plants or relatively even. At this stage of demutation, communities with forest stand mostly 10–15 years old prevail. The forest stands with different density (0.5–0.8) is formed by *Pinus sylvestris* with the participation of *Betula pendula* (9Ps1Bp). Trees at the age of 10 years are 6–7 m tall with an average trunk diameter of 6–8 cm. The undergrowth is not formed. The herbage with a total projective cover of 75–80% is represented by species of various phytocenotic types: *Pilosella officinarum* (40–60%), *Agrostis capillaris* (20–30%), *Calluna vulgaris* (L.) Hull (3–5%), *Helichrysum arenarium* (L.) Moench, *Erigeron canadensis*, *Scorzoneroides autumnalis*, *Plantago lanceolata*, *Nardus stricta* L., *Hypericum perforatum*, *Mentha arvensis* L., *Achillea submillefolium*, *Festuca rubra* L., *Trifolium repens* L., *Jasione montana* L., *Juncus effusus*, *Elymus repens*, *Potentilla argentea* L., *Rumex acetosella*, *Erigeron canadensis*, *Veronica officinalis*, *Carex hirta* L. The moss-lichen layer is not expressed.

The generalized successional sequence of forest demutation on dry fallow lands with sod-podzolic soils is: annual or biennial weeds (*Erigeron canadensis* + *Apera spica-venti*) → perennial weeds (*Helichrysum arenarium*, *Pilosella officinarum*, etc.) + grasses (*Elymus repens*, *Holcus mollis*, *Corynephorus canescens*) → meadow grasses (*Agrostis capillaris*, *Festuca rubra*, *Elymus repens*) + seedlings of *Pinus sylvestris* + *Betula pendula* → *Pinus sylvestris* + *Betula pendula* + *Agrostis capillaris*, *Elymus repens*, *Calamagrostis epigejos* → *Pinus sylvestris* + *Calamagrostis epigejos*; *Pinus sylvestris* + *Calluna vulgaris* (Fig. 2).

In the mixed forests zone, the species composition of forest stands during their demutational development tends to form mixed forest stands in post-agricultural areas. Usually, with the intensification of competitive relations in the struggle for econiches in communities due to the dominance of trees, many heliophytes fall out of the herbage, which leads to an increase in the participation of shade-tolerant (scioheliophyte) species, in particular, the appearance of typical forest plant species in the grass-subshrub layer of common pine communities. In conditions of fresh and wet birch-pine forest, their stand with a crown density of 0.8–1.0 is formed by *Pinus sylvestris* with the participation of *Betula pendula* (8Ps2Bp), which at the age of 15–18 years and a height of 4–6 m has a trunk diameter of 6–8 cm. *Salix cinerea*, *S. aurita* L., *Pyrus communis* L. grow singly in the undergrowth layer. The grass-subshrub layer (75–80%) is dominated by *Calluna vulgaris* (50–70%), *Nardus stricta* (20–30%) with the participation of *Molinia caerulea* (L.) Moench, *Vaccinium myrtillus* L., *Potentilla erecta* (L.) Raeusch., *Pilosella officinarum* and other plant species. The moss-lichen layer is not formed.

In dry pine forest conditions, the stand (0.8–0.9) is also formed by *Pinus sylvestris* with the participation of *Betula pendula*. *Pinus sylvestris* at the age of 15 years is 4–5 m high with a trunk diameter of 4–8 cm. In the undergrowth layer up to 1.0 m high, *Frangula alnus* and *Sorbus aucuparia* L. grow singly. The herbage in such conditions is sparse (15–20%) and is represented by forest and psammophyte plant species: *Lycopodium clavatum* L., *Vaccinium myrtillus*, *Calluna vulgaris*, *Rumex acetosella*, *Festuca ovina*, *Agrostis capillaris*. The moss-lichen layer is formed by *Polytrichum commune* (20%).

It is worth noting, that at the grass stage of demutation with domination of *Calamagrostis epigejos* this process slows down, since this phytocenotic type is competitively sustainable. Therefore, such fallow lands become long-term habitats of plants. This is due to the powerful ability of the dominant species to vegetative reproduction by creeping rhizomes and its wide ecological amplitude, which allows it to colonize fallow lands quickly and to form significant volumes of phytomass, which greatly complicates seeding and seed germination of tree species. These becomes possible only in the case of the release of locus of ecological niche such as the presence of disturbed (mineralized) soil areas due to fires, wild boars' digging activity, trails from cattle driving, etc.

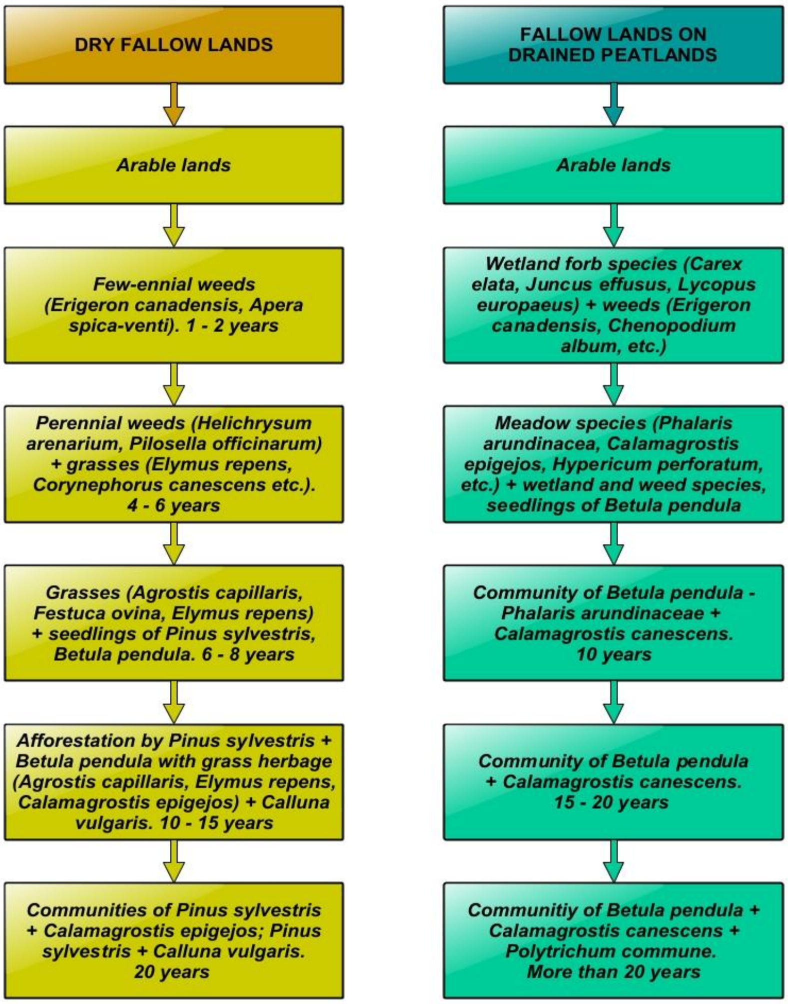

Fig. 2. Restorative successions on fallow lands of Western Polissya

In Central Polissya, natural afforestation occurs on the areas withdrawn from agricultural use due to radioactive contamination after the Chernobyl accident and the cessation of their agricultural use for different reasons. Here, in the natural afforestation of post-agricultural ecosystems, *Pinus sylvestris* dominates, and to a lesser extent *Betula pendula* (Fig. 3), *Populus nigra* L., *Robinia pseudoacacia* L.

Fig. 3. Afforestation of the fallow land with domination of *Betula pendula* (surroundings of the Yazvynka village, Bucha district, Kyiv region, photo is taken by D. V. Dubyna)

Communities with forest stands 15–25 (30) years old prevail. In several subsequent stages of natural afforestation, which are usually more intensive, the source of plant diaspores is not only a forest wall but also the young trees representing younger (6–12 years) neighboring afforestation areas.

In pure self-seeded common pine areas with sod-podzolic soils, the stand with a crown density of 0.6–0.8 is formed by *Pinus sylvestris*, which have a height of 9–12 m at the age of 20–25 years. *Ulmus laevis* Pall. and *Betula pendula* grow singly in the tree layer. In the sparse shrub layer (0.1) 1.0–1.5 m high, *Sambucus nigra* L., *S. racemosa* Lowe, *Sorbus aucuparia* and *Rubus caesius* L. occur. The undergrowth of trees is formed by *Betula pendula*, *Quercus robur*, *Pinus sylvestris*, *Malus domestica* (Borkh.) Borkh., *Pyrus communis*. The herbage is usually medium-dense (30–40%) with a uniform or mosaic cover. It is most often dominated by *Calamagrostis epigejos* (15–20%) and *Solidago canadensis* L. (15–20%). The herbaceous layer contains species of various phytocenotic types and phytocenotic groups with a prevalence of meadow (*Elymus repens*, *Poa angustifolia* L., *Festuca rubra*, *Agrostis canina*, *A. capillaris*, *Dactylis glomerata* L., *Asperula tinctoria* L., *Rumex acetosa* L., *Carex hirta*) and psammophytic (*Koeleria glauca* (Spreng.) DC., *Silene chlorantha* (Willd.) Ehrh., *Rumex acetosella*, *Pilosella officinarum*, *Oenothera biennis* L., *Trifolium arvense* L., *Myosotis stricta*

Roem. & Schult., *Jasione montana*, *Verbascum densiflorum* Bertol., *Veronica chamaedrys* L.) species, as well as with the participation of species of the remaining weed complex (*Erigeron annuus* (L.) Pers., *Verbena officinalis* L., *Reseda lutea* L., *Silene latifolia* Poir., *Anchusa officinalis* L.) and a small number of forest species (*Polygonatum odoratum* (Mill.) Druce, *Campanula rotundifolia* L., *Vincetoxicum hirundinaria* Medik., *Thymus serpyllum* L.).

It was established that the species composition of stands during their development tends to form mixed forest stands on self-afforested post-agricultural lands, the ecological conditions of which are most correlated with the type of forest-vegetation conditions of these areas. In the Polissya region, middle-aged birch–pine communities formed on fallow lands were found. Their forest stands with a crown density of 0.7–0.9 are formed by *Pinus sylvestris* and *Betula pendula*. 30-year-old *Pinus sylvestris* trees have a height of 13–15 and a trunk diameter of 15–18 cm; *Betula pendula* trees are higher (14–16 m). The undergrowth is insignificant. It contains single examples of shrub species (*Rhamnus cathartica* L. and *Rubus caesius*). *Betula pendula*, *Malus domestica*, *Pyrus communis*, and *Quercus robur* are common in the undergrowth among the tree species. The herbage is usually sparse (25–35%) with a mosaic cover. The dominant species are still *Calamagrostis epigejos* (10–15%) and *Solidago canadensis* (10%). The herbaceous layer is characterized by a lower total number of plant species, but an increased proportion of forest species (*Luzula pilosa* (L.) Willd., *Betonica officinalis* (L.) Trevis., *Melica nutans* L., *Geranium sanguineum* L., *Genista tinctoria* L.) and a decrease in weed species diversity.

A feature of the mixed forest zone is the afforestation of fallow lands nearby to forest belts formed by the introduced species *Robinia pseudoacacia*. The forest belt stand with a crown density of 0.7–0.9 is formed by *Robinia pseudoacacia* trees, which at the age of 20–25 years and a height of 15–17 m have a trunk diameter of 15–20 cm. In the indistinct second layer, single trees of *Acer negundo* L., *Betula pendula*, *Ulmus laevis* grow. In the sparse undergrowth (0.1), *Sambucus nigra*, *Crataegus monogyna* Jacq., *Ulmus pumila* L., *Prunus cerasus* L., *Rubus idaeus* L. occur, it can also be absent. Under the dense canopy of trees and shrubs, a sparse (20–25%) herbaceous layer is formed without a distinct domination of species. *Elymus repens*, *Solidago canadensis*, *Calamagrostis epigejos*, *Galium aparine* L., *Erigeron canadensis*, *Bromopsis inermis* Leyss., *Carex praecox* Schreb., *Chelidonium majus* L., *Urtica dioica* grow with a cover of 3–5%. The phytocenotic group of ruderal species is numerous, but they grow singly. There are *Anthriscus sylvestris* (L.) Hoffm., *Impatiens parviflora* DC., *Berteroa incana* (L.) DC., *Echium vulgare* L., *Geranium robertianum* L., *Lactuca serriola* L., *Lapsana communis* L., *Artemisia scoparia* Waldst. & Kit., *Euphorbia stricta* L. etc.

Fallow lands in the relief depressions, on the slopes and bottoms of the gullies are afforested in places with *Populus nigra*. Their forest stands are characterized by high density (0.8–0.9). *Populus nigra* trees at the age of 10–15 years are 10–16 m high. *Betula pendula*, *Populus tremula* L., *Acer negundo* are constantly found. *Rubus idaeus*, *Prunus padus*, *Salix caprea* L., *Viburnum opulus*, *Salix cinerea*, *Rhamnus cathartica*, *Sorbus aucuparia* grow in the sparse (0.1) undergrowth with high species diversity. The tree species of undergrowth is represented by *Betula pendula*, *Populus nigra*, *Populus alba*, *Malus sylvestris* Mill., *Pyrus communis*. In the herbaceous layer (cover 30–40%) is represented by *Calamagrostis epigejos*, *Solidago canadensis*, *Elymus* with a projective cover of 7–10% and by *Poa pratensis* L., *Erigeron annuus*, *Glechoma hederacea* L., *Chelidonium majus*, *Oenothera biennis* with projective cover of 3–5%. The species of different ecological and phytocenotic groups occur singly. There are *Symphytum officinale* L., *Urtica dioica*, *Bidens frondosa* L., *Polygonum hydropiper*, *Lycopus europaeus*, *Anacamptis palustris* (Jacq.) R. M. Bateman, Pridgeon et M. W. Chase, *Lysimachia vulgaris*, *Anthoxanthum odoratum* L., *Carex leporina* L., *Lythrum salicaria*, *Veronica longifolia* L., *Agrimonia eupatoria* L., *Trifolium alpestre* L., *Hypericum perforatum* and others.

Biotic ecological factors also affect the restoration of forests in the fallow lands of Central Polissya. In recent years, the spread of the harmful pine seed bug (*Leptoglossus occidentalis* Heidemann, 1910) has been noted in some places, which was first recorded in September 2018 (surroundings of Zhytomyr). The spread of this species significantly reduces the seed productivity of *Pinus sylvestris*, which negatively affects the restoration of its forest stands, including on fallow lands. In Eastern Polissya, natural afforestation is quite successful in areas that were withdrawn from agricultural use due to radioactive contamination after the accident at the Chernobyl nuclear power plant. For example, the forest cover of Chernihiv region increased by 16%, mainly due to the development of self-seeded forests (Bilous, 2006).

Afforestation of fallow lands in this region is quite intensive, but mainly with the participation of *Pinus sylvestris* and *Betula pendula*. In the processes of sylvatization of lands on wet and drained swamp areas, *Betula pendula* is the most active, in some places with the participation of shrub species of the genus *Salix* (*Salix cinerea*, *S. lapponum* L., *S. pentandra* L., *S. viminalis* L., etc.) and sometimes *Alnus glutinosa*. Typically, these forest stands with a crown density of 0.4–0.6 at the age of 15–20 years have a height of 4–7 m. *Betula pendula*, *Acer negundo*, *Fraxinus excelsior* L., *Populus nigra*, *Tilia cordata* Mill., *Alnus glutinosa* and *Ulmus laevis* occur singly also. The undergrowth is insignificant. The canopy of pure birch forest stands is openwork, often with herbage (cover 60–80%), growing under it. As a result of that a typical forest environment is not formed. Herbaceous layer is mostly dominated by meadow grasses (*Agrostis canina* and *Dactylis glomerata*) with a cover of 20–30%, with occasional participation of other meadow and weed plant species (*Achillea submillefolium*, *Epilobium palustre*, *Equisetum arvense* L., *Hypericum perforatum*, *Hypochaeris radicata* L., *Erigeron annuus*, *Jacobaea vulgaris* Gaertn., *Solidago canadensis*, *Vicia angustifolia* L., *Rumex confertus* Willd. and others).

Pinus sylvestris actively inhabits drier and poorer fallows, where pure and mixed forest stands (0.5–0.7) are formed. *Pinus sylvestris* trees at the age of 18–22 years are 8–12 m high. Sometimes, this species co-dominants with *Betula pendula*. *Acer negundo*, *Populus nigra*, *Populus tremula* occur constantly in their stands. The undergrowth is sparse (0.1) and up to 1.0 m high, and *Frangula alnus*, *Ptelea trifoliata* L., *Sorbus aucuparia* grow in it. Young individuals of *Quercus robur*, *Populus tremula*, *Morus nigra* L., *Juglans regia* L. occur in the undergrowth. The herbaceous layer is medium-dense with a total projective cover of 30–40% and with its mosaic arrangement. It is represented by meadow and weed species of plants, among which there are many invasive ones. *Agrostis gigantea* Roth dominates (30%), often with co-domination of *Solidago canadensis* (10–15%); *Parthenocissus quinquefolia* (L.) Planch., *Saponaria officinalis* L., *Impatiens parviflora* occur with a cover of 5–7%; *Agrostis vinealis* Schreb., *A. capillaris*, *Carex hirta*, *Cirsium arvense*, *Elymus repens*, *Equisetum arvense*, *Viola* sp. occur with a cover of 1–2%. Other species occur singly. There are *Apera spica-venti*, *Ambrosia artemisiifolia* L., *Artemisia vulgaris* L., *Asclepias syriaca* L., *Berteroa incana*, *Bromus inermis*, *Chelidonium majus*, *Erigeron canadensis*, *Lactuca muralis* (L.) E. Mey., *Oxalis stricta* L., *Picris hieracioides* L., *Hylotelephium telephium* (L.) H. Ohba, *Senecio nemorensis* L.

In Eastern Polissya, rapid afforestation of young fallow lands by the invasive introduced species *Acer negundo* has been found. In such ecotopes, the formation of high-density (0.8–1.0) thickets of trees and their increased growth in height (up to 4 m) is observed, while the formation of herbage under their canopy is slowed down. *Robinia pseudoacacia* and *Ulmus laevis* occur in the tree stand. In the sparse (10–15%) and species-poor herbaceous layer *Dactylis glomerata*, *Geum urbanum* L., *Erigeron annuus*, *Solidago canadensis* grow with a cover of 3–5%. *Equisetum arvense*, *Parthenocissus inserta* (A. Kern.) Fritsch, *Jacobaea vulgaris*, *Rumex acetosa*, *Heracleum* species, *Humulus lupulus* L., *Hypericum perforatum*, *Hypochaeris radicata*, *Onopordum acanthium* L. occur singly.

Therefore, the generalized regional mesophytic successional sequence of forest demutation on the fallow lands of Ukrainian Polissya can be modeled as: a complex of weed, meadow or wetland forb species + grasses + seedlings of *Pinus sylvestris* and *Betula pendula* → *B. pendula* + *P. sylvestris* – *Calamagrostis epigejos* + other grasses → *P. sylvestris* – *Calluna vulgaris* or *Vaccinium myrtillus*.

In the forest-steppe zone in the context of food security, agricultural lands have a significant advantage over other natural and geographical regions. Therefore, the spontaneous reproduction of phytocenoses, as one of the forms of the transformation of arable lands withdrawn from intensive cultivation into forest lands, is in most cases a rare phenomenon and usually little studied. However, it is well known, that the lack of competition for econiches between plants of the natural flora on the background of typical strategies of their behavior at the first stages of fallow land formation, as a phytocenotic cause for the beginning of sylvatization, governs the formation of successional variants of herbaceous and shrub vegetation.

The largest areas are occupied by shrub communities, which are mainly formed by *Prunus spinosa* L. with an admixture of *Sambucus nigra*, *S. racemosa*, *Rhamnus cathartica* etc. These are highly dense (0.9–1.0) communities with height 1.5–3.5 m, under its canopy a species-poor herbage with a cover of 20–50% is formed. In the herbaceous layer of different communities is dominate (cover of 20–40%) by *Calamagrostis epigejos*, *Elymus repens*, *Bromopsis inermis*, *Arrhenatherum elatius*, *Poa angustifolia*. *Adonis vernalis* L., *Betonica officinalis, Filipendula vulgaris* Moench, *Fragaria viridis* Weston, *Origanum vulgare* L., *Vincetoxicum hirundinaria* occur singly.

On old fallows, there are fragments of self-seeded forest communities dominated by *Fraxinus excelsior*, *Ulmus minor* Mill., *U. laevis* (Fig. 4).

Fig. 4. Fragment of the self-seeded forest communities with domination of *Ulmus minor* on the old fallow lands of Mykhailivska Tsilyna Nature Reserve (photo is taken by M. S. Larionov)

The forest stands of old fallow lands are represented by single examples of *Pyrus communis*, *Malus domestica*, *Acer negundo*, *A. platanoides* L., *A. tataricum* L., and occasionally *Pinus sylvestris*. The centers of seed distribution, from which self-seeding of abandoned agricultural lands occurred, are the nearest forest belts, to a lesser extent – natural forests and forest plantations of artificial origin. Self-seeded communities are characterized by fairly dense (0.7–0.9) forest stands. At a distance of 50–100 m, communities of anemochorous plant species are sparse. In contrast, populations of zoochorous plant species (*Pyrus communis*) are distributed relatively evenly, but singly or in small groups. Such populations can also form closed forest stands of considerable area, especially in the areas of former cattle grazing and near large places of their keeping. Some species have not formed dense forest stands yet, but they are actively spreading: *Elaeagnus angustifolia* L., *Robinia pseudoacacia*, *Malus domestica*, *M. praecox* Borkh, *Morus nigra, M. alba* L., *Acer platanoides*, *A. tataricum*, *Fraxinus excelsior*. Some tree species (*Populus nigra*, *P. tremula*, *Gleditsia triacanthos* L., *Acer saccharinum* L.) are present in forest belts, but for certain reasons practically do not spread to nearby fallow lands.

In the Forest-Steppe, the generalized regional xeromesophytic successional sequence of forest demutation on fallow lands can be modeled as: complex of meadow forb species + grasses + seedlings of *Prunus spinosa* → *P. spinosa* – *Calamagrostis epigejos* + *Elymus repens* + other grasses → *Ulmus laevis* + *Acer platanoides* + *Fraxinus excelsior* + *Robinia pseudoacacia* –*Elaeagnus angustifolia* + *Acer tataricum* + *P. spinosa* → *A. platanoides* + *F. excelsior* – *A. tataricum* + *P. spinosa*. One of the variants of such successional sequence is obtained on the basis of study of fallow lands of different ages in the Mykhailivska Tsilyna Nature Reserve (Fig. 5).

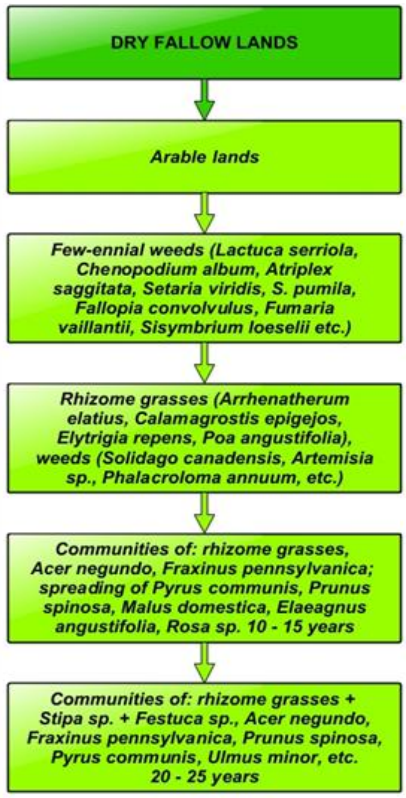

Fig. 5. Restorative successions on fallow lands of the Left-bank Forest-Steppe on the example of dry fallow lands of Mykhailivska Tsilyna Nature Reserve

In the steppe zone, a significant part of its Left-Bank part is currently occupied or in a zone of military operations, so the current state of fallow lands here has not been studied. Currently, military operations have affected an area of almost 3 million hectares of forests, and more than 500 thousand hectares are under occupation (Dorosh, & Zastulka, 2022).

In the Right-Bank Steppe, the formation of self-seeded forests is currently a rare phenomenon, since hydrothermal ecological conditions are not very favorable for the growth and development of native species of trees. In addition, a powerful anthropogenic impact is imposed on the natural background, because tenants use arable lands primarily very intensively. The withdrawal from cultivation of these lands occurs only due to the ecological conditions becoming unfavorable for growing agricultural crops, in particular as a result of an increase in the level of salinity of ground water. Fallow lands in the steppe zone are mostly at the third stage of demutation of zonal steppe vegetation (Lysohor et al., 2016). Over a long period (more than 20 years), phytocenoses of zonal plant formations *Festuceta valesiacae*, *Poeta angustifoliae*, *Koelerieta cristatae*, and sometimes *Stipeta capillatae* have formed here. This occurred as a result of the distribution of seeds of steppe plant species from adjacent undisturbed natural landscapes. However, the process of demutation of the quasi-natural vegetation cover of fallow lands is significantly affected by protective forest belts, which are the sources of distribution of tree and shrub seeds. Single plants (1–3 m high) of *Ulmus minor*, *Elaeagnus angustifolia*, *Juglans regia*, *Ulmus pumila*, *Amorpha fruticosa* L., *Rosa jundzillii* Besser grow on fallow lands.

In small areas of the Right Bank Steppe, a distribution of tree and shrub species and the formation of forest communities (young growth stage) in abandoned garden plots were observed. *Ulmus minor* is forest-forming tree species with crown density 0.2– 0.6. At the age of 10–12 years, the trees are 10–12 m high. A significant part of second layer (density of 0.2–0.3 with a height of 3.0–6.0 m) is formed of alien, primarily invasive, plant species (*Acer negundo*, *Ailanthus* *altissima* (Mill.) Swingle, *Elaeagnus angustifolia*, *Robinia pseudoacacia*, *Ulmus pumila*, *Fraxinus pennsylvanica* Marshall). Shrubs are represented by single individuals of *Cornus sanguinea* L., *Rosa corymbifera* Borkh. In the species-poor and dense (cover of 80–85%) herbaceous layer, grasses dominate usually. There are *Elymus repens* (60%), *Calamagrostis epigejos* (50%), *Poa angustifolia* (40–45%). Constant species with a cover of 3–5% are *Bromus squarrosus* L., *Achillea submillefolium*, *Lactuca serriola*. Species of different phytocenotic types grow singly. There are *Convolvulus arvensis* L., *Ballota nigra* L., *Artemisia absinthium* L., *Sisymbrium loeselii* L., *Jacobaea erucifolia* (L.) G. Gaertn., B. Mey. & Scherb., *Euphorbia virgata* Waldst. & Kit., *Scabiosa ochroleuca* L., *Chondrilla juncea* L., *Melilotus albus* Medik., *Lathyrus tuberosus* L., *Iris lactea* Pall., etc.

In the south of the steppe region, on the fallow lands formed on the site of saline meadow and meadow-steppe phytocenoses, self-seeded forest communities with the domination of invasive transformer-species (*Elaeagnus commutata* Bernh. ex Rydb. and *E. angustifolia*) have formed. Their herbaceous layer is dominated by synanthropic plant species (*Bromus squarrosus*, *Grindelia squarrosa* (Pursh) Dunal, *Atriplex prostrata* Boucher ex DC., *Cichorium intybus* L., *Carduus acanthoides* L., *Bromus tectorum* L., *B. sterilis* L.), which replace species of natural flora.

Fragments of natural afforestation of fallow lands, located among forest massifs, mainly common pine artificial forests, have also been observed. The center of seed distribution is medium-aged forest cultures of *Pinus sylvestris*, from which self-seeding of abandoned agricultural land occurred. A forest stand with a crown density of 0.5–0.6 is formed by *Pinus sylvestris*, whose 20–25 year-old trees reach a height of 8–10 m. In the unformed second layer (4–6 m high), *Robinia pseudoacacia*, *Prunus armeniaca* L., *Salix acutifolia* Willd. grow singly. There is also natural restoration of *Pinus sylvestris*. In the sparse (30–35%) and floristically poor herbaceous layer, *Artemisia campestris* L., *Sisymbrium polymorphum* (Murrey) Roth, *Centaurea sumensis* Kalen, *Stachys recta* L., *Ajuga genevensis* Schreb., *Potentilla argentea*, *Seseli tortuosum* L., *Euphorbia seguieriana* Neck grow.

In the Steppe, it is impossible to distinguish a single generalized regional mesoxerophytic or xerophytic successional sequence of forest demutation on fallow lands. There are three variations of it: 1) a complex of meadow-steppe and steppe forb species + steppe grasses → native zonal phytocenoses of the *Festuceta valesiacae*, *Poeta angustifoliae*, *Koelerieta cristatae* and *Stipeta capillatae* formations; 2) a complex of meadow-steppe and steppe forb species + steppe grasses → *Ulmus minor* + dendrological exotics – grasses: *Elymus repens* + *Calamagrostis epigejos* + *Poa angustifolia*; 3) a complex of meadow, meadow-steppe and steppe forb species + meadow-steppe grasses + seedlings of *Pinus sylvestris* and *Robinia pseudoacacia* → *P. sylvestris* + *R. pseudoacacia* + *Prunus armeniaca* – *Salix acutifolia* – meadow grasses: *Artemisia campestris* + *Sisymbrium polymorphum* + *Centaurea sumensis* + *Stachys recta* + *Ajuga genevensis* + *Potentilla argentea* + *Seseli tortuosum* + *Euphorbia seguieriana* → *P. sylvestris* – *Salix acutifolia* – *Artemisia campestris*.

Table 2

Bioecological characteristics of tree and shrub species that participate in the formation of self-seeded forest communities

No.	Species into families	Climamorphs	Biomorphs	Heliomorphs	Trophomorphs	Hygromorphs	Coenomorphs	Self-restoring ability	Alien species
	Divisio Pinophyta								
	Pinaceae								
1.	*Pinus sylvestris* L.	Ph	Arb	ScHe	OgMsTr	X-Hg	Sil	Significant	–
	Divisio Magnoliophyta								
	Class Magnoliopsida								
	Aceraceae								
2.	*Acer negundo* L.	Ph	Arb	He	Og-MgTr	MsX-HgMs	SilCuRu	Significant	AdvInv
3.	*Acer platanoides* L.	Ph	Arb	HeSc	MgMsTr	Ms	Sil	Medium	–
4.	*Acer saccharinum* L.	Ph	Arb	ScHe	MsTr	XMs	SilCu	Insignificant	Adv
5.	*Acer tataricum* L.	Ph	ArbFr	ScHe	Og-AlkMgTr	MsX-HgMs	SilSMn	Significant	–
	Betulaceae								
6.	*Alnus glutinosa* (L.) Gaerthn.	Ph	Arb	ScHe	MgTr	Hg	PalSil	Insignificant	–
7.	*Betula pendula* Roth	Ph	Arb	ScHe	OgMsTr	MsHg	Sil	Significant	–
	Caesalpiniaceae								
8.	*Gleditschia triacanthos* L.	Ph	Arb	He	MsTr	MsX	SilCu	Medium	Adv
	Caprifoliaceae								
9.	*Sambucus nigra* L.	nPh	Fr	ScHe	MgMsTr	Ms	RuSil	Significant	–
10.	*Sambucus racemosa* L.	nPh	Fr	ScHe	OgMsTr	Ms	PsRuSil	Insignificant	Adv
11.	*Viburnum opulus* L.	nPh	Fr	HeSc	MgTr	Ms	Sil	Insignificant	–
	Cornaceae								
12.	*Swida sanguinea* (L.) Opiz.	Ph	Fr	HeSc	MsTr	Ms	Sil	Medium	–
	Elaeagnaceae								
13.	*Elaeagnus angustifolia* L.	Ph	FrArb	He	AlkMsTr	X-HgMs	SMnPrCuRu	Significant	AdvInv
14.	*Elaeagnus commutata* L.	Ph	FrArb	He	AlkMsTr	X-HgMs	CuRu	Insignificant	Adv
	Fabaceae								
15.	*Amorpha fruticosa* L.	nPh	Fr	ScHe	OgMsTr	MsX-Hg	CuRuSil	Significant	AdvInv
16.	*Robinia pseudoacacia* L.	Ph	Arb	He	Og-MgTr	MsX-MsHg	SilCu	Significant	Adv
	Fagaceae								
17.	*Quercus robur* L.	Ph	Arb	ScHe	AlkOg-MgTr	MsX-MsHg	Sil	Insignificant	
	Juglandaceae								
18.	*Juglans regia* L.	Ph	Arb	He	MsMgTr	Ms	SilCu	Insignificant	Adv
	Moraceae								
19.	*Morus alba* L.	Ph	Arb	He	MsTr	Ms	CuSilRu	Insignificant	Adv
	Oleaceae								
20.	*Fraxinus excelsior* L.	Ph	Arb	ScHe	MsMgTr	MsX-MsHg	Sil	Medium	–
21.	*Fraxinus pennsylvanica* Marschall	Ph	Arb	ScHe	MsMgTr	XMs-HgMs	CuRuSil	Medium	Adv
	Rhamnacaceae								
22.	*Frangula alnus* Mill.	nPh	Fr	HeSc	Og-MgTr	Ms-Hg	SMnSil	Medium	–
23.	*Rhamnus cathartica* L.	nPh	Fr	HeSc	MsTr	Ms	SMnSil	Medium	–
	Rosaceae								
24.	*Armeniaca vulgaris* Lam.	Ph	Arb	He	OgMsTr	MsX	RuSilCu	Medium	Adv
25.	*Cerasus mahaleb* (L.) Mill.	Ph	ArbFr	ScHe	MsTr	XMs	CuRuSMn	Medium	Adv
26.	*Cerasus vulgaris* Mill.	Ph	Arb	ScHe	MgTr	XMs	RuCu	Insignificant	Adv
27.	*Crataegus fallacina* Klokov	nPh	Fr	ScHe	MsMgTr	Ms-X	SilSMnPtSt	Medium	–
28.	*Crataegus monogyna* Jacq.	Ph	ArbFr	ScHe	MsTr	MsX	SilSMnPtSt	Medium	–

No.	Species into families	Climamorphs	Biomorphs	Heliomorphs	Trophomorphs	Hygromorphs	Coenomorphs	Self-restoring ability	Alien species
29.	*Malus domestica* Borkh.	Ph	Arb	ScHe	MsTr	Ms	RuCu	Insignificant	Adv
30.	*Malus praecox* (Pall.) Borkh.	Ph	Arb	HeSc	MgMsTr	X-Ms	SilStSMn	Insignificant	–
31.	*Malus sylvestris* Mill.	Ph	Arb	HeSc	Og-MgTr	MsX-Ms	SMnSil	Insignificant	–
32.	*Padus avium* Mill.	Ph	Arb	ScHe	MgTr	MsHg	CuSil	Insignificant	–
33.	*Prunus stepposa* Kotov	Ph	Fr	ScHe	MsTr	MsX	SMnSt	Significant	–
34.	*Pyrus communis* L.	Ph	Arb	ScHe	MgMsTr	MsX	StSMnSil	Significant	–
35.	*Rosa canina* L.	nPh	Fr	ScHe	MsTr	X-Ms	RuSMnSt	Medium	–
36.	*Rosa corymbifera* Borkh.	nPh	Fr	ScHe	MsTr	MsX	RuSMnSt	Insignificant	–
37.	*Rosa jundzillii* Besser.							Insignificant	–
38.	*Rubus caesius* L.	nPh	Fr	ScHe	OgMsTr	HgMs	RuSil	Medium	–
39.	*Rubus idaeus* L.	nPh	Fr	ScHe	OgMsTr	Ms	PrSil	Insignificant	–
40.	*Rubus nessensis* Hall							Insignificant	–
41.	*Sorbus aucuparia* L.	Ph	Arb	ScHe	OgMsTr	XMs	Sil	Insignificant	–
	Salicaceae								
42.	*Populus alba* L.	Ph	Arb	He	OgMsTr	XMs-Hg	Sil	Medium	–
43.	*Populus nigra* L.	Ph	Arb	He	OgMsTr	XMs-Hg	Sil	Significant	–
44.	*Populus tremula* L.	Ph	Arb	ScHe	OgMsTr	HgMs	Sil	Medium	–
45.	*Salix acutifolia* Willd.	Ph	Fr	ScHe	OgTr	HgMs	SilSMnPs	Medium	–
46.	*Salix alba* L.	Ph	Arb	ScHe	Og-MgTr	XMs-Hg	Sil	Medium	–
47.	*Salix aurita* L	Ph	Fr	ScHe	Og-MgTr	MsHg	PsSMnPal	Insignificant	–
48.	*Salix caprea* L	Ph	Arb	ScHe	OgMsTr	Ms	SilSMn	Insignificant	
49.	*Salix cinerea* L	Ph	Fr	ScHe	MgMsTr	MsHg	SilPal	Insignificant	–
50.	*Salix lapponum* L.	Ph	Fr	HeSc	MsTr	Hg	Pal	Insignificant	–
51.	*Salix pentandra* L.	Ph	Fr	HeSc	MsTr	MsHg	PalSil	Insignificant	–
52.	*Salix viminalis* L.	Ph	Fr	He	MgTr	HgMs	PrSil	Insignificant	–
	Simarubaceae								
53.	*Ailanthus altissima* (Mill.) Swingle	Ph	Arb	ScHe	OgMsTr	X-Ms	SilCuRu	Medium	AdvInv
	Tiliaceae								–
54.	*Tilia cordata* Mill.	Ph	Arb	ScHe	MsMgTr	Ms	Sil	Insignificant	–
	Ulmaceae								
55.	*Ulmus laevis* Pall.	Ph	Arb	HeSc	Og-MgTr	XMs-MsHg	Sil	Insignificant	–
56.	*Ulmus minor* Mill.	Ph	Arb	ScHe	MsTr	MsX	SilSMn	Significant	–
57.	*Ulmus pumila* L.	Ph	Arb	ScHe	OgMsTr	MsX	SilCuRu	Significant	AdvInv

Notes: biomorphs: Fr (Frutex) – shrub, Arb (Arbor) – tree; ecomorphs: climamorphs: Ph – phanerophyte, nPh – nanophanerophyte; heliomorphs: He (Heliophyton) – heliophyte (light-loving species), Sc (Sciophyton) – sciophyte (shade-tolerant species); trophomorphs: OgTr (Oligotroph) – oligotroph (species of poor soils), MsTr (Mesotroph) – mesotroph (species of medium-rich soils), MgTr (Megatroph) – megatroph (species of rich soils); hygromorphs: Hg (Hygrophyton) – hygrophyte (species of wet habitats), Ms (Mesophyton) – mesophyte (species of medium-wet habitats), X (Xerophyton) – xerophyte (species of dry habitats); coenomorphs: Pal (Paludosus) – paludant (swamp species), Pr (Pratensis) – pratant (meadow species), Sil (Silvaticus) – sylvan (forest species), St (Stepposus) – steppe (steppe species), SMn (Margosilvaticus) – silvomargoant (forest edge species), Ps (Psammophyton) – psammophant (sandy soil species), Ru (Ruderatus) – ruderant (weed species), Cu (Cultus) – culturant (cultivated species).

57 tree and shrub species participate in the formation of self-seeded forest communities in various biotopes. Among them, 31 species are trees, 13 species are shrubs, 13 species are tree-shrubs. Most species are scioheliophytes, mesotrophs, mesophytes, obligate sylvans. 17 species are adventive, 5 species are invasive adventive. 13 species have significant self-restoring ability, 18 species – medium, and 26 species – insignificant.

Thus, a comparative assessment of the current state of self-seeded forest communities on fallow lands of the three natural and geographical regions of Ukraine revealed regional distinctive features. The general features are:

– absence of competition in the early stages of fallow land formation as phytocenotic prerequisites for the beginning of their sylvatization by species of natural flora; in the process of demutation of self-seeded forests, typical behavioral strategies of new to fallow lands plant species are observed, which is manifested in the formation of consistently progressive succession variants through the replacement of ecological niches of species of herbaceous and shrub vegetation;

– the rate of sylvatization of post-agricultural ecosystems is manifested in different ways and depends on the proximity of seeding sources and the soil conditions of former agricultural lands; in dry soil conditions this process is long (up to 10 years after the manifestation of the first few stages of demutation), in wet ones it is faster;

– natural restoration of forest is characterized by group arrangement of trees or relatively evenly seeded areas;

– the source of seed distribution, from which self-afforestation of abandoned agricultural lands began, is the nearest natural and artificial forest areas and forest belts;

– the species composition of trees in self-afforested areas on fallow lands is determined by the species composition of forest stands of nearby forests and forest belts, their biological properties, relief features, hydrothermal ecological conditions for germination of plant seeds;

– the species composition of forest stands during their demutational development tends to form mixed forest stands in the future on afforested post-agricultural areas, although at the initial stages of restoration monodominant forest stands are mainly formed;

– in the process of forest demutation on fallow lands, the herabage is characterized by rich species diversity, which belongs to different phytocenotic types with domination of synanthropic and meadow phytocenotic groups of plant species;

– self-seeded forest communities are characterized by the beginning of the formation of a forest edificatory ecological environment, from polydominance to monodominance of forest-forming species of trees.

Self-afforested forest areas on the fallow lands are currently in an unstable sanitary condition, cluttered, often become a source of logging and fires, since forestry measures to form full-structured, highly productive and sustainable forest phytocenoses with rich native biodiversity were not carried out on them. Therefore, an important task for the state is to preserve self-afforested communities on fallow lands, including those damaged by the war. This will increase the area of the forest fund of Ukraine, improve the country's forest cover index and increase its environmental sustainability.

Conclusions

To slow down global climate change in the biosphere, humanity relies heavily on the forest biome. Therefore, it is necessary to adhere to environmentally friendly principles of forest management, and take all possible measures to preserve, restore and increase the area of forests on the Earth's surface. This is called for by Global Forest Landscape Restoration Initiatives, in particular the Bonn Challenge, which aims to create 350 million hectares of forests by 2030.

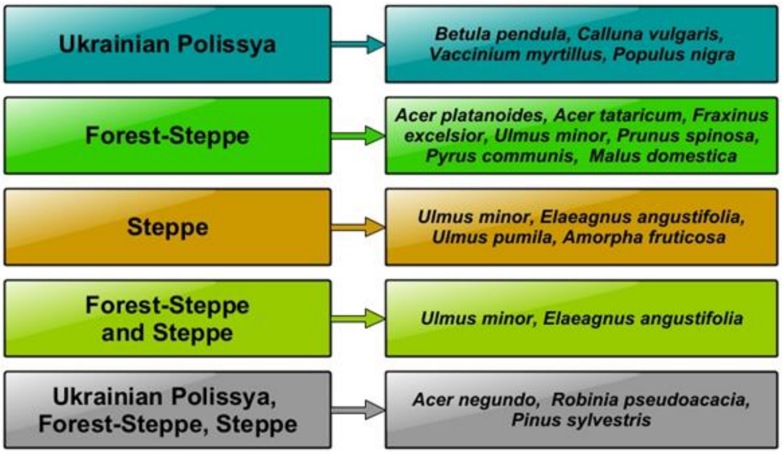

Fig. 6. Regional ecological amplitude of dominant phanerophytes at the stages of forest vegetation demutation on fallow lands of the plain part of Ukraine

In Ukraine, the scenarios for the future state of forests are disappointing. Only 11% of the territory of our country has favorable ecological conditions, 18% are satisfactory, 22% are conflict-prone, 25% are in a pre-crisis and 24% are in a crisis state. Scientists believes that the first step of national importance, without which ecological balance cannot be achieved not only in the Southern Steppe, but also throughout Ukraine under any circumstances, should be to reduce significantly the area of arable land to scientifically determined standards. In 75% of the areas of the administrative regions of Ukraine, the index of forest cover does not reach its optimal level corresponding to the area of the natural and climatic zone. This situation indicates the need to increase the area of forests, including self-seeded, to improve the ecological stability of the regions.

The current self-afforested areas should be considered as future formed forest ecosystems with a proper ecological structure, vegetation and quasi-native biodiversity. Therefore, promising areas of scientific research into formed forests of self-seeded origin should be: determining their current ecological state, identifying floristic and syntaxonomic diversity, establishing patterns of formation of the forest microclimatic environment and developing scientific bases for optimizing forest management.

The authors declare that they have no potential conflict of interest.

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