

Ecological attributes promoting intra-continental range-expansion of a native annual forb triggered by intensified land-use; Eszter Ruprecht, Franz Essl, Augustin C. Moț, Beatrix Balaji, Thomas Kuhn, Annamária Fenesi, Constantin Mardari, Zsombor Miholcsa; correspondence: eszter.ruprecht@ubbcluj.ro; Biodiversity and Conservation

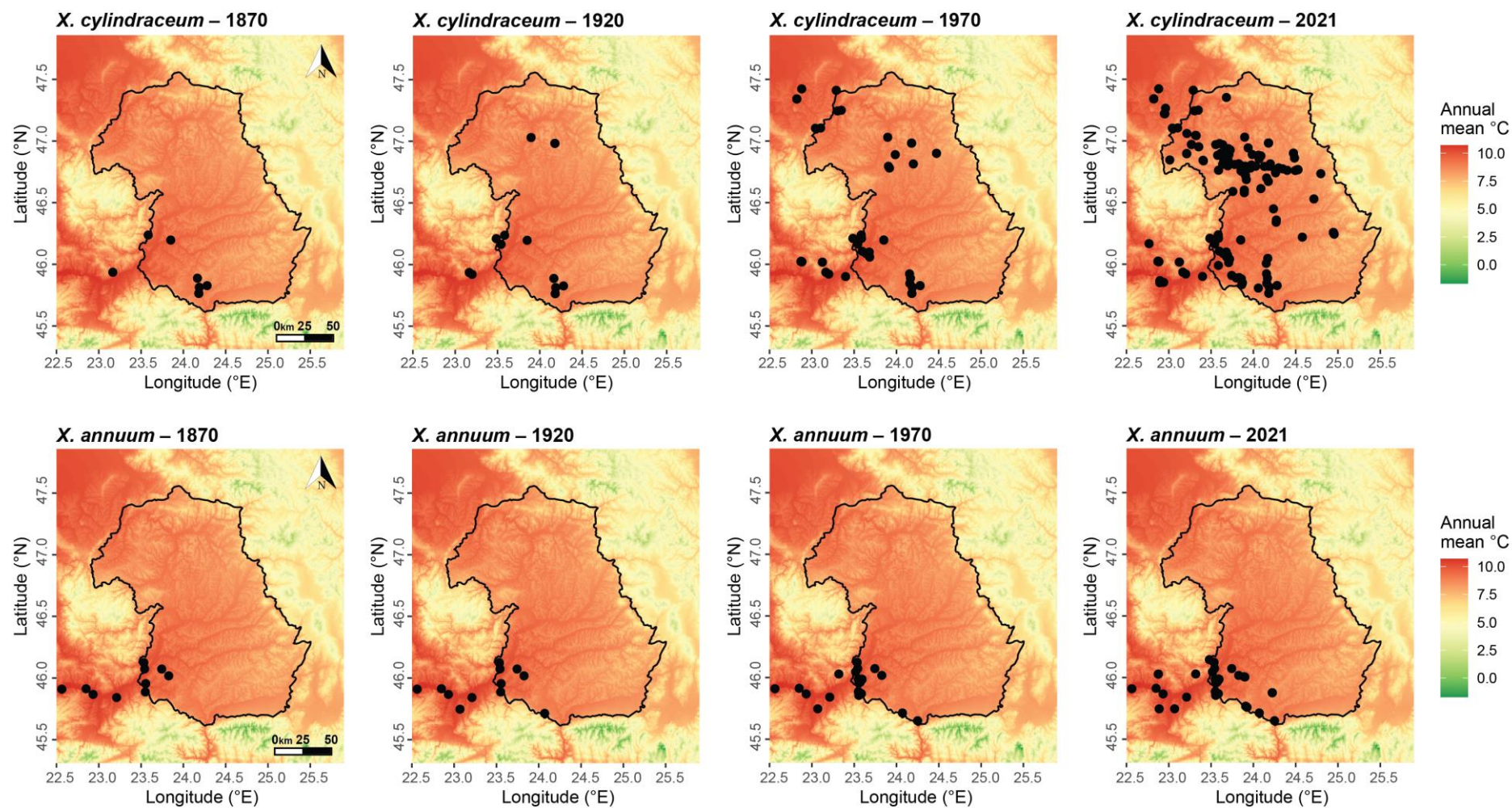


Fig. 1. Reconstruction of the historic documented distribution of *X. cylindraceum* (upper row) and *X. annuum* (lower row) in Transylvania (Romania) in four periods (until 1870, until 1920, until 1990 and until 2021). The Transylvanian Basin is delimited by a black line. Annual mean temperature (°C, 1970-2000 period) data has been extracted from the WorldClim database (Fick and Hijmans 2017). For the distribution maps, we used data obtained from the Romanian Grassland Database, the Herbarium of the Babeş-Bolyai University, selected literature of Romania's floristic surveys listed in Oprea's thematic article (Oprea 2006), and recent observations of the authors of this article and three active field botanist (Anna Szabó, Attila Mátis, Demetra Rákosy).

Table 1. Climatic variables calculated based on bihourly soil surface temperature data registered by temperature loggers in the four transplant sites. FPL (freezing period length), the number of days with daily soil surface temperatures $< 0^{\circ}\text{C}$; FDD (freezing degree days), the sum of daily soil surface temperatures $< 0^{\circ}\text{C}$; GPL (growing period length), the number of days with daily soil surface temperatures $> 5^{\circ}\text{C}$; GDD (growing degree days), the sum of daily soil surface temperatures $> 5^{\circ}\text{C}$. * data extracted from the WorldClim database (for the period 1970-2000; Fick and Hijmans 2017).

Climatic variables	Period	Sites			
		Satu Mare	Cojocna	Inucu	Răchitele
Exact location (GPS coordinates)		N47.801849, E22.864035	N46.745861, E23.832111	N46.843481, E23.248580	N46.695446, E22.889107
Elevation (m)		166	400	513	1070
Mean annual temperature ($^{\circ}\text{C}$)*	multiannual	10.2	8.5	8.0	5.1
Mean temperature of coldest quarter ($^{\circ}\text{C}$)*	multiannual	-0.3	-2.2	-2.0	-3.7
Mean annual precipitation (mm)*	multiannual	726	600	641	833
Precipitation of warmest quarter (mm)*	multiannual	249	237	246	307
Mean soil surface temperature during the experimental period ($^{\circ}\text{C}$)	16. October 2019 – 16. July 2020	9.4	8.5	6.9	6.8
Mean soil surface temperature of coldest quarter ($^{\circ}\text{C}$)	1. December 2019 – 29. February 2020	1.8	0.3	-0.7	0.6
Early seedling stage					
Mean soil surface temperature during the day ($^{\circ}\text{C}$)	16. October 2019 – 10. March 2020	5.3	4.3	3.6	5.1

	Mean soil surface temperature during the night (°C)	16. October 2019 – 10. March 2020	4.9	2.8	1.1	2.1
	FPL (nr. days)	16. October 2019 – 10. March 2020	34	41	60	35
	FDD (°C)	16. October 2019 – 10. March 2020	29.6	78.6	123.2	41.0
	GPL (nr. days)	16. October 2019 – 10. March 2020	62	53	44	43
	GDD (°C)	16. October 2019 – 10. March 2020	644.8	488.6	353.1	421.1
Late seedling stage	Mean soil surface temperature during the day (°C)	11. March – 10. May 2020	1.0	11.7	11.3	9.8
	Mean soil surface temperature during the night (°C)	11. March – 10. May 2020	7.3	6.1	2.6	2.7
	GPL (nr. days)	11. March – 10. May 2020	52	51	44	44
	GDD (°C)	11. March – 10. May 2020	507.2	533.0	409.4	369.4
Adult stage	Mean soil surface temperature during the day (°C)	11. May – 16. July 2020	18.9	18.8	17.7	14.8
	Mean soil surface temperature during the night (°C)	11. May – 16. July 2020	17.9	16.4	12.8	11.8

Table 2. Habitat types, in which the two *Xeranthemum* species have been sampled in Romania, number and percentage of occurrences. Vegetation plot data originating from the Romanian Grassland Database (Vassilev et al. 2018) was classified in EUNIS habitat categories using the expert system EUNIS-ESy (Chytrý et al. 2020).

Habitat code	Habitat name	<i>X. cylindraceum</i>		<i>X. annuum</i>	
		n	%	n	%
R	Grasslands and lands dominated by forbs, mosses or lichens	82	88.2	75	80.6
R11	Pannonian and Pontic sandy steppe	1	1.1	0	0
R16	Perennial rocky grassland of Central and South-Eastern Europe	2	2.2	4	4.3
R1A	Semi-dry perennial calcareous grassland (meadow steppe)	16	17.2	3	3.2
R1B	Continental dry grassland (true steppe)	51	54.8	66	71
R1R	Mediterranean to Atlantic open, dry, acid and neutral grassland	1	1.1	0	0
R21	Mesic permanent pasture of lowlands and mountains	2	2.2	0	0
R22	Low and medium altitude hay meadow	1	1.1	0	0
R	Classified as grassland	8	8.6	2	2.2
S	Heathlands, scrub and tundra	3	3.2	2	2.2
Sb	Dwarf-shrub vegetation	0	0	1	1.1
S35	Temperate and submediterranean thorn scrub	1	1.1	0	0
S36	Low steppic scrub	1	1.1	0	0
S91	Temperate riparian scrub	1	1.1	1	0
V	Vegetated man-made habitats	8	8.6	16	17.2
V15	Bare tilled, fallow or recently abandoned arable land	0	0	0	0
V32	Mediterranean subnitrophilous annual grassland	0	0	0	0
V34	Trampled xeric grassland with annuals	0	0	1	1.1
V37	Annual anthropogenic herbaceous vegetation	3	3.2	3	3.2
V38	Dry perennial anthropogenic herbaceous vegetation	3	3.2	11	11.8
V	Classified as vegetated man-made habitats	2	2.2	1	1.1

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