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Creation and management of field protective forest belts in northeastern Bulgaria – history, problems and gained experience

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Abstract. In the middle of the 20th century, a system of field protective forest belts was created in northeastern Bulgaria to protect agricultural lands from wind erosion, improve moisture storage and increase yields from agricultural crops. The study traces the chronology of the creation of those belts and their management to the present. The main mistakes and omissions made due to the lack of experience and expertise are outlined. Problems and challenges related to environmental conditions, protection of the belts and regulatory weaknesses have been identified. The most serious problem at the moment is the mass drying of the *Fraxinus* spp. belts, and in the medium term - the need to reconstruct large areas of different kinds of degrading belts. Despite the many problems and mistakes made, valuable experience has been gained over the years, important aspects of which are also presented. It is evident that there is a need to develop a comprehensive concept for management of the field protective forest belts, including: a scientifically based methodology for assessing their condition, a differentiated approach for their management, and provision of a stable financial mechanism for restoration of degraded belts and their subsequent cultivation.

Key words: field protective forest belts, forest management, agroforestry, soil protection, Dobrudzha.

Introduction

Field protective forest belts (FPFBs) are defined as specific forests, planned in agricultural areas to protect the soil from wind erosion and degradation, preserve moisture storage, and regulate the water regime (Georgiev, 1960; Marinov et al., 2003; Vassilev et al., 2019). They contribute to improving the environmental microclimate and increasing the fertility of agricultural lands. At the same time, FPFBs increase the forest cover in the plains and thus protect and increase the existing biological diversity. Their important ecological and economic roles are most significant in arid and deforested areas.

The first forest belts planted on agricultural land were created by V. Lomikovsky in the Poltava province of Russia in 1809. The scientific approaches of the field protective silviculture were developed by V. Dokuchaev and G. Vysotsky at the end of the 19th century, when systems of forest belts were created in the steppe regions of the European part of Russia - in the Kamennaya (Stone) Steppe of the Voronezh region, in the Luhansk region and near Mariopol (present-day Ukraine) (Solovyeva, 2014).

In the Romanian part of Dobrudzha (near Bulgaria), the first afforestation to protect agricultural lands and improve the microclimate started at the beginning of the 20th century (Marinov et al., 2003). Good quality soils are distributed in this area, but the limiting factor to agriculture is moisture as the annual amount of precipitation reaches up to 400-450 mm. By 1955, several thousand hectares of FPFBs were planted in Romania. Recently, projects have been implemented to create new protective forest belts (Lup & Miron, 2014).

Results and Discussion

1. Afforestation of field protective forest belts in Bulgaria

On the territory of Bulgaria, the afforestation of field protective forest belts began in the 1920s (Georgiev, 1960). Dobrudzha is the only region in the country where the system of FPFBs is considered almost complete. The history of the afforestation goes through three periods.

1.1. First period (1925-1940)

The first afforestation of FPFBs were carried out in Southern Dobrudzha in 1925-1940 by Romanian foresters (Georgiev, 1960). During this period, the area was a part of the Kingdom of Romania. Forest belts, mainly including fast-growing tree species, were created on the forest and land territories. In the estates of some large landowners, field protective belts with several rows of *Robinia pseudoacacia* L. were planted along roads and borders of the estates or of separate field areas. These are monoculture line-type belts, without undergrowth.

During the period 1936-1939, near the Karvuna village (Municipality of Balchik), FPFBs were created under a project of the Forestry Institute in Bucharest, Romania (Georgiev, 1960). Ten years after the return of Southern Dob-rudzha to Bulgarian territory (1940), these forests were chosen as an experimental field for studying the influence of forest belts on agrocenoses. The first belts could be catego-rized into three types: monoculture-managed forest belts with *R. pseudoacacia* 8-10 m in width, in a planting scheme of 1.0×1.0 m; mixed forest belts of *R. pseudoacacia* and *Gleditsia triacanthos* L. in 10 rows, with shrubs and width of 14 m; mixed forest belts of *Ulmus pumila* L., *Fraxinus excelsior* L., *Fraxinus angustifolia* Vahl and *Populus* x *euramericana* (Dode) Guinier, with shrubs, at the same width and row spacing (Georgiev, 1960).

1.2. Second period (1940-1950)

After 1944, several Labor Agricultural Cooperative Farms (LACF) and State Agricultural Farms (SAF) were established in Dobrudzha under the Law on Labor Land Ownership (State Gazette of the Republic of Bulgaria, 1946). Five- to seven-row forest belts with a width of 7.5 to 10.5 m were created. Fast-growing species capable of quickly for-ming the full arrangement and achieving the expected effects were used – *Populus* spp., *Acer platanoides* L., *A. campestre* L., *A. pseudo-platanus* L., *Fraxinus* spp., *U. pumila*, *R. pseudoacacia* and *G. triacanthos* (Marinov et al., 2003). During this period, the first attempts were made to plant forest belts with *Quercus robur* L. and *Fraxinus oxycarpa* Wild. Georgiev (1960) concluded that the participation of long-lived species in the belts was unsatisfactory. Belts of *Q. robur* were created by planting saplings, mixed with *A. campestre* and *A. tataricum* L.

1.3. Third period (1950-1960)

Complex studies and substantiation of the need for comprehensive agroforestry measures in the region of Dobrudzha began in 1950. The Council of Ministers issued decree No. 236/08.03.1951 '…on the development of agriculture, water supply and electrification of Dobrudzha' (CM, 1951), known as the Transformation Plan of Dobrudzha. In fulfilment of it, railway lines and irrigation systems were built, and an electric trans-mission network was laid. The afforestation of nine State (anti-erosion) forest belts and a complete system of field protective forest belts were also planned. The planning, organization, and implementation of the activities for the creation of the FPFBs turned out to be the most complex and labour-consuming tasks in the plan. For this pur-

pose, in 1952 the Ministry of Agriculture organised a special scientific six-month expedition to the protective afforestation in Dobrudzha. More than 40 scientists (foresters, meteorologists, soil scientists, hydrologists, and agrarian economists) carried out research activities in the field. The Russian scientists Prof. Krylov and Prof. Ishin were also involved in helping the expedition. The main objectives of the expedition were: to study the complex of environmental microclimatic parameters along the route of field protective belts; to evaluate the condition and vitality of the existing tree species; to select the appropriate main and accompanying tree and shrub species planned to be used; to develop a project for the establishment of the field protective system and the sequential order for the construction of the belts. The results of the expedition were published in a special proceeding of the Institute of Botany at the Bulgarian Academy of Sciences (BAS, 1955).

The creation of the FPFBs was entrusted to the LACF and the SAF as the afforestations were carried out on agricultural lands. It was necessary for the process to be fully synchronized with the main agricultural activities. For the needs of afforestation, nurseries were created to produce the necessary planting material. A collection of acorns and other seeds was organized. The activities of soil preparation, afforestation, and the care for young crops were accompanied by various problems and difficulties – a poor organization, shortage of labour, insufficient quantities of seed and planting material, etc., which were overcome by a lot of effort and unplanned expenses (Georgiev, 1960).

The main tree species used for planting were oaks (*Quercus cerris* L., *Q. robur, Q. rubra* L., *Q. frainetto* Ten. and *Q. petraea* (Matt.) Liebl.), ash (*Fraxinus excelsior* L., *F. oxycarpa*, *F. americana* L.), *R. pseudoacacia*, *G. triacanthos*, *Juglans regia* L., elms (*Ulmus minor* Mill. and *U. pumila*), poplars (*Populus* spp.) and other species. As accompanying tree species, ash (*F. americana* and *F. ornus* L.), maple (*Acer* spp.), lindens (*Tilia tomentosa* Moench and *T. platyphyllos* Scop.), *Sophora japonica* L., fruit species (*Prunus mahaleb* L., *P. armeniaca* L., *P. cerasifera* Ehrh., *P. avium* L., *P. persica* (L.) Batsch, *Pyrus pyraster* (L.) Burgsd., *Malus sylvestris* (L.) Mill., *Morus* sp., *Corylus colurna* L., etc.), were used. For shrub species, *Cotinus* sp., *Amorpha fruticosa* L., *Crataegus* sp., *Sambucus nigra* L., *Ligustrum* sp., *Prunus spinosa* L., *Cornus sanguinea* L., etc. were planted. The specified tree and shrub species had different participation in the composition of the mixed deciduous forest belts. Furthermore, in some belts one species played the role of a main species, while in other belts the same species played the role as a companion species (Dodev et al., 2023).

The main field protective forest belts were exposed perpendicularly to the prevailing northeasterly winds, allowing for a 30° deviation. The auxiliary belts were placed perpendicularly to the main ones, creating a net form. The agricultural fields they formed had dimensions of 1000-2000 m (for the main belts) and 400-500 m (for the auxiliary belts).

The construction of the field protection system in Dobrudzha was basically completed by 1960. By the end of 1959, 9650 ha of the projected 13200 ha FPFBs were created (Georgiev, 1960). The creation of the FPFBs continued in the following decade, but at a much lower pace, and after the mid-1960s, it practically ended. As of 2022, the area of FPFBs in Bulgaria is 10695.5 ha (Mateva & Kirilova, 2022).

2. Management of field protective forest belts

2.1. Farming by AIC and LACF (1960-1978)

From the creation of the FPFBs until 1978, they were managed by the local Agrarian-Industrial Complexes (AIC) and LACF. The State Forestry Department had no responsibility for them. During this period, various shrub species were also included in the belt schemes. *Cotinus coggygria* Scop. was widely used, because of the tanning substances contained in its leaves, and *Amorpha fruticosa*, whose seeds contain valuable chemical substances. Accompanying tree species were also used more widely.

2.2. Forest management (1978-present)

According to the decision of the Council of Ministers No.25/25.12.1978, 6518.2 ha of FPFBs were included in the State Forestry

Fund (Yordanova, 2018). The reason for this action was the poor management (one could even say non-management) by agricultural holdings and the active position of the Regional Directorate of Forestry, foresters, and nature protection organizations. The first forest inventory of FPFBs was carried out in 1980, which was more than 20 years after their creation (Yordanova, 2018).

After 1990, illegal logging and grazing in the FPFBs increased sharply due to the impoverishment of the population in the area and the appearance of permanent unemployment. The stubbles were burning massively and uncontrollably, which led to fires and damage in the belts. The ownership of the agricultural lands bordering the FPFBs was changed - from 100% state property to 90% private and 10% state and municipal property.

Climate change was also adversely affecting the FPFBs. The prolonged droughts registered in 2000 and 2001 sharply worsened the already poor sanitary condition of the FPFBs. In this regard, in 2002, a National conference with international participation was held on the problems of the field protecttive forest belts in Dobrudzha, at which a differentiated approach was proposed for their management according to their condition (Marinov et al., 2003).

After 1999, the forestry industry was restructured, with the organization, control and protection of FPFBs carried out by the State Forestries and State Hunting Enterprises, and the economic activity in them - by licensed companies. According to the Law on Forests (State Gazette of the Republic of Bulgaria, 2011), FPFBs were defined as forest territories (Art. 2), public state property (Art. 27, Para. 3, Item 5), with protective functions (Art. 5, Para. 2).

In 2014, the Executive Forest Agency (EFA) issued special Guidelines for the management of FPFBs (EFA, 2014). They were also reflected in the legislation - the Forest Law and Ordinance No.8 on felling in forests (MAF, 2011). According to them, a separate section for FPFBs was drawn up in forestry plans. Previously, their forested area was distributed by forestry classes with felling age and production purposes analogous to those in forests with timber production functions.

According to the instructions of EFA, FPFBs are subject to annual monitoring. It was carried out through an eye assessment by local foresters, and the belts were defined into three categories according to their condition – good, satisfactory, and poor. The monitoring in 2022 covered almost 93% of all FPFBs in the country. The results showed that 7% of them were in poor condition. There was a serious deterioration of the health of the ash (*Fraxinus* spp.) belts and mass drying in them (Mateva & Kirilova, 2022). This was also confirmed by the research of Dodev et al. (2023).

According to Ordinance No.8 on felling in forests, only technical and sanitary fellings are being conducted in the FPFBs, and only in belts in 'poor' condition, 'when complete or partial felling of the tree stand is necessary'. Field protection belts in 'poor' condition are defined as those 'that do not fulfil their purpose due to the obsolescence of the tree stand, fires, abiotic and biotic impacts, the main species are missing or they constitute less than 50% of the composition, or the health status is poor (defoliation above 60%, crown and stem discoloration above 60%, dieback is above 30% with signs of death, dominant structure completely disturbed below 35%)'.

In addition, technical cuttings for coppice regeneration are admissible in *R. pseudoacacia* belts with seed and mixed origin over the age of 20 years; in *R. pseudoacacia* belts with coppice origin older than 15 years; and in *G. triacanthos* belts over the age of 50 years. In the last few years, however, their coppice regeneration has not given good results. From 2020, partial or complete felling of belts with a predominant tree species of ash with coppice origin older than 30 years was allowed. It was not clear whether these fellings were technical or sanitary.

Sanitary fellings of varying intensity were carried out in cases of deteriorating health conditions. Forced felling was carried out in zones seriously affected by abiotic impacts, mainly fires. Pruning of the branches was allowed in the final rows of the FPFBs to increase air ventilation.

3. Management problems

The following main problems in the management of FPFBs in Bulgaria can be identified on the basis of the experience accumulated over the years:

3.1. Mistakes during afforestation

- Lack of scientific and practical experience in the afforestation and management processes of FPFBs in the first decades of their creation was the reason for making serious mistakes.
- Use of biologically incompatible main and accompanying species, such as *Robinia pseudoacacia* with *Gleditsia triacanthos*; *Fraxinus* spp. with *R. pseudoacacia*, and others.
- Use of species that are ecologically incompatible with the natural conditions of the area – *Populus* spp., *Fraxinus americana*, *Acer negundo*, etc. They are not resistant to adverse climatic conditions, exhibit susceptibility to diseases, and suffer from dieback, and this has a very negative effect on the further functioning of the belt as a technical object.
- Oversaturation of the belts with accompanying species and shrubs, some of which, with their rapid growth at a young age, drowned out the main tree species.

3.2. Management omissions

- Until 1978, timely and systematic fellings were not conducted in a larger part of the FPFBs in order to give the main tree species growth space. As a result, the main tree species were suppressed in some places, and their participation in the composition was reduced. The reasons can be summed up in the fact that the FPFBs were not a part of the forest fund and the forestry department did not manage them.
- Weak intervention (cultivation and sanitary cuttings) in the next 10-15 years. Due to minimal experience, large-scale and sufficiently professional actions were not taken. This had a negative impact on the sanitary condition and the quality of the stand.
- The large participation of accompanying and shrub species, and the failure to carry out thinning activities led to the formation of dense belts with an impermeable structure. They did not allow for the snow to reach more than 10-15 away from the belt, which hindered its distribution on the neighbouring fields.
- Since 2020, there has been a mass drying of *Fraxinus excelsior* FPFBs, probably due to the negative impact of insect pests and/or fungal pathogens.
- The belts planted with *Robinia pseudoacacia* were managed as coppice, in the same way as plantations with timber produce functions, which did not correspond to their main purpose. Most of them were on two or three coppice rotations, resulting in poor growth, reduced vigour, and low height.
- The belts with *Robinia pseudoacacia, Fraxinus americana* and *Ulmus minor* should be gradually reconstructed (cut down and reforested with another suitable tree species) (Dodev et al., 2023).
- The belts with *Gleditsia triacanthos* showed good condition, but after the age of 50, they were cut down and regenerated mostly by coppices, which does not meet the purposes for which they were created.
- There is still a lack of adequate professional and public understanding of the nature and functions of FPFBs, as well as profiled specialists in their management.

3.3. Protection issues

- Unregulated logging – FPFBs near settlements with a concentration of some minority groups were often subject to poaching encroachments. In fact, this is illegal logging, mainly done to meet the need for firewood. Access to the FPFBs is greatly facilitated by the flat terrain and the many field roads, which makes it difficult to protect them.
- The mass burning of stubble and grazing until recently also had a significant negative impact and contributed to the disturbance of the belts.
- Ongoing conflicts with owners and tenants of the bordering agricultural lands.

3.4. Climate factors and changes

- Low amount of precipitation, long periods of drought, and temperature extremes determined the low resistance of the FPFBs.
- These factors worsened the phytosanitary condition and led to the development of a number of fungal pathogens and insect pests.

4. Regulatory weaknesses

- According to Art. 27, para. 3, item 5 of the Law of Forests, FPFBs must be public state property. In practice, however, more than 7% are other property - most often municipal and private on agricultural territories (Dodev et al., 2023). Their borders were changed during their restoration according to the Cadastre of the restored property, and a difference in their width occurred as well. This greatly complicated their management and often lead to absurd situations when conducting forestry activities in them.
- The methodology for annual monitoring of the FPFBs is subjective. It needs to be supplemented and refined on the basis of objective and measurable criteria.
- Lack of a comprehensive concept for management of FPFBs – Ordinance No.8 provides logging mainly in belts in poor condition, as well as logging for coppice regeneration of acacia and sedum belts. For all other types of belts (by tree species and condition) no silvicultural management systems have been developed.

5. Gained experience

Regardless of the stated errors and weaknesses in the creation and management of FPFBs, valuable experience has been gained over the years. Some important aspects of it are:

- Belts in good condition – according to the monitoring from 2022, 65% of FPFBs are in good condition, mainly with *Quercus cerris, Q. robur, Q. rubra* and *Gleditsia triacanthos* (Mateva & Kirilova, 2022).
- In parts of the FPFBs, timely thinning has been carried out, as a result a blowable construction has been achieved. In those where this has not been done, but the main tree species are in good condition, it is possible to improve the construction by thinning.
- Soil preparation for afforestation - the area is characterized by the presence of diverse and lush grass vegetation. To combat it, modern chemical means are effectively used, which are applied at the same time as soil preparation.
- Afforestation methods – when seeding oak acorns, it is good to treat them with preparations against fungal diseases, characteristic of the area. When planting saplings with a tree planting machine, it is necessary to tamp the saplings in order to compact the soil around the root neck.
- Seasons for afforestation – it is preferable to seed acorns in autumn and plant saplings in spring. In Dobrudzha, there are successful afforestations with *Robinia pseudo-acacia* and *Quercus rubra* saplings in autumn as well, but this is not typical and carries the risk of their freezing. Fall afforestation is permissible when a warm winter is forecast.
- Agroforestry – on areas with complete soil preparation, it is recommended that in the first years after afforestation, agricultural activity should also be carried out in the inter-rows.
- Tree species used in FPFBs have different biological characteristics and resistance to environmental conditions and pests. Data and experience accumulated over the years should be taken into account when selecting species for afforestation. The use of seed material of local origin is extremely important. When selecting companions, take into account the experimental schemes implemented in the FPFBs in the area of the Dobrudzha Agricultural Institute near the town of General Toshevo.
- Afforestation schemes – the use of an afforestation machine requires row spacing of 2.3 m. This subsequently enables mechanized cultivation in the inter-rows.
- Cultivation of the young belts in Dobrudzha is carried out by manual hoeing of the rows, while mechanized hoeing is applied in the inter-rows. The number of cultivations is done according to the following scheme: three times for the one-year and two-year belts, and twice for the three-year belts. Belts that fall on the territory of NATURA 2000 are cultivated until the fifth year according to the following scheme: three times for one-year and two-year-olds, twice for three-year-olds and four-year-olds, and once for five-year-olds.
- The local State Forestry and Hunting Enterprises successfully use the financial opportunities of various European and National programmes for the afforestation of FPFBs.

Conclusions

Field protective forest belts are a 'national treasure' with great economic importance and environmental value for the 'granary' of Bulgaria – the Dobrudzha region. In this regard, they are reclamation facilities of national importance. In order to fully fulfill their purpose of protecting agricultural lands and improving soil fertility, constant care for their protection, maintenance and restoration needs to be taken. Their specific agro-technical and reclamation functions require their management to be fully subordinated to the purposes for which they were created. Their structural and functional characteristics depend on the physiological and health condition of the tree and shrub vegetation in them. The increasing age of tree stands, the current mass drying of ash belts, the need to reconstruct large areas of degraded belts and many other problems and challenges require the joining of efforts of relevant decision-makers in forest policy, science and practice. It is necessary to develop a comprehensive programme for the management of FPFBs, including: scientifically based methodology for assessing their structural-functional characteristics and health condition (capacity to fulfill their purpose), which is based on objective and measurable criteria and has a proactive nature; a differentiated approach to their management, which is based on the already accumulated experience and achieved results; and a stable financial mechanism to ensure the necessary complex of forestry activities for the restoration of large areas of degraded belts.

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