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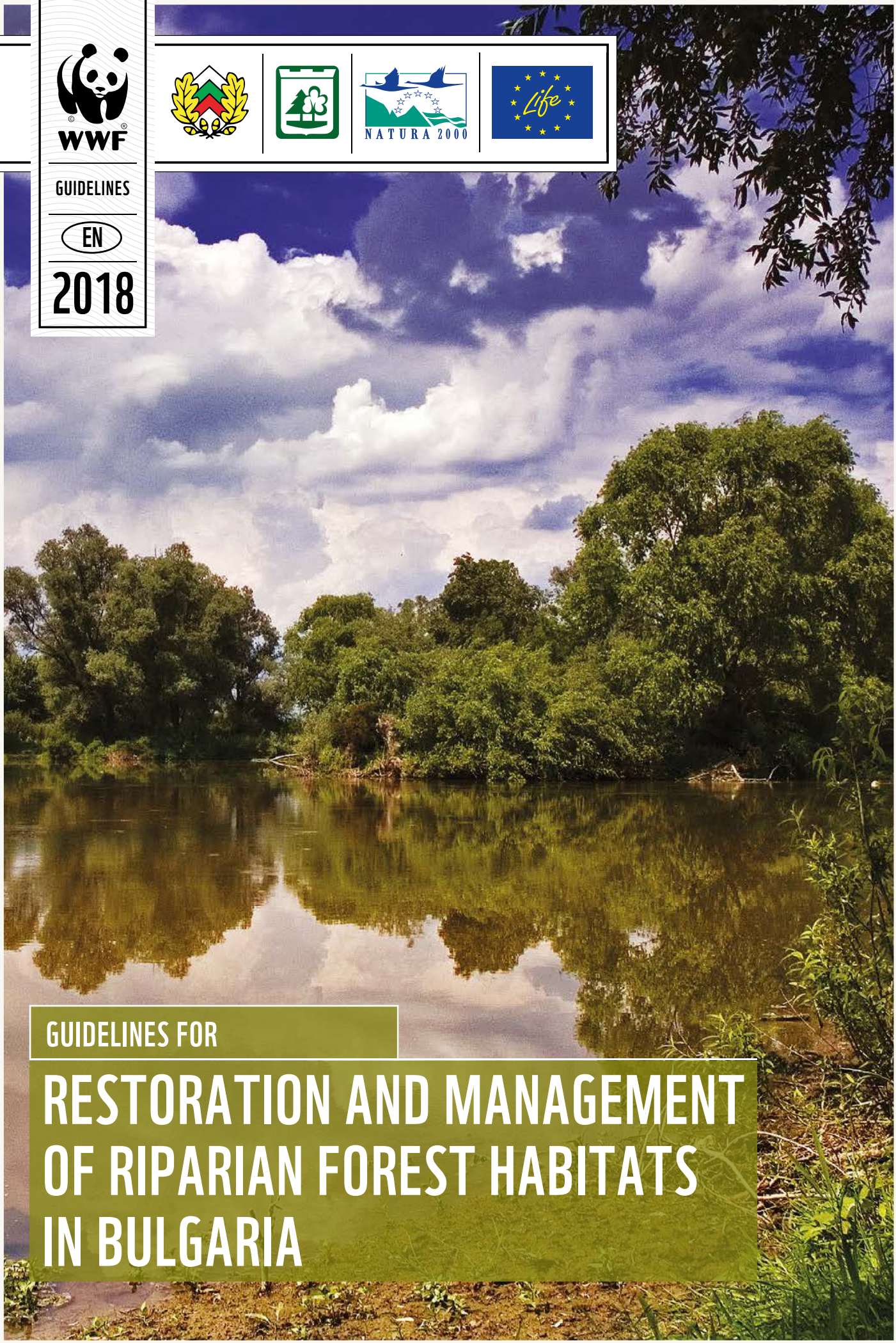

GUIDELINES FOR

RESTORATION AND MANAGEMENT OF RIPARIAN FOREST HABITATS IN BULGARIA

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WWF (World Wildlife Fund) is an international nature conservation organization founded in 1961 and active in more than 100 countries with the support of 4000 employees and more than 5 million volunteers. WWF works for enhancing the condition of the environment so that people can live in harmony with nature. The global priorities of WWF include responsible and sustaina-ble management of forests and water, and finding solutions to pressures and threats posed thereon. In Bulgaria, riparian forests are an important priority for the organization and efforts are being directed towards developing models for their integrated management and conservation, implementation of direct restoration activities, stakeholder capacity and awareness raising, etc.

Sofia, 2018r.

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INTRODUCTION

River valleys have been drawing human attention for thousands of years. The first settlements were established therein and cultural and industrial centers have grown in their environs. Due to their specific location in the transition areas between aquatic and terrestrial ecosystems, riparian forests feature rich biodiversity, both in flora and fauna. They have formed and developed under specific environmental conditions: high humidity furnished by river flows and periodic floods, as well as by high groundwater.

Notwithstanding their extreme importance to river streams and groundwater quality, water balance, riverside protection, borderline plant communities and biological diversity, their current status in most of the country is unsatisfactory. The main reasons for this are the aftereffects of target or elemental human activities: drainage of swamps and marshland; diversion of water-courses; clear-cutting and removal of natural vegetation; change in the land-use pattern in these areas; extraction of aggregates; etc., as well as their improper management: application of inappropriate forestry and agricultural systems and methods of management; use of non-typical alien species in afforestation; induction of unfavourable succession processes with invasive species; etc. Climate aridization and the associated reduction of river flow and groundwater levels are also crucial for the resilience and longevity of these forest populations.

The purpose of these guidelines is to raise the awareness of relevant owners and managers with regard to the special status and particularities of these areas and to assist the experts in the future efforts for restoration and management of riparian habitats.

To avoid conflicting situations and financial losses in the implementation of these activities, environmental benefits should be leading, while taking into account the economic and other in-terests of landowners, as well as ensuring the support of society. This publication also aims to assist the work under projects for restoration and management of riparian forest habitats with an emphasis on preserving the water resources and on ensuring river conductivity and flood control.

This document is of recommendatory nature. Based on the experience gained in the country and abroad, it provides practical guidelines, tailored to the in-country conditions and specifics of the current legislation, which can be applied in the restoration and management of riparian habi-tats, so as to contribute and improve health and to increase the welfare while providing for human demands.

TYPICAL RIPARIAN FOREST HABITATS IN THE COUNTRY

There are 5 types of natural riparian forest habitats within Bulgaria listed in Annex 1 to the Council Directive 92/43 on the conservation of natural habitats and of wild fauna and flora. The description of the relevant types and subtypes of habitats set out in this document is in line with the Red Data Book of the Republic of Bulgaria, Volume 3 (Biserkov et. al., eds. 2015).

91E0* Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno–Padion, Alnion incanae, Salicion albae*)

This habitat includes riparian floodplain forests in lowland and mountainous areas of the country. It develops on rich alluvial soils, periodically flooded by seasonal high flows. The habitat features four subtypes, which are listed in the Red Data Book of Bulgaria as separate types of habitats.

Subtype 1. Riverside woodlands of alder (*Alnus spp.*) and common ash (*Fraxinus excelsior*)

The habitat includes mixed gallery communities with common alder (*Alnus glutinosa*) as the main edificator. In some places edificators and co-edificators are the grey alder (*Alnus incana*), Oriental plane-tree (*Platanus orientalis*) and common ash (*Fraxinus excelsior*). Different willow species, most often fragile willow (*Salix fragilis*) and white willow (*Salix alba*) also take part. This type of gallery forests occurs more often in the low mountain belt and more rarely in the mid-mountain belt.

Riverside woodlands of alder – Matnitza River, Nature Park„Vitosha“

The herbaceous cover most often include *Aegopodium podagraria, Carex remota, C. sylvatica, Circaea lutetiana, Cirsium appendiculatum, Equisetum spp., Filipendula ulmaria, Galium aparine, Ranunculus repens, Rumex sanguineus, Urtica dioica*, etc. The mixed communities edified by common alder in the mountainous areas differ from those in the lowlands and the lower stream sections.

The occurrence of lianas and thermophile species is highly limited in these forests, and the floods are rare and of short duration. In the upper parts of the mountains the common alder is replaced by the grey alder along with some boreal species.

This habitat subtype is distributed fragmentarily along rivers in the foothills and the lower vegetation belt of most mountains in Bulgaria from 300 to about 1000 m of altitude, on damp to wet, sporadically flooded alluvial soils *(Fluvisols)*. Mountainous forests of common alder growing far from rivers and streams occur in limited locations in the Rhodope Mountains (the region of Dospat).

Subtype 2. Mountain Grey alder (*Alnus incana*) galleries

The main edificator of the habitat is the grey alder (*Alnus incana*), and the projective cover of the tree layer is about 60–80 %. In certain places silver fir (*Abies alba*), common alder (*Alnus glutinosa*), silver birch (*Betula pendula*), common beech (*Fagus sylvatica*), common ash (*Fraxinus excelsior*), Norway spruce (*Picea abies*) and other tree species have relatively high abundance in the habitat composition. Among the shrub species, typical are: common hazel (*Corylus avellana*), common hawthorn (*Crataegus monogyna*), *Ribes petraeum, Salix triandra*, black elder (*Sambucus nigra*), rowan (*Sorbus aucuparia*), etc. The projective cover of the herbaceous layer is 40–80 %, with higher abundance of *Impatiens noli–tangere, Oxalis acetosella, Urtica dioica* и *Galium aparine*, and common occurrence of *Aremonia agrimonoides, Cardamine pectinata, Cirsium appendiculatum, Dryopteris filix–mas, Euphorbia amygdaloides, Filipendula ulmaria, Geranium robertianum, Poa nemoralis*, etc. (Dimitrov and Tashev, 2015).

Distribution in Bulgaria: The habitat occurs in most of the mountains from 800 to 1500 m of altitude along rivers on alluvial soils (*Fluvisols*).

Mountain Grey alder galleries - Nature Park "Vitosha"

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Subtype 3. Riverside poplar-willow forests

Main edificators of the habitat are the grey adler (*Salix alba*) and *Salix x rubens* – a hybrid of *Salix alba* and *Salix fragilis*. These are often accompanied by white poplar (*Populus alba*), black poplar (*Populus nigra*) and more rarely by crack willow (*Salix fragilis*), along with single representatives of raywood ash (*Fraxinus oxycrpa*), white mulberry (*Morus alba*), common oak (*Quercus robur*), elms, etc. At places, a shrub layer develops, including *Rubus caesius* var. *aquaticus, Crataegus monogyna, Cornus sanguinea, Euonymus europaeus, Ligustrum vulgare* and rarely *Frangula alnus, Viburnum opulus*. Very often (particularly along the Danube River) the shrub layer is abundant in false indigo bush (*Amorpha fruticosa*). There are also climbing plants – *Clematis vitalba, Humulus lupulus, Vitis sylvestris*. The herbaceous layer includes mainly hygrophytes, nitrophytes and ruderals. The height of this layer can reach 1.5 m and more in sunlit and well-drained places. In the last years there is massive invasion of *Acer negundo* and American neophytes – *Bidens frondosa, Echinocystis lobata, Sicyos angulatus*.

Distribution in Bulgaria: The habitat occurs in Northern Bulgaria, mainly along the Danube River and its islands, as well as in the lower and middle streams of the Danube tributaries, forming small strips dominated by white willow or small spots of white and black poplars, on sandyclayey carbonate alluvial soils (*Calcaric Fluvisols*).

Willow-poplar forests – Nikopol Islands

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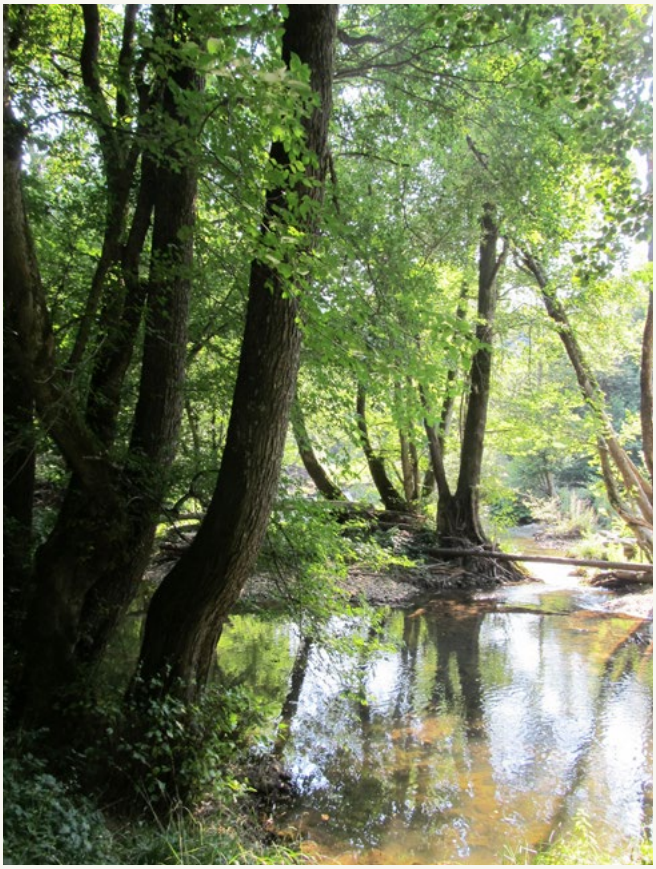
Sybtype 4. Floodplain forests of Common alder (*Alnus glutinosa*)

The main edificator of the habitat is the common alder (*Alnus glutinosa*) with raywood ash (*Fraxinus oxycarpa*) as a sub-edificator in some places. There is no understorey developed, but the phytocoenological shrub layer features solitary shrubs of common dogwood (*Cornus sanguinea*), European spindletree (*Euonymus europaeus*), guelder rose (*Viburnum opulus*) and alder buckthorn (*Frangula alnus*). The herbaceous cover most often consists of *Angelica sylvestris, Carex remota, Circaea lutetiana, Leucojum*

aestivum, Ranunculus repens, Rubus caesius, Rumex sanguineus, Stellaria nemorum, etc. Swamp vegetation with predominance of *Berula erecta, Carex riparia, Iris pseudacorus, Lycopus europaeus, Oenanthe aquatica, Phragmites australis, Scirpus lacustris,* etc. also develops in places where the tree canopy is not very thick.

Distribution in Bulgaria: The habitat has a limited distribution along the lower streams of Black Sea – Mediterranean basin – the rivers of Batova, Kamchia, Ropotamo, Veleka, Rezovska, Tundzha, etc., on alluvial (*Fluvisols*) and marshy meadow (*Mollic Gleyisols*) soils, very humid to overwet, thick, badly aerated, with features of gleying. Quite often it forms complextes with mixed hygrophyte dense forests of the alluvial (longose) type. The total area of the habitat is about 30.000 ha.

Floodplain forests of common alder – Rezovska River



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91F0 Riparian mixed forests of common oak (*Quercus robur*), field elm (*Ulmus laevis*) and common ash (*Fraxinus excelsior*) or *Fraxinus angustifolia* along large rivers (*Ulmenion minoris*)

This habitat consists of mixed lowland and riparian forests, including those in the valleys of a number of large rivers in Bulgaria. The periodic flooding, and in some cases the high atmospheric humidity are typical features. These forests pertain to class *Populetea albae* – orders *Fraxinetalia* and *Populetalia*, and alliances *Alno–Quercion roboris* and *Alnion incanae*. There are three main subtypes.

Subtype 1. Longose forests (association *Smilaco excelsae–Fraxinetum oxycarpae*)

The characteristic appearance of this habitat is featured by the participation of climbing plants with lignified or herbaceous stems – *Calystegia sepium, Clematis vitalba, Hedera helix, Humulus lupulus, Periploca greaca, Smilax excelsa, Tamus communis* and *Vitis sylvestris*. The tree layer includes field maple (*Acer campestre*), common alder (*Alnus glutinosa*), raywood ash (*Fraxinus oxycarpa*), *Fraxinus pallisiae*, white poplar (*Populus alba*), black poplar (*Populus nigra*), common oak (*Quercus robur*, in Strandja Nature Park – *Quercus hartwissiana*), white willow (*Salix alba*), white elm (*Ulmus laevis*) and field elm (*Ulmus minor*). The shrub layer includes *Acer tataricum, Cornus sanguinea, Crataegus monogyna, Euonymus europaeus, Ligustrum vulgare* and *Prunus padus*. The herbaceous cover is of variable composition and includes ruderals, hygrophytes and hygromesophytes; most often the dominant species are *Brachypodium sylvaticum, Galium aparine, Geum urbanum, Poa sylvicola*, etc.

Distribution in Bulgaria: The habitat occurs mainly in places close to the Black Sea, in the valleys of Veleka, Ropotamo, Kamchia, Batova rivers, as well as locally in the Tundzha plain and the Upper Thracial lowland on Quaternery sediments and rich, wet and deep alluvial (*Fluvislols*) and marshy (*Gleysols*) soils. It is pertinent to the transitional continental and Mediterranean climate with mild and humid winters.

Longose forests – Gorna Topchia Reserve

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Subtype 2. Humid lowland oak forests (association *Scutellario altissimae – Quercetum roboris*)

The habitat features multi-layered forests, dominated by common oak (*Quercus robur*) or grayish oak (*Quercus pedunculiflora*) accompanied by climbing plants. The first layer consists of common oak (*Quercus robur*), raywood ash (*Fraxinus oxycarpa*) and *Pyrus pyraster*, with the common oak dominant in height. The second, lower layer, consists of field elm (*Ulmus minor*), Tatarian maple (*Acer tataricum*) and field maple (*Acer campestre*). The shrub layer includes *Crataegus monogyna, Cornus mas, Corylus avellana, Ligustrum vulgare*. The herbaceous cover variably includes: *Anemone ranunculoides, Arum maculatum, Brachypodium sylvaticum, Buglossoides purpurocaerulea, Corydalis bulbosa, Dactylis glomerata, Gagea minima, Galium aparine, Geum urbanum, Isopyrum thalictroides, Physalis alkekengi, Polygonatum latifolium*, etc., as well as some shade tolerant anthropophytes – *Aristolochia clematitis, Calystegia sylvatica, Heracleum sibiricum, Physalis alkekengi, Smyrnium perfoliatum, Urtica dioica.*

Distribution in Bulgaria: The habitat occurs in the Danubian plain and NE Bulgaria (Ludogorie region) up to 40–70 m of altitude on well saturated gravel to sandy alluvial soils (*Fluvisols*) – shallow, but with well-developed humus layer. In the recent past, it had been more widespread in this region, but has been converted into cropland, with only single or group venerable trees preserved.

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Humid lowland oak forests – Genchov Orman Protected Area

Subtype 3. Thracian forests of *Quercus pedunculiflora*

The habitat features limited expanses of lowland riparian forests encompassed by agricultural land. The tree layer is dominated by *Quercus pedunculiflora* and *Quercus robur* (in Strandja – *Quercus hartwissiana*). Often, *Acer campestre, Pyrus pyraster* and *Ulmus minor* also occur, as well as *Fraxinus oxycarpa* – in more humid places, and *Quercus cerris,*

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Thracian forests of Quercus pedunculiflora – PA Gradinska Gora

Tilia spp. and even *Carpinus orientalis* – in drier places. Sometimes there is a second tree layer formed by *Acer tataricum*. The shrub layer features predominance of *Crataegus monogyna, Cornus mas, Corylus avellana, Euonymus europaeus, Ligustrum vulgare, Rosa spp., Sambucus nigra*, and in more humid places – *Rubus spp*. There are also some lianas, such as *Clematis vitalba, Humulus lupulus, Vitis sylvestris*. The herbaceous layer includes many spring-flowering species – *Anemone ranunculoides, Ficaria verna, Polygonatum* spp., *Ranunculus constantinopolitanus, Scilla bifolia, Viola odorata*. Species such as *Arum elongatum, Buglossoides purpurocaerulea, Galium aparine, Geum urbanum, Scutellaria altissima, Smyrnium perfoliatum, Urtica dioica*, etc. also spring up later in the year.

Distribution in Bulgaria: The habitat occurs in the Danubian plain and NE Bulgaria (Ludogorie region) along the lower reaches of Kamichia, Batova, Ropotamo, Dyavolska, Veleka and Rezovska rivers, and to a lesser extent along the middle reaches of Tundzha and Maritsa rivers on wet and fresh rich alluvial soils (*Fluvisols*) and more rarely on clayrich (*Vertisols*) and humusrich (*Chernozem*) soils. Its total area is about 10.000 ha.

92A0 Riparian galleries of *Salix alba* and *Populus alba*

This habitat features riparian forests occurring in the plains and lowlands as narrow strips in the valleys of the larger rivers. The main edificators are white poplar (*Populus alba*), black poplar (*Populus nigra*), white willow (*Salix alba*) and crack willow (*Salix fragilis*). The forest composi-tion also includes common alder (*Alnus glutinosa*) and more rarely field elm (*Ulmus minor*), raywood ash (*Fraxinus oxycarpa*), oriental plane (*Platanus orientalis*) and common oak (*Quercus robur*). Typical for this habitat is the occurrence of climbing plants: hops (*Humulus lupulus*), clematis (*Clematis vitalba, Clematis viticella*), ivy (*Hedera helix*), blackberries (*Rubus* spp.), silkvine (*Periploca graeca*), hedge bindweed (*Calystegia sepium*), wild grapevine (*Vitis sylvestris*).

The shrub-herbaceous layer includes a large number of mobile species and anthropophytes: *Aegopodium podagraria, Aristolochia clematitis, Berula erecta, Bidens tripartita, Bromus sterilis, Chelidonium majus, Galium aparine, Heracleum ternatum, Parietaria erecta, Solanum dulcamara, Urtica dioica*, etc. The willow-poplar galleries in South Bulgaria include more spe-cies of southern origin: *Bryonia alba, Clematis flammula, Clematis viticella, Parietaria erecta, Periploca graeca, Platanus orientalis, Salix xant hicola, Tamarix tetrandra*, etc. (Dimitrov and Tashev, 2015).

Distribution in Bulgaria: The habitat occurs in the most southern parts of the country along the valleys of Maritsa, Tundzha, Struma and Mesta rivers and their tributaries from 50 to 200 m of altitude on rich alluvial soils (*Fluvisols*) periodically flooded in spring for various length of time. Its total area is about 10.000 ha.

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Riparian forests of white willow and white poplar – the Arda River, between Kush Kaya Natural Landmark and Kara Kaya region

92C0 Forests of *Platanus orientalis*

This habitat features riparian forests with the Oriental plane (*Platanus orientalis*) as dominant species. It hosts solitary trees of common alder (*Alnus glutinosa*), common walnut (*Juglans regia*) – of secondary distribution, white willow (*Salix alba*), and at higher altitudes, on the northern slopes of Belasitsa, adjoin the sweet chestnut (*Castanea sativa*), common beech (*Fagus sylvatica*) and hop-hornbeam (*Ostrya carpinifolia*). The herbaceous cover includes predominantly nitrophilic species: *Melissa officinalis, Parietaria erecta (Parietaria officinalis), Urtica dioica* (Gogushev, 2015).

Distribution in Bulgaria: The habitat occurs in South Bulgaria – along the Struma River (southwards of the Kresna Gorge) and its tributaries, the Mesta River (southwards of the village of Gospodintsi) and its tributaries, the Arda River and its larger tributaries, Vacha and Chaia rivers and their tributaries, and the northern slopes of Belasitsa at an altitude of 0-900 m on deep, aerated, rich and moderately wet alluvial soils (*Fluvisols*) and alluvial-delluvial deposits (*Colluviosols)*. Limiting factor for the spread of the plane forests is the temperature, as young seedlings are not resistant to low temperatures and often die. The plane communities usually form narrow strips along the valleys of mountain streams with permanent water flow or on flood cones and ravines with temporary water inflow. Their total area is 556 ha.

Oriental plane forests – Struma River, Yavorov Station

92D0 Southern riparian galleries and thickets (*Nerio–Tamaricetea and Securinegion tinctoriae*)

This habitat features riparian galleries and thickets along permanent or temporary streams and wetlands. Dominant species are tamariks (*Tamarix ramosissima* и *Tamarix tetrandra*), and sub-dominants most often are basket willow (*Salix purpurea*), crack willow (*Salix fragilis*), white willow (*Salix alba*), and in some places – the Oriental plane (*Platanus orientalis*). In the Eastern Rhodope Mountains on thick alluvial deposits along the river valleys of Arda, Krumovitsa, Vurbitsa and Byala Reka the species composition also includes *Alyssum tortuosum, Anchusa officinalis, Artemisia scoparia, Centaurea rutifolia, Chondrilla juncea, Cichorium intybus, Cynodon dactylon, Eryngium campestre, Euphorbia niciciana, Hypericum olympicum, Ononis arvensis, Plantago lanceolata, P. scabra, Salix xanthicola, Salvia tomentosa, Satureja pilosa, Scrophularia canina, Xanthium strumarium*. On sand dunes the habitat includes *Artemisia campestris*. Along the river valley of Struma it features *Artemisia campestris, Artemisia scoparia, Chenopodium botrys, Erianthus ravennae, Scrophularia canina, Xanthium strumarium*, etc. Her-baceous hygrophytes, such as *Elymus repens, Cynodon dactylon, Trifolium fragiferum*, etc. occur fragmentarily in the floodplain terrace of the Danube River.

Distribution in Bulgaria: The habitat occurs along the Danube river valley (*Katinata* Protected Area, near the village of Zagrazhden), the lower reaches of Maritsa, Tundzha, and Struma rivers, in the Eastern Rhodope (along the river valleys of Arda, Krumovitsa, Vurbitsa and Byala Reka) and along the Black Sea coast from 0 to 300 m of altitude, mostly in the widest parts of river valleys with gravel, sand and clay deposits. It also occurs fragmentarily among riparian wood-lands, sometimes having secondary origin. Its total area in Bulgaria is 325 ha.

Southern riparian galleries and thickets – Arda River, between Kush Kaya Natural Landmark and Kara Kaya region

SIGNIFICANCE AND SPECIFIC FEATURES OF RIPARIAN HABITATS

The functional characteristics of riparian habitats are highly dependent on the water balance, as the main factor is the variation of the water level, i.e. the high and low extremes that affect the dynamics of the river flow. The water balance considerably influences the deposition of nu-trients, morphodynamic processes (including soils and sediment dynamics), mechanical pressure on vegetation caused by water, ice, silts and sediments, and the dynamics of plant and animal communities. The height, duration and period of flooding play a decisive role in the develop-ment of watercourse and riparian areas. Long-lasting floods lead to selection among the species which are resistant, tolerant or intolerant to flooding and trigger transition to typical floodplain habitats. In a series of drier years with brief flooding and low water, the succession processes reveal transformation towards drought-resistant plant communities.

Significance of riparian habitats

Notwithstanding the complex effect of rivers on plant communities, the vegetation has a direct effect on the integrity and the specific features of the river systems. In this context, it has a considerable influence, which is mainly expressed in the following major benefits:

- Strengthening of riversides and restraining erosion of waterside areas;
- Acting as a buffer which reduces the amount of deposits drifted in and facilitates their uniform settling;
- Enhancing the surface water infiltration and soil nutrition, thus reducing the peak of high water and contributing to reduce the flow velocity in the watercourse;
- Regulating the evaporation from the land surface and maintaining the groundwater close to the surface;
- Improving the water quality;
- Creating more favorable conditions for a relatively steadier water balance in terms of water quantities and water levels;
- Creating habitats for plants and animals (spawning, feeding, nesting, etc.)

The riparian habitats are:

- A biological and genetic diversity bank for conservation of rare, threatened and endangered species;
- Serving as bio- and migration corridors;
- Producing wood and other important bio-products necessary for the community and the func-tioning of the food chain;
- A source of energy for the animal communities and regulate the flow of light from and to the ambient aquatic and terrestrial ecosystems;
- Enriching the landscape and providing specific conditions and opportunities for recreation, tourism, and educational and awareness-raising programs;
- Increasing the retention capacity of catchment areas to absorb precipitation, and to retain and gradually release it;
- Contributing to limit the clogging of dams and other hydro-technical facilities used for potable water supply, irrigation, energy production, commercial breeding of fish and other aquatic organisms.

Plantations of hybrid poplars

© Alexander Ivanov

Specific features of riparian habitats

The riparian habitats are fragile and relatively vulnerable ecosystems. They are highly sensitive to changes in the hydrological and humidity conditions, and are very susceptible to anthropogen-ic impacts within or adjacent to their localities. Understanding their genesis and specific features is crucial to their preservation and appropriate management. The key features are as follows:

- Riparian habitats generally have three zones, in some cases one or two of them missing (Fig-ures 1 and 2):

Zone 1 – A narrow strip right next to the river bank, which is often a mixture of local tree species, shrubs, semi-shrubs and grasses that have adapted to the specific hydrological conditions. The main role of the vegetation there is to stabilize the riverside, and to provide ecological environment and phyto-material needed for the feeding of many aquatic lifeforms that are the basis of the food pyramid;

Zone 2 – It is much wider than Zone 1 and includes fast-growing trees and shrubs that can withstand periodic flooding. Their function is to extract and retain nutrients and solid sediments from the water. The presence of fallen trees and trunks helps to slow down the water flow. This zone can be managed to produce economic benefits;

Zone 3 – It neighbors cropland and has the task of ensuring surface water infiltration, sedi-ment and nutrient retention and filtration, as well as retention of high tides.

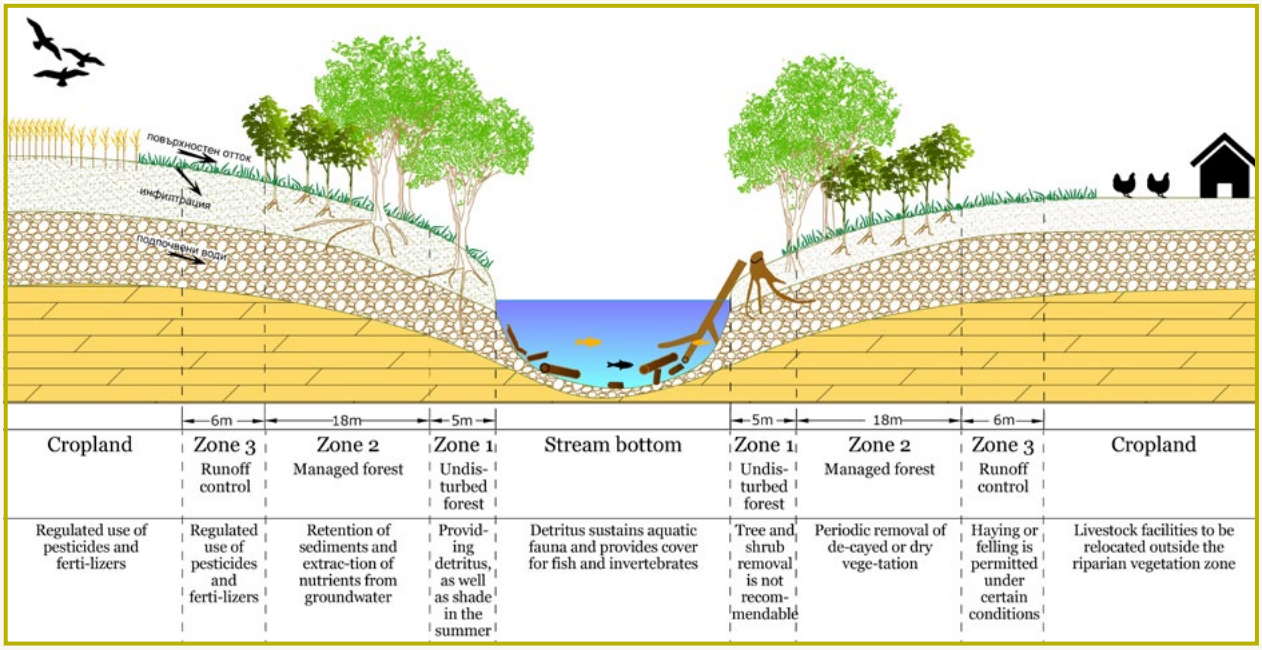

Figure 1. Riparian buffer zoning model and indicative guidelines for its management (adapted from Welsch, 1991).

- Quite often the geological and morphological nature of watercourses is different, which determines the resistance, species composition and dynamics in the riparian communities.
- Most of the riparian habitats are included in protected areas and sites with a specific regime of protection and management regulated by the European and the Bulgarian legislation.
- In most cases the application of traditional practices for management and stewardship of these areas is impossible or restricted.
- Floodplain forests occupy the lowest level in the landscape and integrate processes at the catchment level by collecting plant reproduction material from the entire area upstream. This gives them the role of indicators of the state of the catchment. At the same time, the heterogeneous nature of floodplain forests makes them easy targets for invasion of undesirable species.
- Due to their hydrological regime these areas are attractive in terms of their use for intensive agriculture and forestry.
- These areas can sustain only specific species, which necessitates the maintenance of their natural origin.

Existing and potential threats to riparian habitats

Most of the riparian habitats in the country no longer exist, and some of the existing ones are subject to pressures, which put into question their future survival. The threats are of a different nature and are mainly related to urbanization of the areas, anthropogenic activity and unfavorable climate change towards drought and reduced water flow. The most essential of these are:

- Land use for construction and agriculture;
- Construction of large hydro-technical facilities – dams, HPPs, barriers, etc.;
- Diversion of streams by construction of dams, channels, etc.;
- Extraction of aggregates from the riverbeds;
- Felling of riparian vegetation;
- Failure to undertake actions to limit the erosion in the riverside areas of the hydrographic network;
- Afforestation with non-typical alien species;
- Seizure of the areas by invasive tree, shrub and grass species;
- Intensive and unregulated grazing of domestic and wild animals;
- Climate aridization and change in the water balance;
- Pollution of areas with domestic an industrial waste;
- Excessive removal of vegetation from the riverbeds under the pretext of improving the stream conductivity;
- Water pollution.

THREATS TO RIPARIAN HABITATS – EXCESSIVE CLEARING OF WATERCOURSES UNDER THE PRETEXT OF IMPROVING THE STREAM CONDUCTIVITY

Pursuant to the Water Act, the permanent operational protection against the adverse effects of water includes **maintaining the conductivity of watercourses**. Activities related to riparian forests include: “removal of trees growing in the watercourse; of trunks, shrubs and any trees that have fallen or are in danger of falling down” (Article 140, Para 3, Item 2). Unfortunately, there are several types of issues with the application of these provisions:

1. Clearing of watercourses in the mountain range

Watercourses in the mountain range are relatively narrow and the practice shows that felling of healthy beech and alder trees outside the settlements does not in any way contribute to improving the stream conductivity. On the contrary, the removal of trees that actually strengthen the shores has the opposite effect. A thick shrub layer develops in their place and essentially reduces the stream conductivity. Therefore it is doubtful if the real purpose of such “clearing” is not harvesting of wood. The only clearing justified in the upper water-courses, and yet in rare cases, is the removal of fallen or sloping trees that threaten to deteriorate the conductivity of existing infrastructure – bridges, drainage pipes, etc.

Clearing of watercourses – Stanchevhanska River

2. Clearing of watercourses in the lower and middle stream sections

The relevant issues are related to the cutting of riparian vegetation, in some cases at a dis-tance of up to 500 m from the watercourse, in areas with no dikes. Again, the maintenance of the watercourse conductivity is just a pretext for timber harvesting. Removal of healthy trees often leads to erosion which expands downwards. As a result, the risk of greater dam-age, such as landslides, undermining and collapse of retaining walls, bridges, etc. increases significantly. The global practice to solve these issues is to protect riparian vegetation and even to reinstate it if deteriorated. In Bulgaria, the Water Act also provisions for afforesta-tion as a feasible measure to regulate the flow (Article 117, Para 2, Item 5), and to strengthen the riverbanks and prevent riverside erosion (Article 140, Para 4, Item 3(d)). This provision of the Act has (almost) never been applied.

3. Disposal of branches in the watercourse

Quite often the district administrations responsible for this activity have no means to maintain the stream conductivity and outsource it in exchange of the timber selling. On their part, the contractors are not interested in else than the timber harvest; thus the debris often fall into the watercourse, which practically exacerbates the conductivity issue and creates the preconditions for clogging and formation of "dikes" that burst out with the first more severe torrents.

When it is justified and how to do it:

a) The committees in charge of the activity under the legal provisions shall ensure that trees which have to be removed are marked, instead of clear-cutting the tree vegetation in the relevant stretch of the river;

b) Watercourse clearing outside the settlements is justified when there is a risk to infrastructure – in the case of fallen trees or such in danger of falling down;

c) In rare cases, in river stretches with narrow dikes, the design parameters of the riverbed do not provide for vegetation. The presence of forest vegetation negates the parameters, which could lead to disruption of the dikes.

THREATS TO RIPARIAN HABITATS – DIVERSION AND DIKING OF MIDDLE AND LOWER REACHES OF RIVERS

In the middle of the twentieth century, most of the major Bulgarian rivers were diverted and diked with the purpose of agricultural land expansion and flood prevention. Clear-cutting of the riparian vegetation in the floodplain terraces and removal of vegetation from riverbeds has often been an associated activity to this end. The consequences of this activity are serious and in many cases rather worsen the issues than solve them. The modified streams or stretches are narrower, with increased conductivity, respectively higher flow velocity and higher water levels in the case of flooding. The accelerated flow in turn leads to deepening of the riverbed and changes in the bottom substrate. Thus, intensified erosion increases the water turbidity, effecting pressure on a large part of the aquatic organisms.

In turn, the lack of riparian vegetation in the summer months is associated with increase of the water temperature, reduction in the amount of dissolved oxygen and increased risk for aquatic dwellers. The presence of riparian vegetation is also important for the capture of part of the nutrients that are carried by groundwater.

In view of their stability and security, dikes shall be kept free from shrub and/or tree veg-etation, because they can easily be compromised by the growing root system of some species (poplar, willow) and their integrity can be deteriorated, resulting in a break in the dike and flooding the adjacent territories. The developing vegetation also attracts small mammals that dig holes and tunnels where the water breaks in and forms a suffosion, eventual rupture or collapse of the dike embankment.

Quite a lot of the existing dikes in Bulgaria are not maintained and have overgrown with shrub and tree vegetation. However, many of them continue to perform at least partially their main protective function. This is due to the fact that some shrubs and trees have a shallow root system that does not form as much loose space in the embankment and does not lead to disruption of the dike integrity. If the dikes are already overgrown, removal of vegetation is not recommendable because the mechanical removal of plant roots leads to cracks and holes in the embankment and the risk of downfall or subsidence. Felling of trees is also not a good option for cleaning the dike from vegetation, because the trunk and root system will rot and trigger subsidence processes.

Dike on the Lesnovska River

THREATS TO RIPARIAN HABITATS – EXTRACTION OF AGGREGATES FROM THE RIVERBEDS

Pursuant to the Water Act (Article 118(g), Para 2) extraction of sediment deposits from water bodies, with the exception of the Danube River and the water reservoirs, is prohibited, unless with the purpose of "cleaning of riverbeds from alluvial deposits to ensure their normal conductivity" (Article 140, Para 3, Item 6). Actually, this is a widespread practice af-fecting a number of Bulgarian rivers (e.g. the Maritsa River, the Struma River, the Iskar Riv-er), quite often leading to an overall change in the appearance of many river stretches.

The extraction of aggregates accelerates the erosion processes both on the riversides and on the riverbed and has serious consequences for the aquatic organisms (e.g. direct lethal impact on immobile bottom clingers and slow-moving dwellers, leading to deterioration of the existing food chains).

Due to the fact that rivers and the ambient groundwater are interconnected, any decrease in the river flow level resulting from sinking, which could sometimes reach 5-6 m, leads to a corresponding decrease of the groundwater level, because in this case the river acts as a draining channel. Groundwater lowering results in the riparian tree vegetation drying up and general water scarcity in neighboring cropland, drying of wells, boreholes, etc.

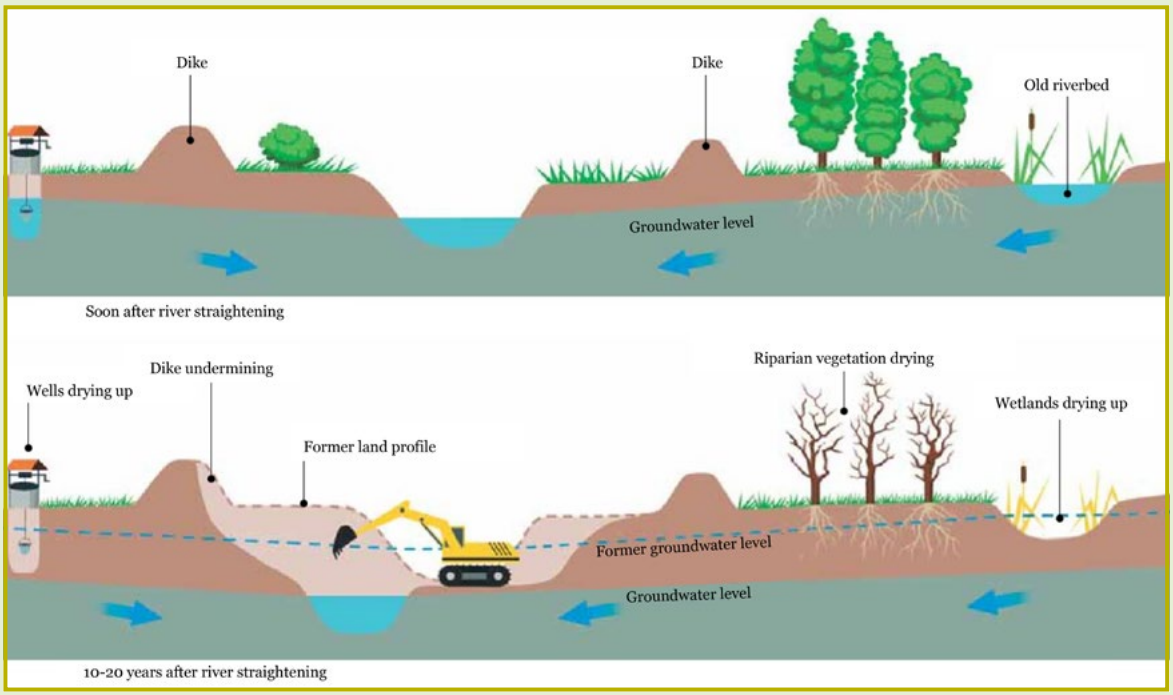

Figure 2: Riverbed lowering as a result of erosion and aggregate extraction
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Legislation related to riparian habitats

- Biological Diversity Act;
- Orders for designation of protected areas and sites of the national ecological network Natura 2000;
- Management plans for protected areas and Natura 2000 sites;
- Ordinance No.18 on the inventory and planning in forest areas;
- Ordinance No.8 on felling in forests;
- Ordinance No.2 on the terms and procedures for afforestation of forest areas and agricultural land used for establishment of special protective and commercial forests in protected areas, inventory of instated plantations, reporting and registering;
- Ordinance No.4 on erosion and torrent control in forest areas and construction of fortifying facilities;
- Regional plans for development of forest areas;
- Forest management plans and programmes;
- A system of procedures and measures for management of forest habitat types under Annex 1 of the Biological Diversity Act;
- The Water Act and associated by-laws;
- Agricultural Land Protection Act;
- Disaster Protection Act;
- Classification scheme of forest habitat types in the Republic of Bulgaria (EFA, 2011).

Specific pressures on riparian habitats

91E0* Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*

- Conversion of wetlands into agricultural areas;
- Replacement of natural vegetation with poplar plantations;
- Unregulated felling and improper implementation of management practices;
- Change in the hydrological regime resulting from construction of infrastructure facilities (small hydropower plants, dikes, roads, drainages, etc.);
- Massive spread of invasive species, which modifies the structure and functions of riparian forests;
- Erosion processes and related changes in the riverside and devastation and emergence of new islands.

91F0 Riparian mixed forests of common oak (*Quercus robur*), field elm (*Ulmus laevis*) and common ash (*Fraxinus excelsior*) or *Fraxinus angustifolia*

- Establishment of arable land;
- Instatement of intensive forest plantations of hybrid poplars;
- Unregulated felling;
- Removal of tree and shrub vegetation from riverbeds;
- Spread of invasive species, leading to irreversible changes in the structure, composition and status of wet longose forests;
- Changes in the water balance resulting from diking, draining and diversion of streams;
- Erosion processes in riverside areas;
- Loss of biodiversity resulting from changes in the water balance and overexploitation of me-dicinal plants;
- High anthropogenic pressure.

92A0 Riparian galleries of *Salix alba* and *Populus alba*

- Afforestation with exotic species and cultivars;
- Inappropriate and unregulated felling;
- Clearing of watercourses;
- Waste disposal and water pollution;
- Invasion of non-typical species (*Acer negundo, Amorpha fruticosa*, etc.);
- Parasitism on trees (by mistletoe and European loranth);
- Conversion of riparian forests into arable land;
- Unregulated grazing;
- Erosion processes in riverside areas;
- Changes in the water balance;
- Unfavourable climatic impacts – natural floods and droughts.

92C0 Forests of *Platanus orientalis*

- Construction of hydrotechnical facilities;
- Unregulated felling;
- Livestock grazing;
- Fires.

92D0 Southern riparian galleries and thickets

- Construction of hydro-ameliorative facilities;
- Diversion of watercourses;
- Extraction of aggregates;
- Cutting and burning of riparian vegetation;
- Grazing.

RESTORATION OF RIPARIAN HABITATS

SOME OF THE RIPARIAN HABITATS ARE IN POOR CONDITION AND SOME ARE PARTIALLY OR COMPLETELY DESTROYED AS A RESULT OF NATURAL CALAMITIES AND MOST BECAUSE OF UNFAVORABLE ANTHROPOGENIC IMPACTS.

In the past, the land use of huge areas has been changed with the purpose of their conversion into agricultural land. The blend of all these reasons has brought the plant communities in the riparian areas and watercourses to a state where they cannot perform their versatile functions. Therefore, urgent actions shall be taken to restore and preserve the still existing ones.

ORGANIZING AND PLANNING - ACTIONS

To implement the restoration and conservation activities in all types of riparian habitats, both specific and general preliminary measures should be taken before the start of activities for achieving the target objectives. These include:

- Identifying the location and the accessibility of the specific area: by map or site visit;
- Identifying the landuse boundaries, the ownership and the size of the area

A large part of the riparian forests within protected areas and sites of the national ecological network Natura 2000 feature boundaries that do not fit the cadastral maps and the maps of restituted property, as well as landuse that differs from their actual designation. The fragmented and inappropriately established ownership of these areas, as well as the issues caused exceedingly by the extraction of aggregates, being the main reason for the watercourse meandering, lead to major problems in the implementation of any activity for restoration and stabilization of the areas of these habitats.

The situation could be clarified with cadastral or forestry maps, property records, etc. To avoid inaccuracies, it is advisable to measure the target area by on site tracking with a GPS device.

- Identifying the habitat type following *the Guide for identification of habitats of European significance in Bulgaria* (Kavrakova et al, eds. 2009);
- Setting out the target objectives, and the methods and ways to achieve them;
- Exploring the habitat type and its specific features

Based on published guides and other supporting literature, as well as on-site visits; ensure good understanding of climatic and vegetative conditions and the type of local vegetation too;

- Identifying the status of the area and its management regimes

  Based on designation orders and management plans (in the case of protected areas and sites), forest management plans and programmes (for forest areas), and other documents issued under the legislation in force concerning biological diversity, environmental protection, water, land management, etc. Account should be taken of the general ban on afforestation of glades and meadows;

- Eligibility check of the activities planned for implementation

  Based on management plans and forest management plans and programmes, and for forest areas that are not designated yet – based on the adopted "Sustainable Forest Management Schemes in Natura 2000" (EFA, 2011);

- Specifying the ways to achieve restoration – either passive or active, or by a combination of both;

- Specifying the site type (if restoring by means of afforestation)

  It should be specified for agricultural land and for forest areas (barrens, areas disturbed by the mining industry, etc., when not defined). This should be undertaken on site in line with the "Instruction for identification and mapping of forest habitat types and determination of the composition of dendrocoenoses" (EFA, 2011) or by correlation of the sites of neighboring forest areas with relatively close features. Any sections with characteristic micro- and macro-depressions and elevations, any sections with intensive erosion processes, occurrence of unde-sirable invasive species, and sites of importance to the flora and fauna should be mapped. The groundwater level (high or low) should be also determined by sight;

- Drafting of a technological plan for afforestation (if restoring by means of afforestation)

  All the attributes should be filled in, and the specific forestry and technological requirements and activities to be carried out should be indicated;

- Drawing up a technological scheme (if restoring by natural regeneration or in combination with human-induced means)

  The methods, seasons and the deadlines for implementing the specific activities should be indi-cated in the scheme;

- Elaborating specialized designs for the construction of hydrotechnical facilities for erosion control (if necessary) – diversion structures, retaining walls, weirs, sills, water inflow or out-flow systems, etc.;

- Drafting of specifications for the assignment of activities (for state and municipal forest administrations), bills of quantity, etc.;

- Award of contracts for the implementation of planned activities

  These should explicitly specify the deadlines for implementation, the results to be achieved, the ways and conditions for accepting the work done, the penalties due, the deadlines for correct-ing any faults and failures, etc.

- Control and monitoring

  It should be undertaken by authorized competent persons during the implementation of the ac-tivities and within a five-year period after their completion. Any findings should be reported in records with prescriptions and deadlines for implementation;

- Taking steps for restored habitats that are in the Natura 2000 network to be listed in by the MoEW.

RESTORATION ACTIVITIES IN THE SPECIFIC TYPES OF RIPARIAN HABITATS

Restoration of riparian habitats can be accomplished by passive or active means, i.e. enhanc-ing the natural restoration processes or by afforestation, or in a combination of both. The choice of restoration method is determined by the state of the habitat, the natural conditions, the avail-able funds, the existing technologies and the workforce that can be employed. The decision is taken by competent experts in the relevant field, considering the provisions of the relevant pro-jects, plans and programmes, and assessing the experience gained and the traditions in the rele-vant regions and areas. The opinions of the owners and local communities are also of particular importance, as well as the evaluation of expected benefits and potential conflicts that could arise as a result of the activities and outputs.

Passive restoration of riparian habitats – by enhancing natural processes

To achieve results to this end, the following separate or complex activities have to be under-taken:

- To create conditions for natural regeneration – removal of sods; loosening in areas without vegetation; creating conditions for abundant fruit-bearing of the key habitat species in place; reseeding, etc.
- To limit grazing practices – by banning, fencing, repellents, placing safety nets or other pro-tective means around the stems of the target specimens of the tree species, limewashing the stumps, etc.
- To remove the invasive species – by cutting or breaking their tops at a height of 30-100 cm. Cutting at the base does not produce good results, for it stimulates the stump sprouting ability.
- To regulate the species composition in restored units by removing undesired undergrowth by cutting or breaking at a height of 30-100 cm.
- To remove competitive vegetation. If necessary, to create conditions for periodic watering.
- If necessary, to take measures to protect the river banks from undermining – by installing di-version structures (of wood, stone, gabion type, etc.), green reinforcement (by willows), shift-ing the erosion base level by construction of reinforcing facilities, minimizing the extraction of aggregates.
- To clean and remove construction and domestic waste.
- To preserve the biotope trees and deadwood.

Active restoration of riparian habitats – by afforestation

Afforestation in the area of Manole

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91E0 Alluvial forests with Alnus glutinosa and Fraxinus excelsior*

Subtype 1. Riparian woodlands of alder (Alnus spp.) and common ash (Fraxinus excelsior)

Habitat edificators and co-edificators are the common alder and, in certain places grey alder, raywood ash, white poplar, elm, oriental plane and common ash. These are also the main species that should be used as keystone species in afforestation. It should be noted that grey alder can be used over 700-800 m of altitude and the oriental plane – in the more southern regions of the country.

Taking into consideration the structure of the existing stands, the most appropriate is the group-mosaic arrangement of the tree species. The stands should preferably be mixed. Where the shores are disrupted or if the riverside has to be strengthened, white willow should be planted in one or two rows along the water edge, as well as crack willow in the middle and upper stream reaches.

Alders prefer to be near running water, which is why the species should be afforested right next to the stream. The raywood and common ash, being more mobile pioneer species, could be arranged outwards of the main stream.

When using a white poplar, it should be placed on small open areas (diameter up to 2 times the height it reaches).

Solitarily or in group, depending on the site conditions, the assemblage may include elms, common walnut, common oak (wet lowland variety), mulberry, wild plum, etc., and in the mid-dle and upper reaches – common beech, silver fir, hornbeam and Turkey oak (on more mesophyt-ic and even xerophytic micro-localities), maple, Norway maple, etc. In sites where the waterlog-ging is longer, the planted saplings could be exposed to the risk of suffocation.

In afforestation of barrens along the watercourses, it is very important to assess their suitability for afforestation, because in some cases there is a close-to-surface layer of solidified clays which impede the development of the root system or contain toxic sediments.

For the restoration of habitats deteriorated by natural factors, complete soil cultivation is inadmissible; patch cultivation (either manual or mechanized) is preferable.

For the restoration of habitats in barrens, cropland and clearings occupied by introduced species – hybrid poplars, false indigo bush, box elder, etc., complete soil cultivation is preferable.

One-year old seedlings (of common an grey alders, raywood and common ashes, oriental plane, white poplar, common oak and the other species) and saplings (of white poplar, willows and oriental plane) should be used for afforestation with single specimens. Seed sowing can be applied for common oak and common walnut, with due protective measures.

The origin of the source reproductive material should correspond to the region of origin where the afforestation will take place.

The following patterns and density rates are recommended for the main species:

- alder – 2.0 (2.5) x 1.0 (0.8) m or 400–500 pcs/dca;
- oriental plane – 2.0 (2.5, 3.0) x 2.0 (1.3, 1.5, 1.6) m or 200–250 pcs/dca;
- elm – 2.0 (2.5) x 1.0 (0.8) m or 400–500 pcs/dca;
- common oak – 2.0 (2.5) x 0.7 (0.8) m or 500–600 pcs/dca;
- common and raywood ash – 2.0 (2.5) x 1.0 (0.8) m or 400–500 pcs/dca.

Where the site conditions are good, a lower density rate should be applied, and in bare areas – a higher one.

The density rates shall be in line with the provisions of Annex 10 to Ordinance No.2. Autumn afforestation with earlier soil cultivation is recommended for sites up to 500-600 m of altitude.

Subtype 2. Mountain Grey alder (Alnus incana) galleries

The main species in afforestation is the grey alder. Concomitant species with single or group contribution are: silver fir, common alder, silver birch, common ash, Norway spruce, etc.

For the restoration of riparian forest habitats destroyed by natural calamities, complete soil cultivation is inadmissible. In these cases, patch cultivation (either manual or mechanized) is rec-ommended.

In barrens and cropland, complete soil cultivation (ploughing and ripping) could be applied. If afforesting deciduous species, one-year old seedlings should be used, and if the species are co-niferous – two-year old seedlings or pitched saplings (2+2; 2+3).

The following pattern and density rate for the main species are recommended:
grey alder – 2.0 (2.5) x 1.0 (0.8) m or 400–500 pcs/dca.

The origin of the source reproductive material should correspond to the region of origin where the afforestation will take place.

The density rates shall be in line with the provisions of Annex 4 to Ordinance No.2.

Around watercourses or small islands and peninsular formations afforestation is applied using "gallery" arrangement of the saplings.

Subtype 3. Riverside poplar-willow forests

The keystone species for the habitat are white willow, crack willow, white and black poplars, which is why these should be the main species for afforestation.

The forest composition may include single trees or groups of common alder, raywood ash, common oak, elms, mulberry, etc.

The species should be arranged in a group – mosaic pattern. The stands should preferably be mixed.

For the restoration of habitats destroyed by natural calamities, complete soil cultivation is in-admissible. One-year old saplings and seedlings should be used in afforestation.

The origin of the source reproductive material should correspond to the region of origin where the afforestation will take place.

The following pattern and density rate for the main species are recommended:

- Willows – 2.0 (2.5) x 1.0 (0.8) m or 400–500 pcs/dca;
- White and black poplars – 2.0 (2.5, 3.0) x 2.0 (1.3, 1.5, 1.6) m or 200–250 pcs/dca;

The density rates shall be in line with the provisions of Annex 4 to Ordinance No.2. Higher density rate should be applied in bare areas.

Where the river banks are disrupted, afforestation could be undertaken with live willow stakes installed into the soil right next to the riverside.

Subtype 4. Floodplain forests of common alder (Alnus glutinosa)

The keystone species of this habitat is the common alder, which makes it the main species in afforestation.

Single specimens or groups of raywood ash could also be employed in afforestation – in sections at a distance from the riverside.

The common alder should be afforested in a linear (gallery) pattern along the watercourse.

For the restoration of this subtype of habitats destroyed by natural calamities, complete soil cultivation is inadmissible; only patch cultivation (either manual or mechanized) should be undertaken. Complete soil cultivation is appropriate for barrens, cropland or clearings that have been afforested with introduced species (Euro-American poplar varieties) or invasive species.

The afforestation pattern for the common alter is 2,0 (2,5) x 1,0 (0,8) m or 400–500 pcs/dca.

The origin of the source reproductive material should correspond to the region of origin where the afforestation will take place.

91F0 Riparian mixed forests of common oak (Quercus robur), field elm (Ulmus laevis) and common ash (Fraxinus excelsior) or Fraxinus angustifolia*

Subtype 1. Longose forests (association Smilaco excelsae–Fraxinetum oxycarpae)

The main species for afforestation are: common alder, raywood ash, white poplar, black poplar, common oak, white willow and field elm, and these are also the keystone species. The stands should preferably be mixed.

When using common alder and white willow, these should be arranged in a linear (gallery) pattern along the riverside, right next to the watercourse.

The common oak should be used singly or in small groups. The raywood ash should be planted in larger groups not so close to the shore. The field elm should be planted in groups in the micro-elevations. The white and black poplars should be afforested in open areas in groups (with a diameter of 2 times the height they reach).

In both the existing habitats and those destroyed by natural calamities complete soil cultivation is not admissible, and patch cultivation could be done by making grids.

Complete soil cultivation can be applied in cropland, barrens and clearings occupied by Euro-American poplar varieties or invasive species.

Afforestation should be with one-year old seedlings of common alder, raywood ash, white poplar, common oak and field elm and one-year old saplings of white poplar, black poplar and white willow.

The following patterns and density rates are recommended:

- common alder – 2.0 (2.5) x 1.0 (0.8) m or 400–500 pcs/dca;
- raywood ash – 2.0 (2.5) x 1.0 (0.8) m or 400–500 pcs/dca;
- white and black poplar – 2.0 (2.5, 3.0) x 2.0 (1.3, 1.5, 1.6) m or 200–250 pcs/dca;
- common oak – 2.0 (2.5) x 0.7 (0.8) m or 500–600 pcs/dca;
- white willow – 2.0 (2.5) x 1.0 (0.8) m or 400–500 pcs/dca;
- field elm – 2.0 (2.5) x 1.0 (0.8) m or 400–500 pcs/dca;

The density rates shall be in line with the provisions of Annex 4 to Ordinance No.2.

The origin of the source reproductive material should correspond to the region of origin where the afforestation will take place.

Autumn afforestation with earlier soil cultivation is recommended.

Subtype 2. Humid lowland oak forests (association Scutellario altissimae–Quercetum roboris)

Typical habitat species are common oak or grayish oak, which should be the main species in afforestation. Single specimens of raywood ash could be planted in unit groups.

In both the existing habitats and those destroyed by natural calamities complete soil cultivation is not admissible; only patch cultivation – in grids.

Complete soil cultivation can be applied in cropland, barrens and clearings of Euro-American poplar varieties or invasive species.

The recommendable patterns and density rates are:

- common / grayish oak – 2.0 (2.5) x 0.7 (0.8) m or 500–600 pcs/dca;
- raywood ash – white willow – 2.0 (2.5) x 1.0 (0.8) m or 400–500 pcs/dca.

The density rates shall be in line with the provisions of Annex 4 to Ordinance No.2.

The origin of the source reproductive material should correspond to the region of origin where the afforestation will take place.

Subtype 3. Thracian forests of Quercus pedunculiflora

The keystone species of the habitat are grayish oak and common oak (in Strandja – *Q. hartwissiana*), which, depending on the site conditions, should be the main species in afforestation. The stand could include single or group field elm, raywood ash (at wetter places) as well as Turkey oak and lime-trees (at drier places).

In both the existing habitats and those destroyed by natural calamities complete soil cultivation is not admissible; only patch cultivation – in grids. Complete soil cultivation can be applied in cropland, barrens and clearings of Euro-American poplar varieties.

One-year old saplings as well as oak seeds should be used for afforestation, with due protective measures against grazing, rodents, etc.

Recommendable density rates:

- oaks – 2.0 (2.5) x 0.7 (0.8) m or 500–600 pcs/dca;
- field elm – 2.0 (2.5) x 1.0 (0.8) m or 400–500 pcs/dca;

The density rates shall be in line with the provisions of Annex 4 to Ordinance No.2.

The origin of the source reproductive material should correspond to the region of origin where the afforestation will take place.

92A0 Riparian galleries of Salix alba and Populus alba

The keystone species of the habitat are white poplar, black poplar, white and crack willows, which should be the main species in afforestation. The common alder could be afforested in galleries (at wetter places), and field elm, raywood ash, oriental plane and common oak – singly or in groups. In both the existing habitats and those destroyed by natural calamities complete soil cultivation is not admissible; only patch cultivation.

Complete soil cultivation can be applied in cropland, barrens and clearings occupied by Euro-American poplar varieties or invasive species.

One-year old saplings should be used, as well as seedlings of poplars and willows.

The origin of the source reproductive material should correspond to the region of origin where the afforestation will take place.

The recommendable patterns and density rates are:

- poplars – 2.0 (2.5, 3.0) x 2.0 (1.3, 1.5, 1.6) m or 200–250 pcs/dca;
- willows – 2.0 (2.5) x 1.0 (0.8) m or 400–500 pcs/dca;
- common alder – 2.0 (2.5) x 1.0 (0.8) m or 400–500 pcs/dca;
- field elm – 2.0 (2.5) x 1.0 (0.8) m or 400–500 pcs/dca;
- raywood ash – 2.0 (2.5) x 1.0 (0.8) m or 400–500 pcs/dca;
- oriental plane – 2.0 (2.5, 3.0) x 2.0 (1,3, 1,5, 1,6) m or 200–250 pcs/dca;
- common oak – 2.0 (2.5) x 0.7 (0.8) m or 500–600 pcs/dca.

The origin of the source reproductive material should correspond to the region of origin where the afforestation will take place.

The density rates shall be in line with the provisions of Annex 4 to Ordinance No.2.

Autumn afforestation with earlier soil cultivation is recommended.

92C0 Forests of Platanus orientalis

The keystone species of the habitat is the oriental plane, which should be the main species in afforestation. Common walnut, and in the region of Belasitsa – sweet chestnut, common beech and hop-hornbeam could be planted singly or in small groups. Common alder and white willow could be planted in galleries right next to the watercourse. The oriental plane should also be planted in galleries.

In both the existing habitats and those destroyed by natural calamities complete soil cultivation is not admissible; only patch cultivation. Complete soil cultivation can be applied in cropland, barrens and clearings of Euro-American poplar varieties.

One-year old saplings as well (white willow) seedlings should be used for afforestation.

The recommendable patterns and density rates are:

- oriental plane – 2.0 (2.5, 3.0) x 2,0 (1.3, 1.5, 1.6) m or 200–250 pcs/dca;
- common walnut – 2.0 (2.5, 3.0) x 2,0 (1.3, 1.5, 1.6) m or 200–250 pcs/dca;
- sweet chestnut – 2.0 (2.5, 3.0) x 2,0 (1.3, 1.5, 1.6) m or 200–250 pcs/dca;
- common beech – 2.0 (2.5) x 0.8 (1.0) m or 600–500 pcs/dca;
- hop-hornbeam – 2.0 (2.5) x 0.8 (1.0) m or 600–500 pcs/dca;
- common alder – 2.0 (2.5) x 1.0 (0.8) m or 400–500 pcs/dca;

The density rates shall be in line with the provisions of Annex 4 to Ordinance No.2.

The origin of the source reproductive material should correspond to the region of origin where the afforestation will take place.

92D0 Southern riparian galleries and thickets (Nerio–Tamaricetea and Securinegion tinctoriae)

Considering the specific features of the habitat and its representative species, the passive (natural) restoration is recommended. With the aim of enhancing the species composition, white and crack willow could be planted in groups or galleries, and in certain places (the river valleys of Struma, Tundzha and Maritsa) oriental plane could also be used.

Patch cultivation should be undertaken in afforestation.

The origin of the source reproductive material should correspond to the region of origin where the afforestation will take place.

Afforestation with typical local species in the area of Gushterova odaya, SCI Maritsa

Management of restored riparian habitats

The success of undertaken restoration activities in riparian habitats is dependent on their proper management and control of processes that directly or indirectly affect their condition and conservation. Climate drought and apparent urbanization pressures represent major challenges to the future survival of these extremely significant ecosystems. In this regard, targeted and timely action is needed towards:

1. Taking care of the passively restored habitats or parts thereof by:

- maintaining a favourable water balance;
- periodic (in 2–3 years) cultivating of young stands by removing any competitive and invasive species and regulating the species composition into the desired direction;
- assisting the regeneration or re-afforesting the unrestored patches;
- taking actions to prevent wild animals grazing in the afforested areas.

2. Taking care of the actively restored habitats or parts thereof by:

- reiterated (2 or 3 procedures) cultivating of stands until the third year of the afforestation by hoeing the plants (in area of 40x40 cm), mowing in-between the rows, and where a complete soil cultivation is applied before the afforestation – discing in-between rows (at a minimum distance of 2,5–3 m between rows);
- replenishing the losses in the stands until the third year;
- watering (if necessary) at least three times in the period June – August;
- removing any sprouts and invasive plants that compete the growth of the afforested plants;
- preserving and tolerating any emerging seedlings and saplings of the main habitat species;
- taking actions to prevent wild animals grazing by fencing, repellents, placing safety nets around each sapling, etc.
- maintaining a favourable water balance;
- maintaining the outmost shore strengthening row of willows by top-trimming;
- undertaking aftercare felling (letting the light in) until the stands develop a good canopy.

3. **Carrying out phytocoenotic monitoring of the habitats;**

4. **Banning and restricting the grazing in the habitats and their neighbouring areas;**

5. **Observing the legal provisions for the area designation and land use change;**

6. **Implementing effective control on felling and on the unregulated extraction of deadwood;**

7. **Carrying out continuous monitoring of the status of restored habitats and undertaking urgent actions, if necessary**

8. **Restricting construction and aggregate extraction in the vicinity of restored habitats;**

9. **Maintaining unevenaged structure of stands.**

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Restored riparian forest on Aleko Island, SCI Marten-Ryahovo

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APPENDIX

GUIDELINES FOR PRODUCING FOREST REPRODUCTIVE MATERIAL OF THE KEYSTONE SPECIES OF RIPARIAN HABITATS

Field maple (*Acer campestre* L.)

Seedlings of field maple are produced in nurseries in lowland, foothill and mid-mountain are-as with rich, deep and fresh soil. The seedlings can tolerate drought to a certain extent, but the production period gets longer.

The seeds exhibit deep physiological dormancy – most apparent as compared to the other maple species. In natural conditions germination usually takes 18 months after ripening. There-fore it is recommendable to gather seeds in physiological maturity (slightly yellow) and promptly plant them after treatment with red lead (minium). When completely mature, the seeds need some 34 weeks of stratification – from the time of gathering to the spring sowing. The stored sowing material should be stratified in a mixed warm and cold pattern – one month at 20–25°C and 4–6 months at 1–5°C, and should be planted in the spring. The seed germination rate is 50–70 %. About 3.000 seedlings could be produced from 1 kg of sowing material. Seeds should be planted in 3 to 5 furrow beds. The sowing rates are: depth of 2–5 cm and density of 3 g or 45 seeds per 1 linear meter. Germination is over in three weeks.

Standard sowing material can be produced in 1 or 2 years. The production rate for 1 linear meter is: 25–30 seedlings in the first year and 20 seedlings in the second year.

Alders (*Alnus sp.*)

Seedlings of alders are produced in nurseries in wet and shadow localities, including in moun-tains.

Sowing should be undertaken in March – April after saturating the seeds in water for 2–3 days; stored seeds should better be stratified for 3–5 weeks at a temperature of 1–5°C. The seedbeds should be covered with fine sand. Most suitable substrate to cover the seeds can be taken from the mountain riversides, rich in fine humus sediments. Sowing should be done at a very shallow depth of 2–5 mm. Mulching should be applied, including a thin (3 cm) layer of fine straw or a special mulching fabric, and then watering at a rate of 4-6 l/m^2. Germination starts in 3–4 weeks.

In the first months, the seedlings are small and grow very slowly. The seedbeds should be weed out and slightly shadowed. Densely planted seedbeds should be thinned out immediately after the massive emergence of seedlings. Standard seedlings with a height of about 40 cm are produced for 1 year. The production rate is: 50–60 pcs per linear meter in the first year, and if the nursing extends to the next year, the number of seedlings is reduced to 18 per linear meter. It is recommendable to grow 60 to 180 seedlings on an area of 1 m^2.

Common alder (*Alnus glutinosa* (L.) Gaertn.)

The germination rate of sowing material varies greatly from 8 to 90%, but in a good year it usually is 60–70% for gatherings in October – December and 25–45% for gatherings in February – March. Some 22 thousand yearlings or 18 thousand biennials can be produced from 1 kg of sowing material. The sowing density rate is 0.1 g or 100 pcs per linear meter.

Grey alder (*Alnus incana* (L.) Moench.)

The germination rate of seeds varies greatly from 10 to 70 %. Although physiological dor-mancy is not commented, certain results demonstrate pre-sowing treatment effects. Without a treatment, the seed germination rate is 28%. Following a cold stratification at a temperature of 5°C for 6 months, it increases up to 35%, and after keeping the stratified sowing material for 3 days at a temperature of –20 °C it reaches 45 %.

Some 31 thousand yearlings or 26 thousand biennials can be produced from 1 kg of sowing material. The sowing density rate is 0.9 g or 120 pcs per linear meter.

Common ash (*Fraxinus excelsior* L.)

Any nurseries (except for those in the high mountains) on deep, rich and fresh soils of lighter mechanical composition are suitable for the production of common ash. However, production operations should take into account the ecotype diversity – dry lowland, plane, or mountainous area.

The seeds exhibit morpho-physiological dormancy. Physiologically mature seeds, treated with repellent after harvesting, should be sown in the first half of September. There are some specific instructions to the warm and cold stratification of seeds sown in spring. The seed moisture content should reach 55-60%. The warm phase at 15–20 °C should last up to 4 months, and the development of germs is monitored by cutting. The warm stratification should be discontinued when the germ grows in length to 80-90% of that of the seed. Afterwards, cold stratification at 3°C is applied for 4 months. The seeds should be saturated in water for 1 hour each week during the warm phase and once every 2 weeks during the cold phase. After stratification, sowing ma-terials could be stored until the time of spring sowing for up to 2 months at –3°C.

After storage, the seeds should be prepared for spring sowing by means of warm and cold stratification for 6–7 months, i.e. 1–2 + 5–6 months respectively.

The germination rate of seeds is 50–90 %. About 5000 yearlings or 4500 biennials can be produced from 1 kg of sowing material.

Seeds should be planted in 3 to 6 furrow beds. The seedbeds should be periodically watered. The sowing rate is: depth of 3–5 cm and density of 2.8 g, or 35 pcs per linear meter.

Standard seedlings can be produced in one year, but their nursing should extend into the sec-ond year, if necessary. The production rate for 1 linear meter is: 25–30 seedlings in the first year and 22 seedlings, if further nursed, in the second year.

Raywood ash (*Fraxinus oxycarpa* Willd.)

Raywood ash seedlings are produced in temperate continental and transitional Mediterranean lowland nurseries on rich, deep and fresh soils of light mechanical composition. The Raywood ash is a thermophilic and hydrophilic tree species.

The germination rate of seeds is 70–90 %. About 5000 yearlings or 4500 biennials can be produced from 1 kg of sowing material. Physiologically mature seeds, treated with repellent af-ter harvesting, should be sown in the beginning of September. For spring sowing, the deep phys-iological dormancy of seeds can be overcome by a warm and hot stratification for 5–6 months (1–2 + 4–5 months). Seeds should be planted in 3 to 6 furrow beds. Standard seedlings can be produced in one vegetation season. The sowing rate is: depth of 3–3.5 cm and density of 2.8 g, or 35 pcs per linear meter.

The seedlings are very similar to those of the common ash and are quite difficult to differentiate. The surest sign is the top bud, which at the end of the first vegetation is brown, and not black, as is the common ash.

The production rate for 1 linear meter is: 25–30 seedlings in the first year and 22 seedlings, if further nursed, in the second year.

White mulberry (*Morus alba* L.)

Seedlings of white mulberry can be produced in any nursery up to 1000 m of altitude.

Parthenocarpy in mulberry fruits is considerable, and therefore in some cases up to 44% of the fruits are seedless. Such fruits feature smaller size. Some varieties of the mulberry are completely seedless.

Prior to harvesting, a check for the presence of seeds in the fruits should be undertaken. When most of fruits have ripened, it is convenient to shake them down on canvas. Fresh fruit could be stored in cold temperatures (3–5 ° C) for up to 2 weeks. The material should be saturated and squashed, as the pulp and empty seeds are separated by flotation. The seeds should then be spread in a thin layer (5–10 mm) to dry in shade, and need frequent stirring. Delays in pro-cessing and long saturation in water result in a rapid reduction of germination. It is recommend-ed that the wet procedures should be completed in not more than 30 minutes. Seed yields are between 2 and 3.5%.

The sowing material features a moderate physiological dormancy that can be overcome by stratification for 30 to 120 days at 1–5 °C before spring sowing.

If sowing is undertaken immediately after the harvest in July, high germination rate (about 75–95 %) can be achieved, but usually only 12 to 50 % of the seeds develop to standard seed-lings.

The sowing density rate is 0.1 g or 40 pcs per linear meter. The sowing depth should be 0.5 – 1 cm. Seedbeds should be mulched and maintained moderately wet until germination, which starts in about 2 weeks.

Seedlings need shading for several weeks after germination. Fungal leaf-spot caused by *Cercospora spp*. and *Mycosphaerella mori* (Fuckel.) E.A. Wolf may cause damage, although it rarely leads to substantial losses. Bacterial leaf-spot caused by *Pseudomonas mori* (Boy. & Lamb.) Stev. is also possible.

About 115 thousand yearlings or 90 thousand biennials can be produced from 1 kg of sowing material.

In principle, yearlings are used for sowing. The production rate for 1 linear meter is: 20–25 seedlings in the first year and 18 seedlings in the second year.

The seedlings develop a very deep and strong central root. Before the seedligs are removed, the roots should be trimmed to a depth of 25 cm. Sharp trimming cylinder should be used.

White poplar (*Populus alba* L.)

Poplars reproduce in natural conditions by seeds, root suckers and stump sprouts.

The seeds of white poplar do not exhibit physiological dormancy and can germinate rapidly at temperatures of 2 to 40°C. The optimal temperature range for germination is 20–30°C, and above 35°C the germination considerably declines. The seeds germinate better in the dark than in the light. Substrates with constant and steady moisture content and a neutral or slightly acid to slightly alkaline pH provide conditions for maximum germination, whereas at high concentrations of salts in the substrate the germination decreases.

For the production of seedlings, it is appropriate to use wide furrows and to put the whole catkins side by side across the furrows and cover them with fine soil. At random sowing, the density rate prescribed is 265 viable seeds per 1 square meter. Thus, some 42–63 seedlings can be yielded from an area of 1 m^2. The small and delicate poplar germs require special care. During the first 3 weeks of germination, appropriate watering is needed, as well as shadowing of 50% intensity rate. The seedlings can be grown in containers of 350–450 cm^3. Sowing should be by hand. The initial nursing for 8–9 weeks is carried out in a greenhouse. For this time the germs grow to a height of 8–10 cm and are transferred outdoors, where their density should be maintained at about 50 pcs per square meter. For one vegetation season the plants reach a height of 60-100 cm and a thickness at the stem base more than 5–7 mm.

White poplar is reproduced most successfully by planting of root cuttings. To yield root cut-tings, stock plants should be established. For the purpose, a plot with relatively light soil should be selected. Root cuttings or seedlings shall be planted and managed for one year or more. In the case of stock plants for yearlings, the seedlings produced from root cuttings can be used for an-nual afforestation. When the seedlings are taken out of the soil, part of their root system is trimmed and the cuttings left from the trimming can be used for another stock plant or new production of seedlings. The stock plant can be multi-annual, if in autumn or in the next spring the roots are trimmed and the stems are cut down. The little stumps thus obtained are pricked out, and this procedure is repeated 2–3 years.

Oriental plane (*Platanus orientalis* L.)

Oriental plane seedlings are produced in lowland nurseries.

The germination rate of seeds often low due to the many empty seeds and varies from 35 to 80% (on average 60%). Around 9000 seedlings can be produced from 1 kg of sowing material.

It is considered that sowing material does not have a physiological dormancy, but a short cold stratification enhances its germination. There are recommendations for stratifying for 2–3 months at 5°C.

Sowing should take place in spring, after the danger of frosts is over, during the first half of April, and in the more southern regions one month earlier, when the air temperature is above 15 °C. The furrows should be at 15-20 cm and about 5 mm deep. The sowing density rate is 60 pcs per linear meter. The seeds should be covered with fine sand. If the moisture is insufficient, the seed plots should be well watered in advance. The seedbed should be kept moist, while prevent-ing soil compaction.

Seedlings suffer from direct sunshine and need shading until forming 4-5 leaves. This period covers the first month of germination. Later in vegetation, watering shall be reduced to 2-3 times a month depending on the necessity. Standard seedlings are usually produced for 1 year and reach a height of over 40 cm. The production is rarely of the 2/0 or 1/1 type. The production rate is 25-30 seedlings per linear meter. When the seedlings are grown for another year, their number is reduced to 20 per linear meter. There are recommendations for trimming the roots in mid-summer, and in some nurseries the tops of the seedlings are pruned in July-August, but it is not recommendable to do both operations in one season.

In our country, vegetative reproduction is implemented through winter stem cuttings in open nursery rows. In the areas envisaged for this purpose, manure (from 3 to 5 tons per decare) and phosphorus fertilizers (at a rate of active substance 6–12 kg per decare) are applied in autumn. Traditionally, deep ploughing is carried out after fertilization.

In spring, the overwintered fallow land is leveled up and surface treatment with a cultivator at a depth of 10–12 cm is applied without turning over the top layer. The sowing pattern in-cludes rows at 60–80 cm in manual processing and at 1.5-1.7 m in mechanized processing, while the cuttings in the rows are at 15-20 cm. Cuttings are planted either by hand or mechanically so that the top is 1 cm beneath the soil surface. Planting of cuttings is undertaken in March – April, and in Northern Bulgaria 1-2 weeks later.

If the moisture is insufficient, the nursery rows are watered until offshoots emerge. In the next period, watering is reduced to 3-4 times per month.

In the course of the vegetation, the rows and the interim lines are repeatedly earthed up and, if necessary, nitrogen fertilizers are applied at a rate of the active substance 5–10 kg/dca, though not later than mid-June. In one year, the saplings reach a height of more than 1 m and are suita-ble for afforestation.

Black poplar (*Populus nigra* L.)

The black poplar is most successfully produced by mature stem cuttings. The production is carried out in lowland and, where possible, riparian nurseries.

The stem cuttings should be 0.8-1.8 cm thick and 20-25 cm long. The cuttings should be smooth, the upper one 2-5 mm above a bud. Each poplar cutting shall have at least 4 buds. High quality cuttings can be produced with an electric cutter, which may yield 4000 cuttings for 8 hours. Cuttings are stored in bundles of 50 pieces each. To preserve their moisture, the bundles of cuttings are put in a superabsorbent solution. During storage, the cuttings should not suffer any freezing or loss of moisture. The open-air deposits represent stabilized and drained traps with a depth of about 2 m.

The outdoor storage is at stabilized and drained traps with a depth of about 2 m. The bundles of cuttings are arranged on rows between layers of sand and topped with a sand layer of about 20 cm. The more consistent alternative for storage options are refrigerators where low positive temperatures and high humidity is maintained. The cuttings may be

stored for up to one month at a temperature of 2–4 °C, and for a longer period of time, a temperature of –4 to –2 °C is recommended.

In conventional practices, main soil cultivation (autumn tilling to a depth of about 30 cm) is carried out in the areas where the nursery rows will be established. In addition, spring milling or cultivation to a depth of 10–12 cm is applied. In the autumn, general fertilizing takes place before tillage, employing manure (3–5 tons/dca) and phosphorus fertilizers (8–15 kg/dca of active substance, i.e. 24–45 kg/dca superphosphate with 33% active substance).

The timeframe for planting the cuttings commences after 1st of March when soils retain a constant temperature of more than 5 °C and when the weather conditions are suitable. Experience has shown that in Southern Bulgaria the appropriate time is until March 15, and for Northern Bulgaria – until April 15. For strict implementation of the planned sowing system, the area is premarked. A row (1.5-1.7 x 0.3-0.5 m) or a double-row pattern is usually applied allowing a higher density rate per unit area. In Bulgaria, a double-row pattern with spacing between the rows of 1.85 m and 0.5 m (between the two convergent rows) is applied. The width of the spacing depends on the available machinery, and where a motor cultivator is used for small plots, it can be just 1 m.

To maintain the turgor of cuttings until their planting, it is advisable to saturate the bundles in an absorbent solution.

The mature stem cuttings should be entirely buried into the soil, with about 1 cm top soil cov-er. Planting is done by hand using a dibble. There are dibbling machines, but investing in such is reasonable when production is quite extensive.

Under normal conditions (temperature around 20 °C and sufficient soil moisture), germination begins 2–3 weeks after planting and offshoots sprout over the soil surface.

The first cultivation care is to remove the leaves at the base while preserving a single offshoot, if more have developed. During the vegetation season, the saplings need to be earthed up several (3–4) times, which is done by hand in the pairs of rows and mechanically in between. Fertilizing with ammonium nitrate at a rate of 20 kg/dca is undertaken twice – in June and July. The fertilizer is dispersed by hand between the two rows or is introduced through a drip irrigation system.

The plots should be watered at each 2–3 days so that the soil maintains 70–80 % of its full water saturation capacity. Drip irrigation (in between the double row) for 8 h per day is most appropriate. The drippers have a flow rate of 2 l/h, and thus the irrigation rate for each sapling is about 16 l. In terms of area, the watering rates start with 50 mm/m² in May and increase to 100–150 mm/m². The watering operations are followed by cultivations to prevent unproductive evap-oration and potential development of weeds. The watering should be concluded until August 15, for the vegetation to end in time, the shoot leaders to lignify and the saplings to be adapted to low winter temperatures.

Offshoot lignifying is aided by phosphorus fertilization with superphosphate, which is introduced during the second half of the vegetation season.

The breaking of sprouts is a specific care for poplar saplings. The purpose is to remove the emerging side branches above the 8-10th leaf (at a height of 70-80 cm). This care is done by hand and before the lignification of offshoots, so that the plant is not impaired. It is repeated 3 or 4 times. The saplings form crowns at a height of 2.5–3 m.

The saplings that have reached the target size are pulled out with a special L-bracket and then stored in pyramids.

Common pear (*Pyrus communis* L.)

Seedlings are produced in lowland and foothill nurseries countrywide.

The fruits ripen from August to October, but are collected in October – November. Any ad-mixtures (twigs, leaves, etc.) and impaired fruits should be removed. Freshly harvested fruits are hard and can endure lengthy transfer and storage for up to 30–40 days. Sowing material can be yielded by hand or mechanical shredding.

The seeds can be sown in autumn until the beginning of winter. They exhibit a physiological dormancy and should be stratified for 60–90 days at a temperature of 2–7 °C in wet sand, if intended for spring sowing.

A very good result is achieved after 3 months of ice bathing. The germination rate is 85 (60–98) %, usually over 80 %. About 15–20 thousand seedlings can be produced from 1 kg of sow-ing material. The sowing rate is: depth of 1–1.5 cm and density of 1.5 g or 50 pcs per linear me-ter.

The germination of pretreated seeds is relatively fast, most active in the second week of the spring sowing, and completes up to the 20th day. During the first year, the seedlings reach a height of about 10 cm. Seedlings are produced for 1 or 2 years. The production rate for 1 linear meter is: 35 seedlings in the first and 25 seedlings in the second year.

Seedlings suffer from powdery mildew caused by *Podosphaera leucotricha* (Ellis & Everh.) E.S. Salmon and root rot.

Common oak (*Quercus robur* L.)

Seedlings of common oak are produced in lowland and foothill nurseries on rich, deep and fresh soils of sandy-clayey mechanical composition.

The years of abundant fruitfulness are relatively rare. Single solitary trees start bearing fruit at 11–13 years of age, and those in stands – at 22–27 years. Most often, however, harvests are yielded by single trees at about 40 years of age, and in stands at about 60–80 years of age. Good harvests are relatively rare – in 4–7 years. Intermediate fruit-bearing may also occur, whereby small batches of good-quality acorns can be harvested.

In harvesting, the acorns damaged by insects and the rotting ones should be avoided. The gnawed fruits usually drop off in the beginning of the dispersal season.

The modern technology of storing acorns includes several phases. The first relates to the cleaning of acorns from admixtures by rinsing in water. The next is the thermal treatment for *Stromatinia pseudotuberosa* Rehm. and represents decontamination of the acorns by their saturation in warm water at 41 °C for 2.5 hours (counted from the time when the relevant temperature is reached). To destroy the larvae of acorn weevil, it is recommended to bathe the acorns in hot water (49 °C) for 40 minutes. Another less desirable practice is the chemical disinfection with methyl bromide, carbon disulfide or bisulfate thiamine.

After removing the acorns from the water bath, they should be dried so as to reach the mois-ture content they had at the time of complete maturity, and then should be arranged in wooden pallets or plastic bins with good aeration where they pass through the tempering phase, staying 2 to 5 days at a temperature of 0–1 °C. Afterwards the acorns should be transferred to refrigera-tors for long-term storage at –1 °C.

This method of storing the oak acorns ensures preservation of their vitality up to 3 years. Be-fore being placed at a negative temperature, the cracked acorns should be removed, as they are vulnerable to freezing (these can be used for autumn sowing). If the acorns are to be used the following spring, storage can be done at 1–3 °C. The overdrying of acorns is detrimental for their vitality – the lethal limit for the species under consideration is moisture of 25–30 % and temperatures below –5 °C. A good practical indication of the degree of dryness is that when staying stratified, the acorns cease to moisten on the surface.

If there are no refrigerators available, some more primitive options may be applied for the acorn storage from autumn to spring. The option for winter storage between well-tight snow layers is difficult to apply because of snow deficiency. A more feasible option is to keep the acorns mixed with pure, coarse-grained wet sand in perforated boxes placed in cool or in trench-es in the open. The trenches should have wooden flooring, drainage runnels, rainfall shelters and air-vents. The appropriate moisture content of the sand is 60 % of its full moisture capacity. For smaller quantities, it is also appropriate to keep the acorns spread between layers of dry oak leaves and wood chips. Periodic checks and aeration of the acorns should be ensured, and the oak leaves should be replaced once in the middle of the period. In all these cases, 10–20 cm thick insulating layers of the relevant substrate should be placed above and below. Initially, the sowing material is camped until the weather is cool enough and is lodged when ambient temper-atures get down to 0–5 °C. When the acorns are laid in layer, it should be not more than 10 cm thick. Measures against mice, squirrels and other rodents need to be taken. The batches should be periodically examined while stirring to ensure aeration and removing the damaged acorns (many of the pests existing at the time of gathering are still inside and the exit holes appear lat-er).

The viability of acorns is about 85 %. Averagely 230 seedlings can be produced form 1 kg of sowing material. The sowing rate is 30 acorns per linear meter.

Oak acorns are sown mainly in the autumn (to avoid their storage) and less frequently in the spring. Sowing is done in patches with the pattern being 30-40 x 25-30 cm, or in seedbeds with 3–4 rows and 20–30 cm spacing between the rows. As regards the depth of sowing, the rule is that larger acorns shall be planted deeper, as well as acorns planted in the autumn.

The following recommendation can be given: in spring sowing the depth should be 4 cm and in autumn – 8 cm. The seedbeds should be mulched, usually with straw. The mulch should be removed in the spring when the first shoots emerge. The seedlings need space to develop, which relates to an average density of 100–160 pcs/m^2.

The germination is hypogenous. Primary leaves are sequentially arranged and resemble a lot to typical ones. Important features are the stalk length and thickness, its pubescence, and the primary leaves.

The seedbeds should be weed out and loosened, and watering is applied if needed – usually 1–2 times during the vegetation.

The production period is 1 year, as the oaks develop a deep, central root. Biennial seedlings can also be produced. For this purpose, early in the spring, the roots should be trimmed with a tractor clamp at a depth of 18–20 cm. After trimming, the seedbeds should be well watered for the soil to settle.

The production rate per 1 linear meter is: 25 seedlings in the first and 20 in the second year.

Prior to being taken out, the seedlings should be trimmed at a depth of 25–30 cm.

White willow (*Salix alba* L.)

The white willow bears fruit regularly and abundantly. It matures and disperses its seeds during the spring and early summer, in June. It can be reproduced by seeds, but seedlings grow slowly and therefore this method is only used for the purposes of selection.

Much faster and more successful is the vegetative reproduction by rooting of stem cuttings. This is implemented by the same methods used for the production of black poplar saplings.

Elms (*Ulmus sp.*)

Elm seedlings are produced in lowland nurseries on lighter, well-aerated, deep and rich soils.

Sowing should be undertaken immediately after the harvesting of seeds (at the latest 4-5 days thereafter) in raised seedbeds with 2 or 3 furrows. The sowing should be shallow – at 5 mm. After soil rolling, the seed beds should be mulched and watered daily until the germination (about 1 week), and afterwards – as needed. With the emergence and strengthening of the germs the mulch from the seedbeds should be gradually thinned and removed.

Vegetative reproduction is achieved by using green stem or root cuttings. Green cuttings are harvested by young (1–3 year old) donors. Entire offshoots of yearlings are suitable for the pur-pose.

The cuttings should be 5–10 cm long. When adult donors (30–40 years of age) are cloned, exogenous Auxin IBA should be applied at a concentration of 100 mg/l or phytostim in concentration of 200-300 mg/l. The cuttings should be planted at a density rate of 10x10, 10x5 or 5x5 cm. The substrate to be used is washed river sand, perlite or a mixture of sand and perlite in the ratio 3:1. Air humidity of over 80%, ambient temperature of 25-30 °C and soil temperature of 18-25 °C should be maintained. Rooting is over in 21-25 days and exceeds 90%. In cold PE greenhouses in the lower altitudes, such conditions are most often achieved in late May – early June.

The roots removed in the root trimming of seedlings are typically used as a source material in the rooting of root cuttings. This is implemented in the nursery, and stock plants are more rarely used. The cuttings should be 7–8 cm long and 6–12 mm thick at the top end. They should be planted in nursing rows at 10–12 cm distance, and the space between rows should be 80–120 cm. Watering should follow immediately after planting. In 20–25 days, a lot of offshoots will emerge in the form of a ring. When these reach 20-25 cm in height, only one should be left, and the excess should be removed by cutting.

The roots develop 15-20 days after the offshoots, and during this period another watering should be carried out. The following aftercare is traditional. For one year the saplings reach a height of 100–150 cm. It is possible for the saplings to be left for another vegetation, in which case at the beginning of the second year they should be stump-trimmed and used as large-sized saplings of the 2/1 type (two-year root, one-year stem). After the emergence of the new off-shoots the excess should be removed.

Before being taken out the saplings should be pruned to leave the central offshoot only.

White elm (*Ulmus laevis* Pall.)

The germination rate of sowing material is 45–65 %. In average, 35 thousand yearlings or 30 thousand biennials can be produced from 1 kg of sowing material. The sowing density rate is 0.6 g or 80 pcs per linear meter.

Field elm (*Ulmus minor* Mill.)

The germination rate of sowing material is usually 25–30 %, and when the seedless fruits are removed it increases to 60–90 %. In average, 30 thousand yearlings or 26 thousand biennials can be produced from 1 kg of sowing material. The sowing density rate is 0.6 g or 60 pcs per linear meter.

The production rate for 1 linear meter is 30 seedlings in the first year and 20 in the second year.

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