NAT. CROAT. | VOL. 35 | No 2 | 0 - 0 | ZAGREB | December 31, 2026

original scientific paper/izvorni znanstveni rad
DOI 10.20302/NC.2026.35.29

DISTRIBUTION OF SOME INVASIVE ALIEN PLANT SPECIES IN THE EASTERN REGION OF KOSOVO

BUJAR KADRIAJ

University of Prishtina, Faculty of Mathematics and Natural Sciences, Department of Biology, Prishtina, Kosovo
(E-mail: bujar.kadriaj@uni-pr.edu; ORCID: https://orcid.org/0000-0003-3597-0798)

Kadriaj, B.: Distribution of some invasive alien plant species in the eastern region of Kosovo. Nat. Croat., Vol. 35, No. 2, _____, 2026, Zagreb.

Invasive alien species (IAS) pose a significant global issue, threatening biodiversity and ecosystems on both local and global scales. As a result of the high degree of globalization, the anthropogenic factor is causing intentionally or unintentionally the introduction of these species into a certain region through various transport routes. This paper presents the currently documented occurrences of twelve invasive alien plant species (IAPS) in the eastern region of Kosovo based on field surveys conducted between 2020–2024. Some species were found in multiple localities and habitats, while others were recorded in fewer sites. Based on observations, rivers had a high number of IAPS occurrences and their populations at several surveyed points along their banks. Research on the distribution of IAPS contributes to addressing this significant issue in the conservation of local biodiversity and ecosystems, as well as the development of effective management strategies for controlling these species.

Keywords: plant invasions, IAPS, distribution, habitats, Kosovo

Kadriaj, B.: Rasprostranjenost nekih invazivnih biljnih vrsta u istočnom dijelu Kosova. Nat. Croat., Vol. 35, No. 2, _____, 2026, Zagreb.

Invazivne strane vrste (IAS) predstavljaju značajan globalni problem, ugrožavajući bioraznolikost i ekosustave na lokalnoj i globalnoj razini. Kao rezultat visokog stupnja globalizacije, antropogeni čimbenik uzrokuje namjerno ili nenamjerno unošenje tih vrsta u određenu regiju putem različitih transportnih pravaca. Ovaj rad predstavlja trenutno dokumentirane pojave dvanaest invazivnih stranih biljnih vrsta (IAPS) u istočnom dijelu Kosova na temelju terenskih istraživanja provedenih između 2020. i 2024. Neke vrste pronađene su na više lokaliteta i staništa, dok su druge zabilježene na manje lokaliteta. Na temelju opažanja velik broj invazivnih biljaka i njihovih populacija zabilježen je uz rijeke, na nekoliko istraživanih točaka duž njihovih obala. Istraživanje rasprostranjenosti IAPS doprinosi prepoznavanju ovog značajnog problema u očuvanju lokalne bioraznolikosti i ekosustava, kao i razvoju učinkovitih strategija upravljanja za kontrolu ovih vrsta.

Ključne riječi: invazivne biljke, IAPS, rasprostranjenost, staništa, Kosovo

INTRODUCTION

Since biological invasion affects all levels of ecological organization, from individuals to ecosystems, it currently represents an important problem at the global level, challenging nature conservation efforts (VAN DER VELDE *et al.*, 2006; SIMBERLOFF *et al.*, 2013; PYŠEK *et al.*, 2020). The

increasing scale of globalization has facilitated the distribution of IAS, accelerating biological invasions, and thus contributing to the homogenization of biota worldwide (SEEBENS *et al.*, 2015; EARLY *et al.*, 2016). The introduction of IAPS into a country can occur either intentionally or unintentionally, through various transport pathways (HULME, 2009; BLACKBURN *et al.*, 2011; CHEN *et al.*, 2017). Their introduction is mainly through horticulture for decorative purposes (MEYERSON & MOONEY, 2007; HULME *et al.*, 2018; MONTAGNANI *et al.*, 2022).

Invasive alien plants encompass a variety of life forms and inhabit both terrestrial and aquatic environments, posing a significant threat to native biodiversity, ecosystem services, agriculture, socio-economic conditions, and human health (PIMENTEL, 2009; RAI & SINGH, 2020; MARTIN *et al.*, 2020; SPAMPINATO *et al.*, 2022). The threat that invasive alien plants pose to native biodiversity results from several key characteristics, including high dispersal ability, adaptability to various habitats, rapid reproduction and growth, production of numerous long-lived seeds, high germination rates, efficient nutrient utilization, herbicide resistance, competitive ability through allelopathy, high photosynthetic capacity, etc. (PYŠEK & RICHARDSON, 2007; KUNWAR & ACHARYA, 2013; VAN KLEUNEN *et al.*, 2015; ESIPENKO *et al.*, 2020). According to RAI (2022), IAPS change the physicochemical and biological characteristics of the soil and thus its stability through erosive action. For example, *Impatiens glandulifera*, which belongs to the group of transformers plants, is an erosion-inducing plant (RICHARDSON *et al.*, 2000). Among these species are plants with medicinal, nutritional, and poisonous properties. *Datura stramonium* L., in addition to being a weed in agricultural crops, contains alkaloids such as atropine, hyoscyamine, and scopolamine, which are toxic to both humans and livestock (DIRDIRI *et al.*, 1981; GRIFFIN & LIN, 2000; TOSTES, 2002; TRANCĂ *et al.*, 2017). *Ambrosia artemisiifolia* also affects human health. According to RICHTER *et al.* (2013), its pollen has a high allergenic effect on humans, while its treatment then causes medical expenses. There are also IAPS that have uses in food for both humans and animals, as well as in pharmaceutical and medical applications, such as *Helianthus tuberosus*, whose edible tubers are rich in inulin, proteins and other bioactive substances (NIKOLIĆ *et al.*, 2014; DIAS *et al.*, 2016; SAWICKA *et al.*, 2020; MÉNDEZ-YÁÑEZ *et al.*, 2022).

In the studied region (eastern region of Kosovo), 20 IAPS have been identified so far as a preliminary list, providing information on their family affiliations, life forms, places of origin, and the types of habitats where they have been found (KADRIAJ *et al.*, 2023). One species, *Echinocystis lobata* (Michx.) Torr. & A. Gray, has been added to the list, while *Erigeron annuus* has been identified with two subspecies: *Erigeron annuus subsp. annuus* and *Erigeron annuus subsp. septentrionalis* (KADRIAJ, 2024). Additionally, two new alien species, *Rudbeckia hirta* and *Oenothera glazioviana*, have been identified in the country (MILLAKU *et al.*, 2024). KRASNIQI *et al.* (2011) published distribution data by locality for only three species: *Amorpha fruticosa* L., *Reynoutria japonica* Houtt., and *Helianthus tuberosus* L. The availability of distribution data for IAPS is of particular importance for the conservation of local biodiversity and the habitats these species occupy, as well as for the development of future management plans.

MATERIALS AND METHODS

Kosovo is geographically divided into two main regions: eastern and western. Research was conducted in the eastern part between 2020 and 2024. The data presented in this paper pertain to the recorded occurrences of 12 invasive alien plant species in this area. Plant species are

presented with accompanying photographs (Fig. 1), while the studied region and the surveyed occurrences of IAPS are shown on the map (Fig. 2). Localities where IAPS have been identified, along with corresponding municipalities, are summarised in Tab. 1.

Fig. 1. Invasive alien plant species: A) *Abutilon theophrasti* Medik., B) *Ailanthus altissima* (Mill.) Swingle, C) *Ambrosia artemisiifolia* L., D) *Amorpha fruticosa* L., E) *Bidens frondosa* L., F) *Echinocystis lobata* (Michx.) Torr. & A. Gray, G) *Helianthus tuberosus* L., H) *Impatiens balfourii* Hook.f., I) *Impatiens glandulifera* Royle, J) *Reynoutria* × *bohemica* Chrtek & Chrtková, K) *Senecio inaequidens* DC., L) *Solidago gigantea* Aiton. Photo by B. Kadriaj.

Tab. 1. Localities of IAPS in the eastern region of Kosovo.

Plant species	**Locality**	**Municipality**
Abutilon theophrasti Medik.	Penuhë	Podujevë
Ailanthus altissima (Mill.) Swingle	Prishtinë	Prishtinë
	Laplasellë	Graçanicë
	Gjurgjedell	Kaçanik
	Paldenicë	Hani i Elezit
	Hani i Elezit	Hani i Elezit
Ambrosia artemisiifolia L.	Recorded at five sites along the railway from Prishtina to the village of Dobroshec in Gllogoc	Prishtinë; Fushë Kosovë; Obiliq; Gllogoc

Plant species	Locality	Municipality
	Harilaq	Fushë Kosovë
	Poturoc	Lipjan
	Prelez i Muhaxherëve	Ferizaj
	Nerodime e Poshtme	Ferizaj
	Gjurgjedell	Kaçanik
	Paldenicë	Hani i Elezit
	Hani i Elezit	Hani i Elezit
Amorpha fruticosa L.	Veternik	Prishtinë
	Laplasellë	Graçanicë
	Prelez i Muhaxherëve	Ferizaj
	Blinajë	Lipjan
	Begracë	Kaçanik
Bidens frondosa L.	Lipjan - along the Sitnica River	Lipjan
	Recorded at five sites along the Lepenc River	Kaçanik; Hani i Elezit
	Korminjan - recorded at two sites along the Morava River	Ranillug
	Barilevë - along the Llap River	Prishtinë
	Batllava Lake	Podujevë
	Vushtrri	Vushtrri
	Kolonia 2	Mitrovicë
	Tuneli i Parë	Mitrovicë
Echinocystis lobata (Michx.) Torr. & A. Gray	Carralevë	Shtime
	Krojmir - along the Drenica River	Lipjan
	Lipjan - along the Sitnica River	Lipjan
	Gjurgjedell - along the Lepenc River	Kaçanik
	Hani i Elezit - along the Lepenc River	Hani i Elezit
	Pogragjë - along the Morava River	Gjilan
	Korminjan - along the Morava River	Ranillug
	Laplasellë	Graçanicë
	Vushtrri	Vushtrri
	Kolonia 2	Mitrovicë
	Tuneli i Parë	Mitrovicë
	Parallovë	Novobërdë
Helianthus tuberosus L.	Carralevë	Shtime
	Pjetërshticë - along the Drenica River	Shtime
	Krojmir - along the Drenica River	Lipjan
	Zabel i Ulët - along the Drenica River	Gllogoc
	Korminjan - along the Morava River	Ranillug
	Prishtinë	Prishtinë
	Keçekollë	Prishtinë
	Bajçinë	Podujevë
	Fushë Kosovë	Fushë Kosovë
	Lipjan	Lipjan
	Rusinoc	Lipjan
	Slivovë	Ferizaj
	Gllogoc	Gllogoc
	Komoran	Gllogoc

Plant species	Locality	Municipality
	Tërstenik	Gllogoc
	Korroticë e Poshtme	Gllogoc
	Zabel i Ulët	Gllogoc
	Stanofc i Epërm	Vushtrri
	Kçiq i Madh	Mitrovicë
	Mitrovicë	Mitrovicë
	Skenderaj	Skenderaj
	Llaushë	Skenderaj
	Gjurgjedell	Kaçanik
	Parallovë	Novobërdë
	Pozheran	Viti
	Dobërçan	Gjilan
Impatiens balfourii Hook.f.	Firajë	Shtërpcë
	Gjurgjedell - along the Lepenc River	Kaçanik
	Pjetërshticë - along the Drenica River	Shtime
Impatiens glandulifera Royle	Recorded at eight sites along the Lepenc River, from the village of Firajë in Shtërpcë to Kaçanik	Shtërpcë; Kaçanik
	Tuneli i Parë	Mitrovicë
Reynoutria × *bohemica* Chrtek & Chrtková	Recorded at 72 localities	Ferizaj; Fushë Kosovë; Gllogoc; Gjilan; Hani i Elezit; Kaçanik; Lipjan; Mitrovicë; Obiliq; Podujevë; Prishtinë; Ranillug; Skenderaj; Shtërpcë; Shtime; Viti; Vushtrri
Senecio inaequidens DC.	Prishtinë - in the industrial area	Prishtinë
	Skenderaj	Skenderaj
Solidago gigantea Aiton	Prishtinë	Prishtinë
	Ferizaj	Ferizaj
	Koshare	Ferizaj
	Lloshkobare	Ferizaj
	Carralevë	Shtime
	Godanc i Poshtëm	Shtime
	Torinë	Lipjan
	Magurë	Lipjan
	Korminjan - recorded at two sites along the Morava River	Ranillug

In this study, a "locality" refers to a village or town where populations of invasive alien plant species (IAPS) were recorded. For linear habitats such as rivers and railway corridors, multiple observation are treated as sites. Where possible, the nearest village or town is named to facilitate interpretation. This approach ensures consistency and allows comparability of records while reflecting currently documented occurrences.

Global and citizen-science repositories were consulted to check occurrence records of invasive alien plant species in the studied region. Records from the GBIF (Global Biodiversity Information Facility) (GBIF, 2026) and iNaturalist (iNATURALIST, 2026) databases were screened, and each species was marked as present (+) or absent (–). Direct links to the corresponding records were compiled, and the results are summarized in Supplementary Tab. S1.

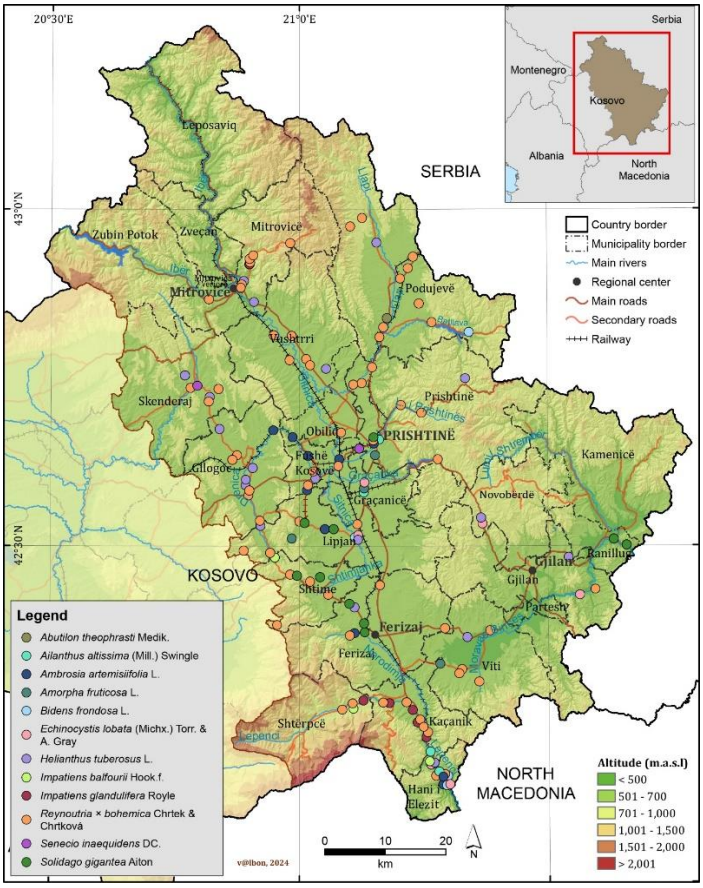

Fig. 2. Surveyed occurrences of invasive alien plant species (IAPS) in the eastern region of Kosovo (map prepared by: Valbon Bytyqi, Professor at the Department of Geography, University of Prishtina).

Surveyed habitats

Most field surveys were conducted along roads, rivers, and other accessible sites, which are also among the habitats most affected by IAPS. This may have facilitated the detection of IAPS in these linear habitats, and occurrences in agricultural interiors and remote areas may be underrepresented due to under-sampling. While these potential biases should be considered when interpreting species occurrences and apparent rarity, the observed patterns provide valuable key information on IAPS presence in the studied region.The main types of habitats where these species have been found are given in Tab. 2, and their numbers in these habitats are shown in Fig. 3.

Selection of species

The twelve invasive alien plant species included in this study were selected based on specific ecological and practical criteria, such as habitat, frequency of occurrence, invasion potential, and management relevance. Some species were selected due to their consistent presence in specific habitats, particularly along watercourses (e.g. *Bidens frondosa*, *Echinocystis lobata*, *Impatiens balfourii*, *Impatiens glandulifera*) and along railway corridors, where a wide distribution was observed during field surveys (e.g. *Ambrosia artemisiifolia*). Other species were included because of their use in the region, such as *Helianthus tuberosus*, cultivated both as a food and ornamental plant, and *Solidago gigantea*, commonly grown for ornamental purposes. Species with numerous recorded occurrences across different habitat types and high invasion risk based on

field observations were also considered (e.g., *Reynoutria* × *bohemica*), which had previously been reported as *Fallopia japonica* before the publication of the preliminary list of invasive alien plants for eastern region of Kosovo (KADRIAJ *et al*., 2023). Based on revised identification during the present field surveys, populations of the species were confirmed to correspond to *Reynoutria* × *bohemica*. Woody and shrubby species with potential management concern in the future were also included (e.g., *Ailanthus altissima*, *Amorpha fruticosa*). Additionally, some species recorded in a few localities (e.g., *Abutilon theophrasti*, *Senecio inaequidens*) were included due to their recognised invasive potential.

These species represent a subset of invasive alien plants recorded during field surveys in the study region and were selected based on the specific ecological and practical criteria described above; this does not imply that other invasive alien plants not included in this study are of lower importance.

Tab. 2. Habitats of IAPS in the eastern region of Kosovo.

Plant species /Habitats	Along roads	Along railways	Along watercourses (rivers, streams and canals)	Cultivated soils	Wastelands	Parks and gardens
Abutilon theophrasti Medik.	+					
Ailanthus altissima (Mill.) Swingle	+					+
Ambrosia artemisiifolia L.	+	+				
Amorpha fruticosa L.	+				+	
Bidens frondosa L.			+			
Echinocystis lobata (Michx.) Torr. & A. Gray			+			
Helianthus tuberosus L.	+		+	+	+	+
Impatiens balfourii Hook.f.			+			
Impatiens glandulifera Royle			+			
Reynoutria × *bohemica* Chrtek & Chrtková	+		+	+	+	+
Senecio inaequidens DC.	+					
Solidago gigantea Aiton	+		+			+

RESULTS AND DISCUSSION

Kosovo, like many other regions worldwide, is undergoing biological invasions by IAPS. The research findings indicate that some species were recorded at fewer localities, while others were observed at more. These records reflect the currently documented occurrences based on field surveys; absence of records does not imply absence of the species in other areas.

Abutilon theophrasti was recorded at a single locality; however, it is likely to be more widespread in the region due to its status as an agricultural and ruderal weed, and this apparent scarcity may reflect the lack of detailed surveys in these habitats, particularly in agroecosystems. *Senecio inaequidens* was recorded at two localities, and *Impatiens balfourii* at three (Tab. 1). *Impatiens*

glandulifera occurred primarily along the Lepenc River, where it was documented at eight points from the village of Firajë in Shtërpcë to Kaçanik, as well as along the Tuneli i Parë watercourse in Mitrovica. The Lepenc River exhibited a high abundance of IAPS (Fig. 2). *Reynoutria* × *bohemica* was recorded at 72 localities, while *Ailanthus altissima* and *Amorpha fruticosa* were each observed at five.

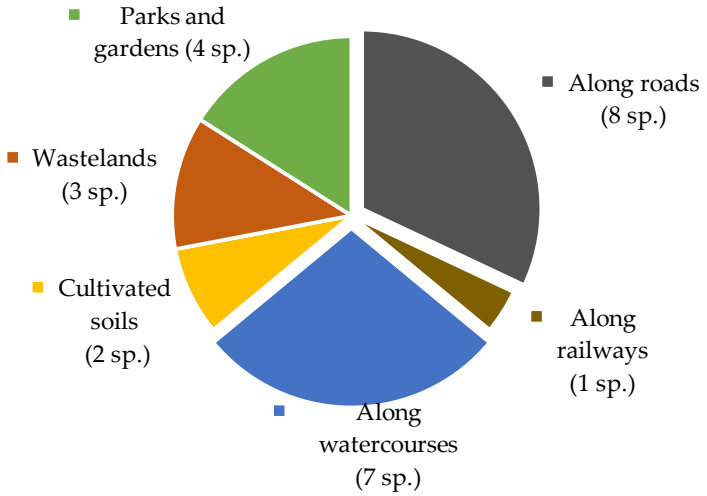

Fig. 3. Number of IAPS across habitats in the eastern region of Kosovo.

Ambrosia artemisiifolia was widely distributed along the railway from Prishtina to the village of Dobroshec in Gllogoc (recorded at five sites along the railway) and in seven other localities. *Bidens frondosa* was found in five sites along the Lepenc River, in two sites along the Morava River, and in six other localities. *Echinocystis lobata* was recorded in 12 localities, *Helianthus tuberosus* in 26, and *Solidago gigantea* in two sites along the Morava River and in eight other localities.

The spread of these species in the studied region occurred both intentionally and unintentionally, driven by various factors. The primary factors contributing to their introduction and spread are human activities, including their use for ornamental purposes, the transportation of soil containing plant material, the construction of roads and railways, among other activities, as well as their extensive distribution along waterways, particularly rivers. Additionally, there are cases where species have been intentionally cultivated for human consumption, such as the use of *Helianthus tuberosus* tubers as food. Roads, railways, water bodies, and green infrastructures are identified as corridors for the introduction and dispersal of alien taxa, and simultaneously, they are among the most impacted areas by IAPS (HULME *et al.*, 2008; CHEN *et al.*, 2012; WRZESIEŃ & DENISOW, 2017; SZILASSI *et al.*, 2021).

Six main habitat types have been identified in the studied region (Tab. 2). The habitats most impacted by IAPS were primarily those along roads, with 8 species, and watercourses, particularly riverbanks, with 7 species (Fig. 3). These environments, heavily impacted by IAPS, often lead to the homogenization of local biodiversity, a pattern that has also been observed in other studies (CHYTRÝ *et al.*, 2008; BENESPERI *et al.*, 2012; LA SORTE *et al.*, 2014; GUARINO *et al.*, 2021).

Bidens frondosa, *Echinocystis lobata*, *Impatiens balfourii*, and *Impatiens glandulifera* were found exclusively along the watercourses, with populations spread widely across rivers (Tab. 2). A high abundance and relatively wide distribution of *Impatiens balfourii* were observed along the banks of the stream in the village of Firajë. Populations of *Helianthus tuberosus* were also widely distributed along the riverbanks, including the Drenica and Morava rivers, as well as the Carraleva watercourse. This is attributed to the dispersal of its tubers via water floods (PYŠEK *et al.*, 2012; SVEHLAKOVA *et al.*, 2017). The spread of *A. artemisiifolia* was particularly evident along railway tracks, where long-distance seed dispersal is facilitated by transport mechanisms (VITALOS & KARRER, 2009; MILAKOVIC *et al.*, 2014; LEMKE *et al.*, 2019). Four species identified in this study— *Ailanthus altissima*, *Ambrosia artemisiifolia*, *Echinocystis lobata*, and *Impatiens glandulifera*— are included in the list of the 100 worst invasive alien species in Europe (DAISIE, 2009; PYŠEK *et al.*, 2009). Additionally, this list includes *Reynoutria japonica*, which crosses with *Reynoutria sachalinensis* to form the hybrid *Reynoutria* × *bohemica*, a species that has been identified in the studied region. The hybrid form is particularly concerning due to its superior invasive abilities and resistance to control efforts (NIKOLIĆ *et al.*, 2014; PAUKOVÁ, 2019; GAŠPAROVIČOVÁ *et al.*, 2022). Based on field observations— such as its wide distribution and vigorous growth— *Reynoutria* x *bohemica* is considered as a species of significant concern for future management in the country. The primary mechanisms contributing to the spread of *Reynoutria* species include the transport of soil containing rhizome fragments and disturbances associated with construction activities, such as road drainage maintenance and various excavation operations (PYŠEK, 2009; DOUGLAS, 2018). Although *Ailanthus altissima* was observed at five localities within the studied region and is likely to be more widespread in other parts of the region as an ornamental and shade-providing plant, it may become a future threat due to its vigorous growth and tendency for population expansion. The rapid spread of this species is attributed to its high seed production and vegetative reproduction (DELGADO *et al.*, 2009; FOTIADIS *et al.*, 2011). Furthermore, *Ailanthus altissima* is globally ranked among the 40 most invasive woody species within angiosperms and is considered the invasive species with the highest rates of reproduction and dispersal in Europe, followed by Asia (REJMÁNEK & RICHARDSON, 1996; WALKER *et al.*, 2017). It is worth noting that *Amorpha fruticosa* exhibited a wide distribution in Veternik, as well as *Senecio inaequidens* in the industrial area of Prishtina. However, the distribution range of *Amorpha fruticosa* in Veternik is concurrently constrained by ongoing urban development. Both species are considered among the most invasive plant species in Europe (DUMITRASCU *et al.*, 2013; LACHMUTH *et al.*, 2017).

Given the substantial ecological risks posed by all the invasive alien plant species discussed, effective management strategies are essential to prevent the introduction of new species and to mitigate the further spread of those already established. This is critical to maintaining the integrity of native biodiversity and the resilience of ecosystems. According to WILSON *et al.* (2009), identifying the dispersal pathways of invasive alien species serves as a preventive measure and is a crucial step for their management. Furthermore, within the framework of management measures of IAPS, various control methods can be implemented, including mechanical control (e.g., uprooting, cutting), chemical control (using herbicides), biological control (natural enemies), and integrated control approaches (ARC, 2014).

CONCLUSIONS

This paper documents the recorded occurrences of 12 invasive alien plant species (IAPS) in the eastern region of Kosovo. The spread of these species has primarily been driven by anthropogenic factors, both intentional and unintentional. *Reynoutria* x *bohemica* is considered a species of significant concern for ecosystems, local biodiversity, and future management in the country due to its wide distribution and vigorous growth. Management recommendations for *Reynoutria* × *bohemica* and other high-impact taxa are provisional, reflecting currently documented occurrences, and should be refined as additional distribution data become available. IAPS that colonised rivers exhibited a broad spatial distribution along their banks, indicating their capacity for long-distance dispersal in riparian ecosystems. Given these findings, this study underscores the urgent need for comprehensive management strategies to address the spread of invasive alien plant species, particularly along transport corridors, to mitigate their ecological impacts. While the research was conducted in the eastern region of Kosovo, further studies are planned in other parts of the country to assess the broader distribution and impact of IAPS.

ACKNOWLEDGMENTS

I am sincerely grateful to Prof. Enver Sherifi, Prof. Fadil Millaku, Prof. Elez Krasniqi, and Dr. Sc. Naim Berisha (Department of Biology, University of Prishtina) for their professional guidance and support during the fieldwork, and to MSc. Jeton Orllati for his assistance in the field. I would also like to express my sincere gratitude to Prof. Kimete Lluga-Rizani (Department of Biology, University of Prishtina) and Prof. Blerina Pupuleku (Department of Biology, University of Elbasan) for their professional support and valuable contributions to this study. I am also grateful to Prof. Valbon Bytyqi (Department of Geography, University of Prishtina) for his help in preparing the map, which was essential for visualizing the study area and species distributions.

Received April 23, 2025

REFERENCES

ARC, 2014: Agricultural Research Council. Management of invasive alien plants. https://www.arc.agric.za/arc-ppri/weeds/Pages/Management-of-invasive-alien-plants-.aspx

BENESPERI, R., GIULIANI, C., ZANETTI, S., GENNAI, M., LIPPI, M. M., GUIDI, T., NASCIMBENE, J. & FOGGI, B., 2012: Forest plant diversity is threatened by *Robinia pseudoacacia* (black-locust) invasion. Biodiversity and Conservation **21**(14), 3555–3568.

BLACKBURN, T. M., PYŠEK, P., BACHER, S., CARLTON, J. T., DUNCAN, R. P., JAROŠÍK, V., WILSON, J. R. U. & RICHARDSON, D. M., 2011: A proposed unified framework for biological invasions. Trends in Ecology and Evolution **26**(7), 333–339.

CHEN, H., LIU, J., XUE, T. & WANG, R., 2012: Roads accelerate the invasion process of alien species. Advanced Materials Research **347-353**, 1483-1487.

CHEN, Y., SUN, C. & ZHAN, A., 2017: Biological invasions in aquatic ecosystems in China. Aquatic Ecosystem Health & Management **20**(4), 402–412.

CHYTRÝ, M., MASKELL, L. C., PINO, J., PYŠEK, P., VILÀ, M., FONT, X. & SMART, S., 2008: Habitat invasions by alien plants: a quantitative comparison among Mediterranean, subcontinental and oceanic regions of Europe. Journal of Applied Ecology **45**(2), 448–458.

DAISIE, 2009: Species Accounts of 100 of the Most Invasive Alien Species in Europe. In: Handbook of Alien

Species in Europe. Invading Nature - Springer Series in Invasion Ecology, vol. 3. p. 269–374.

DELGADO, J. A., JIMENEZ, M. D. & GOMEZ, A., 2009: Samara size versus dispersal and seedling establishment in *Ailanthus altissima* (Miller) Swingle. Journal of Environmental Biology **30**(2), 183–186.

DIAS, N. S., FERREIRA, J. F., LIU, X. & SUAREZ, D. L., 2016: Jerusalem artichoke (*Helianthus tuberosus* L.) maintains high inulin, tuber yield, and antioxidant capacity under moderately-saline irrigation waters. Industrial Crops and Products **94**, 1009–1024.

DOUGLAS, C., 2018: Preventing the Spread of Japanese knotweed (*Reynoutria japonica*, (AKA: *Fallopia japonica*, *Polygonum cuspidatum*). New Hampshire Department of Agriculture, Markets & Food.

DUMITRASCU, M., DOROFTEI, M., GRIGORESCU, I., KUCSICSA, G. & DRAGOTĂ, S., 2013: Key biological indicators to assess *Amorpha fruticosa* Invasive Terrestrial Plant Species in Romanian protected areas. In International Conference on Energy & Environment. p. 144–149.

EARLY, R., BRADLEY, B. A., DUKES, J. S., LAWLER, J. J., OLDEN, J. D., BLUMENTHAL, D. M., GONZALEZ, P., GROSHOLZ, E. D., IBAÑEZ, I., MILLER, L. P., SORTE, C. J. B. & TATEM, A. J., 2016: Global threats from invasive alien species in the twenty-first century and national response capacities. Nature Communications **7**(1).

ESIPENKO, L., PODVARKO, A. & SAVVA, A., 2020: Phenotypic plasticity of an invasive weed *Ambrosia artemisiifolia* L. in agrobiocenoses of the South of Russia. BIO Web of Conferences **21**, 00041.

FOTIADIS, G., KYRIAZOPOULOS, A. P. & FRAGGAKIS, I., 2011: The behaviour of *Ailanthus altissima* weed and its effects on natural ecosystems. Journal of Environmental Biology **32** (6), 801–806.

GAŠPAROVIČOVÁ, P., ŠEVČÍK, M. & DAVID, S., 2022: The Prediction of Distribution of the Invasive *Fallopia* Taxa in Slovakia. Plants **11**(11), 1484.

GBIF, 2026: Global Biodiversity Information Facility. Occurrence dataset. Accessed 15 March 2026. https://www.gbif.org

GRIFFIN, W. J. & LIN, G. D., 2000: Chemotaxonomy and geographical distribution of tropane alkaloids. Phytochemistry **53**(6), 623–637.

GUARINO, R., CHYTRÝ, M., ATTORRE, F., LANDUCCI, F. & MARCENÒ, C., 2021: Alien plant invasions in Mediterranean habitats: an assessment for Sicily. Biological Invasions **23**(10), 3091–3107.

HULME, P. E., 2009: Trade, transport and trouble: managing invasive species pathways in an era of globalization. Journal of Applied Ecology **46**(1), 10–18.

HULME, P. E., BACHER, S., KENIS, M., KLOTZ, S., KÜHN, I., MINCHIN, D., NENTWIG, W., OLENIN, S., PANOV, V. E., PERGL, J., PYŠEK, P., ROQUES, A., SOL, D., SOLARZ, W. & VILÀ, M., 2008: Grasping at the routes of biological invasions: a framework for integrating pathways into policy. Journal of Applied Ecology **45**(2), 403–414.

HULME, P. E., BRUNDU, G., CARBONI, M., DEHNEN-SCHMUTZ, K., DULLINGER, S., EARLY, R., ESSL, F., GONZÁLEZ-MORENO, P., GROOM, Q., KUEFFER, C., KÜHN, I., MAUREL, N., NOVOA, A., PERGL, J., PYŠEK, P., SEEBENS, H., TANNER, R., TOUZA, J., VAN KLEUNEN, M. & VERBRUGGE, L. N. H., 2018: Integrating invasive species policies across ornamental horticulture supply chains to prevent plant invasions. Journal of Applied Ecology **55**(1), 92–98.

INATURALIST, 2026: iNaturalist Research-grade Observations. Accessed 15 March 2026. https://www.inaturalist.org

KADRIAJ, B. M., 2024: The invasive alien plants of the vascular flora in the eastern region of Kosovo. Doctoral Thesis. University of Prishtina "Hasan Prishtina", Faculty of Mathematics and Natural Sciences, Department of Biology, Prishtinë.

KADRIAJ, B., BERISHA, N., KRASNIQI, E. & MILLAKU, F., 2023: Invasive alien plant species (IAPS) in the eastern

region of Kosovo: a preliminary list. Ecologia Balkanica **15 (2)**, 22-31.

KRASNIQI, E., MILLAKU, F., REXHEPI, F., ABDULLAI, K., GASHI, B., UKAJ, SH., BERISHA, N. & SHALA, A., 2011: Some invasive alien plant species in Kosovo. Conference Proceeding. 7th International Symposium on Biodiversity, Conservation and Sustainable Use for Rural Development. Tirana, Albania. p. 172-175.

RAI, P. K., 2022: Environmental Degradation by Invasive Alien Plants in the Anthropocene: Challenges and Prospects for Sustainable Restoration. Anthropocene Science **1**(1), 5–28.

KUNWAR, R. & ACHARYA, R., 2013: Impact Assessment of Invasive Plant Species in Selected Ecosystems of Bhadaure Tamagi VDC, Kaski: An Ecosystem-based Adaptation in Mountain Ecosystem in Nepal. International Union for Conservation of Nature.

LA SORTE, F. A., ARONSON, M. F. J., WILLIAMS, N. S., CELESTI-GRAPOW, L., CILLIERS, S. S., CLARKSON, B. D., DOLAN, R., HIPP, A. L., KLOTZ, S., KÜHN, I., PYŠEK, P., SIEBERT, S. & WINTER, M., 2014: Beta diversity of urban floras among European and non-European cities. Global Ecology and Biogeography **23**(7), 769–779.

LACHMUTH, S., HENRICHMANN, C., HORN, J., PAGEL, J. & SCHURR, F. M., 2017: Neighbourhood effects on plant reproduction: An experimental-analytical framework and its application to the invasive *Senecio inaequidens*. Journal of Ecology **106**(2), 761–773.

LEMKE, A. C., KOWARIK, I. & VON DER LIPPE, M., 2019: How traffic facilitates population expansion of invasive species along roads: The case of common ragweed in Germany. Journal of Applied Ecology **56**(2), 413–422.

MARTIN, P. L., SHACKELFORD, G. E., BULLOCK, J. S., GALLARDO, B., ALDRIDGE, D. C. & SUTHERLAND, W. J., 2020: Management of UK priority invasive alien plants: a systematic review protocol. Environmental Evidence **9** (1).

MÉNDEZ-YÁÑEZ, Á., RAMOS, P. & MORALES-QUINTANA, L., 2022: Human Health Benefits through Daily Consumption of Jerusalem Artichoke (*Helianthus tuberosus* L.) Tubers. Horticulturae **8**(7), 620.

MEYERSON, L. A. & MOONEY, H. A., 2007: Invasive alien species in an era of globalization. Frontiers in Ecology and the Environment **5**(4), 199–208.

MILAKOVIC, I., FIEDLER, K. & KARRER, G., 2014: Management of roadside populations of invasive *Ambrosia artemisiifolia* by mowing. Weed Research **54**(3), 256–264.

MILLAKU, F., KADRIAJ, B. & BERISHA, N., 2024: First records of *Rudbeckia hirta* and *Oenothera glazioviana* in the flora of Kosovo. Botanica **30**(3), 117–124.

MONTAGNANI, C., GENTILI, R., BRUNDU, G. & CITTERIO, S., 2022: Accidental Introduction and Spread of Top Invasive Alien Plants in the European Union through Human-Mediated Agricultural Pathways: What Should We Expect? Agronomy **12**(2), 423.

DIRDIRI, N. E., WASFI, I. A., ADAM, S. E. & EDDS, G.T., 1981: Toxicity of *Datura stramonium* to sheep and goats. Veterinary and Human Toxicology **23**(4), 241–246.

NIKOLIĆ, T., MITIĆ, B. & BORŠIĆ, I., 2014: Croatian flora. Invasive plants. Alfa, Zagreb.

PAUKOVÁ, A., 2019: Occurrence and Spread after 18 Years of Invasion by *Fallopia* × *bohemica* (Slovakia). Journal of Ecological Engineering **20**(3), 85–90.

PIMENTEL, D., 2009: Invasive Plants: Their Role in Species Extinctions and Economic Losses to Agriculture in the USA. In: INDERJIT (eds.) Management of Invasive Weeds. Invading Nature – Springer Series In Invasion Ecology, vol. 5. p. 1-7.

PYŠEK, P. & RICHARDSON, D.M., 2007: Traits associated with invasiveness in alien plants: Where do we stand? In: NENTWIG, W. (eds.) Biological Invasions. Ecological Studies, vol. 193. p. 97–125.

PYŠEK, P., 2009: *Fallopia japonica* (Houtt.) Ronse Decr., Japanese knotweed (Polygonaceae, Magnoliophyta). Species Accounts of 100 of the Most Invasive Alien Species in Europe. In: Handbook of Alien Species in Europe. Invading Nature - Springer Series in Invasion Ecology, vol. 3. p. 348.

PYŠEK, P., CHYTRÝ, M., PERGL, J., SÁDLO, J. & WILD, J., 2012: Plant invasions in the Czech Republic: current state, introduction dynamics, invasive species and invaded habitats. Preslia **84**(3), 575–629.

PYŠEK, P., HULME, P. E., SIMBERLOFF, D., BACHER, S., BLACKBURN, T. M., CARLTON, J. T., DAWSON, W., ESSL, F., FOXCROFT, L. C., GENOVESI, P., JESCHKE, J. M., KÜHN, I., LIEBHOLD, A. M., MANDRAK, N. E., MEYERSON, L. A., PAUCHARD, A., PERGL, J., ROY, H. E., SEEBENS, H., VAN KLEUNEN, M., VILÀ, M., WINGFIELD, M. J. & RICHARDSON, D. M., 2020: Scientists' warning on invasive alien species. Biological Reviews **95**(6), 1511–1534.

PYŠEK, P., LAMBDON, P. W., ARIANOUTSOU, M., KÜHN, I., PINO, J. & WINTER, M., 2009: Alien Vascular Plants of Europe. In: Handbook of Alien Species in Europe. Invading Nature - Springer Series in Invasion Ecology, vol. 3. p. 43-61.

RAI, P. K. & SINGH, J. S., 2020: Invasive alien plant species: Their impact on environment, ecosystem services and human health. Ecological Indicators **111**, 106020.

REJMÁNEK, M. & RICHARDSON, D. M., 1996: What Attributes Make Some Plant Species More Invasive? Ecology **77**(6), 1655–1661.

RICHARDSON, D. M., PYŠEK, P., REJMÁNEK, M., BARBOUR, M. K., PANETTA, F. D. & WEST, C., 2000: Naturalization and invasion of alien plants: concepts and definitions. Diversity and Distributions **6**(2), 93–107.

RICHTER, R., BERGER, U., DULLINGER, S., ESSL, F., LEITNER, M., SMITH, M. R. & VOGL, G., 2013: Spread of invasive ragweed: climate change, management and how to reduce allergy costs. Journal of Applied Ecology **50**(6), 1422–1430.

SAWICKA, B., SKIBA, D., PSZCZÓŁKOWSKI, P., ASLAN, I., SHARIFI-RAD, J. & KROCHMAL-MARCZAK, B., 2020: Jerusalem artichoke (*Helianthus tuberosus* L.) as a medicinal plant and its natural products. Cellular and Molecular Biology **66**(4), 160–177.

SEEBENS, H., ESSL, F., DAWSON, W., FUENTES, N., MOSER, D., PERGL, J., PYŠEK, P., VAN KLEUNEN, M., WEBER, E., WINTER, M. & BLASIUS, B., 2015: Global trade will accelerate plant invasions in emerging economies under climate change. Global Change Biology **21**(11), 4128–4140.

SIMBERLOFF, D., MARTIN, J.-L., GENOVESI, P., MARIS, V., WARDLE, D. A., ARONSON, J., COURCHAMP, F., GALIL, B., GARCÍA-BERTHOU, E., PASCAL, M., PYŠEK, P., SOUSA, R., TABACCHI, E. & VILÀ, M., 2013: Impacts of biological invasions: what's what and the way forward. Trends in Ecology & Evolution **28**(1), 58–66.

SPAMPINATO, G., LAFACE, V.L.A., POSILLIPO, G., ORTIZ, A. C., CANAS, R. Q. & MUSARELLA, C.M., 2022: Alien flora in Calabria (Southern Italy): an updated checklist. Biological Invasions **24**, 2323–2334.

SVEHLAKOVA, H., JANIKOVA, A., KUPKA, J., SOTKOVA, N. & RAJDUS, T., 2017: Possibilities of the management of *Helianthus tuberosus* species in Poodri PLA (Czech Republic). IOP Conference Series: Earth and Environmental Science **92**, 012066.

SZILASSI, P., SOÓKY, A., BÁTORI, Z., HABENZCYUS, A. A., FREI, K., TÖLGYESI, C., VAN LEEUWEN, B., TOBAK, Z. & CSIKÓS, N., 2021: Natura 2000 Areas, Road, Railway, Water, and Ecological Networks May Provide Pathways for Biological Invasion: A Country Scale Analysis. Plants **10**(12), 2670.

TOSTES, R. A., 2002: Accidental *Datura stramonium* poisoning in a dog. Veterinary and Human Toxicology **44**(1), 33–34.

TRANCĂ, S., SZABO, R. M. & COCIŞ, M., 2017: Acute poisoning due to ingestion of *Datura stramonium* – a case report. Romanian Journal of Anaesthesia and Intensive Care **24**(1), 65-68.

VAN DER VELDE, G., RAJAGOPAL, S., KUYPER-KOLLENAAR, M., DE VAATE, A. B., THIELTGES, D. W. & MACISAAC, H. J., 2006: Biological Invasions: Concepts to Understand and Predict a Global Threat. In: BOBBINK, R., BELTMAN, B., VERHOEVEN, J.T.A., WHIGHAM, D.F. (eds.) Wetlands: Functioning, Biodiversity Conservation, and Restoration. Ecological Studies, vol. 191. p. 61–90.

VAN KLEUNEN, M., DAWSON, W. & MAUREL, N., 2015: Characteristics of successful alien plants. Molecular Ecology **24**(9), 1954–1968.

VITALOS, M. & KARRER, G., 2009: Dispersal of *Ambrosia artemisiifolia* seeds along roads: the contribution of traffic and mowing machines. Neobiota **8**, 53–60.

WALKER, G. A., GAERTNER, M., ROBERTSON, M. P. & RICHARDSON, D. M., 2017: The prognosis for *Ailanthus altissima* (Simaroubaceae; tree of heaven) as an invasive species in South Africa; insights from its performance elsewhere in the world. South African Journal of Botany **112**, 283–289.

WILSON, J. R. U., DORMONTT, E. E., PRENTIS, P. J., LOWE, A. J. & RICHARDSON, D. M., 2009: Something in the way you move: dispersal pathways affect invasion success. Trends in Ecology and Evolution **24**(3), 136–144.

WRZESIEŃ, M. & DENISOW, B., 2017: Factors responsible for the distribution of invasive plant species in the surroundings of railway areas. A case study from SE Poland. Biologia **72**(11), 1275–1284.

Suppl. Tab. S1. Presence (+) or absence (–) of invasive alien plant species in the eastern region of Kosovo according to GBIF and iNaturalist.

Plant species	GBIF	iNaturalist	GBIF link	iNaturalist link
Abutilon theophrasti Medik.	+	-	https://www.gbif.org/occurrence/3954326156	
Ailanthus altissima (Mill.) Swingle	+	+	https://www.gbif.org/occurrence/map?q=ailanthus%20altissima&country=XK	https://www.inaturalist.org/taxa/57278-Ailanthus-altissima#map-tab
Ambrosia artemisiifolia L.	-	-		
Amorpha fruticosa L.	-	-		
Bidens frondosa L.	-	-		
Echinocystis lobata (Michx.) Torr. & A. Gray	-	-		
Helianthus tuberosus L.	-	+		https://www.inaturalist.org/taxa/122970-Helianthus-tuberosus#map-tab
Impatiens balfourii Hook.f.	-	-		
Impatiens glandulifera Royle	+	+	https://www.gbif.org/occurrence/4424684447	https://www.inaturalist.org/taxa/47892-Impatiens-glandulifera#map-tab
Reynoutria × *bohemica* Chrtek & Chrtková	-	-		
Senecio inaequidens DC.	+	-	https://www.gbif.org/occurrence/3998243472	
Solidago gigantea Aiton	-	-		