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INTERPRETATIVE MANUAL OF EUROPEAN RIPARIAN FORESTS AND SHRUBLANDS

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EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

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Preface

Riparian ecosystems comprise the physical environment and biological communities that lay at the interface of freshwater and terrestrial systems. They are recognised as ecosystems that are highly diverse and contain specialist ecological communities, as well as providers of multiple ecosystem services. Throughout European history, riparian areas have been heavily utilized and have consequently experienced widespread degradation. The protection and restoration of these transitional socio-ecosystems represent an effective way, in both monetary and spatial terms, of synergistically addressing current international ambitions. For instance, functional riparian zones increase the regional biodiversity, water quality, carbon storage, and landscapes resilience to climate change and associated hydrological impacts. At a global scale, protecting and restoring the functionality of riparian ecosystems contributes to the achievement of several United Nations (UN) Sustainable Development Goals (e.g., SDG 6, 15) and to strategy launched by the UN Decade on Ecosystem Restoration 2021-2030. It also contributes to transnational, national, and regional initiatives and policies (e.g., the European Green Deal and Biodiversity Strategy 2030 or EU Water Framework Directive [WFD]).

Recognition of the importance of riparian ecosystems has resulted in much research within Europe. The majority of this research has focused on riparian vegetation, as plant communities are the main structural component of riparian ecosystems and thus their composition, structure, function and change provide useful information on the underlying processes in the fluvial system. Additionally, riparian vegetation is a reliable tool for monitoring riparian ecosystems state and their related services. Despite this body of work and policy motivation, progress for improving the state of riparian ecosystems across Europe has been very limited. This is probably because of a misalignment of ‘frames’ (i.e., the ways in which individuals or organisations with different backgrounds, geographical origin, cultural contexts, or purpose, know of and conceive such complex systems).

Specific issues related to the misalignment of frames between the stakeholders in riparian research and the management are the following ones: (i) the wide geographical dispersion and heterogeneity of current knowledge across EU Member States with different environmental and socioecological contexts, which limits comparability and transferability of results from place to place; (ii) a lack of effective communication and sharing of knowledge among scientists from different disciplines and from different countries, who generally work in relative isolation; (iii) insufficient and problematic knowledge conversion and experiences sharing from academics to managers/practitioners; (iv) a lack of development and use of integrated assessment indicators that allow comparability between fluvial systems; (v) insufficient momentum behind the body of research to create effective coordinated action or policy creation at the level needed to improve riparian ecosystems within European landscapes. As a result, riparian vegetation remains marginal in environmental policies and management tends to be focused on the control of riparian ecosystems (for example prevention of vegetation regeneration) than recovering appropriate levels of functioning. Significant challenges therefore remain for riparian ecosystem management.

In 2017, a European network dedicated to riparian vegetation was launched through a COST Action grants (the network is named CONVERGES “knowledge conversion for enhancing management of European riparian ecosystems and services”; https://converges.eu/) to address gaps in knowledge sharing and conversion. COST framework is a European mechanism that supports collaborative transnational activities under a system of networks of investigators, connecting research initiatives, but also promoting links with non-academic partners (public administration, private enterprises, NGOs) to extend the research impact to the whole society across and beyond European countries.

The overall aim of CONVERGES Action COST is to create a European network to bring together the diverse body of knowledge that exists across Europe of all the aspects of riparian vegetation (i.e., physical processes, ecological functioning, social issues, management and restoration practices). An additional aim is bringing the focus to riparian vegetation, a key element of the landscape that has been neglected by EU policies. The network structure covers a diversity of environmental and social contexts by explicitly promoting participants inclusiveness and transdisciplinary initiatives, having 39 countries represented in the network.

The following book is undoubtedly a significant contribution to the objectives of the COST Action CONVERGES. As part of the Action, experts working on vegetation have joined forces to produce a description of the alliances appearing in Europe’s riparian areas. This handbook also gives elements concerning species composition, ecology and management, distribution, conservation status, threats to biodiversity and challenges, etc. The book perspective is clearly to establish a bridge between the principles of phytoecology and the current management and restoration needs in riparian ecosystems. It thus offers a crucial contribution to the establishment of reference conditions, which is a critical information for river, forest and nature conservation managers. In short, a masterpiece to improve the knowledge and the pan-European management of riparian areas.

Simon Dufour and Patricia María Rodríguez González
Chair and Vice-chair of the COST Action CONVERGES

INTRODUCTION

This paper comprises an overview of the riverine, swamp, floodplain forests and scrub throughout the continent. The team of researchers from various European countries has considered most of the forest habitats from the Canary Islands to European Russia. It was a difficult task to gather all the knowledge about this type of vegetation across the continent as there are different approaches to the study and elaboration of forest vegetation and the level of knowledge also varies. The backbone of the whole presentation is the work of Ladislav Mucina, a collaborator from 2016, who prepared the list of European alliances and in this way also prepared an overview of the river, swamp and floodplain forests and shrublands. We have considered this list and prepared the description of the majority of the forests and shrublands from the list. Unfortunately, we did not manage to cover all forests included in the list.

The preparation of this paper was supported by the COST Knowledge conversion for enhancing management of European riparian ecosystems and services (CONVERGES), which received financial support from the EU. The project itself was led by Simon Dufour of the University of Rennes and co-supervised by Patricia María Rodríguez-González of the University of Lisbon. This review is the result of WP1 led by Marta González del Tánago from the Politechnical University of Madrid. We owe special thanks to the leader of our subgroup, Dejan Mandžukovski of the Macedonian Forest State Agency, for his efforts in organizing our work. We also owe thanks to all our leaders for organizing this activity, inviting us to participate and leading us to the successful completion of this project. We enjoyed our friendship by sharing our experiences and knowledge about forests and preparing the results, including this book. Many thanks to all of you!

In this booklet we give an overview of the forests and shrublands along European rivers, in their surroundings, on river islands, in depressions and oxbows. These forests are subject to constant change and are maintained by periodic/regular flooding or high groundwater. We call them paraclimatic because they are maintained by occasional catastrophes caused by water. We may find one type of forest in one place, but after a flood it may move to another place the next year. Erosion and sedimentation, the destruction of the vegetation and new establishment alternate. We should keep in mind that these forests also contain different biota. They are very rich and dynamic ecosystems. We can admire this eternal dynamism of life caused by water and we should be aware that these ecosystems are endangered and need to be protected.

Human impact on these ecosystems is quite extensive, as most habitats along rivers were converted to agricultural land or urbanized long ago. In addition to drainage, these habitats are also threatened by hydropower construction, river bank stabilization and regulation, gravel mining, groundwater extraction, and other pressures. These habitats are also among the most vulnerable to invasion by alien and invasive species because water flow is an effective vector for their spread. We find many invasive species in these habitats, such as *Acer negundo, Helianthus tuberosus, Impatiens glandulifera, Rudbeckia laciniata, Solidago canadensis, Echinocystis lobata, Bidens frondosa, Deutzia scabra* and many others. These are the reasons why many of these habitats are listed

in Annex I of the Habitats Directive (Natura 2000), such as 3230 - Alpine rivers and their ligneous vegetation with *Myricaria germanica*, 3240 - Alpine rivers and their ligneous vegetation with *Salix eleagnos*, 91E0 - Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*), 91F0 - Riparian mixed forests of *Quercus robur, Ulmus laevis* and *Ulmus minor, Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (*Ulmenion minoris*). There are many more types listed in the Annex I of the Habitats Directive: 92AO - *Salix alba* and *Populus alba* galleries, 91BO - Thermophilous *Fraxinus angustifolia* woods, 9280 - Riparian formations on intermittent Mediterranean water course with *Rhododendron ponticum*, *Salix* and others, 5230* - Arborescent matorral with *Laurus nobilis*, 92CO - *Platanus orientalis* and *Liquidambar orientalis* woods (*Plantanion orientalis*), 92DO - Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*), 4080 - Rhodope *Potentilla fruticosa* thickets.

We have treated the riverine, swamp and floodplain forests and scrubs in order as they were listed in the already mentioned list of European vegetation. The riverine, swamp and floodplain forests and scrub are divided into five groups: riverine gallery and floodplain forests (***Alno glutinosae-Populetea***), willow and tamarisk forests and scrub (***Salicetea purpureae***), regularly flooded alder carrs and birch wooded mires (***Alnetea glutinosae***), scrubby willow carrs (***Franguletea***) and circum-Mediterranean and Macaronesian riparian scrub (***Nerio-Tamaricetea***).

The overlook begins with the class ***Alno glutinosae-Populetea albae*** P. Fukarek et Fabijanić 1968. These forests occur under periodic or temporary flooding or are, occasionally, under high groundwater. Within this group we classify forests occurring on shallow gravel of the upper reaches, forests along small watercourses, and forests on river sediments in the lower reaches of rivers and forests occurring on the margins of swamps.

Further division of this group shows that these forests appear in two biogeographical regions. ***Populetalia albae*** Br.-Bl. ex Tchou Yen-Tcheng 1949 presents Mediterranean and sub-Mediterranean gallery and floodplain forests, whereas forests from temperate and boreal regions are classified within ***Alno-Fraxinetalia excelsioris*** Passarge 1968.

The Mediterranean and sub-Mediterranean forests of ***Populetalia albae*** are composed of two major groups. In western Mediterranean, we can find: riparian forests of the sub-Mediterranean regions of the southern France and Iberian Peninsula (***Populion albae*** Br.-Bl. ex Tchou Yen-Tcheng 1949), riparian forests of the sub-Mediterranean regions of the northern and central Apennines (***Ligustro vulgaris-Alnion glutinosae*** Poldini, Sburlino et Venanzoni in Biondi et al. 2015), alder and willow riparian forests of the western Mediterranean (***Osmundo-Alnion glutinosae*** (Br.-Bl. et al. 1956) Dierschke et Rivas-Mart. in Rivas-Mart. 1975) and south Iberian Mediterranean riparian forests with relict laurisilva elements (***Rhododendro pontici-Prunion lusitanicae*** A.V. Pérez, Galán et Cabezudo in A.V. Pérez et al. 1999). In the eastern Mediterranean, we can find: Platanus riparian gallery forests of the eastern Mediterranean (***Platanion orientalis*** I. Kárpáti et V. Kárpáti 1961) and riparian gallery forests with relict laurisilva elements of the eastern sub-Mediterranean regions of the Apennine and Balkan Peninsulas (***Lauro-Fraxinion angustifoliae*** I. Kárpáti et Kárpáti 1961).

The temperate and boreal group of forests ***Alno-Fraxinetalia*** is composed of alder-ash and oak riparian floodplain forests on nutrient-rich alluvial soils in the nemoral zone

(***Alnion incanae*** Pawłowski et al. 1928), alder, ash and birch floodplain forests along streams of the Cantabrian region of the Iberian Peninsula (***Hyperico androsaemi-Alnion glutinosae*** (Amigo et al. 1987) Biurrun et al. 2016), elm-ash and oak riparian floodplain forests on nutrient-rich brown soils in the nemoral zone of Europe (***Fraxino-Quercion roboris*** Passarge 1968, alder-oak riparian floodplain forests on nutrient-rich alluvial soils of the temperate regions of the Balkan Peninsula (***Alno-Quercion roboris*** Horvat 1950) and oak-elm riparian floodplain forests on nutrient-rich alluvial soils in the steppe zone of southern Russia (***Poo angustifoliae-Ulmion laevis*** Golub in Golub et Kuzmina 1997).

The next group encompasses willow and tamarisk scrub and low open forests of riparian habitats in the temperate to arctic zones (***Salicetea purpureae*** Moor 1958), being divided into three subgroups as: willow scrub and low open forests of riparian habitats in the temperate to arctic zones of Europe (***Salicetalia purpureae*** Moor 1958), tamarisk riverine scrub of the lowland rivers of the Balkan Peninsula and the Sarmatian region of southern Ukraine and Russia (***Tamaricetalia ramosissimae*** Borza et Boşcaiu ex Dolţu et al. 1980) and willow woodlands on silt-rich alluvia, recent landslides and in beds of irregular streams of Madeira and the Canary Islands (***Rubo bollei-Salicetalia canariensis*** Rivas-Mart. in Capelo et al. 2000).

Willow scrub and low open forests of riparian habitats in the temperate to arctic zones of Europe (***Salicetalia purpureae***) can further be divided into willow scrub on the gravelly stream banks in the submontane to subalpine belts of the temperate and boreal European mountains and the Caucasus (***Salicion eleagno-daphnoidis*** /Moor 1958/ Grass 1993), willow and poplar low open forests of lowland to submontane rivers alluvia in the nemoral zone and at high altitudes of the Mediterranean (***Salicion albae*** Soó 1951), willow scrub on loamy-sandy sedimentary river banks in the lowland to submontane belts of the nemoral zone (***Salicion triandrae*** T. Müller et Görs 1958), willow scrub on riverine dunes of Central Ukraine (***Artemisio dniproicae-Salicion acutifoliae*** Shevchyk et V. Solomakha in Shevchyk et al. 1996), western Iberian thermo- to supra-Mediterranean riparian alluvial willow scrub on the alluvia of mineral-poor rivers (***Salicion salviifoliae*** Rivas-Martinez et al. 1984), eastern Iberian thermo- to supra-Mediterranean riparian alluvial willow scrub on the alluvia of mineral-poor rivers (***Salicion discolori-neotrichae*** Br.-Bl. et O. de Bolòs 1958 corr. Rivas-Martinez et al. 2002), Cantabrian sub-Mediterranean montane pioneer willow scrub on the alluvia of mineral-poor rivers (***Salicion cantabricae*** Rivas-Martinez, T.E. Díaz et Penas in Rivas-Martinez et al. 2011), southern Iberian, Maghrebinian and Calabro-Sicilian thermo- to supra-Mediterranean riparian alluvial willow scrub on the alluvia of mineral-poor rivers (***Salicion pedicellatae*** Galán de Mera et al. in Pérez Latorre et al. 1999), Apennine sub-Mediterranean submontane-montane pioneer willow scrub on gravel alluvial riverine terraces (***Salicion apennino-purpureae*** Biondi et Allegrezza in Biondi et al. 2014).

Tamarisk riverine scrub ***Tamaricetalia ramosissimae*** can be further divided into tamarisk riverine scrub on coarse gravelly soils on lowland river banks of the western regions of the Balkan Peninsula (***Tamaricion parviflorae*** I. Kárpáti et V. Kárpáti 1961) and tamarisk riverine scrub on coarse gravelly soils on lowland rivers banks of the eastern regions of the Balkan Peninsula and the Sarmatian region of Southern Ukraine and Russia (***Artemisio scopariae-Tamaricion ramosissimae*** Simon et Dihoru 1963).

Willow woodlands of Madeira and the Canary Islands ***Rubo bollei-Salicetalia canariensis*** contain only a single group (***Salicion canariensis*** Rivas-Mart., Wildpret, Del Arco,

O. Rodríguez, Pérez de Paz, García Gallo, Acebes, T.E. Díaz et Fernández-González ex Rivas-Martinez et al. 1999).

The third group encompasses mesotrophic regularly flooded alder carr and birch wooded mires (***Alnetea glutinosae*** Br.-Bl. et Tx. ex Westhoff et al. 1946) encompassing mesotrophic regularly flooded alder carr (***Alnetalia glutinosae*** Tx. 1937), basiphilous birch forests on mesotrophic mires (***Salici pentandrae-Betuletalia pubescentis*** Clausnitzer in Dengler et al. 2004) and acidophilous birch forests on mesotrophic mires (***Sphagno-Betuletalia pubescentis*** Scamoni et Passarge 1959). As the overview does not deal with mire vegetation, we present only the mesotrophic carr.

Mesotrophic regularly flooded alder carr (***Alnetalia glutinosae***) is divided into mesotrophic regularly flooded alder carr (***Alnion glutinosae*** Malcuit 1929) and amphiadriatic mesotrophic interdune and karstic ash carr (***Frangulo alni-Fraxinion oxycarpae*** Poldini, Sburlino et Venanzoni in Biondi et al. 2015).

The fourth group presents the willow carr of western Europe, Fennoscandia and the subatlantic regions of central Europe (***Franguletea*** Doing ex Westhoff in Westhoff et Den Held 1969) with only one subgroup ***Salicetalia auritae*** Doing 1962, that is further divided into willow carr of western Europe and the sub-Atlantic regions of central Europe (***Salicion cinereae*** T. Müller et Görs ex Passarge 1961) and alder-willow carr in the boreal zone of Fennoscandia and northern Russia (***Alno incanae-Salicion pentandrae*** Kielland-Lund 1981).

The last group encompasses circum-Mediterranean and Macaronesian riparian scrub (***Nerio-Tamaricetea*** Br.-Bl. et O. de Bolos 1958) with only one subgroup (***Tamaricetalia africanae*** Br.-Bl. et O. de Bol**ò**s 1958). It can be divided into two parts. Western-Mediterranean communities can be classified within infra- to supra-Mediterranean tamarisk riparian scrub in temporarily flooded brackish habitats (***Tamaricion africanae*** Br.-Bl. et O. de Bolòs 1958), infra- to supra-Mediterranean tamarisk riparian scrub in temporarily flooded brackish habitats (***Tamaricion boveano-canariensis*** Izco et al.1984), thermo- to supra-Mediterranean oleander riparian scrub (***Rubo ulmifolii-Nerion oleandri*** O. de Bol**ò**s 1958) and Luso-Estremadurean (Iberian Peninsula) thermo-mesomediterranean riparian thorny tamujal (***Securinegion tinctoriae*** Rivas Goday ex Rivas-Martinez 1975). In the eastern Mediterranean, we can find thermo-meso-Mediterranean tamarisk scrub of the Balkan Adriatic seaboards (***Tamaricion dalmaticae*** Jasprica in Jasprica et al. 2016).

The present overview does not encompass some habitats due to unclear classification or lack of expertise within the project group, such as *Ligustro-Alnion glutinosae, Rubo-Amorphion fruticosae, Artemisio-Tamariscion ramossisimae, Salicion canariensis, Frangulo-Fraxinion oxycarpae, Alno-Salicion pentandrae* and *Rubo sancti-Nerion oleandri*.

Nomenclature of plant species follows the Euro+Med Plantbase, unless the authorship is indicated [Available online: https://www.emplantbase.org]. The authors have listed also diagnostic, dominant and constant species that are of crucial importance for syntaxon (alliance) identification. Diagnostic species is a central concept in vegetation or habitat classification based on species composition. Diagnostic species (including character, differential and indicator species), can be broadly defined as species with a distinct concentration of occurrence or abundance in a particular vegetation type (habitat, alliance). Species of high frequency (constant species) and species of high cover-abundance (dominant species) are also important for identification.

AZONAL VEGETATION
ALLUVIAL FORESTS AND SCRUB

Alno glutinosae-Populetea albae P. Fukarek et Fabijanić 1968
Riparian gallery forests of the Eurosiberian and Mediterranean regions

Populetalia albae Br.-Bl. ex Tchou 1949 nom. conserv. propos.
Mediterranean and sub-Mediterranean riparian gallery forests

Populion albae Br.-Bl. ex Tchou 1949
Riparian edaphohygrophilous forests in the western Mediterranean

Osmundo-Alnion glutinosae (Br.-Bl. et al. 1956) Dierschke et Rivas-Mart. in Rivas-Mart. 1975
Floodplain forests of the western (Atlantic) half of the Iberian Peninsula

Rhododendro pontici-Prunion lusitanicae Pérez Latorre, Galán de Mera et Cabezudo in Pérez Latorre et al. 1999
Floodplain forests with relict laurisilva elements of the Iberian Peninsula and NW Africa

Platanion orientalis I. Kárpáti et V. Kárpáti 1961
Platanus riparian gallery forests of the eastern Mediterranean

Lauro nobilis-Fraxinion angustifoliae I. Kárpáti et V. Kárpáti 1961
Floodplain forests of the coastal regions in the eastern Mediterranean

Alno-Fraxinetalia excelsioris Passarge 1968
Floodplain riparian forests on nutrient-rich alluvial soils of temperate and boreal Europe

Alnion incanae Pawłowski et al. 1928
European nemoral and boreal floodplain forests

Hyperico androsaemi-Alnion glutinosae (Amigo et al. 1987) Biurrun et al. 2016
Cantabrian floodplain forests

Fraxino-Quercion roboris Passarge 1968
Elm-ash and oak riparian floodplain forests on nutrient-rich brown soils in the nemoral zone of Europe

Alno-Quercion roboris Horvat 1950
Alder-oak riparian floodplain forests on nutrient-rich alluvial soils of the temperate regions of the Balkan Peninsula and western Euxine of Turkey

Poo angustifoliae-Ulmion laevis Golub in Golub et Kuzmina 1997
Oak-elm riparian floodplain forests on nutrient-rich alluvial soils in the steppe zone of southern Russia

Populion albae Br.-Bl. ex Tchou 1949

Riparian edaphohygrophilous forests in the western Mediterranean

Idoia Biurrun, Estêvão Portela-Pereira, Carlos Salazar Mendías,
Patricia María Rodríguez-González

Syntaxonomy

Riparian deciduous meso-macroforests of the Mediterranean and sub-Mediterranean regions of the Iberian Peninsula and Southern France (Rivas-Martínez 2002b; Mucina et al. 2016). *Populion albae* is the type of alliance of the order *Populetalia albae* Br.-Bl. ex Tchou 1949 (class *Alno glutinosae-Populetea albae* P. Fukarek & Fabijanić 1968). The type of this alliance is the association *Populetum albae* Br.-Bl. ex Tchou 1949, described from Languedoc region in south-eastern France (Tchou 1949).

This alliance includes two suballiances according to Rivas-Martínez (2011): *Populenion albae* (Br.-Bl. ex Tchou 1949) Rivas-Martínez 1975 (poplar and willow forest flooded only in the rainy periods) and *Fraxino angustifoliae-Ulmenion minoris* Rivas-Martínez 1975 (Mediterranean ash and elm forests developed in scarcely flooded areas). A new proposal by Biurrun et al. (2016) deeply changes the syntaxonomy of the order *Populetalia*, considering the existence of two sub-alliances within *Populion albae*: the aforementioned *Populenion albae* (white poplar, Mediterranean ash and elm hardwood forests), together with the new suballiance *Salici neotrichae-Populenion nigrae* Biurrun et al. 2016 (black poplar, willow and alder softwood forests in submediterranean areas), whilst the suballiance *Fraxino angustifoliae-Ulmenion minoris* is transferred to the alliance *Osmundo-Alnion*. As regards the suballiance *Salici-Populenion nigrae*, it has some similarities with the alliance *Salicion albae* from temperate Europe. In fact, these softwood willow and poplar forests are in an intermediate syntaxonomic position between true floodplain forests and willow scrub of *Salicetea purpureae*.

A considerable number of syntaxa have been described into the alliance *Populion albae*, ranging from 11 to 18 associations depending on the aforementioned authors criteria. Some of them have been recently synonymized (Biurrun et al. 2016) hence decreasing the number of associations.

Species composition

Diagnostic species
Arum italicum, *Biarum carratracense*, *Chamaeiris foetidissima*, *Dorycnium rectum*, *Epipactis rhodanensis*, *Glycyrrhiza glabra*, *Humulus lupulus*, *Populus alba*, *P. nigra*, *Rubia tinctorum*, *Salix alba*, *S. fragilis*, *S. neotricha* Goerz, *S.* x *neofragilis* Rivas-Mart., *S.* x *neoalba* Rivas-Mart., *Vinca difformis*, *Vitis vinifera* subsp. *sylvestris*.

Dominant tree species
Alnus glutinosa, *Celtis australis*, *Fraxinus angustifolia*, *Populus alba*, *P. nigra*, *Salix alba*, *S. fragilis*, *S. neotricha* Goerz, *Ulmus minor*.

Constant species
Agrostis stolonifera, *Arum italicum*, *Biarum carratracense*, *Celtis australis*, *Chamaeiris foetidissima*, *Cucubalus baccifer*, *Dorycnium rectum*, *Epilobium hirsutum*, *Epipactis rhodanensis*, *Fraxinus angustifolia*, *Glycyrrhiza glabra*, *Humulus lupulus*, *Populus alba*, *P. nigra*, *Rubia tinctorum*, *Salix alba*, *S. fragilis*, *S. neotricha* Goerz, *S. purpurea*, *S. triandra*, *S.* x *neofragilis* Rivas-Mart., *S.* x *neoalba* Rivas-Mart., *Solanum dulcamara*, *Symphyotrichum squamatum*, *Ulmus minor*, *Vinca difformis*, *Viola alba*, *Vitis vinifera* subsp. *sylvestris*.

Ecology and forest management

Populion albae encompasses Mediterranean and sub-Mediterranean riverine meso-macroforests growing on wet fluvisols with high water-table over rich soils with slow flowing eutrophic water (Rivas-Martínez et al. 2002b). Poplar, alder and willow forests typically develop on very wet soils (periodically flooded) adjacent to the river stream, that conserve a good humidity level during the summer. On the other hand, Mediterranean ash and elm formations thrive in drier areas that are subject to extraordinary floods in the outer belt of the floodplain. The latter are seriously damaged by agriculture as they occupy the most fertile soils of the valleys. These forests are not subject to management plans, but they have been traditionally used for wood extraction for sticks and other uses.

Bioclimatically speaking, this alliance is typically Mediterranean, sometimes reaching temperate sub-Mediterranean territories, ranging from upper thermo-Mediterranean to lower supra-Mediterranean, and from upper mesotemperate to lower supratemperate belts. Continentality ranges between euoceanic and semi-continental, under dry to sub-humid-humid ombrotypes (Rivas-Martínez et al. 2002a; Biurrun et al. 2016).

Distribution range in Europe

These forests are widespread in the rivers of the Iberian Peninsula (mostly in the central and eastern parts) and southeastern France (Garilleti et al. 2012; Biurrun et al. 2016).

Threats to biodiversity and challenges for conservation

These forests have been almost completely destroyed and converted into fields for agriculture, settlements and industrial areas. They are quite rare and only survive in reduced river stretches (especially those of the lowland areas), and therefore are subject to serious threats. Also, their floristic composition has strongly been affected by the advance of alien species and the use of hybrid tree species in the reforestation works (*Populus* x *canadensis*, *P. deltoides*, *Salix babylonica*, *S.* x *sepulcralis* Simonk., etc.). Clonal varieties of *Populus nigra* have contributed to the genetic contamination of the characteristic species (*Populus nigra*) which is increasingly endangered due to introgression.

Conservation and management

Conservation requires maintaining or restoring natural hydrological conditions (high water table). It also requires preventing the forest from being cut down or planted with alien or hybrid species.

List of conservation and management requirements

Maintenance of the high water table, prevention of water pollution, adaptation of forest management (deforestation), reforestation which avoids the introduction of alien/invasive species, no urbanization and establishment of protected areas (legal protection).

Conservation status

Emerald: G1.3 Mediterranean riparian woodland

Annex 1: 92A0 *Salix alba* and *Populus alba* galleries

EUNIS: These forests were evaluated as Vulnerable in the red list of European habitats (Janssen et al. 2016), under the code G1.3 (Mediterranean and Macaronesian riparian woodland). Further, G1.3 was changed to T14 (Mediterranean and Macaronesian riparian forest) (Chytrý et al. 2020).

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

The habitat can recover in case of propitious site conditions, but it takes relatively long time to become a habitat with high biological value (biodiversity).

Nerio oleandri-Populetum albae (Guadalquivir Valley, Spain)

Tamarici gallicae-Populetum albae in southeastern Spain

Humulo lupuli-Alnetum glutinosae in Zadorra river, Basque Country, Spain

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Osmundo-Alnion glutinosae (Br.-Bl. et al. 1956) Dierschke et Rivas-Mart. in Rivas-Mart. 1975

Floodplain forests of the western (Atlantic) half of the Iberian Peninsula

Idoia Biurrun, Estêvão Portela-Pereira, Carlos Salazar Mendías,
Patricia María Rodríguez-González

Syntaxonomy

Originally created to characterize the western Iberian riparian forests as "*Alnion lusitanicum*" (Braun-Blanquet et al. 1956), this alliance was later widely referred to other western Mediterranean regions, such as Italy (Rivas-Martínez 2011; Mucina et al. 2016). However, a new approach, through the first attempt to produce a formalized plot-based classification of floodplain forests across the Iberian Peninsula (Biurrun et al. 2016), highlights its Iberian Atlantic character, with Iberian endemics as the species with highest diagnostic value. The type of the alliance is the association *Scrophulario scorodoniae-Alnetum glutinosae* Br.-Bl. et al. 1956, first described from Portugal but also present in nearby mesomediterranean areas from western Spain (Rivas-Martínez et al. 1986).

Traditionally *Osmundo-Alnion* included alder, birch and rusty-willow formations (Rivas-Martínez 2011; Costa et al. 2012), but Biurrun et al. (2016) extended its ecologic scope to also include ash, elm and poplar formations, segregating different suballiances, which most of them were previously included in *Populion albae*. *Osmundo regalis-Alnenion glutinosae* mainly includes alder and rusty-willow riparian galleries from the Atlantic watershed of the Iberian Peninsula, from Galicia to central Portugal, including the Central Range. Although there is no consensus among different authors, at least four or five associations have been classified, and there are still other communities to be formally described, mostly dominated by *Salix cinerea* subsp. *oleifolia* (rusty-willow) (Biurrun et al. 2016; Portela-Pereira & Rodríguez-González 2021). The suballiance *Fraxino angustifoliae-Ulmenion* minoris includes three associations of ash and elm forests from the Atlantic watershed in the northwestern Mediterranean Iberia. Finally, thermophilous forests usually dominated by ash or white poplar from the southwestern Iberian Peninsula are included in the suballiance *Nerio oleandri-Fraxinenion angustifoliae*, with at least six formally recognized associations.

Although the most recent approach has yet to be concluded, it seems that it better reflects the great diversity of this type of forests in the Peninsula, compared to the classical approach, which is more general at alliances and suballiances ranks.

Species composition

Diagnostic species
Arum cylindraceum, *Carex reuteriana* subsp. *reuteriana*, *C. reuteriana* subsp. *mauritanica*, *Flueggea tinctoria*, *Galium broterianum*, *Nerium oleander*, *Oenanthe crocata*,

Ornithogalum pyrenaicum, *Paradisea lusitanica*, *Quercus pyrenaica*, *Salix pedicellata*, *Scrophularia scorodonia*, *Silene latifolia*, *Smilax aspera*, *Vinca difformis*.

Dominant tree species
Alnus lusitanica, *Fraxinus angustifolia*, *Populus alba*, *Salix cinerea* subsp. *oleifolia*, *Ulmus minor*.

Constant species
Alnus lusitanica, *Anthriscus caucalis*, *Aristolochia paucinervis*, *Clinopodium vulgare*, *Frangula alnus*, *Fraxinus angustifolia*, *Galium broterianum*, *Oenanthe crocat*a, *Populus alba*, *Pteridium aquilinum*, *Ranunculus ficaria*, *Salix cinerea* subsp. *oleifolia*, *Scrophularia scorodonia*, *Teucrium scorodonia*.

Ecology and forest management

These forests occur in alluvial soils, mainly sandy and silty, normally in siliceous areas, almost from the headwaters of watercourses to the lowlands. Alder and willow forests form riverside galleries in permanent watercourses, while ash, elm, white poplar and other forests are growing on the floodplains (or foothills) of the permanent watercourses, also constituting riverside galleries in temporary rivers or streams or in permanent courses that have had their banks disturbed. Thus, the former are fundamentally constituted as hygrophilous forests, which inhabit almost permanently wet soils on the surface or very close to it, with long periods of flooding and short periods of superficial soil dryness; the latter constitute temporarily wet forests, in soils with high water table in winter, but with a short and irregular (many times sporadic) period of flooding, suffering sub-superficial desiccation in the summer.

Alder forests are those that require greater stability in the river dynamics, water flow and bank features, being still present in the valley bottoms that have not undergone agriculture. The typical forests of the alluvial plains (i.e., not riverside galleries) have only started to recover in the last decades due to agricultural abandonment. Yet most of them are no more than simple hedges on the edges of plains or farmlands.

Regarding the climate, they occur in a Mediterranean and temperate sub-Mediterranean climate, from thermo- to supra-Mediterranean- thermotype levels and in semi-hyperoceanic to semi-continental territories (Biurrun et al. 2016).

Distribution range in Europe

Western (Atlantic) half of the Iberian Peninsula (Biurrun et al. 2016).

Threats to biodiversity and challenges for conservation

These forests have been almost completely destroyed and converted into fields for agriculture, and others into settlements and industrial areas. This is particularly evident in the lowlands and open valleys where agricultural activities go back to ancient times. However, in some regions that suffered depopulation and agricultural abandonment, as mentioned before, the recovery of these forests in the last four/five decades is clearly visible. In others, particularly on agricultural land, regulation works have led to major

changes in hydrogeomorphology and vegetation, including massive plantings of species of often unknown and/or allochthonous origins (e.g., *Salix* subgen. *Salix*, *Populus* spp. and *Arundo donax*). Fast-growing softwood plantations (namely *Populus* spp.) have also occurred on several floodplains. In forestry activities, and also often related to leisure and tourist activities (such as hiking) a threat is the recurrent clearing of shrubs and herbaceous borders, which often turns these forests into veritable park gardens. The construction of dams for energy production and water reservoirs for human consumption or for agriculture, not only flooded many kilometers of watercourses but also changed the fluvial dynamics of the rivers and their alluvial plains. More or less recent, another major threat are the diseases (e. g. in alder and elm trees which led to the extinction of the elm forests of this alliance in Portugal) and the non-native and invasive species, many of them being of ornamental origin. But it was in forest land that these (namely woody species) became “explosive”, encouraged by recurrent rural fires, which also destroyed these forests. Invasive species arrived in valleys where riparian forests were more or less well preserved. In agricultural and urban lands, non-native and/or invasive species (woody or herbaceous) have great expression, often being dominant. Traditional threats, such as intensive grazing or overgrazing by livestock, clear-cutting, removal of all trees or thinning tree layer, turn out to be a minor problem nowadays, being mainly localized problems in some regions.

Primary (i.e., undisturbed) riparian/floodplain forests in western Iberian Peninsula are extremely rare and only a few have survived in small areas. Climate change will increase many of these threats and, although many of these forests show resilience to disturbance (such as natural river dynamics and disturbances caused by traditional human activities), their protection and conservation is essential to recover degraded areas, thus helping to strengthen the remaining areas that are better preserved, as many are interconnected by the watercourses that “feed” them.

Conservation and management

Conservation requires maintaining or restoring the natural hydrogeomorphological conditions (high water table and natural river dynamics) and vegetation. It also requires preventing the forests from being cut down or planted with alien species, or being replaced by new agricultural crops, often intensively. Vegetation clearing should be limited to solving runoff problems in water courses in risky situations and should never be recurrent, including on its edges. This is a region with many rivers regulated by dams and weirs, so it is necessary to dismantle those that are superfluous or abandoned and also to prevent more from being built. Non-native species and diseases spread rapidly in these forests (they are habitats naturally disturbed by river dynamics) so early detection and eradication is even more essential than in other forests. The introduction of non-native species in these habitats has a high risk of their invasion and the lack of control to the invasive species on the riverbanks will promote their dispersal downstream. These forests should always be protected by law and should be included in monitoring efforts, and where possible also integrated into protected areas/landscapes.

List of conservation and management requirements

Maintenance of hydrological flow and high water table and also more or less natural riv-

erbanks; prevention of water pollution; no introduction of non-native/invasive species; no urbanization; restoration of the river channels and their floodplains; and establishment of protected areas (legal protection).

Conservation status

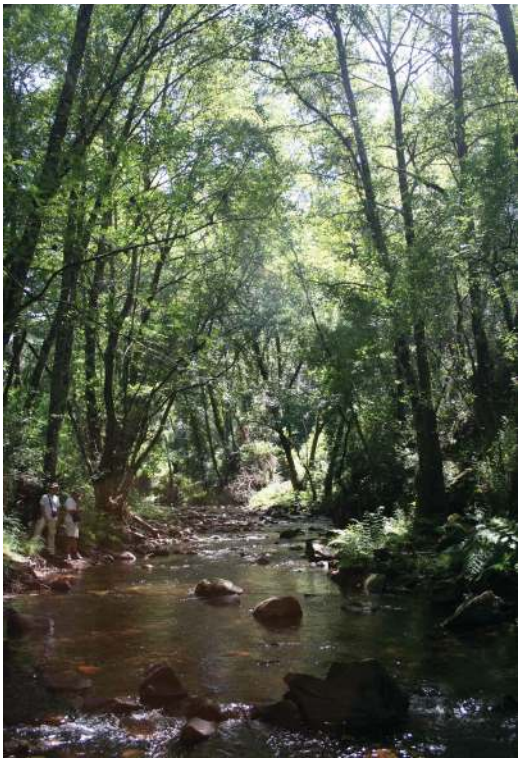
Emerald: G1.3 Mediterranean riparian woodland

Annex 1: 91B0 Thermophilous *Fraxinus angustifolia* woods; 91E0 *Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*); 92A0 *Salix alba* and *Populus alba* galleries.

EUNIS: These forests were evaluated as Vulnerable in the red list of European habitats (Janssen et al. 2016), under the code G1.3 (Mediterranean and Macaronesian riparian woodland). Further, Chytrý et al. (2020) include those dominated by alders in T12 (*Alnus glutinosa-Alnus incana* forest on riparian and mineral soils) and changed G1.3 to T14 (Mediterranean and Macaronesian riparian forest).

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

The habitat can recover in case of propitious site conditions, but it takes relatively long to get a habitat with high biological value (biodiversity). Invasive species can be a serious threat to the desired recovery.



Alder (*Alnus lusitanica*) riparian gallery in Alge stream (*Osmundo-Alnenion*), south of Serra da Lousã, province of Beira Litoral (Central Portugal)

Patches of Mediterranean ash (*Fraxinus angustifolia*) forest with Pyrenean oak (*Quercus pyrenaica*) (*Fraxino-Ulmenion*) in Minas Santo Adrião SCI (traditional landscape of meadows with arboreal hedges on plateaus temporarily flooded in winter, in the province of Trás-os-Montes, NE Portugal)

Oleander (*Nerium oleander*) in Freixo stream (Tera basin), temporary flow with riverside gallery of Mediterranean ash (*Fraxinus angustifolia*) (*Nerio-Fraxinenion*), in the province of Alto Alentejo (CS Portugal)

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Rhododendro pontici-Prunion lusitanicae Pérez Latorre, Galán de Mera et Cabezudo in Pérez Latorre et al. 1999

Floodplain forests with relict laurisilva elements of the Iberian Peninsula and northwest Africa

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Syntaxonomy

Southern Iberian Mediterranean riparian forests with relict laurisilva elements (Mucina et al. 2016; Pérez Latorre et al. 1999). This kind of forest includes more or less arborescent formations dominated by two lauroid species relict in the Iberian Peninsula, Portuguese laurel (*Prunus lusitanica*) and common rododendron (*Rhododendron ponticum*) (Pérez Latorre et al. 1999, 2000). The type of the alliance is the association *Frangulo baeticae-Rhododendretum pontici* Rivas Goday et al. ex Rivas-Martínez et al. 1986. These formations occur not only in the southwest part of the Peninsula, but also in small areas spread out throughout its territory, including in the north, with more temperate climate (Pérez Latorre et al. 1999; Honrado et al. 2007; Biurrun et al. 2016; Portela-Pereira & Rodríguez-González 2021). In particular riparian Portuguese laurel forests have already been included in different taxonomic positions: *Arbuto unedonis-Laurion nobilis* (*Quercetea ilicis*) (Rivas-Martínez et al. 2001) (together with rododendron formations), *Populion albae* (Rivas-Martínez 2011; Costa et al. 2012) and also *Osmundo-Alnion* (Biurrun et al. 2016). So far, three associations of each of these formations have been described, but more comprehensive studies have to be undertaken, as there are other formations with these characteristics already described and which are included in the mesophilic forest vegetation (e.g., *Laurus nobilis* formations) or others yet to be described, such as *Ilex aquifolium* formations (Portela-Pereira & Rodríguez-González 2021).

Due to the characteristics of these formations, relicts, evergreens, more or less hygrophilous it is evident that they constitute a distinct type of vegetation, so the recovery of this alliance by Mucina et al. (2016) seems to make perfect sense.

Species composition

Diagnostic species
Arbutus unedo, *Asplenium onopteris*, *Daphne laureola* subsp. *latifolia*, *Davallia canariensis*, *Erica arborea*, *Frangula alnus* subsp. *baetica*, *Hedera iberica*, *Ilex aquifolium*, *Laurus nobilis*, *Phillyrea angustifolia*, *Prunus lusitanica*, *Rhododendron ponticum*, *Ruscus aculeatus*, *Scrophularia laevigata*, *Viburnum tinus*.

Dominant tree/arborescent shrubs species
Prunus lusitanica, *Rhododendron ponticum*.

Constant species
Athyrium filix-femina, *Blechnum spicant*, *Dryopteris borreri*, *Luzula forsteri*, *L. sylvatica* subsp. *henriquesii*, *Omphalodes nitida*, *Osmunda regalis*, *Prunus lusitanica*, *Rhododendron ponticum*, *Saxifraga spathularis*, *Sibthorpia europaea*.

Ecology and forest management

These forests occur in colluvial-alluvial soils, mainly silty, normally in siliceous areas and in the headwaters of watercourses with irregular flow (temporary or permanent) but with stabilized stream channels, in environments sheltered from adverse environmental conditions (Portela-Pereira & Rodríguez-González 2021). Portuguese laurel and rododendron form riverside galleries in the small rocky streams and ravines, or arborescent edges in the foothills of the larger streams or smaller rivers, between deciduous riparian forests (e.g., *Osmundo-Alnion*) and mesophilous forests, even with edaphic compensation (e.g., *Quercus* spp.). If these deciduous forests suffer senescence or their canopy is destroyed, these evergreen formations can persist for a long time, as long as they are not disturbed. These formations inhabit wet soils in winter, but with a short and irregular period of flooding, and well drained in summer (Portela-Pereira & Rodríguez-González 2021).

These relict formations are not truly floodplain forests (alluvial), but colluvial ones, although they also interact with the fluvial dynamics, albeit with a lower frequency, receiving moisture in the soil and air from running waters, which vary between a torrential and laminar regime. The big difference regarding the biotope to pioneer arborescent riparian thickets (e.g., *Salicetea purpureae*, *Nerio-Tamaricetea*) is that, in this case, these streams have a very stable channel, either because it is rocky or because its colluvia are stabilized. If a catastrophic phenomenon occurs, these relict species would be replaced by pioneer species adapted to temporary wet conditions or by mesophilous ones, depending on the local characteristics (Portela-Pereira & Rodríguez-González 2021).

Regarding the climate, they occur in a Mediterranean and temperate sub-Mediterranean climate, in termo- to mesomediterranean or mesotemperate thermotype level and in semi-hyperoceanic to semi-continental territories (Pérez Latorre et al. 2000; Honrado et al. 2007; Costa et al. 2012; Biurrun et al. 2016).

Distribution range in Europe

Mainly western (Atlantic) half of the Iberian Peninsula, with a few isolated forests in the northeast (Catalonia) (Biurrun et al. 2016).

Threats to biodiversity and challenges for conservation

These small woods are the remnants of relict forests adapted to past environmental and bioclimatic conditions, which have remained until today essentially because they occur in sheltered sites, not only with regards to the environmental conditions, but also because they do not need good conditions for agroforestry activities. *Pinus* (e.g., *P. pinaster*) plantations in the recent past, and *Eucalyptus* spp. today are major threats to these forests, not so much that they can directly destroy them (which also happens but only oc-

casionally), but because recent intensive plantations change the entire morphology and dynamics (namely the hydrological) of the slopes, on which these formations depend to survive. In forestry activities, and also often related to leisure and tourist activities, such as hiking, a threat is the recurrent clearing of the shrubs and herbaceous borders, which often turns these forests into veritable park gardens. Clearing and excessive trampling can aggravate the main threats that these forests suffer from, which is reduced fecundity or genetic depression affecting the natural regeneration of key species such as *Prunus lusitanica*, as they occur in isolated areas; as well as the proliferation of the non-native or invasive species, which are also greatly stimulated by the disturbance caused by the rural fires. The combination of these pressures can lead to the extinction of these forests in certain areas. The construction of dams to produce energy and water reservoirs for human consumption has already destroyed forest areas in the past (e.g., Portugal) and this threat remains nowadays too, despite the protection they hold.

Given their small areas, isolation and relict character (i.e., outdated with current climate conditions) and the threats listed, these are very rare forests of great conservation value. Climate change will increase many of these threats, so with the low resilience of these forests, their future survival depends on strict protection and a management/conservation that focuses on high standards of ecological restoration.

Conservation and management

Conservation requires maintaining or restoring natural hydrogeomorphological conditions (natural stream and slope dynamics) and vegetation. It also requires preventing the forests from being cut down and to interdict any plantation with non-native species or native species that are not characteristic of this habitat. Natural regeneration of key species such as *Prunus lusitanica* should be protected from excessive herbivory/trampling notably where these threats accumulate to other pressures such as recurrent fires (e.g., northwest Iberian Peninsula). Vegetation clearing should be limited to solving runoff problems in watercourses in risky situations and should never be recurrent, not even on its margins. This is a region with many dams, so it is necessary to prevent more from being built. Non-native species can spread rapidly and radically alter the conditions of the biotope in these forests so early detection and eradication is even more essential than in other forests. The introduction of non-native species in these habitats has a high risk of invasion and the lack of control of the invasive species on the streambanks is not only a serious threat to the survival of these less resilient formations, but also will promote the invasion dispersal downstream. These forests should be strictly protected by law, and integrated into protected areas/landscapes.

List of conservation and management requirements

Maintenance of hydrological flow in the streams and natural streambanks; protection of natural regeneration of the key species; prevention of water pollution; adaptation of forest management (interdict deforestation); no introduction of non-native/invasive species; no urbanization; restoration of the stream channels and foothills; and establishment of protected areas (legal protection).

Conservation status

Emerald: G1.3 Mediterranean riparian woodland

Annex 1: 92B0 Riparian formations on intermittent Mediterranean water course with *Rhododendron ponticum*, *Salix* and others; 92D0 Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*); 5230* Arborescent matorral with *Laurus nobilis*.

EUNIS: These forests were evaluated as Vulnerable in the red list of European habitats (Janssen et al. 2016), under the code G1.3 (Mediterranean and Macaronesian riparian woodland), although only rododendron formations were explicitly mentioned. Further, Chytrý et al. (2020) changed G1.3 to T14 (Mediterranean and Macaronesian riparian forest), but also only including rododendron formations; they explicitly include *Prunus lusitanica* formations under T22 (Mainland laurophyllous forest).

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

The habitat cannot recover in case propitious site conditions are profoundly altered (e.g., edaphic moisture conditions, shelter to environmental conditions (cold, heat, dryness, fire, erosion, landslides etc.). One way or another, their recovery is usually slow and challenging, given the threats highlighted, especially getting a habitat with high biological value (biodiversity). Invasive species can be a serious threat to the desired recovery.

Portuguese laurel (*Prunus lusitanica*) from *Luzulo henriquesii-Prunetum lusitanicae*, in SCI e National Park of Peneda-Gerês, province of Minho (NW Portugal)

Portuguese laurel forest (*Frangulo alni-Prunetum lusitanicae*) degraded and threatened by the invasive *Acacia dealbata*, and *Pinus pinaster* plantation, in Água d'Alte stream (Zêzere basin), province of Beira Baixa, C Portugal.

Common rododendron gallery (*Calluno vulgaris-Rhododendretum pontici*) - in the center of the image - in a landscape dominated by *Pinus* and *Eucalyptus* plantations. This scrub inhabits a intermittent small stream in SCI Cambarinho, province of Beira Alta (CN Portugal)

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Platanion orientalis I. Kárpáti et V. Kárpáti 1961

Platanus riparian gallery forests of the eastern Mediterranean

Dejan Mandžukovski, Kiril Vassilev, Renata Ćušterevska

Syntaxonomy

The alliance *Platanion orientalis* includes *Platanus orientalis* gallery forests distributed in the eastern Mediterranean region (Mucina et al. 2016), which belong to the class *Alno glutinosae-Populetea albae* P. Fukarek et Fabijanić 1968. The alliance was described by Kárpáti & Kárpáti (1961) from the territory of Albania with typus *Nerio oleandri-Platanetum orientalis* Kárpáti et Kárpáti 1961 association. According to the comprehensive study of Douda et al. (2016) about the European floodplain forests and alder carrs only 2 associations (*Petasito-Platanetum orientalis*, *Nerio-Platanetum orientalis*) were established on European scale within the alliance. In fact after summarizing of literature data its syntaxonomical diversity up to now is much higher and is represented by 11 associations - *Juglandi-Platanetum orientalis*, *Nerio-Platanetum orientalis*, *Petasiti-Platanetum orientalis*, *Platanetum orientalis balcanicum*, *Euphorbio characiae-Platanetum orientalis*, *Hyperico hircini-Platanetum orientalis*, *Equiseto telmateiae-Platanetum orientalis*, *Querco ilicis-Liquidambaretum orientalis*, *Castaneto-Platanetum*, *Platano-Salicetum pedicellatae*, *Platano-Salicetum gussonei* (Em & Džekov 1961-1961; Kárpáti & Kárpáti 1961; Em et al. 1985; Fotiadis 2004; Öztürk et al. 2008; Caruso et al. 2012; Douda et al. 2016; Gradstein & Smittenberg 2017; Pedashenko et al. 2017; Sarika et al. 2018; Georgieva & Glogov 2019; Vassilev et al. 2021) and 3 plant communities - *Platanus orientalis-Quercus coccifera*, *Alnus glutinosa-Platanus orientalis*, *Platanus orientalis-Juglans regia* (Fotiadis 2004, Sarika et al. 2020).

The syntaxonomical diversity of *Platanus orientalis* woodlands need to be established in regional context with collecting new data from its area e.g., Albania, Italy, parts of North Macedonia, Greece, Crete, Turkey and southern Bulgaria.

Species composition

Moderately to high species-rich communities with semi-open to closed horizontal structure. Semi-open structure is present in forests of *Euphorbio characiae-Platanetum orientalis* association. In the vertical structure are found well-formed tree, shrubs, herb and cryptogam layers. Dominant species is *Platanus orientalis*. Some mesophytic (such as *Fagus sylvatica*, *Ostrya carpinifolia*, *Alnus glutinosa*, *Salix alba*, *S. triandra*, *Populus alba*, *P. nigra*) and xerophytic tree species (such as *Quercus coccifera*, *Q. ilex*) are also frequently found. The shrub layer is formed by young individuals of the above mentioned trees as well as *Nerium oleander*, *Rubus ulmifolius*, *R. fruticosus* agg., *Sambucus nigra*, *Rosa canina*, *Hedera helix*, *Clematis vitalba*. The development of the shrub layer depends on the degree of shading effect of the tree layer. In *Platanus orientalis* forests

in the sub-Mediterranean region, which have closed horizontal structure (total cover 90-100 %) the cover of shrub layer is lower (on average up to 20-30 %). In contrast the Mediterranean forest types have more-open horizontal structure, which lead to higher species diversity and good development of shrub and herb layers.

The cover of the herb layer is ordinarily between 30-80%. Species with high cover in the undergrowth are *Brachypodium sylvaticum*, *Dactylis glomerata* agg., *Galium aparine*, *Pteridium aquilinum*, *Urtica dioica*. Transgressive species of the class *Carpino-Fagetea* (such as *Carpinus betulus*, *Fagus sylvatica*, etc.) and *Quercetea ilicis* (such as *Quercus ilex*, Q. *coccifera*, etc.) are also abundant. Frequently in xerophytic phytocoenosis in the species composition are also found some ruderal species like *Capsella bursa-pastoris*, *Carduus candicans*, *Eryngium campestre*, *Sisymbrium orientale* and *Hordeum murinum*. Also typical in the species composition are many therophyte species (e.g., *Vulpia myurus*, *Petrorhagia saxifraga*, *Anisantha tectorum*, *Daucus broteri*, etc.), which are adapted to prolonged drought period during the summer months and are coming from the neighboring habitats

Diagnostic species: *Platanus orientalis, Adiantum capillus-veneris, Bellis perennis, Brachypodium pinnatum, Campanula cretica, Carex cretica, C. distachya, C. divulsa, C. pendula, C. remota, Cirsium creticum, Clematis flammula, C. vitalba, Clinopodium nepeta, C. vulgare, Cotinus coggygria, Cyclamen creticum, Cyperus longus, Dactylis glomerata, Dorycnium rectum, Equisetum ramosissinum, E. telmateia, Ficus carica, Geranium robertianum, Hippocrepis emerus* subsp*. emeroides, Hypericum perforatum, Lactuca muralis, Lecokia cretica, Luzula forsteri, Melissa officinalis, Mentha longifolia, Nasturtium officinale, Origanum vulgare, Ostrya carpinifolia, Parietalia officinale, P. lusetanica, Phillyrea latifolia, Piptatherum miliaceum, Pistacia lentiscus, P. terebinthus, Plantago major, Prunella vulgaris, Pteridium aquilinum, Quercus ilex, Ranunculus ficaria, Rumex conglomeratus, Scirpoides holoschoenus, Achnatherum bromoides, Trifolium campestre, Tussilago farfara*.

Dominant species: In majority of syntaxa of the alliance *Platanion orientalis* dominant species is *Platanus orientalis*. In *Querco ilicis-Liquidambaretum orientalis* dominant species is *Liquidambar orientalis*. In stands of *Juglandi-Platanetum*, *Castaneo-Platanetum* and *Nerio-Platanetum orientalis* associations *Platanus* orientalis is co-dominating with *Juglans regia*, *Castanea sativa* and *Nerium oleander*.

Ecology and forest management

Platanus orientalis gallery forests are found along river valleys and gorges more frequently in mountain and semi-mountain regions and rarer in plain regions or in the coastal zone of the eastern Mediterranean. This vegetation is colonizing poorly stabilized alluvial zone of the rivers, which is rich with gravel or stone deposits. Terrains are flat to steeply inclined. Soils are alluvial and alluvial-diluvial, moderately-deep to deep, nutrient-rich and wet. During winter, spring and early summer periods (depending on the region) *Platanus orientalis* forests are periodically flooded. In the lowlands its habitats are frequently characterized by higher groundwater levels. This vegetation depends on warmer climate conditions, which is a limiting factor for its distribution.

Platanus orientalis forests are used for logging and pasture of domestic animals and livestock, which leads to changes in the species composition, the horizontal and vertical structure of the phytocoenosis.

Distribution range in Europe

Oriental plane (*Platanus orientalis*) is a large, fast-growing, long-living deciduous tree growing in a wide variety of soils, whose natural distribution extends from the eastern Mediterranean basin - from eastern Sicily through the southern Balkan Peninsula, the islands of the Aegean and Anatolia to the Caucasus, north Iran and further east to central Asia and Afghanistan.

On territory the of Europe, the alliance *Platanion orientalis* occurs in the Mediterranean and sub-Mediterranean regions and is distributed on the territories of Italy, Albania, Bulgaria, Greece, N. Macedonia, Turkey and Crete.

Associations *Nerio-Platanetum orientalis*, *Euphorbio characiae-Platanetum orientalis*, *Hyperico hircini-Platanetum orientalis, Platanetum orientalis balcanicum, Querco ilicis-Liquidambaretum orientalis* (Turkey) are found in warmer habitats, which are rich of Mediterranean species, such as in Greece, Crete, Turkey and Albania. On the other hand, the associations *Juglandi-Platanetum orientalis* (Greece, N Macedonia, Albania, Bulgaria), *Petasito-Platanetum orientalis* (Bulgaria, Albania), *Castaneo-Platanetum* (N. Macedonia, Bulgaria), *Equiseto telmateiae-Platanetum orientalis* (Greece, Crete), *Platanetum orientalis balcanicum* (Albania) are present in xero-mesophytic communities, which are rich with many Mediterranean species as well as central European species widely distributed in the neighboring communities of *Carpino-Fagetea* class.

Threats to biodiversity and conservation challenges

Platanus orientalis woodlands are subject to strong anthropogenic pressure. Phytocoenoses found at higher altitudes and on other less accessible terrains are well preserved. On the other hand, those which are situated close to the settlements, roads and tracks are contaminated with wastes, and these tree species have been frequently cut down during the previous centuries. High level of plant invasion (e.g., invasive and alien species such as *Bidens tripartita, B. cernua, Erigeron canadensis, Impatiens glandulifera, Amorpha fruticosa, Robinia pseudoacacia*) is also assessed as important threat for their biodiversity (Wagner et al. 2017).

Change of hydrological regimes along river valleys is also a threat in the Balkan countries. In lowlands (Albania) many natural habitats of *Platanus orientalis* have been converted to arable fields. The significant degree of landscape regulations (e.g., heterogeneity of arable and natural habitats) leads to increasing of anthropogenic pressure on linear polygon forests formed by *Platanus orientalis* and their degradation.

On the territory of the Balkan Peninsula and Crete part of *Platanus orientalis* forests fall into the category of protected areas (reserves, national and natural parks) and NATURA 2000 sites.

Conservation and management

Conservation requires preserving the existing hydrological regimes, removal of dead and dying trees and limitation of grazing and logging activities. It is also necessary to eliminate and limit distribution of invasive species such as *Robinia pseudoacacia*, *Amorpha fruticosa* etc. Development of *Robinia* plantations closely to the *Platanus orientalis*

forest should be limited. Some sites (mainly out of protected areas or close to settlements) also require restoration of the natural flooding and planting of trees.

List of conservation and management requirements

Preserving of existing water regimes, regulating floods and high water levels, limiting the construction of hydroelectric power stations and other mechanical changes along the rivers and their tributaries, prevention of water pollution, restriction of grazing, adaptation of forest management (deforestation), no introduction and suppression of alien/invasive species.

Conservation status

Annex I: 92C0 *Platanus orientalis* and *Liquidambar orientalis* woods (*Platanion orientalis*)

PAL.CLASS.: 44.71 Oriental plane woods (*Platanion orientalis*); 44.711 Helleno-Balcanic riparian plane forest; 44.712 Hellenic slope plane woods

EUNIS: G1.381 Helleno-Balcanic riparian plane forest G1.382 Hellenic slope plane woods

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

In cases of disturbance or destruction of the typical habitat, its restoration is possible, but it is a slow and long process (at least several dozen years).

Platanus orientalis forest in N. Macedonia (*Juglandi-Platanetum orientalis*) Belica river – Gevgelija (Photo by D. Mandžukovski)

Platanus orientalis forest in N. Macedonia (*Juglandi-Platanetum orientalis*) Belica river - Gevgelija (Photo by D. Mandžukovski)

Nerio-Platanetum orientalis – Korpulu, National Park – Turkey (Photo by A. Kavgacı)

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Lauro nobilis-Fraxinion angustifoliae I. Kárpáti et V. Kárpáti 1961

Floodplain forests of the coastal regions in the eastern Mediterranean

Andraž Čarni, Ali Kavgacı, Željko Škvorc, Vladimir Stupar

Syntaxonomy

The alliance includes floodplain forests found in the Italian and Balkan Peninsula. This treatment is based on a proposal by the EVC (Mucina et al. 2016), which suggested that this concept includes riparian forests with relict laurisilva elements in the eastern sub-Mediterranean regions of the Apennine and Balkan Peninsulas. However, there are also other classification schemes, e.g., Biondi (Biondi et al. 2014), which proposed three alliances for the Italian Peninsula as *Populion albae* for riparian communities, *Alno-Quercion* for marshy and *Carici remotae-Fraxinion* for swamp and floodplain forests. Recently, some additional alliances of swamp and floodplain forests have been introduced in Italy, such as *Dioscoreo communis-Populion nigrae, Lauro nobilis-Ulmion minoris* (Poldini et al. 2017; Poldini & Sburlino 2018; Poldini et al. 2020; Gennai et al. 2021). In this way, further study of floodplain forests in the (sub)Mediterranean region is needed to find out their syntaxonomic position and content, as there are differences between the western and eastern Mediterranean communities and also in the transition of these forests to the continent. It should be taken into account that floodplain and riparian forests occur close to water and the geographical patterns are not so distinct (Douda et al. 2016). Moreover, the ecological conditions of these forests may also change under different macroclimatic conditions. Thus, Kárpáti (Kárpáti & Kárpáti 1961) emphasized that it should be taken into account that *Populetum albae* occurring in the Mediterranean region is coenologically and ecologically equivalent to *Querco-Ulmetum* (*Fraxino-Quercion* /*Alno-Quercion*) occurring in the Central Europe and sub-Mediterranean region. Thus, within this group we are also dealing with poplar (*Populus* sp. div.) dominated forests occurring in the lowlands of the coastal regions. Poplar-dominated forests of the continental parts of Europe and in the highlands of the Mediterranean region are for the major part classified in *Salicetea albae*.

The alliance *Lauro-Fraxinion* was described by Kárpáti (Kárpáti & Kárpáti 1961; Kárpáti 1962) for floodplain forests where some evergreen elements occur. According to EVC (Mucina et al. 2016), this alliance is treated in a broader ecological and geographical sense and the revision of floodplain forests should be done in a larger region to refine the classification pattern and to make a syntaxonomic revision down to the association level.

Species composition

Diagnostic species
Asparagus acutifolius, Cercis siliquastrum, Cyclamen repandum, Ficus carica, Laurus

nobilis, Myrtus communis, Pyracantha coccinea, Quercus coccifera, Rubia tinctorium, Rubus sanctus, Smilax aspera, Vitex agnus-castus, Vitis sylvestis and therophytes that appear during summer drought.

Dominant tree species
Fraxinus angustifolia, Populus alba, Populus nigra, Quercus robur, Alnus glutinosa.

Constanst species
Acer campestre, Asparagus actifolius, Brachypodium sylvaticum, Calystegia sepium, *Cyprus longus, Fraxinus angustifolia, Hedera helix, Laurus nobilis, Lythrum junceum, Myrtus communis, Quercus coccifera, Quercus robur, Populus alba, Populus nigra, Rubia tinctoria, Rubus sanctus, Ruscus aculeatus, Smilax aspera, Ulmus minor, Vitex agnus-castus*.

Ecology and forest management

These forests occur on sandy and muddy floodplain soils in lowland and riparian areas. Their occurrence is limited by water supply, where the water table forms the boundaries of the stand. Sites are often flooded in spring, but the upper soil horizons may dry out during summer droughts, allowing abundant therophytes to occur. These forests are largely formed by mesophilic species, but thermophilic species with a Mediterranean distribution pattern are diagnostic of this vegetation type. These forests occur in the lowlands along the lower reaches of the rivers that flow into the Mediterranean Sea and are often found near the mouths of large rivers.

Along the rivers in the area of distribution of these floodplain forests, we can also find oriental plane tree forests (*Platanus orientalis*). The main difference between these two types is that the floodplain forests thrive on sandy-muddy substrate, while plane forests occur on gravel deposited along the rivers.

Distribution range in Europe

As already said, these forests can be found in the coastal areas of Balkan countries and along Apennines (Kladis et al. 2011; Stešević & Drescher 2014; Fanelli et al. 2015; Škvorc et al. 2017; Drescher 2018).

Threats to biodiversity and challenges for conservation

These forests have been almost completely destroyed and converted into fields for agriculture, settlements and industrial areas. They are extremely rare and only a few have survived in small areas. These forests are under serious threat.

Conservation and management

Conservation requires maintaining or restoring natural hydrological conditions (high water table). It also requires preventing the forest from being cut down or planted with alien species. These forests should be located in protected areas.

List of conservation and management requirements

Maintenance of high water table, prevention of water pollution, adaptation of forest management (deforestation), no introduction of alien/invasive species, no urbanization and establishment of protected areas (legal protection).

Conservation status

Emerald: G1.3 Mediterranean riparian woodland

Annex 1: 91F0 Riparian mixed forests of *Quercus robur, Ulmus laevis* and *U. minor, Fraxinus excelsior* or *F. angustifolia*, along the great rivers (*Ulmenion minoris*); 92A0 *Salix alba* and *Populus alba* galleries

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

The habitat can recover in case of propitious site conditions, but it takes relatively long time to get a habitat with high biological value (biodiversity).

Poplar (*Populus alba*) forest near to the estuary of the Axios river into Aegean Sea.

Bay laurel (*Laurus nobilis*) is an evergreen species that is diagnostic for floodplain forests of coastal regions. It is easily recognizable during winter period (near to the estuary of the Axios river into Aegean sea).

The narrow-leaved ash forest close to the sea, near to salt pans at Pydna (Greece).

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Alnion incanae Pawłowski et al. 1928

European nemoral and boreal floodplain forests

Jan Douda, Michal Slezák

Syntaxonomy

The alliance *Alnion incanae* is comprised of ash-alder stream and seepage forests dominated by *Alnus glutinosa* and *Fraxinus excelsior* in the nemoral and hemiboreal zones and *A. incana* in the boreal zone and mountains. They are distributed from oceanic western Europe to continental eastern Europe within a broad range of continentality and elevation. The alliance was described by Pawłowski et al. (1928) in the Polish part of Tatra mountains from *Alnus incana* dominated forests belonging to the association *Alnetum incanae* Pawłowski et al. 1928, which is the holotypus of the alliance. Our overview is based on the conception of *Alnion incanae* in the EuroVegChecklist (Mucina et al. 2016), according to which the hardwood floodplain forests dominated by *Quercus robur* and *Ulmus* minor occurring in alluvia of large rivers in the nemoral zone of Europe are distinguished in the separate alliance *Fraxino-Quercion roboris* Passarge 1968. Similarly, hyperoceanic alder, ash and birch floodplain forests from streams of the Cantabrian watershed are separated in their own alliance *Hyperico androsaemi-Alnion glutinosae* (Amigo et al. 1987) Biurrun et al. 2016 (Biurrun et al. 2016).

Species composition

Diagnostic species
Aegopodium podagraria, Alnus incana, Anemone nemorosa, Atrichum undulatum, Carex brizoides, Chrysosplenium alternifolium, Ch. oppositifolium, Circaea alpina, Crepis paludosa, Galium odoratum, Impatiens noli-tangere, Lamium galeobdolon agg.*, Oxalis acetosella, Petasites albus, Plagiomnium undulatum, Polygonatum multiflorum, Primula elatior, Pulmonaria officinalis* agg.*, Ranunculus lanuginosus, Stachys sylvatica, Stellaria nemorum, Telekia speciosa.*

Dominant tree species
A*lnus glutinosa, A. incana, A. rohlenae, Fraxinus excelsior.*

Constant species
Alliaria petiolata, Alnus glutinosa, Brachypodium sylvaticum, Carex remota, Corylus avellana, Dryopteris filix-mas, Equisetum arvense, Eurhynchium hians, Filipendula ulmaria, Fraxinus excelsior, Galium aparine, Geranium robertianum, Lamium maculatum, Lysimachia nummularia, Mercurialis perennis, Plagiomnium affine, Poa nemoralis, P. trivialis, Ranunculus repens, Rhizomnium punctatum, Rubus caesius, Sambucus nigra, Urtica dioica.

Ecology and forest management

Floodplain forests of the alliance *Alnion incanae* occur at headwater seepages and stream banks. These forests are adapted to inter- and intra-annual fluctuations in water level, i.e. soils that are usually flooded in spring and temporary drying out in summer. The soils are rich in nutrients and are productive. These forests are characterized by dynamic ecological conditions that control the composition and diversity of the species pool. At larger spatial scale, the plant species composition and diversity of these forests is related to climatic conditions (Slezák et al. 2013; Douda et al. 2016), historical migrations and evolutionary processes (Douda et al. 2018; Hrivnák et al. 2020), whereas landscape configuration and succession (Douda 2010; Petrášová-Šibíková et al. 2017), along-stream dispersal (Kuglerová et al. 2015), duration of floods (from several days to weeks; Douda 2010; Kuglerová et al. 2015), stream power (Pielech 2015; Pielech et al. 2015) and site productivity (Kuglerová et al. 2014; Slezák et al. 2017) are the key factors within catchments. This vegetation has many ecosystem functions and services such as flooding and erosion control and improving of water quality through filtration of nutrients incoming from agricultural lands (Naiman & Decamps 1997). Forest management practices are not usually applied in this vegetation.

Distribution range in Europe

This alliance is distributed in the nemoral and boreal humid zone of Europe, but it also occurs in mountains across southern Europe (Biurrun et al. 2016; Douda et al. 2016). In the temperate part of the Iberian Peninsula, it is replaced by the alliance *Hyperico-Alnion glutinosae* in the Cantabrian rivers and streams, but still persists in the mountain streams of Cantabrian Range and Pyrenees with a slightly distinct plant composition (suballiance *Buxo sempervirentis-Alnenion glutinosae* Biurrun et al. 2016).

Threats to biodiversity and challenges for conservation

Biodiversity in the floodplain forests is vulnerable to stream regulations (i.e., lower frequency of flooding) which facilitate the successional processes leading to mesophilous forests. Most alder dominated forests of *Alnion incanae* originated in the 20th century by spontaneous succession after abandonment of wet grasslands or pastures (Douda 2010). Today, floodplain forests of the alliance *Alnion incanae* are rare in lowlands, where anthropogenic pressure represented by stream canalization, agriculture and urbanization remains strong. On the contrary, highland and mountain streams are frequently accompanied by this vegetation across Europe. One of the most important threats for their biodiversity is the high level of plant invasion (Wagner et al. 2017).

Conservation and management

Conservation of this vegetation often requires restoration of small streams. This consists of creating a new meandering course of the stream with restoration of natural flooding and of planting trees. These forests don't require any specific management, but it is essential to maintain a natural hydrological regime. In the past, these forests were usually coppiced and extensively grazed, which probably increased the species diversity of plants and invertebrates.

List of conservation and management requirements

Conservation efforts include maintenance of regular floods and high water levels, prevention of deforestation and urbanization, active management for suppression of invasive species and establishment of protected areas (legal protection). A suitable forest use for maintaining species diversity should be applied in protected areas depending on the local traditional knowledge including non-intervention, extensive grazing, coppicing and other practices.

Conservation status

Emerald: G1.12 - Boreo-alpine riparian galleries; G1.21 - Riverine *Fraxinus* - *Alnus* woodland, wet at high but not at low water.

Annex 1: 91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*).

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

The habitat recovers under suitable hydrological conditions relatively well, but the recolonization of the site by riparian trees and herbaceous species may take a long time, if there are no floodplain forests nearby.

The black alder stream forest in a small valley on a tributary to the river Lužnice (Czech Republic).

Ash-alder seepage forest at stream headwater site characterized by permanently high water level (Czech Republic).

Alder-ash forest of the suballiance *Buxo-Alnenion glutinosae* in the Irati river (western Pyrenees, Spain).

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Hyperico androsaemi-Alnion glutinosae (Amigo et al. 1987) Biurrun et al. 2016

Cantabrian floodplain forests

Idoia Biurrun, Estêvão Portela-Pereira, Carlos Salazar Mendías,
Patricia María Rodríguez-González

Syntaxonomy

The alliance *Hyperico androsaemi-Alnion glutinosae* comprises stream and seepage forests dominated by *Alnus glutinosa, A. lusitanica* and *Fraxinus excelsior*, also sometimes *Betula pubescens*, in the Cantabrian fringe of the Iberian Peninsula, under temperate-oceanic and hyper-oceanic climate. These forests have been traditionally included in the alliance *Alnion incanae* (Rivas-Martínez 2011; Douda et al. 2016), although they had already been distinguished at a suballiance level by Amigo et al. (1987). Subsequently, Biurrun et al. (2016) raised their syntaxonomic rank to alliance level after analyzing all floodplain forests from the Iberian Peninsula, and restricted *Hyperico-Alnion* to Cantabrian forests, thus excluding Pyrenean ones, that had also been included in *Hyperico-Alnenion*, and are currently classified in *Alnion incanae*, through the suballiance *Buxo sempervirentis-Alnenion glutinosae* (Biurrun et al. 2016). The type of the alliance is the association *Hyperico androsaemi-Alnetum glutinosae*, first described by Braun-Blanquet (1967) from Basque streams. This concept was followed by Mucina et al. (2016) in the Checklist of European vegetation.

These forests occur in areas where *Alnus lusitanica* is present, so *A. lusitanica* is probably present at least in part of their distribution area instead of *A. glutinosa*.

Biurrun et al. (2016) described the new suballiance *Saxifrago spathularis-Fraxinenion excelsioris* to include ash, hazel and birch formations from the north-west Iberian Peninsula growing on siliceous bedrock of headwaters and springs. The typical suballiance includes four associations, spread across from Galicia to Catalonia. *Saxifrago-Fraxinenion* includes four associations mostly located in the mountains of northern Portugal and Cantabrian Range (Biurrun et al. 2016).

Species composition

Diagnostic species
Asplenium scolopendrium, Athyrium filix-femina, Cardamine flexuosa, Chaerophyllum hirsutum, Chrysosplenium oppositifolium, Circaea lutetiana, Culcita macrocarpa, Cyclosorus pozoi, Dryopteris aemula, D. borreri, Euphorbia dulcis, Hymenophyllum tunbrigense, Hypericum androsaemum, Lysimachia nemorum, Myosotis martini, Oxalis acetosella, Polystichum setiferum, Saxifraga hirsuta subsp. *hirsuta, Scrophularia auriculata, Valeriana pyrenaica, Woodwardia radicans*.

Dominant tree species
Alnus glutinosa, A. lusitanica, Betula pubescens, Corylus avellana, Fraxinus excelsior.

Constant species
Alnus glutinosa, A. lusitanica, Angelica sylvestris, Athyrium filix-femina, Brachypodium sylvaticum subsp*. sylvaticum, Carex pendula, C. remota, Circaea lutetiana, Cornus sanguinea, Corylus avellana, Crepis lampsanoides, Dryopteris affinis* subsp*. affinis, D. borreri, Fraxinus excelsior, Geranium robertianum, Hypericum androsaemum, Lamium galeobdolon, Lonicera periclymenum* s.l., *Oxalis acetosella, Polystichum setiferum, Ranunculus repens, Salix cinerea* subsp*. oleifolia, Schenodorus giganteus.*

Ecology and forest management

Floodplain forests of the alliance *Hyperico androsaemi-Alnion glutinosae* occur at headwaters down to the valleys, in ravines, streams and small rivers. Depending on the bedrock and the topographic position, these forests are adapted to a wide range of soil reaction, nutrient content and water level fluctuations (Loidi et al. 2011). Alder forests in the valleys are very species-rich, with many species typical of the meso-eutrophic forests. In calcareous ravines the water level is highly fluctuating, and ash and hazel are usually dominants. Siliceous ravines on coastal hills are home to a very special alder forest type rich in ferns (*Athyrium filix-femina, Blechnum spicant, Dryopteris affinis, Osmunda regalis*), some of them are endangered species with restricted distribution in Europe: *Culcita macrocarpa, Cyclosorus pozoi, Dryopteris aemula, Woodwardia radicans*. Ecosystem functions and services provided by these forests are similar to those provided by forests of *Alnion incanae*, such as flooding and erosion control and improving of water quality through filtration of nutrients incoming from the agricultural lands (Naiman & Decamps 1997). These forests are not subject to management plans, but they have been traditionally used for wood extraction for sticks and other uses.

Distribution range in Europe

This alliance is distributed in the Cantabrian valleys of the northern Iberian Peninsula, but it is also probably present in western France and the British Isles (Biurrun et al. 2016). Eastwards and southwards, in the Pyrenean and Cantabrian mountains, it is replaced by the alliance *Alnion incanae*. However, these temperate riparian forests are replaced by Mediterranean ones as soon as the rivers enter into the Mediterranean region on their way down the valleys: *Osmundo-Alnion* in the Duero basin, and *Populion albae* in the Ebro basin.

Threats to biodiversity and challenges for conservation

One of the most important threats for Cantabrian alder forests is the plant invasion (Liendo et al. 2016), which is a common feature of the riparian ecosystems, as the most sensitive ones to plant invasion (Richardson et al. 2007). In fact, floodplain forests are the most invaded forest types in Europe (Wagner et al. 2017), and this also holds for Cantabrian streams (Liendo et al. 2021). Hydrological alterations such as water abstraction and river regulation, affect the forest species composition (Kopeć et al. 2014) and often facilitate the process of plant invasion (Liendo et al. 2015). Alien plants may also be important in the ravines, even without any hydrological alteration, due to afforestation conducted in the nearby slopes that both destroy the forest during forestry works and fa-

vour the entry of alien trees such as *Acacia* sp.pl. (Loidi et al. 2011). In the valleys, alien trees have been traditionally planted on the floodplain itself, such as *Platanus hispanica*, although the main challenges for the valley forests are stream channeling, agriculture and urbanization, which either directly destroy the forest or disturb it.

Conservation and management

These forests do not require any specific management, but it is essential to maintain a natural hydrological regime and avoid channeling, works and activities with machinery on the nearby slopes and any other hydrological or mechanical disturbances. On ravines, there should be implemented some legislation forbidding afforestation and forestry works near a certain limit to the ravine. Also environmentally respectful forest practices such as Forest certification, that requires respecting the riparian zone, should be applied. Restoration projects should be tried out in the most degraded riverbanks using plant material and seeds from that region.

List of conservation and management requirements

Conservation efforts include maintenance of the natural hydrological regime, prevention of deforestation and minimizing channeling and urbanization. Regarding the plant invasion, the best management is monitoring and prevention. Active management for suppression is recommended with only using the methods that do not destroy the natural vegetation, and also monitoriing for further change is always advisable. Establishment of protected areas in well-conserved forests across their distribution range is also required.

Conservation status

Emerald: G1.21 - Riverine *Fraxinus* - *Alnus* woodland, wet at high but not at low water

Annex 1: 91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*)

EUNIS: These forests were evaluated as Least Concern in the red list of European habitats (Janssen et al. 2016), under the code G1.2a (Alnus woodland on riparian and upland soils), where they were joined with those of the alliance *Alnion incanae.* However, Chytrý et al. (2020) modified the code and content of this EUNIS unit to T12 (*Alnus glutinosa-Alnus incana* forest on riparian and mineral soils), also including Mediterranean alder forests of the alliance *Osmundo-Alnion glutinosae*.

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

The habitat recovers relatively well under suitable hydrological conditions, but the recolonization of the site by riparian trees and herbaceous species may take a long time, if there are no floodplain forest nearby. Recovery also depends on the previous level of habitat degradation and plant invasion.

Ravine forest of the association *Stegnogrammo pozoi-Alnetum glutinosae* (*Hyperico-Alnion*) on a coastal hill in Bakio (Basque Country, Spain). In the foreground, *Osmunda regalis*, *Woodwardia radicans* and *Athyrium filix-femina*.

Alder forest of the association *Hyperico androsaemi-Alnetum* (*Hyperico-Alnion*) in a Cantabrian stream (Basque Country, Spain).

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Fraxino-Quercion roboris Passarge 1968

Elm-ash and oak riparian floodplain forests on nutrient-rich brown soils in the nemoral zone of Europe

Remigiusz Pielech

Syntaxonomy

Elm-ash and oak riparian floodplain forests have been traditionally included in the *Alnion incanae* alliance, along with other streamside and seepage forests. As such, they were usually distinguished under *Ulmenion* Oberd. 1953 suballiance. However, in the recent synthesis of the European plant communities (EuroVegChecklist, Mucina et al. 2016), hardwood floodplain forests of large rivers in the nemoral part of Europe have been distinguished as an independent alliance *Fraxino-Quercion roboris* Passarge 1968 and subordinate to the *Alno-Fraxinetalia excelsioris* Passarge 1968 alliance.

Species composition

Diagnostic species
Acer campestre, Anemone ranunculoides, Cornus sanguinea, Corydalis cava, Ficaria verna, Gagea lutea, Quercus robur, Ulmus minor

Dominant tree species
Fraxinus excelsior, Prunus padus subsp*. padus, Quercus robur, Tilia cordata, Ulmus laevis*

Constant species
Acer campestre, Aegopodium podagraria, Alliaria petiolata, Anemone nemorosa, Brachypodium sylvaticum, Crataegus monogyna, Corydalis cava, Cornus sanguinea, Euonymus europaeus, Fraxinus excelsior, Galium aparine, Geranium robertianum, Geum urbanum, Glechoma hederacea, Lamium maculatum, Milium effusum, Prunus padus subsp*. padus, Pulmonaria officinalis* agg*., Quercus robur, Sambucus nigra, Stachys sylvatica, Stellaria nemorum, Ulmus minor, U. laevis, Urtica dioica*

Ecology and forest management

Elm-ash and oak riparian forests occur within the floodplains along the middle and lower reaches of the large rivers. This forest type is also known as hardwood riparian forests because they are built by hardwood broadleaved trees. They develop on alluvial deposits and occupy the highest elevations within the floodplains that are inundated only during floods of the highest magnitudes (Danielewicz & Pawlaczyk 2004). These floods occur mainly in early springs, but also during summers. Lower elevations within the floodplains are inundated more frequently and are occupied by softwood riparian forests.

Besides the frequency and duration of the inundation caused by flooding, the most important factor determining the occurrence of hardwood floodplain forests is the particle size of the sediments, as they prefer areas of finer sediments (Leuschner & Ellenberg 2017). Groundwater tables may drop below one meter beneath the ground surface during summer (Boublík et al. 2013), and therefore, besides anoxic conditions during flooding, hardwood floodplain forests are also subjected to stress related to water limitations in the hottest months of the year.

Widespread occurrence of vernal geophytes in early summer is typical of this riparian forest type (Pielech et al. 2012). They are replaced by nitrophilous forest herbs and grasses in late spring and summer. Hardwood riparian forests have been recognized as hotspots for woody species as they host numerous trees and shrubs, including regionally rare species (Härdtle et al. 2020). Canopy gaps are frequent in hardwood forests due to the natural disturbances in the floodplains.

Distribution range in Europe

Forests of *Fraxino-Quercion roboris* occur in the nemoral zone of Europe within extensive floodplains of big rivers. They are typical of foothills and lowlands.

Threats to biodiversity and challenges for conservation

Hardwood riparian forests occupy the most productive habitats and were therefore subjects to strong anthropogenic pressures. In many regions, less than 10% of the former natural area remained (Härdtle et al. 2020) because of river regulations, settlements and agriculture within the floodplains. Although this forest type has been recognized as a biodiversity hotspot and provides numerous ecosystem services, it is still exposed to multiple human pressures, including i) river regulations and following changes to the hydrological regime, ii) building dikes and reservoirs as measures of flood prevention, iii) forest management, mainly exploitation of valuable tree species and planting alien tree species within the floodplains, iv) expansion of ash and elm diseases and v) plant invasions (Décamps et al. 1988; Matuszkiewicz 2001; Danielewicz & Pawlaczyk 2004; Tabacchi & Planty-Tabacchi 2005; Härdtle et al. 2020).

Conservation and management

Conservation of hardwood riparian forests is difficult because they depend on the natural hydrological regime and deposition of fine material within the floodplain. Human-induced alterations of the hydrological regime lead to degradation of the structure and the functions in floodplain forests. To protect these communities, all possible efforts should be taken to minimize the acting pressures described above. In addition, whenever possible, dikes removal to restore natural flooding in river valleys can be also a good strategy to restore hardwood floodplain forests.

List of conservation and management requirements

Restoration or maintaining natural hydrological regime, dikes removal to restore flooding in river valleys, exclusion from management of the most valuable fragments of hard wood riparian forests, restrictions regarding planting alien tree species within floodplains, eradication of invasive species.

Conservation status

Annex 1: 91F0 – Riparian mixed forests of *Quercus robur, Ulmus laevis* and *Ulmus minor, Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (*Ulmenion minoris*)

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality

Recovery of structure and function of ash-elm and oak forests depends on the factors that caused the habitat degradation. If the main drivers of the degradation are negative alterations of hydrological regime and deposition of fine sediments, habitat recovery could be impossible. If natural hydrological processes are maintained, habitat recovery is possible but may take a very long time. Also, some additional interventions may be required, for example, removal of the invasive species.

Flooded hardwood riparian forests in the vicinity of Nowa Sól, the Odra River valley, Poland (Photo by R. Pielech).

Forest floor in elm-ash-oak floodplain forest in early spring, dominated by vernal geophytes. The Rędziński Forests in Wrocław, the Odra River valley, Poland (Photo by Z. Dajdok).

Forest floor in late spring dominated by *Allium ursinum*. Vicinity of Kotowice, the Odra River valley, Poland (Photo by Z Dajdok).

Hardwood floodplain forests in the summer. The Rędziński Forests in Wrocław, the Odra River valley, Poland (Photo by Z. Dajdok).

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Alno-Quercion roboris Horvat 1950

Alder-oak riparian floodplain forests on nutrient-rich alluvial soils of the temperate regions of the Balkan Peninsula and western Euxine of Turkey

Željko Škvorc, Vladimir Stupar, Ali Kavgacı

Syntaxonomy

The *Alno-Quercion roboris* was first invalidly described by Horvat (1937) and successively considered by the same author (Horvat, 1938) as synonym of *Alnion incanae* Pawłowski et al. 1928. Later, Horvat (1950) validly described this alliance. This alliance was accepted by many authors as periodically flooded forests that occur on river plains on southern edge of the Pannonian plain (Horvat 1963, Horvat et al. 1974, Jovanović et al. 1986, Zupančič 1986). Brullo and Spampinato (1999) made a syntaxonomical revision extending the alliance definition to hygrophilous forest vegetation dominated by hardwood species (*Quercus robur, Fraxinus oxycarpa, Ulmus minor, Alnus glutinosa*) in floodplains of south-east Europe. Formalized classifications of European floodplain forests and alder carrs conducted by Douda et al. (2016) did not support the differentiation of *Alno-Quercion roboris* from *Alnion incanae*. Finally, *Alno-Quercion roboris* is sometimes considered as part of *Alnion incanae* as a synonym for the suballiance *Ulmenion* Oberd. 1953 (Vukelić 2012).

These syntaxonomical inconsistencies are probably caused by ecological differences between southern and central/northern Europe. In southern Europe, there are considerable differences between lowland periodically flooded forests dominated by hardwood species, growing on deep alluvial soils with fine texture (*Alno-Quercion roboris*) and occasionally flooded forests of grey and black alder on gravel and/or sandy alluvial deposits along mountain streams and on humid terraces (*Alnion incanae*). This contrast becomes less obvious in northern and central Europe. Consequently, treatment of *Alno-Quercion roboris* in this review is based on a proposal by the EVC (Mucina et al. 2016), which suggested a separate position of the alliance including alder-oak riparian periodically flooded forests in the lowland area of the temperate regions of the Balkan Peninsula, vicariant to alliance *Fraxino-Quercion roboris* Passarge 1968 appearing in the northern and central Europe.

There are numerous associations described (Zupančič 1986; Tzonev et al. 2009; Tomić & Rakonjac 2011; Šilc & Čarni 2012; Vukelić 2012, Biserkov et al. 2015; Kavgacı et al. 2016), and the revision should be done to refine the classification pattern down to the association level. Some of them (e.g., *Leucojo aestivi-Fraxinetum angustifoliae* Glavač 1959) occupy shallow relief depressions within the flood zone. These are transitional communities to swamp forests (Vukelić 2012) so they are sometimes classified within *Alnion glutinosae* Malcuit 1929 (Douda et al. 2016).

Species composition

The canopy in high-forest stands can be very tall and multi-layered, dominated by hard wood species (*Quercus robur, Fraxinus angustifolia, F. pallisae*). *Ulmus laevis* and *U. minor* are also very important species but because of Dutch Elm Disease they gradually disappeared from the tree layer and remained in the shrub layer. Shrub layer is well-developed and often structurally complex, with many species that are more typical of mesic forests (*Carpinion*, *Erythronio-Carpinion*). The herbaceous layer is also well developed, with diverse species composition depending on micro topography and water regime.

Diagnostic species
Acer campestre, A. tataricum, Carex brizoides, C. remota, C. sylvatica, Carpinus betulus, Circaea lutetiana, Convallaria majalis, Cornus sanguinea, Crataegus sp. div., *Euonymus europaeus, Fraxinus angustifolia, Geum urbanum, Glechoma hederacea, Ligustrum vulgare, Lysimachia nummularia, Malus sylvestris, Polygonatum latifolium, Pyrus communis, Quercus robur, Rubus caesius, Rumex sanguineus, Sambucus nigra, Ulmus laevis, Ulmus minor, Veronica hederifolia, Viburnum opulus, Viola reichenbachiana*

Dominant tree species
Quercus robur, Fraxinus angustifolia.

Constanst species
Acer campestre, Brachypodium sylvaticum, Carex remota, Circaea lutetiana, Cornus sanguinea, Crataegus spp.*, Euonymus europaeus, Fraxinus angustifolia, Galium aparine, Geum urbanum, Lysimachia nummularia, Quercus robur, Rubus caesius, Sambucus nigra, Ulmus minor, Urtica dioica, Ficaria verna, Glechoma hederacea*

Ecology and forest management

It is mainly developed along the large lowland rivers in a transitional zone between highest river terraces (beyond the reach of floods) and depressions with stagnant water. These communities are periodically flooded, mostly in spring and autumn and their existence and development strongly depend on regular seasonal alternations of ground water tables and periodic flooding. They often form a very complex pattern of communities depending on the micro topography and ground water table. In the period between the floods soil may be dry or wet depending on the flood duration and ground water table. Soils are mainly pseudogley. These stands are highly productive and often serve as important source of valuable timber.

Distribution range in Europe

In south-eastern Europe this alliance is recorded along large rivers of most countries. It has been recorded in: Slovenia, Croatia, Bosnia and Herzegovina, Albania, Serbia, Bulgaria, Greece, Romania, Hungary and Turkey.

Threats to biodiversity and challenges for conservation

These communities have been affected by human activities since ancient times. Their habitats are fragmented or destroyed for creting agricultural land or intensive plantations

of hybrid poplars. They are mainly endangered by hydro-ameliorative activities: construction of dikes, draining and redirection of riverbeds. These activities caused changes in the natural water regime and habitat homogenization, losing complex pattern of different plant communities and decreasing of biodiversity. It is less endangered by invasive alien species compared to habitats of pioneer softwood species, but in the case of high disturbance there can be significant threats (especially *Amorpha fruticosa*). In recent years many stands are severely affected by dieback of *Fraxinus angustifolia* trees caused by *Chalara fraxinea* (Enderle et al. 2019).

List of conservation and management requirements

Remaining stands should be protected from expansion of urbanization, agriculture, and poplar plantation. It is generally important to prevent introduction of alien/invasive species. The remaining parts of free-flowing rivers with periodic flooding should be protected from damming and river regulation. On regulated rivers restoration is possible to enable periodic flooding of the surrounding forest stands. Prevention of water pollution. Establishment of protected areas where it is possible (legal protection).

Conservation status

Emerald: G1.22 Mixed *Quercus* - *Ulmus* - *Fraxinus* woodland of great rivers

Annex I: 91F0 Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *U. minor*, *Fraxinus excelsior* or *F. angustifolia*, along the great rivers (*Ulmenion minoris*).

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

If natural water regime is changed, restoration measures can lead to recovering but it takes long time to get a habitat with high biological value (biodiversity). When the typical trees have been replaced by alien poplars, recovering is much easier and faster. High abundance of competitive alien species would make a restoration more complicated and less efficient.

Quercus robur and *Fraxinus angustifolia* dominated stand in Spačva region (eastern Croatia)

Fraxinus angustifolia forest stand in Spačva region (eastern Croatia)

Fraxino-Ulmetum laevis stand in İğneada floodplain forest (north-western Turkey)

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Poo angustifoliae-Ulmion laevis Golub in Golub et Kuzmina 1997

Oak-elm riparian floodplain forests on nutrient-rich alluvial soils in the steppe zone of Southern Russia

Dmytro Iakushenko

Syntaxonomy

Alliance *Poo angustifoliae-Ulmion laevis* includes *Quercus robur* and *Ulmus laevis* gallery forests distributed in lower part of the Volga river valley. Syntaxonomical diversity of this alliance is presented by 2 associations: *Poo angustifoliae-Quercetum roboris* Golub et Kuzmina 1997 and *Poo angustifoliae-Ulmetum laevis* Golub et Kuzmina 1997 (Golub & Kuzmina 1997). These riparian woodlands need further studies in regional context from its areal in the steppic regions of south Russia and west Kazakhstan. The characteristic of the alliance is done based on limited numbers of articles (Golub & Kuzmina 1997, Kuzmina 2013, Bondareva 2018, Golub & Bondareva 2018).

Species composition and phenology

Moderately species-rich communities (generally about 20-40 vascular plant species per plot). Dominant species are *Quercus robur* or *Ulmus laevis*, also *Populus nigra, Salix alba, Fraxinus pennsylvanica, Morus nigra* occur in the stands. Shrub layer is formed by *Prunus stepposa, Rhamnus catharticus, Crataegus ambigua, Rubus caesius*. Total cover of undergrowth layer varies from 5-10 to 30-40 %, constant herbaceous species are *Carex melanostachya, Aristolochia clematitis, Calamagrostis epigejos, Poa angustifolia,* and *Elymus repens*. Species from dry grasslands (*Galium verum, Eryngium planum, Carex praecox, Artemisia pontica*) and some ruderal species as *Cannabis sativa* var. *spontanea, Cirsium arvense, Erysimum cheiranthoides, Lactuca serriola, Sonchus arvensis* are also abundant.

Vascular plants composition: *Agrimonia eupatoria, Arctium lappa, A. tomentosum, Aristolochia clematitis, Calamagrostis epigeios, Cannabis sativa* var. s*pontanea, Carex melanostachya, Chelidonium majus, Crataegus ambigua, Cynoglossum officinale, Elymus repens, Erysimum cheiranthoides, Fallopia convolvulus, Lathyrus incurvus, Leonurus cardiaca, Poa angustifolia, Prunus spinosa, Quercus robur, Rhamnus catharticus, Rubus caesius, Scrophularia nodosa, Silene latifolia* subsp. *alba, Ulmus laevis, Vincetoxicum scandens.*

Ecology and forest management

Quercus robur gallery forests are found along water courses on elevated geomorphological elements with loamy alluvial soils, 8-9 m above average water level. In the low stage, the groundwater level is situated on the depth of 3-4.5 m. Currently, after the regulation of the water regime and due to constructed dams by 1958, spring-summer floods are irregular and short-term. They occur very rare and last about 5-10 days.

These park-like forests (cover of the tree layer varies from 50 to 60 %) are built by a multiple shrubwood generations, and the average tree age is about 60-70 years. Seed regeneration is poor: oak seedlings occur occasionally, and plants older than 2 years have not been found. The average height of the trunks is 15 m.

Lower Volga oak and elm woodlands were subjects of strong anthropogenic impact during centuries. They were used as excessive pastures, as well as for wood cutting and haymaking. Pastoralism could partly explain the significant share of ruderal species in floristic composition. Nowadays this gallery forests are widely used for recreation purposes.

Distribution range in Europe

Distribution range of the alliance is limited to the south-eastern part of the continent – Lower Volga valley. Association *Poo angustifoliae-Quercetum roburi* is distributed in the northern part of the Volga-Akhtuba floodplain, and localities of the association *Poo angustifoliae-Ulmetum laevis* occur a little bit southward along the river.

Threats to biodiversity and conservation challenges

Gallery oak forests were a significant source for wood in this semi-arid area, so old trees were cut at least in the end of the 19th century. Current phytosanitary state of the *Quercus robur* stands is unsatisfactory. Also some alien species such as *Fraxinus pennsilvanica* and *Amorpha fruticosa* are frequenttly found in the communities of the alliance *Poo angustifoliae-Ulmion laevis*.

The riparian forests of this alliance need to be included into the system of nature protected areas.

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AZONAL VEGETATION
ALLUVIAL FORESTS AND SCRUB

Salicetea purpureae Moor 1958
Willow and tamarisk scrub and low open forests of riparian habitats in the temperate to arctic zones of Europe

Salicetalia purpureae Moor 1958
Willow scrub and low open forests of riparian habitats in the temperate to arctic zones of Europe

Salicion elaeagno-daphnoidis (Moor 1958) Grass 1993
Scrub vegetation of subalpine to submontane river gravel bars of the temperate and boreal European mountains and the Caucasus

Salicion albae Soó 1951
Softwood alluvial forests of lowland to submontane river alluvia of Europe

Salicion triandrae T. Müller et Görs 1958
Willow scrub on loamy-sandy sediments on river banks

Artemisio dniproicae-Salicion acutifoliae Shevchyk et V. Solomakha in Shevchyk et al. 1996
Eastern European willow scrub on riverine dunes

Salicion salviifoliae Rivas-Mart. et al. 1984
Western Iberian thermo- to supra-Mediterranean riparian alluvial willow scrub on the alluvia of mineral-poor rivers

Salicion discolori-neotrichae Br.-Bl. et O. de Bolòs 1958 corr. Rivas-Mart. et al.
Eastern Iberian thermo- to supra-Mediterranean riparian alluvial willow scrub on the alluvia of mineral-poor rivers

Salicion cantabricae Rivas-Mart., T.E. Díaz et Penas in Rivas-Mart. et al. 2011
Cantabrian sub-Mediterranean montane pioneer willow scrub on the alluvia of mineral-poor rivers

Salicion pedicellatae Galán de Mera et al. in Pérez Latorre et al. 1999
Southern Iberian, Maghrebinian and Calabro-Sicilian thermo- to supra-Mediterranean riparian alluvial willow scrub on the alluvia of mineral-poor rivers

Tamaricetalia ramosissimae Borza et Bosşcaiu ex Dolţu et al. 1980
Tamarisk riverine scrub of the lowland rivers of the Balkan Peninsula and the Sarmatian region of Southern ukraine and Russia

Tamaricion parviflorae I. Kárpáti et V. Kárpáti1961
Tamarisk riverine scrub on coarse gravelly soils on lowland river banks of the western regions of the Balkan Peninsula

Salicion eleagno-daphnoidis (Moor 1958) Grass 1993

Scrub vegetation of subalpine to submontane river gravel bars of the temperate and boreal European mountains and the Caucasus

Đorđije Milanović, Vladimir Stupar

Syntaxonomy

The alliance *Salicion eleagno-daphnoidis* comprises scrub semi-open to closed formations on gravel and/or sandy deposits of montane, altimontane and subalpine belts in the upper water courses with fast and turbulent flows, dominated by low- to medium tall shrubs: *Salix eleagnos, Salix amplexicaulis, Salix daphnoides, Salix purpurea, Hippophaë rhamnoides* subsp. *fluviatilis* and/or *Myricaria germanica*. The alliance was first time mentioned by Aichinger (1933) as *Salicion incanae*, but later described by Moor (1958) as *Salicion eleagni* and *Salicetum eleagno-daphnoidis* (nomenclatural type of the alliance).

Physiognomically similar vegetation of gravel bars of Cantabria belongs to vicariant alliance *Salicion cantabricae* Rivas-Martínez, T.E. Díaz et Penas in Rivas-Martínez et al. 2011, while *Salix* scrub developed in beds of periodically dry Mediterranean rivers from southern Europe belongs to specific alliances: *Salicion discolori-neotrichae* Br.-Bl. et O. de Bolòs 1958 corr. Rivas-Mart. et al. 2002 from eastern Iberian Peninsula and *Salicion salviifoliae* Rivas-Mart. et al. 1984 from western Iberian Peninsula (Rivas-Martínez 1984; Mucina et al. 2016). After systematic revision of gravel bar plant communities (Kalnikova et al. 2021) only four associations have been recognized so far as follows:

- *Salici purpureae-Myricarietum germanicae* Moor 1958 – with domination of *Myricaria germanica* distributed throughout of the range of the alliance;
- *Salicetum eleagno-purpureae* Sillinger 1933 – with domination of *Salix eleagnos* and *S. purpurea* distributed in Pyrenees, Alps, Apennines, Carpathians, and Balkan Peninsula;
- *Salici eleagni-Hippophaëtum rhamnoidis* Braun-Blanquet in Volk 1939 – with domination of *Hippophaë rhamnoides* distributed in Alps, Apennines and Caucasus;
- *Saponario officinalis-Salicetum purpureae* Tchou 1948 – with domination of *Salix purpurea* distributed in Pyrenees, Apennines, Alps, Carpathians, and Balkan.

In the montane alluvial deposits, initial scrub associations of *Salicion eleagno-daphnoidis* are often in direct contact (and sometimes in mosaics) with the herbaceous open vegetation of gravel bars (*Epilobion fleischeri, Calamagrostion pseudophragmitis*), mostly on the side facing the watercourse, while in the opposite side these are higher and with dense canopy, which are floristically closer and often adjoined to alder forests (*Alnion incanae*). This means that some associations from these contact alliances are in direct

syndinamycal relations, often forming transitional communities and consequently have similar floristic composition, which result in the fact that they are hard to classify and differentiate from each other.

Species composition

Diagnostic species of the alliance (Chytry 2013; Kalnikova et al. 2021)
Alnus incana, Cardamine flexuosa, Chaerophyllum aromaticum, Daucus carota, Elymus caninus, Epilobium dodonaei, Eupatorium cannabinum, Hippophaë rhamnoides subsp. *fluviatilis, Medicago lupulina, Melilotus albus, Mentha longifolia, Myricaria germanica, Petasites hybridus, P. kablikianus, Poa compressa, Salix amplexicaulis, S. daphnoides, S. eleagnos, S. euxina, S. purpurea, Silene vulgaris, Stachys sylvatica, Tanacetum vulgare, Tussilago farfara*

Dominant species
Hippophaë rhamnoides subsp. *fluviatilis, Myricaria germanica, Salix eleagnos, S. purpurea*

Constant species
Agrostis stolonifera agg.*, Artemisia vulgaris*, *Galium mollugo, Salix eleagnos, S. purpurea, Tussilago farfara,* etc.

Ecology and forest management

It generally occurs on gravel and/or sandy alluvial deposits on terraces of small rivers and streams alongside turbulent watercourses predominantly in montane and altimontane belts, growing on shallow terraces of wider river valleys where the regular spring and autumns torrents are not so strong, enabling deposition of fine- to coarse-grained material carried by the stream. These habitats are highly dynamic, periodically flooded, and well-drained, indicating very wet conditions in one part of the year (spring, autumn) when the water level is high, and very dry in the summer when the water recedes into the trough. Such harsh circumstances are inconvenient for most of the tree species, with exception of *Salix eleagnos* and some other shrubs, which can survive due to their strong vertical root system, forming open, semi-open or dense scrub to low-forest formations which are, therefore, not of interest in forestry. The grey willow (*Salix eleagnos*) is best adapted species to mentioned habitat conditions having an important role in the stabilization of these deposits and providing favorable conditions for further colonization of the less adaptable species such as *Alnus incana*, *Alnus glutinosa* etc. in the subsequent succession of vegetation. Furthermore, *Salix eleagnos* is a pioneer species which grows also in the most mobile deposits in the contact zone with the river body, but always in form of seedlings, considering that the regular and strong moving of the substrate every year doesn't allow their further growth. This means that communities of *Salicion eleagno-daphnoidis* are often developed in several vegetation stages on one place: from pioneer scrub to higher formations with dense canopy.

This scrub vegetation of gravel bars is not subject to any kind of forest management, but at the same time is under high and systematic pressure by man and needs conservation.

Distribution range in Europe

The communities of *Salicion eleagno-daphnoidis* have typical disjunct distribution confined to upper valleys of rivers in the Pyrenees, Alps, Apennines, mountains of Balkan Peninsula, Carpathians, Caucasus, and Scandinavia.

Threats to biodiversity and challenges for conservation

These communities are under very strong impact by man in the last 70 years throughout Europe, resulting in destruction and detriment of the habitat in many European countries and considered as vulnerable in whole Europe (Janssen et al. 2016). The planning of numerous small hydropower plants on montane river courses in south-eastern Europe, where this type is still very representative and well-preserved, indicates a challenge for the whole Europe to maintain it in favourable conservation status.

The main pressures are human actions that lead to modifications of the hydrologic regime and functioning of the watercourse, because the extreme fluctuation of the water level during the year is most important factor for natural preservation of these scrub vegetation. Construction of dams and barriers, as well as subsequent pipe-routes for energy production are still very frequent. Sand and gravel extraction have represented a common problem for this habitat. Solid and chemical pollution represent another very frequent threat for watercourses. This habitat, when disturbed by human activities, is subject to easy invasion by pioneer exotic plants that can sometimes even become dominant. Climate changes represent a potential threat for the habitat because it can cause the permanent alteration of the water regime (Janssen et al. 2016).

Conservation and management

Well preserved communities of this type developed along free-floating montane watercourses with undisturbed hydrologic regime don't require any specific management but should be protected and exempted from any human influence. In disturbed areas there is a need to reach the right compromise between habitat conservation and the satisfaction of human needs (exploitation of water resources, extraction of sediments), to make some parts of the conflict zone enabled for their natural restauration. Nevertheless, specific measures aimed to limit the habitat erosion and invasion of exotic plants should be adopted in all European countries, especially those where urban and industrial areas are now rapidly developing after difficult political and economic historical periods.

List of conservation and management requirements

Maintenance of undisturbed hydrologic regime through establishment of new protected areas and enacting a moratorium on further construction of hydropower plants in intact areas throughout Europe, restoring/improving water quality and hydrologic regime in disturbed areas, enable natural restoration of some parts of the conflict zones subjected to extraction of sediments, eradication of alien tree species (if needed).

Conservation status

Emerald: F9.1 Temperate and boreal riparian scrub

Annex 1 of the Habitats Directive: 3230 Alpine rivers and their ligneous vegetation with *Myricaria germanica*; 3240 Alpine rivers and their ligneous vegetation with *Salix elaeagnos*

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

The capacity of this habitat to recover differs according to the type of damage that the habitat has undergone. If, as is most frequent, the damage influences the hydrology and morphology of the stream or its basin, the recovery time can be very long or even unattainable and restoration always requires intervention. If the damage is from water pollution, the habitat can be restored in a relatively short time (10 years, or even less) but anyway through intervention and the complete removal of the causes of pollution.

Typical *Salix eleagnos* and *Salix amplexicaulis* low formations, along Tara river, Montenegro (Photo by Đ. Milanović)

Salix eleagnos stripe formations along montane rivers, along Vrbnica river, Montenegro (Photo by Đ. Milanović)

Dense stands of *Myricaria germanica,* along Pčinja river, S Serbia (Photo by Đ. Milanović)

Typical appearance of the gravel bar scrub, along Lim river, Montenegro (Photo by Đ. Milanović)

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Salicion albae Soó 1951

Softwood alluvial forests of lowland to submontane river alluvia of Europe

Vladimir Stupar, Đorđije Milanović, Jozef Šibík, Andraž Čarni

Syntaxonomy

The alliance *Salicion albae* encompasses azonal riparian forests along the banks of large rivers where they grow on the lowest parts of the alluvial plane. They are dominated by arborescent willows and poplars such as: *Salix alba, Salix euxina, Populus nigra*, while to the south these stands can contain *Populus alba*. Compared to the hardwood alluvial forests they are more species-poor, but can sustain frequent repetitive, high and long-lasting flooding very well. Soil is usually undeveloped due to constant deposition of alluvial material. Due to strong hydrological dynamics two types of these forests can be distinguished depending on how wet the site is. Sites with longer period of flooding and higher groundwater level are occupied by more hygrophilous associations *Salicetum albae* Issler 1926, *Salicetum fragilis* Passarge 1957 and *Salicetum albo-fragilis* Soó 1958, while dryer sites on higher parts of alluvial plane with shorter period of flooding and lower groundwater level come with more poplars in the mixture (*Salici albae-Populetum nigrae* Tx. 1931, *Populetum nigro-albae* Slavnić 1952 (in south-eastern Europe)). Soil is more stable in the latter and shows first signs of pedogenetic evolution. As a result, shrub layer is relatively abundant with *Cornus sanguinea, Viburnum opulus, Frangula alnus, Sambucus nigra, Crataegus monogyna* etc.These forests can be sometimes colonized by invasive alien tree and shrub species such as *Acer negundo, Morus alba, Fraxinus americana* and *Amorpha fruticosa* (Sanda et al., 2008; Borhidi et al., 2012; Šilc & Čarni, 2012; Vukelić, 2012; Chytrý, 2013; Tomić & Rakonjac, 2013).

Species composition

Diagnostic species
Acer negundo, Amorpha fruticosa, Artemisia vulgaris, Calystegia sepium agg., *Cornus sanguinea, Echinocystis lobata, Fraxinus americana, F. pennsylvanica, Humulus lupulus, Morus alba, Phalaris arundinacea, Populus alba, P. nigra, Rubus caesius, Salix alba, S. euxina, S. triandra, Symphytum officinale, Ulmus laevis, Urtica dioica, Agrostis stolonifera* agg.

Dominant tree species
Salix alba, S. euxina, Populus alba, P. nigra

Constant species
Herb layer depends on developmental stage of these forests, it is very poor in young (2-3 years) and thick grows, while in older, relatively open stands it can be relatively rich,

comprised mainly by hygrophilous and nitrophilous species: *Solanum dulcamara, Lycopus europaeus, Symphytum officinale, Lysimachia nummularia, Stachys palustris, Lythrum salicaria, Leucojum aestivum, Iris pseudacorus, Mentha aquatica, Galium aparine, Solidago gigantea, Agrostis stolonifera, Urtica dioica, Phalaris arundinacea* etc.

Ecology and forest management

Riverine softwood forests of *Salicion albae* are adapted to periodic floods or occasionally elevated groundwater levels and occur directly along rivers. They occur on annual alluvial deposits (fluvisols) which are loamy and nutrient rich. The development of these stands is associated with running water causing erosion and accumulation, mechanical damage or ice damage and is limited to a narrow strip along the large lowland rivers, but on sites that are better protected from disturbances by the current (Chytrý, 2013). Various species of willows thrive here, along with the predominant white and brittle willow (*Salix alba, S. euxina*) and their hybrid (*Salix* x *rubens*), as well as many shrub species such as red willow, basket, almond willow (*Salix purpurea, S. viminalis, S. triandra*). All willows have narrow leaves to make it easier to survive flood waves, the trunks and the branches can bend as they become wooded relatively late. If damaged, they grow quickly and bloom, and bear fruit in late summer. The individual parts of the willows brought by the water take root quickly. The flood period is usually in spring and depends on the water regime of the river. Dry summers are a very big problem for plants in these forests, when the flow of the rivers is lower and the water level drops deep below the surface, so the habitats are extremely dry (Vukelić, 2005; Košir et al., 2013). Sites with fewer wet conditions are occupied by admixtures or pure stands of *Populus nigra* and *P. alba* (south-eastern Europe). *Salicion albae* communities can have pronounced temporal dynamics, as poplars can easily withdraw during wetter periods and come back again with drier conditions (Tomić & Rakonjac, 2013).

Because of the frequent flooding that sometimes rises to more than 5 m, these sites are hardly ever used for agricultural or forestry purposes (Bohn & Neuhäusl, 2004). However, in some regions (Slavonija, Vojvodina) they are replaced by plantations of fast growing hybrid poplars (Vukelić, 2012; Tomić & Rakonjac, 2013), which are then intensively managed, i.e. cut mainly for cellulose. The management of these forests also depends on the size of the area they occupy, e.g., it is regularly cut in Danube River basin of Serbia, Hungary and Romania where they are found on larger areas, while for example in Bosnia and Herzegovina this practice is sporadic as they are considered “protective” forests.

Distribution range in Europe

Communities of *Salicion albae* are found from western Europe (France, Spain) to southern Russia, while their main distribution area is in the south of Central Europe and the north of southern Europe. Larger areas of these forests are found in Italy, Hungary, Croatia, Serbia, as well as in Danube lowland plain and Danube delta of Romania (Bohn & Neuhäusl, 2004).

Threats to biodiversity and challenges for conservation

As with all riverine woodlands, a major threat are anthropogenic changes in hydrology, such as canalization and water deviation. Natural habitats are eradicated or fragmented by hydro meliorative systems, gravel quarries, urbanization and agriculture, *Populus* plantations etc. Also, one of the major treats are invasive alien species, which are well adapted to disturbed and nutrient rich habitats, and at certain sites can completely replace natural vegetation (Janssen et al., 2016).

Conservation and management

Well preserved communities of this type don't require any specific management, except of maintaining a natural hydrological regime. However, degraded stands and stands invaded by invasive alien species are under increased threat of disappearance. The management should be towards the restoration of natural community. Planting of alien tree species, but also of fast-growing poplar clones should be avoided. In some regions the key to the conservation is a strict protection of the remaining sites.

List of conservation and management requirements

Maintenance of high water table, eradication of alien tree species, establishment of protected areas.

Conservation status

Emerald: G1.11 - Riverine *Salix* woodland; G1.3 - Mediterranean riparian woodland

Annex 1: *91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*); 92A0 *Salix alba* and *Populus alba* galleries

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

Restoration should involve improving the hydrological functioning, by restoring natural river banks and removing dams. If the habitat is not invaded by invasive alien species (*Amorpha fruticosa, Acer negundo* etc.) under favourable hydrological conditions it has a potential to recover relatively well.

Well preserved *Salix alba* forest, along Una river, NW Bosnia and Herzegovina

Plant communities of *Salicion albae* along Danube river, locality Grabčikovo, Slovakia

*Populus alb*a forest, along Una river, NW Bosnia and Herzegovina

Invasion of *Amorpha fruticosa* inside degraded *Salix alba* forest, along Sava river, N Bosnia and Herzegovina

Solidago gigantea, Echinocystis lobata and *Acer negundo* in place of *Salicion albae*, along Una river, NW Bosnia and Herzegovina

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Salicion triandrae T. Müller et Görs 1958

Willow scrub on loamy-sandy sediments on river banks

Andraž Čarni, Mária Šibíková

Syntaxonomy

These scrub communities are (co)dominated by almond willow (*Salix triandra*) and osier (*Salix viminalis*). There is a slight difference in ecological conditions between these two species: almond willow is more common along slow-moving streams on wet and clayey soils, while osier prefers faster watercourses and sandy soils; but communities dominated by purple willow (*Salix purpurea*) occur along very fast watercourses. Willows form a narrow belt of scrub known as the mantle, which is up to 5 meters high between the river and the stands dominated by white willow (*Salix alba*) and broken willow (*Salix fragilis*).

These riverine scrub communities are subject to periodic flooding and a high water table. Flowing water causes erosion and deposition of sediment, mechanical damage, and there a damage appears caused by ice during winter. All willow species have narrow leaves that allow them to survive better under floodwaters. Stems and branches can bend because they lignify relatively late. When damaged, they grow quickly, flower, and bear fruit in late summer. The individual parts of the willows brought by the water quickly take root. The flooding season is usually in spring and depends on the water regime. After the spring floods, the flow of the river decreases and the water level drops during the dry summer months. This creates another problem for vegetation, as sites become dry.

We find these communities along the lower reaches of rivers in the lowlands. Here the watercourse has a moderate gradient and there is an increasing deposition of sediment. These deposits of silt contain a lot of nutrients. These communities thrive on soils dominated by fine soil particles, while they do not appear on sites with a higher sand content or on gravel surfaces.

In comparison with the willow scrub on the gravelly stream banks in the submontane to subalpine belts of the *Salicion eleagno-daphnoidis* alliance, the almond willow and osier shrub occurs in the lowlands where water flow is slower and the sites are rich in sediment and nutrients, but during the summer these stands may suffer from lack of moisture.

Besides almond willow and osier, we can find in these stands also scrub of white willow (*Salix alba*), purple willow (*Salix purpurea*) and crack willow (*Salix fragilis*). The communities are dense, therefore in the herb layer, there appear only a few herb species, originated mainly from reed communities (*Phragmitetea*) and annual eutrophic pioneer vegetation (*Bidentetea*) (Oberdorfer 1992; Mucina et al. 1993; Šilc 2003; Chytrý 2013).

Some associations: *Salicetum triandae, Salicetum triandrae-viminalis, Polygono hydropiperis-Salicetum triandrae*.

Species composition

Dominant species
Salix triandra, S. viminalis

Dominant and diagnostic species
Agrostis stolonifera, Atriplex prostrata, Bidens frondosa, Galium palustre, Myosotis scorpioides, Persicaria hydropiper, Plantago major, Rorippa amphibia, R. sylvestris, Rumex crispus, Senecio sarracenicus, Phalaroides arundinacea, Urtica dioica.

Ecology and forest management

These scrub communities occur along watercourses and require no special management (if the hydraulical functioning is maintained). Since the white willow forests are occasionally cut down, these communities can also be destroyed. However, they recover in parallel with the white willow stands. The spread of these riverine communities occurs via water and they recover relatively quickly.

Distribution range in Europe

The whole Europe except northern and southern Europe.

Threats to biodiversity and challenges for conservation

The greatest threat is the regulation of river beds. If the riverbed is channelized, these communities will be irreversibly destroyed. There is also the threat of urbanization (construction of properties on the river banks), trails (including for fishermen), pollution, establishment of invasive species, etc. If rebuilt, these communities would quickly reestablish themselves if silt habitat were restored. The process can be accelerated by planting.

Conservation and management

These paraclimatic communities need periodic flooding (normal hydrological functioning of a river). In this case, they do not need special management. They are threatened by the change of the river regime (e.g., by dam construction) or change of the river bed.

List of conservation and management requirements

Maintain river dynamics.

Conservation status

EUNIS: F9.121 : Almond willow-osier scrub

MAES-2: Heathland and shrub

IUCN: Temperate shrubland

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

Reconstruction would take a relatively short time. If suitable sites are restored and the source of the species is available, it will take around 10 years for the community to re-establish itself.

View of the riverbank vegetation. There are gallery forests dominated by white willow (*Salix alba*) and we can find almond willow and osier co-dominated scrub (*Salicion triandrae*) close to the water table (river Ljubljanica, near village Podpeč, Ljubljansko barje, Slovenia).

Typical view of almond willow communities (*Salicetum triandrae*) above the water table, along Drina river, NE Bosnia and Herzegovina (Photo by V. Stupar).

Almond willow (*Salix triandra*) up and osier (*Salix viminalis*) down on the river bank of the Ljubljanica river. Both species have narrow shaped leaves to better support floods.

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Artemisio dniproicae-Salicion acutifoliae Shevchyk et V. Solomakha in Shevchyk et al. 1996

Eastern European willow scrub on riverine dunes

Dmytro Iakushenko

Syntaxonomy

The alliance *Artemisio dniproicae-Salicion acutifoliae* comprises willow shrubs dominated by *Salix acutifolia* on alluvial sand dunes in river valleys mainly in Dnieper River basin. They are distributed from nemoral zone in continental region of eastern Europe via steppe zone to the Black Sea coast.

The alliance was described in Ukraine, in the Middle Dnieper area from shrub-dry grassland mosaic communities dominated by *Salix acutifolia*, belonging to the association *Artemisio dniproicae-Salicetum acutifoliae* Shevchyk et Solomakha in Shevchyk et al 1996 (Shevchyk et al. 1996). Originally, it was put into the alliance *Festucion beckeri* Vicherek 1972 (*Festucetea vaginatae* Soó ex Vicherek 1972) (Shevchyk & Solomakha 1996). In western Russia, the association *Agrostio vinealis-Salicetum acutifoliae* Bulokhov 2005 and also the alliance *Agrostio vinealis-Salicion acutifoliae* Bulokhov 2005 were described, further corrected as *Agrostio vinealis–Salicion acutifoliae* Bulokhov in Bulokhov et Semenishchenkov 2015 but in the frame of *Rhamno-Prunetea* Rivas Goday et Borja Carbonell ex Tüxen 1962 class (Bulokhov & Semenishchenkov 2015).

In the conception of *Artemisio dniproicae-Salicion acutifoliae* in the EuroVegChecklist (Mucina et al. 2016), the alliance was relocated into *Salicetea purpurea* Moor 1958 class, and the names *Agrostio vinealis–Salicion acutifoliae* Bulokhov 2005 and *Agrostio vinealis–Salicion acutifoliae* Bulokhov in Bulokhov et Semenishchenkov 2015 are recognized as its synonyms.

Three associations were distinguished so far:

- *Artemisio dniproicae-Salicetum acutifoliae* Shevchyk et Solomakha in Shevchyk et al. 1996 – willow shrub communities with *Salix acutifolia* on riverine dunes in the central Ukraine (Solomakha 2008, Fitsailo et al. 2019);
- *Agrostio vinealis-Salicetum acutifoliae* Bulokhov 2005 – psammophytic shrub communities dominated by *Salix acutifolia* in the nemoral zone of western Russia (Bulokhov & Semenishchenkov 2015);
- *Agrostio giganteae-Salicetum acutifoliae* Bulokhov 2017 – wet shrub communities with *Salix acutifolia* in the nemoral zone of western Russian (Bulokhov 2017).

Species composition

Diagnostic species
Agrostis vinealis, Aristolochia clematitis, Artemisia campestris, Bromopsis inermis, Calamagrostis epigejos, Carex ligerica, C. praecox, Euphorbia esula subsp. *tommasiniana, Festuca beckeri, Galium verum, Jacobaea borysthenica, Myosotis stricta*, *Poa angustifolia, Rubus caesius, Salix acutifolia, Scutellaria hastifolia, Tanacetum vulgare.*

Dominant shrub species
Salix acutifolia.

Constant species
Aristolochia clematitis, Artemisia campestris, Calamagrostis epigejos, Elytrigia repens, Galium verum, Poa angustifolia, Rumex thyrsiflorus, Rubus caesius, Salix acutifolia.

Ecology and forest management

Scrub communities dominated by *Salix acutifolia* occur at floodplains and terraces on alluvial sand dunes. These communities are usually flooded on rare occasions and for a very short time. Water regime changes intermittently from wet to semi-dry and dry conditions, and depends mostly on precipitation. The soils are sandy, slightly acidic and poor in nutrients. Average height of the shrub layer is 3-4 m, density is 0,5-0,8. *Salix acutifolia* is dominant, but *Amorpha fruticosa* and *Frangula alnus* also occur. The cover of herb layer varies from 40 % to 80 %, dry-tolerated psammophytic graminoids (*Agrostis vinealis, Festuca beckeri, Calamagrostis epigeios, Poa angustifolia, Carex praecox, Carex ligerica*) are widespread (Borsukevych 2018; Borsukevych & Dubyna 2020; Fitsailo 2011).

Forest management practices are not usually applied in this vegetation. It should be admitted, *Salix acutifolia* is often used in forest amelioration in the regions on dry fluvioglacial sandy soils outside river valleys. Such communities do not belong to the described alliance.

Distribution range in Europe

This alliance is distributed in the Dnieper River basin in the eastern Europe (Ukraine, south-east Belarus, west Russia) along large and middle rivers (Dnieper, Desna, Khorol, Oril, Prypiat, Samara, Sejm, Sluch, Sozh, Vorskla, etc.), as well as in the river mouth region of the Southern Bug, and has been also reported for Danube delta (Borsukevych 2018; Borsukevych & Dubyna 2020; Fitsailo 2011; Fitsailo et al. 2019; Panchenko 2013).

Threats to biodiversity and challenges for conservation

Biodiversity in riverine willow scrub is vulnerable to changes in hydrological regime of the river valleys. Important threats are construction of infrastructural elements (roads, bridges, dams, etc.), improvement of recreational zones, cutting of the trees and shrubs. A significant threat for this communities is the spreading of invasive plants (*Amorpha fruticosa*).

Conservation and management

Limitation of the direct impact of human activities and maintaining of the natural hydrological regime in the river valleys are considered the main ways to protect these habitats (Borsukevych 2018). In Ukraine, communities of the alliance *Artemisio dniproicae-Salicion acutifoliae* are protected in several national parks and natural reserves.

List of conservation and management requirements

Conservation efforts include maintenance of the natural water regime, prevention of urbanization and habitat fragmentation, active steps for limitation of the spreading of invasive plants, establishment of protected areas. Very likely, extensive pasture regime is important for support of the semi-open mosaic structure in this communities, and this type of activity currently is almost disappeared.

Conservation status

No special conservation status

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

The habitat recovers quite well and quickly, *Salix acutifolia* demonstrates a pioneer strategy.

Open community of the association *Artemisio dniproicae-Salicetum acutifoliae* on Shelestiv island, Dnieper River (Ukraine) in June, 2011. Photo by M. Borysenko.

The *Salix acutifolia* shrubs on the bank of the river Sluch (Ukraine) in August, 2017. Photo by L. Borsukevych.

Willow shrubs of the alliance *Artemisio dniproicae-Salicion acutiformis* in the river Sejm (Ukraine) in July, 2017. Photo by L. Borsukevych.

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Salicion salviifoliae Rivas-Mart. et al. 1984

Western Iberian thermo- to supra-Mediterranean riparian alluvial willow scrub on the alluvia of mineral-poor rivers

Idoia Biurrun, Estêvão Portela-Pereira, Carlos Salazar Mendías,
Patricia María Rodríguez-González

Syntaxonomy

This alliance was described by Rivas-Martínez et al. (1984), who typified it by the association *Salicetum lambertiano-salviifoliae* Rivas-Mart. 1965 corr. Rivas-Mart. et al. 1986, from the mountain streams of Central Range (Rivas-Martínez 2011). Currently it includes two other associations from nortg-west Mediterranean Iberia and southern Portugal.

Species composition

Diagnostic species
Salix salviifolia.

Dominant scrub species
Salix cinerea subsp. *oleifolia*, *S. salviifolia.*

Constant species
Salix cinerea subsp. *oleifolia, S. purpurea, S. salviifolia, S. triandra.*

Ecology and forest management

Salix salviifolia scrub grow along soft-water streams under Mediterranean climate, from the thermo- to the supra-Mediterranean belt. They are no subject to any forest management.

Distribution range in Europe

This alliance is distributed in the western Iberian Peninsula, from southern Portugal to the southern temperate sub-Mediterranean areas in Galicia and northern Castilla.

Threats to biodiversity and challenges for conservation

The most drastic threat is damming for hydrological power plants and also water deviation, as well as cleaning of the rivers, which often target scrub and just leave the big trees. Introduction of invasive species and land use changes may also have an impact.

Conservation and management

The most important management action is to restore the water regime to a level that water fluctuations are as close as possible to natural conditions. Other measures are to eradicate invasive species and to protect sites with a representative set of good examples of the habitat (Janssen et al. 2016).

List of conservation and management requirements

Restoring/improving the hydrological regime. Legal protection of the habitats and species. Management of the landscape features.

Conservation status

Emerald: F9.1 Riverine scrub

Annex 1: None of the Annex 1 habitats matches this scrub.

EUNIS: This scrub was evaluated as Least Concern in the red list of European habitats (Janssen et al. 2016), under the code F9.1 (Temperate and boreal riparian scrub). However, the assignation of these alliances to this habitat in this assessment is not so clear, although Chytrý et al. (2020) repeat it.

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

Restoration of watercourses may have an effect in a relatively short time if the measures are robust enough. Several full-scale restoration projects have been carried out, most of them with great success.

Salicetum lambertiano-salviifoliae in Lozoya stream, Central Range, Spain.

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Salicion discolori-neotrichae Br.-Bl. et O. de Bolòs 1958 *corr.* Rivas-Mart. et al. 2002

Eastern Iberian thermo- to supra-Mediterranean riparian alluvial willow scrub on the alluvia of mineral-poor rivers

Idoia Biurrun, Estêvão Portela-Pereira, Carlos Salazar Mendías,
Patricia María Rodríguez-González

Syntaxonomy

This alliance was described by Braun-Blanquet & O. Bolòs (1958) and its type is the association *Salicetum neotrichae*, from the Ebro valley. Currently it includes five associations (Rivas-Martínez 2011).

Species composition

Diagnostic species
Salix neotricha Goerz, *S. triandra*.

Dominant scrub species
Salix eleagnos subsp. *angustifolia, S. neotricha* Goerz, *S. triandra*.

Constant species
Salix eleagnos subsp. *angustifolia, S. neotricha* Goerz, *S. purpurea, S. triandra, Saponaria officinalis.*

Ecology and forest management

This *Salix* scrub grows along streams under Mediterranean climate in the thermo- to supra-Mediterranean belt. They are not a subject to any forest management.

Distribution range in Europe

This alliance is distributed in eastern Iberian Peninsula, from the Ebro valley to Andalusia.

Threats to biodiversity and challenges for conservation

The most drastic threat is damming for hydrological power plants and also water deviation, as well as cleaning of rivers, which often target scrub and just leave the big trees. Introduction of invasive species and land use changes may also have an impact.

Conservation and management

The most important management action is to restore the water regime to a level where water fluctuations are as close as possible to natural conditions. Other measures are to eradicate invasive species and to protect sites with a representative set of good examples of the habitat (Janssen et al. 2016).

List of conservation and management requirements

Restoring/improving the hydrological regime. Legal protection of the habitats and species. Management of the landscape features.

Conservation status

Emerald: F9.1 Riverine scrub

Annex 1: None of the Annex 1 habitats matches these scrubs.

EUNIS: This scrub was evaluated as Least Concern in the red list of European habitats (Janssen et al. 2016), under the code F9.1 (Temperate and boreal riparian scrub). However, the assignation of these alliances to this habitat in this assessment is not so clear, although Chytrý et al. (2020) repeats it.

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

Restoration of watercourses may have an effect in a relatively short time if the measures are robust enough. Several full-scale restoration projects have been carried out, most of them with great success.

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Salicion cantabricae Rivas-Mart., T.E. Díaz et Penas in Rivas-Mart. et al. 2011

Cantabrian sub-Mediterranean montane pioneer willow scrub on the alluvia of mineral-poor rivers

Idoia Biurrun, Estêvão Portela-Pereira, Carlos Salazar Mendías,
Patricia María Rodríguez-González

Syntaxonomy

This alliance was described by Rivas-Martínez (2011), who typified it in the association *Salicetum salviifolio-cantabricae* Rivas-Mart. et al. 2011, from mountain streams of mountains and high plateaus of northern Castilla. Currently it only includes two associations.

Species composition

Diagnostic species
Salix cantabrica, S. salviifolia.

Dominant scrub species
Salix cantabrica.

Constant species
Frangula alnus, Salix alba, S. cantabrica, S. cinerea subsp. *oleifolia*, *S. eleagnos* subsp. *angustifolia, S. salviifolia, S. triandra, Saponaria officinalis*.

Ecology and forest management

Salix cantabrica scrub grows on hard and soft-water streams under temperate and sub-Mediterranean climate, in the supra-orotemperate belts. They are no subject to any forest management.

Distribution range in Europe

It is distributed in the northern part of western Iberian Peninsula, in the Cantabrian Range and northern Castilian areas.

Threats to biodiversity and challenges for conservation

The most drastic threat is damming for hydrological power plants, water deviation, as well as cleaning of the rivers, which often targets shrubs and just leave the big trees. Introduction of invasive species and land use changes may also have an impact.

Conservation and management

The most important management action is to restore the water regime to a level where water fluctuations are as close as possible to the natural conditions. Other measures are to eradicate invasive species and to protect sites with a representative set of good examples of the habitat (Janssen et al. 2016).

List of conservation and management requirements

Restoring/improving the hydrological regime. Legal protection of the habitats and species. Management of the landscape features.

Conservation status

Emerald: F9.1 Riverine scrub

Annex 1: None of the Annex 1 habitats matches this scrub.

EUNIS: This scrub was evaluated as Least Concern in the red list of European habitats (Janssen et al. 2016), under the code F9.1 (Temperate and boreal riparian scrub). However, the assignation of these alliances to this habitat in this assessment is not so clear, although Chytrý et al. (2020) repeats it.

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

Restoration of watercourses may have an effect in a relatively short time if the measures are robust enough. Several full-scale restoration projects have been carried out, most of them with great success.

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Salicion pedicellatae Galán de Mera et al. in Pérez Latorre et al. 1999

Southern Iberian, Maghrebinian and Calabro-Sicilian thermo- to supra-Mediterranean riparian alluvial willow scrub on the alluvia of mineral-poor rivers

Idoia Biurrun, Estêvão Portela-Pereira, Carlos Salazar Mendías,
Patricia María Rodríguez-González

Syntaxonomy

This alliance was described by Galán de Mera et al. (in Pérez Latorre et al. 1999), who typified it in the association *Equiseto telmateiae-Salicetum pedicellatae* Díez Garretas et al. 1986, from Atlantic coastal areas in Andalusia. Currently it includes six associations (Rivas-Martínez 2011).

Species composition

Diagnostic species
Salix pedicellata.

Dominant scrub species
Salix cinerea subsp. *oleifolia, S. eleagnos* subsp. *angustifolia, S. pedicellata*.

Constant species
Erica terminalis, Flueggea tinctoria, Galium viridiflorum, Nerium oleander, Salix cinerea subsp. *oleoides*, *S. salviifolia, S. triandra, Saponaria officinalis, Scirpoides holoschoenus*.

Ecology and forest management

Salix pedicellata scrub grows on soft and slightly hard-water streams in soils that dry out in summer, alternating with alder forests and rhododendron scrub in the stretches with more permanent water (Pérez Latorre et al. 1999). Regarding the climate, they grow under Mediterranean climate under severe drought, in the thermo-mesomediterranean belt. They are no subject to any forest management.

Distribution range in Europe

It is distributed in Andalusia and adjacent areas in northern Morocco.

Threats to biodiversity and challenges for conservation

The most drastic threat is damming for hydrological power plants, water deviation, as well as cleaning of the rivers, which often targets schub and just leave the big trees. Introduction of invasive species and land use changes may also have an impact.

Conservation and management

The most important management action is to restore the water regime to a level where water fluctuations are as close as possible to the natural conditions. Other measures are to eradicate invasive species and to protect sites with a representative set of good examples of the habitat (Janssen et al. 2016).

List of conservation and management requirements

Restoring/improving the hydrological regime. Legal protection of the habitats and species. Management of the landscape features.

Conservation status

Emerald: F9.1 Riverine scrub

Annex 1: None of the Annex 1 habitats matches this scrub.

EUNIS: This scrub was evaluated as Least Concern in the red list of European habitats (Janssen et al. 2016), under the code F9.1 (Temperate and boreal riparian scrub). However, the assignation of these alliances to this habitat in this assessment is not so clear, although Chytrý et al. (2020) repeats it.

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

Restoration of watercourses may have an effect in a relatively short time if the measures are robust enough. Several full-scale restoration projects have been carried out, most of them with great success.

Salix pedicellata scrub of the association *Nerio oleandri-Salicetum pedicellatae* (*Salicion pedicellatae*) in Andalusia, southern Spain

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Tamaricion parviflorae I. Kárpáti et V. Kárpáti 1961

Tamarisk riverine scrub on coarse gravelly soils on lowland river banks of the western regions of the Balkan Peninsula

Dejan Mandžukovski, Kiril Vassilev, Renata Ćušterevska

Syntaxonomy

According to Mucina et al. (2016) this alliance includes tamarisk riverine scrub on coarse gravelly soils on lowland river banks. It was originally described by Kárpáti & Kárpáti (1961) with two associations (*Tamarici-Salicetum purpureae* Kárpáti et Kárpáti 1961, *Nerio-Salicetum purpureae* Kárpáti et Kárpáti 1961) from Albania. This vegetation presents a pioneer shrubland vegetation developing in lowlands and flat areas of the riverbanks on sandy soils.

Up to now *Tamaricion parviflorae* is represented by seven associations (*Tamarici-Salicetum purpureae* Kárpáti et Kárpáti 1961, *Nerio-Salicetum purpureae* Kárpáti et Kárpáti 1961, *Tamaricetum smyrnensis* Seçmen et Leblebíci 1996, *Tamaricetum parviflorae* Kárpáti 1961, *Vitici-Tamaricetum dalmaticae* Ruci et al. 1995, *Viticetum agni-casti* Lakušić 1972, *Rubo-Viticetum agni-casti* Lakušić et al. 1980) and two plant communities - *Tamarix-Platanus-Vitex* comm., *Tamarix tetrandra* comm. (Kárpáti & Kárpáti 1961, Dring et al. 2002, Dimopolos & Bazos 2012, Jasprica 2016, Drescher 2018, Hadžiablahović 2018, Sarika et al. 2018, Vassilev et al. 2021).

According to Sarika et al. (2018) eastern Mediterranean tamarisk communities of lowland water-course galleries, humid depressions and slightly saline coastal flats from the Greece which are characterized by *Tamarix smyrnensis*, *T. parviflora* or *T. tetrandra* and simultaneously lack of the halophytic species should be included within the alliance *Tamaricion parviflorae*. Contrary, communities of the same species that occur in saline or hyper-saline coastal habitats and are characterized by an obvious abundance of halophytic species could be assigned to *Tamaricion dalmaticae* alliance.

Syntaxonomical diversity of *Tamaricion parviflorae* alliance needs to be established in the regional context from its areal e.g., Albania, N. Macedonia, Bulgaria, Greece.

Species composition

It includes moderately species rich communities with semi-closed horizontal structure and strongly dominated by *Tamarix parviflora*, *T. smyrnensis* and *Salix purpurea* subsp. *amplexicaulis*. Subdominants in some stands are *Ulmus minor* and *Clematis vitalba*. These species form low-tree or high shrub layer with cover between 50 and 90 %. The cover of herb layer is also very high (e.g. between 60 and 90 %). The herb layer was composed by species such as *Anisanta sterillis, Brachypodium sylvaticum, Hordeum murinum, Galium aparine, Dasypyrum villosum, Cynodon dactylon, Elymus repens, Ar-*

temisia campestris, Anchusa officinalis, Chondrilla juncea, etc.

Species composition is similar to stands of the alliance *Rubo ulmifolii-Nerion oleandri* (*Rubo ulmifolii-Viticetum agni-casti*) sharing some common species such as *Rubus ulmifolius, Vitex agnus-castus.*

Diagnostic species
Tamarix parviflora, T. smyrnensis, Salix purpurea subsp. *amplexicaulis, S. eleagnos*

Dominant species
Tamarix parviflora, T. smyrnensis, *Salix purpurea* subsp. *amplexicaulis*

Ecology and forest management

They are found on flat and wide sections of the river valleys along river banks and wet habitats. These shrublands are found in the middle and lower part of river reaches. Sometimes this vegetation also replaces degraded natural *Salix alba* and *S. purpurea* forests). During the spring and early summer they are periodically flooded. During the summer and early autumn water level is low or water is completely missing. Soils are shallow to moderately deep with high gravel, sand and clay deposition. Soil of *Tamarix parviflora* stands situated closely to the coastline might be slightly saline but halophytic species are rarely found. On the other hand, sites of *Tamarix smyrnensis* coastal saline habitats of Marmara region (Turkey) are almost exclusively accompanied by halophytic species (Sarika et al. 2018). *Tamarix smyrnensis* dominated stands can also grow well on riverine localities periodically inundated by freshwater.

Tamaricion parviflorae phytocoenoses are used for pasture of domestic animals, which leads to changes in the species composition. Sometimes they also may be used for logging.

Distribution range in Europe

According to Mucina et al. (2016) the distribution of this alliance is limited along lower rivers banks in western Balkan peninsula. Nowadays the alliance is established in Greece, N. Macedonia, Albania, southern part of Bulgaria which expanded its areal to central and eastern parts of the Balkan peninsula and Turkey also.

Threats to biodiversity and conservation challenges

These shrubs have been destroyed or degraded as a result of long-term and strong anthropogenic pressure. Their use as pastures and the deposition of wastes on the river banks lead to significant extent of ruderalization and distribution of alien species such as *Bidens tripartita, B. cernua, Conyza canadensis, Impatiens glandulifera, Amorpha fruticosa*. Negative impact on hydrological regime has the construction of hydro-ameliorative facilities, hydroelectric power stations and extraction of gravel from the rivers.

Conservation and management

Conservation requires preserving of existing hydrological regimes, limitation of grazing pressure and cutting activities. Control over alien species population and their planting in the surrounding areas is also required. These forests should be located in protected areas and NATURA 2000 network.

List of conservation and management requirements

Preserving of existing water regimes, maintenance of suitable water table, decreasing of grazing pressure, prevention of water and riverbank pollution, adaptation of forest management (deforestation), no introduction of alien/invasive species.

Conservation status

Annex I: 92D0 Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*)

PAL.CLASS.: 44.8133 East-Mediterranean *Tamarix* thickets; 44.8141 Pontic Tamarix stands

EUNIS: F9.3133 East Mediterranean tamarisk thickets, F9.3141 Pontic tamarisk stands

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

In cases of disturbance or destruction of the typical habitat, its restoration is possible, and the habitat will develop naturally within a short time period.

Community with *Tamarix parviflora* on the bank of Bregalnica river in N. Macedonia (Photo by D. Mandžukovski)

Community with *Tamarix parviflora*, East Rhodope Mts, along Krumovitsa river, Bulgaria (Photo by K. Vassilev)

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AZONAL VEGETATION
SWAMP FORESTS AND SCRUB

Alnetea glutinosae Br.-Bl. et Tx. ex Westhoff et al. 1946
European mesotrophic regularly flooded alder carr and birch wooded mires

Alnetalia glutinosae Tx. 1937
European mesotrophic regularly flooded alder cars

Alnion glutinosae Malcuit 1929
Swamp forests mostly dominated by *Alnus glutinosa*

Alnion glutinosae Malcuit 1929

Swamp forests mostly dominated by *Alnus glutinosa*

Jan Douda, Michal Slezák

Syntaxonomy

The alliance includes vegetation of swamps mostly dominated by *Alnus glutinosa*, with a herb layer composed of tall sedges and wetland herbs. In the southeastern Europe, some types of swamp forests are also dominated by *Fraxinus angustifolia*, which is widespread along oxbows of large rivers predominantly in lowlands. The alliance was described in the massif of French Vosges by Malcuit (1929) from a forest dominated by *Alnus glutinosa* (association à *Alnus glutinosa* Malcuit 1926, holotypus). According to recent European synthesis (Douda et al. 2016), the alliance *Alnion glutinosae* comprises: oligotrophic peatland carrs dominated by *Alnus glutinosa* (ass. *Sphagno palustris-Alnetum glutinosae* Lemée 1937); mesotrophic carrs dominated by *Alnus glutinosa* and characterized by the presence of mesotrophic swamp species (ass. *Carici elongatae-Alnetum glutinosae* Tüxen 1931); eutrophic carrs dominated by *Alnus glutinosa* and by nutrient-demanding species (ass. *Carici ripariae-Alnetum glutinosae* Weisser 1970); swamp forests dominated by *Fraxinus angustifolia* that are widespread along oxbows of large rivers (ass. *Leucojo aestivi-Fraxinetum angustifoliae* Glavač 1959); and endemic swamp forests of Iberian Peninsula dominated by *Alnus lusitanica* and other endemic species of southwestern Europe (ass. *Carici lusitanicae-Alnetum glutinosae* Díaz et Prieto 1994).

Species composition

Diagnostic species
C*alamagrostis canescens, Calla palustris, Calliergonella cuspidata, Carex acutiformis*, *C. elata, C. elongata, C. paniculata* ssp. *lusitanica, C. riparia, Dryopteris carthusiana, Equisetum fluviatile, Galium palustre* agg., *Hottonia palustris, Lycopus europaeus, Lysimachia vulgaris, Mnium hornum, Peucedanum lancifolium, P. palustris, Scutellaria galericulata, S. minor, Sium latifolium, Solanum dulcamara, Thelypteris palustris, Urtica kioviensis.*

Dominant tree species

Alnus glutinosa, A. lusitanica, Fraxinus angustifolia.

Constant species
Alnus glutinosa, Carex remota, Equisetum arvense, Filipendula ulmaria, Galium aparine, Humulus lupulus, Lysimachia nummularia, Plagiomnium affine, Poa trivialis, Ranunculus repens, Rubus caesius, Sambucus nigra.

Ecology and forest management

The vegetation develops in shallow waterlogged depressions, mainly near lakes, fishponds and in broad river floodplains. The dominance of wetland species in the herb layer, especially sedges (e.g., *C. acutiformis, Carex elongata* and *C. riparia*,) that are well-adapted to permanent waterlogging, is a typical feature of this alliance. These forests are usually inundated by groundwater for considerable part of the growing season; as a consequence, soils lack well-aerated horizons and are often characterized by high organic matter content, often even peat. The species composition of alder carrs depends primarily on the soil acidity gradient (Slezák et al. 2017), but other factors such as microtopography (Douda et al., 2012), successional status of site (Douda 2008) and regional specificity (Hrivnák et al. 2020) are also important. The *Alnus* stands are usually even-aged, in most cases developed through overgrowing of open wetlands or fens by *Alnus* (Douda et al. 2009). Diverse forest structure and open forest canopy have been shown to promote biodiversity in *Alnus* swamp forests (Natlandsmyr & Hjelle 2016). Douda et al. (2020) suggested that selective cutting (i.e., single-tree selection harvest) is a sustainable management in *Alnus* swamp forests since it mimics the natural disturbance regime occurring within these stands.

Distribution range Europe

The alliance is distributed in the nemoral and boreal zones of Europe but rarely occurs in the Mediterranean region (Douda et al. 2016).

Threats to biodiversity and challenges for conservation

They were proposed to be included among threatened ecosystems listed in Habitat Directive of the European Union (Evans 2010), but there is still no consensus on their conservation strategy. They significantly contribute to regional species pool and provide suitable habitats for many important regional flora and fauna species. Their high biodiversity value is closely coupled with unique ecological conditions, which should be objectives for management and conservation efforts. Many areas of swamp forests have already been destroyed or at least degraded because these ecosystems are sensitive to synergistic impacts of anthropogenic disturbances. Alder carrs from southern Europe are specially threatened, due to their rarity in the landscape (Amigo et al. 2004).

Conservation and management

Conservation of this vegetation often requires restoration of hydrological regime using technical removal of the drainage system. In the past, swamp forests were usually coppiced during the winter, which enhanced within-site heterogeneity of light conditions and probably increased species diversity of wetland plants. These forests are also subject to strong eutrophication, because they occur on the shores of heavily eutrophicated productive fishponds, landscape depressions and river oxbows where nutrients from the settlements and agriculture accumulate. Hence, protection of this vegetation should include ensuring water quality whether by cleaning the water from the settlements or setting requirements for fisheries and agricultural management.

List of conservation and management requirements

Habitat conservation requires maintenance of high-water level in soils, prevention of deforestation and urbanization and requirements decreasing intensity of fisheries and agricultural management in surrounding landscape. In protected areas suitable management for maintaining species diversity should be applied depending on local traditional knowledge including non-intervention, coppicing or selective tree harvesting.

Conservation status

Emerald: G1.41 – *Alnus* swamp woods not on acid peat

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

The habitat recovers under suitable hydrological conditions relatively well, but the recolonization of the site by riparian trees and herbaceous species may take a long time, if these species are not present in surrounding wetlands.

Black alder swamp forest with dominant tussock sedge (*Carex elata*) and bog arum (*Calla palustris*) in littoral zone of fishpond Černiš (Czech Republic)

Black alder swamp forest with dominant ferns (*Thelypteris palustris*) in Natura 2000 locality Jurský Šúr (Slovakia)

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AZONAL VEGETATION
SWAMP FORESTS AND SCRUB

Franguletea Doing ex Westhoff in Westhoff et Den Held 1969
Willow carrs of western Europe, Fennoscandia and the subatlantic regions of central Europe

Salicetalia auritae Doing 1962
Willow carrs of western Europe, Fennoscandia and the subatlantic regions of central Europe

Salicion cinereae T. Müller et Görs ex Passarge 1961
Willow carrs of western Europe and the subatlantic parts of central Europe

Salicion cinereae Th. Müller et Görs ex Passarge 1961

Willow carr of western Europe and subatlantic parts of central Europe

Andraž Čarni

Syntaxonomy

This group includes willow communities that are pioneer stages (first woody species) on marshy and boggy sites. These sites are permanently wetted by groundwater on organic, marshy and peaty substrates. They occur between wet meadows or sedge communities on one side, and stands of black alder (*Alnus glutinosa*) on the other. In terms of ecological conditions, willow carr can occur on both nutrient-rich as well as on acidic, nutrient-poor sites. It is often found along channels between wet meadows, as a successional stage of wet habitats, or as a mantle of black alder woodlands. In some cases, scrub dominated by grey willow (*Salix cinerea*) is also found along the banks of rivers, but these stands belong to the habitat of almond willow (*Salicion triandrae*).

If we compare this vegetation with the riverine scrub (*Salicion triandrae*) - paraclimatic communities thriving along white willow gallery forests (*Salicion albae*), willow carr communities (*Salicion cinereae*) appear on marshy and peaty sites, where *Alnus glutinosa* forests build a potential vegetation. At lower altitudes, in warm sites, we find communities dominated by *Salix cinerea*, but at higher altitudes, in the (sub)montane belt, this species is replaced by *Salix aurita*; however, in some places we can find stands dominated by *Betula humilis*. The latter is found in swampy areas that are moderately acidic (Oberdorfer 1992; Mucina et al. 1993; Šilc 2002; Chytrý 2013).

Some associations: *Betuletum humilis* Steffen 1931*, Salicetum auritae* Jonas 1935, *Salicetum cinereae* Zólyomi 1931.

Species composition

Dominant species in scrub layer
Betula humilis, Frangula alnus, Myrica gale, Salix aurita, Salix cinerea (also subsp. *oleifolia*), *Salix pentandra, Salix repens* (also subsp. *rosmarinifolia*)

Diagnostic and constant species
Anthoxanthum odoratum, Betula humilis, Carex canescens, Carex diandra, Carex elata, Carex limosa, Carex nigra, Eriophorum vaginatum, Filipendula ulmaria, Galium palustre agg., *Geum rivalae, Iris pseudacorus, Lythrum salicaria, Lysimachia vulgaris, Pinus sylvestris, Salix aurita, Salix cinerea, Salix pentandra, Salix repens, Solanum dulcamara, Vaccinium uliginosum*, on acid sites we can find also various species from the genus *Sphagnum*.

Ecology and forest management

These scrub communities occur on waterlogged, marshy and swampy sites in the successional line of black alder (*Alnus gutinosa*) forests. No special management is required, they are mown/cut regularly (e.g., when cleaning and maintaining canals) and in this way the reforestation process is stopped.

Distribution range in Europe

The whole Europe except southern Europe (Montenegro, Greece and Albania).

Threats to biodiversity and challenges for conservation

The main threat present the hydrological changes, especially the drainage of the wetlands and converting them into arable fields or urban areas. In the areas, where these communities appear on peaty sites, the extraction of peat is a threat to these communities.

Conservation and management

The most important action is to maintain these habitats waterlogged. Drying up the wetlands is problematic for them.

List of conservation and management requirements

Waterlogged habitat, periodic cutting, and prevention of eutrophication.

Conservation status

EUNIS: F9.2 *Salix* carr and fen scrub

Annex 1: We integrated into this group also shrubby cinguefoil (*Potenilla fruticosa*) scrub, as Janssen et al. (2016) classified it with the salix fen scrub (F.2). Bisserkov et al. (2015) considered this, the rhodope thickets of Shrubby cinquefoil (*Potentilla fruticosa*) as critically endangered for Bulgaria. Its syntaxomonic status is still under consideration.

MAES-2: Heathland and shrub

IUCN: Temperate shrubland

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

The recovery in precipitation rich and humid environment is rather fast. In areas with dry and warm climate is rather slow and the process takes longer. Practically irreversible is the disappearance of these stands on acid and nutrient poor sites due to eutrophication.

Grey alder (*Salix cinerea*) The leaves are borne on short stalks (i.e. petioles) 2-5 mm long. They are elliptic or obovate with serrulate margins and acute apices. Their upper surfaces are bright green and sparsely hairy, while their undersides are pale green or bluish-green and densely hairy.

Grey willow forms a hedgehog-like scrub along channels in wet meadows in Ljubljanko barje (Slovenia).

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INTRAZONAL MEDITERRANEAN SCRUB

Nerio-Tamaricetea Br.-Bl. et O. de Bolòs 1958
Circummediterranean and Macaronesian riparian scrub

Tamaricetalia africanae Br.-Bl. et O. de Bolòs 1958
Circummediterranean and Macaronesian riparian scrub

Tamaricion africanae Br.-Bl. et O. de Bolòs 1958
Tamarisk riparian dwarf forests or scrub in temporarily flooded freshwater habitats of the western Mediterranean and Macaronesia

Tamaricion boveano-canariensis Izco et al.1984
Tamarisk riparian dwarf forests or scrub of the western Mediterranean and Macaronesia

Rubo ulmifolii-Nerion oleandri O.Bolòs 1985
Thermo- and mesopra-Mediterranean oleander riparian scrub of the western Mediterranean

Securinegion tinctoriae Rivas Goday ex Rivas-Mart. 1975
Lusitan-Estremadurean (Iberian Peninsula) thermo-mesomediterranean riparian thorny formations (tamujal)

Tamaricion dalmaticae Jasprica in Jasprica et al. 2016
Thermo-mesomediterranean tamarisk scrub of the Balkan Adriatic seaboards

Tamaricion africanae Br.-Bl. & O. de Bolòs 1958

Tamarisk riparian dwarf forests or scrub in temporarily flooded freshwater habitats of the western Mediterranean and Macaronesia

Idoia Biurrun, Estêvão Portela-Pereira, Carlos Salazar Mendías,
Patricia María Rodríguez-González

Syntaxonomy

This alliance spreads in the western Mediterranean basin (northern Africa and southern Europe) reaching the Canary Islands (Rivas-Martínez 2011; Mucina et al. 2016). It is a type of alliance of the order *Tamaricetalia africanae* Braun-Blanquet & O. de Bolòs 1958, the only order in the class *Nerio-Tamaricetea* Braun-Blanquet & O. de Bolòs 1958. It was first described in the northeastern Iberian Peninsula (Catalonia, Spain) based on the type association *Tamaricetum gallicae* Br.-Bl. & O. de Bolòs 1958.

It is well known for its notable diversification in the Iberian Peninsula (Garilleti et al. 2012), having been subject to several syntaxonomical approaches (Izco et al. 1984; Cano et al. 2004; Asensi & Díez-Garretas 2011). This is the second most diversified alliance of the class *Nerio-Tamaricetea*. According to Asensi & Díez-Garretas (2011), nine associations are recognized as valid syntaxa. It is worth noting that the nomenclature of three of these associations might change in the future as it seems that *Tamarix canariensis* Willd. only grows in the Canary Islands and that in continental Europe it has been confused with *Tamarix gallica* L. (Villar et al. 2019).

Species composition

Diagnostic species
Tamarix africana, T. canariensis, T. dalmatica, T. gallica, T. tetragyna.

Dominant tree (shrub) species
Nerium oleander, Tamarix africana, T. canariensis, T. dalmatica, T. gallica, T. tetragyna.

Constant species
Arundo donax, Brachypodium phoenicoides, Cynanchum acutum, Dittrichia viscosa, Elymus repens, Imperata cylindrica, Nerium oleander, Phragmites australis, Piptatherum miliaceum, Pistacia lentiscus, Populus alba, Retama sphaerocarpa, Rubus ulmifolius, Scirpoides holoschoenus, Tamarix africana, T. gallica, Tripidium ravennae, Typha domingensis, Vitex agnus-castus.

Ecology and forest management

The tamarisk scrub of *Tamaricion africanae* develops in freshwater rivers, temporary pools, and intermittent streams with moderately hard to very hard water (Rivas-Martínez et al. 2002). They can grow in the first line next to the riverbed or behind, replacing

other riparian deciduous forests of greater size, because *Tamarix* species are very deep rooted phreatophytes that tolerate superficial soil drying. They are no subject to any forest management. This scrub usually thrives under Mediterranean euoceanic to semi-continental bioclimate, from infra-Mediterranean to lower supra-Mediterranean belt, and arid to dry ombrotype (Rivas-Martínez 2011).

Distribution range in Europe

The alliance extends from the Canary Islands (Spain) to the European Mediterranean basin: Iberian Peninsula (Spain and Portugal), France and Italy, both in coastal and inland territories.

Threats to biodiversity and challenges for conservation

Tamarisk scrub suffers from human induced impacts such as hydrological disturbances (including channelization of water courses) mainly for agricultural purposes. Other pressures are urban and farming pollution (including pesticides), afforestation (forestry), removal of shrubs, urbanization and overgrazing. Some alien *Tamarix* species (*T. parviflora, T. chinensis, T. mascatensis, T. dalmatica, T. ramosissima*) commonly cultivated as ornamental seems to be expanding in similar places to the native species.

Conservation and management

Conservation requires maintaining or restoring natural hydrological conditions, i.e., an adequate flow regime. It also requires preventing the scrubs from being cut down. Probably the excesses in river regulation are favoring the expansion of tamarisks at the expense of other riparian forests, at least in some Mediterranean rivers.

List of conservation and management requirements

Maintenance of suitable water table, control of the forest management (deforestation), avoiding the introduction of alien/invasive species with reforestation, and establishment of protected areas (legal protection).

Conservation status

Emerald: F9.3 Southern riparian galleries and thickets

Annex 1: 92D0 Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*)

EUNIS: This riparian scrub was evaluated as Least Concern in the red list of European habitats (Janssen et al. 2016), under the code F9.3 (Mediterranean riparian scrub), renamed to S93 by Chytrý et al. (2020).

Polygono-Tamaricetum africanae in southwestern Spain
(Low Guadalquivir Valley)

Tamaricetum gallicae in southeastern Spain

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

When the hydrological functioning of rivers is restored through intervention, the habitat will develop naturally within a short time frame. Therefore restoration is a combination of intervention (first) and spontaneous development (next).

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Tamaricion boveano-canariensis Izco et al. 1984

Tamarisk riparian dwarf forests or scrub of the western Mediterranean and Macaronesia

Idoia Biurrun, Estêvão Portela-Pereira, Carlos Salazar Mendías,
Patricia María Rodríguez-González

Syntaxonomy

Infra- to supra-Mediterranean tamarisk riparian scrub in temporarily flooded brackish habitats of the western Mediterranean and Macaronesia (Mucina et al. 2016). This alliance spreads from the Canary Islands to western Mediterranean (northern Africa and Iberian Peninsula) (Rivas-Martínez 2011). It belongs to *Tamaricetalia africanae* Braun-Blanquet & O. de Bolòs 1958, the only order in the class *Nerio-Tamaricetea* Braun-Blanquet & O. de Bolòs 1958. It is based in the type association *Inulo crithmoidis-Tamaricetum boveanae* Izco et al. 1984, described in northeastern Spain in the Ebro basin (Izco et al. 1984).

There is a narrow dynamic relationship between tamarisk formations and other halophilous formations belonging to classes such as *Salicornietea fruticosae*, *Juncetea maritimi*, *Saginetea maritimae* or *Therosalicornietea*.

Its remarkable presence is well known in the Iberian Peninsula (Garilleti et al. 2012), having been subject to several syntaxonomical approaches (Izco et al. 1984; Cano et al. 2004; Asensi & Díez-Garretas 2011). It is a poorly diversified alliance, since according to Asensi & Díez-Garretas (2011), only four associations are recognized as valid syntaxa. It is worth noting that the nomenclature of one of these associations might change in the future as it seems that *Tamarix* canariensis Willd. only grows in the Canary Islands and that in mainland Spain it is being confused with *Tamarix gallica* L. (Villar et al. 2019).

Species composition

Diagnostic species
Tamarix boveana, T. canariensis.

Dominant tree (shrub) species
Elaeagnus angustifolia (alien), *Tamarix africana, T. boveana, T. canariensis, T. gallica*.

Constant species
Arundo donax, Cynanchum acutum, Dittrichia viscosa, Elymus repens, Frankenia pulverulenta, Hordeum marinum, Juncus acutus, J. maritimus, J. subulatus, Limbarda crithmoides, Limonium delicatulum, L. supinum, Polypogon maritimus, Phragmites australis, Sarcocornia alpini, Sarcocornia fruticosa, Spergularia marina, Suaeda vera, Tamarix africana, T. boveana, T. canariensis, T. gallica.

Ecology and forest management

The halophilous tamarisk scrub of *Tamaricion boveano-canariensis* develops in brackish to saline water rivers, temporary pools, and intermittent streams (Rivas-Martínez et al. 2002). They are no subject to any forest management.

This scrub usually thrives under Mediterranean euoceanic to semi-continental bioclimate, from infra-Mediterranean to lower supra-Mediterranean belt, and arid to semiarid (dry) ombrotype (Rivas-Martínez 2011).

Distribution range in Europe

The alliance extends from the Canary islands (Spain) to eastern Iberian Peninsula (Spain), mainly in coastal territories reaching some inland territories.

Threats to biodiversity and challenges for conservation

Halophilous tamarisk scrub suffers from human induced impacts such as hydrological disturbances (overexploitation of aquifers and canalization of water courses) mainly for agricultural purposes. Other pressures are urban and farming pollution (including pesticides), planting of trees (forestry), removal of shrubs, urbanization and overgrazing.

Conservation and management

Conservation requires maintaining or restoring natural hydrological conditions, i.e., an adequate flow regime. It also requires preventing the scrubs from being cut down.

List of conservation and management requirements

Maintenance of suitable water table, control of the forest management (deforestation), avoiding the introduction of alien/invasive species with reforestation, and establishment of protected areas (legal protection).

Conservation status

Emerald: F9.3 Mediterranean riparian scrub (LC, least concern).

Annex 1: 92D0 Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*)

EUNIS: This riparian scrub was evaluated as Least Concern in the red list of European habitats (Janssen et al. 2016), under the code F9.3 (Mediterranean riparian scrub), renamed to S93 by Chytrý et al. (2020).

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

When the hydrological functioning of the rivers is restored through active management

(intervention), the habitat will develop naturally within a short time frame. Therefore restoration is a combination of intervention (first) and spontaneous development (next).

Elymo repentis-Tamaricetum canariensis in southern Spain (river Guadalquivir)

Inulo-Tamaricetum boveanae in southeastern Spain
(Cabo de Gata, Almería).

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Rubo ulmifolii-Nerion oleandri O. Bolòs 1985

Thermo- and mesoprameditеrranean oleander riparian scrub of the western Mediterranean

Idoia Biurrun, Estêvão Portela-Pereira, Carlos Salazar Mendías,
Patricia María Rodríguez-González

Syntaxonomy

Oleander and chaste tree riparian scrub develops on stony and sandy streambeds (Rivas-Martínez 2002; Mucina et al. 2016). This alliance spreads from the Iberian Peninsula and northern Africa to the Adriatic coasts (Asensi & Díez-Garretas 2011). It belongs to the order *Tamaricetalia africanae* Braun-Blanquet & O. de Bolòs 1958, the only order in the class *Nerio-Tamaricetea* Braun-Blanquet & O. de Bolòs 1958. The type association is *Rubo ulmifolii-Nerietum* oleandri O. Bolòs 1956, spread in eastern Iberian Peninsula, Ibiza and probably southern France (Bolòs 1985).

Due to the low water table level of the streams that these formations colonize, they tend to be floristically poor and usually contain many species of nearby climatic vegetation, most of them belonging to *Quercetea ilicis*.

This is the most diversified alliance of the class *Nerio-Tamaricetea*. A high number of communities (25) have been described up to now. According to Asensi & Díez-Garretas (2011), 14 associations and 7 subassociations can be considered as valid syntaxa.

Species composition

Diagnostic species
Lonicera biflora, Vitex agnus-castus.

Dominant tree (shrub) species
Nerium oleander, Tamarix africana, T. gallica, Vitex agnus-castus.

Constant species
Asparagus acutifolius, Brachypodium phoenicoides, Dittrichia viscosa, Imperata cylindrica, Nerium oleander, Piptatherum miliaceum, Pistacia lentiscus, Retama sphaerocarpa, Rhamnus alaternus, Rubia peregrina, Rubus ulmifolius, Scirpoides holoschoenus, Smilax aspera, Tamarix africana, T. gallica, Tripidium ravennae, Vitex agnus-castus.

Ecology and forest management

Oleander or chaste tree scrubby communities develop in rivulets and dry ravines with discontinuous fresh water, over stony or sandy streambeds (Asensi & Díez-Garretas 2011). This alliance mainly develops in carbonated substrata except in southern Iberian

Peninsula appearing on siliceous soils (Fuente et al. 2007). They are no subject to any forest management.

This scrub usually thrives under Mediterranean euoceanic bioclimate, from thermo-Mediterranean to lower meso-Mediterranean belt and on arid to dry ombrotype (Rivas-Martínez 2011). They are quite common along coastal zones, reaching inland territories with a mild and frost-free climate.

Distribution range in Europe

The alliance is widespread in the Iberian Peninsula with a high diversification in the eastern part (Garilleti et al. 2012) and extends to France and Italy, reaching the Adriatic coasts and Sicily (Asensi & Díez-Garretas 2011).

Threats to biodiversity and challenges for conservation

Due to the low water level and rockiness of the streams where these formations develop, they are not seriously damaged by extensive human activities such as agriculture and urbanization. Nevertheless, there are some local negative impacts such as hydrological disturbances, overgrazing, fires, sport activities and quarrying (limestone, dolomites or sands).

Conservation and management

Conservation requires maintaining or restoring natural hydrological conditions, i.e., an adequate flow regime. It also requires preventing the shrubs from being cut down.

List of conservation and management requirements

Maintenance of suitable water table, control of the forest management (deforestation), avoiding the introduction of alien/invasive species with reforestation, and establishment of protected areas (legal protection).

Conservation status

Emerald: F9.3 Mediterranean riparian scrub (LC, least concern).

Annex 1: 92D0 Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*)

EUNIS: This riparian scrub was evaluated as Least Concern in the red list of European habitats (Janssen et al. 2016), under the code F9.3 (Mediterranean riparian scrub), renamed to S93 by Chytrý et al. (2020).

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

When the hydrological functioning of the rivers (and coastal sites) is being restored through management actions (intervention), the habitat will develop naturally within a

short time frame. Therefore restoration is a combination of intervention (first) and spontaneous development (next).

Rubo ulmifolii-Nerietum oleandri in southern Spain

Limonio delicatuli-Nerietum oleandri in semiarid southeastern Spain (Guadiana Menor Valley)

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Securinegion tinctoriae Rivas Goday ex Rivas-Martinez 1975

Lusitan-Estremadurean (Iberian Peninsula) thermo-mesomediterranean riparian thorny formations (tamujal)

Idoia Biurrun, Estêvão Portela-Pereira, Carlos Salazar Mendías,
Patricia María Rodríguez-González

Syntaxonomy

This is an isolated alliance, which is endemic to western Iberian Peninsula (Lusitan-Estremadurean province). It belongs to the *Tamaricetalia africanae* Braun-Blanquet & O. de Bolòs 1958, the only order in the class *Nerio-Tamaricetea* Braun-Blanquet & O. de Bolòs 1958. It was placed formerly in other phytosociological classes such as *Quercо-Fagetea* or *Crataego-Prunetea*, thus denoting its controverted syntaxonomical framing because of its original and unique character species. Rivas-Martínez et al. (2002) proposed the mutation of the name to *Flueggeion tinctoriae*, as the currently accepted name for *Securinega tinctoria* (L.) Rothm. (=*S. buxifolia* auct.) is *Flueggea tinctoria* (L.) G.L. Webster.

Due to the low water table level of the streams that these formations colonize, they tend to be floristically poor and usually contain many species of nearby climatic vegetation, most of them belonging to *Quercetea ilicis, Crataego-Prunetea* and *Cisto-Lavanduletea*.

This is the least diverse alliance of the class *Nerio-Tamaricetea*, with only one association: *Pyro bourgaeanae-Securinegetum tinctoriae* Rivas Goday 1964 which is the type association of the alliance (Asensi & Díez-Garretas 2011).

Species composition

Diagnostic species

Clematis campaniflora, Flueggea tinctoria, Thapsia garganica.

Dominant tree (shrub) species

Flueggea tinctoria, Nerium oleander, Pyrus bourgaeana, Tamarix africana.

Constant species

Cistus ladanifer, C. monspeliensis, Crataegus monogyna, Daphne gnidium, Myrtus communis, Nerium oleander, Piptatherum miliaceum, Pistacia lentiscus, Retama sphaerocarpa, Rubus ulmifolius, Salix salviifolia, Scirpoides holoschoenus, Tamarix africana, T. gallica.

Ecology and forest management

This dense thorny scrub develops both in freshwater river floodplains (constituting a serial stage of Mediterranean ash and alder forests) and in streambeds or creeks where

they behave as a climax formation. In most of the cases, the water table is quite deep as waters rapidly disappear after floods (Rivas-Martínez 2011). They are no subject to any forest management.

This alliance thrives under Mediterranean euoceanic and semi-continental bioclimate, from thermo-Mediterranean to meso-Mediterranean belts with dry to subhumid ombrotypes (Rivas-Martínez 2011).

At lower altitudes, under mild climatic conditions (frost-free areas) they enrich with *Nerium oleander* thus being quite difficult to distinguish "tamujares/tamujais" from *Rubo-Nerion oleandri* communities.

Distribution range in Europe

This is an endemic alliance restricted to western and southwestern Iberian Peninsula (Spain and Portugal).

Threats to biodiversity and challenges for conservation

Despite the low agricultural value and rockiness of the soils where these formations mostly develop, they have been strongly damaged by human activities such as agriculture and urbanization, hydrological disturbances and fires in many places. In areas of intensive agriculture (e.g., Alqueva dam irrigation area in southern Portugal), where the natural river network has been totally destroyed and transformed, the type of tributaries they could inhabit have been transformed in channels or they are now areas for cultivation of intensive olive crops.

Conservation and management

Conservation requires maintaining or restoring the natural hydrological conditions, i.e., an adequate flow regime. It also requires preventing the scrub from being cut down.

List of conservation and management requirements

Maintenance of suitable flow regime, control of the forest management (deforestation) and intensive agriculture, avoiding the introduction of alien/invasive species with reforestation, and establishment of protected areas (legal protection).

Conservation status

Emerald: F9.3 Southern riparian galleries and thickets

Annex 1: 92D0 Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*)

EUNIS: This riparian scrub was evaluated as Least Concern in the red list of European habitats (Janssen et al. 2016), under the code F9.3 (Mediterranean riparian scrub), renamed to S93 by Chytrý et al. (2020).

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

When the hydrological functioning of rivers (and coastal sites) is being restored through active management (intervention), the habitat will develop naturally within a short time frame. Therefore, restoration is a combination of intervention (first) and spontaneous development (next).

Pyro bourgaeanae-Securinegetum tinctoriae in a tributary of the river Guadalquivir (Rumblar stream, Jaén).

Flueggea tinctoria

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Tamaricion dalmaticae Jasprica in Jasprica et al. 2016

Thermo-mesomediterranean tamarisk scrub of the Balkan Adriatic seaboards

Dejan Mandžukovski, Nenad Jasprica

Syntaxonomy

The alliance *Tamaricion dalmaticae* was described by Jasprica (2016).This alliance belongs to the class *Nerio oleandri-Tamaricetea africanae* Braun-Blanquet & O. Bolòs 1958 and the order *Tamaricetalia africanae* Braun-Blanquet & O. Bolòs 1958 em. Izco, Fernández-González & A. Molina 1984. The alliance was proposed by Jasprica et al. (2008) as a preliminary concept (*nomen provisorium*) and without an original diagnosis. After (2016) Jasprica performed the formal validation of this alliance according to ICPN (Weber et al. 2000). Holotypus was *Tamaricetum dalmaticae* association described from Adriatic seaboards by Jasprica (2016) and this is the only one association described.

The *Tamaricion dalmaticae* is considered analogous to the western Mediterranean *Tamaricion africanae*.

Species composition

Diagnostic species
Tamarix dalmatica

Constant species
Tamarix dalmatica, Phleum arenarium, Daucus carota, Phragmites australis, Limbarda crithmoides, Elymus pycnanthus, Xanthium strumarium, Salsola soda, Elymus farctus, Cynodon dactylon, Hordeum murinum subsp*. leporinum, Glycyrrhiza glabra, Cynanchum acutum, Dittrrichia viscosa, Rumex* sp., *Juncus maritimus, Calystegia sepium, Cirsium vulgare, Aristolochia clematitis, Halimione portulacoides, Atriplex prostrata, A. prostrata* subsp. *latifolia, Polypogon monspeliensis, Parapholis incurva*.

Ecology and forest management

Tamaricion dalmaticae is localized on the saline or sub-halophilous conditions within the thermo-Mediterranean and meso-Mediterranean belts of the eastern Adriatic coast.

The *Tamaricetum dalmaticae* association shows a high ecological amplitude in terms of moisture. It develops on sandy soils which are only periodically inundated with sea or brackish water, as well as on non-flooded areas. It has connections with the halophyte communities of the *Sarcocornietea fruticosae* and *Ammophiletea* classes, and the xe-

rophilous ruderal communities of the *Artemisietea vulgaris* class. The habitats are exposed to disturbances and fragmentation.

Distribution range in Europe

This alliance is distributed in Croatia, Bosnia and Herzegovina, Montenegro and Albania. We predict occurrence in Greece as well.

Threats to biodiversity and conservation challenges

Construction of hydro-ameliorative devices, redirection of river beds, building of water power stations, cutting and burning of the riverside vegetation during river clearings and for the exploitation of inert materials. To the most important threats belong cultivation, temperature changes (e.g., rise of temperature & extremes), sand and gravel extraction, forest replanting (non native trees), modification of hydrographic functioning, general, intensive mixed animal grazing, removal of hedges and copses or scrub, invasive non-native species, irrigation, water abstractions from surface waters, mining and quarrying and pollution to groundwater (point sources and diffuse sources).

The most important pressures are cultivation, forest exploitation without replanting or natural regrowth, urbanized areas, human habitation, invasive non-native species, sand and gravel extraction, water abstractions from surface waters, forest replanting (non native trees), human induced changes in hydraulic conditions, modification of hydrographic functioning, non intensive mixed animal grazing, removal of the hedges and copses or the scrubs.

Conservation and management

In natural functioning rivers, extreme dynamics (temporary flooding, strong periodical drought) cause regularly development of new habitat and at the same time prevent succession of the habitat into alluvial forest at large scale. In these situation no management is needed. However, where the hydrological conditions have been altered, restoration practices should be applied, focussing on restoration of the hydrological functioning of rivers and coastal sites. In this way the habitat will develop spontaneously.

List of conservation and management needs

Conservation requires maintaining or restoring natural hydrological conditions (an adequate water table). It also requires preventing the scrub from being cut down. Measures related to wetland, freshwater and coastal habitats. Restoring/improving the hydrological regime. Restoring coastal areas. Maintenance of suitable water table, control of the forest management (deforestation), avoiding the introduction of alien/invasive species with reforestation, and establishment of protected areas (legal protection).

Conservation status

Emerald: F9.3 Southern riparian galleries and thickets

Annex 1: 92D0 Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*)

EUNIS: This riparian scrub was evaluated as Least Concern in the red list of European habitats (Janssen et al. 2016), under the code F9.3 (Mediterranean riparian scrub), renamed to S93 by Chytrý et al. (2020).

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

When the hydrological functioning of the rivers (and coastal sites) is being restored through intervention, the habitat will develop naturally within a short time frame. Therefore restoration is a combination of intervention (first) and spontaneous development (next).

Tamaricon dalmaticae on Croatian coastline (Photo by N. Jasprica)

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CONCLUSION

INFLUENCE OF THE WATER ON RIPARIAN VEGETATION AND HOW RIPARIAN VEGETATION INFLUENCES WATER BODIES AND REQUIRES ACTIVE CONSERVATION MEASURES

Marta González del Tánago

This manual on forests and shrublands of European rivers offers a complete phytosociological overview of the variety of existing species, alliances and communities at European scale. It represents an unavoidable tool for their knowledge and management, including systematic insights of taxonomical aspects (i.e., diagnostic, dominant and constant species), practical synecological information, and comments on threats and challenges for the management and conservation of each type of group of forests. Thus, it represents a very valuable information, not only for the scientific community but also for managers as well as for river restoration and conservation practitioners.

Perhaps the most essential feature of the riparian forests and shrub communities described in this manual is their strong and permanent relationship with the presence of water in their surroundings. The floodplain forests that we find along the river valleys are the result of long-term hydrological conditions created by the variability of the flow regime (Greet et al., 2011). Soil moisture, groundwater level and flood exposure influence all the stages of the riparian vegetation development and succession, and their temporal patterns are closely associated to the river flow regime. Particularly, high flows and flooding are needed for riparian species regeneration (Hughes, 2003). High flows periodically induce physical disturbances that erode, transport and deposit sediments, creating newly deposited land forms on the floodplain where many species can regenerate only there (Richards et al., 2002). Maintenance of soil moisture during the recession limb of flood hydrographs is important for allowing seedlings elongate sufficiently to resist water table decline during low flows (Rood & Mahoney, 1990). In general, native plant species have evolved to synchronize their life stages with the natural hydrograph. Most of their functional traits (e.g., response to disturbance, flexibility) are related to water availability and disturbance patterns. Among the riparian species, a wide variety of responses exist regarding their flood tolerance (Glenz et al., 2006), seed and growth requirements or resistance to fluvial morphological processes (Diehl et al., 2017). Finally, riparian plants usually need high rates of soil moisture for transpiration and growth, and remove water from the unsaturated and saturated soil layers which would otherwise drain to recharge aquifers. In general, riparian trees consume for evapotranspiration much more groundwater than shrubs, herbs and grass species. This high water uptake from the soil may affect water regional budgets, but also can play an important role for attenuation of nutrients transported with groundwater, mitigating eutrophication effects (Satchithanantham et al., 2017).

The close relationship of water and riparian vegetation may be evaluated not only with respect to water needs for plant regeneration and development, but also with respect to the role that riparian vegetation exerts on water bodies, particularly in relation to the in-

teractions with the physical processes of the river. By the continuous effects of plants on trapping sediments and woody debris, influencing flow resistance and direction of flows, riparian vegetation represents an active driver of the hydraulic and geomorphic channel conditions, creating and modifying river landforms, controlling bank erosion and inducing changes in channel patterns (Bertoldi et al., 2015).

The presence of particular riparian plant species, and their spatial arrangement in specific riparian associations and communities along the river segments, depends on whether water availability and disturbance patterns are suitable for their establishment and development stages. The high spatial and temporal ecological complexity of riparian and floodplain landforms, based on heterogeneous environments in terms of temperature, substratum, water and nutrients availability and disturbance patterns (Ward et al., 2002), explains the high diversity of type of forests described in the Manual. Biogeographical features also contribute to this diversity of alluvial forests, determining their spatial distribution across European rivers. As the different authors report, each type of forest likely occurs on specific biogeographical context, under local conditions of soil texture, type of hydrologic regime, duration and timing of flooding and soil dryness, water table depth and channel stability. All these features respond to the scale-dependent influence of climate and geology, moisture availability and fluvial disturbance on vegetation, which promote, within the respective biogeographical regions, the longitudinal zonation of associations and communities along the continuum of rivers, as well as the transversal arrangement of vegetation functional zones along the lateral gradients of fluvial processes (Gurnell et al., 2016).

Human activities regulating the river flow regimes by large dams and reservoirs, converting floodplains into agricultural or urban fields, channelizing rivers, planting commercial forests, sealing riparian soils, or depositing debris along river reaches have altered flooding magnitude and timing and reduce soil moisture and groundwater availability. Because of this, the functional floodplain areas have been drastically reduced and many of the original type of forests described in this Manual have been destroyed. Climatic changes may represent an additional threat for many of these alluvial forests, if significant decrease in discharge and flood frequency and magnitude takes place, as it has been predicted for the Mediterranean regions (García Ruiz et al., 2011) and also intensification of dryness affects species growth and productivity (Rodríguez González et al., 2021).

Sustainable management and active river restoration measures including restoring natural hydro-morphological conditions, preventing water pollution, controlling invasive species and leaving free room for rivers are highlighted by the authors of this Manual as essential requirements for the maintenance and conservation of riparian communities. In many cases, these communities represent very valuable and unique habitats which should be considered under restricted conservation status.

The publication of this Manual will significantly contribute to implement strategies for sustainable management and conservation of the studied alluvial forests. Not only it will facilitate knowledge transfer from the scientific community to the river managers, but also it will promote an understanding of the main causes that are threatening their maintenance and conservation. Furthermore, this better knowledge of the European alluvial forests will increase the social perception and awareness that many of them represent unique vegetated landscapes which offer very valuable and uncounted environmental services.

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From the review of Marius Dimitrov

The Interpretative manual of riparian forests and shrublands presents summarized syntaxonomic, ecological, chorological and conservation characteristics of riparian plant communities in Europe especially to the level of their affiliation to alliances.

The riparian forest and scrub communities have significant ecological importance, which have a major role both for the environmental processes and human activities. Among their numerous ecological functions are the conservation of plant and animal species, prevention of the riverbank erosion, and their support for prevention of the floods by the water retention. The riparian phytocoenoses are mainly associated with the rivers and wetlands and it is the reason for their primary restricted range of distribution. The riparian habitats are among of the most vulnerable and rare natural habitats. In the historical aspect, the rivers and wetlands have been reduced due to the area loss mostly because of intensive agricultural activities. Nowadays, the most serious reasons of their loss and destruction are the intensive cultivation of poplar plantations, the rectifying of river streams sand also extraction of inert materials from the river terraces. All these activities have led to dramatic changes in the water flow regimes but also the unauthorized and improperly conducted logging, changes in the hydrologic regime as a consequence of infrastructure construction (hydropower plants, dykes, roads, drainages, etc.) and wildfires. The climatic changes are also reason for significant negative influence which leads to big floods and droughts, massive invasion of alien species, dumpsites and water pollution.

Riparian phytoceonoses still preserve very rich biodiversity. They have been established and developed under specific environmental conditions such as high humidity supplied by river stream, some periodic flooding and also the high content of underground waters. Riparian forests are an integral part of biocorridors for migration of the biodiversity. They have an important role in the maintaining of water quality and in the soil preservation. Generally, they have a positive effect on all aquatic ecosystems.

Together with their high ecological importance, the riparian phytocoenoses and habitats also provide number of direct economic benefits such as timber and medicinal plant production, fishing and recreational incomes, etc. The vegetation has environmental role also in the prevention of river stream erosion.

In the context of all above mentioned, this Manual is current and will contribute for the identification, conservation and maintenance of important and vulnerable riparian forest and shrub communities and habitats.

The authors are adopted the current syntaxonomic scheme (Mucina et al. 2016) and they also presented the classification of plant communities on the alliance level. The characteristics of the individual regional alliances produced by the authors‘ team demonstrated their relevant qualifications and experiences and also that they are familiar with local and regional peculiarities of riparian vegetation.

Each article includes th e following sections: Syntaxonomy, Species composition, Ecology and Forest management, Distribution range in Europe, Threats to biodiversity and challenges for conservation, Conservation and management, List of conservation and management requirements, Conservation status, When severely damaged, does the

habitat retain the capacity to recover its typical character and functionality, Bibliography.

The section “Syntaxonomy” presents the current syntaxonomic status of communities on the alliance level. Some of the authors also present newly established sub-alliances on the regional level. The brief phytocenological characteristic will help users of this handbook to identify the individual plant communities, and this is very useful for the practice.

The paragraph “ Species composition” lists the diagnostic, dominant and constant species, which are completed the characteristic and emphasized the differentiation within the communities by their floristic composition.

Ecological features and differentiations are described in the section “Ecology and forest management”. However, it is better to rename this section “Ecology and traditional activities”, because large part of the riparian forest and scrub communities are included in protected areas or they have some conservation status at European and regional level. Therefore, there are no forestry activities, which are planned or implemented in them.

Summarized chorological information is presented in the section “Distribution range in Europe” . It emphasizes the geographical differentiation of communities and would make it to be easier for the users of this Manual, especially to identify this vegetation.

The major threats are presented on the “Threats to biodiversity and challenges for conservation”. Some of the threats are given in details depending from their strength but others are only mentioned. Most of the authors emphasize the serious threat to these communities from the introduction of alien, invasive species as well as also the replacement of natural tree and shrub species with forest plantations from non-native species. In my opinion, there is no enough and adequate comments to the impact of climate change (temperatures, precipitation) and as a consequence - the increased number of natural disasters such as floods and fires.

“Conservation and management” - in this section attention is directed to the measures that must be taken for future restoration and maintaining of specific environmental conditions: ensuring water flow through the ban of construction or removal of existing infrastructure facilities; prohibition of clear-cutting; removal of plantations; etc.

The rubric “List of conservation and management requirements” presents the most important activities that must be carried out for the maintenance and protection of habitats: maintenance of high water level, prevention of water pollution, adaptation of forest management (deforestation), no introduction of alien/invasive species, no future urbanization, etc. New protected areas have been suggested in some descriptions, which will be important contribution for the conservation of the riverine habitat.

“Conservation status” for each alliance is determined in most of articles. It is produced. according to the classification of Emerald Network, Annex I of Directive 92/43 and EUNIS. Some authors also indicate and the code according to PAL.CLASS, MAES-2 and IUCN.

In the section “When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?” the possibilities of each habitat for restoration in case, if it was significantly disturbed, are presented as summary. The probable dynamic processes, their rate and direction, as well as the probable future prospects are also indicated. These data are very important and outline in general the necessity for future restoration activities.

“Bibliography” - only the most important literature sources have been cited in the article. They contain information for the vegetation on the European as well as on national level, but also it includes some detailed description of the habitat’s locality.

As a conclusion, I highly appreciate this handbook. It was done by highly qualified specialists and also it is written in a solid scientific style. The book was accompanied by very good illustrative material. Its publishing and also application will contribute to the identification, maintenance and conservation of the vulnerable and mostly rare riparian forest and scrub communities.

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