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Notes on the distribution and conservation status of some rare plants of wet habitats in Bosnia and Herzegovina

Original Article

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Abstract:
Wetland habitats in Bosnia and Herzegovina are usually small, fragmented and under numerous anthropogenic pressures. Therefore species confined to such habitats can be considered being among the most threatened plant species in Bosnia and Herzegovina. The focus of this article is the distribution pattern and threatened status of five such plant species: *Achillea ptarmica*, *Carex elongata*, *Carex strigosa*, *Comarum palustre* and *Prunus padus*. While these taxa can be common in other parts of Europe, in Bosnia and Herzegovina, they are rare and usually restricted to a small number of localities. Wetland flora can be found in the Dinaric mountains, where it is confined to the karst fields, mountain plateaus, spring areas and banks of glacial lakes, but as well in the lowlands in the north of the country, occupying the remnants of wetland habitats. Published, new and unpublished (herbarium) chorological data for Bosnia and Herzegovina, description of the habitat, population estimate, threats on habitats and species, and estimation of threatened status based on IUCN criteria are given for each studied species.

Key words:
Achillea ptarmica, *Carex elongata*, *Carex strigosa*, *Comarum palustre*, *Prunus padus,* distribution, ecology

Apstrakt:
O rasprostranjenju i ugroženosti nekih retkih biljnih vrsta vlažnih staništa Bosne i Hercegovine
Močvarna staništa u Bosni i Hercegovini su obično mala, fragmentirana i pod brojnim antropogenim pritiscima. Stoga se vrste ograničene na takva staništa mogu svrstati među najugroženije biljne vrste u Bosni i Hercegovini. Fokus ovog rada su rasprostranjenje i status ugroženosti pet takvih biljnih vrsta: *Achillea ptarmica, Carex elongata, Carex strigosa, Comarum palustre* i *Prunus padus*. Iako su ovi taksoni većinom uobičajeni u drugim dijelovima Evrope, u Bosni i Hercegovini oni su retki i obično ograničeni na mali broj lokaliteta. Močvarna flora se može naći i na Dinarskim planinama, gde je svedena na kraška polja, planinske visoravni, izvorišta i obale glacijalnih jezera, ali i u nizijama na severu zemlje, zauzimajući ostatke močvarnih staništa. Za svaku proučavanu vrstu dati su objavljeni, novi i neobjavljeni (herbarijski) horološki podaci za Bosnu i Hercegovinu, opis staništa, procena populacije, ugroženost staništa i vrsta, te procena ugroženosti na osnovu IUCN kriterijuma.

Ključne reči:
Achillea ptarmica, *Carex elongata*, *Carex strigosa*, *Comarum palustre*, *Prunus padus*, rasprostranjenost, ekologija vrsta

Introduction

At a broad geographical scale, species distribution is determined by macroclimate, evolutionary and migration history (Huntley et al., 1995; Knollová & Chytrý, 2004; Pearson et al., 2004; Tsiftsis et al., 2012). The distribution of species is also influenced by relief, soil properties, mesoclimate and microclimate at smaller scales, as well as human activities that can introduce or cause the extinction of species in certain locations. At the border of the distribution area, a species often transits from a continuous to a disjunct distribution pattern. This is caused by the fact that favourable ecological conditions appear in disjunct patches in limited areas because of a special constellation of conditions. At the edge of their range, populations have restricted areas of occurrence; often, they are ecologically

different and characterized by low abundance in terms of population size (Lesica & Allendorf, 1995; Duffy et al., 2009). Furthermore, plant populations that are at the edge of their distribution range are often at their ecological limits because their habitats are of declined suitability, and therefore they are more sensitive to changes in ecological conditions (Koljanin et al., 2021).

Knowledge of distribution patterns and ecology can be considered fundamental for species conservation (Heywood & Iriondo, 2003). Species of wet habitats can be considered to be one of the most threatened vascular plants in Bosnia and Herzegovina (Redžić et al., 2009). Due to precipitation regimes in the growing season, with long dry periods, significantly higher temperatures, and dominant types of water-permeable geological substrata (especially limestones), the Balkan Peninsula is less covered by wetland habitats than most of the central and northern parts of Europe. Therefore, some species that are common in wetlands of the northern parts of Europe are rare or absent in the Balkans.

Peatlands are of greater value in southern regions than those further on the north, as they usually have specifically distinctive fauna and flora, as well as isolated and possibly more genetically divergent populations of circumboreal species than those of northern mires (Desrochers et al., 2000). In Bosnia and Herzegovina, mires occupy about 16,250 ha scattered throughout the country, with most of them more or less degraded in the last 150 years (Milanović, 2017a). There are only two larger areas with the accumulation of peat (Livanjsko polje and Hutovo blato), with an area of around 13,000 ha (Milanović, 2017a), while all others occupy small areas, mostly on higher elevations, where a particular constellation of ecological factors ensures the existence of these habitats (Barudanović et al., 2019). Since these sites are very sensitive to changes and usually have a limited area, any exploitation of these sites could have huge negative consequences for biodiversity.

The northern part of Bosnia and Herzegovina overlaps with the edge of the Pannonian plain, which is dominantly characterized by typical plain configuration influenced by slow-flowing and large alluvial rivers; this area was very rich in wetland habitats several centuries ago. Due to the unregulated banks of these rivers, the surrounding lowlands were normally seasonally flooded, while rivers often changed their beds, creating conditions necessary for the development of various wetland habitats on the river terraces. The deterioration of wetlands in northern Bosnia and Herzegovina began with the systematic regulation of the flow of the Sava River in the second half of the 18th century and continued with the construction of a reclamation system to preserve agricultural land (Mrgić, 2007). It could be assumed that these changes caused the disappearance of many populations and even species confined to wetland habitats. Such an example is *Fritillaria meleagris* L. which disappeared from many localities after the construction of the drainage system (Koljanin et al., 2021).

Going from north to south of Bosnia and Herzegovina, the northern lowlands gradually rise to the mountain chain of the Dinaric Alps, which is an ecologically very heterogeneous area. In this area, wetland flora is typically limited to karst fields, mountain plateaus and depressions, flattened small river terraces, and fragments alongside mountain brooks and around springs. These habitats are relict remnants of vegetation where some species had found a refugium and have great importance for biodiversity on a national level, as they are inhabited by many plant species that are rare in the country. A great example of such a species is *Liparis loeselii* (L.) Rich. which is found only in one locality in Balkan Peninsula (Milanović, 2012).

One of the fundamental problems in the protection of plants and habitats is the lack of data on these species. The Dinaric part of the country is rich in endemic plant species, while they are absent in northern lowlands (Lubarda et al., 2014), which makes it less attractive for botanical studies. This resulted in a lack of data for some species that have main distribution in the northern part of Bosnia and Herzegovina. On the other hand, some species in the Dinaric mountains are confined to small, refugial areas; therefore, some populations went undetected.

In this paper, we provide new chorological and ecological data for five species that are most common in wetlands of central European countries but occur very rarely in Bosnia and Herzegovina: *Achillea ptarmica* L., *Carex elongata* L., *Carex strigosa* Huds., *Comarum palustre* L. and *Prunus padus* L. Also, we estimated the most appropriate Red list category for all of them.

Materials and Methods

All chorological data on the occurrence of five target species (*Achillea ptarmica*, *Carex elongata*, *Carex strigosa*, *Comarum palustre* and *Prunus padus*) in Bosnia and Herzegovina were collected from the available literature. All literature records were georeferenced using topographic maps with a scale of 1:25,000 in QGIS software.

Fieldwork was conducted in the period from 2006 to 2021 in various wetlands in the northern plains of Bosnia and Herzegovina and in the karst fields, where such habitats are registered or

expected, but also in the Dinaric Alps, at higher elevations, especially around glacial lakes and springs. Coordinates were recorded in WGS1984 using a GPS device, and digital photographs were also collected in the field. Herbarium material was stored in the Herbarium of the Faculty of Forestry of the University of Banja Luka and in the private collection of Đorđije Milanović. This material was used for identification mainly following identification keys in Flora Europaea (Ball et al., 1968; Webb & Rix, 1972; Richardson, 1976; Chater, 1980) while the nomenclature follows the Euro+Med (2006) and Stupar et al., (2021).

Target species are listed alphabetically with the following parameters: literature and new chorological data, general distribution and ecology, habitat and species threats and conservation status. Published and new records are indicated by: locality name (bolded if it is a new record), WGS1984 coordinates, elevation (if available for literature data), MGRS 10×10 km grid code, plant community/habitat type (if available), soil type (if available), population characteristics (if available), date of collecting, collector and bases of record. Maps of species distribution in Bosnia and Herzegovina are presented on a 10×10 km MGRS grid, using different symbols for published, new and unpublished (herbarium) data. Short descriptions of habitats and their stability were given based on field observations. Threat status for each species was estimated or reassessed following the IUCN criteria and categories (IUCN Species Survival Commission, 2012a, 2012b). Given that the area of occupancy (AOO) for each of the species under study is estimated to be less than 10 km^2, we applied the B2 criterion to each species. Additionally, considering that the likelihood of immigration from neighbouring countries is very low, based on the IUCN Species Survival Commission (2012b), we decided to maintain the original category from the initial assessment in step one for each species, as noted by the IUCN Species Survival Commission (2012a).

Results and discussion

Achillea ptarmica L.

Published and new chorological data

Achillea ptarmica is a herbaceous perennial plant easily recognizable by linear undivided leaves with serrate margins (**Fig. 1**) and without glandular punctuations on the leaf surface (Richardson, 1976). This species was previously reported only from three localities in Nevesinjsko polje (Sagorski, 1901; Ritter-Studnička, 1954; Beck-Mannagetta et al., 1983). New records show that species have a wider distribution in various conditions in Bosnia and Herzegovina (**Fig. 2**).

Fig. 1. *Achillea ptarmica* at locality of Berek (© D. Koljanin)

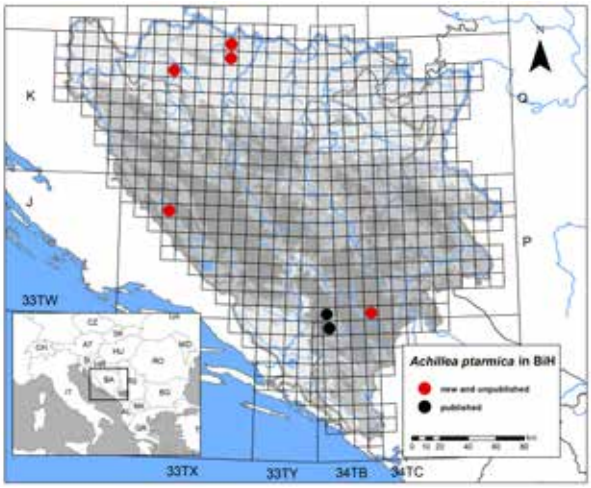

Fig. 2. Distribution of *Achillea ptarmica* in Bosnia and Herzegovina

This species was recorded in the following localities:

- between Nevesinje and Pustoljani (Nevesinjsko polje); *Coordinates*: 18.159896°E, 43.292712°N; *Elevation*: ca 850 m; *MGRS 10×10 square*: BN69; *Habitat*: wet meadows with *Sparganium microcarpum*; *Population*: numerous individuals; *Date*: 1912; *Collector*: E. Sagorski; *Bases of record*: literature (Sagorski, 1901; Ritter-Studnička, 1954; Beck-Mannagetta et al., 1983), marked from a Ritter-Studnička, (1954) as probably extinct.
- banks of Dušila stream (Nevesinjsko polje); *Coordinates*: 18.15°E, 43.31667°N; *Elevation*: ca 850 m; *MGRS 10×10 square*: BP60; *Habitat*: stream banks; *Date*: 08.1955, 09.08.1956;

Collector: Z. Devetak, Hilda Ritter-Studnička; *Bases of record:* as f. *linearis*, in herbarium SARA 42214, SARA 42215; corresponding literature (Ritter-Studnička, 1954; Beck-Mannagetta et al., 1983).

- Zlatac (Nevesinjsko polje); *Coordinates*: 18.141459°E, 43.341539°N; *Elevation*: ca 850 m; *MGRS 10×10 square*: BP60; *Habitat*: stream banks; *Population*: unknown; *Date*: 1954; *Collector*: Z. Devetak; *Bases of record*: literature (Ritter-Studnička, 1954; Beck-Mannagetta et al., 1983), as f. *lineare*.
- right bank of the river Sana, near village Pejići (downstream from Sanski Most); *Coordinates*: 16.724544°E, 44.886894°N; *Elevation*: 147 m; *MGRS 10×10 square*: XK37; *Habitat*: wet meadows; *Population*: unknown; *Date*: 10.08.1985; *Collector*: Č. Šilić; *Bases of record*: herbarium SARA 50346-50349.
- at few microlocalities on slopes of the Zimomor peak towards Štirinsko lake (Zelengora Mt.); *Coordinates*: 18.490669°E, 43.373269°N; *Elevation*: 1720 m; *MGRS 10×10 square*: BP90; *Habitat*: mountain spring communities and *Calthion* meadows; *Population*: estimated about one-two thousand flowering individuals; *Date*: 05.08.2008; *Collector*: Đ. Milanović; *Bases of record*: new – herbarium DjM 180/01-001.
- Gredina near Sajković (Livanjsko polje); *Coordinates*: 16.660997°E, 43.982725°N; *Elevation*: 707 m; *MGRS 10×10 square*: XJ37; *Habitat*: seasonally flooded *Molinia* meadows in karst fields on sandy soils; *Population*: several hundred flowering individuals; *Date*: 09.08.2015; *Collector*: Đ. Milanović; *Bases of record*: new – herbarium DjM 180/01-002.
- Berek (Lijevče polje); *Coordinates*: 17.2361511°E, 45,0343937°N; *Elevation*: 96 m; *MGRS 10×10 square*: XK78; *Habitat*: wet meadows in succession; *Soil type*: pseudogley on tertiary sediments; *Population*: several hundred flowering individuals; *Date*: 26.06.2021; *Collector*: D. Koljanin; *Bases of record*: new – herbarium Herb. Fac. Silv. 000368.
- Elezagići (Lijevče polje); *Coordinates*: 17.244907°E, 45.066040°N; *Elevation:* 102 m; *MGRS 10×10 square*: XK79; *Habitat*: on the edge of wet meadow, alongside the ditch; *Population*: ca 50 adult individuals; *Date*: 13.10.2021; Collector: D. Koljanin; *Bases of record*: observation.

General distribution and ecology

Achillea ptarmica is distributed in most of Europe, reaching France and the British Isles in the west, Scandinavia in the north, the western bank of the Odra River in Poland and northern Ukraine in the east. The species is relatively common in Central Europe. In most of southern Europe, it is rare, occurring sporadically at isolated localities or is completely absent in some countries (Bilz, 2012). It has boreal-subboreal Eurasian distribution, reaching the southernmost limit in the Balkan Peninsula and can be considered a boreal relict in Balkan flora (Stevanović, 1999). The known populations in the Balkan Peninsula are rare and distant from each other, thus forming a disjunct distribution pattern. Also, this species is rare in Montenegro, with only one known locality from Durmitor Mt. (Stevanović, 1999). In Croatia, the species is known only from a few localities in the northern part of the country (Nikolić, 2010). The species has been recorded in Serbia in the past, but recent research has not confirmed its occurrence suggesting that it may be considered extinct at the national level (Stevanović, 1999; Bilz, 2012).

In Central Europe, the species is noted to occur on non-calcareous and permanently moist soils in open habitats, including *Calthion palustris* wet meadows (most often), *Molinion caeruleae* meadows, *Deschampsion cespitosae* alluvial meadows and other wet habitats, including even ruderal habitats (Dudáš et al., 2017; Kaplan et al., 2020), scrub formations and wood margins (Richardson, 1976).

Habitat and species threats in Bosnia and Herzegovina

Achillea ptarmica inhabits various wet meadows and more/less permanently wet banks of small lowland streams and mountain springs in Bosnia and Herzegovina. In the northern part of the country, the populations are situated on the border of *Trifolion pallidi* and *Deschampsion caespitosae* mown meadows, under intense pressure from alien and/or ruderal plant species and natural succession at the same time. The further negative impact could result in the disappearance of this species in the northern part of the country. The populations on Zelengora Mt. and in Livanjsko polje are numerous and stable, without observed negative influences. However, they still have limited spatial distribution, where some potential impacts could cause a substantial reduction in their populations.

Conservation status

The global IUCN status of *Achillea ptarmica* is Least Concern (Bilz, 2012). In Serbia, the species has the category Extinct in the Wild (Stevanović, 1999). Šilić (1996) assessed the species as Vulnerable in the List of Vascular Plants (*Pteridophyta* and

Spermatophyta) for the Red Book of Flora of Bosnia and Herzegovina. In the Red List of Flora of the Federation of Bosnia and Herzegovina, the species was also assessed as Vulnerable (Đug et al., 2013).

Considering the available data, i.e., area of occupancy (AOO) is less than 10 km^2, regional population is severely fragmented, and there is continuing decline in area, extent and/or quality of habitat, we suggest regional conservation status for Bosnia and Herzegovina: Critically Endangered - CR B2ab(iii).

Carex elongata L.

Published and new chorological data

Carex elongata belongs to the subgenus *Vignea* and the section *Elongatae* (Kunth) Kük. The species can be recognized by the following set of characteristics: densely caespitose plants often forming tussocks, all spikes (6-12) with female flowers on top and male below, utricles without wings with entire not 2-fid beak and two stigmas, lowest bract shorter than inflorescence (Chater, 1980) (**Fig. 3**). The species was known from several localities in Bosnia and Herzegovina scattered throughout the country (**Fig. 4**):

- under Koran near Pale; *Coordinates*: 18.575645°E, 43.804779°N; *Elevation*: ca 850 m; *MGRS 10×10 square*: CP05; *Habitat*: wet meadows with *Scirpus sylvaticus, Cardamine pratensis* and *Scutellaria galericulata*; *Population*: unknown; *Date*: 03.06.1934 and 03.06.1935; *Collector*: K. Malý; *Bases of record*: SARA 3932 – SARA 3933; corresponding literature record (Malý, 1935). *Remark*: the area has been urbanized in the last 50 years, and the occurrence of this species is uncertain today.
- Gradiška; *Coordinates*: 17.248848°E, 45.135396°N; *Elevation*: ca 95 m; *MGRS 10×10 square*: XL70; *Habitat*: *Cynosuretum cristati*; *Population*: unknown; *Date*: 1959; *Collector*: J. Kovačević; *Bases of record*: literature (Kovačević 1959).
- Berek (Lijevče polje); *Coordinates*: 17.242484°E, 45.041149°N; *Elevation*: ca 105 m; *MGRS 10×10 square*: XK78; *Habitat*: *Cynosuretum cristati*; *Population*: unknown; *Date*: 1959; *Collector*: J. Kovačević; *Bases of record*: literature (Kovačević 1959); *Remark*: several hundred individuals have been recently confirmed but in monodominant swamp forests of *Quercus robur* (D. Koljanin, 16.06.2021. *Bases of record*: observation).
- in the vicinity of Bosanska Dubica; *Coordinates*: 16.932538°E, 45.266012°N; *Elevation*: ca 93 m; *MGRS 10×10 square*: XL51; *Habitat*: *Leucojo-Fraxinetum angustifoliae* and *Genisto elatae-Quercetum roboris*; *Population*: unknown; *Date*: 1964; *Collector*: M. Glišić; *Bases of record*: literature (Glišić, 1964).
- Jakovica near the village of Cerik (orig. Cerje); *Coordinates*: 18.522109°E, 44.808918°N; *Elevation*: ca 100 m; *MGRS 10×10 square*: CQ06; *Habitat*: *Carpino betuli-Quercetum roboris* forest; *Population*: unknown; *Date*: 1975; *Collector*: P. Fukarek; *Bases of record*: literature (Fukarek, 1975).
- Hrastik near the village of Donji Žabar; *Coordinates*: 18.656429°E, 44.941478°N; *Elevation*: ca 85 m; *MGRS 10×10 square*: CQ17; *Habitat*: *Carpino betuli-Quercetum roboris* forest; *Population*: unknown; *Date*: 1975; *Collector*: P. Fukarek; *Bases of record*: literature (Fukarek, 1975).
- Burumac (orig. Baranac) in the vicinity of Bosanski Šamac; *Coordinates*: 18.521154°E, 45.004933°N; *Elevation*: ca 95 m; *MGRS 10×10 square*: CQ08; *Habitat*: *Carpino betuli-Quercetum roboris* forest; *Population*: unknown; *Date*: 1975; *Collector*: P. Fukarek; *Bases of record*: literature (Fukarek, 1975).
- Gromiželj in Semberija; *Coordinates*: 19.311810°E, 44.866086°N; *Elevation*: ca 82 m; *MGRS 10×10 square*: CQ66; *Habitat*: *Alnus glutinosa* forest; *Population*: numerous individuals; *Date*: 29.05.2010; *Collector*: Đ. Milanović, J. Brujić, V. Stupar and D. Nikić; *Bases of record*: literature (Petronić et al., 2010; Milanović et al., 2011;) Herb. DjM: 65/04–045.
- Han Kram on Sljemeska Mt.; *Coordinates*: 18.906667°E, 44.038889°N; *Elevation*: ca 1050 m; *MGRS 10×10 square*: CP37; *Habitat*: edge of *Pino-Betuletum pubescentis*; *Population*: scattered individuals; *Date*: 28.06.2010; *Collector*: Đ. Milanović, J. Brujić and J. Travar; *Bases of record*: literature (Milanović et al., 2011), Herb. DjM: 65/04–046.
- above Donja pećina in Bijambare; *Coordinates*: 18.502953°E, 44.093964°N; *Elevation*: ca 925 m; *MGRS 10×10 square*: CP08; *Habitat*: tall herbs with *Scirpus sylvaticus* on a brook terrace; *Population*: less than ten flowering individuals; *Date*: 13.06.2020; *Collector*: Đ. Milanović; *Bases of record*: Herb. DjM: 65/04-047.
- Podbrdo in Podrašničko polje; *Coordinates*: 16.985369°E, 44.457024°N; *Elevation*: 730 m; *MGRS 10×10 square*: XK52, *Habitat*: well preserved *Alnus glutinosa* forest; *Soil type*: gley on diluvial sediments; *Population*: a dozen tussocks at

the edge of the forest; *Date*: 29.05.2021; *Collector*: J. Brujić and D. Koljanin; *Bases of record*: Herb. Fac. Silv: 000277.

- Marčete in Podrašničko polje; *Coordinates*: 16.961526°E, 44.481430°N; *Elevation*: 740 m; *MGRS 10×10 square*: XK52, *Habitat*: young *Alnus glutinosa* forest with *Betula pubescens*; *Soil type*: gley on diluvial sediments; *Population*: ca 30 tussocks were counted; *Date*: 29.05.2021; *Collector*: J. Brujić and D. Koljanin; *Bases of record*: observation.
- Elezagići in Lijevče polje; *Coordinates*: 17.241189°E, 45.068918°N; *Elevation*: 96 m; *MGRS 10×10 square*: XK79; *Habitat*: swamp forest of *Quercus robur,* in a micro-depression; *Soil type*: pseudogley over tertiary sediments; *Population*: several hundred tussocks; *Date*: 26.06.2021.; *Collector*: D. Koljanin; *Bases of record*: Herb. Fac. Silv: 000278.
- Kočićevo in Lijevče polje; *Coordinates*: 17.383162°E, 45.078864°N; *Elevation*: 92 m; *MGRS 10×10 square*: XK89; *Habitat*: *Carici elongatae-Alnetum glutinosae*; *Soil type*: gley on tertiary sediments; *Population*: several dozens of tussocks; *Date*: 07.08.2021; *Collector*: D. Koljanin; *Bases of record*: observation.
- Bardača in Lijevče polje; *Coordinates*: 17.397036°E, 45.092282°N; *Elevation*: 91 m; *MGRS 10×10 square*: XK89; *Habitat*: *Carici elongatae-Alnetum glutinosae*; *Soil type*: pseudogley on tertiary sediments; *Population*: couple tussocks; *Date*: 18.08.2021; *Collector*: D. Koljanin; *Bases of record*: Herb. Fac. Silv. 000367.
- Mašići in Lijevče polje; *Coordinates*: 17.245689°E, 45.0157962°N; *Elevation*: 107 m; *MGRS 10×10 square*: XK78; *Habitat*: along a temporary brook in a micro-depression with *Quercus robur* and *Acer tataricum*; *Soil type*: pseudogley on tertiary sediments; *Population*: ca. 30 tussocks; *Date*: 17.04.2022; *Collector*: D. Koljanin and J. Brujić; *Bases of record*: observation.
- Posavine in Lijevče polje; *Coordinates*: 17.161216°E, 45.13591°N; *Elevation*: 92 m; *MGRS 10×10 square*: XL70; *Habitat*: *Leucojo-Fraxinetum angustifoliae*; *Soil type*: pseudogley on tertiary sediments; *Population*: several hundred tussocks; *Date*: 08.05.2022; *Collector*: D. Koljanin; *Bases of record*: observation.
- Stanari; *Coordinates*: 17.821632°E, 44.750471°N; *Elevation*: 171 m; *MGRS 10×10 square*: YK25; *Habitat*: *Carici elongatae-Alnetum glutinosae*; *Soil type*: planohistosol and pseudogley on tertiary sediments; *Population*: several hundred tussocks; *Date*: 22.05.2022; *Collector*: V. Stupar, J. Brujić, Đ. Milanović & D. Koljanin; *Bases of record*: DjM: 65/04-048.

Fig. 3. *Carex elongata* near Stanari (© Đ. Milanović)

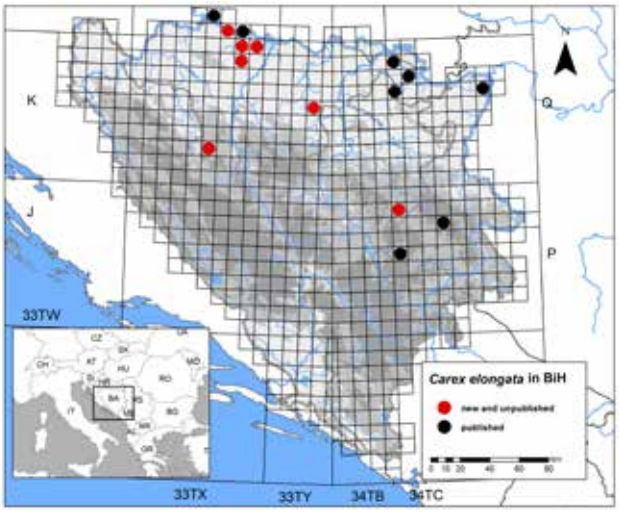

Fig. 4. Distribution of *Carex elongata* in Bosnia and Herzegovina

General distribution and ecology

Carex elongata is widespread in Europe and Western Asia. This species is common in central Europe, inhabiting various wetland habitats. The species is often a member of hygrophilous forests where stagnant water is present for a significant period of the year, and it is common in the *Alnus glutinosa* carrs (Willner & Grabherr, 2007; Douda, 2008; Borhidi et al., 2012; Slezák et al., 2014; Hulík & Douda, 2017). In addition, the species is also common in narrow-leaved ash swamp forests (*Leucojo-Fraxinetum angustifoliae*) in Balkan Peninsula (Glavač, 1959; Glišić, 1964), monodominant swamp *Quercus robur* forests in Hungary (Borhidi et al., 2012)

and Poland (Sokołowski, 1972) and swamp *Alnus incana* communities in Austria (Willner & Grabherr, 2007). In Croatia, the species is distributed mainly in the lowlands in the northern and central parts of the country (Nikolić, 2020). In Serbia, the species is noted to be common in swamp forests, wet meadows and channel margins from lowlands to mountainous regions (Josifović, 1972). Still, there are only a few precise data on the distribution and ecology of the species in this country.

Habitat and species threats in Bosnia and Herzegovina

Recent research shows that the species is not as rare throughout northern Bosnia and Herzegovina as previously considered (Milanović et al., 2011). Here, this species is a typical forest plant, inhabiting more or less permanently moist parts of various riparian forests, with a development optimum in preserved *Alnus glutinosa* swamp forests and *Quercus robur* swamp forests with +/- developed peat layer. In contrast, in other forest types, where water is stagnant for a part of the vegetation season, it is restricted to micro depressions, channel margins or alongside permanent or temporal stream beds. Due to large-scale hydrological meliorations in the past, habitats suitable for this species are severely restricted, degraded, and fragmented, while flood prevention and changes in water regimes still negatively affect its populations.

In the montane region of the Dinaric Alps, the species is less common, with scattered individuals on stream terraces or at the edges of peatland complexes inhabiting wet tall-herb communities and edges of mixed broadleaved-coniferous forests. Various negative impacts on these habitats have been recorded there: trampling in the Bijambare Nature Park, urbanization in Koran near Pale, and hydrological meliorations in Han Kram at Sljemenska Mt.

Conservation status

Global and European IUCN status of *Carex elongata* has not been estimated yet. The species is not listed in national Red Lists in most central European countries. In neighbouring Croatia, the species is listed as Data Deficient (Nikolić & Topić, 2005). Šilić (1996) has considered doubtful previously known data, and therefore the species was not included in the List of Vascular Plants (*Pteridophyta* and *Spermatophyta*) for the Red Book of Flora of Bosnia and Herzegovina.

However, considering the available data, i.e., AOO is less than 10 km^2, the regional population is severely fragmented, and there is continuing decline in area, extent and quality of habitat, we suggest regional conservation status for Bosnia and Herzegovina: Critically Endangered - CR B2ab(iii).

Carex strigosa Huds.

Published and new chorological data

Carex strigosa belongs to the section *Strigosae* (Fries) (Chater, 1980). This species was often overlooked in some parts of its distribution due to low study levels and a small percentage of suitable habitats (Trčak & Bačič, 2017), which could also be stated for Bosnia and Herzegovina. From other species of the section, it could be recognized by mainly not pendent, thin and lax female spikes, green utricles with a very short beak and acute female glumes (Chater, 1980) (**Fig. 5**). The species has been recorded from only several localities in northern Bosnia and Herzegovina, but recent records confirm that the species has a somewhat wider distribution in this part of the country (**Fig. 6**):

- in the vicinity of Bosanska Dubica; *Coordinates*: 16.932538°E, 45.266012°N; *Elevation*: ca 93 m; *MGRS 10×10 square*: XL51; *Habitat*: *Genisto elatae-Quercetum roboris*; *Population*: unknown; *Date*: 1964; *Collector*: M. Glišić; *Bases of record*: literature (Glišić, 1964). *Note*: This record is confirmed, and the species was considered rare (a few dozen individuals) at Donja Gradina near Bosanska Dubica in the well-preserved forest of *Fraxinus angustifolia* and *Quercus robur*, 15.05.2015, Đ. Milanović & V. Stupar, DjM: 65/04-160.
- Jakovica near the village of Cerik (orig. Cerje); *Coordinates*: 18.522109°E, 44.808918°N; *Elevation*: ca 100 m; *MGRS 10×10 square*: CQ06; *Habitat*: *Carpino betuli-Quercetum roboris* forest; *Population*: unknown; *Date*: 1975; *Collector*: P.

Fig. 5. *Carex strigosa* at Donja Gradina (© Đ. Milanović)

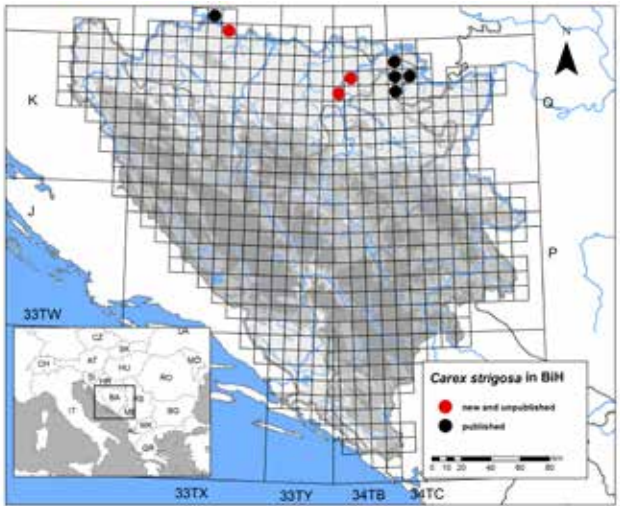

Fig. 6. Distribution of *Carex strigosa* in Bosnia and Herzegovina

Fukarek; *Bases of record*: literature (Fukarek, 1975).

- Lipovica forest near the village of Pelagićevo; *Coordinates*: 18.564017°E, 44.886848°N; *Elevation*: ca 80 m; *MGRS 10×10 square*: CQ07; *Habitat*: *Carpino betuli-Quercetum roboris* forest; *Population*: unknown; *Date*: 1975; *Collector*: P. Fukarek; *Bases of record*: literature (Fukarek, 1975).
- Hrastik near the village of Donji Žabar; *Coordinates*: 18.656429°E, 44.941478°N; *Elevation*: ca 85 m; *MGRS 10×10 square*: CQ17; *Habitat*: *Carpino betuli-Quercetum roboris* forest; *Population*: unknown; *Date*: 1975; *Collector*: P. Fukarek; *Bases of record*: literature (Fukarek, 1975).
- a forest in the village of Obudovac; *Coordinates*: 18.578385°E, 44.954521°N; *Elevation*: ca 80 m; *MGRS 10×10 square*: CQ08; *Habitat*: *Carpino betuli-Quercetum roboris* forest; *Population*: unknown; *Date*: 1975; *Collector*: P. Fukarek; *Bases of record*: literature (Fukarek, 1975).
- Burumac (orig. Baranac) in the vicinity of Bosanski Šamac; *Coordinates*: 18.521154°E, 45.004933°N; *Elevation*: ca 95 m; *MGRS 10×10 square*: CQ08; *Habitat*: *Carpino betuli-Quercetum roboris* forest; *Population*: unknown; *Date*: 1975; *Collector*: P. Fukarek; *Bases of record*: literature (Fukarek, 1975).
- Dubrave near Vrbaška; *Coordinates*: 17.157772°E, 45.137031°N; *Elevation*: 94 m; *MGRS 10×10 square*: XL70; *Habitat*: *Leucojo-Fraxinetum angustifoliae*; *Soil type*: pseudogley over tertiary sediments; *Population*: less than 20 flowering individuals; *Date*: 28.05.2016; *Collector*: Đ. Milanović; *Bases of record*: observation.
- Suvopolje near Grapska; *Coordinates*: 18.062530°E, 44.789970°N; *Elevation*: ca 130 m; *MGRS 10×10 square*: BQ66; *Habitat*: A degraded forest of white willow (*Salix alba*); *Soil type*: fluvisol over alluvial deposits; *Population*: a dozen individuals scattered in the forest; *Date*: 13.05.2017; Collector: Đ. Milanović & V. Stupar; *Bases of record*: DjM 65/04-161.
- Jabučik near Kožuhe; *Coordinates*: 18.096060°E, 44.859240°N; *Elevation*: 128 m; *MGRS 10×10 square*: BQ77; Habitat: well-preserved *Alnus glutinosa* forest; *Soil type*: eugley river terrace; *Population*: less than 100 individuals scattered in the forest; *Date*: 13.05.2017; *Collector*: Đ. Milanović & V. Stupar; *Bases of record*: observation.
- Kutlovac near Podnovlje; *Coordinates*: 18.142250°E, 44.934760°N; *Elevation*: 116 m; *MGRS 10×10 square*: BQ77; *Habitat*: A well-preserved grove of white willow; *Soil type*: fluvisol over alluvial deposits; *Population*: a dozen scattered individuals throughout the forest; *Date*: 14.05.2017; *Collector*: Đ. Milanović & V. Stupar; *Bases of record*: observation.
- Rastoka near Podnovlje; *Coordinates*: 18.114401°E, 44.919059°N; *Elevation*: 119 m; *MGRS 10×10 square*: BQ77; *Habitat*: Degraded grove of white willow; *Soil type*: fluvisol over alluvial deposits; *Population*: Only a few individuals; *Date*: 14.05.2017; *Collector*: Đ. Milanović & V. Stupar; *Bases of record*: observation.

General distribution and ecology

This subatlantic species is widespread in a large part of western and central Europe, the Caucasus, and northern Iran, and very rare in the Iberian Peninsula (Laskurain et al., 2003; Liendo et al., 2016). In Central Europe, the species is found mainly in lowlands, wet to damp places, nutrient-rich and pH-neutral soils, in semi-shaded to shaded habitats in the floodplains of larger rivers (Kaplan et al., 2020). It usually grows in communities of poplars and tall willows, narrowed-leaved ash, European white elm and pedunculate oak which are often under the impact of flooding (Borhidi et al., 2012; Chytrý, 2013). In Slovenia, this species is noted to grow in communities belonging to the *Montio-Cardaminetea* class but more often in lowland riparian forest communities (Trčak & Bačič, 2017). In Croatia, this species is mostly found in the northern part of the country near the Sava and Drava rivers (Nikolić, 2020). The species is also found in Serbia in wet and

swamp lowland forests (Josifović, 1976).

Habitat and species threats in Bosnia and Herzegovina

In Bosnia and Herzegovina, the species is restricted to northern lowlands where it occurs in remnants of riparian forests, irregularly scattered in the lower flow of major rivers of the Danube catchment. These habitats are rare in Bosnia and Herzegovina due to intensive changes in the water regime and uncontrolled logging. Historically, the species was exposed to similar negative impacts as *Carex elongata,* but it has a wider ecological amplitude, ranging from swamps to meso-hygrophilous forests. Invasive species are also a threatening factor. Severe habitat changes could lead to species extinction in Bosnia and Herzegovina.

Conservation status

Global and European IUCN status of *Carex strigosa* is not assessed. It has different conversation statuses in European countries; Nederland – Vulnerable (Sparrius et al., 2014), Czech Republic – Endangered Taxa (Grulich, 2012), Croatia – Data Deficient (Nikolić & Topić, 2005), Spain – Critically Endangered Taxa (Liendo et al., 2016) etc.

Considering the available data, i.e., AOO is less than 10 km^2, the regional population is severely fragmented, and there is continuing decline in area, extent and habitat quality, we suggest regional conservation status for Bosnia and Herzegovina: Critically Endangered - CR B2ab(iii).

Comarum palustre L.

Published and new chorological data

Genus *Comarum* is represented by only one species in European flora: *Comarum palustre*. It is similar to the genus *Potentilla*, but it has lateral and filiform style and purple petals (Ball et al., 1968) (**Fig. 7**). The species is very rare in Bosnia and Herzegovina, recorded only from wet refugia around glacial lakes (**Fig. 8**):

- banks of Kukavičko jezero (Kupreško polje); *Coordinates*: 17.331487°E, 43.949120°N; *Elevation*: 1202 m; *MGRS 10×10 square*: XJ86; *Habitat*: banks of the lake; *Population*: numerous individuals; *Date*: 1925.09.1924, 04.07.1955, 19.06.1990; *Collector*: Ž. Protić, Č. Šilić, Hilda Ritter-Studnička; *Bases of record*: herbarium SARA 17641, SARA 17642, SARA 0051634; corresponding literature (Ritter-Studnička, 1954). *Note*: Recently confirmed in *Alnus incana* forest around a lake in about hundred flowering individuals, 25.07.2021, observation by Đ. Milanović, M. Hayek, P. Haykova & D. Dite.

Fig. 7. *Comarum palustre* around Jugovo jezero (© Đ. Milanović)

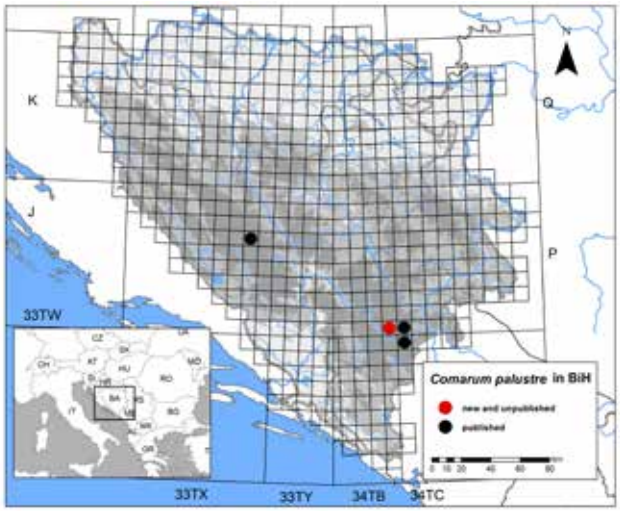

Fig. 8. Distribution of *Comarum palustre* in Bosnia and Herzegovina

- banks of Gornje bare (Zelengora Mt.); *Coordinates*: 18.607463°E, 43.320720°N; *Elevation*: 1515 m; *MGRS 10×10 square*: CN09; *Habitat*: bank of the lake; *Population*: only one individual; *Date*: 1969; *Collector*: R. Lakušić; *Bases of record*: literature (Bjelčić et al., 1969); stated by authors as new for Bosnia and Herzegovina. *Note*: Recently (19.07.2016) confirmed population numbers of a few hundred individuals in various sedge stands (*Carex rostrata, C. limosa, C. vesicaria* and *C. acuta* aggr.) and as very rare in *Deschampsia cespitosa* grasslands around the lake (Milanović, 2017b).

- banks of Kotlaničko lake (Zelengora Mt.); *Coordinates*: 18.482280°E, 43.362913°N; *Elevation*: 1530 m; *MGRS 10×10 square*: BP90; *Habitat*: *Comaro-Menyanthetum trifoliatae* on the bank of the lake; *Population*: unknown; *Date*:

1978; *Collector*: R. Lakušić; *Bases of record*: literature (Lakušić et al., 1978; Drešković et al., 2011; Redžić et al., 2013). *Note*: The record of *Comarum palustre* around Kotlaničko lake has been only indirectly gathered from a Report on the vegetation map of Bosnia and Herzegovina for the period of 1977-1980 (was not available to the authors) as well as from Prodromus of plant communities of Bosnia and Herzegovina (Lakušić et al., 1978) where the community of *Comaro-Menyanthetum* is stated but without an exact record of the species. In the same references (Drešković et al., 2011; Redžić et al., 2013), the community of *Comarum-Menyanthes* was also mentioned for some lakes from Treskavica Mt., based on the Report on the vegetation map of Bosnia and Herzegovina for 1977, but this report was available for the authors, and this community was not stated there. More than 5000 flowering individuals of this species have been recently confirmed in floating carpets of *Comarum palustre-Menyanthes trifoliata, Carex limosa* and *Equisetum fluviatile* stands around Kotlaničko lake, 18.08.2006 and 21-22.07.2016, Đ. Milanović, DjM: 84/09-001.

- Crno lake (Zelengora Mt.); *Coordinates*: 18.583443°E, 43.386275°N; *Elevation*: 1440 m; *MGRS 10×10 square*: CP00; *Habitat*: *Phragmites communis* stands and floating carpets with *Comarum palustre*; *Population*: several hundred flowering individuals; *Date*: 14.07.2016; *Collector*: Đ. Milanović; *Bases of record*: literature (Milanović, 2017b).
- Jugovo lake (Zelengora Mt.); *Coordinates*: 18.530804°E, 43.375774°N; *Elevation*: 1550 m; *MGRS 10×10 square*: CP00; *Habitat*: *Carex rostrata* stands along banks of the lake, and around a source above the lake; *Population*: a few hundred flowering individuals; *Date*: 21.07.2016; *Collector*: Đ. Milanović; *Bases of record*: observation.

General distribution and ecology

Comarum palustre has a wide circumboreal distribution, encompassing the temperate to arctic regions of Eurasia, North America, and the southern parts of Greenland (Kaplan et al., 2017). In Central Europe, the species is found in various habitats, but most commonly on moist, acidic, and nutrient-poor soils, such as fens, transitional mires, wet moss-rich meadows, tall sedge stands, edges of fishponds, and alder carrs, less often also in bog hollows (Kaplan et al., 2017). It is also usually found in *Salix cinerea* scrub communities (Borhidi et al., 2012; Chytrý, 2013).

The species is rarely found in southern Europe. In Croatia, the species can be considered rare. It has been recently confirmed in only one locality, while previous literature records stay unconfirmed (Nikolić & Topić, 2005). In Serbia, the species is known from the eastern part of the country and could also be considered rare (Josifović, 1972). In Montenegro, the species occurs at three spatially close localities at the Durmitor Mt. (Caković & Stešević, 2021), all at high elevations.

Habitat and species threats in Bosnia and Herzegovina

The species is recorded only in mountain depressions around glacial lakes in Bosnia and Herzegovina. There it occupies wet habitats on the edge of water bodies of the lakes, often forming floating carpets with other herbaceous plants (Kotlaničko Lake, Jugovo lake, Crno lake and Gornje bare), while only around Kukavičko lake it inhabits *Alnus incana* forests.

In spite of the fact that the recorded populations are located far from settlements and sometimes within protected areas (Sutjeska National Park), some of the recorded populations are exposed to strong current or potential human pressures. Due to illegal off-road activities around Crno lake, water from springs on the slope above the northeast bank of the lake, which provide permanent moistening of the lake terrace, is drained through the tire tracks, causing dryness during the driest part of the year. The populations around Jugovo (Borilovačko) lake will be even more affected by the plans for the urbanization of the area surrounding the lake.

Conservation status

Global IUCN status of *Comarum palustre* is Least Concern (Maiz-Tome, 2015). The species is considered Critically Endangered in Croatia (Nikolić & Topić, 2005). Šilić (1996) included the species in the List of Vascular Plants for the Red Book of Bosnia and Herzegovina as Vulnerable. In the Red List of Flora of the Federation of Bosnia and Herzegovina, the species was estimated as Vulnerable (Đug et al., 2013).

Considering the available data, i.e., AOO is less than 10 km^2, the regional population is severely fragmented, and there is continuing decline in area, extent and habitat quality, we suggest regional conservation status for Bosnia and Herzegovina: Critically Endangered - CR B2ab(iii).

Prunus padus L.

Published and new chorological data

Prunus padus is sometimes planted tree species in horticulture in Bosnia and Herzegovina, while its natural populations in the country are very rare (**Fig.**

Fig. 9. *Prunus padus* in blooming stage on slopes of Stožer Mt. (© Đ. Milanović)

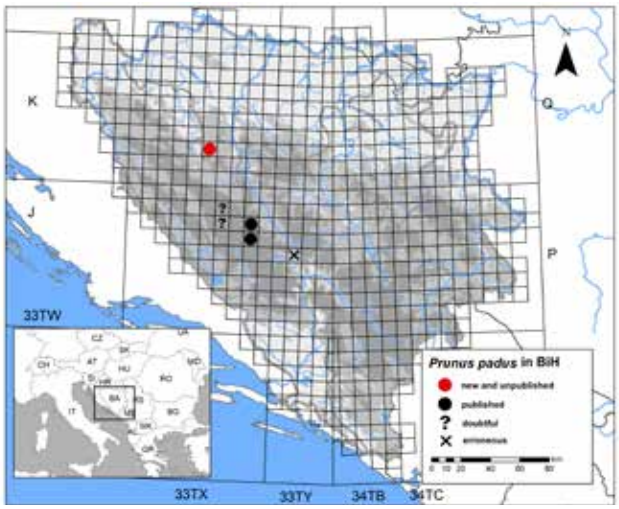

Fig. 10. Distribution of *Prunus padus* in Bosnia and Herzegovina

9, **Fig. 10**). Only known populations are scattered on the edge of Kupreško field, where they were originally considered as potentially escaped from gardens (Ritter-Studnička, 1958) but later confirmed as autochthonous (Ritter-Studnička, 1972). Recently, the species was also mentioned for northern Bosnia (Šilić, 2005; Stupar et al., 2021), potentially based on findings in some prehistoric archaeological sites (Maly, 1904), but without any exact locality or coordinates. Moreover, our recent research in the area did not confirm these allegations. Furthermore, it should be stated that Redžić & Golić (1985) noted *Prunus padus* in Maoča at Konjuh Mt. in forest clearings of *Pinus nigra* forests (phytosociological table). Neither in the following text (Redžić & Golić, 1985) nor in subsequent research of the same plots (Redžić, 1988) *Prunus padus* was not mentioned again, but *Prunus mahaleb* is regularly noted. Therefore, we consider that „*Prunus padus*" is a lapse probably referring to *Prunus mahaleb* which is ecologically suited for such habitats.

We considered these lapse as this species is not mentioned in the further text and is replaced by *Prunus mahaleb* in further research on those permanent vegetation plots. *Prunus padus* has been reported from the following localities:

- Humbat hill near Prozor; *Coordinates*: 17.616170°E, 43.816082°N; *Elevation*: ca 770 (orig. 856 m) m; *MGRS 10×10 square*: YJ15; *Habitat*: unknown; *Population*: unknown; *Date*: 21.07.1907; *Collector*: J. Stadlmann; *Bases of record*: literature (Stadlmann, 1912) *Note*: Later indicated as erroneous record after consulting the original herbarium material (Ritter-Studnička, 1972) - misidentification with *Prunus mahaleb*.
- near the road on slopes of Kupreška vrata towards Kupres; *Coordinates*: 17.293807°E, 44.007529°N; *Elevation*: 1200-1300 m; *MGRS 10×10 square*: XJ87; *Habitat*: in forests and scrubs; *Population*: numerous individuals; *Date*: 01.08.1958; *Collector*: L. Lažetić; *Bases of record*: herbarium SARA 18992-18993, corresponding literature (Ritter-Studnička, 1958, 1972, 1974). *Note*: Recently confirmed throughout the slopes of Kupreška vrata and Stožer Mt. towards Kupres, optimally developed in *Alnus incana* forest in several hundred flowering individuals and much more in the vegetative stage as a shrub in the canopy, 30.04.2018, Đ. Milanović, G. Tomović & K. Jakovljević, DjM: 84/24–001; 13.07.2021, J. Brujić & D. Koljanin, *Herb. Fac. Silv:* 000274.
- banks of Kukavičko lake (Kupreško polje); *Coordinates*: 17.331487°E, 43.949120°N; *Elevation*: 1202 m; *MGRS 10×10 square*: XJ86; *Habitat*: banks of the lake; *Population*: scattered individuals; *Date*: 1972; *Collector*: H. Ritter-Studnička; *Bases of record*: literature (Ritter-Studnička, 1972, 1974). *Note*: Recently confirmed in *Alnus incana* forest around the lake – only a few individuals have been registered, 25.07.2021, Đ. Milanović, M. Hayek, P. Haykova & D. Dite, DjM: 84/24–002.
- Hrbljina; *Coordinates*: 17.097371°E, 44.005508°N (unprecise); *Elevation*: ca 1300 m; *MGRS 10×10 square*: XJ67; *Habitat*: unknown; *Population*: scattered individuals, rare; *Date*: 1972; *Collector*: N. Zubić; *Bases of record*: literature (Ritter-Studnička, 1972). *Note*: The record is a personal observation of Novak Zubić, a geographer that at the time was employed at the Faculty of Natural Sciences in Sarajevo, and having in mind that the reported locality doesn't fit in the species ecology,

we consider this record as doubtful.

- Vitorog Mt.; *Coordinates*: 17.096455°E, 44.084158°N (unprecise); *Elevation*: ca 1500 m; *MGRS 10×10 square*: XJ68; *Habitat*: unknown; *Population*: scattered individuals, rare; *Date*: 1972; *Collector*: N. Zubić; *Bases of record*: literature (Ritter-Studnička, 1972). *Note*: We consider this record doubtful for the same reasons as in the previous case. Later research on the flora and vegetation of this mountain did not confirm this species either (Redžić et al., 1984; Zubić & Topalić-Trivunović, 2011).
- Podbrdo in Podrašničko polje; *Coordinates*: 16.985369°E, 44.457024°N; *Elevation*: 730 m; *MGRS 10×10 square*: XJ52; *Habitat*: well preserved *Alnus glutinosa* forest; *Soil type*: eugley over diluvial sediments; *Population*: several flowering individuals; *Date*: 29.05.2021; *Collector*: J. Brujić & D. Koljanin; *Bases of record*: Herb. Fac. Silv: 000275 & Herb. Fac. Silv: 000276.

General distribution and ecology

Prunus padus is a Eurasian species with an almost compact distribution range that is gradually becoming disjunct on its southern border. It is widespread in most parts of Europe except the southern areas (Webb & Rix, 1972; Kurtto et al., 2013). In Central Europe, it typically occurs in closed forests and is a common and diagnostic taxon of *Alnion incanae* alliance, but it can be found in a wide range of habitats (Willner & Grabherr, 2007; Borhidi et al., 2012; Chytrý, 2013). This species is common in most Central European countries (Rhodes & Maxted, 2013), including Slovenia, and northern and western Croatia, which represents the edge of its compact distribution range. In the western Balkan, it has a disjunct distribution, occurring mostly at higher altitudes with lower temperatures. It appears that the species is frequent in lowland forests only in colder and more humid climates, while in the Balkan Peninsula, the species could be considered a glacial relict.

Habitat and species threats in Bosnia and Herzegovina

The species is found at higher altitudes in moist habitats on silicate substrates. On Kupres, species grow in grey alder stands and in the succession of fir-beech-spruce forests. Some old individuals are also found along roads. It seems that on Kupres, this species does not have a narrow distribution, and it is capable of thriving in different habitats. In Sitnica, species is found in only one *Alnus glutinosa* stand, but it is likely to exist in other nearby locations.

The main threat for *Prunus padus* populations is land use change. Any changes in the hydrological regime of its habitats could also be a threat causing population number and density decline. As *Prunus padus* wood is valuable for wood carving and making lockers (Nestby, 2020), there is a potential risk for the older trees. Also, as some localities in Bosnia and Herzegovina are in succession stages, it could be expected that this natural process would be followed by a decreasing number of individuals.

Conservation status

Global and European IUCN status of *Prunus padus* supsp. *padus* is the Least Concern (Sparrius et al., 2014), and it is not listed on the national Red Lists of the majority European countries. The species is not considered native in Serbia (Josifović, 1972) and, therefore, is not included in the list. Species was assessed as Vulnerable in a proposal for the Red List of Vascular Flora of Bosnia and Herzegovina (Šilić, 1996). In the Red List of Flora of the Federation of Bosnia and Herzegovina, the species was also assessed as Vulnerable (Đug et al., 2013).

Considering the available data, i.e., AOO is less than 10 km^2, the regional population is severely fragmented, and there is continuing decline in area, extent and quality of habitat, we suggest regional conservation status for Bosnia and Herzegovina: Critically Endangered - CR B2ab(iii).

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