

# “Plant Conservation and Ecosystem Restoration in the Mediterranean”

## Are Urban Rivers Areas of Interest for the Conservation of Riparian Flora? The Case of the Manzanares River in the City of Madrid (Spain).

Pedro Molina-Holgado<sup>1</sup> (pedro.molina@uam.es) (\*), Fernando Allende-Álvarez<sup>1</sup> (fernando.allende@uam.es),  
Nieves López-Estébanez<sup>1</sup> (nieves.lopez@uam.es), Fátima Franco-Múgica<sup>2</sup> (fatima.franco@uam.es) (\*) correspondence  
<sup>1</sup>Departamento de Geografía. <sup>2</sup>Departamento de Ecología. Universidad Autónoma de Madrid, Spain.



This work is a partial synthesis of the results of a larger project focused on analysis, characterisation, assessment and management of the flora of the Manzanares River in the city of Madrid (19 UTM 1 km<sup>2</sup>, 13.59 km). All the information comes from the fieldwork carried out by the authors in the study area (2021-2023).

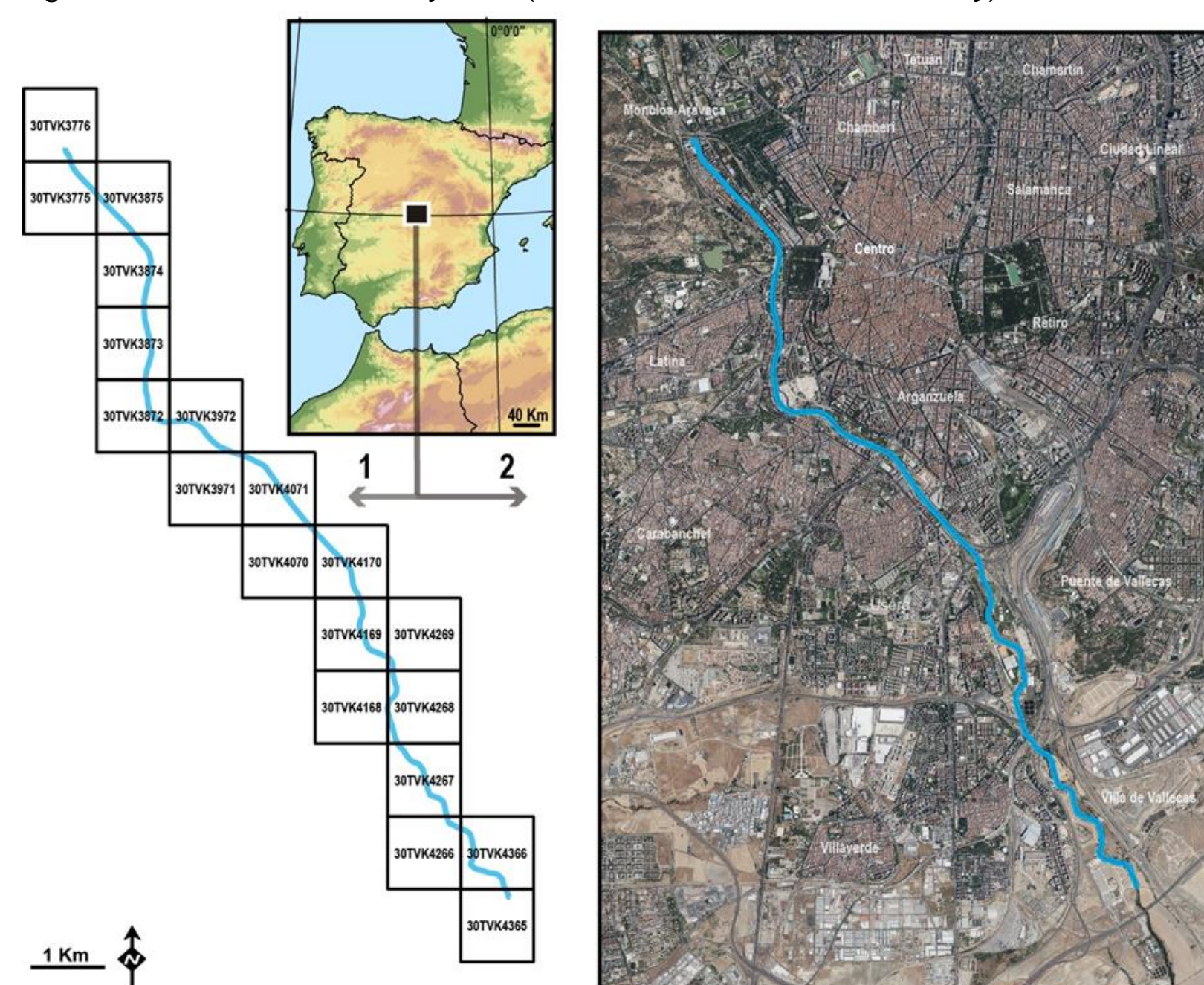
### 1. Introduction

While rivers outside metropolitan contexts suffer prolonged drought cycles due to the effects of climate change, urban rivers such as the Manzanares maintain stable flows even in dry periods (Molina Holgado *et al.*, 2023). The permanent contributions from the wastewater treatment systems of cities constitute the base flow of many watercourses located in Mediterranean metropolitan areas, as is the case of the river analysed. This circumstance favours the maintenance of a large number of taxa that benefit from the hydrological stability of urban river areas. In the specific case of the Manzanares river as it passes through the city of Madrid, moreover, the renaturalisation project of the river space developed since 2016 has favoured its rapid regeneration. This is to a large extent due to the opening of the floodgates of the 8 dams that fragmented the riverbed, which allowed the partial recovery of the river's hydrological and hydraulic characteristics.

### 2. Location of the study area

The analysis area covers a total length of 13.58 km (Figure 1,2,3), 51.1 % of which is located in consolidated urban territory, with a high density of buildings and population. In particular, the section located in the districts of Centro and Arganzuela, register population densities of 27014.27 inhabitants/km<sup>2</sup> and 23868.5 inhabitants/km<sup>2</sup> (Ayuntamiento de Madrid, 2021).

Figure 1. Location of the study area (Manzanares River in Madrid city)



The annual inflows of the Manzanares at the gauging station closest to the beginning of the study area (Parque Sindical nº 3070), recorded mean values of 141.18±60.84 hm<sup>3</sup> in the period 1965-2018 (57.20±33.30 hm<sup>3</sup> in the period 2001-2018) (CEDEX, 2022a). Downstream, in the gauging before the mouth of the Manzanares at 19.6 km from the Jarama river, the mean annual inflow recorded values of 840.35±109.97 hm<sup>3</sup> (1965-2018) and 351.62±39.91 hm<sup>3</sup> (2001-2018) (CEDEX, 2022b), with practically no natural inflow.

The river increases its flow significantly (x 6.1; period 2001-2018) after passing through the urban-metropolitan environment. This is due to the discharges from the complex system of wastewater treatment and regeneration plants of the city of Madrid and its metropolitan area (Lastra de la Rubia, 2021), which currently constitute the river's true base flow.

Cartographic base source: Base Digital Spain DEM (Digital Elevation Model) from USGS (United States Geological Survey Shuttle Radar Topography, 2004). National Topographic Map (Instituto Geográfico Nacional E: 1.25.000).

Figure 2. The urban river in Madrid downstream of the M50 highway



(1) View of the river upstream from Queen's Bridge (30TVK3785, 07/13/2023). (2) View downstream from the Queen's Bridge (30TVK3874, 11/20/2019). (3) Surrounding area of the Segovia Bridge (30TVK3873, 10/22/2022). (4) Surroundings of Arganzuela (30TVK4071, 08/28/2022). (5) The river in the Parque Lineal (30TVK4170, 01/11/2022). (6) The river in Parque Lineal 2 downstream of the M40 motorway (30TVK4267, 11/25/2022). Image source: the authors

Figure 3. Location and characteristics of the Manzanares River

UTM 1km <sup>2</sup>	km	Scope (and abbreviation)	Channel	Uses Environment
1 30TVK3776	0.24	Madrid Río (MR)	Breakwater	Green areas Residential
2 30TVK3775	0.61			
3 30TVK3875	0.73			
4 30TVK3874	1.09			
5 30TVK3873	1.02			
6 30TVK3872	0.79			
7 30TVK3972	0.93			
8 30TVK3971	0.21			
9 30TVK4071	1.32			
10 30TVK4070	0.14	Madrid Río 2 (MR2)	Breakwater	Green áreas Public roads
11 30TVK4170	1.12	Madrid Río 2 (MR2) Parque Lineal (PL)	Breakwater	Green areas Industrial areas Public Roads Wastelands Public Services
12 30TVK4169	1.07	Parque Lineal (PL)	Breakwater	
13 30TVK4269	0.18			
14 30TVK4168	0.16			
15 30TVK4268	0.99	Parque Lineal (PL) Parque Lineal 2 (PL2)	Breakwater	
16 30TVK4267	1.31	Parque Lineal 2 (PL2)	Breakwater	
17 30TVK4266	0.31			
18 30TVK4366	1.20			
19 30TVK4365	0.17			
Total	13.58			

### 3. Methodology

This work analyses the richness and density of the flora of the 19 UTM 1 km<sup>2</sup> squares that form the urban-peri-urban section of the Manzanares River in Madrid. The information comes from fieldwork carried out in 2021, 2022 and 2023.

Taxa of special interest due to their rarity, conservation status, absence in the regional territory or the city of Madrid have been included in the following categories:

- Taxa not recorded in the territory of the Community of Madrid (NR\_CM)
- Taxa not recorded in the urban area of the Municipality of Madrid (NR\_M)
- Taxa not recorded in the city of Madrid since the 19th century (NR\_19)
- Taxa extinct in the city of Madrid or in the territory of the Community of Madrid (Ex)
- Taxa included in the *Red List of the Urban Flora of Madrid* (RL)
- Other taxa of interest (OEI)

References to species included in the *Red List of Urban Flora of Madrid* are taken from Bot. Mat. (2023). Data on the presence-absence of species in the Madrid region are from Grijalbo (2023), Enriquez de Salamanca *et al.*, (2020, 2021, 2023), López Jiménez (2007) and Castroviejo Bolívar *et al.* (1986-2021).

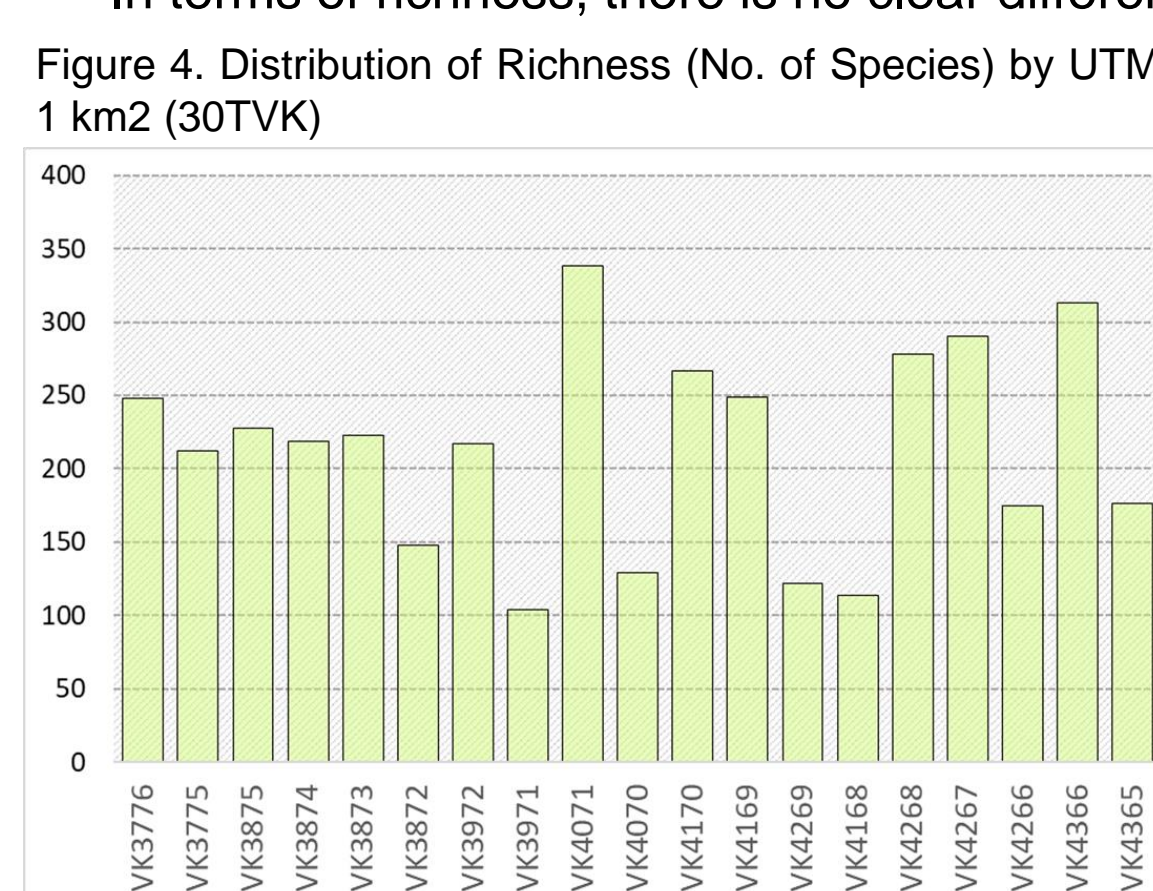
### 4. Results and discussion

General characteristics of the flora of the study area:

- The flora of the urban-periurban section of the Manzanares river is integrated by 590 taxa until 09/30/2023.
- The Manzanares River in the city of Madrid is home to 36.7% of the urban flora (1603 taxa) in 0.16% of the city's territory.
- It supports 22.3% of the regional flora (2649 taxa) in 0.006% of the territory of the Community of Madrid and 6.63% of the Iberian Flora, made up of 8882 taxa.
- Of the 590 taxa identified, 197 can be considered of special interest (35.5%). Of these,
  - 12 have not been recorded in the Community of Madrid (NR\_CM)
  - 28 have not been recorded in the urban sector of the city of Madrid (NR\_M)
  - 7 have not been recorded in the urban environment since the 19th century (NR\_19)
  - 2 have so far been considered extinct (Ex)
  - 22 are included in the *Red List of the Urban Flora of Madrid* (RL).

Aspects related to the distribution of richness by UTM 1 x 1 km grid squares (Figure 4):

- There is a clear positive correlation between the length of the river sections analysed and the number of taxa present ( $r_s=0.829$ ,  $p<0.05$ ,  $n=19$ ).
- There are no statistically significant differences in the richness of all the stretches ( $K-S=0.131$ ;  $p=0.200$ ;  $n=19$ ).
- The sections T09 (30TVK4071, Puente de Praga-Legazpi, Madrid Río) (1.32 km) (339 taxa) and T18 (30TVK4366, Parque Lineal 2) (1.19 km) (313 taxa) have the highest richness values.
- In terms of richness, there is no clear differentiation between urban and peri-urban sections.



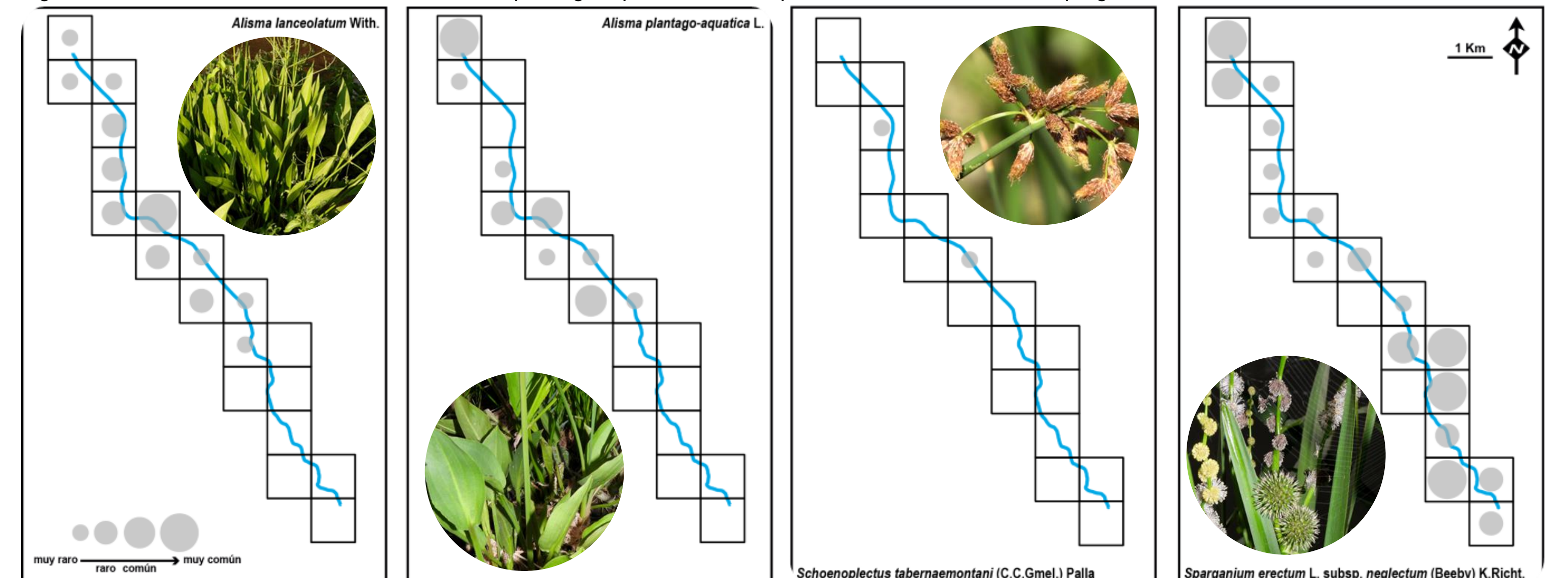
Source: Own data. Own elaboration.

Considerations on the progression of the area of distribution of the flora of the river area and the presence of autochthonous, absent or sparsely distributed taxa in Madrid:

- A rapid progression of some helophytes that were absent in the urban section before the start of the renaturation project can be observed from the few existing nuclei upstream of the city of Madrid (Figure 5).
- The colonisation of the previous elements in the urban-peri-urban section of the Manzanares river should therefore facilitate its expansion downstream in the same river and in the main course, the Jarama river.
- The urban-peri-urban section of the Manzanares River is currently home to a good number of very rare autochthonous taxa in the Madrid region, absent from the urban space since the 19th century or with no records in

the region or in the city (Figure 6). Among others, *Ajuga iva* (L.) Schreb., *Centranthus ruber* (L.) DC., *Erodium cium* (L.) Willd., *Isatis tinctoria* L., *Lepidium graminifolium* L., *Linum bienne* Mill., *Lotus pedunculatus* Cav., *Lysimachia vulgaris* L., *Persicaria amphibia* (L.) Delarbre, *Pteridium aquilinum* (L.) Kuhn, *Rorippa palustris* (L.) Besser., *Rubia peregrina* L., *Scutellaria gallericulata* L., *Silene inaperta* L. subsp. *inaperta*, *Sisymbrium erysimoides* Desf.

Figure 5. Distribution of *Alisma lanceolatum*, *Alisma plantago-aquatica*, *Schoenoplectus tabernaemontani* and *Sparganium erectum*



Source images: The authors. Source maps: Molina Holgado *et al.*, 2023.

Figure 6. Some taxa of special interest



Image source: The authors

### Conclusions

The Manzanares River is a corridor of special significance for the conservation of biodiversity in general and flora in particular in the current climate crisis scenario. While river courses located outside metropolitan contexts suffer prolonged cycles of drought, urban watercourses maintain stable flows thanks to the permanent contributions of urban purification systems, making it an area of opportunity in terms of conservation.

The 590 taxa recorded in the 54 ha of the study area contrast, for example, with the 1978 taxa that make up the total flora of Denmark, Norway and Sweden (817191 km<sup>2</sup>) (Tackenberg, 2019; Sætersdal, Birks & Peglar, 1998) or the 3227 species present in the British Isles (315134 km<sup>2</sup>) (Henniges, Powell & Mian, 2022).

The high richness values observed in the urban sector of the Manzanares and the presence of threatened or sparsely distributed species are other factors that highlight the value of the study area.

For all these reasons, it is important to intervene in the urban river area considering its important environmental value. In short, it is necessary to reconcile the complex management of the urban space (hydrological, hydraulic, sanitary) with the maintenance of its outstanding environmental values.

### Referencias

Ayuntamiento de Madrid. (2021). Padrón municipal de habitantes. Ciudad de Madrid. Explotación Estadística 1 de enero de 2021. Madrid: Ayuntamiento de Madrid. Subdirección General de Estadística. Bot. Mat. (2023). Flora Urbana de Madrid. Catálogo. Lista Roja y recomendaciones para la gestión del patrimonio botánico de la ciudad. Madrid: Doce Calles. Castroviejo Bolívar, S., Lainz, M., López González, G., Montserrat, P., Muñoz Garmendia, F., Paiva, J., & Villar, L. (1986-2021). Flora Iberica. Plantas Vasculares de la Península Ibérica e Islas Baleares. (Vols. I-XXXII). Madrid: Real Jardín Botánico, CSIC. Retrieved from <http://www.floriberica.es/>. CEDEX. (2022a). Estaciones de aforo: datos anuales. Estación 3070: río Manzanares en Madrid (Parque Sindical). Anuario de Aforos 2018-2019. Retrieved from [https://ceh.icedex.es/anuarioaforos/afos/estaf-datos\\_anual.asp?indica=3070](https://ceh.icedex.es/anuarioaforos/afos/estaf-datos_anual.asp?indica=3070). CEDEX. (2022b). Estaciones de aforo: datos anuales. Estación 3177: río Manzanares en Vaciamadrid. Anuario de Aforos 2018-2019. Retrieved from [https://ceh.icedex.es/anuarioaforos/afos/estaf-datos\\_anual.asp](https://ceh.icedex.es/anuarioaforos/afos/estaf-datos_anual.asp). Enriquez de Salamanca, A., & Gabriel y Galán, J.M. (2020). Atlas de la flora alóctona de Madrid. I. Monilophyta-Gymnospermae. *Botanica Complutensis*, 29-59. <http://dx.doi.org/10.5209/bocm.67409>. Enriquez de Salamanca, A., Gabriel y Galán, J.M., Cabezas, F., & Martínez Ronda, M. (2021). Atlas de la flora alóctona de Madrid. II. Nymphaeales-Gramineae. *Botanica Complutensis*, 45, 1-62. <https://doi.org/10.5209/bocm.75354>. Enriquez de Salamanca, A., Cabezas, F., Lafuente, I., López Manso, P., Martínez Ronda, M., & Martorell, A. (2023). Atlas de la flora alóctona de Madrid. III. Papaveraceae-Urticaceae. *Botanica Complutensis*, 47, e79529. <https://doi.org/10.5209/bocm.79529>. Grijalbo Cervantes, J. (2023). Catálogo Flora Madrid 2023. In *Apuntes de campo*. Retrieved from <https://ajvs.grijalbo.blogspost.com/catalogo.html>. Henniges, M., Powell, R., & Mian, S. (2022). A taxonomic, genetic and ecological data resource for the vascular plants of Britain and Ireland. *Sci Data*, 9 (1). <https://doi.org/10.1038/s41597-021-01104-5>. Lastra de la Rubia, A. (2021). Madrid y río Manzanares. Los tanques de tormenta como infraestructuras de atenuación de las presiones de los sistemas de saneamiento unitario sobre las masas de agua. In CONAMA 2020. 16º Congreso Nacional de Medio Ambiente Comunicaciones de Difusión de Proyectos (págs. 1-39). Madrid: Fundación CONAMA. Retrieved from [http://www.conama2020.org/web/guest/menu-257&lang-es&orden=apellidos&orden\\_tipo=ASC&pagina=7](http://www.conama2020.org/web/guest/menu-257&lang-es&orden=apellidos&orden_tipo=ASC&pagina=7). López Jiménez, N. (2007). Las plantas vasculares de la Comunidad de Madrid. Catálogo florístico, claves dicotómicas y estudio detallado de la familia Compositae Giseke. Madrid: Universidad Complutense de Madrid. Retrieved from <https://eprints.ucm.es/deliver/54180>. Molina Holgado, P., Allende Álvarez, F., López Estébanez, N. (2023). Los efectos positivos de la renaturalización del río Manzanares (Madrid) en la riqueza florística del espacio fluvial urbano. En *revisión Sætersdal, M., Birks, H., & Peglar, S. (1998). Predicting changes in Fennoscandian vascular plant species richness as a result of future climatic change. Journal of Biogeography*, 25. <https://doi.org/10.1046/j.1365-2688.1998.251192.x>. Tackenberg, O. (2019). Flora of Scandinavia. (Flora - Plant Guide Book 16). Flora.