Scientific Papers. Series B, Horticulture. Vol. LXIX, No. 1, 2025
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

MODELLING THE DISTRIBUTION OF THE RARE, ENDEMIC, TERTIARY RELICT AND VULNERABLE SPECIES *SYRINGA JOSIKAEA* JACQ. FROM APUSENI MOUNTAINS (WESTERN ROMANIAN CARPATHIANS)

Marilena ONETE[1], Florian Paul BODESCU[2], Roxana NICOARĂ[1], Minodora MANU[1], Simona MIHAILESCU[1]

[1]Institute of Biology Bucharest of Romanian Academy, 296 Splaiul Independenței, District 6, Bucharest, Romania
[2]Multidimension SRL, 7 Ciprian Porumbescu Street, Săveni, Ialomița County, Romania

Corresponding author email: florianbodescu@gmail.com

Abstract

The spontaneous species Syringa josikaea Jacq. (Transylvanian lilac, wind wood) is a very important species in Romanian flora (rare, endemic, tertiary relict, and vulnerable), being under Romanian and European special protection. Small populations with a low number of individuals are distributed only in western Romanian Carpathians (Apuseni Mountains) and Ukrainian Carpathians (Latorica River watershed). We developed, in Maxent, a distribution model based on the following parameters: ecological (climatic, geomorphologic, soil distribution), biological (interactions among species, characteristic plant species communities), anthropic (land use, biodiversity conservation), and cultural (local and traditional practices). The development of such a model leads to: the assessment of the impact of climate, and to analyze projections that may affect the distribution of the species in the future, the conservation of the characteristic habitats by developing management strategies thus ensuring the sustainability of the species. This model is also a direct support for the EU-specific reporting of Romania in the context of Article 17 of the Habitats Directive. Due to its beauty, the Transylvanian lilac is cultivated in the gardens and urban parks of the world.

Key words*: Syringa josikaea, distribution, modelling, Maxent, Western Romanian Carpathians.*

INTRODUCTION

When scientists recorded the influence of the environmental variables on the development and distribution of plant species (Crawley, 1997; Hageer et al., 2017), they used qualitative estimations but also accurate numerical techniques (Rosenzweig, 1995; Rockwood, 2006) and developed models that have strong predictive capabilities for describing species distribution in their natural range (Guisan & Thuiller, 2005; Reese et al., 2005; Elith & Leathwick, 2009).

Following species inventory from an area and recording the spatial characteristics or/and environmental factors from that area, for estimating their complex relationship, it has been developed species distribution models (SDMs) (Elith et al., 2011; Wisz et al., 2013).

Species distribution models for plants and animals (called also bioclimatic or environmental niche modelling) progressed hugely for usage in: forecasting anthropogenic effects on patterns of biodiversity at different spatial scales (Guisan & Thuiller, 2005; Reese et al., 2005), providing estimates of the spatial distributions of rare species with limited occurrence for their conservation management (Hernandez et al., 2006; Sharma et al., 2018) or with very small populations (Liu et al., 2024) estimating species responses to climate change (Austin, 2007; Hosseini et al., 2024), estimating the potential for species populations to occur in areas not previously surveyed (Hernandez et al., 2008; Rhoden et al., 2017; Ma & Sun, 2018; Bao et al., 2022). In the recent years many methods are available in ecology, conservation biology, biogeography (Franklin, 2013), being distinctive throughout the data used (Elith et al., 2011). Some database might contain accurate data but other data are limited in presence-absent and occurrence of the species (Merow et al., 2013). But not all the time a good data set is

available for developing a good predictive model for most of the taxa (Wisz et al., 2008).

Following recording environmental factors together with the presence-only occurrence of a species, many ecological applications use Maxent (maximum entropy) model for predicting: the potential suitable habitat of species (historic, current and future distribution trends) (Dai et al., 2022), the suitable habitat for a species new populations (even those species having specialized habitat requirements and narrow geographical ranges) (Williams et al., 2009), and also for transferring it in another climatic conditions or geographic areas (Hernandez et al., 2008), the influence of climate change on the potential distribution of medicinal plant (Yang et al., 2013; Khanum et al, 2013; Yi et al., 2016; Tang et al., 2021), of invasive plant species (Qin et al., 2014), relict plants species (Rotllan-Puig & Traveset, 2016), extremely endangered plant species (Qin et al., 2017), colonisations and extinctions of plant species (Venne & Currie, 2021), global potential distribution of some plant species (Zhang et al., 2021), suitable habitat for rehabilitation of different type of forest at landscape-scale (Tesfamariam et al., 2022).

Maxent model can use small datasets and run complex models; for presence-only modelling methods are necessary only data about species distribution together with topographic, climatic, edaphic, biogeographic data as predictor variables (Phillips & Dudík, 2008). Maxent program implement the maximum-entropy method and is a machine-learning algorithm capable both to model the spatial distribution of species and predict their presence in a geographic area relying on presence-only occurrence data of the species in the locations without considering the locations of documented absences (Lissovsky & Dudov, 2021).

In the situation that scientists need more ecological information about species habitats (vegetation presence, net primary productivity, and photosynthetic efficiency, anthropogenic impact, etc.). The data can be excerpts from the multispectral satellite images and aerial high-resolution orthophotos, to provide Normalized Difference Vegetation Index (NDVI) NDVI (Dunea et al., 2014; Boc et al., 2020), Green Normalized Difference Vegetation Index (GNDVI) (Dunea et al., 2021), etc.

Genus Syringa L. (lilac) together with Jasminum and Forsythia are beautiful ornamental shrubs belonging to Oleaceae Family (including also Fraxinus, Ligustrum, Olea genera) (Ciocârlan, 2009). The Romanian Flora comprise two *Syringa* species: *vulgaris* L. and *josikaea* Jacq. f. ex. Rchb., both shrubs and very ornamental but only *S. josikaea* is rare, Carpathians endemic, tertiary relict in Romanian Flora (Boşcaiu & Onete, 2009; Sârbu et al., 2013).

As ornamental plant, some comparative studies have been developed on *S. josikaea* about quantitative anatomy of epidermal cells in smaller leaf side considered adaptive mechanism for reducing its asymmetry (Polonskiy & Polyakova, 2015). Individual of *S. josikaea* introduced in urban arctic climate develop polyvariance of the floral organogenesis (based on morpho-physiological analysis of the reproductive buds) (Vasilevskaya & Morozova, 2020) and high morphological variability and large proportion of sterile pollen due to pollution (Vasilevskaya & Morozova, 2024). *S. josikaea* is used as an ornamental shrub in different cities (Gizhitskaya & Lyakh, 2020). For expanding the genetic diversity of the species, have been developed studies on the hybridization of lilac genotypes with different origins (taxonomic and genetic); the crosses combinations ended up by good fruits sets in the presence of pollinators (Pavlenkova, 2024).

Based on chemical substances (iridoids) content mainly in *S. josikaea* but also *Fraxinus excelsior* and *S. vulgaris*, Damtoft et al. (1995) suggest that the taxonomy of the Oleaceae Family should be discussed, the Family should be considered member of Gentianales Order rather than Lamiales Order.

Apart of being very important for horticulture (USDA, 2025), Lendvay et al. (2013) developed genetic studies, mainly characterizing and optimizing microsatellite markers for using them on *S. josikaea.* The authors studied later (2015) the historical biogeography and intraspecific variation of the species using nuclear ribosomal DNA sequences, multiple DNA sequences and microsatellites. The scientists learned that during Early Pleistocene, *S. josikaea* disrupted from its Asian relatives or colonized from one glacial refugia, and have a very low sequence variation and complete identity of cpDNA among all samples (implying

a bottleneck), Also, in *S. josikaea* populations from Ukrainian and Romanian Carpathians indicate no geographic differentiation based on the presence on four different ribotypes and weak differentiation based on microsatellite variation.

MATERIALS AND METHODS

Syringa josikaea Jacq. f. ex Rchb. is an extant (resident) species in Romania and Ukraine, an endemic Carpathian (Witkowski et al., 2003; Ciocârlan, 2009; Sârbu et al., 2013; Macalik et al., 2013) (Figure 1), subendemic Romanian (Oltean et al., 1994) and relict (Boșcaiu & Onete, 2009; Dihoru & Negrean, 2009) species from Oleaceae Family, vulnerable (Witkowski et al., 2003) and rare (Ciocârlan, 2009; Sârbu et al., 2013). Boșcaiu et al. (1994) consider this species as critically endangered and in risk of extinction, Dihoru & Negrean (2009) consider it as low risk of danger (Least Concern - LC according to IUCN) and is listed as Endangered under IUCN criteria (IUCN, 2018) (Figure 1).

Figure 1. Distribution of *S. josikaea* in Europe (After IUCN, 2018) (left) and Romanian alpine bioregion Art17 (2012 report – right up and 2018 report – right down)

S. josikaea has 2186 as Natura 2000 code, is distributed in alpine biogeographic region (ALP) from Romania and is present in Annex II (Animal and plant species of community interest whose conservation requires the designation of special areas of conservation) of Habitat Directive (H.D., 1992).

Data collection started with desk investigation of reports, scientific articles and management plans, followed by field trips.

Romania must report the conservation status of the plants and habitats of European interest, thus, during two monitoring periods: 2011-2015 in the framework of P.O.S. project (2011) and 2019-2023 in the farmwork of P.O.I.M. (2023) project (Mihăilescu et al., 2024). The field assessment and monitoring of the conservation status of Romanian species of community interest started in 2011 and continued in 2019, during two reporting periods (six years each) toward the European Commission. Based on our data and knowledge, the Annex 1 from M.O. 3351 (2023) was developed and published.

For generating the distribution maps, we used the standard methods: grid ETRS89 of 10 x 10 Km plot and 1 x 1 km grid, projective ETRS LAEA 5210. The necessary data used for generating the maps have been collected during one year or one period for monitoring the species because ethe mapping the distribution of a species might necessitate a few years of field identification and assessment. (Figure1- right up and down).

The location of the individuals has been marked with GPS Garmin eTrex Summit. The data regarding biotic and abiotic factors influencing the distribution of the species have been collected from the field in filed data sheets and used for modelling with Maxent version 3.4.4 software.

The method relied on complete study or a solid statistical estimation, using good data regarding environmental variables like geomorphological (elevation, exposition, slope, plan and profile curvature), climatic (temperature and precipitation), biological (interactions among species, characteristic plant species communities), anthropic (land use, biodiversity conservation), and cultural (local and traditional practices) from the entire distribution range of the species for calibrating and evaluating the predictive performances.

We assessed the conservation status of *S. josikaea* in its distribution area according with the methods established in the methodological guides (Mihăilescu et al., 2015a; 2015b; M.O. 3351, 2023). From the field, data have been collected on field data forms comprising: location, population parameters, habitats characteristics, pressures and threats. Romanian reporting format toward European Commission has individuals/population density as reporting unit for the species belonging of the group "Vascular plant species from the water's edge or wet areas, places periodically flooded, water banks (more or less steep)" (M.O. 3351, 2023) in which *S. josikaea* belongs to.

The direct (presence/absence, population size, age/size classes) and indirect (niche availability, hydrology, water quality, vegetation structure, impact factors, negative indicators such as: shadow, competition, fragmentation, extreme drought, alien species) attributes are mandatory to be evaluated during the optimal flowering season (May-June). The monitoring plots have been set on transect along river banks where *S. josikaea* was recorded, according with the management needs, length and width of the vegetation distribution and habitat discontinuities. The frequency of the monitoring activities depends both on the distribution impact or reporting cycles for European Commission (6 years). If the direct and indirect attributes are not met in the field, it means that there are unfavourable conditions for existence. The population size was reported as an interval (minim and maxim) or a single value (measured or estimated) when it is known only one single value obtained throughout expert opinion.

The monitoring method used in the filed investigations for detecting the population size and the range of the species habitat (two very important populational parameters) have been realized accordingly with the growth strategies of the species. In areas where the individuals' growth was lax, counting the individual stems have been possible. Where the stems of the individuals' growth were dens (due to vigorous clonal reproduction), we measured the projection area of their crowns on the soil.

Monitoring protocols may differ in relation to the size of the population of each species, the integrating habitat and their biological and ecological characteristics. Direct and indirect attributes are mandatory. If these attributes do not meet, it means that there are unfavourable conditions of existence.

Field trips realized in 2011 (POS, 2011) on Valea Iadului (Stâna de Vale Locality, Bihor County) have been made for 5 x 5 m plots installation for monitoring *S. josikaea*. We installed 3 permanent monitoring plots on Valea Iadului.

Our paper focused on using the Maxent model to estimate the distribution areal for *S. josikaea* and taking into account the high confidence of estimates for respectively value equal with 1. For estimating the population size, we used the medium value of density for 0.1 ha 5 individuals multiplied with normalized of hotspot analysis index.

RESULTS AND DISCUSSIONS

The rare, endemic, tertiary relict and vulnerable species *S. josikaea* is distributed in eastern Carpathian Mountains, in 17 known localities (2 uncertain) from Latorica, Rika, Uzh and Stryi Rivers in the Ukrainian Carpathians and 7 known localities (6 uncertain) from Crişul Negru, Valea Iadului (Bihor County), Valea Sebeşului, Someşul Cald (Cluj County), Arieş (Alba County) Rivers in Romanian Carpathians (Apuseni Mountains) (Lendvay et al., 2013; 2015; Macalik et al., 2013). A proper conservation strategy might consist in maintaining connectivity among sites and understanding the species' reproductive strategy (clonal propagation in detriment of sexual reproduction). The population might consist in a few clones only thus might enhance the resilience of the population (Lendvay et al., 2015) or determine the rapid deterioration of the individuals due to low genetic variability (Crawley, 1997; Rockwood, 2006).

The distribution of the studied species on small areas is strongly related with river valleys: alongside river margins (on the shore) (Figure 2), adjacent areas (rocky shores, cliffs) (Figure 3) and in hilly areas in rivers floodplains.

Figure 2: *S. josikaea* individuals distributed on Valea Iadului river shore

The species is integrated in *Alno incanae-Syringetum josikaeae* (Borza 1965) Rațiu et al. 1984 Association (Romanian habitat R4413 South-East Carpathian thickets with *Syringa josikaea*) (Doniță et al., 2005).

Figure 3: *S. josikaea* individuals distributed on adjacent Valea Iadului river margins (cliffs)

This plant association and Romanian habitat are integrated in Natura 2000 habitat 40A0* Subcontinental peri-Pannonic scrub (Gafta & Mountford, 2008; Goriup, 2008). The habitat is distributed on narrow mountainous valleys, on humid districtsambosols with 5.8-7.5 soil reaction (pH), temperature 7.0-5.5^{0}C and 800-900 mm rainfall (Doniță et al., 2005). In Apuseni Mountains, the distribution localities are situated at 500-1100 m attitude, on different expositions according with the river direction.

In Bihor County, Stâna de Vale Locality, we installed in 2011, monitoring plots in habitats with 100 ha surface area in which the distribution of *S. josikaea* is on about 50 m^2. The locations of the plots are different, according to the distribution of *S. josikaea* in the region (Table 1).

The surrounding vegetation structure consists in trees layer in one plot (Valea Iadului 3 and 4, alongside river shore close to the forest), highest shrubs layer in two plots (Valea Iadului 1 and 2, vegetating on rocky shores, cliffs, at 3-4 m above the 108J road) and one richest species site (Leșu touristic locality, hilly areas in rivers floodplains).

The Natura 2000 protected areas in which the species might be distributed are: ROSCI0002 Apuseni, ROSCI0062 Defileul Crișului Repede - Pădurea Craiului, ROSCI0121 Muntele Vulcan, ROSCI0262 Valea Iadei (S.F., 2011). Following the field trips in these protected areas, the presence of *S. josikaea* was not confirmed in ROSCI0062 and ROSCI0121.

The Maxent model reveal the total potential distribution area of *S. josikaea* is about 177.31 ha with estimated population size of circa 90,464 individuals (Table 2).

Table 1. Surrounding vegetation structure and species richness in plots comprising *S. josikaea*

Sit's name	Valea Iadului 1	Valea Iadului 2	Valea Iadului 3	Valea Iadului 4	Leșu
Total vegetation coverage (%)	100	100	100	100	100
Vegetation layers					
- max. height of the trees layer (m)	-	-	7	-	-
- max. coverage of the trees layer (%)	-	-	30	-	-
- max. height of the shrubs layer (m)	3	4	2.7	3	3
- max. coverage of the shrubs layer (%)	50	70	50	50	50
- max. height of the herbaceous layer (cm)	100	30	100	100	100
- max. coverage of the herbaceous layer (%)	100	30	100	100	100
Species richness (number)	7	3	10	6	16
Alno incanae-Syringetum josikaeae Association					
Characteristic species					
Alnus incana			+		
Syringa josikaea	+	+	+	+	+
Other species					
Anemone ranunculoides					+
Campanula serrata					+
Clematis alpina	+				+
Fagus sylvatica			+		+
Geum rivale			+		
Luzula sp.	+				+
Melica uniflora				+	+
Myosotis sylvatica	+	+			+
Petasites albus		+	+		
Polygonum bistorta				+	
Polygonatum verticillatum				+	+
Rosa pendulina					+
Rubus idaeus			+		
Salix capraea					+
Salix sp.	+		+	+	+
Sambucus nigra			+		
Sorbus aucuparia	+				+
Spiraea sp.					+
Trolius europaea				+	
Urtica dioica			+		
Valeriana montana	+		+		+
Veratrum album					+

Table 2. Estimates surfaces for areal distribution for *S. josikaea* in alpine bioregion Romania

Category	Number	Minimum size (ha)	Maximum size (ha)	Surface (ha)	Estimated number of individuals
Cold spot 99% confidence	3,159	0.00633	0.3022	30.136	21,698
Cold spot 95% confidence	2,141	0.00635	0.1398	21.243	14,020
Cold spot 90% confidence	1,014	0.00635	0.4341	10.283	6,170
Not significant	3,197	0.00634	0.2569	36.338	19,623
Hot spot 90% confidence	75	0.00681	0.1087	1.1374	546

Hot spot 95% confidence	234	0.00681	0.3228	4.3586	1,831
Hot spot 99% confidence	3,788	0.00637	1.4581	73.821	26,576
Total	**13,608**	**0.00633**	**1.4581**	**177.31**	**90,464**

The development of such a model leads to: the assessment of the impact of climate, and to analyse projections that may affect the distribution of the species in the future, the conservation of the characteristic habitats by developing management strategies thus ensuring the sustainability of the species. This model is also a direct support for the EU-specific reporting of Romania in the context of Article 17 of the Habitats Directive (Figure 4).

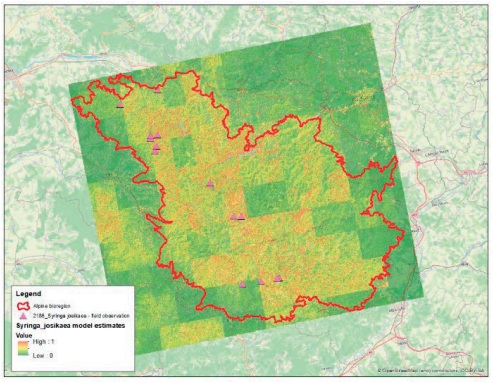

Figure 4. The Maxent model estimates for *S. josikaea* distribution

Conservation measure for central (Hotspot - red) and marginal (Coldspot - blue) spots relay on maintain the current range of the populations and/or the current areal of habitats for the species. On the interval confidence of both cold spot >90% (confidence blue spots) and Hot spot >90% (confidence red spots) (Figure 5), the dominant pressure and threats are clear-cutting (removal of all trees), the destruction of the species habitats (*i.e.* hydrotechnical engineering of mountainous water courses) and the collecting of the species from the wild and move it in the peoples' gardens.

S. josikaea is a threatened species of the Carpathians mostly growing as extremely small populations at distant sites, our analysis reveals the estimated areal distribution is in small surfaces (max. 1.4 ha) cover total 177 ha in 5,856 km^2.

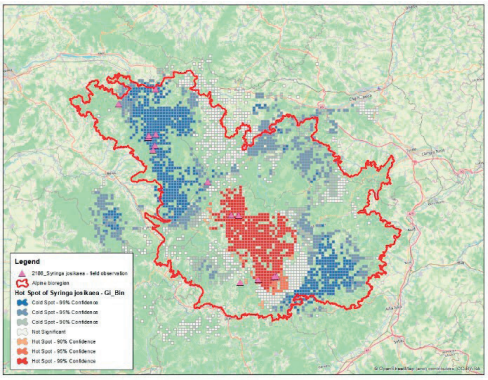

Figure 5. Hot spot analysis for *S. josikaea* distribution areal

In this respect we observe that the reported surface on 2,400 km^2 is overestimated base on chorological methods of reporting tool. The estimated population size near to 90,000 individuals need to be validated before next report to European Commission. The hot spot analysis of *S. josikaea* areal estimates shows the clustering of metapopulation for *S. josikaea* distribution plots, central areas (hot spot >90% confidence) and marginal areas (cold spot >90% confidence), to validate the specific appropriate conservation measures to achieve the conservation objectives especially for Natura 2000 sites.

In June, the monitoring of the population of *S. josikaea* from downstream the dam Beliș toward Valea Neagră confluence reported 300 individuals in 2020 and 2021-2022 distributed on about 16 ha, indicating that this population is relatively stable, with a favourable conservation status. It was identified a new location on Someșul Cald valley with 6 individuals. The main threats affecting the species distribution and populations density are: collecting individuals from the wild and the proliferation of exotic/invasive species. In ROSCI0002 Apuseni, *S. josikaea* has a favourable conservation status and due to low impact of the threats, the perspectives are good, determining the conservation of this species in the wild (APNA, 2022).

Our field trips in 2022 (P.O.I.M., 2023) at the beginning of June on Valea Iadului, upstream of Lești lake (Lești touristic locality), showed difficulties to find the species individuals in the wild but we found about 500 individuals

forming a green fence of a private property that developed till the edge of the river water course (Figure 6).

Figure 6. Private fence formed by *S. josikaea* individuals

In the *Habitats Directive* (92/43/EEC), species monitoring belonging to Annex II and Annex IV is required in both Article 11 and Article 17 preceding the reporting of the species conservation status at every six years toward the European Commission. Measures taken pursuant to the *Habitats Directive* shall be designed to maintain or restore, at favourable conservation status for species of wild flora of Community interest.

In the last 12 years, all Member States, including Romania, has reported two times to the Commission: in 2013 (for the evaluation period 2007-2012) and 2019 (for the evaluation period 2013-2018), based on every 6 years of the assessed conservation status for habitats of community interest. For the next report (deadline 31 July 2025), was approved in 2023 the reporting format on species types (DG Environment, 2023).

For the period 2013-2018 the population size measured in number of individuals was estimated between 10 and 240.

Under the Habitats Directive - Article 17 reporting process these assessments have been carried out in EU25 for the period 2001-2006, in EU 27 for the period 2007-2012 and in EU28 for the period 2013-2018 (EIONET, 2019).

During 2007-2019, the conservation status was ”unfavourable - inadequate” (U1), due to increasing trends in the intensity of different impacts upon the species habitat. In the period 2020-2024, after implemented the conservation measures included in the Management Plan of the Apuseni Natural Park (O.M., 2024), this overall assessment was changed as ”favourable” (FV) (Table 3).

Table 3. Overall assessment of the conservation status on each reporting period

Species	2013	2019	2025
	ALP	ALP	ALP
2186 *Syringa josikaea* Jacq.	U1	U1	FV

List of pressures and threats and conservation measures was updated in 2024 for the period 2019-2024 (EIONET, 2025). During 2007-2019, main conservation measures according with EU code: CB01 - Prevent conversion of (semi-) natural habitats into forests and of (semi-) natural forests into intensive forest plantation.

CONCLUSIONS

The spontaneous species *Syringa josikaea* Jacq. (Transylvanian lilac, Hungarian lilac, wind wood) is a very important species in Romanian flora (rare, endemic, tertiary relict and vulnerable), being under Romanian and European special protection. The species populations distributed in western Romanian Carpathians (Apuseni Mountains) are basically small (low number of the individuals), genetically homogenous, distributed at distant sites. The distribution model developed using Maxent highlighted the anthropogenic and climate impacts that can affect the population density and distribution. The analysis of the projection of the main threats and pressures that may affect the distribution of the species in the future, lead the actions regarding the conservation of the characteristic habitats by developing management strategies thus ensuring the sustainability of the species. The hot spot analysis of *S. josikaea* areal estimates help to validate the specific appropriate conservation measure to achieve the conservation objectives especially for Natura 2000 sites.

The populations are relatively stable, with a favourable conservation status and protected in areas under conservation regulation. Maintaining the favourable conservation status still depends on the continued application of conservation measures, both for the species and its habitat.

Due to its beauty, the Transylvanian lilac is cultivated in the gardens and urban parks of the world.

ACKNOWLEDGEMENTS

The data have been obtained in the framework of the Sectorial Operational Programme ENVIRONMENT 2007-2013 (POS no. 130537/10.01.2011) and the Large Infrastructure Operational Programme 2014-2020 (POIM no. 238/11.03.2019) projects financed by the Ministry of Investments and European Projects. The paper was written in the framework of projects RO1567-IBB01, RO1567-IBB03 and RO1567-IBB04 from Institute of Biology Bucharest of Romanian Academy financed by Romanian Academy.

REFERENCES

APNA (2022). RNP Romsilva-Administration of Natural Park Apuseni, Activity report for natural protected areas Natural Park Apuseni, ROSPA0081 Munții Apuseni-Vlădeasa, ROSCI0002 Apuseni, ROSCI0016 Buteasa and the 55 natural protected areas that make the subject of the contract no. 132/18.11.2014

Austin, M. (2007). Species distribution models and ecological theory: a critical assessment and some possible new approaches. *Ecological modelling*, *200*(1-2), 1-19.

Bao, R., Li, X., Zheng, J. (2022). Feature tuning improves Maxent predictions of the potential distribution of Pedicularis longiflora Rudolph and its variant. *PeerJ*, *10*, e13337.

Boc, V. I., Mihalache, B., Tudor, T. I., Zeca, L. (2020). Vegetation habitats mapping in Văcăreşti Natural Park. *Scientific Papers. Series B, Horticulture*, *LXIV*(1): 549-553

Borza, A. (1925). *The flora of peasant Romanian gardens: plants of adornment, medicine, charms and beliefs*. Institutul de Arte Grafice Ardealul.

Boşcaiu, N., Coldea, G., Horeanu, C. (1994). The red list of extinct, threatened, vulnerable and rare vascular plant species form Romanian Flora. *Ocrotirea Naturii şi a Mediului Înconjurător, 38*(1) 45-56.

Boşcaiu, N., Onete, M. (2009). A tertiary relict in Romanian Flora: *Syringa josikaea* Jacq., Argesis. *Studii şi Comunicări Seria Ştiinţele Naturii*, Piteşti, XVII: 43-46.

Ciocârlan, V. (2009). *Ilustrated flora of Romania. Pteridophyta et Spermatophyta*, Editura Ceres, Bucureşti. 1141 p.

Crawley, M.J. (1997). *Plant Ecology*, Blackwell Science, 717 p.

Dai, X., Wu, W., Ji, L., Tian, S., Yang, B., Guan, B., Wu, D. (2022). Maxent model-based prediction of potential distributions of *Parnassia wightiana* (Celastraceae) in China. *Biodiversity Data Journal* 10: e81073.

Damtoft, S., Franzyk, H., Jensen, S.R. (1995). Biosynthesis of iridoids in Syringa and Fraxinus: Secoiridoid precursors. *Phytochemistry*, *40*(3), 773-784.

DG Environment (2023). *Reporting under Article 17 of the Habitats Directive: Guidelines on concepts and definitions – Article 17 of Directive 92/43/EEC, Reporting period 2019-2024*. Brussels, https://cdr.eionet.europa.eu/help/habitats_art17

Dihoru, G., Negrean, G. (2009). *The Red Book of vascular plants from Romania*, Editura Academiei Române, Bucureşti, 630 p.

Doniţă, N., Paucă-Comănescu, M., Popescu, A., Mihăilescu, S., Biriş, I. A. (2005). *Habitatele din România*. Bucureşti. Editura Tehnică Silvică.

Dunea, D., Bretcan, P., Purcoi, L., Tanislav, D., Serban, G., Neagoe, A., Iordache, V., Iordache, Ş. (2021). Effects of riparian vegetation on evapotranspiration processes and water quality of small plain streams. *Ecohydrology & Hydrobiology, 21*(4), 629-640.

Dunea, D., Dincă, N., Iordache, Ş. (2014). Spatio-temporal characterization of natural grasslands from Bucegi Natural Park using remote sensing resources. *Scientific Papers - Series A, Agronomy*, 57, 180-185.

EIONET (2019). Article 17 web tool - the Article 17 web tool on biogeographical assessments of conservation status of species and habitats under Article 17 of the Habitats Directive, https://nature-art17.eionet.europa.eu/article17/species/report/?period=3&group=Vascular+plants&country=RO&region=

EIONET (2025). *Reference portal for reporting under Article 17 of the Habitats Directive*, https://cdr.eionet.europa.eu/help/habitats_art17 (accessed January 2025).

Elith, J., Leathwick, J. R. (2009). Species distribution models: ecological explanation and prediction across space and time. *Annual review of ecology, evolution, and systematics*, *40*(1), 677-697.

Elith, J., Phillips, S. J., Hastie, T., Dudík, M., Chee, Y. E., Yates, C. J. (2011). A statistical explanation of Maxent for ecologists. *Diversity and distributions*, *17*(1), 43-57.

Franklin, J. (2013). Species distribution models in conservation biogeography: developments and challenges. *Diversity and distributions*, *19*(10), 1217-1223.

Gafta, D., Mountford, O.J. (Coord.) (2008). *Manual of interpreting Natura 2000 from Romania*, Editura Risoprint.

Gizhitskaya, S.A., Lyakh, E.M. (2020). Potential for using ornamental bushes for greening the city of Novosibirsk: in case of the genus Syringa L. In *BIO Web of Conferences* (Vol. 24, p. 00024). EDP Sciences.

Goriup, P. (Coord.) (2008). Natura 2000 in Romania. Species fact sheets. EU Phare Project on Implementation of Natura 2000 Network in Romania EU Phare EuropeAid/12/12160/D/SV/RO.

Guisan, A., Thuiller, W. (2005). Predicting species distribution: offering more than simple habitat models. *Ecology letters*, 8(9), 993-1009.

H.D. (1992) Habitat Directive, Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora, *Official Journal of the European Union*, 206(7), 50. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31992L0043

Hageer, Y., Esperón-Rodríguez, M., Baumgartner, J. B., Beaumont, L. J. (2017). Climate, soil or both? Which variables are better predictors of the distributions of Australian shrub species?. *PeerJ*, *5*, e3446.

Hernandez, P.A., Franke, I., Herzog, S.K., Pacheco, V., Paniagua, L., Quintana, H.L., Soto, A., Swenson, J.J., Tovar, C., Valqui ,T.H., J. Vargas, Young, B.E. (2008). Predicting species distributions in poorly-studied landscapes. *Biodiversity and conservation*, *17*, 1353-1366.

Hernandez, P.A., Graham, C.H., Master, L.L., Albert, D.L. (2006). The effect of sample size and species characteristics on performance of different species distribution modeling methods. *Ecography*, *29*(5), 773-785.

Höhn, M., Lendvay, B. (2018). *Syringa josikaea*. *The IUCN Red List of Threatened Species*, 2018: e.T162267A99428926. https://dx.doi.org/10.2305/IUCN.UK.2018-1.RLTS.T162267A99428926.en.

Hosseini, N., Ghorbanpour, M., Mostafavi, H. (2024). Habitat potential modelling and the effect of climate change on the current and future distribution of three Thymus species in Iran using Maxent. *Scientific Reports*, *14*(1), 3641.

IUCN (2018). *Syringa josikaea*. *The IUCN Red List of Threatened Species. Version 2024-2*, www.iucnredlist.org/species/162267/99428926.

Khanum, R., Mumtaz, A. S., Kumar, S. (2013). Predicting impacts of climate change on medicinal asclepiads of Pakistan using Maxent modeling. *Acta Oecologica*, *49*, 23-31.

Lendvay, B., Kadereit, J. W., Westberg, E., Cornejo, C., Pedryc, A., Höhn, M. (2015). Phylogeography of *Syringa josikaea* (Oleaceae): Early Pleistocene divergence from East Asian relatives and survival in small populations in the Carpathians. *Biological Journal of the Linnean Society*, *119*(3), 689-703.

Lendvay, B., Pedryc, A., Höhn, M. (2013). Characterization of Nuclear Microsatellite Markers for the Narrow Endemic *Syringa josikaea* Jacq. fil. ex Rchb. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, *41*(1), 301-305.

Lissovsky, A.A., Dudov, S.V. (2021). Species-distribution modeling: advantages and limitations of its application. 2. Maxent. *Biology Bulletin Reviews*, *11*(3), 265-275.

Liu, Y., Cai, L., Sun, W. (2024). Current conservation status and potential distribution under climate change of *Michelia lacei*, a Plant Species with Extremely Small Populations in Yunnan, China. *Oryx*, *58*(5), 631-640.

M.O. (2023). Ministry Order no. 3351 from 28 December 2023 for the approval of the "Guide on protocols and unitary methodologies for monitoring the conservation status of species of Community interest", Annex 1. Guide with protocol and methodology for monitoring the conservation status of plant species of community interest, https://legislatie.just.ro/public/Detalii Document/ 278140

Ma, B., Sun, J. (2018). Predicting the distribution of Stipa purpurea across the Tibetan Plateau via the Maxent model. *BMC ecology*, *18*, 1-12.

Macalik, K., Tamás, R., Kolcsár, L.P., Keresztes, L. (2013). Present status of the *Syringa josikaea* Jacq. ex Rchb., an endemic species which contributes to the diversity of the Flora of the Carpathians. *Studia Universitatis Babeş-Bolyai. Series Biologia*, *58*(2), 31-40.

Merow, C., Smith, M.J., & Silander Jr, J.A. (2013). A practical guide to Maxent for modeling species' distributions: what it does, and why inputs and settings matter. *Ecography*, *36*(10), 1058-1069.

Mihăilescu, S., Onete, M., Bodescu, F.-P., Gheorghe, I.F., Strat, D., Sahlean, T, Nicoară, G-R., Mihai, L.-S., Manu, M., Mountford, J.O., (2024). Approaches to the assessment of some habitats of community importance in Romania, *Scientific Papers. Series A. Agronomy*, LXVII (2): 529-539

Mihăilescu, S., Anastasiu, P., Popescu, A., Alexiu, A.F., Negrean, G.A., Bodescu, F., Manole (Aiftimie), A., Ion, R.G., Goia, I.G., Holobiuc, I., Vicol, I., Neblea, M.A., Dobrescu, C., Mogîldea, D.E., Sanda, V., Biță-Nicolae, C.D., Comănescu, P. (2015a). *Monitoring Guide for community interest plant species from Romania*, Editura Dobrogea.

Mihăilescu, S., Strat, D., Cristea, I., Honciuc, V. (2015b). *Synthetic report regarding conservation status of community interest plants and habitats from Romania*, Editura Dobrogea.

O.M. (2024). Official Monitor I Part no. 1071Bis, Annex at Order of Environment, Water, and Forests Ministry no. 2.238/2024 regarding the approval of integrative management Plan of Apuseni Natural Park and integrated protected areas, https://lege5.ro/MonitorOficial/mongq3danzygiyq/monitorul-oficial-partea-i-nr-1171-25-11-2024

Oltean, M., Negrean, G., Popescu, A., Roman, N., Dihoru, G., Sanda, V., Mihăilescu, S., (1994). *The red list of superior plants from Romania*, Institute of Biology, Romanian Academy.

P.O.I.M. (2023). Completing the level of knowledge of biodiversity by implementing the system for monitoring the conservation status of species and habitats of Community interest in Romania and reporting on the basis of Article 17 of Habitats Directive 92/43/EEC", funded by the Large Infrastructure Operational Programme, 2014-2020.

P.O.S. (2011). *Monitoring the conservation status of species and habitats from Romania under article 17 of Habitat Directive*, Contract no. 130537/10.01.2011, https://www.ibiol.ro/posmediu/index.htm.

Pavlenkova, G.A. (2024) Fruit setting as a result of hybridization of Syringa representatives in the conditions of the Orel region, Agrarian Scientific Journal. 12 :57–65.

Phillips, S.J., Dudík, M. (2008). Modeling of species distributions with Maxent: new extensions and a comprehensive evaluation. *Ecography*, *31*(2), 161-175.

Polonskiy, V.I., Polyakova, I.S. (2015). Increased size of epidermal cells in *Syringa josikaea* Jacq. smaller leaf side as an adaptive mechanism for reducing its asymmetry. *Russian Journal of Developmental Biology*, *46*, 356-361.

Qin, A., Liu, B., Guo, Q., Bussmann, R.W., Ma, F., Jian, Z., Xu, G., Pei, S. (2017). Maxent modeling for predicting impacts of climate change on the potential distribution of *Thuja sutchuenensis* Franch., an extremely endangered conifer from southwestern China. *Global Ecology and Conservation*, *10*, 139-146.

Qin, Z., DiTommaso, A., Wu, R.S., Huang, H.Y. (2014). Potential distribution of two *Ambrosia* species in C hina under projected climate change. *Weed Research*, *54*(5), 520-531.

Reese, G.C., Wilson, K.R., Hoeting, J.A., Flather, C.H. (2005). Factors affecting species distribution predictions: a simulation modeling experiment. *Ecological Applications*, *15*(2), 554-564.

Rhoden, C.M., Peterman, W.E., Taylor, C.A. (2017). Maxent-directed field surveys identify new populations of narrowly endemic habitat specialists. *PeerJ*, *5*, e3632.

Rockwood, L.L., (2006). *Introduction to population ecology*, Blackwell Science, 339 p.

Rosenzweig, M. L. (1995). *Species diversity in space and time*. Cambridge University Press, 436 p.

Rotllan-Puig, X., Traveset, A. (2016). Declining relict plants: climate effect or seed dispersal disruption? A landscape-scale approach. *Basic and Applied Ecology*, *17*(1), 81-91.

S.F. (2011). Natura 2000 Standard Form https://www.mmediu.ro/app/webroot/uploads/files/Formulare_standard_SCI.pdf

Sârbu, I., Ștefan, N., Oprea, A. (2013). *Vascular plants from Romania. Illustrated field identification manual*. Editura Victor B Victor. 1320 p.

Sharma, S., Arunachalam, K., Bhavsar, D., Kala, R. (2018). Modeling habitat suitability of *Perilla frutescens* with Maxent in Uttarakhand - A conservation approach. *Journal of Applied Research on Medicinal and Aromatic Plants*, *10*, 99-105.

Tang, X., Yuan, Y., Wang, L., Chen, S., Liu, X., Zhang, J. (2021). Identifying prioritized planting areas for medicinal plant *Thesium chinense* Turcz. under climate change in China. *Ecological Informatics*, *66*, 101459.

Tesfamariam, B. G., Gessesse, B., Melgani, F. (2022). Maxent-based modeling of suitable habitat for rehabilitation of Podocarpus forest at landscape-scale. *Environmental Systems Research*, *11*(1), 4.

USDA (2025). *Syringa josikaea* Jacq. f. ex Rchb., U.S. Department of Agriculture, Natural Resources Conservation Service, https://plants.sc.egov.usda.gov/plant-profile/SYJO4

Vasilevskaya, N., Morozova, D. (2020). Monitoring the growth and development of *Syringa josikaea* Jacq. fil. in the conditions of the euro-arctic region (on the example of the city of Murmansk). Principles of the Ecology, 9, 2(36). DOI: 10.15393/j1.art.2020.10342

Vasilevskaya, N., Morozova, D. (2024). Morphological variability and fertility of *Syringa josikaea* pollen under industrial pollution of the Arctic city. In *BIO Web of Conferences* (Vol. 130, p. 01008). EDP Sciences.

Vasilevskaya, N.V., Morozova, D.A. (2018). Polyvariance of Floral Organogenesis of *Syringa josikaea* Jacq. (Oleaceae) in the Conditions of the Arctic Urbanized Territory. *Ecology and Sustainable Development*, *1*(1), 31-39.

Venne, S., Currie, D. J. (2021). Can habitat suitability estimated from Maxent predict colonizations and extinctions? *Diversity and Distributions*, *27*(5), 873-886.

Williams, J. N., Seo, C., Thorne, J., Nelson, J. K., Erwin, S., O'Brien, J. M., Schwartz, M. W. (2009). Using species distribution models to predict new occurrences for rare plants. *Diversity and distributions*, *15*(4), 565-576.

Wisz, M.S., Hijmans, R.J., Li, J., Peterson, A.T., Graham, C.H., Guisan, A., NCEAS Predicting Species Distributions Working Group. (2008). Effects of sample size on the performance of species distribution models. *Diversity and distributions*, *14*(5), 763-773.

Wisz, M. S., Pottier, J., Kissling, W.D., Pellissier, L., Lenoir, J., Damgaard, C.F., Dormann, C.F., Forchhammer, M.C., Grytnes, J.-A., Guisan, A., Heikkinen, R.K., Høye, T.T., Kühn, I., Luoto, M., Maiorano, L., Nilsson, M.-C., Normand, S, Öckinger, E., Schmidt, N.M., Termansen, M., Timmermann, A., Wardle, D.A., Aastrup, P., Svenning, J.-C., Svenning, J. C. (2013). The role of biotic interactions in shaping distributions and realised assemblages of species: implications for species distribution modelling. *Biological reviews*, *88*(1), 15-30.

Witkowski, Z. J., Król, W., Solarz, W. (Eds.) (2003). *Carpathian list of endangered species, WWF and Institute of Nature Conservation*, Polish Academy of Science, Europress, Kraków, Poland.

Yang, X.Q., Kushwaha, S.P., Saran, S., Xu, J., Roy, P.S. (2013). Maxent modeling for predicting the potential distribution of medicinal plant, *Justicia adhatoda* L. in Lesser Himalayan foothills. *Ecological engineering*, *51*, 83-87.

Yi, Y.J., Cheng, X., Yang, Z.F., Zhang, S.H. (2016). Maxent modeling for predicting the potential distribution of endangered medicinal plant (*H. riparia* Lour) in Yunnan, China. *Ecological Engineering*, *92*, 260-269.

Zhang, Y., Tang, J., Ren, G., Zhao, K., Wang, X. (2021). Global potential distribution prediction of *Xanthium italicum* based on Maxent model. *Scientific reports*, *11*(1), 16545.